VOL. 109 JANUARY 2007 NO. 1
(ISSN 0013-8797)

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY of WASHINGTON

PUBLISHED
QUARTERLY

CONTENTS

(Continued on back cover)

THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

ORGANIZED MARCH 12, 1884

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, ℅ Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168.

MEETINGS.—Regular meetings of the Society are held in the Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 7:00 P.M. Minutes of meetings are published regularly in the *Proceedings*.

MEMBERSHIP.—Members shall be persons who have demonstrated interest in the science of entomology. Annual dues for members are $25.00 (U.S. currency).

PROCEEDINGS.—The *Proceedings of the Entomological Society of Washington* (ISSN 0013-8797) are published quarterly beginning in January by The Entomological Society of Washington. POSTMASTER: Send address changes to the Entomological Society of Washington, ℅ Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember U.S. subscriptions are $60.00 per year and foreign subscriptions are $70.00 per year, payable (U.S. currency) in advance. Foreign delivery cannot be guaranteed. All remittances should be made payable to *The Entomological Society of Washington*.

The Society does not exchange its publications for those of other societies.

PLEASE SEE PP. 263-264 IN THIS ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, ℅ Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Editor: David R. Smith, Systematic Entomology Laboratory, ARS, USDA, ℅ Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Books for Review: David R. Smith, Systematic Entomology Laboratory, ARS, USDA, ℅ Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 2 January 2007

Periodicals Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 1–8

A NEW SPECIES OF *ELASMOSOMA* RUTHE (HYMENOPTERA: BRACONIDAE: NEONEURINAE) FROM THE NORTHWESTERN UNITED STATES ASSOCIATED WITH THE WESTERN THATCHING ANTS, *FORMICA OBSCURIPES* FOREL AND *FORMICA OBSCURIVENTRIS CLIVIA* CREIGHTON (HYMENOPTERA: FORMICIDAE)

Scott R. Shaw

U.W. Insect Museum, Department of Renewable Resources, University of Wyoming, 1000 East University Avenue, Laramie, WY 82071-3354, U.S.A. (e-mail: braconid@uwyo.edu)

Abstract.—A **new species** of neoneurine braconid, ***Elasmosoma michaeli***, is described from Oregon, Washington, and Wyoming (Yellowstone National Park). The new species is an imagobiont endoparasitoid of adult workers of *Formica obscuripes* Forel in Washington and Wyoming. This species was recorded as a parasitoid of *Formica obscuriventris clivia* Creighton workers in Oregon. This is the first record of *Elasmosoma* attacking *Formica obscuripes*.

Key Words: new species, Neoneurinae, *Elasmosoma*, Oregon, Washington, Wyoming, Yellowstone National Park, ant parasites, *Formica obscuripes* Forel

The braconid subfamily Neoneurinae comprises a small group of relatively rare parasitic wasps that are associated with worker ants of the *Formica fusca* L. and *F. rufa* L. species groups (Shenefelt 1969, Shaw 1997). Little is known about their biology but neoneurine species have long been assumed to be endoparasitoids of adult worker *Formica* ants (Muesebeck 1941, Marsh et al. 1987, Quicke and van Achterberg 1990, Shaw and Huddleston 1991, Poinar and Miller 2002, Poinar 2004, Shaw 2004). The North American species of the neoneurine genus *Elasmosoma* Ruthe were studied by Muesebeck (1922, 1941) and later revised by Huddleston (1976), who recognized five species in the continental United States and Canada. The North American species, their distributions, and known host associations were catalogued by Marsh (1979). Shaw (1985) examined *Elasmosoma petulans* using scanning electron microscopy and illustrated diagnostic features of the head, leg, and metasoma. The legs of *Elasmosoma* are unusual in having vestigial tarsal claws and greatly enlarged pulvilli (Shaw 1985: fig. 6). Egg deposition by neoneurine females into the abdomens of adult worker ants has been observed by numerous authors (Olivier 1893; Pierre 1893; Wasmann 1897; Donisthorpe 1927; Kariya 1932; Shaw 1992, 1993) but the details of larval development have only recently been described (Poinar 2004). The process of oviposition is extremely rapid, requiring only a fraction of a second. Wasmann (1897) reported rearing an adult *Elasmosoma* from a cocoon found attached to the abdomen of a dead worker *Formica* ant, but only recently has any neoneurine been raised from egg to adult in a laboratory setting (Poinar 2004). Neoneurines fly close to the ground and stay very near nests (Poinar 2004) and raiding trails (Muesebeck 1941) of *Formica* ants. They are usually found hovering over, or near, ant nests and trails, where they can be sampled by aspirator. Although *Formica* ant mounds are quite common in southern Yellowstone National Park (YNP), Wyoming, U.S.A., until recently no neoneurines were known to occur there.

The 1988 fires in YNP burned 400,000 ha or 45% of the park and attracted international attention Christensen et al. (1989). Following that event there was a renewed interest in YNP biotic communities, and new studies of insects were conducted. During the summer of 1990, we operated four Malaise traps in burned and unburned areas of south YNP (Lockwood et al. 1996). Our study found a total of 603 Hymenoptera species, representing 36 families (from a total of 2,331 hymenopteran specimens sampled). Of these, the parasitic wasp family Braconidae was well represented, with 109 species found in south YNP. That study also yielded the first record of the ant-associated subfamily Neoneurinae in YNP: a single (damaged) specimen of *Elasmosoma*, apparently a new species. Although intriguing, the damaged condition of this single specimen prevented further taxonomic study.

In 1999, I was contacted by Jack Longino who kindly sent a nice series of 13 *Elasmosoma*. These were collected on the campus of Evergreen State College (Thurston County, Washington) in association with the western thatching ant, *Formica obscuripes* Forel. He later sent two specimens from Long Beach (Pacific County, Washington), also found attacking workers of *F. obscuripes*. Finally, in 2001, George Poinar sent a series of *Elasmosoma* collected in Lincoln County, Oregon. All of these specimens appeared to be the same as the putative new species from YNP.

During the summer of 2002, I had the opportunity to return to south YNP for braconid sampling, now armed with the knowledge that *F. obscuripes* is the likely host ant for this wasp species. Despite expectations that this wasp species would be rather rare and difficult to locate, it was instead found to be quite common. Within minutes of first arriving in YNP we successfully located and observed *Elasmosoma* hovering by a *F. obscuripes* mound near the South Gate Ranger Station. Over the next two weeks observations were made and samples were obtained for descriptive purposes. The purpose of this paper is to describe and name this new neoneurine species as a contribution to continuing studies of the insect fauna of YNP, and to stimulate and facilitate more detailed biological studies of neoneurine wasps.

METHODS AND TERMINOLOGY

Specimens of *Elasmosoma* were sampled using a wet-aspirator and preserved directly into 2 dram vials of 90% ethanol. The wasps are intent on chasing ants and not too difficult to observe or aspirate. The main difficulty with this sampling method is that they fly close to the mound so sand and nest debris is easily aspirated as well. The other hazard is simply working in close proximity to such active and aggressive ants. The samples were moved to clean 90% ethanol, then later into 100% ethanol for 24 hours. Dry specimens were prepared by placing them in fine wire baskets, soaking in chloroform for 20 minutes, and air-drying under a fume hood, prior to point-mounting. This method approximates the results of critical-point-drying at less expense.

Species covered in this paper can be identified as members of the subfamily Neoneurinae using the subfamily key by Sharkey (1997). The definition of *Elasmosoma* follows that of Muesebeck (1922, 1941), Huddleston (1976); Marsh et al. (1987) and Shaw (1997). Specimens can be determined as *Elasmosoma* by using the keys of Marsh et al. (1987) and Shaw (1997). Morphological terminology follows that of Shaw (1992, 1997) and Sharkey and Wharton (1997). Wing vein terminology agrees with the system proposed by Sharkey and Wharton (1997) for the *Manual of the New World Genera of the Family Braconidae.* A labeled diagram of wing veins for *Elasmosoma* was given by (Sharkey and Wharton 1997: 37, fig. 18). The following key to species is modified after Huddleston (1976) and based on examination of the holotypes of all included species. Because of sexual variation, *Elasmosoma* species are most reliably identified based on female specimens.

KEY TO FEMALES OF THE DESCRIBED NORTH AMERICAN SPECIES OF *ELASMOSOMA*

1 Metasoma elongate, conspicuously longer (1.5–2.0 times) than head and mesosoma combined, strongly compressed; tergite 3 at least as long as wide . . *E. schwarzi* Ashmead

– Metasoma at most equal in length to head and mesosoma combined, not compressed; tergite 3 conspicuously wider than long 2

2(1) Distance between lateral ocellus and eye about twice diameter of lateral ocellus, or slightly less; hypopygium of female folded along midline and compressed . . . . *E. petulans* Muesebeck

– Distance between lateral ocellus and eye greater than twice diameter of lateral ocellus; hypopygium of female flat, not folded along midline or compressed . . . 3

3(2) Hind tibial spur longer than hind basitarsus; first metasomal tergite wider than long; hypopygium of female arising near middle of metasoma, hypopygium concealed below metasoma . . . . *E. vigilans* Cockerell

– Hind tibial spur at least slightly shorter than hind basitarsus; first metasomal tergite about as wide as long; hypopygium of female arising in distal 1/3 of metasoma, hypopygium wide and flat, with lateral lobes projecting beyond sides of metasoma 4

4(3) Hind tibial spur relatively short, longer spur just slightly longer than ½ basitarsus length; hypopygium of female densely setose, apical margin of hypopygium narrowly and deeply U-shaped; clypeus pale yellow or white . . . . *E. michaeli*, n.sp.

– Hind tibial spur relatively longer, longer spur just slightly shorter than entire basitarsus length; hypopygium of female sparsely setose, apical margin of hypopygium broadly and shallowly V-shaped; clypeus black . . . . *E. pergandei* Ashmead and *E. bakeri* Ashmead [*E. bakeri* Ashmead is known only from male specimens. It is not certain if it can be maintained as a distinct species from *E. pergandei* Ashmead.]

Elasmosoma michaeli Shaw, new species

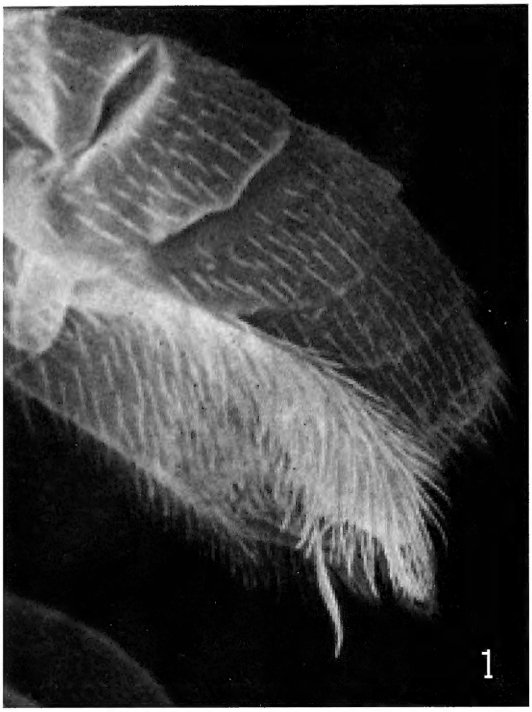
(Figs. 1–6)

Critical diagnosis.—Clypeus pale yellow or white; distance between lateral ocellus and eye greater than twice the diameter of lateral ocellus; hind tibial spur relatively short, longer spur just slightly longer than ½ basitarsus length; first metasomal tergite about as wide as long; hypopygium of female densely setose, apical margin of hypopygium narrowly and deeply U-shaped; hypopygium of female flat, not folded along midline or compressed.

Female.—Habitus of adult female as illustrated by (Poinar 2004: fig. 6c). Body length 2.0 mm.

Color: Body mostly black, except metasomal tergum 2 sometimes with yellowish brown along anterior and posterior margins. Clypeus and labrum pale yellow to white. Mandible white except tip reddish brown. Compound eye silvery gray. Front legs mostly white, front femur and tibia infused with pale yellow, apical tarsomere reddish brown. Middle and hind legs with similar color pattern except darker, more extensively infused with pale yellow to yellowish brown. Apex of hypopygium pale yellowish brown to white.

Head: Compound eyes, extremely large and strongly converging anteriorly and ventrally (Fig. 2). Malar space extremely narrow. Width of malar space

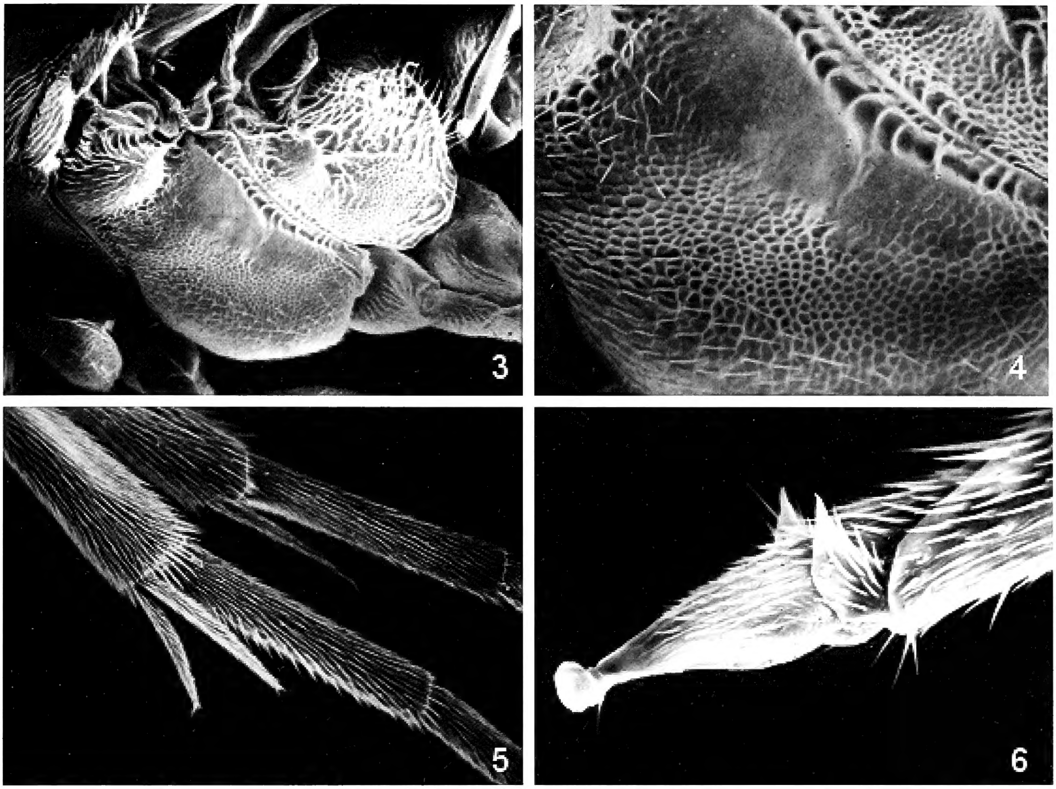


Figs. 1–2. *Elamosoma michaeli.* 1, Metasoma, lateral view showing ovipositor and densely setose hypopygium. 2, Head and antenna, lateral view.

near anterior condyle of mandible slightly less than width of mandible near tip. Face narrow, width of face slightly less than clypeus width. Antenna short (Fig. 2), flagellum length equal to mesosoma length (in lateral profile). Antennal scape short, slightly shorter than first flagellomere. Pedicel ½ length of scape. Flagellum with 10 compact flagellomeres, each of similar size and just slightly longer than wide, except apical (10th) flagellomere about 2× the length of first flagellomere. Apical flagellomere tapers to pointed apex. Apical flagellomere partly divided dorsally, thus appearing to have 11 flagellomeres in dorsal view but only 10 flagellomeres in lateral or ventral view. Ocellar triangle equilateral. Distance between lateral ocellus and eye slightly greater than twice the diameter of lateral ocellus. Surface sculpture of head very finely coriaceous.

Mesosoma: Mesosoma very compact. Mesosoma length in profile about 1.6× head length. Mesonotum finely coriaceous and densely covered with microscopic setae, no trace of notauli. Pronotum finely coriaceous. Dorsoposterior lobe of mesopleuron (Figs. 3–4) smooth and shining, devoid of sculpture and setae. Remainder of mesopleuron with dense, fine, foveolate sculpture (Fig. 4). Sternaulus not clearly differentiated from broad patch of foveolate mesopleural sculpture. Propodeum coarsely rugulose. Hind tibial spur relatively short, longer spur just slightly longer than ½ basitarsus length (Fig. 5). Hind tarsus (Fig. 6) with pulvillus greatly enlarged, tarsal claws greatly reduced and nearly vestigial.

Wings: Venation extremely reduced, as illustrated in (Shaw 1997: fig. 2). Pattern of venation highly distinctive for genus but with little discernable variation be-



Figs. 3–6. *Elamosoma michaeli*. 3, Mesosoma, lateral view. 4, Mesopleuron, lateral view showing detail of surface sculpture. 5, Hind leg, lateral view showing apex of hind tibia and length of tibial spurs relative to basitarsus. 6, Apex of hind tarsus showing vestigial tarsal claws and modified pulvillus.

tween species. Forewing length 1.0 mm. Costa and pterostigma dark brown to black. Remaining veins light brown.

Metasoma: Metasoma about equal in length to head and mesosoma combined, not compressed. Tergite 3 conspicuously wider than long. Metasomal terga finely coriaceous, sparsely setose, setae not obscuring surface sculpture. Hypopygium of female densely setose, flat, not folded along mid-line or compressed. Apical margin of hypopygium narrowly and deeply U-shaped. Lateral lobes of hypopygium extensively desclerotized and thin, nearly transparent. Ovipositor (Fig. 1) about as long as apical tergite, thin, sharply pointed, and flexible.

Male.—Similar to female except more extensively black, lacking light colors on clypeus and metasoma, and hind coxa black. Antenna longer, thicker, and more densely setose than in female, with 12 flagellomeres. Each flagellomere about 2× longer than wide, and densely setose. Flagellum tapering gradually from base to apex, apical flagellomere (12th) only about ½ as thick as first flagellomere. Compound eye smaller than in females, and malar space broader. Width of malar space about equal to length of antennal scape. Male genitalia mostly retracted into metasoma and not visible, except for small narrow parameres, about equal in size to apical hind tarsomere.

Holotype.—Female, United States of America: Washington, Thurston County, Evergreen State College, 20 September 1999, Jack Longino, #4191, at *Formica obscuripes* nest. Deposited in

University of Wyoming Insect Museum, Laramie, Wyoming.

Paratypes.—Oregon: 16 ♀, Lincoln County, between Newport and Waldport, 8 September 2001, aspirated near ant nest, George Poinar, coll.; 2 ♀, 1 ♂, Waldport, 7 August 2001, George Poinar, coll. Washington: 8 ♀, 5 ♂, Thurston County, Evergreen State College, 20 September 1999, Jack Longino, #4191, at *Formica obscuripes* nests; 2 ♀, Pacific County, Long Beach, #4160, 46° 20.8′N, 124° 03.7′W, attacking *Formica obscuripes*; 9 ♀, Yakima County, Pleasant Valley Campground, Highway 410, 46° 57′N, 121° 20′W, 1,000 m, 30 August 2003, J. Longino, #5136. Wyoming: 21 ♀, 1 ♂, Yellowstone National Park, near South Entrance, 1 August 2002, Michael J. Shaw and Scott R. Shaw coll., aspirated by ant nest, USDI-NPS YNP Scientific Research Permit Number YELL-2002-SCI-5310; 20 ♀, same data except collected 30 July 2002. Deposited in University of Wyoming Insect Museum, Laramie, Wyoming and National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Etymology.—This species is named for my son, Michael Joseph Shaw, for his assistance during the 2002 field season in Yellowstone and Grand Teton.

Biology.—The egg-laying behavior, embryonic development, larval development, and cocoon-forming behavior of this species was described by Poinar (2004) as "an undescribed species of *Elasmosoma* near *pergandei* Ashmead." Poinar reported this species as attacking workers of *Formica obscuriventris clivia* Creighton workers in Oregon. In Washington and Wyoming it was found attacking workers of *Formica obscuripes.* According to Jack Longino, the majority of ants in the YNP samples are *F. obscuripes* but a few individuals from the same mound resembled *F. propinqua* Wheeler. There were other ant mounds in the vicinity. It is possible that some workers of *F. propinqua* wandered near the *F. obscuripes* mound. Another possibility is that *F. propinqua* were temporary social parasites in nests of *F. obscuripes* and that YNP mounds were mixed nests. In all three cases the ants usually make similar, very large, thatched dome nests. It seems likely that the parasitoid attacks any of these host ants with similar behavior. The behavior of adult *E. michaeli* in YNP was the same as described by Poinar (2004) in Oregon. *Elasmosoma michaeli* adults were quite active on sunny mornings between 9am and 11am, with activity tapering off at midday.

Discussion.—*Elasmosoma michaeli* is most similar to *E. pergandei.* Females of both species have a broad, flat hypopygium that projects beyond the sides and apex of the metasoma. The lateral lobes of the hypopygium are extensively desclerotized and thin. When viewed from above these hypopygial lobes are rather transparent and windowlike. *Elasmosoma michaeli* can be distinguished by the hypopygium of the female being more densely setose (Fig. 1), and the apical margin of the hypopygium being narrowly and deeply U-shaped. The hypopygium of *E. pergandei* is less densely setose, with the apical margin more broadly V-shaped, and having a distinct sharp notch at the midline where the hypopygium margin meets the ovipositor base. *Elasmosoma michaeli* is also similar to *E. bakeri* (a species known only from male specimens). *Elasmosoma michaeli* can be distinguished from both *E. pergandei* and *E. bakeri* by the shorter tibial spurs (Fig. 5). The tibial spurs are much longer in *E. pergandei* and *E. bakeri* (nearly as long as the entire basitarsus). *Elasmosoma michaeli* females can be distinguished from those of *E. pergandei* by the pale yellow or white clypeus. The clypeus is black in females of *E. pergandei.* The clypeus color of *E. bakeri* females is not known.

ACKNOWLEDGMENTS

Thank you to Christie Hendrix and Nicki Tippets for their assistance with scientific research and collecting permits in Yellowstone National Park and Grand Teton National Park, respectively. This work was supported, in part, by a 2002 research grant from the UW-NPS Research Station, and by McIntire-Stennis project number WYO-362-02, braconid wasps in forest ecosystems. Park science ranger Rick Mossman was of great assistance by pointing out the location of several ant mounds in southern Yellowstone NP. Special thanks to my son Michael J. Shaw for his assistance in the field with setting up and monitoring Malaise traps in Grand Teton National Park and with aspirator sampling in southern Yellowstone. His keen eyesight was crucial to the success of this project. Additional thanks are due to Hank Harlow for assistance with local arrangements at the UW-NPS Research Station. Thank you to Jack Longino and George Poinar for providing wasp specimens, ant associations, data, and observations from Washington and Oregon, respectively. Stefan Cover (Harvard University) and Jack Longino (Evergreen College) provided identifications of host ants from Yellowstone. David Smith arranged the loan of type specimens of *Elasmosoma* from the collection of the National Museum of Natural History, Smithsonian Institution. Zhaojie Zhang, director of the University of Wyoming Microscopy Facility, assisted with the production of scanning electron microscope images.

LITERATURE CITED

Christensen, N. L., J. K. Agee, P. F. Brussard, J. Hughes, D. H. Knight, G. W. Minshall, J. M. Peek, S. J. Pyne, F. J. Swanson, J. W. Thomas, S. Wells, S. E. Williams, and H. A. Wright. 1989. Interpreting the Yellowstone fires of 1988. Bioscience 39: 678–685.

Donisthorpe, H. St. J. K. 1927. The Guests of British Ants, Their Habits and Life Histories. G. Routledge and Sons, Ltd., London. 244 pp.

Huddleston, T. 1976. A revision of *Elasmosoma* Ruthe (Hymenoptera: Braconidae) with two new species from Mongolia. Annales Historico-Naturales Musei Nationalis Hungarici 68: 215–225.

Kariya, M. 1932. Observations on a braconid species parasitic on ants. Konchu Sekai 36: 298–301 (in Japanese).

Lockwood, J. A., S. R. Shaw, and J. M. Struttmann. 1996. Biodiversity of wasp species (Insecta: Hymenoptera) in burned and unburned habitats of Yellowstone National Park, Wyoming, U.S.A. Journal of Hymenoptera Research 5: 1–15.

Marsh, P. M. 1979. Family Braconidae, pp. 144–313. *In* Krombein, K. V., P. D. Hurd Jr., D. R. Smith, and B. D. Burks, eds. Catalog of Hymenoptera in America North of Mexico, Smithsonian Institution Press, Washington, D.C., Volume 1, 1198 pp.

Marsh, P. M., S. R. Shaw, and R. Wharton. 1987. An identification manual for the North American genera of the family Braconidae (Hymenoptera). Memoirs of the Entomological Society of Washington, No. 13, 98 pp.

Muesebeck, C. F. W. 1922. A revision of the North American ichneumon-flies belonging to the subfamilies Neoneurinae and Microgastrinae. Proceedings of the United States National Museum 61: 1–76.

———. 1941. A new ant parasite (Hymenoptera, Braconidae). Bulletin of the Brooklyn Entomological Society 36: 200–201.

Olivier, E. 1893. [no title]. Annales Société Entomologique France 1893: 71.

Pierre, A. 1893. Un parasite des fourmis *Elasmosoma berolinense* Ruthe. Revue Scientifique Bourbon Centre France 6: 112–114.

Poinar, G. Jr. 2004. Behavior and development of *Elasmosoma* sp. (Neoneurinae: Braconidae: Hymenoptera), an endoparasite of *Formica* ants (Formicidae: Hymenoptera). Parasitology 128: 521–531.

Poinar, G. Jr. and J. C. Miller. 2002. First fossil record of endoparasitism of adult ants (Formicidae: Hymenoptera) by Braconidae (Hymenoptera). Annals of the Entomological Society of America 95(1): 41–43.

Quicke, D. L. J. and C. van Achterberg. 1990. Phylogeny of the subfamilies of the family Braconidae (Hymenoptera: Ichneumonoidea). Zoologische Verhandelingen Leiden 258: 1–95.

Sharkey, M. J. 1997. Key to the New World subfamilies of the family Braconidae, pp. 39–63. *In* Wharton, R. A., P. M. Marsh, and M, J. Sharkey, eds. Manual of the New World genera of the family Braconidae. Special Publication of the International Society of Hymenopterists, No. 1, 438 pp.

Sharkey, M. J. and R. A. Wharton. 1997. Morphology and terminology, pp. 19–38. *In* Wharton, R. A., P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World genera of the family Braconidae. Special Publication of the International Society of Hymenopterists, No. 1, 438 pp.

Shaw, M. R. and T. Huddleston. 1991. Classification and biology of braconid wasps (Hymenoptera: Braconidae). Handbooks for the Indentification of British Insects 7(11): 1–126.

Shaw, S. R. 1985. A phylogenetic study of the subfamilies Meteorinae and Euphorinae (Hymenoptera: Braconidae). Entomography 3: 277–370.

———. 1992. Seven new North American species of *Neoneurus* (Hymenoptera: Braconidae). Proceedings of the Entomological Society of Washington 94: 26–47.

———. 1993. Observations on the ovipositional behavior of *Neoneurus mantis*, an ant-associated parasitoid from Wyoming. Journal of Insect Behavior 6: 649–658.

———. 1997. Subfamily Neoneurinae, pp. 374–377. *In* Wharton, R. A., P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World Genera of the Family Braconidae (Hymenoptera). Special Publication of the International Society of Hymenopterists, Number 1, 438 pp.

———. 2004. Essay on the evolution of adult-parasitism in the subfamily Euphorinae (Hymenoptera: Braconidae). Proceedings of the Russian Entomological Society, St. Petersburg 75: 82–95.

Shenefelt, R. D. 1969. Pars 4. Braconidae 1, Hybrizontinae, Euphorinae, Cosmophorinae, Neoneurinae, Macrocentrinae, pp. 1–176. *In* Ferrière, C. and J. van der Vecht, eds. Hymenoperorum Catalogus (nova editio). Dr. W. Junk, The Hague.

Wasmann, E. 1897. *In* Marshall, T. A., Les Braconides, pp. 188–189. *In* André, E. ed. Species des Hyménoptères d'Europe et d'Algérie, Volume V. Dubosclard, Paris.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 9–16

HIGHER DIPTERA ASSOCIATED WITH THE MARSH SPIKE-RUSH, *ELEOCHARIS PALUSTRIS* (CYPERACEAE), IN NORTHEASTERN OHIO

B. A. Foote

Department of Biological Sciences, Kent State University, Kent, Ohio 44242 (e-mail: bfoote@kent.edu)

Abstract.—Information is given on 28 of the 50 species of higher Diptera that were found in stands of the marsh spike-rush, *Eleocharis palustris* (L.) Roemer & Schultes, in northeastern Ohio. Seasonal distributions, abundances, and larval feeding habits of selected species are presented.

Key Words: *Eleocharis*, Diptera, freshwater marshes, Ohio

This is the ninth paper in a series that focuses on the species of higher Diptera (Schizophora) that occur in freshwater marshes in northeastern Ohio (Todd and Foote 1987a, b; Rogers et al. 1991; Wearsch and Foote 1994; Larson and Foote 1997; Keiper et al. 1998; Foote 2004a, b). The present study gives survey data obtained during one field season of collecting higher Diptera from a near-monoculture stand of the marsh spike-rush, *Eleocharis palustris* (L.) Roemer & Schultes, growing in a roadside drainage ditch near Kent in northeastern Ohio. Information is given on seasonal occurrence and larval feeding habits of 28 of the 50 associated species.

Materials and Methods

Eleocharis palustris is a widespread, narrow-leaved, emergent, perennial species of Cyperaceae having horizontal, mat-forming rhizomes (Ball et al. 2002). The study stand was located in a shallow drainage ditch bordering Hodgeman Lane, a small road leading to the Kent Water Treatment Plant on the east side of the city in Portage County (41° 08′ 33″N × 81° 19′ 19″W). The stand was long and narrow (100 × 5 m) and consisted of a near monoculture of *E. palustris*, although a few individuals of rice cut grass, *Leersia oryzoides* (L.) Swartz, were scattered throughout the stand. The stand was bordered on either side by an undetermined species of grass and by narrow-leaved cattail (*Typha angustifolia* L.) at its northern end. The study site was mowed periodically by county maintenance crews throughout the summer months. Water, at a depth of some 10 cm, was present during the spring months. Water depths receded steadily as summer advanced, although summer rains caused temporary fluctuations. By late August, no standing water was present.

Specimens of Diptera were obtained by sweep samples consisting of 15 back and forth movements of a 15 inch diameter standard aerial insect net through the stand. Sampling took place weekly for 22 weeks between 6 May and 30 September, 2004. Nearby stands of rice cutgrass and other undetermined grass species were swept for comparative purposes.

Rearings were initiated from larvae or adults collected from the host plant.

Rearing containers were small (5.5 × 7.0 cm) plastic jars from which the bottom had been removed. The jar was then inserted into a Petri dish containing a layer of moist peat moss. The top of the jar was covered with fine-mesh nylon. A small pellet of moistened honey and yeast was affixed to the wall of the jar to serve as food for the adults.

Once larvae were obtained, they were transferred to Petri dishes containing fragments of the host plant or a field-collected sample of detritus or algae. Larvae were killed in hot water and preserved in 70% ethanol. Puparia that produced adults were placed in small plastic vials and pinned beneath the emerged adults. Voucher specimens are deposited in the insect collection of the author.

RESULTS

A total of 875 specimens from 35 genera and 50 species were collected from the stand of *Eleocharis* during the summer of 2004 (Table 1). In the following annotated list, 28 species are covered in greater detail with respect to their seasonal occurrence, relative abundance, and larval feeding habits.

Annotated List of Selected Species

Family Chloropidae

Chlorops obscuricornis Loew.—This Nearctic species is a stem borer of *Eleocharis*, having been reared from stems of *E. palustris* and *E. obtusa* (Willd.) (Wearsch and Foote 1994). It was an univoltine species having a flight period from late May to early August. Adults were particularly common in June. Eggs found on the surface of *Eleocharis* stems had an incubation period of 5–7 days. Newly hatched larvae bored through the stem cuticle and subsequently fed on the tissue within the stem. Larvae overwintered as first and second instars within stems, with the third instar being reached the following late April or May. Mature larvae migrated to the rhizomes where they formed puparia in May. The pupal period ranged from 10–15 days under laboratory conditions. Stem infestation rates were quite low, with 5 samples of 30 field-collected stems each having emergence rates ranging from 0 to 5%. Infested stems rarely produced inflorescences.

Diplotoxa inclinata Becker.—This strictly Nearctic species has a transcontinental distribution in North America and was abundant in the study stand between early May and early September. It was usually the first species of *Diplotoxa* to appear at the study site. Based on evidence obtained from the sweep samples and from laboratory rearings, it was an univoltine species. Mated females confined with *Eleocharis* in breeding jars readily deposited eggs on the stems, although a few eggs were also deposited on the underlying peat moss. Most of the eggs were placed at the base of the stem just above the peat moss, but a few were attached at greater heights. None was placed on inflorescence. The incubation period lasted 4–5 days. Newly hatched larvae crawled down the stem and entered young shoots at the base of the plant where they began feeding on the stem tissue. Older larvae moved downward within the stem and penetrated into the rhizomes attached to the crown of the plant. They then continued to feed within the meristematic tissue of the rhizome. Overwintering occurred as inactive second instars, and feeding recommenced during early April. Puparia were formed within the rhizomes during the last two weeks of April. Larvae and puparia were easily distinguished from those of *Chlorops* and other species of *Diplotoxa* by their greenish color. The life cycle was elucidated by Wearsch and Foote (1994) who also described and illustrated the egg and all larval instars.

Table 1. Species, numbers collected, and trophic guilds of higher Diptera associated with *Eleocharis palustris* in northeastern Ohio.

Species	Number of Adults Collected	Trophic Guild
Agromyzidae		
Cerodontha dorsalis (Loew)	1	Leaf miner of grasses
Undetermined sp.	2	Unknown
Anthomyzidae		
Anthomyza sp.	1	Stem borer
Mumetopia occipitalis Melander	2	Stem borer
Chloropidae		
Apallates neocoxendix (Sabrosky)	26	Unknown
Apallates particeps (Becker)	1	Unknown
Chlorops obscuricornis Loew	209	Stem borer of *Eleocharis*
Diplotoxa inclinata Becker	112	Stem borer of *Eleocharis*
Diplotoxa nigripes (Coquillett)	30	Stem borer of *Eleocharis*
Diplotoxa near *versicolor*	14	Stem borer of *Eleocharis*
Elliponeura debilis Loew	11	Seed predator of *Eleocharis*
Eribolus longulus (Loew)	1	Secondary invader of damaged stems
Incertella minor (Adams)	1	Secondary invader of damaged stems
Incertella incerta (Becker)	1	Secondary invader of damaged stems
Meromyza americana Fitch	1	Stem borer of grasses
Oscinella frit Linneaus	4	Stem borer of grasses
Pseudopachychaeta approximatonervis (Zett.)	14	Seed predator of *Eleocharis*
Rhopalopterum carbonaria (Loew)	51	Secondary invader of damaged stems
Thaumatomyia glabra (Meigen)	1	Predator of root aphids
Drosophilidae		
Scaptomyza pallida (Zetterstedt)	11	Scavenger of detritus
Ephydridae		
Hydrellia formosa Loew	2	Leaf miner of grasses
Hydrellia griseola (Fallén)	1	Leaf miner of many plant taxa
Leptopsilopa atrimana (Loew)	1	Scavenger of detritus
Notiphila caudata Fallén	44	Scavenger of detritus
Notiphila scalaris Loew	9	Scavenger of anaerobic detritus
Ochthera anatolikos Clausen	2	Insect predator
Pelina truncatula Loew	1	Consumer of Cyanobacteria
Scatella stagnalis (Fallén)	10	Scavenger, phycovore
Typopsilopa atra (Loew)	12	Secondary invader of damaged stems
Milichiidae		
Phyllomyza securicornis Fallén	1	Unknown
Opomyzidae		
Opomyza petrei Mesnil	81	Stem borer of grasses
Otitidae		
Chaetopsis massyla (Walker)	7	Secondary invader of damaged stems
Sciomyzidae		
Atrichomelina pubera (Loew)	9	Predator of stranded aquatic snails
Pherbellia nana (Fallén)	16	Predator of stranded aquatic snails
Pherbellia parallela (Walker)	4	Predator of stranded aquatic snails
Pherbellia schoenherri maculata (Cresson)	2	Predator of amber snails
Dictya borealis Curran	1	Predator of aquatic snails
Dictya expansa Steyskal	1	Predator of aquatic snails
Dictya sabroskyi Steyskal	9	Predator of aquatic snails

Table 1. Continued.

Species	Number of Adults Collected	Trophic Guild
Dictya steyskali Valley	1	Predator of aquatic snails
Sepedon armipes Loew	8	Predator of aquatic snails
Sepedon fuscipennis Loew	28	Predator of aquatic snails
Sepedon tenuicornis Cresson	5	Predator of aquatic snails
Sepsidae		
Enicomira minor (Haliday)	5	Scavenger of detritus
Sepsis punctum (Fabricius)	6	Scavenger of detritus, feces
Sphaeroceridae		
Leptocera sp.	39	Scavenger of detritus
Muscidae		
Coenosia tigrina (Fabricius)	18	Insect predator
Lispa sp.	29	Insect predator
Schoenomyza chrysostoma Loew	21	Stem borer of *Eleocharis*
Schoenomyza dorsalis Loew	8	Stem borer of *Eleocharis*

Number of species: 50.
Number of genera: 35.
Number of individuals: 875.

Diplotoxa nigripes (Coquillett).—An uncommon species in the stand of *E. palustris*, this small, dark species was common to abundant in nearby stands of the annual spike-rush, *E. obtusa* (Willd.) Scultes. The larvae are stem borers. The life cycle and the immature stages were described and illustrated by Wearsch and Foote (1994).

Diplotoxa sp. near *versicolor* (Loew).—The late Curtis W. Sabrosky (personal communication) recognized this form as a distinct species near *D. versicolor*, based upon the presence of white hairs on the dorsum of the abdomen instead of the dark hairs found in the *D. versicolor*. It was a fairly common species in the stand of *Eleocharis*, whereas adults of *D. versicolor* itself were far more commonly encountered on stands of the path rush, *Juncus tenuis* Willd. (Juncaceae). This stem borer was an univoltine species in northeastern Ohio, with a flight period extending from early May to late September. Overwintering occurred as second instars within the plant stems. Fully grown larvae were found near the bases of *Eleocharis* during late March and early April. Puparia were formed within the stems in early April, with emergence occurring in early May. The wasp *Chaenusa* sp. (Hymenoptera: Braconidae) was an important parasitoid, as 15 of 16 collected puparia were infested. The life cycle and immature stages were described and illustrated by Wearsch and Foote (1994).

Elliponeura debilis Loew.—This was an uncommon, multivoltine seed predator, having a flight period extending from mid-May to late September. Eggs were attached to the lower bracts subtending the inflorescence, with only 1 or 2 eggs being found on each inflorescence. Examination of inflorescence collected from the stand revealed infestation rates varying from zero to 27%. Larvae fed on the developing achenes, with each larva consuming 3–5 seeds. Puparia were formed in the inflorescence within the space formerly filled by an eaten achene. The pupal period lasted 6–8 days.

Pseudopachychaeta approximatonervis (Zetterstedt).—Like *E. debilis*, this species fed on the developing achenes, and had a similar life cycle and flight period.

However, older larvae and puparia were yellowish in color, whereas those of *E. debilis*, were greenish. Interestingly, only one species of the two seed predators was found in each infested inflorescence. An indication that this species is not strictly a seed predator was the rearing of adults from larvae that were feeding within damaged stems of yellow nelumbo, *Nelumbo lutea* (Willd.) Persoon (Nymphaeaceae), that had been attacked by larvae of the moth *Bellura obliqua* (Walker) (Noctuidae) in northern Ohio (J. B. Keiper, personal communication).

Rhopalopterum carbonaria (Loew).—This was a common species within the stand, with over 50 specimens being collected. Its larvae are secondary invaders of culms of wetland monocots that previously had been damaged by primarily phytophagous species (Valley et al. 1969).

Family Drosophilidae

Scaptomyza pallida (Zetterstedt).—This was a fairly common species within the stand being found in low numbers throughout the summer months. Its larvae are saprophagous in decaying plant material (Ferrar 1987).

Family Ephydridae

Notiphila caudata Fallén.—This was an abundant species during late May and early June. Its larvae were non-selective consumers of unicellular algae and decaying particulate plant material (Eastin and Foote 1971).

Notiphila scalaris Loew.—A few specimens of this small species were taken within the *Eleocharis* stand, but it was far more abundant in nearby stands of rice cutgrass. Keiper and Walton (2002) collected numerous adults from a monoculture stand of California bulrush, *Schoenoplectus californicus* (Meyer) Soják in California.

Scatella stagnalis (Fallén).—This was a relatively common species in the *Eleocharis* stand, with 10 specimens being recorded. The larvae are generalized consumers of algae and organic detritus (Zack and Foote 1978, Foote 1979).

Typopsilopa atra (Loew).—This was a common species, becoming particularly noticeable in mid-August. Its larvae are saprophagous, having been reared in laboratory cultures of decaying lettuce (Foote 1995). A related species, *T. nigra* (Williston), was found to be a secondary invader of the stems of California bulrush and cattail (*Typha* sp.) damaged by the feeding of larvae of the primary invader *Bellura obliqua gargantua* (Dyar) (Lepidoptera: Noctuidae) in southern California (Keiper et al. 2001).

Family Opomyzidae

Opomyza petrei Mesnil.—Although this was an abundant species in the *Eleocharis* stand, occurring throughout the collecting season, it was not directly associated with the sedge, Its larvae are known to be stem borers of grasses (Nye 1958) which were abundant on either side of the *Eleocharis* stand. This is a common, non-native species in the eastern states.

Family Otitidae

Chaetopsis massyla (Walker).—This was a relatively uncommon species within the *Eleocharis* stand. It appeared to be multivoltine, as adults were taken throughout the summer. The larvae are secondary invaders of the stems of wetland plants (Allen and Foote 1992), but no larvae were found in the stems of *Eleocharis*.

Family Sciomyzidae

Atrichomelina pubera (Loew).—This species was regularly encountered in the *Eleocharis* stand, and appeared to be multivoltine. Its larvae are generalized predators of aquatic pulmonate snails that have been stranded by dropping water levels (Foote et al. 1960).

Pherbellia nana (Fallén).—This was a fairly common species, occurring in low numbers throughout the summer months. Like those of *A. pubera*, its larvae prey on stranded aquatic snails (Bratt et al. 1969).

Dictya expansa Steyskal, *D. sabroskyi* Steyskal, and *D. steyskali* Valley.—Adults of these *Dictya* spp were taken in low numbers throughout the summer. They are known to be multivoltine, and their larvae are generalized predators of aquatic pulmonate snails (Valley and Berg 1977).

Sepedon armipes Loew, S. fuscipennis Loew, and *S. tenuicornis* Cresson.—These *Sepedon* spp. were uncommon to abundant within the stand of *Eleocharis*. Larvae of all three prey on aquatic pulmonate snails (Neff and Berg 1966).

Family Sepsidae

Enicomira minor (Haliday), *Sepsis puncta* (Fabricius).—Both of these species were minor components of the fly community, occurring in low numbers throughout the summer. Larvae of both are saprophagous on decaying plant material and feces (Ferrar 1987).

Family Sphaeroceridae

Leptocera spp..—Although numerous adults of this genus were swept from the stand, no larvae were found. Ferrar (1987) reported that larvae are saprophagous, coprophagous, and necrophagous.

Family Muscidae

Coenosia tigrina (Fabricius).—This was a common species, occurring throughout the summer. Larvae are predators of the stem-boring chloropid larvae in sedges (Kuehne 1991). Larvae also prey on earthworms and other soft-bodied invertebrates in moist to sodden soils (Ferrar 1987).

Lispe sp.—Adults of this species were found throughout the summer. The larvae are known to be general predators of soft-bodied invertebrates (Skidmore 1985).

Schoenomyza chrysostoma Loew, and *S. dorsalis* Loew.—Both *Schoenomyza* spp. were commonly taken in the stand, being particularly abundant in June. Larvae are stem borers of wetland monocots (Skidmore 1985, Ferrar 1987).

DISCUSSION

There was obvious partitioning of food resources within the stand of *Eleocharis*, and eight trophic guilds were recognized (Table 1). A large guild consisting of 11 species fed as generalized scavengers of decaying organic matter. The guild of secondary invaders consisted of six species whose larvae fed as scavengers on stem tissues previously damaged by phytophagous species. The phytophagous community consisted of 11 species of stem borers, three species of leaf miners, two species of seed predators, and one species that fed on blue-green algae (Cyanobacteria). Predacious species consisted of a snail-killing guild that contained 11 species and a insect-attacking guild that contained two species. The larval feeding habits of four species remain unknown. Only six of the 50 species (12%) encountered within the stand fed directly on tissues of *E. palustris*, although another four species fed as secondary invaders of *Eleocharis* stems that had been damaged by truly phytophagous insects.

The family containing the greatest number of species within the stand was Chloropidae with 15. The same family also produced the greatest number of individuals (n = 477). Over 65% of these belonged to two species of stem borers, *Chlorops obscuricornis* (n = 209) and

Diplotoxa inclinata (n = 112). The abundance of these two species suggests that larval infestations of the stems and rhizomes could be significant.

The degree of possible competition that exists among the six species that fed as larvae within the *Eleocharis* stems is unknown and warrants additional study. Interactions among the two species of seed predators, *E. debilis* and *P. approximatonervis*, and species of other insect families (Curculionidae, Cecidomyiidae, undetermined family of Lepidoptera) that were also encountered in the inflorescence need to be elucidated.

ACKNOWLEDGMENTS

I am indebted to Barbara Andreas, Kent State University, for aid in determining the species of *Eleocharis* at the study site. J. B. Keeper of the Cleveland Museum of Natural History and Eric G. Chapman of Kent State University offered suggestions for the improvement of the manuscript.

LITERATURE CITED

Allen, E. J. and B. A. Foote. 1992. Biology and immature stages of *Chaetopsis massyla* (Diptera: Otitidae), a secondary invader of herbaceous stems of wetland monocots. Proceedings of the Entomological Society of Washington 94: 320–328.

Ball, P. W., A. A. Reznicek, and D. F. Murray. 2002. 210. Cyperaceae, pp. 3–608. *In* Ball, P. W. et al., eds. 2002. Flora of North America. Oxford University Press, Oxford.

Bratt, A. D., L. V. Knutson, B. A. Foote, and C. O. Berg. 1969. Biology of *Pherbellia* (Diptera: Sciomyzidae). New York Agricultural Experiment Station 404: 1–247.

Eastin, W. C. and B. A. Foote. 1971. Biology and Immature Stages of *Dichaeta caudata* (Diptera: Ephydridae). Annals of the Entomological Society of America 64: 271–279.

Ferrar, P. 1987. A Guide to the Breeding Habits and Immature Stages of Diptera, Cyclorrhapha. Part I. Text. Brill, Leiden.

Foote, B. A. 1979. Utilization of algae by larvae of shore flies, pp. 61–71. *In* Deonier, D. L. ed. First Symposium on the Systematics and Ecology of Ephydridae (Diptera). North American Benthological Society.

———. 1995. Biology of shore flies. Annual Review of Entomology 40: 417–442.

———. 2004a. Acalyptrate Diptera associated with stands of *Carex lacustris* and *C. stricta* (Cyperaceae) in northeastern Ohio. Proceedings of the Entomological Society of Washington 106: 166–175.

———. 2004b. Acalyptrate Diptera of a fen at the Herrick Preserve in Portage County, Ohio. The Great Lakes Entomologist 35: 131–148.

Foote, B. A., S. E. Neff, and C. O. Berg. 1960. Biology and immature stages of *Atrichomelina pubera* (Diptera: Sciomyzidae). Annals of the Entomological Society of America 53: 192–199.

Keiper, J. B. and W. E. Walton. 2002. Effects of three management strategies on shore-flies (Diptera: Ephydridae) in newly constructed treatment wetlands. Annals of the Entomological Society of America 95: 570–576.

Keiper, J. B., P. L. Brutsche, and B. A. Foote. 1998. Acalyptrate Diptera associated with water willow, *Justicia americana* (Acanthaceae). Proceedings of the Entomological Society of Washington 100: 576–587.

Keiper, J. B., J. Jiannino, M. Sanford, and W. E. Walton. 2001. Biology and immature stages of *Typopsilopa nigra* (Williston) (Diptera: Ephydridae), a secondary consumer of damaged stems of wetland monocots. Proceedings of the Entomological Society of Washington 103: 89–97.

Kuehne, K. D. 1991. Bionomic and behavioural studies on *Coenosia tigrina* (Dipt., Muscidae), an unnoticed predator of stem-boring flies (Diptera: Chloropidae). Journal of Applied Entomology 112: 512–519.

Larson, L. and B. A. Foote. 1997. Biology of four species of *Notiphila* Fallén associated with the yellow water lily, *Nuphar luteum* (Nymphaeceae). Proceedings of the Entomological Society of Washington 99: 541–559.

Neff, S. E. and C. O. Berg. 1966. Biology and immature stages of malacophagous Diptera of the genus *Sepedon* (Sciomyzidae). Virginia Agricultural Experiment Station Bulletin 566: 1–113.

Nye, I. W. B. 1958. The external morphology of some of the dipterous larvae living in the Gramineae of Britain. Transactions of the Royal Entomological Society of London 110: 411–487.

Rogers, T. P., J. L. Todd, and B. A. Foote. 1991. Biology and immature stages of *Chlorops certimus* and *Epichlorops exilis* (Diptera: Chloropidae), stem-borers of wetland sedges. Journal of the New York Entomological Society 99: 664–683.

Skidmore, P. 1985. The Biology of the Muscidae of the World. Series Entomology 9: 1–550.

Todd, J. L. and B. A. Foote. 1987a. Spatial and temporal distribution of shore flies in a freshwater marsh (Diptera: Ephydridae). Proceedings of the Entomological Society of Washington 89: 448–457.

———. 1987b. Resource partitioning in Chloropidae (Diptera) of a freshwater marsh. Proceedings of the Entomological Society of Washington 89: 803–810.

Valley, K. and C. O. Berg. 1977. Biology and immature stages of snail-killing Diptera of the genus *Dictya* (Sciomyzidae). Search Agricultural (Geneva, New York) 7: 1–44.

Valley, K. R., T. Wearsch, and B. A. Foote. 1969. Larval feeding habits of certain Chloropidae (Diptera). Proceedings of the Entomological Society of Washington 71: 29–34.

Wearsch, T. K. and B. A. Foote. 1994. Biology and immature stages of Chloropidae (Insecta: Diptera) associated with spike-rushes (Cyperaceae: *Eleocharis*). I. Stem borers. Annals of the Carnegie Museum 63: 193–213.

Zack, R. S. and B. A. Foote. 1978. Utilization of algal monocultures by larvae of *Scatella stagnalis*. Environmental Entomology 7: 509–511.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 17–28

ECOLOGY, DISTRIBUTION, AND CONSERVATION BIOLOGY OF THE TIGER BEETLE *CICINDELA PATRUELA CONSENTANEA* DEJEAN (COLEOPTERA: CARABIDAE: CICINDELINAE)

Jonathan R. Mawdsley

Department of Entomology, MRC 187, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, Washington, DC 20013-7012, U.S.A. (e-mail: jonathan.mawdsley@nfwf.org)

Abstract.—The tiger beetle *Cicindela patruela consentanea* Dejean is known only from the mid-Atlantic coastal plain of the United States, where it is closely associated with pine and oak barrens ecosystems. Historic collecting records document the past presence of this subspecies at multiple sites in New Jersey and Long Island, while single specimens are also known from Delaware, Maryland, and Pennsylvania. This tiger beetle apparently has been extirpated from much of its former range, and extant populations are known only from sites within state forests and state wildlife management areas in the Pine Barrens region of New Jersey. Soil, vegetation, and forest stand characteristics were studied at four sites occupied by populations of *C. p. consentanea* in 2004, 2005, and 2006. Observations on adult biology and population dynamics are reported. Adult beetles were active along sandy trails and firebreaks in pine-oak woodlands dominated by *Pinus rigida* Miller (Pinaceae) and several *Quercus* species (Fagaceae), primarily *Quercus ilicifolia* Wangenheim. The use of prescribed fire as a forest management tool was evident at three of the four sites. Management activities which may benefit these populations include the continuation of prescribed burns as well as routine trail and firebreak maintenance.

Key Words: *Cicindela patruela*, tiger beetle, conservation, distribution, habitat characterization, habitat management

The tiger beetle *Cicindela patruela* Dejean is distributed throughout much of northeastern North America, where it is associated with pine or oak barrens ecosystems on sandy soils. Typically occurring in small, localized populations, this species has become the subject of conservation concern in recent years. Extirpations of *C. patruela* populations have been reported in New York (McCabe 1995), the District of Columbia, and Maryland (Glaser 1984, Mawdsley 2005), and this species currently is listed as "Endangered" by the states of Maryland and Massachusetts (Maryland Department of Natural Resources 2003, Massachusetts Division of Fisheries and Wildlife 2004).

Three subspecies are recognized within *C. patruela* (Werner 1993, Pearson et al. 2006). The nominate form, green with white elytral markings, occurs sporadically from Massachusetts west to Minnesota and south through the Appalachian Mountains to northern Georgia (Kaulbars and Freitag 1993). *Cicindela patruela huberi* Johnson from central Wisconsin differs from the nominate form in having brown or black dorsal coloration with white markings (Johnson 1989). *Cicindela patruela consentanea* Dejean, a black form with white elytral markings, was reported historically from the Atlantic coastal plain from Long Island south through New Jersey to the Delmarva peninsula (Kaulbars and Freitag 1993, Freitag 1999).

Recent studies have investigated various aspects of the biology and distribution of both the nominate subspecies and *C. p. huberi* (Knisley et al. 1990; Willis 2000, 2001). This paper summarizes the known information regarding the biology and distribution of *C. p. consentanea*, provides a more robust characterization of the habitat at sites occupied by populations of this subspecies, and identifies potential management strategies that may help insure the long-term survival of this tiger beetle.

MATERIALS AND METHODS

For this study, I examined the complete collections of *Cicindela patruela* in the American Museum of Natural History (AMNH) and the National Museum of Natural History, Smithsonian Institution (NMNH), which included 287 specimens of *C. p. consentanea*. Ninety-two of the specimens in both museums were collected during intensive searches for this subspecies in the 1970s and 1980s by H. Boyd, D. Pearson, J. Sheppard, J. Stamatov, and E. Stiles. Howard Boyd (in litt.) also graciously provided me with his own, unpublished data regarding these latter collections, which included data on an additional 547 specimens which were captured between 1971 and 1982.

From museum specimen labels, I was able to identify four specific sites in Burlington and Ocean counties, New Jersey, at which specimens of *C. p. consentanea* were collected in the 1970s and 1980s. During May and September, 2004, May, July, and September, 2005, and May, 2006, I visited all four of these sites in search of adult *C. p. consentanea*. On these trips, I also examined sixteen additional sites in the New Jersey Pine Barrens which were occupied by populations of other tiger beetle species. These additional sites are mostly unpaved sand roads and trails, although power line rights-of-way, abandoned sand pits, and roadside clearings were also included. I selected the dates of these trips (except for the July visit) to coincide with the greatest number of past collections of *C. p. consentanea*, as indicated by museum specimen labels.

Because *C. p. consentanea* is closely associated with woodlands, I was interested in determining whether certain features of forest stand composition and structure were characteristic of sites occupied by this subspecies. Accordingly, I used standard techniques to assess forest stand composition and quantify stand structure at the four sites where adults of *C. p. consentanea* were found. Specific measurements taken at each site included: diameter at breast height (DBH, measured 137 cm above mean ground level) of a random sample of 10 or more *Pinus rigida* and 10 or more *Quercus* spp. along trails where adults were observed; stand basal area, estimated as the average of measurements made using a "cruiser's crutch" tool at 10 randomly selected points along occupied paths; maximum heights of at least 10 randomly selected understory shrubs; and the width of paths on which adult beetles were found, measured at 5 randomly selected points (these paths tended to be fairly uniform in width; thus, only a smaller number of measurements was taken).

RESULTS

Historic Distribution

The following list of sites represents the known historic distribution of *C. p.*

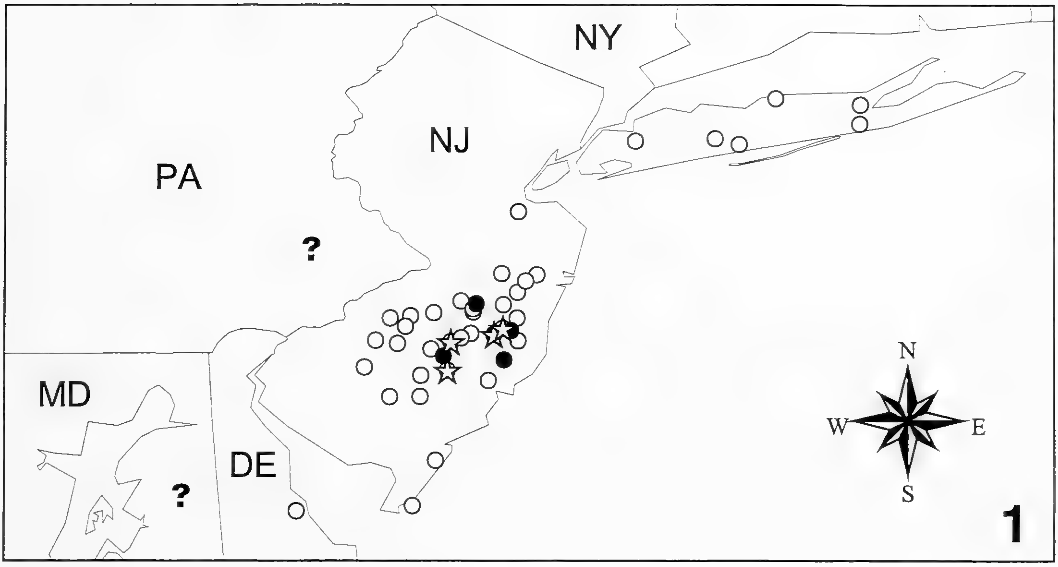


Fig. 1. Collecting localities for *Cicindela patruela consentanea*, mapped using ArcView Geographic Information System software. Open circles indicate historic (pre-1970) collections; closed circles indicate collections between 1971 and 1982; open stars are the author's study sites; question marks indicate state records only.

consentanea. Boyd (1978) and Leonard (1926) have summarized many of the older records from New Jersey and New York based on material from multiple museum collections. Localities followed by AMNH or NMNH represent new records from these museum collections. A Geographic Information System (GIS) map showing these localities is provided as Fig. 1.

DELAWARE: Sussex County: Milford (Glaser 1984; Knisley and Schultz 1997).

MARYLAND: No locality specified (NMNH).

NEW JERSEY: Atlantic County: Buena, DaCosta, Weymouth. Burlington County: Atsion, Batona Trail (AMNH), Batsto (NMNH), Browns Mills, Carranza Memorial, Chatsworth, Harris Station, Marlton, Medford, Mt. Misery, New Gretna, Quaker Bridge, Retreat, Taunton Lakes, Upton Station, West Plains, Whitesbog. Camden County: Atco, Pine Hill. Cape May County: Seaville, Wildwood. Gloucester County: Fries Mill. Middlesex County: Browntown, 13-Oak Forest. Ocean County: Bamber Lake, Brackenville, Brookville, Cassville, Cedar Bridge, East Plains, Lacey Township, Lakehurst, Lakewood, Manchester, Whitesville, Whiting (Boyd 1978).

NEW YORK: Queens County: Alley Pond (Malkin 1941). Suffolk County: Bay Shore (NMNH), Port Jefferson, Riverhead, Westhampton, Wyandanch (Leonard 1926).

PENNSYLVANIA: No locality specified (NMNH).

There are also unconfirmed reports of specimens of *C. p. consentanea* from Rhode Island and Massachusetts (Boyd 1978 and in litt.). The museum specimens that I examined from these two states were all from the nominate form, *C. p. patruela*. Leonard and Bell (1999) reviewed the tiger beetle fauna of these states in greater detail and also examined historic specimens from the relevant regional collections; these authors likewise only report the nominate subspecies of *C. patruela* from Massachusetts and Rhode Island.

Present-Day Distribution

Cicindela patruela consentanea has apparently been extirpated from much of its historic range. As discussed in more detail below, recent (post-1941) records of this tiger beetle are only from the Pine Barrens region of New Jersey. However, this subspecies appears to be widely distributed within this region and may even be locally abundant at certain sites. Fig. 1 indicates localities at which this species has been collected since 1971, including the author's four study sites.

The records of *C. p. consentanea* from Delaware, Maryland, and Pennsylvania are based in each case on single specimens, which in the case of the Maryland and Pennsylvania specimens in NMNH are undated but clearly very old. Given the lack of any recent records from these three states (Knisley and Schultz 1997, Boyd 1978, NatureServe 2005), it is doubtful whether this subspecies still occurs in any of them.

If *C. p. consentanea* was ever found in either Rhode Island or Massachusetts, it is no longer present. The species *C. patruela* is considered extirpated from Rhode Island and only a small population of the nominate subspecies *C. p. patruela* survives at the Myles Standish State Forest in Massachusetts (Leonard and Bell 1999).

The last report of *C. p. consentanea* from New York is that of Malkin (1941). There is no recent material of this subspecies from Long Island in AMNH, no other recent reports from New York (NatureServe 2005) and thus this subspecies should probably be considered extirpated from the state.

Recent (post-1941) records of *C. p. consentanea* are all from the core Pine Barrens region of central New Jersey, principally sites in Burlington and Ocean counties. Howard Boyd and other tiger beetle workers (D. Pearson, J. Sheppard, J. Stamatov, E. Stiles) spent considerable time and energy searching for this subspecies in the 1970s and 1980s, with the resulting discovery of a number of localized populations (Boyd 1973, 1978). The best current estimate is that there are approximately 10–20 occupied sites within the Pine Barrens region (NatureServe 2005), although, as discussed at the end of this paper, there are reasons to suspect that this may be an underestimate.

The most recent (post-1970) collecting sites for this tiger beetle are widely scattered throughout the Pine Barrens region and it seems probable that *C. p. consentanea* is generally distributed throughout this area. Some sites have evidently supported large populations in recent years, as demonstrated by collecting records provided to the author by Howard Boyd from the 1970s and early 1980s, which indicate that up to 57 specimens of this tiger beetle were collected at one site on a single day. The recent collecting sites for *C. p. consentanea* are all located within tracts of land in Burlington and Ocean counties which are owned by the State of New Jersey and managed for conservation purposes, including Bass River State Forest, Brendon T. Byrne (formerly Lebanon) State Forest, Greenwood Forest State Wildlife Management Area, Stafford Forge State Wildlife Management Area, and the Wharton State Forest.

It should be noted that characteristic Pine Barrens vegetation can still be found at sites in several of the other New Jersey counties which have historic records of *C. p. consentanea* (NatureServe 2005). Because these areas have not been surveyed recently for *C. p. consentanea*, it is not possible to state at this time whether or not this tiger beetle still occurs in these counties.

Habitat Characterization

I found adults of *C. p. consentanea* at four sites in New Jersey during field trips in 2004, 2005, and 2006. Two sites where I found adults were locations at which specimens of *C. p. consentanea* had been collected in the 1970s and 1980s. Three sites are located in Burlington County, while the fourth is located in Ocean County. Adults were found during all six field trips.

In addition to the four sites which were occupied by populations of this subspecies, I observed single adult females on two separate occasions on large, heavily-trafficked sand roads near two of the occupied sites in May, 2005, and May, 2006. As discussed below, I interpret the occurrences of these isolated individuals in what are evidently marginal or unsuitable habitats as representing dispersal events, rather than established populations.

To protect this subspecies from possible over-collecting, the exact locations of the occupied sites will be described only in general terms. One of these sites is a sand trail within the Bass River State Forest, another site is a sandy trail near Batsto Village in the Wharton State Forest, the third site is a firebreak and associated clearing in the Greenwood Forest State Wildlife Management Area, while the fourth site is a sandy trail near Tabernacle in the Wharton State Forest.

All four sites are located in pine-oak woodlands. The dominant tree species at the Batsto site are *Pinus rigida* Miller (Pinaceae) and *Quercus marilandica* (L.) Münchhausen, with *Q. coccinea* Münchhausen and *Q. falcata* Michaux (all Fagaceae) also present. The stands at the Bass River and Greenwood Forest sites consist of *P. rigida* and *Q. ilicifolia* Wangenheim, with *Q. stellata* Münchhausen also present at Greenwood Forest. The Tabernacle site is located in an almost pure stand of *P. rigida*, with widely scattered *Q. ilicifolia*. The Batsto, Greenwood Forest, and Tabernacle sites are open woodlands, with mature trees (> 8 meters in height), a relatively open canopy, and a well-defined understory of short (< 1 meter in height) shrubs of species in the genera *Vaccinium* and *Gaylussacia* (Ericaceae). The Bass River site is located in a "scrub" forest composed of short (< 4 meters in height) individuals of *P. rigida* and *Q. ilicifolia*, with intermingled shrubs of the genera *Kalmia* (Ericaceae), *Vaccinium*, and *Gaylussacia*. Canopy cover is nearly 100% in the scrub forest. Sedges (*Carex* spp., Cyperaceae), mosses, and lichens are found along the trails and roads at all four sites.

Forest stand measurements such as basal area and average diameter at breast height (DBH) of the canopy trees varied widely between sites (Table 1), suggesting that these variables may be less important to the beetles than other factors such as substrate type or the presence of recent fire. However, it should be noted that the greatest numbers of adult beetles were observed at the Greenwood Forest and Tabernacle sites, which are very similar in terms of their forest stand characteristics.

Exposed substrate at all four sites consists of unconsolidated fine white sand with intermixed fine dark organic matter, giving the substrate an overall grey appearance. Larger organic matter (dead leaves, needles, twigs, branches, cinders) was distributed sparsely over the surface of the trails. At all four sites the cover of organic matter on the forest floor proper was 100%. As noted above, single adult females were encountered on two separate occasions on large, heavily-trafficked sand roads. In both of these cases, the substrate consisted of unconsolidated yellow sand with intermixed small (< 2 cm diameter) rounded pebbles. Howard Boyd, who has had more experience with this subspecies than

Table 1. Physical attributes and forest stand measurements of four sites occupied by populations of *Cicindela patruela consentanea*. All figurès are averages of multiple measurements.

Site	Average DBH of Canopy Trees		Stand Basal Area	Average Understory Shrub Height	Average Path Width	Substrate Exposed in Trails / Paths	Recent Fire?
	Pinus rigida	*Quercus* spp.					
Bass River	4.3 cm	2.3 cm	< 2 m²/ha	44 cm	132 cm	White sand intermixed with fine, black organic matter	No
Batsto	30 cm	29 cm	22 m²/ha	44 cm	137 cm	As above	Yes
Greenwood Forest	13 cm	3.0 cm	9.0 m²/ha	51 cm	204 cm	As above	Yes
Tabernacle	13 cm	3.9 cm	14 m²/ha	61 cm	119 cm	As above	Yes

anyone else, has noted a general association of *C. p. consentanea* with coarser substrates (Boyd 1973, 1978).

Three of the four sites receive regular human use. Human traffic was not observed at the Bass River site during this study, but adjacent roads are heavily used by motorized vehicles and are also regularly maintained by heavy equipment. The sand trail at the Batsto site receives moderate pedestrian and bicycle traffic but no motorized vehicle use. The firebreak at the Greenwood Forest site was actively maintained by a bulldozer between the 2004 and 2005 field seasons. The sand trail at the Tabernacle site receives heavy horse and pedestrian traffic but no motorized vehicle use.

The use of light ground fire as a general forest management tool is evident at the Batsto, Greenwood Forest, and Tabernacle sites. Evidence of such fires includes superficial basal fire scars on trunks of the canopy trees and the presence of ash and cinders on the ground. The woodland along one side of the Greenwood Forest site was burned between the 2004 and 2005 field seasons, killing the aboveground portions of the understory vegetation and leaving superficial fire scars to 1.2 meters on the trunks of the canopy trees. This burning had no evident impacts on the beetle population, as the numbers of adult beetles observed at this site were roughly the same in September, 2004, and May, 2005. Although evidence of recent burning was not observed at the Bass River site during this project, this general area is known to have an average fire frequency of 10–20 years (Boyd 1991). Leng (1902b) noted an association of *C. p. consentanea* with "burnt ground" near Lakehurst. Taken together, these observations suggest that this tiger beetle may have a more general association with burned areas.

Adult Biology

Adults of *C. p. consentanea* are quite wary, perhaps more so than any of the other, more common tiger beetle species in the New Jersey Pine Barrens. They are difficult to locate in the field, as their black and white coloration is strongly cryptic on the grey sandy trails and adjoining dark areas of moss, lichens, and organic debris. When first approached, adults will typically stop moving and remain motionless until they are approached more closely, at which time they fly rapidly away from the disturbance. As noted by Boyd (1973, 1978) their flight may take them into low vegetation where they are extremely difficult to re-locate. On linear trails, I have found that adults will often fly 5–10 meters ahead and land on the trail or along its sides. They may tumble upon landing, much like *C. formosa* *generosa* Dejean, and some individuals may make a buzzing noise during flight. If they land in the open, adults typically remain motionless for some time and are very difficult to find until they move again. Upon landing, adults may also run short distances to conceal themselves under vegetation or organic debris.

Boyd (1973, 1978) noted that adults of *C. p. consentanea* were most active in the morning and again in mid-afternoon, an observation which is supported by my own field experiences. During mid-day and in the evening, adults conceal themselves under organic debris or low vegetation.

Predation on small ants was observed several times in the field; predatory behaviors are as described for other tiger beetles (Knisley and Schultz 1997).

Reproductive behaviors (mating, mate guarding, and female testing of substrate prior to oviposition) were only observed during the May field trips. Oviposition was not observed, suggesting that it may occur in areas away from the sandy trails where the adults are most commonly found, as is the case with other subspecies of *C. patruela* (Knisley et al. 1990; Willis 2000, 2001).

Other species of tiger beetles were often found at sites with *C. p. consentanea*. The most frequently encountered species included *C. purpurea purpurea* Olivier (2 sites, but abundant at both), *C. scutellaris rugifrons* Dejean and *C. tranquebarica tranquebarica* Herbst (both present at 3 sites, but in smaller numbers), and also *C. sexguttata* Fabricius (common at 2 sites in May only). Species found in small numbers included *C. formosa generosa* Dejean (1 individual at 1 site) and *C. punctulata punctulata* Olivier (2 individuals each at 2 sites).

Larval Biology

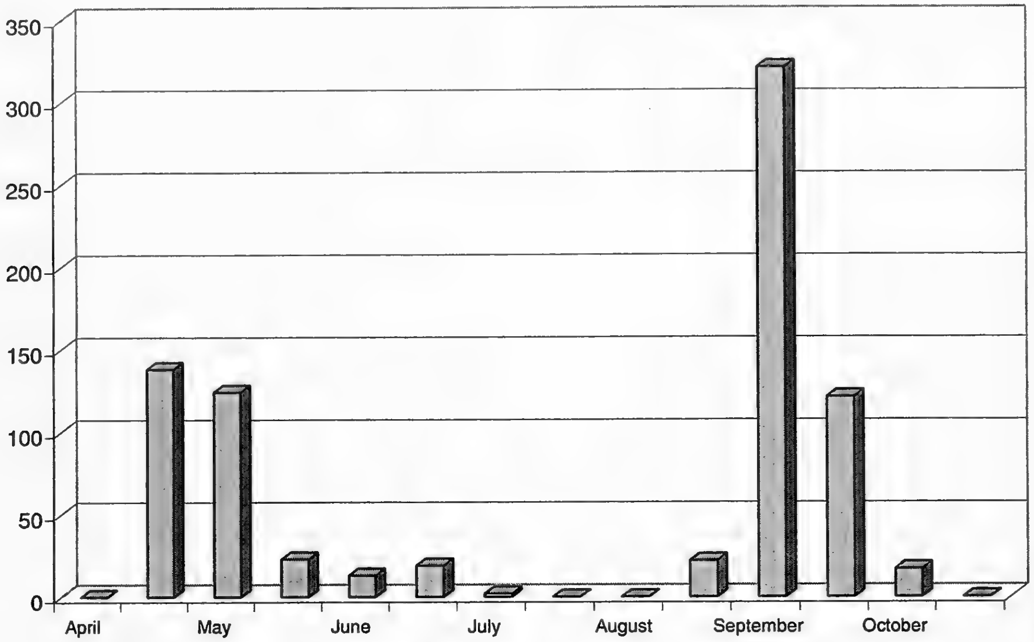
Larval biology was not studied in detail. In general, larval burrows were not found on the sand trails occupied by the adult beetles at any of the study sites. The Greenwood Forest site (which had the greatest number of active adults of *C. p. consentanea* of any site visited during this study, and where *C. p. consentanea* was the most abundant tiger beetle during my site visits) was carefully searched for larvae and larval burrows. At this site, larvae and burrows of multiple tiger beetle species, possibly including *C. p. consentanea*, were observed in a small area of sandy soil in a clearing covered with small pebbles ($<$ 2 cm diameter), lichens, mosses, and sedges. The larvae of other subspecies of *C. patruela* are known to occur in similar microhabitats located away from the sand trails where adults are found (Knisley et al. 1990, Willis 2000). Further investigations of the larval habitats and larval biology of this subspecies are needed.

A specimen in AMNH from Mt. Misery is labeled "Reared from larvae," suggesting that captive rearing of this tiger beetle is possible.

The length of the life cycle in *C. p. consentanea* is not known, but is probably at least two years, as is the case in other subspecies of *C. patruela* (Knisley and Schultz 1997).

Observations on Population Dynamics

Adult activity in *C. p. consentanea* is on a "spring-fall" cycle, as is the case with the other subspecies of *C. patruela* (Knisley and Schultz 1997; Willis 2000, 2001). Adults emerge in late summer, are active for several weeks, and then dig burrows in loose sand or under objects on the ground where they spend the winter. In the spring, they re-emerge, mate, and the females oviposit. Based on museum specimens and other collecting records (Fig. 2), fall activity in *C. p. consentanea* commences during the last week in August and peaks in mid-September, with occasional adults found



2

Fig. 2. Collecting dates for *Cicindela patruela consentanea*, based on specimens in AMNH and NMNH and additional records provided by Howard P. Boyd, summed across all years and tabulated semi-monthly. The vertical axis indicates numbers of specimens.

as late as October 12. Spring activity begins mid-April, with adult beetles found until mid-June and a few lasting into early July.

Specimen labels from AMNH and NMNH as well as additional collecting records supplied by Howard Boyd suggest that this subspecies is somewhat more abundant in the fall than in the spring. Across all years, 319 specimens were collected during the interval March 30 to July 5, while 481 specimens were collected during the interval August 20 to October 12. A similar pattern is exhibited by the graph of 135 collecting records presented by Kaulbars and Freitag (1993). There may be a bias towards fall collecting records, due to the coincidence of the fall activity period with the U.S. “Labor Day” holiday weekend, when more collectors may be active.

For tiger beetle species such as *C. patruela* which have multi-year life cycles, the numbers of adults observed at a particular site may fluctuate from year to year, sometimes quite dramatically. For example, *C. p. consentanea* adults were abundant at the Greenwood Forest site in September, 2004, and May, 2005, with up to 12 individuals observed on a single day. In contrast, very few adults were observed at this same site in September, 2005, and May, 2006, with at most two individuals observed on a single day. The beetles in September, 2004, and May, 2005, were presumably part of the same generational cohort, while those in September, 2005, and May, 2006, may represent a different, smaller cohort; alternatively, these may simply be individuals from the previous season’s cohort exhibiting delayed emergence (see discussion in Knisley and Schultz 1997). Such fluctuation in population size between successive years is probably to be expected in this species and should be taken into account when designing surveys or monitoring protocols.

The sex ratio in *C. p. consentanea* is evidently close to 1:1; of the 287 museum specimens examined, 148 were males and 139 were females.

As with other tiger beetles (Knisley and Schultz 1997), there is some evidence to suggest that adults of *C. p. consentanea* may disperse from occupied sites. Adults are strong flyers and certainly have the capability to disperse long distances. The observations noted above of single beetles on heavily trafficked sand roads in May are perhaps best interpreted as examples of such dispersal. On the subject of dispersal, it is interesting to note that most of the specimens in AMNH and NMNH represent unique, single-specimen collecting events, and that of the 23 localities for this subspecies represented in NMNH, 14 are represented by single specimens only. Similar patterns are evident in data presented by Boyd (1978). It seems possible that some of these collections may represent dispersing individuals, rather than established populations.

It is difficult to estimate current population size for *C. p. consentanea.* Obtaining an accurate count of active adults at a particular site is challenging, given the beetles' cryptic coloration and readiness to take flight at the slightest disturbance. Under even the most optimal circumstances, visual surveys of adult tiger beetles will underestimate population size by 50% to 80%, with lower accuracy for woodland taxa (Knisley and Schultz 1997). My own counts of adult beetles at sites in the Pine Barrens are undoubtedly underestimates. That said, the individual populations of *C. p. consentanea* which I observed are small. The greatest number of adults that I observed at one site on a single day was 12 at the Greenwood Forest site in September, 2004. More typical observations were of one or two beetles on a single day at an occupied site. Given the strong likelihood of dispersal by adults, it is probable that these small, scattered populations are actually part of larger meta-populations. If this is in fact the case, the effective population size would be larger than the number of beetles observed at any one site.

Long-term population trends of *C. p. consentanea* in New Jersey are also difficult to assess. This tiger beetle has always been a challenge for collectors to find in the field, and thus it is difficult to infer past population sizes from either published accounts or museum specimen records. Leng (1902a) says "it is the least abundant of the Pine Barrens Cicindelae, but under favorable circumstances a dozen may be taken in a day," an observation which is certainly consistent with my own recent experiences. Howard Boyd (1973) introduces his discussion of *C. p. consentanea* with the statement "this is a very elusive species" and indicates that he had only encountered it twice in the period 1940 to 1970. However, from 1971 through the early 1980s, Boyd and other collectors found *C. p. consentanea* in large numbers at a few sites, with as many as 57 specimens collected on a single day (Boyd 1973, 1978, and in litt.).

Discussion and Management Recommendations

Since *C. p. consentanea* has evidently been extirpated from much of its former range, every effort should be made to insure that this subspecies is not driven to extinction through human activities. Fortunately, much of the remaining occupied or potential habitat for this subspecies has already been protected by the State of New Jersey and is being actively managed in a manner that should insure the long-term viability of the beetle populations.

The most important management recommendation for *C. p. consentanea* is for the continued protection and wise management of the occupied habitats. Sites at which this subspecies has been collected within the past thirty years are all within areas which are owned and actively managed by the State of New Jersey for conservation purposes. These areas include Bass River State Forest, Brendon T. Byrne (formerly Lebanon) State Forest, Greenwood Forest State Wildlife Management Area, Stafford Forge State Wildlife Management Area, and the Wharton State Forest. Although I am not aware of occupied sites on private lands, any such sites that are identified through future surveys should be made priority locations for land protection efforts (fee title acquisition and/or protective conservation easements) to prevent the destruction of the natural vegetative communities through residential or commercial development. Such development has been responsible for extirpating *C. patruela* populations elsewhere (Mawdsley 2005) and would undoubtedly eliminate populations of *C. p. consentanea* were it to occur on occupied sites.

Beyond land protection, the ongoing management of pine and oak barrens sites is essential to prevent canopy closure and the loss of open barrens habitat (Boyd 1991, Knisley and Hill 1992). Fortunately the State of New Jersey has a long history of management activities such as prescribed fire, thinning of forest stands, and regular maintenance of firebreaks and sand roads in the Pine Barrens, activities which are primarily directed at preventing catastrophic wildfires (Boyd 1991). On the basis of the habitat characterization which has been developed in this study, it is clear that these forest management activities probably benefit *C. p. consentanea*. Particularly valuable activities include the use of low-intensity prescribed burns to reduce understory vegetation and woody debris, as well as the construction and periodic maintenance of firebreaks and sand trails. Continuation of these management practices should help to maintain existing habitats and create new areas of suitable habitat for *C. p. consentanea*.

Given the highly elusive nature of the adult beetles, modest collecting activities probably pose no significant threat to *C. p. consentanea*. However, since this tiger beetle evidently has small population sizes, collectors should refrain from taking large series of specimens from occupied sites. The collection of small numbers of voucher specimens, especially from newly discovered sites, should be encouraged as long as these specimens will be deposited in permanent museum collections. The timing of collecting activities is also important, given that mating and oviposition apparently occur only in the spring and early summer. In particular, collectors should avoid taking large series of beetles in the fall and spring before the adult beetles have had a chance to deposit at least some of their eggs.

Further Research

Key research needs for *C. p. consentanea* include a more detailed study of larval biology and larval habitats as well as more comprehensive surveys for adult beetles in areas of potential habitat in New Jersey. Based on my field experiences, I suspect that there are other occupied sites within the core Pine Barrens area which have not yet come to the attention of collectors. There are literally hundreds of miles of sandy woodland trails on state, private, and federal lands in south-central New Jersey. Many of these trails have probably not been searched recently (if at all) for *C. p. consentanea*. It is quite possible that more in-depth surveys will reveal that this beetle is present at more sites or in larger numbers than are currently known. As precedent, I would cite the experience of Willis (2000, 2001) with *C.*

p. huberi in Wisconsin. Prior to Willis's collecting effort in 1999 and 2000, *C. p. huberi* was known from only three small sites in central Wisconsin. Through careful surveys, Willis found adults of this subspecies at an additional 32 sites. To judge from the number of specimens collected (up to 44 specimens collected on the same date at one site), some of these newly discovered *C. p. huberi* populations are quite large. Further survey work, particularly in larger forest blocks such as the Wharton State Forest and also in areas seldom visited by collectors such as Fort Dix and the Lakehurst Naval Air Engineering Station, is needed to clarify the size and status of the *C. p. consentanea* populations in the New Jersey Pine Barrens.

ACKNOWLEDGMENTS

I thank Terry L. Erwin for his continued support of my work as a Research Associate of the National Museum of Natural History. Lee Herman at the American Museum of Natural History graciously allowed examination of specimens in his care. Corinne M. Carter provided much valuable assistance with the field portion of this study. Howard P. Boyd, David G. Furth, C. Barry Knisley, Charles L. Staines, and Michael A. Valenti all provided helpful comments on earlier drafts of the manuscript. I also thank Howard P. Boyd for generously sharing his collecting data and much additional information with me.

LITERATURE CITED

Boyd, H. P. 1973. Collecting tiger beetles in the Pine Barrens of New Jersey. Cicindela 5(1): 1–12.

———. 1978. The tiger beetles (Coleoptera: Cicindelidae) of New Jersey with special reference to their ecological relationships. Transactions of the American Entomological Society 104(2): 191–242.

———. 1991. A Field Guide to the Pine Barrens of New Jersey: Its Flora, Fauna, Ecology, and Historic Sites. Plexus Publishing, Medford, New Jersey. 423 pp.

Freitag, R. 1999. Catalogue of the Tiger Beetles of Canada and the United States. NRC Research Press, Ottawa. vii + 195 pp.

Glaser, J. D. 1984. The Cicindelidae (Coleoptera) of Maryland. Maryland Entomologist 2(4): 65–76.

Johnson, W. N. 1989. A new subspecies of *Cicindela patruela* from west-central Wisconsin. Cicindela 21(2): 27–32.

Kaulbars, M. M. and R. Freitag. 1993. Geographical variation, classification, reconstructed phylogeny, and geographical history of the *Cicindela sexguttata* group (Coleoptera: Cicindelidae). The Canadian Entomologist 125(2): 267–316.

Knisley, C. B. and J. M. Hill. 1992. Effects of habitat change from ecological succession and human impact on tiger beetles. Virginia Journal of Science 43(1b): 133–142.

Knisley, C. B. and T. D. Schultz. 1997. The Biology of Tiger Beetles and a Guide to the Species of the South Atlantic States. Virginia Museum of Natural History, Martinsville, Virginia. 210 pp.

Knisley, C. B., T. D. Schultz, and T. H. Hasewinkel. 1990. Seasonal activity and thermoregulatory behavior of *Cicindela patruela* (Coleoptera: Cicindelidae). Annals of the Entomological Society of America 84(5): 911–915.

Leng, C. W. 1902a. Revision of Cicindelidae of boreal America. Transactions of the American Entomological Society 28: 93–186.

———. 1902b. Notes on the Cicindelidae of the Pine Barrens of New Jersey. Journal of the New York Entomological Society 10(4): 236–240.

Leonard, J. G. and R. T. Bell. 1999. Northeastern Tiger Beetles: A Field Guide to Tiger Beetles of New England and Eastern Canada. CRC Press, Boca Raton, Florida. xii + 176 pp.

Leonard, M. D. 1926. A list of the insects of New York with a list of the spiders and certain other allied groups. Cornell University Agricultural Experiment Station Memoirs 101, 1121 pp.

Malkin, B. 1941. *Cicindela patruela* on Long Island. Bulletin of the Brooklyn Entomological Society 36(1): 28.

Maryland Department of Natural Resources. 2003. Rare, threatened, and endangered animals of Maryland, December 12, 2003. World Wide Web document at http://dnrweb.dnr.state.md.us/download/rteanimals.pdf (accessed September 13, 2005).

Massachusetts Division of Fisheries and Wildlife. 2004. Massachusetts List of Endangered, Threatened, and Special Concern species. June

18, 2004. World Wide Web document at http://www.mass.gov/dfwele/dfw/nhesp/nhrare.htm (accessed September 13, 2005).

Mawdsley, J. R. 2005. Extirpation of a population of *Cicindela patruela* Dejean (Coleoptera: Carabidae: Cicindelinae) in suburban Washington, D.C., U.S.A. Proceedings of the Entomological Society of Washington 107(1): 64–70.

McCabe, T. L. 1995. The changing insect fauna of Albany's Pine Barrens. World Wide Web document at http://biology.usgs.gov/s+t/noframe/f124.htm (accessed September 13, 2005).

NatureServe. 2005. *Cicindela patruela consentanea*, May 12, 2005. World Wide Web document at http://www.natureserve.org (accessed September 13, 2005).

Pearson, D. L., C. B. Knisley, and C. J. Kazilek. 2006. A Field Guide to the Tiger Beetles of the United States and Canada: Identification, Natural History, and Distribution of the Cicindelidae. Oxford University Press, New York. vi + 227 pp. + 24 pls.

Werner, K. 1993. The Beetles of the World, Volume 18, Cicindelidae, Part 3, Regionis Nearcticae 1: Tribes Collyrini, Megacephalini, Cicindelini 1. Sciences Nat, Venette, France. 163 pp + 24 pls.

Willis, H. L. 2000. Collecting notes for *Cicindela patruela* in Wisconsin. Cicindela 32(3–4): 49–54.

———. 2001. Zoogeography of *Cicindela patruela* in Wisconsin (Coleoptera: Cicindelidae). Cicindela 33(1–2): 1–18.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 29–33

A NEW SPECIES OF *PLACOSCELIS* STÅL (HEMIPTERA: HETEROPTERA: COREIDAE: ACANTHOCEPHALINI) FROM BRAZIL AND SURINAME, AND A KEY TO THE KNOWN SPECIES

Harry Brailovsky and Ernesto Barrera

Departamento de Zoología, Instituto de Biología, UNAM, Apdo Postal No. 70153, México 04510, D.F., México (e-mail: coreidae@servidor.unam.mx)

Abstract.—One new species, ***Placoscelis adustus***, from Brazil and Suriname is described, and a key to the known species of *Placoscelis* is included. A dorsal habitus illustration and drawings of antennae and hind legs are provided.

Key Words: Insecta, Heteroptera, Coreidae, Acanthocephalini, *Placoscelis*, new species, Brazil, Suriname

The Neotropical genus *Placoscelis* Stål belongs to the strictly New World tribe Acanthocephalini. Species of *Placoscelis* superficially resemble those of the well-known genus *Nyttum* Spinola but differ from them in the well-developed tylus, the ventrally armed hind femur, and the dilated hind tibiae. In *Nyttum*, the tylus is weakly developed, the hind femur unarmed, and the hind tibia is non-dilated (Dolling 1978, Dolling and Casini 1988).

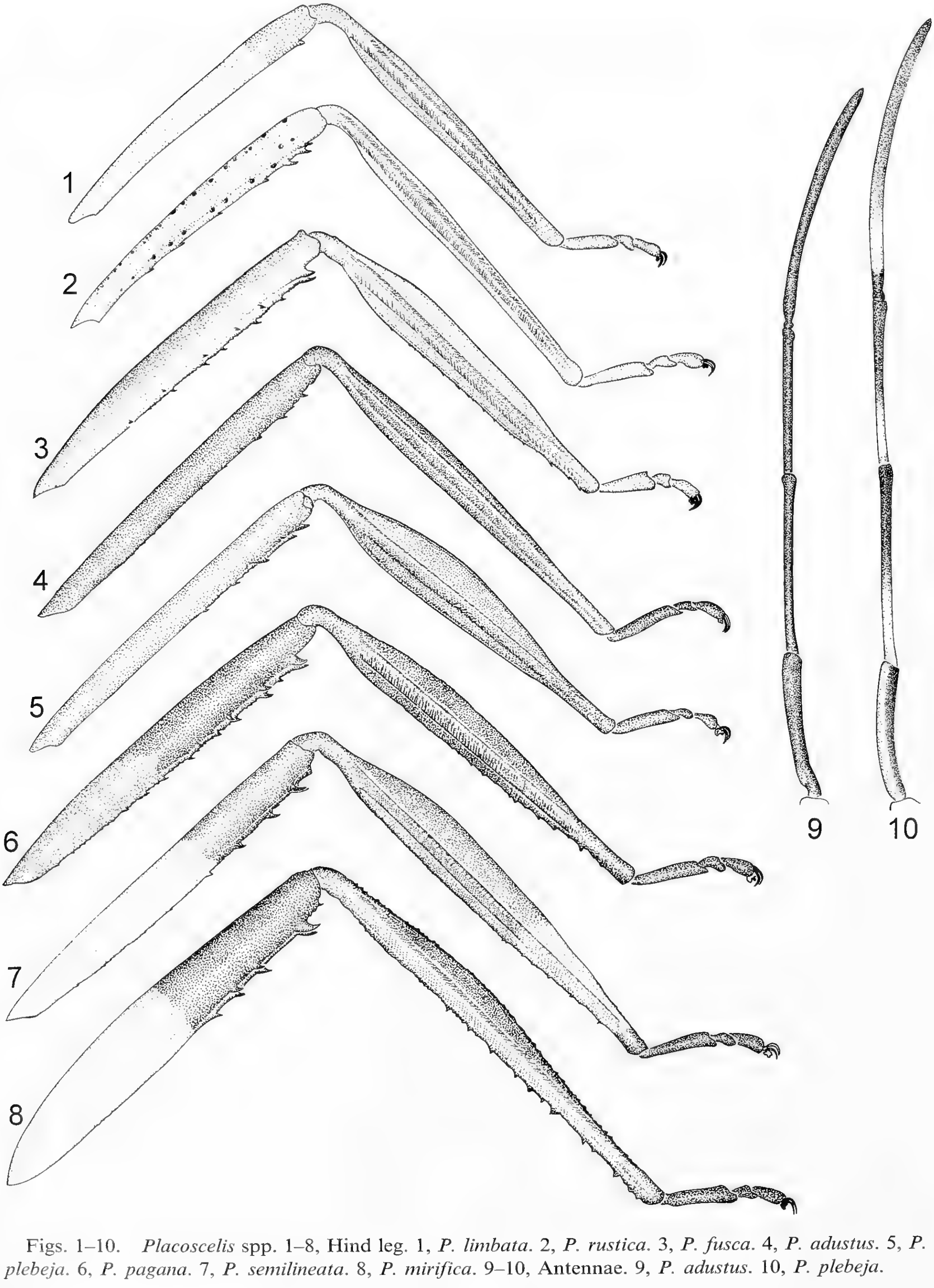
Previous to this paper seven species were referable to this genus: *P. fusca* Spinola, *P. limbata* (Berg), *P. mirifica* Montandon, *P. pagana* (Burmeister), *P. plebeja* Stål, *P. rustica* Stål, and *P. semilineata* Stål. In this paper, we add one new species from Brazil and Suriname and provide a key to the known species of *Placoscelis*.

The following abbreviations are used for the institution cited in this paper: CUIC (Cornell University Insect Collection, Ithaca, New York); MNHN (Muséum National d'Histoire Naturelle, Paris, France); MNR (Museum National, Rio de Janeiro, Brazil); RNHL (Rijksmuseum van Natuurlijke Histoire, Leiden, Netherlands); UNAM (Instituto de Biología, Universidad Nacional Autónoma de México).

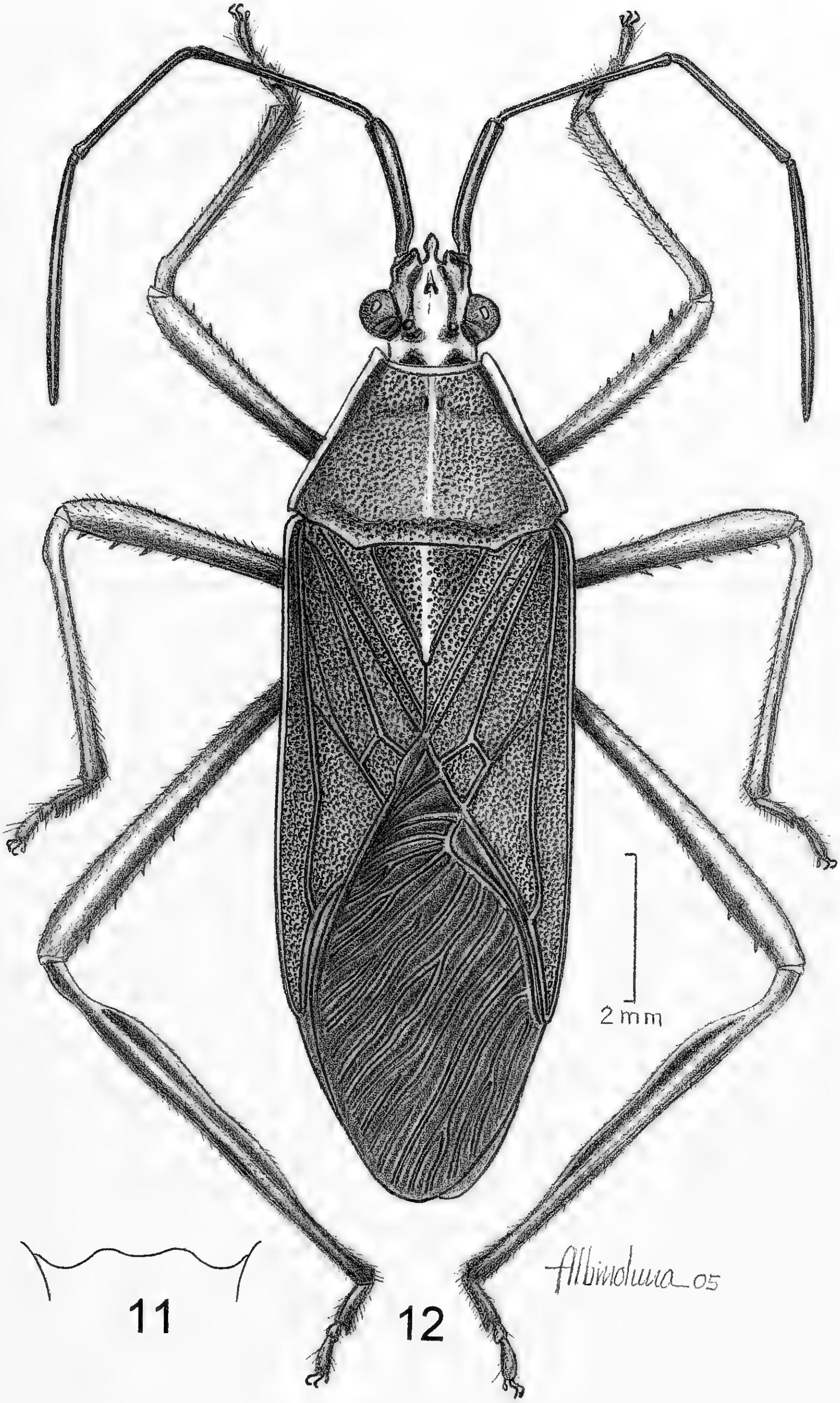
All measurements are given in millimeters.

Placoscelis adustus Brailovsky and Barrera, new species
(Figs. 4, 11–12)

Description.—*Measurements:* Male: Head length 1.40; width across eyes 1.88; interocular space 0.98; interocellar space 0.49; preocular distance 0.84; length antennal segments: I, 2.32; II, 2.80; III, 2.28; IV, 3.84. Pronotum: Length 2.68; width across humeral angles 3.84. Scutellar length 1.72; width 1.64. Body length 12.15. Female: Head length 1.56; width across eyes 2.00; interocular space 1.02; interocellar space 0.51; preocular distance 0.90; length antennal segments: I, 2.56; II, 3.00; III, 2.48; IV, 4.20. Pronotum: Length 3.04; width across humeral angles 4.36. Scutellar length 2.00; width 1.96. Body length 14.27.



Figs. 1–10. *Placoscelis* spp. 1–8, Hind leg. 1, *P. limbata.* 2, *P. rustica.* 3, *P. fusca.* 4, *P. adustus.* 5, *P. plebeja.* 6, *P. pagana.* 7, *P. semilineata.* 8, *P. mirifica.* 9–10, Antennae. 9, *P. adustus.* 10, *P. plebeja.*



Figs. 11–12. *Placoscelis adustus*. 11, Male genital capsule in caudal view. 12, Dorsal view, female.

Male (holotype). *Dorsal coloration*: Head ochre with lateral margins and two short longitudinal stripes at each side of middle line black; tylus ochre with black middle stripe; antennal segments I to IV black (Fig. 9); pronotum ochre with anterolateral margins shiny orange and following areas black: punctures, inner face of each calli, and a narrowly longitudinal stripe close to anterolateral margins; scutellum ochre, with punctures black and apex creamy white; clavus dark orange red, and punctures black; corium dark orange red with basal half of costal border shiny orange, and punctures and area near costal margin black; hemelytral membrane brown with basal angle darker; connexivum shiny orange, with inner angle of posterior border black; dorsal abdominal segments black. *Ventral coloration*: Head, including buccula, dark yellow with pale brown reflections; middle third of head entirely black; rostral segments I to III dark yellow and IV dark hazel brown; propleura dark yellow with black patch near anterodorsal angle, a black semidiscoidal spot near middle third, and with punctures reddish brown; mesopleuron and metapleuron dark yellow with black patch near anterodorsal angle, two round black spots near middle third, and with punctures reddish brown; prosternum and metasternum black; mesosternum black with dark orange spot laterally flanking; anterior lobe of metathoracic peritreme black, and posterior lobe dark yellow; legs dark yellow; inner third of coxae, tarsi, and hind tibia black; abdominal sterna dark yellow with dark brown reflections, and with following areas black: middle third and posterior margin of sterna III to VII, a discoidal spot at external margins near anterior border, and rim of abdominal spiracles; pleural margins of sterna III to VII with upper border shiny orange, and inner border pale yellow; genital capsule dark yellowish brown.

Structure: Apex of tylus elevated; rostrum reaching posterior margin of mesosternum; pronotum moderately declivous; collar distinct; frontal angles projecting forward as medium-sized conical lobes; humeral angles rounded, not exposed; femora ventrally spined; fore and middle tibiae sulcate; hind tibia with weakly foliaceous expansions, uniformly lanceolate, and without emarginations (Fig. 4).

Genital capsule: Posteroventral edge elevated, convex, slightly concave at middle third, laterally with deep U-shaped concavity, and with lateral angles elevated (Fig. 11).

Integument: Body surface rather dull, almost glabrous, with short decumbent to suberect indistinct pubescence; abdominal sterna with moderately long and conspicuous bristlelike hairs; pubescence of tibiae and tarsi longer and rather dense.

Female. Coloration similar to male holotype. Connexival segments VIII and IX shiny orange; dorsal abdominal segments VIII and IX black; genital plates dark yellow, infuscate with pale to dark brown.

Variation.—1, Rostral segment IV dark yellow. 2, Anterolateral margins of pronotum pale yellow. 3, Basal half of costal margin of corium pale yellow. 4, Connexivum pale yellow with posterior border black, and sometimes inner margin also black. 5, Posterior margin of abdominal sterna dark yellowish brown. 6, Pleural abdominal margins III to VII pale yellow.

Type material.—Holotype ♂, Brazil: Manaus, km 60 INPA, 29-III-1989, G. Couturier (MNHN). Paratypes: 4 ♂, 4 ♀, Brazil: Manaus, km 60 INPA, 8-29-III-1989, G. Couturier (MNHN, UNAM). 1 ♀, Brazil: Amazonas, Serra dos Porcos, 0°25′N 69°22′W, 2-25-V-1977, Franklin and Moore (MNR).1 ♀, Suriname: Gansee Sur, Inbos op Struik, 15-III-1959, Heyde (RNHL). 2 ♂, Suriname: Ongelijk, Para River, 30-IV-1927 (CUIC). 1 ♂, Suriname: Pzandevy, 3-X-1965 (RNHL).

Host plant.—Nymphs and adults were collected from *Ipomea* sp. (Batatas).

Discussion.—This new species resembles *P. fusca* Spinola in having the antennal segments black, femora and tibiae unicolorous, clavus and corium without green or blue iridescence, pronotal disk almost glabrous with short indistinct pubescence, and thorax with a black discoidal spot on the propleura, mesopleura, and metapleura.

Placoscelis fusca is more slender and elongate, with the femora and tibiae pale reddish brown and the corium pale reddish brown with the basal half of the costal margin yellow. *Placoscelis adustus* is more robust, with the femora and tibiae dark yellow, the corium dark orange red with the basal half of the costal border shiny orange to yellow, and the area near the costal margin black. The hind tibiae of *P. adustus* are narrowed, and weakly foliaceous (Fig. 4), and in *P. fusca* their are foliaceous and more widened (Fig. 3).

Etymology.—From the Latin *adustus*, for brown or dark, referring to the general color of the insect.

KEY TO *PLACOSCELIS* SPECIES

1. Antennal segments III and IV reddish brown with basal third yellow (Fig. 10) (Brazil) . . . . *P. plebeja* Stål
– Antennal segments III and IV unicolorous (Fig. 9) 2
2 Femur of each leg pale orange, with dense black dots (Fig. 2) (Brazil) . . *P. rustica* Stål
– Femur of each leg not orange and without black dots (Figs. 3–8) 3
3 Hind tibia reddish brown or black, with apical third yellow (Fig. 7) (Brazil) . . . . *P. semilineata* Stål
– Hind tibia unicolorous (Figs. 4–5) 4
4 Clavus and corium black with green metallic iridescense; scutellum pale yellow (Brazil, Ecuador, Peru) . . . . *P. mirifica* Montandon
– Clavus and corium without green metallic iridescense; scutellum ochre with punctures reddish brown to black 5
5 Pronotal disk densely covered with short upright setae; propleuron, mesopleuron and metapleuron with small black discoidal spot (Argentina, Brazil, Paraguay) . . . . *P. limbata* (Berg)
– Pronotal disk almost glabrous; propleuron, mesopleuron and metapleuron with large black discoidal spot 6
6 Hind femur bicolorous, yellow with apical third black (Fig. 6) (Argentina, Bolivia, Brazil, Paraguay). . . . *P. pagana* (Burmeister)
– Hind femur unicolorous (Figs. 3–4) 7
7 Hind femur pale reddish brown (Fig. 3); hind tibia pale reddish brown, foliaceous and more widened (Fig. 3) (Argentina, Brazil, Uruguay) . . . . *P. fusca* Spinola
– Hind femur dark yellow (Fig. 4); hind tibia dark yellow, narrowed, and weakly foliaceous (Fig. 4) (Brazil, Suriname) . . . . *P. adustus*, new species

ACKNOWLEDGMENTS

We thank Richard E. Hoebeke (CUIC), the late Jose Candido de Melo Carvalho (MNR), Guy Couturier (MNHN), Dominique Pluot (MNHN), and Jan van Tol (RNHL) for the loan of specimens. We also thank Albino Luna (UNAM) for the dorsal view illustration.

LITERATURE CITED

Dolling, W. R. 1979. Systematic changes in the Coreidae (Hemiptera). Entomologist's Monthly Magazine 114: 97–98.

Dolling, W. R. and C. E. Casini. 1988. Revision of the Neotropical genus *Nyttum* (Hemiptera: Coreidae). Systematic Entomology 13: 143–156.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 34–44

THE GENUS *STATHEROTMANTIS* DIAKONOFF (LEPIDOPTERA: TORTRICIDAE: OLETHREUTINAE) ON THE CHINESE MAINLAND, WITH DESCRIPTIONS OF FOUR NEW SPECIES

HOUHUN LI AND HALI YU

College of Life Sciences, Nankai University, Tianjin, 300071, P. R. China (e-mail: lihouhun@nankai.edu.cn)

Abstract.—Five species of *Statherotmantis* Diakonoff are known from the Chinese mainland, four of which are described as new, ***Statherotmantis expansa*** **Li and Yu, n. sp.**, ***S. spinulifera*** **Li and Yu, n. sp.**, ***S. maoerica*** **Li and Yu, n. sp.** and ***S. triangularis*** **Li and Yu, n. sp.** *Statherotmantis shicotana* (Kuznetsov) is newly recorded from Tianjin, Hebei, Henan, Hubei, and Hunan provinces. Keys to the species of the genus based on male and female genitalia are given for the world fauna.

Key Words: Lepidoptera, Tortricidae, Olethreutinae, *Statherotmantis*, systematics, new species, China

Statherotmantis Diakonoff, 1973, is a small genus of Olethreutini, consisting of four species to date: *S. peregrina* (Falkovitch 1966), *S. shicotana* (Kuznetsov 1969), *S. pictana* (Kuznetsov 1969), and *S. laetana* Kuznetsov 1988. They are all known from eastern and southeastern Asia (Falkovitch 1966; Kuznetsov 1969, 1988, 2001; Diakonoff 1973; Kawabe et al. 1992; Byun et al. 1998; Liu and Li 2002). Adults of *Statherotmantis* possess a large triangular, rectangular, or semicircular white costal spot on the forewing formed by the oblique extension of costal strigulae three through seven. The male genitalia usually possess the following combination of characters: uncus ovate or bilobed; socius large, long ovate and densely covered with long hairs; gnathos a strong transversal band expanded medially, with two small lateral prominences and a long dorsal median prominence (except *S. shicotana*); and valva with a ridge or fold at base of cucullus. In the female genitalia, the eighth tergite is a large collar; sterigma is a simple sclerite or tucked around ostium, often extending laterally and anteriorly; and there are two large pectic signa. The presence of the transversal rib of the valva occasionally accompanied by a ventral lobe in the male genitalia may be an autapomorphy of the genus (Razowski 1989). Detailed descriptions of the morphology of *Statherotmantis* were provided by Diakonoff (1973) and Razowski (1989).

In China, two species of *Statherotmantis* were recorded previously, *S. pictana* from Taiwan (Kawabe et al. 1992) and *S. shicotana* from Shandong Province (Liu and Li 2002). In this study five species of the genus from the Chinese mainland are recognized, including *S. shicotana* and four previously undescribed species: *S. expansa*, n. sp., from Fengyongzhai Nature Reserve, Sichuan Province and Zhangjiajie Nature Reserve, Hunan Province; *S. spinulifera*, n. sp., from Fanjing Nature Reserve, Guizhou Province; *S. maoerica*, n. sp., from Mt. Mao'er Nature Reserve, Guangxi; and *S. triangularis*, n. sp., from Mt. Mao'er, Guangxi and Mt. Leigong Nature Reserve, Guizhou Province.

Materials and Methods

Specimens used in this study were collected by light traps from ten forest reserves and three mountain villages in China. The vegetation of the sites is mainly hardwood forest or mixed conifer and hardwood forest. Terminology for wing patterns follows R. Brown and J. Powell (1991) as refined by J. Baixeras (2002). Methods of genitalia dissection follow H. Li and Z. Zheng (1996). Permanent slides of the abdominal pelts and genitalia were mounted in Canada balsam. Photographs of adults and genitalia of both sexes were taken with a Nikon Coolpix 4,500 digital camera adapted to an Olympus CH30-313E microscope. The types and other specimens examined are deposited in the Insect Collection, College of Life Sciences, Nankai University, Tianjin, China.

Systematics

Statherotmantis Diakonoff 1973

Statherotmantis Diakonoff 1973: 288. Type species: *Proschistis pictana* Kuznetsov 1969, by original designation.

Adults of *Statherotmantis* resemble *Cephalophyes* Diakonoff and some species of *Statherotis* Meyrick in appearance by possessing a white costal spot, but they can be distinguished by the male genitalia. In *Cephalophyes* the uncus is oval or somewhat inverted-triangular, constricted at the base, and has lateral projections; the socius is small; the gnathos is a simple membranous band; and the valva has no ridge or fold. In *Statherotis* the uncus is hooked and often bifurcate apically; the socius is small; the gnathos is variably developed, if present, often projecting medially, but lacking lateral prominence; and the valva is expanded outward at about distal 1/3 of ventral margin forming a triangular process. Some species in *Neopotamia* Diakonoff are similar to members of *Statherotmantis* in the female genitalia, with the eighth tergite a large collar; however, *Neopotamia* can be separated easily by its two large and unequal signa.

Key to *Satherotnantis* Species of the World Based on Male Genitalia

1. Uncus with two central hairy areas and naked margins; socius very small; gnathos without median prominence, lateral prominences long (Fig. 6) . . . . *shicotana* (Kuznetsov)
– Uncus with dense hairs throughout; socius large, oval; gnathos with a long median prominence, lateral prominences short . . . 2
2. Uncus small, hooked; socius triangular (Kuznetsov 1988: 170, pl. 3, Fig. 5). . . . . *laetana* Kuznetsov
– Uncus large, oval or bilobed; socius ovate or elongate-ovate 3
3. Gnathos with median prominence furcate apically 4
– Gnathos with median prominence not furcated apically 7
4. Gnathos with median prominence inverted T-shaped apically, lateral prominences broad, tonguelike, with dense spinules (Fig. 9) . . . . *spinulifera* Li and Yu
– Gnathos with median prominence bifid apically, lateral prominences narrow, short, fingerlike, naked 5
5. Valva with costa possessing a vertical lobe medially, rounded and naked; cucullus long and triangular, sharply narrowed apically (Fig. 8) . . . . *triangularis* Li and Yu
– Valva without vertical lobe at middle of costa; cucullus elongate 6
6. Valva with sacculus constricted at distal 1/3, apex broad and rounded (Kuznetsov 1969: 355, Fig. 5) . . . . *pictana* (Kuznetsov)
– Valva with sacculus slightly concave at distal half, apex narrow and pointed (Kuznetsov 2001: 231, pl. 139, Fig. 4) . . . . *peregrina* (Falkovitch)
7. Uncus large, bilobed; gnathos with median prominence coincident in breadth at apical half, lateral prominences absent; valva with a triangular lobe at apex of sacculus (Fig. 10) . . . . *maoerica* Li and Yu

– Uncus relatively small, oval; gnathos with median prominence expanded apically, apex about 1.5 times as broad as 3/5 length (the narrowest portion); valva with a rounded lobe at apex of sacculus (Fig. 7) . . . . *expansa* Li and Yu

KEY TO *SATHEROTNANTIS* SPECIES OF THE WORLD BASED ON FEMALE GENITALIA (Females of *S. laetana* Kuznetsov and *S. spinulifera* Li and Yu are unknown)

1. Sterigma two times as large as papilla analis (Fig. 11) . . . . . *shicotana* (Kuznetsov)
– Sterigma smaller than papilla analis 2
2. Sterigma a simple sclerite without lateral folds 3
– Sterigma with lateral folds 4
3. Sterigma round (Fig. 14) . . . . *maoerica* Li and Yu
– Sterigma trapezoidal (Kuznetsov 1969: 355, Fig. 6) . . . . *pictana* (Kuznetsov)
4. Sterigma small, folded over ostium; ostium slitlike (Fig. 12) . . . . . . *expansa* Li and Yu
– Sterigma moderate, not folded over ostium; ostium oval 5
5. Sterigma subcrescentic, lateral angle sharp, lateral folds pear-shaped, narrow (Falkovitch 1966: 211, Fig. 4) . . . . *peregrina* (Falkovitch)
– Sterigma somewhat jar-shaped, lateral angle rounded, lateral folds rounded (Fig. 13) . . . . *triangularis* Li and Yu

Statherotmantis shicotana (Kuznetsov 1969)
(Figs. 1, 6, 11)

Proschistis shicotana Kuznetsov 1969: 357, fig. 7.
Statherotmantis shicotana: Diakonoff 1973: 289, fig. 435.

Adult (Fig. 1).—Forewing length 4.0–5.0 mm in male.

Male genitalia (Fig. 6): As illustrated.

Female genitalia (Fig. 11): As illustrated.

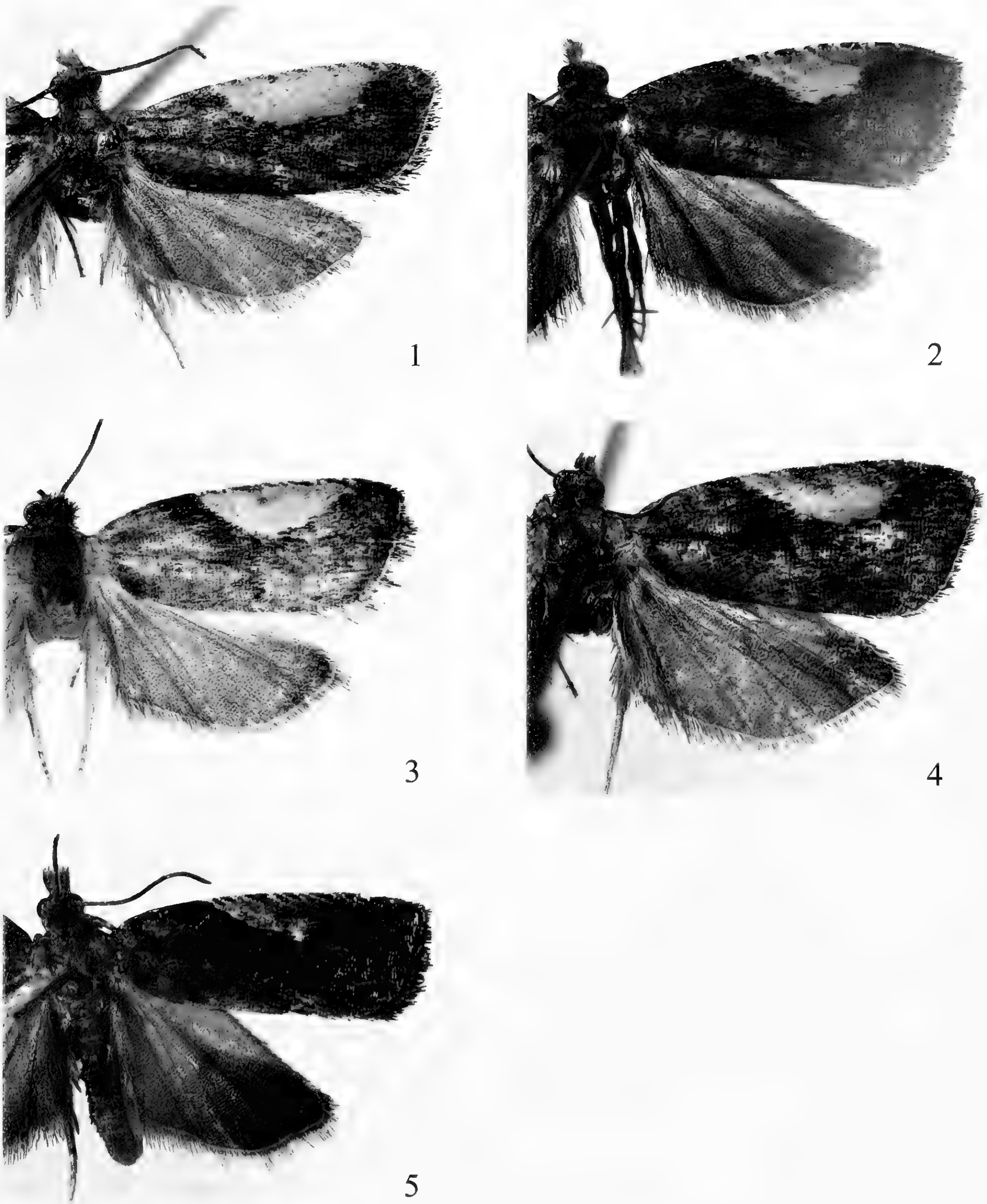
Remarks.—This species is relatively small and differs greatly from other known species of the genus in the male genitalia. The uncus is very large, naked on margin, and with two fine hairy areas medially; the socius is very small; the gnathos has two well-developed lateral prominences and lacks a median prominence; and the valva is broad, almost naked, and has a large lobe at apex of sacculus.

Distribution.—China (Tianjin, Hebei, Shandong, Henan, Hubei, Hunan); Korea; Japan; Russia (Far East). Liu and Li (2002) reported it from Shandong Province.

Material examined.—China: Mt. Baishi (39°12′N, 114°41′E), Hebei Province, 1,300 m, 21 vii 2000, 1 ♂, leg. Haili Yu, Hongmei Li and Yurong Wang; She County (36°34′N, 113°40′E), Hebei Province, 700 m, 2 viii 2000, 1 ♂, leg. Haili Yu, Hongmei Li and Yurong Wang; Ji County (40°02′N, 117°24′E), Tianjin, 130 m, 9 vi 2004, 1 ♂, leg. Houhun Li; Ji County (40°02′N, 117°24′E), Tianjin, 550 m, 23 vi 2001, 1 ♀, leg. Houhun Li; Wufeng County (30°12′N, 116°40′E), Province Hubei, 1,000 m, 12 vii 1999, 1 ♂, leg. Houhun Li; Lushi County (34°03′N, 111°02′E), Henan Province, 1,000 m, 20 vii 2001, 1 ♂, leg. Dandan Zhang; Song County (34°08′N, 112°05′E), Henan Province, 1580 m, 18~25 vii 2002, 4 ♂, leg. Xinpu Wang; Hui County (35°27′N, 113°47′E), Henan Province, 780 m, 12 vii 2002, 1 ♂, leg. Xinpu Wang; Sangzhi County (29°23′N, 110°11′E), Hunan Province, 1250 m, 14 viii 2001, 1 ♂, leg. Houhun Li and Xinpu Wang.

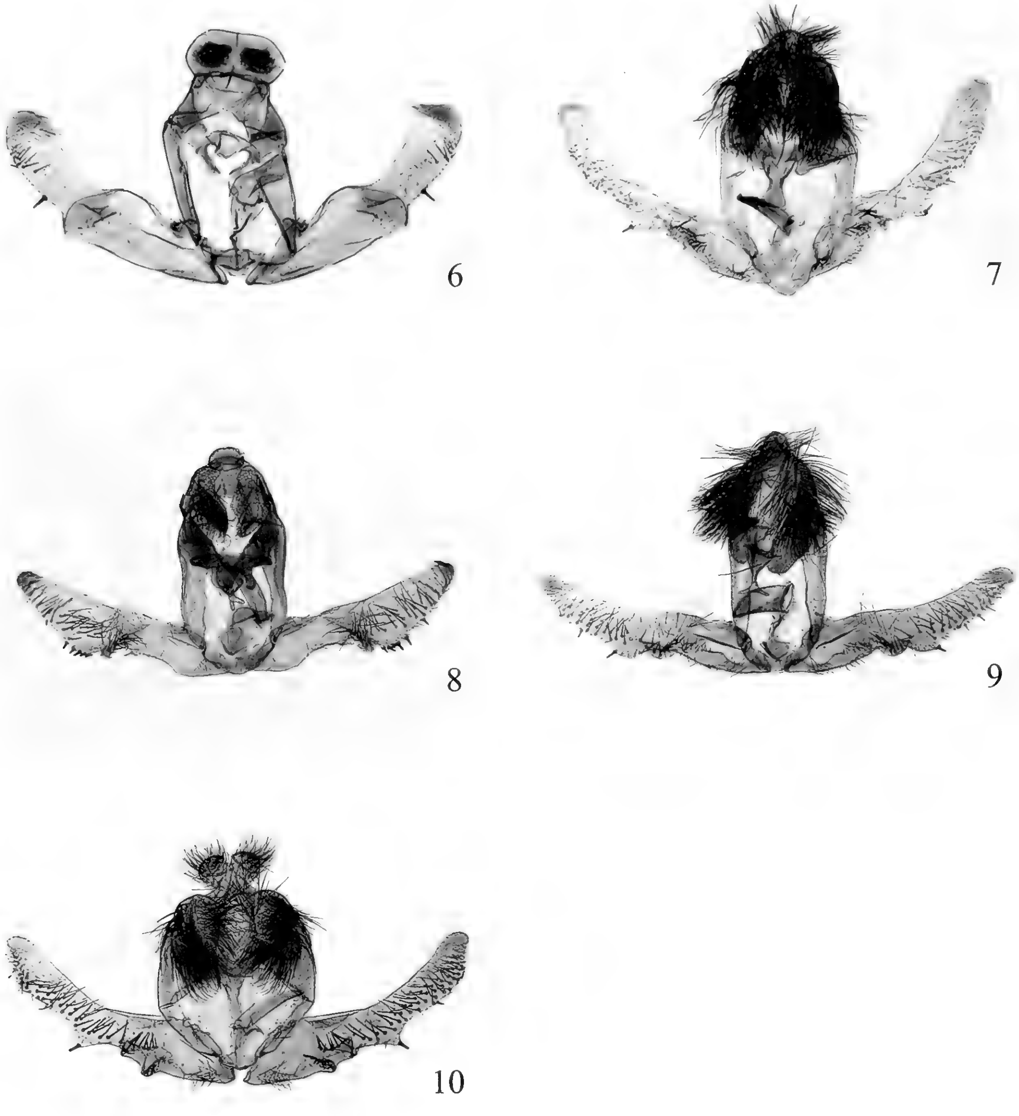
***Statherotmantis expansa* Li and Yu, new species**
(Figs. 2, 7, 12)

Diagnosis.—This species is similar to *S. maoerica* in the male genitalia, but can be separated from it by the following characters: tegumen long and narrow; uncus small, oval; and gnathos with median prominence expanded apically, lateral prominences distinct. In *S. maoerica*, the tegumen is short and broad, the uncus is large, broad, and bilobed, and the gnathos has a median prominence not expanded apically and lacks lateral prominences.



Figs. 1–5. Adults of *Statherotmantis* spp. 1, *S. shicotana*, male. 2, *S. expansa*, female, paratype. 3, *S. triangularis*, male, holotype. 4, *S. spinulifera*, male, holotype. 5, *S. maoerica*, male, paratype.

Description (Fig. 2).—Head roughly scaled, deep fuscous. Antenna fuscous. Labial palpus porrect or ascending; basal segment gray white or pale fuscous; median segment pale fuscous basally, distal half with long rough scales, from pale fuscous to deep fuscous; terminal segment fuscous to deep fuscous, pointed. Thorax and tegula fuscous, with a crest posteriorly. Legs pale fuscous or



Figs. 6–10. Male genitalia of *Statherotmantis* spp. 6, *S. shicotana* (slide no. YHL04148). 7, *S. expansa*, holotype (slide no. YHL04904). 8, *S. triangularis*, holotype (slide no. YHL04918). 9, *S. spinulifera*, holotype (slide no. YHL04917). 10, *S. maoerica*, holotype (slide no. YHL04149).

pale yellowish fuscous; tarsi deep fuscous, with a yellowish fuscous ring at apex of each subsegment; median tibia fuscous, densely covered with narrow, pointed scales, and a yellowish-fuscous ring at middle and apex; posterior tibia pale gray, with dense scales and a pale yellow hair pencil at base.

Forewing length 6.0–8.0 mm in male, 6.2 mm in female. Upperside ground color fuscous; costa with nine pairs of strigulae from base to R_4; strigulae distributed as follows: four pairs (strigulae 1–4) between base of wing and point where Sc meets costa, two pairs (strigulae 5–6) between Sc and R_1, one pair (strigula 7) between R_1 and R_2, one pair (strigula 8) between R_2 and R_3, one pair (strigula 9) between R_3 and R_4; each pair of strigulae with a leaden (silvery) stria extending obliquely; basal two pairs before 1/4 forewing length, indistinct, striae from them extending to base and 1/3 length of dorsum, respectively; strigulae three to seven white, striae from strigulae three and four extending obliquely to dorsum before tornal angle, broken from base of R_2 to 1/6 length of M_3; striae form strigulae five and six extending obliquely to tornus, broken at midlength of M_2; strigulae eight and nine represented by a single marking, striae from them and strigula seven confluent, extending to termen between R_5 and M_1; strigula ten on termen between apex and R_5, indistinct; strigulae on termen undefined, no more than three distinguishable; fasciae indistinguishable, except subbasal fascia deep fuscous, broad, fused with broken umbrae of median fascia and postmedian fascia, forming a large V-shaped fascia, extending to dorsum between 1/2 and 3/4 length; a large, inverted triangular white suffusion with yellow spot from strigulae three to seven below costa, surrounded by the V-shaped fascia, its lower angle reaching base of M_2; sparse small white dots between M_2 and distal 1/3 of dorsum; cilia fuscous, with deep fuscous baseline; underside fuscous, gray white in overlapping area, costal strigulae one and two pale fuscous, three to nine and terminal strigulae white, area of hindwing overlap posterior to CuP. Hindwing upperside fuscous, pale gray on area of forewing overlap; cilia pale gray with fuscous baseline; underside concolorous with forewing underside.

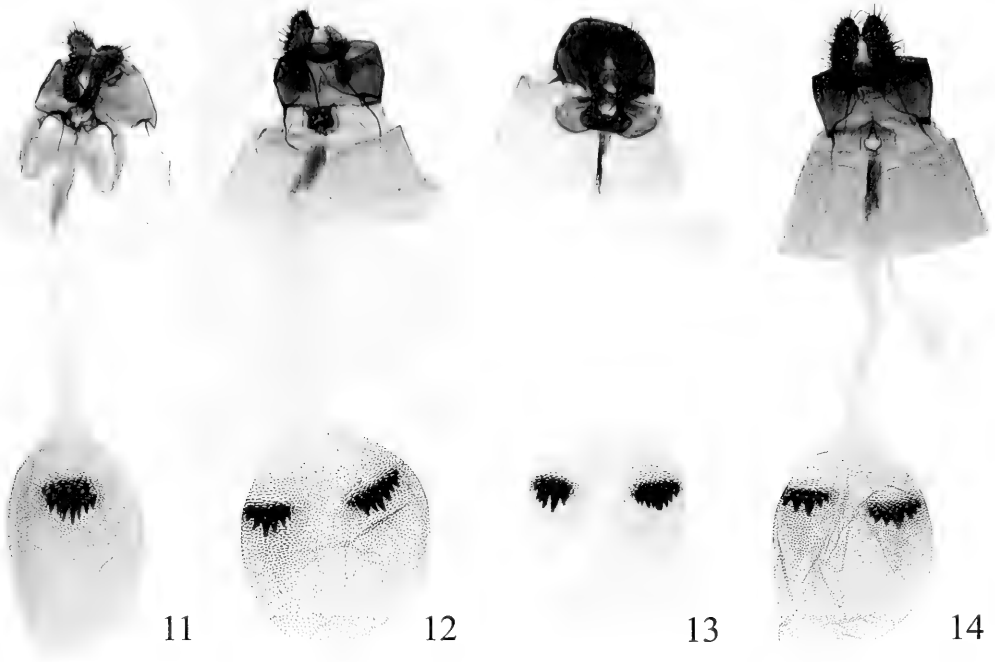
Male genitalia (Fig. 7): Tegumen long, narrow. Uncus small, oval, drooping, with dense scale-like hairs beneath. Socius large, elongate-oval, with dense scalelike hairs. Gnathos with a long dorsal prominence at middle, broad at base, constricted at 3/5 length, expanded apically, apex about 1.5 times width at basal 3/5 in breadth, lateral prominences short, rounded and naked. Valva slender; sacculus with sparse spines, two small rounded lobes near apex: the proximal one vertical with short spines, the distal one transverse with thin thorns; cucullus densely thorny on ventral part, protruding ventrally at base, with a pointed angle, carrying a thorn apically. Aedeagus short and narrow.

Female genitalia (Fig. 12): Apophyses anterior slightly shorter than apophyses posterior. Sterigma small, folded over ostium, nearly quadrate, with spinules and small lateral folds below. Ostium slot-like. Colliculum long. Ductus bursae long. Corpus bursae oval, densely granulated, with two pectinate signa.

Types.—Holotype ♂, China: Baoxing County (30°22′N, 102°50′E), Sichuan Province, alt. 1,600 m, 3 viii 2004, leg. Yingdang Ren, genitalia slide no. YHL04904. Paratypes: 3 ♂, same data as holotype; 2 ♂, 1 ♀, Zhangjiajie (29°49′N, 110°26′E), Hunan Province, alt. 650 m, 8~9 viii 2001, leg. Houhun Li and Xinpu Wang.

Etymology.—The specific name is derived from the Latin *expansus* (= expanded), to note the apical shape of the median prominence of the gnathos.

Remarks.—*Statherotmantis expansa, S. peregrina, S. pictana, S. spinulifera, S. maoerica*, and *S. triangularis* all possess specialized hairs on the uncus and socii, which are narrow, scalelike, and flat, with a rounded base and pointed apex. And according to the figures of Diakonoff (1973) and Kuznetsov (2001), we presume this kind of scale is present in *S. pictana* and *S. peregrina*. But it is uncertain to be present in *S. laetana*, which was described in Russia, and it is difficult to draw a conclusion



Figs. 11–14. Female genitalia of *Statherotmantis* spp. 11, *S. shicotana* (slide no. YHL04967). 12, *S. expansa* (slide no. YHL04908). 13, *S. triangularis* (slide no. YHL05210). 14, *S. maoerica* (slide no. YHL04909).

from the figure. In *S. shicotana* the uncus possesses very fine and long hairs. We think the vestiture on the uncus and socius in this genus is an important taxonomic character. The costal strigulae of *S. triangularis*, and *S. spinulifera* have the same ground plan as that of *S. expansa*.

Statherotmantis triangularis **Li and Yu, new species**

(Figs. 3, 8, 13)

Diagnosis.—This species resembles *Statherotmantis peregrina* in the genitalia, but it can be distinguished from the latter by the shape of valva in the male and the shape of sterigma in the female. These differences are described in the key to species.

Description (Fig. 3).—Head roughly scaled, fuscous. Antenna fuscous. Labial palpus porrect, slightly ascending; basal segment pale fuscous; median segment pale fuscous except apex fuscous, distal half with long rough scales; terminal segment fuscous, pointed. Thorax fuscous; tegula pale fuscous. Legs pale fuscous; anterior and median tarsi deep fuscous, with yellowish fuscous ring at apex of each subsegment; median tibia pale fuscous, densely covered by narrow, pointed scales, and yellowish fuscous ring at middle and apex; posterior tibia with dense scales, a pale yellow hair pencil at base.

Forewing length 7.0–7.5 mm. Upperside ground color fuscous, fasciae indistinct; costa with nine pairs of strigulae from base to R_4: strigulae one and two indistinct; strigulae three to eight from 1/3 length of costa to R_3, white; distal pair indistinct; striae from pairs of strigulae indistinguishable; subbasal fascia extending obliquely to midlength of dorsum, lower part below cell indistinct; a white semicircular spot below costa between third and eighth pairs of strigulae, suffused with yellow, lower margin reaching base of M_1; cilia fuscous, with deep fuscous baseline; underside fuscous, except third to eighth pairs of strigulae and patch below them yellowish fuscous; area of hindwing overlap paler. Hindwing upperside fuscous except pale gray on area of forewing overlapping; cilia pale gray, with fuscous baseline; underside concolorous with forewing underside.

Male genitalia (Fig. 8): Tegumen long, narrow. Uncus small, oval, drooping, with dense scalelike hairs beneath. Socius large, elongate oval, with dense scalelike hairs. Gnathos with a long median bifid prominence, basal 2/3 very broad, constricted at apical 1/4, apex furcated, inverted V-shaped; a ventral inverted trapeziform prominence below median prominence, extending to its 2/3 length and narrower than it; lateral prominence fingerlike, naked. Valva with basal 1/3 narrow; costa with a vertical lobe medially inside vesica, directing inward, translucent, rounded and naked, and concealed by thin spines on distal lobe near apex of sacculus; sacculus concave, with a transverse ridge densely covered by fine spines, apex becoming a rounded lobe, folded; cucullus long-triangular, sparsely covered by fine spines, with five short spines along 1/4 length of ventral margin at base, sharply narrowed apically. Aedeagus short, pointed apically.

Female genitalia (Fig. 13): Apophyses anterior shorter than apophyses posterior. Sterigma extending anteriorly, somewhat jarlike, broad, with spinules medially and around ostium, with rounded lateral folds below. Ostium oval. Colliculum long. Ductus bursae long. Corpus bursae oval, densely granulated, with two pectinate signa.

Types.—Holotype ♂, China: Mt. Mao'er (25°53′N, 110°25′E), Guangxi, alt. 550 m, 20 iv 2002, leg. Shulian Hao and Huaijun Xue, genitalia slide no. YHL04918. Paratypes: 1 ♂, 1 ♀, Leishan County (26°22′N, 108°03′E), Guizhou Province, alt. 900 m, 13 ix 2005, leg. Jialiang Zhang.

Etymology.—The specific name is derived from the Latin *triangularis* (= triangular), referring to the shape of the cucullus in the male genitalia.

Remarks.—The hairs on uncus and socius were removed in the genitalia preparation.

Statherotmantis spinulifera **Li and Yu, new species**

(Figs. 4, 9)

Diagnosis.—*Statherotmantis spinulifera* is similar to *S. pictana* and *S. peregrina* in the male genitalia, but differs from them by the gnathos. In *S. spinulifera*, the median prominence is inverted T-shaped apically, the branches are long, and the lateral prominences bear dense spinules. In *S. pictana* and *S. peregrina* the median prominence is inverted V-shaped apically, the branches are short, and the lateral prominences are naked.

Description (Fig. 4).—Head roughly scaled, fuscous. Antenna fuscous. Labial palpus gray white, ascending; median segment with long rough scales distally, pale gray; terminal segment pointed, gray fuscous. Thorax fuscous; tegula fuscous basally, pale fuscous distally. Legs pale fuscous suffused with white, anterior and median tarsi fuscous, with pale yellow rings at apex of each subsegment, median tibia with narrow and pointed scales, fuscous basally and pale fuscous apically; posterior tibia with dense scales at basal half and a pale yellow hair pencil at base.

Forewing length 7.0 mm in male. Upperside ground color fuscous; fasciae deep fuscous, undefined; costa with nine pairs of white strigulae: strigulae one and two pale fuscous, before 1/5 length of forewing, striae from them extending to base of dorsum, indistinct; strigulae 3 and 4 white, at 2/5 length of forewing, striae from them indistinct; distal five pairs pale fuscous, striae from them indistinct; strigulae eight and nine represented by one single marking; subbasal fascia broad, fused with median fascia and postmedian fascia on cell, forming a large V-shaped fascia, extending dorsally to 2/3 length of dorsum, median fascia represented by a small spot on costa, broken; a long white spot below costal strigulae three and four, with sparse pale yellow scales, extending obliquely to 1/4 length of R_5 distally, lower margin reaching base of M_1, surrounded by large V-shaped fascia; cilia fuscous; underside fuscous, costal strigulae pale yellow, and spot pale fuscous, area of hindwing overlap white. Hindwing with upperside grayish white on area of forewing overlapping, cilia gray; underside paler than underside of forewing.

Male genitalia (Fig. 9): Tegumen long, narrow. Uncus small, oval, drooping, with dense scalelike hairs beneath. Socius large, elongate-oval, with dense scalelike hairs. Gnathos with a long median prominence, basal half broad, distal half strongly constricted and bifurcate apically; inverted T-shaped, with long branches; lateral prominences tonguelike, with dense spinules. Valva slender; sacculus with sparse spines, and two rounded lobes apically: the proximal one small and transversal, bearing short spines, distal one large, vertical, and distally reaching base of cucullus, with short thorns; cucullus with sparse fine spines, its base rounded and protruding ventrally, carrying a short thorn apically. Aedeagus short, somewhat thick.

Female: Unknown.

Types.—Holotype ♂, Mt. Fanjing (27°55′N, 108°41′E), Guizhou Province, alt. 2100 m, 30 vii 2001, leg. Houhun Li and Xinpu Wang, genitalia slide no. YHL04917. Paratype: 1 ♂, same data as holotype.

Etymology.—The specific name is derived from the Latin *spinulifer* (= spinulate), referring to the spinulate lateral prominences of the gnathos.

Remarks.—This species is very similar to *S. triangular* in appearance, especially in the wing patterns, but they are different remarkably in the male genitalia by the shape of gnathos and valva.

Statherotmantis maoerica Li and Yu, new species

(Figs. 5, 10, 14)

Diagnosis.—This species can be separated easily from other described species of the genus by the large, bilobed uncus. It resembles *S. laetana* and *S. expansa* in the shape of the gnathos. The differences among them are discussed under *S. expansa*.

Description (Fig. 5).—Head roughly scaled, gray fuscous, yellowish fuscous, or blackish fuscous. Antenna from yellowish fuscous to blackish fuscous. Labial palpus ascending, slightly porrect; basal segment white or pale fuscous; median segment with long rough scales distally, pale gray fuscous or fuscous; terminal segment pointed, pale gray fuscous or fuscous. Thorax and tegula fuscous or deep fuscous. Legs pale yellow or pale fuscous, anterior and median tarsi deep fuscous, with a pale yellow or pale fuscous ring at apex of each subsegment; median tibia pale fuscous or fuscous, with narrow pointed scales, as well as pale fuscous rings at middle and apex; posterior tibia with a white or pale yellow hair pencil at base.

Forewing length 7.0–8.0 mm; upperside ground color fuscous to deep fuscous, fasciae blackish fuscous; costa with nine pairs of strigulae from base to R_4: strigulae one and two before 1/4 length of costa, fuscous, lower angle reaching base of M_1, striae from them extending to base and 2/5 length of dorsum; distal seven pairs white; strigulae three and four with striae extending obliquely to distal 1/3 of dorsum, broken from base of R_3 to midlength of R_2; strigulae five and six with striae extending obliquely to tornus, broken from 2/3 length of R_3 to 3/5 length of M_2; strigulae eight and nine represented by a single marking; striae from strigulae seven, eight, and nine confluent, extending to termen between R_5 and M_1; basal fascia with fuscous spot; subbasal fascia broad, extending obliquely to midlength of dorsum, distal margin reaching lower angle of cell; median fascia narrow, bordered by yellow edge, broken, lower margin confluent with postmedian fascia and subbasal fascia, forming a large V-shaped marking; postmedian fascia with distal margin reaching termen between M_2 and CuA_1; terminal fascia a small dot; an inverted triangular white spot below costa between strigulae three and seven, its upper part with dense yellow scales, surrounded by V-shaped fascia, intersected by striae from strigulae three and seven; strigulae on wing margin between apex and M_2 white, confluent, forming a short line; cilia fuscous, intermixed with white, with blackish fuscous baseline; underside fuscous, distal seven pairs of costal strigulae and strigulae on wing margin pale yellow, area of hindwing overlap white. Hindwing upperside fuscous except gray white on area of forewing overlap; cilia pale fuscous, with fuscous baseline; underside concolorous with forewing underside.

Male genitalia (Fig. 10): Tegumen short and broad. Uncus large, bilobed, drooping, with dense scalelike hairs beneath. Socius large, oval, drooping, with dense scalelike hairs. Gnathos with a long median prominence; basal half broad; apical half narrow, 1/2 width of base, without lateral prominences. Valva narrow; sacculus with sparse spines basally, a small transversal lobe at 2/3 length of ventral edge, densely covered with short spines; a triangular transversal lobe apically, with a line of slender thorns along proximal margin; cucullus with sparse thorns, protruding at 1/4 length of ventral edge, forming a pointed angle, with a thorn apically. Aedeagus slender.

Female genitalia (Fig. 14): Apophyses anterior short, half as long as apophyses posterior. Sterigma broad, weakly sclerotized, naked. Ostium ovoid. Colliculum long. Ductus bursae long. Corpus bursae ovoid, densely granulated, with two pectinate signa.

Types.—Holotype ♂, Mt. Mao'er (25°53′N, 110°25′E), Guangxi, 550 m, 20 iv 2002, leg. Shulian Hao and Huaijun Xue, genitalia slide no. YHL04149. Paratypes: 3 ♂, 1 ♀, same data as holotype; 14 ♂, 4 ♀, same data as holotype except 1,100 m; 2 ♂, 2 ♀, same data as holotype except 19 iv 2002.

Etymology.—The specific name is from the type locality, Mao'er, Guangxi.

Remarks.—This species is a little different from other congeners by the narrow and subrectangular forewing with a relatively darker and narrower costal spot. It is distinguishable by the different structure of the male genitalia.

ACKNOWLEDGMENTS

We thank Prof. Guofang Jiang, Guangxi Academy of Sciences, Prof. Zizhong Li, Guizhou University, Prof. Meicai Wei, Central South Forestry University, Prof. Xiaocheng Shen, Henan Academy of Agricultural Sciences, and Dr. Fu-Ming Shi, Hebei University, China for their assistance in the field. We are also deeply grateful to the anonymous reviewers for providing us very helpful comments and suggestions on this paper. The project was supported by the National Natural Science Foundation of China for the Special Program.

LITERATURES CITED

Baixeras, J. 2002. An overview of genus-level taxonomic problems surrounding *Argyroploce*

Hübner (Lepidoptera: Tortricidae), with description of a new species. Annals of the Entomological Society of America 95: 422–431.

Brown, R. L. and J. Powell. 1991. Description of a new species of *Epiblema* (Lepidoptera: Tortricidae: Olethreutinae) from coastal redwood forests in California with an analysis of the forewing pattern. Pan-Pacific Entomologist 67: 107–114.

Byun, B. K., Y. S. Bae, and K. T. Park. 1998. Illustrated Catalogue of Tortricidae in Korea. *In* Park, K. T. and H. Y. Park, eds. Insects of Korea Series [2]. Junghaeng-Sa, Seoul. 1–317.

Diakonoff, A. 1973. The south Asiatic Olethreutini (Lepidoptera, Tortricidae). Zoölogische Monographieën van het Rijksmuseum van Natuurlijke Historie No. 1: 1–700, pls. 1–15.

Falkovitch, M. J. 1966. New Palaearctic species of leaf-rollers of the subfamily Olethreutinae (Lepidoptera, Tortricidae). Trudy Zoologicheskogo Instituta Leningrad 37: 208–227 (in Russian).

Kawabe, A., F. Komai, and J. Razowski. 1992. Tortricoidea, pp. 103–109. *In* Heppner, J. B. and H. Inoue, eds. Lepidoptera of Taiwan Vol. 1 part 2, Checklist. Scientific publishers, Taipei. 1–276.

Kuznetsov, V. I. 1969. New East Asiatic species of the leaf-rollers (Lepidoptera, Tortricidae). Entomologicheskoe Obozrenie 48: 352–372 (in Russian, English translation, 1969, Entomological Review 48: 206–218).

———. 1988. Review of tortrix moths of supertribes Gatesclarkeanidii and Olethreutidii (Lepidoptera, Tortricidae) of the fauna of North Vietnam. Trudy Vsesojuznogo Entomologicheskogo Obscestva 70: 165–181 (in Russian).

———. 2001. Tortricidae, pp. 11–472. *In* Ler, P. A. ed. Key to the insects of Russian Far East. Vol. V. Trichoptera and Lepidoptera. Pt 3, Dal'nauka, Vladivostok. 622 pp. (in Russian).

Li, H. H. and Z. M. Zheng. 1996. Methods and techniques of specimens of Microlepidoptera. Journal of Shaanxi Normal University (Natural Science Edition) 24(3): 63–70 (in Chinese).

Liu, Y. Q. and G. W. Li. 2002. Fauna Sinica Insecta Vol. 27 Lepidoptera: Tortricidae. Science Press, Beijing. 463 pp. (in Chinese).

Razowski, J. 1989. The genera of Tortricidae (Lepidoptera). Part II: Palaearctic Olethreutinae. Acta Zoologica Cracoviensia 32: 107–328.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 45–51

BIOLOGY AND DESCRIPTION OF A NEW SPECIES OF *LAURELLA* HERATY (HYMENOPTERA: EUCHARITIDAE) FROM ARGENTINA

Javier Torréns, John M. Heraty, and Patricio Fidalgo

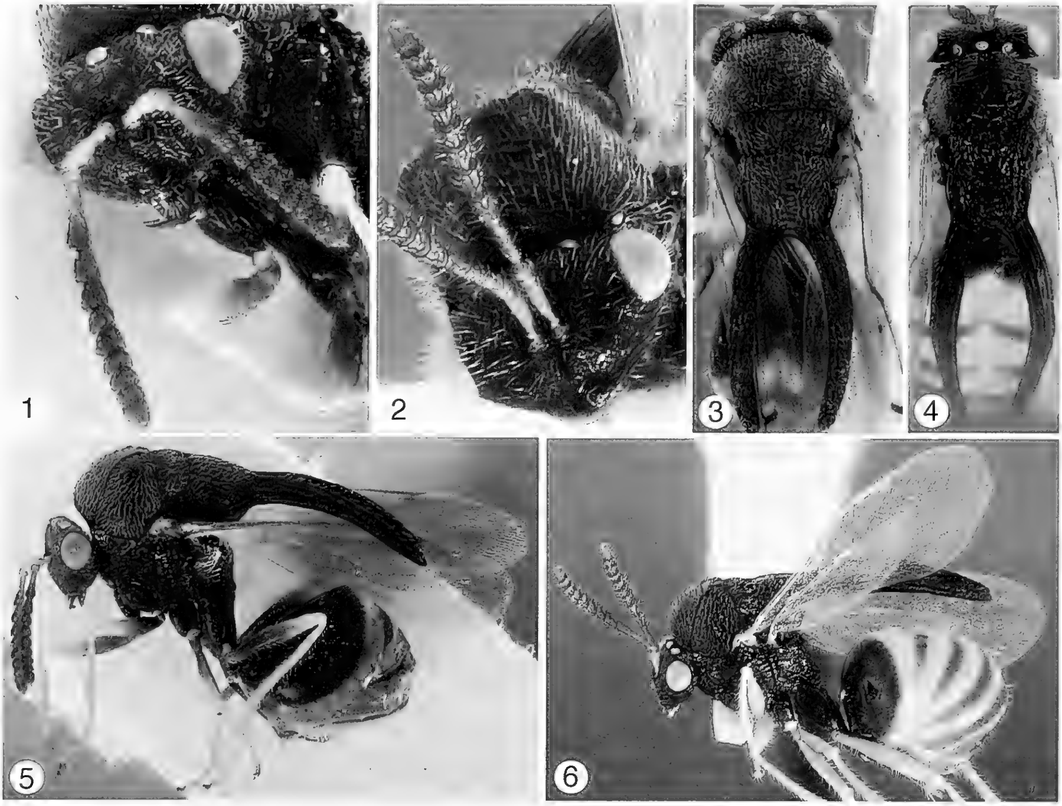
(JT, PF) CRILAR-CONICET, Entre Ríos y Mendoza, 5301 Anillaco, La Rioja, Argentina (e-mails: jtorrens@crilar-conicet.com.ar; pfidalgo@crilar-conicet.com.ar); (JMH) Department of Entomology, University of California, Riverside, CA 92521, USA (e-mail: john.heraty@ucr.edu)

Abstract.—Description of the adult, egg, and planidium of a **new species**, ***Laurella rugosa* Torréns, Heraty, and Fidalgo** (Hymenoptera: Eucharitidae), from Salta, Argentina, is provided, along with a new key for the species of the genus. *Laurella rugosa* deposits eggs on the underside of leaves of *Serjania glabrata* Kunth (Sapindaceae), a climbing plant that grows in the understory of *Piptadenia macrocarpa* Benth. (Leguminoceae).

Key Words: *Laurella rugosa*, egg, planidium, host plant

Laurella (Hymenoptera: Eucharitidae) was initially described to include three species, *L. bonariensis* (Gemignani), *L. vianai* (Gemignani), and *L. guriana* Heraty (Heraty 2002). Two of these species were described by Gemignani (1947) as *Lirata bonariensis* and *Parakapala vianai. Laurella* belongs to the largely Neotropical Kapala clade within the Eucharitinae, which usually can be recognized by the parallel elongate projections arising from the scutellum (Heraty 2002). Oviposition takes place with the deposition of large numbers of eggs, either in cavities in plant buds or with the eggs scattered over the undersurface of the leaf (Clausen 1940a, Heraty and Darling 1984, Heraty 2002). All members of the *Kapala* clade are known to only attack the immature stages of large poneromorph ants in the subfamilies Ectatomminae, Ponerinae, and Paraponerinae (*sensu* Bolton 2003). Larvae initially attach to the host larva, but most development occurs on the host pupa (Clausen 1940b).

The biology of *Laurella* was unknown, and its immature stages undescribed, with the exception of a single planidium taken from the body of an adult of *L. vianai* from Tucumán, Argentina (Heraty 2002). The larva was similar in morphology to that of a closely related genus, *Thoracantha* Latreille, with both genera sharing elongate channels on the cranium (Heraty 2002). Attachment of larvae to the adult host is relatively common in eucharitids attacking poneromorph ants and is associated with highly active larvae seeking an adult ant host for phoretic transfer back to the brood in the ant nest. These active planidia may attach accidentally to an adult eucharitid visiting oviposition sites used by other females of the same species; thus, these attached planidia on the eucharitid adult are likely from the same species (Heraty, unpublished).



Figs. 1–6. 1, *Laurella rugosa*, head and antenna (female, sublateral). 2, *L. guriana*, head and antenna (female, frontal). 3, *L. rugosa*, head and mesosoma (female, dorsal). 4, *L. guriana*, head and mesosoma (female, dorsal). 5, *L. rugosa*, habitus (female). 6, *L. guriana*, habitus (female).

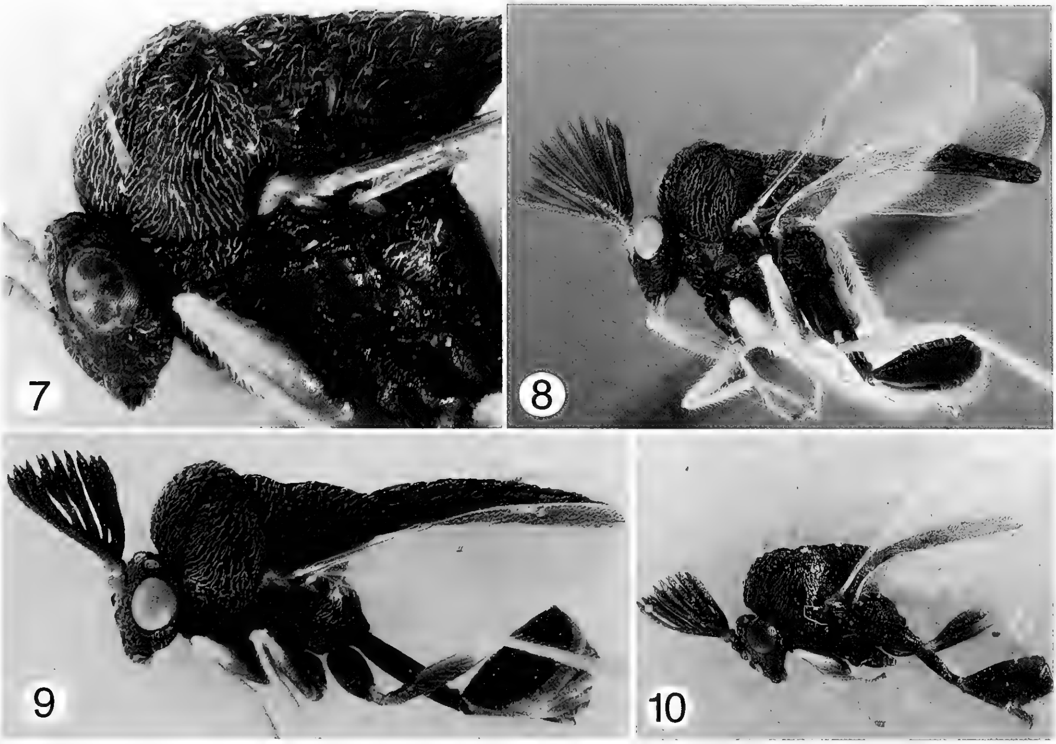
Laurella is known only from South America, with scattered locality records from Argentina, Paraguay, Uruguay, and Venezuela. A new species, *Laurella rugosa*, was discovered in northern Argentina, and information is included on its life history and immature stages. Morphological terms used in the descriptions are from Heraty (2002) and Darling (1988), with details on sculpture from Eady (1968).

Type material is deposited in the following collections: MACN, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina; IFML, Instituto Fundación Miguel Lillo, Tucumán, Argentina; FSCA, Florida State Collections of Arthropods, Gainesville, Florida, U.S.A.; UCRC, University of California, Riverside, California, U.S.A.

Laurella rugosa Torréns, Heraty, and Fidalgo, new species

(Figs. 1, 3, 5, 7, 9, 11–20)

Diagnosis.—Distinguished from the other species by a combination of semi-appressed setae on the head and mesosoma, darkened femora basally, and thick scutellar spines that are slightly bowed in dorsal view (Fig. 3). Additionally, females have an elongate basal flagellomere that is lightly colored basally, and the mesoscutum is strongly rounded in profile (Fig. 5). The egg is stalked and similar to other Eucharitinae as described by Heraty and Darling (1984). The planidium is almost identical



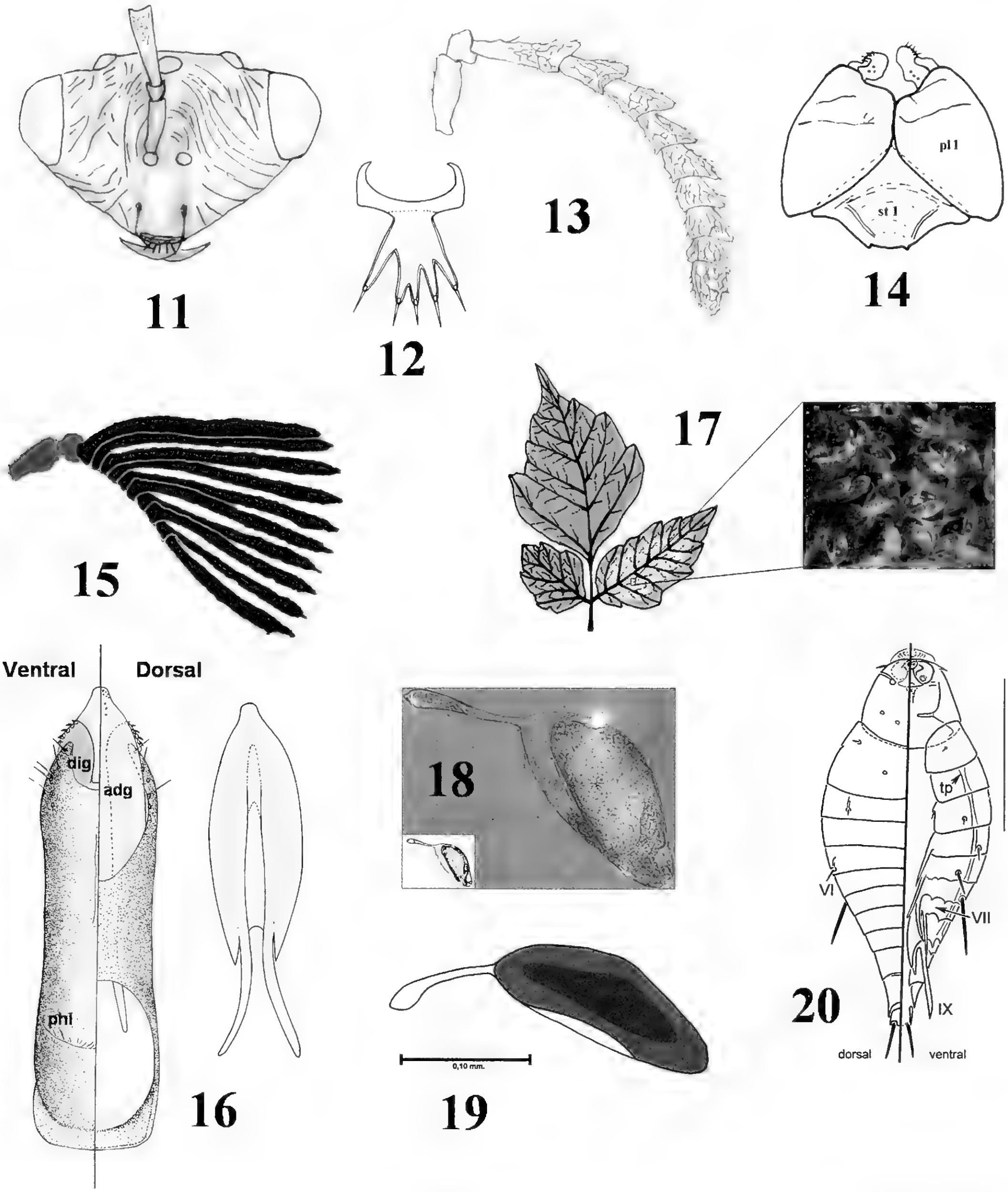
Figs. 7–10. 7, *Laurella rugosa*, head and mesosoma (female, lateral). 8, *L. guriana*, habitus (male). 9, *L. rugosa*, habitus (male). 10, *L. bonariensis*, habitus (male).

to that of *Thoracantha striata* Perty (Heraty 2002), with both planidia having a distinct line extending laterally from anterior cranial sensilla and presense of a seta ventrally on T1. *Laurella rugosa* differs by having a seta ventrally on TI and no ventral or lateral seta on TII. As well, the ventral posterior process on TIX is divided and developed laterally in *L. rugosa*.

Holotype female.—Length 3.6 mm. Body completely black except light brown tegula; scape, pedicel, basal half of F2 light brown, rest of flagellum dark brown; femora dark brown basally, distal half of femora, tibiae, and tarsi yellow. Wings evenly infuscate with venation dark brown.

Head: 1.5× as broad as high (Figs. 1, 11). Face with surface weakly scabrous and with weak striae converging from genae to clypeus, and from lower face to median ocellus (Fig. 11). Eyes separated by 2.4× their height. Labrum with five digits, each digit with a terminal flattened seta (Fig. 12). Clypeus smooth; supraclypeal area swollen, slightly reticulate with a few weak transverse striae. Antenna with 11 segments (Figs. 1, 13), scape swollen apically, not reaching to ventral margin of median ocellus. Length of flagellum 1.5× height of head, basal flagellomere 6.2× as long as basal width, 1.9× as long as following segment; basal flagellomere flared apically, following segments flared and weakly serrate apically, clava rounded; all flagellar segments scabrous.

Mesosoma (Figs. 3, 5): Mesoscutum rounded anteriorly; midlobe with irregular transverse carinae, and with weak longitudinal depression medially; side lobe with similar carinae but less distinct; entire surface covered by semi-appressed



Figs. 11–20. 11–14, *Laurella rugosa* (female). 11, Head (frontal). 12, Labrum. 13, Antenna. 14, Prosternum and propleura (ventral). 15–16, *L. rugosa* (male). 15, Antenna. 16, Genitalia and aedeagus. 17–20, Host plant and immature stages. 17, Underside of *Serjania glabrata* with eggs (white area). 18, Recently deposited egg. 19, Egg two days old with outline of planidium. 20, Planidium. Abbreviations: pl_1= propleura; st_1= prosternum; adg= aedeagus; dig= digitus; phl= phallobase; tp= tergopleural line.

setae; tegula with scattered setae. Notauli vaguely impressed anteriorly to strongly impressed posteriorly. Axilla, scutellum, and scutellar spine with strong longitudinal striae, sculpture becoming rugose in posterior half of spine, spines slightly bowed in dorsal view (Fig. 3); frenum glabrous and smooth, reflexed below spines and with a medial carina. Propodeal disc rounded and slightly rugose, with a broad medial depression. Mesepisternum glabrous and smooth; upper mesepimeron weakly reticulate to smooth dorsally, becoming more strongly rugose-areolate ventrally, femoral depression deeply and narrowly impressed and with strong tranverse carinae; prepectus triangular and separated from tegula by mesoscutum and acropleuron (Fig. 7). Prosternum (st1) trapezoidal with two carina directed medially (Fig. 14). Forecoxa mostly smooth and bare, becoming reticulate with scattered setae anteriorly; midcoxa mostly smooth two lateral longitudinal carina; hind coxa smooth to slightly reticulated apically, with few setae, hind coxa 1.8× as long as broad. Forewing 2.5× as long as broad; stigmal vein rectangular, 2.4× as long as broad; postmarginal vein as long as stigmal vein.

Metasoma: Petiole 3.1× as long as broad and 1.3× as long as hind coxa, petiole mostly smooth with weak longitudinal carinae. Gastral terga black to brown, terga smooth; Gt_1 with few scattered curved setae; hypopygium with cluster of dense long hairs apically.

Variation.—Length 3.5–3.8 mm. Head 1.4–1.5× as broad as high; eyes separated by 1.9–2.6× their height. Length of flagellum 1.5–1.6× height of head, basal flagellomere 5–6.2× as long as basal width and 1.5–1.9× as long as following segment. Labrum with 5–6 digits. Depression of midlobe weak to almost absent. Tegula whitish to light brown. Scutellar spine with variation in breadth, and more than apical half can be rugose. Frenum with 1–3 carinae in different forms. Hind coxa 1.6–1.9× as long as broad. Forewing 2.4–2.6× as long as broad. Petiole 2.7–3.2× as long as broad and 1.3–1.5× as long as hind coxa.

Male.—Length 3.3–3.6 mm (Fig. 9). Similar to female except for following: head with sculpture more prominent; mesosoma with carinae more irregular; scutellar spine almost completely rugous; mesepisternum and mesepimeron with carinae prominent and surface more evenly rugose-areolate; legs with same coloration as female but darker; antenna pectinate (Figs. 9, 15), with same coloration as female but darker, branch of basal flagellomere equal or shorter than height of head and 3.5–4.4× as long as scape; mesoscutum more vaulted in lateral view; forewing hyaline; petiole 1.6–1.8× as long as hind coxa. Gastral terga black and more slender. Genitalia (Fig. 16) typical of most Eucharitidae; volsellus with several small marginal spines, aedeagus subacuminate.

Description of immatures.—*Eggs*: Undeveloped eggs whitish and translucent with a smooth chorion, slightly flattened ventrally along egg body, and convex dorsally (Figs. 18, 19). Within four days, dark coloration of developing embryo noticed, giving egg a dark color (Fig. 19); length of egg body about 0.17 mm and caudal stalk 0.08 mm. In mature eggs, larva occupies almost entire egg body with head oriented to caudal stalk. *Planidium* (Fig. 20): Morphology and setal pattern is typical of most Eucharitinae. Described by following features: length 0.10 mm; width 0.03 mm; pleurostomal spine present; three pairs of placoid sensilla on cranium, anterior pair connected to lateral margin by single line of weakness, dorsal cranial spines absent; hatchet-shaped sclerite present; pleurostoma extending laterally as a distinct spine; ventral transverse process of cranium fingerlike and separated medially; tergopleural line (tp) separating pleural and dorsal tergites present on tergites TII–VIII; TI and TII fused dorsally, with 1 pair of small setae ventrally and dorsally with one anterolateral pair of setae and 1 medial pair of placoid sensilla; TIII with three pairs of setae; TIV with 1 setae lateral to tp; TVI with one small pair of dorsolateral setae and one pair of stout seta medial to tp; TVII with minute seta on ventral margin; TIX entire and with two long lateral processes ventrally, lateral process reaching beyond TXI; caudal cerci not quite as long as TXI+XII and stiff.

Type material.—Holotype female: Argentina, SALTA: Termas de Rosario de la Frontera, 24/I/04, Coll. J. Torréns and P. Fidalgo. Deposited in MACN. Paratypes: SALTA: Termas de Rosario de la Frontera, Hotel Termal, 25°50′14″S 64°55′55″W, 899 m, 21/III/2003, P. Fidalgo, H03-10b, sclerophyll forest, UCR DNA voucher #1073 (1 ♀, 8 ♂, UCRC specimen numbers 91466, 91828–91834, 92210); same data, collector J. Heraty, UCR DNA voucher #1092 (2 ♀, UCRC specimen 91820–91821); Termas de Rosario de la Frontera, 15/IV/2003, J. Torréns and P. Fidalgo (1 ♀, 3 ♂, FSCA); 10/XI/03, J. Torréns and P. Fidalgo (1 ♀, IFML); 07/I/2004, J. Torréns and P. Fidalgo (1 ♂, IFML); 24/I/04, J. Torréns and P. Fidalgo (7 ♀, 4 ♂, MACN); 10/II/04, J. Torréns and P. Fidalgo (3 ♀, 1 ♂ UCRC); 07/III/2004, J. Torréns and P. Fidalgo (1 ♂, IFML); TUCUMÁN: Tapia, 14/I/1993, Cuezzo and Fidalgo (M.T.) (1 ♂, IFML).

Distribution.—Argentina: Salta, Tucumán.

BIOLOGY

Location and habitat.—Specimens were collected in Los Baños, Rosario de la Frontera (Salta: Argentina), within 500 m of the Hotel Termas. The host plant, *Serjania glabrata* Kunth (Sapindaceae), grows in the understory of a forest of "cebil colorado," *Piptadenia macrocarpa* Benth. (Leguminosae). The host plant are small shrubs approximately 60 cm high, dispersed between the trees in the collected place. Adults of *L. rugosa, S. glabrata*, and the potential host ants were collected in 2003 and 2004. All of the adults of *L. rugosa* were collected in the same location, mainly close to or on the host plant. Most adults were collected January 24, 2004. The ant host is unknown, however nests of *Odontomachus chelifer* (Latreille) (Formicidae: Ponerinae) were common near the host plant, *S. glabrata. Odontomachus* Latreille is a common host for the *Kapala* clade (Heraty 2002).

Life history.—In experimental trials, females were offered leaves of *S. glabrata*, and oviposition observed with a magnifying glass. Leaves with eggs were subsequently put in a glass container with dampened cotton. Females collected in January and February of 2004 that were provided the host plant, deposited their eggs on the underside of the leaves (Fig. 17). A single gravid female oviposited about 25 eggs per 1 mm^2 on one leaf. Eggs hatched within 6 days; however, many of the remaining eggs contained mature, darkened planidia that did not hatch.

KEY TO SPECIES OF *LAURELLA* HERATY

1\. Semi-erect setae on head and mesosoma (Figs. 2, 4, 6, 8) . . . . . . *guriana* Heraty

– Appressed setae on head and mesosoma (Figs. 1, 3, 5) 2

2 (1). Side lobe of mesoscutum smooth dorsally. Scape reaching ventral margin of median ocellus. Antenna yellow. Petiole in female as long as hind coxa. Male unknown . . . . *vianai* (Gemigniani)

– Side lobe of mesoscutum carinate or rugose. Scape not reaching ventral margin of median ocellus. Antenna dark brown or bicolored. Petiole in female longer than hind coxa 3

3 (2). Scutellum longitudinally carinate, carinae reaching to apex of scutellar spine; carina twisted along scutellar spine. Coxae black, rest of legs yellow. Antenna dark brown (Fig. 10); male with branch of basal flagellomere 1.5–2.6× as long as scape; female funicle not serrate. Petiole in female 2.0× as long as hind coxa . . *bonariensis* (Gemigniani)

– Scutellum with irregular longitudinal carinae, spines becoming rugose apically (Fig. 3). Coxae and basal two-thirds of femora dark, distally yellow (Fig. 5). Antenna with scape, pedicel and basal half of basal flagellomere light brown, rest of flagellum dark brown (Figs. 5, 15); male with branch of basal flagellomere 3.5–4.4× as long as scape; female funicle serrate (Fig. 13). Petiole in female 1.3–1.5× as long as hind coxa . . . . *rugosa*, n. sp.

ACKNOWLEDGMENTS

This investigation was funded by Project PIP 702/8 of CONICET. We thank Dr. Fabiana Cuezzo for identifications of the ants, Lic. Alberto Slanis for identifications of the plants, and Dr. Arturo Roig who very kindly loaned the specimens in the Museo de Ciencias Naturales "Bernardino Rivadavia."

LITERATURE CITED

Bolton, B. 2003. Synopsis and classification of Formicidae. Memoirs of the American Entomological Institute 71: 1–370.

Clausen, C. P. 1940a. The oviposition habits of the Eucharidae (Hymenoptera). Journal of the Washington Academy of Sciences 12: 504–516.

———. 1940b. The immature stages of the Eucharidae. Proceeding of the Entomological Society of Washington 42: 161–170.

Darling, D. C. 1988. Comparative morphology of the labrum in Hymenoptera: the digitate labrum of Perilampidae and Eucharitidae (Chalcidoidea). Canadian Journal of Zoology 66: 2811–2835.

Eady, R. D. 1968. Some illustrations of microsculpture in the Hymenoptera. Proceedings of the Royal Entomological Society of London (A) 43: 66–72.

Gemignani, E. V. 1947. Nuevas especies de la Familia "Eucharidae" (Insecta, Hymenop. Chalcid.). Comunicaciones del Museo Argentino de Ciencias Naturales, Serie Ciencias Zoológicas 1: 1–15.

Heraty, J. M. 2002. A Revision of the genera of Eucharitidae (Hymenoptera: Chalcidoidea) of the World. Memoirs of the American Entomological Institute 68: 1–359.

Heraty, J. M. and D. C. Darling. 1984. Comparative morphology of the planidial larvae of Eucharitidae and Perilampidae (Hymenoptera: Chalcidoidea). Systematic Entomology 9: 309–328.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 52–65

FIRST OBSERVATION OF PARASITIC RELATIONS BETWEEN BIG-HEADED FLIES, *NEPHROCERUS* ZETTERSTEDT (DIPTERA: PIPUNCULIDAE) AND CRANE FLIES, *TIPULA* LINNAEUS (DIPTERA: TIPULIDAE: TIPULINAE), WITH LARVAL AND PUPARIAL DESCRIPTIONS FOR THE GENUS *NEPHROCERUS*

David P. Koenig and Chen W. Young

Section of Invertebrate Zoology, Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, Pennsylvania 15213, U.S.A. (e-mail: koenigd@carnegiemnh.org; youngc@carnegiemnh.org)

Abstract.—*Nephrocerus atrapilus* Skevington 2005 (Diptera: Pipunculidae) and *Nephrocerus daeckei* Johnson 1903 were reared as endoparasitoids of three species of adult crane flies in the genus *Tipula* Linnaeus (Diptera: Tipulidae). Two additional *Tipula* species were observed to host pipunculid larvae presumed to be species of *Nephrocerus*. Pipunculid larvae are known to parasitize auchenorrhynchous Hemiptera, particularly Cicadellidae, Delphacidae and Cercopidae but this is the first report of hosts for *Nephrocerus*, and the first recorded instance of adult Tipulidae being parasitized by another true fly. The rate of pipunculid parasitism of female crane flies in this study from all collecting sites was 42% (82/193), but the rate for males was 0.008% (1/119). Endoparasitoid pipunculid larvae undergo a rapid active feeding stage for less than 20 days, and then enter an intensive diapause for ten months before pupariation. External anatomical features of larvae and puparia of *Nephrocerus* are described and illustrated. Techniques for collecting and rearing *Nephrocerus* are described.

Key Words: Diptera, Pipunculidae, Tipulidae, *Nephrocerus*, larva, puparium, *Tipula*, parasitoids, host records

---

Big-headed flies, family Pipunculidae, are worldwide in distribution, with 155 species and five subspecies recorded from the Nearctic Region (De Meyer 1996, De Meyer and Skevington 2000). The genus *Nephrocerus* is recently revised and has 18 extant species occurring mainly in the Holarctic Region (six of these in the Nearctic Region) (Skevington 2005). Pipunculid larvae are known to be parasitoids of auchenorrhynchous hemipterans. Skevington and Marshall (1997) presented a definitive summary of known Nearctic pipunculid host associations and indicated pipunculids as being exclusive endoparasitoids of various families of leafhoppers and planthoppers. The list of host families known to be parasitized includes Cercopidae, Cicadellidae, Cixiidae, Delphacidae, Flatidae, Fulgoridae, and Membracidae (Skevington and Marshall 1998). These authors also predicted the likelihood that *Nephrocerus* species would have life histories different from those of other big-headed flies, based on their larger size and different appearance from other pipunculids.

Species of Tipulidae s.l., or crane flies, make up the largest family of the order Diptera or true flies. In North America, more than 1,500 species of crane flies have been described, and 581 species belong to the subfamily Tipulinae (Tipulidae s.s. Oosterbroek 2005). Most species of Tipulinae are of larger body size than the remaining species of Tipulidae. The genus *Tipula* contains about 495 Nearctic species (Oosterbroek 2005) in 27 subgenera (Alexander 1965). The known parasitoids of crane flies include tachinid flies that attack the larval stages (Rennie and Sutherland 1920; Arnaud 1978). Arnaud (1978) lists two genera and five species of tipulid hosts being utilized by six species of tachinids in five genera. Gelhaus (1987) noted *Allophorocera arator* (Aldrich) (Diptera: Tachinidae) as a parasitoid of the larva of *Tipula* (*Triplicitipula*) sp., probably *flavoumbrosa* Alexander (Diptera: Tipulidae). At least two species of *Nephrocerus* are here documented to be parasitoids of adult crane flies in the genus *Tipula.*

Field collecting of crane flies for a faunistic survey of Pennsylvania's Tipulidae (Young and Gelhaus 2000) unexpectedly revealed an unknown parasitic relationship between two true flies. During field collecting, adult crane flies were routinely captured with an aerial net and dispatched in a translucent killing bottle containing potassium cyanide. In 1997 the senior author (DPK) observed a small maggot erupting from the abdomen of an adult crane fly, a male of *Tipula (Lunatipula) submaculata* Loew. As this host fly became anesthetized inside the killing bottle and then completely motionless, a yellow larva penetrated the left pleural membrane of the second abdominal segment, extricated itself completely from the host in a few seconds, and began to crawl about in the bottle. The larva was preserved directly in 80% aqueous ethanol. The identity of this larva could not be determined, but was presumed to belong to the parasitic fly family Tachinidae.

Further fieldwork (2000–2004) at other study sites resulted in observation of additional, similar instances of parasitization. Several more larvae were observed erupting from adult crane flies, thus prompting the authors to keep the larvae alive in order to rear adult parasitoids that would permit species-level determination. Thirty-one larval parasitoids were successfully reared and emerged as adult pipunculid flies. These were determined to be species of *Nephrocerus* Zetterstedt using the keys of Hardy (1943, 1987). This was an exciting and unexpected discovery as they were originally expected to be tachinid flies. Jeffrey H. Skevington later identified 24 flies as *Nephrocerus atrapilus* Skevington, and two as *Nephrocerus daeckei* Johnson. The successful rearing of larvae to adults allows the present study to contribute the first record of host-parasitoid relationships of big-headed flies and crane flies, as well as descriptions and illustrations of larvae and puparia for the genus *Nephrocerus*.

MATERIALS AND METHODS

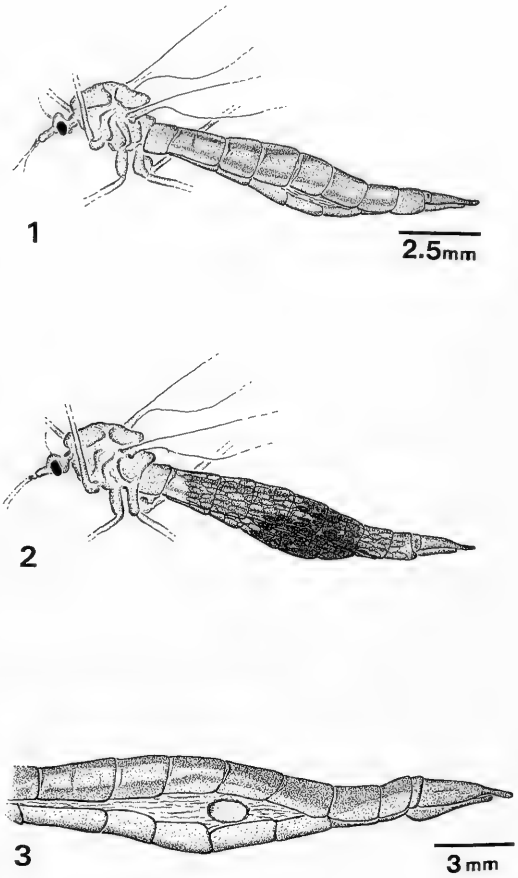
Field observations and collections.—The primary collecting site for this study is located at Boyce Regional Park (40°-27′-42″N, 79°-45′-26″W; elevation 375 m), a suburban park east of Pittsburgh, Allegheny County, Pennsylvania. The habitat is a moderately mesic, second growth, mixed-deciduous forest. Boyce Park is in the Pittsburgh Low Plateau Ecological Region with the rolling hills typical of the topography of that region. There are utility rights-of-way and foot trails creating a mosaic of forest plots, forest edges, and open canopy spaces with uncut grass and wildflowers. The hardwood forest is diverse, dominated by *Prunus serotina* Ehrh. (black cherry; Rosaceae), species of *Acer* (maples; Aceraceae) and *Sassafras albidum*

(Nutt.) Nees (sassafras; Lauraceae). Common shrubs are *Lindera benzoin* (L.) Blume (spicebush; Lauraceae), *Rosa multiflora* Thunberg ex Murr. (multiflora rose; Rosaceae) and species of *Rubus* (blackberry; Rosaceae). Forest undergrowth includes vines, herbaceous plants, and grasses. Forest leaf litter and leaf molds are present over most of the level area and gentler slopes. The larvae of many terrestrial *Tipula* species feed on the detritus and mold just beneath the leaf litter. Both woodland and grassland species of crane flies are common in this habitat.

A total of twenty-six diurnal collecting forays was conducted over the course of five collecting seasons from June through August between 2000 and 2004. Aerial net sweeping was the basic method of collecting. Adult crane flies were taken either at resting sites among the vegetation, or in the air as they flew. Crane flies of both sexes were collected and kept individually to ensure positive host-parasitoid association with any emerging parasitic larvae. Holding jars for captured flies were plastic (5 cm diameter × 6.5 cm tall) with screw-top lids.

Some crane flies were recognized as being parasitized by a distinct swelling restricted to the middle abdominal segments (Fig. 1). Specimens with this condition would often, but not always, host a parasitic larva. Superficially, these infected female flies appeared gravid (Fig. 2), except no black eggs were visible; black, mature eggs are visible through many abdominal segments of truly gravid females. On occasion, a parasitic larva would unexpectedly emerge during specimen retrieval from the aerial net or when the host fly was placed in a killing jar. Most larvae emerged later while host flies were in their separate holding jars.

Early collections at the primary site produced only female hosts. This observation resulted in the later forays with a collection bias toward female specimens in an effort to obtain more pipunculid larvae. Adult crane flies of larger species can be sexed visually in the field from a distance of about two meters as they rest on top of vegetation. The outline of the caudal abdominal segments is expanded and round in males. In contrast, the female has a tapering abdomen that terminates with an acute ovipositor. In addition, crane flies can be sexed by their flight pattern in the air. Males have an erratic flight with undulations and spiral rotations along the axis of travel. Females maintain a more direct, steady, and straight flight path.



Figs. 1–3. Adult female of *Tipula (Lunatipula) duplex*. 1, Parasitized female, left lateral view. 2, Non-parasitized gravid female, left lateral view. 3, Exit hole of *Nephrocerus* larva on parasitized female, left lateral view.

Rearing methods and observations.—Adult crane flies were collected and held in separate plastic jars at approximately room temperature (19–26°C). A few drops of tap water were placed in each holding jar and often consumed by the crane flies. The flies were kept alive to allow the pipunculid larvae, if present, to reach maturity before they left the host. The flies were checked daily to search for recently emerged pipunculid larvae. As emerged larvae were first spotted, the condition of the host was recorded as being either alive or dead. Dead host specimens were submerged in Peterson's fixative (1:1:2:9 kerosene, dioxane, acetic acid, 95%ethanol) for twenty-four hours, and then transferred to 70% ethanol to await dissection.

Prepupae were transferred into separate round plastic culture dishes (8 cm diameter × 3 cm tall) with airtight, snap lids. These culture dishes were filled with soil from the collecting sites mixed with commercial potting soil to a depth of approximately 1.5 cm. The medium was kept moist at all times. Newly introduced larvae immediately dug down into the medium. Cultures were inspected multiple times over the next ten months with the aid of a dissecting microscope. Inspections helped to monitor larval health, movement, and pupariation. Recently expired individuals were salvaged for morphological study.

Observation showed that prepupae may crawl through the medium for a period of time during the summer and fall months, remain quiescent for a long period, and may resume movement again prior to pupariation the following spring. Prepupae were never seen exposed on top of the soil medium. Prepupae usually became darker in color, changing from pale yellow or white to honey-brown, in the days following their initial introduction into the soil. They would remain this color until pupariation. As prepupae became less active they also appeared more contracted and wrinkled.

The prepupae were held at temperatures that roughly coincided with the outside seasonal temperatures. The range throughout the months of June to August was 19–26°C, for September through November, 13–21°C. All specimens were placed in a refrigerator at approximately 2°C for about 98 days, from December through February. The cultures were removed from the refrigerator and stored at 12–14°C in March and part of April, and at 15–25°C through April and May when outside temperatures steadily rose. Light levels and photoperiod were not monitored or controlled in any manner.

Puparia always develop in the spring. The overwintering prepupae would "awaken" after a long period of inactivity and start moving through the soil. After a short period of movement, the prepupae settled into another quiescent period prior to pupariation. Adult pipunculid flies would eclose, sometimes dragging the pupal exuviae to the surface of the soil. No attempt was made to maintain or breed the adult pipunculids in captivity and their potential adult longevity was not studied. The intact adult specimens were frozen and later pinned or pointed. Specimens that did not eclose successfully or failed to harden their teneral cuticle properly were preserved in 70% ethanol.

Dissection of *Tipula* host.—Approximate body length was recorded from the tip of the nasus to the tip of the abdomen. All measurements are approximate due to curvature of the abdomen and the head being deflected downward. Under the dissecting microscope, the abdomen was cut and separated at the base of the first segment. The inner surface of the metathorax was inspected for any possible damage by the parasitoid. The abdomen was cut along its full length through the middle of the ster-

Table 1. Parasitization of adult female *Tipula* by *Nephrocerus* larvae, 2000–2004, at Boyce Regional Park, Allegheny County, Pennsylvania.

Tipula spp. (Females Only)	No. of *Tipula* Observed	No. of *Tipula* Infested	% of Hosts Infested	No. of Parasitoid Larvae Emerged	No. of Parasitoid Larvae Found *in situ* by Dissection	No. of *Nephrocerus atrapilus* Reared	No. of *Nephrocerus daeckei* Reared
T. (*L.*) *duplex*	156	69	44	49	21	15 ♂ 13 ♀	0
T. (*L.*) *mallochi*	24	9	38	6	3	0	1 ♂ 1 ♀
T. (*L.*) *submaculata*	9	2	22	1	1	0	1 ♂
T. (*B.*) *borealis*	2	0	0	0	0	0	0
TOTALS	191	80 *	42	56 *	25 *	28	3

* The discrepancy between the sum of total *Nephroceus* parasitoids (81) and the total *Tipula* infested (80) is due to the fact that one dissected female contained two parasitoid larvae.

nites. The pleural membranes were kept intact as many larvae were observed to exit through that lateral part of the abdomen. Exit holes of some larvae were located (Fig. 3), their positions recorded, and the contents of the abdomen were noted. Specimens thought to be unparasitized were dissected and their contents noted for comparison. Some of these without distinctive abdominal swelling contained pipunculid larvae. The location and orientation of pipunculid larvae within the host's abdomen was recorded. Dissected specimens were returned to 70% ethanol for permanent storage.

RESULTS

Results from collection and rearing.—Over five collecting seasons, 2000–2004, a total of 309 specimens of *Tipula* (118 males and 191 females) was captured at Boyce Park and observed in captivity for parasitoid infestation. Eighty specimens (26% of total crane flies examined) were found to be infested with an endoparasitic larva and all of these were female (therefore 42% of captured female hosts were infested). In 2003, the most productive season, 159 specimens of *Tipula* (33 males and 126 females) were captured for study; of these, sixty females were infested (38% of total crane flies observed, and 48% of the females).

Eight species of *Tipula* were collected at the primary study site. The two most common species, *Tipula (Lunatipula) duplex* Walker and *Tipula (Lunatipula) mallochi* Alexander are recorded here as hosts for larvae of *N. atrapilus* Skevington. A third species, *T. (L.) submaculata* Loew, as well as *T. mallochi*, are here documented as hosts of larvae of *Nephrocerus daeckei* Johnson (see Table 1). All infested hosts at this site were females with body lengths of 20 to 28 mm. The remaining species observed in captivity were: *Tipula* (*Beringotipula*) *borealis* Walker, *T.* (*L.*) *johnsoniana* Alexander, *T.* (*L.*) *flavibasis* Alexander, *T.* (*Triplicitipula*) *colei* Alexander, and *T.* (*Yamatotipula*) *tricolor* Fabricius. No male crane flies were found to harbor parasitic larvae in this site. Except in one instance, infested female crane flies contained only one parasitic pipunculid larva each.

Female *Tipula* flies lived from 1–8 days in captivity. Males lived from 1–11 days. The age of these flies at the time of collection is unknown. A teneral female, collected as it eclosed from the pupal exuvium on the forest floor, lived for eight days in captivity. The time elapsed from host fly capture to parasitoid larval emergence was 1–5 days. The condition of the host crane fly was recorded at the time of larval emergence. Many host flies were still alive after parasitoid emergence, most for approximately one additional day. Others lived less time and were found lying on their sides motionless or only twitching. A number of hosts were found dead with an associated, emerged parasitoid larva.

Fifty-six cultures of parasitoid larvae were maintained after emergence from their hosts, overwintered under refrigeration, and some were reared to pupariation and adults in the spring. A total of 31 adult *Nephrocerus* specimens was reared, comprising 17 males and 14 females. Jeff Skevington identified 22 dried specimens and 2 in ethanol as *N. atrapilus* and two dried specimens as *N. daeckei*. Five *Nephrocerus* adults in ethanol are in poor condition and not identified. Larvae in the remaining 25 cultures were not successfully reared. Some larvae and puparia were preserved for morphological study and therefore adult flies were not reared or determined. Thirty-one puparial exuviae were preserved in ethanol. Voucher material is deposited at Carnegie Museum of Natural History (CMNH) and the Canadian National Collection of Insects, Arachnids and Nematodes (CNC).

After overwintering, parasitoid larvae were removed form refrigeration and after 43 to 75 days became active, crawling about through the soil medium. This activity lasted about 3 to 8 days, after which the prepupae again became quiescent and soon pupariated. Puparia would initially lack respiratory horns and require several days before the developing pupa would shift inside its puparium and project its respiratory horns, a process similar to that described by Roddy (1955) for the muscid fly *Ophyra aenescens* (Weidemann). Adult pipunculid eclosion occurred 66–101 days (n = 26) from the day of removal from refrigeration, and about ten months after larval emergence from the host (298–321 days, n = 26). There was little difference in developmental time between genders. Adult males eclosed at 66–100 days (n = 13) from refrigeration and females 66–101 days (n = 13).

Crane fly parasitoids were also documented from three other Pennsylvania localities. A single parasitized crane fly was collected at each of these localities. A female *T.* (*Yamatotipula*) *tricolor* Fabricius was collected by light trap at Powdermill Nature Reserve (40°-09′-30″N, 79°-16′-25″W) on 6 August 2002, in Westmoreland County. A female *T.* (*Y.*) *furca* Walker was hand collected at Green's Island, Lake Clarke, along the Susquehanna River (39°-58′-37″N, 76°-28′-05″W) on 7 August 2003, in Lancaster County. A male *T.* (*L.*) *submaculata* Loew was hand collected at Pennsylvania State Game Lands No. 90 (41°-06′-10″N, 78°-28′-15″W) on 26 July 1997, in Clearfield County. A larva emerged from this male host in the field as discussed in the introduction. This record represents the only male crane fly infested with a pipunculid larva. No rearing larva–adult associations were established for these three samples due to the fact that emergent larvae were either preserved or were retrieved from preserved crane fly specimens. They are similar to the larvae from the Boyce Park study site and appear to be *Nephrocerus*.

Results from dissection.—Dissections were performed on 156 ethanol-preserved, adult *Tipula* from Boyce Park. This resulted in our obtaining 25 additional pipunculid larvae from 136 female crane flies but none from 20 male flies. Two distinctive larval forms were observed from these dissections. We believe these belong to two larval instars of one species of parasitoid fly based on observations of several larvae that were preserved shortly before they were ready to molt. These molting larvae still had the penultimate instar's cuticle attached. The posterior spiracles of the ultimate instar are clearly visible under the partially cast cuticle and its associated posterior spiracles. The posterior spiracles of the two instars are easily distinguishable morphologically and were used in this study to differentiate the larval instars. Due to the uncertainty as to the actual number of instars in the pipunculid larvae, in this paper we do not number the insters, rather use "penultimate" instar for the earlier stage, and "ultimate" for the last instar prior to pupariation.

The dissections yielded 11 ultimate instars and 9 penultimate. Most of the penultimate instars (8) were found with their mandibles facing posteriorly inside the host's abdomen, one was found facing anteriorly. Of the ultimate larvae, 7 were found facing posteriorly, 3 were facing anteriorly and one was unducumented. The penultimate instars were found in crane fly abdominal segments 3 to 7. The ultimate instars were found in abdominal segments 2 to 8. Large, ultimate instars would often occupy two or three consecutive abdominal segments.

In four dissections where parasites were discovered in situ, the crane fly host had at least one of its own mature black eggs (i.e., fully chorionated egg) inside the abdomen. The following details are from these dissections: one host with one mature egg and a penultimate instar parasite; one host with four mature eggs and an ultimate instar parasite; one host with five mature eggs and a penultimate instar; one host with two mature eggs and a penultimate instar parasite. Many dissected non-infested specimens had developing, immature eggs.

There were 56 host crane flies that ultimately had pipunculid prepupae emerge through their body walls. The hosts showed emergence holes through the pleural membrane on either side of the abdomen. Abdominal segments 3–6 typically exhibited an emergence hole, and that hole might also occur between any two consecutive segments. Emergence holes were restricted to the pleural regions and were not found through or between abdominal tergites or sternites. Two hosts with emergence holes contained mature black eggs. One host had only one egg, the other over 50. The majority of the infested hosts had neither black eggs nor any developing immature eggs in the abdominal cavity.

Internal abdominal tissue damage caused by feeding activity of endoparasitic pipunculid larvae was not clearly observed. All infested hosts had reduced fecundity or complete lack of egg production. No infested host was observed to lay eggs, but many unparasitized females deposited mature eggs. Many hosts that contained large, ultimate instar pipunculid larvae had very little fat body or mature eggs in the basal segments; these were, however, present in the more posterior segments 6 to 8 of the same flies. The digestive tract and spermatheca were found to be intact in all hosts. Large, last instar parasitoid larvae may compact internal host tissue into the posterior abdominal segments of the host. One pipunculid larva emerged from a host that contained more than 50 mature eggs. This host was the only one ever observed to have damage to the posterior side of its metathorax. In fact, a single black egg was lodged in the middle of its thoracic cavity.

On one occasion the process of parasitoid emergence from a dead host was observed with the aid of a microscope. The larva placed itself transversely inside the abdomen and pushed its mandibles through the pleural membrane while extending its body against the opposite abdominal wall. The mandibles were not seen to bite or cut through the pleural membrane, but they functioned as a sharp tip to forcefully puncture the membrane. The parasitoid larva emerged from the right pleural region of the host between segments 4 and 5.

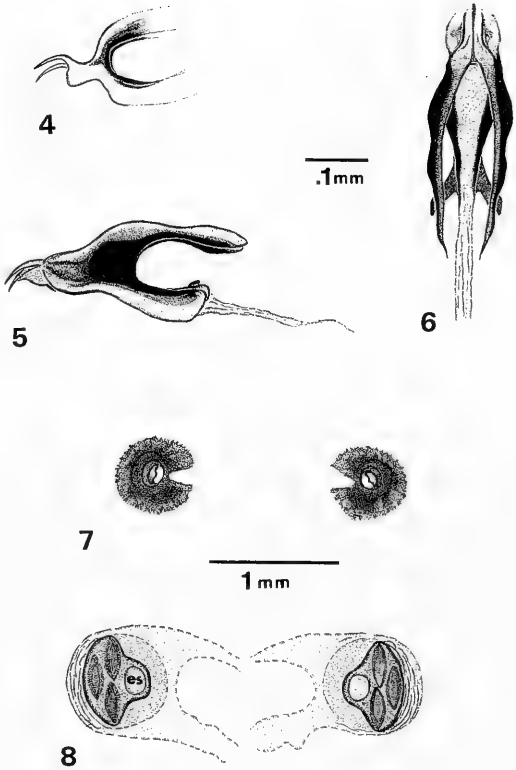
Only a single instance of multiple conspecific parasitoids in a single host was observed. An ultimate instar pipunculid larva emerged from one individual of *T. (L.) duplex*. The body of the host crane fly was then dissected and found to contain a penultimate instar *Nephrocerus* larva in segment 6. There was no evidence of multiparasitism (more than one species of parasitoids in the same host) in any host *Tipula* observed in this study.

Summary of results.—This study obtained a total of 81 parasitoid larvae from 309 randomly collected adult crane flies, representing a 26% rate of parasitism. Among these parasitoids, 56 left the hosts voluntarily within 5 days after the capture, and the other 25 were obtained by dissection of the hosts. A high percentage of the parasitoids remaining inside the host were penultimate instar or immature ultimate instars judging from the external morphology of the posterior spiracles. The rate of pipuculid parasitism of female crane flies in this study was 42% (82/193) and the rate was less than 1% (1/119) for host males. Thirty-one of the parasitoids were successfully reared to the adult stage and consisted of two species of Pipunculidae belonging to the genus *Nephrocerus*.

The endoparasitoid pipunculid larvae undergo a rapid active feeding stage inside the adult crane fly hosts for less than 20 days to reach maturity. Mature parasitoids emerged from the hosts in summer; they then go through about ten months (298–321 days) of a non-feeding diapause period before pupariation takes place the following spring.

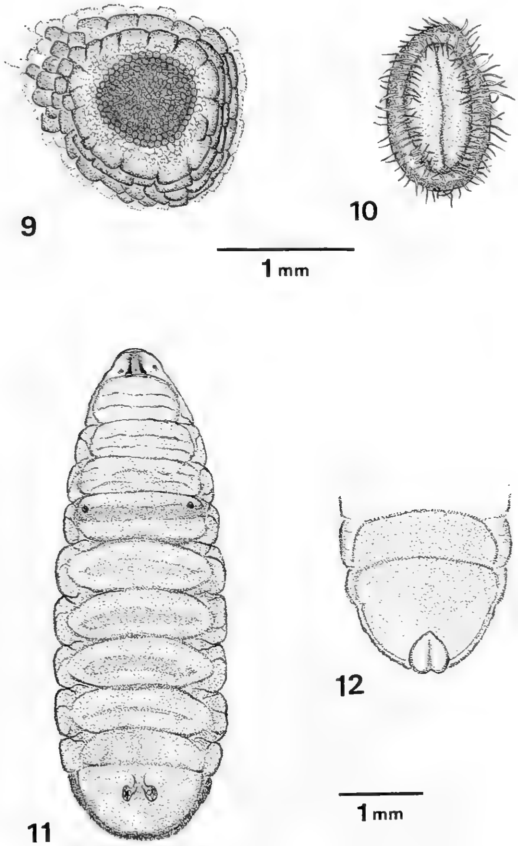
DESCRIPTIONS OF IMMATURE STAGES OF *Nephrocerus* (Figs. 4–14)

Larva.—Penultimate larval instar. Body length 1.6–3.3 mm; width 0.5–1.1 mm. Body elongate with indistinct segmentation; posterior end without obvious spiracular disc. Cephalopharyngeal skeleton lightly sclerotized with distinct, paired mouth hooks (Fig. 4). Spiracular plates heavily sclerotized, raised mounds with single, round spiracular aperture (Fig. 7).



Figs. 4–8. 4–6, Cephalopharyngeal skeleton of *Nephrocerus* larvae. 4, Penultimate instar larva, left lateral view. 5, Ultimate instar larva, left lateral view. 6, Ultimate instar larva, dorsal view. 7–8, Posterior spiracles of *Nephrocerus* larvae. 7, Penultimate instar larva, posterodorsal view. 8, Ultimate instar larva, posterodorsal view.

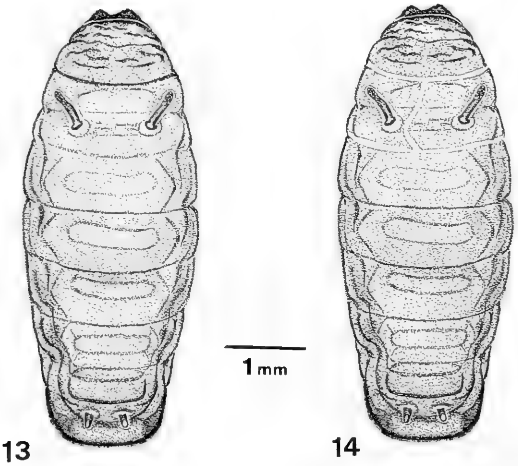
Ultimate larval instar. Body length 4.6–7.8 mm; width 1.9–2.6 mm. White to pale yellow white in color, diapausing larvae honey brown (degree of yellow coloration probably due to amount of fat stored in body). Body oval, stout when contracted, elongated when relaxed (Fig. 11). Acephalic, wrinkled, anterior end tapering to acute tip with mandibles extruded, or truncated with mandibles retracted; posterior half of body broadly



Figs. 9–12. Ultimate larva of *Nephrocerus*. 9, Circular spot on the first abdominal segment, dorsal view. 10, Anal plate on the last abdominal segment, ventral view. 11, Ultimate larva, dorsal view. 12, Inflated anal papillae, ventral view.

rounded. Cuticle of body at 30× magnification with microsculpture of rounded or polygonal "scales", each scale convex in lateral view and varying in diameter depending on location; cuticle covered with microtrichia, especially along ridges of annulations; microtrichia brown, stout and directed backward, or pale and straight.

Head: Antenna tiny, bulbous; maxillary palp positioned close to each other along dorsolateral edge of mouth opening, not visible when head is retracted within thorax; cephalopharyngeal skeleton well sclerotized, with paired, sharp, downwardly directed mouth hooks (Figs. 5–6).



Figs. 13–14. Puparium of *Nephrocerus*. 13, Puparium, dorsal view. 14, Puparuim showing line of fracture, dorsal view.

Thorax: Anterior spiracle reduced in size and without projection, located on dorsolateral edge of prothorax.

Abdomen: Abdomen reduced to six visible segments with secondary annulations forming transverse, elliptical ridges in dorsal or ventral aspect. Pair of darker circular spots (Roddy 1955) approximately 0.14 mm in diameter, dorsolaterally on first visible abdominal segment (Fig. 11) (spots are portals for eversion of respiratory horns in mature puparium); spots with internal microsculpture uniform, grainy, very different from rest of body (Fig. 9). Posterior spiracles without common disc, each elevated on sclerotized plate; each plate with three spiracular openings and one ecdysial scar arranged as in Fig. 8, close to each other on mesal, anterodorsal plane of last visible abdominal segment. Anus ventral on last abdominal segment, with convex longitudinal cleft bordered by defining perianal pad with ring of dense microtrichia (Fig. 10). Anal plate (convex dome) forming anal papillae when inflated (Fig. 12); anal papillae heart shaped when fully inflated with median furrow representing anal slit (larval specimens show anal papillae of varying degrees of inflation; some larvae observed *in situ* with inflated papillae, all emerged specimens without).

Puparium.—Length 6.5 mm; width 2.6 mm. Body wedge-shaped, broadest just behind respiratory horns on anterior abdomen (Fig. 13); body tapering to truncated mouth opening anteriorly and to evenly rounded posterior end; body heavily sclerotized, reddish brown, with larval segmentation visible to a lesser degree, giving body a slightly bloated appearance. Cuticle of puparium retains scaly appearance, as in larva. Cephalopharyngeal skeleton and cephalic sensory organs retracted within puparium. Pair of respiratory horns on first abdominal segment, appearing within a week of pupariation; horns spikelike, simple, heavily sclerotized, slightly curved, with multiple air holes along distal half of shaft and one single hole near tip.

Note: The respiratory horns of the puparium are located exactly above the circular spots of the larva. The relationship between these two structures has been demonstrated by Roddy (1955). The puparium opens for adult emergence by the lifting of an anterodorsal operculum and the dorsal plate of first abdominal segment. The first abdominal tergum is broken into two pieces along a definite fracture line, each piece with one respiratory horn. The line of fracture is skewed toward the left respiratory horn in anterodorsal view (Fig. 14).

DISCUSSION

Parasitism of Diptera by other true flies is uncommon. In all known cases the parasites have been identified as species of Tachinidae, and the hosts are larvae of Tipulidae and Tabanidae (Ferrar 1977). Adult Diptera that serve as hosts for other parasitic Diptera are even more rare. Ferrar reported two cases in Australia of tachinid flies attacking adult flies of *Amenia* (Calliphoridae) and *Dasybasis* (Tabanidae). The current study provides some unique observations of host-parasitoid relationships between adult flies of Tipulidae and Pipunculidae.

Adult crane flies are short-lived. In our study area, adult emergence for one species may be spread over one month, and the average individual adult lives about two weeks. This forces parasitic larvae to undergo rapid development. Ferrar (1987) indicated that pipunculids are unusual among Cyclorrhapha in that there are apparently only two larval instars, a condition compatible with the short adult life span of their hosts. There seems to be ample evidence that at least in genus *Chalarus* there are indeed only two larval instars (Jervis 1980). We have noticed only two larval instars for pipunculids in this study but have made no observations on eggs or oviposition and cannot with certainty state that there are in fact just two instars. The penultimate instars show a great range in body size but with identical size and all morphological characteristics of posterior spiracles. The morphology of the ultimate instar is the same as that of the emerged prepupae. These two instars can be easily distinguished by the structure of the posterior spiracles and the cephalopharyngeal skeleton. The posterior spiracles of the penultimate instar have no visible ecdysial scar (Fig. 7) as is present on the ultimate instar (Fig. 8).

Parasitized crane flies do not exhibit altered behavior or deleterious effects with respect to their ability to fly. In the field they all seemed to be healthy and vigorous, indicating that the flight muscles and nervous systems are not disrupted by the parasitoids. This is in contrast with observations of behavior change in parasitism by Pipunculidae in at least some Rice Leafhoppers Yano et al. (1985), and movements impaired of leafhopper hosts due to the damage to the thoracic muscles and nervous system (May 1979). It is likely that the parasitoids did not consume any of the vital organs of the hosts. However, developing eggs were absent or noticeably reduced in number in all of the parasitized females, an indication that the reproductive system of the host was consumed by the pipunculid larva. One female host did have about fifty mature eggs left in the posterior end of the abdomen, and in these the chorion was already black. All hosts examined still had intact spermathecae. It therefore seems possible that parasitized hosts might oviposit viable eggs after emergence of the parasitoid. The high percentage 98% (82/83) of hosts being female crane flies may also indicate that feeding on crane fly eggs is required for complete development of the parasitic larvae. The absence or reduction in number of developing eggs within the host's abdominal cavity may also indicate early oviposition by the parasitoid. This high percentage of female crane fly hosts also leads to the speculation that female *Nephrocerus* have the ability to discriminate the sex of adult crane flies, and may strongly favor ovipositing in females.

When the first adult *Nephrocerus* was reared, efforts were made to search for them at the primary study site. Pipunculid species in other genera are considered to have restricted flight times (Hardy 1943). We made 26 collections at various hours of the day between 8:00 am and 9:00 pm, but no adult pipunculids were observed or collected at this site. We did not utilize any specialized techniques for the collection of Pipunculidae, such as Malaise traps, aerial suction traps, attractant sprays on foliage, etc. (Skevington and Marshall 1998). However, a black light collection in May of 2005 in Westmoreland County did yield two female specimens of *N. daeckei*. This may indicate some nocturnal activities of the adult female flies.

Our study demonstrated that adult crane flies in the genus *Tipula* serve as hosts for the parasitoid *Nephrocerus*. The known host species belong to the subgenera *Lunatipula* and *Yamatotipula* within the genus *Tipula*. The majority of species of *Lunatipula* in our study area are univoltine, and they are common spring and summer elements in habitats of mixed deciduous woodlands of oak, hickory, maple, and black cherry. Their larvae are found in the upper soil layers under leaf litter in terrestrial situations. Adult flies of *Yamatotipula* in the study area are bivoltine, first emerging in late April, disappearing in summer, and recurring in August. They are usually found in the vicinity of watercourses in woodland habitats, and their larvae live in a wide variety of aquatic and semiaquatic habitats. Our rearing results and the black light traps indicated that the primary flight period for *Nephrocerus* is from mid-May to early July, and is most common in mid-June. This record suggests that *Nephrocerus* in our study area is univoltin, which falls within the parameters in the recent study of this genus in North America (Skevington 2005). This observation also concurs with the study of the phenology of three species of *Nephrocerus* occurring in Belgium are univoltine (De Meyer, M., and L. De Bruyn 1989).

The records of *N. atrapilus* reared from *T. (L.) duplex* and *N. daeckei* reared from *T. (L.) mallochi* and *T. (L.) submaculata*, indicate a narrow host-parasitoid relationship and no overlap of hosts between parasitoid species in our study. More research is needed to determine host-parasitoid relationship (i.e. *Nephrocerus* are oligophagous). Other workers have also observed similar occurrences of parasitic larvae emerging from field captured adult crane flies, in Great Britain by Alan Stubbs (J. Skevington, personal communication), in Lithuania by Sigitas Podenas (J. Gelhaus, personal communication), and in Mongolia by J. Gelhaus and S. Podenas

(S. Podenas, personal communication). The documented hosts in North America are five *Tipula* species within the subgenera *Lunatipula* and *Yamatotipula*. In the Old World additional host records have been observed in two subgenera of Tipula *Beringotipula* Savchenko and *Pterelachisus* Rondani, as well as in another genus, *Nephrotoma* Meigen (S. Podenas, personal communication). However, there are no data available for either the sex of these crane flies or the identity of the parasitic larvae. The actual range of host species is still largely unknown. The geographic distribution of the known New World species of *Nephrocerus* is presented by (Skevington 2005: 34) and suggests future survey into additional potential host species. Further investigation may prove that *Nephrocerus* has a much broader range of crane fly hosts.

Host-searching behavior of *Nephrocerus* was not observed in the field. Hardy (1943) described pipunculid females of other genera actively seeking out prey such as leafhoppers. Once the prey is located, the pipunculid will physically grasp the prey and quickly inject an egg into the victim's abdomen or thorax. It is unlikely that *Nephrocerus* females grasp adult crane flies in a similar manner due to the comparatively larger body size of the hosts. Kozanek and Belcari (1997) present some unique character states in morphology of the ovipositor in *Nephrocerus* including well-developed accessory glands and exceptional location of long haired sensilla at the apex of ovipositor. They indicated that the oviposition strategy in these species could be different from other Pipuncuidae.

Based on the facts that female crane flies are the target for the parasitoids, and there is an absence of mature eggs in the host flies, it is suggested that the ovipositing *Nephrocerus* flies might detect pheromonal cues to locate newly eclosed female crane flies. Most species of crane flies mate soon after emergence; the males fly low over the ground in search of females extracting themselves from the pupal exuviae (Pritchard 1983). An alternative host detection scenario may involve female *Nephrocerus* flies detecting male crane fly aggregations near the eclosing females. In both situations the host flies are recently eclosed, teneral and less mobile, therefore more vulnerable to parasitoid oviposition.

In summary, species of the genus *Nephrocerus* represent a pivotal lineage for interpreting the phylogeny of the Pipunculidae. Recent classification studies conducted by Rafael and DeYeyer (1992), and phylogeny analysis based on DNA sequence and morphology by Skevington and Yeates (2000) have both treated *Nephrocerus*, along with genus *Protonephroceurs* as a monophyletic subfamily Nephrocerinae. *Nephrocerus* occupies a transitional position whereby more basal lineages, subfamily Chalarinae, as well as higher lineages, subfamily Pipunculinae, are parasites of auchenorrhynchous Hemiptera (Skevington and Marshall 1998). The knowledge of the larvae and the life histories has always been sought to help unravel these relationships (Skevington 2005). The current study has demonstrated *Nephrocerus* to be endoparasitoids of adult crane flies of the genus *Tipula*. This would make the parasitism of Tipulidae an apomorphic character. The larval biology of *Protonephrocerus*, the sister group of *Nephrocerus* is still unknown.

The mode of infestation in this study is only hypothesized; the specific behavior is still unknown. Further observations on the life history of *Nephrocerus* are needed, especially of host location and oviposition behavior under natural conditions. Of particular value will be observations to determine the time of oviposition of parasitoids to ensure effective development of parasitoid larvae. An investigation into the possible strategies that the female host species may have evolved to cope with their high pipunculid parasitism rate would be of interest. Since the parasitoids may have a negative impact on the size of the host population, *Nephrocerus* could also be investigated as a potential biological control agent for the introduced European crane fly, *Tipula (Tipula) paludosa* Meigen, and marsh crane fly, *Tipula (Tipula) oleracea* Linnaeus, which have established themselves in the Pacific Northwest and more recently in the eastern United States (Gelhaus 2005, Hoebeke and Krass 2005). Both species are considered to be turf and pasture pests, unlike the forest inhabiting *Tipula* species investigated here.

The likelihood of this parasitism coming to light at this time is probably due to the intensive field collecting of crane flies of both sexes for conducting the faunistic survey. Generally female crane flies tend to be neglected in collecting due to the lack of key characters for specific identification. We believe that there were instances in the past when the pipunculid larvae were observed crawling out of crane fly adults by others and were mistaken for tachinid larvae. Attempts might have also been made to rear the larvae to adult stages but failed due to lack of existing references. Diligent maintenance in an artificial environment of the parasitoid larvae allowed for their survival through the prolonged diapause period that had contributed directly to the unexpected discovery of this unique parasitism. Once we had broken the life history of the parasitoid flies, our subsequent collecting tended to be biased toward visibly infested female crane flies in order to obtain more larvae. This may have led to the appearance of a high infestation rate in our study area.

ACKNOWLEDGMENTS

We thank George W. Byers and Anne Koenig for their valuable suggestions on an earlier draft of the manuscript. John E. Rawlins, Robert L. Davidson, Jim W. Fetzner, and Robert A. Androw for discussions and comments that greatly improved the manuscript. Thanks to John E. Rawlins for suggestions of rearing techniques and continuous encouragement, and to our colleague Bonnie Isaac from the Botany Section for her help in plant identification. Thanks also to Marc De Meyer, Jon K. Gelhaus, and Jeff H. Skevington for reviewing the manuscript, Jeff H. Skevington also for identifying *Nephrocerus* flies. This project was supported partially by a grant from Pennsylvania Wild Resource Conservation Fund SP#321994.

LITERATURE CITED

Alexander, C. P. 1965. The Crane Flies of California. Bulletin of the California Insect Survey 8: 1–269.

Arnaud, P. H., Jr. 1978. A Host-Parasite Catalog of North American Tachinidae (Diptera). U.S.D.A. Miscellaneous Publication No. 1319. 860 pp.

De Meyer, M. 1996. World Catalogue of Pipunculidae (Diptera). Studiedocumenten van het Koninklijk Belgisch Instituut voor Natuurwetenschappen 86: 1–127.

De Meyer, M. and L. De Bruyn. 1989. Seasonal occurrence and voltinism of Pipunculidae (Ddiptera) in Belgium. Bulletin de L'Institut Royal des Sciences Naturelles de Belgique, Entomologie 58: 71–81.

De Meyer, M. and J. H. Skevington. 2000. First addition to the World Catalogue of Pipunculidae. Bulletin de l'Institut Royal des Sciences Naturelle de Belgique, Entomologie 70: 5–11.

Ferrar, P. 1977. Parasitism of other adult Diptera by Tachinidae in Australia. Journal of the Australian Entomological Society 16: 397–401.

———. 1987. Family Pipunculidae, pp. 291–294. *In* A Guide to the Breeding Habits and Immature Stages of Diptera Cyclorrhapha (Part 1:text). Entomonograph vol. 8.

Gelhaus, J. K. 1987. A detritivore *Tipula* (Diptera: Tipulidae) as a secondary host of *Poecilogonalos costalis* (Hymenoptera: Trigonalidae). Entomological News 98(4): 161–162.

———. 2005. The crane fly *Tipula (Tipula) oleracea* (Diptera, Tipulidae) reported from Michigan; a new pest of turfgrass in eastern North America. The Great Lake Entomologist 38: 96–98.

Hardy, D. E. 1943. A revision of Nearctic Dorilaidae (Pipunculidae). University of Kansas Science Bulletin 29(1): 1–231.

———. 1987. Pipunculidae, pp. 745–748. *In* McAlpine, J. F. ed. Manual of Neartic Diptera, Vol. 2. Agriculture Canada Monograph No. 28. 657 pp.

Hoebeke, E. R. and C. Krass. 2005. *Tipula paludosa* Meigen and *T. oleracea* Meigen, European crane flies new to the eastern United States: Potentially serious turfgrass and pasture pest. Proceedings, 16th U.S. Department of Agriculture interagency research forum on gypsy moth and other invasive species 2005: 43.

Jevis, M. A. 1980. Studies on oviposition behaviour and larval development in species of *Chalarus* (Diptera, Pipunculidae), parasites of typhlocybine leafhoppers (Homoptera, Cicadellidae). Journal of Natural History 14: 759–768.

Kozanek, M. and A. Belcari. 1997. Structure of the ovipositor, associated sensilla and spermathecal system of entomoparasitic pipunculid flies (Diptera, Pipunculidae). Journal of Natural History 31: 1273–1288.

May, Y. Y. 1979. The biology of *Cephalops curtifrons* (Diptera: Pipunculidae), an endoparasite of *Stenocranus minutes* (Hemiptera: Delphacidae). Zoological Journal of the Linnean Society 66: 15–29.

Oosterbroek, P. 2005. Catalogue of the Craneflies of the World. The catalogue is on-line available via http://www.science.uva.nl/zma/.

Pritchard, G. 1983. Biology of Tipulidae. Annual Review of Entomology 28: 1–22.

Rennie, J. and C. H. Sutherland. 1920. On the life-history of *Bucentes (Siphona) geniculata*, parasite of *Tipula paludosa* and other species. Parasitology 12: 199–211.

Roddy, L. R. 1955. A morphological study of the respiratory horns associated with the puparia of some Diptera, especially *Ophyra anescnes* (Wied.) Annals of the Entomological Society of America 48: 407–415.

Skevington, J. H. 2005. Revision of Nearctic *Nephrocerus* Zetterstedt (Diptera: Pipunculidae). Zootaxa 977: 1–36.

Skevington, J. H. and S. A. Marshall. 1997. First record of a big-headed fly, *Eudorylas alternatus* (Cresson) (Diptera: Pipunculidae), reared from the subfamily Cicadellinae (Homoptera: Cicadellidae), with an overview of pipunculid-host associations in the Nearctic Region. The Canadian Entomologist 129: 387–398.

———. 1998. Systematics of New World *Pipunculus* (Diptera: Pipunculidae). Thomas Say Publications in Entomology, Monographs, Entomological Society of America, Lanham, Maryland. 201 pp.

Yano., et al. (1985). An evidence for behavioral change in *Nephotettix cincticeps* Uhler (Hemiptera: Deltocephalidae) parasitized by pipunculid flies (Diptera: Pipunculidae). Applied Entomology and Zoology 20(1): 94–96.

Young, C. W. and J. K. Gelhaus. 2000. Crane Flies of Pennsylvania: Preliminary checklist and database development with emphasis on aquatic species. Report submitted to the Wild Resource Conservation Fund, Harrisburg, PA. i–ii, pp. 1–256.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 66–74

INTRODUCED APIONIDAE AND BRENTIDAE (COLEOPTERA: CURCULIONOIDEA) IN THE MARITIME PROVINCES OF CANADA

Christopher G. Majka, Robert S. Anderson, and Eric Georgeson

(CGM) Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia, Canada B3H 3A6 (e-mail: c.majka@ns.sympatico.ca); (RSA) Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Ontario, Canada K1P 6P4 (e-mail: randerson@mus-nature.ca); (EG) Nova Scotia Department of Natural Resources, P.O. Box 130, Shubenacadie, Nova Scotia, Canada B0N 2H0 (e-mail: georgeeg@gov.ns.ca)

Abstract.—The introduced Apionidae and Brentidae in the Maritime Provinces of Canada are surveyed. *Perapion curtirostre* (Germar) is recorded for the first time in Canada from specimens collected in New Brunswick, Nova Scotia, and Prince Edward Island. *Rhopalapion longirostre* (Olivier) is recorded for the first time in Nova Scotia and Atlantic Canada. Changes in the range of *Omphalapion hookerorum* (Kirby) in Nova Scotia are discussed, and a Nova Scotia record of an intercepted specimen of *Arrenodes minutus* (Drury) is noted. All records are briefly discussed in the context of introduced Coleoptera in the region.

Key Words: Coleoptera, Apionidae, Brentidae, *Perapion*, *Rhopalapion*, *Omphalapion*, *Arrenodes*, Maritime Provinces, introduced species, new records, biodiversity

---

The literature pertaining to introduced species found in Atlantic Canada continues to grow. Brown (1940, 1950, 1967), Lindroth (1957), Johnson (1990), Wheeler and Hoebeke (1994), Hoebeke and Wheeler (1996a, 1996b, 2000, 2003, 2005a, 2005b), Majka (2005), Majka and Klimaszewski (2004), Majka and LeSage (2006), and Majka et al. (2006b) are some of the studies that have contributed to this topic. Although the treatments by Brown and Lindroth dealt with introduced weevils in the region, comparatively little attention has been given to introduced and adventive Apionidae and Brentidae. In this paper we discuss recent records of four adventive species in the region – *Arrenodes minutus* (Drury), *Perapion curtirostre* (Germar), *Omphalapion hookerorum* (Kirby), and *Rhopalapion longirostre* (Olivier) – within the larger context of introduced insects in North America.

Conventions

Abbreviations of collections referred to in this study are:

ACNS	Agriculture and Agri-Food Canada, Kentville, Nova Scotia.
CBU	Cape Breton University, Sydney, Nova Scotia.
CUIC	Cornell University Insect Collection, Ithaca, New York.
CGMC	Christopher G. Majka collection, Halifax, Nova Scotia.
JOC	Jeffrey Ogden Collection, Truro, Nova Scotia.

NSAC	Nova Scotia Agricultural College, Bible Hill, Nova Scotia.
NSMC	Nova Scotia Museum, Halifax, Nova Scotia.
NSNR	Nova Scotia Department of Natural Resources, Shubenacadie, Nova Scotia.
RPWC	Reginald P. Webster collection, Charter's Settlement, New Brunswick.

The number of specimens is noted in parentheses. If not specified, it is assumed to be one.

RESULTS

Brentidae

Arrenodes minutus (Drury 1770)

NOVA SCOTIA: Halifax Co.: Haliburton, 10.ii.2005, M. Knapp, NSMC.

A specimen of this species was intercepted after it emerged from wooden furniture imported to Nova Scotia from Indiana, U.S.A. Although a Nearctic species, it is not native to Atlantic Canada. Generally distributed in the eastern United States (Anderson and Kissinger 2002), it ranges north into southern Ontario and Québec (McNamara 1991). Adults are found under the bark of oaks (*Quercus* spp.) (Fagaceae); larvae bore into the wood (Buchanan 1960).

Apionidae

Perapion curtirostre (Germar 1817)

NEW BRUNSWICK: Albert Co.: Mary's Point, 8.ix.2002, C.G. Majka, (2), CGMC; Mary's Point, 13.ix.2006, C.G. Majka, (2), CGMC. Queens Co.: Canning: Scotchtown near Indian Point, 5.vi.2004, R.P. Webster, margin of lake: oak-maple forest on sandy soil, RPWC. NOVA SCOTIA: Annapolis Co.: Annapolis Royal, 30.vi.2002, C.G. Majka, CGMC; Granville Ferry, 30.vi.2002, C.G. Majka, (7), CGMC; Hampton, 7.viii.2005, C.G. Majka, CGMC; Middleton, 5.viii.2001, E.R. Hoebeke and A.G. Wheeler, CUIC; Bridgetown, 5.viii.2001, E.R. Hoebeke and A.G. Wheeler, (24), CUIC. Colchester Co.: Bible Hill, 29.vii.2003, E.R. Hoebeke and A.G. Wheeler, (8), CUIC; Bible Hill, 3.viii.2003, E.R. Hoebeke and A.G. Wheeler, (61), CUIC; Bible Hill, 10.vi.2004, K. Aikens, (2), CBU; Bible Hill, 14.v.2005 & 31.v.2005, S. Townsend, (44), CBU. Digby Co.: Brier Island, 22.vi.2003, J. Ogden & K. Goodwin, (2), JOC. Halifax Co.: Point Pleasant Park, 7.vi.2001 & 15.xi.2001, C.G. Majka, CGMC; south-end Halifax, 20.v.2002, 23.v.2002, & 21.vi.2002, C.G. Majka, (18), CGMC; Herring Cove, 11.viii.2002, C.G. Majka, (2), CGMC; West Dover, 7.ix.2003, C.G. Majka, (7), CGMC; Dartmouth, 27–28.vii.2003, E.R. Hoebeke and A.G. Wheeler, (35), CUIC. Hants Co.: Ellershouse, 30.vi.2002, C.G. Majka, CGMC; Noel Shore, 2.vii.2002, A.J. Hebda, (3), NSMC. Inverness Co.: Port Hawkesbury, 31.vii.2003, E.R. Hoebeke and A.G. Wheeler, CUIC. Kings Co.: Sheffield Mills, 26.vi.2002, K. Neal, NSMC; Sheffield Mills, 19.vi.2005 & 3.vii.2005, S. Westby, ACNS; Upper Canard, 10.viii.2004, C. Sheffield, (5), ACNS. Lunenburg Co.: Elmwood, 1.xi.2005, Moore & LeBlanc, (3), NSNR. Pictou Co.: Pictou, 30.vii.2003, E.R. Hoebeke and A.G. Wheeler, (2), CUIC. PRINCE EDWARD ISLAND: Kings Co.: Caledonia, 12.vii.2002, C.G. Majka, CGMC; Woodville Mills, 25.viii.2003, C.G. Majka, (3), CGMC. Queens Co.: St. Patricks, 14.vii.2002, C.G. Majka, CGMC; Princeton-Warburton Rd., 27.vi.2003, C.G. Majka, CGMC.

Whitehead (1980) first reported this Palearctic species from specimens collected in 1968, northwest of Bar Harbor, Maine, and from Suffolk County, New York. Until recently it had not been further reported in North America. Downie and Arnett (1996) listed it from

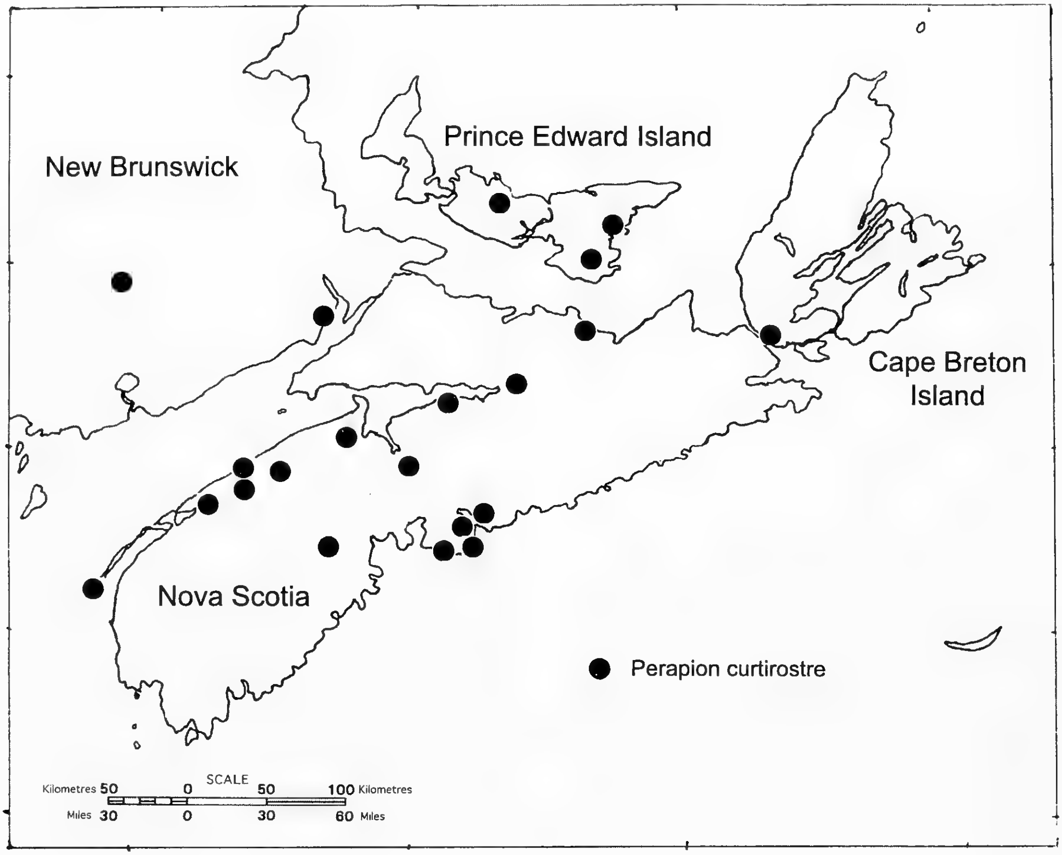


Fig. 1. Distribution of *Perapion curtirostre* in the Maritime Provinces.

Indiana; however, no source is provided for this report and it is almost certainly in error. Recent research in the Maritime Provinces has shown that this species is common and generally distributed except for Cape Breton Island (Fig. 1). In Europe, it is associated with *Rumex* spp., including *R. acetosa* L., *R. acetosella* L., *R. crispus* L., and *R. obtusifolius* L. (Polygonaceae) (Hoffman 1958), all of which have been introduced to the Maritime Provinces. In Bible Hill, Nova Scotia, it has been sweep-netted in fields where *R. acetosella*, *R. crispus*, and *R. obtusifolius* are present. Most specimens collected by E.R. Hoebeke and A.G. Wheeler, Jr. in Nova Scotia were swept from *R. acetosella* although at Bible Hill some were also collected from *R. crispus* (E.R. Hoebeke, pers. com.).

Several specimens of *P. curtirostre* were collected from the foliage of balsam fir (*Abies balsamea* (L.) Mill) (Pinaceae) that had been cut and stored in a field in preparation for export to the United States as Christmas trees. One of us (R.S.A.) also recently received specimens of *P. curtirostre* which had been intercepted in Panama on Canadian balsam firs exported as Christmas trees. This is a hitherto undocumented mode of dispersal for this species. The association may be fortuitous, the weevils having simply climbed into the foliage of trees. Christmas trees are often stored for extended periods lying prone in fields before being shipped to markets. Another possibility may be that adults overwinter in the foliage of *A. balsamea*. In the case of the chrysomelid, *Oulema* *melanopus* (Linné), adults beetles sometimes overwinter in the foliage of *Pinus resinosa* Ait., *P. sylvestris* L., and *P. nigra* Arnold, a behavior which has led to a quarantine of Christmas trees of these species in some jurisdictions (Royce and Simko 2000).

The Christmas tree industry, which is sizeable in Nova Scotia, began in 1922–23 and peaked in 1957 when 3.8 million trees were exported (Nova Scotia Department of Natural Resources 2002). Currently (2003 figures) Nova Scotia exports 0.8 million trees and New Brunswick 0.4 million (Natural Resources Canada 2005). The Christmas Tree Council of Nova Scotia (representing 2,500 growers) exports trees to Bermuda, Brazil, Cuba, Mexico, Panama, Puerto Rico, the United States, and Venezuela (Christmas Tree Council of Nova Scotia 2005). Given the abundance and wide distribution of *P. curtirostre* in the Maritime Provinces, the long history of export of trees from this region, and the scale of the past and present export trade, its is possible that the Maine and New York populations might have originated in the Maritime Provinces. In the Old World, *P. curtirostre* is found throughout Europe, east to the Caucasus (Hoffmann 1958).

Omphalapion hookerorum (Kirby 1808)

NOVA SCOTIA: Cape Breton Co.: Glace Bay, 1.viii.2003, E.R. Hoebeke and A.G. Wheeler, (19), CUIC; Sydney, 31.vii.2003, E.R. Hoebeke and A.G. Wheeler, (7), CUIC. Colchester Co.: Truro, 29.vii.2003, E.R. Hoebeke and A.G. Wheeler, (15), CUIC; Truro, 3.viii.2003, E.R. Hoebeke and A.G. Wheeler, (43), CUIC; Bible Hill, 25.vi.2004, K. Aikens, CBU; Tatamagouche, viii.1992, G. Sampson, NSAC. Halifax Co.: Point Pleasant Park, 24.viii.2002, C.G. Majka, (4), CGMC. Pictou Co.: Pictou, 22.vii.1994, E.R. Hoebeke and A.G. Wheeler, CUIC. Richmond Co.: Arichat: Isle Madame, viii.1992, G. Sampson, NSAC.

Peschken et al. (1993) and Sampson and McSween (1993) reported this species as new for North America from specimens collected in 1990 in Antigonish, Nova Scotia. Subsequently it was found during 1991 in surveys in northern Nova Scotia (Colchester, Pictou, Antigonish, and Inverness counties) in 13 localities on scentless chamomile, *Tripleurospermum maritima inodorum* (L.) Applequist (Asteraceae) (formerly *Matricaria maritima* (Less.) Porter; see Applequist (2002)) Peschken et al. (1993b). Additional records are reported above and are shown in Fig. 2. This introduction was coincidentally discovered as part of a program to investigate the suitability of this weevil as a biocontrol agent for *T. maritima*; the adults and larvae feed on the flowers and seeds of the plant. Deliberate introductions into the Truro-Bible Hill area, from stock collected in northern Nova Scotia, have also been made (G. Sampson, pers. com.). The specimens collected by E.R. Hoebeke and A.G. Wheeler, Jr. were all collected from stinking mayweed, *Anthemis cotula* L. (Asteraceae).

Peschken et al. (1993) proposed that fishing or pleasure boats calling at the ports of Pictou or Antigonish may have been responsible for the introduction. Another possibility, however, is that this species was introduced via dry-ballast as proposed by Brown (1940, 1950) and Lindroth (1957). In a survey of eight principal sites in Great Britain where dry-ballast destined for Atlantic Canada originated, Lindroth (1957) found *T. maritima* at both Poole and Appledore and collected *O. hookerorum* at the latter site. Although specific historical data are lacking, the important ports of Pictou, Port Hawkesbury, and Sydney all lie within the area where the species has been found, and many other coastal

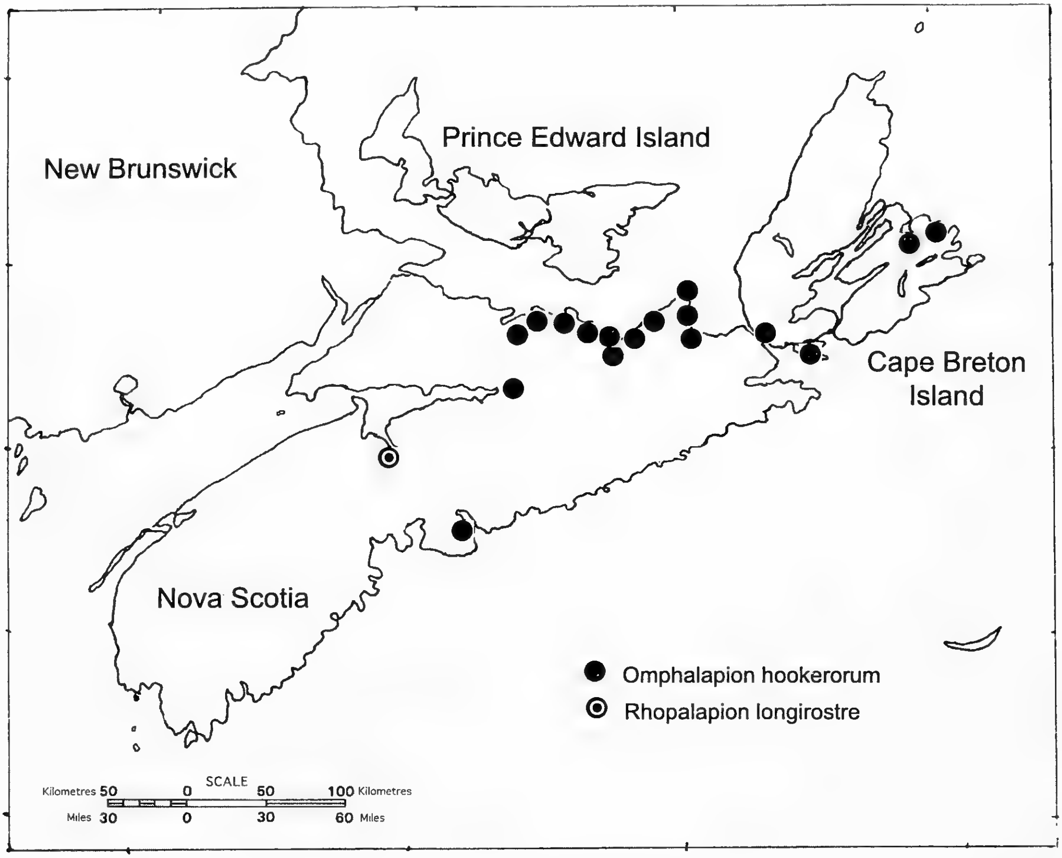


Fig. 2. Distribution of *Omphalapion hookerorum* and *Rhopalapion longirostre* in the Maritime Provinces.

towns in this area had important shipbuilding and timber exporting enterprises during the nineteenth century. Given that Brown (1940, 1950, 1967) and Lindroth (1957) documented many other species of Coleoptera introduced into North America via this pathway, *O. hookerorum* may also be a member of this suite of insects.

Omphalapion hookerorum has been introduced into portions of British Columbia, Alberta, Saskatchewan, and Manitoba (Harris and McClay 2001). It appears to favor a continental climate, and in Alberta has been naturally dispersing at a rate of 2.8 km/year (Harris and McClay 2001). In Nova Scotia the species is abundant in coastal localities on the northern shore of the province, particularly between Cape George and Antigonish (G. Sampson, pers. com.). The records cited above indicate the species is now found further east (Sydney and Glace Bay) and south (Halifax) than reported by Peschken et al. (1993) and occupies a much larger portion of the province. Whether this simply adds to the knowledge of its distribution in the province, or indicates that the species is expanding its range, remains to be determined; however, it appears that the latter may be the case. There has been extensive prior collecting for weevils and other Coleoptera by many researchers interested in adventive species in Sydney (Harrington 1891, Lindroth 1957, Brown 1967, McCorquodale et al. 2005) and Halifax (Brown 1950; Lindroth 1957;

Hoebeke and Wheeler 1996a, 1996b; Majka et al. 2004) and this species had not been found.

Of further interest are the Wheeler and Hoebeke's collections of *O. hookerorum* on *Anthemis cotula*. This differs from previous findings. Peschken et al. (1993) sampled *T. maritima*, *Matricaria matricarioides* (Less.) Porter, *A. cotula*, and *Chrysanthemum leucanthemum* L. (Asteraceae) finding *O. hookerorum* only on *T. maritima*. Peschken and Sawchyn (1993) concluded that only *T. maritima* and *M. matricarioides* would be suitable field hosts for *O. hookerorum*. In Europe, *O. hookerorum* is reported only from *T. maritima* (Dieckmann 1977). Thus it would appear that *O. hookerorum* is diversifying its food-plant preferences in the New World environment. In the Old World, it is found throughout Europe (including Great Britain), east to western Siberia and the Caucasus, and south to Algeria and Morocco (Hoffmann 1958, Peschken et al. 1993).

Rhopalapion longirostre (Olivier 1807)

NOVA SCOTIA: Hants Co.: Windsor, 21.xi.2002, G. Oikle, (10), NSMC.

Sleeper (1953) first reported this Palearctic species from specimens collected in Georgia, U.S.A., in 1914 and 1922. Brown (1967) subsequently reported that it from New York and Ontario, south to Arkansas and North Carolina, and in California. O'Brien and Wibmer (1982) expanded the range to include Massachusetts, Oregon, Washington, and Colorado. Bright (1993) added British Columbia and Québec to the Canadian range. The species is associated with hollyhock, *Althea rosea* L. (Malvaceae), where adults and larvae feed on flowers and seeds. The specimens collected in Nova Scotia (Fig. 2) were found on *A. rosea* growing in a horticultural setting.

Brown (1967) remarked that in Eurasia the species is found primarily in warmer climates from Italy, Hungary, and Crimea to Turkistan and Iran, and that consequently its persistence in cooler climates may be transitory. It is not known if the Nova Scotia collections represent an ephemerally adventive population introduced via the horticultural trade or an established population. Windsor does lie within a comparatively warmer portion of the province, one of only three pockets in Nova Scotia where the number of annual degree-days above 5°C exceeds 1,800 (McCalla 1988). Nonetheless, its presence in Nova Scotia indicates that the species is continuing to expand its range, either by dispersion, the assistance of human agency, or a combination of both processes.

DISCUSSION

The above accounts illustrate a broad range of circumstances, which apply to introduced species, including inadvertent and deliberate introductions, a variety of mechanisms of introduction, and a variety of pathways of subsequent dispersal. Both *O. hookerorum* and *P. curtirostre* are well established in large areas of the region and may be increasing their ranges. The status of *R. longirostre* is uncertain. More research is required to determine if it will persist in Nova Scotia. *Arrenodes minutus* was intercepted in Nova Scotia and does not persist.

The situation with introduced Apionidae in the Maritime Provinces parallels that of other groups of Coleoptera in the region. Bousquet (1992) listed 45 taxa of exotic Carabidae established in northeastern North America. Of these, 32 are found in the Maritimes and 15 were first recorded in North America from the region. Overall 12% (35 of 285 species) of carabids in Nova Scotia and 15% (24 of 159 species) on Prince Edward Island are introduced (Majka et al. 2006). Majka et al. (in press) summarize the weevil (Curculionoidea) fauna of the Maritimes and document 59 introduced species, which comprise 21% of the weevil fauna. In Nova Scotia, 23 of 172 species (13%) of Chrysomelidae are introduced species (C.G. Majka, unpublished data). In the case of Apionidae four of the 13 species (31%) recorded in the region are introduced Majka et al. (in press), double the overall proportion of 14.6% introduced species of Coleoptera in Nova Scotia (C.G. Majka, unpublished data).

Both *O. hookerorum* and *P. curtirostre* can be considered potentially beneficial species; they feed on, and may have biocontrol potential against these introduced weeds. *Rhopalapion longirostre* can itself be considered a "pest" because it feeds on a desirable horticultural plant (hollyhock). These categories are, of course, relative to their impact on human activities. The impact of such species on native faunas and environments has been little investigated.

Introduced taxa sometimes have complex impacts on ecosystems. For instance, Maerz et al. (2005) examined the role of introduced invertebrates on populations of red-backed salamanders (*Plethodon cinereus* (Green)). Weevils comprised the largest proportion of food items for salamanders in upland forests and the second largest proportion (after earthworms) in lowland forests. Of these, the introduced weevil *Barypeithes pellucidus* (Boheman) accounted for more than 90% of prey items, leading the authors to conclude that "the seasonally hyper-abundant *Barypeithes pellucidus* had a strong effect on seasonal fluctuations in *P. cinereus* diet," and to further hypothesize that the "influence of introduced prey on temporal and geographic food resources contributes to temporal and geographic demographic and phenotypic variation among *P. cinereus* populations." Any such effects of these introduced weevils in native environments in North America remain to be investigated.

ACKNOWLEDGMENTS

We thank Peter Harris, Karen Sawchyn, Cory Sheffield, and Susan Westby (Agriculture and Agri-food Canada); Kathleen Aikens, Clayton D'Orsay, and Sheena Townsend (Cape Breton University), E. Richard Hoebeke (Cornell University), Glen Sampson (Nova Scotia Agricultural College); Jeff Ogden (Nova Scotia Department of Natural Resources), and Reginald P. Webster for their assistance. Particular thanks to Charles O'Brien (University of Arizona) and A. G. Wheeler, Jr. (Clemson University) for their constructive reviews of the manuscript. The first author thanks his colleagues at the Nova Scotia Museum, Calum Ewing and Andrew Hebda, for continuing support and encouragement. This work has been assisted by a research grant from the Nova Scotia Museum of Natural History.

LITERATURE CITED

Anderson, R. S. and D. G. Kissinger. 2002. Brentidae Billberg 1820, pp. 711–719. *In* Arnett, R. H., Jr, M. C. Thomas, P. E. Skelley, and J. H. Frank, eds. American Beetles, Volume 2: Polyphaga: Scarabaeoidea through Curculionoidea. CRC Press, Boca Raton, U.S.A.

Applequist, W. 2002. A reassessment of the nomenclature of *Matricaria* L. and *Tripleurospermum* Sch. Bip. (Asteraceae). Taxon 51: 757–761.

Bousquet, Y. 1992. *Bembidion femoratum* Sturm and *Amara communis* (Panzer) (Coleoptera: Carabidae) new to North America. Journal of the New York Entomological Society 100: 503–509.

Bright, D. E. 1993. The Weevils of Canada and Alaska: Volume 1: Coleoptera: Curculionoidea, excluding Scolytidae and Curculionidae. Agriculture Canada: Research Branch, Publication 1882. 217 pp.

Brown, W. J. 1940. Notes on the American distribution of some species of Coleoptera common to the European and North American continents. The Canadian Entomologist 72: 65–78.

———. 1950. The extralimital distribution of some species of Coleoptera. The Canadian Entomologist 82: 197–205.

———. 1967. Notes on the extralimital distribution of some species of Coleoptera. The Canadian Entomologist 99: 85–93.

Buchanan, W. D. 1960. Biology of the oak timberworm, *Arrhenodes minutus*. Journal of Economic Entomology 53: 510–513.

Christmas Tree Council of Nova Scotia. Available from http://www.ctcns.com/ (accessed 14 April 2006).

Dieckmann, L. 1977. Beiträge zur Insektenfauna der DDR: Coleoptera–Curculionidae (Apioninae). Beiträge zur Entomologie (Berlin) 27: 7–143.

Downie, N. M. and R. H. Arnett, Jr. 1996. The Beetles of Northeastern North America. Sandhill Crane Press, Gainesville, Florida. 1721 pp.

Harrington, W. H. 1891. Notes on a few Canadian Rhyncophora. The Canadian Entomologist 23: 21–27, 114.

Harris, P. and A. McClay. 2001. *Omphalapion hookeri* Kirby. Seed-headed weevil. Available from http://res2.agr.ca/lethbridge/weedbio/agents/aomphook_e.htm (accessed 16 April 2006).

Hoebeke, E. R. and A. G. Wheeler, Jr. 1996a. *Meligethes viridescens* (F.) (Coleoptera: Nitidulidae) in Maine, Nova Scotia, and Prince Edward Island: diagnosis, distribution, and bionomics of a Palearctic species new to North America. Proceedings of the Entomological Society of Washington 98: 221–227.

———. 1996b. Adventive lady beetles (Coleoptera: Coccinellidae) in the Canadian Maritime Provinces, with new eastern U.S. records of *Harmonia quadripunctata*. Entomological News 107: 281–290.

———. 2000. *Telmatophilus typhae* (Fallén) (Coleoptera: Cryptophagidae), a Palearctic cattail specialist established in the Canadian Maritime Provinces. Proceedings of the Entomological Society of Washington 102: 398–402.

———. 2003. *Sphaeroderma testaceum* (F.) (Coleoptera: Chrysomelidae), a Palearctic flea beetle new to North America. Proceedings of the Entomological Society of Washington 105: 990–994.

———. 2005a. First records of adventive Hymenoptera (Argidae, Megachilidae, Tenthredinidae, and Vespidae) from the Canadian Maritimes and the United States. Entomological News 116: 159–165.

———. 2005b. Establishment of three European flea beetles in Nova Scotia: *Longitarsus ganglbaueri* Heikertinger, *L. jacobaeae* (Waterhouse), and *L. rubiginosa* (Foudras) (Coleoptera: Chrysomelidae: Alticinae). Proceedings of the Entomological Society of Washington 107: 319–322.

Hoffman, A. 1958. Coléoptères. Curculionoides (Troisième Partie). Faune de France. Vol 62. Fédération Française des Sociétes de Science Naturelles, Paris. pp. 1209–1839.

Johnson, P. J. 1990. Notes on the naturalization of two species of European Byrrhidae (Coleoptera) in North America. Journal of the New York Entomological Society 98: 434–440.

Lindroth, C. H. 1957. The Faunal Connections between Europe and North America. Almqvist & Wiksell, Stockholm, Sweden. 344 pp.

Maerz, J. C., J. M. Karuzas, D. M. Madison, and B. Blossey. 2005. Introduced invertebrates are important prey for a generalist predator. Diversity and Distributions 11(1): 83–90.

Majka, C. G. 2005. The Palearctic species *Bembidion femoratum* and *Amara communis* (Coleoptera: Carabidae): new records and notes on modes of introduction to North America. The Canadian Entomologist 137: 532–538.

Majka, C. G. and J. Klimaszewski. 2004. *Phloeocharis subtilissima* Mannerheim (Staphylinidae: Phloeocharinae) and *Cephennium gallicum* Ganglbauer (Scydmaenidae) new to North America: a case study in the introduction of exotic Coleoptera to the port of Halifax, with new records of other species. Zootaxa 781: 1–15.

Majka, C. G. and L. LeSage. 2006. Introduced leaf beetles of the Maritime Provinces, 1: *Sphaeroderma testaceum* (Fabricius) (Coleoptera: Chrysomelidae). Proceedings of the Entomological Society of Washington 108: 243–247.

Majka, C. G., R. S. Anderson, and D. B. McCorquodale. In press. The weevils of the Maritime Provinces of Canada, II: new records from Nova Scotia and Prince Edward Island (Coleoptera: Curculionoidea). The Canadian Entomologist.

Majka, C. G., J. Cook, and S. Westby. 2006a. Introduced Carabidae (Coleoptera) from Nova Scotia and Prince Edward Island: new records and ecological perspectives. The Canadian Entomologist 138: 602–609.

Majka, C. G., C. Noronha, and M. Smith. 2006b. Adventive and native Byrrhidae (Coleoptera) newly recorded from Prince Edward Island. Zootaxa 1168: 21–30.

McCalla, R. J. 1988. The Maritime Provinces Atlas. Maritext Ltd., Halifax, NS. 96 pp.

McCorquodale, D. B., B. L. Musgrave, S. Atkins, C. Majka, and R. S. Anderson. 2005. New records of native and introduced weevils (Coleoptera: Curculionidae) for Nova Scotia from Cape Breton Island. The Coleopterists Bulletin 59: 27–34.

McNamara, J. 1991. Family Brentidae: brentid beetles. pp. 327. *In* Bousquet, Y. ed. Checklist of Beetles of Canada and Alaska. Agriculture Canada: Research Branch, Publication 1861/E.

Natural Resources Canada. 2005. The State of Canada's Forests 2004–2005. Available from http://www.nrcan-rncan.gc.ca/cfs-scf/national/what-quoi/sof/sof05/statistics_e.html (accessed 14 April 2006).

Nova Scotia Department of Natural Resources. 2002. History of the Nova Scotia Xmas tree Industry. Available from http://www.gov.ns.ca/natr/extension/christmastrees/tradition.htm (accessed 14 April 2006).

O'Brien, C. W. and G. J. Wibmer. 1982. Annotated checklist of the weevils (Curculionidae *sensu lato*) of North America, Central America, and the West Indies (Coleoptera: Curculionoidea). Memoirs of the American Entomological Institute (Gainesville) No. 34. 382 pp.

Peschken, D. P. and K. C. Sawchyn. 1993. Host specificity and suitability of *Apion hookeri* (Coleoptera: Curculionidae), a candidate for the biological control of scentless chamomile, *Matricaria perforata* Mérat (Asteraceae), in Canada. The Canadian Entomologist 125: 619–628.

Peschken, D. P., K. C. Sawchyn, and D. E. Bright. 1993. First record of *Apion hookeri* Kirby (Coleoptera: Curculionidae) in North America. The Canadian Entomologist 125: 629–631.

Royce, L. A. and B. Simko. 2000. Cereal Leaf Beetle: Identification, Control, and California Quarantine Alert. Oregon State University, Extension Service, publication EM8762. Available from http://eesc.orst.edu/agcomwebfile/edmat/EM8762.pdf (accessed 14 April 2006).

Sampson, M. G. and T. MacSween. 1993. Biological control of weeds in Nova Scotia. Nova Scotia Department of Agriculture and Marketing, Final Report TD63. 47 pp.

Sleeper, E. L. 1953. New genera and species of Curculionoidea with a new species of Anthribidae. Ohio Journal of Science 53: 113–120.

Wheeler, A. G., Jr and E. R. Hoebeke. 1994. First records from the Canadian Maritime provinces of three European insects injurious to ornamental plants. Proceedings of the Entomological Society of Washington 96: 749–756.

Whitehead, D. R. 1980. The weevil *Apion (Perapion) curtirostre* Germar in North America, and the systematic position of *Perapion* Wagner with a review of the North American species (Coleoptera: Curculionoidea: Apionidae). The Coleopterists Bulletin 34: 397–400.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 75–80

THE LASIOCHILIDAE, LYCTOCORIDAE, AND ANTHOCORIDAE (HEMIPTERA: HETEROPTERA) OF THE HAWAIIAN ISLANDS: NATIVE OR INTRODUCED?

JOHN D. LATTIN

Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902, U.S.A.

Abstract.—Twenty-three species of Lasiochilidae, Lyctocoridae, and Anthocoridae are known from the Hawaiian Islands. Twelve species of Lyctocoridae (1 sp.) and Anthocoridae (11 spp.) are considered to be non-indigenous to these islands (52%). The history of each non-indigenous species and two native species are provided.

Key Words: Hemiptera, Heteroptera, Lasiochilidae, Lyctocoridae and Anthocoridae, Hawaiian Islands, endemic, native and non-indigenous species

The true bug family Anthocoridae is now considered to represent three families: Lasiochilidae, Lyctocoridae, and Anthocoridae (Schuh and Štys 1991, Schuh and Slater 1995). This paper follows the higher classification of the former family Anthocoridae by Schuh and Štys (1991) and Schuh and Slater (1995). The higher classification of Anthocoridae follows the same authors, including the supra-generic classification at the tribal level. Higher categories above the tribes await a world-wide review for proper subfamily placement. The family organization extends from the most generalized (Lasiochilidae) to the most specialized (Lyctocoridae to Anthocoridae). Representatives of these families have been taken on one or more of the Hawaiian Islands (Zimmerman 1947, 1948; Nishida 1994, 1997, 2002; Brenner and Lattin 2001; Lattin 2005a). Twenty-three species of these families are presently known to have been taken on one or more of the islands.

Eleven (48%) species occur naturally on the islands (9 endemic and 2 native) and 12 (52%) species are considered non-indigenous. This is a remarkably high percentage of introduced species. Endemic is defined here as species occurring only on one or more of the Hawaiian islands and native is defined as occurring on one or more of the islands and also found naturally elsewhere.

The endemic species (confined to the Hawaiian Islands) and not treated in this paper include: *Lasiochilus decolor* (White) (1880), *L. denigratus* (White) (1880), *L. montivagus* (Kirkaldy (1908), *L. nubigenus* Kirkaldy (1908), *L. silvicola* Kirkaldy (1908), *L.* sp. nov., *Lilia dilecta* White (1880), *Orius persequens* (White) (1877), and *Scolopa* sp. nov. The new species stated above will be published elsewhere.

The two native species are *Alofa sodalis* (White) (1878) and *Physopleurella mundula* (White) (1877). *Alofa sodalis* (described as *Cardiastethus sodalis*) is now known throughout the Pacific Region as well as Africa, North, Central and South America and the West Indies. It is difficult to state exactly where it occurs naturally, but early original description from the Hawaiian Island suggests that it is native to the Hawaiian Islands. *Physopleurella mundula* also was described from the Hawaiian Islands (as *Cardiastethus mundulus*). Swezey (1904) reported it feeding on various insects. Perkins (1906) stated that it was abundant in cane fields. Perkins (1913) presented a more extensive discussion of this species and its biology as he did with *Alofa sodalis* (as *Buchananiella sodalis*). Zimmerman (1948) recorded *Physopleurella mundula* from Hawai'i, Kaua'i, Maui, Molakai'i and O'ahu. Usinger reported it from Guam (1946) and Herring (1967) listed it from much of Micronesia. This bug is considered native to the Hawaiian Islands. Both species belong to the Anthoridae, Anthocorini.

Non-indigenous Species

Non-indigenous species are discussed below, including those introduced for potential biological control as well as those introduced accidentally, with families ordered from the least to most specialized:

Lyctocoridae

Lyctocoris campestris (Fabricius 1794) is the only member of the Lyctocoridae found in the Hawaiian Islands. This species was described from Europe and has been introduced into many localities around the world by commerce. On the Hawaiian Islands, it has been found most commonly associated with litter in and around domestic animals (Beardsley 1981). *Nesidiocheilus hawaiiensis* was described by Kirkaldy in 1902 from Haleakala, Maui. It is now considered to be a synonym of *L. campestris* (Lattin 2006).

Anthocoridae

Anthocorini

Macrotrachelia nigronitens (Stål 1860) was described from Rio Janeiro, Brazil (as *Anthocoris nigronitens*). It was reported from Panama by Champion (1900). Davis and Krauss (1966) introduced 45 individuals from Cuernavaca, Morelos, Mexico at Aliomanu, O'ahu under the name *Macrotrachelia thripiformis* Champion 1900. This name was used by early authors discussing its introduction (e.g. Davis for Chong 1967, Davis and Chong 1968, Nishida 1994, 1997). I have examined a series of six specimens from the original introduction that are now in the Bishop Museum (Lattin 2005a) and have determined that they are *Macrotrachelia nigronitens* (Stål), not *M. thripiformis* Champion. This species was deliberately introduced for biological control of thrips but did not become established.

Dufouriellini

Amphiareus constrictus (Stål 1860) was described from Brazil (as *Xylocoris constrictus*). It was reported from Kaua'i and O'ahu by Zimmerman (1948) and Nishida (1994, 1997) (as *Cardiastethus fulvescens* (Walker) (1872), a synonym of *A. constrictus* Stål). Brenner and Lattin (2001) reported it from the island of Hawai'i. This species is considered an introduction into the Hawaiian Islands.

Buchananiella continua (White 1880) was described from Madeira (as *Cardiastethus continuus*). Later, it also was described from California by Blatchley (1934) (as *Cardiastethus cavicollis* Blatchley, now a synonym of *B. continua* (Lattin et al. 2001)). Péricart (1972) published a useful account from Europe and Ford (1979) reported *B. continua* from the Azores, Madeira, Reunion Island and Europe. Brenner and Lattin (2001) reported it from the island of Hawai'i, the first record of the species from the Hawaiian Islands. It is considered introduced species in the Hawaiian Islands.

Cardiastethus minutissimus Usinger, 1946, was described from Guam. It is widespread throughout much of Micronesia (Herring 1967). It was first reported from Kaua'i by Beardsley (1977a) (as *Cardiastethus* sp.). Subsequently, it was reported from several localities on Kaua'i by Asquith and Messing (1992) and I have examined specimens in the Bishop Museum from O'ahu. Herring (1967) stated that several species of *Cardiastethus* were found "...in shipments of grain and other foodstuffs." This bug is considered to be an accidental introduction into Kaua'i and O'ahu and was so treated by Nishida (1994, 1997, 2002).

Dufouriellus ater (Dufour 1833) was described from Europe (as *Xylocoris ater*). This is another species that is widely distributed in Asia, Europe and North America (Péricart 1996). It was collected on the island of Hawai'i from the borings of *Plasithymus* beetles in *Chenopodium* (Lattin 2005a). This anthocorid is a well-known predator of bark beetles. It is also associated with a variety of stored products where it feeds on other insects (Arbogast 1984). There is a possibility that it will be recovered from similar habitats in the Hawaiian Islands. It is considered an accidental introduction into the Hawaiian Islands.

Oriini

Montandoniola moraguesi (Puton 1896) was described from Spain (as *Montandoniella moraguesi*). Péricart (1972) published an account of this species from Europe with excellent illustrations and considered the species to be widely distributed around the world. It has been introduced into many localities as a biological control agent against thrips on *Ficus*. Davis and Krauss (1965) reported the introduction of this species from the Philippines into the Pauoa Valley, O'ahu and Port Allen, Kaua'i in 1964. It quickly became established and spread to other Hawaiian Islands without further intervention. In an unusual turn of events, *M. moraguesei* was found feeding on the thrips *Liothrips urichi* Karny, introduced into the Hawaiian Islands in 1953 as a biological control agent of an introduced weed, thus becoming a classic case of biotic interference (Reimer 1988).

Orius insidiosus (Say 1832) was described from "United States" (as *Reduvius insidiosus*) (this meant eastern United States to Say). It is widespread in central and eastern Canada and the United States and extends south through Mexico to South America and the West Indies (Herring 1966). According to Weber (1953), specimens were introduced into the Hawaiian Islands from Iowa and Missouri to assist in control of the corn earworm. It was first released at Mokule'ia, O'ahu in 1951. Oatman (1978) stated that this species did not become established on the islands. However, Vargas and Nishida (1980) reported the bug as a predator of the corn earworm on O'ahu and Takahara and Nishida (1981) reared it on oriental fruitfly eggs. Nishida (1994, 1997, 2002) reported it from Kaua'i and O'ahu.

Orius tristicolor (White 1880) was described from California (as *Triphleps tristicolor*). It is widely distributed in western North, Central, and South America (Herring 1966, Henry 1988). Davis and Krauss (1963, 1965) reported the introduction of *Orius tristicolor* into O'ahu (Moanalua) and Kaua'i (Port Allen), based on specimens received from Arizona. According to Clausen (1978), these introductions were not successful. Nishida (1994) included this species on his list but removed it in 1997. Cullney and Nagamine (2000) documented the introduction of this species for biological control in Hawai'i from 1978–1996.

Brenner and Lattin (2001) reported it from Mauna Kea, Hawai'i. It now seems that this species is established, most likely to be found at higher elevations on the islands.

Paratriphleps laeviusculus Champion, 1900, was described from Panama. Later, it also was reported from Honduras (Drake and Harris 1926), Peru (Hambleton 1944, Wille 1951), Florida (Bacheler and Baranowski 1975), Puerto Rico, Mexico and Panama (Henry 1988), and Nicaragua (Carpintero et al. 1997). It was first reported from the Hawaiian Islands by Beardsley (1977b), based on specimens from Ewa, O'ahu. Mau (1977) reported this species from eggplant flowers at Waimanalo, O'ahu in May. Nakahara (1981) cited it from Moloka'i and Asquith and Messing (1992) collected it on Kaua'i. This species has been taken from light traps around Honolulu near produce from the mainland. It is considered accidentally introduced in the Hawaiian Islands.

Xylocorini

Xylocoris (*Arrostelus*) *flavipes* (Reuter 1875) was described from Algeria (as *Piezostethus flavipes*). It too has been distributed widely via commerce. Péricart (1972) discussed this species and provided excellent illustrations of both short and long winged individuals. There are two brachypterous specimens of this tiny species in the collections of the Bishop Museum from Honolulu and Kalmuki, O'ahu. The specimens were associated with sorghum feed and fertilizer (Lattin 2005a). This is an introduced species in the Hawaiian Islands.

Xylocoris (*Proxylocoris*) *galactinus* (Fieber 1837) was described from Europe (as *Anthocoris galactinus*) and has been distributed throughout much of the world by commerce. It was first reported from O'ahu by Van Duzee as *Xylocoris discalis* (Van Duzee 1936). Originally described as *Scoloposcelis discalis* Van Duzee from southern California (1914), this species is now considered a synonym of *Xylocoris galactinus* (Fieber) (Lattin 2005b). Toyama and Ikeda (1976) reported *X. galactinus* from O'ahu taken around animal farms and I have identified specimens from Kaua'i, Maui and O'ahu in the collections of the Bishop Museum. This is a clear introduction into the Hawaiian Islands.

ACKNOWLEDGMENTS

My thanks to the late P.D. Ashlock, W.C. Gagné, R.L. Usinger, and E.C. Zimmerman for their past work on the Hawaiian Hemiptera; to A. Asquith, J.W. Beardsley, G.J. Brenner, T.J. Henry, and G.M. Nishida for their current work, A. Ramsdale for the loan of specimens from the Bishop Museum, T.M. Lewis for careful review; and to L. Parks for close attention to the manuscript.

LITERATURE CITED

Arbogast, R. T. 1984. Demography of the predaceous bug *Dufouriellus ater* (Hemiptera: Anthocoridae). Environmental Entomology 13: 990–994.

Asquith, A. and R. Messing. 1992. Annotated insect distribution records of the island of Kauai. Proceedings of the Hawaiian Entomological Society 31: 151–158.

Bacheler, J. S. and R. M. Baranowski. 1975. *Paratriphleps laeviusculus*, a phytophagous anthocorid new to the United States (Hemiptera: Anthocoridae). Florida Entomologist 58: 157–163.

Beardsley, J. W. 1977a. *Cardiastethus* sp. Proceedings of the Hawaiian Entomological Society 22(3): 392.

———. 1977b. *Paratriphleps laevisculus* Champion. Proceedings of the Hawaiian Entomological Society 22(3): 392.

———. 1981. *Lyctocoris campestris* reported from Mauna Kea, Hawaii. 7,800'. Proceedings of the Hawaiian Entomological Society 23(3): 327.

Blatchley, W. S. 1934. Notes on a collection of Heteroptera taken in winter in the vicinity of Los Angeles, California. Transactions of the American Entomological Society 60: 1–16.

Brenner, G. J. and J. D. Lattin. 2001. Notes on three species of Anthocoridae (Hemiptera:

Heteroptera) from Hawaii including the first record of *Buchananiella continua* (White). Proceedings of the Entomological Society of Washington 103: 386–388.

Carpintero, D. L., J. M. Maes, and M. D. Coscaron. 1997. Catalogo de los Anthocoridae (Heteroptera) de Nicaragua. Revista Nicaraguense de Entomologia, No. 41. 23–28.

Champion, G. C. 1897–1901. Insecta: Rhynchota (Hemiptera - Heteroptera). Vol. II, pp. 305–344. *In* Godman and Salvin, eds. Biologia Centrali-Americana, London. 1900.

Clausen, C. P., ed. 1978. Introduced Parasites and Predators of Arthropod Pests and Weeds: A World Review. U.S. Department of Agriculture, Agricultural Research Service, Agriculture Handbook 480. 545 pp.

Cullney, T. W. and W. T. Nagamine. 2000. Introductions for biological control in Hawaii, 1987–1996. Proceedings of the Hawaiian Entomological Society 34: 121–133 pp.

Davis, C. J. and M. Chong. 1967. *Macrotrachelia thripiformis* Champion. Proceedings of the Hawaiian Entomological Society 19: 329.

———. 1968. Recent introductions for biological control in Hawaii, - XIII. Proceedings of the Hawaiian Entomological Society 20: 25–34.

Davis, C. J. and N. L. H. Krauss. 1963. Recent introductions for biological control in Hawaii. 8. Proceedings of the Hawaiian Entomological Society 18: 245–249.

———. 1965. Recent introductions for biological control in Hawaii. X. Proceedings of the Hawaiian Entomological Society 19: 87–90.

———. 1966. Recent introductions for biological control in Hawaii. XI. Proceedings of the Hawaiian Entomological Society 19: 201–207.

Drake, C. J. and H. M. Harris. 1926. Notes on American Anthocoridae with descriptions of new forms. Proceedings of the Biological Society of Washington 39: 38–46.

Dufour, L. 1833. Memoire sur les genres *Xylocoris*, *Leptopus* et *Velia*. Annales de la Société des Entomologique de France 2: 104–118, 1 plate.

Fabricius, J. C. 1794. Entomologia systematica emendata et aucta, sucundum classes, ordines, genera, species, adjectis synonymis, loci, observationibus. C.G. Proft, D. Hafniae 4: i–vi, 1–472.

Fieber, F. X. 1836–1837. Beiträge zur gestammten Natur - und Heilwissenschaft (W.R. Weitenweber ed.). Barth. Prague. 1(1)1836: 97–111, 1837: 337–355.

Ford, L. J. 1979. The phylogeny and biogeography of the Cimicoidea (Insecta: Hemiptera). M.S. Degree, University of Connecticut, i–vii + 138.

Hambleton, E. J. 1944. *Heliothis virescens* as a pest of cotton, with notes on host plants in Peru. Journal of Economic Entomology 37: 660–666.

Henry, T. J. 1988. Family Anthocoridae Fieber, 1837. pp. 12–28. *In* Henry, T. J. and R. C. Froeschner, eds. Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States. E.J. Brill, Leiden. 958 pp.

Herring, J. L. 1966. The genus *Orius* of the Western Hemisphere (Hemiptera: Anthocoridae). Annals of the Entomological Society of America 59: 1093–1109.

———. 1967. Insects of the Micronesia Heteroptera: Anthocoridae. Bishop P. Museum, Insects of Micronesia, Vol. 7, No. 8. 391–414.

Kirkaldy, G. W. 1902. Hemiptera. Fauna Hawaiiensis, III. pt. II: 93–174, pls. 4–5. London.

———. 1908. A list of the described Hemiptera (excluding Aleyrodidae and Coccidae) of the Hawaiian Islands. Proceedings of the Hawaiian Entomological Society 1: 135–161.

Lattin, J. D. 2005a. *Dufouriellus ater* (Puton), *Macrotrachelia nigronitens* (Stål) and *Xylocoris* (*Arrostelus*) *flavipes* (Reuter) (Hemiptera: Heteroptera: Cimicoidea: Anthocoridae): first records from the Hawaiian Islands. Proceedings of the Entomological Society of Washington 107: 466–468.

———. 2005b. *Scoloposcelis discalis* Van Duzee, 1914 a synonym of *Anthocoris galactinus* Fieber and *Xylocoris umbrinus* Van Duzee, 1921 a synonym of *Piezostethus californicus* Reuter, 1884 (Hemiptera: Heteroptera: Anthocoridae). Proceedings of the Entomological Society of Washington 107: 971–972.

———. 2006. *Nesidiocheilus hawaiiensis* Kirkaldy, 1902, a synonym of *Acanthia campestris* Fabricius, 1794 (Hemiptera: Heteroptera: Lyctocoridae). Proceedings of the Entomological Society of Washington 108: 240.

Lattin, J. D., T. Lewis, and D. R. Horton. 2001. *Buchananiella continua* (White) (Hemiptera: Heteroptera: Anthocoridae) from California, with new synonymy. Proceedings of the Entomological Society of Washington 103: 558–560.

Mau, R. 1977. *Paratriphleps laeviusulus* Champion. Proceedings of the Hawaiian Entomological Society 22(3): 399.

Nakahara, L. 1981. *Paratriphleps laevisculus* Champion on alfalfa at Hoolehua, Molokai. Proceedings of the Hawaiian Entomological Society 23(2): 332.

Nishida, G. M., ed. 1994. Hawaiian Terrestrial Arthropod Checklist. Second Edition. Bishop Museum Technical Report No. 4. 287 pp.

———. 1997. Hawaiian terrestrial arthropod checklist. Third Edition. Hawaiian Biological

Survey. Bishop Museum. Bishop Museum Technical Report No. 12. 263 pp.

———. 2002. Hawaiian terrestrial arthropod checklist. Fourth Edition. Hawaiian Biological Survey. Bishop Museum. Bishop Museum Technical Report No. 22. iv+310 pp.

Oatman, E. R. 1978. Noctuidae pp. 205–210. *In* Clausen, C. P., ed. Introduced Parasites and Predators of Arthropod Pests and Weeds: A World Review. U.S.D.A., Agricultural Research Service, Agriculture Handbook No. 480. 545 pp.

Péricart, J. 1972. Hémiptères Anthocoridae, Cimicidae, et Microphysidae de l'Ouest - Paléarctique. *In* Faune de l'Europe et du Bassin Méditerranéen 7: i–iv, 1–404. Masson, Paris.

———. 1996. Family Anthocoridae Fieber 1836, pp. 108–140. *In* Aukema, B. and C. Rieger, eds. Catalogue of the Heteroptera of the Palearctic Region. Vol. 2 Cimicomorpha I. 361 pp.

Perkins, R. C. L. 1906. Leaf-hoppers and their natural enemies (Introduction). Report of work of the Experiment Station of the Hawaiian Sugar Planters' Association. Division of Entomology. Bulletin No. 1. Introduction pp. 232–236. pl. 15, figs. 4–6.

———. Introduction. *In* Fauna Hawaiiensis. David Sharp, ed. I. xv–ccxxviii, pls. 1–16. Cambridge University Press.

Puton, A. 1896. Hémiptères nouveaux. Revue d' Entomologie 15: 233–234.

Reimer, N. J. 1988. Predation of *Liothrips urichi* Karny (Thysanoptera: Phlaeothripidae): a case of biotic interference. Environmental Entomology 17: 132–134.

Reuter, O. M. 1875. Genera Cimicadarum Europae. Bihang till Konglia Svenska Vetenskaps-Akademiens Handlingar 3: 1–66.

Say, T. 1831–1832. Descriptions of New Species of Heteropterous Hemiptera of North America. New Harmony, Indiana. 39 pp.

Schuh, R. T. and J. A. Slater. 1995. True Bugs of the World (Heteroptera: Heteroptera). Comstock Press, Ithaca, New York. 336 pp.

Schuh, R. T. and P. Štys. 1991. Phylogenetic analysis of cimicomorphan family relationships (Heteroptera). Journal of the New York Entomological Society 99: 298–350.

Stål, C. 1860–1862. Bidrag till Rio Janeiro traktens Hemipter - fauna. Kongliga Svenska Vetenskaps - Academiens Handlingar. 2(7): 1–84 (1860; 3(6): 1–75 (1862).

Swezey, O. H. 1905. Leaf-hoppers and their natural enemies (Part VII. Orthoptera, Coleoptera, Hemiptera). Hawaiian Sugar Planters' Association Experiment Station, Division of Entomology Bulletin 1(7): 211–238.

Takahara, J. and T. Nishida. 1981. Eggs of the oriental fruit fly for rearing the predaceous anthocorid, *Orius insidiosus* (Say). Proceedings of the Hawaiian Entomological Society 23: 441–445.

Toyama, G. M. and J. K. Ikeda. 1976. An evaluation of the predators at animal farms on Leeward and Central Oahu. Proceedings of the Hawaiian Entomological Society 22: 369–379.

Usinger, R. L. 1946. Hemiptera: Heteroptera of Guam, pp. 11–103. *In* Insects of Guam, II. Bishop Museum Bulletin No. T89. 237 pp.

Van Duzee, E. P. 1914. A preliminary list of the Hemiptera of San Diego County, California. Transactions of the San Diego Society of Natural history 2: 1–57.

———. 1936. A report on some Heteroptera from the Hawaiian Islands, with descriptions of new species. Proceedings of the Hawaiian Entomological Society 9: 219–229.

Vargas, R. and T. Nishida. 1980. Life table of the corn earworm *Heliothis zea* (Bodde), in sweet corn in Hawaii. Proceedings of the Hawaiian Entomological Society 23: 301–307.

Walker, F. 1872. Catalogue of the specimens of Hemiptera Heteroptera in the collection of the British Museum. British Museum (Natural History), London 5: 1–202.

Weber, P. W. 1953. Recent liberations of beneficial insects in Hawaii. Proceedings of the Hawaiian Entomological Society 15: 127–130.

White, F. B. 1877. Descriptions of new species of heteropterous Hemiptera collected in the Hawaiian Islands by the Rev. T. Blackburn. No. 1. Annals and Magazine of Natural History (4)5: 110–114.

———. 1878. Descriptions of new species of heteropterous Hemiptera collected in the Hawaiian Islands by the Rev. T. Blackburn. No. 2. Annals and Magazine of Natural History (V)1: 356–374.

———. 1880. Descriptions of new Anthocoridae. Entomologist's Monthly Magazine 16: 142–148.

Wille, J. E. 1951. Biological control of certain cotton insects and the appliction of new organic insecticides in Peru. Journal of Economic Entomology 44: 13–18.

Zimmerman, E. C. 1947. Insects of Hawaii. Vol. 1. Introduction. University of Hawaii Press, Honolulu. 206 pp.

———. 1948. Insects of Hawaii. Vol. 3. Heteroptera. University of Hawaii Press, Honolulu. 255 pp.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 81–85

A NEW SPECIES OF *HAPLUSIA* (DIPTERA: CECIDOMYIIDAE: PORRICONDYLINAE) FROM SOUTHWESTERN PENNSYLVANIA

JOHN D. PLAKIDAS

111 Emerson Avenue, Pittsburgh, PA 15215, U.S.A. (e-mail: johnplakidas@comcast.net)

Abstract.—The larva, pupa, and adults of a new species, ***Haplusia funebris* Plakidas**, from southwestern Pennsylvania, are described and illustrated. *Haplusia funebris* is compared to *H. rubra* (Felt) and *H. fusca* (Felt) in a key to the North American species.

Key Words: *Haplusia*, new species, Cecidomyiidae, Porricondylinae

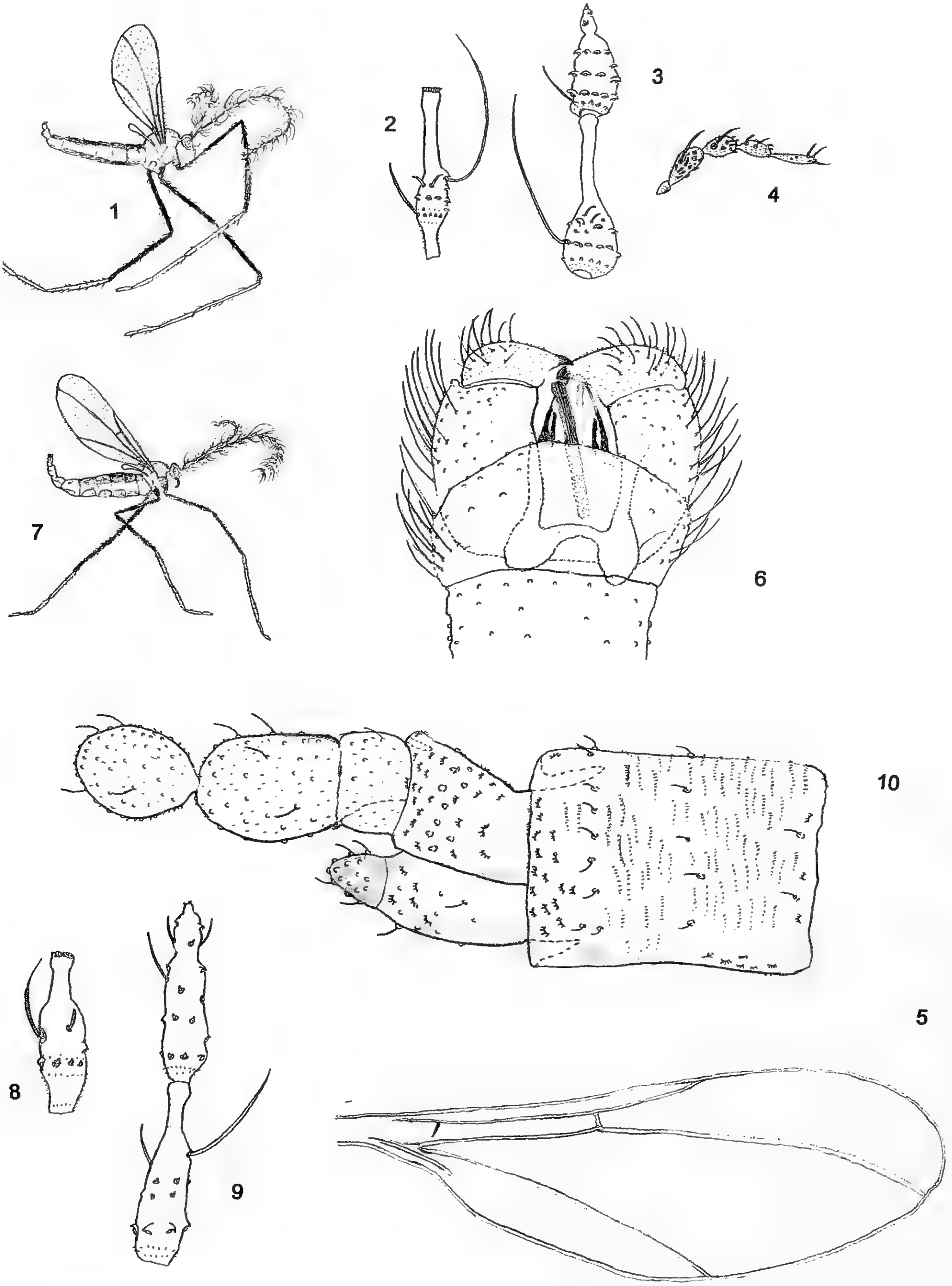
The genus *Haplusia* Karsch(Diptera: Cecidomyiidae: Porricondylinae) is worldwide in distribution with 17 extant and 1 fossil species (Gagné 1978, 2004). Adults are dark brown to black with white tarsi and have 14 flagellomeres that lack circumfila. The larvae have a densely spiculose cuticle and a head capsule with apodemes joined posteriorly. The biology of three larvae, *H. brevipalpis* (Mamaev), *H. heteroptera* (Mamaev and Spuņģis), and *H. palpata* (Mamaev) were first described by Spuņģis (1985) in which they were found to inhabit decaying wood. Plakidas (1999) reported *H. rubra* (Felt) from crevices of rotting bark on ash or tulip poplar. Full grown larvae of both *H. rubra* and *H. funebris* overwintered full grown with adults emerging in May and June.

Here I describe a newly discovered *Haplusia* whose larvae were found living in bark of a fallen black cherry tree, *Prunus serotina* Ehrh., in advanced decay. The rotting bark was light brown in color, moist, and easily pulled open to reveal the hidden larvae, 15 collected in all. Three were cleared in KOH and slide mounted in euparal, the remainder were cultured in plastic petri dishes moistened with paper towels. Four adults, one male and three females were reared. All were lightly cleared in KOH and slide mounted in euparal. Comparison of these adults and larvae with other known *Haplusia* from North America is presented in an accompanying key to species.

Haplusia funebris Plakidas, new species.
(Figs. 1–13)

Adult.—Eye black, antenna slate gray with black setal whorls; thorax brown dorsally, yellow brown laterally; wings smoky black, without spots and fringed with black, setiform scales; coxae, trochanters, femora, tibiae, and first tarsomere black, the last four tarsomeres white; abdomen dorsally and ventrally slate gray except yellow brown laterally.

Male (Fig. 1): Length: 3.5 mm. *Head*: antenna with 14 flagellomeres that lack circumfila; first flagellomere (Fig. 2) with basal stem densely covered with microtrichia, the node with a basal whorl of long setae, microtrichia extending



Figs. 1–10. *Haplusia funebris*. 1, Male. 2, Male 1st flagellomere. 3, Male flagellomeres 13–14. 4, Male palpus. 5, Wing. 6, Male genitalia. 7, Female. 8, Female 1st flagellomere. 9, Female flagellomeres 13–14. 10, Female abdomen, segments 9–10.

only to whorl of longer setae at midlength, neck bare, remaining flagellomeres (Fig. 3) without basal stem, microtrichia extending only to basal whorl of setae; palpus with palpiger + four segments, last segment equal in length to third, each segment covered with microtrichia and sparsely covered with setae. *Thorax*: Scutum with dorsocentral and dorsolateral rows of setae, lateral sclerites bare; wing (Fig. 5) 4 mm: Rs vein nearly perpendicular to R5; medial veins absent; Cu not forked, extending to wing margin; Cu1 absent; A1 prominent near base, remainder obsolete. Tarsal claws simple, empodia rudimentary. *Abdomen*: Tergites 1–7 and sternites 2–7 densely covered with microtrichia and sparsely covered with long setae; 8th and 9th segments lightly sclerotized, covered with microtrichia and sparsely covered with long setae. *Genitalia* (Fig. 6): Cerci convex apically; aedeagus sclerotized, as long as gonocoxites; parameres sclerotized laterally, joined ventrad of aedeagus; gonostyli densely covered with microtrichia, with long setae dorsally, the apical tooth comprised of a tuft of closely appressed bristles.

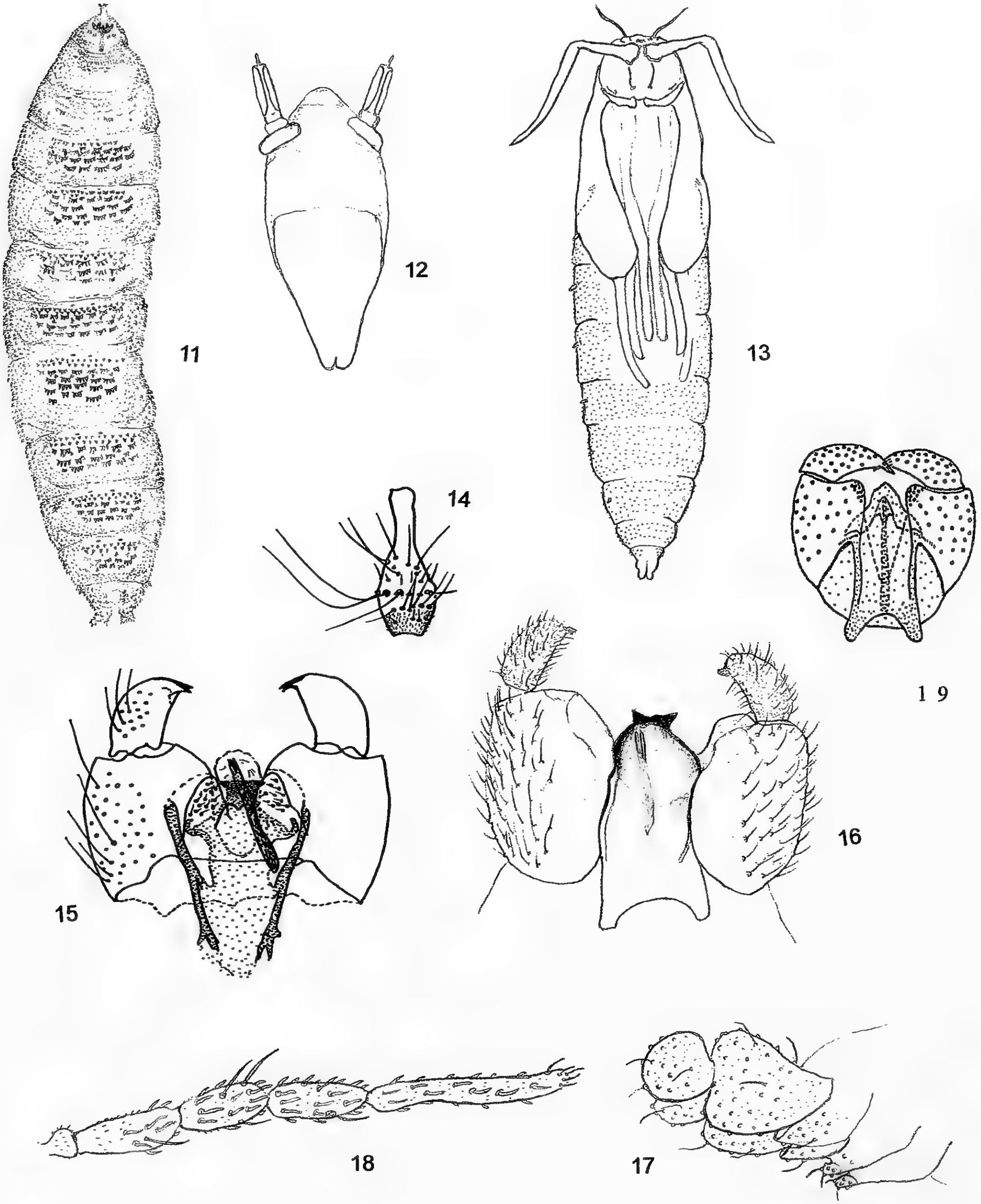
Female (Fig. 7): Length: 4 mm. *Head*: antenna with 14 flagellomeres, circumfila absent; first flagellomere (Fig. 8) with a short basal stem and rows of microtrichia confined mainly to stem and basal 3rd of node, neck bare; remaining flagellomeres (Fig. 9) lacking basal stem and microtrichia extending to basal whorl of setae. *Thorax*: Scutum with dorsocentral and dorsolateral rows of setae, lateral sclerites lacking setae; wing and tarsal claws as in male. *Abdomen*: First tergite with a single posterior row of setae, tergites 2–8 lightly sclerotized and sparsely covered with setae; sternites 2–7 lightly sclerotized and sparsely covered with setae; 9th segment (Fig. 10) membranous, protrusible, dorsum covered with rows of microtrichia, ventral surface sparsely covered with fanlike patches of microtrichia; hypoproct bilobed and densely covered with short setae apically; cercus 2-segmented, first segment elongate to rectangular, the cuticle folded near base giving appearance of a third segment; second segment ovoid and much shorter than first (Fig. 10), densely covered with microtrichia and setae.

Larva (Fig 11).—Elongate, 4–5 mm in length; dusty white; head capsule (Fig. 12) elongate-ovoid with apodemes joined posteriorly and shorter than head; antenna about 4 times longer than wide, with an apical papilla; spatula tridentate, flanked on each side by 2 groups of 2 lateral papillae, each with a coniform seta. Entire lateral cuticle spiculose. Ventral surface of abdominal segments 1–8 with transverse fanlike rows of blunt spicules. Spiracles of 8th segment situated on posterolateral margin extending above body wall; 9th segment bilobed, the anus flanked by rounded platelets.

Pupa (Fig 13, illustrated from a female pupal skin).—Head: Face with 2 pair of papillae, 1 of each pair simple, the other setiform, situated anterior to clypeus; thoracic spiracles short, rounded at apex and elevated above body wall, with 1 simple and 1 setiform papilla situated posterior to each spiracle; abdominal cuticle covered with posteriorly directed macrospicules, except for 9th segment which is smooth and bilobed; abdominal spiracles situated on dorsolateral margins of segments 1–7 with 2 setiform papillae situated posterior to each spiracle.

Type material.—Holotype: Male, reared 27-V-2000, collected 5 km N Aspinwall, Allegheny Co. PA. Paratype: Female; reared 24-V-2000, 5 km N Aspinwall, Allegheny Co. PA. Paratype: Larva; same pertinent data. All type material deposited in the National Museum of Natural History, Smithsonian Institution, Washington D.C.

Etymology.—The specific name, *funebris*, refers to the black color of the adults.



Figs. 11–19. 11–13, *Haplusia funebris*. 11, Larva, ventral. 12, Head capsule, dorsal. 13, Pupa, ventral. 14–15, *Haplusia fusca*. 14, Male 3rd flagellomere. 15, Male genitalia (from Parnell 1971). 16–18, *Haplusia rubra*. 16, Male genitalia with 10th segment removed. 17, Female cercus and hypoproct, lateral. 18, Palpus. 19, *Haplusia palpata* male genitalia, dorsal (from Spuņģis 1985).

Discussion.—*Haplusia funebris* is easily differentiated from the other two North American species, *H. fusca* (Felt) and *H. rubra* (Felt), by genitalic differences. Both *H. fusca* (Fig. 15) and *H. rubra* (Fig. 16) have heavily pigmented parameres with toothlike apices, whereas *H. funebris* (Fig. 6) has parameres sclerotized basally and laterally and membranous apically. One Palearctic species, *H. palpata* (Mamaev) (Fig 19), is generally similar to *H. funebris* but differs with respect to the sclerotization of the parameres and morphology of the gonocoxal apodemes. In *H. palpata* (Fig. 19), the parameres are heavily sclerotized apically and the gonocoxal apodemes narrow basally with a wide transverse bridge. Conversely, *Haplusia funebris* (Fig. 6) has membranous parameres and the gonocoxal apodemes are broadly rounded basally with a narrow transverse bridge.

THE FOLLOWING KEY TO NORTH AMERICAN SPECIES IS MODIFIED FROM PARNELL (1971).

1. Male 3rd flagellomere with stem shorter than node (Fig. 14), parameres sclerotized apically and appearing toothlike (Fig. 15); female unknown . . . . *fusca*
– Male 3rd flagellomere with stem longer than node, parameres either sclerotized or membranous apically 2
2. Male genitalia with parameres sclerotized apically and appearing toothlike (Fig 16); basal segment of female cercus pyriform (Fig 17); palpus with 4th segment twice as long as 3rd (Fig 18) . . . . *rubra*
– Male genitalia with parameres sclerotized laterally, fused apically and not appearing toothlike (Fig. 6); basal segment of female cercus cylindrical (Fig 10); palpus with 4th segment nearly same length as 3rd (Fig 4) . . . . *funebris*

ACKNOWLEDGMENTS

I thank Dr. R.J. Gagné, Research Entomologist, Emeritus, Systematic Entomology Laboratory, USDA for reviewing and making helpful comments on the manuscript. I also thank Dr. V. Spuņģis, Faculty of the Department of Zoology and Animal Ecology, University of Latvia, for his review and for providing the illustration for *H. palpata*, (Fig. 19). I thank the Entomological Society Of America for permission to use figs. 8 and 9 (*Haplusia fusca*) from Parnell (1971).

LITERATURE CITED

Gagné, R. J. 1978. New synonymy and a review of *Haplusia* (Diptera: Cecidomyiidae). Proceedings of the Entomological Society of Washington 80(4): 517–519.

———. 2004. A Catalog of the Cecidomyiidae (Diptera) of the World. Memoirs of the Entomological Society of Washington, No. 25, 408 pp.

Parnell, J. R. 1971. A revision of the Nearctic Porricondylinae (Diptera: Cecidomyiidae) based largely on an examination of the Felt types. Miscellaneous Publications, Entomological Society of America 7: 275–348.

Plakidas, J. D. 1999. Identification of the North American Porricondyline Larvae (Diptera: Cecidomyiidae). Loyalfield Publishing, Pittsburgh, PA. 129 pp.

Spuņģis, V. 1985. Gall midges of the subtribe Diallactini (Diptera: Cecidomyiidae) in Latvia. Latvijas Entomologs 28: 38–53. (in Russian with English summary).

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 86–89

DESCRIPTION OF THE *LIMNEPHILUS GRANTI* (NIMMO) FEMALE WITH A REDESCRIPTION OF THE MALE (TRICHOPTERA: LIMNEPHILIDAE)

David E. Ruiter

6260 South Grant Street, Centennial, CO 80121, U.S.A. (e-mail: druiter@msn.com)

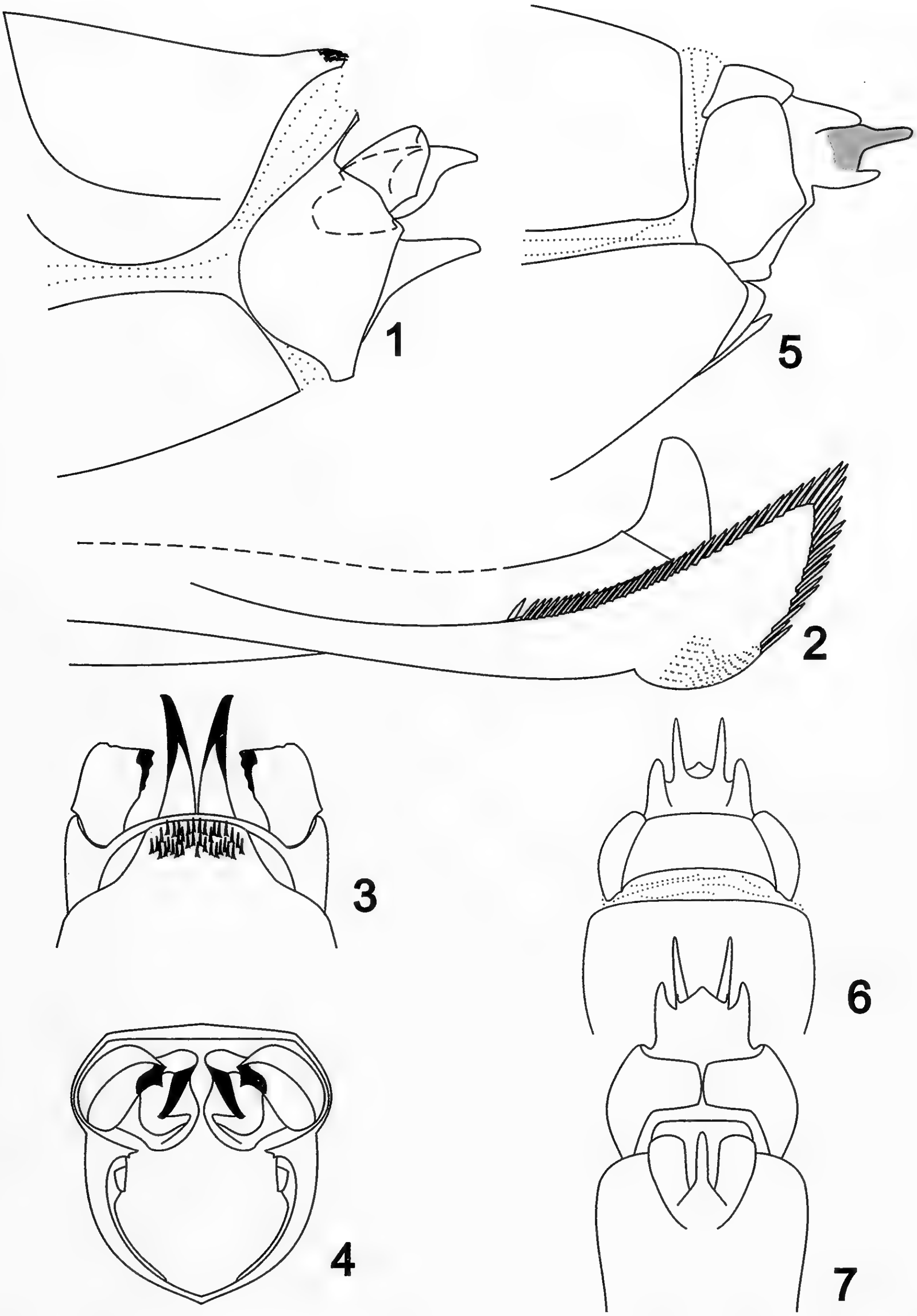
Abstract.—Description of the female and redescription of the male of *Limnephilus granti* (Nimmo 1991) are provided. Additional Arizona collection localities are presented.

Key Words: Trichoptera, Limnephilidae, *Limnephilus granti*, Arizona, caddisfly

Limnephilus granti (Nimmo 1991) was described from a single male (AZ: Graham County, Grant Creek, Hospital Flat Campground, Graham Mountains). Nimmo (1991) indicated similarity with Schmid's (1955) *L. assimilis* group, in particular *L. parvulus* (Banks) while Ruiter (1995) indicated a questionable affinity with *L. rohweri* (Banks). Discovery of the female does not support either conclusion although the reduced spur count is found in some members of Schmid's *L. assimilis* group. The *L. granti* spur count is reduced from 1-3-4 in both sexes. The female can be distinguished from other *Limnephilus* by the combination of low spur count; completely sclerotized subgenital plate; 9th segment with distinct tergite and distinct ventromesal separation; and tubular 10th segment. The reduced spur count of *L. granti* leads to couplet 10 (*L. solidus* (Hagen) and *L. hamifer* Flint) in Ruiter (1995). The laterally and ventrally divided 9th segment also support this association. However, numerous characteristics of the female 9th tergite and 10th segment, and the male 9th tergal strap and aedeagal parameres, do not support a close relationship with either *L. solidus* or *L. hamifer*. Therefore, *L. granti* should still be considered *incertae sedis*. *Limnephilus granti* is apparently extremely rare and all specimens have been collected from springs and their immediate outlets in the ponderosa pine region of eastern Arizona. Additional efforts to preserve these rare habitat types and survey their aquatic communities should continue. The following description is based on one male and three females.

Limnephilus granti (Nimmo 1991)
(Figs. 1–7)

Adult.—Head yellow orange with dark brown blotches surrounding ocelli and anterior warts; antenna about 0.7 length of forewing, between 60 and 70 segments, scape about 4 times length of 2nd segment, 3rd segment about twice length of 2nd segment, 4th segment about 1.5 length of 2nd segment, remaining segments subequal to mid-antenna then gradually decreasing in length to apex; 3 ocelli, lateral ocelli subequal to pre-ocelli wart; lateral ocelli located one ocelli width closer to eye than medial suture, located mid-length of head; eye large, width equal to distance between medial suture and eye; medial suture complete;



Figs. 1–7. *Limnephilus granti.* 1, Male genitalia, lateral aspect. 2, Male aedeagus, lateral aspect. 3, Male genitalia, dorsal aspect. 4, Male genitalia, posterior aspect. 5, Female genitalia, lateral aspect. 6, Female genitalia, dorsal aspect. 7, Female genitalia, ventral aspect.

posterior warts oval, width about 2 times length, with about 12 macrosetae; head surface with numerous small, hairlike setae between and slightly behind lateral ocelli, most setae with small, pale, single, basal warts, single pair of large macrosetae located between and slightly behind lateral ocelli; facial warts consisting of 2 subequal, lateral pairs; mesal wart not obvious, mesal area covered with macrosetae; postocular wart relatively narrow, linear, as long as eye height; maxillary palpus three-segmented in male and five-segmented in female, male proportions = 0.4:1:1, female proportions = 0.3:1:1:0.6:0.8; labial palpus 3-segmented in both sexes. proportions = 0.5:0.7:1, basal 2 segments flattened tear-shaped, oval, flattened mesally; labrum 2 times as long as widest portion, widest portion at basal swelling; anterior genal projection present; temporal suture inconspicuous. Pronotum yellow orange, with single pair dorsomesal warts, separated mesally; lateral pronotal area with several individual macrosetae. Mesonotum yellow orange, with pair of linear setal areas, each comprised of 4–6 macrosetae, distinct warts absent; scutellar setal area dark brown with 3–4 isolated macrosetae arranged linearly on each side.

Legs yellow orange, darkening towards tarsi, spines black, tibial spurs orange. Male forefemur with basal black spicules reaching mid length of femur. Tibia and first four tarsal segments with numerous black spines. Apical tarsal segments with single pair of dark spines on ventral surface. Male and female foretarsal proportions = 1:0.6:0.4:0.3:0.3. Tibial spurs variable in female; 1-2-2 in male, 1-2-2 or 1-2-4 in female; evidence of a 1-2-3 and 1-3-4 spur count usually present with reduced basal pits at point of typical spur attachment.

Wing length 13–14 mm. Forewing five times as long as widest portion; brightly contrasted coloration, base color pale orange; hyaline speckling in radial and apical cells; larger hyaline stripes in thyridial cell and at base of cell V; setae on veins slightly upright, not particularly strong; setae on wing membrane recumbent, fine, hairlike, same color as underlying membrane, i.e., white on white, orange on orange. Hind wing pale yellow, darker along costal area; setae on veins pale, upright, fine, sparse; setae on membrane pale, recumbent, fine, sparse at base, denser towards apex.

Venation similar in both sexes; distal margins smoothly rounded. Forewing with R1–R2 separate throughout length, narrowed and slightly curved at pterostigma; apical forks I, II, III, and V, all cells sessile; anastomosis staggered, R3-discoidal cell common boundary slightly longer than t1, less than discoidal cell height; discoidal cell about 1.5 length of RS; t1 linear, about twice length t2; t1 and t2 not parallel; t3 long, originating on Cu1, nearly perpendicular to thyridial cell, curved posteriorly; three anal cells, cells A1 andA3 small, A2 about 0.5 length of A1+2+3. Hindwing with enlarged anal area; distal margin at Cu not strongly incised; hooked setae along anterior margin absent; R1–R2 separate throughout length, touching near base, separating towards apex, curved at pterostigma; apical forks I, II, III, and V present, all cells sessile; anastomosis staggered; R3-discoidal cell common boundary equal or shorter than t1, less than discoidal cell height; discoidal cell about twice RS; t1 linear, about equal in length to t2; t1 and t2 not parallel; t3 long, originating on Cu1, strongly oblique to wing length; posterior 3 anal cells with long, hairlike setae.

Abdomen orange, becoming brown dorsally; setae fine, inconspicuous except stronger on male 8th; 5th segment gland, kidney shaped, large, surface of 5th tergite finely reticulate over entire surface; ventral spurs absent.

Male genitalia (Figs. 1–4): Tergite 8 with small posteromesal spinate patch, spines appressed. Segment 9 with very narrow, tall tergite. Superior appendages roughly quadrate laterally; thick and widely separated mesally. Intermediate appendages longer than superior appendages, narrowed apically to slightly downturned apex. Inferior appendages broadly separated ventromesally; directed caudad with nearly acute apex, extending caudally as far as intermediate appendages. Parameres extending beyond endophallus; apical 1/4 expanded with marginal fringe of strong setae.

Female genitalia (Figs. 5–7): Median lobe of subgenital plate subequal to lateral lobes; narrowest at apex; apex narrow, nearly acute. Lateral lobes of subgenital plate roughly parallel; separated laterally from 8th segment. Subgenital plate broad. Ventral lateral lobes of ninth large, quadrate, distinctly separated from tergum, nearly fused mesally. Ninth tergum broad dorsally; ventrolaterally slightly separated from 10th. Tenth segment strongly sclerotized, comprised of a complete cylinder; dorsal lateral appendages separated from 10th; apex of 10th with bladelike dorsal lateral lobes, dorsomesal margin concave, ventromesal margin, acutely convex. Spermatheca with spermathecal vestibule globular, smoothly merged with spermathecal body, with constriction at confluence of vestibule with body; chitinous spermathecal ring tapered, cap-like; no constriction below chitinous ring; additional spermathecal gland located about one width of spermathecal vestibule from spermathecal vestibule; entire inner surface of spermatheca with minute spicules, without obvious addition markings.

Material examined.—ARIZONA: Apache County, Government Spring, about 2 miles south of Greer, along West Fork Little Colorado River, Dean W. Blinn, 8 June 2003, 2♀; same, 9 June 2003, 1♂; light trap, Rosey Creek at Highway 373, near Greer, Dean W. Blinn, 2 July 2003, 1♀. Rosey Creek female designated allotype and deposited at California Academy of Sciences, San Francisco, CA, with holotype. Remainder of material placed in author's collection.

ACKNOWLEDGMENTS

I thank Dean W. Blinn for his continued search for, and collecting at, these small isolated habitats and providing the material on which this paper is based. The Ohio Biological Survey kindly provided permission for reuse of the male figures. I also thank three reviewers for comments which improved this paper.

LITERATURE CITED

Nimmo, A. P. 1991. Seven new species of *Limnephilus* from western North America with description of female of *L. pallens* (Banks) (Trichoptera: Limnephilidae, Limnephilinae, Limnephilini). Proceedings of the Entomological Society of Washington 93(2): 499–508.

Ruiter, D. E. 1995. The adult *Limnephilus* Leach (Trichoptera: Limnephilidae) of the New World. Ohio Biological Survey Bulletin, New Series 11(1): iv + 200 pp.

Schmid, F. 1955. Contribution à l'étude des Limnophilidae (Trichoptera). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 28: 1–245.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 90–101

A NEW GENUS AND SPECIES OF FLEA BEETLE (COLEOPTERA: CHRYSOMELIDAE: ALTICINAE) FROM THE RAINFOREST CANOPY IN COSTA RICA

DAVID G. FURTH

Department of Entomology, National Museum of Natural History, Smithsonian Institution, P. O. Box 37012, MRC 165, Washington, D. C. 20013-7012, U.S.A. (e-mail: furthd@si.edu)

Abstract.—***Laselva***, **n. gen**, and ***Laselva triplehorni***, **n. sp.**, are described and illustrated from the canopy of a lowland Atlantic rainforest in Costa Rica. The genus belongs to the "Sphaeronychini" of the Alticinae.

Key Words: La Selva, ALAS Project, morphology, rainforest canopy fogging, Sphaeronychini, Monoplatini

This new genus belongs to an unusual group of genera of the Alticinae often called the "Monoplatini or Sphaeronychini." This group has tradtitionally been placed near the end of the Alticinae in checklists (e.g., Seeno and Wilcox 1982) and cataloges (e.g., Heikertinger and Csiki 1939–40, Riley et al. 2003) – a kind of "cataloge phylogeny" without any explanation as to the reason for such placement. The genera included in the "Monoplatini or Sphaeronychini" may be monophyletic, but no true study of this has been undertaken. Morphologically this group of Alticinae genera is characterized by a globosely swollen apical metatarsal segment, closed procoxal cavities, and striate elytra often with thick or very dense patterned or colored pubescence. However, there has never been an accurate or comprehensive treatment of the Alticinae at a tribal level, so the use of tribal names is not really a true reflection of their classification. As discussed in Furth and Suzuki (1998), Furth and Lee (2000), and elsewhere, I prefer not to follow the classification scheme in Reid (1995) that uses the tribal terminology of Alticini and Galerucini within the Galerucinae. See Discussion section below for more details about the use of the name "Monoplatini and Sphaeronychini."

Species in the "Monoplatini/Sphaeronychini" are relatively uncommon in collections and especially rare as series of specimens (personal observation). I have long believed that this is because many or most live in the forest canopy. Furth et al. (2003) reported 247 species in 68 genera of Alticinae collected by various structured/quantitative sampling techniques from a single site (La Selva Biological Station, Costa Rica) over a 9-year period. This study showed that over such a long sampling period Malaise trapping was more efficient on a per-individual basis and canopy fogging was more efficient on a per-sample basis. This study also demonstrated that fogging multiple tree species captured species at a higher rate than fogging a single tree species when species accumulation curves were compared on a per-individual basis, but not when compared on a per-sample basis. In Furth et al. (2003), of the 247 species collected only 37 species showed a bias for being found by canopy fogging and only 23 of these species showed a strong bias (i.e., $p<0.001$) for the canopy, one of these was listed as "Monoplatini new genus" and is the subject of this paper.

METHODS

The study site is La Selva Biological Station (Heredia, Costa Rica, 84° 01′W, 10° 26′N). It consists of a lowland Atlantic tropical rainforest of about 1500 hectares with elevations from 50–150 m and a mean annual rainfall of 4 m. The habitat is a mosaic of lowland rainforest, second growth forest of various ages and abandoned pastures (McDade et al. 1993).

The Alticinae inventory of La Selva was conducted as part of Project ALAS (http://viceroy.eeb.uconn.edu/ALAS/ALAS.html). Project ALAS was a large collaborative effort to survey the arthropods of La Selva Biological Station. A generalized set of sampling methods was applied to a wide range of arthropod taxa, from spiders and mites to many groups of Coleoptera, Diptera, Lepidoptera, and Hymenoptera. Field sampling and sample processing was been carried out largely by a resident staff of four persons recruited from communities surrounding La Selva and trained in entomological techniques (parataxonomists, *sensu* Janzen 1991). A relational database of collection, specimen, and identification data is managed using the biodiversity database application *Biota* (Colwell 1996). This project was a collaboration with the Instituto Nacional de Biodiversidad in Costa Rica (INBio, Gamez 1991). All specimens resulting from this project are labeled with INBio barcodes (in addition to standard locality labels). Specimens are deposited in the INBio collections facility in Santa Domingo de Heredia, Costa Rica, with the exception of those distributed to taxonomic specialists or collaborators, following INBio and Costa Rican regulations.

Canopy fogging sampling methods were described in Furth et al. (2003) and followed the general procedures of Erwin (1983), Adis et al. (1984), and Stork (1988). During the 1993–1994 sampling period, eighteen trees were selected for canopy fogging: six individual trees of the most common tree species at La Selva (*Pentaclethra macroloba* (Willd.) O. Ktze., Fabaceae), six individual trees of a species of intermediate abundance (*Virola koschnyi* Warb., Myristicaceae), and one individual each of trees from six additional families. Six areas dispersed across the available primary forest were chosen. In each area three trees were selected: a *Pentaclethra*, a *Virola*, and one of the six unique species. The three trees in a group were usually fogged on consecutive days, and the 6 groups were fogged at approximately two–month intervals over one calendar year. In October and November of 1994 a second sampling was done by fogging seven sets of three trees, all compressed into this two–month period instead of spread over a year. Again each group of three contained a *Pentaclethra macroloba*, a *Virola koschnyi*, and a distinct species in the "other" category. Another set of six samples was taken in late December 1999 and early January 2000. These were from diverse species in a variety of families, all from one area in primary forest. Finally, a set of six samples was taken in late December 1999 and early January 2000, all from one area in primary forest. Specimens were captured in funnels slung beneath tree crowns. Following fogging, a two-hour drop time was allowed. The fogging machine used a 3% solution of a natural pyrethrin insecticide with synergists, in a petroleum distillate carrier.

Specimens have three labels, one a general project locality label, a second with exact date, collecting code with the collecting method (FPM = fogging of *Pentaclethra macroloba*, FVK = fogging of *Virola koschnyi*, FOT = fogging of other species of trees), fogging event number, and funnel number, and the third is the project bar code. The holotype and some paratypes are deposited in the collection at the Instituto Nacional de Biodiversidad (INBio) in San José, Costa Rica. Other paratypes are deposited at the Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, D. C. U.S.A. (USNM).

The numbers associated with the antennomeres are not actual measurements, they are relative numbers taken from the ocular scale in the Leitz MZ APO dissecting microscope used in this study to indicate the relative lengths of the antennomeres.

The photographs of the genitalia and metafemoral spring were taken with an Olympus BX50 compound microscope using Auto-Montage imaging software.

RESULTS

***Laselva* Furth, new genus**

Type species: *Laselva triplehorni* Furth.

Description.—General shape oval. Body size small, less than 2 mm in length. Entire dorsum, including head, densely evenly pubescent (Fig. 1). Head broad, densely, coarsely punctate; due to heavy punctation without apparent frontal bossae or frontal furrows; eyes large, oval, interocular distance relatively narrow, especially on vertex; antennae short only reaching elytral humeri, stout with apical 4–5 antennomeres apparently more swollen than previous antennomeres; mandibles narrow, apically tapering, each with 3 teeth. Pronotum wide at least twice as wide as long, lateral margins subparallel, only slightly narrowing anteriorly, only slightly narrower than base of elytra; punctation dense, coarse; seta in anterolateral, subapical pore approximately as long as pronotum. Elytra with strong humeri, prominent basal calli (*sensu* Scherer 1983; subbasal raised areas); striate with 10 rows (including scutellar row) of subcontiguous punctures; epipleuron strongly arched dorsally to receive metafemur. Metafemur very swollen and relatively large; pro and mesotarsi with minutely appendiculate claws; metatibia (Figs. 2, 3) extending significantly beyond tarsal insertion (a distance approximately equal to first tarsal segment length). Metatarsal apical segment distinctly swollen, subglobose (sometimes with minutely subrugose surface as in Figs. 2, 3); metatibial apex with stout spine. Procoxal cavities open. Metafemoral spring: *Psylliodes* Morpho-Group (Furth 1989; Furth and Suzuki 1994; Furth and Suzuki 1998) with extended arm of dorsal lobe very short (not extending much beyond apex of ventral lobe), apically depressed, basal edge of spring flat-sided at about a 70 degree angle to central axis of dorsal lobe, basal angle of ventral lobe narrow, pointed dorsally, with very distinct sclerotized recurved flange (Fig. 4), length = 0.28 mm.

Remarks.—This new genus differs in form from all other "Monoplatini/Sphaeronychini" relative to the antennae, eye shape and size, metabibae, elytral punctation and pubescence, and body shape and size. It most closely resembles *Distigmoptera* Blake and *Hypolampsis* Clark, but has open procoxal cavities. With *Distigmoptera* it shares antennal form of the apical 5 antennomeres short and swollen, dorsum with dense coarse punctation and dense pubescence, and epipleura strongly arched dorsally to accommodate greatly swollen metafemora; however, *Distigmoptera* has the dorsum with much denser pubescence

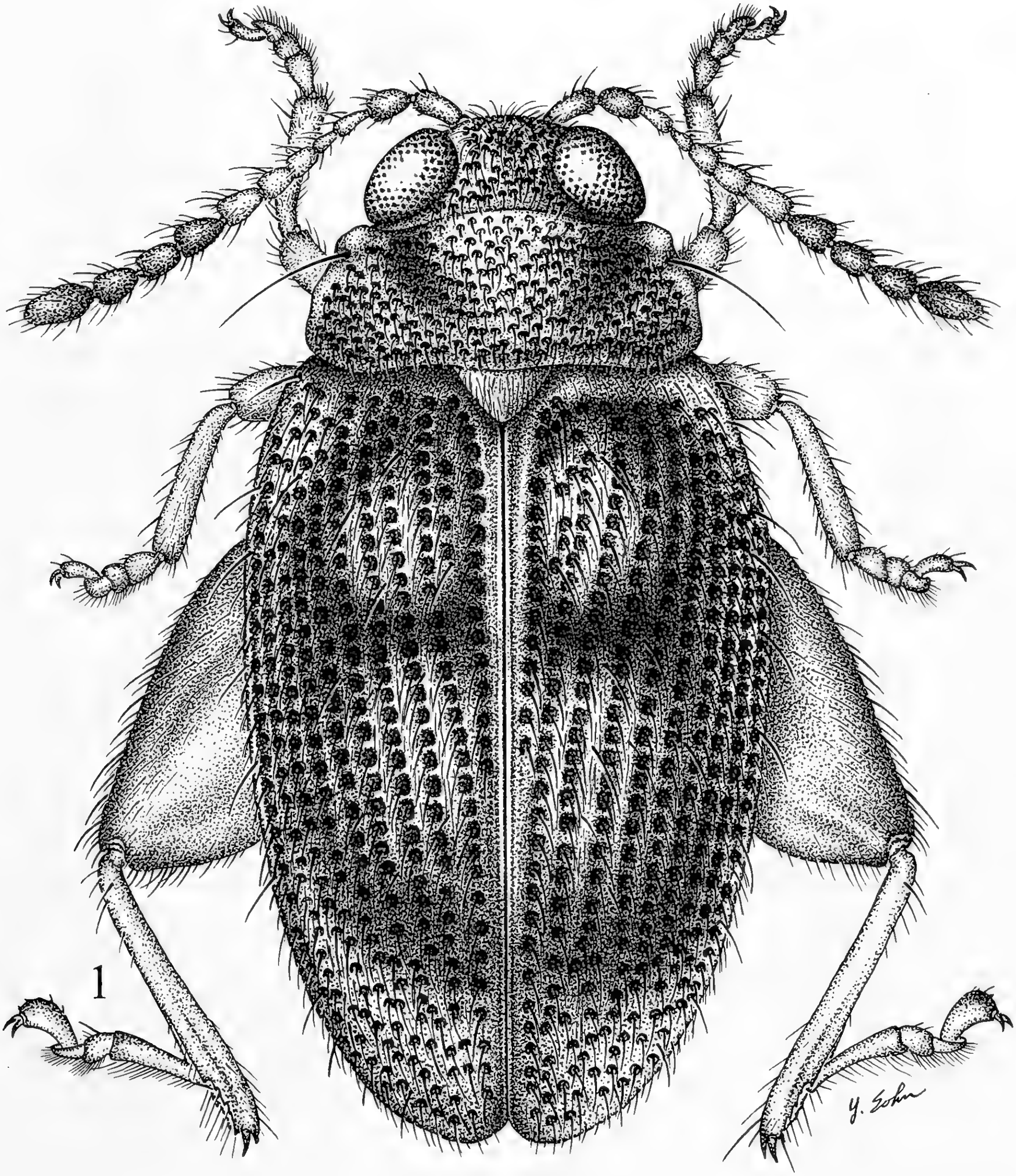
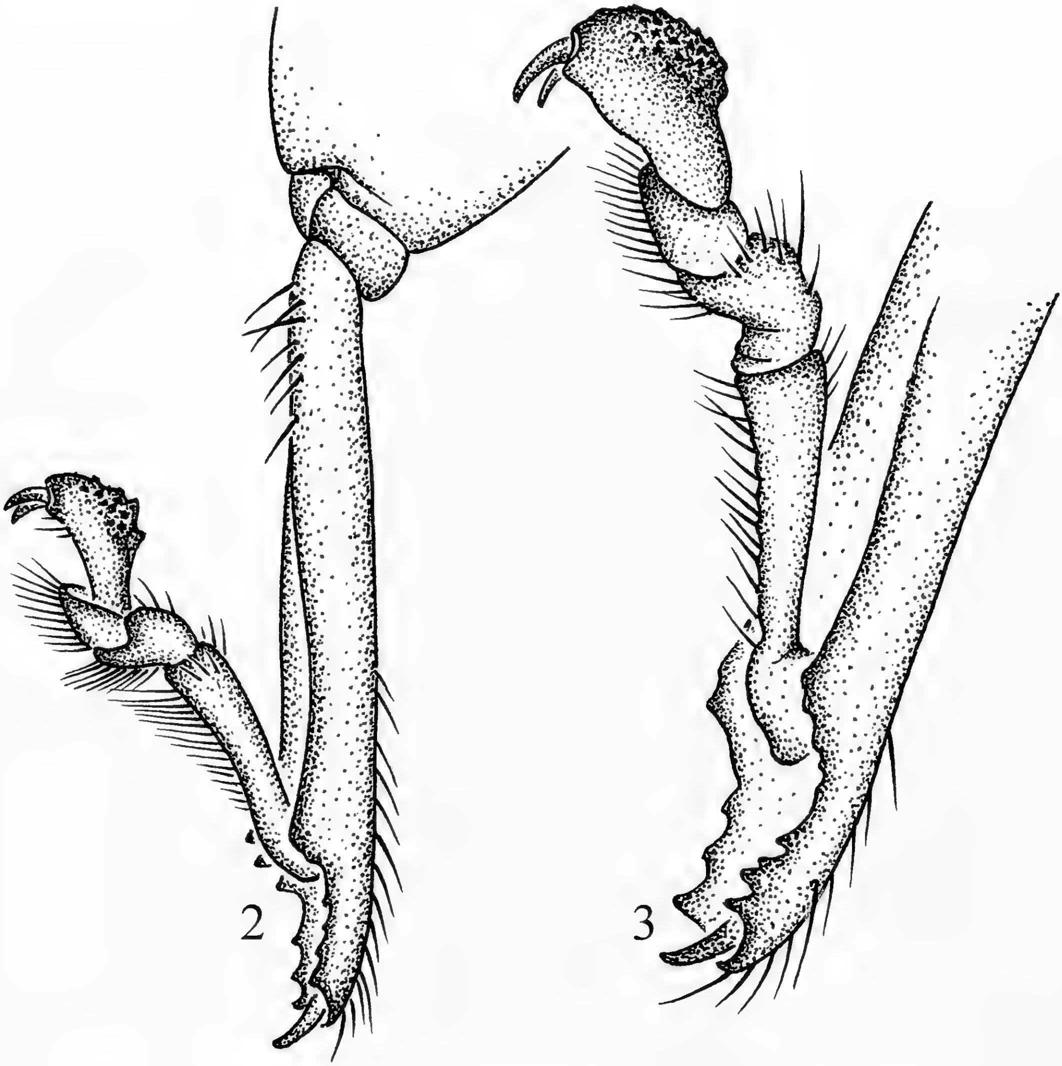


Fig. 1. *Laselvia triplehorni.* Dorsal habitus.

and coarser, more rugose punctation, elytra with more distinct basal calli, pronotum distinctly narrower at base than elytra and with protuberant medial area of disc, metatibia not extending far beyond metatarsal insertion, eyes small round, interocular distance at least twice that of the maximum eye width, and body size larger over 2.0 mm. It is less similar to *Hypolampsis* Clark, *Laselva* differing by oval body shape rather than elongate, evenly distributed dorsal pubescence rather than very dense patterned pubescence, coarse dorsal punctation, especially on



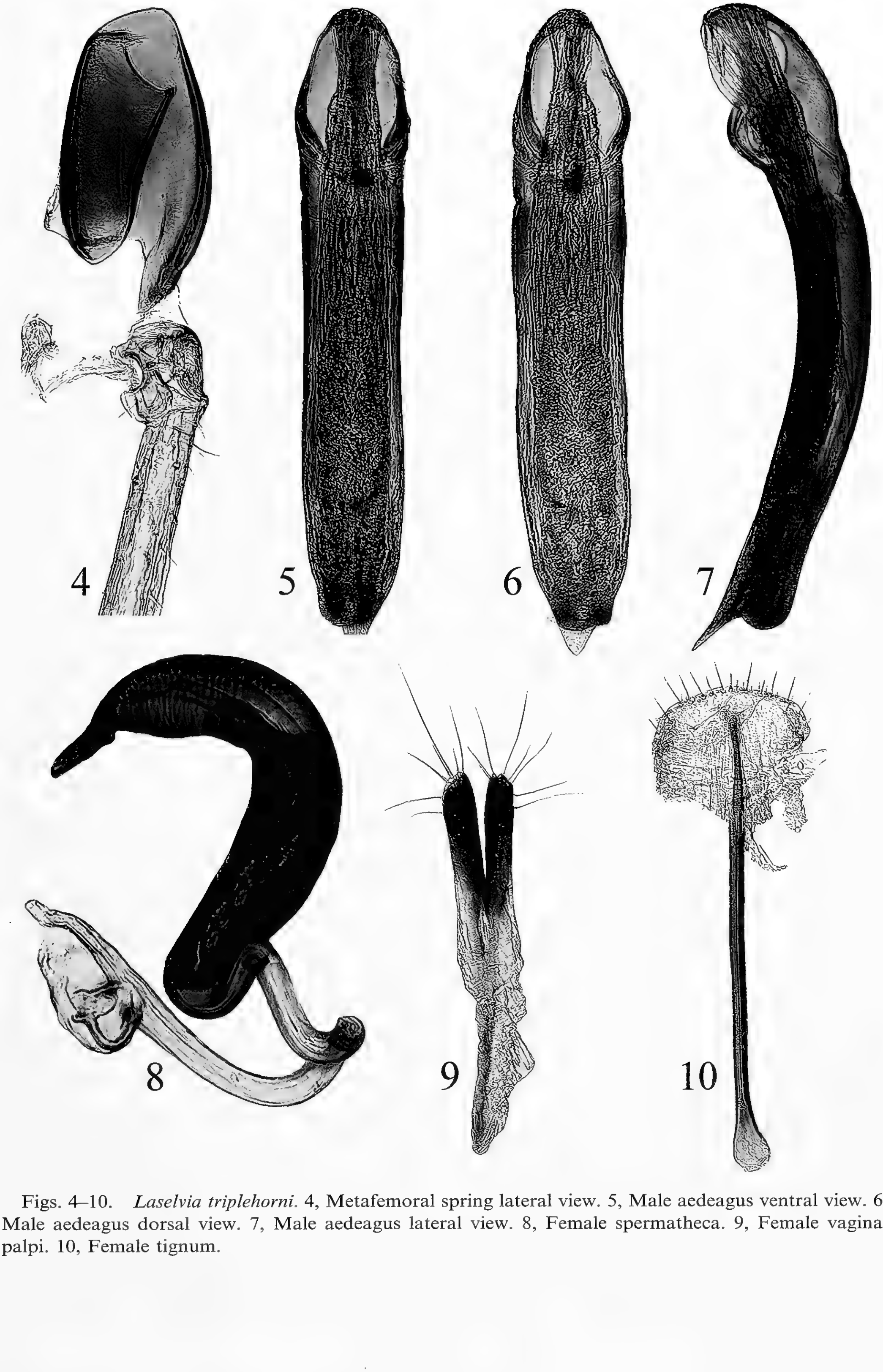
Figs. 2–3. *Laselvia triplehorni*. 2, Metatibia, medial view. 3, Metatibia, medial view, twisted and enlarged.

vertex and frons, extended metatibial apex. *Laselva* has somewhat similar oval body shape, metafemoral shape, and unusual metatarsal insertion to *Ulrica* Scherer, but differs in many characters such as the stout thickened antennal form, prominent elytral humeri and basal calli, coarse dorsal punctation, and dorsal pubescence.

Etymology.—By an arbitrary combination of letters in the female gender, this genus is named for La Selva Biological Station (Heredia, Costa Rica) where it was discovered as part of the ALAS Project. La Selva means "the forest" in Spanish, and this genus is only known from the canopy of the forest.

Laselva triplehorni Furth, new species
(Figs. 1–10)

Description.—Body dark brown. Dorsum (head, pronotum, elytra) covered



Figs. 4–10. *Laselvia triplehorni.* 4, Metafemoral spring lateral view. 5, Male aedeagus ventral view. 6, Male aedeagus dorsal view. 7, Male aedeagus lateral view. 8, Female spermatheca. 9, Female vaginal palpi. 10, Female tignum.

with dense golden pubescence – one seta associated with each puncture. Venter and femora reddish brown, tibiae light brown/yellow. Male body length: 1.01–1.80 mm. Female body length: 1.58–1.98 mm. Male maximum body width: 0.75–1.01 mm. Female maximum body width: 0.80–1.08 mm (just behind humeri).

Antenna (Fig. 1): Short, stout, extending only a little beyond humeri. Antennomeres 1 and 2 very swollen, dark brown, 3 to 7 light brown or yellow, 3 narrow subequal in length to 2, 4 shortest, narrow, 5 somewhat thicker (in male only) than 4 only slightly shorter than 3, 6 somewhat thickened like 5 and subequal to 5, 7 swollen, subequal in length to 2, 8 swollen, dark brown, subequal to 7, 9 and 10 swollen, dark brown, subequal to 8, 11 swollen, dark brown, distinctly longer than other antennomeres. Relative antennomere lengths: Male: 8:5:5:3:4:5:6:6:6:6:8. Female: 6:6:5:3:3:2:5:4:5:4:7. Antennomere number 6 is distinctly the smallest in female, not so in male.

Head: Above dark brown, below usually lighter brown, above entirely covered with dense coarse punctures (subrugose) each with seta, thus pubescent; depression just above longitudinal frontal carina, carina not evident due to punctures that extend to lower frons, below lower frons with lateral frontal carina angled laterally inflated, smooth; maxillary palp basally swollen apically tapered; eye large, oval, ventrally tapered, interocular distance (dorsally) subequal to maximum eye width.

Pronotum: Dark brown, evenly pubescent, narrow, anterior and posterior margins straight and subparallel; densely punctured with coarse punctures often contiguous, giving a subrugose appearance; anterolaterally evidently protruding, but not truly angled/beveled, anterolateral pore subapical (just behind anterior margin) with a very long seta subequal to pronotal length (Fig. 1); posterolaterally rounded; often with a sublateral, anterolaterally oriented depression giving an elevated appearance to the central pronotal disc. Male width: 0.50–0.65 mm. Female width: 0.54–0.69 mm. Male length: 0.24–0.27 mm. Female length: 0.24–0.27 mm.

Elytron: Dark brown, evenly pubescent, gradually tapered apically; striate with coarse punctures, each with a seta, setae also inserted on interstrial ridges; sparsely placed longer, dark, erect setae inserted on interstrial ridges; epipleura extending entire length of elytra ending subapically, laterally flattened and smooth throughout length; 10 striae, including scutellar striae (extending over half elytral length), strial punctures very deep, coarse, almost contiguous, giving the appearance of ridges/carinae between striae, each puncture with golden, posteriorly recumbent seta, giving the appearance of rather dense golden pubescence throughout elytra; base of each elytron centrally raised as distinct bossae (see Scherer 1983); humerus strong, prominent. Male length: 1.01–1.35 mm. Female length: 1.20–1.50 mm. Male maximum width: 0.36–0.50 mm. Female maximum width: 0.39–0.54 mm.

Legs: All tibiae lighter brown/yellow; metafemora darker brown, densely pubescent, very swollen/inflated, dorsoventral width approximately equal to width of elytron; male first foretarsal segment not evidently swollen; metatibia apically with medial dorsal margin excavated just beyond insertion of tarsus, with serrations especially apically, outer dorsal margin with strong serrations from apex extending basally past tarsal insertion almost to midtibia with fewer teeth basally (not indicated in figures) (Figs. 2, 3). Apical metatarsal segment globosely swollen, but not as spherical as in *Disigmoptera*, *Hypolampsis*, and most "Sphaeronychini/Monoplatini" (Figs. 1–3).

Venter: Dark brown; prosternal process flat, hour-glass shaped; male with a dark longitudinal mark along midline of apical abdominal sternite.

Genitalia: Male Aedeagus: Ventrally smooth surfaced, parallel-sided gradually tapering to narrowly pointed apex (Fig. 5); dorsal view (Fig. 6); lateral view gradually curved (Fig. 7). Length = 0.55 mm. Female: Spermatheca: (Fig. 8), length = 0.20 mm, including ductus coil. Vaginal palpi: (Fig. 9), basally joined, length = 0.34 mm. Tignum: (Fig. 10), length = 0.55 mm.

Holotype.—Male (INBio): Costa Rica: Heredia, Est. Biol. La Selva 50–150 m. 10° 26′N 84° 01′W, Nov. 1993, INBio-OET; 6 Noviembre 1993, FMP/13/27, *Pentaclethra macroloba*; bar code no. INBIOCRI002257021.

Paratypes.—Males (INBio, USNM): Costa Rica: Heredia, Est. Biol. La Selva 50–150 m. 10° 26′N 84° 01′W, Jan. 1993, INBio-OET; 14 ENE 1993, ex *Virola koschnyi*, FVK/01/32; bar code no. INBIOCRI002256507. Jan. 1993, INBio-OET; 14 Enero 1993, ex *Virola koschnyi*, FVK/01/29; INBIOCRI002268996. Mar. 1993; 6 Marzo 1993, FPM/03/21, *Pentaclethra macroloba*; INBIOCRI02262785. May 1993; 7 Mayo 1993, FVK/06/14, *Virola koschnyi*; INBIOCRI002262660. ibid., INBIOCRI002262659. Jul 1993; 5 de Julio 1993, *Virola koschnyi*, FVK/09/02; INBIOCRI002256805. ibid., INBIOCRI002256807. ibid., FVK/09/04; INBIOCRI002262944. ibid., FVK/09/11; INBIOCRI002269027. Nov 1993; 6 Noviembre 1993, *Pentaclethra macroloba*, FPM/13/02; INBIOCRI002263253. ibid., FPM/13/08; INBIOCRI002257180. ibid., FPM/13/19; INBIOCRI002257032. ibid., FPM/13/20; INBIOCRI002257077. ibid., INBIOCRI002257074. ibid., INBIOCRI 002257075. ibid., INBIOCRI002257076. 6 Noviembre 1993, *Pentaclethra macroloba*, FPM/13/30; INBIOCRI002257016. Nov 1993; 6 Noviembre 1993, FOT/14/39, *Sacoglottis trichogyna*; INBIOCRI002263005. ibid., FOT/14/13; INBIOCRI002262984. Nov 1993; 9 Noviembre 1993, *Virola koschnyi*, FVK/15/04; INBIOCRI002269357. ibid., FVK/15/05; INBIOCRI002269342. ibid., INBIOCRI002269343. ibid., INBIOCRI 002269345. ibid., INBIOCRI002269346. ibid., INBIOCRI002269347. INBIOCRI002269348. ibid., FVK/15/20, INBIOCRI002269333. ibid., FVK/15/23, INBIOCRI002269337. Jan 1994; 5 Enero 1994, *Vitex cooperi*, FOT/16/30; INBIOCRI002268889. Oct 1994; 14 Octubre 1994, FPM/23/01, *Pentaclethra macroloba*, INBIOCRI002270122. ibid., FVK/23/04, Virola koschnyi; INBIOCRI 002269772. ibid., FPM/23/15; INBIOCRI002269725. ibid., FPM/23/19; INBIOCRI002269872. ibid., *Pentaclethra macroloba*, FPM/23/28; INBIOCRI 002270104. ibid., INBIOCRI002270103. ibid., FPM/23/31; INBIOCRI002269739. ibid., FPM/23/35; INBIOCRI002269700. ibid., FPM/23/36; INBIOCRI002269754. Oct 1994; 20 Octubre 1994, *Virola koschnyi*, FVK/27/15; INBIOCRI002286337. ibid., FVK/27/21; INBIOCRI002285906. Dec 1999; FOT/43/04; *Minquartia guianensis*; INBIOCRI002726447. Jan 2000; 04 Enero 2000, FOT/45/32, *Pouruma minor*; INBIOCRI002725464. 05 Enero 2000, *Eugenia* sp., FOT/46/03; INBIOCRI002725749. ibid., FOT/46/11; INBIOCRI002725885. ibid., FOT/46/11; INBIOCRI002725885. ibid., FOT/46/20; INBIOCRI002725999. ibid., FOT/46/26; INBIOCRI002726018.

Females (INBio, USNM): Costa Rica: Heredia, Est. Biol. La Selva 50–150 m. 10° 26′N 84° 01′W, Jan. 1993, INBio-OET; 14 Enero 1993, *Virola koschnyi*, FVK/01/09; INBIOCRI002268989. ibid., INBIOCRI002268990. ibid., FVK/01/31; INBIOCRI002262415. Mar 1993; 5 Marzo 1993, FOT/02/14, *Carapa guianensis*; INBIOCRI002256546. Jul 1993; 4 Julio 1993, *Pentaclethra macroloba*, FPM/08/40; INBIOCRI002263649. ibid., 5 Julio 1993, *Virola koschnyi*, FVK/09/15; INBIOCRI002268750. ibid., FVK/09/26; INBIOCRI002269284. Sep 1993; 3 Setiembre 1993, FOT/10/34, *Tapirira guianensis*; INBIOCRI002256861. Nov 1993; 6 Noviembre 1993, FPM/13/25, *Pentaclethra macroloba*; INBIOCRI 002257028. ibid., INBIOCRI0022570237. ibid., FPM/13/26; INBIOCRI002269084. ibid., FPM/13/38; INBIOCRI002262329. ibid., FPM/13/34; INBIOCRI002269089. Nov. 1993, 9 Noviembre, *Virola koschnyo*, FVK/15/05; INBIOCRI002269344. Jan 1994; 5 Enero 1994, *Vitex cooperi*, FOT/16/03, INBIOCRI002268904. ibid., FOT/16/19; INBIOCRI002268808. ibid., FOT/16/24; INBIOCRI002268788. Oct 1994; 8 Octubre 1994, FVK/19/14, *Virola koschnyi*, INBIOCRI002269593. ibid., FVK/19/20; INBIOCRI002269671. ibid., 14 Octubre 1994, FPM/23/07, *Pentaclethra macroloba*, INBIOCRI002269732. ibid., FPM/23/08; INBIOCRI002269805. ibid., FPM/21/19; INBIOCRI002269873. ibid., FPM/23/23; INBIOCRI002269814. ibid., FPM/23/34; INBIOCRI002269787. ibid., FPM/23/36; INBIOCRI002269755. ibid., INBIOCRI002269753. ibid., FPM/23/37; INBIOCRI002269746. Dec 1999; 29 Diciembre 1999, *Inga leiocalycina*, FOT/42/15; INBIOCRI002725670. ibid., FOT/42/30; INBIOCRI002725711. ibid., FOT/41/32, *Tachigalis costaricensis*; INBIOCRI002725157. Jan 2000; 04 Enero 2000, *Pouruma minor*, FOT/45/04; INBIOCRI002725478. ibid., 05 Enero 2000, *Eugenia* sp., FOT/46/08; INBIOCRI 002725857. ibid., FOT/46/37; INBIOCRI002725734. ibid., FOT/46/40; INBIOCRI002725985. ibid., FOT/46/21; INBIOCRI002725773.

Etymology.—This species is named for Dr. Charles A. Triplehorn (Prof. Emeritus, The Ohio State University, Columbus, Ohio) who was the author's M.Sc. advisor as well as an inspiration and a colleague for many years since.

Discussion

Specimens described above were taken by canopy fogging from 11 species of trees (numbers of specimens in parentheses): *Pentaclethra macroloba* (Fabaceae) (33), *Virola koschnyi* (Myristicaceae) (28), *Sacoglottis trichogyna* Cuatrec. (Humiriaceae) (2), *Vitex cooperi* Standl. (Lamiaceae) (4), *Minquartia guianensis* Aubl. (Olacaceae) (1), *Pouruma minor* Benoist (Cecropiaceae) (2), *Eugenia* sp. (Myrtaceae) (8), *Carapa guianensis* Aubl. (Meliaceae) (1), *Tapirira guianensis* Aubl. (Anacardiaceae) (1), *Inga leiocalycina* Benth. (Fabaceae) (2), *Sclerobium costaricense* N. Zamora & Poveda (Fabaceae) (1). Although the larger numbers are associated with *P. macroloba* and *V. koschnyi* these are also the most common trees and there is no clear dominant tree species. Therefore, it is assumed that none of these tree species is necessarily the true food plant of *Laselva triplehorni*. Certainly its food plant is a canopy plant species, but further closer investigation is necessary, possibly using more careful host plant association sampling methods like those in Novotny and Basset (2000) in order to reliably determine the food plant. The plant association results for *L. triplehorni* typify the results in Furth et al. (2003) that rather surprisingly there was relatively little tree species effect from fogging. The ALAS fogging program was structured to investigate the effect of tree species on fogging efficiency. The expectation was that if there were some degree of host specificity among arthropods, then fogging multiple species of trees would produce more species than fogging single species of trees. There are all degrees of host specificity in Alticinae, although in the author's experience, more often species are at least oligophagous – feeding on several genera/species of the same plant family. It may be that in rainforests the complexity of individual tree crowns masks any tree species effect. Fairly large-scale canopy fogging as carried out here captures arthropods from a column of fogged vegetation. Although that column contains primarily the crown of the focal tree, it also contains the edges of adjacent crowns, lianas in the focal tree, and countless species of epiphytes.

Only one species is currently known in the genus.

Considerable confusion with the use of the names "Monoplatini" and "Sphaeronychini", including by myself, calls for some clarification. Clark (1860) published the first somewhat comprehensive treatment of this group – "Monoplatini" and he referred to Dejean (1836–1837, p. 407) as the original description for the type genus *Monoplatus*. Scherer (1962, 1983) considered the valid genus to be *Monoplatus* Clark (1860) with the type species *M. nigripes* Clark. Clark (1860) described 42 genera and 245 species; however, as indicated by Scherer (1962, 1983) there is considerable ambiguity and confusion in this group, beginning with the use of maxillary palpi by Clark (1860). Scherer (1962, 1983) discussed the problems of this group and stated that in the Coleopterorum Catalogus (Heikertinger and Csiki 1939–1940) further confusion occurred because some genera were incorrectly combined. Scherer (1962, 1983) included keys to 35 Neoptropical genera of this group, plus 3 not included in his keys, and synonymized several genera, including *Sphaeronychus* Dejean, *in litteris* and *Metriotes* Clark, 1869, as junior under *Monoplatus*. Scherer (1962 only) included a checklist of the genera and species of the "Monoplatini" with many new combinations and some new synonymies. Seeno and Wilcox (1982) included a list of 45 genera of this group (reflecting the additional genera described by Jan Bechyné) in 3 groupings, but indicated that the use of the type genus *Monoplatus* Clark, 1860, had been preceded by the use of *Sphaeronychus* Dejean, 1837. This was also stated in Monrós and Bechyné (1956). The detailed explanation for the above is as follows: In the second edition of Dejean's Catalogue des Coléoptères (1833–1836), on page 383 both *Sphaeronychus* Dejean [misspelled as *Sphraeronychus*] (with three species: *excelsus* Dejean, *cinctipennis* Dejean, and *melanurus* Olivier) and *Monoplatus* Chevrolat (with two species: *rubicundus* Dejean and *dimidiatus* Dejean) were listed, the same was repeated on page 407 of Dejean's third edition, 1837. *S. excelsus* Dejean, *S. cinctipennis* Dejean are apparently *nomina nuda*, but *S. melanurus* Olivier was originally described as *Altica* by Olivier (1808). Both *M. rubicundus* Dejean and *M. dimidiatus* Dejean are also apparently *nomina nuda*; therefore, *Sphaeronychus melanurus* (Olivier) is the type species and *Monoplatus* is a synonym of *Sphaeronychus* as stated in Monrós and Bechyné (1956). The explanation of the correct year of publication is as follows: According to Barber and Bridwell (1940) pages 361–443 of Dejean's second edition were published in 1837 (see also White 1970). However, as Madge (1988) and Pope (1992) pointed out the second edition of Dejean was actually published in 1836 and the genera attributed to Chevrolat in Dejean's second edition were described by Chevrolat and should be quoted as Chevrolat in Dejean and this was recently corroborated by Bousquet (2004). However, in this case *Sphaeronychus* was not listed by Dejean as a Chevrolat name; therefore, I now prefer to use *Sphaeronychus* Dejean 1836 as the type genus of this still dubious tribal group name "Sphaeronychini" as was indicated in Seeno and Wilcox (1982).

ACKNOWLEDGMENTS

The habitus and metatibial illustrations were done by Mr. Young Sohn (Smithsonian Institution). The specimens are from the ALAS Project supported by National Science Foundation grants

BSR-9025024, DEB-9401069, DEB-9706976, and DEB-0072702. Auto-Montage photos were taken by L. Rodriguez (Systematic Entomology Lab, USDA, Washington, D. C.).

Literature Cited

Adis, J., Y. Lubin, and G. G. Montgomery. 1984. Arthropods from the canopy of inundated and terra firme forests near Manaus, Brazil, with critical considerations on the pyrethrum-fogging technique. Studies on Neotropical Fauna and Environment 19: 223–236.

Barber, H. S. and J. C. Bridwell. 1940. Dejean catalogue names (Coleoptera). Bulletin of the Brooklyn Entomological Society 35(1): 1–12.

Bousquet, Y. 2004. The works of PFMA Dejean, with emphasis on publication dates and new carabid taxa proposed. Fabreries 29: 33–48.

Clark, H. 1860. Catalogue of the Halticidae in the collection of the British Museum. Physapodes and Oedipodes, Part 1. London: Printed by order of the trustees. 301 pp. 10 plates.

Colwell, R. K. 1996. Biota: The Biodiversity Database Manager. Sinauer Associates, Sunderland, Massachusetts.

Dejean, P. F. M. A. 1833–1836. Catalogue des Coleoptères de la collection de M. le Compte Dejean. – 2nd Ed. (443 pp.) (Fascicle 5, pp. 361–443, end 1836) [includes descriptions by L. A. A. Chevrolat].

———. 1836–1837. Catalogue des Coleoptères de la collection de M. le Compte Dejean. Troisième Edition, Revue, Corrigée et Augmentée. xiv + 503 pp. (Fascicle 5, pp. xiv + 385–503, May 1837).

Erwin, T. L. 1983. Beetles and other insects of tropical forest canopies at Manaus, Brazil, sampled by insecticidal fogging. *In* Sutton, S. L., T. C. Whitmore, and A. C. Chadwick, eds. Tropical Rain Forest: Ecology and management. Blackwell Scientific, Oxford, UK. 512 pp.

Furth, D. G. 1989. Metafemoral spring studies of some Neotropical genera of Alticinae, pp. 410–510. *In* Furth, D. and T. Seeno, eds. Proceedings of the Second International Symposium on Chrysomelidae. Entomography. vol. 6.

Furth, D. G. and J. E. Lee. 2000. Similarity of the *Blepharida*-Group genera using larval and adult characters (Coleoptera: Chrysomelidae: Alticinae). Journal of the New York Entomological Society 108(1–2): 26–51.

Furth, D. G. and K. Suzuki. 1994. Character correlation studies of problematic genera of Alticinae in relation to Galerucinae. (Coleoptera: Chrysomelidae), pp. 116–135. *In* Furth, D. G., ed. Proceedings of the Third International Symposium on the Chrysomelidae, Beijing, 1992. Backhuys Publishers, Leiden. 150 pp.

———. 1998. Studies on Oriental and Australian Alticinae genera, based on the comparative morphology of the metafemoral spring, genitalia, and hind wing venation, pp. 91–124. *In* Biondi, M., M. Daccordi, and D. Furth, eds. Proceedings of the Fourth International Symposium on the Chrysomelidae. Atti Museo Regionale Scienze Naturali Torino 1998. 327 pp.

Furth, D. G., J. Longino, and M. Paniagua. 2003. Survey and quantitative assessment of flea beetle diversity in a Costa Rican rainforest (Coleoptera: Chrysomelidae: Alticinae), pp. 1–23. *In* Furth, D. G., ed. Topics in Leaf Beetle Biology: Proceedings of the Fifth International Symposium on the Chrysomelidae, 25–27 August 2000, Iguassu Falls, Brazil. XXI International Congress of Entomology. Pensoft Publishers, Sofia. 337 pp.

Gamez, R. 1991. Biodiversity conservation through facilitation of its sustainable use: Costa Rica's National Biodiversity Institute. Trends in Ecology and Evolution 6: 377–378.

Heikertinger, F. and E. Csiki. 1939–1940. Chrysomelidae, Halticinae. Coleopterorum Catalogus. Volume XXV, Pars 166, pp. 1–336, Pars 169. pp. 337–635. Uitgeverij Dr. W. Junk, Gravenhage.

Janzen, D. H. 1991. How to save tropical biodiversity. American Entomologist 37: 159–171.

McDade, L. A., K. S. Bawa, H. A. Hespenheide, and G. S. Hartshorn, eds. 1993. La Selva, ecology and natural history of a Neotropical rainforest. University of Chicago Press, Illinois, USA. 486 pp.

Madge, R. B. 1988. The publication dates of Dejean's catalogues. Archives of Natural History 15: 317–321.

Monrós, F. and J. Bechyné. 1956. Über einige verkannte Chrysomeliden-Namen. Entomologische Arbeiten Museum G. Frey 7: 1118–1137.

Novotny, V. and Y. Basset. 2000. Rare species in communities of tropical insect herbivores: Pondering the mysteries of singletons. Oikos 89: 564–572.

Olivier, A. G. 1808. Entomologie ou Histoire Naturelle des Insectes. 6: 613–1104.

Pope, R. D. 1992. The authorship of certain genera first defined in the catalogues of Dejean. Coccinnella 4(1/2): 17–18.

Reid, C. A. M. 1995. A cladistic analysis of subfamilial relationships in the Chrysomelidae *sensu lato* (Chrysomeloidea), pp. 559–631. *In*

Pakaluk, J. and S. A. Slipinski, eds. Biology, Phylogeny, and Classification of Coleoptera. Muzeum i Instytut Zoologii PAN, Warzawa, 2 vols., 1092 pp.

Riley, E. G., S. M. Clark, and T. N. Seeno. 2003. Catalog of the leaf beetles of America north of Mexico (Coleoptera: Megalopodidae, Orsodcnidae, and Chrysomelidae, excluding Bruchinae). The Coleopterists Society, Special Publication No. 1, 290 pp.

Scherer, G. 1962. Bestimmungsschlüssel der neotropischen Alticinen-Genera (Coleoptera: Chrysomelidae: Alticinae). Entomologische Arbeiten Museum G. Frey 13(2): 497–607.

———. 1983. Diagnostic key for the Neotropical Alticine genera (Coleoptera: Chrysomelidae: Alticinae). Entomologische Arbeiten Museum G. Frey 31/32: 1–89.

Seeno, T. N. and J. A. Wilcox. 1982. Leaf beetle genera (Coleoptera: Chrysomelidae). Entomography 1: 1–221.

Stork, N. E. 1988. Insect diversity: facts, fiction, and speculation. Biological Journal of the Linnaean Society 35: 321–337.

White, R. E. 1970. Authorship of the genus *Phyllotreta* (Chrysomelidae: Coleoptera). Proceedings of the Entomological Society of Washington 72(3): 388–389.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 102–120

SYSTEMATICS OF *KIMIA*, A NEW GENUS OF SABETHINI (DIPTERA: CULICIDAE) IN THE ORIENTAL REGION

Ralph E. Harbach, Vu Duc Huong, and Ian J. Kitching

(REH, IJK) Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K. (e-mail: r.harbach@nhm.ac.uk); (VDH) Department of Entomology, National Institute of Malariology, Parasitology and Entomology, Luong Thé Vinh Street, BC10.200 Tu Liem, Hanoi, Vietnam

Abstract.—***Kimia* Vu Duc Huong and Harbach, n. gen.**, a small homogeneous group of mosquitoes of tribe Sabethini from eastern areas of the Oriental Region, is described and diagnosed based on shared morphological features observed in the adult, larval, and pupal stages of five species, all of which were previously included in subgenus *Suaymyia* Thurman of genus *Topomyia* Leicester. Generic status of *Kimia* is supported by a cladistic analysis of morphological data, as well as data not included in the analysis, that indicate a relationship with New World *Trichoprosopon* and Old World *Tripteroides*. Salient differences that distinguish *Kimia* and *Topomyia* are contrasted. Nominal species belonging to *Kimia* include *Topomyia decorabilis* Leicester, *Topomyia imitata* Baisas, *Topomyia miyagii* Toma, *Topomyia nemorosa* Gong, and *Topomyia suchariti* Miyagi and Toma. The lectotype of the type species, *Km. decorabilis*, is designated. The adults, pupa, and unique larva of the type species are described and its male genitalia, pupa, and larva are illustrated. The systematics, bionomics, and distribution of the genus and type species are discussed.

Key Words: *Kimia decorabilis*, *imitata*, *miyagii*, *nemorosa*, *suchariti*, mosquitoes, new genus, phylogeny, Sabethini

Tribe Sabethini includes 414 currently recognized species that occur principally in tropical and subtropical areas of the world. The species are placed in 13 genera, nine in the New World (221 species) and four in the Old World (193 species). Although the tribe as a whole has received relatively little attention, the imbalance in the number of genera recognized in the two hemispheres suggests that the sabethine fauna of the Old World has been neglected in comparison with that of the New World. As noted by Belkin (1962), the majority of Old World species, "except for the few aberrant and specialized forms placed in *Malaya*, *Topomyia*, and *Maorigoeldia*, …are placed in the rather generalized genus *Tripteroides*." Of the Old World species, 12 are placed in genus *Malaya* Leicester, one in genus *Maorigoeldia* Edwards, 57 in genus *Topomyia* Leicester, and 122 in genus *Tripteroides* Giles. Five of the species placed in *Topomyia* clearly represent a separate phyletic line based on unique characteristics of the larval and pupal stages, as well as features of the male genitalia, and are herein recognized as constituents of a new genus. These species include *To. decorabilis* Leicester, *To. imitata* Baisas, *To. miyagii* Toma, *To. nemorosa* Gong, and *To. suchariti*

Miyagi and Toma. It is interesting to note that Edwards (1922) found the adults of *To. decorabilis* "so distinct from the others [other species of *Topomyia*] that it might almost be placed in a separate genus." The immature stages of mosquitoes were either unavailable or largely neglected by taxonomists prior to World War II, but had Edwards studied the larva and pupa of *To. decorabilis* he probably would have proposed a new genus for this species. The new genus established below is typified by *To. decorabilis* and supported by a cladistic analysis of morphological data, as well as diagnostic features not included in the analysis.

MATERIALS AND METHODS

Morphological structures were examined in the adult, pupal, and fourth-instar larval stages. The principal material examined, including the type specimens of *To. decorabilis*, are deposited in The National History Museum (NHM), London. Some specimens collected by Vu Duc Huong and colleagues in various provinces in northern Vietnam between 1979 and 1982 (see Material examined below) reside in the Culicinae collection of the National Institute of Malariology, Parasitology, and Entomology (NIMPE), Hanoi. Diagnostic and differential characters were confirmed in all specimens examined. Observations of adult mosquitoes were made under simulated natural light. Larval and pupal stages and male genitalia were studied using differential interference contrast microscopy. Unless indicated otherwise, numbers in parentheses represent modes of the reported ranges. Morphological terminology follows Harbach and Knight (1980, 1982) and Harbach and Kitching (1998). Life stages of material examined are indicated by the symbols ♂ (male), ♀ (female), L (fourth-instar larva), Le (larval exuviae), and Pe (pupal exuviae). The letter G (genitalia) is used in combination with the male symbol.

The phylogenetic relationships of *Kimia* with other sabethine genera were examined by including character data for *Kimia* in the data set of Harbach and Kitching (1998), as modified by Harbach and Peyton (2000) to include genus *Onirion* Peyton and Harbach, and then subjecting the combined data set to an implied weights parsimony analysis using PIWE version 3.0 (for Windows) (Goloboff 1997). Forty-four genera (42 of Harbach and Kitching + *Onirion* and the new genus described herein) were coded for 73 characters (Appendix). Genera that were polymorphic for different states of a character were explicitly coded as possessing all those states. All multistate characters were treated as unordered. The PIWE commands amb-, hold 100,000, hold/50, mult*5,000 were used and the concavity constant was set to 1 to down weight the most homoplastic characters as much as possible, in line with previous analyses. It was not found necessary to swap further the cladograms found by "mult" by using the command max*.

TAXONOMIC TREATMENT

Kimia Vu Duc Huong and Harbach, new genus

Type species: *Topomyia decorabilis* Leicester 1908, Malaysia.

Topomyia in part of Edwards 1922: 437–440, pl. VIII (*decorabilis*); Baisas 1946: 32–39, 43 (*imitata*); Edwards 1932: 63, 67, 69, 89–91 (*decorabilis*); Mattingly 1971: 12, 15, 23, 29, 32, (35, unspecified reference to *decorabilis*, *imitata*), pl. 9 (*decorabilis*), pl. 26 (*decorabilis*?); Rattanarithikul and Panthusiri 1994: 36, 51; Harbach and Sandlant 1997; Harbach and Kitching 1998: 333, 335, 344, 346, 350, 352, 359–361; Harbach and Peyton 2000: 165–167; Rueda et al. 1998; Huang 2002: 2, 22; White et al. 2004.

Topomyia (*Suaymyia*) in part of Thurman 1959: 44–45 (*decorabilis*, *imitata*);

Stone et al. 1959: 95–96 (*decorabilis*, *imitata*); Knight and Stone 1977: 310 (*decorabilis*, *imitata*); Tsukamoto et al. 1985: 156 (*imitata*); Ward 1992: 204 (*suchariti*); Harbach and Peyton 1993: 2, 4, 8 (*imitata*); Judd 1996: 132, 137–139, 141; Judd 1998: 68–75.

Adults.—Sexes essentially identical in body size and outward appearance. Medium-sized mosquitoes with broad flat scaling on head capsule, thoracic pleura, scutellum, coxae and abdomen; anterior triangular area of vertex, posterior area of antepronotum, median longitudinal stripe (acrostichal area) on scutum and median anterior area of scutellum with metallic silvery white scales; longitudinal silver stripe of scutum comprised of 2 rows of broad rounded spatulate scales emanating from midline; broad lateral areas of scutum with dense covering of dark narrow falcate scales that become noticeably larger and intermixed with dark setae on supraalar area and at sides of prescutellar area; lobes of scutellum with dark broad flat scales and several long dark stout setae; scales of postgena, thoracic pleura and coxae metallic silver to gold, mainly gold, similar scales on pre- and postprocoxal membranes; legs dark-scaled, ventral surfaces of femora narrowly pale-scaled; wing entirely dark-scaled, alula with fringe of rather long piliform scales; abdominal terga primarily dark-scaled, lateral margins and sterna with yellow to gold scaling (sternum VIII of female dark-scaled).

Females.—*Head*: Eyes joined above and below. Occiput without transverse row of erect scales at back of head. Ocular setae dark, conspicuous, close to margin of eye; 2 long, dark, approximated interocular setae present. Interantennal ridge incomplete, frontal pit reinforced by cuticular ring associated with postfrontal sutures. Antenna slightly shorter than proboscis; pedicel large, surface pubescent, with inconspicuous setae and scales on dorsomesal surface, basomesal microsetae present; flagellum moderately verticillate, whorls with 8–10 setae, longest setae about twice length of corresponding flagellomere. Clypeus without setae and scales, with dense covering of silvery pubescence. Proboscis straight or slightly bent and slightly expanded distally, slightly longer than antenna, slightly shorter than forefemur; labellum comprised of 2 sclerites of similar size, proximal sclerite with scales. Maxillary palpus short, with 2 palpomeres. *Thorax*: Integument brown; setae present on antedorsocentral area, supraalar area, lateral prescutellar area, posterior margin of scutellum, anterior surface of antepronotum, posterior margin of postpronotum, and upper proepisternal, prespiracular, prealar, lower mesokatepisternal and upper mesepimeral areas; paratergite and mesopostnotum bare. Lower proepisternum without scales, scales on upper proepisternum contiguous with scales on ante- and postprocoxal membranes; mesopleuron with scales except on lower anterior margin of mesokatepisternum, posterior margin of mesepimeron and mesomeron; large patch of scales below spiracle on metapleuron, absent on metameron. *Wing*: Dark-scaled; alula with piliform scales on margin; calypters without setae; cell R_2 much longer than vein R_{2+3}; anal vein ends well beyond junction of mcu and CuA. *Halter*: Scabellum bare, integument pale; pedicel and capitellum dark-scaled. *Legs*: Coxae and trochanters with golden scales, trochanters with dark scales dorsally at apex; femora, tibiae and tarsi dark-scaled, femora narrowly pale ventrally. Forefemur slightly longer than proboscis, slightly longer than mid- and hindfemora; foretarsomere 1 shorter than foretarsomeres 2–5 combined. Ungues small, simple. *Abdomen*: Coloration as noted above, lateral pale areas of terga usually rounded, especially on more posterior segments; sternum IX without setae and scales.

Males.—Like female except for sexual characters. *Legs*: Foretarsomere 5 elongate C-shaped in lateral view, with basal inner lobe bearing specialized setae; foreungues unequal, inner unguis larger, with lobe(s) or denticle(s). *Genitalia*: Tergum and sternum IX articulated laterally; tergum IX lobes widely separated, elongate, columnar, each lobe with short curved bladelike seta at apex and group of lanceolate setae on mesal side of base, latter setae nearly as long as lobe. Gonocoxite elongate, tapered distally, tergomesal surface membranous, sternal and lateral surfaces with setae and scales; basal mesal lobe with 2 or more long rodlke or otherwise specialized setae. Gonostylus without accessory lobes, with prominent simple setae on sternal surface and gonostylar claw at apex. Aedeagus formed of two plates with digitiform sternal and tergal arms. Proctiger with long slender tapered paraproct and basal sclerotization (tergum X) articulated with tergum IX at base of tergal lobe; cercal setae absent.

Pupae.—*Cephalothorax*: Dorsal apotome long, weakly sclerotized medially, seta 1-CT strongly developed, long, usually double; 3,4,7–10-CT usually single. *Trumpet*: Short, cylindrical; pinna essentially absent; supporting tubercle and tracheoid area absent. *Abdomen*: Seta 1-I well developed, moderately long, dendritic, 1-II mesal to seta 2, 1-III mesal or lateral to seta 2, 1-IV–VI lateral to seta 2, 1-VII closely associated with and usually mesal to seta 1, 1-IX absent; 2-II–VII near posterior margin of tergum, 2-IV–VI mesad of other dorsal setae; 3-I usually mesal to seta 2, 3-III not longer than 3 on following segments; 5-II,VI, VII weakly developed, 5-II single, 5-VI,VII single or multiple-branched, 5-III–V strongly developed, long, normally single; 6-II–VI similarly developed, short, usually single or double, inserted dorsomesal and usually slightly anterior to seta 9, 6-VII strongly developed, similar to seta 9, inserted anterior to seta 9; 7-I slightly if at all longer than seta 6; 9-II–VI minute, inserted posterolaterally at very edge of ventral surface, 9-VII,VIII very strongly developed, fanlike with aciculate branches, 9-VII inserted dorsally near posterolateral corner of segment, 9-VIII inserted ventrally in same location; 10-II present; 14-III–VIII absent; punctures III–V absent. *Paddle*: Short, much shorter than seta 9-VIII; tapered in distal half, margins spiculate; asymmetrical, outer part broader than inner part; setae 1,2-Pa absent.

Larvae, fourth-instars.—*Head*: Slightly if at all wider than long, somewhat square in dorsal view. Occipital foramen more or less oval, midventral angle extended anterior to posterior tentorial pit (PTP), bounded by ill-defined collar. PTP at margin of collar. Hypostomal suture long but normally ending short of PTP. Dorsomentum short, triangular, median tooth slightly longer than others. Maxilla elongate, maxillary body, hypostomal sclerite and maxillary palpus separate components; maxillary brush represented by an articulated rigid bundle of coalesced spicules (maxillary bundle), apical tooth stout, rigid, tapered, slightly bent mesad, about half length of maxillary bundle; laciniarastrum composed of long flexible spicules; seta 3-Mx strongly developed, long, projecting orally. Seta 1-C strongly developed, stout; 4–7,14-C normally single, 4–7-C slender, simple, 14-C stout, spinelike; 8-C slightly posterior and 9-C far posterior to 10-C; 11–13-C close-set near anterior margin of head capsule adjacent to base of antenna. *Antenna*: Short, cylindrical; seta 1-A short, single, borne dorsally about 0.7 from base. *Thorax*: Seta 0-P mesal to 4-P, near 1-P; 9-P well developed, with numerous branches; 8-M absent (seta 13-M labelled incorrectly as 8-M in Miyagi and Toma's (1989) illustration of *Km. suchariti*); 3-T small, with numerous filamentous branches; 8-T dorsal to plate bearing 9–13-T; 13-T inserted mesally on plate shared with 9–12-T. *Abdomen*: Seta 1-I weakly developed, mesad of seta 2, 1-II–VII progressively more strongly developed, laterad of seta 2; 2-I anterolaterad of seta 1, 2-II–VII well anteromesad of seta 1; 3-I moderately long, 3-I–III,V single or branched, 3-IV,VI branched, 3-VII always single, relatively longer than others, inserted lateral to seta 5; seta 5-VII weakly developed, 5-I–V normally single or double, 5-VI,VII usually double or triple; 6-I–V relatively short, mainly shorter than length of segment, 6-I,III–V branched, 6-II,VI single, 6-VI very long, much longer than others; punctures absent from segments III–V. *Segment VIII*: Comb plate absent; scales in irregular single row, thornlike. Seta 3-VIII strongly developed, multiple branched; 4-VIII inserted anterior to 5-VIII. *Siphon*: Widest at base, gradually narrowed to apex; pecten absent; anterior and posterior margins each beset with 2 close-set rows of off-set strongly developed setae. *Segment X*: Saddle relatively small, extending to lateral midline of segment. Setae 1–3-X strongly developed, 1-X very long, inserted on posterolateral corner of saddle; setae 2,3,4-X fanlike with numerous simple branches, 4-X of opposite sides borne on common ventrocaudal plate.

Eggs.—Unknown.

Included species.—*Kimia decorabilis* (Leicester 1908), *Km. imitata* (Baisas 1946), *Km. suchariti* (Miyagi and Toma 1989), *Km. nemorosa* (Gong 1996), and *Km. miyagii* (Toma and Mogi 2003).

Etymology.—This genus is dedicated to Tran Thi Bach Kim, medical biologist and wife of the second author of this paper, Dr Vu Duc Huong, who recognized *Kimia* as a new genus more that 25 years ago. Kim is honored for assisting her husband's work over a period of nearly 40 years. It is befitting that Kim in old Vietnamese means "new" or "present". Kim is also the first syllable of the old Vietnamese word *kim ngan* and the second syllable of *bach kim*, which mean "jewellery" and "platinum", respectively. *Kimia* is a feminine generic name. In keeping with the practice initiated by Reinert (1975), the two-letter abbreviation *Km.* is recommended for this genus.

Systematics.—Analysis of the data set under implied weighting generated three most parsimonious cladograms (MPCs) with fit = 288.0 (29%). The inclusion of character data for *Kimia* in the data set of Harbach and Peyton (2000) did not alter relationships of the non-sabethine genera, therefore only the Sabethini clade from the strict consensus tree of the three MPCs is illustrated here (Fig. 1), with Bremer and relative Bremer support values (Fig. 1A) and supporting characters (Fig. 1B) indicated on the branches.

The inclusion of *Kimia* in the analysis produced a very different pattern of relationships among sabethine genera than that recovered by Harbach and Kitching (1998) and Harbach and Peyton (2000). Contrary to the findings of these authors, and Judd (1996), the New World genera of Sabethini are not recovered as a monophyletic clade in a derived relationship to the Old World genera. The New World genus *Trichoprosopon* Theobald is paired with the Old World *Tripteroides* in a sister relationship with *Kimia*, and the Old World *Malaya*, which was sister to *Topomyia* in previous analyses, is placed as sister to the New World *Limatus* (Fig. 1). Although the depicted relationships are generally weakly supported, they are no less tenable than the relationships recovered in the earlier studies. Although the sister-group relationship between *Kimia* + (*Trichoprosopon* + *Tripteroides*) is not strong (Bremer support 0.2;

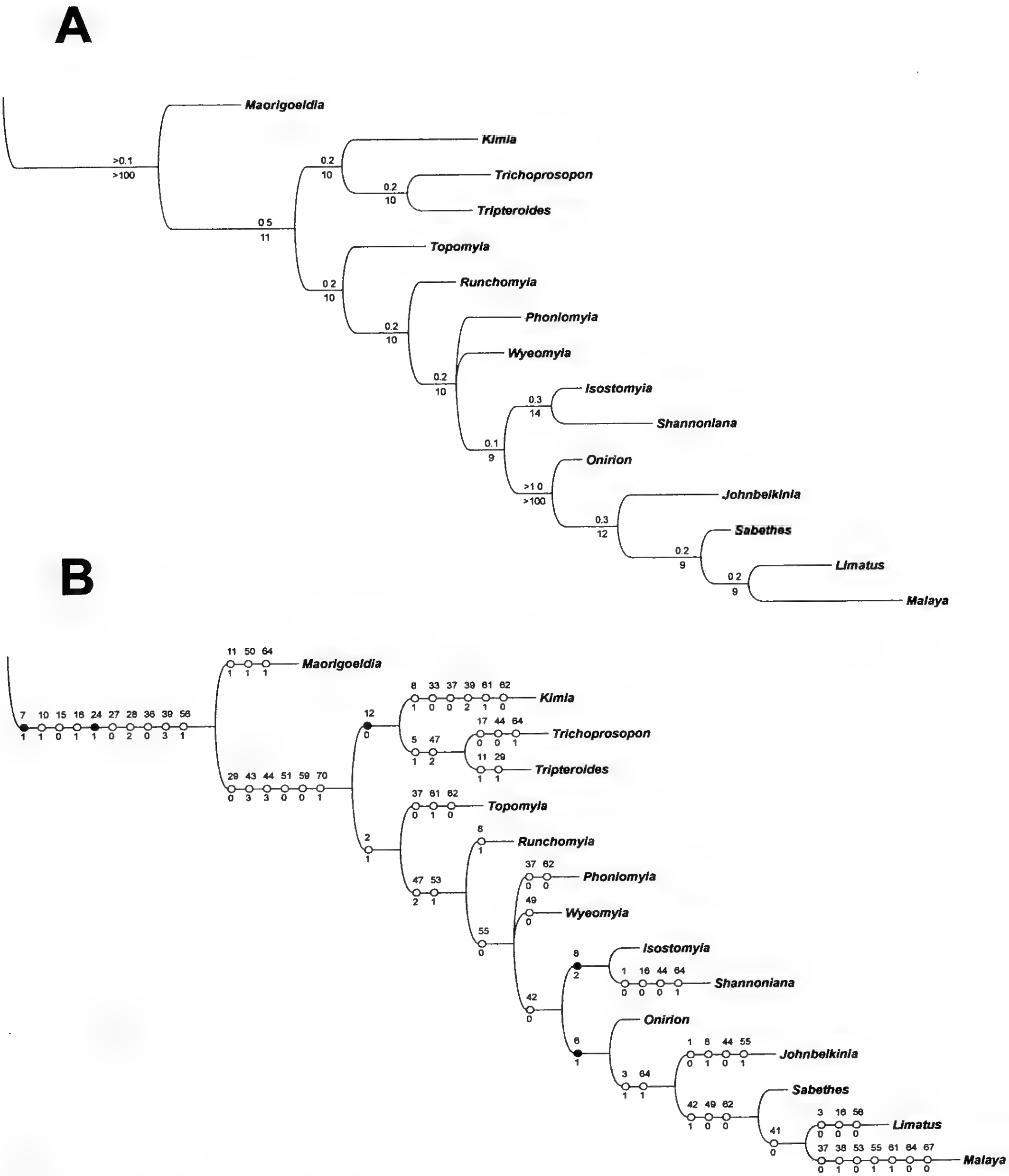


Fig. 1. Topology of the Sabethini clade with character data for *Kimia* included in the data set of Harbach and Peyton (2000). A, Strict consensus tree of three MPCs (Fit = 288.0) obtained from the analysis of the data under implied weights. Bremer support and relative Bremer support values of each clade are indicated above and below the branches, respectively. B, Same with unambiguously optimized supporting characters mapped onto the branches.

relative Bremer support 10), it is supported by a single unique character (12:0, absence of larval seta 8-M) that is not contradicted. Of the six homoplastic characters that diagnose *Kimia*, two (33:0, absence of pupal setae 14-VIII, and 39:2, interantennal ridge of females incomplete with frontal pit reinforced by a cuticular ring associated with the postfrontal sutures) are unique within tribe Sabethini. It should be evident that the characters included in the cladistic analysis determine the relationships portrayed in Fig. 1. A number of morphological characters not included in the analysis (see below) further corroborate the uniqueness of *Kimia* and its similarities with *Trichoprosopon* and *Tripteroides*.

It is obvious that species of *Kimia* were placed in genus *Topomyia* based principally on the ornamentation of adults. Despite the striking similarity in adult habitus, *Kimia* and *Topomyia* do not appear to be closely related. The many characteristics that distinguish these genera are listed in Table 1. The larvae and pupae of the two genera share a number of features but are quite distinct overall. The presence of an oval occipital foramen in larvae suggests that *Kimia* most likely share affinities with the Old World *Tripteroides* and the New World *Shannoniana* Lane and Cerqueira, *Johnbelkinia* Zavortink, and *Trichoprosopon*. The absence of larval seta 8-M in *Kimia*, *Trichoprosopon*, and most species of subgenus *Tricholeptomyia* Dyar and Shannon of genus *Tripteroides* suggests a closer relationship between these taxa. In addition to the similar development of the occipital foramen and absence of seta 8-M in *Kimia* and *Trichoprosopon*, the larvae of these two genera also lack a pecten and have seta 13-T inserted on a plate with setae 9–12-T. A pecten is present in *Topomyia* and *Tripteroides* and absent in *Johnbelkinia* and *Shannoniana*. The insertion of seta 13-T and setae 9–12-T on a common plate in *Kimia* and *Trichoprosopon* is a unique feature among sabethine genera.

The absence of setae on the upper calypter of the wing and the presence of a median longitudinal stripe of silvery scales on the scutum have been used as key characters to distinguish the adults of *Topomyia* from those of *Tripteroides* (e.g., Thurman 1959), and there is no doubt that these features in *Kimia* resulted in the placement of these species in *Topomyia*. A median longitudinal stripe of silvery scales is not unique to species of *Topomyia* or *Kimia*. A similar stripe is also present in some species of *Malaya*. As Belkin (1962) suggested, "*Malaya* appears to be an ancient derivative from a generalized sabethine stock which also gave rise to *Topomyia*." *Malaya* species also do not have setae on the upper calypter. In contrast, species of the New World genera mentioned above do not have a longitudinal stripe on the scutum. Whereas all species of *Johnbelkinia* and *Shannoniana* have setae on the upper calypter, these setae are absent in some species of *Trichoprosopon*, which is not inconsistent with a possible affinity with *Kimia*.

In some respects, the male genitalia of *Kimia* bear a closer resemblance to those of *Tripteroides* than to species of *Topomyia*, especially in the shape of the basal mesal lobe and its association with the gonocoxite. The basal mesal lobes of *Kimia* and *Tripteroides* (*Tripteroides*) are crescent-shaped with the distal part produced, not joined to one another, and incompletely separated from the gonocoxite. They are similarly shaped but separated from the gonocoxite in *Johnbelkinia*, *Shannoniana*, and *Trichoprosopon*.

Whereas punctures are present on two or three of segments III–V in pupae of *Johnbelkinia*, *Topomyia*, and *Tripteroides*, they are entirely absent in *Kimia*, *Trichoprosopon*, and *Shannoniana*. Seta 6-VII is strongly developed and inserted anterior to 9-VII in pupae of *Kimia* and *Malaya*. This seta, although not strongly developed, is also inserted anterior to 9-VII in *Trichoprosopon* and subgenera *Polylepidomyia* Theobald, *Rachionotomyia* Theobald, *Rachisoura* Theobald, and *Tripteroides* of genus *Tripteroides*.

Table 1. Salient anatomical differences that distinguish the adults, pupae, and fourth-instar larvae of *Kimia* and *Topomyia*.

Character	*Kimia*	*Topomyia*
Adult females		
Sternum IX	Without setae and scales	With setae and scales[1]
Adult males		
Foreungues	Inner larger, with lobe(s) or denticles(s)	Equal, simple
Foretarsomere 5	C-shaped in lateral view, with basal inner lobe bearing specialized setae	More or less cylindrical, without basal lobe
Basal mesal lobe	Crescentic, produced distally, incompletely separated from gonocoxite, not joined with its mate	Irregularly shaped plaque or lobed structure, distinctly separated from gonocoxite, narrowly joined with its mate
Cercal setae	Absent	Present
Aedeagus	Broad, short	Narrow, elongate
Pupae		
Seta 1-VII	Usually mesal to 2-VII	Lateral to 2-VII
Setae 2,3-X	Highly branched, 3-X not longer than siphon	With fewer branches, usually longer than siphon
Seta 3-I	Usually mesal to 2-I	Lateral to 2-I
Seta 3-III	Short, weaker than 5-IV, similar to 3 on following segments	Usually long, similar to 5-IV, more strongly developed than 3 on following segments
Seta 5-III	Long, similar to 5-IV,V	Short, dissimilar to 5-IV,V
Seta 5-VI	Short, much weaker than 5-IV,V, similar to 5-VII	Long, similar to 5-IV,V, much stronger than 5-VII
Seta 6-VII	Strongly developed, similar to 9-VII, inserted far anterior to 9-VII	Weakly developed, much smaller and inserted immediately mesal to 9-VII[2]
Seta 10-II	Present	Usually absent
Seta 14-VIII	Absent	Present
Punctures III–V	Absent	Present or absent of III, present on IV and V
Larvae		
Occipital foramen	More or less oval	Transverse, slitlike
Seta 8-C	Slightly posterior to 10-C	Anterior to 10-C
Seta 9-C	Far posterior to 10-C	Level with to slightly anterior to 10-C
11–13-C	Close together near margin of head capsule	More widely separated and removed from anterior margin of head capsule
Seta 3-Mx	Strongly developed, prominent	Otherwise
Seta 0-P	Mesal to 4-P, near 1-P	Posterior to 4-P, far from 1-P
Seta 9-P	With numerous branches	With fewer branches
Seta 8-M	Absent	Present
Seta 3-T	With numerous branches	With fewer branches
Seta 8-T	Dorsal to 9–13-T	Dorsal to 7-T
Seta 13-T	On plate with 9–12-T	Not on plate with 9–12-T
Seta 3-VII	Lateral to 5-VII	Mesal to 5-VII
Seta 3-VIII	Strongly developed, with numerous branches	Weaker, with few branches
Seta 4-VIII	Anterior to 5-VIII	Posterior to 5-VIII
Seta 4-X	Highly branched	With fewer branches
Seta 6-I–V	Short, mainly shorter than length of segment	Long, much longer than length of segment
Seta 6-VI	Much longer than 6-I–V	As long or shorter than 6-I–V
Pecten	Absent	Present
Siphon setae	Numerous, long, highly branched	Variable, never as long, numerous or highly branched

[1] Except *To. yanbarensis* (see Lu Baolin et al. 1997).
[2] Except *To. malaysiensis* where 9-VII is slightly lateral but far anterior to 6-VII.

It is moderately to strongly developed and inserted anterior and lateral to 9-VII in species of *Johnbelkinia*. The long seta 5-III and short seta 5-VI distinguish the pupae of *Kimia* from those of *Topomyia* and *Tripteroides* in which 5-III is short and 5-VI is long. These setae, as well as their homologs on segments VI and V, are weak and short on *Trichoprosopon* pupae. Seta 5-III is well developed in *Johnbelkinia* and *Shannoniana*. Whereas seta 14-III–VII is present in *Tripteroides*, it is absent in *Kimia*, *Malaya*, *Topomyia*, and the New World *Johnbelkinia*, *Shannoniana*, and *Trichoprosopon*. The absence of pupal seta 14-VIII in *Kimia* is a unique feature within Sabethini; in fact this seta is present in all other Culicidae except for some species of *Toxorhynchites* Theobald.

Detailed comparative analysis of the known species of *Kimia* is limited by a paucity of available specimens. Except for *Km. decorabilis* (see below), nominal species of the genus are known only from a holotype (*Km. imitata* and *Km. suchariti*) or a holotype and a number of paratypes (*Km. miyagii* and *Km. nemorosa*) from or near the type locality. Based on published illustrations of male genitalia, it appears that *Km. nemorosa* may be a junior synonym of *Km. suchariti*. In depth study of all life stages of these two nominal forms is required to determine whether they represent the same or different species.

Bionomics.—Little bionomical information is available for species of *Kimia*. Adult and pupal stages have never been collected in the wild and are known only from laboratory rearings of larvae found in bamboo stumps and erect bamboo internodes bearing small holes presumably made by beetles. It is uncertain whether larvae are facultative or obligatory predators. The maxillae appear to be modified for grasping. Before reaching the pupal and adult stages, the holotype of *Km. suchariti* was seen to prey on larvae of *Armigeres* Theobald and *Tripteroides* (Miyagi and Toma 1989). Larvae of *Stegomyia aegypti* (Linnaeus) (=*Aedes aegypti* prior to Reinert et al. 2004) were used as a source of food while rearing the larvae of *Km. decorabilis* that were collected in northern Vietnam in 2005 for the present study (see Bionomics of *Km. decorabilis* and Material examined below).

Distribution.—Species of *Kimia* are only definitely recorded from China (Yunnan Province, *Km. nemorosa*), Indonesia (Flores, *Km. miyagii*), peninsular Malaysia (Perak and Selangor states, *Km. decorabilis*), Philippines (Mindanao, *Km. imitata*), Thailand (Chanthaburi Province, *Km. suchariti*), and northern Vietnam (Bac Kan, Bac Thai, Ha Son Binh, Ha Tuyen, Hoang Lien Son, Thai Nguyen, and Thanh Hoa provinces, *Km. decorabilis*). Edwards (1932), and subsequently Stone et al. (1959) and Knight and Stone (1977), indicated that *Km. decorabilis* also occurs on Borneo, but the source of this record is unknown and requires confirmation.

Kimia decorabilis (Leicester)

(Figs. 2–4)

1908. *Topomyia decorabilis* Leicester 1908: 239 (♂, ♀). Lectotype ♂, hereby designated to fix the application of the specific name, bearing the following original data: "In jungle/ The Gap [Selangor, Malaysia]/24/4/ 04" (NHM), **n. comb.** The specimen bears a label indicating lectotype selection by T.J. Zavortink, but the intended selection was never formally fixed by publication.

Female.—As described for genus. *Head*: Antenna dark; length about 2.0 mm, slightly shorter than proboscis; flagellomere 1 slightly swollen, with some slender scales among setae. Proboscis slightly bent and slightly expanded distally; length about 2.3 mm, slightly longer than antenna, about 0.9 length of forefemur; with 2 or 3 basal labial setae. Maxillary palpus about 0.1 length of proboscis; dark-scaled. *Thorax*: Integument light brown. Antedorsocentral, antepronotal, supraalar and scutellar setae strong, conspicuous, dark; lateral prescutellar setae similar but less conspicuous; antealar area with lateral line of golden spatulate scales that partially project over paratergite; prescutellar area small, sometimes with short lateral lines of silver spatulate scales contiguous with spot of similar scales on median anterior area of scutellum. Postpronotal, upper proepisternal, prespiracular and prealar setae dark; lower mesokatepisternal and upper mesepimeral setae pale. *Wing*: Length 3.5–4.2 mm; decumbent spatulate scales on all veins except semierect fusiform scales on dorsal surface of R_s and M. *Legs*: Forefemur about 1.1 length of proboscis.

Male.—As described for genus; like female except for sexual differences. *Genitalia* (Fig. 2C–E): Tergum VIII (ventral in position) (not figured) with posterior cluster of long setae that decrease in number and length laterally. Tergum IX lobe with group of 2–5(3) lanceolate setae at mesal side of base; sternum IX broadest in middle, progressively narrowed laterally, posterior margin evenly rounded, without setae and scales. Gonocoxite tapered distally, lateral setae strongly developed, a group of relatively long setae distally on mesal surface near base of gonostylus; basal mesal lobe separated from gonocoxite by narrow membranous area for most of length, contiguous with gonocoxite proximally, apex with 2 long rodlke setae and a slightly longer thickened or lanceolate seta that reach beyond apex of gonocoxite, with group of shorter setae on tergomesal surface at base of 3 long apical setae. Gonostylus short, about half length of gonocoxite, bent, slightly twisted and projecting tergomesad over lateral side of basal mesal lobe, slightly flattened and tapered distally, sternal surface lined with short simple setae, peglike gonostylar claw at apex. Aedeagus slightly longer than wide, resembling a cupped human hand in lateral view, with long slightly tergally curved sternal arm (forefinger) and shorter mesally bent tergal arm (thumb), sternal arms well separated, tergal arms meet at midline. Proctiger with long tapered paraproct and heavily sclerotized tergum X, tergum X narrowly fused with base of paraproct and articulated with tergum IX at base of tergum IX lobe.

Pupa (Fig. 2A,B).—As described for genus; character and positions of setae as figured, numbers of branches in Table 2. *Cephalothorax*: Moderately tanned, with mottling of slightly darker areas on dorsum. Seta 1-CT usually double, branches nearly straight, hooked apically; 3,7,8,10-CT usually single, 4,9-CT always single; 13-CT or its alveolus usually present, single when developed. *Trumpet*: Moderately tanned, yellow compared to brown scutum; abruptly expanded at base into broad short cylinder; pinna essentially absent; length 0.35–0.52 mm (mean = 0.45 mm), width 0.17–0.23 mm (mean = 0.20 mm), index 1.96–2.48 (mean = 2.74). *Abdomen*: Moderately tanned, terga and sterna progressively paler, especially anteriorly, on successive posterior segments; length 4.2–5.0 mm (mean = 4.6 mm). Seta 1-II frequently double but usually with more than 2 branches, 1-III–VI moderately developed, frequently with 2 or 3 branches; setae 6,7-I relatively long, usually with 3 or more branches, infrequently single; 10-I or its alveolus present, single when present; 8-II usually absent, occasionally alveolus or single seta present; 5-II,VI,VII much smaller than 5-III–V, 5-III–V about length of following tergum. *Genital lobe*: Moderately tanned; length about 0.30 mm in female, about 0.40 mm in male. *Paddle*:

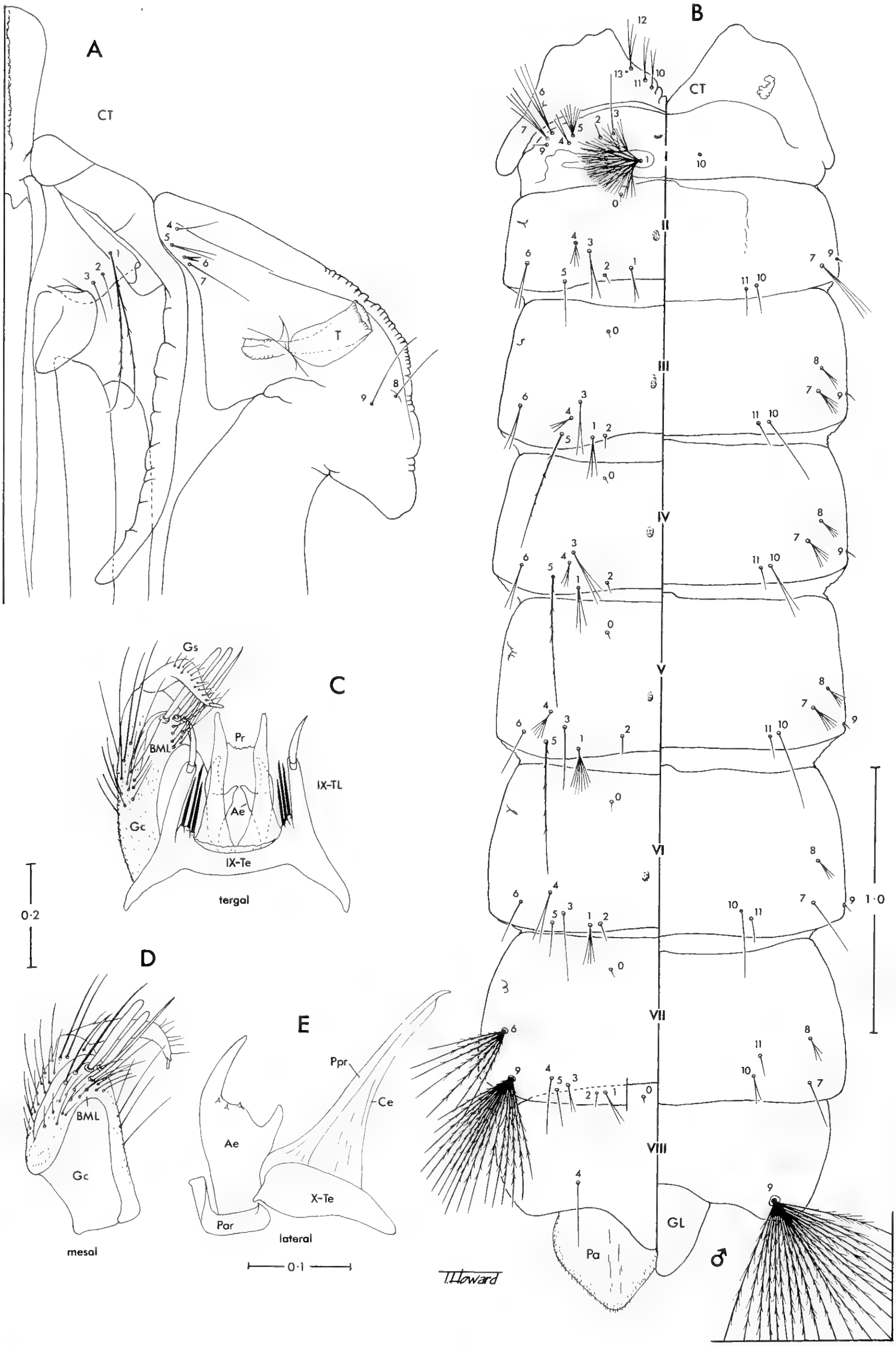


Fig. 2. Pupa and male genitalia of *Kimia decorabilis*. A,B, Pupa: (A) left side of cephalothorax, dorsal to right; (B) dorsal (left) and ventral (right) aspects of metathorax and abdomen. C–E, Male genitalia, aspects as indicated. Ae = aedeagus; BML, basal mesal lobe; Ce, cercus; CT = cephalothorax; Gc = gonocoxite; GL = genital lobe; Gs = gonostylus; Pa = paddle; Par, paramere; Ppr, paraproct; Pr, proctiger; T = trumpet; IX-Te, tergum IX; IX-TL, tergum IX lobe; X-Te, tergum X; I–VIII = abdominal segments I–VIII; 0–11 = setal numbers for specified areas, e.g. seta 5-III. Scales in mm.

Table 2. Numbers of branches for setae of pupae of *Kimia decorabilis*. Range (mode) based on six specimens (12 setae) from Vietnam (3) and Malaysia (3).

Seta	Cephalothorax	Abdominal segments									Paddle
	CT	I	II	III	IV	V	VI	VII	VIII	IX	Pa
0	—	—	1	1	1	1	1	1	1	—	—
1	2–5(2)	5–9*	2–6(2)	1–4(3)	1–6(3)	1–7(3)	1–9(4)	1–3(1)	—	—	—
2	1,2(2)	1,2(1)	1	1–4(1)	1	1	1	1	—	—	—
3	1,2(1)	1,2(1)	1–3(2)	1–3(1)	1–4(3)	1	1,2(1)	1–4(2)	—	—	—
4	1	1–3(1)	2–8(5)	1–4(3)	1–3(3)	2–7(5)	1,2(1)	1	1	—	—
5	1–3(1)	5–9(5)	1	1,2(1)	1,2(1)	1	1–5(1)	1–4(2)	—	—	—
6	1–5(1)	1–5(3)	1–3(1)	1–3(2)	1–3(1)	1,2(1)	1–3(1)	5–12(7)	—	—	—
7	1,2(1)	1–7(3)	1–5(3)	2–6(5)	2–6(5)	2–8(5)	1,2(1)	1	—	—	—
8	1–3(1)	—	0,a,1(0)†	1–4(1)	1–4(1)	1–4(1)	1–4(4)	1–4(3)	—	—	—
9	1	1,2(1)	1	1	1	1	1	13–23(17)	17–26(22)	—	—
10	1–3(1)	a,1(a)†	1,2(1)	1,2(1)	1,2(1)	1	1,2(1)	1,2(1)	—	—	—
11	1,2(2)	—	0,1(0)†	1	1	1	1	1,2(1)	—	—	—
12	1–4(3)	—	—	—	—	—	—	—	—	—	—
13	a,1(a)†	—	—	—	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—	—	—	—	—

* Primary branches. Terminal branches too numerous to count accurately.
† a = represented by alveolus only; 0 = entirely absent.

Moderately tanned; asymmetrical, outer part broader than inner part, inner, outer and apical margins spiculate; length 0.45–0.51 mm (mean = 0.47 mm), width at widest point 0.31–0.42 mm (mean = 0.39 mm), index 1.10–1.65 (mean = 1.24).

Larva, fourth-instar (Figs. 3 and 4).—As described for genus; character and placement of setae as figured, numbers of branches in Table 3. *Head*: Moderately and evenly tanned; length 1.01–1.28 mm (mean = 1.13 mm); width 1.02–1.38 mm (mean = 1.18 mm). Dorsomentum heavily tanned, with 6 or 7 short blunt teeth on either side of slightly larger median tooth. Seta 1-C spiculate apically; 15-C forked or branched distally. *Antenna*: Moderately and evenly tanned; length 0.25–0.33 mm (mean = 0.28 mm). Setae 2-A single. *Thorax*: Integument hyaline, smooth. Setae 5,7, 9,10-P and 7,9,13-T with many distinctly aciculate branches, other thoracic setae normally with simple branches; 14-P always single; 14-M always branched. *Abdomen*: Integument hyaline, smooth; segments I–VII each with prominent midventral lobe, lobes become more caudal in position and project more strongly caudad on successive posterior segments. Setae 6-I,II,VI, 1-VI,VII, 3-VIII and siphonal setae with distinctly aciculate branches; other abdominal setae normally with simple branches; seta 11-VII anteromesal to 10-VII; 13-VII always single. *Segment VIII*: Comb with 5–13 (mean = 9) short pointed scales with minute fringe of spicules on sides at base. *Siphon*: Moderately tanned, surface smooth; long, slightly bent distally, length 1.07–1.40 mm (mean = 1.25 mm), width at base 0.21–0.36 mm (mean = 0.28 mm), index 3.94–5.40 (mean = 4.50). Anterior margin with 18–25(23) fanlike setae with 5–13(9) branches, distal setae with fewer branches, longest setae about twice diameter of siphon; posterior margin with 24–30(29) fanlike setae with 2–14(10) branches, distal setae with progressively fewer setae toward apex of siphon, longest setae about 3 times diameter of siphon. *Segment X*: Saddle moderately pigmented, length 0.25–0.37 mm (mean = 0.30 mm); siphon/saddle index 3.65–

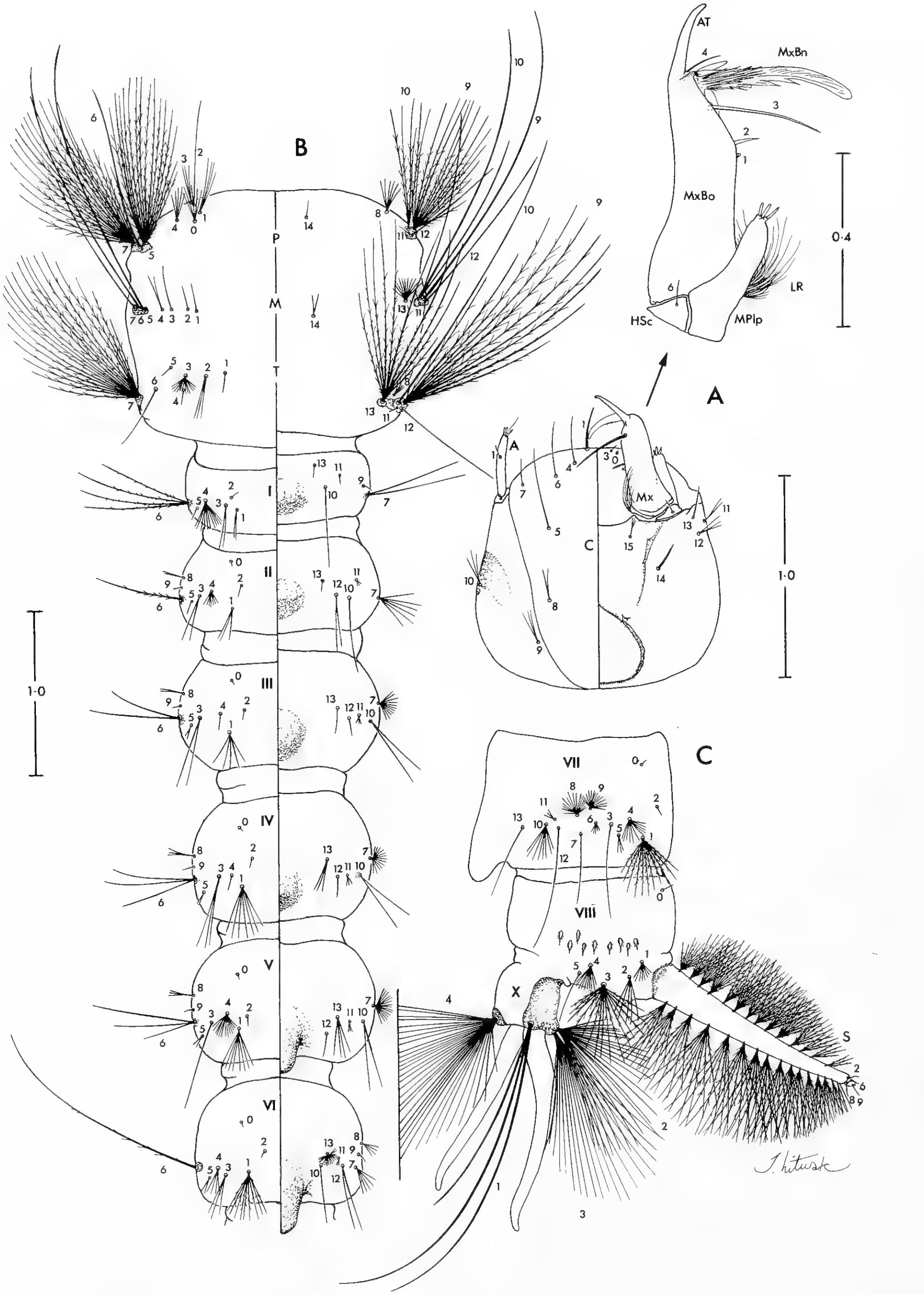


Fig. 3. Fourth-instar larva of *Kimia decorabilis*. A, Head, dorsal (left) and ventral (right) aspects of left side; enlargement of right maxilla, ventral aspect. B, Thorax and abdominal segments I–VI, dorsal (left) and ventral (right) aspects of left side. C, Abdominal segments VII–X, left side. A, antenna; AT, apical tooth; C, cranium; HSc, hypostomal sclerite; LR, laciniarastrum; M, mesothorax; MPlp, maxillary palpus; Mx, maxilla; MxBn, maxillary bundle; MxBo, maxillary body; P, prothorax; S, siphon; T, metathorax; I–VIII,X = abdominal segments I–VIII and X; 1–15 = setal numbers for specified areas, e.g., seta 6-Mx. Scales in mm.

Table 3. Numbers of branches for setae of fourth-instar larvae of *Kimia decorabilis*. Range (mode) based on six specimens (12 setae) from Vietnam (3) and Malaysia (3).

Seta	Head	Thorax			Abdominal segments								
	C	P	M	T	I	II	III	IV	V	VI	VII	VIII	X
0	1	5–13(10)	—	—	—	1	1	1	1	1	1	1	—
1	1	2–5(4)	1	1,2(1)	1–4(4)	1–4(3)	2–6(4)	4–10(7)	4–15(10)	27–15(13)	8–13(10)	5–9(8)	2–4(3)
2	—	1	1	2–6(2)	1	1	1	1	1	1	1	3–6(4)	18–28(23)
3	1	2,3(3)	1	12–24(20)	1–3(2)	1–3(2)	1–3(2)	2–4(3)	1–3(1)	2–6(3)	1	14–18(16)	14–20(15)
4	1	2–8(5)	2,3(2)	1	9–25(24)	4–11(7)	1	1,2(1)	10–30(21)	4–8(6)	8–22(15)	7–25(15)	32–45(40)
5	1	8–15(12)	1	1	1,2(1)	1,2(1)	1,2(2)	1–3(2)	1–3(2)	1–4(2)	2–4(2)	1,2(1)	—
6	1	1	1	1–5(1)	2–5(4)	1	2,3(2)	2–4(3)	2–4(2)	1	3–5(4)	—	—
7	1,2(1)	12–21(16)	1	11–25(19)	1–5(1)	3–10(6)	10–32(22)	10–29(20)	13–37(22)	4–9(6)	1	—	—
8	2–4(2)	4–19(16)	—	3–14(8)	—	1–3(2)	1–4(2)	2,3(3)	2–4(2)	3–7(6)	10–31(21)	—	—
9	1–4(3)	9–17(17)	1	6–11(9)	1,2(1)	1	1	1	1	1,2(1)	11–29(23)	—	—
10	2,3(3)	3–8(3)	2–4(3)	1	1,2(1)	1,2(1)	1–3(2)	2,3(2)	1,2(2)	1–3(1)	6–13(8)	—	—
11	2–4(2)	1	1	1	1–3(1)	2–4(3)	2–4(3)	1–4(3)	2–5(3)	3–5(3)	2,3(3)	—	—
12	2–4(3)	1,2(1)	1	1	—	1,2(2)	1	1	1,2(1)	1–3(2)	1	—	—
13	1–5(4)	—	8–28(14)	7–11(10)	1,2(1)	1	1,2(1)	1–5(3)	1–4(3)	14–33(25)	1	—	—
14	1	1	2–4(2)	—	—	—	—	—	—	—	—	—	—
15	3–8(4)	—	—	—	—	—	—	—	—	—	—	—	—

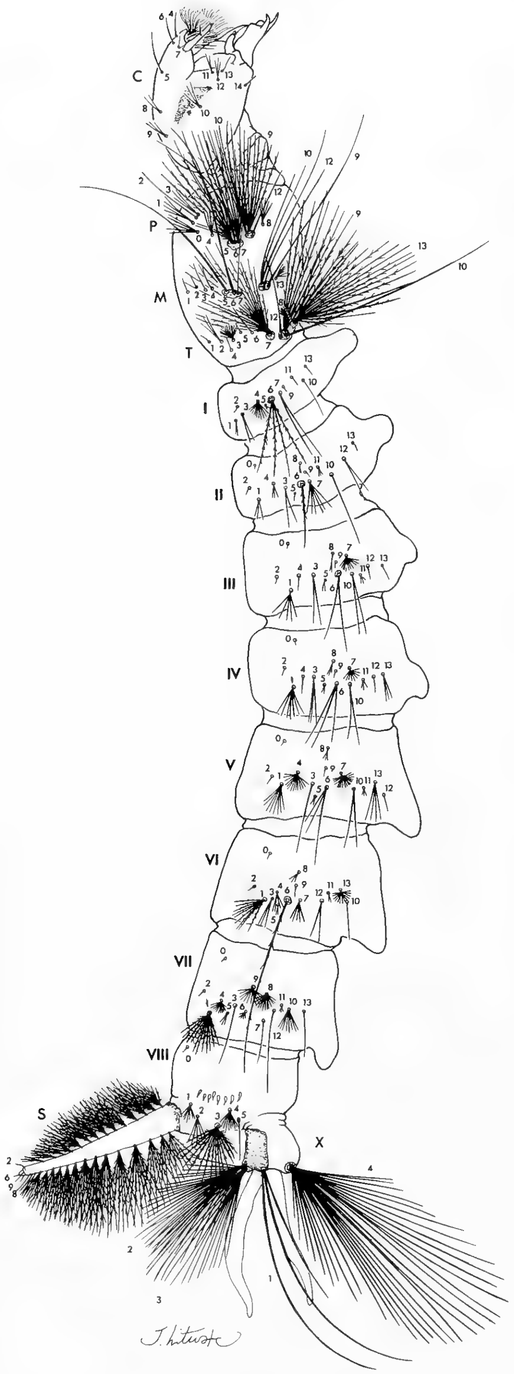


Fig. 4. Fourth-instar larva of *Kimia decorabilis*, lateral view of right side showing the prominent midventral lobes of the abdominal segments. Abbreviations and numbers as in Fig. 3.

4.80 (mean = 4.15); dorsal and ventral anal papillae long, slender, tapered, more or less equal length.

Discussion.—Based on similarities in male genitalia, *Km. decorabilis* appears to be more closely related to allopatric *Km. imitata* (Philippines) than to the other three species of the genus. The holotype male of *Km. imitata* (the only known specimen) and its associated larval exuviae were examined, but the male and larval exuviae are in poor condition and could not be studied in detail. It is obvious, however, that the larva of this species differs from the larva of *Km. decorabilis* in having a shorter, spiculate siphon with fewer dorsal (12) and ventral (about 20) setae. The setae have fewer branches and those on the ventral margin are much longer (more than twice as long) than those on the dorsal margin. A rather superficial examination of the pupal exuviae did not reveal any obvious distinctions. The male genitalia differ from those of *Km. decorabilis* in having three rodlike setae on the basal mesal lobe and a very short, distally expanded, clublike gonostylus. A dense cluster of long, curved setae on the basal mesal lobes of *Km. nemorosa* and *Km. suchariti*, and the long narrow and flexible gonostylus and row of stout setae on the basal mesal lobe of *Km. miyagii*, easily distinguish the males of these species from those of *Km. decorabilis* and *Km. imitata*. Larvae and pupae of the first three species were not available for study and the original and only descriptions and illustrations of these life stages lack details that might distinguish them from one another and the other two species. It would be interesting to know whether the larva of *Km. decorabilis* is unique in having prominent midventral lobes on the abdominal segments. Except for *Km. nemorosa*, larvae of the other species were described from the exuviae of reared specimens. According to Gong (1996), the type series of

Km. nemorosa includes both larvae and larval exuviae, and his illustration of abdominal segments VII–X in lateral view appears to have been drawn from a larva. The most notable feature of this illustration is what appears to be a small lobelike expansion on the ventral side of segment VII.

Bionomics.—Larvae of *Km. decorabilis* are found in green, upright bamboo internodes that bear small holes presumably made by beetles. Specimens from northern Vietnam were collected alone or in association with unidentified *Topomyia* larvae from small-stem bamboo (cavity diameter of 2–3 cm) of genera *Maclurocheoa*, *Phyllostachys*, and *Schizostachyum* (Vu Duc Huong personal observation). The specimens were provided with larvae of *St. aegypti* while being reared in the laboratory. The larva used principally to draw Figs. 3 and 4 was found along with larvae of *Aedes* Meigen, *Anopheles* (*noniae* Reid), and *Topomyia* in an internode of *Dendrocalamus* bamboo with a diameter of approximately 10 cm. This larva, apparently now lost or misplaced in the Smithsonian Institution (R.C. Wilkerson personal communication), was collected in Perak State of peninsular Malaysia on 8 January 1988 by Mohd Nohr and Bruce A. Harrison, who made the following observations while attempting to rear the larva in captivity. The larva was fairly sessile, moved slowly about by twisting, and rested on the midventral abdominal lobes while opening and closing its maxillae (and mandibles) in the debris on the bottom of the rearing container. The maxillary bundles were observed to lift debris from the substrate to the proximity of the mandibles. The long setae 6-VI were held outward and downward in touch with the substrate, and thus served as stabilizers to keep the larva from tilting from side to side. The larva was not seen to come to the surface for air.

Distribution.—Disregarding the questionable record of *Km. decorabilis* on Borneo (Edwards 1932), before now this species was only definitely known to occur in Selangor State of peninsular Malaysia (based on the type specimens and others in the NHM). The present study is based in part on specimens collected in northern Vietnam (see below), which significantly extend the range of this species and suggest that it is probably widely distributed in mainland areas of Southeast Asia.

Material examined.—Fifty-five specimens (7♂, 5♀, 6♂G, 1♀, 15Le, 13Pe, 7L), including 10 individual rearings. Lectotype ♂, with dissected genitalia on acetate strip on pin, MALAYSIA: *Selangor*, The Gap, in jungle, 24 Apr 2004; paralectotype ♀, same locality as lectotype, 14 April 2004 (NHM). MALAYSIA: 1LePe♂ (0353/9), 1♀LePeG (0353/1), *Selangor*, Ulu Gombak, 16th mi., 8 Oct 1957; 1LePe♂G (0391/4), same locality, 5 Nov 1957; 1♀LePe (0534/1), same locality without mile, 12 Mar 1958. VIETNAM: 1LePe♂G (BC1), 1♀LePe (BC2), *Bac Kan Province*, Cho Don District, Binh Trung Commune, 150 km north of Hanoi, bamboo internode, 17 Jun 2005 (*Vu Duc Huong & Nguyen Thi Bich Lien*). 2LePe (nos. 4 and 5, 2♂ destroyed), *Bac Thai Province*, Phu Luong District, Thanh Mai Commune, Apr 1982 (Vu Duc Huong et al.). 1L, *Ha Son Binh Province*, Kim Boi District, Thuong Tien Commune, Oct 1981 (Vu Duc Huong et al.). 1L, *Ha Tuyen Province*, Bac Quang District, Tan Lap Commune, Aug 1979 (Vu Duc Huong et al.). 1LePe (no. 3, adult ♀ destroyed), *Hoang Lien Son Province*, Van Yen district, Dong Cuong commune Sep 1980 (Vu Duc Huong et al.). 3LePe♂G (TN1, with head on microscope slide; TN3; TN16), 1♀LePe (TN2, with head on microscope slide), 2Le (TN4; TN5), 5L (TN8–TN12), *Thai Nguyen Province*, Dinh Hoa District, Qui Ky Commune, 150 km north of Hanoi, bamboo internode, 14–16, 18 Jun 2005 (*Vu Duc Huong & Nguyen Thi Bich Lien*). 1Le♂G (no. 1), *Thanh Hoa Province*, Luong Ngoc District, Quang Hien Commune, May 1980 (Vu Duc Huong et al.).

ACKNOWLEDGMENTS

We are grateful to Nguyen Thi Bich Lien and Do Thi Hien, National Institute of Malariology, Parasitology and Entomology, Hanoi, for assistance in making collections in Vietnam; to Taina Litwak, formerly of the Walter Reed Biosystematics Unit (WRBU), Washington, DC, for preparing pencil drawings of the larva; to Theresa Howard, The Natural History Museum, London, for modifying and inking the pencil drawings and illustrating the pupa and male genitalia; to Bruce Harrison for critically reviewing the manuscript and sharing his observations on the single larva that he collected and was used to sketch Figs. 3 and 4 (the larva was subsequently lost or misplaced in the Smithsonian Institution); to John F. Reinert for reviewing the manuscript; and to Richard C. Wilkerson, WRBU, for loaning specimens and allowing us to use the pencil drawings.

LITERATURE CITED

Baisas, F. E. 1946. Notes on Philippine mosquitoes, XII. *Topomyia*. Philippines Bureau of Health Monthly Bulletin 22(4): 31–47.

Belkin, J. N. 1962. The Mosquitoes of the South Pacific (Diptera, Culicidae). Vol. 1. University of California Press, Berkeley and Los Angeles. xii + 608 pp.

Edwards, F. W. 1922. A synopsis of adult Oriental culicine (including megarhinine and sabethine) mosquitoes. The Indian Journal of Medical Research 10: 430–475, 3 pls.

———. 1932. Genera Insectorum. Diptera. Fam. Culicidae. Desmet-Verteneul, Bruxelles. Fascicle 194. 258 pp. illustrations.

Goloboff, P. 1997. PIWE Version 3.0 (for Windows). MS-DOS program. Published by the author, San Miguel de Tucumán, Argentina.

Gong, Z. 1996. A new species of *Topomyia* from the bamboo stumps in Yunnan, China (Diptera: Culicidae). Acta Zootaxonomica Sinica 21: 362–365 (in Chinese).

Harbach, R. E. and I. J. Kitching. 1998. Phylogeny and classification of the Culicidae (Diptera). Systematic Entomology 23: 327–370.

Harbach, R. E. and K. L. Knight. 1980. Taxonomists' Glossary of Mosquito Anatomy. Plexus Publishing, Inc., Marlton, New Jersey. xi + 415 pp.

———. 1982. Corrections and additions to *Taxonomists' Glossary of Mosquito Anatomy*. Mosquito Systematics (1981) 13: 201–217.

Harbach, R. E. and E. L. Peyton. 1993. Morphology and evolution of the larval maxilla and its importance in the classification of the Sabethini (Diptera: Culicidae). Mosquito Systematics 25: 1–16.

———. 2000. Systematics of *Onirion*, a new genus of Sabethini (Diptera: Culicidae) from the Neotropical Region. Bulletin of the Natural History Museum Entomology Series 69: 115–169.

Harbach, R. E. and Sandlant, G. R. 1997. CABIKEY Mosquito Genera of the World. Windows CD-ROM. CAB International, Wallingford, England.

Huang, Y.-M. 2002. A pictorial key to the mosquito genera of the world, including subgenera of *Aedes* and *Ochlerotatus* (Diptera: Culicidae). Insecta Koreana 19(1): 1–130.

Judd, D. D. 1996. Review of the systematics and phylogenetic relationships of Sabethini (Diptera: Culicidae). Systematic Entomology 21: 129–150.

———. 1998. Exploring component stability using life-stage concordance in sabethine mosquitoes (Diptera: Culicidae). Cladistics 14: 63–93.

Knight, K. L. and A. Stone. 1977. A catalog of the mosquitoes of the world (Diptera: Culicidae). Second edition. The Thomas Say Foundation 6: xi + 1–611.

Leicester, G. F. 1908. The Culicidae of Malaya. Studies from the Institute for Medical Research, Federated Malay States 3(3): 18–261.

Lu Baolin et al. [*sic*]. 1997. Fauna Sinica, Insecta Vol. 8, Diptera: Culicidae 1. Science Press, Beijing. xiii + 884 pp.

Mattingly, P. F. 1971. Contributions to the mosquito fauna of Southeast Asia. – XII. Illustrated keys to the genera of mosquitoes (Diptera, Culicidae). Contributions of the American Entomological Institute *(*Ann Arbor*)* 7(4): 1–84.

Miyagi, I. and T. Toma. 1989. A new species of *Topomyia* (*Suaymyia*) *sucharití* from Thailand (Diptera: Culicidae). Mosquito Systematics 21: 16–24.

Rattanarithikul, R. and P. Panthusiri. 1994. Illustrated keys to the medically important mosquitos [*sic*] of Thailand. Southeast Asian Journal of Tropical Medicine and Public Health 25(Suppl. 1): 1–66.

Reinert, J. F. 1975. Mosquito generic and subgeneric abbreviations (Diptera: Culicidae). Mosquito Systematics 7: 105–110.

Reinert, J. F., R. E. Harbach, and I. J. Kitching. 2004. Phylogeny and classification of Aedini (Diptera: Culicidae) based on morphological characters of all life stages. Zoological Journal of the Linnean Society 142: 289–368.

Rueda, L. M., S. A. Stockwell, J. E. Pecor, and T. V. Gaffigan. 1998. Key to the mosquito genera of the World. *In* The Diptera Data Dissemination Disk. Vol. I. North American Dipterists Society of Washington, DC.

Stone, A., K. L. Knight, and H. Starcke. 1959. A synoptic catalog of the mosquitoes of the world (Diptera, Culicidae). The Thomas Say Foundation 6: 1–358.

Thurman, E. B. 1959. A contribution to a revision of the Culicidae of northern Thailand. University of Maryland Agricultural Experiment Station Bulletin A-100: 1–182.

Toma, T. and M. Mogi. 2003. *Topomyia* (*Suaymyia*) *miyagii* (Diptera: Culicidae): A new species from Flores Is., Indonesia. Medical Entomology and Zoology 54: 25–30.

Tsukamoto, M., I. Miyagi, and T. Toma. 1985. A revised checklist of the Philippine mosquitoes. Tropical Biomedicine 2: 149–160.

Ward, R. A. 1992. Third supplement to "A Catalog of the Mosquitoes of the World" (Diptera: Culicidae). Mosquito Systematics 24: 177–230.

White, I. M., R. E. Harbach R.E., and G. R. Sandlant. 2004. Fauna Malesiana: Interactive Key for Mosquito Vectors of Human Disease (Diptera: Culicidae). CD-ROM. Biodiversity Centre of ETI, Associated Party Software. UNESCO-Publishing, Paris.

APPENDIX

Anatomical characters used in the cladistic analysis. See Harbach and Kitching (1998) for coding and discussions of the characters. Character states observed in *Kimia* are listed with the numerical character code of Harbach and Kitching in parentheses.

Larvae (*fourth-instars*)

1. *Hypostomal suture*: complete to posterior tentorial pit (1).
2. *Occipital foramen*: circular to oval (0).
3. *Maxillary palpus*: appended to maxillary body (0).
4. *Hypostomal sclerite*: detached from lateralia (2).
5. *Hypostomal sclerite and maxillary palpus*: separate (0).
6. *Hypostomal sclerite and maxillary body*: separate (0).
7. *Apical tooth of maxilla*: present (1).
8. *Maxillary brush*: represented by a flexible bundle of coalesced spicules (1).
9. *Seta 2-C*: absent (0).
10. *Seta 3-C*: present, on oral surface of head (1).
11. *Seta 13-P*: absent (0).
12. *Seta 8-M*: absent (0).
13. *Seta 1 on some or all of abdominal segments I–VII*: with normal stemlike branches (1).
14. *Setae 6,7-I,II*: one or more main stems without plumose branching (1).
15. *Seta 12-I*: absent (0).
16. *Seta 5-VIII*: close to seta 4, usually near or above level of dorsal margin of segment X (1).
17. *Comb*: present (1).
18. *Comb plate*: absent or weakly developed (0).
19. *Siphon* (degree of development): elongate fully sclerotized tube (3).
20. *Seta 1-S*: inserted beyond base of siphon (1).
21. *Pecten*: absent (0).
22. *Accessory setae of siphon* (*other than 1,2-S*): present (1).
23. *Saddle*: incomplete (1).
24. *Pairs of seta 4-X*: one pair (1).

Pupae

25. *Dorsal apotome*: weakly sclerotized medially, appearing as two sclerites joined by membrane (1).
26. *Trumpet*: supporting tubercle absent (0).
27. *Tracheoid area of trumpet*: absent (0).
28. *Seta 1-CT* (degree of development): very strongly developed, considerably larger than setae 2,3-CT (2).

29. *Seta 14-III–VII*: absent (0).
30. *Seta 9-IV–VII*: removed from caudolateral angle of tergum (1).
31. *Seta 0-VIII*: inserted on anterior area of tergum (0).
32. *Seta 9-VIII*: ventral in insertion (0).
33. *Seta 14-VIII*: absent (0).
34. *Seta 1-IX*: absent (0).
35. *Seta 1-XI*: absent (0).
36. *Paddle seta(e)*: absent (0).

Adults (both sexes except where otherwise indicated)

37. *Erect scales of head*: absent (0).
38. *Interocular space* (principally females): constricted, without scales/setae extending to postfrontal sutures (0).
39. *Interantennal ridge* (females): incomplete in dorsal area of postfrons, with frontal pit reinforced by cuticular ring associated with postfrontal sutures (2).
40. *Interantennal ridge* (males): incomplete (absent) in postfrons (1).
41. *Basal microsetae of antennal pedicel*: present (1).
42. *Apical flagellomeres* (males): these flagellomeres not disproportionately long in comparison with the others (1).
43. *Maxillary palpomeres* (females): two, third vestigial if present (3).
44. *Maxillary palpomeres* (males): two, third vestigial or absent (3).
45. *Mouthparts*: long, developed into a proboscis (1).
46. *Labellum*: comprising two separate sclerites (0).
47. *Proximal sclerite of labellum*: short, similar in size to distal sclerite (1).
48. *Labellar scaling*: present (1).
49. *Antepronota*: smaller (usually) and more widely separated (1).
50. *Acrostichal setae*: absent (0).
51. *Dorsocentral setae*: absent (0).
52. *Scutellum*: trilobed (1).
53. *Mesopostnotal setae and/or scales*: absent (0).
54. *Paratergite*: bare (0).
55. *Postpronotal setae*: present (1).
56. *Prespiracular setae*: present (1).
57. *Postspiracular setae*: absent (0).
58. *Prealar setae*: present (1).
59. *Upper mesokatepisternal setae*: absent (0).
60. *Lower mesepimeral seta(e)*: absent (0).
61. *Metepisternal scales*: present (1).
62. *Upper calypter*: bare (0).
63. *Vestiture of alula*: present (1).
64. *Vein R_s with basal spur*: absent (0).
65. *Vein R_2*: equal or longer than vein R_{2+3} (1).
66. *Precubital furrow*: absent (0).
67. *Anal vein*: ends beyond junction of mcu and CuA (1).
68. *Microtrichia of wing membrane*: distinct, clearly visible at low magnification (1).
69. *Tarsomere 1 of fore- and midlegs*: shorter than tarsomeres 2–5 combined (0).
70. *Base of hindcoxa*: more or less in line with or slightly above dorsal margin of mesomeron (1).
71. *Pulvilli*: absent or rudimentary (inconspicuous) (0).
72. *Spermathecal capsules* (females): three (1).
73. *Paraprocts* (males): strongly developed, apex without crown of spicules (1).

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 121–124

AULACUS JURINE (HYMENOPTERA: AULACIDAE) FROM CHINA WITH A NEW SPECIES PARASITIZING *XIPHYDRIA POPOVI* (HYMENOPTERA: XIPHYDRIIDAE)

Shu-Ping Sun and Mao-Ling Sheng

General Station of Forest Pest Management, State Forestry Administration, Shenyang, Liaoning, 110034, China (e-mail: shengmaoling@163.com)

Abstract.—***Aulacus salicius*, n. sp.**, reared from *Xiphydria popovi* Semenov-Tian-Shanskij and Gussakovskij in Heilongjiang Province, China, and *A. striatus* Jurine, 1807, a new record for China, are reported. A key is provided for the six Palaearctic species and one Oriental Chinese species of *Aulacus*.

Key Words: Hymenoptera, Aulacidae, *Aulacus*, new species, China, Xiphydriidae

Sixty-two world species of *Aulacus* Jurine, 1807, have been described (Smith 2001, 2005a, b; He et al. 2002; Jennings et al. 2004a, b, c; Turrisi 2005). Two species, *A. erythrogaster* He and Chen 2002, described from the Oriental part of China and *A. schoenitzeri* Turrisi 2005, described from the Palaearctic part of China, are known in China. In this study, one new species reared from *Xiphydria popovi* Semenov-Tian-Shanskij and Gussakovskij (Xiphydriidae), a woodborer of *Salix* sp. and *Betula* sp., is described, and one species is newly recorded for China.

Identification of *A. striatus* Jurine, 1807, is based on determined specimens lent by Dr. J. Hilszczanski. Information on *A. schoenitzeri* Turrisi 2005, *A. japonicus* Konishi 1990, *A. flavigenis* Alekseev 1986, and *A. jeoffreyi* Alekseev 1993, mentioned in the following key are based on the original descriptions. Identification of *Xiphydria popovi* is based on determined specimens preserved in the Insect Museum, General Station of Forest Pest Management, State Forestry Administration. All specimens examined, including those of the host, are deposited in the Insect Museum, General Station of Forest Pest Management, State Forestry Administration, Shenyang, China.

KEY TO SPECIES OF *AULACUS* OF CHINA AND THE PALAEARCTIC REGION

1. Tergites of metasoma black. 2
– Tergites of metasoma, at least 2nd and 3rd, brown or reddish brown. 3
2. Ovipositor 0.9× as long as forewing length. Antenna extensively reddish orange with segments 1–4 and 11–14 dark orange (China: Shaanxi) . . . *A. schoenitzeri* Turrisi
– Ovipositor 0.4× as long as forewing length. Antenna blackish brown (Japan: Houshu) . . . . *A. japonicus* Konishi
3. Postocellar line 1.4× as long as ocular-ocellar line. Ovipositor about as long as forewing length. Frons yellow (Russia: Primorski Krai) . . . . *A. flavigenis* Alekseev
– Postocellar line shorter than or subequal to ocular-ocellar line. Ovipositor at most 0.8× as long as forewing length. Frons black or partly black, if reddish brown, postocellar line 0.45× as long as ocular-ocellar line. . . 4
4. Head entirely black. Metasoma entirely dark brown (Russia: Sakhalin) . . . . *A. jeoffreyi* Alekseev
– Head with reddish brown portions. Only apical portion of metasoma black. 5

5. Head mainly black with malar area and gena brown. Stigma 3.6×–3.8× as long as its width (Europe and northern Asia to far eastern Russia; China: Inner Mongolia) . . . . *A. striatus* Jurine
– Head mainly reddish brown. Upper portion of frons and median portion of vertex black. Stigma at most 3.3× longer than its width 6
6. Forecoxa black. Postocellar line 0.45× as long as ocular-ocellar line. Third flagellomere 4.5× longer than its width (China: Zhejiang) . . . . *A. erythrogaster* He and Chen
– Forecoxa brown. Postocellar line 0.6×–0.7× as long as ocular-ocellar line. Third flagellomere 6× longer than its width (China: Heilongjiang) . . . . *A. salicius*, n. sp.

Aulacus salicius Sun and Sheng, new species

(Figs. 1–4)

Diagnosis.—Head and basal portion of metasoma mainly reddish brown. Mesosoma mainly black. Forecoxa brown. Malar space 0.7×–0.8× basal width of mandible. Postocellar line 0.6×–0.7× as long as ocular-ocellar line. Length of 3rd flagellomere 6× longer than its width. Stigma 3.2×–3.3× longer than its width. Ovipositor sheath length 0.7×–0.8× forewing length.

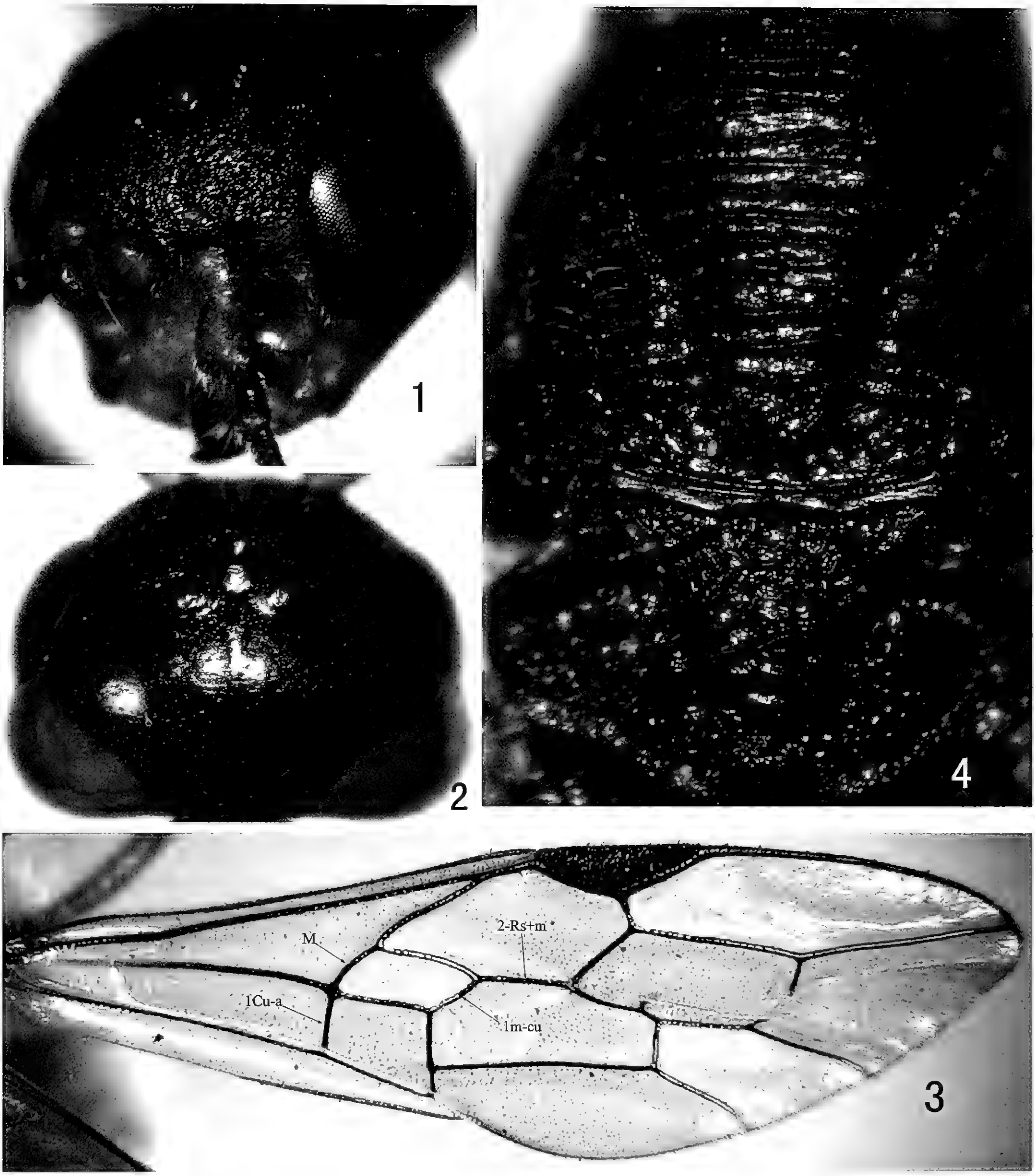
Female.—Body length, 7.0–11.5 mm. Forewing length, 8.5–11.0 mm. Ovipositor sheath length, 6.5–8.0 mm. *Color*: Antenna black with scape and apex of pedicel reddish brown. Head reddish brown with teeth of mandible, upper portion of frons and median portion of vertex black. Mesosoma black, with anterior portion of propleuron and anterolateral of pronotum brown. Wing brownish hyaline. Fore- and midlegs except midcoxa, apices of hind femur and tibia, and hind tarsus brown to yellowish brown. Basal half of metasoma reddish brown except base and apical half black. Stigma brownish black. Veins brownish black with basal portions brownish.

Head: Lower portion of frons with very sparse and indistinct punctures, upper portion (Fig. 1) weakly sculptured, with more or less distinct oblique transverse rugae. Clypeus flat, 0.5×–0.6× as long as wide, front margin with a projecting median tooth. Malar space 0.7×–0.8× as basal width of mandible, about 0.4× as eye height. Gena smooth, about as long as eye in dorsal view; median portion swollen longitudinally, with very fine, sparse and indistinct punctures. Vertex (Fig. 2) almost smooth, with very sparse and fine punctures. Postocellar line 0.6×–0.7× as long as ocular-ocellar line. Ratio of lengths of first 3 flagellomeres as 25:52:53. Third flagellomere 6× longer than its width.

Mesosoma: Notauli reaching transscutal articulation (Fig. 4), not meeting each other behind. Mesoscutum with prominent transverse rugae. Scutellum and Axilla with oblique transverse rugae. Lateral front portion of pronotum with fine and indistinct punctures, diameter of punctures subequal to distance between punctures, median lower portion with prominent transverse rugae, hind portion with weak oblique rugae. Mesopleuron and metapleuron irregularly reticulate, former with oblique rugae. Basal and lateral portion of propodeum with longitudinal rugae, apical portion with transverse rugae. Forewing (Fig. 3) vein 1Cu-a opposite or slightly distad of M; 2-Rs+m 1.3×–1.4× longer than 1m-cu. Stigma 3.2×–3.3× longer than its width. Hind wing veins unpigmental, Cu opposite r-m. Outsides of mid- and hind coxae with fine transverse rugae. Hind coxa with elongate ventral lobe, inner side with a median longitudinal ovipositor guide.

Metasoma: About 1.1× longer than mesosoma, smooth. Subbasal portion of first tergite with longitudinal wrinkles. Ovipositor sheath 0.7–0.8× as long as forewing length.

Holotype.—Female, China: Chaihe (44°51′N, 129°26′E), 514 m, Heilongjiang Province, June 21, 2004, Mao-Ling Sheng.



Figs. 1–4. *Aulacus salicius.* 1, Frons. 2, Vertex. 3, Forewing. 4, Mesosoma, dorsal view.

Paratypes.—6 ♀, same data as for holotype.

Host.—Reared from wood of *Salix* sp. from which many *Xiphydria popovi* emerged.

Etymology.—The name of the new species is based on the food plant of its host.

Discussion.—*Aulacus salicius* is similar to *A. striatus* and *A. erythrogaster. Aulacus salicius* can be distinguished from *A. striatus* by the very sparse and fine punctures on the vertex (Fig. 2), mostly black antennae, and mostly reddish-brown head. *Aulacus striatus* has coarse and dense punctures on the vertex, blackish-brown antennae, and the head extensively black. *Aulacus salicius* can be distinguished from *A. erythrogaster* by characters in couplet 6 of the preceding key.

Aulacus striatus Jurine, 1807

Specimen examined.—1 ♀, labeled "China: Alihe, Inner Mongolia, August 14, 1981, Nankai University." New record for China.

Acknowledgments

We are deeply grateful to Dr. D. Smith, Systematic Entomology Laboratory, USDA, National Museum of Natural History, Smithsonian Institution, Washington, U.S.A., for his kindness in reviewing manuscript. We also thank Dr. J. Hilszczanski, Department of Forest Protection, Forest Research Institute, Warsaw, Poland, for lending specimens. Financial support from the National Natural Science Foundation of China (NSFC, No. 30471397) is thankfully acknowledged.

Literature Cited

Alekseev, V. N. 1986. Aulacidae (Hymenoptera Evanioidea) of Eastern Siberia and the Soviet Far East. pp. 15–18. *In* Ler, P. A., Belokobylskii, S. A., and Storozheva, N. A., eds. [Hymenoptera of Eastern Siberia and the Far East. Collected works], Academy of Sciences USSR, Far East Science Centre, Vladivostok, 1986: pp. 1–152.

———. 1993. *Gasteruption daisyi* sp. n. and *Aulacus jeoffreyi* sp. n. (Hymenoptera, Evanioidea) new species of evanioid parasitic wasps from Middle Asia and Russian Far East. Zoologicheskii Zhurnal 72: 152–154.

He, J., X. Chen, and Y. Ma. 2002. Two new species of Aulacidae from Zhejiang Province, China (Hymenoptera). Acta Zootaxonomica Sinica 27: 149–152.

Jennings, J. T., A. D. Austin, and N. B. Stevens. 2004a. Species of the wasp genus *Aulacus* Jurine (Hymenoptera: Aulacidae) endemic to South Australia. Transactions of the Royal Society of South Australia 128: 13–21.

———. 2004b. The aulacid wasp fauna of Western Australia with descriptions of six new species. Records of the Western Australian Museum 22: 115–128.

———. 2004c. First record of Aulacidae (Hymenoptera: Evanioidea) from New Caledonia with descriptions of three new species of *Aulacus* Jurine. Journal of Australian Entomology 43: 346–352.

Konishi, K. 1990. A revision of the Aulacidae of Japan (Hymenoptera, Evanioidea). Japanese Journal of Entomology 58: 637–655.

Smith, D. R. 2001. World catalog of the family Aulacidae (Hymenoptera). Contributions on Entomology, International 4(3): 263–319.

———. 2005a. Review of the Aulacidae (Hymenoptera) of Chile and adjacent Argentina. Proceedings of the Entomological Society of Washington 107(4): 820–834.

———. 2005b. Aulacidae (Hymenoptera) of northern South America, emphasizing Colombia. Transactions of the American Entomological Society 131: 217–253.

Turrisi, G. F. 2005. Description of *Aulacus schoenitzeri* spec. nov. (Hymenoptera, Evanioidea, Aulacidae) from China. Linzer Biologische Beiträge 37(1): 797–803.

PROC. ENTOMOL. SOC. WASH.
109(1), 2006, pp. 125–130

BIOLOGY OF *ILYTHEA CANICEPS*, *I. SPILOTA*, AND *ZEROS FLAVIPES* (DIPTERA: EPHYDRIDAE), CASE-MAKING CONSUMERS OF DIATOMS ON SHORELINES

B. A. FOOTE

Department of Biological Sciences, Kent State University, Kent, Ohio 44242 (e-mail: bfoote@kent.edu)

Abstract.—Life history information is presented for *Ilythea caniceps* Cresson, *I. spilota* (Curtis), and *Zeros flavipes* (Williston) (Diptera: Ephydridae). Adults of all three species were commonly encountered along shorelines of small streams that possessed moist to wet substrates, where adults deposited eggs. The incubation period lasted two to three days. Larvae consumed a mix of pinnate diatoms. Newly hatched larvae formed a protective case by affixing a mix of sand grains and detrital particles to their dorsal surfaces. The larval period lasted 8–10 days. Puparia were formed in the same habitat occupied by the larvae. The dorsal cases formed by the larvae remained in place on the upper surface of the puparia. The pupal period lasted 6–10 days. All three species were multivoltine.

Key Words: Diptera, Ephydridae, *Ilythea*, *Zeros*, life histories, larval feeding habits

Shore flies of the family Ephydridae occur in nearly all of the world's biotic regions and consist of nearly 1800 described species, as well as a host of undescribed taxa (Mathis and Zatwarnicki 1995). It is the second largest family of acalyptrate Diptera in the Nearctic Region, consisting of over 460 species in 71 genera. Phylogenetically, the family is considered to be particularly close to the Risidae, and both families are currently placed in the superfamily Ephydroidea along with the Camillidae, Diastatidae, Campichoetidae, Drosophilidae, and Curtonotidae (Grimaldi 1990).

Knowledge of the biology and ecology of the Nearctic species of Ephydridae is weak but improving (Deonier 1979, Foote 1995). Information is particularly extensive for those species that occur in more unusual aquatic habitats. For example, life history studies of species of the tribe Ephydrini that are found in alkaline or saline lakes and ponds and in thermal springs are fairly numerous, but relatively few studies have focused on the numerous species of the family that occur in less exotic habitats (Foote 1995). Overall, probably no more than 25% of the Nearctic species of Ephydridae have been investigated with respect to their life cycles and larval feeding habits. Knowledge of the morphology of the immature stages is even less extensive, and probably less than 10% of the larvae of the North American species have been described. In agreement with those of the Drosophilidae, most ephydrid larvae are basically microphagous in feeding habits, with microorganisms and finely divided particulate matter serving as the nutrient base. However, in contrast to the yeast-feeding habits of the drosophilids, larvae of some ephydrid taxa commonly ingest algal cells (see references in Foote 1995, Keiper et al. 2002). Another biological difference in the two families is the occurrence of Drosophilidae in shaded forested habitats, whereas species of Ephydridae are most commonly encountered in open wetland sites where autotrophic microorganisms are abundant.

Ilythea, Zeros, and *Donaceus* are the only genera belonging to the tribe Ilytheini (Ilytheinae) (Mathis and Zatwarnicki 1995). The genus *Donaceus*, consisting of two species, is Oriental and Afrotropical in distribution and unknown biologically. *Ilythea*, with 12 species, has a Holarctic, Neotropical, and Afrotropical distribution, whereas *Zeros*, with 11 species, occurs in the Holarctic, Neotropical, Afrotropical, and Oriental regions. The Nearctic Region contains three species of *Ilythea*. *Ilythea caniceps* Cresson has been recorded from California, Oregon, and Washington south into Mexico and Costa Rica, *I. flaviceps* Cresson is known only from Arizona and California, and *I. spilota* (Curtis) has a transcontinental distribution in North America and also occurs in the Palearctic Region. The genus *Zeros* has five species in North America. *Zeros calverti* (Cresson) and *Z. fenestralis* (Cresson) are known only from Florida in the Nearctic Region but also occur in the Neotropical Region, *Z. flavipes* (Williston) is widespread in the eastern states and Canadian provinces and also occurs in the Neotropical and Afrotropical Regions, *Z. obscurus* (Cresson) has been recorded only from Arizona and New Mexico and from the Neotropical Region, and *Z. vicinus* Cresson occurs only in Florida in North America but also has been recorded from the Afrotropical Region.

Little has been published on the biology of any species of the tribe Ilytheinae, and no larvae or puparia have been described. The egg of *Z. flavipes* was illustrated by Scheiring and Connell (1979) who reported that eggs are inserted into moist soil. They suggested that the slender filament arising from the dorsal surface of the egg serves as an aeropyle (Hinton 1968). Foote (1995) reported that larvae of *Ilythea* and *Zeros* consume diatoms.

This paper presents information on habitat occurrence, larval feeding habits, case-building behavior, and general life history of *Ilythea caniceps*, *I. spilota*, and *Zeros flavipes* whose larvae consume diatoms in shoreline habitats. The biology of the three species is contrasted and compared with that of other species of Ephydridae having larvae that feed on diatoms, and resource partitioning within this guild of diatom-feeders is discussed.

MATERIALS AND METHODS

Field work for this study was carried out in northeastern Ohio near Kent in Portage County between 1982 and 1996, and in southern Arizona in 1970–1971. Habitats studied included riffle rocks in small woodland streams, gravely, sandy desert streams, and muddy shorelines. Pairs of adults obtained by sweep netting in nature were established in small breeding jars (5.5 × 7.0 cm) containing substrate taken from the habitat. Eggs obtained from these pairs were either allowed to hatch on the field-collected substrate or were transferred to large Petri dishes containing a monoculture of diatoms (*Navicula pelliculosa* (Bréb.) Hilse) growing on nutrient agar (Zack and Foote 1978).

RESULTS AND DISCUSSION

Life History of *Ilythea Caniceps*

Rearings of this species were initiated on 12-V-1971 from a gravid female collected along a small, intermittent stream in Upper Sabino Canyon near Tucson, AZ (32°19′19″N, 110° 48′ 35″W).

Additional rearings were initiated with larvae collected in a sandy substrate along the same shallow stream on 20-V-1971. Other ephydrid adults collected at the same site included *Lytogaster excavata* (Sturtevant and Wheeler), *Pelina* sp., *Athyroglossa* sp., *Discocerina obscurella* (Fallén), *Parydra appendiculata* Loew, *Scatella laxa* Cresson, *S. marinensis* (Cresson), and *S. paludum* (Meigen). The sand shore was moist to wet and had a distinct yellow-green cast due to an abundance of algae, including large numbers of diatoms. Examination of the gut of one adult showed that it had ingested diatoms.

Four eggs were noticed on V-15 in the sand substrate in the breeding jar. They were placed horizontally in the moist sand and had a distinct elongate stalk at midlength that extended into the overlying air. Hatching began that evening when one larva was discovered moving slowly over the sand substrate. It had a distinct hump-backed shape and continuously moved its mouthparts in a flickering motion. Within an hour of hatching, I noticed that the larva had formed a case composed of sand grains and small detritus particles that covered its dorsal surface. The case retained its shape when removed from the larva, and the particles appeared to be glued together by a secretion released by the larva.

On V-20, six third-instar larvae of *I. caniceps*, 12 larvae of a species of *Lamproscatella*, 6 larvae of at least 2 species of *Scatella*, and numerous eggs of *Parydra appendiculata* were collected at the same site. All of the *Ilythea* were distinctly hump-backed and possessed dorsal cases composed of sand grains and detritus. The integument appeared to be distinctly thinner in the area covered by the dorsal case. The larvae moved about on the moist sand rather swiftly while exhibiting the flickering movement of the mouthparts. I removed the dorsal case from one of the larvae and noted that it immediately gathered up small particles from the substrate and reformed the case within a few minutes. Larvae moved about on the surface of the moist sand but did not burrow down into it. The gut on one examined larva was filled with a mix of pinnate diatoms belonging to the genera *Navicula, Stauroneis*, and *Synedra*. No non-diatom algal taxa were noted in the gut, suggesting that this species is a specialist on diatoms.

On V-24, numerous eggs, and at least 16 second- and third-instar larvae were found in a Petri dish-sized sample (area of 64 cm^2) taken near the center of the sampling site that was about 3600 cm^2. The larval period varied from 5 to 10 days (5 larvae).

Puparia were formed in the same area where larvae occurred and all retained the dorsal case. The pupal period lasted 9–10 days (4 puparia).

Life History of *Ilythea Spilota*

Adults of this species were most commonly encountered in shoreline habitats that contained large populations of pinnate diatoms. Numerous specimens were also collected from various-sized rocks that projected above the water line in riffles of small woodland streams. Interestingly, habitats that were open to sunlight did not contain larger populations of *Ilythea* than sites that were partially or mostly shaded. In fact, populations frequently were comparatively larger in shaded habitats than in the more open areas of the shoreline or riffle. Deonier (1965), in a study of ephydrid habitats in Iowa, reported that *I. spilota* was most commonly encountered in the stream-rock habitat, although it was found also in the limnic-wrack, sedge- meadow, and muddy-shore habitats. In contrast, Scheiring and Foote (1973) collected adults most commonly on muddy shores, with fewer recorded from limnic-wrack, grass-shore, rain-pool, and marsh-reed habitats. Results similar to the latter paper were obtained in Scandinavia by Dahl (1959) who reported that the center of ecological distribution for adults of this species was the mud-shore biotope, although he also regularly encountered them in moist meadows and over wrack deposited on high beaches bordering freshwater lakes.

This is a multivoltine species, and adults are repeatedly collected throughout the warm season in northeastern Ohio. The first specimens were obtained on April 15, and the last on October 2. Populations were particularly large in mid and late summer once stream flows stabilized and diatom populations surged. As reported by Deonier (1972), adults fed on pinnate diatoms. Guts of field-collected adults of both sexes contained nearly pure cultures of diatoms with only occasional cells of other algal taxa. There was no obvious trophic separation between adults and larvae, as similar diatom taxa were found in both life stages.

A male and female collected in a stand of skunk cabbage (*Symploricarpos foetidus* (L.) Nuttall) along the Cuyahoga River in Kent, Ohio, was placed in a Petri dish supporting a pure culture of *Navicula* diatoms on 20-VIII-1976. Adults fed on the lawn of diatoms, as numerous areas cleaned of cells were noted. Six eggs were laid on August 23. All were placed horizontally in the layer of diatoms and all supported an upright stalk at mid-length. Hatching began on VIII-24, giving an incubation period of 1–2 days. The larvae fed steadily on the monoculture of *Navicula* and all formed dorsal cases of diatoms. Larval feeding ended on IX-02, giving a larval period of 8–10 days (n = 5). The dorsal cases remained in place on the upper surface of the puparia. The female died on IX-06, having lived for 17–18 days in the *Navicula* culture. Adults emerged from the 5 puparia on IX-08 and IX-09, giving a pupal period of 6–7 days. Three of the emerged adults (2 males, 1 female) that were transferred to a fresh plate of *Navicula* on IX-13 began laying eggs on IX-23, giving a pre-oviposition period of some 10 days.

Several larvae were collected from a muddy, diatom-laced shoreline of Cave Creek in the Chiracahua Mountains of southeastern Arizona on X-23-1976. All larvae bore dorsal cases composed of diatoms and detrital particles, although one larva had attached an empty *Ilythea* egg shell, and another had affixed a small, dead larva to the case. Gut examinations of two third-instar larvae disclosed a nearly pure culture of pinnate diatoms belonging to several undetermined genera.

Numerous collections of adults and immature stages between late May and early October in northeastern Ohio indicate that this is a multivoltine species. With an incubation period of 2–3 days, a larval period of 10–13 days, and a pupal period of 6–10 days, there could be as many as 7–8 generations produced during a warm season of some 180 days in this latitude and longitude.

Life History of *Zeros Flavipes*

The single rearing of this species was initiated from a gravid female collected on VIII-13-1976, from the sandy/muddy shores of the Cuyahoga River in Kent. She was placed in a large Petri dish that contained a monoculture of the diatom *Navicula pelliculosa*. By VIII-15, she had scattered eight eggs over the diatom culture, with each egg being buried horizontally in the agar except for the upward-directed projection arising at mid-length on the dorsal side of the egg. The incubation period of the eight eggs was two days. The female died on VIII-16, although numerous eggs were still visible within her abdomen.

The six newly hatched larvae moved slowly over the surface of the diatom culture and quickly began ingesting diatoms, as shown by the yellowish material that appeared in the gut. All larvae constructed a dorsal case of diatoms and egg shells within one day of hatching. Larvae continued to feed on the diatom culture, with the first stadium lasting three days (n = 6); the second, two days (n = 2); and the third stadium, five days (n = 1). The total larval period from hatching to pupariation in the single larva that formed a puparium was nine days. The dorsal case was-reconstructed after each of the first two molts and remained in place over the puparium. A male emerged on VIII-31, giving a pupal period of 6 days (n = 1).

Another gravid female was collected on IX-01-1982 near the original collecting site. She was associated with the shore flies *I. spilota, Athyroglossa granulosa*, and *Scatella picea*, but deposited no eggs during the 14 days she was held in a Petri dish containing a monoculture of *Navicula*. This collection was interesting in that it showed that both *I. spilota* and *Z. flavipes* can co-occur in the same habitat.

Undoubtedly the most interesting and distinctive behavior of the larvae of these two genera was the repeated construction of a case that covered their dorsal surfaces. Case building began almost as soon as larvae hatched, was maintained through all three larval instars, and remained in place on the dorsal side of the puparium. When I removed the case, the larva quickly began the construction of a replacement. Because the construction of a dorsal case requires an energy expenditure, it appears that there is selective value in its construction, and at least two possible roles of the case can be suggested. Because the larvae crawl about on exposed surfaces (mud, sand, rock), there is high likelihood of contacting predators such as larvae of Hydrophilidae (Coleoptera) that are common in such habitats. Therefore, it is possible that the case serves a protective role in that it serves to camouflage the feeding larva. The integument of larva appears to be quite thin under the case, and it is possible that the case shields the larva from ultra-violet radiation, prevents overheating or retards desiccation.

One interesting puzzle is how the co-occurring larvae of two or more species manage to avoid competition, assuming that there is a limiting resource. This was not explored in this study, but it quite possible that there is some microspatial segregation of the feeding larvae. For example, larvae of one species could occur on somewhat drier surfaces, whereas the second species occurs more commonly on wetter surfaces. Of course, there is also the possibility that there is no limiting resource (diatoms) because larval populations are relatively low.

The utilization of diatoms by ephydrid larvae is particularly well developed in these two genera and in species of *Parydra*, and all commonly co-occur in diatom-rich habitats. One interesting difference in the feeding of *Parydra* larvae (Deonier 1978) versus that of the larvae of *Ilythea* and *Zeros* is their mode of segregating diatoms from the substrate. There is no indication of pharyngeal ridges in the mouthparts of *Parydra*, but they are present in larvae of the other two genera. It has been shown that pharyngeal ridges serve as a filtering device in particle-feeding larvae of acalyptrate larvae (Ferrar 1987), but the mode of filter-feeding in *Parydra* larvae remains unknown.

ACKNOWLEDGMENTS

I am indebted to Joe B. Keiper, Cleveland Museum of Natural History, and Eric. G. Chapman, Department of

Biological Sciences, Kent State University, for making numerous suggestions for the improvement of this manuscript.

Literature Cited

Dahl, R. G. 1959. Studies on Scandanavian Ephydridae (Diptera Brachycere). Opuscula Entomologia Supplement 15: 1–224.

Deonier, D. L. 1965. Ecological observations on Iowa shoreflies (Diptera, Ephydridae). Proceedings of the Iowa Academy of Sciences 71: 496–510.

———. 1972. Observations on mating, oviposition, and food habits of certain shore flies (Diptera: Ephydridae). Ohio Journal of Science 72: 22–29.

Deonier, D. L., ed. 1979. First Symposium on the Systematics and Ecology of Ephydridae (Diptera). North American Benthological Society. 147 pp.

Deonier, D. L. and J. T. Regensburg. 1978. Biology and immature stages of *Parydra quadrituberculata* (Diptera: Ephydridae). Annals of the Entomological Society of America 71: 341–353.

Ferrar, P. 1987. A Guide to the breeding Habits and Immature Stages of Diptera, Cyclorrhapha. Part I. Text. Brill, Leiden.

Foote, B. A. 1995. Biology of shore flies. Annual Review of Entomology 40: 417–442.

Grimaldi, D. A. 1990. A phylogenetic, revised classification of genera in the Drosophilidae (Diptera). Bulletin of the American Museum of Natural History 197: 1–139.

Hinton, H. E. 1968. Respiratory systems of insect egg shells. Annual Review of Entomology 14: 343–368.

Keiper, J. B., W. E. Walton, and B. A. Foote. 2002. Biology and ecology of higher Diptera from freshwater wetlands. Annual Review of Entomology 47: 207–232.

Mathis, W. N. and T. Zatwarnicki. 1995. World catalog of shore flies (Diptera: Ephydridae). Memoirs on Entomology International 4: 1–423.

Scheiring, J. F. and T. D. Connell. 1979. A description of the egg of *Zeros flavipes* (Cresson) (Diptera: Ephydridae). Journal of the Kansas Entomological Society 52: 609–612.

Scheiring, J. F. and B. A. Foote. 1973. Habitat distribution of the shore flies of northeastern Ohio (Diptera: Ephydridae). Ohio Journal of Science 73: 152–166.

Zack, R. S. Jr. and B. A. Foote. 1978. Utilization of algal monocultures by larvae of *Scatella stagnalis* (Diptera: Ephydridae). Annals of the Entomological Society of America 71: 509–511.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 131–135

A KEY TO SPECIES OF THE GENUS *CACCOBIUS* THOMSON (COLEOPTERA: SCARABAEIDAE: SCARABAEINAE) FROM CHINA, WITH DESCRIPTION OF A NEW SPECIES

MING BAI, YOUWEI ZHANG, AND XINGKE YANG

(MB, YZ, XY) Institute of Zoology, Chinese Academy of Sciences, 36 Box, 25 Bei SiHuanXiLu, Haidian, Beijing, 100080, China (e-mail: baim@ioz.ac.cn); (MB) Graduate School, Chinese Academy of Sciences, Yuquanlu, Shijingshan, Beijing, 100039, China (e-mail: yangxk@ioz.ac.cn). Corresponding author: Xingke Yang (e-mail: yangxk@ioz.ac.cn)

Abstract.—Diagnosis, description, and illustrations of the head, pronotum, profemur, protibia, pygidium, and aedeagus of ***Caccobius* (*Caccobius*) *excavatus*, n. sp.**, are given. A key to the species of *Caccobius* Thomson from China is included.

Key Words: China, *Caccobius*, Scarabaeinae, Scarabaeidae, Coleoptera, new species, key

The genus *Caccobius* (Coleoptera: Scarabaeidae: Scarabaeinae: Onthophagini) was established by Thomson in 1863. There are 89 world species (Gillet 1911, Balthasar 1963) and 18 species currently known in China, including one new species described here. Species of *Caccobius* are tunnellers, and their nesting behavior is complex (Halffter and Edmonds 1982, Philips et al. 2004). They can be collected from various animal excrement, such as cow, elephant, gaur, buffalo, pig, and human. The species of this genus are of short compact form and generally of small size, some of them very small. The front angles of the thorax have a deep, sharply defined, hollow beneath. Males may be armed with a single short horn, a pair of horns, or they may be entirely without armature.

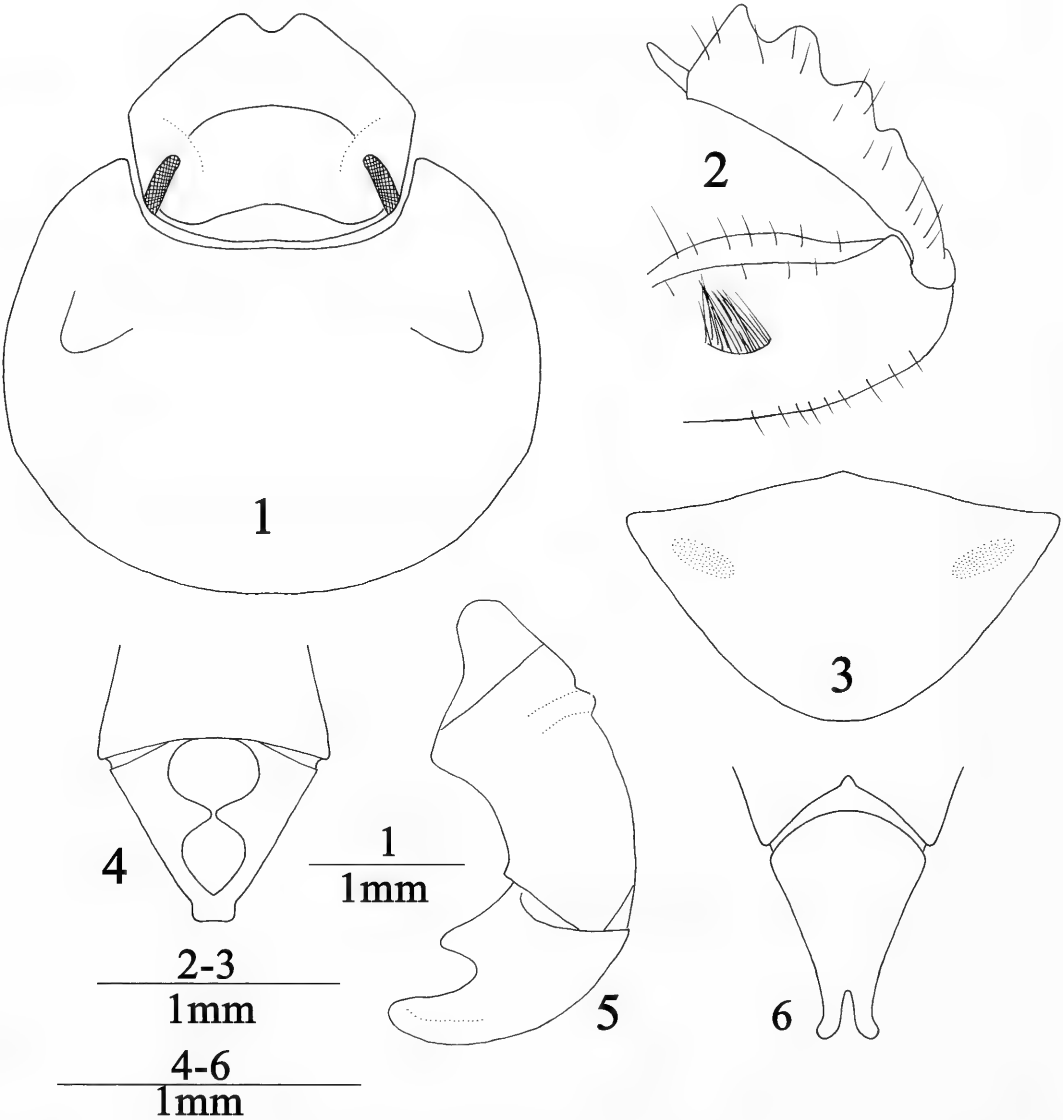
In this paper, 18 species of *Caccobius* from China are treated, among them *Caccobius* (*Caccobius*) *excavatus* described as new. A key to the species of China and illustrations of the head, pronotum, profemur, protibia, pygidium, and aedeagus of *C. excavatus* and *C. jessoensis* are given.

***Caccobius* (*Caccobius*) *excavatus* Bai, Zhang, and Yang, new species**

(Figs. 1–6)

Holotype male.—Length from clypeus to pygidium 6.5 mm; width across humeri 3.5 mm. Shape broadly oval, compact, convex. Color deep dark brown; head and pronotum slightly metallic, elytra brown at base and apex.

Head: Clypeus with front margin deeply notched in middle, finely and closely rugulose. Anterior carina of head short, not close to front margin. *Thorax*: Shape of pronotum parabolic, 1.2 times wider than long. Surface strongly and closely punctate, without median line, completely margined. Anterolateral angles of pronotum acute (Fig. 1). Profemur with strong, dense punctures, meso- and metafemora with fine and sparse punctures. Procoxa with long pubes-



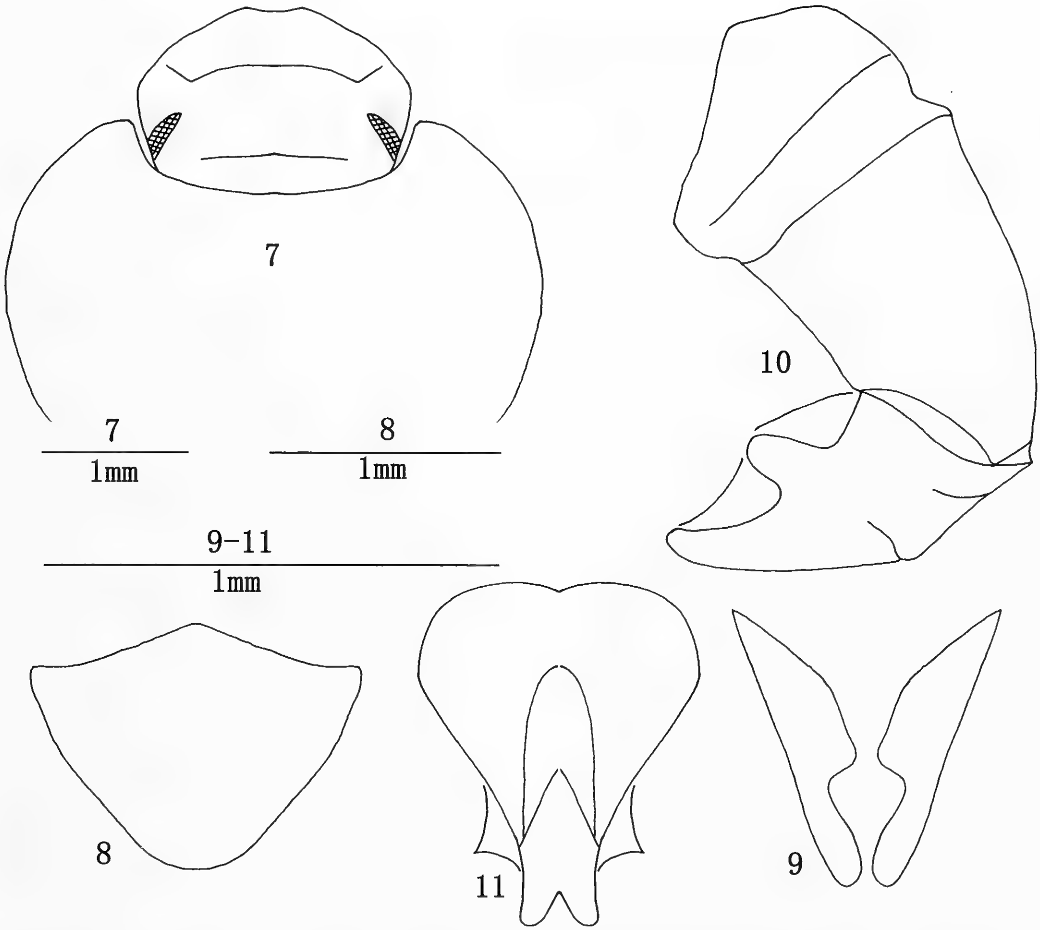
Figs. 1–6. *Caccobius* (*Caccobius*) *excavatus*. 1, Dorsal view of head and pronotum. 2, Profemur and protibia. 3, Pygidium. 4, Parameres, ventral view. 5, Aedeagus, lateral view. 6, Parameres, dorsal view.

cence. *Abdomen*: Elytral striae distinct, intervals flat and microscopically punctate. Shape of pygidium parabolic, 1.7 times wider than long. Surface with 2 shallow foveae near front margin (Fig. 3). 1st to 5th segments sparsely and strongly punctate, 6th segment densely and finely punctate. Aedeagus (Figs. 4–6) with basal plate 1.6 times longer than parameres, parameres with 2 broad, deep notches in lateral view.

Female.—Length 7.2 mm; width across humeri 4.1 mm. Similar to male except notch of clypeal front margin shallower and anterior carina of head longer.

Variation in paratypes.—Length from clypeus to pygidium 6.5–7.2 mm; width across humeri 3.5–4.1 mm. Light brown marks on elytra present in some males.

Type material.—Holotype: P. R. CHINA. ♂, Xizang, Jilong, 2800 m, 25 July 1971, Col. Xue-zhong Zhang. Paratypes:



Figs. 7–11. *Caccobius* (*Caccobius*) *jessoensis*. 7, Dorsal view of head and pronotum. 8, Pygidium. 9, Parameres, ventral view. 10, Aedeagus, lateral view. 11, Parameres, dorsal view.

P. R. CHINA. 1♂, Same data as holotype; 1♀, Xizang, Chaya, Jitang, 3600 m, 8 July 1976, Col. Yin-heng Han. Type material deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing, P. R. China (IZAS).

Distribution.—China (Xizang).

Diagnosis.—The new species is similar to *Caccobius* (*Caccobius*) *jessoensis* Harold, 1867 (Figs. 7–11), but differs primarily by the deep notch in the middle of the clypeal front margin (Fig. 1), the acute anterolateral angles of the pronotum (Fig. 1), and the presence of two shallow foveae near the front margin of the pygidium (Fig. 3). *Caccobius* (*C.*) *jessoensis* has the front margin of the clypeus shallowly notched in the middle (Fig. 7), the anterolateral angles of the pronotum blunt (Fig. 7), and the pygidium without foveae near the front margin (Fig. 8).

Etymology.—The name is from Latin and refers to the deep notch on the front margin of the clypeus.

KEY TO ADULTS OF *CACCOBIUS* FROM CHINA

1 Upper surface of head and pronotum smooth, entirely without setae. Prosternum with 2 carinae (subg. *Caccobius*) 2

– Upper surface of head and pronotum setose. Prosternum with 1 carina (subg. *Caccophilus*) 8

2 Elytra black or dark brown 3

– Elytra bicolored, at least reddish brown or yellow at apex 5

3 Body length over 6.0 mm. Front margin of clypeus notched (Fig. 1). Head and pronotum metallic 4

– Body length 4.5–5.0 mm. Front margin of clypeus not notched. Head and pronotum not metallic (China: Xizang) . . . .
. . . . . . *C.* (*Caccobius*) *imitans* Balthasar, 1933

4 Front margin of clypeus deeply notched (Fig. 1). Anterior carina of head far from front margin. Anterolateral angles of pronotum acute (China: Xizang) . . . .
. . . . *C.* (*Caccobius*) *excavatus*, n. sp.

– Front margin of clypeus shallowly notched (Fig. 7). Anterior carina of head close to front margin. Anterolateral angles of pronotum round (China: Beijing, Hebei, Shanxi, Shaanxi, Henan, Guangxi, Sichuan, Yunnan; Japan) . . . .
. . . . . . *C.* (*Caccobius*) *jessoensis* Harold, 1867

5 Size small, body length not over 3.0 mm. Male pronotum simple, not armed (China: Taiwan) . . . .
. . *C.* (*Caccobius*) *flavolimbatus* Balthasar, 1942

– Size large, body length at least 5.0 mm. Male pronotum armed 6

6 Pronotum not metallic. Elytral interstriae flat and sparsely, deeply punctate, with large punctures (China: Taiwan) . . . . .
. . . . *C.* (*Caccobius*) *chujoi* Paulian, 1942

– Pronotum slightly metallic. Elytral interstriae convex and densely, shallowly punctate, with small punctures 7

7 Male with anterior carina of head feeble and straight, female with anterior carina of head curved. Female pronotum feebly armed (China: Hubei, Hunan, Fujian, Taiwan, Sichuan, Yunnan; Vietnam; Laos; India) . . . .
. . *C.* (*Caccobius*) *gonoderus* (Fairmaire, 1888)

– Both sexes with anterior carina of head distinct and somewhat curved. Female pronotum not armed (China: Yunnan; Vietnam) . . . .
. . . *C.* (*Caccobius*) *demangei* Boucomont, 1919

8 Pronotum armed with 1 tooth. Elytra dark red or brown. Interstriae convex 9

– Pronotum armed with more than 1 tooth or unarmed. Elytra with different colors, not red or brown. Interstriae flat 10

9 Upper surface opaque. Male with anterior carina of head absent. Pronotum with simple punctures. Body length 6.0–7.0 mm (China: Sichuan, Yunnan) . . . .
. . *C.* (*Caccophilus*) *boucomonti* Balthasar, 1935

– Upper surface shining. Male with anterior carina of head present. Pronotum with umbilicate punctures. Body length 5.0–6.5 mm (China: Hebei, Shanxi; Russia; Korea) . . . .
. . . . . *C.* (*Caccophilus*) *sordidus* Harold, 1886

10 Body length 3.5 mm or less. Male and female pronotum simple, unarmed 11

– Body length 4.5–9.0 mm. Male pronotum armed, female pronotum unarmed 14

11 Male head without carina, female head with short carina or without carina (China: Fujian) . . . .
. . . . . *C.* (*Caccophilus*) *scrofa* Balthasar, 1941

– Male and female head with distinct and somewhat curved carinae 12

12 Male head without tooth and anterior carina of head arcuate, posterior carina of head curved. (China: Fujian) . . . .
. . . . *C.* (*Caccophilus*) *pullus* Jekel, 1872

– Male head without anterior carina and with 1 tooth pointing posteriorly, posterior carina of head stright 13

13 Pronotum with sparse punctures. Elytral interstriae coarsely punctate. Body length 2.5–3.0 mm (China: Heilongjiang, Jilin, Liaoning, Beijing, Hebei, Shanxi, Hubei, Hunan, Hainan, Sichuan; Vietnam; Philippines; Myanmar; India) . . . .
. . *C.* (*Caccophilus*) *unicornis* (Fabricius, 1789)

– Pronotum with dense punctures. Elytral interstriae with fine rugosity. Body length 3.0–3.5 mm (China: Shanghai, Fujian) . .
. . . . . . *C.* (*Caccophilus*) *fukiensis* Balthasar, 1941

14 Posterior carina of head triangular in male 15

– Posterior carina of head crescent-shaped or simple in male 17

15 Front margin of clypeus round in male and female (China: Heilongjiang, Jilin, Liaoning, Henan, Xizang; Russia; Korea) . . .
. . . . *C.* (*Caccophilus*) *christophi* Harold, 1879

– Front margin of clypeus of male not round, somewhat notched, front margin of female straight or somewhat notched 16

16 Front margin of clypeus slightly notched in male (similar to Fig. 7), front margin clearly round in female. Male pronotum armed, female pronotum simple. Body length 8.0–9.0 mm (China: Gansu, Shaanxi, Henan; Russia) . . . .
. . . . *C.* (*Caccophilus*) *sibiricus* Balthasar, 1935

– Front margin of clypeus deeply notched in male (similar to Fig. 1), female front margin notched deeper than male. Male and female pronotum simple. Body length 4.6–4.8 mm (China: Yunnan) . . . .
. . *C.* (*Caccophilus*) *yunnanicus* Kabakov, 1994

17 Posterior carina of head forming a tooth in male and female. Body length 4.0–5.0 mm (China: Fujian, Guangdong; India; Indo-

nesia) . . . .
. . . . *C.* (*Caccophilus*) *tortus* Sharp, 1875

– Posterior carina of head simple in male and female. Body length 4.5–5.5 mm (China: Heilongjiang, Jilin, Liaoning, Shanxi; Korea; Japan) . . . .
. . . . *C.* (*Caccophilus*) *brevis* Waterhouse, 1875

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of Dr. Ales Bezdek (Institute of Entomology, Academy of Sciences of the Czech Republic), Dr. Giuseppe M. Carpaneto (Università degli Studi Roma Tre, Italy), Dr. Bert Kohlmann (Universidad EARTH, Costa Rica), and Dr. Patrick Prevost (Chez Tartaud, France) for obtaining literature. Dr. Si-Qin Ge (IZAS) and Dr. Li-Jie Zhang (IZAS) provided useful advice. The project is supported by a China National Science Fundation Grant (No. 30200025).

LITERATURE CITED

Balthasar, V. 1963. Monographie der Scarabaeidae und Aphodiidae der Palaearktischen und Orientalischen Region Band 2. Verlag der Tschechoslowakischen Akademie der Wissenschaften, Prague. 627 pp.

Gillet, J. J. E. 1911. Coleopterorum Catalogus Pars 38, Scarabaeidae: Coprinae. Dr. W. Junk, Berlin. 263 pp.

Halffter, G. and W. D. Edmonds. 1982. The nesting behavior of dung beetles (Scarabaeinae): an ecological and evolutive approach. Instituto de Ecología, México, D. F. 177 pp.

Philips, T. K., E. Pretorius, and C. H. Scholtz. 2004. A phylogenetic analysis of dung beetles (Scarabeinae: Scarabaeidae): Unrolling an evolutionary history. Invertebrate Systematics 18: 53–88.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 136–154

SUMMER EPHEMEROPTERA, PLECOPTERA, AND TRICHOPTERA FROM SOUTHWESTERN DRAINAGES IN GREAT SMOKY MOUNTAINS NATIONAL PARK, WITH ADDITIONAL EPHEMEROPTERA RECORDS

R. Edward DeWalt, Luke M. Jacobus, and W. P. McCafferty

(RED) Illinois Natural History Survey, 1916 S Oak St., Champaign, IL 61820, U.S.A. (e-mail: edewalt@inhs.uiuc.edu); (LMJ, WPM) Department of Entomology, Purdue University, West Lafayette, IN 47907-1158, U.S.A.

Abstract.—Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (in total, EPT) were inventoried during May 2003, June 2003, and early July 2004 at 15 stream reaches in southwestern Great Smoky Mountains National Park (GRSM). Adults and immatures were collected using ultraviolet light traps, sweepnetting, and handpicking. At least 169 species were collected, including 54 mayfly species, 38 stonefly species, and 77 caddisfly species. Two small, western, low elevation streams, Shop Creek and Tabcat Creek, produced the greatest number of species at 61 and 56 species, respectively. The two large streams, Eagle and Deep creeks, also produced high species richness at 53 species each. A species accumulation curve and two richness estimates demonstrated that EPT richness in this particular area may be 80 to 120 species higher than observed. A cluster analysis showed that adjacent stream reaches had relatively similar faunas and that different habitats supported quite different assemblages. Significant regional records included *Ameletus tertius* McDunnough and *Epeorus fragilis* (Morgan). Several Ephemeroptera species are reported for the first time from North Carolina (4), Tennessee (6), and GRSM (7). Four Trichoptera species are reported from GRSM for the first time.

Key Words: Ephemeroptera, Plecoptera, Trichoptera, Great Smoky Mountains National Park

The National Park Service has been conducting an All Taxa Biodiversity Inventory (ATBI) in the Great Smoky Mountains National Park (GRSM) since 1997 (Sharkey 2001), one of relatively few Park Service properties receiving any such attention (Baumgardner and Bowles 2005). The inventory efforts in GRSM have yielded data that augment our knowledge of the diversity and distribution of aquatic insects in North America, including the discovery of several new species (Parker 2000; Petersen et al. 2004; Etnier et al. 2004; Jacobus and McCafferty 2006). The southern Appalachian Mountain Range and GRSM, in particular, are important sources of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (hereafter referred to as EPT) diversity (Morse et al. 1993; Jacobus and McCafferty 2003, 2005). DeWalt and Heinold (2005), working in the western Abrams Creek drainage of GRSM, recorded 39 EPT species not previously reported from GRSM, eight of which were new Tennessee state records. Other GRSM areas that appear

Table 1. Location information, approximate stream width, elevation, dates of collection, and methods used at 15 stream sites in southwestern Great Smoky Mountains National Park in May and June 2003 and July 2004. Stream sites oriented from west to east.

Site	Creek	Lat.	Long.	Width (m)	Elevation (m)	Dates	Methods
Blount County, Tennessee							
1	Shop Cr.	35.5308	83.9878	4	268	6/1, 6/9	sweep, handpicking, UV light
2	Tabcat Cr.	35.5196	83.9793	5	299	5/21, 5/22, 6/8	sweep, handpicking, UV light
3	Seeps Cattail Br.	35.5149	83.9763	0.5	311	5/21, 5/22	sweep, handpicking
4	Cattail Br.	35.5149	83.9763	2	311	5/21, 5/22	sweep, handpicking
Swain County, North Carolina							
5	Twentymile Cr. CG 93	35.4730	83.8524	6	579	5/21, 7/2	handpicking, UV light
6	John's Cove	35.4725	83.8515	2	579	5/22	sweep
7	Proctor Br.	35.4856	83.8368	2	768	5/22, 6/5, 7/3	sweep, handpicking, UV light
8	Twentymile Cr. CG 92	35.4968	83.8337	3	713	6/5, 7/3	sweep, handpicking, UV light
9	Gunna Cr.	35.5512	83.7322	6	1109	6/3	sweep, handpicking, UV light
10	Eagle Cr. CG 90	35.4880	83.7718	12	533	5/28, 7/4	sweep, handpicking, UV light
11	Eagle Cr. CG 89	35.4985	83.7638	10	585	5/28, 6/10	sweep, handpicking, UV light
12	Ekaneetlee Cr.	35.4981	83.7664	8	585	5/28, 6/10	sweep, handpicking, UV light
13	Hazel Cr.	35.4744	83.7245	10	531	5/29, 6/11	sweep, UV light
14	Hammer Br.	35.4739	83.4311	2	585	5/24	sweep, handpicking, UV light
15	Deep Cr.	35.4730	83.4300	10	594	5/24, 5/31, 6/12	sweep, handpicking, UV light

to be poorly studied include numerous locales east of Abrams Creek in Tennessee, east into North Carolina. This southwestern end of the Park is remote and constitutes the largest roadless area in GRSM. Much of the region occurs north of Lake Fontana, making access difficult. The building of a proposed highway, the so-called North Shore Road, has loomed as a threat to this area for over 50 years and would run along the northern boundary of Lake Fontana, so it is imperative to record rare species and unique communities from this area to document its importance to GRSM.

Our objective was to inventory the summer EPT of 15 stream reaches spanning the distance from the mouth of Shop Creek in Blount County, Tennessee, to Deep Creek near Bryson City, Swain County, North Carolina. Particular effort was made to inventory several streams that are tributaries of Lake Fontana.

MATERIALS AND METHODS

Fifteen reaches (Table 1) were accessed by foot and by boat from 21 May to 12 June, 2003 and 1–4 July, 2004. Most sites were inventoried on multiple occasions using multiple methods (Table 1). Ultraviolet (UV) light trapping was conducted using a Bioquip™, 12 v light and battery. Effort was standardized by time (approximately one hour beginning at sunset) and reflective sheet size (1 m^2). Trays of 80% EtOH were positioned below the sheet to capture falling insects. Mayfly subimagoes were captured from the sheet and reared to imagoes. Males of Perlidae and Perlodidae stoneflies were captured and their intromittent organ extruded to facilitate species identification. Remoteness of access meant that we could not control for variability of weather, hence, some difference in effort is acknowledged. Sweepnetting of riparian vegetation for adults and handpicking in streams for nymphs, larvae, and pupae was also conducted until no new species were detected. Geographic coordinate data were captured using a Garmin™ 12XL global positioning system at each site.

Samples were sorted in their entirety and specimens identified to species. Often only the males of species could be identified, but where it seemed that color pattern, size, or wing veination was consistent with males of known identity, they too were determined. All specimens are housed in the INHS insect collection and were entered into the INHS insect collection database (INHS 2005).

An EPT species richness data matrix was constructed with the number of collections, number of methods, elevation, and stream wetted width (size) as potential correlative variables. Relationships among these were tested using Spearman Rank Correlation (Cody and Smith 1991). Another matrix, one of stream reach-by-species presence or absence was built in order to determine efficacy of sampling. Here, all methods for a reach were pooled, taxa at the genus level discarded unless they were unique, and data from John's Cove excluded due to poor sampling. The data matrix was analyzed using PCOrd™ software (McCune and Mefford 1999), with species accumulation curves and jackknifing options chosen. The species accumulation curve assesses sample adequacy by repeatedly sampling the data matrix to provide a prediction of richness versus subsample units. It also calculates standard deviation about this predicted value. Curves that climb rapidly and level out demonstrate saturation of effort in the area. Those whose slope is steep have not nearly exhausted the available species.

PCOrd also provides two jackknife estimates of species richness from random permutations of the data matrix. McCune and Mefford (1999) provide a brief explanation of two procedures, the first-order and second-order jackknife estimators. The first-order estimator makes use of the number of species occurring in just one sample unit (singletons), the total number of species, and the number of sample units (Palmer 1990). The second-order estimator uses the number of species that occur in two sample units, in addition to the singletons. Biases of both methods are discussed by Hellman and Fowler (1999).

Another data matrix was constructed for species abundances by stream reach. This data set was used in an unweighted pair-group method cluster analysis provided in PCOrd. Options chosen included flexible beta linkage ($\beta = -0.25$) and the distance measure used was Sørensen's (1948) similarity subtracted from one. Five groupings were specified for the analysis, a choice that minimized the percent chaining of small groups to large ones, an outcome that biases cluster analysis results (McCune and Mefford 1999). We assumed here that adjacent streams, those of similar size and gradient, and of the same habitat type should cluster closer together than those that do not share these habitat similarities.

RESULTS

Our efforts yielded 169 EPT species, with mayflies, stoneflies, and caddisflies contributing 54, 38, and 77 species, respectively (Table 2). Mayflies were

Table 2. Ephemeroptera, Plecoptera, and Trichoptera taxa taken from 15 stream reaches in southwestern Great Smoky Mountains National Park, May and June 2003, July 2004. Sites organized from west to east along southern Park boundary. Site numbers refer to stream reaches in Table 1.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Ephemeroptera																0
Ameletidae																0
Ameletus tertius McDunnough															2	2
Baetidae																
Acerpenna macdunnoughi (Ide)	1				1											2
Acentrella ampla Traver	1	1														2
Acentrella sp.										2	8					10
Baetis brunneicolor McDunnough	3															3
Baetis flavistriga McDunnough	1	1														2
Baetis tricaudatus Dodds							4									4
Baetis sp.		1										1	3		12	17
Centroptilum sp.	1															1
Caenidae																0
Caenis macafferti Provonsha	27															27
Ephemerellidae																
Dannella lita (Burks)					4											4
Dannella simplex (McDunnough)					3											3
Drunella lata (Morgan)		2														2
Drunella tuberculata (Morgan)					1											1
Ephemerella catawba Traver		3			1											4
Ephemerella dorothea (Needham)	6	8		12				1	1				1			29
Ephemerella excrucians Walsh									1							1
Ephemerella hispida Allen & Edmunds															1	1
Ephemerella sp.		3			1						10	1	18		27	60
Serratella deficiens (Morgan)	1	4														5
Serratella molita (McDunnough)	1									1						
Serratella serrata (Morgan)					11											11
Serratella sp.	1															1

Table 2. Continued.

Order/Family/Genus	Site Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Ephemeridae																0
Ephemera guttulata Pictet		2			3									3		8
Ephemera varia Eaton															2	2
Hexagenia limbata (Serville)	1														2	3
Heptageniidae																
Epeorus dispar (Traver)		3					9	4			6	1			18	41
Epeorus fragilis (Morgan)															1	1
Epeorus rubidus (Traver)					3											
Epeorus subpallidus (Traver)					1											1
Epeorus vitreus (Walker)		1														1
Epeorus sp.															20	20
Leucrocuta aphrodite (McDunnough)	43	26								20						89
Leucrocuta juno (McDunnough)										21					15	36
Leucrocuta minerva (McDunnough)		3														3
Leucrocuta thetis (Traver)	1						4	4								9
Leucrocuta sp.	12	15			7											34
Maccaffertium carlsoni (Lewis)	2									4			1			7
Maccaffertium ithaca (Clemens & Leonard)	2												2		2	6
Maccaffertium meririvulanum (Carle & Lewis)							2									2
Maccaffertium mexicanum (McDunnough)		1														1
Maccaffertium modestum (Banks)	1	7									2					10
Maccaffertium pudicum (Hagen)	2	4								4		1			1	12
Maccaffertium terminatum (Walsh)				3	7			1	1				6			18
Maccaffertium vicarium (Walker)												1				1
Maccaffertium sp.	1													1		2
Nixe spinosa (Traver)															1	1
Rhithrogena amica Traver											1				1	2
Rhithrogena fasciata Traver										20						20
Rhithrogena sp.											3					3
Stenacron carolina (Banks)	1							2								3
Stenacron interpunctatum (Say)	4	6									2	1			1	14
Stenacron pallidum (Traver)	1	6			4		5									16
Isonychiidae																
Isonychia bicolor (Walker)										1	1				1	3
Isonychia similis Traver							4									4

Table 2. Continued.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Leptophlebiidae																
Habrophlebia vibrans Needham	4		16								3	4		3		30
Habrophlebiodes americana (Banks)	7	3	9	1							2		1			23
Habrophlebiodes sp.	3	2			1											6
Paraleptophlebia assimilis (Banks)		1					2				3			1		7
Paraleptophlebia guttata (McDunnough)		1	1				1	1								4
Paraleptophlebia mollis (Eaton)															4	4
Paraleptophlebia sp.					1				2					1		4
Neoephemeridae																
Neoephemera purpurea (Traver)															1	1
Siphlonuridae																
Siphlonurus typicus (Eaton)															1	1
Chloroperlidae																
Alloperla atlantica Baumann															12	12
Alloperla nanina Banks							2									2
Alloperla usa Ricker					1			3								4
Alloperla sp.		3			1		3									7
Haploperla brevis (Banks)							1				1				1	3
Suwallia marginata (Banks)								1								1
Sweltsa lateralis (Banks)									2							2
Sweltsa mediana (Banks)											5			1	3	9
Sweltsa sp.	1	2				1	2		2				1			9
Leuctridae																
Leuctra carolinensis Claassen							13							3		16
Leuctra ferruginea (Walker)	14	19														33
Leuctra mitchellensis Hanson									18							18
Leuctra sibleyi Claassen							1									1
Leuctra sp.	13			3			2		12		1	1	1		3	36
Nemouridae																
Amphinemura nigritta (Provancher)		1	1				1		4		1					8
Amphinemura wui (Claassen)						2	23				5	1		10		41
Amphinemura sp.	1			1			2	1		1	10	1			1	18
Soyedina sp.			2													2

Table 2. Continued.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Peltoperlidae																
Tallaperla anna (Needham & Smith)							6	2								8
Tallaperla cornelia (Needham & Smith)							16		3							19
Tallaperla elisa Stark											1					1
Tallaperla laurie (Ricker)		3	17	1			1				2					24
Tallaperla maria (Needham & Smith)	1		2												2	5
Tallaperla sp.															2	2
Viehoperla ada (Needham & Smith)							6				1					7
Perlidae																
Acroneuria abnormis (Newman)	6	16			8		1	7		5	10	6	1			60
Acroneuria filicis Frison					1											1
Agnetina capitata (Pictet)		1														1
Eccoptura xanthenes (Newman)	1				3			3				1				8
Neoperla occipitalis (Pictet)	26															26
Neoperla sp.	3	6														9
Perlesta frisoni Banks					1		1	4			1		2			9
Perlodidae																
Cultus decisus (Walker)											2					2
Diploperla duplicata (Banks)		6	1								2				1	10
Isoperla dicala Frison											1		1		5	7
Isoperla distincta Nelson									1							1
Isoperla holochlora (Klapalek)	4	5					4	1			3	1		2		20
Isoperla orata Frison											2		1			3
Isoperla sp.M8		3			1			3							11	18
Isoperla sp.											36					36
Oconoperla innubila (Needham & Claassen)							2									2
Remenus bilobatus (Needham & Claassen)	1	5	1	3	1		1		1		1	1				15
Yugus arinus (Frison)											1			2		3
Pteronarcyidae																
Pteronarcys scotti Ricker					1											1
Pteronarcys sp.	1	3									1				1	6
Taeniopterygidae																
Bolotoperla rossi (Frison)											1					1

Table 2. Continued.

Order/Family/Genus	Site Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Trichoptera																
Brachycentridae																
Brachycentrus sp.					1											1
Micrasema charonis Banks											1				1	2
Micrasema rickeri Ross & Unzicker															8	8
Micrasema wataga Ross		1														1
Micrasema sp.									1						5	6
Dipseudopsidae																
Phylocentropus carolinus Carpenter												1				1
Phylocentropus lucidus Hagen								1	1		1	1				4
Glossosomatidae																
Agapetus pinatus Ross										4	3				6	13
Agapetus iridis Ross								1						3		4
Agapetus sp.	1	1								76	17	2		1	33	131
Glossosoma nigrior Banks		1		1												2
Glossosoma sp.	11	3			8			3		1			2			28
Goeridae																
Goera calcarata Banks	7									6			2		7	22
Helicopsychidae																
Helicopsyche borealis (Hagen)		2								8						10
Hydropsychidae																
Arctopsyche irrorata Banks								1								1
Ceratopsyche macleodi (Flint)												4				4
Ceratopsyche morosa (Hagen)														1		1
Ceratopsyche slossonae (Banks)					12					2	6				2	22
Ceratopsyche sparna (Ross)	23	9						1		17	8	11	10	30	110	219
Ceratopsyche sp.												2				2
Cheumatopsyche harwoodi Denning	18	2								3	42	10	14		94	183
Cheumatopsyche analis (Banks)	4															4
Cheumatopsyche sp.	8	23														31
Diplectrona metaqui Ross	1	1	3													5
Diplectrona modesta Banks	6	21		4	40		3	42	2	3	14	21			1	157
Hydropsyche betteni Ross	3	4														7
Hydropsyche betteni or depravata	7														1	8
Hydropsyche sp.												1				1
Parapsyche cardis Ross							2	1						2		5

Table 2. Continued.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Hydroptilidae																
Hydroptila oneili Harris	3															3
Hydroptila valhalla Denning	1															1
Hydroptila sp.		15									1				7	23
Stactobiella delira (Ross)					6											6
Stactobiella martynovi Schmid															3	3
Stactobiella sp.														7	11	18
Lepidostomatidae																
Lepidostoma lydia Ross											1					1
Lepidostoma ontario Ross															1	1
Lepidostoma pictile (Banks)														5	2	7
Lepidostoma tibiale (Carpenter)										19						19
Lepidostoma sp.		3	1		4					1						9
Theliopsyche grisea (Hagen)	1															1
Leptoceridae																
Ceraclea diluta (Hagen)															5	5
Ceraclea flava (Banks)										1						1
Ceraclea tarsipunctata (Vorhies)	1															1
Ceraclea transversa (Hagen)	122	35			1					1	3					162
Nectopsyche exquisita (Walker)	2															2
Oecetis avara (Banks)										10						10
Oecetis inconspicua (Walker)	8	1			3							1			1	14
Oecetis persimilis (Banks)										23						23
Oecetis sp.	1															1
Triaenodes taenius Ross		1														1
Limnephilidae																
Hydatophylax argus (Harris)															7	7
Pseudostenophylax sparsus (Banks)					1		27	11	103							142
Pycnopsyche flavata (Banks)									2							2
Pycnopsyche gentilis (McLachlan)			2				2				1					5
Pycnopsyche sp.	2	1			2			1				1				7
Molannidae																
Molanna ulmerina Navas	12															12
Molanna sp.											1					1

Table 2. Continued.

Order/Family/Genus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Odontoceridae																
Psilotreta amera Ross								1								1
Psilotreta sp.			1													1
Philopotamidae																
Chimarra aterrima Hagen			3													3
Dolophilodes distinctus (Walker)					11		1				1				1	14
Dolophilodes major (Banks)					1											1
Dolophilodes sp.		2						4			3				4	13
Wormaldia moesta (Banks)														1		1
Wormaldia sp.	1	2	1						1							5
Phryganeidae		1														1
Ptilostomis ocellifera (Walker)					1			1								2
Polycentropodidae																
Neureclipsis sp.	1															1
Nyctiophylax affinis (Banks)	2															2
Nyctiophylax celta Denning										5						5
Nyctiophylax denningi Morse	6	12														18
Nyctiophylax moestus Banks	3															3
Nyctiophylax nephophilus Flint					5			5			3	3				16
Nyctiophylax sp.	5										1		1		3	10
Plectrocnemia cinerea (Hagen)	6	3			1			4								14
Polycentropus confusus Hagen	42	2								1					2	47
Polycentropus maculatus Banks					1											1
Polycentropus sp.	31	1			1					32	1					66
Psychomyiidae																
Lype diversa (Banks)	7	1	1		8		1	10	3	1	6	2		2		42
Psychomyia flavida Hagen	3	6			8				1		62	14			2	96

Table 2. Continued.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Rhyacophilidae																
Rhyacophila amicis Ross															5	5
Rhyacophila atrata Banks												3				3
Rhyacophila carolina Banks	1				3	1		2	1	1	1			5	5	20
Rhyacophila carpenteri Milne							2		1						1	4
Rhyacophila fuscula (Walker)					3			2			10	11	2	2	22	52
Rhyacophila glaberrima Ulmer								1						1		2
Rhyacophila nigrita Banks						1	11		4		1	3				20
Rhyacophila teddyi Ross											3				1	4
Rhyacophila torva Hagen	1							2	1		1			1		6
Rhyacophila sp.							1		1						1	3
Sericostomatidae																
Agarodes griseus Banks or *tetron* (Ross)															1	1
Fattigia pele (Ross)						2	2		1		3					8
Uenoidae																
Neophylax consimilis Betten	4															4
Neophylax mitchelli Carpenter					9		2	3	7							21
Neophylax oligius Ross											2		1			3
Neophylax ornatus Banks		1			4			5	1							11
Neophylax sp.		1														1
Total Count	559	341	74	45	221	31	201	172	215	334	370	161	123	144	568	3074
Ephemeroptera	21	19	3	3	14	0	8	6	4	8	10	7	6	4	17	54
Plecoptera	10	13	6	4	8	2	16	9	6	2	19	6	6	5	10	38
Trichoptera	30	24	7	2	22	3	10	21	15	17	24	16	7	12	26	77
Total EPT	61	56	16	9	44	5	34	36	25	27	53	29	19	21	53	169

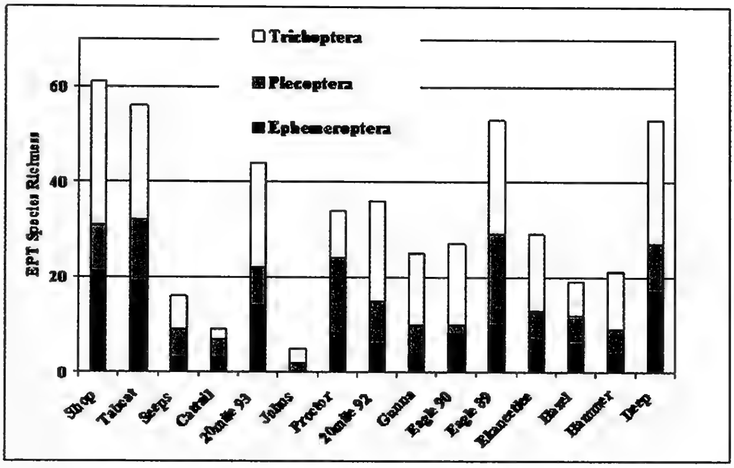


Fig. 1. Ephemeroptera, Plecoptera, and Trichoptera species richness from stream reaches in southwestern Great Smoky Mountains National Park, Tennessee and North Carolina.

dominated by Heptageniidae (23 species among six genera) and Ephemerellidae (11 species among four genera). Plecoptera were dominated by Perlodidae (10 species among six genera) and Chloroperlidae (seven species among four genera). Among the Trichoptera, the Hydropsychidae were dominant (11 species among five genera). Nine species were collected from each of three other families: Leptoceridae, Polycentropodidae, and Rhyacophilidae. Caddisflies dominated species richness at 12 of 15 locations. This appeared to be a natural pattern for reaches with diverse faunas and wetted widths greater than 2 m. Proctor Branch, a moderately diverse (34 EPT) and narrow stream (2 m), was the only site where stoneflies contributed the greatest number of EPT species.

Our data suggest that the most important factor explaining species richness in this study is the number of collections, essentially the number of visits, to a given reach (Spearman Rank correlation, R=0.70, p=0.004). Neither elevation, wetted width, nor the number of methods used produced a significant correlation. Species richness ranged from five (Johns Creek, incompletely sampled) to 61 (Shop Creek) (Fig. 1). Five streams could be viewed as hyperdiverse (>40 species) in light of the richness of the other 10 reaches. These included Shop Creek and Tabcat Creek, Twentymile Creek at campground 93, Eagle Creek at campground 89, and Deep Creek.

Shop Creek and Tabcat Creek each drained relatively open, hardwood forests, had narrow widths (4–5 m wetted width), and were at the lowest elevations (268–299 m) of all reaches sampled. Additionally, the Tabcat Creek drainage was unique in that it had a well-developed floodplain above and below the sample reach. The remaining hyperdiverse reaches were moderate to large streams with high gradients. Deep Creek was the most open canopied of the large streams.

It appears that our sampling was not so extensive as to exhaust the area species pool. This is evident by the slope of the species accumulation curve being nearly 45, with only a hint of leveling off. Jackknife estimator procedures both produced estimates much greater than our current 169 species. The first-order jackknife was 245 species, while the second-order was 293. Between these two estimates are 76–124 addition EPT species to be found in the local area of SW GRSM.

The cluster analysis produced several clusters of stream reaches (Fig. 3). The two Twentymile Creek reaches were the most similar pair, being only three to four miles apart and flowing through the same elevational gradient and vegetation type. Eagle Creek at campground 89 and Ekaneetlee Creek also clustered closely. These were adjacent, with the latter being tributary to the former. Other reach pairs that clustered tightly together were Proctor Branch + Gunna Creek and Tabcat Creek + Shop Creek. Cattail Branch and its seeps also formed a cluster, but at a much greater distance. Both drain low gradient floodplain habitat and were curiously depauperate. Overall, the cluster analysis suggested that many of these reaches have great turnover in EPT community composition and that EPT fauna are not evenly distributed in the region.

Significant Records

Ephemeroptera

Ameletidae

Ameletus tertius McDunnough.—Two larvae were collected from Deep Creek. Zloty (1996) reported *A. tertius* from southeastern Canada, Maine, Vermont, and New York in his review of North American species of the genus. This is the first record of the species from GRSM, North Carolina, and the southern Appalachian Mountains. Additional GRSM specimens exist in the Purdue Entomology Research Collection [PERC]: NC: Swain Co., Oconaluftee River, 35°31′59″N, 83°18′08″W, 15-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph. TN: Blount Co., Middle Prong, 35°38′30″N, 83°41′25″W, 18-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph; Cocke Co., Cosby Creek, 35°46′59″N, 83°13′06″W, 17-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph; Sevier Co., Jakes Creek, 35°38′44″N, 83°35′02″W, 12-VI-2003, J. M. Webb, L. M. Jacobus, one nymph.

Baetidae

Acerpenna macdunnoughi (Ide).—Two specimens were collected from Shop Creek and Twentymile Creek at campground 93. These represent new GRSM and Tennessee records. Morihara and McCafferty (1979) listed this species from North Carolina, but they provided no actual record data (sensu McCafferty 2001).

Caenidae

Caenis macafferti Provonsha.—This species was first reported from GRSM as *Caenis* nr. *macafferti* by DeWalt and Heinold (2005), based on adult specimens from lower Abrams Creek. We now have larvae from Shop Creek and Abrams Creek Campground and one reared adult of each sex from the latter location. The larvae might be identified as *C. tardata* McDunnough when using the key provided by Provonsha (1990); they have the operculate second gill uniformly brown and hind tarsal fimbriate spurs numbering 12. However, the Y-ridge diverges in the anterior half of the operculate gill, not in the posterior as in *C. tardata*. Adults will key (Provonsha 1990) to near *C. macafferti*, with forewing vein ICuA1 forked from CuA2 just distad of the CuA1-CuP crossvein; abdominal terga 1–10 shaded blackish brown and terga nine and 10 lacking triads of black dots; each egg has one polar cap. However, they lack the fleshy protuberance characteristic of *C. macafferti* (Provonsha 1990). Provonsha (1990) lists it from Florida to New York, with a disjunct population in the Ozark Mountains of Arkansas. This is a new North Carolina state record.

Ephemeridae

Hexagenia limbata (Serville).—Three specimens were collected from Deep Creek and Shop Creek. The species has a transcontinental distribution on North America (McCafferty 1994) including North Carolina Pescador et al. (1999) and Tennessee (Long and Kondratieff

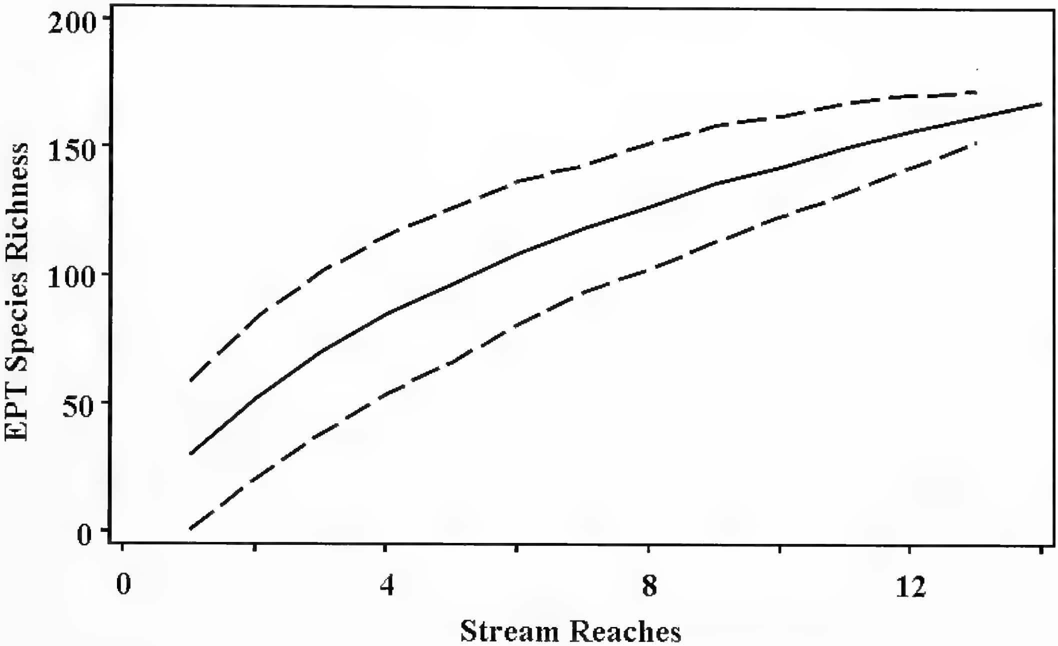


Fig. 2. Species accumulation curve for Ephemeroptera, Plecoptera, and Trichoptera species richness from stream reaches in southwestern Great Smoky Mountains National Park, Tennessee and North Carolina. Solid line is predicted line-of-best-fit, dashed lines are one standard deviation out as confidence intervals.

1996). It was reported by Spieth (1941) from Bryson City, North Carolina, just outside of GRSM, but this is the first published record from within GRSM.

Heptageniidae

Epeorus fragilis (Morgan).—A single female subimago was collected from Deep Creek. A male adult was collected from a nearby drainage in GRSM: NC: Haywood Co., Trib. Hemphill Creek, 5 km WNW Jonathan, 35°34′35″N, 83°04′22″W, 31-V-2003, R. E. DeWalt, Catalogue # INHS 9961. Authors LMJ and WPM report additional specimens from several streams elsewhere in GRSM—NC: Haywood Co., Big Creek at Big Creek picnic area, 35°45′05″N, 83°06′31″W, 12-VI-2003, J. M. Webb, L. M. Jacobus, one nymph. TN: Sevier Co.,Tributary Little River, 35°38′45″N, 83°35′03″W, 16-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, 4 nymphs; Sevier Co., Injun Creek at Greenbrier Ranger Station, 35°43′49″N, 83° 24′22″W, 7-XII-2001, J. F. MacDonald, L. M. Jacobus, 4 nymphs [PERC]. The species has been reported from West Virginia (Faulkner and Tarter 1977), Virginia (Kondratieff and Voshell 1983), and New York (Jacobus and McCafferty 2001). Our data represent new GRSM, North Carolina, and Tennessee records.

Nixe spinosa (Traver).—A single specimen was taken from Deep Creek. It is known from North Carolina (Pescador et al. 1999) and the Abrams Creek drainage of GRSM (DeWalt and Heinold 2005). The species is seldom reported, perhaps because the larva is unknown. However, LMJ and WPM note that adults have been collected commonly at lights elsewhere in GRSM, especially from some of the more eastern drainages (Jacobus and McCafferty, unpublished data).

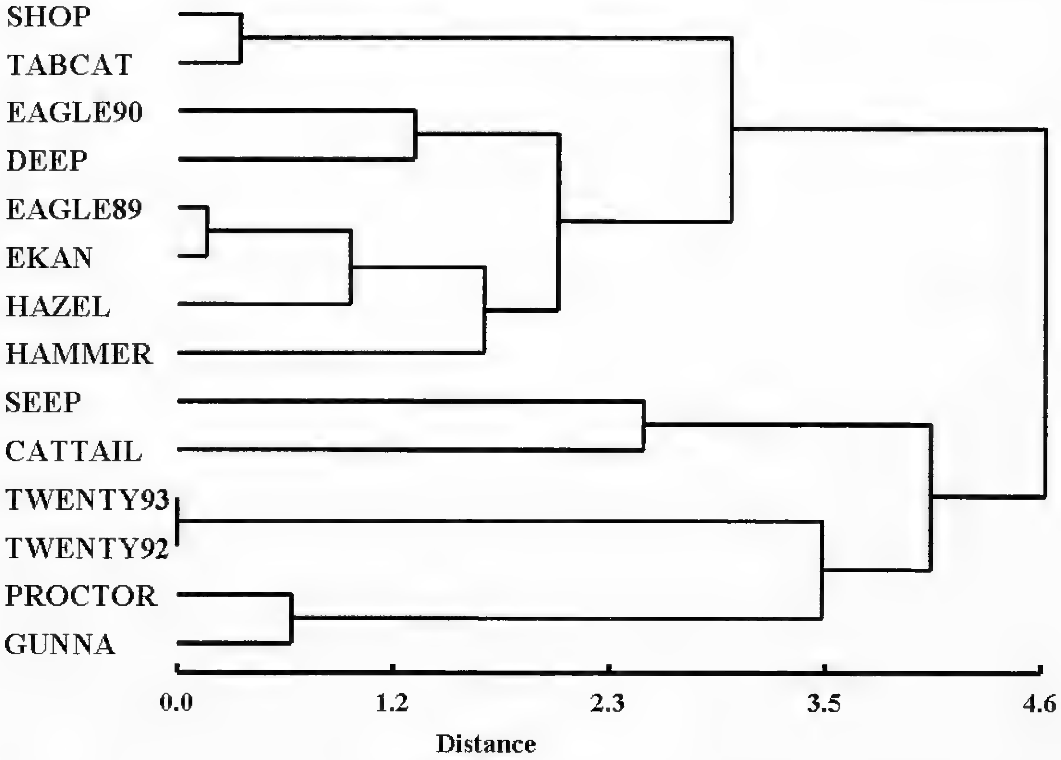


Fig. 3. Unweighted pair-group method cluster analysis of Ephemeroptera, Plecoptera, and Trichoptera assemblages in stream reaches in southwestern Great Smoky Mountains National Park, Tennessee, and North Carolina.

Rhithrogena fasciata Traver.—A large population was taken at Eagle Creek at campground 90. Traver (1933) listed it from several western North Carolina sites, including Waynesville in Haywood County, adjacent to GRSM. It has been reported also from South Carolina (Pescador et al. 1999) and Georgia (Berner 1977). The species has been collected from one other GRSM location: NC: Swain Co., Bradley Fork at Smokemont, 24-IX-2002, L. M. & P.D. Jacobus, one nymph [PERC]. These are new records for GRSM.

Stenacron pallidum (Traver).—Sixteen specimens were collected from four locations in Tennessee and North Carolina. Lewis (1974) reported it as restricted to the North Carolina mountains. Subsequently, it was reported from South Carolina (Morse et al. 1989), New York (Jacobus and McCafferty 2001), and Tennessee (DeWalt and Heinold 2005) in GRSM. Authors LMJ and WPM have collections from widely distributed locations in the GRSM.

Maccaffertium carlsoni Lewis.—Seven specimens were collected as part of this study from three reaches in Tennessee and North Carolina, representing new GRSM and Tennessee records. Morse et al. (1989) previously reported *M. carlsoni* from North Carolina. Additional specimens residing in PERC include: TN: Sevier Co., LeConte Creek, 35°40′34″N, 83°29′16′W, 16-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph; Sevier Co., Tributary LeConte Creek, 35°40′41″N, 83°28′55′W, 3-XII-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph; Blount Co. Tributary Anthony Creek, 35°35′06″N, 83°45′29′W, 19-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph.

Leptophlebiidae

Paraleptophlebia guttata (McDunnough).—Single specimens were taken from four locations in North Carolina and Tennessee. Pescador et al. (1999) listed it from North and South Carolina and Long and Kondratieff (1996) listed it from several Tennessee counties, including Sevier, but neither provide specific locality records (sensu McCafferty 2001), so it is not possible to know if these represent GRSM records. LMJ and WPM note that this species is generally widespread in GRSM, and that it has been collected from habitats ranging from spring seeps to large streams. These are the first confirmed records of the species from GRSM.

Paraleptophlebia mollis (Eaton).—Four specimens were collected from Deep Creek. Pescador et al. (1999) recorded it from North and South Carolina and Long and Kondratieff (1996) reported it only from Sevier County in Tennessee. Neither work provided specific locality data. This is the first confirmation of its presence in GRSM.

Neoephemeridae

Neoephemera purpurea (Traver).—One larva was collected from Deep Creek as part of this study. It is noted here due it apparent rarity in GRSM. Elsewhere, it is relatively widespread, being known from Florida, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia (Traver 1935; Faulkner and Tarter 1977; Harker et al. 1979; Bae and McCafferty 1998).

Siphlonuridae

Siphlonurus typicus (Eaton).—One specimen was collected from Deep Creek as part of this study. DeWalt and Heinold (2005) reported a single male from Abrams Creek. It is known from scattered locations in the Midwest, the northeastern states and Canada (Provonsha and McCafferty 1982; Randolph and McCafferty 1998), and from New York (Jacobus and McCafferty 2001). This is a new North Carolina state record.

Plecoptera

Perlodidae

Oconoperla innubila (Needham and Claassen).—A male and female were taken from Proctor Branch. Stark and Stewart (1982) proposed the genus and described a new species *Oconoperla weaveri*. Stark (1985) later moved *Yugus innubilus* (Needham and Claassen) to *Oconoperla*, and synonomized *O. weaveri* with it. This is a rare species from North and South Carolina and Tennessee. It is known from a total of seven locations, including Clingman's Dome, GRSM (Stark 1985; Stark and Stewart 1982).

Trichoptera

Glossomatidae

Agapetus iridis Ross.—Three males were taken from Hammer Branch. Unzicker et al. (1982) reported it from mountain and piedmont ecoregions of North and South Carolina. It is known from two counties in Tennessee (Etnier et al. 1998) and is a new GRSM record.

Leptoceridae

Ceraclea diluta (Hagen).—Several specimens were taken from Deep Creek. It was reported from the North Carolina coastal plain by Unzicker et al. (1982) and several east-central counties of Tennessee Etnier et al. (1998). It is a new GRSM record.

Triaenodes taenius Ross.—A single male was collected from Tabcat Creek. It was described at the GRSM doorstep by Ross (1938) and was confirmed for GRSM by DeWalt and Heinold (2005). Morse (unpubl. data) reported it from the Ravensford area of GRSM. Etnier et al. (1998) provided one Cocke Co. record adjacent to GRSM.

Molannidae

Molanna ulmerina Navas.—Twelve specimens were taken from Shop Creek. DeWalt and Heinold (2005) reported it from low elevation Abrams Creek reaches of GRSM. It is known from Cumberland County in Tennessee (Etnier et al. 1998).

Polycentropodidae

Nyctiophylax denningi Morse.—Thirteen males were taken from Shop and Tabcat creeks. Armitage and Hamilton (1990) listed it from Alabama, Georgia, Mississippi, South Carolina, and Tennessee (the latter also by Etnier et al. 1998). It is a new GRSM record.

Sericostomatidae

Agarodes tetron (Ross) or *grisea* Banks.—One female was taken from Deep Creek. Ross and Scott (1974) provided a key to *Agarodes*, but could not separate females of these species. *Agarodes tetron* has been reported from unspecified Tennessee locations adjacent to GRSM (Etnier et al. 1998) and from Ravensford in North Carolina by Morse (unpubl. data). This is a new generic GRSM record.

Discussion

This inventory produced a total of 169 EPT species, four more than was found by DeWalt and Heinold (2005) in their examination of the Abrams Creek drainage in GRSM. Sørensen's quotient of similarity between these two data sets demonstrated a 61% overlap in species composition.

This study produced many more mayfly species, especially in the families Heptageniidae, Ephemerellidae, and Baetidae than did the Abrams Creek work. Among the latter two families, additional handpicking of larvae may have helped to increase our recognition of species richness. Among stoneflies, Perlidae were not as rich as in Abrams Creek, the majority being lost in the genus *Perlesta*. Additionally, caddisfly richness was much less than for Abrams Creek, with major losses among the Hydroptilidae and Leptoceridae. The lack of a large, warm, placid stream, like lower Abrams Creek, is probably the cause of the difficiency in these two families.

The current study produced significant regional records for the mayflies *Ameletus tertius* and *Epeorus fragilis*. Additionally, a number of first reports of Ephemeroptera species are provided for North Carolina (four), for Tennessee (five), and for GRSM (seven). Four new GRSM records of Trichoptera are included also.

Species accummulation curves predicted that potentially 80 to 120 more EPT species will be collected from this region of GRSM. There are still many drainages north of Lake Fontana that have been poorly studied, and it is likely that other areas will yield additional species. For instance, further inventories of EPT species in the highest elevations of GRSM will yield records representing significant range extensions for some species (E. Fleek, pers. comm.). Investigations of remote, higher elevation streams in the southern Appalachians, in general, are needed to assess the biological diversity of this region. For example, recent sampling from remote stream reaches in southern North Carolina revealed a genus previously unreported from North America (Waltz 2002).

Acknowledgments

We thank DLIA for funding and C. Parker for guidance in picking locations. DLIA employee J. Hilten arranged for housing in GRSM, and K. Langdon and the National Park Service have supported our efforts and requests for permits. Additionally, S. Johnson, J. Burbank, J. Lowe, S. Higdon have helped pack in heavy batteries and spent long evenings with the ultraviolet lights in the back country. M. Meyer, Purdue University, identified most mayfly specimens, and A. Provonsha, Purdue University, identified *Caenis macafferti*. Finally, the efforts of B. D. Heinold were instrumental in collecting specimens for this study.

LITERATURE CITED

Armitage, B. J. and S. W. Hamilton. 1990. Diagnostic Atlas of the North American Caddisfly Adults. II. Ecnomidae, Polycentropodidae, Psychomyiidae, and Xiphocentronidae. The Caddis Press, Athens, AL. 150 pp.

Bae, Y. J. and W. P. McCafferty. 1998. Phylogenetic systematics and biogeography of the Neoephemeridae (Ephemeroptera: Pannota). Aquatic Insects 20: 35–68.

Baumgardner, D. and D. Bowles. 2005. Preliminary survey of the mayflies (Ephemeroptera) and caddisflies (Trichoptera) of Big Bend Ranch State Park and Big Bend National Park. Journal of Insect Science 5:28. available online: insectscience.org/5.28.

Berner, L. 1977. Distributional patterns of southeastern mayflies (Ephemeroptera). Bulletin of the Florida State Museum, Biological Science Series 22: 1–55.

Cody, R. P. and J. K. Smith. 1991. Applied Statistics and the SAS Programming Language, 4th Ed. Prentice-Hall, Inc., New Jersey. 445 pp.

DeWalt, R. E. and B. D. Heinold. 2005. Summer emerging Ephemeroptera, Plecoptera, and Trichoptera of Abrams Creek, Great Smoky Mountains National Park. Proceedings of the Entomological Society of Washington 107: 34–48.

Etnier, D. A., C. R. Parker, and I. C. Stocks. 2004. A new species of *Rhyacophila* Pictet (Trichoptera: Rhyacophilidae) from Great Smoky Mountains National Park, with illustrations of females of *R. appalachia* Morse and Ross and *R. mycta* Ross. Proceedings of the Entomological Society of Washington 106: 396–406.

Etnier, D. A., J. T. Baxter, Jr., S. J. Fraley, and C. R. Parker. 1998. A checklist of the Trichoptera of Tennessee. Journal of the Tennessee Academy of Science 73: 53–72.

Faulkner, G. M. and D. C. Tarter. 1977. Mayflies, or Ephemeroptera, of West Virginia with emphasis on the nymphal stage. Entomological News 88: 202–206.

Harker, D. F., Jr., S. M. Call, M. L. Warren, Jr., K. E. Camburn, and P. Wigley. 1979. Aquatic biota and water quality survey of the Appalachian Province, eastern Kentucky. Technical Report of the Kentucky Nature Preserves Commission, Frankfurt, KY.

Hellman, J. J. and G. W. Fowler. 1999. Bias, precision, and accuracy of four measures of species richness. Journal of Environmental Management 21: 331–341.

INHS. 2005. An on-line database of insects specimens at the Illinois Natural History Survey. http://ctap.inhs.uiuc.edu/insect/search.inhs.asp.

Jacobus, L. M. and W. P. McCafferty. 2001. The mayfly fauna of New York state (Insecta: Ephemeroptera). Journal of the New York Entomological Society 109: 47–80.

———. 2003. An introduction to the Smoky Mountain mayflies (Insecta: Ephemeroptera). Southeastern Biology 50: 358–360.

———. 2005. Mayfly (Ephemeroptera) diversity in the Great Smoky Mountains. Southeastern Biology 52(1): 45–46.

———. 2006. A new species of *Acentrella* Bengtsson (Ephemeroptera: Baetidae) from Great Smoky Mountains National Park, North Carolina and Tennesee, USA. Aquatic Insects 28: 101–112.

Kondratieff, B. C. and J. R. Voshell, Jr. 1983. A checklist of the mayflies (Ephemeroptera) of Virginia, with a review of pertinent taxonomic literature. Journal of the Georgia Entomological Society 18: 259–272.

———. 1984. The North and Central American species of *Isonychia* (Ephemeroptera: Oligoneuriidae). Transactions of the American Entomological Society 110: 129–244.

Lewis, P. A. 1974. Taxonomy and ecology of Stenonema *mayflies (Heptageniidae: Ephemeroptera)*. United States Environmental Protection Agency, EPA-670/4-74-006, 80 pp.

Long, L. S. and B. C. Kondratieff. 1996. The mayflies (Ephemeroptera) of Tennessee, with a review of the possibly threatened species occurring within the state. The Great Lakes Entomologist 29: 171–182.

McCafferty, W. P. 1994. Distributional and classificatory supplement to the burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. Entomological News 105: 1–13.

———. 2001. Reporting species record data. Entomological News 111: 312311.

McCune, B. and M. J. Mefford. 1999. PC-ORD. Multivariate Aanlysis of Ecological Data, Version 4. MjM Software Design, Gleneden Beach, Oregon, USA. 237 pp.

Morihara, D. K. and W. P. McCafferty. 1979. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). Transactions of the American Entomological Society 105: 139–221.

Morse, J. C., S. W. Hamilton, and K. M. Hoffman. 1989. Aquatic insects of the Lake Jocassee catchment in North and South Carolina, with descriptions of four new species of caddisflies (Trichoptera). The Journal of the Elisha Mitchell Scientific Society 105: 14–33.

Morse, J. C., B. P. Stark, and W. P. McCafferty. 1993. Southern Appalachian streams at risk: implications for Mayflies, Stoneflies, Caddisflies, and other aquatic biota. Aquatic Conservation: Marine and Freshwater Ecosystems 3: 293–303.

Palmer, M. W. 1990. The estimation of species richness by extrapolation. Ecology 71: 1195–1198.

Parker, C. R. 2000. *Neophylax kolodskii* (Trichoptera: Uenoidae), a new species from the Great Smoky Mountains National Park, USA. Aquatic Insects 22: 271–274.

Pescador, M. L., D. R. Lenat, and M. D. Hubbard. 1999. Mayflies (Ephemeroptera) of North Carolina and South Carolina: an update. Florida Entomologist 82: 316–332.

Petersen, M. J., J. K. Gelhaus, and E. C. Bernard. 2004. New species and records of crane flies (Diptera, Tipuloidea) from Great Smoky Mountains National Park, Tennessee and North Carolina, U.S.A. Transactions of the American Entomological Society 130: 439–455.

Provonsha, A. V. 1990. A revision of the genus *Caenis* in North America (Ephemeroptera: Caenidae). Transactions of the American Entomological Society 116: 801–883.

Randolph, R. P. and W. P. McCafferty. 1998. Diversity and distribution of the mayflies (Ephemeroptera) of Illinois, Indiana, Kentucky, Michigan, Ohio, Wisconsin. Ohio Biological Survey Bulletin 13: 1–188.

Ross, H. H. 1938. Descriptions of Nearctic caddis flies. Bulletin of the Illinois Natural History Survey 21: 101–183.

Ross, H. H. and D. C. Scott. 1974. A review of the caddisfly genus *Agarodes*, with descriptions of new species (Trichoptera: Sericostomatidae). Journal of the Georgia Entomological Society 9: 147–155.

Sharkey, M. J. 2001. The All Taxa Biological Inventory of the Great Smoky Mountains National Park. Florida Entomologist 84: 556–564.

Sørensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Det Kongelige Danske Videnskabernes Selskabs Biologiske Skrifter 5: 1–34.

Spieth, H. T. 1941. Taxonomic studies on the Ephemeroptera. 2 The genus *Hexagenia*. American Midland Naturalist 26: 233–280.

Stark, B. P. 1985. Notes on *Oconoperla* (Plecoptera: Perlodidae). Entomological News 96: 151–155.

Stark, B. P. and K. W. Stewart. 1982. *Oconoperla*, a new genus of North American Perlodinae (Plecoptera: Perlodidae). Proceedings of the Entomological Society of Washington 84: 746–752.

Traver, J. R. 1933. Mayflies of North Carolina, Part III. The Heptageniidae. The Journal of the Elisha Mitchell Scientific Society 48: 141–206.

———. 1935. Part II, Systematic, pp. 239–739. *In* Needham, J. G., J. R. Traver, and Y.-C. Hsu, eds. The biology of mayflies. Comstock Publishing Co., Ithaca, New York.

Unzicker, J. D., V. H. Resh, and J. C. Morse. 1982. Chapter 9, Trichoptera, pp. 9.1–9.138. *In* Brigham, A. R., W. U. Brigham, and A. Gnilka, eds. Aquatic Insects and Oligochaetes of North and South Carolina. Midwest Aquatic Enterprises, Mahomet, Illinois.

Waltz, R. D. 2002. *Baetopus trishae* (Ephemeroptera : Baetidae): A new species and new genus for North America. Entomological News 113: 187–191.

Zloty, J. 1996. A revision of the Nearctic *Ameletus* mayflies based on adult males, with descriptions of seven new species (Ephemeroptera: Ameletidae). The Canadian Entomologist 128: 293–346.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 155–159

CORETHRELLA ANDERSONI (DIPTERA: CORETHRELLIDAE), A NEW SPECIES FROM LOWER CRETACEOUS BURMESE AMBER

George O. Poinar and Ryszard Szadziewski

(GP) Department of Zoology, Oregon State University, Corvallis, OR 97331, U.S.A. (e-mail: poinarg@science.oregonstate.edu); (RS) Department of Invertebrate Zoology, University of Gdańsk, Pilsudskiego 46, 81-378 Gdynia, Poland (e-mail: szadz@sat.ocean.univ.gda.pl)

Abstract.—***Corethrella andersoni*, n. sp.** (Diptera: Corethrellidae), is described from Lower Cretaceous Burmese amber. The new species can be distinguished from all previously described extinct and extant *Corethrella* Coquillett by the very short wing veins R_2 and R_3.

Key Words: *Corethrella andersoni*, Corethrellidae, Burmese amber

---

The dipterous family Corethrellidae includes the single genus *Corethrella* Coquillett with over 60 extant species, all which occur in warm climates (subtropics and tropics) (Borkent 1993). Females have biting mouthparts (with one exception) and are reported to feed on frogs, mammals and birds (Williams and Edman 1968).

All previously described fossil corethrellids are males in Miocene-Oligocene Dominican amber (*Corethrella nudistyla* Borkent and Szadziewski 1992), Eocene Baltic amber (*C. prisca* Borkent and Szadziewski 1992, *C. miocaenica* Szadziewski et al. 1994) and Lower Cretaceous Lebanese amber (*C. cretacea* Szadziewski 1995).

The present study describes the first female fossil corethrellid from Burmese amber.

MATERIALS AND METHODS

Amber from Myanmar (Burma) occurs in lignitic seams in sandstone-limestone deposits in the Hukawng Valley. Palynomorphs obtained from the amber beds where the fossil originated have been assigned to the Upper Albian (~ 100–110 mya) of the Lower Cretaceous (Cruickshank and Ko 2002).

Observations and photographs were made with a Nikon SMZ-10 stereoscopic microscope and Nikon Optiphot optical microscope (with magnifications up to 650×). Drawings were made with a camera lucida.

Whereas the majority of the fossil corethrellid is intact (Fig. 1), the terminal abdominal segments separated and are now adjacent to the wing apex, the left wing is incomplete with only the base preserved, the mid legs have tarsomeres 2–4 separated, tarsomeres 3–5 of both hind legs are missing, and the left palpus, while complete, is separated from the proboscis.

Family Corethrellidae Edwards, 1932
Genus *Corethrella* Coquillett, 1902

***Corethrella andersoni* Poinar and Szadziewski, new species**

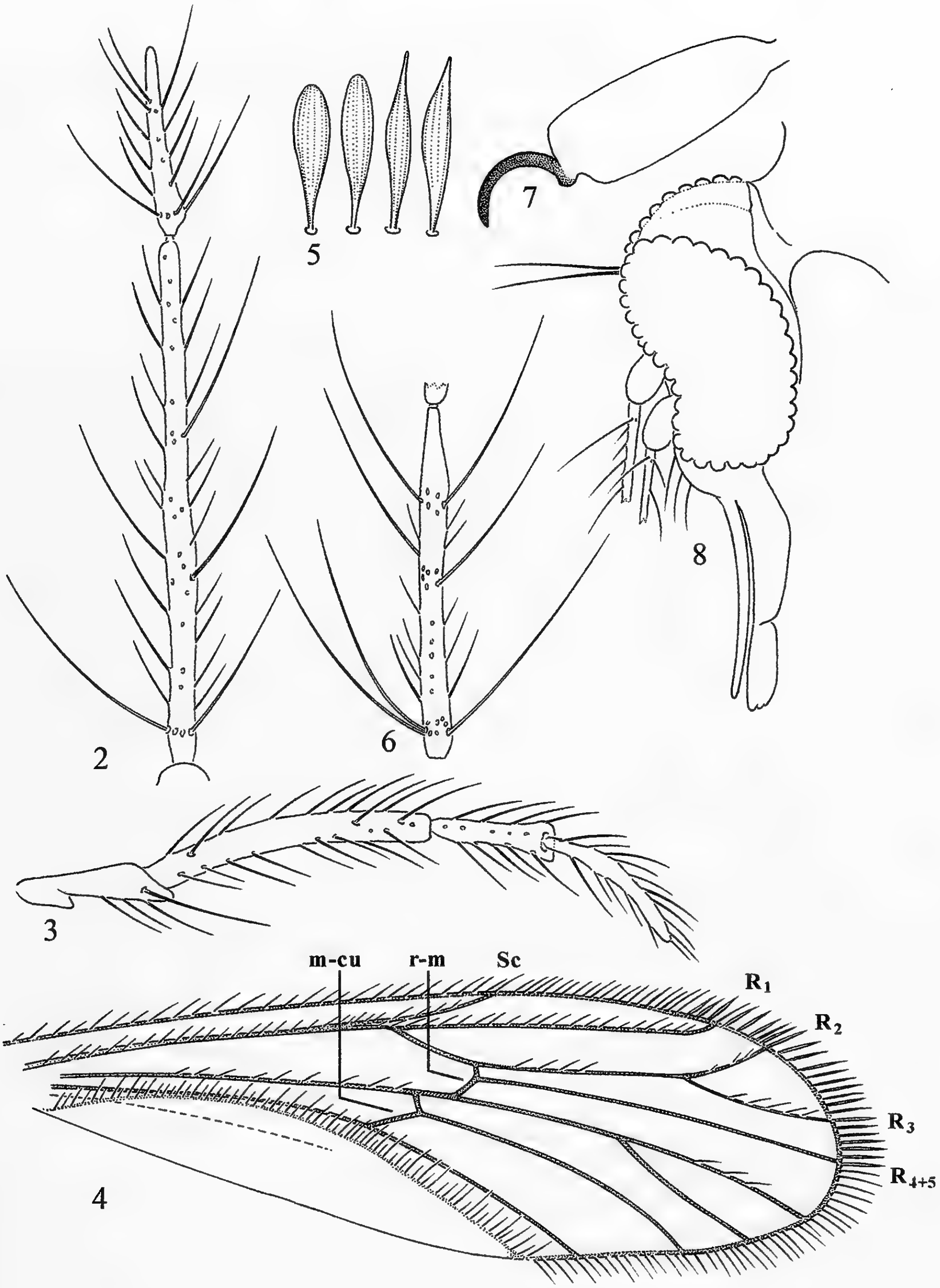
(Figs. 1–8)

Description.—Female (Fig. 1): Body length about 2.5 mm. Proboscis slightly

Fig. 1. Holotype female of *Corethrella andersoni*, lateral view. Bar = 0.83 mm.

elongate, as long as height of head (Fig. 8); eyes above antennae narrowly separated; pedicel slightly enlarged; flagellum very long, 2.20 mm, with 13 slender flagellomeres; first flagellomere 385 μm long, almost 2.3 times longer than flagellomere 2 (170 μm); all flagellomeres with distinct basal whorl of long setae; flagellomeres 2–12 with 2–3 more or less distinct whorls of longer setae (Figs. 2, 6); flagellomeres 3–13 subequal, between 164 μm and 180 μm in length.

Clypeus and proboscis with simple setae; palpus 5-segmented (Fig. 3), 370 μm long, longer than proboscis. Third palpal segment 268 μm long; fourth 133 μm; fifth 185 μm; labrum distinct, long, slender; mandibles and laciniae not visible.



Figs. 2–8. *Corethrella andersoni* in Burmese amber. 2, Flagellomeres 1 and 2. 3, Palpus. 4, *Wing*. 5, Striated scales from femur. 6, Flagellomere 5. 7, Fifth tarsomere of mid leg. 8, Head, lateral view.

Table 1. Lengths of leg segments and tarsomeres of *Corethrella andersoni* (in mm).

	Femur	Tibia	Tarsomere 1	Tarsomere 2	Tarsomere 3
Foreleg	0.95	0.94	0.77	0.46	0.26
Midleg	1.31	1.49	0.74	0.54	–
Hind leg	1.06	1.12	0.82	–	–

Wing length 1.95 mm; venation as in Fig. 4; vein R_1 moderately long, ending at level of fork of R_{2+3}; R_2 and R_3 short, about 1.5 times shorter than petiole R_{2+3}; Sc ending at level of transverse vein r-m; transverse vein m-cu proximal to r-m; veins with simple setae, except for costal vein bearing striated lanceolate scales visible on apical wing margin; wing membrane with distinct microtrichia.

Scutum and scutellum with very long setae; legs (femora, tibiae and all tarsomeres) covered with striated lanceolate scales (Fig. 5); femur and tibia of midleg longer and stouter than those of fore-and hind legs; lengths of leg segments as in Table 1; claws simple, evenly bent (Fig. 7); tarsal ratio of foreleg TR (I) 1.7, of midleg 1.4? (not clearly visible).

Abdomen lacking lanceolate scales; cerci and seminal capsules not visible.

Male: Unknown.

Material examined.—Holotype female in Burmese amber, Lower Cretaceous, deposited in the Poinar collection (accession # B-D-56) maintained at Oregon State University.

Type locality.—Amber mine in the Hukawng Valley, southwest of Maingkhwan in the state of Kachin (26°20′N, 96°36′E), northern Myanmar (Burma).

Etymology.—The species is named for Scott Anderson, who provided this specimen for study.

Syninclusions.—Lepidoptera, 1 incomplete adult; Psocoptera, 1; Coleoptera, 1.

Diagnosis.—This is the first description of a corethrellid from Burmese amber. The species can be distinguished easily from all previously described extinct and extant *Corethrella* by its short R_2 and R_3.

DISCUSSION

In many respects, *Corethrella andersoni* is a typical female corethrellid with a moderately long vein R_1 and midlegs with enlarged femora and tibiae. Enlarged midlegs in female corethrellids may be an adaptation for feeding on particular hosts, such as frogs. This character also occurs on females of *Corethrella appendiculata* Grabham in Costa Rica (Borkent, pers. comm.). The female of *C. andersoni* can be separated from the Lebanese amber male *C. cretacea*, which lacks wings and has almost invisible palps, by the lanceolate scales on its legs.

The short R_2 and R_3 in *C. andersoni* is unique within the genus. However, this character occurs in both sexes of the Burmese amber chaoborid, *Chaoburmus breviusculus* Lukashevich 2000 and in males of the Upper Jurassic or Lower Cretaceous chaoborid, *Baleiomyia discussoria* Kalugina 1993. The latter species has antennae similar to those of extant *Corethrella* and there are actually no features that distinguish *Baleiomyia* Kalugina from *Corethrella*.

The character previously used to separate extant corethrellids from chaoborids was the termination point of R_1, which is closer to Sc than to R_2 in corethrellids and closer to R_2 than Sc in chaoborids (Cook 1981). However, this feature can vary between the two groups and other characters, such as enlarged midlegs and closely approximate eyes, are now used to distinguish corethrellids.

ACKNOWLEDGMENT

Thanks are extended to Roberta Poinar for comments on earlier drafts of this paper.

LITERATURE CITED

Borkent, A. 1993. A world catalogue of fossil and extant Corethrellidae and Chaoboridae (Diptera), with a listing of references to keys, bionomic information and descriptions of each known life stage. Entomologica Scandinavica 24: 1–24.

Borkent, A. and R. Szadziewski. 1992. The first record of fossil Corethrellidae (Diptera). Entomologica Scandinavica 22: 457–463.

Cook, E. F. 1981. Chaoboridae. pp. 335–339. *In* McAlpine, J. F., B. V. Peterson, G. E. Shewell, H. J. Tesky, J. R. Vockeroth, and D. M. Wood, eds. Manual of Nearctic Diptera. Volume 1. Monograph No. 27, Research Branch, Agriculture Canada, Ottawa.

Cruickshank, R. D. and K. Ko, K. 2002. Geology of an amber locality in the Hukawng Valley, northern Myanmar. Journal of Asian Earth Sciences 21: 441–455.

Kalugina, N. S. 1993. Chaoborid and chironomid midges from Upper Mesozoic of East Transbaikalia. Mesozoic insects and ostracods from Asia. Trudi Paleontologicheskogo Instituta (Moscow) 252: 117–139 (in Russian).

Lukashevich, E. D. 2000. Phantom midges (Diptera: Chaoboridae) from Burmese amber. Bulletin of the Natural History Museum, London (Geology) 56: 47–52.

Szadziewski, R. 1995. The oldest fossil Corethrellidae (Diptera) from Lower Cretaceous Lebanese amber. Acta Zoologica Cracoviensia 38: 177–181.

Szadziewski, R., W. Krzemiński, and M. Kutscher. 1994. A new species of *Corethrella* (Diptera: Corethrellidae) from Miocene Saxonian amber. Acta Zoologica Cracoviensia 37: 87–90.

Williams, J. A. and J. D. Edman. 1968. Occurrence of blood meals in two species of *Corethrella* in Florida. Annals of the Entomological Society of America 61: 1336.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 160–165

NEW DISTRIBUTIONAL RECORDS OF NEW WORLD CASSIDINAE (COLEOPTERA: CHRYSOMELIDAE)

C. L. STAINES

3302 Decker Place, Edgewater, MD 21037, U.S.A. (e-mail: stainesc@si.edu)

Abstract.—New country and new state records for the United States are presented for 39 species of New World hispines. Localities for these new records from Brazil, Colombia, Costa Rica, Ecuador, Honduras, Mexico, Nicaragua, Peru, Suriname, and the United States are presented.

Key Words: Chrysomelidae, Cassidinae, hispine, new record

The New World hispines (sensu strictu) are poorly known. The literature is scattered and very few genera have been revised. Many species are known only from their type localities and most countries have no regional keys, monographs, or checklists. The most recent world catalog is Uhmann (1957, 1964), but much field and taxonomic work has been done.

As part of my ongoing work on New World hispines, I have been examining the holdings of various museums. The following new country and state records were discovered during the course of this work.

The following abbreviations are used in the label data: FIT, flight intercept trap; PNN, Parque Nacionales Natural; RN, Reservas Naturales; SFF, Santurarios de Flora y Fauna Forestal. Acronyms for collections are listed in the acknowledgments.

Aslamidium impurum (Boheman) was described from Brazil (Boheman 1850) and has been reported from Brazil, Colombia, Costa Rica, Guatemala, Mexico, Nicaragua, and Panama (Borowiec 2000). ECUADOR, Napo, Yasuni Res. Stn., Lot#096, 0°40.5′S, 76°24′W, 14–24 July 1999, at large, A. Tischechkin (LSUC). HONDURAS, 5 mi. S. La Ceiba, 16.IX.1972, 100 m, J. Helava (CNC).

Aslamidium quatuordecimpunctatum (Latrielle) was described from Colombia (Latreille 1811) and has been reported from Colombia and Venezuela (Borowiec 2000). BRAZIL, Rondônia, 62 km Ariquemas, nr. Fzda. Rancho Grande, 30-III-10-VI-1992, J. E. Egger coll. (FSCA); Brazil, Rondônia, 62 km Ariquemas, nr. Fzda. Rancho Grande, 3-15-XII-1996, J. E. Egger coll. (FSCA). ECUADOR, Oriental, 00°24′S, 76°36′W, Limnocha, 29-VI to 9-VII-70, Peter L. Kazan (FSCA). PERU, Loreto Prov., Explorama Lodge, 50 mi NE Iquitos on Amazon R., 19-29-III-1988, J. E. Egger (FSCA); Peru, Loreto Prov., Explorama Lodge, 50 mi NE Iquitos on Amazon R., 16-20-VII-1989, G. B. Edwards (FSCA); Peru, Huanuco Dept., Cueva de la Luchuzas, S. of Tingo Maria, 30-IX-1988, J. Ch. de Vela Coll. (FSCA); Peru, Madre de Dios, Río Tambopata Res., 30 km (air) SW Puerto Maldonado, 290 m, 1-14-XI-1982, R. Wilkerson (FSCA); Peru, Iquitos, Mar. 24, 1969, B. K. Dozier (FSCA); Peru, Iquitos, Mar. 14, 1969, B. K. Dozier (FSCA). SURINAME, Tibiti River, R. S. M. Camp, 21-24.I.1972, F. Scott (CNC).

Aslamidium strandi (Uhmann) was described from Costa Rica (Uhmann 1930). NICARAGUA, Rio San Juan Dept., 8 km SE El Castillo, Refugio Bertola, 30 m, rainforest, N10°58.6′; W84°20.4′, FIT, 25-31.V.2002, S. Peck, 02-09 (CMNC); Rio San Juan Dept., 60 km SE San Carlos, Refugia Bartola, 100 m, 10°58.40′N, 84°20.30′W, 25-28-V-2002, R. Brooks, Z. Falin, S. Chatzimanolis, flight intercept trap (SEMC).

Baliosus marmoratus (Baly) was described from Guatemala, Mexico, Nicaragua, and Panama (Baly 1885). COLOMBIA, Magdalena, PNN Tayrona, Camino Cañaveral-Arrecifes, 11°18′N 73°56′W, 50 m, Sweeping, 21–23.vii.2002, M. Sharkey, D. Arias, & E. Torres (IAVH).

Baliosus nervosus (Panzer) has been recorded from Nova Scotia to Florida west to Arizona and north through Colorado to Ontario Riley et al. (2003). UNITED STATES: Nebraska, Lincoln, May 7, 1911, R. W. Dawson (UNSM).

Brachycoryna melsheimeri (Crotch) has been reported from Alabama, District of Columbia, Louisiana, Missouri, Ohio, Oklahoma, Pennsylvania, and Texas (Staines 1986, 1995). UNITED STATES: Illinois, Eldred, May 23, 1950, M. W. Sanderson, sweeping at edge of prairie on hilltop (INHS). North Carolina, Haywood Co., GSMNP, The Purchase, 7 May 2005, A. J. Mayor, blue bowl trap (GSMNPC). Tennessee, Franklin Co., AEDC, 12 May 1998, Pine SW 4 (ECUT). Virginia: Cumberland County, 2 km SW of Columbia, clearcut north, 2 Sept 1990, J. C. Mitchell (VMNH).

Bruchia fulvipes (Baly) was described from Panama (Baly 1885). COLOMBIA, Amazonas, PNN Amacayacu, San Martín, 3°46′S 70°18′W, 150 m, 22–30.iv.2000, Malaise, B. Amado (IAVH); Amazonas, PNN Amacayacu, San Martín, 3°46′S 70°18′W, 150 m, 17–30.vii.2000, Malaise, B. Amado (IAVH); Meta, PNN Sierra de La Macarena, Caño Curia Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 25.x–30.xi.2004, W. Villalba (IAVH); Amazonas, PNN Amacaycau, Matamata, 3°41′S 70°15′W, 150 m, Malaise, 1–10.iii.2004, T. Pape & D. Arias (IAVH); Amazonas, PNN Amacayacu, Centro de visitants "Yewae," 3°41′S 70°15′W, 150 m, Malaise, 1–10.iii.2004, T. Pape & D. Arias (IAVH); Amazonas, PNN Amacayacu, Matamata 3°23′S 70°06′W, 150 m, Malaise, 16.iv–7.v.2001, D. Chota (IAVH). COSTA RICA, Puntarenas, 23 km N. Puerto Jiménez, La Palma, 10 m, V–VI 1992, col. P. Hanson (UCRC); Costa Rica, Puntarenas, Pen. Osa, Puerto Jiménez, 10 m, X–XI 1992, P. Hanson (UCRC).

Calliaspis rubra (Olivier) has been reported from Brazil, Ecuador, and French Guiana (Borowiec 2000). COLOMBIA, Leticia, Amazonas, 700 ft., Feb.23–Mar. 2/74, H. & A. Howden (CMNC). PERU, Loreto Prov., Exploronapo Camp on R. Sucucari nr. R. Napo, 12-19-III-1988, J. E. Egger (FSCA).

Cephaloleia congener Baly was described from Panama (Baly 1885) and has been reported from Guatemala, Costa Rica, and Nicaragua (Staines 1996). COLOMBIA, Chocó, PNN Ensenada de Utria, Cocalito, 6°01′N 77°20′W, 20 m, Malaise, 16.viii–7.ix.2000, J. Pérez (IAVH); Amazonas, PNN Amacayacu, Matamata, 3°23′S 70°06′W, 150 m, Malaise, 17.xii.2000–2.i.2001, A. Parente (IAVH).

Cephaloleia eumorpha Staines was described from Panama (Staines 1996). COSTA RICA, San José, Zurquí de Moravia, 1600 m, X.1995, Hanson & Godby (UCRC).

Cephaloleia insidiosa Pic was described from Ecuador (Pic 1934). COLOMBIA, Meta, Sierra de La Macarena, Caña

Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 13–30.ix.2004, W. Villalba (IAVH); Valle del Cauca, PNN Farallones de Cali, Anchicaya, 3°26′N 76°48′W, 650 m, Malaise, 16–30.i.2001, S. Sarria (IAVH).

Cephaloleia lata Baly was described from Panama (Baly 1885) and has been reported from Costa Rica and Mexico (Staines 1996). NICARAGUA, Rio San Juan Dept., 60 km SE San Carlos, Refugia Bartola, 100 m, 10°58.40′N, 84°20.30′W, 25-28-V-2002, R. Brooks, Z. Falin, S. Chatzimanolis, ex. palm fruit and flowers (SEMC).

Cephaloleia splendida Staines was described from Costa Rica and Panama (Staines 1996). NICARAGUA: Matagalpa Dept., 6 km N Matagalpa, Selva Negra Hotel, 1530 m, 12°59.99′N, 85°54.53′W, 20-22-V-2002, R. Brooks, Z. Falin, S. Chatzimanolis, ex. flight intercept trap, mosquito trail (SEMC).

Cephaloleia tenella Baly was described from Guatemala (Baly 1885) and has been reported from Mexico to Panama (Staines 1996). COLOMBIA, Meta, PNN Sierra de La Macarena, Caño Curia Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 13–30.ix.2004, W. Villalba (IAVH); Bolivar, SFF Los Colorados, Villa Roca, 9°54′N 75°07′W, 180 m, Malaise, 6–21.vi.2001, E. Deulufeut (IAVH).

Cephaloleia uhmanni Staines was described from Panama (Staines 1996). COLOMBIA, Meta, PNN Sierra de La Macarena, Caño Curia Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 13–30.ix.2004, W. Villalba (IAVH); Meta, Sumapáz, Qda. La Cristalina, 3°48′N 73°50′W, 614 m, Malaise, 13–28.iv.2004, A. Torrijos (IAVH).

Chalepus pici Descarpentries & Villiers, replacement name for *Chalepus reductus* Pic, is known from Nicaragua to Brazil (Uhmann 1957). COLOMBIA, Magdalena, PNN Tayrona, Camino Cañaveral-Arrecifes, 11°18′N 73°56′W, 50 m, Sweeping, 21–23.vii.2002, M. Sharkey, D. Arias, & E. Torres, 23–25.vii.2002, 18–25.vii.2002 (IAVH).

Chalepus subhumeralis Baly was described from Guatemala (Baly 1885) and has been reported from Mexico and Costa Rica (Uhmann 1957). COLOMBIA, Magdalena, PNN Tayrona, Cañaveral, 11°20′N 74°02′W, 30 m, Malaise, 29.ix–17.x.2000, R. Henríquez (IAVH); Cauca, PNN Gorgona, Alto El Mirador, 2°58′N 78°11′W, 180 m, Malaise, 26.vi–18.vii.2000, H. Torres (IAVH).

Charistena bergi (Duvivier) is known from Argentina, Bolivia, French Guiana, and Paraguay (Uhmann 1957). COLOMBIA, Meta, Sierra de La Macarena, Caña Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 13–30.ix.2004, W. Villalba (IAVH); Meta, Sierra de La Macarena, Caña Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 1–25.x.2004, W. Villalba (IAVH); Meta, Sumapáz, Qda. La Cristalina, 3°48′N 73°50′W, 614 m, Malaise, 27–28.iii.2004, D. Arias & T. Arias (IAVH); Meta, Sumapáz, Cabaña Las Mirias, 3°48′N 73°52′W, Sweeping, 27–28.iii.2004, D. Arias & T. Arias (IAVH); Vichada, PNN Tuparro, Cerro Tomás, 5°21′N 67°51′W, 140 m, Malaise, 21–31.i.2001, W. Villalba (IAVH).

Chelobasis bicolor Gray was described from South America (Gray 1832) and has been reported from Colombia, Costa Rica, Guatemala, and Panama (Uhmann 1957). NICARAGUA, Matagalpa Dept., 6 km N Matagalpa, Selva Negra Hotel, 1350 m, 12°59.99′N, 85°54.53′W, 19-V-2002, R. Brooks, Z. Falin, S. Chatzimanolis, ex. misc. collecting (SEMC).

Cnetispa flavipes (Baly) was described from Panama (Baly 1885). COLOMBIA, Bolivar, SFF Los Colorados, Villa Roca, 9°54′N 75°07′W, 180 m, Malaise, 3–18.vii.2001, E. Deulufeut (IAVH).

Euxema insignis Baly was described from Panama (Baly 1885). COLOMBIA, Magdalena, PNN SN de Santa Marta, San Lorenzo, 10°48′N 73°39′W, 2200 m, Malaise, 15–29.xii.2000, J. Cantillo (IAVH).

Pentispa morio (Fabricius) was described from America meridionali (Fabricius 1801) and has been reported from Mexico (Uhmann 1957). UNITED STATES: Arizona, Nogales, St. Cruz Co., X.4.06, F. W. Nunenmacher (INHS).

Probaenia variegata Baly was described from Panama (Baly 1885). COLOMBIA, Meta, Sierra de La Macarena, Caña Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 13–30.ix.2004, W. Villalba (IAVH); Meta, Sierra de La Macarena, Caña Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 1–25.x.2004, W. Villalba (IAVH); Meta, Sumapáz, Qda. La Cristalina, 3°48′N 73°50′W, 614 m, Malaise, 13–30.ix.2004, W. Villalba (IAVH).

Prosopodonta scutellaris (Waterhouse) was described from Ecuador (Waterhouse 1881). COLOMBIA, Valle del Cauca, PNN Faraliones de Cali, 3°26′N 76°48′W, 900 m, Malaise, 30.i–13.ii.2001, S. Sarria (IVAH).

Prosopodonta tristis Uhmann was described from Ecuador (Uhmann 1939). COLOMBIA, Nariño, Ricaurte, RN La Planada, Via Hondón, 1°15′N 78°15′W, 1930 m, Sweeping, 09–12.viii.2004, D. Arias (IAVH).

Pseudispa annulicornis (Pic) was described from Venezuela (Pic 1934). COLOMBIA, Amazonas, PNN Amacayacu, San Martín, 3°23′S 70°06′W, 150 m, Malaise, 12–19.vi.2000, B. Amado (IAVH); Amazonas, PNN Amacayacu, San Martín, 3°23′S 70°06′W, 150 m, Malaise, 24.ix–2.x.2000, B. Amado (IAVH); Cauca, PNN Gorgona, Alto El Mirador, 2°58′N 78°11′W, 180 m, Malaise, 10–26.vi.2000, H. Torres (IAVH); Magdalena, PNN Tayrona, Zaino, 11°21′N 74°02′W, 50 m, Malaise, 29.ix–17.x.2000, R. Henríquez (IAVH); Valle del Cauca, PNN Farallones de Cali, Anchicaya, 3°26′N 76°48′W, 730 m, Malaise, 18.vii–1.viii.2000, S. Sarria (IAVH).

Pseudispa gemmens (Baly) was described from Guatemala (Baly 1885). COSTA RICA, Alajuela, Peñas Blancas, IX-X-1986, E. Cruz, M.T. (CMNC).

Pseudispa sinuata Staines was described from Costa Rica (Staines 2002). PANAMA, Chiriqui, La Fortuna, 0.5 km N. Contin. Divide Trail, 1100 m, 21–23.V.1995, J.S. & A.K. Ashe, ex: FIT (044) (CMNC); Coclé, 7.2 km N.E. El Copé, 730 m, 20.V–7.VI.1995, J. Ashe & R. Brooks, ex: FIT (140) (CMNC).

Pseudispa tuberculata Staines was described from Costa Rica (Staines 2002). MEXICO, Hildago, 2.4 mi. N. Tlanchinol, 16-VI-1983, C. O'Brien & G. Marshall, Berlese cloud forest litter (FSCA); Hildago, Tlanchinol, 43 km SW Huejutla, 14.VI–4.VIII.83, S&J Peck, 1500 m, cloud forest FIT (CMNC). PANAMA, Chiriqui, La Fortuna, 0.5 km N. Contin. Divide Trail, 1100 m, 21–23.V.1995, J.S. & A.K. Ashe, ex: FIT (044) (CMNC).

Sceloenopla balyi Grimshaw, replacement name for *Cephalodonta maculata* Baly, was described from Guatamala (Baly 1885). MEXICO, Chiapas, Cerro Huitepec, 2 km in on road, 2500 m, 25.IX.1992, 92-118, R. S. Anderson, oak/pine forest (CMNC); Guerrero, 34.6 km S.W. Xochipala, 2030 m, 13.VII.1992, 92-004, R. S. Anderson, oak pastureland (CMNC); Guerrero, 34.6 km S.W. Xochipala, 2030 m, 14.VII.1992, 92-005, R. S. Anderson, oak pastureland (CMNC).

Sceloenopla rubivittata Staines was described from Costa Rica (Staines 2002). COLOMBIA, Amazonas, PNN Amacayacu, Matamata, 3°23′S 70°06′W, 150 m, Malaise, 6–12.vii.2000, A. Parente (IAVH); Vaupés, Estación Biologica Mosiro-Itajura (Caparú), Centro Ambiental, 1°04′S 69°31′W, 60 m, Malaise, 10–17.iv.2003, J. Pinzón (IAVH).

Sceloenopla scherzeri (Baly) was described from Costa Rica (Baly 1858) and has been reported from Nicaragua and Panama (Staines 2002). COLOMBIA, Magdalena, PNN Tayrona, Cañaveral, 11°20′N 74°02′W, 30 m, Malaise, 15.xii. 2000, R. Henríquez, 30.viii–19.ix.2000, 3–22.xi.2000 (IAVH).

Sceloenopla vitticollis (Weise) was described from Peru (Weise 1905). COLOMBIA, Meta, Sumapáz, Qda. La Cristalina, 3°48′N 73°50′W, 614 m, Malaise, 27.iii–13.iv.2004, D. Arias & T. Arias (IAVH); Meta, Sumapáz, Sendero Las Mirias, 3°48′N 73°52′W, 779 m, Malaise, 14–29.v.2004, H. Vargas (IAVH).

Solenispa laetifica Weise was described from Colombia (Weise 1910). COSTA RICA, Prov. Heredia, 6 km ENE Vara Blanca, 1950–2050 m, 10°11′N 84°07′W, 23 marzo 2002, 09 abril 2002, 21 abril 2002 (ALAS).

Stethispa conicicollis Baly was described from French Guiana (Baly 1864). COLOMBIA, Amazonas, PNN Amacayacu, San Martín, 3°23′S 70°06′W, 150 m, Malaise, 15–20.xi.2000, A. Parente (IAVH).

Stilpnaspis tricolor (Spaeth) was described from Costa Rica (Spaeth 1938). PANAMA, Panama, Cerro Campana, 20–23.X.1972, 8°45′N, 79°55′W, J. Helava, 900–1000 m (CNC).

Sumitrosis rosea (Weber) is a widespread North American species known from eastern and central Canada and United States (Butte 1969). UNITED STATES: Nebraska, Bellevue (Childs Point), May 1, 1910, R. L. Wolcott (UNSM).

Uroplata angulosa (Olivier) has been reported from French Guiana and Suriname (Uhmann 1957). COLOMBIA, Meta, PNN Sierra de La Macarena, Caño Curia Sendero Cachicamos, 3° 21′N 72°38′W, 493 m, Malaise 1, 1–25.x.2004, W. Villalba (IAVH); Meta, PNN Sierra de La Macarena, Caño Curia Sendero Cachicamos, 3°21′N 72°38′W, 493 m, Malaise 1, 13–30.ix. 2004, W. Villalba (IAVH); Amazonas, PNN Amacayacu, San Martín, 3°23′S 70°06′W, 150 m, Malaise, 10–18.x.2000, B. Amado (IAVH).

Uroplata spaethi Uhmann was described from Brazil (Uhmann 1940). COLOMBIA, Bolivar, SFF Los Colorados, Diana Villa Roca, 9°54′N 75°07′W, 150 m, Malaise, 16–30.xi.2000, E. Deulufeut (IAVH); Bolivar, SFF Los Colorados, Diana Villa Roca, 9°54′N 75°07′W, 150 m, Malaise, 2–16.xi.2000, E. Deulufeut (IAVH); Magdalena, PNN Tayrona, Cañaveral, 11°20′N 74°02′W, 30 m, Malaise, 15.xii. 2000–2.i.2001, R. Henriquez (IAVH); Magdalena, PNN Tayrona, Camino Cañaveral-Arrecifes, 11°18′N 73°56′W, 50 m, Sweeping, 21–23.vii.2002, M. Sharkey, D. Arias, & E. Torres (IAVH).

ACKNOWLEDGMENTS

I thank the following curators for access to the collections under their care: Canadian Museum of Nature, Ottawa, Canada (CMNC), R. S. Anderson; Canadian National Collection, Ottawa, Canada (CNC), L. LeSage; University of Costa Rica, San José, Costa Rica (UCRC), P. Hanson; Florida State Collection of Arthropods, Gainesville, FL, U.S.A. (FSCA), M. C. Thomas; Great Smoky Mountains National Park, Gatlinburg, TN, U.S.A. (GSMNPC), A. J. Mayor; Illinois Natural History Survey, Champaign, IL, U.S.A. (INHS), C. Favret; Instituto de Investigación de Recurses Biológicos Alexander von Humboldt, Villa de Leyva, Colombia (IAVH); Arthropods of La Selva Project, (ALAS, INBio), M. Paniagua; Louisiana State University, Baton Rouge, LA, U.S.A. (LSUC), V. Bayless; University of Nebraska State Museum, Lincoln, NE, U.S.A. (UNSM), B. C. Ratcliffe; Snow Entomological Collection, Lawrence, KS, U.S.A. (SEMC), Z. H. Falin; University of Tennessee, Knoxville, TN, U.S.A. (ECUT), P. Lambdin; Virginia Museum of Natural History, Martinsville, VA, U.S.A. (VNMH), R. L. Hoffman.

LITERATURE CITED

Baly, J. S. 1858. Catalogue of Hispidae in the collection of the British Museum. London. 172 pp.

———. 1864. Descriptions of genera and species of Hispidae. The Annals and Magazine of Natural History 14(3): 261–271, 334–345.

———. 1885. Hispidae. *In* Godman, F. D. and O. Salvin, eds. Biologia Centrali–Americana, Zoology, Insecta, Coleoptera, Phytophaga 6(2): 1–124. London.

Boheman, C. H. 1850. Monographia cassididarum. Vol. 1. Holmiae. 452 pp.

Borowiec, L. 2000. Notes on the genus *Stilpnaspis* Weise, with a description of *Pseudostilpnaspis*, new genus and eleven new species of the tribe Imatidiini (Coleoptera: Chrysomelidae: cassidoid Hispinae). Genus 11: 147–195.

Butte, J. G. 1969. Revision of the tribe Chalepini of America north of Mexico. IV. Genus *Sumitrosis* Butte (Coleoptera: Chrysomelidae). Journal of the New York Entomological Society 76: 12–30.

Fabricius, J. C. 1801. Systema eleutheratorum II. Kiliae. 687 pp.

Gray, G. R. 1832. Notices of new genera and species. *In* Griffith, E. and E. Pidegon, eds. The Animal Kingdom Arranged in Conformity with its Organization by the Baron Cuvier. Vol. 15, The Class Insecta (Part II). Whittaker, Teacher & Co., London. 796 pp.

Latreille, P. A. 1811. Insectes de l'Amérique Equinoxiale, recueillis pendant le voyage de MM. de Humboldt et Bonpland, Paris. pp. 127–252.

Pic, M. 1934. Hispides nouveaux du Vénézuéla. Revue Française d'Entomolgie 1: 154–157.

Riley, E. G., S. M. Clark, and T. N. Seeno. 2003. Catalog of the leaf beetles of America north of Mexico (Coleoptera: Megalopodidae, Orsodacnidae and Chrysomelidae, excluding Bruchinae). Coleopterists Society Special Publication No. 1, 290 pp.

Spaeth, F. 1938. Die Gattung *Himatidium* Fab. (Col. Cassidinae). Revista de Entomologia 9: 305–317.

Staines, C. L. 1986. A revision of the genus *Brachycoryna* (Coleoptera: Chrysomelidae). Insecta Mundi 1: 231–241.

———. 1995. Range extensions in North American Hispinae (Coleoptera: Chrysomelidae). Great Lakes Entomologist 28: 89–92.

———. 1996. The genus *Cephaloleia* (Coleoptera: Chrysomelidae) in Central America and the West Indies. Special Publication No. 3 of the Revista de Biología Tropical, 87 pp.

———. 2002. Nomenclatural notes and new species of Sceloenoplini (Coleoptera: Chrysomelidae: Cassidinae). Zootaxa 89: 1–32.

Uhmann, E. 1930. Neue Hispinen von Costa Rica. 24. Beitrag zur Kenntnis der Hispinen (Col. Chrys.). Folia Zoologica et Hydrobiologica 2: 135–144.

———. 1939. Hispinen des Deutschen Entomologischen Instituts, Berlin-Dahlem. III. Teil. (Coleoptera: Chrysomelidae). 82. Beitrag zur Kenntnis der Hispinen (Coleoptera: Chrysomelidae). Arbeiten über morphologische und taxonomische Entomologie aus Berlin-Dahlem 6: 151–156.

———. 1940. Hispinen aus dem Britischen Museum.- III. Teil. Amerikaner. 84. Beitrag zur Kenntnis der Hispinen (Coleoptera, Chrysomelidae). The Annals and Magazine of Natural History 6(11): 449–461.

———. 1957. Coleopterorum Catalogus Supplementa. Chrysomelidae: Hispinae, Hispinae Americanae. W. Junk. s'Gravenhage. Pars 35(1): 1–153.

———. 1964. Coleopterorum Catalogus, Supplementa, Chrysomelidae: Hispinae. W. Junk. s'Gravenhage. Pars 35(3): 399–490.

Waterhouse, C. O. 1881. On the Coleopterous insects belonging to the family Hispidae collected by Mr. Buckley in Ecuador. Proceedings of the Zoological Society of London. 260–269.

Weise, J. 1905. Beschreibung einiger Hispinen. Archiv für Naturgeschichte 71: 49–104.

———. 1910. Beitrag zur Kenntnis der amerikanischen Hispinen. Archiv für Naturgeschichte 76: 67–127.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 166–181

HYPOGEAL MARGARODIDS OF THE GENUS *HETEROMARGARODES* JAKUBSKI (HEMIPTERA: MARGARODIDAE) FROM THE WESTERN UNITED STATES

C. M. Unruh and P. J. Gullan

Department of Entomology, University of California, One Shields Avenue, Davis, CA 95616, U.S.A. (e-mail: cmunruh@ucdavis.edu; pjgullan@ucdavis.edu)

Abstract.—Soil-dwelling scale insects with cystlike feeding stages, called ground pearls, belong to several genera of Margarodidae (Hemiptera: Coccoidea), including *Heteromargarodes* Jakubski known only from the western United States. We revise and redescribe *Heteromargarodes* and its type species, *H. americanus* Jakubski, based on the adult female. In addition, *Margarodes chukar* McDaniel and *Margarodes hiemalis* Cockerell are transferred to *Heteromargarodes* as *H. chukar* (McDaniel), **new combination**, and *H. hiemalis* (Cockerell), **new combination**, respectively, and redescribed based on the adult female. A lectotype is designated for *M. hiemalis.* Another North American ground-pearl species, *Margarodes dactyloides* McDaniel, is found to be a **new synonym** of *Eumargarodes laingi* Jakubski. A key to the genera of ground pearls found in North America is included.

Key Words: Scale insects, ground pearls, hypogeal insects, taxonomy

The hypogeal margarodids, also called ground pearls, have been treated as the tribe Margarodini of the Margarodidae *sensu lato* by Morrison (1928), as part of the subfamily Margarodinae (Ben-Dov 2005), as two families, Margarodidae *sensu stricto* and Termitococcidae, by Jakubski (1965), and as one family, Margarodidae *sensu stricto* by Koteja (2001), Foldi (2005), and Hodgson and Foldi (2006). This group is considered to comprise the following ten genera: *Dimargarodes* Silvestri, *Eumargarodes* Jakubski, *Eurhizococcus* Silvestri, *Heteromargarodes* Jakubski, *Margarodes* Guilding, *Margarodesia* Foldi, *Neomargarodes* Green, *Porphyrophora* Brandt, *Promargarodes* Silvestri, and *Termitococcus* Silvestri (Ben-Dov 2005). In Jakubski's (1965) taxonomic monograph, he described the immature and adult females of all species known at that time, but he illustrated only the spiracles and pores. His generic concepts are difficult to apply, some genera may be synonyms, and his subfamily and tribal classification appears to be artificial. Foldi (2001) listed a total of 107 species of hypogeal margarodids belonging to the above genera, including a number of recently described species from Kazakhstan, Turkmenistan, Mongolia (e.g., Jashenko 1989, 1990, 1994) and China (Tang and Hao 1995, Tang 2000). The genus *Porphyrophora* has been revised recently for species from Europe, the Middle East and North Africa (Vahedi 2002, Vahedi and Hodgson in press) and the South African species of *Margarodes* have been revised by De Klerk (1982) and De Klerk et al. (1982, 1983). However, there appears to be much convergence in morphology among genera, it is not clear which morphological characters are informative phylogenetically, and there have been no molecular phylogenetic studies to provide data for re-interpreting morphological taxon concepts.

The name ground pearls derives from the cystlike nymphs which are very reduced in morphology and live underground on the roots of their host plants, protected inside a membranous or hardened covering that is frequently pearly in appearance (Morrison 1928, Jakubski 1965). The life cycles of most species of ground pearls have not been studied, however most species are considered to have just three instars in the female: first, second (cyst stage) and adult (Jakubski 1965, Danzig 1980), although Foldi (2005) suggested that up to three cyst stages may occur, depending on species. A number of species are injurious to their host plants, often grasses, attacking turf grass in parts of the U.S.A. (Hoffman and Smith 1991, Gill 1993), sugar cane in Australia (Dominiak et al. 1989), and grape vines in South Africa and South America (De Klerk et al. 1982, Foldi and Soria 1989). The centipede grass ground pearl, *Dimargarodes meridionalis* (Morrison), is known to infest the roots of both grape vines and a range of grasses in the southwestern and southeastern United States (Barnes et al. 1954, Ebeling 1959, Kouskolekas and Self 1974, Gill 1993).

The biology of North American pestiferous ground pearls has been reviewed by Kouskolekas and Self (1974) and Hoffman and Smith (1991). These species overwinter as cysts and females mature in late spring to mid summer and emerge from the cyst. In sexual species the adults mate, and the adult females produce and deposit their eggs in an ovisac at the roots of the host plants before autumn. There is usually one generation per year, but there can be as many as three (Baker 1982). If conditions are not favorable for emergence, the overwintering cysts may remain in that stage for several years (Brandenberg 1995) with the record reported for cyst dormancy being 17 years in *Margarodes vitis* (Philippi) (Ferris 1919). In Australia, the ground pearl *Eumargarodes laingi* Jakubski is univoltine and adult females emerge beginning in spring and continue to emerge through the summer months (Allsopp and McGill 1997, Samson and Harris 1998).

Five genera–*Dimargarodes*, *Eumargarodes*, *Heteromargarodes*, *Margarodes*, and *Promargarodes*–and a total of nine species of hypogeal margarodids have been recorded from North America (Jakubski 1965; McDaniel 1965, 1966), but few have been described by modern standards and the most comprehensive key (McDaniel 1966) dealt with only five species. The monotypic genus *Eumargarodes* has been recorded from the southeastern United States but is also a pest in Australia (Jakubski 1965) and is believed to be native to North America (Jakubski 1965). *Heteromargarodes* was described for *H. americanus* Jakubski, known only from Wyoming with no recorded host plant (Jakubski 1965), and was redescribed by Foldi (2005) based on one adult female that he designated as the lectotype. Until recently, most other North American species of hypogeal margarodids have been treated as members of *Margarodes* (Foldi 2001; Ben-Dov 2005), although this generic placement is uncertain. Jakubski (1965) transferred *Margarodes hiemalis* Cockerell to *Porphyrophora*, although it is not clear why as he did not list any specimens he examined. He also transferred *Margarodes meridionalis* to *Dimargarodes* apparently based on pore characteristics of the adult female. The recent catalogue of Margarodidae (Ben-Dov 2005) followed Jakubski's placement of these two species, and also transferred *Promargarodes floridanus* Jakubski to *Margarodes* following Vahedi (2002). The placement of *M. meridionalis* in *Dimargarodes* appears to be justified, but the justification for the other two transfers is unclear. Thus below, we continue to refer to these two species by their most widely used combinations, i.e., *M. hiemalis* and *P. floridanus*. The nine ground-pearl species known to occur in the U.S.A. are distributed as follows: *D. meridionalis* in southern U.S.A., Arizona, and California (Barnes et al. 1954, Ebeling 1959, Gill 1993), *E. laingi* found only in the southeastern states (Spink and Dogger 1961, Jakubski 1965), *H. americanus* in Wyoming (Jakubski 1965), *M. chukar* La Rivers in Nevada (La Rivers 1967), *M. dactyloides* McDaniel and *M. morrisoni* McDaniel in Texas (McDaniel 1965), *M. hiemalis* in New Mexico (Cockerell 1899), *M. rileyi* Giard in Florida and the Caribbean (Jakubski 1965), and *P. floridanus* (Jakubski) in Florida (Giard 1894, Morrison 1927, Jakubski 1965).

We revise the genus *Heteromargarodes*, which is here considered to comprise three species. *Margarodes chukar* and *M. hiemalis* are transferred to *Heteromargarodes* as *H. chukar*, new combination, and *H. hiemalis*, new combination, respectively, based on examination of the type specimens. We provide a revised description of the genus and a description of each species based on the adult females, as well as a diagnosis of the cyst stage. In addition, *M. dactyloides* is synonymized with *E. laingi* based on study of the newly rediscovered holotype of *M. dactyloides*. We include a key to all genera of ground pearls found in North America.

MATERIALS AND METHODS

All material studied consisted of slide-mounted museum specimens, a few of which were remounted using a method adapted from Kozarzhevskaya (1986) and described in Gullan (1984). Specimens are deposited in the Australian National Insect Collection, CSIRO, Canberra (ANIC); the Bohart Museum of Entomology, University of California, Davis (BME); The Natural History Museum, London (BMNH); the California State Collection of Arthropods (CSCA), Plant Pest Diagnostics Branch, California Department of Food and Agriculture (CDFA), Sacramento; and the National Entomological Collection of the National Museum of Natural History, housed in Beltsville, Maryland (USNM). One adult female specimen (♀) is mounted on each slide, unless otherwise stated.

The morphological terms of Jakubski (1965) and Vahedi (2002) are used with some modifications. Setae are distinguished from spines by the presence of a basal collar by which each seta articulates with the cuticle. Spines lack this feature. Body setae in *Heteromargarodes* are of two types: long hairlike setae arranged in segmental bands, and short hairlike setae scattered amongst the long setae, and especially numerous near the ventral midline. Antennae have coeloconic sensilla (Koteja 1980), short hairlike setae, long hairlike setae (also called flagellate setae) and fleshy setae; the latter are stouter than hairlike setae and have blunt apices. The trochanter of each leg has campaniform sensilla, which are small, clear, oval pores that may or may not have sensory function. Similar structures to these are found on the derm outside the opening of the thoracic spiracles. These are called perispiracular pores and their function is not known. Pores found on the ventral and dorsal surface of the derm are called multilocular pores because they each contain several to many circular loculi (openings). The multilocular pores of *Heteromargarodes* do not have a distinct outer rim of small loculi, as found in many other ground-pearl genera, and are referred to here as sievelike multilocular pores. Measurements are expressed as the range and are given in millimeters (mm) and in micrometers (μm). The enlargements are not drawn to the same scale as each other. The measurements and figures of the adult female of *H. chukar* are based only on the type material, whereas for *H. hiemalis* measurements from the holotype and another specimen were included, and for *H. americanus* measurements from the lectotype and seven other specimens were included. The generic description of the cyst stage is based on the paralectotype of *H. americanus* and on material of *H. hiemalis* from Santa Rita Experimental Station, Arizona.

Key to Genera of North American Ground Pearls Based on Slide-Mounted Adult Females (Note that this key will not work in other regions.)

1 Spines absent from derm. Dorsal pores without outer rim of small loculi; each pore with either multilocular or sievelike center 2

– Spines present on derm. Dorsal pores with rim of small loculi; each pore with either bi- or multilocular center. 3

2(1) Abdominal cuticle without raised bare patches of cuticle. Abdominal spiracles in 3 pairs. Setae on legs robust, spinelike, with large collars. Dorsal pores each with 4–8 loculi in central circle . . . . *Eumargarodes* Jakubski

– Abdominal cuticle with raised bare patches of cuticle. Abdominal spiracles in 6 pairs. Setae on legs hairlike, similar to setae on cuticle. Dorsal pores sievelike, each with 10–30 loculi . . . . *Heteromargarodes* Jakubski

3(1) Derm pores with distinct bilocular center . . . . *Dimargarodes* Silvestri

– Derm pores with multilocular center . . . 4

4(3) Abdominal spiracles in 6 pairs. Cicatrices absent on venter of abdomen. Apices of spines on cuticle always pointed . . . . *Promargarodes* Silvestri

– Abdominal spiracles in 5 or 7 pairs. Cicatrices present or absent on venter of abdomen. Apices of spines on cuticle rounded, or pointed . . . . *Margarodes* Guilding

Heteromargarodes Jakubski

Heteromargarodes Jakubski 1965. Type species: *Heteromargarodes americanus* Jakubski 1965, by original designation and monotypy.

Description.—*Adult female:* Body oval, 3.8–10.9 mm long, 3.0–10.0 mm wide, abdomen with 9 segments; abdominal segment I represented ventrally by a small area lateral to metathoracic leg; apex of abdomen with or without a membranous, setose projection or boss. Derm with dense papillae (each 7–12 μm across) over entire body. Eyes absent. Antenna 8-segmented, segments II and III partially fused giving a 7-segmented appearance; segment I longest and widest with papillose derm and 3–7 hairlike setae 15–124 μm (mostly <35) long; segments II and III almost bare, each with 0–5 short hairlike setae, 15–25 μm long; segments IV–VIII cylindrical, with apical segment (VIII) narrowest, 60–110 μm long, 40–110 μm wide; sensilla and setae of segments IV–VIII as follows (many setae broken and missing and number often unreliable): flagellate setae each 40–250 μm long: 1–5 on IV, 3–7 on V, 3–8 on VI, 4–8 on VII and 8–12 on VIII; long fleshy setae (10–30 μm long): 1 or 2 on IV, 2–4 on V, 5–7 on VI, 4–6 on VII and 8–16 on VIII; short fleshy setae: probably 1 or 2 on VIII (difficult to see); coeloconic sensilla (not illustrated) 1–3 on at least each of segments IV–VI (difficult to see). Mouthparts absent, represented only by cuticular folds. Prothoracic legs fossorial, much larger than mesothoracic and metathoracic legs; base of coxa with 10–12 short setae each 10–15 μm long; trochanter + femur 350–1000 μm long, 400–800 μm in basal width; tibia and tarsus 360–1025 μm long; sclerotized claw 380–650 μm long, without denticle; trochanter with 7–9 campaniform sensilla on each side; femur with hairlike setae (80–250 μm long), most numerous anteroventrally, and scattered short hairlike setae (15–30 μm long); tibia and tarsus with a group of setae (60–100 μm long) present anteroventrally. Mesothoracic and metathoracic legs similar in structure to prothoracic legs, but smaller and narrower; base of each coxa 350–750 μm wide with short setae (10–15 μm long) and long setae (200–500 μm long) ventromedially; trochanter + femur 150–300 μm long, 200–500 μm in basal width; tibia plus tarsus 200–350 μm long; sclerotized claw 200–300 μm long, almost straight, without denticle; trochanter narrow with 4–7 campaniform sensilla on each side, without hairlike setae; femur sparsely covered with short setae dorsally and laterally and group of long setae ventrally; tibia partially fused with tarsus, covered with short setae dorsally and laterally, several long setae ventrally; tarsus completely fused with claw, with a trace of suture all round, 3 or 4 long (80–100 μm) ventral setae. Anal area at posterior end of body, dorsally on segment IX; anal opening circular on an elliptical sclerotized area; anal tube simple, with simple sclerotized anal ring and lateral apodemes. Thoracic spiracles large, ovalshaped, well chitinized; atrium of each peritreme with numerous sievelike multilocular pores in 1–2 dense rows, similar in structure to pores found on derm, each pore 12–16 μm in diameter with definite outer rim and 20–30 loculi tightly arranged, each loculus 1–2 μm in diameter; 5–6 perispiracular pores posterior to each peritreme. Abdominal spiracles in 6 pairs; inner and outer atria of posterior pair slightly smaller than other 5 pairs; each spiracle with sievelike multilocular pores present in outer atrium.

Dorsal surface: Densely covered in long hairlike setae, each 150–550 μm long, scattered on head and thorax and arranged in segmental bands on abdomen, collar of each seta very small; densest vestiture on last 4 abdominal segments. Short hairlike setae, each 15–50 μm long, rare, scattered among long hairlike setae. Multilocular pores sievelike, each 15–16 μm in diameter with sclerotized outer rim, with 8–30 tightly arranged, similar-sized loculi, each loculus 1–2 μm in diameter; pores scattered among setae, more densely on midline and around margin of abdomen, especially on posterior segments; pores scattered, rare, or absent on head and thorax. Abdomen with conspicuous, elongate oval to round, raised areas of bare cuticle in a partial transverse row on each segment; distributed marginally to submarginally on abdominal segments II to IV, across entire segment on V to VIII, absent on segment IX.

Ventral surface: Covered in long hairlike setae (100–500 μm long), on all body segments, densest on last 4 abdominal segments. Short hairlike setae (10–50 μm long) scattered irregularly marginally and midventrally on abdominal segments. Sievelike multilocular pores, similar in size and structure to those on dorsum; distributed segmentally on abdomen, becoming densest near posterior abdomen and scattered, rare, or absent on head and thorax. Sternal apodemes present medially between legs of mesothoracic and metathoracic pairs. Genital opening circular with radiating fissures, situated anteriorly on segment VIII, devoid of setae and pores. Abdomen with conspicuous, elongate oval to round, raised areas of bare cuticle in a complete or partial transverse row on each of segments II to VIII.

Description.—*Cyst stage:* Body oval (2.8–5.3 mm long, 2.5–3.8 mm wide). Derm smooth. Antenna reduced to a pair of small plates, each 30–40 μm wide, with 3–6 sensory setae. Mouthparts present; 2–3 pairs of short setae on labium; derm surrounding labium with 14–20 small peri-oral pores, each 7–10 μm wide, with a sclerotized rim and 1–4 loculi. Thoracic spiracles well developed, each with a circular orifice to spiracular atrium; 8–12 pores arranged in 2–3 rows in atrium; atrial pores with bilocular center and outer rim of 14–18 smaller loculi. Abdominal spiracles in 6 pairs, last pair considerably smaller (about one-quarter size) than first 5; 2–3 rows of 6–12 pores each arranged around inner atrium of first 5 pairs of spiracles; last pair with 3–4 pores; pores similar in structure to those of thoracic spiracles. Cicatrices arranged around posterior abdomen in 5–7 rows of 2–8 cicatrices each; each cicatrix concave circular, 15–18 µm in diameter, 23–25 µm deep. Anal opening forming a sclerotized tube, 30 µm in diameter, with or without concentric circles of patterning on derm.

Diagnosis.—*Heteromargarodes* is characterized in the adult female by three features that are unique among North American genera: (i) raised bare patches on the derm, (ii) long hairlike body setae, and (iii) sievelike multilocular pores. Pores appear sievelike because they have 10–30 evenly distributed loculi, and lack the distinct outer ring of loculi found in other genera; all other North American genera have pores with a unilocular, bilocular or multilocular center and the number of central loculi rarely exceeds eight. The cyst stage of *Heteromargarodes* is characterized by peri-oral pores and numerous concave cicatrices. In both the adult female and cyst stage, *Heteromargarodes* differs from *Eumargarodes* by the number of abdominal spiracles (six pairs in *Heteromargarodes*, three pairs in *Eumargarodes*) and the cyst stage of *Heteromargarodes* has more than 10 cicatrices surrounding the anal opening whereas that of *Eumargarodes* has no more than six cicatrices.

Distribution.—Species of the genus *Heteromargarodes* are found in western North America and have been recorded from the states of Arizona, California, Nevada, New Mexico, and Wyoming. Species are also found in Baja California, Mexico.

Notes.—A redescription of this genus was part of a revision of the type species of all genera of ground pearls by Foldi (2005). At the time of Foldi's work, *Heteromargarodes* was monotypic, but we include two other species: *H. chukar* and *H. hiemalis*.

The CSCA and the USNM collections of margarodids from the western United States have a few adult females of several other apparently undescribed ground-pearl species that share some features with species of *Heteromargarodes*, including bands of raised bare patches of cuticle, sievelike pores and papillae on the derm. The adult females of these undescribed species differ from described *Heteromargarodes* species in the number of pairs of abdominal spiracles, the number of antennal segments, and the number of loculi in the pores. There are not enough well-prepared slides available to describe these species adequately.

KEY TO SPECIES OF *HETEROMARGARODES* BASED ON SLIDE-MOUNTED ADULT FEMALES

1 Derm pores rare or absent on head and thorax; pores on anterior of body with fewer loculi (6–12) (Fig. 3G) than pores on posterior of body (18–30 loculi) (Fig. 3E). Conspicuous boss, covered with setae and pores, projecting from posterior end of abdomen (Fig. 3) 2

– Derm pores scattered on head and thorax; locular number consistent (20–30) in pores over entire body. Boss absent (Fig. 2) . . . . *H. chukar*

2 Thoracic spiracles with 18–23 sievelike multilocular pores in atrium (Fig. 1C) . . . . *H. americanus*

– Thoracic spiracles with 8–10 sievelike multilocular pores in atrium (Fig. 3F) . . . . *H. hiemalis*

Heteromargarodes americanus Jakubski (Fig. 1)

Heteromargarodes americanus Jakubski 1965: 85; Foldi 2005: 513.

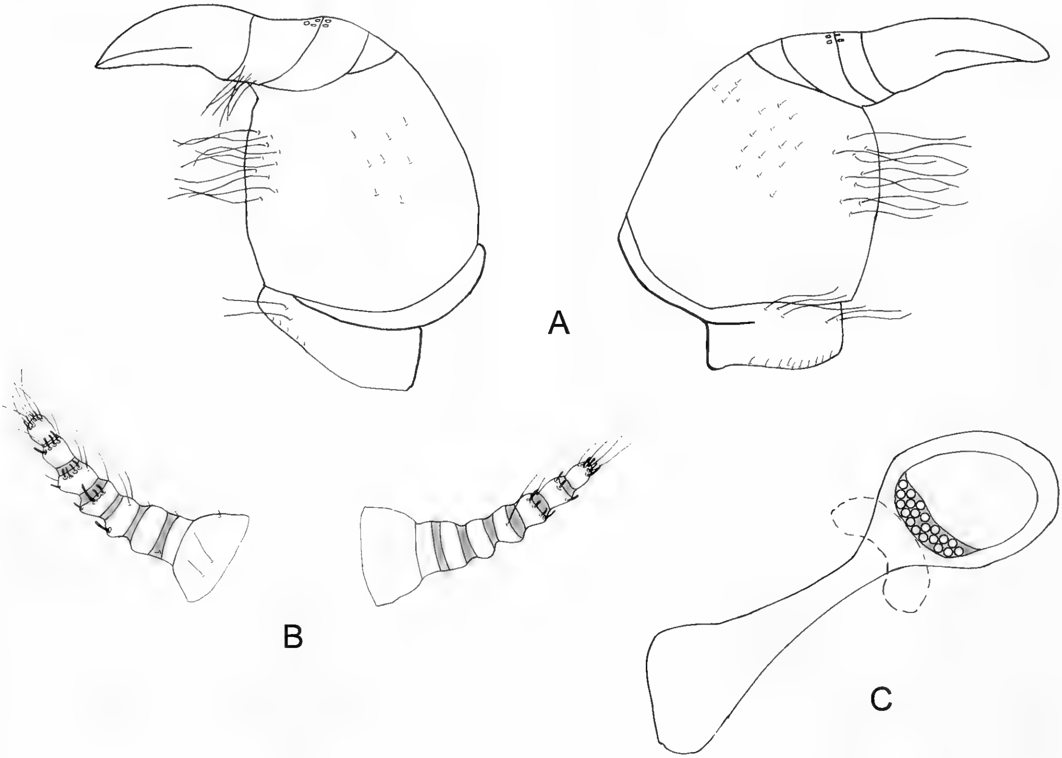


Fig. 1. Adult female of *Heteromargarodes americanus*. A, Prothoracic legs. B, Antennae. C, Thoracic spiracle.

Description.—*Adult female* (measurements based on lectotype and 7 specimens from Teel's Marsh, NV): Body 6.4–10.9 mm long, 6.1–10.0 mm wide; apex of abdomen with a membranous projection covered in sievelike multilocular pores and long hairlike setae (compressed and not obvious on lectotype). Antenna 580–750 µm long. Prothoracic leg: trochanter + femur 650–1000 µm long, 700–800 µm in basal width; tibia and tarsus 700–1025 µm long; claw missing on lectotype, 500–600 µm long on non-type material; hairlike setae 200–500 µm long on femur. Mesothoracic and metathoracic legs: trochanter + femur 900–1150 and 800–1100 µm long, respectively; hind trochanter + femur 280–450 µm in basal width. Anal tube diameter 40–60 µm at opening. Thoracic spiracles including muscle plates 300–500 µm long, 90–220 µm wide with atrial openings 50–100 µm long, 65–120 µm wide; atrium with 10–23 sievelike multilocular pores arranged in two or more rows. Abdominal spiracles with diameter of outer atria of first 5 pairs 40–60 µm, diameter of atria of last pair 20–30 µm; 0–12 sievelike multilocular pores arranged around central opening into inner atrium of each spiracle, each pore 15 µm in diameter, similar in structure to those of thoracic spiracles.

Dorsal surface: Long hairlike setae (250–550 µm long) and short hairlike setae (15–30 µm long) irregularly scattered across each segment. Sievelike multilocular pores scattered amongst setae on abdomen; pores on first 4 abdominal segments with fewer loculi (6–12) than pores on posterior abdominal segments (18–30 loculi); pores rare or absent on head and thorax, if present, similar to those on anterior abdominal segments.

Ventral surface: Hairlike setae (230–500 µm long), short hairlike setae (10–30 µm long) and sievelike multilocular pores similar in structure to those on dorsum but more densely distributed; pores rare or absent on head and thorax.

Variation.—We have examined material from three collections that we believe to be conspecific with the lectotype specimen of *H. americanus* and there is little variation. The only characteristics that seem to vary are the density of body setae (probably due to the size of specimens and amount of damage during slide-mounting) and the appearance of a posterior abdominal extension, or "boss" as referred to by McDaniel (1965); the angle of compression of the posterior abdomen can reduce the conspicuousness of this structure.

Diagnosis.—The adult female of *H. americanus* differs from that of *H. hiemalis* in its generally larger body and legs, larger thoracic spiracles with more sievelike multilocular pores, and generally longer and denser body setae. The pores in the atrium of the thoracic spiracles of *H. americanus* form two or more rows whereas the pores of *H. hiemalis* are arranged in a single row. The long hairlike setae of *H. americanus* are 250–550 µm, whereas the long setae of *H. hiemalis* are rarely longer than 500 µm. The shorter setae of *H. americanus* are also, on average, longer (20–40 µm) than the shorter setae of *H. hiemalis* (15–30 µm).

Type material.—Lectotype (designated by Foldi 2005): ♀ of *Heteromargarodes americanus*. U.S.A., Wyoming, Powell, 24.ix.1949 (H. S. Beaduoin [sic]) (USNM). Paralectotype: cyst-stage nymph, same data as holotype (USNM). [The collector's name, H. L. Beaudoin, is misspelled on the slide label.]

Other material examined.—U.S.A.: 7 ♀, Nevada, Mineral County, Teel's Marsh [spelled Teal Marsh on label], ii.1979, on the roots of undetermined grass in a sand dune (R. J. Gill) (CSCA); 4 ♀, California, San Bernardino County, Lucerne Valley, Dead Man's Point, 4.v.1961, in an onion field (N. Welch) (CSCA); 1 ♀, California, San Bernardino County, Victorville area, 19.v.1961, soil in onion field (N. Welsh) (CSCA).

Discussion.—The lectotype of *H. americanus* is missing both prothoracic claws. It is difficult to distinguish the presence of a bosslike extension on the abdomen of the lectotype because it appears that area has been compressed during the slide-mounting process. Foldi (2005) published a redescription of *H. americanus* based on the lectotype slide of *H. americanus*, but his drawing of the adult female does not show the abdominal boss due to the poor quality of the specimen, nor does it include the raised bare patches present on the dorsal and ventral surfaces of the abdomen.

Ben-Dov (2005) and Foldi (2005) treated "Deuteromargarodes americanus" as a *nomen nudum* and claimed that it was discovered by Jakubski (1965). However, Jakubski only stated that the type slides were labeled "*Deuteromargarodes americanus*" (apparently a manuscript name), and he appropriately used the name in quotes. Thus Jakubski did not discover or create a *nomen nudum*.

In his description of the *H. americanus* cyst, (Jakubski 1965: 86) referred to the anal opening being "on top of a flat protuberance (*circa* 125 µ) constructed of numerous heavily chitinized circles." The anal opening on the paralectotype, which is the specimen that Jakubski examined, does not fit this description and it appears that he misinterpreted an abdominal spiracle as the anal area. Jakubski (1965) also described an adult male collected in Idaho in 1931 that may not be conspecific with *H. americanus*. This male was not collected with the type material or with any other material that we believe to be *H. americanus*. Jakubski expressed his uncertainty concerning the identity of this specimen. Foldi (2005) referred to *H. americanus* as having bisexual reproduction, but this statement is presumably based on the questionably associated male specimen from Idaho. The mode of reproduction of *H. americanus* is thus unknown at this point. Hodgson and Foldi (2006) redescribed and illustrated this male specimen.

Heteromargarodes hiemalis (Cockerell), **new combination**

(Fig. 3)

Margarodes hiemalis Cockerell 1899: 416.
Coccionella hiemalis (Cockerell): Lindinger 1954: 615.
Porphyrophora hiemalis (Cockerell): Jakubski 1965: 46.

Description.—*Adult female* (measurements based on lectotype and a non-type adult female from Tucson, AZ): Body 5.0–6.6 mm long, 4.6–5.9 mm wide; apex of abdomen with a membranous projection covered in sievelike multilocular pores and long hairlike setae. Antenna 470–550 µm long. Prothoracic leg: trochanter + femur 670–790 µm long, 750 µm in basal width; tibia and tarsus 700 µm long; claw 500–530 µm long; hairlike setae 100–500 µm long on femur. Mesothoracic and metathoracic legs: trochanter + femur 750–990 and 730–800 µm long, respectively; hind trochanter + femur 280–330 µm in basal width. Anal tube diameter 45–60 µm at opening. Thoracic spiracles including muscle plates 265–275 µm long, 200 µm wide, atrial openings each 50–75 µm long, 60–90 µm wide; atrium with 8–10 sievelike multilocular pores arranged in a single row, widening at one end. Abdominal spiracles with diameter of outer opening of first 5 pairs 50–60 µm, diameter of atria of last pair 30–40 µm; 0–12 sievelike multilocular pores arranged around opening into inner atrium of each spiracle, each pore 15 µm diameter, similar in structure to those of thoracic spiracles.

Dorsal surface: Long hairlike setae (200–500 µm long) and short hairlike setae (20–40 µm long) irregularly scattered across each segment. Sievelike multilocular pores scattered amongst setae on abdomen; pores on first four abdominal segments with fewer loculi (6–12) than pores on posterior abdominal segments (18–30 loculi); pores rare or absent on head and thorax.

Ventral surface: Structure and distribution of long hairlike setae (230–500 µm long) and sievelike multilocular pores as on dorsal surface; short hairlike setae, 20–40 µm long, more numerous midventrally than on dorsal surface; pores rare or absent on head and thorax.

Variation.—We compared the two adult females available for study and there is little variation. The specimen from Tucson has slightly denser setae than the lectotype. The posterior boss of the female from Tucson is difficult to identify because it is compressed on the slide.

Diagnosis.—*Heteromargarodes hiemalis* is most similar to *H. americanus* [see diagnosis under *H. americanus* for a detailed comparison].

Type material.—Lectotype (here designated): adult ♀ of *Margarodes hiemalis.* U.S.A.: New Mexico, Mesilla Park, i.1899 (Cockerell) (USNM). Paralectotype: adult ♂ of *Margarodes hiemalis,* same data as lectotype (USNM). We designated the adult female from the two specimens originally described by Cockerell (1899) as the lectotype in order to preserve stability of nomenclature for this species.

Other material examined.—1 adult ♀ and 1 cyst-stage nymph (same slide), Arizona, 30 mi [48 km] south of Tucson, Santa Rita Experimental Range, xii.1978, ex *Prosopis* (E. Hoffman) (CSCA).

Discussion.—Jakubski (1965) placed *M. hiemalis* in *Porphyrophora*, but in the most recent revision of that genus, Vahedi (2002) did not include *M. hiemalis* because it is found in North America. *Heteromargarodes* and *Porphyorphora* have similar hairlike setae covering the body, but differ in the number of abdominal spiracles, antennal shape and sensory structures. McDaniel (1965, 1966) described "tooth-like structures" on the foreleg claw of *M. hiemalis*, but these structures were not apparent on the lectotype or the other specimen that we considered as conspecific.

(Cockerell 1899: 416) described the adult female of *M. hiemalis* as: "Bright lemon yellow, very soft, oval; 5.5 mm. long, 4 broad, 2.5 high; segmentation distinct, each segment with a whorl of mostly blackish but inconspicuous hairs; apex of abdomen with a small reddish hairy prominence;..." This contrasts with La Rivers (1967) description of *M. chukar* (see below). In his original description, Cockerell described walking up a path and seeing male scales "hurrying to and fro." He then watched as one of them started digging, almost completely burying itself. Cockerell dug after it and discovered a "plump yellow female coccid" (1899: 415). He explained that the purpose of a thickened femur on the anterior pair of legs in males of *Margarodes* spp. was unknown until he witnessed the male of *M. hiemalis* digging with its enlarged fossorial prothoracic legs.

Heteromargarodes chukar (La Rivers), **new combination**

(Fig. 2)

Margarodes chukar La Rivers 1967: 4.

Description.—*Adult female* (based on 5 slide-mounted paratype specimens): Body 3.8–10.0 mm long, 3.0–8.4 mm wide; apex of abdomen rounded, without a membranous projection. Antenna 450–800 μm long. Prothoracic leg: trochanter + femur 350–800 μm long, 400–600 μm in basal width; tibia + tarsus 360–900 μm long; sclerotized claw 380–650 μm long; hairlike setae 200–500 μm long on femur. Mesothoracic and metathoracic legs: trochanter + femur 550–1180 μm and 500–1100 μm long, respectively; hind trochanter + femur 180–450 μm in basal width. Anal tube diameter 30–50 μm at opening. Thoracic spiracles including muscle plate 180–350 μm long, 50–100 μm wide, atrial opening 120 μm long, 80 μm wide; atrium with 6–10 sievelike multilocular pores; each pore 10–12 μm in diameter with definite outer rim and 20–30 tightly arranged loculi, each loculus 1–2 μm in diameter, pores in a single row, number of pores increasing at one end. Abdominal spiracles in 6 pairs; outer opening of 5 anterior pairs 40–70 μm in diameter with 0–8 sievelike multilocular pores, outer opening of posterior pair 20–30 μm in diameter with 6–8 sievelike multilocular pores; pores 9–10 μm in diameter, arranged around central opening into inner atrium; pores similar to those of thoracic spiracles.

Dorsal surface: Long hairlike setae (250–550 μm long); short hairlike setae (20–40 μm long) rare, irregularly scattered. Sievelike multilocular pores with 20–30 tightly arranged loculi found on head, thorax and abdomen.

Ventral surface: Structure of long hairlike setae (230–500 μm long), short hairlike setae (20–40 μm long) as on dorsum, setae more dense on venter than dorsum; sievelike multilocular pores as on dorsal surface; pores scattered amongst setae on head, thorax and distributed segmentally on abdomen.

Variation.—We examined paratypes and other specimens that we believe to be conspecific with the paratypes. We noted variation in the body size of adult females, even within a single collection, and density of setae varies among collections, rather than among specimens

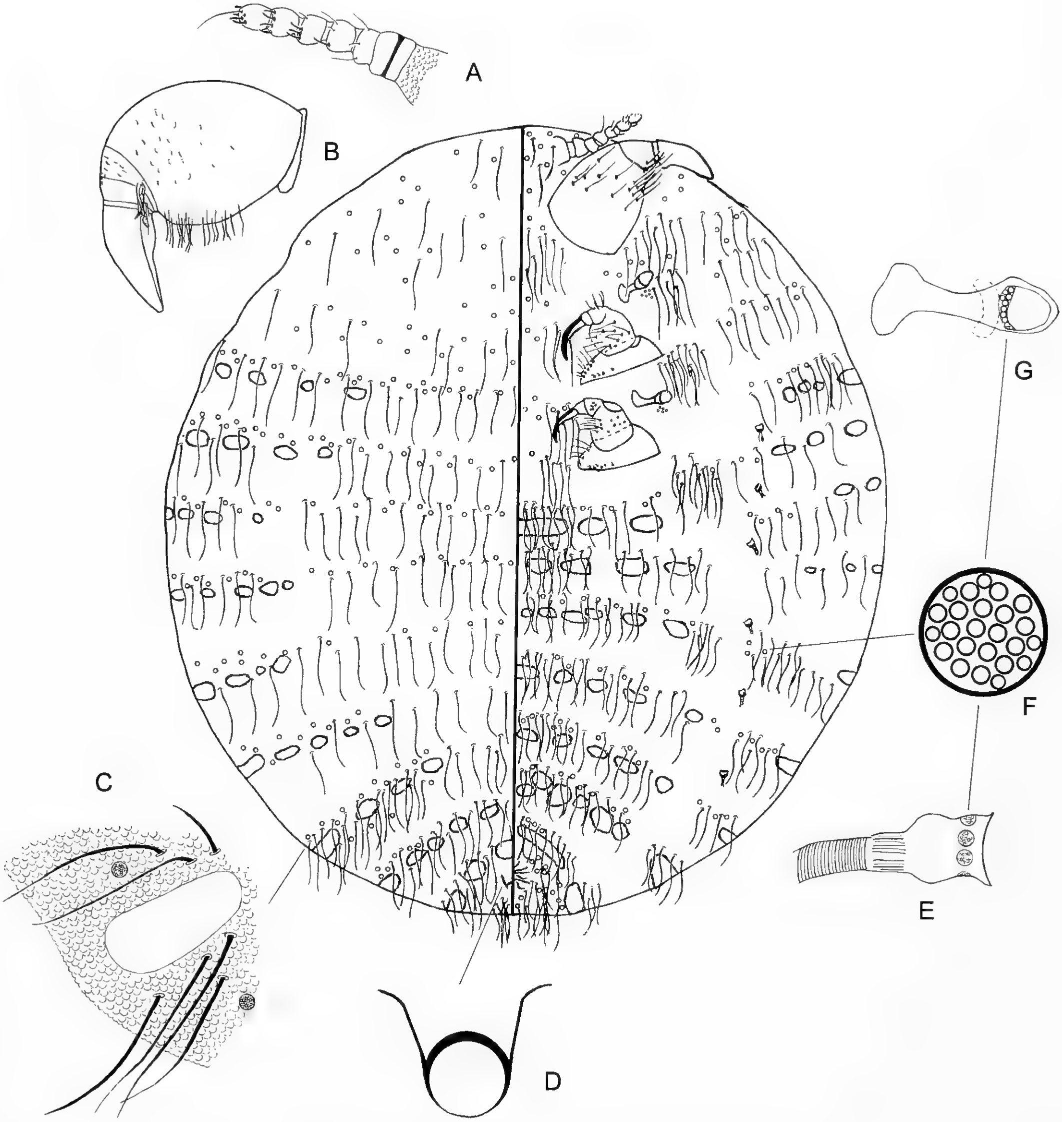


Fig. 2. Adult female of *Heteromargarodes chukar*. A, Dorsal surface of antenna. B, Dorsal surface of prothoracic leg. C, Derm enlargement. D, Anal opening. E, Abdominal spiracle. F, Multilocular pore. G, Thoracic spiracle.

of different sizes. The large adult female from Mexico is covered with very dense setae and both large and small adult females from Red Rock Canyon have many fewer setae than the Mexican specimen.

Diagnosis.—The adult female of *H. chukar* differs from that of *H. hiemalis* and *H. americanus* by the absence of a conspicuous boss projecting from the posterior end of the abdomen and by the presence of pores on the head and thorax. All derm pores found in *H. chukar* have a consistent number of loculi (20–30) as opposed to the varying numbers on anterior versus posterior abdomen found in *H. hiemalis* and *H. americanus*.

Type material.—Paratypes of *Margarodes chukar*: 5 adult ♀, U.S.A.: Nevada,

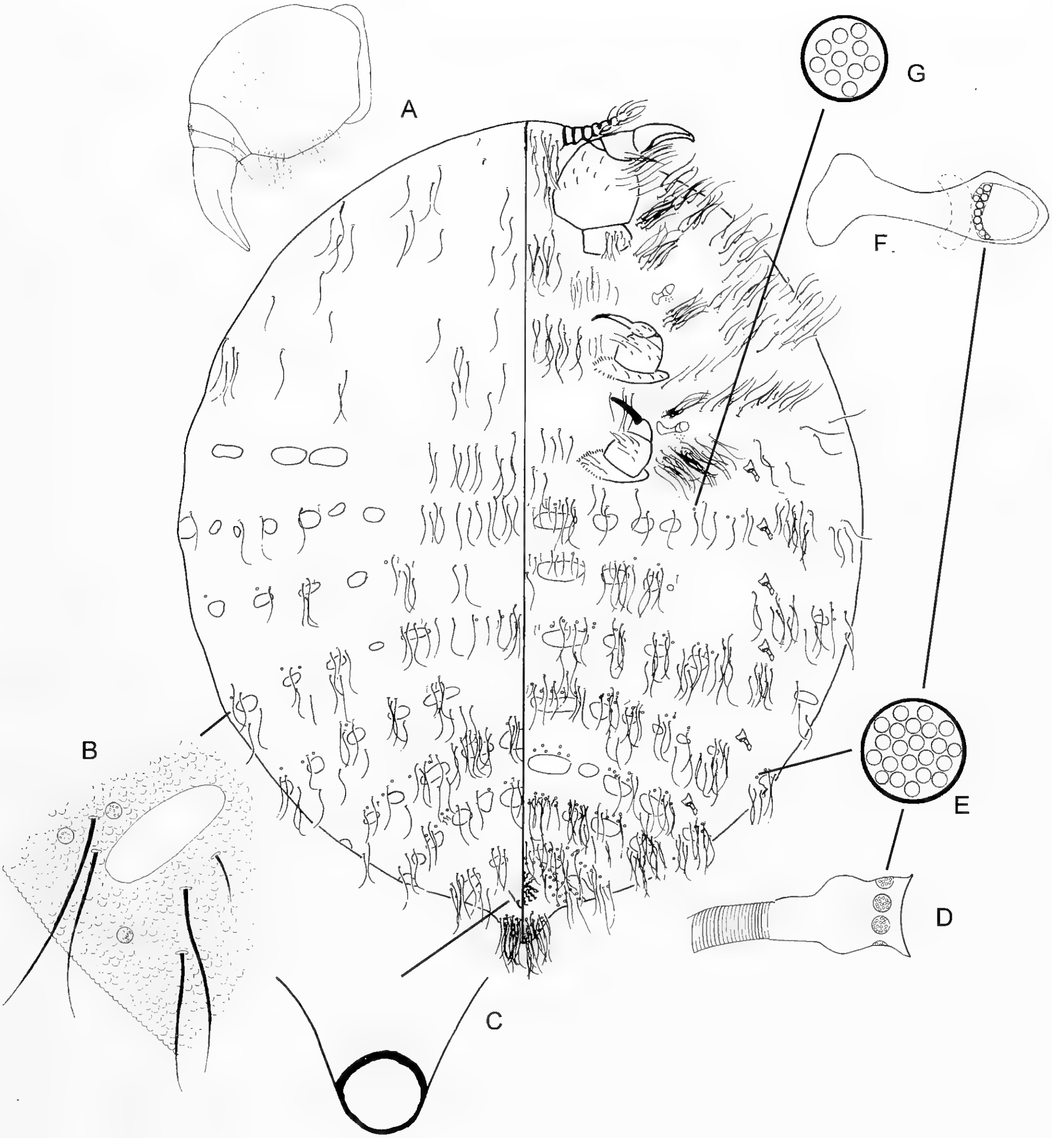


Fig. 3. Adult female of *Heteromargarodes hiemalis*. A, Dorsal surface of prothoracic leg. B, Derm enlargement. C, Anal opening. D, Abdominal spiracle. E, Multilocular pore found in spiracles and on posterior abdomen. F, Thoracic spiracle. G, Multilocular pore found on anterior abdomen.

Washoe County, Red Rock Canyon, 26.ix.1964, in crop of chukar *Alectoris graeca* (L. Bouy and D. Savage) (CSCA). The above material is part of La Rivers' original collection because the collection data precisely match those given in the original description, except that the name of one of the collectors, Laun Buoy, apparently is misspelled as "Bouy" on the slide labels. These five specimens were prepared as microscope slides by R. F. Wilkey, who worked at the CDFA at that time (R. J. Gill, personal communication). No other original specimens of this species could be found at the collection of the Nevada Department of Agriculture, where La Rivers material might have been deposited. The entomologist responsible for that collection was uncertain of the depository of La Rivers' specimens of *M. chukar* and suggested that they may have been lost after his death (J. B. Knight, in litt.). We here treat the five slides held at the CSCA as paratypes because the original description clearly says that there was "a type and a large number of paratypes (all females)" (La Rivers 1967: 6) and the measurements given in the original description are for the "type" only. Even though La Rivers probably did not see Wilkey's slide-mounted females, he presumably sent the specimens to Wilkey from his type series. The holotype appears to be lost.

Other material examined.—U.S.A.: 7 ♀, Nevada, Washoe County, Leadville, 25.ix.1963, being carried to the nest by *Pogonomyrmex salinus* (R. C. Bechtel) (CSCA). MEXICO: Baja California, 5 mi [8 km] N of Guerrero Negro, 14.iv.1991, on the coastal sand dunes below *Senecio* sp. (G. R. Ballmer) (CSCA).

Discussion.—The original specimens of *M. chukar* were discovered in eastern Nevada in the crop of the partridge *Alectoris chukar* (originally called *Alectoris graeca* by La Rivers), commonly called the chukar. The main diet of the chukar in the fall is cheatgrass (*Bromus tectorum*) (Walter and Reese 2003), but no ground pearls were found on that plant, although it was prominent in the location where the chukars were found. (La Rivers 1967: 4) described the body of the adult female as: "color white; body oval, moderately beset with long white hairs of setae; segmentation evident on all sides; length of preserved type 9 mm., width 7 mm." He said that the specimens were alive when taken from the crops of the chukars, and thus the color given in his description may be that of living adult females. However, he may have been describing the color of preserved females, since his description was published nearly three years after the collection of the specimens. Cockerell (1899) described the adult female of the *M. hiemalis* as bright lemon yellow (see above under that species). LaRivers (1967) pointed out in his description of *M. chukar*, that when using McDaniel's (1966) key, *M. chukar* will key to *M. hiemalis*, but the difference between the two species is that *M. chukar* lacks an abdominal boss.

Eumargarodes laingi Jakubski

Eumargarodes laingi Jakubski 1950: 397; Jakubski 1965: 49.

Margarodes dactyloides McDaniel 1966: 237. **New synonym.**

The holotype of *Margarodes dactyloides* McDaniel is a slide-mounted adult female that has a damaged posterior abdomen and the slide-mount is poor. The paratypes (immature specimens) that McDaniel (1966) mentioned in his original description could not be located in any of the institutions that are known to house McDaniel's material (see below). Examination of the holotype reveals that *M. dactyloides* is identical to Jakubski's concept of *Eumargarodes laingi*. It has the following diagnostic characteristics of *E. laingi*: three pairs of abdominal spiracles, multilocular pores with 6–8 loculi arranged in a circle, and derm with sparse hairlike setae that taper to a point. In the original description, McDaniel (1966) described the abdomen of the holotype of *M. dactyloides* as having a "conspicuous stout boss broadly curved at the apex and devoid of any hair-like setae and multilocular pores." This structure appears to be the everted vulvar area. Based upon examination of the type material of *M. dactyloides* and material from the type locality of *E. laingi*, we synonymize *M. dactyloides* with *E. laingi*.

Type material.—Holotype ♀ of *Eumargarodes laingi*. AUSTRALIA: Queensland, Bundaberg, Nov. 1938, on sugarcane roots, R. W. Mungomery (BMNH). This slide was not examined for the present work, but we examined 2 adult female specimens of *E. laingi* that were slide-mounted by P. J. Gullan and compared with the holotype of *E. laingi* by P. J. Gullan in 1983. These slides have the following data: AUSTRALIA: 2 ♀, Queensland, Bundaberg, Qunaba area, Burnett Heads Road, Jorgansen Bros, 15.viii.1972, ex sugar cane - second ratoon crop (R. M. Bull) (ANIC).

Holotype ♀ of *Margarodes dactyloides*. U.S.A.: Texas, Scotland, North on Highway 281, on *Buchloe dactyloides*, 21.vi.1965 (S. McDaniel and B. McDaniel) (USNM). McDaniel stated in the original description that the holotype was deposited in the USNM collection and paratypes were kept in McDaniel's personal collection. The USNM had no record of the slide in their collection, and McDaniel's personal collection was deposited at the museum at Texas A&M in College Station, Texas, whereas remnants of a teaching collection were left at South Dakota State University (SDSU) in Brookings, South Dakota. The holotype slide appeared to be lost because it could not be located initially when we contacted the latter institutions, but was discovered in an old slide store box at the Insect Research Collection at SDSU by Dr. Paul Johnson, and now has been deposited in the USNM. Unfortunately, the paratypes from McDaniel's personal collection have not been found.

ACKNOWLEDGMENTS

Douglass Miller and Debra Creel (Systematic Entomology Laboratory, ARS, USDA, Beltsville, Maryland) kindly arranged the loan of specimens from the Coccoidea collection of the USNM; Ray Gill (CDFA, Sacramento) collected a number of the specimens and kindly loaned us many ground pearl slides; Paul Johnson (Insect Research Collection, South Dakota State University, Brookings) located the missing holotype of *Margarodes dactyloides* and sent it to us on loan; Imre Foldi (Muséum National d'Histoire Naturelle, Paris, France) generously provided information on ground pearls and gave us access to some of his loan material; Chris Hodgson, Takumasa Kondo, Douglass Miller and one anonymous reviewer made valuable comments on a draft of the manuscript. This research was supported in part by a NSF Graduate Research Fellowship to Corinne Unruh, and by Hatch funding from the California Agricultural Experiment Station and by grant DEB-0118718 from the U.S. National Science Foundation (Partnerships for Enhancing Expertise in Taxonomy program) to Penny Gullan.

LITERATURE CITED

Allsopp, P. G. and N. G. McGill. 1997. Variation in resistance to *Eumargarodes laingi* (Hemiptera: Margarodidae) in Australian sugar cane. Journal of Economic Entomology 90: 1702–1709.

Baker, J. R. 1982. Insects and Other Pests Associated with Turf: Some Important, Common, and Potential Pests in the Southeastern United States. North Carolina Agricultural Extension Service, AG-268. 108 pp.

Barnes, M. M., C. R. Ash, and A. S. Deal. 1954. Ground pearls on grape roots. California Agriculture 8: 5, 10.

Ben-Dov, Y. 2005. A Systematic Catalogue of the Scale Insect Family Margarodidae (Hemiptera: Coccoidea) of the World. Intercept Limited, Wimborne. 400 pp.

Brandenberg, R. L. 1995. Ground pearls, pp. 62–63. *In* Brandenberg, R. L. and M. G. Villani, eds. Handbook of Turfgrass Insect Pests. Entomological Society of America, Lanham, MD.

Cockerell, T. D. A. 1899. On the habits and structure of the coccid genus *Margarodes*. The American Naturalist 33: 415–417.

De Klerk, C. A. 1982. Two new species of *Margarodes* Guilding (Homoptera: Coccoidea: Margarodidae) from South Africa. Phytophylactica 15: 85–93.

De Klerk, C. A., Y. Ben-Dov, and J. H. Giliomee. 1982. Redescriptions of four vine infesting species of *Margarodes* Guilding (Homoptera: Coccoidea: Margarodidae) from South Africa. Phytophylactica 14: 61–76.

———. 1983. General morphology of South African species of *Margarodes* Guilding (Homoptera: Coccoidea: Margarodidae) with keys to nymphs and adult females. Phytophylactica 15: 133–144.

Dominiak, B. C., P. G. Allsopp, and K. D. Corrie. 1989. The pink ground pearl *Eumargarodes laingi* Jakubski: past, present and future. Proceedings of the Australian Society of Sugar Cane Technology 11: 110–115.

Ebeling, W. 1959. Subtropical Fruit Pests. University of California Division of Agricultural Sciences Bulletin, Los Angeles. 436 pp.

Ferris, G. F. 1919. Notes on Coccidae — III. (Hemiptera). Canadian Entomologist 51: 108–113.

Foldi, I. 2001. A world list of extant and fossil species of Margarodidae *sensu lato* (Hemiptera, Coccoidea). Nouvelle Revue d'Entomologie (N.S.) 18: 195–231.

———. 2005. Ground pearls: a generic revision of the Margarodidae *sensu stricto* (Hemiptera: Sternorrhyncha: Coccoidea). Annales de la Société Entomologique de France (N.S.) 41: 81–125.

Foldi, I. and S. J. Soria. 1989. Les Cochenilles nuisibles à la vigne en Amérique du Sud (Homoptera, Coccoidea). Annales de la Société Entomologique de France 25: 411–430.

Giard, A. 1894. Troisième note sur le genre *Margarodes*. Comptes Rendus de la Société de Biologie 1: 710–713 (712).

Gill, R. J. 1993. The Scale Insects of California, Part 2, The Minor Families (Homoptera: Coccoidea). California Department of Food & Agriculture, Sacramento. 241 pp.

Gullan, P. J. 1984. A revision of the gall-forming coccoid genus *Apiomorpha* Rübsaamen (Homoptera, Eriococcidae, Apiomorphinae). Australian Journal of Zoology, Supplementary Series 97: 1–203.

Hodgson, C. and I. Foldi. 2006. A review of the Margarodidae *sensu* Morrison (Hemiptera: Coccoidea) and some related taxa based on the morphology of adult males. Zootaxa 1263: 1–250.

Hoffman, E. and R. L. Smith. 1991. Emergence and dispersal of *Margarodes meridionalis* (Homoptera, Coccoidea) in hybrid bermudagrass. Journal of Economic Entomology 84: 1668–1671.

Jakubski, A. W. 1950. The first margarodine (tribe Margarodini) coccid from Australia. Annals and Magazine of Natural History 3: 397–413.

———. 1965. A Critical Revision of the Families Margarodidae and Termitococcidae (Hemiptera: Coccoidea). Trustees of the British Museum (Natural History), London. 187 pp.

Jashenko, R. V. 1989. Two new species of carmine coccids from Kazakhstan (Homoptera, Coccinea, Margarodidae). Bulletin of Moscow Society of Natural Testers, Biology Department 94: 67–71.

———. 1990. A new species of Margarodidae (Coccinea) from Terskey Ala-tau. News of Faunistics and Systematics (Kiev), 36–39.

———. 1994. New species of the genus *Porphyrophora* Brandt (Coccinea, Margarodidae) from Kazakhstan, Turkmenistan and Mongolia. Selevinia 2: 22–38.

Koteja, J. 1980. Campaniform, basiconic, coeloconic, and intersegmental sensilla on the antennae in the Coccinea (Homoptera). Acta Biologica Cracoviensia Series Zoologia 22: 73–88.

———. 2001. Essays on coccids (Hemiptera: Coccinea): double function of margarodid halteres. Annales de la Société Entomologique de France 37: 357–365.

Kouskolekas, C. A. and R. L. Self. 1974. Biology and control of the ground pearl in relation to turfgrass infestations, pp. 421–423. *In* E. C. Roberts ed. Proceedings of the Second International Turfgrass Research Conference. American Society of Agronomy, Inc. and the Crop Science Society of America, Inc., Madison, WI.

Kozarzhevskaya, E. F. 1986. Techniques for preparing slides for coccoid (Homoptera: Coccoidea) determination. Entomological Review 47: 146–149.

La Rivers, I. 1967. II—A new species of *Margarodes* from Nevada. Occasional Papers of the Biological Society of Nevada 14: 4–6.

Lindinger, L. 1954. Neue Beiträge zur Schildlausnomenklatur und Anderes (Homoptera: Coccoidae). Beiträge zur Entomologie 4: 614–620.

McDaniel, B. 1965. North American species of the genus *Margarodes* Guilding, with a description of a new species found in Texas (Coccoidea: Margarodidae). Proceedings of the Entomological Society of Washington 67: 15–23.

———. 1966. A new species of the genus *Margarodes* Guilding from buffalograss in Texas (Coccoidea: Margarodidae). Proceedings of the Entomological Society of Washington 68: 237–240.

Morrison, H. 1927. Descriptions of the genera and species belonging to the coccid family Margarodidae. Proceedings of the Biological Society of Washington 40: 99–110.

———. 1928. A classification of the higher groups and genera of the coccid family Margarodidae. United States Department of Agriculture. Technical Bulletin 52: 1–239.

Samson, P. R. and W. J. Harris. 1998. Seasonal phenology and distribution in soil in sugarcane fields of the pink ground pearl, *Eumargarodes laingi* Jakubski, with notes on *Promargarodes* spp. (Hemiptera : Margarodidae). Australian Journal of Entomology 37: 130–136.

Spink, W. T. and J. R. Dogger. 1961. Chemical control of the ground pearl, *Eumargarodes laingi*. Journal of Economic Entomology 53: 423–424.

Tang, F.-D. 2000. *Neomargarodes* (Coccoidea: Margarodidae) and a new species reported from China. Wuyi Science Journal 16: 1–5.

Tang, F.-D. and J.-J. Hao. 1995. The Margarodidae and Others of China. (Homoptera: Coccinea of Insecta). Chinese Agricultural Science Technology Press, Beijing. 738 pp.

Vahedi, H.-A. 2002. A Revision of the Genus *Porphyrophora* (Hemiptera: Coccoidea: Margarodidae) with Particular Reference to the Middle East and with a Discussion of the Relationships of the Hypogaeic Margarodids. Doctor of Philosophy Thesis, Department of Agricultural Sciences, University of London, Wye, U.K.

Vahedi, H.-A. and C. J. Hodgson. In press. Some species of the hypogeal scale insect *Porphyrophora* Brandt (Hemiptera: Sternorrhyncha: Coccoidea: Margarodidae): Some species from Europe, the Middle East and North Africa. Biodiversity and Systematics.

Walter, H. and K. P. Reese. 2003. Fall diet of chukars (*Alectoris chukar*) in eastern Oregon and discovery of ingested lead pellets. Western North American Naturalist 63: 402–405.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 182–186

NESTING HABITS OF *ECTEMNIUS SCABER* (LEPELETIER AND BRULLÉ) (HYMENOPTERA: CRABRONIDAE)

E. E. GRISSELL

P.O. Box 739, 38 Terry Lane, Sonoita, AZ 85637-0739, U.S.A. (e-mail: egrissell@dtg-llc.com)

Abstract.—*Ectemnius scaber* (Lepeletier and Brullé) was found nesting in a dried flower stalk of parsley (*Petroselinum crispum* Nyman). A single entrance hole was made 30 cm above ground level. Five cells, each provisioned with *Toxomerus marginatus* Say (Diptera: Syrphidae), were constructed above the entrance point. This is the first report of the genus as a host for *Ectemnius*. The biologies of seven species of Nearctic *Ectemnius* and three Holarctic species are reviewed.

Key Words: Hymenoptera, Crabronidae, Syrphidae, *Ectemnius scaber*, *Toxomerus marginatus*

The genus *Ectemnius* Dahlbom comprises 184 species worldwide (Pulawski 2005) of which 27 are Nearctic (Bohart and Kimsey 1979). Species are known to provision their nests with adult flies and nest in decaying and rotten wood, pithy plant stems, or in the ground (Tsuneki 1960, Court 1976, Takumi 1999, Pulawski 2005).

In this paper I present new nest information and prey records for *Ectemnius scaber* (Lepeletier and Brullé) for which no previous documented records have been published. Although Krombein (1979) listed a record as "nests in pine" this record remains unsubstantiated and is almost certainly incorrect based on direct observations presented below. In addition to these observations I present a review of the biology of Nearctic species based on the comprehensive overview of Sphecidae given by Pulawski (2005).

METHODS

Nest material was collected in my garden on 29 August 2004 in Silver Spring, Montgomery County, Maryland. While cutting the vertical, spent flower stalks of parsley (*Petroselinum crispum* Nyman) I noticed a quantity of white, powdery "sawdust" on the leaves of one plant. I found an entrance hole in one stalk. I cut the stem at the base and took it to my lab the following day. After slicing the stem vertically I took a series of digital photos using a Nikon Coolpix 90 camera. The stem halves were taped together and placed in a cardboard rearing container with the lid replaced by a black funnel to which was attached a clear plastic vial. The container was placed in the refrigerator at 40°F (4.5°C) until mid-March 2005 at which point it was removed and placed next to an interior window. Two adult female wasps emerged into the rearing vial on 18 April.

Identification of reared adult wasps was made using Bohart and Kimsey (1979) and comparison with specimens in the collection of the National Museum of Natural History. Voucher specimens of the wasps have been placed in that museum.

RESULTS

Nest structure (Figs. 1–3).—The nest entrance, 3 mm in diameter, was located about midway up the 60 cm drying flower stalk, and about 4.5 cm below a branching point (Fig. 2; stem removed, stub visible). The inner wall of the stem was lined with a thin layer of irregular pith abutting the outer wall. Five cells were found in linear fashion, all built above the nest entrance. The section of stem with cells was about 6–7 mm in diameter with a central hollow core about 4 mm in diameter. The topmost cell was about 16 cm above the entrance (Figs. 1, 3). From top to bottom the cells consisted of three prepupae in cocoons, one larva spinning a cocoon, and one feeding larva (Fig. 3). The two larvae nearest the entrance indicate that the wasp worked from the top down. The venter of the lowest cell (most recent) was about 4.5 cm from the entrance. I could not determine if the nest had been completed, but the space from the most recent cell to the entrance was empty indicating that more cells could have been constructed in the stem.

Each completed cell (Fig. 3) contained (top to bottom) a pith plug (white), a compressed mass of intertwined fly pieces (black), a cocoon (brown) or larva (white), and an empty gap before the next pith plug. No meconia were seen. The measurements for each cell are: pith plug = 10–12 mm; fly mass = 2–3 mm; cocoon 8–10 mm or larva 8–9 mm; gap 5–6 mm. The total cell length varied from 20 to 30 mm. Two cocoons were suspended from the top of the cell but the topmost cocoon was disturbed when the stem was cut and thus is at the bottom of the cell in Fig. 3. Based on the orientation of these bands it appears that the fly prey are placed in the cell after the pith plug is made. Placement of an egg with respect to the prey is unknown for *Ectemnius scaber* because no eggs were found.

Adult emergence.—Adult emergence appears to be from the top of the stem downward and out the entrance hole as there were no other exterior exits and the pith plug above the topmost cell was not breached. The plug beneath had been burrowed through.

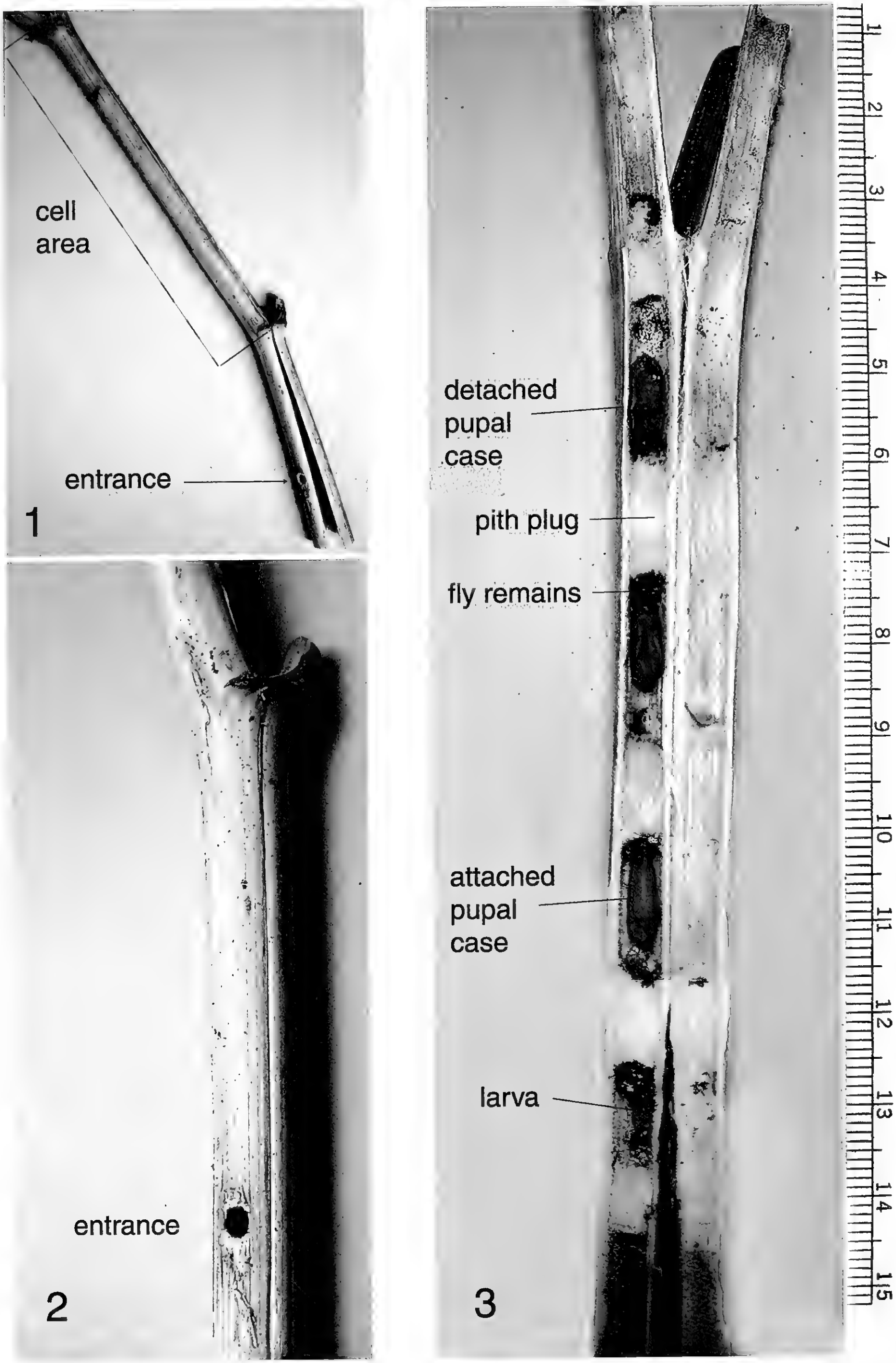
Host.—Prey were identified as *Toxomerus marginatus* Say (Diptera: Syrphidae).

DISCUSSION

The above description disagrees with that of Krombein (1964) for *Ectemnius paucimaculatus* in that the cell construction and lay out (his figs. 7a, 7b) appear to be the exact reverse of *E. scaber*. I am confident about the orientation of the stem in my Figs. 1–3, and those of Krombein appear to be correct as well, so perhaps the differences are distinctive of the species.

Krombein (1964) noted that for *E. paucimaculatus* the wasp egg was laid on the first provisioned fly, whereas Hook (1982) found that for *E. centralis* the egg was laid on the last provisioned fly but that the prey were then rearranged with that fly placed farthest into the cell. With *E. scaber* the fly remains are compressed against the top of the cell which might indicate that it feeds upon the flies from below pushing their remains upward as it feeds and creating a gap between itself and the bottom pith plug. This seems rather odd but fits the cell construction pattern.

Among Nearctic species, only two have been reported using syrphids as prey. *Ectemnius spiniferus* Fox, which normally provisions with acrocerid flies, was found to have a single syrphid prey in one cell (Bechtel and Schlinger 1957), and *E. maculosus* (Gmelin) had prey listed as "syrphids" with no additional data (Krombein 1963b). Three Palearctic species are known to use syrphids as prey: *E. cavifrons* (Thomson), *E. confinis* (Walker), and *E. sexcinctus* (Fabricius),



Figs. 1–3. Parsley stem nest of *Ectemnius scaber*. 1, Stem above entrance hole, area of cell construction indicated by dashed line. 2, Entrance hole. 3, Cross section of stem, rule in mm.

as is the Holarctic species *E. lapidarius* (Panzer) (summarized by Pulawski 2005).

Because there is little available literature pertaining to the biology of Nearctic *Ectemnius*, I present a summary of what is known, drawn from the world catalog of Pulawski (2005).

Ectemnius atriceps (Cresson): Evans (1957: figs. 91–94) described and illustrated the larva collected in a *Sambucus* stem. Krombein (1963b, as *Ectemnius brunneipes* (Packard)) reported this species nesting in logs.

Ectemnius centralis Cameron: Hook (1982) reported this species nesting in a broken, dead limb of live oak (*Quercus* sp.), which he characterized as decaying. Each wasp created side burrows branching off a central nest burrow. These side burrows contained 1 or 2 cells arranged linearly. Prey consisted of flies in the families Stratiomyiidae, Bombliidae, Sarcophagidae, Muscidae, and Tachinidae.

Ectemnius excavatus (Fox): Krombein (1963b) reported this species nesting in rotten logs.

Ectemnius maculosus (Gmelin): Krombein (1963b, as *Ectemnius singularis* (F. Smith)) reported this species provisioning with unidentified Syrphidae.

Ectemnius paucimaculatus (Packard): Krombein (1964) wrote and illustrated an extensive paper on this species, which is the best known of all Nearctic taxa. It makes linear cells in stems of hibiscus (*Hibiscus militaris* Cavanilles). The number of cells varied from 1 to 13 below the entrance and from 1 to 8 above the entrance. Ninety-nine percent of the prey consisted equally of Agromyzidae (*Melanagromyza diantherae* (Malloch)) and several species of Ephydridae (*Notiphila carinata* Loew; *Hydrellia* spp.). Additional families each represented by a few specimens included Dolicopodidae, Ottitidae, Lauxaniidae, Lonchaeidae, Sciomyzidae, Sphaeroceridae, and Muscidae. Evans (1964: fig. 113) described and illustrated the larva of this species based on material from Krombein's study.

Ectemnius stirpicola (Packard): Evans (1957: figs. 85–89) described and illustrated the larva. Later he added a few additional notes to his description (Evans 1959). Krombein (1963b) listed this species (as "*stirpicda*," a lapsus) nesting in twigs and preying on small acalyptrate muscoid flies.

Ectemnius spiniferus Fox: Bechtel and Schlinger (1957) reported this species nesting in dead or dying twigs of elderberry (*Sambucus coerulea* Rafinesque). Each wasp created a single, linear burrow with up to 6 cells. Prey consisted mostly of Acroceridae (*Ogcodes eugonatus* Loewe) but there were also a few Anthomyiidae (*Hylemya* sp.), and a single Syrphidae (*Sphaerophoria* sp.). A large number of Phoridae (*Megaselia* sp.) were present, but these appeared to be scavengers and not prey.

The following species are Holarctic taxa for which there is minimal data in the Nearctic:

Ectemnius continuus (Fabricius): Krombein (1963a) reported this species nesting in a rotten pear limb. There were seven or eight cells which presumably were arranged in a linear burrow. Prey consisted of Diptera in the families Calliphoridae, Tachinidae, Sarcophagidae, and Muscidae, each being represented by few individuals. The larva was described and illustrated by Evans (1964: fig. 114) based on material from Krombein. The species also was reported nesting in logs by Krombein (1963b).

Ectemnius dives (Lepeletier and Brullé): Krombein (1963b) listed this species nesting in logs, timber, and stems. It provisioned with muscoid flies.

Ectemnius lapidarius (Panzer): Krombein (1963b) reported this species nesting in rotten wood and provisioning with unidentified Syrphidae and Anthomyiidae.

ACKNOWLEDGMENTS

I thank Chris Thompson, Systematic Entomology Laboratory, for the identification of host syrphids. I thank Wojciech Pulawski, California Academy of Sciences, San Francisco, for reading the manuscript and correcting many factual and nomenclatural errors. The input of an unidentified reviewer was also helpful, and I accepted most, if not all, of his or her voluminous suggestions with appreciation.

LITERATURE CITED

Bechtel, R. C. and E. I. Schlinger. 1957. Biological observations on *Ectemnius* with particular reference to their *Ogcodes* prey (Hymenoptera: Sphecidae. –Diptera: Acroceridae). Entomological News 68: 225–232.

Bohart, R. M. and L. S. Kimsey. 1979. A key to the species of *Ectemnius* in America north of Mexico with notes and description of a new species (Hymenoptera: Sphecidae). Proceedings of the Entomological Society of Washington 81: 486–498.

Court, H. 1976. Subfamily Crabroninae. pp. 357–431. *In* Bohart, R. M. and A. S. Menke, eds. Sphecid Wasps of the World, a Generic Revision. University of California Press, Berkeley.

Evans, H. E. 1957. Studies on the larvae of digger wasps (Hymenoptera, Sphecidae) part III: Philanthinae, Trypoxyloninae, and Crabroninae. Transactions of the American Entomological Society 83: 79–117.

———. 1959. Studies on the larvae of digger wasps (Hymenoptera, Sphecidae) part IV: Conclusion. Transactions of the American Entomological Society 85: 137–191.

———. 1964. Further studies on the larvae of digger wasps (Hymenoptera: Sphecidae). Transactions of the American Entomological Society 90: 235–299.

Hook, A. 1982. Notes on nesting behavior of *Ectemnius centralis* (Cameron) (Hymenoptera: Sphecidae). Entomological News 93: 75–76.

Krombein, K. V. 1963a. Miscellaneous prey records of solitary wasps. V. (Hymenoptera: Aculeata). Bulletin of the Brooklyn Entomological Society 58: 118–120.

———. 1963b. Natural history of Plummers Island, Maryland. XVII. Annotated list of the wasps (Hymenoptera: Bethyloidea, Scolioidea, Vespoidea, Pompiloidea, Sphecoidea). Proceedings of the Biological Society of Washington 76: 255–280.

———. 1964. Natural history of Plummers Island, Maryland. XVIII. The hibiscus wasp, an abundant rarity, and its associates (Hymenoptera: Sphecidae). Proceedings of the Biological Society of Washington 77: 73–112.

———. 1979. Superfamily Sphecoidea, pp. 1573–1740. *In* Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. Catalog of Hymenoptera in America north of Mexico, Vol. 2, Apocrita (Aculeata). Smithsonian Institution Press, Washington, D.C.

Pulawski, W. J. 2005. Catalog of Sphecidae sensu lato (= Apoidea excluding Apidae). California Academy of Sciences, Golden Gate Park, San Francisco, http://www.calacademy.org/research/entomology/Entomology_Resources/Hymenoptera/sphecidae/Genera_and_species_PDF/introduction.htm [accessed August 2005].

Takumi, R. L. 1999. A systematic review of the *Ectemnius* (Hymenoptera: Sphecidae) of Hawaii. University of California Publications in Entomology 118: i–viii, 1–55, 24 figs.

Tsuneki, K. 1960. Biology of the Japanese Crabroninae (Hymenoptera, Sphecidae). Memoirs of the Faculty of Liberal Arts, Fukui University Series II, Natural Science, No. 10(1): 1–53.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 187–197

NATURAL ENEMIES OF THE CRYPTIC AND SYMPATRIC SPECIES, *TRUPANEA NIGRICORNIS* (COQUILLETT), A POLYPHAGE, AND THE NARROWLY OLIGOPHAGOUS *T. BISETOSA* (COQUILLETT) (DIPTERA: TEPHRITIDAE)

KHOUZAMA M. KNIO, RICHARD D. GOEDEN, AND DAVID H. HEADRICK

(KMK) Biology Department, American University of Beirut, P.O. Box 11-0236, Riad El Solh, Beirut, Lebanon (e-mail: kknio@aub.edu.lb); (RDG) Department of Entomology, University of California Riverside, CA 92521, U.S.A.; (DHH) Horticulture and Crop Science Department, California Polytechnic State University, San Luis Obispo, CA 93407, U.S.A.

Abstract.—The flower head-infesting tephritids *Trupanea nigricornis* (Coquillett) and *T. bisetosa* (Coquillett) occur in sympatry in southern California. They are closely related cryptic species and difficult to differentiate morphologically. However, *T. nigricornis* behaves as a generalist infesting at least eight tribes of the Asteraceae while *T. bisetosa* is mainly a specialist on wild sunflowers. This study investigates the types of natural enemies that attack *T. nigricornis* and *T. bisetosa* and whether the difference in diversity and densities of parasitoids attacking the two cryptic species help to explain their different modes of herbivory. Results showed that percentage parasitism was much higher in samples infested with *T. nigricornis* (21.5–58.2%) than *T. bisetosa* (4.5–16.1%). The generalist species was also attacked by more species of parasitoids than the specialist species (5 vs. 1). Moreover, there were fewer samples yielding *T. nigricornis* that were free of parasitoids than samples yielding *T. bisetosa* free of parasitoids. Therefore, by overcoming the tough biophysical features of wild sunflowers such as resins and hard bracts, host specialization by *T. bisetosa* may provide escape from natural enemies.

Key Words: Natural enemies, Tephritidae, *Trupanea*, parasitoids, sympatry, cryptic species, enemy-free space, polyphagy, oligophagy

The flower head-infesting tephritids *Trupanea nigricornis* (Coquillett) and *T. bisetosa* (Coquillett) are closely related species that occur in sympatry in southern California (Foote et al. 1993). They are considered cryptic species as all immature stages are highly similar and difficult to separate (Knio et al. 1996a), and the adults show great morphological similarities (Cavender and Goeden 1983). However, the two species can be differentiated behaviorally and ecologically. *Trupanea nigricornis* is a generalist, attacking the flower heads of at least 71 species of Asteraceae belonging to 8 tribes and 33 genera. On the other hand, *T. bisetosa* is an oligophagous species so far known to attack only 6 species of Asteraceae belonging to only one tribe, the Heliantheae (Goeden 1985, 1992). Subtle differences were detected in the courtship and mating behaviors of the two species, but the main behavioral distinction was in the oviposition behavior of the females. *Trupanea nigricornis* females pierced the plant's host tissues during oviposition in a way that the posterior ends of the eggs were always inserted in the immature achene or corolla's tissues while *T. bisetosa* females deposited their eggs loosely among the corolla tubes without injuring the host tissues. The oviposition behavior of *T. bisetosa* females was critical to their survival and is an adaptation to their most common host, wild sunflowers, *Helianthus annuus* L., that exude sticky resins when injured, fatally entrapping females that accidentally puncture plant tissues during oviposition (Knio et al. 1996b).

Resource utilization studies showed that the larvae of *T. nigricornis* and *T. bisetosa* exploited the flower heads of their hosts in a similar way and the percentage of damaged achenes per larva was similar in both species, taking into account the flower head size (Knio et al. 2001). However, the fecundity of *T. nigricornis* was higher and the percentage of flower heads infested by *T. nigricornis* in the field was higher than the percentage of flower heads infested by *T. bisetosa*. Moreover, the number of collected samples of *T. nigricornis* hosts that did not yield any *T. nigricornis* was much lower than the number of *T. bisetosa* hosts not yielding any *T. bisetosa* (Knio et al. 2001).

One factor that molds the community structure of phytophagous insects is interspecific competition. In many cases, interspecific competition is low because the population densities of phytophagous insects are kept at low levels as a result of predation and parasitism (Strong et al. 1984). In previous studies by Knio et al. (2001), it was shown that *Trupanea nigricornis* and *T. bisetosa* follow several evasion strategies that reduce interspecific competition. However, the impact of natural enemies on population densities of both species was not evaluated. This study focuses on the diversity and density of parasitoids attacking *T. nigricornis* and *T. bisetosa* natural populations. It is one of a series of comparative studies intended to shed light on the nature of polyphagy/oligophagy in the closely related, sympatric, cryptic species, *T. nigricornis* and *T. bisetosa*.

Materials and Methods

Parasitism of the immature stages of *T. nigricornis* and *T. bisetosa* was studied by examining field-collected flower heads of Asteraceae in the laboratory. Flower head samples of the host plants of *T. nigricornis* and *T. bisetosa* were collected during four years from 42 interior valley and desert sites in southern California. The host plants of *T. nigricornis* included *Encelia farinosa* Gray, *E. fructescens* Gray, *E. virginensis* A. Nelson, *Haplopappus acradenius* (Greene) Hall, *H. venetus* (Humboldt) Blake, and *Viguiera deltoidea* Gray. Sampled host plants of *T. bisetosa* were *Helianthus annuus* L., *H. niveus* (Bentham) Brandegee, and *Geraea canescens* A. Gray.

Every sample consisted of mature flower heads (100–1,500) picked at random from different plants at each site, stored in a plastic bag, and transported in an ice chest to the laboratory. All samples were stored under refrigeration until processed.

For every sample, flower heads were counted, then dissected and examined in the laboratory under a stereomicroscope until obtaining a subsample of 25 infested flower heads. The following data were recorded: number, size (length and diameter) and stage of *T. nigricornis*/ *T. bisetosa* larvae and puparia; state of the larvae (healthy, feeding, discolored, sluggish, parasitized, dead); presence of external parasites feeding on the larvae; number and stages of other insect species.

Third instars and puparia removed from the dissected flower heads were placed individually in small glass vials plugged with cotton to capture the emerging insect (adult fly or parasite) and determine the number of days from caging to emergence. These vials were held in a humidity chamber (76%) in the laboratory and checked daily for emergence.

The remaining flower heads in every sample were placed in glass-topped, sleeve, cages (34×32×35 cm) in the insectary at the University of California, Riverside at 60% RH and 12/12 (LD) photoperiod from 0500–1700 h. The numbers and identities of the insects and parasitoids that emerged were recorded.

Percentage parasitism in samples was estimated by dividing the number of parasitoids emerged by the total number of dipterous insects and parasitoids obtained from that sample, including reared dipterous insects from the dissected subsample. Only species confirmed as parasitoids of *T. nigricornis* and *T. bisetosa* from individually reared host larvae or puparia were included in the calculation of percentage parasitism; however, we assumed that these parasitoids did not distinguish among dipterous larvae as some of the species were reared from other dipterous insects, e.g., Agromyzidae associated with *T. nigricornis* and *T. bisetosa* flower heads. Percentage parasitism was only calculated from samples that yielded tephritids and parasitoids; the samples that yielded tephritids, but no parasitoids, were listed separately.

The parasitoids were identified by J. LaSalle. Voucher specimens of *T. nigricornis*, *T. bisetosa* and their parasitoids are housed in the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM).

RESULTS AND DISCUSSION

The data obtained from dissecting samples of flower heads collected over a four year period showed that the immature stages of *T. nigricornis* suffered mortality due to parasitism by several species of Pteromalidae and other chalcidoid Hymenoptera, while those of *T. bisetosa* suffered mortality due to parasitism by only one species of Pteromalidae (Table 1). Rearing records of individual larvae and puparia confirmed the following five species as parasitoids of *T. nigricornis*: *Halticoptera* sp. (Pteromalidae), *Pteromalus* sp. 1 (Pteromalidae), *Colotrechnus ignothus* Burks (Pteromalidae), *Eurytoma* sp. (Eurytomidae), and an unidentified perilampid (Perilampidae). Rearing of individual puparia of *T. bisetosa* confirmed *Pteromalus* sp. 2 (Pteromalidae) as the sole parasitoid of *T. bisetosa* (Table 1). The *Pteromalus* specimens from *T. nigricornis* and *T. bisetosa* were determined only to genus; although they are superficially similar, further work should be conducted to determine if they are different species or not. We have labeled them 1 and 2 to clarify associations only.

The two pteromalids, *Halticoptera* sp. (subfamily Miscogasterinae) and *Pteromalus* sp.1 (subfamily Pteromalinae) were identified as primary, solitary, internal larval-pupal parasitoids of *T. nigricornis*. Neither parasitoid species altered the shape of the larva or puparium during feeding. Parasitized *T. nigricornis* larvae continued to feed and grow. Adult parasitoids later emerged from their host puparia. The presence of the parasitoid was not suspected until its emergence. The size of the puparia from which either *Halticoptera* sp. or *Pteromalus* sp. emerged fell within the normal size range (1–1.25 mm in diameter, and 2.5–3 mm in length) of *T. nigricornis* puparia as reported by Knio et al. (2001). The behavior of the parasitized larvae also was not altered. Parasitized third instar larvae (n = 5) removed from dissected flower heads and individually reared pupated like healthy larvae of *T. nigricornis*. The length of time from

Table 1. Rearing records of the parasitoids isolated from individual puparia of *Trupanea nigricornis* and *T. bisetosa* dissected from flower heads of different hosts.

Host Plant	N[a]	Parasitoid Species	Number Reared Females: Males		Number of Days to Emergence[b]
T. nigricornis hosts:					
E. farinosa	12	*Halticoptera* sp.	13	11	4–25
	3	*Pteromalus* sp. 1	6	1	14
	1	Perilampid	1	—	56
E. fructescens	8	*Halticoptera* sp.	8	1	7–25
	4	*Pteromalus* sp. 1	5	3	6–20
	1	*Eurytoma* sp.	1	—	106
	1	Perilampid	1	1	81–111
E. virginensis	3	*Halticoptera* sp.	3	1	9–10
	3	*Pteromalus* sp. 1	4	1	7–10
	4	*Colotrechnus ignothus*	4	4	12–13
	1	*Eurytoma* sp.	1	1	—
H. acradenius	1	*Pteromalus* sp. 1	1	1	10
	1	*Eurytoma* sp.	—	1	24
T. bisetosa hosts:					
H. annuus	3	*Pteromalus* sp. 2	4	4	10–12

[a] Number of sites where flower head samples were collected and that yielded the specific parasitoid species.

[b] Number of days from the time third instar larvae or puparia were dissected out of the flower heads and individually caged until the emergence of the parasitoids.

caging to emergence of the parasitoids was similar to that observed for *T. nigricornis* adults: ca. 13 days (12.83 ± 2.02 (SE); range: 4–25; n = 12) for *Halticoptera* sp. and ca. 12 days (11.88 ± 1.7; range: 6–20; n = 8) for *Pteromalus* sp. (Table 1).

Both of these parasitoids were also recovered from other insects associated with *T. nigricornis* host plants. *Halticoptera* sp. was reared from individual puparia of *Melanagromyza viridis* (Frost) (Agromyzidae), but not from *Neotephritis finalis* Loew (Tephritidae), a common insect infesting *Encelia* species. *Pteromalus* sp. was reared from individual puparia of both *M. viridis* and *N. finalis*. Goeden et al. (1987) also identified *Pteromalus* sp. as a larval-pupal parasitoid of *N. finalis*.

Halticoptera and *Pteromalus* spp. seem to be common parasitoids of flower head-infesting tephritids. *Pteromalus purpureiventrus* (Ashmead) was reported as a primary, solitary larval-pupal parasitoid of *T. conjuncta* (Adams) (Goeden 1987) and *T. imperfecta* (Coquillett) (Goeden 1988). *Pteromalus coloradensis* (Ashmead) was identified as a larval-pupal parasitoid of *Paracantha gentilis* Hering, and it was the only parasitoid recovered from this tephritid (Headrick and Goeden 1989). Unidentified *Pteromalus* spp. were reared as primary, solitary parasitoids of *Tomoplagia cressoni* Aczél (Goeden and Headrick 1991a), *Procecidochares lisae* Goeden (Silverman and Goeden 1980; as *Procecidochares* sp.), and *Paracantha cultaris* (Coquillett) (Cavender and Goeden 1984). *Halticoptera stella* Girault was reared from galls of *Procecidochares lisae* (Silverman and Goeden 1980). Both *Halticoptera* sp. and *Pteromalus* sp. were reported as parasitoids of *Tephritis baccharis* (Coquillett) (Goeden and Headrick 1991b). However, unlike the larval-pupal *Halticoptera* sp. parasitizing *T. nigricornis*, the *Halticoptera* sp. parasitizing *T. baccharis* was an external larval parasitoid (Goeden and Headrick 1991b).

Pteromalus sp. 2 was also the only parasitoid reared from individual puparia of *T. bisetosa*. As with *T. nigricornis*, *Pteromalus* sp. 2 was identified as a solitary, primary, larval-pupal parasitoid of *T. bisetosa*. The number of days from caging to emergence was 10–12 days (11 ± 1; n = 2) (Table 1). Similarly, Cavender and Goeden (1982) recovered *Pteromalus* sp. (as *Habrocytus* sp.) from *T. bisetosa* puparia, and also reared *Bracon nuperus* Cresson from *T. bisetosa* larvae. In this study, three external hymenopterous parasitoid larvae were observed to feed on *T. bisetosa* larvae, but were not successfully reared to adulthood.

A third pteromalid parasitoid of *T. nigricornis* was *Colotrechnus ignothus*, which was identified as an external larval parasitoid. *Colotrechnus ignothus* larvae were observed to feed externally on second and third instars of *T. nigricornis*, which became yellowish, sluggish, and eventually died. The contents of the larvae were liquefied. The hymenopterous larvae were white with shades of gray and pink on their dorsa. Late instars of the parasitoid (0.4–0.8 mm wide; 0.9–2 mm long) were observed to change their diets. They fed and bored into a small portion of an achene, then pupated in the cavity so produced. They took 12–13 days (n = 3) to emerge from their pupae (Table 1). Similarly, *Colotrechnus ignotus* was reported as a larval parasite of *T. actinobola* (Loew) (Stegmaier 1968). It was also reared from a *Tomoplagia cressoni* puparium (Goeden and Headrick 1991a).

The remaining parasitoid species recovered from *T. nigricornis* puparia were *Eurytoma* sp. and an unidentified perilampid. These were primary, solitary, larval-pupal endoparasitoids. They did not change the shape or behavior of the parasitized larvae, but they altered the size of the parasitized puparia, which became larger than unparasitized *T. nigricornis* puparia: 1.4–1.5 mm in width and 3–3.3 mm in length for parasitized puparia (n = 7) vs. 1–1.25 mm in width and 2.5–3 mm in length for healthy puparia (n = 100). Also, both of these parasitoid species had a longer development period than other parasitoid spp.: 24–106 days for *Eurytoma* sp. and 56–111 days for the perilampid (Table 1).

Eurytoma species have been reported as parasitoids of other flower head-infesting tephritids. *Eurytoma vernonia* Bugbee was identified as a solitary, primary, larval-pupal endoparasitoid of *Neotephritis finalis* (Goeden et al. 1987), *Trupanea conjuncta* (Goeden 1987), *T. imperfecta* (Goeden 1988), and *Tomoplagia cressoni* (Goeden and Headrick 1991a). *Eurytoma* sp. was reared as parasitoids of *T. imperfecta* (Goeden 1988) and *Procecidochares lisae* (Silverman and Goeden 1980).

Percentage parasitism was much greater in samples infested with *T. nigricornis* than in samples infested with *T. bisetosa* (Table 2). Parasitism of *T. bisetosa* was 9.6% (range: 4.5–16.1) in *Helianthus annuus*, and only involved *Pteromalus* sp. On the other hand, parasitism was much higher, ranging from 21.5% to 58.2%, in host plants of *T. nigricornis*, and was caused by up to five species of parasitoids (Table 2). In the most common and widespread host of *T. nigricornis*, *Encelia farinosa*, total percentage parasitism was 30.4% (6.7–72.9%) and was caused by the five species identified above as *T. nigricornis* parasitoids, with *Halticoptera* sp. being the most abundant parasitoid species in those samples, followed closely by *Pteromalus* sp. (Table 3). In *E. fructescens*, total parasitism was 37.7% (13.8–51.5%) and involved the same five species of parasitoids with *Halticoptera* sp. and *Pteromalus* sp. again as the most numerous parasitoids (Table 3). Total percentage parasitism in *E. virginensis* was 37.9% (15.4–54.4%). It was caused by four species of parasi-

Table 2. Mean percentage total parasitism and comparison of parasitoids reared from flower heads samples from different host plants of *Trupanea nigricornis* and *T. bisetosa*.

Plant Species	Parasitism[a] (%) Mean ± SE (range)	N[b]	Reared Parasitoids[c]
T. nigricornis hosts:			
Encelia farinosa	30.4 ± 3.5 (6.7–72.9)	29	H, P, C, E, Pr
E. fructescens	37.7 ± 4.0 (13.8–51.5)	10	H, P, C, Pr, E
E. virginensis	37.9 ± 4.4 (15.4–54.4)	8	C, H, P, E
Viguiera deltoidea	21.5 ± 1.5 (20–23.1)	2	H, P
Haploppapus venetus	54.5 ± 3.6 (50.9–58.1)	2	P, E
H. acradenius	58.2 ± 9.3 (47.1–76.8)	3	E, P, H
T. bisetosa hosts:			
Helianthus annuus	9.6 ± 0.6 (4.5–16.1)	18	P

[a] Parasitism was calculated by dividing the number of parasitoids confirmed as *T. nigricornis* or *T. bisetosa* parasitoids by the total number of dipterous insects and parasitoids that emerged from a host sample.

[b] Number of flower head samples.

[c] C = *Colotrechus ignothus*; E = *Eurytoma* sp.; H = *Halticoptera* sp.; P = *Pteromalus* sp.; Pr = perilampid. The parasitoids are listed in decreasing order of abundance.

toids, *C. ignothus*, being the most numerous, followed by *Halticoptera* sp., *Pteromalus* sp., and *Eurytoma* sp. (Table 3). Total parasitism in *Viguiera deltoidea* samples was 21.5% (20–23.1%) and only involved *Halticoptera* sp. and *Pteromalus* sp. (Table 3). In *Haplopappus venetus*, parasitism totaled 54.5% (50.9–58.1%) and was caused by *Pteromalus* sp. and *Eurytoma* sp. (Tables 2, 3). In *H. acradenius* samples, total parasitism was the highest at 58.2% (47.1–76.8%) and was due to *Eurytoma* sp., which was the most numerous, followed by *Pteromalus* sp., and *Halticoptera* sp. (Table 3).

Out of a total of 54 samples belonging to different hosts of *T. nigricornis*, only three samples (5.6%) yielded *T. nigricornis* but no parasitoids (Table 4). Moreover, none of the 29 samples of *E. farinosa* collected during 4 years was free of parasitoids. *Encelia farinosa* is the most widespread host of *T. nigricornis* in southern California. On the other hand, 50% of the samples (20 out of 40) of *T. bisetosa* were free of parasitoids.

Some reasons that very few samples of *T. nigricornis* hosts were free of parasitoids may be: the hosts of *T. nigricornis* sampled are in bloom for only short periods (ca. 2 months) in southern California; these hosts are usually heavily infested with *T. nigricornis*; *Trupanea nigricornis* populations have a high reproductive rate and make effective use of the plant resources available to them for only short periods; and these flies have an even distribution in the field. All these factors make *T. nigricornis* populations a reliable host for parasitoids.

In contrast, the greater number of *T. bisetosa* samples free parasitoids could be due to the following reasons: wild sunflower, the most common host of *T. bisetosa*, blooms throughout the year in southern California in the absence of frost; field populations of *T. bisetosa* larvae persist at low densities throughout the year as long as their hosts are present; the distribution of *T. bisetosa* in the field is uneven and clumped as flies are found only in a few patches within large populations of sunflowers; sunflower heads are covered with hard bracts and exude large amounts of resins when pierced, which probably deter most parasitoids from ovipositing in these heads.

The other common host plant of *T. bisetosa*, *Geraea canescens*, blooms only

Table 3. Total number of fly hosts and parasitoids reared from flower heads collected from all of the samples of the different hosts of *T. nigricornis* and *T. bisetosa.*

Flower Heads	Number and % of Reared Parasitoids[b]					Number and % of Reared Flies[c]					
N[a]	H	P	C	Pr	E	Tn	Nf	M	Tb	U	O
T. nigricornis hosts:											
E. farinosa											
13,860	517	241	46	2	8	1,379	934	55	—	—	1[d]
	63.5%	29.6%	5.7%	0.2%	1%	**58.2%**	39.4%	2.3%	—	—	0.04%
E. fructescens											
2,690	59	40	9	2	1	165	12	43	—	—	—
	53.2%	36%	8.1%	1.8%	0.9%	**75%**	5.5%	19.5%	—	—	—
E. virginensis											
2,080	30	31	82	—	5	202	20	38	—	—	—
	20.3%	20.9%	**55.4%**	—	3.4%	**77.7%**	7.7%	14.6%	—	—	—
H. acradenius											
4,250	1	39	—	—	84	62	—	—	—	2	—
	0.8%	1.5%	—	—	**67.7%**	**96.9%**	—	—	—	3.1%	—
H. venetus											
1,980	—	41	—	—	4	34	—	—	—	3	2[e]
	—	**91.1%**	—	—	8.9%	**87.2%**	—	—	—	7.7%	5.1%
V. deltoidea											
350	2	2	—	—	—	12	—	2	—	—	—
	50%	**50%**	—	—	—	**85.7%**	—	14.3%	—	—	—
T. bisetosa host:											
H. annuus											
3,660	—	107	—	—	—	—	272	18	685	—	12[f]
	—	**100%**	—	—	—	—	27.6%	1.8%	**69.4%**	—	1.2%

[a] Total number of flower head collected from all samples.

[b] C = *Colotrechus ignothus*; E = *Eurytoma* sp.; H = *Halticoptera* sp.; P = *Pteromalus* sp.; Pr = perilampid.

[c] Tn = *Trupanea nigricornis*; Nf = *Neotephritis finalis*; M = *Melanagromyza viridis*; Tb = *T. bisetosa*; U = *Urophora formosa*; O = other tephritids:

[d] *T. wheeleri*;

[e] Nb = *Neaspilota brunneostigmata*;

[f] Pc = *Paracantha cultaris*.

In bold, are the dominant species of parasitoid and host fly per plant species.

Table 4. Host plant samples of *Trupanea nigricornis* and *T. bisetosa* that yielded flies but no parasitoids.

Plant Species	Number of Samples Free of Parasitoids	Total Number of Collected Flower Heads	Total Number of Reared Flies in Samples Free of Parasitoids[a]					
			Tn	Tb	Tw	Nf	M	Pc
Hosts of *T. nigricornis*								
E. fructescens	2	350	5	—	—	3	—	—
H. acradenius	1	500	1	—	1	—	—	—
Hosts of *T. bisetosa*								
H. annuus	18	2,250	—	105	6	—	15	1
H. niveus	1	110	—	2	—	—	3	—
G. canescens	3	745	—	21	—	—	152	—

[a] Tn = *Trupanea nigricornis*; Tb = *T. bisetosa*; Tw = *T. wheeleri*; Nf = *Neotephritis finalis*; M = *Melanagromyza viridis*; Pc= *Paracantha cultaris*.

Table 5. List of parasitoids and insects other than tephritids, agromyzids and their confirmed parasitoids that emerged from the samples of flower heads infested with *Trupanea nigricornis*.

Parasitoids and Insects Reared[a]	*Encelia farinosa* (4/29 sites)[b]	*Encelia fructescens* (2/10 sites)	*Encelia virginensis* (4/8 sites)	*Haplopappus acradenius* (3/3 sites)
Parasitoids:				
Braconidae	11	–	1	7
Cynipidae	–	–	1	–
Eucoilidae	2	5	2	–
Eulophidae	1[c]	5[c, d,]	9[c, e, f]	23[f]
Eupelmidae	–	–	–	6
Platygasteridae	–	–	–	1
Pteromalidae	11[g]	–	–	6[g]
Torymidae	1	–	1[h]	–
Insect hosts:				
Cecidomyiidae	+	+	+	+
Noctuidae	+	–	+	+
Curculionidae	–	–	–	+
Thrips	+	+	+	–

[a] Parasitoids not confirmed as tephritids' parasitoids and additional insects reared other than tephritids and agromyzids.

[b] Number of flower head samples (one sample per site) yielding these insects out of the total number of samples collected.

[c] *Eutetrastichus* sp. emerging from cecidomyiid galls.

[d] *Thriposoma grafi.*

[e] *Telenomus* sp.

[f] *Aprostocetus* sp.

[g] *Zatropus* sp.

[h] *Torymus* sp.

for a short period (1–2 months), like the various hosts of *T. nigricornis*, and its flower heads are not covered by hard bracts nor do they exude resins. The absence of parasitoids in the three samples of *G. canescens* that yielded *T. bisetosa* probably was because of the limited reproduction of this host plant for the four years of the study due to drought in southern California. The collected samples were heavily infested with generalist agromyzids and only a few *T. bisetosa*. The parasitoids probably were too scarce and less efficient at detecting this plant.

Other parasitoids were recovered from flower heads of *T. nigricornis* and *T. bisetosa* host plants, but they were not reared from individual larvae or puparia of *T. nigricornis* and *T. bisetosa* and thus were not confirmed as parasitoids of these tephritids. The parasitoids and insects, other than dipterous flies, that emerged from some of the host samples also containing *T. nigricornis* are listed in Table 5. The Hymenoptera include braconids, torymids, platygasterids, cynipids, eupelmids, *Zatropus* sp. (Pteromalidae), and eulophids. The eulophids consisted of several genera: *Telenomus* sp., a parasitoid of lepidopterous eggs, *Eutetrastichus* sp., *Thriposoma grafi* Crawford, four species of *Aprostocetus* sp., and an identified species of eulophid that emerged from cecidomyiid galls. Other non-dipterous insects that occurred in these samples were noctuids, curculionids, free-living, predacious cecidomyiids, gall-forming cecidomyiids, anthocorids, aphids, and thrips. The parasitoids and non-dipterous insects that emerged from samples of hosts also containing *T. bisetosa*, i.e., *Helianthus annuus* and *H. niveus*, included braconids, eulophids, noctuids, aphids, and anthocorids.

It was not determined whether the eulophids, braconids, torymids and the other reared parasitoids also parasitized *T. nigricornis* or *T. bisetosa* because they were not individually reared from these tephritids and some may have been hyperparasitic.

In addition to parasitism, adults of *T. nigricornis* and *T. bisetosa* suffered mortality in the field due to predation. Both jumping spiders (Salticidae) and crab spiders (Thomisidae) commonly attacked adults of *T. nigricornis* and *T. bisetosa*. The spiders were observed hiding under leaves and bracts of flower heads and they ambushed newly emerged adult males (n = 5) during resting (n = 5) or courtship (n = 3) and females during probing or oviposition (n = 10). They were not specific to *Trupanea* spp. as they also were observed to capture *Neotephritis finalis* females (n = 4) while they were probing on wild sunflower heads. Coccinellid larvae were observed (n = 4) to prey on newly emerged *T. nigricornis* adults on *E. farinosa* flower heads in the field and in insectary cages. Noctuid larvae feeding within *E. farinosa* flower heads occasionally killed any *T. nigricornis* larvae they encountered.

Spiders and birds have been reported as potential mortality factors of other flower head-infesting tephritids. Jumping and crab spiders were common predators of *Trupanea conjuncta* adults (Goeden 1987) and *Paracantha gentilis* adults (Headrick and Goeden 1990). The jumping spider, *Pellenes signatus* (Banks), was observed preying on adults of *Procecidochares lisae* (Silverman and Goeden 1980). Spiders were also reported to prey on adults of the gall-forming species of the genus *Valentibula* (Wangberg 1978). The inquiline *Mordellistena unicolor* LeConte (Coleoptera: Mordellidae) was reported to attack galls of *Eurosta solidaginis* (Fitch) of different diameters; moreover, avian birds, such as, downy woodpeckers and black-capped chickadees, were commonly observed to break large galls and prey on these larvae during the winter months (Abrahamson et al. 1989). Heavy predation by birds was also observed on the overwintering larvae of the gall-forming species *Tephritis baccharis* (Goeden and Headrick 1991b) and *Eutreta diana* (Osten Sacken) (Goeden 1990). Moreover, *E. diana* larvae were subject to predation by unidentified clerid larvae and to occasional killing by Lepidoptera and Coleoptera (*Apion* sp., Apionidae) larvae that were feeding as inquilines inside the galls (Goeden 1990). In the gall-forming *Procecidochares* spp., the inquiline curculionid, *Apion* sp., occasionally killed the resident tephritid larvae, and beetle larvae of *Phyllobaenus* sp. (Cleridae) were general predators of the gall-former (Wangberg 1980). In *Chaetostomella undosa* (Coquillett), ants were reported to prey on the pupae and centipedes occasionally preyed on larvae (Steck 1984).

In summary, both parasitoids and predators imposed important mortality factors on the immatures and adults of *T. nigricornis* and *T. bisetosa*. The parasitoids attacking these species were generalists that attacked larvae of other dipterous larvae. The impact of natural enemies on these two closely related species that have adopted different modes of herbivory was significantly different. By adopting a narrowly oligophagous mode of herbivory and mainly specializing on wild sunflowers in southern California, *T. bisetosa* is restricting its diet breadth, but appears to escape from natural enemies. *Trupanea bisetosa* was attacked by fewer parasitoid species (one vs. five identified species) and had much lower total parasitism rates than the generalist *T. nigricornis*. Although these two sympatric species do share one host plant genus, *Geraea* (Goeden 1992), that could represent the ancestral host genus of both species or just another expansion to the host range of either tephritids, the exact causes that lead to the speciation of these two species cannot be known. However, natural enemies constitute one of the reasons causing diet specialization. Lack of 'enemy-free' space for phytophagous insects can be the critical factor limiting new species from colonizing a certain plant (Strong et al. 1984). Further, "host-plant use or changes in use that reduce predation are advantageous... Within a given place and time, preference for a plant less likely to be visited by natural enemies could evolve rapidly. Specializations for continued avoidance of predators may also then be rapidly selected for and established" (Bernays and Graham 1988). Thus, natural enemies may constitute an important factor that limits insect host range (Bernays and Graham 1988). Additionally, the biophysical features of plants are important factors in determining host suitability (Zwölfer and Harris 1971). Biophysical features of wild sunflowers, such as resins and toughness of the bracts, might then limit the number of parasitoid species able to attack *T. bisetosa*, by making it difficult for the parasitoids to gain access to *T. bisetosa* larvae in the flower heads.

In other tephritids, host shifts have been recorded that resulted in escape from natural enemies (Feder 1995). Experiments demonstrated that parasitoid attack was much lower in the derived apple race of *Rhagoletis pomonella* (Walsh) than in the ancestral hawthorn race. The bigger apple host was found to provide a physical refuge for the apple maggot larvae from the parasitoids. Therefore, enemy-free space was one important factor in host range expansion and host formation in *R. pomonella* (Feder 1995). It appears that the "major processes acting in many communities work vertically through the food chain, not horizontally with other species in the same trophic level" (Strong et al. 1984). Thus, by specializing on a few host plants, *T. bisetosa* gained some protection from potential natural enemies.

LITERATURE CITED

Abrahamson, W. G., J. F. Sattler, K. D. McCrea, and A. E. Weis. 1989. Variation in selection pressures on the goldenrod gall fly and the competitive interactions of its natural enemies. Oecologia 79: 15–22.

Bernays, E. and M. Graham. 1988. On the evolution of host specificity in phytophagous arthropods. Ecology 69: 886–892.

Cavender, G. L. and R. D. Goeden. 1982. Life history of *Trupanea bisetosa* (Diptera: Tephritidae) on wild sunflower in southern California. Annals of the Entomological Society of America 75: 400–406.

———. 1983. On distinguishing *Trupanea bisetosa* (Coquillett) from *T. nigricornis* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 85: 275–281.

———. 1984. The life history of *Paracantha cultaris* (Coquillett) on wild sunflower, *Helianthus annuus* L. ssp. *lenticularis* (Douglas) Cockerell, in southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 60: 213–218.

Feder, F. L. 1995. The effects of parasitoids on sympatric host races of *Rhagoletis pomonella*-Diptera: Tephritidae. Ecology 76: 801–813.

Foote, R. H., F. L. Blanc, and A. L. Norrbom. 1993. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Cornell University Press, Ithaca, New York. xii + 571 pp.

Goeden, R. D. 1985. Host-plant relations of *Trupanea* spp. (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 87: 564–571.

———. 1987. Life history of *Trupanea conjuncta* (Adams) on *Trixus californica* Kellogg in southern California. Pan-Pacific Entomologist 63: 284–291.

———. 1988. Life history of *Trupanea imperfecta* (Coquillett) on *Bebbia juncea* (Bentham) Greene in the Colorado Desert of southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 64: 345–351.

———. 1990. Life history of *Eutreta diana* (Osten Sacken) on *Artemesia tridentata* Nuttall in southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 66: 24–32.

———. 1992. Analysis of known and new host records for *Trupanea* from California (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 94: 107–118.

Goeden, R. D. and D. H. Headrick. 1991a. Notes on the biology, hosts, and immature stages of *Tomoplagia cressoni* Aczél in southern California (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 93: 549–558.

———. 1991b. Life history and descriptions of immature stages of *Tephritis baccharis* (Coquillett) on *Baccharis salicifolia* (Ruiz and Pavon) Persoon in southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 67: 86–98.

Goeden, R. D., T. D. Catadal, and G. A. Cavender. 1987. Life history of *Neotephritis finalis* (Loew) on native Asteraceae in southern California (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 89: 552–558.

Headrick, D. H. and R. D. Goeden. 1989. Life history of *Pteromalus coloradensis* (Ashmead) (Hymenoptera: Pteromalidae) a parasite of *Paracantha gentilis* Hering (Diptera: Tephritidae) in *Cirsium* thistle capitula. Proceedings of the Entomological Society of Washington 91: 594–603.

———. 1990. Life history of *Paracantha gentiles* (Diptera: Tephritidae). Annals of the Entomological Society of America 83: 776–785.

Knio, K. M., R. D. Goeden, and D. H. Headrick. 1996a. Descriptions of the immature stages of *Trupanea nigricornis* and *T. bisetosa* (Diptera: Tephritidae) from southern California. Annals of the Entomological Society of America 89: 1–11.

———. 1996b. Comparative biologies of the cryptic, sympatric species, *Trupanea bisetosa* and *T. nigricornis* (Diptera: Tephritidae) in southern California. Annals of the Entomological Society of America 89: 252–260.

———. 2001. Resource utilization on the sibling species *Trupanea nigricornis* (Coquillett), a polyphage, and the narrowly oligophagous *T. bisetosa* (Coquillett) (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 103: 946–961.

Silverman, I. and R. D. Goeden. 1980. Life history of a fruit fly, *Procecidochares* sp., on the ragweed, *Ambriosa dumosa* (Gray) Payne, in southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 56: 283–288.

Steck, G. J. 1984. *Chaetostomella undosa* (Diptera: Tephritidae): Biology, ecology, and larval description. Annals of the Entomological Society of America 77: 669–678.

Strong, D. R., J. H. Lawton, and R. Southwood. 1984. Insects on Plants: Community Patterns and Mechanisms. Harvard University Press, Cambridge, Massachusetts. 313 pp.

Stegmaier, C. E. 1968. Notes on the biology of *Trupanea actinobola* (Diptera: Tephritidae). The Florida Entomologist 51: 95–99.

Wangberg, J. K. 1978. Biology of gall-formers of the genus *Valentibulla* (Diptera: Tephritidae) on rabbitbrush in Idaho. Journal of the Kansas Entomological Society 51: 472–483.

———. 1980. Comparative biology of gall-formers in the genus *Procecidochares* (Diptera: Tephritidae) on rabbitbrush in Idaho. Journal of the Kansas Entomological Society 53: 401–420.

Zwölfer, H. and P. Harris. 1971. Host specificity determination of insects for biological control of weeds. Annual Review of Entomology 16: 156–178.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 198–207

THE LARVA OF *CERMA* HÜBNER AND ITS ENIGMATIC LINKAGES TO THE ACRONICTINAE (LEPIDOPTERA: NOCTUIDAE)

DAVID L. WAGNER

Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT 06269, U.S.A. (e-mail: david.wagner@uconn.edu)

Abstract.—The larva of *Cerma cerintha* (Treitschke) is described and figured and compared to that of *C. cora* Hübner. Both *C. cerintha and C. cora* are illustrated with photographs. The presence of only two SV setae on A1 and fully-developed prolegs on A3–A6 suggest that *Cerma* is neither an Acontiinae nor Eustrotiinae, the two subfamilies in which the genus is classified in modern taxonomic works. Morphological and behavioral similarities shared with *Acronicta fragilis* (Guenée), *Harrisimemna trisignata* (Walker), and other acronictines are discussed: *Cerma* Hübner and *Harrisimemna* Grote appear to have an especially close association. If *Cerma* proves to be an acronictine, its membership will call into question two of the strongest larval characters that have been used to diagnose the dagger moth subfamily: i.e., the presence of secondary setae and two or more setae on the L3 pinaculum on A1–A8. An alternative interpretation for the numbering of the L seta on the ninth segment is suggested. It is hypothesized that the aposematic coloration and alarm posture of *Cerma* are functionally linked to defensive secretions released from the larva's enlarged cervical gland.

Key Words: wood tunneling, alarm response, cervical gland, *Comachara*, *Harrisimemna*, *Polygrammate*, aposematic

The common, handsomely-colored adults of *Cerma cerintha* (Treitschke) are familiar to most eastern moth collectors. The forewings, a muddled mix of white and gray, give the resting moth the appearance of a bird dropping. Largely because of its coloration, *Cerma cerintha* has been classified in or near the Acontiinae [it was even described in the nominate genus *Acontia* Ochsenheimer by Treitschke (1826)]. For many years two (of the three) North American species of *Cerma* Hübner were not recognized as congeners. In McDunnough's (1938) checklist, *C. cora* Hübner, the type species of the genus, was treated as a cuculliine. In addition to *C. cora*, McDunnough's concept of *Cerma* included all described members of the bryophiline genus *Cryphia* Hübner; *C. cerintha* was left in Guenée's *Chamyris* in the Acontiinae—a position unchanged from earlier taxonomic works (e.g., Dyar et al. 1902 and Holland 1903). Forbes (1954) moved *C. cerintha* into *Cerma*, excluded all *Cryphia*, and placed the genus near *Ogdoconta* Butler and *Perigea* Guenée (= *Condica* Walker) in his "isolated Acronyctine genera." (At that time, Forbes' concept of the Acronyctine [sic] was extremely broad, encompassing members from ten of Fibiger and Lafontaine's 2005 trifid subfamilies.) Crumb (1956) placed *C. cerintha* in his

Lithacodiinae—an unnatural assemblage with little allegiance to one another, held together, in part, by the relative position of the stemmata. Most recently *Cerma* has been classified as an acontiine (Franclemont and Todd 1983) or eustrotiine (Fibiger and Lafontaine 2005). Here I describe the larva of *C. cerintha* and identify characters that suggest that *Cerma* might be best placed in the Acronictinae, near to or as the sister of *Harrisimemna* Grote.

MATERIALS AND METHODS

The description of *C. cerintha* is based on four mature larvae from a single ex ova cohort reared on *Prunus serotina* Ehrh. (Rosaceae). Data for the mother: NY: Albany Co., Pine Bush, 42°42′45″N and 73°52′53″W, 25 July 1981, T. L. McCabe. Larvae of *Cerma cora* (NY: Albany Co., Pine Bush, 42°42′45″N and 73°52′53″W, mother taken 8 July 1988, T. L. McCabe, reared on *Prunus pensylvanica* L. (Rosaceae), n=5) and *Harrisimemna trisignata* (NY: Hamilton Co., Pine Bush, 43°45′30″N and 74°10′14″W, mother taken 1 August, 1980, T. L. McCabe, reared on *Spiraea latifolia* (Ait.) Borkh. (Rosaceae), n=4) were also examined. Larval specimens are deposited at the New York State Museum, Albany.

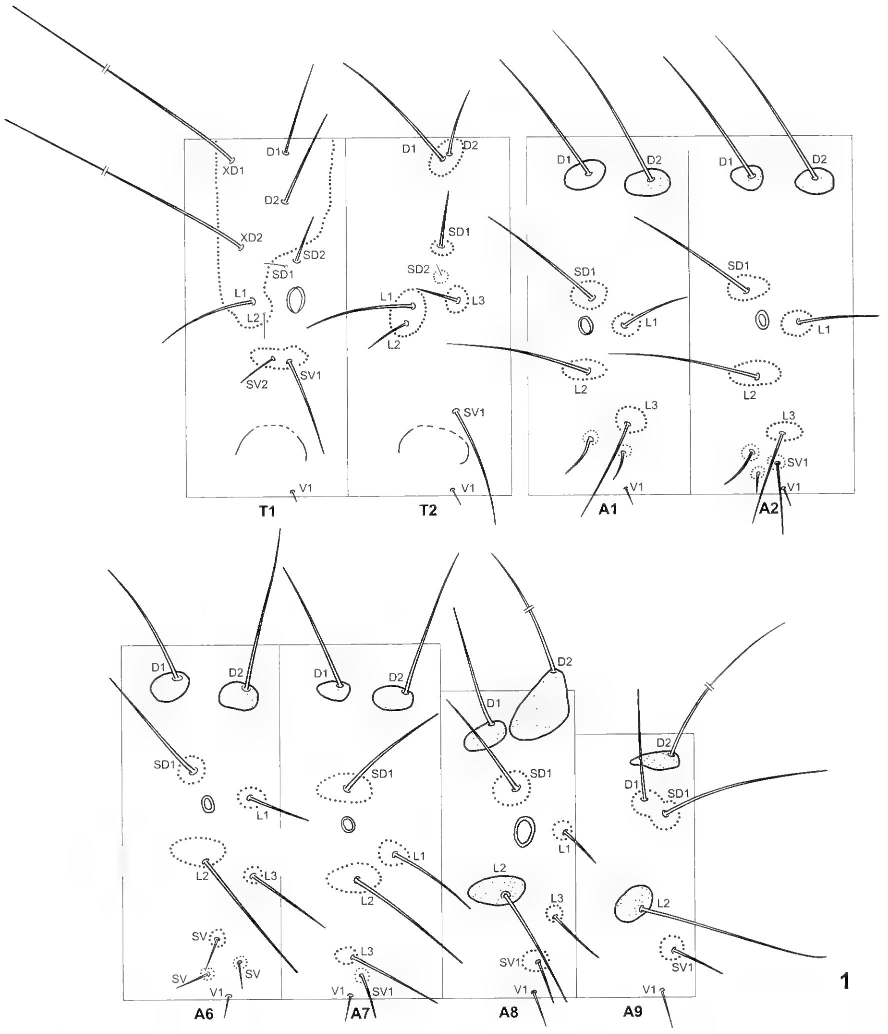
Descriptions of the living larvae are based on 42 images of *C. cerintha* from four different collections of wild larvae from Connecticut and Massachusetts and 20 images of *C. cora* larva from two collections of wild larvae from Florida and Ontario. Additionally, *Cerma* larvae were compared to images of 664 other North American Noctuidae sensu lato Franclemont and Todd (1983), including 7 genera and 53 species of Acronictinae, housed at the University of Connecticut.

A single *C. cerintha* larva was prepared for SEM study by running it through a series of ethanol baths (70%, 80%, 90%, 95%, 100%) before it was placed in a Polaron E 3000 critical point drying apparatus. The caterpillar was then coated with gold-palladium for three minutes in a Polaron E 5100 sputter coater. Images were obtained with a Zeiss DSM-982 Gemini FE SEM at 3–4 kv.

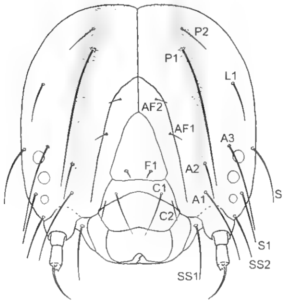
DESCRIPTION

Last instar of *Cerma cerintha*.—Length of preserved individuals: 28–31 mm (n=4). Initially bright lime to emerald green; integument shiny. Body wall translucent with tracheal trunk visible. Body constricted between segments (in preserved larvae). Setae long, thickened, mostly black, often from enlarged pinacula. Dorsum cherry red to smoky maroon with broad white subdorsal stripe from T1 to anterior of A8; stripe narrowing and more likely to include yellow pigment at either end of body. A8–A10 with broad white lateral line that dodges or is broken about spiracle on A8; lateral line subtended by narrow cherry red patch on A8–A9 with ray extending forward across A7 and down outer face of anal proleg. Spiracles pale orange. Middle instars lack brick red color over dorsum and each lobe of head draws to a point that bears a single black, bladelike seta. Prepupal larva tending towards glaucous green, dull, with reddish cast to lateral areas and subdorsal stripe with pink tints; noticeably thickened through the abdominal segments; dorsum fading to smoky maroon.

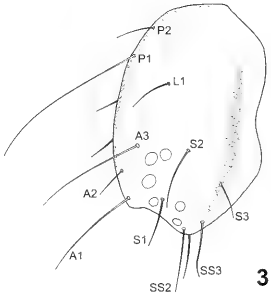
Head (Figs. 2–11): Smooth with long, thickened bristlelike setae; secondary setae absent. Capsule high relative to both depth (length) and width (Fig. 5); dark band extending from vertex down toward antenna but ending above A1 and second narrower band beginning under L seta and extending forward along gena, ending below ocellus 6. Triangle short, only about 0.4× height



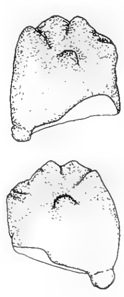
1



2

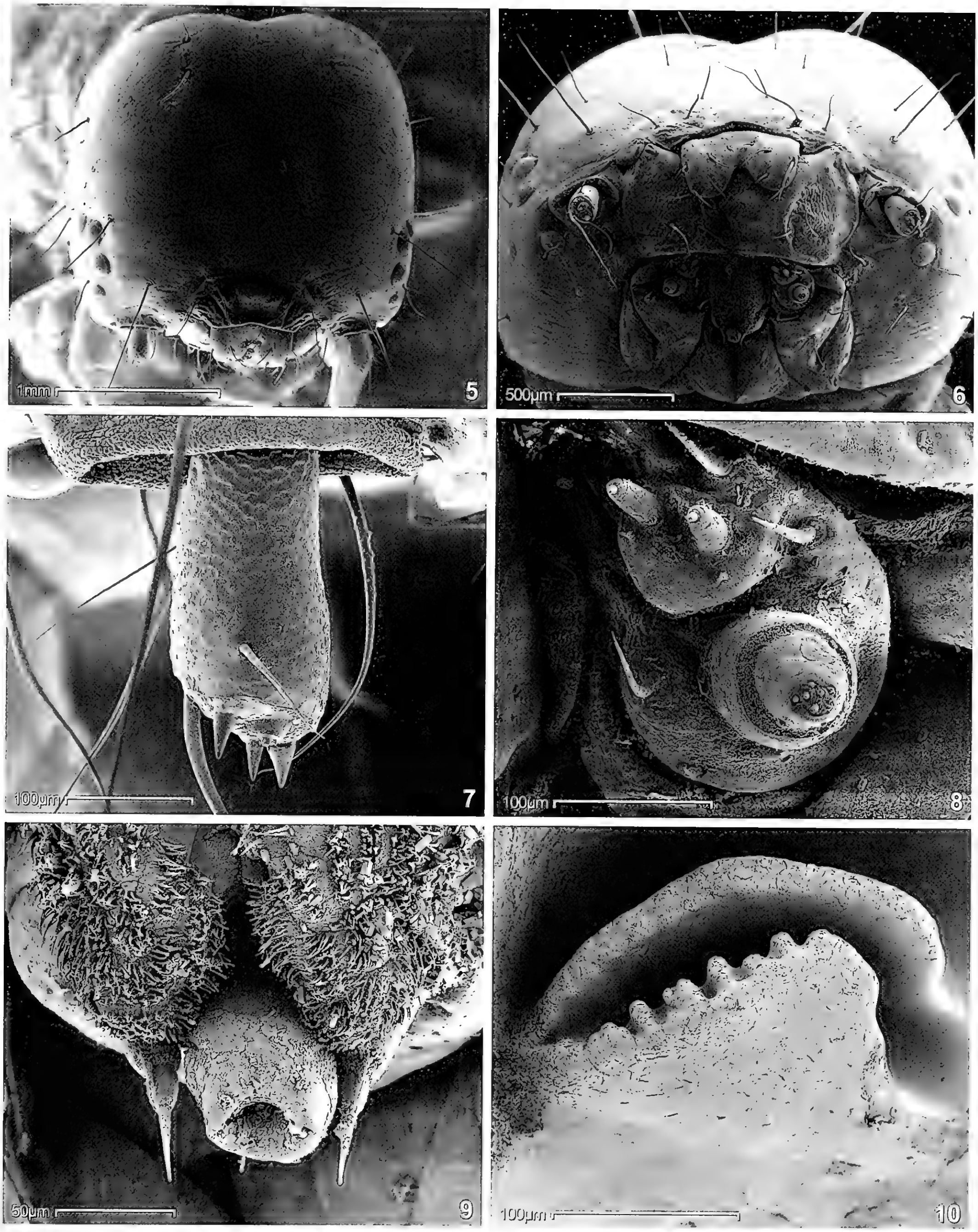


3



4

Figs. 1–4. *Cerma cerintha* larva. 1, Last instar chaetotaxy map, T1–T2, A1–A2, and A6–A9. 2, Head, frontal. 3, Head, lateral. 4, Mandibles, mesal surfaces. SV2 and SV3 setae on A1 and A2 are unnumbered, in part because it appears that SV3 is missing on A1 whereas others (e.g., Kitching and Rawlins 1998) state that it is SV2 that is absent.



Figs. 5–10. Scanning electron micrographs of last instar *Cerma cerintha*. 5, Frontal view of head. 6, Mouthparts. 7, Antenna. 8, Maxilla. 9, Spinneret. 10, Mola.

of head; AF and, especially F, setae short. Clypeus (and anteclypeus) little more than twice wide as broad; anteclypeus furrowed; C1 twice length of C2. P1, A3, and A1 very elongate, thickened, and brown. P1 extremely long, nearly height of head, circa 7× length of P2. Antenna as in Figs. 6, 7. Labrum somewhat quadrangular, deeply cleft. Maxilla as in Fig. 8. Mandible robust with three short teeth and central mola (Fig. 4); mola in end view consisting of two ridges; lower ridge with serrate margin (Fig. 10). Spinneret short, tubular, with apical pore, no dorsal groove, and no lateral flaps (Fig. 9). Hypopharyngeal spines extend to base of labial palpi (Fig. 9).

Body (Figs. 1, 11–17): Secondary setae absent. All dorsal setae including both XD on T1, L1 on T1, all L setae on T2–A9, and SV1 on all segments, very long, brown, thickened, more bristle-like than hair-like; D2 longer than D1 on abdominal segments. Dorsum between D2 pinacula covered by field of brown pavement granules (that appear rusty brown in preserved larvae). A8 humped.

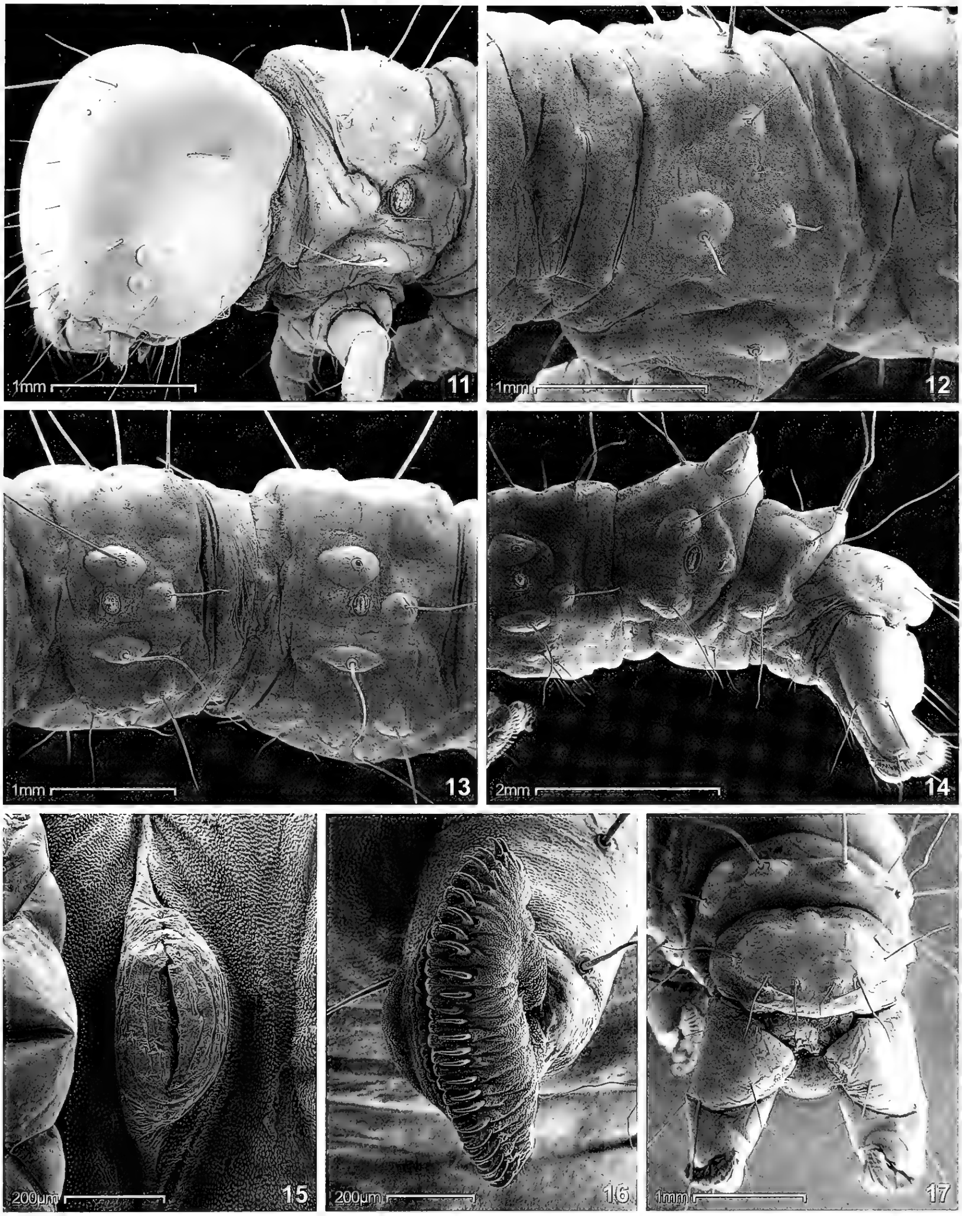
Thorax (Figs. 1, 11, 12, 15): Prothoracic shield undifferentiated (Fig. 11). XD1 and XD2 exceptionally long, approximately 5× as long as D1. L1 and hair-thin L2 included on prothoracic shield. SD2 short and thin on T1–T3. Prominent, midventral cervical gland on A1 (Fig. 15). Legs long, subequal to height of segment that bears them.

Abdomen (Figs. 1, 13, 14, 17): D1 and D2 setae getting progressively longer caudad to A8. Similarly, dorsal pinacula larger, more melanized, and more elevated to A8; D2 pinaculum on A8 grossly enlarged and bearing body's longest seta—its length often greater than length of A8–A10. D2 seta on A9 also very long and borne from greatly enlarged pinaculum. D1 and SD1 pinacula fused on A9. SD2 highly reduced. L2 borne from enlarged sclerotized pinaculum on A8, 2× length of L1; single L2 seta on A9 borne from enlarged melanized pinaculum. Two SV setae on T1; 1 SV seta on T2–T3; 2 SV on A1; 3 on A2–A6; 1 on A7–A9; SV1 much longer than SV2 and SV3 on A2 (Figs. 1, 13). V setae closely approximate on T1, more distantly and progressively longer caudad. MD, MSD, and MV proprioreceptors very reduced (or absent) on the thoracic and abdominal segments. All prolegs present, slightly larger caudad; planta long, sometimes with reddish-brown plate along outer face (n=1/4). Crochets in a uniordinal mesoseries; crochet complement on A3–A6, A10: 26–29, 28–30, 31–32, 32–34, and 29–30, respectively (Fig. 16). Anal proleg well developed, longer than combined length of A9–A10 (Fig. 14), with elongate sclerotized plate on outer surface and smaller plate, roughly half length of former, along anterior surface.

Last Instar of *Cerma cora*.—Length of preserved individuals: 26–28 mm (n=3). Aposematic; ground smoky with bright yellow (to orange) and white markings. Setae long, black, borne from enlarged blackened pinacula. A8 strongly humped. White middorsal stripe nearly continuous on thorax; broken over abdomen, usually expressed anterior to D1 and posterior to D2 pinacula. Broad white, lateral band running between D2 and L2 pinacula heavily suffused with bright yellow and orange, especially on A1–A8; yellow and/or orange spilling onto T3 and A9 in some individuals. A9 mostly white with boldly contrasting pinacula. Abdominal prolegs with shiny black plate along outer surface. Spiracles black. Thoracic legs shiny black. Head black, except for gray-white frons and adfrontal areas; lower half of frons also pale.

DISCUSSION

Last instars of *Cerma cerintha* and *C. cora* are readily distinguished from one another: *C. cerintha* is green with a brick red dorsum; *C. cora* is an aposematically-colored insect, mostly black with yellow and white markings. In *C. cora*, all the large setae of the thorax and abdomen are borne from blackened pinacula, the setae are generally longer and more darkly pigmented, and the



Figs. 11–17. Scanning electron micrographs of last instar *Cerma cerintha*; head to left. 11, Head and T1. 12, T3. 13, A1–A2. 14, A7–A10. 15, Cervical gland on venter of T1. 16, Crochets on A3. 17, Caudal segments.

prolegs on A3–A7 bear a strongly melanized plate. D1 and D2 are subequal in length in *cerintha*, while D2 is half again as long as D1 in *cora*. The D pinacula are fused on T2 and approximate over T3 in *C. cerintha*; but well separated on both T2 and T3 in *cora*.

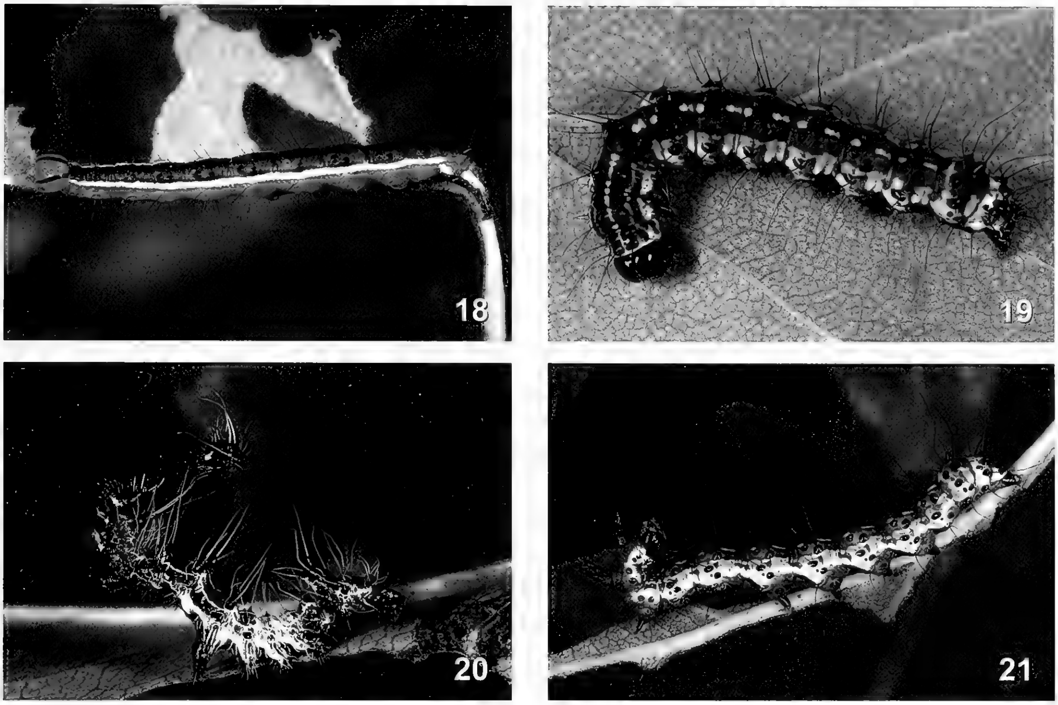
Larval characters shared by *C. cerintha* and *C. cora* that reinforce their congeneric status include the presence of a field of brownish dorsal pavement granules from (at least) T2 back to A9; deep constrictions between segments (in preserved larvae); exceptionally long, strongly-pigmented, thickened primary setae, the longest being P1 on the head, XD1 and XD2 on T1, and D2 on A8 and A9, with latter often exceeding the combined length of A8–A10; elongated planta, nearly as long as the segment that bears it on A3–A6, and the absence of secondary setae. The degree to which the D2 pinaculum is enlarged on A8 in both insects is exceptional. A significant synapomorphy for the two species is the reduction of the SD2 seta on the abdominal segments and the MD, MSD, and MV proprioreceptors on the thoracic and abdominal segments. In addition, the cervical gland on T1 (Fig. 15) appears to be well developed in the larvae of both *Cerma*. Finally, both feed on woody members of the Rosaceae, especially *Crataegus*, *Prunus*, and related species (Tietz 1972; Robinson et al. 2002).

LINKAGES TO ACRONICTINAE

Larval characters exclude *Cerma* from membership in either the Acontiinae or Eustrotiinae, the two subfamilies in which the genus has most recently resided (Franclemont and Todd 1983; Covell 2005, and Fibiger and Lafontaine 2005). Prolegs are absent on A3 and sometimes A4 in the former subfamily and from A3 in the latter subfamily. *Cerma* has a full complement of prolegs. No Acontiinae or Eustrotiinae possess long, thick, pigmented setae as do *C. cerintha* and *C. cora*. *Cerma* have prominent, raised pinacula, with those on A8 (especially the D2 pinacula) grossly enlarged—similar pinacula are not present in acontiines or eustrotiines. Acontiines have greatly thickened setae on the anal plate (Crumb 1956)—no such setae are present in *Cerma*.

While it is clear that *Cerma* is neither an acontiine nor eustrotiine, the argument that *Cerma* is an acronictine is weaker. *C. cerintha* and *C. cora* lack the most commonly identified features to circumscribe acronictines: verrucae, secondary setae, and the presence of extra setae on the L3 pinaculum on A1–A8 (Crumb 1956; Kitching and Rawlins 1998; Beck 1999, 2000). One character linking *Cerma* to acronictines (and arctiids) is the fusion of the dorsal pinacula over T2 and near fusion of the dorsal pinacula on T3 (in *C. cerintha* only). Based on my collections of noctuid larvae and larval images (representing 664 species of North American Noctuidae), *Cerma* shows greatest similarity to members of the Acronictinae, and in particular *Acronicta fragilis* (Guenée) and *Harrisimemna trisignata* (Walker). Habitus proportions, posture, setal girths and lengths, and development of the dorsal pinacula are reminiscent of those of *A. fragilis*.

Harrisimemna and *Cerma* share a number of similarities: both have thickened, darkly-pigmented dorsal setae that are borne from enlarged, black, pimplelike pinacula (Figs. 18–21). In *C. cora* and *H. trisignata*, A2 is modestly swollen laterally and dorsally–this segment has the widest girth of any of the anterior body segments; A1 and A3 are somewhat smaller in girth; all three segments have a greater circumference than that of T3. The eighth abdominal segment bears an enormous dorsal hump in *H. trisignata*, a prominent dorsal hump in *C. cora*, but only a low swelling in *C. cerintha* (at the midline, A8 is about 0.2× higher than the height of A9). In *C. cora* and *H. trisignata*, A8 is arched high above the adjacent segments. The planta is unusually long in both genera—in *Cerma*, the height of the planta is subequal to that of the segment from which it issues on A3–A6 (Fig. 21). The planta of *Harrisimemna* is also elongate (Fig. 20). In describing *H. marmarota* Hampson, an East Asian species, Yamamoto and Sugi (1987) noted that it possessed “extraordinary [sic] long prolegs.” Additionally, the planta bears a strongly



Figs. 18–21. Last instars of *Cerma* and *Harrisimemna*. 18, *C. cerintha*. 19, *C. cora*. 20, Defensive posture of *H. trisignata*. As is commonly the case in *Harrisimemna*, a previously shed head capsule is adhering to the caterpillar's prothoracic setae. 21, Defensive posture of *C. cora*. Note display of long black thoracic legs in both.

melanized (armored) plate on A3–A6 in *H. trisignata* and *C. cora* (but only 1 of 4 of the *C. cerintha* larvae examined). Both *Cerma* and *Harrisimemna* possess stout, armored anal prolegs with an elongate sclerotized plate running along the outer face on the proleg and a smaller sclerite along the anterior face of the proleg. At rest the long anal prolegs splay outward behind the body in each.

Both genera share similarities in their alarm responses. An extremely rapid (blurring) side-to-side shaking response occurs in both *Harrisimemna trisignata* and *Cerma cerintha*. A shared alarm posture has been observed in larvae of *H. trisignata* and both *Cerma* species: disturbed larvae arch the head up and back and extend the long, often blackened, thoracic legs outward (Figs. 20–21) (*H. trisignata* may also lift the caudal segments). This posture exposes the larva's cervical gland (Fig. 15) located between the prothoracic coxae. (Presumably this posture and the aposematic coloration of *C. cora* larvae will be found to be functionally linked to a defensive secretion released from the gland). In the preserved specimens of both *Cerma* (n=9) and *Harrisimemna* (n=4) a portion of the gland is everted. This 'spigot' is especially well developed in the latter genus, extending outward 1.6 mm from the venter of the thorax in last instars (nearly reaching the spinneret in some individuals). Although a cervical gland capable of discharging defensive secretions is known in notodontids (Weatherston et al. 1979; Attygalle et al. 1993) and the noctuid *Spodoptera* Guenée (Marti and Rogers 1988), and may prove to be part of the noctuoid groundplan, I expect that its development in *Cerma*, *Harrisimemna*, and other acronictines will be found to be elaborated relative to most noctuid lineages. The presence of a defensive secretion would explain the comparatively conspicuous perching behaviors of some *Acronicta* (e.g., *A. impleta* Walker, *A. morula* Grote &. Robinson, and *A. hasta* Guenée), which perch on leaf uppersides by day, and the bright 'warning' coloration of *Cerma cora* and other acronictines (e.g., *Acronicta oblinita* (J. E. Smith), *A. funeralis* G. & R., *A. longa* Guenée, and *Simyra henrici* (Grote) (see Wagner 2005).

Cerma, and three acronictine genera, *Comachara* Franclemont, *Harrisimemna*, and *Polygrammate* Hübner, tunnel deep into wood as prepupae (Wagner 2005; Wagner et al. 2006). In the case of *Harrisimemna*, the caterpillars can bore into solid woods, e.g., dry indoor fir molding (Pat Burkett personal communication). The enlarged hump over A8, elongate prolegs, and sclerotized plates on the anal prolegs of *Cerma* and *Harrisimemna* may be functionally related to the biomechanics of tunneling into wood.

The weight of the evidence suggests that *Cerma*, despite its exceptional chaetotaxy, is closely related to the acronictine genus *Harrisimemna*. The latter genus is unequivocally acronictine in nature: it possesses larval characters noted above as being characteristic of acronictines; it has acronictine forewing patterning; it shares a seemingly unique tunneling/ball-rolling behavior with the acronictine genera *Comachara* and *Polygrammate* (Wagner et al. 2006, unpublished data); and has been treated as an acronictine by all modern noctuid workers (e.g., Forbes 1954; Crumb 1956; Franclemont and Todd 1983; Yamamoto and Sugi 1987). The inclusion of *Cerma* in the Acronictinae, would negate the most widely cited larval characters believed to uniquely identify the subfamily (presence of secondary setae and presence of one or more extra setae on the L3 pinaculum). Other morphological and molecular data are needed to corroborate or refute the character evidence presented here. As importantly, if *Cerma* proves to be an acronictine, additional data will help to clarify the position of the genus within the subfamily.

ACKNOWLEDGMENTS

Tim McCabe supplied last instars of *Cerma cerintha*, *C. cora*, and *Harrisimemna trisignata*. René Twarkins assembled the artwork and digital images for the plates. Jim Romanow helped with the scanning electron microscopy. Eric Quinter, Jadranka Rota, and J. Bolling Sullivan provided helpful suggestions on drafts of the manuscript. The reviews of Don Lafontaine and Michael Pogue were especially helpful. Financial support came from the U.S. Department of Agriculture, Forest Services, Forest Health Technology Enterprise Team, cooperative agreement number 01-CA-11244225-215 to DLW. Discover Life in America provided monetary support and lodging for the work carried out in Great Smoky Mountains National Park.

LITERATURE CITED

Attygalle, A. B., S. R. Smedley, J. Meinwald, and T. Eisner. 1993. Defensive secretion of two notodontid caterpillars (*Schizura unicornis*, *S. badia*). Journal of Chemical Ecology 19: 2089–2104.

Beck, H. 1999. Die Larven der Europäischen Noctuidae—Revision der Systematik der Noctuidae. Herbipolianna 5. Volumes 1, 2. Verlag Dr. Ulf Eitschberger, Marktleuthen, Germany. 859 pp. + 447 pp.

———. 2000. Die Larven der Europäischen Noctuidae—Revision der Systematik der Noctuidae. Herbipolianna 5. Volumes 3, 4. Verlag Dr. Ulf Eitschberger, Marktleuthen, Germany. 336 pp. + 512 pp.

Covell, C. V., Jr. 2005. A Field Guide to the Moths of Eastern North America. 2nd Ed. Virginia Museum of Natural History, Martinsville, VA. 496 pp.

Crumb, S. E. 1956. The caterpillars of the Phalaenidae. U.S. Department of Agriculture Technical Bulletin, 1135, Washington, DC. 356 pp.

Dyar, H. G., C. H. Fernald, G. D. Hulst, and A. Busck. 1902. A List of the North American Lepidoptera and Key to the Literature of This Order of Insects. Bulletin of the National Museum 52, 723 pp.

Fibiger, M. and J. D. Lafontaine. 2005. A review of the higher classification of the Noctuoidea (Lepidoptera) with special reference to the Holarctic fauna. Esperiana. Buchreihe zur Entomologie 11: 1–205.

Forbes, W. T. M. 1954. Lepidoptera of New York and Neighboring States, Part III. Cornell University Agricultural Experiment Station, Ithaca, NY, Memoir 329. 433 pp.

Franclemont, J. G. and E. L. Todd. 1983. Noctuidae, pp. 120–159. *In* Hodges, R. W., et al., eds. Check List of the Lepidoptera of America North of Mexico, E.W. Classey Ltd. and The Wedge Entomological Research Foundation. Cambridge Univ. Press, Cambridge, United Kingdom.

Holland, W. J. 1903. The Moth Book: A Guide to the Moths of North America. Doubleday, Page, and Co., New York. 479 pp.

Kitching, I. J. and J. E. Rawlins. 1998. The Noctuoidea, pp. 355–401. *In* Kristensen, N. P., ed. Lepidoptera, Moths and Butterflies. Volume 1: Evolution, Systematics, and Biogeography. Handbook for Zoology. Volume IV. Arthropoda: Insecta, Walter de Gruyter, Berlin.

Marti, O. G. and C. E. Rogers. 1988. Anatomy of the ventral eversible gland of fall armyworm, *Spodoptera frugiperda* (Lepidoptera Noctuidae), larvae. Annals of the Entomological Society of America 81: 308–317.

McDunnough, J. 1938. Checklist of the Lepidoptera of Canada and the United States of America. Part 1. Macrolepidoptera. Memoirs of the Southern California Academy of Sciences. 272 pp.

Robinson, G. S., P. R. Ackery, I. J. Kitching, G. W. Beccaloni, and L. M. Hernández. 2002. Hostplants of the Moth and Butterfly Caterpillars of America North of Mexico. Memoirs of the American Entomological Institute, Gainesville, Florida. Volume 69. 824 pp.

Tietz, H. M. 1972. An Index to the Described Life Histories, Early Stages and Hosts of the Macrolepidoptera of the Continental United States and Canada (2 volumes). Allyn Museum of Entomology, Sarasota, Florida. 1041 pp.

Treitschke, F. 1826. Die Schmetterlinge von Europa. Volume 5. Abteilung 3. Leipzig. Gerhard Fleischer, 420 pp.

Wagner, D. L. 2005. Caterpillars of Eastern North America: A Guide to Identification and Natural History. Princeton University Press, 512 pp.

Wagner, D. L., E. W. Hossler, and F. E. Hossler. 2006. Not a Tiger but a Dagger: The larva of *Comachara cadburyi* and reassignment of the genus to the Acronictinae (Lepidoptera: Noctuidae). Annals of the Entomological Society of America 99: 638–647.

Weatherston, J., J. E. Percy, L. M. MacDonald, and J. A. MacDonald. 1979. Morphology of the prothoracic defensive gland of *Schizura concinna* (J.E. Smith) (Lepidoptera: Notodontidae) and the nature of its secretion. Journal of Chemical Ecology 5: 165–177.

Yamamoto, M. and S. Sugi. 1987. Noctuidae excluding Herminiinae. pp. 185–238. *In* Sugi, S., ed. Larvae of the Larger Moths of Japan. Toppan Printing Co., Ltd., Tokyo, Japan.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 208–222

THE IDENTITY AND DISTRIBUTION OF *EFFERIA PLENA* (HINE) AND *E. NEMORALIS* (HINE) (DIPTERA: ASILIDAE)

Jeffrey K. Barnes

The Arthropod Museum, Department of Entomology, University of Arkansas, Fayetteville, Arkansas 72701-1201, U.S.A. (e-mail: jbarnes@uark.edu)

Abstract.—*Efferia plena* (Hine) and *E. nemoralis* (Hine) from the eastern and south-central United States are redescribed and illustrated. These members of the *Efferia staminea* species group are similar in appearance, and specimens of *E. plena* often have been misidentified as *E. nemoralis*. Several characters for reliable identification of males are offered. The distributions of the species are mapped. A lectotype is designated from the syntype series of *Erax nemoralis* Hine.

Key Words: Diptera, robber fly, Asilidae, *Efferia*, *Erax*, *Pogoniefferia*, *Pogonioefferia*, Nearctic

---

Efferia, with about 110 species recognized in the United States (Poole 1996) and more than 110 species in the more southern reaches of the Americas (Martin and Papavero 1970), is one of the largest genera of Asilidae in the New World. Coquillett (1893) erected the genus to receive a small group of North American species previously referred to the old Palearctic genus *Erax* Scopoli, while leaving other North American species in that Old World genus. He subsequently (Coquillett 1910) designated *E. candida* Coquillett as type species of his new North American genus.

Assignment of Western Hemisphere robber flies to *Erax* began with Macquart (1838) and continued for a long period. He assigned 29 species, most of them American, to the genus. Williston (1891) listed 74 species from South America. In his *Erax* revision, Hine (1919) recognized 76 valid North American species of *Erax* sensu Macquart, and he placed them in eight informal species groups, based largely on wing characteristics.

American species were assigned to *Erax* until Martin (1961) showed that Macquart should have erected a new genus for the American species. He recognized that *Efferia* is the first generic name available for the North and South American species. Hull (1962), apparently unaware of Martin's (1961) work, stated that the New World species only superficially resemble the Old World *Erax* species and proposed the new genus *Nerax* to receive the majority of American species, while reserving *Efferia* for the species included in Hine's *Erax anomalus* group — the species in which the recurrent branch of vein R_4 joins R_{2+3} rather than ending blindly in cell r_{2+3}. Martin (1965) soon synomymized *Nerax* under *Efferia*. In his revision of the North American species, Wilcox (1966) followed Martin's (1961, 1965) interpretation of the genus *Efferia* and Hine's (1919) species group classification. He described 30 new species and recognized a total of 100 species in North America north of Mexico.

Artigas and Papavero (1997) divided *Efferia*. They continued to recognize the genera *Diplosynapsis* Enderlein and *Porasilus* Curran, removed *Nerax* from synonymy, reserved *Efferia* for *anomola*-group species, and described the five new genera *Albibarbefferia*, *Aridefferia*, *Carinefferia*, *Pogoniefferia*, and *Tuberculefferia* to receive other species. (Artigas and Papavero (1997) used the spelling *Pogoniefferia* most frequently, but they apparently misspelled it as *Pogonioefferia* in one instance; the former spelling is here selected as correct.) These genera are nearly identical to Hine's (1919) species groups, based on superficial differences in setation and wing venation that can vary among individuals of the same species. Although the latest catalog of robber fly genera recognizes all of the Artigas and Papavero genera (Geller-Grimm 2003), it is perhaps better to treat them as synonyms of *Efferia* until in depth phylogenetic analysis provides additional data upon which to base a conclusion.

New species of *Efferia* are still being recognized and described in western North America (Bullington and Lavigne 1984; Forbes 1987, 1988), but it is rare to find new species in the East. While surveying the robber flies of the south-central United States, it became evident that trays of *Efferia nemoralis* (Hine) at the University of Arkansas Arthropod Museum and other collections actually contained two species. Differences in coloration of the vestiture of the mystax and legs initially suggested the presence of two species. A specimen with a mystax that is interpreted as being "yellow or yellowish" keys to *E. nemoralis*, and a specimen with a mystax that is interpreted as being white keys to *E. monki* (Bromley) in Wilcox's (1966) seminal monograph on North American *Efferia*. On closer examination, it was found that males of the two species differ in the color pattern of the third abdominal tergite and in the form of the gonocoxite and the apex of the epandrium.

Hine (1911) described *Erax nemoralis* from several specimens, both male and female, collected at New Roads, Pointe Coupée Parish, Lousiana, on July 15, 1905. Bromley (1951) described *Erax monki* from a male holotype collected at Donna, Hidalgo County, Texas, on October 1, 1933. He distinguished it from *E. nemoralis* by its smaller size, more slender build, hyaline wings, white mystax and beard, darker legs, and more rounded male genitalia. Wilcox (1966) did not study specimens of *E. monki* before publishing his work on North American *Efferia*. He merely quoted Bromley's description, and did the best he could in constructing the keys. Bromley (1951) indicated that the holotype was in the American Museum of Natural History, but thorough searches of that museum, the National Museum of Natural History, the California Academy of Sciences, the Texas A&M University Insect Collection, and several other museums and collections have failed to produce any type specimens of *E. monki*. A syntype series of *E. nemoralis* and the holotype of *E. plana* were located in the Charles A. Triplehorn Insect Collection, Ohio State University. I now regard *E. monki* as a *species inquirenda*, of doubtful identity and needing further investigation. The holotype and some other specimens were collected in the Gulf Coastal region late in the season, suggesting that it might be junior a synonym of *E. nemoralis*.

Study of the genitalia of the *E. plena* holotype and *E. nemoralis* lectotype, designated herein, has led me to the conclusion that specimens of *E. plena* have often been misidentified as *E. nemoralis* and placed in trays with properly identified *E. nemoralis*. For this reason, *E. plena* was recorded from only Kansas and Oklahoma by Martin and Wilcox (1965) in their catalog of North American robber flies, and its widespread occurrence in Arkansas was not recognized (Scarbrough 1972, Whitcomb and Bell 1964). Hine (1916) described *Erax plenus* from a male holotype collected in Douglas County, Kansas. No date was given. That specimen and several others studied by Hine have a light colored abdominal tergite 7. One specimen from Onaga, Pottawatomie County, Kansas has a dark colored tergite 7, but Hine (1916) dismissed this condition as intraspecific variation. However, Wilcox (1966) admitted to no variation, and he identified only specimens with a "silvery pollinose" segment 7 as *Efferia plena*. Most specimens of *E. plena* that I have seen have a dark-colored tergite 7, and they are identified as *E. nemoralis* when using Wilcox's (1966) key.

In his revision of the genus *Erax*, Hine (1919) separated male *E. plena* from male *E. nemoralis* by the color pattern of abdominal tergites 1–3. The holotype of *E. plena* has the first three abdominal segments dark, mostly with black hair above (Fig. 1). That species is thus distinguished from *E. nemoralis*, which Hine describes as having male abdominal segments 1–2 and a basal triangle of segment 3 dark and largely clothed with black hair, but the apex of 3 is white and covered with long white hair parted in the middle and directed outward (Fig. 4A). Unfortunately, there is a great deal of variation in the color pattern of abdominal tergite 3 of *E. plena* specimens, with many showing a well developed white posterior band and long, white parted hairs (Fig. 2). Even the holotype has some posterolateral white areas and some long, white hairs (Fig. 1)

Efferia plena and *Efferia nemoralis* are members of Hine's (1919) *staminea* group of species. The junction of wing veins R_4 and R_5 is located basad to the level of the basal section of vein M_2 (apex of cell d), and the male abdomen has several silvery pollinose segments with long, parted, white hairs. Within the *staminea* group, they are segregated from many other species by the black femora and white or yellow mystax. Both *Efferia plena* and *Efferia nemoralis* occur widely in Arkansas, where the former species is apparently most abundant in June, and the latter species is most abundant in July and August. *Efferia plena* has a wide distribution from Maryland and North Carolina in the East to Kansas, Oklahoma, and Texas in the Midwest. *Efferia nemoralis* is strictly a south-central species, occurring also in Mississippi, Louisiana, northeastern Texas, and southeastern Oklahoma. The ranges of the two species overlap in Arkansas and Mississippi. Several characters for reliable identification of males are described. No reliable characters have been found separating the females of the two species.

MATERIALS AND METHODS

Terminology largely follows that found in the *Manual of Nearctic Diptera* (McAlpine 1981, Wood 1981). Antennomere to scape ratios were formulated by dividing the length of each antennomere by the length of the first antennomere (the scape) and then listing the numbers in order.

Specimens from the following collections were studied: Colorado State University, Department of Bioagricultural Sciences and Pest Management, C. P. Gillette Museum of Arthropod Diversity, Ft. Collins (CSUC); Mississippi State University, Mississippi Entomological Museum, Mississippi State (MEMU); National Museum of Natural History, Smithsonian Institution, Washington, D. C. (USNM); Charles A. Triplehorn Insect Collection, Ohio State University, Columbus (OSUC); Oklahoma State

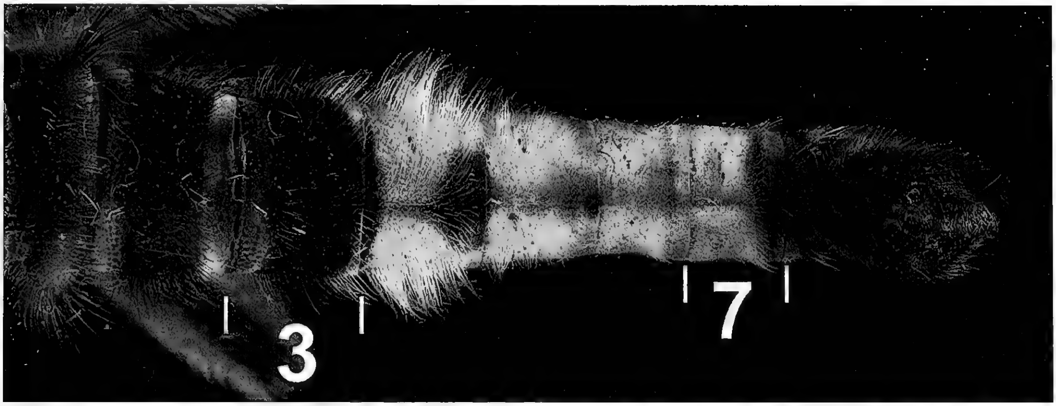


Fig. 1. *Efferia plena*, holotype abdomen, dorsal view showing abdominal tergites 3 and 7.

University, K. C. Emerson Museum, Stillwater (OSEC); Kansas State University, Department of Entomology, Manhattan (KSUC); Texas A & M University Insect Collection, College Station (TAMU); University of Arkansas Arthropod Museum, Fayetteville (UAAM); University of Kansas Natural History Museum, Snow Entomological Collections, Lawrence (SEMC); University of Michigan Museum of Zoology, Insect Division, Ann Arbor (UMMZ); University of Missouri, Department of Entomology, Wilbur R. Enns Entomology Museum, Columbia (UMEE).

SYSTEMATICS

KEY TO ADULT MALES

Both *E. plena* and *E. nemoralis* key to couplet 9 in Wilcox's (1966) key to males of the *staminea* group. They can be separated as follows:

1. Abdominal tergite 3 mostly shining black or dark brown dorsally and bearing many black setae (Fig. 2A); epandrium with shallow apical notch, as in Fig. 2B; gonocoxite with posteroventral lobe broad basally, tapered to rounded apex; apex not surpassing that of anterodorsal lobe; gonostylus short, not surpassing gonocoxite by distance approximating length of apical gonocoxite lobes (Fig. 2C); aedeagus smoothly rounded basally (Fig. 2-D) . . . . *Efferia plena* (Hine)

– Abdominal tergite 3 shining dark brown to black dorsally on anterior half, almost devoid of black setae, with broad, posterior, silvery pollinose band V-notched at midline (Fig. 4A); epandrium with deep apical notch, as in Fig. 4B; gonocoxite with posteroventral lobe narrow, more or less parallel-sided; apex surpassing that of anterodorsal lobe; gonostylus long, surpassing gonocoxite by distance approximating length of apical gonocoxite lobes (Fig. 4C); aedeagus sharply hooked and somewhat sigmoid basally (Fig. 4D) . . . . *Efferia nemoralis* (Hine)

Efferia plena (Hine)
(Figs. 1–3)

Erax plenus Hine 1916: 21; Hine 1919: 148.
Efferia plena: Wilcox 1966: 214.
Pogoniefferia plena: Artigas and Papavero 1997: 73.

Male.—*Body length:* 19.4–28.6 mm (mean ± S.D.: 23.0 ± 1.8; N = 63).

Head: Width 1.5 times eye height. Face golden tomentose, with large gibbosity about as deep as length of scape extending nearly two-thirds of distance from oral margin to antennal bases. Mystax consisting of long pale yellow to deep golden yellow bristles covering entire facial gibbosity, sometimes with 1–4 black bristles in ventolateral corners. Gena brown, thinly golden pollinose. Frons brown, subshining medially, golden pollinose laterally, with 3–5 long black bristles and patch of many black, shorter, hairlike setae laterally. Vertex, including ocellar tubercle, golden pollinose. Ocellar tubercle bearing 2–4 long, strong, black bristles and several weaker ones. Postcranium white tomentose. Dorsal postocular setae black; lateral postocular setae pale yellow. Lower occiput, postgena, and base of labium with dense vestiture of long, slender, golden plumose hairs. Proboscis black; palpus black, usually with black setae dorsally and apically, golden setae ventrally near base. Antenna, including style, 2.0–2.5 mm long, brown; scape setose dorsally, laterally, and ventrally, with setae usually black dorsally, often golden yellow laterally and ventrally; pedicel setose apically; first flagellomere attenuate; antennomere to scape ratios 1.0–0.5–1.0–1.5.

Thorax: Cervical sclerites brown, sparsely golden pollinose, covered with long, pale, plumose hairs. Pronotum sparsely golden pollinose, covered with sparse pile of long, slender pale and black hairs; antepronotum with transverse row of about 6–11 black bristles; postpronotal lobe brown, densely golden pollinose, covered with short, black, erect to reclinate setae. Propleuron brown, golden pollinose, with vestiture of long, declinate, plumose white hairs on anterior portion of proepisternum; declinate golden hairs on posterior portion of proepisternum; and reclinate golden to brown hairs on proepimeron. Scutum brown in ground color, covered throughout with vestiture of short or long, black, erect or slightly reclinate setae; postsutural hairs and setae longer than presutural hairs and setae; lateral margin of scutum, in addition to several weaker black setae, with 3–4 strong, black presutural setae and 1–3 strong, black postsutural, supra-alar setae; scutum mostly covered with dense golden pollen except for pair of broad, posterolateral, thinly pollinose or bare patches, each divided by narrow line of pollen along transverse suture, and pair of thinly pollinose, central, brown vittae extending from pronotum to region just posterior to transverse suture, pair separated by narrow line of golden pollen along mid-dorsal line of scutum. Postalar callus densely golden pollinose, covered with short black setae and 3–6 long, strong black bristles. Scutellum convex, brown, golden pollinose, with 6–12 strong, long, erect, black marginal bristles and many short black setae on disc. Mediotergite brown, thinly golden pollinose; anatergite gray pollinose; katatergite gray pollinose, with dense fan of long black and golden bristles. All mesopleural sclerites brown, golden pollinose. Anepisternum with long, fine, golden to dark brown, apically-crinkled hairs along anterior, dorsal and posterior margins; anterior and dorsal hairs erect; posterior hairs reclinate. Anterior basalare brown, thinly pollinose, with long, fine, black, apically-crinkled hairs along anterior margin; posterior brown, thickly golden pollinose. Katepisternum with long, fine, black, apically-crinkled hairs posterodorsally. Anepimeron with few long, fine, black or pale, apically-crinkled hairs posteriodaorsally. Katepimeron and meron lacking setae or hairs. Basal swelling of pleural wing process golden pollinose. Subalar sclerite brown. Metepisternum golden pollinose, covered with several long, fine, black or pale, apically-crinkled hairs and dense crescentic patch of short brown hairs posteroventrally. Metepimeron gray pollinose, with very fine, apically-crinkled, erect golden hairs.

Legs: Coxae brown in ground color, golden pollinose; forecoxa densely covered with long, golden, declinate bristles anteriorly; midcoxa with long, golden, declinate bristles anteroventrally and some stronger golden bristles laterally; hind coxa with fine, long, apically-crinkled, pale hairs anterolaterally and posteriorly, and about 3 long black to

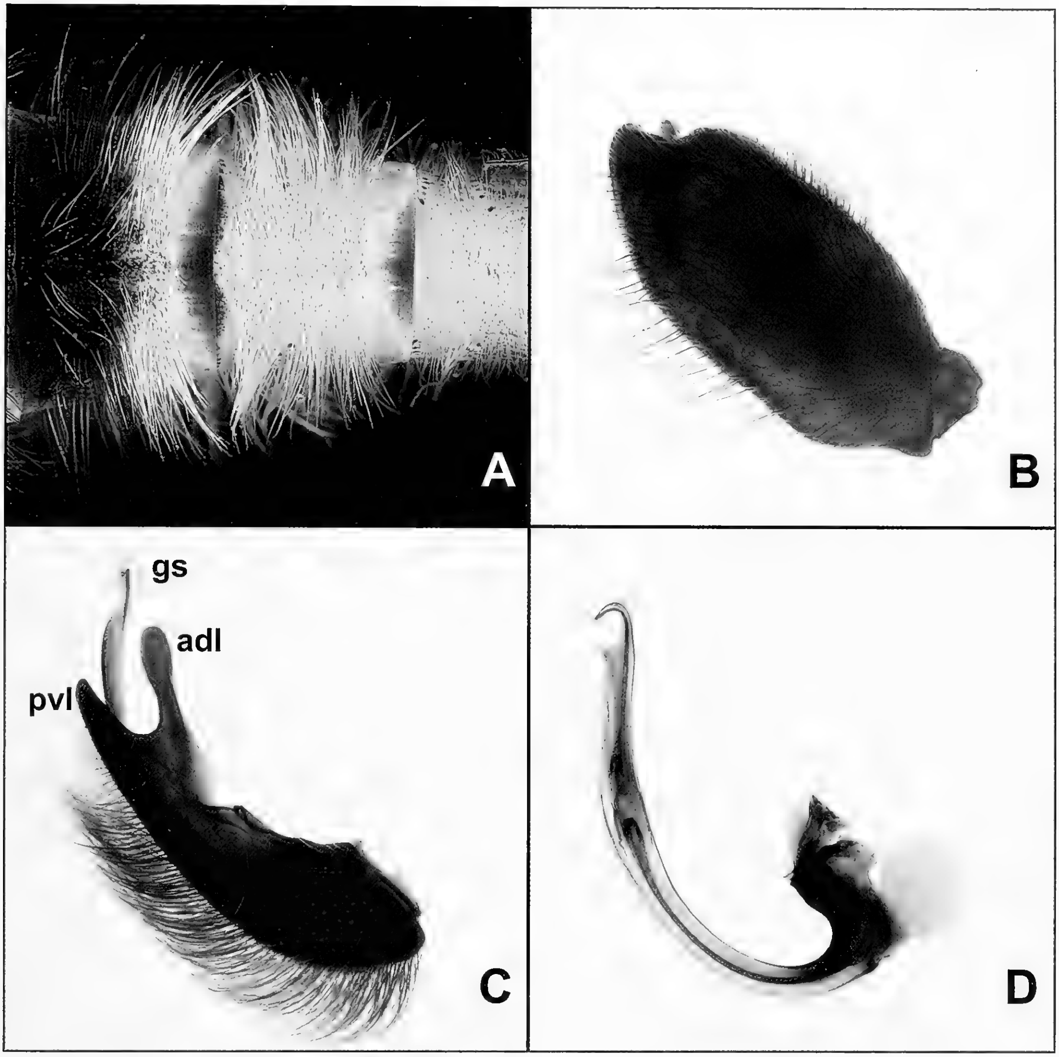


Fig. 2. *Efferia plena*, male. A, Tergites 3–5, left to right (Arkansas: Craighead Co., near Jonesboro). B–D, Male genitalia (Arkansas: Benton Co., Siloam Springs, Chesney Prairie Natural Area). B, Epandrium, right lateral view. C, Gonocoxite and gonostylus, right lateral view. D, Aedeagus, right lateral view. Abbreviations: adl, anterodorsal lobe of gonocoxite; gs, gonostylus; pvl, posteroventral lobe of gonocoxite.

pale bristles posterolaterally. Femora dark brown to black, subshining. Forefemur lacking stout bristles, with many long, black hairlike setae dorsally, anteriorly, and ventroapically, and with many long, golden, hairlike setae posteriorly and ventrally near base, these ventral setae much longer than others. Midfemur similar to forefemur, but with anteroventral and posteroventral rows of 4–5 stout, black bristles and 2–3 stout, black bristles on basal half of anterior face. Hind femur with many short golden setae anterodorsally on basal three-fourths; many long, dark, apically-crinkled, hairlike setae posteroventrally; ventral row of 7–9 stout black bristles; and anterior row of 2–3 stout black bristles. Tibiae reddish brown, darkened at apices. Foretibia with many long, golden, apically-crinkled, hairlike setae posteroventrally; dense brush of short, fine, golden hairs anteroventrally; rows of stout, black bristles anterodorsally and posterodorsally; and circle of several stout, black bristles at apex. Midtibia with many long, golden, apically-crinkled, hairlike setae ventrally; row of 4–6 stout black bristles posterodorsally; and circle of several stout, black bristles at apex. Hind tibia with many long, golden, apically-crinkled, hairlike setae ventrally; dense elongate patch of short golden setae posterodorsally; and stout black bristles as follows: 1 anterodorsally and 1 posterodorsally near base, 1–2 anterodorsally at about midlength, 1 anteriorly at about apical fourth, 2 anteroventrally along apical third, and 5 circling apex except posterodorsally. Tarsi uniformly brown; length of first tarsomere about 1.0–1.3 times length of second and third combined. All claws black with brown base. All pulvilli pale yellow.

Wing: 11.6–18.0 mm long (mean ± S.D.: 14.5 ± 1.4; N = 63). Very lightly infuscated, nearly hyaline; sometimes more heavily infuscated in subcostal cell. Halter with stem yellow, knob often darker.

Abdomen: Tergites dark brown to black in ground color. Tergite 1 brown in ground color; covered with grayish brown pollen and fine black setae throughout; with 5–8 stout black bristles and several long, pale, apically-crinkled hairlike setae posterolaterally. Tergite 2 mostly shining dark brown to black, with broad lateral and narrow posterior grayish brown pollinose band; covered dorsally with many long, black, hairlike setae; with narrow lateral band of long, pale, hairlike setae. Tergite 3 (Fig. 2A) mostly shining dark brown to black, usually with broad lateral grayish brown pollinose band and narrow posterior silvery pollinose band; covered mostly with black setae; with posterior and lateral bands of white, apically-crinkled, hairlike setae; posterior band narrow, with setae parted at midline, falling over sides of tergite. Tergite 4 (Fig. 2A) almost entirely silvery pollinose; devoid of black; covered with many long, white, apically-crinkled, hairlike setae parted at midline and falling over sides of tergite. Tergites 5 (Fig. 2A) and 6 almost entirely silvery pollinose; devoid of black setae and covered with many short, fine, white setae parted at midline and falling over sides of tergite. Tergite 7 (Fig. 1) sometimes silvery pollinose, but usually largely shining brown except for silvery to grayish brown pollinose anterior V-shaped area and narrow lateral band; covered with many short, fine, recumbent, posteriorly directed, black setae. Sternites 1–3 grayish brown pollinose, except for narrow, silvery pollinose posterior marginal band on sternite 3. Sternites 4–7 silvery pollinose. Sternites 1–4 covered with many long, white, apically-crinkled, hairlike setae; sternites 5–7 with shorter, white, hairlike setae. Sternite 8 shining brown, with narrow posterior band of long, slender, black bristles directed posteriorly.

Epandrium with shallow apical notch, as in Fig. 2B. Gonocoxite with posteroventral lobe broad basally, tapered to rounded apex; apex not surpassing that of anterodorsal lobe. Gonostylus short, not surpassing gonocoxite by distance approximating length of apical gonocoxite lobes (Fig. 2C). Aedeagus smoothly rounded basally (Fig. 2D).

Type Material.—The holotype male is in the Charles A. Triplehorn Insect Collection at Ohio State University. It is labeled "Douglas Co., Kan. 900 ft., F. H. Snow./TYPE [red label]/Erax plenus Hine [handwritten, with black border]." The specimen is 27.4 mm long, and its wings are 15.5 mm long. Tergite and sternite 7 are silvery pollinose. A paratype male in the same collection is labeled "Osborne Co, Kan. 1557 ft., F. X. Williams, Aug. 3, 1912 [date handwritten]/PARATYPE

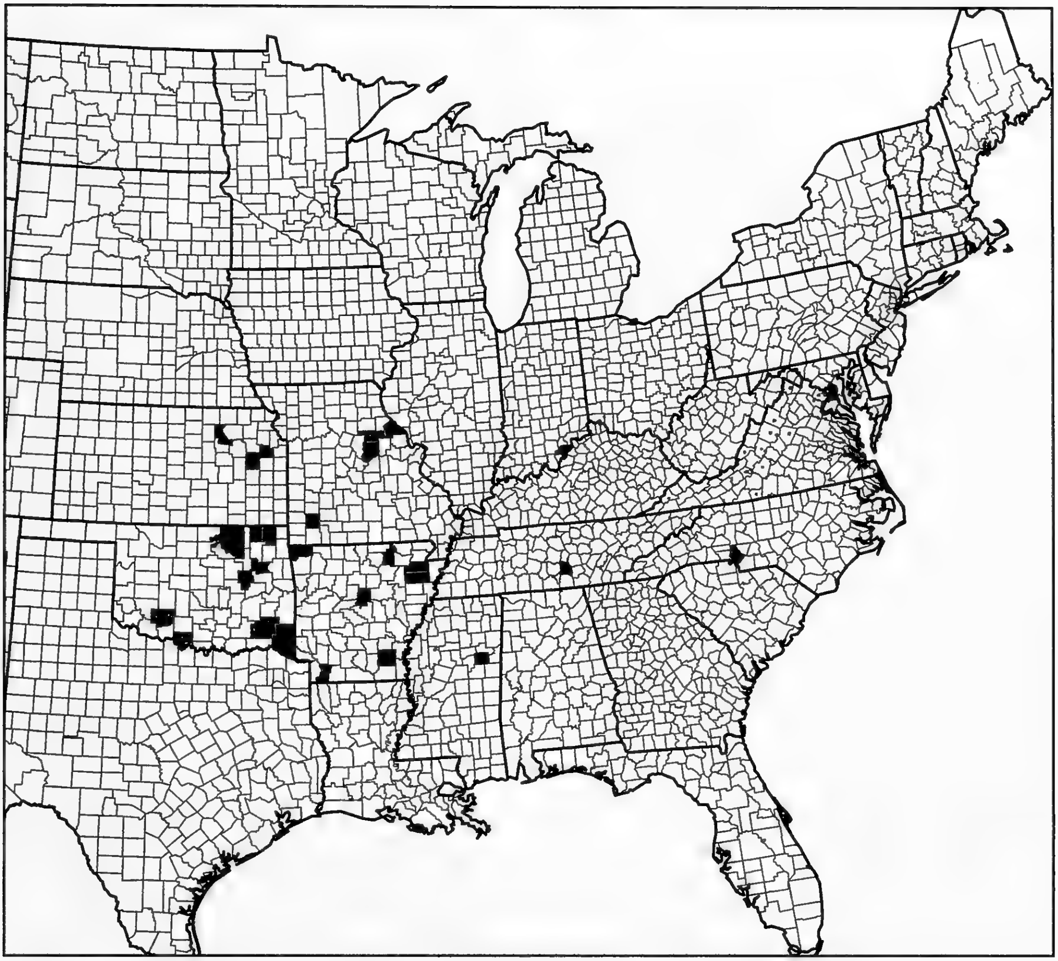


Fig. 3. Distribution of *Efferia plena* by county.

[red label]. It also has a silvery pollinose tergite and sternite 7.

Other specimens examined.—ARKANSAS. Benton Co.: Chesney Prairie Natural Area, near Siloam Springs, 7–12 June 2004, J. K. Barnes (1 ♂, UAAM); 12–18 June 2004, J. K. Barnes (3 ♂, UAAM). Boone Co.: Baker Prairie Natural Area, 2 July 2003, M. D. Warriner (1 ♂, UAAM). Craighead Co.: Bono Bog, 22 May 2003, N. Lavers (1 ♂, UAAM); Hatchie Coon, on mud in overflow area, 1 August 2004, N. Lavers (1 ♂, UAAM); Hatchie Coon, 1 August 2004, N. Lavers (2 ♂, UAAM); Hatchie Coon Wildlife Management Area, tall grass and forbs, 15 July 2004, N. Lavers (1 ♂, UAAM); Jonesboro, 5 June 1964, A. G. Scarbrough (1 ♂, UAAM), 28 June 1964, A. G. Scarbrough (1 ♂, UAAM), 31 May 2004, N. Lavers (1 ♂, UAAM); near Jonesboro, 16 June 1971, A. G. Scarbrough (2 ♂, UAAM). Drew Co.: Seven Devils Wildlife Management Area, understory trail, above swamp, 23 August 2004, H. Raney (1 ♂, UAAM). Faulkner Co.: Bell Slough Wildlife Management Area, 26 May 2003, H. Raney (1 ♂, UAAM); Camp Robinson Wildlife Management Area, 1 June 2003, H. Raney (1 ♂, UAAM). Franklin Co.: Cherokee Prairie Natural Area, 19 May

2003, M. D. Warriner (1 ♂, UAAM). Lafayette Co.: Lafayette Wildlife Management Area, roadcut along fields, 15 August 2004, H. Raney (1 ♂, UAAM). Poinsett Co.: Lake Hogue, 27 June 2004, N. Lavers (1 ♂, UAAM). Sharp Co.: Strawberry River Preserve, in open field near river, 22 May 2004, H. Raney (1 ♂, UAAM).

INDIANA. Clark Co.: State Forest, 13 June 1933, Montgomery (1 ♂, UMMZ).

KANSAS. Clay Co. (1 ♂, OSUC). Douglas Co.: 5 mi. NE of Lawrence, 18 June 1971, V. P. Gapud (1 ♂, SEMC). Osage Co.: 12 June 1923, H. Darby (1 ♂, UAAM), 14 June 1923, H. Darby (1 ♂, UAAM), 16 June 1923, R. H. Beamer (1 ♂, UAAM). Riley Co.: 5 June 1955, W. W. Gibson (1 ♂, KSUC). Pottawatomie Co.: Onaga, 20 August 1901 (1 ♂, OSUC).

MARYLAND. Prince George's Co.: College Park, 9 June 1935, C. T. Greene (1 ♂, USNM).

MISSISSIPPI. Oktibbeha Co.: 3 June 1989, T. L. Schiefer (3 ♂, MEMU); 3 mi. W of Adaton, 20 June 1996, T. L. Schiefer (1 ♂, MEMU), 12 June 1998, T. L. Schiefer (1 ♂, MEMU); 6 mi. SW of Starkville, 6–7 July 1984, R. L. & B. B. Brown (1 ♂, MEMU); Agricultural College, 16 May 1921, W. F. Turman (1 ♂, MEMU); John Starr Memorial Forest, 14 June 1995, D. M. Pollock (1 ♂, MEMU); Longview, 8 June 1919, F. Oswalt (1 ♂, MEMU); State College, 1 May 1940, C. M. Wells (1 ♂, MEMU).

MISSOURI. Audrain Co.: Mexico, 1 August 1993, T. Woods (1 ♂, UMEE). Callaway Co.: Tucker Prairie, 19–20 June 1968 (2 ♂, UMEE), 2–6 July 1968 (5 ♂, UMEE), 8 July 1968 (2 ♂, UMEE), 12 July 1968 (3 ♂, UMEE), 14 July 1968 (1 ♂, UMEE), 18 July 1968 (1 ♂, UMEE). Lawrence Co.: Mt. Vernon, 16 June 1954, W. R. Enns (2 ♂, UMEE). Pike Co.: New Hartford, 24 June 1938, W. S. Craig (1 ♂, USNM).

NORTH CAROLINA. Mecklenburg Co.: Charlotte, 5 June 1927 (5 ♂, USNM).

OKLAHOMA. Comanche Co.: Fort Sill, East Range, Parks Hill, 12 June 2003, J. Owens, J. Schmidt (1 ♂, CSUC); Fort Sill, East Range, nr Hoyle Bridge, pinned with presumed prey: *Colias philodice* Godart, clouded sulphur butterfly, 12 June 2003, J. Owens, J. Schmidt (1 ♂, CSUC). Craig Co.: Bluejacket, 17 June 1931 (1 ♂, OSEC); Centralia, 26 June 1931 (1 ♂, OSEC). Jefferson Co.: Waurika Lake, 13 July 1983, H. C. Reed & J. Nelson (2 ♂, OSEC). McCurtain Co.: Idabel, 9 June 1931, (1 ♂, OSEC). Nowata Co.: Nowata, 28 June 1935, C. A. Sooter (1 ♂, OSEC). Okmulgee Co.: Bryant, 11 June 1934, C. A. Sooter (1 ♂, USNM), 13 June 1934, C. A. Sooter (2 ♂, USNM); Henryetta, 7 June 1934, C. A. Sooter (1 ♂, USNM), 15 June 1934, C. A. Sooter (1 ♂, USNM). Osage Co.: Pawhuska, 3 June 1934, A. E. Pritchard (1 ♂, USNM). Pushmataha Co.: Tuskahoma, 23 May 1928, R. H. Beamer (1 ♂, UAAM).

TENNESSEE. Coffee Co.: Manchester, 20 June 1941, W. S. Craig (1 ♂, UMEE).

TEXAS: Calhoun Co.: Port Lavaca, 12 August 1925 (1 ♂, OSUC).

Distribution (Fig. 3).—Nearctic: United States (Arkansas, Indiana, Kansas, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, Tennessee, Texas). Existing collection records seem to indicate that *E. plena* is relatively rare east of the Mississippi, but abundant in Kansas, Oklahoma, Arkansas, and Missouri. It is tempting to speculate that this is a prairie species that spread eastward with deforestation.

Note.—The mystax and the long ventral hairs of the femora and tibiae usually are golden yellow, although in some specimens they appear to be paler. They are usually distinctly more richly colored than those of *E. nemoralis*.

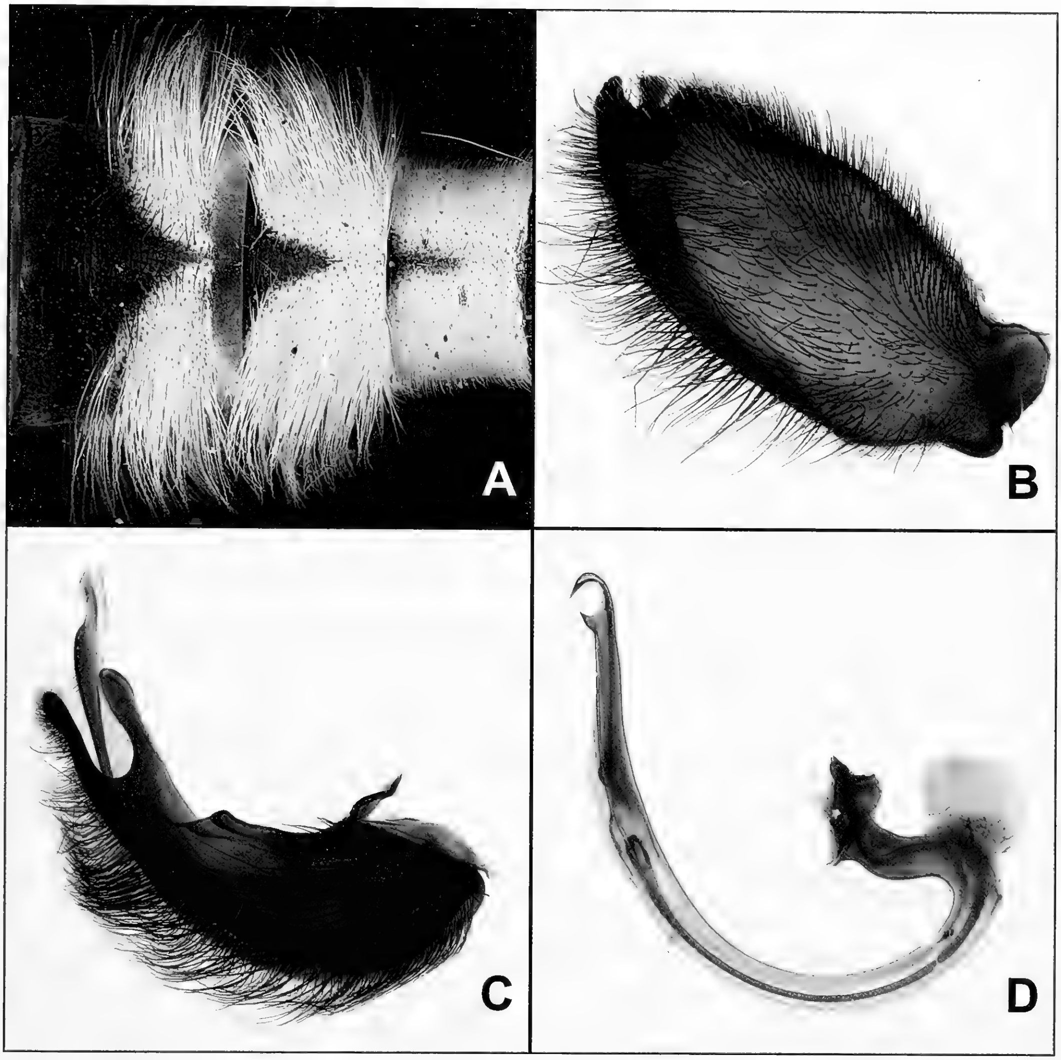


Fig. 4. *Efferia nemoralis*, male. A, Tergites 3–5, left to right, lectotype (Louisiana: Point Coupée Parish, New Roads). B–D, Male genitalia (Arkansas: Hempstead Co. Rick Evans Grandview Prairie). B, Epandrium, right lateral view. C, Gonocoxite and gonostylus, right lateral view. D, Aedeagus, right lateral view.

A specimen from Fort Sill, Comanche Co., Oklahoma is pinned with its presumed prey, an adult clouded sulphur butterfly, *Colias philodice* Godart.

Efferia nemoralis (Hine)
(Figs. 4–5)

Erax nemoralis Hine 1911: 311; Hine 1919: 147.
Efferia nemoralis: Wilcox 1966: 208.
Pogoniefferia nemoralis: Artigas and Papavero 1997: 73.

Male.—*Body length:* 20.5–27.9 mm (mean ± S.D.: 24.2 ± 1.9; N = 49).

Head: Width 1.5 times eye height. Face white tomentose, with large gibbosity about as deep as length of scape extending nearly two-thirds of distance from oral margin to antennal bases. Mystax consisting of long white or slightly yellowed bristles covering entire facial gibbosity, sometimes with 1 or a few black bristles in ventolateral corners. Gena brown, thinly pale pollinose. Frons brown, subshining medially, golden pollinose laterally, with 3–5 long black bristles and patch of many black, shorter, hairlike setae laterally. Vertex, including ocellar tubercle, golden pollinose. Ocellar tubercle bearing 2–4 long, strong, black bristles and several weaker ones. Postcranium white tomentose along ocular margin, with thin pale pollen elsewhere. Dorsal postocular setae black; lateral postocular setae pale yellow or brown. Lower occiput, postgena, and base of labium with dense vestiture of long, slender, white, plumose hairs. Proboscis black; palpus black, with black setae dorsally and apically, white setae ventrally near base. Antenna, including style, 2.2–2.6 mm long, brown; scape setose dorsally, laterally, and ventrally, the setae usually black dorsally, often white laterally and ventrally; pedicel setose apically; first flagellomere attenuate; antennomere to scape ratios 1.0–0.5–0.9–2.1.

Thorax: Cervical sclerites brown, golden pollinose, covered with long, white, plumose hairs. Pronotum sparsely golden pollinose, covered with sparse pile of long, slender pale and black hairs; antepronotum with transverse row of about 11–20 black bristles; postpronotal lobe brown, densely golden pollinose, covered with short, black, erect to reclinate setae. Propleuron brown, golden pollinose; with vestiture of long, declinate, plumose white hairs on anterior portion of proepisternum; declinate golden hairs on posterior portion of proepisternum and anterior portion of proepimeron; and reclinate black hairs on posterior portion of proepimeron. Scutum brown in ground color, covered throughout with vestiture of short or long, black, erect or slightly reclinate setae; postsutural hairs and setae longer than presutural hairs and setae; lateral margin of scutum, in addition to several weaker black setae, with 2–4 strong, black presutural setae and 1–3 strong, black postsutural, supra-alar setae; scutum mostly covered with dense golden pollen except for pair of broad, posterolateral, thinly pollinose or bare patches, each divided by narrow line of pollen along transverse suture, and pair of thinly pollinose, central, brown vittae extending from pronotum to region just posterior to transverse suture, the pair separated by narrow line of golden pollen along mid-dorsal line of scutum. Postalar callus densely golden pollinose, covered with short black setae and 2–4 long, strong black bristles. Scutellum convex, brown, golden pollinose, with 6–10 strong, long, erect, black marginal bristles and short black setae on disc. Mediotergite brown, thinly pollinose; anatergite gray pollinose; katatergite gray pollinose, with dense fan of long black and pale bristles. All mesopleural sclerites brown, at least partly golden or gray pollinose. Anepisternum with long, fine, golden to dark brown, apically-crinkled hairs along anterior, dorsal and posterior margins; anterior and dorsal hairs erect; posterior hairs reclinate. Anterior basalare brown, thinly pollinose, with long, fine, black, apically-crinkled hairs along anterior margin; posterior basalare yellowish brown, silvery pollinose. Katepisternum with long, fine, black, apically-crinkled hairs posterodorsally. Anepimeron with few long, fine, black or pale, apically-crinkled hairs posteriodorsally. Katepimeron and meron lacking setae or hairs. Basal swelling of pleural wing process silvery pollinose. Subalar sclerite brown. Metepisternum golden pollinose, covered with several long, fine, black or pale, apically-crinkled hairs and dense crescentic patch of short brown hairs posteroventrally. Metepimeron gray pollinose, with very fine, apically-crinkled, erect white to golden hairs.

Legs: Coxae brown in ground color, gray to golden pollinose; forecoxa densely covered with long, white, declinate bristles anteriorly; midcoxa with long, white, declinate bristles anteroventrally and longer, stronger, white to pale golden bristles laterally; hind coxa with sparse, fine, long, apically-crinkled, white hairs anterolaterally and posteriorly and about 3 long black to pale bristles posterolaterally. Femora dark brown to black, subshining. Forefemur lacking stout bristles, with many long, black hairlike setae dorsally, anteriorly, and ventroapically, and with many long, pale, hairlike setae posteriorly and ventrally near base, these ventral setae much longer than others. Midfemur similar to forefemur, but with anteroventral and posteroventral rows of 4–5 stout, black bristles and 1–2 stout, black bristles on basal half of anterior face. Hind femur with many short yellow setae anterodorsally on basal three-fourths; many long, pale, apically-crinkled, hairlike setae posteroventrally; ventral row of 5–9 stout black bristles; and anterior row of 4–5 stout black bristles. Tibiae yellowish brown, darkened at apices. Foretibia with many long, pale, apically-crinkled, hairlike setae posteroventrally; dense brush of short, fine, golden hairs anteroventrally; rows of stout, black bristles anterodorsally and posterodorsally; and circle of several stout, black bristles at apex. Midtibia with many long, pale, apically-crinkled, hairlike setae ventrally; row of 4–6 stout black bristles posterodorsally; and circle of several stout, black bristles at apex. Hind tibia with many long, pale, apically-crinkled, hairlike setae ventrally; dense, elongate patch of short golden setae posterodorsally; and stout black bristles as follows: 1 anterodorsally and 1 posterodorsally near base, 1 anterodorsally at about midlength, 1 anteriorly at about apical fourth, 2 anteroventrally along apical third, and 5 circling apex except posterodorsally. Tarsi uniformly brown; length of first tarsomere about 1.3–1.4 times length of second and third combined. All claws black with brown base. All pulvilli pale yellow.

Wing: 13.7–18.8 mm long (mean ± S.D.: 15.8 ± 1.0; N = 49). Lightly infuscated; more heavily infuscated in subcostal cell. Halter with stem and knob yellow.

Abdomen: Tergites dark brown to black in ground color. Tergite 1 brown in ground color; covered with grayish brown pollen and fine black setae throughout; with 5–8 stout black bristles and several long, pale, apically-crinkled hairlike setae posterolaterally. Tergite 2 mostly shining dark brown to black, with broad lateral and narrow posterior grayish brown pollinose band; covered dorsally with many long, black, hairlike setae; with narrow lateral band of long, pale, hairlike setae. Tergite 3 (Fig. 4A) shining dark brown to black dorsally on anterior half; with broad silvery pollinose band laterally and along posterior half, V-notched at midline; almost devoid of black setae and bearing many long, white, apically-crinkled, hairlike setae parted at midline and falling over sides of tergite. Tergite 4 (Fig. 4A) mostly silvery pollinose except for anterior, mid-dorsal V-notch; devoid of black setae and covered with many long, white, apically-crinkled, hairlike setae parted at midline and falling over sides of tergite. Tergites 5 (Fig. 4A) and 6 mostly silvery pollinose except for usually brown mid-dorsal line or V-notch; devoid of black setae and covered with many short, fine, white setae parted at midline and falling over sides of tergites. Tergite 7 largely shining brown except for silvery pollinose anterodorsal V-shaped area and narrow lateral band; covered with many short, fine, recumbent, posteriorly directed, black setae. Sternites 1 and 2 brownish gray pollinose, except for narrow, silvery pollinose posterior marginal band on sternite 2. Sternites 3–7 silvery pollinose. Sternites 1–4 covered with many long, white, apically-crinkled, hairlike setae; sternites 5–7 with shorter, white, hairlike setae. Sternite 8 shining brown, with narrow posterior band of

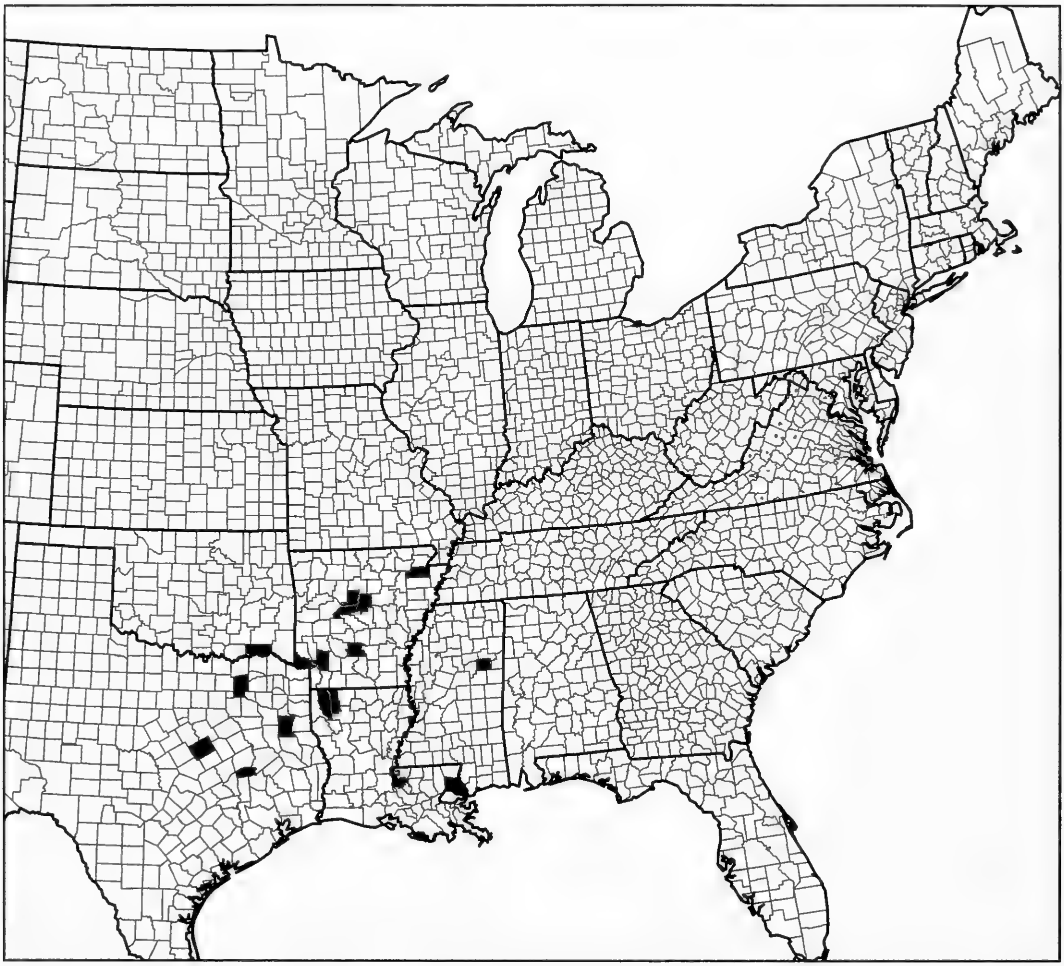


Fig. 5. Distribution of *Efferia nemoralis* by county and parish.

long, slender, black bristles directed posteriorly.

Epandrium with deep apical notch, as in Fig. 4B. Gonocoxite with posteroventral lobe narrow, more or less parallel-sided; apex surpassing that of anterodorsal lobe. Gonostylus long, surpassing gonocoxite by distance approximating length of apical gonocoxite lobes (Fig. 4C). Aedeagus sharply hooked and somewhat sigmoid basally (Fig. 4D).

Type material.—None of the female syntypes were found. One specimen from a syntype series of four males located at the Ohio State University Insect Collection is hereby designated lectotype for clarification and to ensure stabilization in nomenclature. It is labeled "New Roads, La, July 14–18'05/Jas. S Hine, Collector/COTYPE" [red label]/*Erax nemoralis* Hine [handwritten, with black border]/Lectotype Male [red type], Diptera: Asilidae, *Efferia nemoralis* (Hine)/ designated by, J. K. Barnes [red border]." New Roads, Louisiana, is located in Point Coupée Parish. The lectotype abdomen is mounted on a paper point, and the dissected genitalia are in a microvial, both attached to the same pin that holds the main body of the lectotype. Paralectotypes, 3 males, United States: "New Roads, La, July 14–18'05/Jas. S

Hine, Collector/COTYPE [red label]/ Paralectotype Male [red type], Diptera: Asilidae, *Efferia nemoralis* (Hine)/det. J. K. Barnes [red border]." The lectotype and paralectotypes range in length from 24.4 to 25.0 mm; their wings range from 15.1 to 16.5 mm long. The lectotype wing is 16.5 mm long.

Other specimens examined.—ARKANSAS. Conway Co.: Pointe Remove, 27 July 2003, H. Raney (1 ♂, UAAM). Craighead Co.: Hatchie Coon, 18 July 2003, N. Lavers (1 ♂, UAAM), 24 August 2003, N. Lavers (1 ♂, UAAM). Dallas Co.: sweepings, 15 August 1960, P. Deema (1 ♂, UAAM). Faulkner Co.: Camp Robinson, 21 July 2003, B. Baldwin (1 ♂, UAAM); Camp Robinson Wildlife Development Area, 26 July 2003, (1 ♂, UAAM). Hempstead Co.: cotton, 1 July 1959, (1 ♂, UAAM); sweepings, 10 August 1960, P. Deema (1 ♂, UAAM); Rick Evans Grandview Prairie, 400 ft., 25 May–2 June 2004, J. K. Barnes (1 ♂, UAAM), 2–14 June 2004, J. K. Barnes (1 ♂, UAAM), 18 June–2 July 2004, J. K. Barnes (3 ♂, UAAM), 26 August–7 September 2004, J. K. Barnes (1 ♂, UAAM). Little River Co.: weeds, 4 July 1961, (2 ♂, UAAM). Perry Co.: Harris Brake Wildlife Management Area, 19 July 2003, H. Raney (1 ♂, UAAM).

LOUISIANA. Bossier Parish: Barksdale Air Force Base, 3 June 1998, D. M. Pollock (3 ♂, MEMU). St. Tammany Parish: Madisonville, 11 June 1951, P. Beamers (1 ♂, SEMC). Webster Parish: Lake Bistineau State Park, 22 May 1996, M. MacGown (1 ♂, MEMU).

MISSISSIPPI. Oktibbeha Co.: Starkville, 22 June 1982, R. L. Brown (1 ♂, MEMU); State College, July 1948, Simmons (1 ♂, MEMU).

OKLAHOMA. Choctaw Co.: Hugo, 20 June 1934, A. E. Pritchard (1 ♂, USNM).

TEXAS. Hunt Co.: Greenville, 10 June 1935, (2 ♂, TAMU), 13 June 1935, (6 ♂, TAMU; 2 ♂, USNM). Madison Co.: 21 June 1931, Bibby & Tate (1 ♂, TAMU); S. Bromley (1 ♂, USNM). McLennan Co.: Waco, 22 June 1948, P. A. Glick (1 ♂, USNM). Rusk Co.: Tatum, 8 June 1949, D. J. & J. N. Knull (1 ♂, OSUC). Co. unknown: Liberty, 10 June 1934 (8 ♂, TAMU).

Distribution (Fig. 5).—Nearctic: United States (Arkansas, Louisiana, Mississippi, Oklahoma, Texas).

Note.—The mystax and the long ventral hairs of the femora and tibiae are usually straw yellow, although in some specimens they appear to be sordid white. They are usually distinctly paler than in specimens of *E. plena*.

ACKNOWLEDGMENTS

I am grateful to Norm Lavers of Joneboro, Arkansas, for drawing my attention to the problem that is the subject of this paper and to Eric Fisher, California Department of Food and Agriculture, Sacramento, for discussions concerning the genus *Efferia*. Eric Fisher, Torsten Dikow (Cornell University and American Museum of Natural History), and an anonymous reviewer provided thoughtful suggestions that materially improved the manuscript. The following individuals donated specimens used in this study: Norm Lavers, Herschel Raney (Conway, Arkansas), and Aubrey Scarbrough (Towson University, Maryland). The following individuals provided loans of specimens: Boris Kondratieff (CSUC); Terence Lee Schiefer (MEMU); F. Christian Thompson (USNM); Luciana Musetti and Creighton Freeman (OSUC); Don. C. Arnold (OSEC); Gregory Zolnerowich (KSUC); Edward G. Riley (TAMU); Zachary H. Falin (SEMC); Mark F. O'Brien (UMMZ); and Robert W. Sites (UMEE).

LITERATURE CITED

Artigas, J. N. and N. Papavero. 1997. The American genera of Asilidae (Diptera): keys for identification with an atlas of female spermathecae and other morphological details. IX.2. Subfamily Asilinae Leach – *Efferia*-group, with the proposal of five new genera and a catalogue of the Neotropical species. Arquivos de Zoologia 34(3): 65–95.

Bromley, S. W. 1951. Asilid notes (Diptera), with descriptions of thirty-two new species. American Museum Novitates 1532. 36 pp.

Bullington, S. W. and R. J. Lavigne. 1984. Description and habitat of *Efferia kondratieffi* sp. nov. with notes on *Efferia aestuans* (L.) (Diptera: Asilidae). Annals of the Entomological Society of America 77(4): 404–413.

Coquillett, D. W. 1893. A new asilid genus related to *Erax*. Canadian Entomologist 25: 175–177.

———. 1910. The type-species of the North American genera of Diptera. Proceedings of the United States National Museum 37: 499–647.

Forbes, G. S. 1987. The status of *Efferia similis* (Williston), with descriptions of three new Nearctic *Efferia* species in the *albibarbis* group (Diptera: Asilidae). Pan-Pacific Entomologist 63(3): 292–300.

———. 1988. Three new species of *Efferia* from southern California and Arizona (Diptera: Asilidae). Annals of the Entomological Society of America 81(4): 554–559.

Geller-Grimm, F. 2003. A world catalogue of the genera of the family Asilidae (Diptera). Studia dipterologica 10(2): 473–526.

Hine, J. S. 1911. New species of Diptera of the genus *Erax*. Ohio Naturalist 11(6): 307–311.

———. 1916. Descriptions of robber flies of the genus *Erax*. Ohio Journal of Science 17(1): 21–22.

———. 1919. Robberflies of the genus *Erax*. Annals of the Entomological Society of America 12: 103–154.

Hull, F. M. 1962. Robber flies of the world: The genera of the family Asilidae. Part 2. United States National Museum Bulletin 224(2): 433–907.

Macquart, J. 1838. Diptéres exotiques nouveaux ou peu connus, volume 1, part 2. Paris. 207 pp.

Martin, C. H. 1961. The misidentification of *Erax* Scopoli in the Americas. Journal of the Kansas Entomological Society 34(1): 1–4.

———. 1965. Distribution patterns and corrected identifications of asilid species reported as common to North and South America (Diptera: Asilidae). Transactions of the American Entomological Society 91: 1–37.

Martin, C. H. and N. Papavero. 1970. Family Asilidae. A catalogue of the Diptera of the Americas south of the United States, fascicle 35b. Museu de Zoologia, Universidada de São Paulo, Brazil. 139 pp.

Martin, C. H. and J. Wilcox. 1965. Family Asilidae, pp. 360–401. *In* Stone, A., C. W. Sabrosky, W. W. Wirth, R. H. Foote, and J. R. Coulson, eds. A Catalog of the Diptera of Amercia North of Mexico. United States Department of Agriculture, Agriculture Research Service, Agriculture Handbook 276. 1696 pp.

McAlpine, J. F. 1981. Morphology and terminology – Adults, pp. 9–63. *In* McAlpine, J. F., et al., eds. Manual of Nearctic Diptera, volume 1. Research Branch Agriculture Canada Monograph 27. 674 pp.

Poole, R. W. 1996. Diptera, pp. 15–604. *In* Poole, R. W. and P. Gentili, eds. Nomina Insecta Nearctica: A Check List of the Insects of North America, volume 3. Diptera, Lepidoptera, Siphonaptera. Entomological Information Services, Rockville, Maryland. 1143 pp.

Scarbrough, A. G. 1972. Records of robber flies from northeastern Arkansas. Proceedings of the Entomological Society of Washington 74(4): 375–378.

Wilcox, J. 1966. *Efferia* Coquillett in America north of Mexico (Diptera: Asilidae). Proceedings of the California Academy of Sciences 34(2): 85–234.

Williston, S. W. 1891. Catalogue of the described species of South American Asilidae. Transactions of the American Entomological Society 18: 67–91.

Whitcomb, W. H. and K. Bell. 1964. Predaceous insects, spiders, and mites of Arkansas cotton fields. University of Arkansas Agricultural Experiment Station Bulletin 690, 84 pp.

Wood, G. C. 1981. Asilidae, pp. 549–573. *In* McAlpine, J. F., et al., eds. Manual of Nearctic Diptera, volume 1. Research Branch Agriculture Canada Monograph 27. 674 pp.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 223–239

REVIEW OF THE GENUS *MENGENILLA* HOFENEDER 1910 (STREPSIPTERA: MENGENILLIDAE), WITH DESCRIPTION OF A NEW SPECIES FROM MADAGASCAR

JERRY L. COOK

Department of Biological Sciences, Sam Houston State University, Huntsville, TX 77341-2116, U.S.A. (e-mail: bio_jlc@shus.edu)

Abstract.—The genus *Mengenilla* Hofeneder 1910 is considered the most primitive, extant group within the Strepsiptera. With the description herein of ***Mengenilla leucomma*, n.sp.**, from Madagascar there are 19 described species included in this genus, ten of which are now considered valid. However, there is some question as to the status of several species that have been placed previously as synonyms of the type species *Mengenilla chobauti* Hofeneder. Many of these questionable species are linked by their sharing a common host, but there are considerable differences in some characters. This problem is discussed but currently cannot be resolved because of the lack of specimens available for further analysis. The species and history of the genus are reviewed and many characters are illustrated. A revised key is provided that includes all currently recognized species.

Key Words: Mengenillidae, *Mengenilla*, key

Strepsipterans in the genus *Mengenilla* Hofeneder 1910 are part of what is considered the most primitive extant family, Mengenillidae (Kinzelbach 1991, Pohl 2002). Mengenillidae includes the only living strepsipterans whose adult females, as well as adult males, are free-living. Additional plesiomorphic characters include five-jointed tarsi, inwardly directed mandibles, a round head capsule, presence of abdominal stigmata, adult female with only one genital opening, and adult male with a straight aedeagus (Kathirithamby 1989).

The genus *Mengenilla* and family Mengenillidae were proposed by Hofeneder (1910) for a new strepsipteran species collected in Algeria by Dr. A. Chobaut. Since this original description, an additional 16 species and one subspecies have been named. Eight of these species and one subspecies were synonymized with *Mengenilla chobauti* Hofeneder 1910 by Kinzelbach (1970). This, and subsequent descriptions, resulted in nine recognized species prior to the species described herein.

Little is known about the biology and natural history of any *Mengenilla* species. Males are known for all currently recognized species, but females have been described for only two species. Larvae also are known for only two of the presently recognized species. The host of only two *Mengenilla* species has been discovered; *M. chobauti* utilizes *Ctenolepisma ciliata* (Dufour) (Thysanura, Lepismatidae) (Silvestri 1941b, 1943) and *Mengenilla parvula* (Silvestri) utilizes *Ctenolepisma michaelseni* Escherich (Silvestri 1942, 1943). It is presumed that all other species in *Mengenilla* use thysanurans as hosts (Kathirithamby 1989). Silvestri (1943) provided some information on the developmental stages of *M. chobauti*, which he had described as six different species (these were later synonymized by Kinzelbach (1970)). Silvestri (1940, 1941a) also documented observations of reproductive behavior. Parasites of *Mengenilla* have been documented by Kinzelbach (1969), who found a mermithid nematode parasitizing the male imago of *Mengenilla parvula* Silvestri 1941; and Silvestri (1943) described a hymenopteran hyperparasite, *Lochites gregarius* (Torymidae), parasitizing *Mengenilla quaesita* Silvestri 1933 (= *M. chobauti*).

Genus *Mengenilla* Hofeneder

Mengenilla Hofeneder 1910: 34. Type species: *Mengenilla chobauti* Hofeneder 1910: 34, by monotypy.

Austrostylops Lea 1910: 514. Type species: *Austrostylops gracilipes* Lea, original description (location of type unknown). Synonymy by Silvestri (1946).

Tetrozocera Pierce 1918: 428. Type species: *Tetrozocera santchii* Pierce, original description (type deposited in the National Museum of Natural History, Smithsonian Institution (USNM No. 21434)). Synonymy by Silvestri (1933).

Mengenillopsis Hofeneder 1926: 56. Type species: *Mengenillopsis theryi* Hofeneder, original description (type deposited in The Natural History Museum, London). Synonymy by Silvestri (1943).

Hofeneder (1910) recognized that his newly described genus was related to the genus *Mengenea* (Menge), in the family Mengeidae Pierce (1908), but distinctly different enough to place it in a new family, Mengenillidae. Major visible differences are that members of Mengenillidae have a six-segmented antenna, as opposed to seven in Mengeneidae; the prementum is fused to the hypopharynx in Mengenillidae, but free in Mengeidae; and Mengeidae have a cell in the wing formed by MP + CuA and the front branch of MA is absent, with this branch present in Mengenillidae. Lea's (1910) description of *Austrostylops* was published in the same year, but after that of Hofeneder, giving Hofeneder's genus name, *Mengenilla* (and family name, Menginillidae) priority. However, it is interesting that Lea had collected his specimens in 1895 but did not describe them until after he read Pierce's (1909) monograph of the Strepsiptera. Hofeneder (1926, 1928) described the genus *Mengenillopsis* for two new species, *Mengenillopsis theryi* and *Mengenillops mauretanica*, but these were later synonymized with *M. chobauti* making the genus *Mengenillopsis* likewise a synonym of *Mengenilla* (Silvestri 1943). Other genera in Mengenillidae include *Eoxenos* Peyerimhoff 1919 and *Congoxenos* Kinzelbach 1972, both of which differ from *Mengenilla* by lacking a flabellum on the fifth antennal segment.

Diagnosis of *Mengenilla*.—Males with six-segmented antennae, flabella on the third through fourth segments. Vertex, frons, and clypeus fused to form one sclerite. Mandibles robust, crossed, curved inward apically. Maxilla with single palpus. Simple pro- and mesosternum. Metacoxae not fused medially. Tarsi five-segmented, without sensory spots, with single pair of claws. Wing with MA_1 elongated and sturdy. Aedeagus relatively straight, with pointed apex (Hofeneder 1910; Kinzelbach 1970; Kathirithamby 1989).

Females are free-living as adults. Head with three- to four-segmented antennae. Tarsi two to three segmented, with claws. Single genital pore on seventh abdominal segment (Silvestri 1933, 1943; Kinzelbach 1970; Kathirithamby 1989).

First instar larvae of *Mengenilla* share one apomorphy with other known Mengenillidae, fused abdominal segments nine and ten, which separates them from species of other families (Pohl 2002).

Identification keys.—Identification keys were published previously by Silvestri (1941b, 1943); Kinzelbach (1979); and Kifune and Hirashima (1980). The following key utilizes some of the same characters, but some previously used characters (such as total length) proved to be unreliable with the discovery of new specimens. Figs. 3, 5, and 6 illustrate the aedeagus, mandible, and maxilla, respectively, of most species. However, caution should be used in relying solely on these single characters for identification because there is variation and they are often difficult to properly view in some specimens.

KEY TO SPECIES OF *MENGENILLA*

1. Antennae relatively short (less than 2 times head length); flabella somewhat rounded (Fig. 2C and 4A) 2
- Antennae relatively long (greater than 2 times head length); flabella somewhat pointed (Fig. 2D and 4B) 5
2. Anterior of head concave, with antennae appearing to attach to the front of the head (Fig. 4A); Sri Lanka . . . . *M. orientalis*
- Antennae of thead convex or transverse, antennae not appearing to attach to the front of the head (Fig. 2A) 3
3. R$_2$ of hind wing close to and appearing almost in line with R$_1$, not halfway between R$_1$ and R$_3$ (Fig. 1A) 4
- R$_2$ of hind wing approximately halfway between R$_1$ and R$_3$ (Fig. 1C); Kazakhstan . . . . *M. marikovskii*
4. Eye with around 30 facets; maxillae with pronounced lappet (Fig. 6B); Australia . . . . *M. australiensis*
- Eye with around 60 facets; maxillae with a small lappet at most (Fig. 6I); China . . . . *M. sinensis*
5. Eye distinctly two toned, dorsal region of eye white to light tan, rest of eye brown; Madagascar . . . *Mengenilla leucomma*, n. sp.
- Eye uniformly colored, usually brown to yellow brown 6
6. Eye with less than 30 facets; maxilla without lappet; aedeagus with somewhat bulbous base (Fig. 3E); Australia. . . . . *M. gracilipes*
- Eye with more than 30 facets; maxilla with or without a lappet; aedeagus with or without a bulbous base 7
7. Total length less than 3 mm; eye with less than 40 facets; maxilla without a conspicuous lappet (Fig. 6H), mandible broad at base, apical $\frac{1}{3}$ without microtrichia (Fig. 5H); Italy (Sicily) . . . . *M. parvula*
- Not matching all the above characters . . . 8
8. Anterior of head narrowed, with antennae appearing to emerge between eyes and anterior end (Fig. 2B); eyes protruding from sides of head 9
- Anterior of head rounded, antennae appearing to be attached near anterior margin; Eyes only slightly protruding from head; Algeria, Morocco, Italy, Spain, Portugal, Malta . . . . *M. chobauti*
9. Microtrichia extending almost to tip of mandible and 4 times as long as wide (Fig. 5C); Saudi Arabia . . . . . . *M. arabica*
- Microtrichia extending about half way to tip of mandible and more than 4 times as long as wide (Fig. 5D); Mongolia. . . . . *M. kaszabi*

SPECIES OF *MENGENILLA*

Mengenilla arabica Kinzelbach 1979 (Figs. 3A, 5A, 6A)

Mengenilla arabica Kinzelbach 1979: 331.

Kinzelbach described *M. arabica* from one male collected in 1977 by Dr W. Büttiker in Jeddah, Saudi Arabia (labeled as Dschidda, German for Jeddah). The holotype (examined) is deposited in Naturhistorisches Museum Basel (Bearbeitungs – Nr. 1187), and is slide-mounted in Canadian balsam. This specimen is 2.8 mm in total length. The mandible is narrow, approximately 155 μm, and is covered with microtrichia except for a distal portion, which is lightly sclerotized (Fig. 5A). The maxilla is covered with microtrichia; the palp, which appears as a second segment, is not attached to the apical end of the fused cardo and stipes (first segment), thus forming a lappet (Kifune and Hirashima 1980) and the length of the basal segment (70 μm) is slightly shorter than that of the second segment (95 μm)

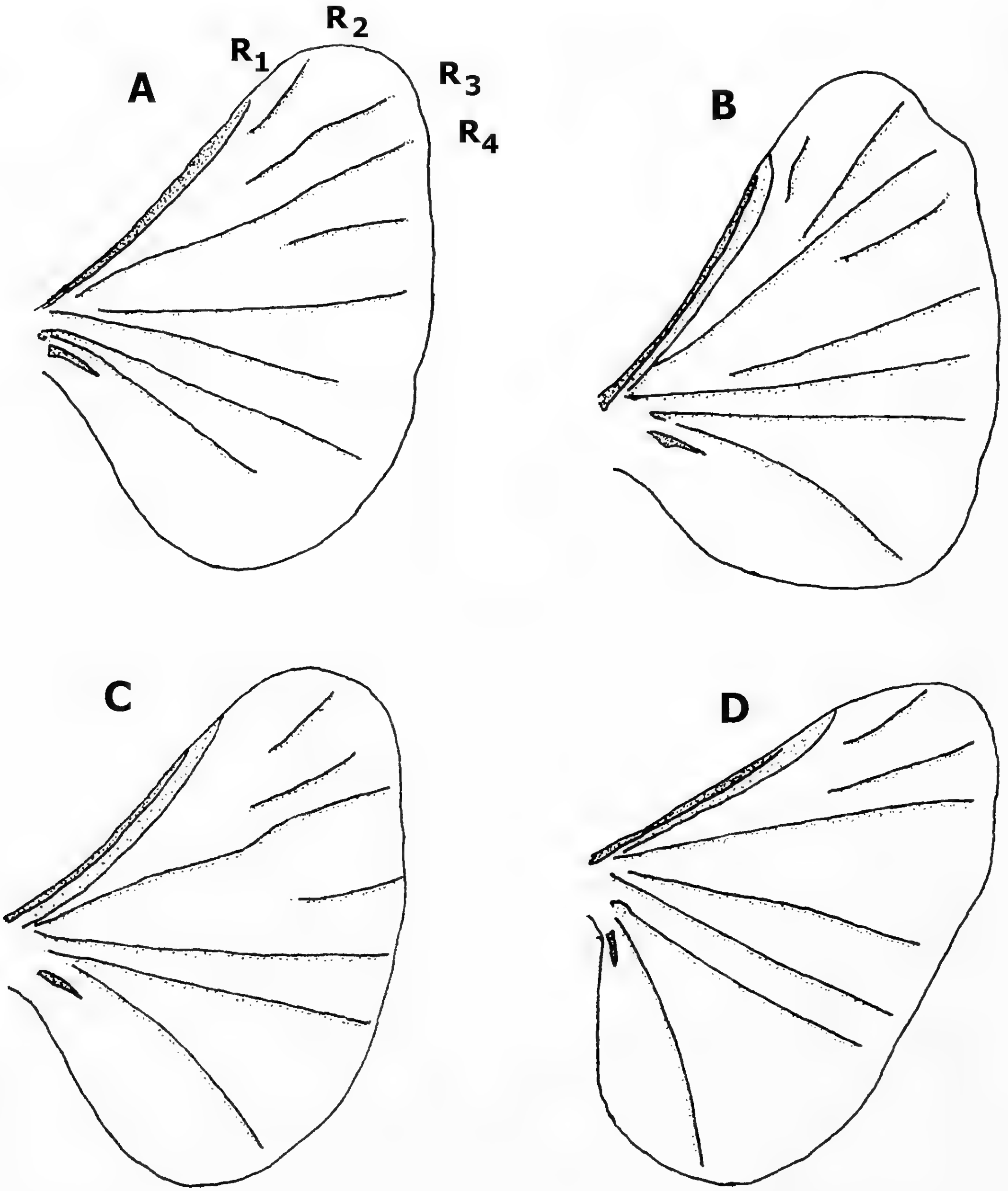


Fig. 1. Wings. A, *Mengenilla australiensis* (redrawn after Kifune and Hirashima 1983). B, *M. kaszabi* (redrawn after Kinzelbach 1971). C, *M. marikovskii* (redrawn after Medvedev 1970). D, *M. chobauti.*

(Fig. 6A). However, the lappet can easily go unnoticed if viewed from the wrong angle. The eyes of the holotype have 38 ± 1 ommatidia. The antennae have all flabella terminating at about an equal distance from the antennal base, and a sensory spot (Hofeneder organ) near the base of the second flabellum (segment IV). All flabella are approximately equal in length. The antenna is approximately 480 μm. The aedeagus is relatively thick, tapering, but not bulbous at

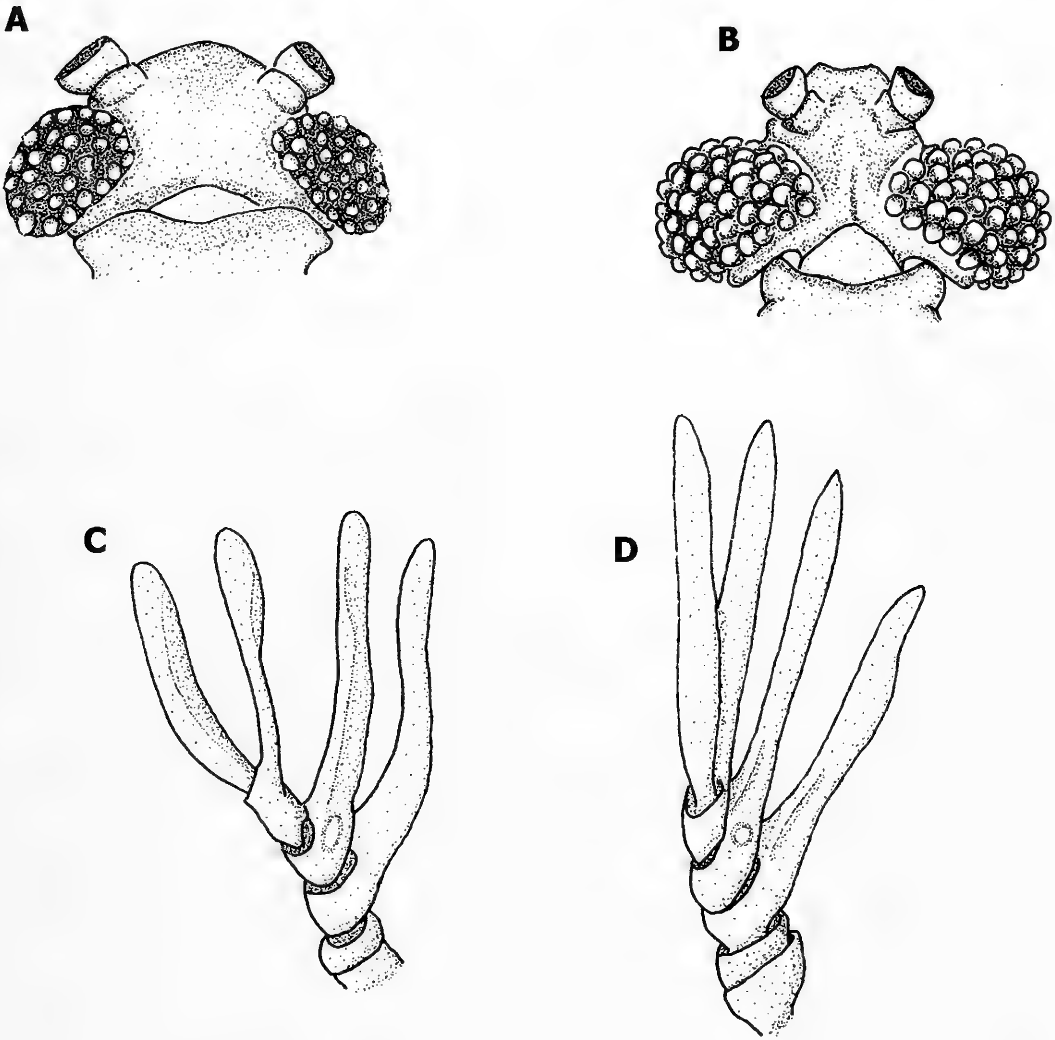


Fig. 2. Heads, with antennal segments III–VI removed. A, *Mengenilla australiensis*. B, *M. kaszabi*. Antennae. C, *Mengenilla australiensis* (redrawn after Kifune and Hirashima 1983). D, *M. kaszabi* (redrawn after Kinzelbach 1971).

the base (Fig. 3A), and is about 140 μm in length. Illustrations of the thorax and legs are found in Kinzelbach (1979).

Additional male specimens have been collected since the original description. I examined three additional specimens collected in Saudi Arabia that are deposited in Naturhistorisches Museum Basel, one of which has been noted by Kinzelbach (1980). These differed from the holotype primarily in size, ranging from 3.0 to 3.4 mm, and in number of ommatidia, all being around 50. All were collected in Saudi Arabia (Wadi Turabah camp 2, 7–18 X 1979, W. Büttiker; Hofuf, 5 XII 1982, A. S. Talhouk; Fifa, 1 IV 1983, A. S. Talhouk). Additionally, Al-Houty (1989) reports the collection of six additional males collected from Sulabiya, Saudi Arabia in 1983, but does not give any physical description or deposition location of specimens.

Knowledge of the variation of male characters in light of the additional known specimens makes the keys by Kinzelbach (1979) and Kifune and Hirashima (1980) obsolete. These keys utilized size as the first deciding characteristic, dividing species into those less than 3 mm and more than 3 mm. The addition specimens of *M. arabica* currently establishes a known range of 2.8 to 3.4 mm. Size may be highly variable in this species and throughout the genus, and is probably not a good character by which to define species.

The female, larvae, and host of *M. arabica* are unknown. Kinzelbach (1979) questioned whether this species was using *Ctenolepisma* as a host species, as other *Mengenilla* whose hosts are known, due to the arid habitat type around Jeddah, Saudi Arabia.

Mengenilla australiensis Kifune and Hirashima 1983
(Figs. 1A, 2A, 3B, 5B, 6B)

Mengenilla australiensis Kifune and Hirashima 1983: 157.

Kifune and Hirashima described *M. australiensis* from two specimens collected at blacklight by G. F. Hevel and J. A. Fortin and deposited the Smithsonian Institution, National Museum of Natural History, Department of Entomology (examined). The type locality is 8 km north of Kulgera, N. T., Australia. The type and paratype are 3.14 and 3.10 mm respectively. Total length is between 3.10 and 3.14 mm. The head is somewhat different than the normal trapezoidal shape found in most members of the genus (Fig. 2A). The anterior of the head, between antennal segments, is convex and the distance between the eyes is relatively large (250 µm space between eyes, head width at eyes is approximately 730 µm). The eyes have approximately 60 ommatidia. The flabella of the antennae protrude about an equal distance away from the base of the antennae, making the third flabellum (antennal segment V) shorter than the other two. The Hofeneder organ is present on the inside of the second flabellum (antennal segment IV). The mandible is 400 µm and covered with microtrichia except at the apex. (Fig. 5B). The maxillary palp forms a lappet, but is relatively close to the apex of the fused cardo and stipes (1st segment), both segments are approximately equal in length (about 330 µm), and both segments are covered with microtrichia (Fig. 6B). The sclerite of the labrum is free as noted by Beutel and Pohl (2006), but it is very difficult to distinguish with a dissecting microscope. The prothorax has a pronounced concave anterior margin and is slightly narrower than the mesothorax. The aedeagus is slightly curved and bulbous at the base (Fig. 3B). Line drawings were provided by Kifune and Hirashima (1983).

The female and host are unknown. This is one of two species known from Australia, however Reik (1970) stated that members of this family are widespread, and at least eight species exist. I have not seen specimens to validate this statement.

Mengenilla chobauti Hofeneder 1910
(Figs. 1D, 3C, 5C, 6C)

Mengenilla chobauti Hofeneder 1910: 34.
Tetrozocera santchii Pierce 1918: 429.
Mengenillopsis theryi Hofeneder 1926: 56.
Mengenillopsis mauretanica Hofeneder 1928: 195.
Mengenilla quaesita Silvestri 1933: 2.
Mengenilla spinulosa Silvestri 1940: 614.
Mengenilla nigritula Silvestri 1941b: 58.
Mengenilla subnigrescens Silvestri 1941b: 58.
Mengenilla laevigata Silvestri 1941b: 58.
Mengenilla nigritula quadriarticulata Luna de Carvalho 1953: 2.

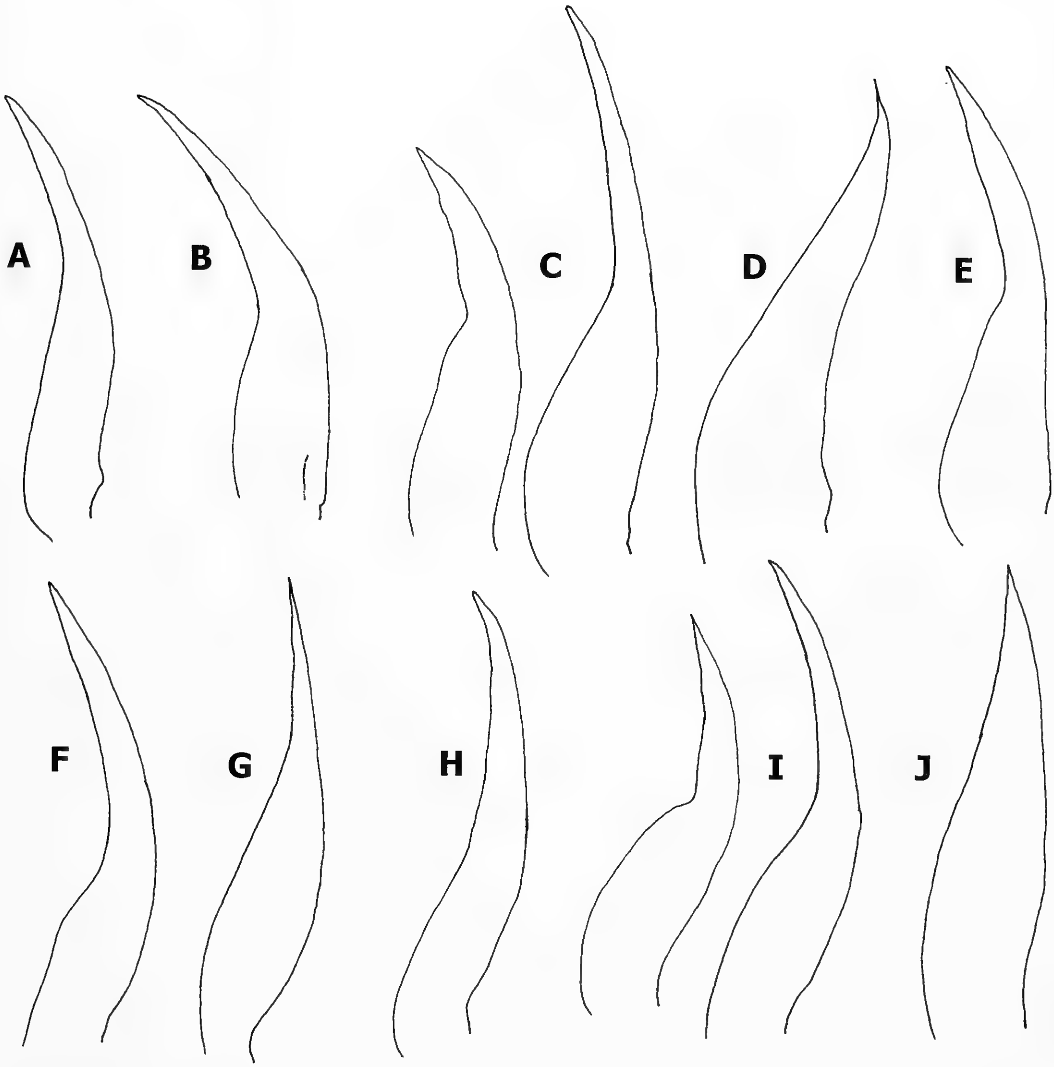


Fig. 3. General shape of the aedeagus. A, *Mengenilla arabica* (redrawn after Kinzelbach 1979). B, *M. australiensis*. C, *M. chobauti* (redrawn after Kinzelbach 1971). D, *M. gracilipes* (redrawn after Kinzelbach 1971). E, *M. kaszabi* (redrawn after Kinzelbach 1971). F, *M. leucomma*. G, *Mengenilla marikovskii* (redrawn after Medvedev 1970). H, *M. orientalis* (redrawn after Kifune and Hirashima 1980). I, *M. parvula* (redrawn after Kinzelbach 1971). J, *M. sinensis* (redrawn after Miyamoto 1960 and Kinzelbach 1971). Note that there is variability within species and some figures represent an average shape for each species; where large variation is known two figures are illustrated to show the range in variation.

Hofeneder (1910) described *M. chobauti* from material collected by A. Chobaut in Algeria. The holotype (not observed) was originally kept in the collection of A. Chobaut and is now probably in Muséum d'Histoire Naturelle, Paris (Kinzelbach 1970). Subsequently, eight species and one subspiecies have been named and later declared junior synonyms of *M. chobauti*. Pierce (1918) described *Tetrozocera santchii* from a single male collected by F. Santchi in Tunisia. The specimen varies from others only by having a high number of ommatidia (80–90). This specimen is deposited in the Smithsonian

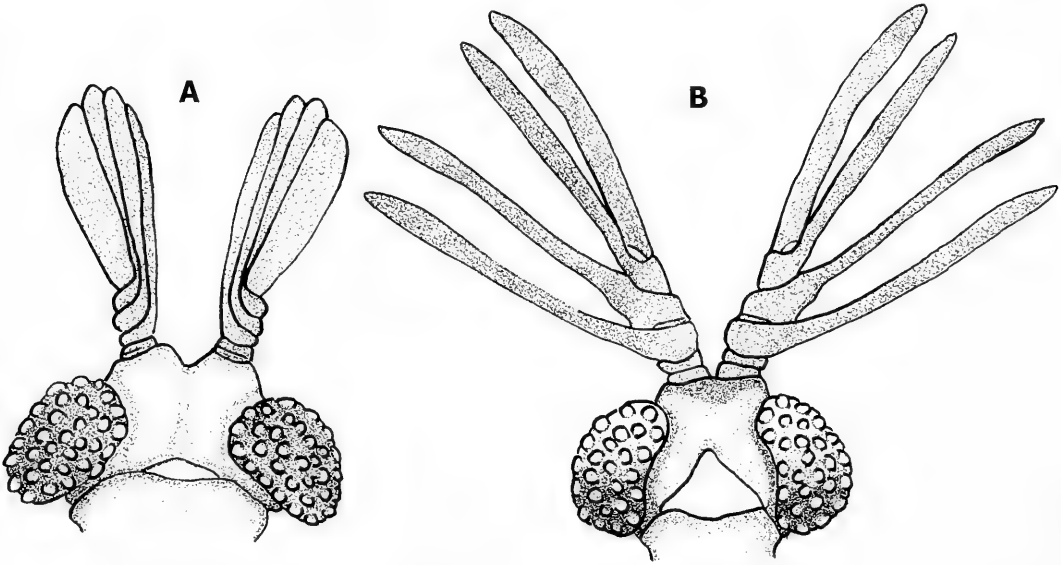


Fig. 4. Dorsal view of head. A, *Mengenilla orientalis*. B, *M. leucomma*.

Institution, National Museum of Natural History (USNM No. 21434). Silvestri (1933) noted that *T. santchii* was probably the same as *M. chobauti*, but in 1943 still listed it as a valid species, although in the genus *Mengenilla* (Silvestri 1943). It was finally synonymized with *M. chobauti* by Kinzelbach (1970). After describing *M. chobauti*, Hofeneder described two more species that were later synomymized with *M. chobauti*. *Mengenillopsis theryi* was collected by Dr. A Théry in Rabat, Morocco in July 1923 and later named by Hofeneder (1926). The holotype is in The Natural History Museum, London. An addition specimen was collected in July 1930 by H. Riser in southern Spain and identified by Hofeneder (Kinzelbach 1970). This dried specimen is deposited in Naturhistorisches Museum Wien. *Mengenillops mauretanica* was named two years later by Hofeneder (1928) from six specimens that were also collected by Dr. A. Théry in Rabat, Morocco, in 1923. Both species were moved to *Mengenilla* by Silvestri (1943) and were later synonymized by Kinzelbach (1970), who considered the differences in the specimens within the variation found in *M. chobauti*. Two characters that do fall at the extreme of the variation known for *M. chobauti* is the small size of the *M. theryi* type, which was 2.6–2.8 mm, and the large lappet found in the maxilla of *M. mauretanica* (illustrated by Kinzelbach (1970)). Silvestri (1933, 1940, 1941b) described five species that were later synonymized by Kinzelbach. Types were not designated by Silvestri, but I examined his collection, which are presumably the specimens used to describe his species. They are deposited in Dipartimento di Entomologia e Zoologia Agraria, Università di Napoli Federico II, Portici, Italy. *Mengenilla quaesita* was described from males and females collected from Pisciotta, Salerno, Italy (Silvestri 1933). *Mengenilla spinulosa* was described from Sicily (Silvestri 1940). *Mengenilla nigritula*, *M. subnigrescens*, and *M. laevigata* were described from Puglia, Italy; Palermo, Sicily, Italy; and Cosenza, Italy, respectively. These species were described from male, female, and larval specimens and were reported by Silvestri (1941b) to all use *Ctenolepisma ciliata* as a host. The

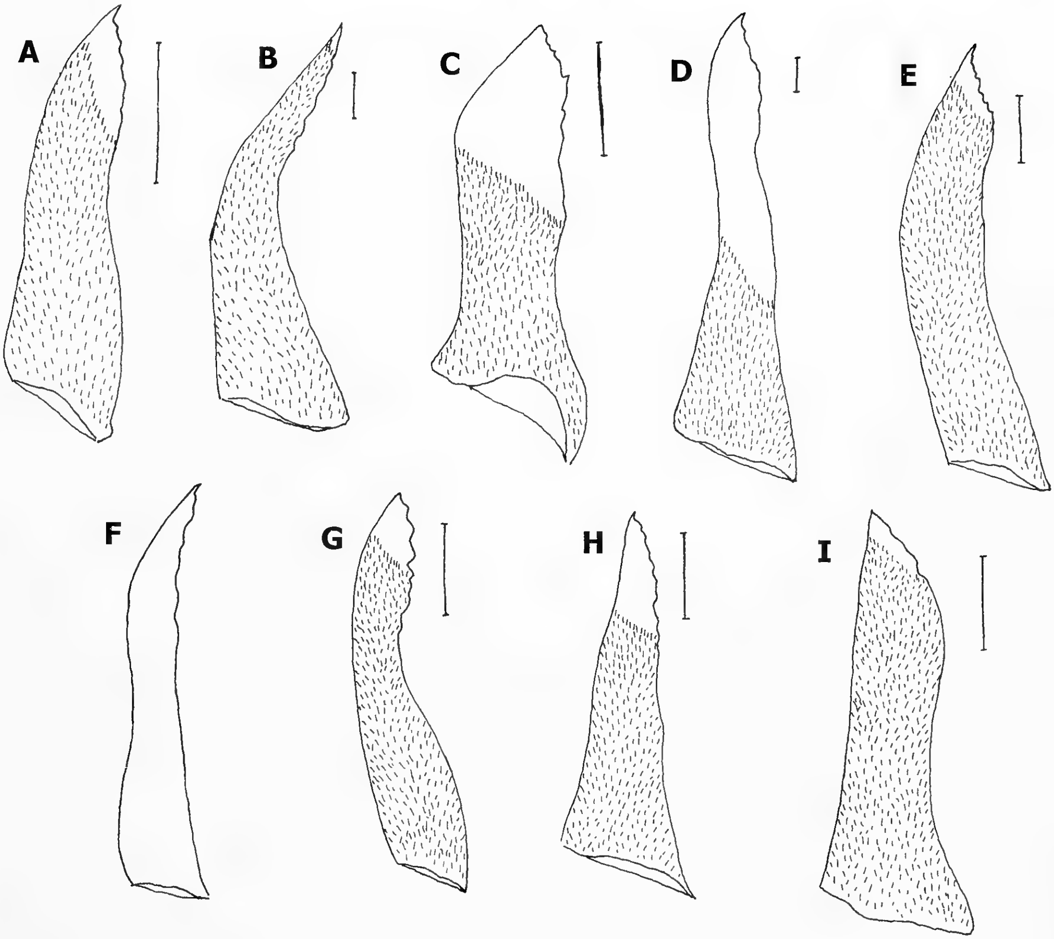


Fig. 5. Mandibles. A, *Mengenilla arabica*. B, *M. australiensis*, C, *M. chobauti* (redrawn after Kinzelbach 1971). D, *M. kaszabi* (redrawn after Kinzelbach 1971). E, *M. leucomma*. F, *M. marikovskii* (covering of microtrichia is unknown) (redrawn after Medvedev 1970). G, *M. orientalis*. H, *M. parvula* (redrawn after Kinzelbach 1971). I, *M. sinensis* (redrawn after Miyamoto 1960 and Kinzelbach 1971). Scale bars are all 50 μ.

common host use and overlap of many characters with *M. chobauti* led Kinzelbach (1970) to synonymize these species. Luna de Carvalho (1953) described what he thought was a new subspecies of *M. nigritula* as *M. nigritula quadriarticulata* primarily because the female specimen he collected had four antennal segments instead of the three reported by Silvestri (1941a, 1943). This subspecies was also synonymized by Kinzelbach (1970). The result of including all of these specimens as *M. chobauti* is that it constitutes a species with a considerable amount of variation, if it is indeed one species. I concur with Kinzelbach (1970) that the above five species named by Silvestri should currently be included as *M. chobauti*. However, each of Silvestri's species are consistent in their characters as he described them and may constitute distinct species that simply utilize the same host species. I examined between five and ten specimens of each of the five Silvestri named species (including types) and within each of these there is little variation. Still, they are most likely local variations of the same species. The specimens that were originally placed in *Mengenillopsis* by Hofeneder (1926, 1928) are somewhat more questionable because they show extremes not found in other specimens of *M. chobauti*. The obvious resolution to this problem would be to use molecular techniques to compare specimens, but unfortunately there are no specimens available for this analysis. A future analysis may reinstate one or more of these species, or confirm that they are all *M. chobauti*. Until this information is available, Kinzelbach's classification appears to be the most logical to follow.

Mengenilla chobauti ranges in size from 2.6 to 5.9 mm, although the only specimen known that are less than 4.0 mm is the specimen that was originally described by Hofeneder (1928) as *M. theryi*. The number of ommatidia ranges from 35 to 80. All flabella lengths are approximately equal, and a Hofeneder's organ is found at the base of the second flabellum (fourth antennal segment). The mandible is somewhat variable between known specimens, as is the amount of microtrichia on the mandible (Fig. 5C) (mandible variation is illustrated by Kinzelbach 1970). The maxillary palp also exhibits some variation, but in general the maxilla has a small lappet of the cardio-stipes with the palp (Fig. 6C). The aedeagus is variable, ranging from somewhat uniformly tapered to bulbous.

Mengenilla chobauti is one of the two species whose female, larva, and host are known. The female of this species is larviform, but free living. The antennae are reported as either three or four segmented (Silvestri 1933, 1934; Luna de Carvalho 1953). The first two antennal segments (when there are four antennal segments) are subequal in length and much shorter than the terminal two antennal segments. There are between 12 and 25 ommatidia in each eye, and mandibles and maxillae are small, but visible. Like males, the female maxilla has a one-segmented palp, with the basal cardo and stipes making the maxilla look like a two-segmented structure. Wings are absent, but legs with three tarsal segments are present. There is one genital pore on the seventh abdominal segment. The female, first instar larvae, and pupa of *M. chobauti* were illustrated by Silvestri (1933, 1943).

Mengenilla gracilipes (Lea 1910)
(Figs. 3E, 6D)

Austrostylops gracilipes Lea 1910: 515.

Lea (1910) collected "a number of specimens" in 1895 from Bridgetown, W. Australia, and these were later described as *Austrostylops gracilipes*. A slide mounted type specimen labeled "cotype" is in The Natural History Museum, London. The habitus of *A. gracilipes* was originally illustrated by Lea and later redrawn by Pierce (1918) and Silvestri (1946). The species was placed in *Mengenilla* by Silvestri (1946). The original length of this species was given by Lea as approximately 2.5 mm, but more accurately reported by Kinzelbach (1970) as 2.8 mm. *Mengenilla gracilipies* has eyes with between 25 and 27 ommatidia. The maxilla, including the palp, is covered with microtrichia; without a lappet, and the apical segment is longer (220 μm) than the basal segment (130 μm) (Fig. 6D). A free labrum is reported to be present in all Australian *Mengenilla* (Beutel and Pohl 2006), but I was not able to confirm its presence in *M. gracilipes*. Antennae have flabella on the fourth and fifth segments that extend further from the antennal base than do the third and sixth. There is a Hofeneder's organ at the base of the fourth segment. The aedeagus tapers gradually, and is slightly bulbous at its base (Fig. 3E). The female, larvae, and host are unknown.

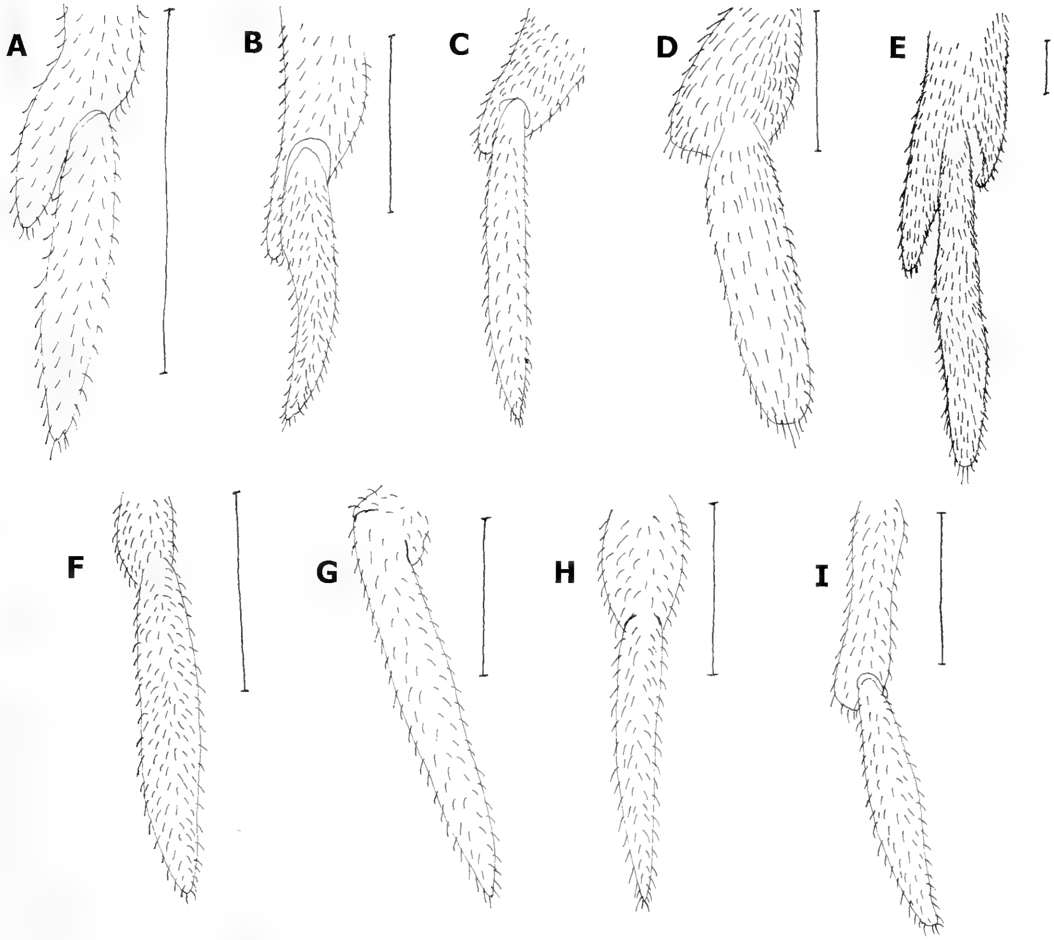


Fig. 6. Maxillae. A, *Mengenilla arabica*. B, *M. australiensis*. C, *M. chobauti*. D, *M. gracilipes* (redrawn after Kinzelbach 1971). E, *M. kaszabi* (redrawn after Kinzelbach 1971). F, *M. leucomma*. G, *M. orientalis*. H, *M. parvula*. I, *M. sinensis* (redrawn after Miyamoto 1960 and Kinzelbach 1971). Scale bars are all 100 μ.

Mengenilla kaszabi Kinzelbach 1970 (Figs. 1B, 2B, 2D, 3F, 5D, 6D)

Mengenilla kaszabi Kinzelbach 1970: 227.

Mengenilla kaszabi was described from a series (79 males) of specimens that were collected by Dr. Z. Kaszabi at lights at the Echin Oasis, Bayankongor Aimag (Province), Mongolia. A holotype and five paratypes are deposited in the Hungarian Natural History Museum, Budapest.

The adult males have a known size range of 3.2 to 5.1 mm. The head is somewhat square anteriorly, between the antennae, and the distance between the eyes is less than the dorsal eye diameter (Fig. 2B). The mandible is relatively long (~0.7 mm) with microtrichia on the basal half (Fig. 5D). The maxilla is covered with microtrichia, has a lappet, and the palp is slightly longer (530 μm) than the basal maxillary segment (430 μm) (Fig. 6D). The eyes have between 45 and 65 ommatidia. Flabella on segments 4 and 5 extend slightly beyond those of segments 3 and 6, and the flabellum of segment 4 has a small Hoffeneder's organ at its base. The fragmented R_2 wing vein is near (almost touching) R_1 (Fig. 1B). The aedeagus is slightly bulbous at the base (Fig. 3F). Kinzelbach (1971: 256) provides a detailed habitus. The female, larva, and host are unknown.

Mengenilla leucomma Cook, new species
(Figs. 3G, 4B, 5E, 6F, 9)

The description of this new species is based on five male specimens collected by Fisher, Griswold, et al. from Reserve Spéciale d'Ambre (3.5 km SW of Sakaramy), Province d'Antstranana, Madagascar. The specimens were all collected between January 26–31, 2001 by Malaise trap in tropical dry forest at an elevation of 325 m. The female, larval stages, and host are unknown. The following description is of the holotype with variation or range of paratypes in parenthesis:

Description.—*Body:* Total length = 2.6 mm (2.4–2.8 mm). Head + thorax length = 1.6 mm (1.6–1.8 mm). Thorax breadth = 0.57 mm (0.53–0.59 mm). Color mostly light brown, with dark brown markings on some sclerites (Fig. 8). Head dark brown except for cream-colored to white anterior dorsal region of the eyes.

Head: Roughly trapezoidal, with anterior edge straight and posterior edge deeply concave. General head capsule shape as in Fig. 4B. Number of facets in eye approximately 50, about half of which visible in dorsal view. Anterior facets white, with facets becoming darker posteriorly. Area of eye surrounding facets with color pattern corresponding to color of facets. Flabella on segments III–V relatively long and slender (Fig. 4B), all with sensilla. Segments III–VI extending about an equal distance away from head. Antennal segment IV with a ventral Hofeneder's organ at base of flabellum. Mandible about 335 μ, somewhat curved inward, with microtrichia (only seen at high magnification) except at apex (Fig. 5). Maxillary palp attached to end of fused cardo and stipes, not forming a lappet; covered with microtrichia; fused cardo and stipes (< 50 μ) much shorter than palp (170 μ) (Fig. 6F).

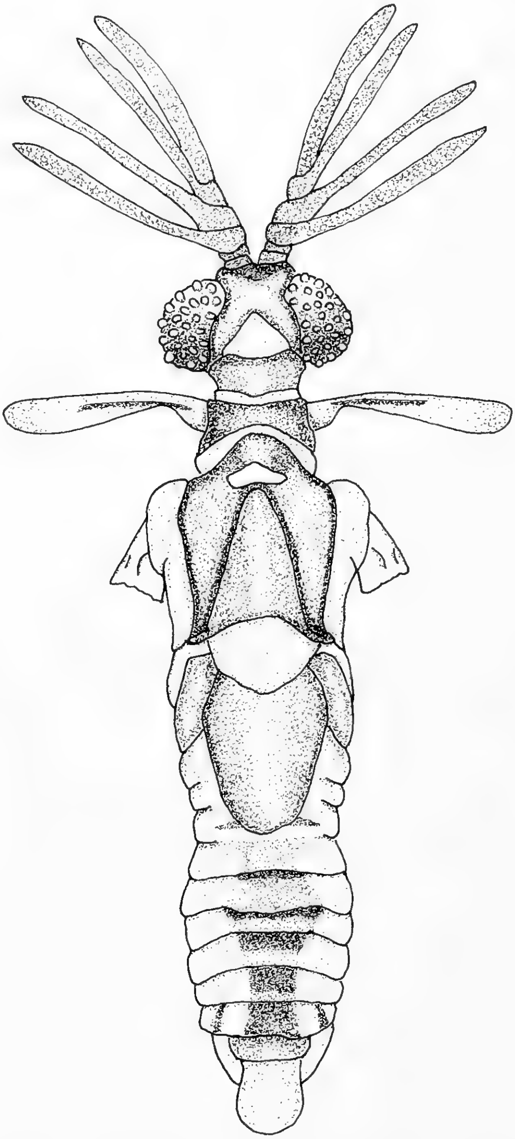


Fig. 7. Habitus, minus appendages, of *Mengenilla leucomma*.

Thorax: Dorsal sclerites as in Fig. 8. Wing with R_2 closer to R_1 than to R_3. R_3 short, subequal in length to R_2. R_5, MA_1, MA_2, and Cu_1 extending to near wing margin (Fig. 8). Measurements (microns) for prothoracic, mesothoracic, and metathoracic legs respectively: femur 290, 280, 415; tibia 320,320,330; tarsi (proximal to distal) (180, 105, 90, 80, 105), (150, 85, 85, 60, 85), (225, 135, 105, 85, 120) (Fig. 9). Hind trochanter as shown in Fig. 9. Aedeagus 225 μ, slightly bulbous at base, curved, tapering to point (Fig. 3G).

Holotype.—Male is deposited in the California Academy of Sciences, San Francisco. Label information as follows: Madagascar: Province d'Antsiranana, Réserve Spéciale d'Ambre, 3.5 km 235°SW Sakaramy, 325 m, 26–31 Jan. 2001 m 12°28′8″S 49°14′32″E, coll. Fisher, Griswold et al., Calif. Acad. of Sciences, Malaise trap in tropical dry forest, Coll. code BLF 2661.

Paratypes.—Four male paratypes deposited in the California Academy of Sciences, San Francisco. Collection data same as holotype

Etymology.—The specific epithet is a Greek derivative meaning white eyes. This refers to the anterior dorsal portion of the eyes that are white, changing to tan, and then brown posteriorly. All known specimens have this character, which is not found in other species in this genus.

Discussion.—*Mengenilla leucomma* most closely resembles *M. orientalis* except for the pale eye coloration described above, having an anterior region of the head straight instead of concave, and antennae that are relatively long and slender as illustrated in Fig. 4. I viewed one specimen of *M. arabica* that has an eye pattern similar to *M. leucoma*, but not nearly as pronounced. The wing veination of *M. leucomma* closely resembles *M. australiensis*, but there are distinct differences, such as the length of R_3 (Figs. 2A, 8). The aedeagus of all *Mengenilla* species are slightly curved and tapering to a point. Most species have a bulbous base of various size. While the aedeagus is distinctive between species, there is also variation, as illustrated by *M. chobauti*'s considerable variation (Fig. 3C) and in the slight variation in the aedeagus base of *M. parvula* (Fig. 3J). However, it is possible that *M. chobauti* could be a species complex, thus accounting for the perceived large variability now recognized within this species. The aedeagus of *M. leucomma* varies slightly from all other *Mengenilla* species (Fig. 3). Mandibles of *Mengenilla* species probably constitute good species characters, but are sometimes difficult to view. Mandibles are curved inward to some extent in all species, and have distinctive shapes and patterns of microtrichia, which requires a compound microscope to view. Differences between *M. leucomma* and other species is illustrated in Fig. 5. The maxillae are the easiest of the mouthparts to observe in specimens and can usually be viewed with a dissecting microscope. The maxilla of all *Mengenilla* species consist of a basal segment that represents a fused cardo and stipes, and an apical single palp segment. The lengths of these maxillary structures and the length comparison of the two segments appears to be a good taxonomic character. Additionally, some species have a distinct lappet formed by the apical end of the basal segment extending beyond the base of the apical, palp segment. *Mengenilla leucomma* has no lappet and has a very short basal segment in relation to its maxillary palp (Fig. 6).

Mengenilla marikovskii Medvedev 1970
(Figs. 1C, 3H, 5F)

Mengenilla marikovskii Medvedev 1970: 199

Mengenilla marikovskii was described from two males collected in southeastern Kazakhstan by P. I. Marikovskiy and T.

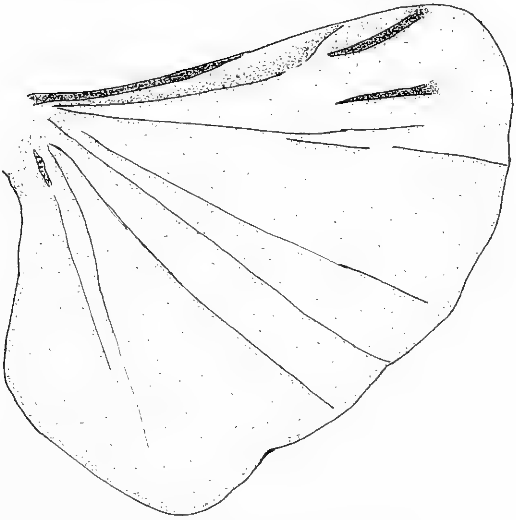


Fig. 8. Wing of *Mengenilla leucomma*.

P. Marikovskaya on May 8, 1962. These specimens (not examined) are deposited in the Zoological Institutute, Russian Academy of Sciences, St. Petersburg, Russia.

Males are 3.6 mm in length. Mandibles are relatively narrow (Fig. 5F); structure of the maxillae is unknown. Flabella of all segments are approximately equal in length. R_2 of the hind wing is located almost half way between R_1 and R_3 (Fig. 1C). The aedeagus is only slightly bulbous at its base (Fig. 3H). Figures were provided by Medvedev (1970), but are lacking in detail. The host, female, and larvae are unknown.

Mengenilla orientalis Kifune and Hirashima 1980
(3I, 4A, 5G, 6G)

Mengenilla orientalis Kifune and Hirashima 1980: 144.

Mengenilla orientalis was named from a male specimen collected at a black light by G. F. Hevel, R. E. Dietz IV, S. Kuranaratne, and D. W. Balasooriya from Olatithoduvai (10 miles NW of Mannar), Sri Lanka on Nov. 4–5, 1976. The holotype (observed) is deposited in alcohol in the Smithsonian Institution, National Museum of Natural History (USNM 76712).

The holotype male is 2.6 mm in total length. The maxillary palp is much longer (~220 μm) than the basal segment of the maxilla (~20 μm) (Fig. 6G). No lappet is formed by the maxilla. The mandible is about 220 μm long and covered with microtricha except at the apical tip (Fig. 5G). The antennae are relatively short (600 μm), with thick flabella (Fig. 4A). The flabella on segments 4 and 5 extend slightly further than do those on segments 3 and 6. The fourth antennal segment has a large Hoffeneder's organ at its base. Each eye has approximately 50 ommatidia. The base of the aedeagus is only slightly thickened (Fig. 3I). The host, female, and larvae are unknown. Only the holotype is known. *Mengenilla orientalis* was illustrated by Kifune and Hirashima (1980).

Mengenilla parvula Silvestri 1941
(Figs. 3J, 5H, 6H)

Mengenilla parvula Silvestri 1941b: 58.

Silvestri described *M. parvula* from specimens collected in 1938 in Carlentini and Lentini, Siracusa Province, Sicily. I did not locate these specimens, but examined specimens collected from the same area in 1939 and identified by Silvestri. These specimens are now in Dipartimento di Entomologia e Zoologia Agraria, Università di Napoli Federico II, Portici, Italy. Adult males, females, first-instar larvae, and pupae are known. The host is *Ctenolepisma michaelseni.* Adult males range in length from 1.7 to 2.7 mm (measured from the above mentioned specimens collected by Silvestri, and from his published data). Kinzelbach (1970) reported the length of males to be 2.6 mm compared to Silvestri's reported length of 2 mm. The maxilla is

Fig. 9. Leg structures of *Mengenilla leucomma*. A, Femur, tibia, and tarsus (prothoracic leg on top, mesothoracic leg in middle, metathoracic leg on bottom). B, Trochanter of metathoracic leg. Scale bars are both 100 μ.

relatively long and thin, with no lappet. The basal part of the maxilla (0.545 mm) is shorter than the palp (1.744 mm) (Fig. 6H). The mandible is about the same length as the total length of the maxilla, and slightly wider than the maxilla. Microtrichia cover approximately the basal 2/3 of the mandible (Fig. 5H). The extensions of the flabella are subequal, although in some specimens segments 4 and 5 extend slightly further than 3 and 6. Eyes have 35–40 ommatidia. The aedeagus is bulbous at the base, although there is variation between specimens in the size of the bulb (Figs. 3J).

Adult females are similar to those described for *M. chobauti*, with a few minor exceptions. The eyes have 13 to 15 ommatidia. The antenna in all specimens is four segmented, with the first segment much smaller than the second, both of which are shorter than the subequal third and fourth segments.

Mengenilla sinensis Miyamoto 1960
(Figs. 3L, 5I, 6I)

Mengenilla sinsensis Miyamoto 1960: 37.

Miyamoto named this species based on one male collected by K. Yasumatsu from Shansi Province, North China. The location of the holotype is unknown. The holotype is described by Miyamoto to be generally brown with brown veins in the wings, but the legs are paler towards the apices. The abdomen is pale. The anterior portion of the head between the antennae is convex. Eyes are widely separated (distance between them is about 250 μm), and the distance between the eyes is greater than the dorsal view eye diameter (210 μm). Eyes protrude from the side of the head and appear bulging. Each eye has about 60 ommatidia. Antennae are relatively short (about 660 μm), with the sixth antennal segment shorter than the subequal flabella on segments III–V. The palp has no lappet, and the palp is approximately the same length (120 μm) as the basal cardo-stipes (Fig. 6I). The mandible (Fig. 5I) is slightly shorter (220 μm) than the maxillae, with palp (240 μm). The aedeagus is short and thickened, but not bulbous, at the base (Fig. 3L). Miyamoto

(1960) provided a habitus drawing as well as other line drawings. The female and host are unknown.

Acknowledgments

I Thank Norm Penny and the California Academy of Sciences for the opportunity to view and describe the Strepsiptera specimens from Madagascar, Cristina Digilio for arranging the loan of Silvestri's *Mengenilla* collections, Gary Hevel for loans from the Smithsonian Institution, Daniel Burckhardt for loans from Natuhistorisches Museum Basel, and Hans Pohl, Universität Rostock, for reprints of two of Silvestri's papers. Collection of the specimens from Madagascar was supported by a grant from the National Science Foundation (DEB-0072713).

Literature Cited

Al-Houty, W. 1989. Insect Fauna of Kuwait. University of Kuwait, Kuwait. 187 pp.

Beutel, R. G. and H. Pohl. 2006. Head structures of males of Strepsiptera (Hexopoda) with emphasis on basal splitting events within the order. Journal of Morphology 267: 536–554.

Hofeneder, K. 1910. *Mengenilla* n. g. *chobautii* n. sp. eine neue strepsiptère aus Nordafrika. Berichte des Naturwissenschaftlich-Medizinischen Bereins in Innsbruck 32: 33–58.

———. 1926. Zwei neue Strepsipteren aus Marokko, 1. Teil. Bulletin de la Société des Sciences Naturelles du Maroc 6: 65–64.

———. 1928. Zwei neue Strepsipteren aus Marokko, 2. Teil. Bulletin de la Société des Sciences Naturelles du Maroc 8: 195–211.

Kathirithamby, J. 1989. Review of the order Strepsiptera. Systematic Entomology 14(1): 41–92.

Kifune, T. and Y. Hirashima. 1980. Records of the Strepsiptera of Sri Lanka in the collection of the Smithsonian Institution, with descriptions of seven new species (Notulae Strepsipterologicae – VI). Esakia 15: 143–159.

———. 1983. Records of the Strepsiptera from Australia and Sri Lanka in the collection of the Smithsonian Institution, with descriptions of four new species (Notulae Strepsipterologicae – XI). Esakia 20: 157–165.

Kinzelbach, R. 1969. Nematodenbefall bei *Mengenilla parvula* Silvestri 1941 (Insecta: Strepsiptera: Mengenillidae). Bollettino del Laboratorio di Entomologia Agraria 28: 190–193.

———. 1970. Die männlichen imagines der Mengenillidae und *Mengenilla kaszabi* n. sp. ergebnisse der zoologischen forschungen von Dr. Z. Kaszab in der Mongolei (Strepsiptera, Insecta). Reichenbachia 12(24): 217–247.

———. 1971. Morphologische Befunde an Facherfluglern und ihre phylogenetische Bedeutung (Insecta: Strepsiptera). Zoologica 41(119): 1–256.

———. 1972. Die Fächerflügler des Senckenberg-museums. II Mengenillidae (Insecta: Strepsiptera). Senckenberiana Biologica 53(5/6): 403–409.

———. 1979. Insects of Arabia: Strepsiptera. Fauna of Saudi Arabia 1: 331–333.

———. 1980. Insects of Saudi Arabia Strepsiptera (2. Beitrag). Fauna of Saudi Arabia 2: 159–163.

———. 1991. The systematic position of Strepsiptera (Insecta). American Entomologist 36(4): 292–303.

Lea, A. M. 1910. On a new genus of Stylopidae from Australia. Transactions of the Entomological Society of London 58: 514–516.

Luna de Carvalho, E. 1953. Contribuição para o conhecimento dos strepsípteros de Portugal. Memórias e Estudos do Museu Zoológico da Universidade de Coimbra 215: 5–13.

Medvedev, L. N. 1970. [A family of Strepsiptera new to the fauna of the USSR and new species from southeastern Kazakhstan.] Entomologicheskoe Obozrenie 49: 199–200. (English translation, Entomological Review 49: 113–114)

Miyamoto, S. 1960. A new strepsipteran form Shansi, North China, *Mengenilla sinensis* Miyamoto. Mushi 33(5): 37–38, 1 plate.

Peyerimhoff, P. de. 1919. Un nouveau type d'insectes strepsipères. Bulletin de la Société Entomologique de France 1919: 162–172 + 1 plate.

Pierce, W. D. 1908. A preliminary review of the classification of the order Strepsiptera. Proceedings of the Entomological Society of Washington 9: 75–85.

———. 1909. A monographic revision of the twisted winged insects comprising the order Strepsiptera Kirby. U.S. National Museum Bulletin 66: 1–221.

———. 1918. The comparative morphology of the order Strepsiptera together with records and descriptions of insects. Proceedings of the U.S. National Museum 54: 391–501.

Pohl, H. 2002. Phylogeny of the Strepsiptera based on morphological data of the first instar larvae. Zoologica Scripta 31: 123–134.

Riek, E. F. 1970. Strepsiptera, pp. 622–635. *In* The Insects of Australia. Melbourne University Press, CSIRO, Australia.

Silvestri, F. 1933. Descrizione della femmina e del maschio di una nuova specie di *Mengenilla* Hofeneder (Strepsiptera). Bollettino del Laboratorio di Zoologia Generale e Agraria della Facoltà Agraria di Portici 28: 1–10.

———. 1940. Descrizione preliminare di una specie nuova di *Mengenilla* (*M. spinulosa*, Insecta, Stepsiptera) della Sicilia e notizie sul suo ciclo e sul particolare modo de fecondazione. Rendiconti della Classe di Scienze Fisiche, Matematiche e Natuali Serie Lettima 1(10): 614–618.

———. 1941a. Sulla maniera di fecondazione della femmina negli "Stylopidae" (Insecta Strepsiptera). Rendiconti della Classe di Scienze Fisiche, Matematiche e Natuali Serie Lettima 2(7)L: 553–556.

———. 1941b. Notizie, specialmente corologiche e biologiche, sulle specie di *Mengenilla* (Insecta Strepsiptera) finora trovate in Italia. Acta Pontificiae Academiae Scientiarum 5(9): 57–67.

———. 1942. Nuove osservazioni sulla *Mengenilla parvula* Silv. (Insecta Strepsiptera). Acta Pontificiae Academiae Scientiarum 6(11): 95–96.

———. 1943. Studi sulgi "Strepsiptera" (Insecta) III. Descrizione e biologia di 6 specie Italiane di *Mengenilla*. Bollettino del Laboratorio di Zoologia Generale e Agraria della Facoltà Agraria in Portici 32: 197–282.

———. 1946. Identità dei generi di Mengenillidae (Strepsiptera) *Austrostylops* Lea et *Mengenilla* Hofeneder. Bollettino del Laboratorio di Entomologia e Agraria in Portici 6: 15–16.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 240–248

FIRST REPORTED OCCURRENCE OF *XYLEBORINUS ALNI* (COLEOPTERA: CURCULIONIDAE: SCOLYTINAE) IN THE EASTERN UNITED STATES, WITH NOTES ON ITS RECOGNITION AND TREE HOSTS

E. Richard Hoebeke and Robert J. Rabaglia

(ERH) Department of Entomology, Comstock Hall, Cornell University, Ithaca, NY 14853-2601, U.S.A. (e-mail: erh2@cornell.edu); (RJR) USDA Forest Service, Forest Health Protection, Arlington, VA 22209 (e-mail: brabaglia@fs.fed.us)

Abstract.—*Xyleborinus alni* (Niisima), an Asian ambrosia beetle first detected in North America in the Pacific Northwest in the late 1990s, is reported for the first time from the eastern United States. Locality data for specimens captured in Lindgren funnel traps from nine eastern states are listed and mapped; these data suggest that this immigrant xyleborine is widely established in the Northeast. A habitus illustration and a diagnosis are provided to differentiate it from the other widespread immigrant *Xyleborinus* species in North America, *X. saxesenii* (Ratzeburg).

Key Words: Coleoptera, Curculionidae, Scolytinae, Xyleborina, eastern United States, exotic species, new distribution records

The genus *Xyleborinus* Reitter, previously recognized by most authors either as a subgenus or a synonym of *Xyleborus* Eichhoff (Wood 1982), is comprised of at least 81 nominate species distributed worldwide (http://xyleborini.tamu.edu/browse.php?genus=Xyleborinus), with the majority occurring in Africa and Asia. Three species of the genus are found in America north of Mexico, two of which are endemic to Europe and Asia (Rabaglia et al. 2006). *Xyleborinus saxesenii* (Ratzeburg) is transcontinental in North America. Although considered by some to be an unintentional exotic introduction (i.e., Atkinson and Peck 1994), others consider it to be naturally Holarctic, with Asia, Europe, and North America in its native distribution (Wood and Bright 1992). *Xyleborinus saxesenii* also has been introduced into Australia, Hawaii, and South America (Argentina, Brazil, and Chile). *Xyleborinus gracilis* (Eichhoff) is native to South America and North America; in the United States, it is reported from Florida, Louisiana, North Carolina, and South Carolina (Rabaglia et al. 2006). It can be distinguished from *X. saxesenii* and *X. alni* (Niisima) by the absence of denticles on interstriae 1 and its small size (<2 mm). *Xyleborinus alni*, a native to Asia, was detected in North America during surveys conducted between 1996 and 1998 in the Pacific Northwest. Selected high-risk sites, such as importers, warehouses, wood recyclers, mills, and other businesses in or near ports or port areas in Washington and Oregon were closely monitored using baited Lindgren funnel traps (Mudge et al. 2001). All sites were known to have received or handled imported wood or wood products.

Xyleborinus alni was first found at 6 port area sites in Olympia, Washington, and at 4 such sites in Tacoma, Washington, between March 12 and April 17, 1996 (Lagasa et al. 1997). It also was trapped in Oregon at Rainer (Columbia Co.) in April and May 1997, and at Portland (Multnomah Co.) in March and May 1998 (Mudge et al. 2001). There are unpublished records for the earlier collection of *X. alni* in 1995 at 4 sites around Vancouver, British Columbia (L. C. Humble, unpublished data, cited in Mudge et al. 2001). In subsequent surveys, *X. alni* was again trapped at a number of high-risk sites in one county in Washington (Clark Co.) and in seven additional Oregon counties (Benton, Clackamas, Linn, Marion, Polk, Washington, and Yamhill) between 1999 and 2002 (LaBonte et al. 2005). Based on these new distributional records, it appears that *X. alni* is widely distributed throughout much of the Willamette Valley of northwestern Oregon (LaBonte et al. 2005).

As a result of extensive trapping surveys conducted as part of the joint USDA-APHIS-PPQ and USDA-Forest Service "Early Detection and Rapid Response" program between 2001 and 2005 in the northeastern United States, *X. alni* has been collected in Maine, Massachusetts, Michigan, New Jersey, New York, Ohio, and Pennsylvania. Additional distributional records for *X. alni* have resulted from the USDA's Cooperative Agricultural Pest Survey (CAPS) program conducted by Departments of Agriculture of New York, Pennsylvania, Maryland, Maine, and Vermont. These new state records represent the first documented occurrence of *X. alni* in the eastern United States.

Here, we list and map (Fig. 1) distributional data taken from specimens of *X. alni* captured in Lindgren funnel traps, with few exceptions, deployed as part of these trapping surveys of the Northeast. The majority of specimens examined are deposited in the Cornell University Insect Collection (Ithaca, NY), and with others in the reference collections of the Maine Forest Service (Augusta), Maryland Department of Agriculture (Annapolis), Massachusetts Department of Conservation and Recreation (Amherst) (2005 collections), Pennsylvania Department of Conservation and Natural Resources (Middletown) (2005 collections), and in the personal collection of R. J. Rabaglia.

NEW EASTERN UNITED STATES RECORDS

Distribution records are followed by the number of specimens examined (in parentheses) and the lure types (AP-EtOH = alpha-pinene + UHR ethanol; Ips = 3-component Ipslure; Chal = Chalcoprax; EtOH-MB = ethanol + methyl butenol; AP-MB = alpha-pinene + methyl butenol; EtOH = ethanol only), when available.

MAINE: *Cumberland Co.*, Portland Harbor, 2-IV-2004 (1), (EtOH, 1); 30-IV-2004 (16), (Ips, 1; AP-EtOH, 2; EtOH, 13); 14-V-2004 (2), (AP-EtOH, 2); Mackworth Island, 14-V-2004 (2), (EtOH, 2); Falmouth, 14-V-2004 (18), (AP-EtOH, 8; EtOH, 10). *Kennebec Co.*, Gardiner, 2-VI-2004 (3); Waterville, 20-IV-2004 (3). *York Co.*, Saco, 14-IV-2004 (1). MARYLAND: *Frederick Co.*, Middletown, 7-II-2005 (1), (AP-EtOH, 1); Monrovia, 7-II-2005 (5), (AP-EtOH, 5); 7-III-2005 (8), (AP-EtOH, 8); Mt. Airy, 7-II-2005 (1), (AP-EtOH, 1). *Garrett Co.*, Accident, 2-30-VII-2002 (1), (Alison-Pike trap, 1); 14-19-IV-2004 (2), (Alison-Pike trap, 2); 3-V-2004 (1), (Alison-Pike trap, 1). *Montgomery Co.*, Boyds, 7-II-2005 (1), (AP-EtOH, 1); Dickerson, 7-II-2005 (5), (AP-EtOH, 5). MASSACHUSETTS: *Barnstable Co.*, Sandwich, 11-IV-2005 (66), (AP-EtOH, 10; EtOH, 56); 25-IV-2005 (45), (AP-EtOH, 5; EtOH, 40); 23-V-2005 (2), (AP-EtOH, 1; EtOH, 1); 6-VI-

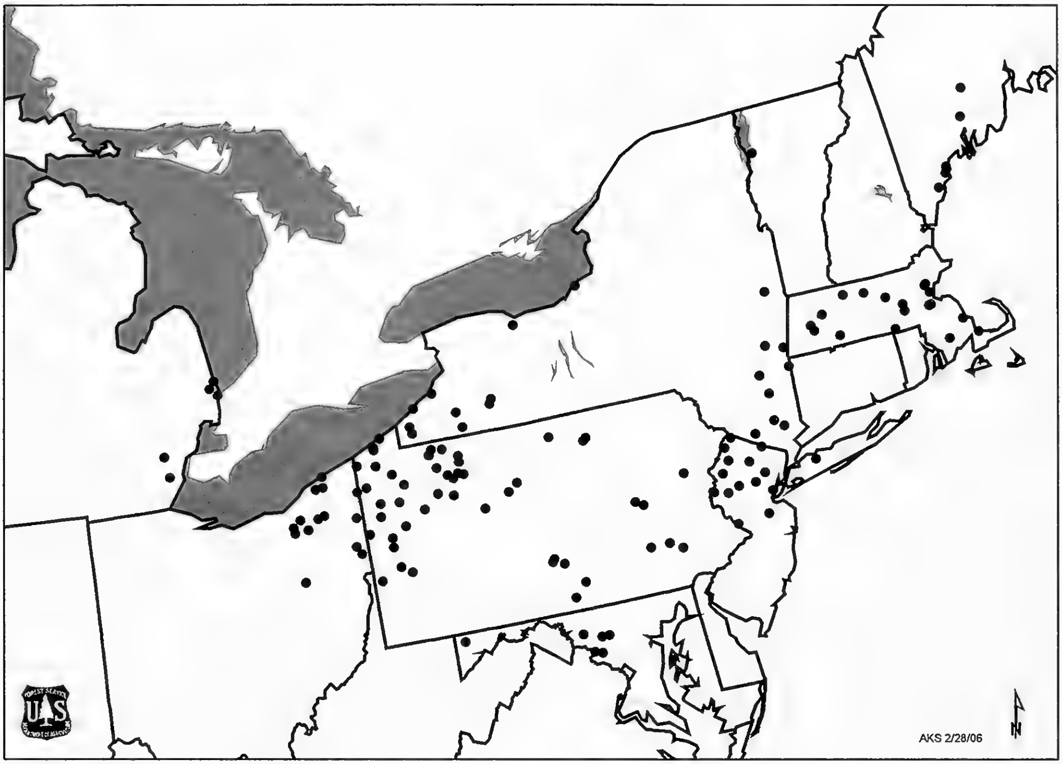
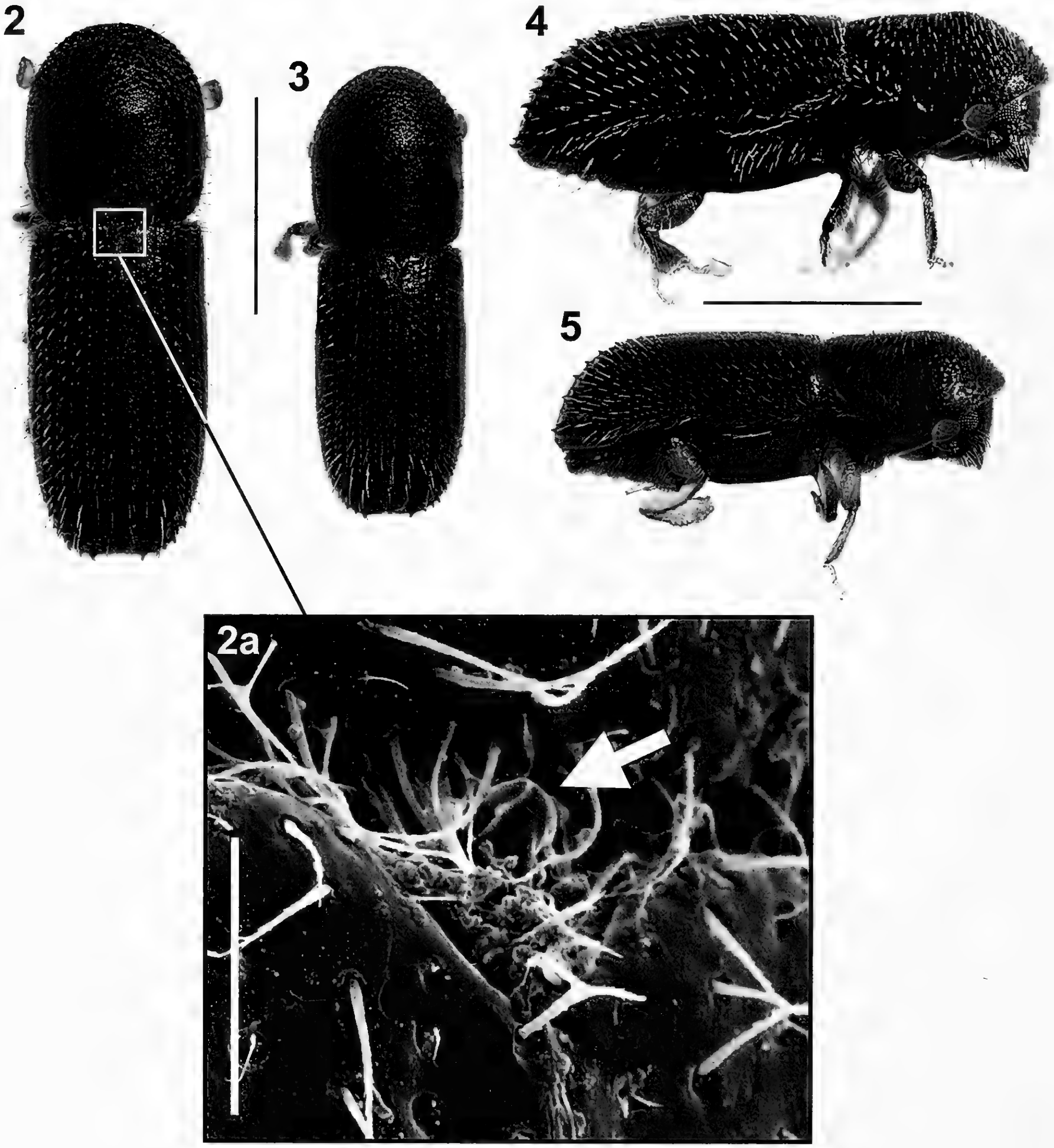


Fig. 1. Locality records of *Xyleborinus alni* in the eastern United States, based on specimens captured in baited Lindgren funnel traps deployed for the "Early Detection and Rapid Response" bark beetle survey and various state CAPS programs from 2001–2005.

2005 (1), (EtOH, 1). *Bristol Co.*, Freetown (Freetown S. F.), 11-IV-2005 (4), (EtOH, 4); 25-IV-2005 (3), (AP-EtOH, 1; EtOH, 2).). *Franklin Co.*, Erving (Erving S. F. Hdqts.), 19-IV-2005 (12), (AP-EtOH, 2; EtOH, 10); 2-V-2005 (5), (AP-EtOH, 1, EtOH, 4). *Hampden Co.*, Chester, 20-IV-2005 (9), (AP-EtOH, 3; EtOH, 6); 18-V-2005 (1), (EtOH, 1); Chicopee (Chicopee S. F.), 19-IV-2005 (31), (Ips, 3, AP-EtOH, 7; EtOH, 21); 16-V-2005 (1), (EtOH, 1). *Hampshire Co.*, Goshen, 25-IV-2005 (12), (Ips, 1; AP-EtOH, 2; EtOH, 9); 4-V-2005 (6), (AP-EtOH, 3; EtOH, 3); 18-V-2005 (1), (AP-EtOH, 1); Middlefield, 19-IV-2005 (45), (Ips, 2; AP-EtOH, 3; EtOH, 40); 2-V-2005 (12), (AP-EtOH, 2; EtOH, 10); 16-V-2005 (12), (Ips, 2; AP-EtOH, 2; EtOH, 8). *Middlesex Co.*, Hopkinton (Whitehall Boat Ramp), 11-IV-2005 (14), (AP-EtOH, 7; EtOH, 7); Middlesex Fells Reserve, 9-IV-2004 (1), (AP-EtOH, 1); 26-IV-2004 (15), (AP-EtOH, 2; EtOH, 13); 23-V-2004 (1), (AP-EtOH, 1). *Norfolk Co.*, Blue Hills Reserve, 26-IV-2004 (1), (EtOH, 1); 7-VI-2004 (1), (EtOH, 1). *Plymouth Co.*, Plymouth (Myles Standish S. F.), 25-IV-2005 (1), (EtOH, 1).). *Suffolk Co.*, Boston (urban site), 23-V-2004 (1), (AP-EtOH, 1); (forest site), 7-VI-2004 (1), (EtOH, 1). *Worcester Co.*, Douglas (Douglas S. F.), 19-IV-2005 (2), (AP-EtOH, 1; EtOH, 1); 17-V-2005 (1), (EtOH, 1); Southborough, 11-IV-2005 (21), (AP-EtOH, 21); 25-IV-2005 (1), (AP-EtOH, 1).); Sterling (Central East Field Office), 19-IV-2005 (1), (EtOH, 1); 4-V-2005 (1), (EtOH, 1); 16-V-2005 (2), (AP-EtOH, 1; EtOH, 1); Templeton (Otter River S. F.), 19-IV-2005 (7), (AP-EtOH, 2, EtOH, 5). MICHIGAN: *St.*

Clair Co., Lakeport S. P. (urban forest), 22-IV-2004 (701), (Ips, 1; AP-EtOH, 57; EtOH, 643); 5-V-2004 (197), (Ips, 5; AP-EtOH, 117; EtOH, 75); 17-V-2004 (56), (Ips, 1; AP-EtOH, 55); 27-V-2004 (1), (EtOH-MB, 1); 7-VI-2004 (1), (AP-EtOH, 1); Port Huron RR (SWPM site), 22-IV-2004 (12), (Ips, 1; AP-EtOH, 6; EtOH, 5); 5-V-2004 (24), (AP-EtOH, 15; EtOH, 9); 17-V-2004 (3), (AP-EtOH, 2; EtOH, 1); Port Huron S. F. (rural forest), 22-IV-2004 (134), (Ips, 6; AP-EtOH, 19; EtOH, 109); 5-V-2004 (52), (Ips, 1; AP-EtOH, 9; EtOH, 42); 17-V-2004 (15), (AP-EtOH, 8; EtOH, 7). *Wayne Co.*, Detroit Yazaki Corp. (SWPM site), 16-IV-2004 (2), (AP-EtOH, 1; EtOH, 1); 29-IV-2004 (2), (AP-EtOH, 1; EtOH, 1); Detroit Tree Farm (rural forest), 28-IV-2004 (6), (AP-EtOH, 2; EtOH, 4); 13-V-2004 (2), (EtOH, 2); Dearborn (Heritage Park), 7-IV-2005 (1), (EtOH, 1); 11-IV-2005 (108), (Ips, 8; EtOH, 100); 12-IV-2005 (120), (AP-EtOH, 120); 28-IV-2005 (3), (AP-EtOH, 3); 10-V-2005 (4), (AP-EtOH, 4); Inkster (Ford-Wixom plant), 14-IV-2005 (5), (EtOH, 5); Rockwood (F.W. Ritters & Sons), 29-IV-2005 (1), (AP-EtOH, 1); 11-V-2005 (1), (EtOH, 1). NEW JERSEY: *Essex Co.*, West Orange, 15-IV-2004 (1), (AP-EtOH, 1); 27-IV-2004 (1), (AP-EtOH, 1); 12-V-2004 (2), (AP-EtOH, 2). *Hunterdon Co.*, Voorhees S. P., 16-III-2004 (3), (ETOH, 3); 30-III-2004 (3), (ETOH, 3); 13-IV-2004 (4), (AP-ETOH, 1; Ips, 3). *Mercer Co.*, Washington Crossing S. P., 14-V-2002 (1), (Chal, 1). *Middlesex Co.*, Monroe Twp., 29-III-2004 (7), (Ips, 1; AP-EtOH, 5; EtOH, 1); 25-IV-2004 (1), (AP-EtOH, 1). *Morris Co.*, Blairstown, 22-III-2004 (1), (AP-EtOH, 1); 15-IV-2004 (1), (AP-EtOH, 1); Green Village, 20-II-2004 (1), (AP-EtOH, 1); 22-III-2004 (39), (AP-EtOH, 39); 1-IV-2004 (1), (AP-EtOH, 1); 15-IV-2004 (4), (AP-EtOH, 4); Hacklebarney S. P., 16-III-2004 (6), (EtOH, 6); 30-III-2004 (1), (EtOH, 1); 13-IV-2004 (2), (EtOH, 2); Marcella, 22-III-2004 (45), (AP-EtOH, 45); 1-IV-2004 (2), (AP-EtOH, 2); 15-V-2004 (13), (AP-EtOH, 13). *Passaic Co.*, Ringwood S. P., 15-IV-2004 (2), (AP-EtOH, 2); 21-IV-2004 (1), (AP-ETOH, 1); Wanaque Reserve, 11-III-2004 (1), (AP-EtOH, 1); 15-IV-2004 (1), (AP-EtOH,1). *Sussex Co.*, Fredon, 15-IV-2004 (6), (AP-EtOH, 6); Hainesville, 15-IV-2004 (37), (AP-EtOH, 37); 23-IV-2004 (4), (AP-EtOH, 4); High Point S. P., 15-IV-2004 (4), (AP-EtOH, 4). *Union Co.*, Carteret, 7-V-2004 (1), (EtOH, 1). *Warren Co.*, Hope, 22-III-2004 (17), (AP-EtOH, 17); 15-IV-2004 (22), (AP-EtOH, 22); Merrill Creek Reservoir, 16-III-2004 (129), (AP-EtOH, 2; EtOH, 120; Ips, 7); 30-III-2004 (62), (AP-EtOH, 4; EtOH, 56; Ips, 2); 13-IV-2004 (125), (AP-EtOH, 9; EtOH, 115; Ips, 1); 27-IV-2004 (2), (EtOH, 2). NEW YORK: *Allegany Co.*, Belfast, 31-III-2004 (7), (Ap-EtOH, 7); 13-IV-2004 (3), (AP-EtOH, 3); Cuba, 13-IV-2004 (8), (AP-EtOH, 8); 27-IV-2004 (1), (AP-EtOH, 1). *Cattaragus Co.*, Allegany S. P., 9-IV-2003 (58), (Ips, 6; AP-EtOH, 11; EtOH, 41); 23-IV-2003 (77), (Ips, 15; AP-EtOH, 17; EtOH, 45); 5-V-2003 (22), (Ips, 1; AP-EtOH, 3; EtOH, 18); 19-V-2003 (7), (Ips, 2; AP-EtOH, 1; EtOH, 4); 13-IV-2004 (46), (AP-EtOH, 46); 27-IV-2004 (2), (AP-EtOH, 2); Little Valley, 22-IV-2003 (7), (Ips, 1; AP-EtOH, 2; EtOH, 4); 13-IV-2004 (11), (AP-EtOH, 11). *Chautauqua Co.*, Lake Erie S. P., 10-IV-2003 (2), (EtOH, 4); 23-IV-2003 (8), (AP-EtOH, 1; EtOH, 7); 6-V-2003 (5), (EtOH, 5); Mayville, 23-IV-2003 (2), (EtOH, 2); 13-IV-2004 (4), (AP-EtOH, 4); 27-IV-2004 (1), (AP-EtOH, 1); Panama, 10-IV-2003 (1), (AP-EtOH, 1); 23-IV-2003 (8), (Ips, 1; AP-EtOH, 3; EtOH, 4); 6-V-2003 (1), (AP-EtOH, 1); 13-IV-2004 (3), (AP-EtOH, 3); Silver Creek, 10-IV-2003 (2), (EtOH, 2). *Columbia Co.*, Hillsdale, 21-IV-2005 (1), (AP-MB, 1); Hudson, 2-V-2005 (1), (AP-MB, 1).

Dutchess Co., Millerton, 27-IV-2004 (2), (AP-MB, 2); Poughkeepsie, 8-IV-2004 (1), (AP-MB, 1); 26-IV-2004 (5), (AP-MB, 5); 6-V-2004 (1), (AP, 1). *Monroe Co.*, Rochester, 9-V-2005 (1), (Ips, 1). *Nassau Co.*, Woodbury, 8-IV-2005 (1), (AP-MB, 1). *Oswego Co.*, Oswego (port area), 25-IV-2001 (4), (AP-EtOH, 1; EtOH, 3); Oswego (urban site), 25-IV-2001 (17), (Ips, 1; AP-EtOH, 10; EtOH, 6); 9-V-2001 (6), (EtOH, 6); Oswego (forest site), 24-IV-2001 (1), (EtOH, 1); 25-IV-2001 (17), (Ips, 2; AP-EtOH, 4; EtOH, 11); 9-V-2001 (3), (AP-EtOH, 2; EtOH, 1). *Putnam Co.*, Garrison, 12-IV-2005 (1), (AP-MB, 1). *Rensselaer Co.*, Tomhannock Reservoir, 12-V-2004 (1), (AP-MB, 1). *Ulster Co.*, Kingston, 11-IV-2005 (3), (AP-MB, 3); 25-IV-2005 (1), (AP-MB, 1). *Westchester Co.*, Yorktown, 14-IV-2005 (2), (AP-MB, 2). OHIO: *Ashtabula Co.*, Pymatuning S. P., 31-III-2003 (1), (Ips, 1); 17-IV-2004 (4), (AP-EtOH, 3; EtOH, 1). *Columbiana Co.*, New Waterford, 12-III-2004 (1), (AP-EtOH, 1). *Cuyahoga Co.*, Brecksville, 12-III-2004 (1), (AP-EtOH, 1); 12-IV-2004 (1), (AP-EtOH, 1); Oakwood, 12-IV-2004 (1), (AP-EtOH, 1). *Geauga Co.*, Parkman, 27-III-2004 (7), (AP-EtOH, 7); 12-IV-2004 (9), (AP-EtOH, 9); Thompson, 27-III-2004 (1), (AP-EtOH, 1); 12-IV-2004 (16), (AP-EtOH, 16). *Lake Co.*, Leroy Center, 13-III-2004 (8), (AP-EtOH, 8); 27-III-2004 (9), (AP-EtOH, 9); 12-IV-2004 (19), (AP-EtOH, 19); North Madison, 13-III-2004 (11), (AP-EtOH, 11); 27-III-2004 (1), (AP-EtOH, 1); 12-IV-2004 (21), (AP-EtOH, 21). *Mahoning Co.*, North Lima, 25-III-2004 (1), (AP-EtOH, 1). *Portage Co.*, Mantua Corners, 27-III-2004 (7), (AP-EtOH, 7); 12-IV-2004 (17), (AP-EtOH, 17). *Summit Co.*, CVNP Horseshoe Pond, 12-III-2004 (1), (AP-EtOH, 1); CVNP Oak Hill PA, 28-III-2004 (1), (AP-EtOH, 1). *Trumbull Co.*, Youngstown State University arboretum, 3-IV-2003 (1), (AP-EtOH, 1). *Tuscarawas Co.*, Beach City Dam, 24-III-2004 (1), (AP-EtOH, 1). PENNSYLVANIA: *Allegheny Co.*, Beechwood Farms ANC, 19-III-2004 (19), (AP-EtOH, 19); 2-IV-2004 (3), (AP-EtOH, 3); Wexford, 19-III-2004 (4), (AP-EtOH, 4); 3-IV-2004 (5), (AP-EtOH, 5). *Beaver Co.*, Racoon S. P., 29-III-2003 (2), (EtOH, 2*). Berks Co.*, Nolde S. F., 5-IV-2005 (67), (Ips, 1; AP-EtOH, 4; EtOH, 62); 19-IV-2005 (83), (Ips, 16; AP-EtOH, 37; EtOH, 30); 31-V-2005 (1), (Ips, 1). *Bradford Co.*, Chapman Rd. (NNW of Canton), 11-IV-2005 (27), (Ips, 15; AP-EtOH, 6; EtOH, 6); 26-IV-2005 (102), (Ips, 50; AP-EtOH, 7; EtOH, 45); 9-V-2005 (11), (Ips, 3; AP-EtOH, 5; EtOH, 3); 23-V-2005 (14), (Ips, 3; AP-EtOH, 3; EtOH, 8). *Butler Co.*, Annandale, 25-II-2004 (1), (AP-EtOH, 1); 25-III-2004 (5), (AP-EtOH, 5); 10-IV-2004 (3), (AP-EtOH, 3) ; Harmony, 29-III-2003 (21), (Ips, 6; AP-EtOH, 8; EtOH, 7); 12-IV-2003 (4), (Ips, 1; AP-EtOH, 2; EtOH, 1); 27-IV-2003 (4), (AP-EtOH, 3; EtOH, 1); 17-V-2003 (1), (AP-EtOH, 1); Moraine S. P., 29-III-2003 (6), (Ips, 5; EtOH, 1); 12-V-2003 (2), (Ips, 1; EtOH, 1); 25-III-2004 (20), (AP-EtOH, 20); 10-IV-2004 (4), (AP-EtOH, 4). *Cameron Co.*, Lincoln Rd. (Elk S. F., Gibson Twp.), 6-IV-2005 (19), (Ips,4; AP-EtOH, 1; EtOH, 14); 20-IV-2005 (104), (Ips, 10; AP-EtOH, 22; EtOH, 72); 6-V-2005 (2), (AP-EtOH, 1; EtOH, 1); 17-V-2005 (34), (AP-EtOH, 10; EtOH, 24). *Chester Co.*, State Game Lands No. 43 (Pine Swamp), 5-IV-2005 (8), (EtOH, 8); 19-IV-2005 (8), (Ips, 3; AP-EtOH, 3; EtOH, 2); 3-V-2005 (1), (EtOH, 1). *Clarion Co.*, Knox, 25-III-2004 (1), (AP-EtOH, 1); 10-IV-2004 (11), (AP-EtOH, 11); Tylersburg, 25-III-2004 (9), (AP-EtOH, 9); 10-IV-2004 (17), (AP-EtOH, 17). *Clearfield Co.*, Anderson Creek (W of Anderson Creek), 19-IV-2005 (121), (Ips, 16; AP-EtOH, 22; EtOH, 83); 4-V-2005 (24), Ips, 1; AP-EtOH, 9; EtOH, 14); 17-V-2005 (17), (AP-EtOH, 5; EtOH, 12). *Columbia Co.*, Roaring Creek S. F. (N of Aristes), 14-IV-2005 (591), (Ips, 165; AP-EtOH, 66; EtOH, 360); 28-IV-2005 (173), (Ips, 36; AP-EtOH, 41; EtOH, 96); 11-V-2005 (91), (Ips, 12; AP-EtOH, 31; EtOH, 48); 25-V-2005 (17), (AP-EtOH, 8; EtOH, 9). *Crawford Co.*, Crossingville, 31-III-2003 (1), (EtOH, 1); 17-IV-2003 (3), (AP-EtOH, 1; EtOH, 2); 30-IV-2003 (3), (AP-EtOH, 1; EtOH, 2); New Richmond, 31-III-2003 (1), (AP-EtOH, 1); 17-IV-2003 (6), (AP-EtOH, 1; EtOH, 5). *Cumberland Co.*, Micheaux Rd. (W. of Pine Grove Furnace), 12-IV-2005 (1), (EtOH, 1). *Erie Co.*, Erie (port area), 17-IV-2001 (5), (EtOH, 5); 2-V-2001 (10), (AP-EtOH, 3; EtOH, 7); 16-V-2001 (1), (AP-EtOH, 1); Erie (industrial site), 2-IV-2002 (11), (AP-EtOH, 2; EtOH, 9); 16-IV-2002 (22), (AP-EtOH, 11; EtOH, 11); 16-IV-2002 (11), (AP-EtOH, 11); 1-V-2002 (1), (EtOH, 1); Erie (urban site), 2-IV-2002 (16), (Chal, 1; AP-EtOH, 2; EtOH, 13); 16-IV-2002 (25), (Chal, 2; AP-EtOH, 5; EtOH, 18); Erie (forest site), 2-IV-2002 (103), (Ips, 1; AP-EtOH, 31; EtOH, 71); 16-IV-2002 (175), (Ips, 2; AP-EtOH, 46; EtOH, 127); 1-V-2002 (6), (Ips, 1; Chal, 1; AP-EtOH, 1; EtOH, 3); Erie (Lakeside Cemetery), 13-IV-2004 (17), (AP-EtOH, 2; EtOH, 15); 28-IV-2004 (4), (EtOH, 4); Erie (Eriez Magnetics), 13-IV-2004 (5), (AP-EtOH, 2; EtOH, 3); Erie (Asbury Nature Center), 13-IV-2004 (8), (AP-EtOH, 1; EtOH, 7). *Elk Co.*, Chaffee, 16-IV-2004 (24), (AP-EtOH, 24); 30-IV-2004 (2). (AP-EtOH, 2); Highland Corners, 16-IV-2004 (31), (AP-EtOH, 31); 30-IV-2004 (1), (AP-EtOH, 1). *Forrest Co.*, Lynch, 16-IV-2004 (22), (AP-EtOH, 22); Pigeon, 16-IV-2004 (1), (AP-EtOH, 1). *Franklin Co.*, Irishtown Rd. (E of Sidetown), 12-IV-2005 (1), (EtOH, 1). *Huntingdon Co.*, Indian Hanna Hunt Club (NNE of Valley Point), 12-IV-2005 (22), (AP-EtOH, 5; EtOH, 17). *Jefferson Co.*, Barkett Rd. (NE of Clear Creek S. P.), 5-IV-2005 (1), (AP-EtOH, 1); 19-IV-2005 (908), (Ips, 25; AP-EtOH, 110; EtOH, 773); 3-V-2005 (81), (AP-EtOH, 10; EtOH, 71); 16-V-2005 (365), (Ips, 2; AP-EtOH, 80; EtOH, 283). *Juniata Co.*, State Farm (N of Wistie), 12-IV-2005 (19), (AP-EtOH, 1; EtOH, 18). *Lancaster Co.*, State Game Lands No. 46 (Middle Creek), 5-IV-2005 (1), (EtOH, 1); 19-IV-2005 (1), (EtOH, 1). *Lawrence Co.*, Edinburg, 25-III-2004 (1), (AP-EtOH, 1). *McKean Co.*, Allegany N. F., 25-II/29-III-2004, M. MacKenzie, coll. (9), (EtOH, 9); 29-III/22-IV-2004 (3); Red Bridge, 16-IV-2004 (19), (AP-EtOH, 19); Wetmore, 16-IV-2004 (3), (AP-EtOH, 3). *Mercer Co.*, Camp Perry, 19-III-2003 (1), (AP-EtOH, 1); 3-IV-2003 (2), (AP-EtOH, 1; EtOH, 1); 16-IV-2003 (1), (EtOH, 1); Mercer, 3-IV-2003 (1), (EtOH, 1). *Monroe Co.*, Dixon R. Miller Rec. Area, (N of Indian Mountain Lake), 14-IV-2005 (6), (Ips, 1; AP-EtOH, 1; EtOH, 4); 28-IV-2005 (4), (Ips, 3; AP-EtOH, 1); 11-V-2005 (2), (AP-EtOH, 1; EtOH, 1). *Perry Co.*, Blain, 12-IV-2005 (9), (EtOH, 9). *Schulkill Co.*, Frackville cloverleaf, 14-IV-2005 (34), (Ips, 5; AP-EtOH, 9; EtOH, 20); 28-IV-2005 (10), (AP-EtOH, 3; EtOH, 7); 11-V-2005 (2), (AP-EtOH, 1; EtOH, 1); 25-V-2005 (1), (AP-EtOH, 1). *Tioga Co.*, Asaph Rd. (NW of Asaph), 11-IV-2005 (148), (Ips, 82; AP-EtOH, 30; EtOH, 36); 25-IV-2005 (208), (Ips, 74; AP-EtOH, 73; EtOH, 61); 9-V-2005 (94), (Ips, 39; AP-EtOH, 32; EtOH, 23); 23-V-2005 (65), (Ips, 1; AP-EtOH, 42; EtOH, 22); Groover Rd. (W of Canton), 11-IV-2005 (88), (Ips, 34; AP-EtOH, 24; EtOH, 30); 26-IV-2005 (151), (Ips, 8; AP-EtOH, 61; EtOH, 82); 9-V-2005 (25), (Ips, 8; AP-EtOH, 7; EtOH, 10); 23-V-2005 (62), (Ips, 14; AP-EtOH, 24; EtOH, 24). *Venango Co.*, Polk, 19-III-2003 (1), (EtOH, 1); 3-IV-2003 (3), (EtOH, 3); 16-IV-2003 (2), (Ips, 1; EtOH, 1); Wallaceville, 8-IV-2003 (2), (EtOH, 2); 6-V-2003 (1), (AP-EtOH, 1). *Warren Co.*, Chandlers Valley, 8-IV-2003 (1), (EtOH,

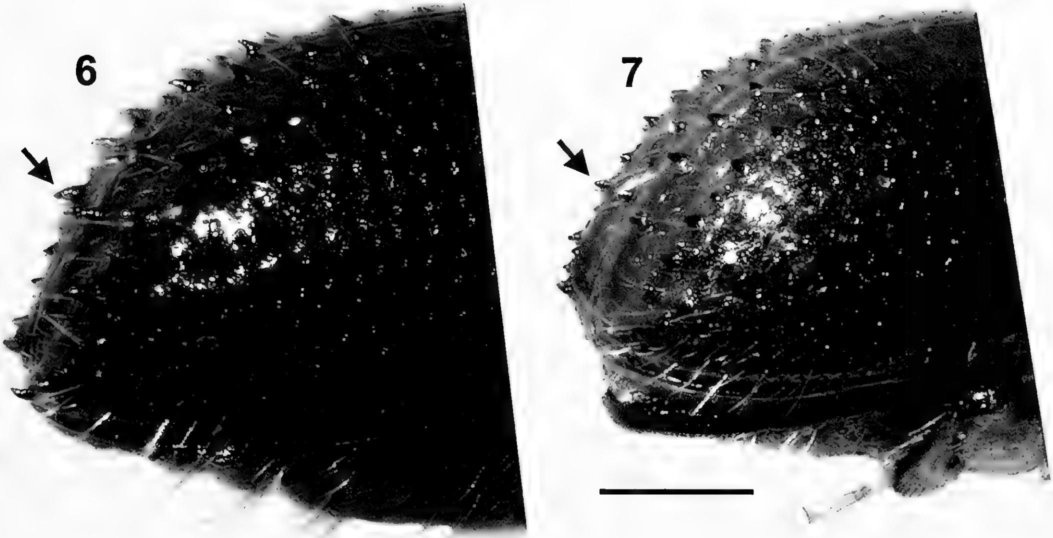


Figs. 2–5. Dorsal and lateral habitus of *Xyleborinus* spp. 2 and 4, *Xyleborinus alni*. 3 and 5, *Xyleborinus saxesenii*. 2a, Scanning electron micrograph of scutellum of *X. alni*; arrow denotes conical scutellum. Scale line for Figs. 2–5 = 1 mm; scale line for Fig. 2a = 100 µm.

1); 22-IV-2003 (7), (AP-EtOH, 2; EtOH, 5); Hearts Content, 16-IV-2004 (44), (AP-EtOH, 44); 30-IV-2004 (4), (AP-EtOH, 4); Youngsville, 8-IV-2003 (4), (AP-EtOH, 1; EtOH, 3); 22-IV-2003 (4), (AP-EtOH, 2; EtOH, 2; 16-IV-2004 (4), (AP-EtOH, 4). VERMONT: *Chittenden Co.*, Burlington, 23-IV/7-V-2002 (1), (AP-EtOH, 1).

Recognition Features

Species of *Xyleborinus* are distinguished from those of *Xyleborus* by the conical scutellum (Fig. 2a), the basal margin of the elytra being abrupt and precipitous in the median area, and by the posterior margin of the elytral declivity bearing distinct short or hooked denticles or tubercles (Figs. 6, 7). *Xyle-*



Figs. 6–7. Elytral declivity of *Xyleborinus* spp. 6, *Xyleborinus alni*. 7, *Xyleborinus saxesenii*. Arrow denotes elytral tubercles.

borinus alni (Figs. 2, 4) can be separated from *X. saxesenii* (Figs. 3, 5) by its larger size (2.5–2.8 mm vs. 1.9–2.4 mm), by the larger, hooked tubercles of the elytral declivity (Fig. 6 vs. 7), and by a slightly shorter pronotum (Fig. 2 vs. 3) (Holzschuh 1994).

NATIVE DISTRIBUTION and KNOWN HOSTS

Xyleborinus alni is native to Asia (Japan and eastern USSR), but also is adventive in Europe (Austria, Czechoslovakia, Germany and Poland) (Wood and Bright 1992, Bright and Skidmore 1997, http://xyleborini.tamu.edu/query.php?tax_id=829). In the Palearctic Region, known hosts include a variety of deciduous trees: *Alnus glutinosa* (L.) Gaertn., *A. hirsuta* (Spach.) Rupr., *Alnus* spp., *Betula japonica* Sieb. ex H. Winkler, *B. latifolia* Regel, *B. platyphylla* var. *japonica* Hara, *Corylus avellana* L., *Quercus robur* L., *Q. petraea* (Mattuschka) Liebl., (also known and cited as *Q. sessiflora*), *Salix alba* L., *S. viminalis* L., *S. caprea* L., and *Tilia amurensis* Rupr. (Wood and Bright 1992, Holzschuh 1994, Bright and Skidmore 1997, http://xyleborini.tamu.edu/query.php?tax_id=829). A breeding population from wind-blown red alder, *Alnus rubra* Bongard, was verified near the port of Olympia, Washington, in April 1997 (Mudge et al. 2001). Also, a specimen was extracted from a trunk of flowering cherry (*Prunus* "Canada Red") from a Salem, Oregon (Polk Co.) nursery in May 2001 (LaBonte et al. 2005).

ACKNOWLEDGMENTS

We thank numerous people involved in the national "Early Detection and Rapid Response" (EDRR) exotic bark beetle program and various state CAPS programs in the Northeast. In particular, we are grateful to those responsible for trap collections and screening samples, including James Manor (USDA-APHIS-PPQ, Detroit, MI), Sven-Erik Spichiger (Pennsylvania Dept. of Conversation & Natural Resources, Middletown, PA), Charles Burnham (Massachusetts Department of Conservation & Recreation, Amherst, MA), Robert Tracey (USDA-APHIS-PPQ, Linden, NJ), Paul Wrege (USDA-APHIS-PPQ, Oneida, NY), and Carolyn Klass (Department of Entomology, Cornell University). Technical assistance was provided by Donald Duerr (USDA Forest Service, Atlanta, GA), and Robert Acciavatti (US Forest Service, Morgantown, WV). Helen Butalla and Ann Steketee (USDA Forest Service, Morgantown, WV) compiled locality data for *X. alni* captured over the survey period and mapped this locality data, respectively. Kent Loeffler (Department of Plant Pathology, Cornell University) provided the habitus photographs of *X. alni* and *X. saxesenii.* Robert Acciavatti, James LaBonte (Oregon Department of Agriculture), and Natalia Vandenberg (Systematic Entomology Laboratory, USDA, Washington, DC) reviewed a draft of the manuscript and provided comments for its improvement. Stephanie Dole (Department of Entomology, Texas A&M University, College Station) (TAMU) provided the image of the scutellum of *X. alni,* made possible by a NSF-PEET grant (DEB-0328920) awarded to Anthony Cognato (TAMU).

Literature Cited

Atkinson, T. H. and S. B. Peck. 1994. Annotated checklist of the bark and ambrosia beetles (Coleoptera: Platypopdidae and Scolytidae) of tropical southern Florida. Florida Entomologist 77: 313–329.

Bright, D. E. and R. E. Skidmore. 1997. A catalog of Scolytidae and Platypodidae (Coleoptera), Supplement 1 (1990–1994). NRC Research Press, Ottawa, Ontario, Canada. 368 pp.

Holzschuh, C. 1994. Zur Unterscheidung von *Xyleborinus saxesenii* (Ratzeburg) und *X. alni* (Niisima) (Coleoptera, Scolytidae). Entomologica Basiliensia 17: 311–318.

LaBonte, J. R., A. D. Mudge, and K. J. R. Johnston. 2005. Nonindigenous woodboring Coleoptera (Cerambycidae, Curculionidae: Scolytinae) new to Oregon and Washington, 1999–2002: Consequences of the intracontinental movement of raw wood products and solid wood packing materials. Proceedings of the Entomological Society of Washington 107: 554–564.

LaGasa, E., M. M. Furniss, and H. Kampling. 1997. 1996 Washington State port area exotic bark beetle survey – a Lindgren trap, multiple lure detection survey for *Tomicus piniperda*, *Ips typographus*, *Hylastes opacus*, and other exotic species. 1996 Entomology Project Report, Laboratory Services Division, Washington State Department of Agriculture. 5 pp.

Mudge, A. D., J. R. LaBonte, K. J. R. Johnston, and E. H. LaGasa. 2001. Exotic woodboring Coleoptera (Micromalthidae, Scolytidae) and Hymenoptera (Xiphydriidae) new to Oregon and Washington. Proceedings of the Entomological Society of Washington 103: 1011–1019.

Rabaglia, R. J., S. A. Stephens, and A. I. Cognato. 2006. A review of the Xyleborina (Coleoptera: Curculionidae: Scolytinae) in America north of Mexico, with an illustrated key. Annals of the Entomological Society of America 99(6): 1034–1056.

Wood, S. L. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs 6. 1359 pp.

Wood, S. L. and D. E. Bright. 1992. A catalog of Scolytidae and Platypodidae (Coleoptera), Part 2: taxonomic index. Great Basin Naturalist Memoirs 13: 1–1553.

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 249–252

NOTE

Biological Notes on *Heriades carinatus* Cresson, *Heriades leavitti* Crawford, and *Heriades variolosus* (Cresson) (Hymenoptera: Megachilidae)

Biological information is available for three of the 13 North American species of the bee genus *Heriades* Spinola (Megachilidae: Osmiini) (Griswold 1985): *Heriades carinatus* Cresson (Rau 1922; Matthews 1965; Krombein 1967; Jensen et al. 2003), *Heriades leavitti* Crawford (Krombein 1967), and *Heriades variolosus* (Cresson) (Fischer 1955). Here, we describe the structure of *H. carinatus* nests in Montana and compare it to observations from other locations. For all three species, we add data on emergence sex ratios, and for *H. leavitti*, we report records for nest associates, including *Sapyga* spp. (Sapygidae).

To construct trap-nests, we drilled 15 cm long holes of varying diameter into pine boards and then inserted paper tubes with internal diameters of 3.2, 3.7, 4.6, 5.9, 7.5, 8.0, and 9.0 mm. Nest boards, with the nest holes facing southeast, were placed adjacent to trees at heights of 1.5–2.0 m at sites in Gallatin Co., Montana, during the last week of May 1999 and 2000 (by PDJ and KMO) and Seneca Co., New York, on 16 May 2002 (by KMO and JFO). We collected completed nests and held them at room temperature until late fall each year when they were transferred to a 8°C /85% relative humidity cold room. The following April, nests were returned to room temperature for post-diapause rearing.

Heriades carinatus.—We found *H. carinatus* in trap nests at seven sites in Gallatin Co., Montana: 1) 13 km S. of Three Forks along the Madison River; 2) 5.2 km north of Logan along an intermittent stream; 3) 3 and 5 km northeast of Norris along a stream; 4) 5 km northeast of Manhattan along a Bullrun Creek at the edge of a pasture on Fulker Farm; 5) 4 km south of Bozeman along Hyalite Creek; 6) 3 km east of Bozeman between a stream and a cultivated field on Rocky Creek Farm; and 7) Bozeman at the Montana State University Horticultural Farm. Most *H. carinatus* nested in 3.2 and 3.7 mm diameter tunnels. Of the 254 emerging *H. carinatus* adults that we could associate with nests of known diameter, 105 came from 3.2 mm nests, 134 from 3.7 mm nests, ten from 4.6 mm nests, three from 5.9 mm nests, and one each from 7.5 and 8.0 mm nests. Matthews (1965) found that *H. carinatus* usually nested in 3.1 mm holes in Michigan and 3.5 mm holes in Oregon, differences between the sites being attributable to the different sizes of trap-nests placed in the two locations. When Krombein (1967) provided trap-nests ranging from 3.2–12.7 mm in diameter, *H. carinatus* used only the two smallest hole sizes, 3.2 and 4.8 mm. Thus, the choice of nest hole sizes appears to be relatively constant among populations.

Of the ten nests dissected, seven contained only *H. carinatus* cells, whereas three also contained cells of *Trypoxylon* (*Trypoxylon*) sp. (Hymenoptera: Crabronidae). The latter included one nest with two *H. carinatus* cells outside of five *Trypoxylon* cells, one with four *H. carinatus* cells outside of two *Trypoxylon* cells, and one with two *Trypoxylon* cells outside of one *H. carinatus* cell.

The inner portion of seven completed *Heriades*-only nests included a basal space (0–69 mm long; mean ± SE = 19.3 ± 9.8). Next, was a sequence of 2–9 contiguous brood cells (mean = 5.4 ±

1.1 per nest), 6–13 mm long (mean = 8.8 ± 3 mm; N = 36). Each cell was delineated from others and from the basal space by 1–2 mm thick partitions of plant resin, but cells were not lined with any visible material. The final cell in each nest was followed by one (N = 4) or two empty "vestibular" spaces. When two vestibular spaces were present, they were separated from each other by a 1–3 mm thick resin plug. The total vestibular space, including that in nests in which *Heriades* superseded *Trypoxylon*, ranged from 22–122 mm (mean = 66.3 ± 12.0 mm). Each of the nine nests finished by a *Heriades* female was capped with a final 3–7 mm thick resin plug (mean = 4.8 ± 0.5 mm). Overall, 34.0 ± 7.5% of space in *Heriades*-only nests was devoted to brood cells and their partitions, with empty space comprising 62.5 ± 7.8% and the final plug 3.5 ± 0.4%. Matthews (1965), who provided shorter nest tunnels, reported no basal spaces in *H. carinatus* nests, so that the initial cells were either directly against the inner end of the boring or against a resin plug placed at the inner end. Like Krombein (1967), we found no plugs delineating the inner border of basal spaces. Matthews and Krombein both reported vestibular cells, although they were absent in 13% of 89 nests examined by Matthews. The range in the number of cells in Montana nests was nearly identical to that seen by Matthews (1965) in Michigan. Because nest holes were shorter in Michigan, the similar number is likely due to lack of a basal space in Michigan nests. The greater number of cells Matthews observed in Oregon (mean = 6.4, range: 2–13), was offset by shorter vestibular cells.

Sex ratios of emerging *H. carinatus* from all Montana sites combined were highly skewed towards females in 3.2 mm nests (94.4% female, N = 108; $\chi^2 = 85.3$, $P < 0.001$) and 3.7 mm nests (78.1% females, N = 137; $\chi^2 = 43.3$, $P < 0.001$). The 15 bees that emerged from 4.6–8.0 mm nests included nine females ($\chi^2 = 0.60$, $P > 0.50$). No one site produced less than 74% females. Another group of nests, for which we did not record the diameter of tunnels from which each bee emerged, produced 83.9% females (N = 155, $\chi^2 = 71.1$, $P < 0.001$). The strong and consistent bias towards females contrasts with Matthews (1965) results from Michigan where he observed emergence sex ratios of 26% females in 1963 (N = 57, $\chi^2 = 12.8$, $P < 0.001$) and 71% females in 1964 (N = 21, $\chi^2 = 3.86$, $P < 0.05$) (our analysis of his data). In trap-nesting species, it is common for cells constructed for daughters (inner cells) to be larger than those made for sons (Krombein 1967). However, we found no correlation between cell position and cell length (Spearmann rank correlation, $P = 0.82$; N = 36) and no difference between the length of the innermost and outermost cell in each nest (Wilcoxon Signed Rank Test, $P = 0.09$). Similarly, Matthews (1965) found no difference in the size of male and female *H. carinatus* cells, although females tended to occupy inner cells.

Heriades leavitti.—The single previous report of *H. leavitti* nests was by Krombein (1967), who found five nests at Lake Placid, Florida, all in 3.2 mm diameter tunnels; he reared just one individual of each sex from nests, and found no nest associates. In 2002, we found *H. leavitti* in seven 3.2 mm nests along the south edge of the North Pool at Montezuma National Wildlife Refuge, Seneca Co., New York. This extends our knowledge of the distribution of *H. leavitti*, which had not been previously reported in New York State (Hurd 1979; J. Ascher, personal communication). The nests produced 25 adult female and 18 adult male *H. leavitti* ($\chi^2 = 1.14$, $P > 0.10$), but five nests also had other occupants (Table 1). The single nest that we dissected contained ten cells whose

Table 1. Contents of *H. leavitti* nests from the Montezuma National Wildlife Refuge.

Nest number	*Heriades leavitti* Males	*Heriades leavitti* Females	Other Nest Occupants
1	0	5	*Hylaeus annulatus* (L.)[1] (5 ♂, 3 ♀); *Sapyga* sp.(1 ♂, 2 ♀)
2	0	1	*H. annulatus* (2 ♂)
3	4	0	
4	3	7	*Sapyga louisi* Krombein (1 ♂, 2 ♀)
5	4	10	
6	5	1	*S. louisi* (4 ♀)
7	2	1	*H. carinatus* (2 ♀)
Total	18	25	

[1] = *Hylaeus ellipticus* (Kirby) (Colletidae).

contents, beginning with the innermost cell, were: one female *S. louisi*, one female *H. leavitti*, four male *H. leavitti*, three female *S. louisi*, and one male *H. leavitti*. In North America, *Sapyga* have been reported attacking only Megachilidae (Krombein 1979), so it seems likely that they attacked *Heriades* rather than *Hylaeus* in our nests. If so, *Sapyga* spp. infested 18% of the *Heriades* cells in NY. This is higher than the overall rate reported by Matthews (1965), who observed *S. louisi* in 0.4% of *H. carinatus* cells, but much lower than the maximum rate of 74% for *Sapyga pumila* Cresson attacking *Megachile rotundata* (L.) (Torchio 1972); in the latter case, however, bees cells were at extremely high densities in populations managed to aid alfalfa pollination.

Heriades variolosus.—Two nests collected in 1999 from the Fulker Farm in Montana were occupied *by H. variolosus*. One male and 11 females emerged from a 3.2 mm nest, and five females emerged from a 3.7 mm nest. A 5 mm nest collected in 2000 produced one male *H. variolosus*. The only previous report on this species was that of Fischer (1955) who found a single five-celled nest in hollow sumac (*Rhus glabra* L.) stem with a bore diameter of 3 mm.

Acknowledgments.—We thank William Kemp for providing trap-nesting materials, and Richard Miller, Terry Griswold, and Karl Magnacca for identifying bees. John Ascher provided helpful comments on the manuscript, and shared his knowledge of the distribution of *Heriades*. Peter Fay, Marguerite Fulker, Bret and Katherine Olson, Robert Lane, and the Montezuma Wildlife Refuge allowed use of their properties for the study; Tracy Gingrich, the Refuge Biologist, provided assistance in locating suitable trap-nesting sites. Voucher specimens of *Heriades* have been placed in the Montana Entomology Collection, Montana State University. The research in Montana was done in partial fulfillment of requirements for an M.S. in Entomology at Montana State University by Peter D. Jensen, and was supported by the Montana Agricultural Experiment Station.

LITERATURE CITED

Fischer, R. L. 1955. A nest of *Heriades variolosus* (Cress.); (Hymenoptera: Megachilidae). Canadian Entomologist 88: 33–36.

Griswold, T. L. 1985. A generic and subgeneric revision of the *Heriades* genus-group. Ph.D. Thesis, Utah State University. xiii + 207 pp.

Hurd, P. D., Jr. 1979. Apoidea, pp. 1741–2209. *In* Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. Catalog of Hymenoptera in America North of Mexico. Vol. 2. Apocrita (Aculeata). Smithsonian Institution Press, Washington, DC. xvi + pp. 1199–2209.

Jensen, P. D., K. M. O'Neill, and M. Lavin. 2003. Pollen provision records for three species of solitary bees (Hymenoptera: Megachilidae;

Megachile, *Heriades*) in southwestern Montana. Proceedings of the Entomological Society of Washington 105: 196–203.

Krombein, K. V. 1967. Trap-nesting Wasps and Bees: Life Histories, Nests, and Associates. Smithsonian Press, Washington, D.C. 570 pp.

———. 1979. Sapygidae, pp. 1319–1321. *In* Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. Catalog of Hymenoptera in America North of Mexico. Vol. 2. Apocrita (Aculeata). Smithsonian Institution Press, Washington, DC. xvi + pp. 1199–2209.

Matthews, R. W. 1965. The biology of *Heriades carinata* Cresson. Contributions of the American Entomological Institute 1: 1–33.

Rau, P. 1922. Ecological and behavior notes on Missouri insects. Transactions of the St. Louis Academy of Science 24: 1–71.

Torchio, P. F. 1972. *Sapyga pumila* Cresson, a parasite of *Megachile rotundata* (F.) (Hymenoptera: Sapygidae; Megachilidae). I: Biology and Description of Immature Stages. Melanderia 10: 1–22.

Peter D. Jensen, Kevin M. O'Neill, James F. O'Neill, and Richard S. Miller. *(PDJ) Department of Entomology, Montana State University, Bozeman, MT 59717. U.S.A. (present address: Department of Entomology, University of Maryland, College Park, MD 20742, U.S.A.); (KMO) Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59717, U.S.A. (author to whom reprint requests should be submitted) (e-mail: koneill@montana.edu); (JFO) 188 Woodlawn Avenue, Auburn, NY 13021, U.S.A.; (RSM) Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59717, U.S.A.*

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 253–256

NOTE

A Note on the Ocurrence of the Lone Star Tick, *Amblyomma americanum* (Acari: Ixodidae), in the Maryland Suburban Counties Near Baltimore and Washington, D.C.

The lone star tick, *Amblyomma americanum* (L.), occurs over much of the southeastern and central U. S., with an extension attenuating northward along the Atlantic Coast (Keirans and Durden 1998). Over the past 20 years, the blacklegged tick, *Ixodes scapularis* Say, has largely supplanted the American dog tick, *Dermacentor variabilis* (Say), as the principal tick species causing concern among the public and health care professionals in central Maryland. Like *I. scapularis*, *A. americanum* has been extending its range and experiencing increased population densities (Ginsberg et al. 1991, Ginsberg and Zhioua 1996, Means and White 1997). Lone star ticks are not involved in transmission of the Lyme disease pathogen, *Borrelia burgdorferi*, and therefore have received less publicity than *I. scapularis*. Recently, however, Childs and Paddock (2003) pointed out a significant rise of *A. americanum* as a public health problem, and anticipated a continued increase in cases of human disease caused by *A. americanum*-associated pathogens (*Ehrlichia chaffeensis*, *E. ewingi*, "*Borrelia lonestari*"). Having been familiar with *D. variabilis*, in which only adults bite large mammals, many central Maryland residents remain naïve about the possibility of being bitten by the small larvae and nymphs of *A. americanum* and *I. scapularis*. Described here are the results of a survey for *A. americanum* in the surburbanized areas surrounding Baltimore and Washington, District of Columbia (D. C.), where suitable habitat and hosts for this species exist amidst a large human population. The survey findings are combined with collection data from the past 20 years to better define the distribution of *A. americanum* in the area. The phenology of *A. americanum* in south-central Maryland is also described.

In 2002, eight state and municipal parks, a watershed area and the western campus of the USDA, ARS, Beltsville Agricultural Research Center (BARC) in Maryland were sampled for host-seeking ticks by flagging (Table 1). These sites were suspected to straddle the western edge of the range of *A. americanum* in Maryland. A 0.5 by 0.5 m flag of laminated flannel crib cloth was flip-flopped on leaf litter and low vegetation, as the operator walked slowly for 30 s, advancing ≈10 m, in a straight line, as obstructions allowed. Ten such subsamples were taken at 5–7 sites at each location. Larval and nymphal ticks were removed from flag cloths on pieces of transparent tape and affixed in notebooks, and the ticks identified under a dissecting microscope in the laboratory. Three 600–700 m routes on the eastern campus of BARC were flagged 2–4 times per month during 1999–2001 to define seasonal activity periods of host-seeking ticks.

Lone star ticks were found at the BARC-West Campus and three of the nine park and watershed areas sampled in 2002 (two areas were sampled in the elongate Gunpowder Falls State Park) (Fig. 1). Two of the locations, where *A. americanum* was found were in easternmost Montgomery County, near the border of Prince George's County. The third location was in southeastern Balti-

Table 1. Locations in Maryland sampled for *A. americanum* by flagging in 2002.

Locality	*A. americanum* found
Baltimore County	
Gunpowder Falls State Park – Germantown	–
Gunpowder Falls State Park – Chase	+
Howard County	
Patapsco Valley State Park – Ellicott City	–
Montgomery County	
Blockhouse Point Park	–
Fairland Regional Park	+
Rock Creek Regional Park – Lake Needwood	–
Paint Branch Park	+
Wheaton Regional Park	–
Prince George's County	
T. Howard Duckett Watershed (Rocky Gorge Reservoir) – Supplee Area	–
BARC-West Campus	+

more County, where Gunpowder Falls State Park fronts the Chesapeake Bay. In the 1980s, the author found a well-established population of *A. americanum* at Cedarville State Forest in southern Prince George's County, but rarely captured the species by dragging at BARC and the USGS Patuxent Wildlife Research Center in the northern part of the county. No *A. americanum* were found in extensive drag sampling in Montgomery County in the mid-late 1980s (Carroll and Schmidtmann 1986, Carroll et al. 1991). However, by 1994, a substantial population of *A. americanum* was found at NASA Goddard Space Flight Center, Greenbelt, a property adjoining the BARC-East campus, where *A. americanum* was no longer scarce. In Harford County, populations of *A. americanum* occur at the Aberdeen Proving Ground and Edgewood Arsenal along the Chesapeake Bay. Repeated flag sampling associated with the USDA Northeast Tick Control Project (1998–2003) revealed that *A. americanum* was widespread at USGS Patuxent Wildlife Research Center North Tract, Downs Park and Gibson Island in Anne Arundel County (Carroll et al. 2002). In sampling for the Northeast Tick Control Project at Loch Raven Reservoir, an impoundment of Gunpowder Falls connected by riparian forest with Gunpowder Falls State Park, no *A. americanum* were captured, although there were dense populations of white-tailed deer, *Odocoileus virginianus* (Zimmermann), the principal host of *A. americanum* (Carroll et al. 2002).

The distribution of *A. americanum* in Maryland corresponds closely to the Coastal Plain (Fig. 1). The Baltimore-Washington, D. C. Corridor appears to be in the vanguard of western expansion of *A. americanum* in Maryland. Although *A. americanum* was not found at sampling sites in central and western Montgomery County, Howard County, and the more inland sites in Baltimore County, localized populations could exist in those areas, isolated from the more continuously distributed Coastal Plain populations. Prince George's and Anne Arundel County sites in the Northeast Tick Control Project that did not receive control treatments showed increased *A. americanum* density from 1998–2003 (Carroll et al. 2002).

In south-central Maryland, host-seeking adult *A. americanum* were found from March (warm days) to July, with a peak in June. Host-seeking nymphs occurred with adults, but the activity season began later, early May, and lasted longer into July. Nymphal activity peaked in June. Larval clusters were occasionally encountered in early June, but the great majority of larval host-seeking took place from late July to early September. These activity periods resemble those reported for coastal and Piedmont Virginia (Sonenshine and Levy 1971) and to a lesser extent Arkansas (Patrick and Hair 1977), where the

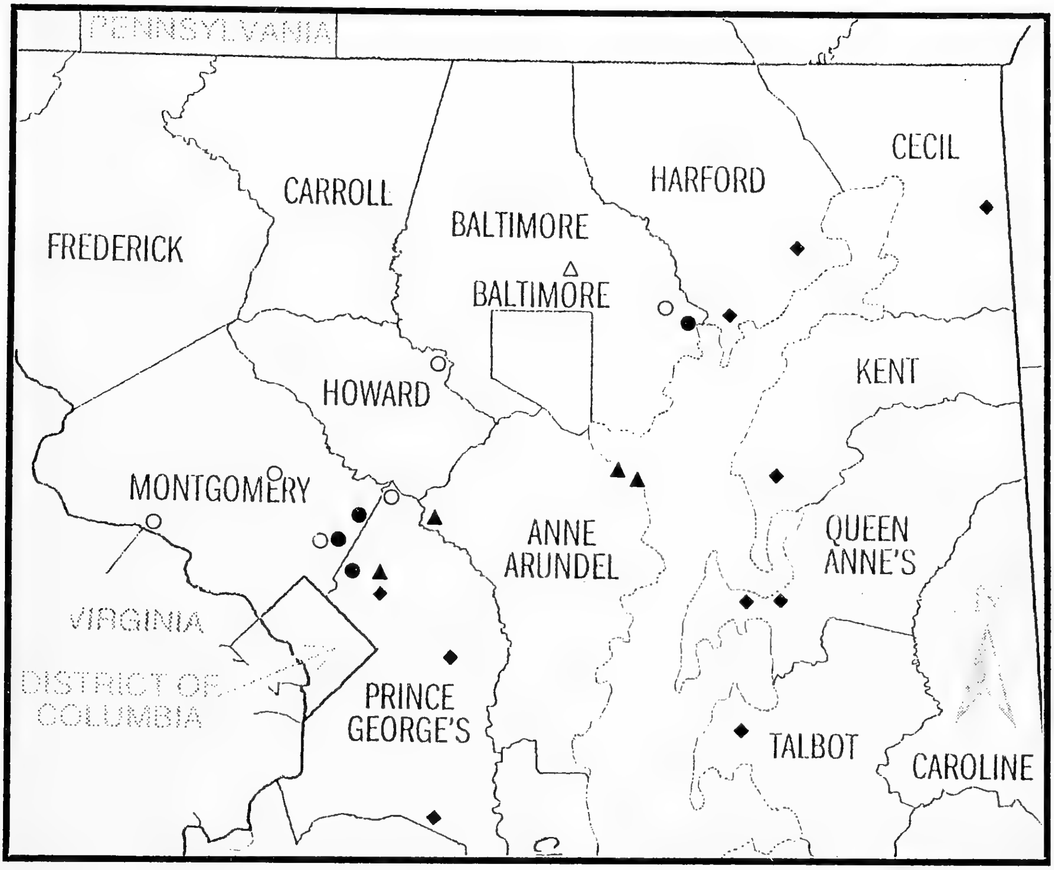


Fig. 1. The distribution of *A. americanum* in central Maryland corresponds closely with the Coastal Plain. Solid symbols indicate locations where *A. americanum* was found. Circles indicate parks and BARC West campus sampled in 2002. Triangles indicate sites extensively sampled 1998–2003 for USDA Northeast Tick Control Project. Diamonds indicate sites where *A. americanum* was captured by flagging during the course of other studies 1993–1997. The Chesapeake Bay is the large unlabeled body of water slightly to right of center of the map. *Amblyomma americanum* is widespread on Maryland's Eastern Shore, those counties on the Delmarva Peninsula on the right side of the map.

nymphal activity season is longer. In Georgia, drag collections showed longer activity periods for all host-seeking stages and earlier peaks (Davidson et al. 1994) than observed in Maryland. However, CO_2 sampling in Georgia by Davidson et al. (1994) showed much earlier *A. americanum* activity for adults and nymphs (largest catches in March) than drag sampling.

As in the case of *I. scapularis*, the growth and spread of *A. americanum* populations can be attributed to the enormous increase in white-tailed deer numbers in the past half century. Means and White (1997) suggested that repopulation of many areas of the northeast by wild turkeys, *Meleagris gallopavo* L., suitable hosts for immature *A. americanum*, has facilitated the spread of these ticks. Transportation of horses to farms in Maryland may also contribute to colonization by *A. americanum*. The author had an opportunity to examine a horse heavily infested with *A. americanum* that had been brought into Montgomery County from Virginia the previous day.

The combination of factors (especially deer and forested habitats) that have allowed the blacklegged tick to become a major problem in suburban areas in the northeastern U. S., including Maryland, exists in the Baltimore-Washington Corridor and favors the spread and establishment of *A. americanum* populations. Although the present distribution of lone star ticks in Maryland corresponds closely to the Coastal Plain, the spread of *A. americanum* into interior New York State, with its upland physiography and cooler climate (Means and White 1997), portends a westward expansion of the range of *A. americanum* into the Piedmont in Maryland. Residents and health care professionals will need to be more aware of *A. americanum* and the symptoms of diseases caused by pathogens it can transmit. The northward and westward spread of *A. americanum* in the northeastern U. S. is consistent with the current trend of climatic warming allowing species with southern origins to occupy previously inhospitable areas.

Acknowledgments.—I thank Kenneth Young, Hasani Martin and Michael Theis for their assistance in sampling for ticks. I am grateful for permission to collect ticks in Montgomery County Parks, Gunpowder Falls State Park and Patapsco Valley State Park.

LITERATURE CITED

Carroll, J. F. and E. T. Schmidtmann. 1986. American dog tick (Acari: Ixodidae), summer activity on equine premises enzootic for Potomac horse fever in south-central Maryland. Journal of Economic Entomology 79: 62–66.

Carroll, J. F., E. Russek-Cohen, J. D. Nichols, and J. E. Hines. 1991. Population dynamics of American dog ticks (Acari: Ixodidae) along park trails. Environmental Entomology 20: 922–929.

Carroll, J. F., P. C. Allen, D. E. Hill, J. M. Pound, J. E. George, and J. A. Miller. 2002. Control of *Ixodes scapularis* and *Amblyomma americanum* through use of the '4-poster' treatment device on deer in Maryland. Experimental and Applied Acarology 28: 289–296.

Childs, J. E. and C. D. Paddock. 2003. The ascendancy of *Amblyomma americanum* as a vector of pathogens affecting humans in the United States. Annual Review of Entomology 48: 307–337.

Davidson, W. R., D. A. Siefken, and L. H. Creekmore. 1994. Seasonal and annual abundance of *Amblyomma americanum* (Acari: Ixodidae) in Georgia. Journal of Medical Entomology 31: 67–71.

Ginsberg, H. S. and E. Zhioua. 1996. Nymphal survival and habitat distribution of *Ixodes scapularis* and *Amblyomma americanum* ticks (Acari: Ixodidae) on Fire Island, New York, U.S.A. Experimental and Applied Acarology 20: 533–544.

Ginsberg, H. S., C. P. Ewing, A. F. O'Connell, Jr., E. M. Bosler, J. G. Daley, and M. W. Sayre. 1991. Increased population densities of *Amblyomma americanum* (Acari: Ixodidae) on Long Island, New York. Journal of Parasitology 77: 493–495.

Keirans, J. E. and L. A. Durden. 1998. Illustrated key to nymphs of the genus *Amblyomma* (Acari: Ixodidae) found in the United States. Journal of Medical Entomology 35: 489–495.

Means, R. G. and D. J. White. 1997. New distribution records of *Amblyomma americanum* (L.) (Acari: Ixodidae) in New York State. Journal of Vector Ecology 22: 133–145.

Patrick, C. D. and J. A. Hair. 1977. Seasonal abundance of lone star ticks on white-tailed deer. Environmental Entomology 6: 263–269.

Sonenshine, D. E. and G. F. Levy. 1971. The ecology of the lone star tick, *Amblyomma americanum* (L.), in two contrasting habitats in Virginia (Acarina: Ixodidae). Journal of Medical Entomology 11: 559–563.

J. F. Carroll, *U. S. Department of Agriculture, Agricultural Research Service, Animal Parasitic Diseases Laboratory, Beltsville, MD 20705, U.S.A. (e-mail: jcarroll@anri.barc.usda.gov)*

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 257–258

NOTE

A New Replacement Name For *Pterocalla* Panfilov, 1980 (Neuroptera: Polystoechotidae), A Junior Homonym of *Pterocalla* Rondani, 1848 (Diptera: Ulidiidae)

The neuropteran generic name *Pterocalla* was proposed by Panfilov (1980) for the fossil species *Pterocalla superba*, which was based on a single strikingly-marked forewing from the Upper Jurassic of southern Kazakhstan. Panfilov originally placed *Pterocalla* in the neuropteran family Osmylidae, but the genus was reassigned to the family Polystoechotidae by Makarkin and Archibald (2005), and subsequently treated there by Archibald and Makarkin (2006).

It has recently been discovered that Panfilov's *Pterocalla* is a junior homonym of the dipteran genus-group name *Pterocalla* Rondani (Rondani 1848), which is currently considered to be a valid genus in the family Ulidiidae (Thompson 2006). *Pterocalla superba* Panfilov is regarded as a valid taxon, and is the subject of active paleoentomological research. Because *Pterocalla* Panfilov has no synonyms, a new replacement name is required for it, for which I propose the name ***Paleopterocalla*, new name**. I also create the **new combination** *Paleopterocalla superba* for its type species, the only species currently placed in the genus.

These neuropteran names now may be cited synoptically as follows:

Neuroptera: Polystoechotidae

Paleopterocalla Oswald, new name. Type species: *Pterocalla superba* Panfilov 1980: 96, fixed automatically from the original type species designation for *Pterocalla* Panfilov 1980, nec Rondani 1848. Etymology: Paleo- (from Greek palaios, ancient) + -pterocalla (from *Pterocalla*, a polystoechotid genus-group name), in reference to the junior homonym for which *Paleopterocalla* was proposed as a new replacement name, and to the fossil nature of its only known species. Gender: Feminine, from the gender appropriate to the Latin suffix -a (Art. 30.1.3).

Pterocalla Panfilov 1980: 96 (nec Rondani 1848: 83). Type species: *Pterocalla superba* Panfilov 1980: 96, by original designation. Etymology: Unexplained, probably Ptero- (from Greek pteron, wing) + -calla (from Greek kallos, beautiful), in reference to the strikingly patterned wing of its type species. Gender: Feminine, from the gender appropriate to the Latin suffix -a (Art. 30.1.3).

Acknowledgments.—I thank my colleagues Vladimir Makarkin and Bruce Archibald for reviewing this note prior to submission.

LITERATURE CITED

For more complete bibliographical and dating information about the references cited below see the cited reference numbers in the Bibliography of the Neuropterida [BotN] at http://entowww.tamu.edu/research/neuropterida/neur_bibliography/bibhome.html.

Archibald, S. B. and V. N. Makarkin. 2006. Tertiary giant lacewings (Neuroptera: Polystoechotidae): Revision and description of new taxa from western North America and Denmark. Journal of Systematic Palaeontology 4: 119–155 [errata included in publisher's pdf separate]. [BotN r#11800]

Makarkin, V. N. and S. B. Archibald. 2005. Substitute names for three genera of fossil Neuroptera, with taxonomic notes. Zootaxa 1054: 15–23. [BotN r#11650]

Panfilov, D. V. 1980. Novye predstaviteli setcharokrylykh (Neuroptera) iz yury Karatau [= New representatives of lacewings (Neuroptera) from the Jurassic of Karatau], pp. 82–111. *In* Dolin, V. G., D. V. Panfilov, A. G. Ponomarenko, and L. N. Pritykina, eds. Iskopaemye nasekomye mezozoya [= Fossil insects of the Mesozoic], Akademiya Nauk Ukrainskoi SSR, Institut Zoologii. Naukova Dumka, Kiev. 130 pp. [BotN r#5061]

Rondani, C. 1848. Esame di varie specie d'insetti ditteri brasiliani, pp. 63–112. *In* Baudi di Selve, F. and E. Truqui, eds. Studi entomologici. Stamperia degli artisti tipografi, Torino. 376 pp. [BotN r#11656]

Thompson, F. C. ed. 2006. *Pterocalla* Rondani. Biosystematic Database of World Diptera. 1 work record (not peer-reviewed material). http://www.sel.barc.usda.gov/diptera/biosys.htm, accessed on 14 June 2006.

John D. Oswald, *Department of Entomology, Texas A&M University, College Station, TX 77843-2475, U.S.A. (e-mail: j-oswald@tamu.edu)*

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 259–260

NOTE

Revalidation of *Fallceon sonora* (Allen and Murvosh), n. comb. (Ephemeroptera: Baetidae)

Baetis sonora was originally described from six larvae taken from far northern Mexico in the state of Sonora by Allen and Murvosh (1987). The species or any variety of species matching the description of the species have not been reported since that time. Lugo-Ortiz and McCafferty (1994) in their review of the genus *Fallceon* Waltz and McCafferty recognized that *B. sonora* had all of the generic characteristics associated with the latter genus [lacking all *Baetis* complex characteristics (see Waltz and McCafferty 1987)], and placed it in synonymy with *F. quilleri* (Dodds), the most widespread (Central America to Canada) and ubiquitous species of this psammophilous group of small minnow mayflies. The assumption was made that *B. sonora* was merely a smaller-in-size, differently-colored variant of *F. quilleri.*

I have examined numerous populations of *F. quilleri* from central and western North America over the past several years and never found any mature *Fallceon* material as small in size or with the particular tergal color pattern that was associated with *B. sonora*. Recently, however, I and S. Smallidge of New Mexico State University were able to collect several samples from the Rio Grande near Las Cruces, New Mexico, that were an identical match to the Allen and Murvosh description of *B. sonora*. In some samples (Dona Ana Co, Rio Grande, south of bridge on U.S. Hwy 70, west of Las Cruces, 19-X-2002), typical *F. quilleri* larvae were also taken along with the *sonora* type in the same kick screen. Not only were the two types clearly and dramatically different in size [with mature *sonora* about half the size (ca. 3.0 mm) of the mature *quilleri*], but the markings also differed dramatically as shown by a comparison of the alternating areas of uniformly solid abdominal tergal coloration as illustrated by Allen and Murvosh (1987, fig. 5) for *sonora*, and the more detailed intratergal patterning with pale dots and uneven bordering as illustrated by Morihara and McCafferty (1979, fig. 37e) for *quilleri*. Critically, the absence of any intermediate forms where the two types cohabit argues strongly for the recognition of two species.

Therefore, *Fallceon sonora*, **n. comb.**, is formally recombined and revalidated. The possibility remains that the larvae of *F. sonora* eventually may prove to be the undescribed larvae of *F. eatoni* (Kimmins), another little known southwestern species, known presently only from its distinctive adults (see McCafferty 2006).

LITERATURE CITED

Allen, R. K. and C. M. Murvosh. 1987. New Baetidae from the southwestern United States and northern Mexico (Ephemeroptera: Insecta), with notes. Canadian Entomologist 119: 1059–1099.

Lugo-Ortiz, C. R. and W. P. McCafferty. 1994. Contribution to the taxonomy of the Panamerican genus *Fallceon* (Ephemeroptera: Baetidae). Journal of the New York Entomological Society 102: 460–475.

McCafferty, W. P. 2006. Rediscovery of *Fallceon eatoni* (Kimmins) (Ephemeroptera: Baetidae). Proceedings of the Entomological Society of Washington 108: 248.

Morihara, D. K. and W. P. McCafferty. 1979. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). Transactions of the American Entomological Society 105: 139–221.

Waltz, R. D. and W. P. McCafferty. 1987. New genera of Baetidae previously included in *Baetis* Leach (Ephemeroptera). Annals of the Entomological Society of America 80: 667–670.

W. P. McCafferty, *Department of Entomology, Purdue University, West Lafayette, IN 47907, U.S.A. (e-mail: mccaffer@purdue.edu)*

NOTE

Cachaniellus, a Replacement Name for the Preoccupied Genus *Cachanocoris* (Hemiptera: Heteroptera: Pentatomidae)

Cachan (1952) proposed the new generic name *Sambirania* for an undescribed species of Pentatomidae endemic to Madagascar. Cachan was apparently unaware that the generic name *Sambirania* had already been used for a genus in the Buprestidae (Coleoptera) (Obenberger 1942). I (Rider 1998) inadvertently created my own homonym when I proposed *Cachanocoris* as a replacement name for *Sambirania* Cachan. I overlooked the fact that Villiers (1959) had already described *Cachanocoris* as a genus of assassin bugs (Heteroptera: Reduviidae). As a result, I propose the replacement name ***Cachaniellus*, new name**, for the junior homonym *Cachanocoris* Rider, 1998. *Cachaniellus obscurus* (Cachan), the type species of the genus and only included species, is a new combination.

Although Cachan (1952) originally placed *Sambirania* in the Carpocorini, he had a relatively broad concept of this tribe, placing in it several genera which are now placed in other tribes. Furthermore, he discussed the tribe Eysarcorini as part of the Carpocorini. He treated *Sambirania* between *Corisseura* Cachan, a member of the Eysarcorini, and *Antestia* Stål, a member of the Antestiini. From the description and illustrations, it appears that *Sambirania* (= *Cachaniellus*) is more closely related to *Corisseura* and other eysarcorines.

LITERATURE CITED

Cachan, P. 1952. Les Pentatomidae de Madagascar (Hémiptères Hétéroptères). Mémoires de l'Institut Scientifique de Madagascar (E) 1(2): 231–462, pls. 6–14.

Obenberger, J. 1942. De agrilinorum insulae Madagascaris generibus novis quinque. Sbornik Entomologického Oddělení Národního Museo v Praze 20: 7–13.

Rider, D. A. 1998. Nomenclatural changes in the Pentatomoidea (Hemiptera-Heteroptera: Pentatomidae, Tessaratomidae). III. Generic level changes. Proceedings of the Entomological Society of Washington 100(3): 504–510.

Villiers, A. 1959. Hémiptères Réduviidés de Côte d'Ivoire. Bulletin de l'Institut Français d'Afrique Noire 21: 301–345.

David A. Rider, *Department of Entomology, Box 5346, University Station, North Dakota State University, Fargo, ND 58105, U.S.A. (e-mail: david.rider@ndsu.edu)*

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, p. 262

ENTOMOLOGICAL SOCIETY OF WASHINGTON

SCHEDULE OF REGULAR MEETINGS FOR 2006–2007

October 5. Akito Kawahara, University of Maryland, MCSE, College Park. *Thirty-Foot Telescopic Nets, Bug-Collecting Videogames, and $1000 Beetle Pets: Entomology in Modern Japan.*

November 2. Faith Deering, University of Massachusettes, Amherst. *Lac, from Forest to Factory.*

December 7. Molly Rightmyer, University of Kansas, Lawrence, and Smithsonian Institution. *Phylogenetics and Special Adaptations for Parasitism in the Bee Tribe Epeolini, with Emphasis on the Genus Triepeolus (Hymenoptera: Apidae).*

January 4. Steve Lingafelter, Systematic Entomology Laboratory, USDA, Washington, DC. *Cerambycidae of Fiji.*

February 1. Randy Mercurio, American Museum of Natural History, New York, NY. *An Overview of Centipedes (Chilopoda) in New York State and North America.*

March 1. Jay Evans, USDA Bee Laboratory, Beltsville, MD. *Genomics of Social Insects.*

April 5. Linda Rayor, Cornell University, Ithaca, NY. *Living with Cannibals: Cooperation and Conflict in an Unusual Social Huntsman Spide*r.

May 3. Thomas Allen, Academy of Natural Sciences, Philadelphia, PA. *Four Years of Collecting and Camping: The Insect Biodiversity of the Southeastern United States.*

Meetings at 7:00 PM
Cathy Kerby Seminar Room (CE-340)
National Museum of Natural History
10th and Constitution Ave., Washington, DC
Meetings Open to the Public
Regular Pre-Meeting Dinner, 5:30 PM

PROC. ENTOMOL. SOC. WASH.
109(1), 2007, pp. 263–264

INSTRUCTIONS FOR AUTHORS

General policy.—Articles for publication are accepted from members and non-members. However, non-members pay a higher publication charge and cannot apply for a waiver of page charges. Only one author of an article needs to be a member for member rates. Articles must be in English, but an abstract in French, German, Spanish, Portuguese, Russian, and some other languages is acceptable. Such an abstract should be placed immediately after the English abstract and may be a translation of that abstract.

Manuscripts of 15 printed pages or less are encouraged, but longer manuscripts are acceptable and considered. Publication charges for pages over 15 are at a higher rate and are never waived. About two and one-half double-spaced typewritten pages equal one printed page. Manuscripts are peer reviewed before acceptance. Final acceptance is the responsibility of the Editor. Articles are published in the order received, not the date of acceptance. Immediate publication ahead of schedule is available with payment of full page charges. Notes, book reviews, and obituaries are published as space is available.

Manuscript submittal.—Manuscripts may be submitted as hard copy or electronically. For electronic submittal, send as an attachment to the editor: dsmith@sel.barc.usda.gov. Illustrations sent electronically should be in TIFF format. When submitting printed copies, please include three copies to the Editor. It is not necessary to send original illustrations until requested after the manuscript has been accepted. After acceptance, the editor will give instructions on sending the final copy and illustrations.

Format for manuscripts submitted should fit letter-sized paper. The entire manuscript should be double spaced, allowing adequate (1–1½″) margins. Words to be italicized may be indicated in italic form or underlined. Do not use bold face; the editor will mark what is to be in bold. Manuscript contents should be in the following sequence, and items 1–6 should begin a new page:

1. Title page with title, author(s), and author(s) byline. The corresponding author and address, telephone and fax numbers, and e-mail should be in the upper left corner. Title must include order and family placement, e.g., "… (Hymenoptera: Xyelidae)." Taxa of the genus- and species-group levels may have the author's name.
2. Abstract; key words. Key words should include those that do not appear in the title.
3. Text of paper; acknowledgments at end.
4. Literature cited (see below).
5. Figure legends.
6. Appendix; footnotes (if any).
7. Copies of tables; legends for tables are placed at the top of each table.
8. Copies of plates arranged in final form by author.

Illustrations.—There is no extra charge for line drawings or half tones. Authors should plan illustrations for reduction to dimensions of the printed page and allow room for legends at the bottom. Illustrations may be submitted on disk or CD, and should be in TIFF format with a resolution of 400–600 dpi; however, a printout of each illustration/plate should be provided. Illustrations also may be submitted mounted on suitable board which will be scanned by the printer. These should be trimmed, grouped together, abutted, and numbered when mounted, i.e., the author is responsible for preparation of the final plate. Consecutive figure numbers are preferred (not 1a, 1b, . . ., 2a, 2b, . . ., etc.), numbered consecutively in the sequence in which they are referred to in the text,

and positioning of the numbers for the figures at the lower right of each is preferred. Reference in the text should be as "Fig. 1," "Figs. 2, 3," "Figs. 2–5," and for Tables, "Table 1," etc. See recent *Proceedings* for style of figure legends.

Literature cited.—Cite only papers referred to in the text; list alphabetically by author; spell out references (e.g., journal names) completely, including conjunctions and prepositions. Do not italicize journal names or titles of books. See recent *Proceedings* for style of journals, books, and book chapters.

When referring to references in text, format as follows: Henry (1990), (Henry 1990), (Henry 1987, 1990), (Smith 1990, Henry 1991), (Smith 1990; Henry 1991, 1995), (Miller 1990a, 1990b), (Gagné et al. 1999). Do not italicize "et al." Citations "in press" should be cited as "in press," not with the expected year of publication. Cite as "in press" those papers that have been accepted for publication.

Names of persons providing unpublished information should include initials and be referenced in the text as: W. Mathis (personal communication) [information obtained orally] or W. Mathis (in litt.) [information obtained in writing].

Names of organisms.—The first mention of a plant or animal should include the full scientific name including the authority, spelled in full (authorities for plant names may be abbreviated). Generic names may be abbreviated after first use but should always be spelled out at the beginning of a sentence or if two or more genera being discussed have the same first letter. Within sentences use the generic name or initial preceding a species name.

Taxonomic papers.—Taxonomic papers must conform to requirements of the *International Code of Zoological Nomenclature* (1999). Holotypes must be designated for new species described, type depositories must be clearly indicated, and new taxa must be clearly differentiated from existing taxa by means of keys or differential diagnoses. An etymology section should provide the derivation of name(s), and the gender should be stated for all new genus-group names. In short, papers must conform to good taxonomic practices.

Book reviews.—Send to Dr. Raymond J. Gagné, Book Review Editor, or Editor at the address of the Society on the inside front cover. Electronic transmission is acceptable, to: rgagne@sel.barc.usda.gov, or dsmith@sel.barc.usda.gov. See recent issues of the *Proceedings* for format.

Charges.—Authors will be assessed a charge to cover editing and publication expenses. The current charges are $40.00 per printed page up to 15 pages for members and $60.00 per printed page for non-members, for all pages over 15, and for immediate publication. Charges for reprints, if ordered, and for author's corrections in proof are extra.

Member authors who are retired or not affiliated with an institution may request to have charges partially or completely waived *and should do so when the manuscript is submitted.* A maximum of 15 pages of an article may be waived. A complete or partial waiver may delay publication. Waiver of publication charges do not include cost of reprints, if ordered, or author's corrections in proof.

Acceptance of papers in based only on scientific merit without regard to the author's financial support.

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

MISCELLANEOUS PUBLICATIONS

A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera): Second Edition, Revised, by E. Eric Grissell and Michael E. Schauff. 87 pp. 1997	15.00
Revision of the Oriental Species of *Aphthona* Chevrolat (Coleoptera: Chrysomelidae), by Alexander S. Konstantinov and Steven W. Lingafelter. 349 pp. 2002	40.00
Revision of the Genus *Anoplophora* (Coleoptera: Cerambycidae), by Steven W. Lingafelter and E. Richard Hoebeke. 236 pp. 2002	30.00
A Phylogenetic Revision of the Napaeina (Lepidoptera: Riodinidae: Mesosemiini), by Jason P. W. Hall. 233 pp. 2005 Softcover 18.00, Hardcover	25.00

MEMOIRS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Memoirs 1, 2, 3, and 9 are no longer available.

No.4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No.5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No.6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No.7.	Ant larvae: Review and Synthesis, by George C. and Jeanette Wheeler. 108 pp. 1976	11.00
No.8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No.10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky, edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No.11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kammiya, 370 pp. 1983	18.00
No.12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No.13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton, 98 pp. 1987	18.00
No.14.	Biology and Phylogeny of Curculionoidea, edited by R. S. Anderson and C. H. C. Lyal. 174 pp. 1995	25.00
No.15.	A Revision of the Genus *Ceratopogon* Meigen (Diptera: Ceratopogonidae), by A. Borkent and W. L. Grogan, Jr. 198 pp. 1995	25.00
No.16.	The Genera of Beridinae (Diptera: Stratiomyidae), by Norman E. Woodley. 231 pp. 1995	25.00
No.17.	Contributions on Hymenoptera and Associated Insects, Dedicated to Karl V. Krombein, edited by B. B. Norden and A. S. Menke. 216 pp. 1996	25.00
No. 18.	Contributions on Diptera, Dedicated to Willis W. Wirth, edited by Wayne N. Mathis and William L. Grogan, Jr. 297 pp. 1997	25.00
No. 19.	Monograph of the Stilt Bugs, or Berytidae (Heteroptera), of the Western Hemisphere, by Thomas J. Henry. 149 pp. 1997	18.00
No. 20.	The Genera of Elaphidiini Thomson 1864 (Coleoptera: Cerambycidae), by Steven W. Lingafelter. 118 pp. 1998	12.00
No. 21.	New World *Blepharida* Chevrolat 1836 (Coleoptera: Chrysomelidae: Alticinae), by David G. Furth. 110 pp. 1998	12.00
No. 22.	Systematics of the North American Species of *Trichogramma* Westwood (Hymenoptera: Trichogrammatidae), by John D. Pinto. 287 pp. 1999	28.00
No. 23.	Revision of the Net-Winged Midges of the Genus *Blepharicera* Macquart (Diptera: Blephariceridae) of Eastern North America, by Gregory W. Courtney. 99 pp. 2000	14.00
No. 24	Holcocerini of Costa Rica (Lepidoptera: Gelechioidea: Coleophoridae: Blastobasinae), by David Adamski. 147 pp. 2002	18.00
No. 25	A Catalog of the Cecidomyiidae (Diptera) of the World, by Raymond J. Gagné. 408 pp. 2004	50.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $60.00 per volume to non-members and $25.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra on all orders. Dealers are allowed a discount of 10 percent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Treasurer, Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, D.C. 20013-7012.

CONTENTS

(Continued from front cover)

NOTES

MISCELLANEOUS

VOL. 109 APRIL 2007 NO. 2
(ISSN 0013-8797)

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY
of WASHINGTON

PUBLISHED
QUARTERLY

CONTENTS

(Continued on back cover)

THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

ORGANIZED MARCH 12, 1884

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168.

MEETINGS.—Regular meetings of the Society are held in the Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 7:00 P.M. Minutes of meetings are published regularly in the *Proceedings*.

MEMBERSHIP.—Members shall be persons who have demonstrated interest in the science of entomology. Annual dues for members are $25.00 (U.S. currency).

PROCEEDINGS.—The *Proceedings of the Entomological Society of Washington* (ISSN 0013-8797) are published quarterly beginning in January by The Entomological Society of Washington. POSTMASTER: Send address changes to the Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember U.S. subscriptions are $60.00 per year and foreign subscriptions are $70.00 per year, payable (U.S. currency) in advance. Foreign delivery cannot be guaranteed. All remittances should be made payable to *The Entomological Society of Washington*.

The Society does not exchange its publications for those of other societies.

PLEASE SEE PP. 511–512 IN THIS ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Editor: David R. Smith, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Books for Review: David R. Smith, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 5 April 2007

Periodicals Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 265–276

A NEW GALL-INDUCING TORTRICID (LEPIDOPTERA: TORTRICIDAE: OLETHREUTINAE) ON LIMA BEAN (*PHASEOLUS LUNATUS*; FABACEAE) FROM COSTA RICA

John W. Brown and Kenji Nishida

(JWB) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, DC 20013-7012, U.S.A. (e-mail: john.brown@ars.usda.gov); (KN) Sistema Estudios de Posgrado en Biología, Escuela de Biología, Universidad de Costa Rica, 2060 San José, Costa Rica (e-mail: kenji.nishida@gmail.com)

Abstract.—***Lusterala phaseolana*, new genus** and **new species**, is described and illustrated from Costa Rica. The new genus can be distinguished from all other Olethreutinae by its unusual male genitalia, with a digitate uncus covered with long hairs and the absence of socii, and its distinctive forewing maculation (i.e., dark brown with scattered iridescent scales). Assignment of the new genus to Grapholitini is provisional based on the general appearance and chaetotaxy of the larva and a feature of the wing venation (i.e., M_2 and M_3 parallel and widely separated at the base). The entire type series was reared from stem galls on lima bean, *Phaseolus lunatus* L. (Fabaceae).

Resumen.—Se describen e ilustran un **género y especie nuevos, *Lusterala phaseolana***, de Costa Rica. El nuevo género puede distinguirse de resto de Olethreutinae por el patrón de las alas anteriores, con escamas iridiscentes dispersas, y por la inusual genitalia del macho, sin socii y con un uncus grande, en forma de lóbulo y cubierto de pelos largos. La posición de este nuevo género en Grapholitini es provisional. Todos los especímenes de serie tipo fueron obtenidos a partir de agallas del tallo del frijol lima, *Phaseolus lunatus* L. (Fabaceae).

Key Words: gall, life history, neotropics, new genus, new species, taxonomy, *Cydia torostoma*, *Dolichogenidea*

Gall-inducing in Lepidoptera was reviewed by Miller (2005) who recognized 39 species of Tortricidae in 14 genera worldwide as gall-inducers, which is second only to Gelechiidae in the number of gall-inducing species in any family of microlepidoptera. Given that more than 9,100 species of tortricids have been described (Brown et al. 2005), and hosts have been documented for many (Robinson et al. 2006), gall-inducing by larvae of this family appears to be a relatively rare habit that has evolved independently numerous times in various lineages. Known gall-inducers are found primarily in three tribes, Cochylini (4 genera) (Nishida and Adamski 2004, Miller 2005 and references therein), Grapholitini (3 genera) (Miller 2005), and Eucosmini (6 genera) (Miller 2005);

single species are reported in Olethreutini (Miller 2005), Enarmoniini (Miller 2005), Euliini (Brown and Nishida 2003), and Hilarographini (Brown et al. 2004). The purposes of this paper are to describe and illustrate a new genus and species of Olethreutinae that induces galls on *Phaseolus lunatus* L. (Fabaceae: Papilionoideae) in Costa Rica and to provide comments on its biology. The new taxon is placed provisionally in Grapholitini.

Phaseolus lunatus, the larval host plant of the new tortricid, is known commonly as lima bean, sieva bean, or butter bean (Iziko Museums of Cape Town 2004). It is a vine that frequently grows in disturbed habitats and urban areas, climbing over adjacent vegetation (Fig. 8) and fences. The plant is common in tropical climates with distinct wet and dry seasons (Sauer 1993). Although Central and South American in origin (Sauer 1993), it has been domesticated for more than 8,500 years, and it now ranges in the New World from northwestern U.S. to Argentina; it also occurs in Europe, central Africa, Madagascar, and the Philippine Islands (Missouri Botanical Garden 2005). In Costa Rica, *P. lunatus* is known on the Pacific slope from sea level to about 1800 m elevation (INBio 1997, Missouri Botanical Garden 2005). The species has been targeted for conservation of plant genetic resources (Vargas et al. 2003).

MATERIALS AND METHODS

Galls induced by Lepidoptera larvae were collected from *P. lunatus* between April 2000 and March 2002 in Quitirisí, Ciudad Colon (1050 m) and Aserrí Centro (1300 m), both in San José Province, Costa Rica. The climate at these two sites is considered "tropical humid" with three to six months of dry season annually (Herrera and Gómez 1993). Galls were placed in transparent plastic bags and taken to the entomological laboratory at Escuela de Biología, Universidad de Costa Rica (1150 m), San José, where they were maintained at ambient indoor temperature (23 to 24°C). To examine their contents, galls were split open longitudinally. A subset of larvae and pupae and reared parasitoid wasps were preserved in 75% EtOH. As adult moths emerged they were killed and pin-mounted.

Dissection methodology follows that presented in Brown and Powell (1991, 2000). Digital images of the life history were captured with a Nikon Coolpix© camera. Images of adults and genitalia were captured using a Microptics© digital camera system and enhanced using Adobe Photoshop© and Illustrator© software. Terminology for genitalia structures and wing venation follows Horak (1984). Terminology for larval chaetotaxy follows R. Brown (1987). Paratypes are deposited in The Natural History Museum, London, United Kingdom (BMNH); Instituto Nactional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (INBio); National Museum of Natural History, Washington, D.C., U.S.A. (USNM); and Escuela de Biología, Universidad de Costa Rica, San José, Costa Rica (UCR). Vouchers of larvae are deposited in USNM.

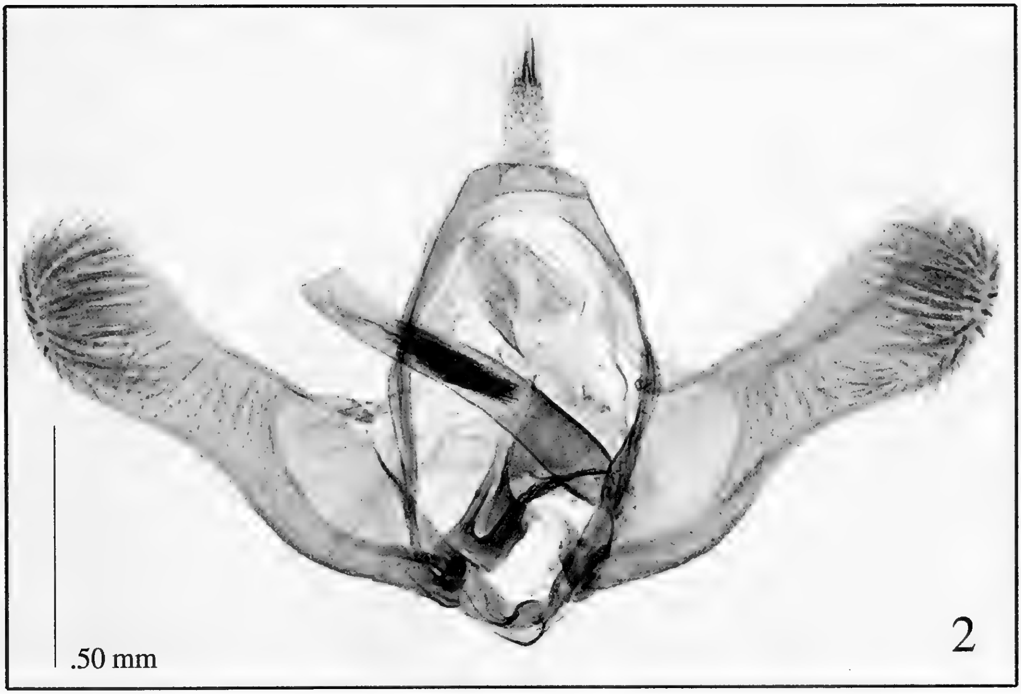
SYSTEMATICS

Lusterala Brown and Nishida, new genus

Type species: *Lusterala phaseolana* Brown and Nishida, new species.

Diagnosis.—*Lusterala* can be distinguished morphologically from other genera of Olethreutinae by the somewhat digitate, weakly sclerotized uncus of the male genitalia combined with the absence of socii (Fig. 2), and superficially by the slightly upraised iridescent scales on an otherwise nearly uniform dark brown forewing (Figs. 1, 11).

Lusterala is assigned to Olethreutinae on the basis of the antenna with one ring of scales per flagellomere; the hindwing



Figs. 1–2. *Lusterala phaseolana*. 1, Holotype male (left side and mirror image). 2, Male genitalia of paratype, aedeagus in situ (USNM slide 84,931).

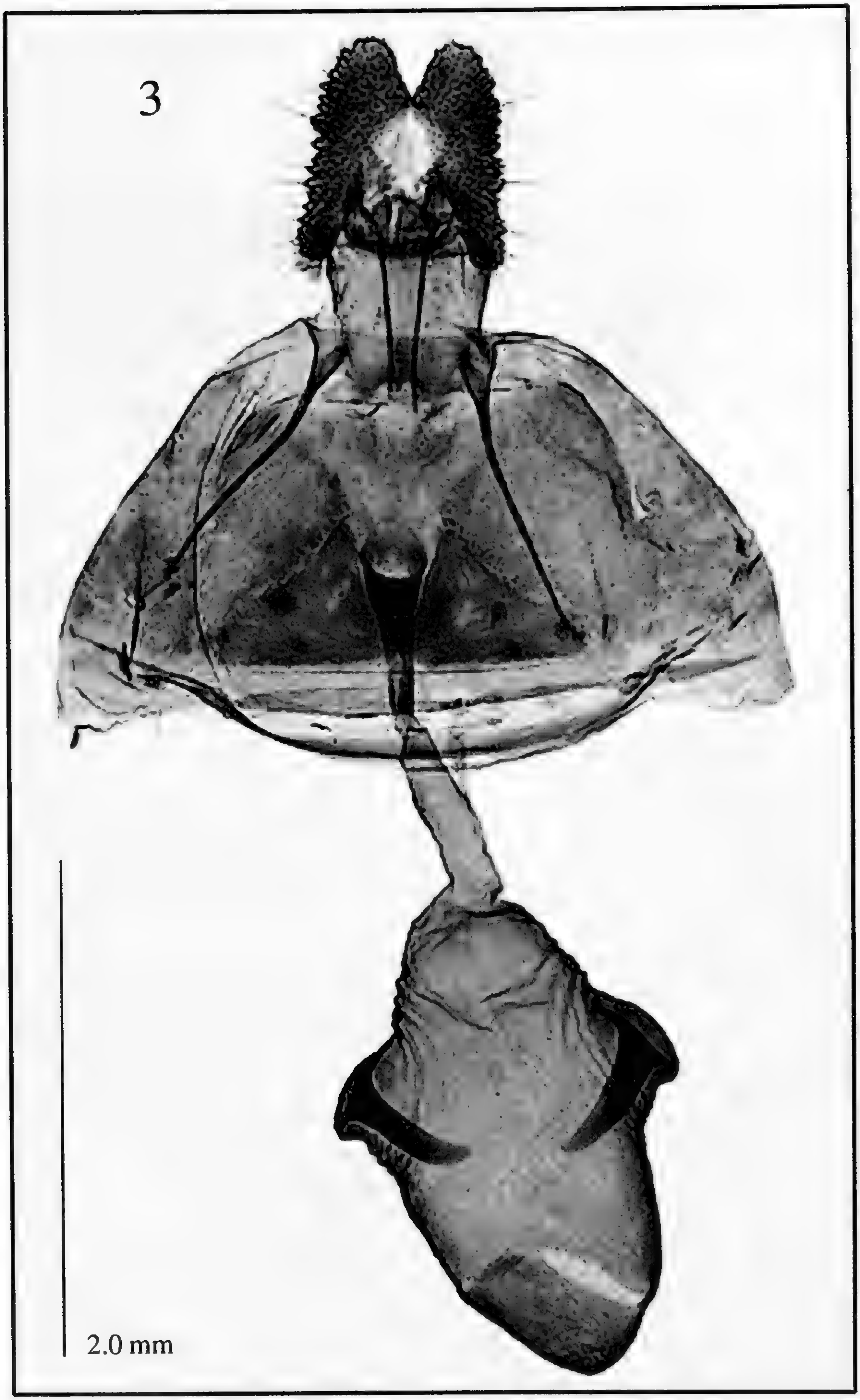


Fig. 3. Female genitalia of *Lusterala phaseolana* paratype (USNM slide 84,928).

with cubital pecten; the male genitalia with the transtilla and gnathos absent, the valva with a conspicuous basal excavation, and the aedeagus fused with the anellus and juxta (Fig. 2); and the female genitalia with two large hornlike signa (Fig. 3) (Horak 1998). Its tribal assignment is considerably more difficult. The large, paired, hornlike signa (Fig. 3) exclude it from Bactrini, Endotheniini, and Gatesclarkeanini, and combined with the general aspect of the male genitalia, from Olethreutini. *Lusterala* also lacks a modified anal region in the hindwing and modified scales of the basal portion of the patagia, which are characteristic of many male Olethreutini. The dark brown color of the forewing and the somewhat digitate uncus densely covered with hairs are highly reminiscent of those of *Cryptaspasma lugubris* (Felder) and some other Microcorsini (see Diakonoff 1959, Brown and Brown 2004), but *Lusterala* lacks virtually all of the characters that define that tribe. While the number and arrangement of the cornuti in the aedeagus are similar to those of *Ancylis* (Enarmoniini), other features typical of that tribe, e.g., falcate apex of forewing, valva usually with large basal excavation, a single or bifid thorn from the cucullus, and a pair of large angulate signa (Horak 2006), are lacking in *Lusterala*. The form of the aedeagus and cornuti, the presence of an uncus, the long ductus bursae, and the saberlike signa suggest an affinity with Eucosmini; however, the venation of the hindwing clearly contradicts this placement. *Lusterala* is superficially similar to some species of Grapholitini; the larvae are similar to many internal-feeding Grapholitini (e.g., *Cydia*); the overall aspect of the male and female genitalia are consistent with members of that tribe; and hindwing veins M_2 and M_3 are parallel and widely separated at the base—a character that has been used to define Grapholitini. On the basis of these characters, *Lusterala* is assigned provisionally to Grapholitini.

Within Grapholitini, *Lusterala* is superficially most similar to *Gymnandrosoma*, *Ecdytolopha*, *Thaumatotibia*, and relatives, characterized by a dark brown forewing with few distinct pattern elements. In addition, virtually all members of the *Gymnandrosoma* genus group are internal feeders. *Lusterala* can be distinguished from that group of genera by a more rounded forewing apex and the absence of a white or pale dot near the end of the discal cell characteristic of that group; also, males lack secondary sexual scales typical of the group (Adamski and Brown 2001). The larvae of *Lusterala* lack the large, sclerotized pinacula, including the distinctive enlarged L-pinaculum of the prothorax and the posteriorly displaced spiracle on A9 that are diagnostic for the *Gymnandrosoma* group (Adamski and Brown 2001).

According to Horak and Brown (1991), Grapholitini may represent a polyphyletic assemblage of genera in which features of the genitalia and wing venation reflect parallel reductions rather than synapomorphies. In contrast, Komai (1999) recognizes the shortened sternum 8 in the male with a straight posterior margin as a putative synapomorphy for the tribe. In *Lusterala* the sternum is not particularly short, and the margin is slightly convex.

Description.—*Adult: Head*: Frons weakly convex, with small appressed scales; vertex with forward projecting scales, approaching but not reaching base of labial palpus, each scale with a scalloped tip. Antenna ca. 0.5 as long as forewing length; setae less than 0.25 times width of flagellomere, much more dense in males than in females; one row of scales per flagellomere. Labial palpus short, ca. 1.2 times horizontal diameter of compound eye; first segment short, upcurved; second segment longest, densely scaled, ca. 6 times as long as third segment, slightly upcurved; third segment short, barely extending beyond scaling of second. Maxillary palpus inconspicuous. Proboscis developed, naked. Ocelli large, chaetosemata well developed. A narrow band of long semierect scales from lateral posterior part of vertex to occiput and surrounding compound eyes. *Thorax*: Dorsum and tegula smooth scaled; posterior tuft weak, comprised of a patch of conspicuously broad, somewhat elongate-rectangular scales (worn and/or lacking in most specimens). Legs unmodified. Forewing with all veins present and separate beyond discal cell; discal cell ca. 0.65 times length of wing; M-stem weak, chorda present forming short accessory cell arising ca. midway between R_2 an R_3 and extending to base of R_5; base of R_5 closer to base of R_4 than to base of M_1; M_2, M_3, and CuA_1 nearly parallel, with bases nearly equidistant among them; CuP weak, present only at wing margin; anal loop ca. 0.35 times length of 1A+2A; male without costal fold. Hindwing with veins Sc+R straight, closely parallel to Rs in basal 0.5; M_1 parallel to Rs in basal 0.25; M_2 only slightly closer to M_3 than to M_1 at base; M_2 and M_3 parallel, widely separated at bases; M_3 and CuA_1 coincident at base; CuP present, but weak throughout; basal stem of CuP and 1A+2A setose. Frenulum in female with three bristles, male with one. *Abdomen*: Sternum 8 in male with slightly convex posterior margin; coremata absent in male; no specialized corythrogyne scales in female. Male genitalia (Fig. 2) (3 preparations) with tegumen simple, ovoid; uncus moderately large, somewhat digitate, rounded distally, weakly sclerotized, densely covered with long hairs somewhat thicker distally; socius and gnathos absent; anal tube poorly defined, represented by round, weakly sclerotized region; valva broadest in basal 2/5, slightly narrowed in middle, slightly dilated distally, rounded apically, costa very slightly undulate, cucullus well-developed in distal 1/4. Aedeagus simple, long, ca. 4/5 length of valva, vesica with 35–40 slender cornuti, sometimes in a dense, elongate patch and sometimes scattered throughout. Female genitalia (Fig. 3) (2 preparations) with ovipositor short; papillae anales simple with relatively short setae from papillate bases; apophyses long and slender, apophyses anteriores ca. 1.3 times the length of aphophyses posteriores; ostium ringlike; a small cup-shaped antrum between ostium and ductus bursae; sternite of seventh segment with a pair of irregularly triangular, lightly sclerotized areas antero-laterad to ostium; ductus bursae relatively straight, ca. 2/3 length of corpus bursae, slightly broadened in anterior 1/2, membranous; ductus seminalis from lateral right portion of ductus bursae ca. 2/3 distance from ostium to junction with corpus bursae; corpus bursae elongate-ovoid, without spicules; two large signa each consisting of a long, broad, straight, attenuate thorn, weakly curved apically, from a broad, round, invaginated, sclerotized pocket of the outer wall of corpus bursae.

Etymology.—The genus name is from the Latin "*luster*" (= illuminate), in reference to the iridescent scales of the forewing, and the Latin "*ala*" (= wing). The gender is masculine.

Lusterala phaseolana **Brown and Nishida, new species**

(Figs. 1–4, 11)

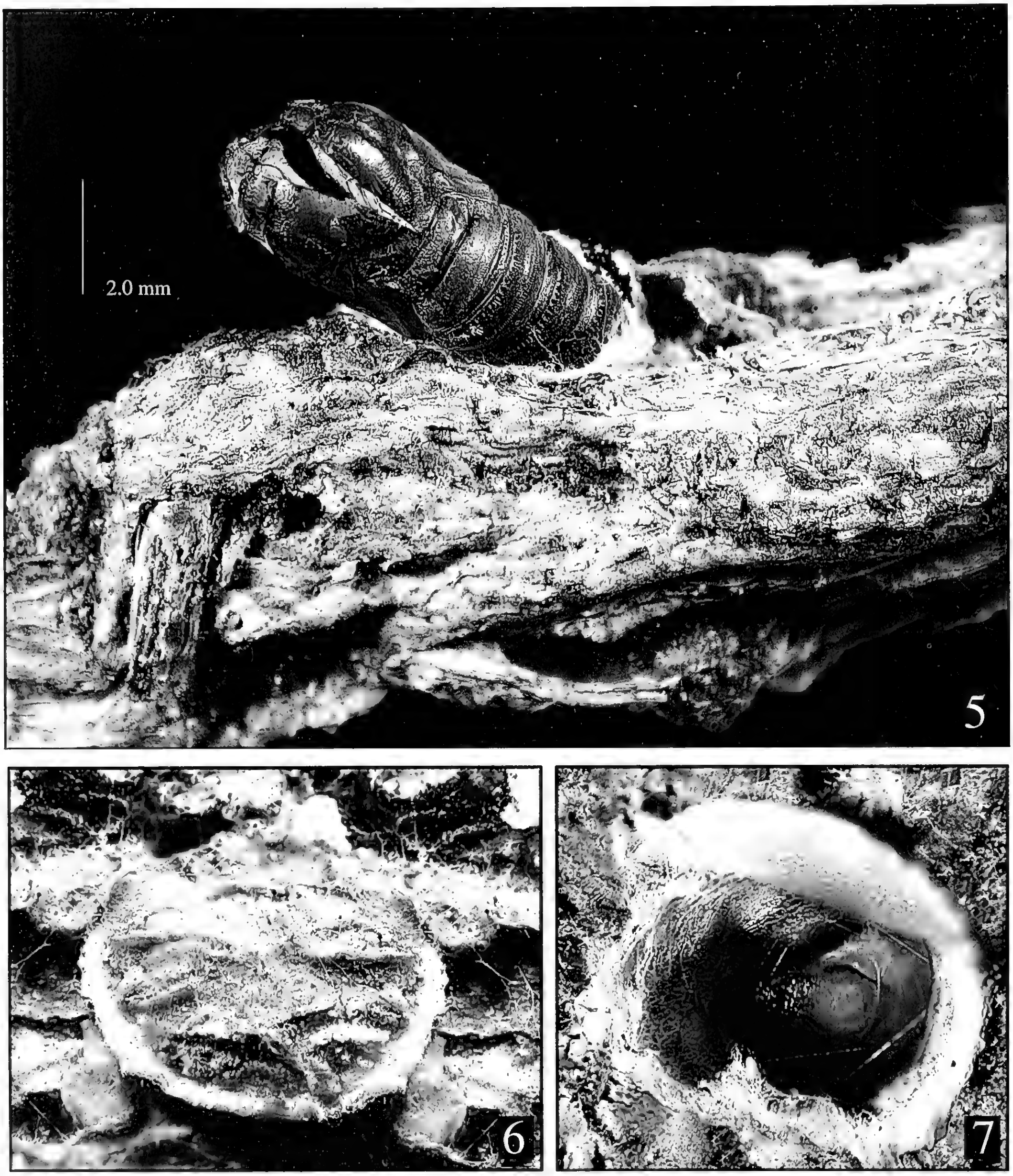
Diagnosis.—As presently defined, *Lusterala* is monotypic. The single included species can be distinguished superficially from all other Grapholitini by the sparse irregular lines and small patches of iridescent scales (slightly bluish) on the forewing and dorsum of the thorax. Distinctive morphological features include the digitate uncus in the male

Fig. 4. Pupal exuviae of *Lusterala phaseolana*; venter (on right) and dorsum (on left).

genitalia and the deeply invaginated, strongly sclerotized bases of the hornlike signa in the female genitalia. Females are conspicuously larger than males.

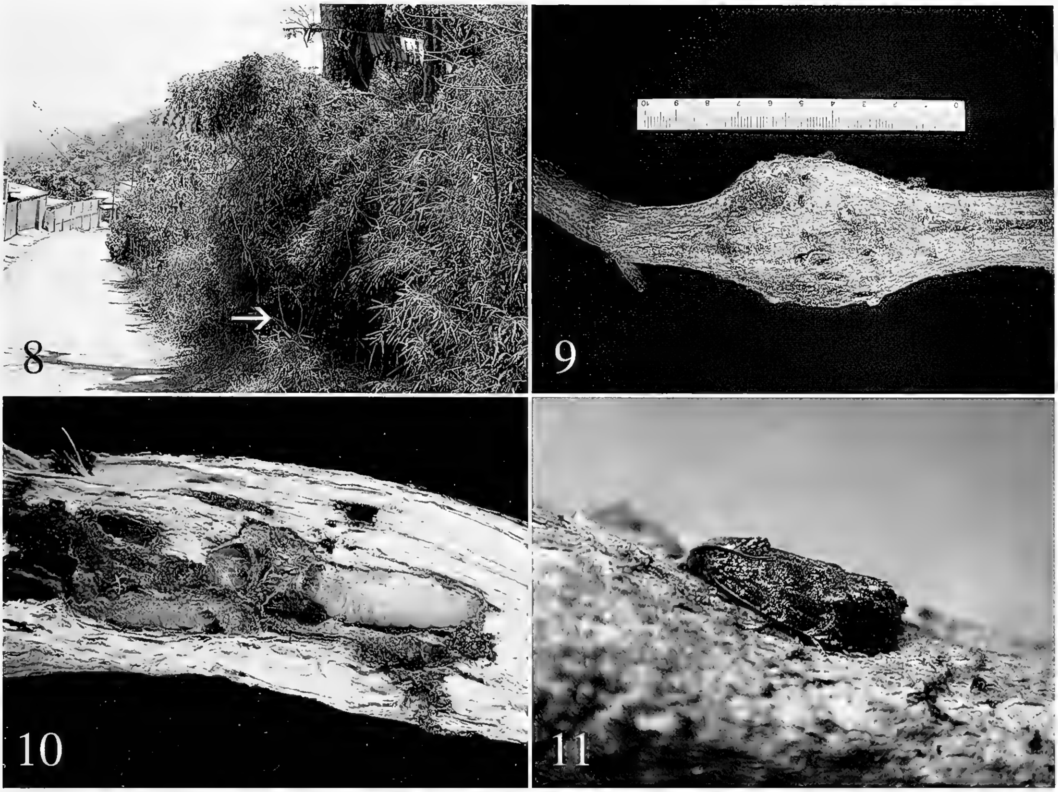
Description.—*Adult: Head:* Frons and vertex dark brown; labial palpus lighter brown with faint bluish iridescence. *Thorax*: Dark brown with scattered iridescent scales; posterior tuft a low, rounded patch of blackish brown scales. Forewing length 6.9–8.0 mm ($\bar{x}$ = 7.1; n = 10) in males, 8.5–9.5 mm ($\bar{x}$ = 9.2; n = 10) in females; dorsal surface entirely dark brown, with sparse irregular lines and small patches of slightly upraised, iridescent scales (reflecting slightly bluish), rarely with extremely sparse whitish striae; costal strigulae extremely weak, overscaled with brown; fringe dark brown. Undersurface uniform dark brown. Hindwing dorsal surface dark brown, concolorous with forewing; fringe pale cream; male without specialized scales. Undersurface uniform dark brown. *Abdomen*: Dark brown, outer surface of valva of male with sparse, fine, pale brown scales; no conspicuous specialized scales in male or female. Male genitalia (Fig. 2) as described above for genus. Female genitalia (Fig. 3) as described above for genus.

Larva: Based on four probable last instars. In general, the larva is short (8.0–8.5 mm in length), plump, and pale cream or pinkish; the pinacula lack distinct sclerotization; and the anal fork is absent, features typical of many internal-feeding Olethreutinae, especially Grapholitini (e.g., *Cydia* spp.). The spiracles are distinctly ovoid, the prothoracic spiracle is ca. 2.5 times the size of the others, and the spiracle on abdominal segment 9 is only slightly larger than those of other abdominal segments. The head is pale amber with an extremely faint genal bar. The prothoracic shield is ill-defined, represented by a pair of weakly sclerotized, triangular patches, one on each side of the dorsum. The L-group on the prothorax is bisetose, which is rare in Tortricidae. Although endophagous Tortricinae have a propensity for the loss of one of the L setae, this is seldom, if ever, the case in endophagous Olethreutinae (Dugdale pers. comm., Brown et al. 2004). The SV-group on thoracic segments 1, 2 and 3 is 2:1:1, typical of Tortricidae. The SV-group on abdominal segments 1, 2, 7, 8, 9 is 2:2:2:1:1 (variable within most tribes of Olethreutinae). On abdominal segment 8, seta SD1 is directly anterior to the spiracle. On abdominal segment 9, the D2 setae are on a shared, unsclerotized, dorsal pinaculum; setae D1 and SD1 are on a shared pinaculum; and the L-group is bisetose. The distance between the V setae on abdominal segment 9 is about two-thirds that between the V setae of abdominal segment 8. The setae of the anal shield are short. The prolegs of abdominal segments 3–6 bear 25–35 uniordinal crochets, the proleg of segment 10 bears 8–10.



Figs. 5–7. *Lusterala phaseolana* gall. 5, Pupal exuviae protruding from gall. 6, Exit cover of gall. 7, Larva within gall chamber with exit cover opened.

Pupa (Figs. 4, 5): Based on 15 exuviae. Typically tortricoid, without conspicuous sculpturing or cephalic prominence; length 8.0–10.0 mm in males, 11.5–12.0 mm in females. Dorsum of abdominal segment 1 without spines and with spiracle inconspicuous. Dorsum of abdominal segments 2–7 with two distinct rows of spines, anterior row on segment 2 with only 2–4 small spines, posterior row well developed; anterior row on segments 4–7 extending from spiracle to spiracle. Dorsum of abdominal segments 8–10 with a single row of large thorns



Figs. 8–11. Habitat, gall, and resting posture of *Lusterala phaseolana*. 8, Roadside habitat and host (arrow indicates position of gall). 9, Globose gall induced by *L. phaseolana* (scale bar in mm/cm). 10, Inside of elongate gall induced by *L. phaseolana* showing larvae in chambers. 11, Adult *L. phaseolana* resting on branch of host.

representing anterior row; no conspicuous hooked seta on abdominal segment 10. Cremaster absent.

Type material.—Holotype ♂, Costa Rica, Provincia San José, Aserrí Centro (site E43), 1400 m, 7 Jun 2000, r.f. *Phaseolus lunatus*, collected by M.-H. Kestemont, reared by K. Nishida. Deposited in USNM.

Paratypes: COSTA RICA: Provincia San José: Aserrí Centro (site E43), 1400 m, 8 May 2000 (1♂), 10 May 2000 (1♂, 3♀), 15 May 2000 (1♀), 16 May 2000 (3♂, 3♀), 23 May 2000 (2♂, 1♀), 3 Jun 2000 (2♂, 1♀), 7 Jun 2000 (1♂, 1♀), gregarious gall former on *Phaseolus lunatus*, collected by M.-H. Kestemont, reared by K. Nishida. Ciudad Colon, Quitirisí, De Quebrada Honda, 2 km hacia Quitirisí, 16 Apr 2000 (1♂, 1♀), K. Nishida. Site MH1, 18 Mar 2000 (1♂), 20 Mar 2000 (3♂), 31 Mar 2000 (1♀), gregarious gall former on *Phaseolus lunatus*, collected by M.-H. Kestemont, reared by K. Nishida.

Etymology.—The specific epithet is derived from the host plant genus, *Phaseolus*.

BIOLOGY

The galls of *Lusterala phaseolana* are variable from elongate spindle-shaped to globose (Figs. 5, 9, 10). They were discovered on old (lignified) stems of *Phaseolus lunatus* growing along roadsides (Fig. 8, arrow). The galls usually were located near the basal part of the plant close to the ground (Fig. 8). Gall-induction usually caused wilting and eventual death of the plant (E. Castro, personal communication). A single large gall (ca. 10 cm × 1.6 cm; stem diameter of 8 mm) contained as many as 12 last instar larvae (unilocular, i.e., one larva per chamber). Apparently, swelling of the stem (i.e., gall) is the result of enlarged parenchyma tissue. Several galls had a purplish tint in tissue that surrounded the larvae or pupae. One gall collected in Aserrí Centro contained coexisting larvae of *Lusterala phaseolana* and *Carmenta mimosa* Eichlin and Passoa (Sesiidae). This gall was larger than galls occupied by *Lusterala* alone. Larvae of *C. mimosa*, erroneously cited as *Synanthedon* sp. by Saunders et al. (1998), are recorded as gall-inducers on some bean plants (Saunders et al. 1998) including *P. lunatus* in Costa Rica (K. Nishida, personal observation).

Each larval chamber of last instar *Lusterala* larvae (Fig. 10) was lined with silk, the chambers clustered together within the gall. Frass was present in spaces surrounding and between chambers and was more or less compacted. Some of it protruded from the gall surface through the exit holes. Some frass was exuded and attached along shallow longitudinal grooves of the gall surface (Fig. 9).

Last instar larvae reacted to gentle probing with forceps by regurgitating a translucent fluid. Agitated larvae kept their mandibles open after regurgitating and aggressively moved toward and bit at the source of agitation.

The pupal chamber in the gall is ca. 12 × 3 mm, cylindrical, and white to cream white. The outer surface of the cocoon is brown and covered with frass. The exit hole from the chamber (Figs. 6, 7, 9) is round, ca. 2.8 mm in diameter; each larva has its own exit hole. The exit "valve" is penelliptical, constructed by silk with the peridermal layer of the plant tissue on the outside (Figs. 6, 7). The pupa protrudes prior to adult emergence (Fig 5). Emerged adults perched on the host (Fig. 10), where they were highly camouflaged by their barklike appearance.

The galls of *Lusterala* are superficially similar to those described for *Cydia torostoma* (Clarke) (Clarke 1972), which is also a pest of beans in Costa Rica (Saunders et al. 1998). The adult of *C. torostoma* is somewhat similar to that of *Lusterala*; however, the similarity is merely the result of the shared absence of distinct forewing pattern elements; i.e., both species are mostly nondescript little brown moths; however, *C. torostoma* has considerably more whitish scaling on the forewing. The genitalia of the two species demonstrate that they are not closely related.

It is interesting that no specimens of *L. phaseolana* were discovered in the rather extensive Lepidoptera collection at INBio, suggesting that the species may be diurnal or possibly not attracted to ultraviolet light; the latter is the standard collecting method. Hence, the discovery of species related to *Lusterala phaseolana* may require the rearing of larvae.

A series of *Dolichogenidea* sp. (Hymenoptera: Braconidae: Microgastrinae) (determined by Alejandro Valerio) parasitoid wasps was reared from larvae of *L. phaseolana*. Several specimens of *Perilampus* sp. (Hymenoptera: Perilampidae) (identified by Paul Hanson) also were reared as a hyperparasitoid of *Dolichogenidea* sp.

ACKNOWLEDGMENTS

We thank Marie-Helene Kestemont and Arnauld Thiry (Faculté des Sciences Agronomiques de Gembloux, Gembloux, Belgium) for sharing specimens and for providing collecting data; Tom Eichlin (California Department of Food and Agriculture, Sacramento, California, USA) for identifying the sesiid moth; Oscar Rocha (University of Costa Rica, San José, Cost Rica) for sharing useful information on the host plant; Alejandro Valerio (Instituto Centroamericano de Investigación en Biología y Conservación, San José, Costa Rica) and Paul Hanson (University of Costa Rica, San José, Costa Rica) for identifying parasitoids; and Revista Biologia Tropical for providing copies of literature. Marie Metz (SEL, c/o National Museum of Natural History, Washington, DC, USA) captured the images of the adult and genitalia and prepared the plates of illustrations, except for the plate of figures 8–11 which was prepared by Nishida. The following provided helpful reviews of the manuscript: Sonja Scheffer (SEL, USDA, Beltsville, Maryland, USA), Thomas Henry (SEL, USDA, c/o National Museum of Natural History, Washington, DC, USA), William E. Miller (University of Minnesota, St. Paul, Minnesota, USA), Joaquin Baixeras (Universitat de Valencia, Valencia, Spain), and Richard Brown (Mississippi State, USA).

LITERATURE CITED

Adamski, D. and J. Brown. 2001. Revision of the *Ecdytolopha* group of genera (Lepidoptera: Tortricidae: Grapholitini) in the New World. Entomologica Scandinavica Supplements 58: 1–86.

Brown, J. W. and R. L. Brown. 2004. A new species of *Cryptaspasma* (Lepidoptera: Tortricidae: Olethreutinae) from Central America, the Caribbean, and southeastern United States, with a catalog of the world fauna of Microcorsini. Proceedings of the Entomological Society of Washington 106: 288–297.

Brown, J. W. and K. Nishida. 2003. First record of larval endophagy in Euliini (Tortricidae: Euliini): A new species of *Seticosta* from Costa Rica. Journal of the Lepidopterists' Society 56: 113–120.

Brown, J. W. and J. A. Powell. 1991. Systematics of the *Chrysoxena* group of genera (Lepidoptera: Tortricidae: Euliini). University of California Publications in Entomology 111. 87 pp. + figs.

———. 2000. Systematics of *Anopina* Obraztsov (Lepidoptera: Tortricidae: Euliini). University of California Publications in Entomology 120. 128 pp. + figs.

Brown, J. W., et al. (2005). World catalogue of insects. Volume 5. Tortricidae (Lepidoptera). Apollo Books. 741 pp.

Brown, J. W., J. Baixeras, J. A. Solorzano-Filho, and J. E. Kraus. 2004. Description and life history of an unusual fern-feeding tortricid moth (Lepidoptera: Tortricidae) from Brazil. Annals of the Entomological Society of America 97: 865–871.

Brown, R. L. 1987. Tortricidae (Tortricoidea), pp. 419–433. *In* Stehr, F. W., ed. Immature Insects, volume 1. Kendall/Hunt, Dubuque, Iowa.

Clarke, J. F. G. 1972. Two pests of beans from tropical America. Proceedings of the Entomological Society of Washington 74: 467–471.

Diakonoff, A. 1959. Revision of *Cryptaspasma* Walsingham, 1900 (Lepidoptera, Tortricidae). Zoologische Verhandelingen, Leiden 43: 1–60.

Herrera, S. W. and L. D. Gómez. 1993. Mapa de Unidades Bióticas de Costa Rica. Escala 1: 685. U.S. Fish and Wildlife Service – TNC – INCAFO – CBCCR – INBio – Fundación Gómez-Dueñas, San José, Costa Rica.

Horak, M. 1984. Assessment of taxonomically significant structures in Tortricinae (Lep., Tortricidae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 57: 3–64.

———. 1998. Tortricoidea, pp. 199–215. *In* Kristensen, N., ed. Lepidoptera, moths and butterflies. Volume 1: Evolution, systematics, and biogeography. Handbook of Zoology 4 (35), Arthropoda: Insecta. Walter de Gruyter, Berlin & New York.

———. 2006. Olethreutinae moths of Australia (Lepidoptera: Tortricidae). Monographs on Australian Lepidoptera 10. 522 pp.

Horak, M. and R. L. Brown. 1991. 1.2 Taxonomy and phylogeny, pp. 23–48. *In* van der Geest, L. P. S. and H. H. Evenhuis, eds. Tortricid pests, their biology, natural enemies and control. Elsevier Science Publishers B. V., Amsterdam.

INBio. 1997. INBio Atta database. URL: http://www.inbio.ac.cr/bims/BIMS.html. (accessed 31 July 2005).

Iziko Museums of Cape Town. 2004. URL: http://www.museums.org.za/bio/plants/fabaceae/phaseolus_lunatus.htm. (accessed 31 July 2005).

Komai, F. 1999. A taxonomic review of the genus *Grapholita* and allied genera (Lepidoptera: Tortricidae) in the Palaearctic region. Entomologica Scandinavica Supplement 55: 1–226.

Miller, W. E. 2005. Gall-inducing Lepidoptera, pp. 431–465. *In* Raman, A., C. A. Schaefer, and T. Withers, eds. Biology, ecology, and evolution of gall-inducing arthropods. Science

Publishers, Inc., Enfield, New Hampshire, U.S.A. and Plymouth, U.K.

Missouri Botanical Garden. 2005. w3TROPICOS Nomenclatural Data Base. URL: http://mobot.mobot.org/cgi-bin/search_vast. (accessed 23 August 2005).

Nishida, K. and D. Adamski. 2004. Two new gall-inducing *Saphenista* Walsingham (Lepidoptera: Tortricidae: Cochylini) from Costa Rica. Proceedings of the Entomological Society of Washington 106: 133–139.

Robinson, G. S., P. R. Ackery, I. J. Kitching, G. W. Beccaloni, and L. M. Hernández. 2006. HOSTS - a database of the hostplants of the world's Lepidoptera. The Natural History Museum, London. URL: http://www.nhm.ac.uk/research-curation/projects/hostplants/#10 (accessed 15 April 2006).

Sauer, J. D. 1993. Historical geography of crop plants: a select roster. CRC Press, Boca Raton, Florida. 309 pp.

Saunders, J. L., D. T. Coto, and A. B. S. King. 1998. Plagas invertebradas de cultivos anuales alimenticios en américa central. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica. xiv + 305 pp.

Vargas, E. M., E. Castro, G. Macaya, and O. J. Rocha. 2003. Variación del tamaño de frutos y semillas en 38 poblaciones silvestres de *Phaseolus lunatus* L. del Valle Central de Costa Rica. Revista de Biología Tropical 51: 707–724.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 277–285

THE THREAD-LEGGED ASSASSIN BUG GENUS *CALPHURNIOIDES* DISTANT (HEMIPTERA: HETEROPTERA: REDUVIIDAE) FROM EASTERN JAVA AND BALI, INDONESIA

Tadashi Ishikawa, Wayan Susila, and Shûji Okajima

(TI, SO) Laboratory of Entomology, Faculty of Agriculture, Tokyo University of Agriculture, Funako 1737, Atsugi-shi, Kanagawa, 243-0034, Japan (e-mail TI: kr-chu@nodai.ac.jp; e-mail SO: okajima@nodai.ac.jp; (WS) Department of Plant protection, Faculty of Agriculture, Udayana University, JL. PB., Sudirman, Denpasar, Bali, Indonesia

---

Abstract.—Three assassin bug species of the emesine genus *Calphurnioides* Distant are reported from eastern Java and Bali, Indonesia. ***Calphurnioides conjunctus* Ishikawa and Okajima, n. sp.**, is described and illustrated, and two previously known species, *C. emmesius* (McAtee and Malloch) and *C. velutinervis* (McAtee and Malloch), are recorded there for the first time and diagnosed with habitus photos.

Key Words: Heteroptera, Reduviidae, Emesinae, Ploiariolini, *Calphurnioides*, Indonesia

---

The genus *Calphurnioides* Distant belongs to the tribe Ploiariolini of the assassin bug subfamily Emesinae and is represented by ten described species (Wygodzinsky 1966, Maldonado Capriles 1990, Ishikawa and Yasunaga 2004). This genus has been reported so far from the tropical and subtropical Ethiopian, Oriental, and Australian regions (Wygodzinsky 1966, Maldonado Capriles 1990), with one species known from temperate zone of Japan (Ishikawa and Yasunaga 2004).

Recently, we obtained approximately 40 specimens of *Calphurnioides* from eastern Java and Bali, Indonesia, from where there is no published record of the genus. These specimens were found to represent one undescribed species and two previously known ones, *C. emmesius* (McAtee and Malloch) and *C. velutinervis* (McAtee and Malloch). Here we describe and illustrate the new species, and record the other species from Java and Bali for the first time. Photos of the habitus are provided for all species.

The type material is housed in the Laboratory of Entomology, Faculty of Agriculture, Tokyo University of Agriculture, Atsugi-shi, Kanagawa, Japan. A pair of paratypes is preserved in both the American Museum of Natural History, New York, U.S.A., and the Bernice P. Bishop Museum, Honolulu, Hawaii, U.S.A.

Calphurnioides Distant

Calphurnioides Distant 1913: 164. Type species: *Calphurnioides elongatus* Distant 1913. Subsequent designation by Wygodzinsky (1966).

Pseudobolos McAtee and Malloch 1926: 119 (as a subgenus of *Emesopsis* Wolff 1811, synonymized by Wygodzinsky 1966). Type species: *Emesopsis (Pseu-*

dobolos) velutinervis McAtee and Malloch 1926. Original designation.
Pseudobolos: Wygodzinsky 1954: 571 (as n. stat.).

Diagnosis.—Distinguished from other genera of the tribe Ploiariolini by a combination of the following characters: Body shining, almost uniformly yellowish or brownish; scutellum lacking spine; metanotum armed with a long spine; hemelytron having a single discal cell and one longitudinal stripe along outer margin on basal half (submarginal stripe); two longitudinal veins (M and Cu) extend from base of discal cell; and discal cell of hemelytron more than twice as long as its maximum width, with apical part narrowed conspicuously. Wygodzinsky (1966) provided a detailed description.

Habitat.—Most specimens of the species mentioned in this paper were collected from dead leaf clusters of banana trees in Java and Bali, Indonesia.

Calphurnioides conjunctus Ishikawa and Okajima, new species

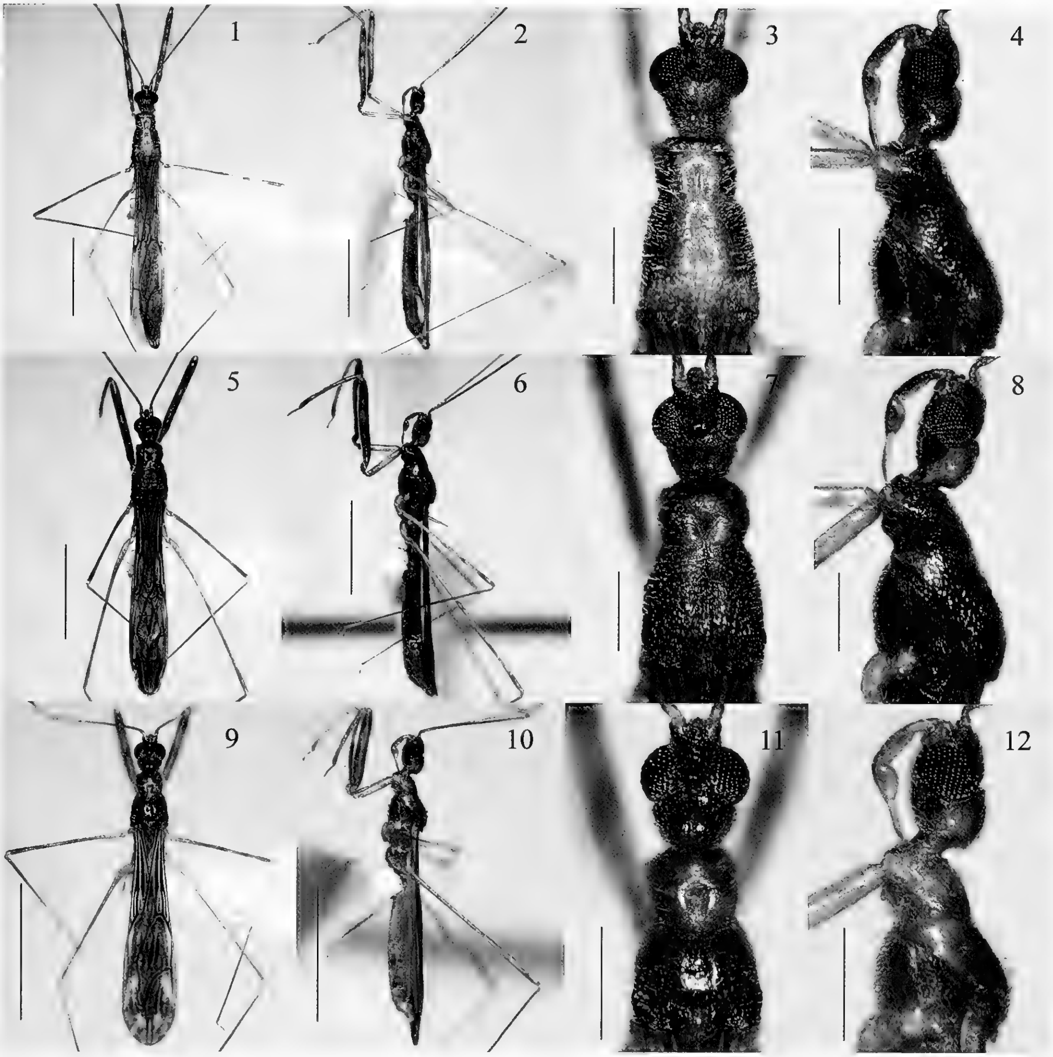
(Figs. 1–4, 13, 14, 19–30)

Diagnosis.—This species is recognized by a combination of the following characters: body yellowish brown, with pronotal disc brownish yellow; mesopleuron dark brown; pronotum 1.6 times as long as head and 1.6 times as long as humeral width (Figs. 3–4); profemur brownish yellow, with four brownish annulations (Fig. 2); submarginal stripe of hemelytron connected to veins M and Cu by short veinlike markings (Figs. 13–14); discal cell with one longitudinal brownish stripe (Fig. 13); endosoma of phallus with two pairs of membranous expansions in addition to a pair of vesica arms (Figs. 28–29); and vesica arm long and slender, curved ventrad in apical one-third (Figs. 28–29).

Description.—Male (holotype): *Color:* Body generally yellowish brown. Mesopleuron dark brown. Dorsum of posterior lobe of head and disc of pronotum brownish yellow. Rostral segment III, supracoxal areas, and metanotal spine pale yellow. Foreleg brownish yellow, with brownish annulations on basal one-tenth, basal two-fifths, apical one-fourth and apical one-tenth of femur and on middle of tibia (Fig. 2); trochanter and apical part of tibia dark brown; tarsus and apical one-third of coxa brownish. Femora of mid- and hind legs pale yellow, with brownish annulations on middle, apical one-third and apical one-tenth of mesofemur; apices of meso- and metafemora yellowish brown; tibiae and tarsi of mid- and hind legs brownish yellow. Hemelytron (Figs. 13–14) transparent, iridescent, weakly tinged with brown, mottled with 2 brown spots between veins M and Cu before base of discal cell, one of these connecting veins M and Cu; submarginal stripe (Figs. 13–14, ss) dark brown, connected to veins M and Cu by 1 and 2 short veinlike markings, respectively; discal cell (Fig. 13, dc) with one slender, longitudinal, brownish stripe; veins yellowish brown to brown. Abdomen yellowish brown, weakly tinged with red laterally, and with connexiva pale yellow.

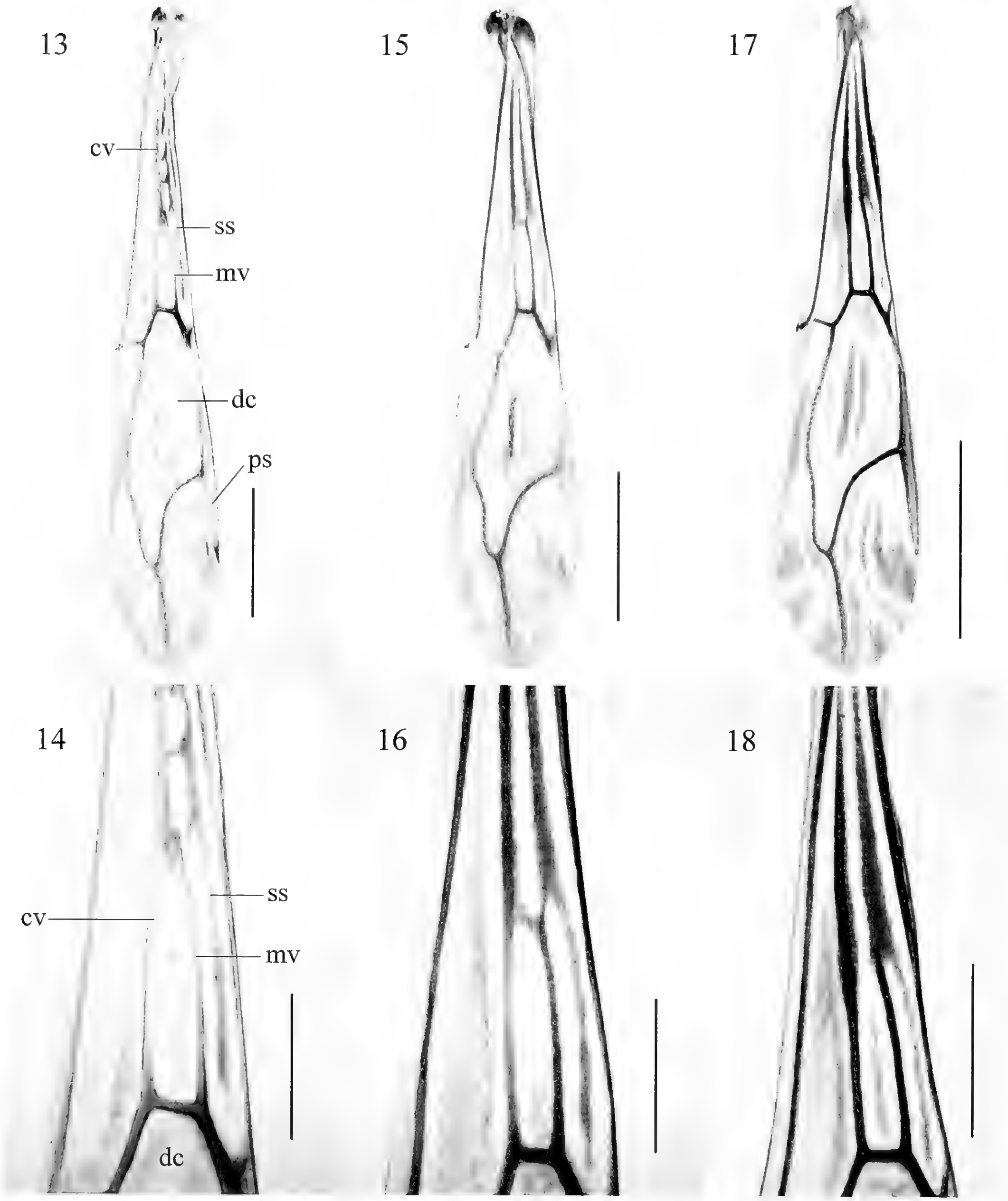
Head (Figs. 3–4): Elliptical, 1.2 times as long as width across eyes, covered with short, decumbent and suberect setae; anteoculus 0.6 times as long as postoculus. Eyes (Figs. 3–4) large, just reaching level of ventral surface of head in lateral view (Fig. 4), as wide as interocular space in dorsal view (Fig. 3). Antenna covered with short, decumbent setae; approximate proportion of segments I to IV as 5: 4: 2: 1. Rostrum covered with short, curved setae; approximate proportion of segments I to III as 17: 10: 13.

Thorax: Pronotum (Figs. 3–4) 1.6 times as long as head, 1.6 times as long as humeral width, covered with short and long erect setae except disc of



Figs. 1–12. Males of *Calphurnioides* spp. 1–4, *C. conjunctus*, holotype. 5–8, *C. emmesius*. 9–12, *C. velutinervis*. 1, 5, 9, Habitus, dorsal view. 2, 6, 10, Habitus, lateral view. 3, 7, 11, Head and prothorax, dorsal view. 4, 8, 12, Head and prothorax, lateral view. Scales: 2.0 mm for 1–2, 5–6, 9–10; 0.5 mm for 3–4, 7–8, 11–12.

anterior lobe with decumbent setae; anterior lobe 0.85 times as long as its maximum width, with lateral margins roundly expanded; posterior lobe transversely rugose, roughly punctate, 1.6 times as long as anterior lobe, as long as humeral width; posterior margin roundly concave at middle. Metanotal spine straight, 0.9 times as long as humeral width. Foreleg (Fig. 19) covered with sparse, long, erect setae on coxa and with dense, short, decumbent setae on femur, tibia, and tarsus; trochanter and femur ventrally covered with dense, short to long erect setae; coxa about 8 times as long as its maximum width; femur twice as long as coxa, about 11 times as long as its maximum width, with anteroventral and posteroventral series of about 40 small to medium-sized spines each; tibia slightly curved, about 0.8 times as long as femur, ventrally with 2 series of about



Figs. 13–18. Right hemelytron of *Calphurnioides* spp. (14, 16, 18, around basal one-third). 13–14, *C. conjunctus*. 15–16, *C. emmesius*. 17–18, *C. velutinervis*. Abbreviations: cv, Cu vein; dc, discal cell; mv, M vein; ps, pterostigma; ss, submarginal stripe. Scales: 1.0 mm for 13, 15, 17; 0.4 mm for 14, 16, 18.

40 appressed, strong setae; tarsus 0.2 times as long as tibia. Mid- and hind legs covered with short, decumbent setae. Hemelytra (Fig. 20) scarcely reaching posterior apex of abdomen, not covering apical parts of parameres and posterior process of pygophore; vein M free from vein Cu before base of discal cell

(Fig. 20, cv, mv); apex of pterostigma (Fig. 20, ps) slightly exceeding distal end of discal cell.

Abdomen: Sparsely covered with long, suberect setae intermixed with dense, short, decumbent setae.

Male genital structure (paratypes): Pygophore excluding posterior process twice as long as its height, triangularly projected posteriad at distal end of each side of pygophore in lateral view (Figs. 22–23); posterior process (Figs. 22–23, pp) large, narrowed apicad, with apex acute in lateral view and rounded in ventral view. Paramere (Figs. 24–25) laterally compressed, hooked in apical part, acute at apex in dorsal view, covered with erect setae variable in length in apical half. Phallosoma of phallus uniformly sclerotized, apically with ventral projection; ventral projection (Fig. 30, vp) about 8 times as long as its maximum width. Endosoma (Figs. 28–29) with 2 pairs of membranous expansions in addition to a pair of vesica arms; vesica arm (Figs. 28–29, va) long and slender, weakly sclerotized ventrally, gently bent dorsally at middle, curved ventrad in apical one-third; membranous expansions one-third as long as vesica arm; outer expansion (Figs. 28–29, oe) acute at apex; inner expansion (Figs. 28–29, ie) slightly exceeding apex of outer expansion, obtuse at apex.

Female (paratypes): In general appearance, almost similar to male. Hemelytron slightly exceeding posterior apex of abdomen. Valvifer I (Fig. 26, vf1) about twice as long as basal width, acute at apex; valvula I (Fig. 26, vl1) apically rounded. Styloides (Fig. 27) V-shaped, with posterior margin rounded.

Measurements (holotype; in mm): Body length 6.87 [paratypes: 6.50–6.90 in male (n=5), 6.55–6.80 in female (n=5)]. Head length including neck 0.77; width across eyes 0.64; interocular space 0.22. Antenna length 7.91; lengths of segments I, II, III and IV 3.25, 2.74, 1.25 and 0.67. Rostrum length 0.92; lengths of segments I, II and III 0.39, 0.23 and 0.30. Pronotum length 1.20; width across humeri 0.74. Hemelytron length 4.90. Lengths of femur, tibia, and tarsus of foreleg 2.04, 1.65 and 0.30; of midleg 3.20, 4.30 and 0.22; of hind leg 4.80, 6.60 and 0.22, respectively. Abdomen length 4.38.

Holotype.—♂ (Figs. 1–4, 19), Tumpang, Malang, Java, Indonesia, 8°01′39″S, 112°46′26″E, ca 690 m alt., 22. VIII. 2005, T. Ishizaki.

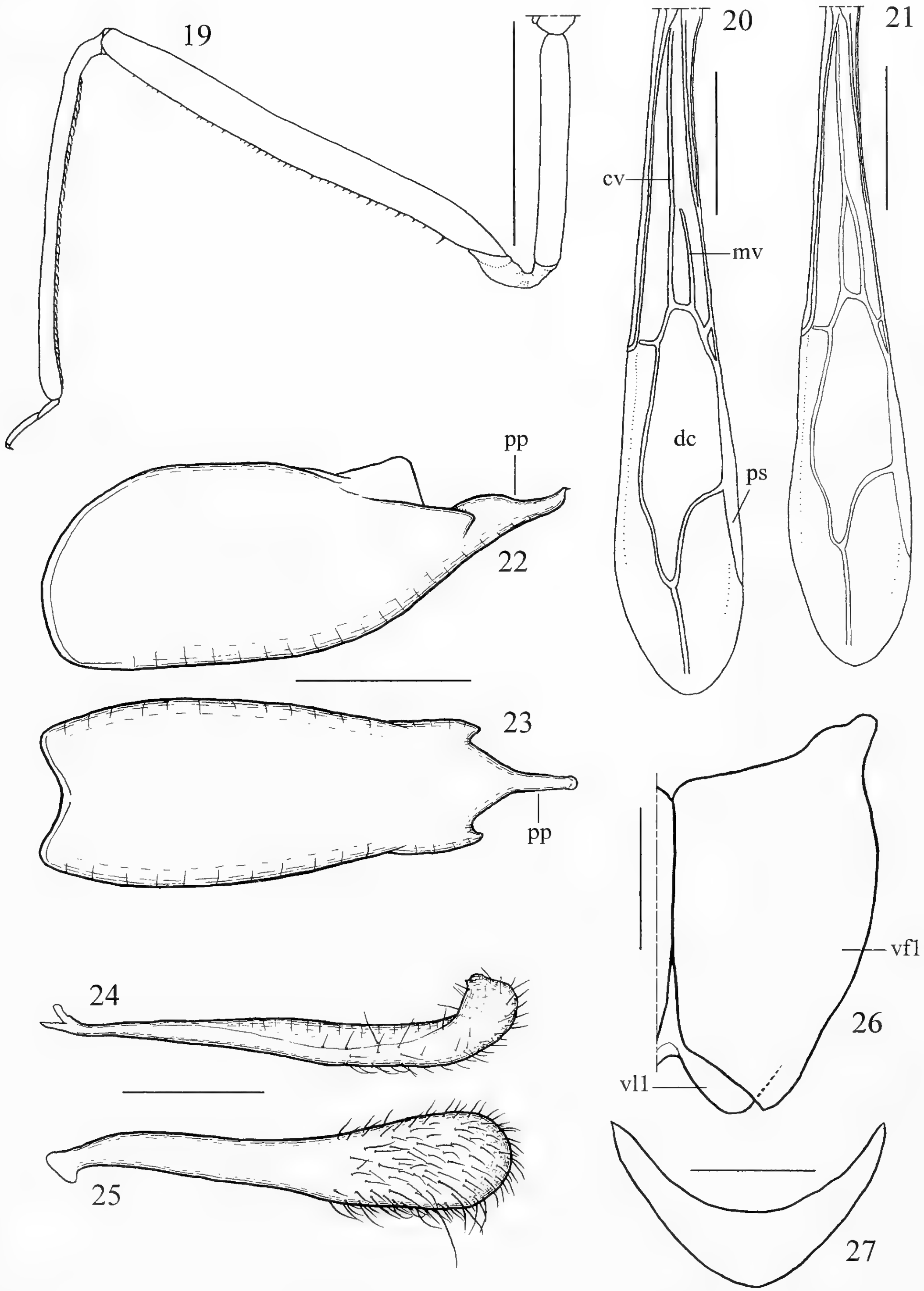
Paratypes.—Java: 1♀, Buring, Malang, Java, 7°59′41″S, 112°39′39″E, ca 515 m alt., 24. VIII. 2005, T. Ishizaki; 4♂ (one shown in Figs. 13–14, 20; other shown in Fig. 21; other shown in Figs. 22–25, 28–30), 3♀ (one shown in Figs. 26–27), same data as for holotype; 1♀, same locality and date as for holotype, T. Ishikawa.

Distribution.—Indoneasia (eastern Java).

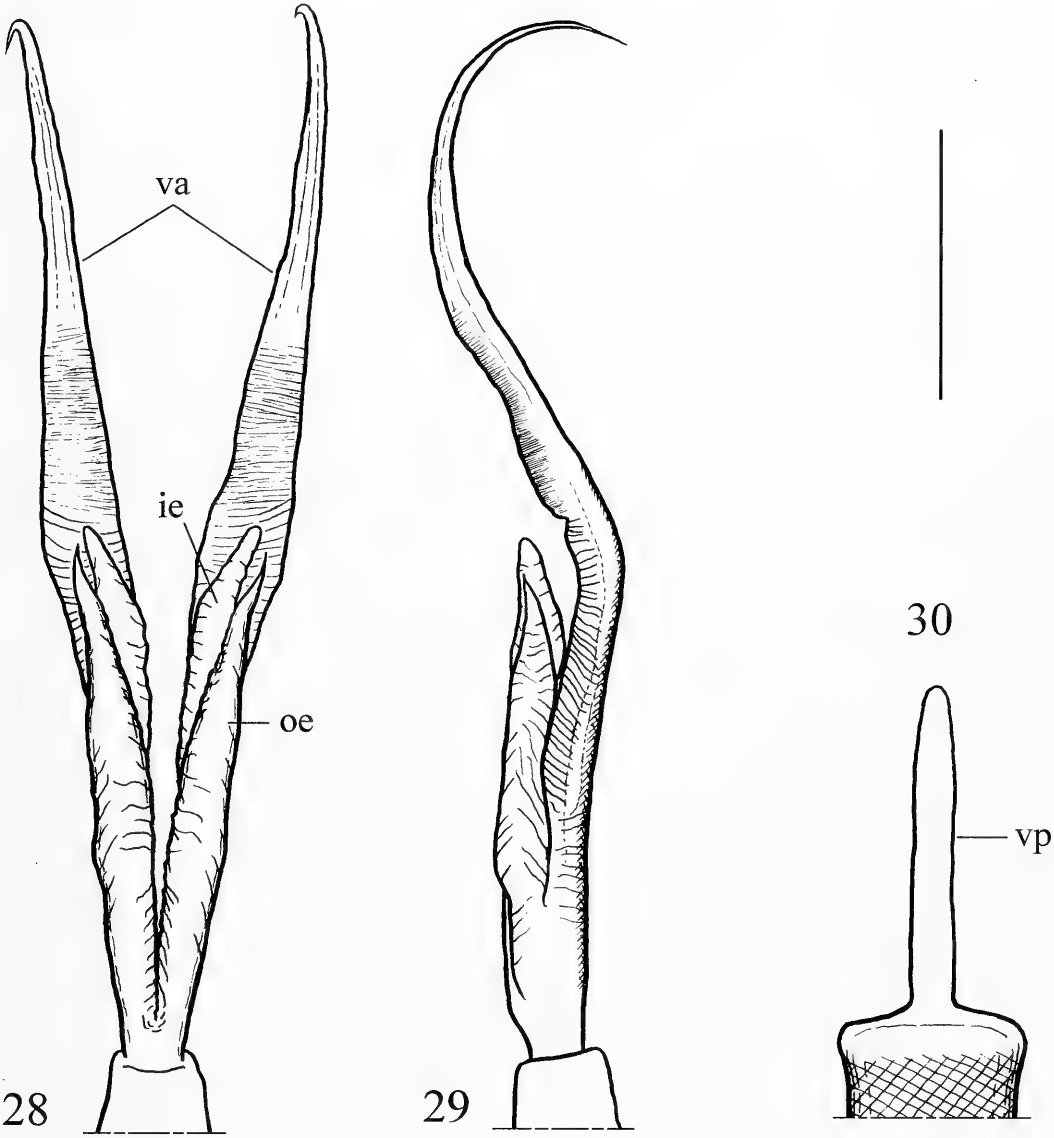
Etymology.—From the Latin, *conjunctus*, (= connected) referring to the hemelytral veins M and Cu connected to the submarginal stripe by transverse markings; an adjective.

Remarks.—In general habitus, this new species resembles *Calphurnioides australis* Wygodzinsky, 1956, known from Australia (Queensland) and Indonesia (Moluccas); however, it can be distinguished from the latter by the antennal segment I not annulated (in *C. australis*, annulated); the tibiae of the mid- and hind legs not annulated (vs. annulated); the submarginal stripe of the hemelytron connected to vein Cu by transverse markings (Figs. 13–14) (vs. not connected); and different shape of the endosoma of the phallus (Figs. 28–29).

In this new species as well as other members of *Calphurnioides*, the hemelytral veins M and Cu extending from the base of a discal cell are generally free and are sometimes connected to each other



Figs. 19–27. *Calphurnioides conjunctus* (setae omitted except for 24–25). 19, Left foreleg, lateral view. 20–21, Right hemelytron. 22–23, Pygophore, lateral (22) and ventral (23) views. 24–25, Left paramere,



Figs. 28–30. Phallus of *Calphurnioides conjunctus*. 28–29, Endosoma, dorsal (28) and lateral (29) views. 30, Apical part of phallosoma, ventral view. Abbreviations: ie, inner expansion; oe, outer expansion; va, vesica arm; vp, ventral projection. Scale: 0.2 mm.

←

dorsal (24) and lateral (25) views. 26, Left valvifer I and valvula I, ventral view. 27, Styloides, dorsal view. Abbreviations: cv, Cu vein; dc, discal cell; mv, M vein; pp, posterior process; ps, pterostigma; vf1, valvifer I; vl1, valvula I. Scales: 1.0 mm for 19–21; 0.5 mm for 22–23; 0.2 mm for 24–26; 0.1 mm for 27.

by a brown spot, forming an apparent subbasal cell (Figs. 13–14). Observation of the hemelytra of the paratypes under a compound microscope revealed that veins M and Cu were directly connected to each other, forming a true subbasal cell (Fig. 21) in one of the paratypes. This could be merely an aberration of the venation in this specimen.

Calphurnioides emmesius (McAtee and Malloch)
(Figs. 5–8, 15–16)

Emesopsis (Pseudobolos) emmesius McAtee and Malloch 1926: 120, 125.
Calphurnioides emmesius: Wygodzinsky 1966: 351.

Diagnosis.—This species is recognized by the following characters: body brown to dark brown; pronotum 1.5 times as long as head and 1.5 times as long as humeral width (Figs. 7–8); profemur decorated with median pale annulation, 2.2 times as long as coxa and about 9.5 times as long as its maximum width (Fig. 6); submarginal stripe of hemelytron connected to vein M by a short veinlike marking, but not connected to vein Cu (Figs. 15–16); hemelytral veins M and Cu connected to each other by a brown spot before base of discal cell (Figs. 15–16); and hemelytral discal cell with one conspicuous and one inconspicuous, longitudinal brownish stripes (Fig. 15). Body length ranges from 6.1 to 6.5 mm (n=6).

Material examined.—Bali: 1♂ (Figs. 15–16), Pura Luhur, Muncak Sari, Tabanan, 8°23′05″S, 115°05′10″E, ca 780 m alt., 2. IX. 2005, T. Ishikawa; 1♂, Pura Jero Sasah, near Wangaya, Tabanan, 8°22′09″S, 115°06′25″E, ca 900 m alt., 4. IX. 2005, T. Ishikawa; 2♂, same locality and date as above, T. Ishizaki; 1♂ (Figs. 5–8), Jatiluwih (Peteli Temple), Tabanan, 8°21′40″S, 115°06′53″E, ca 890 m alt., 14. III. 2005, T. Ishikawa; 1♀, Jatiluwih (Peteli Temple), Tabanan, 8°21′40″S, 115°06′54″E, ca 890 m alt., 13. VIII. 2005, T. Ishikawa.

Distribution.—Indonesia (Bali, Irian Jaya); Philippines.

Calphurnioides velutinervis (McAtee and Malloch)
(Figs. 9–12, 17–18)

Emesopsis (Pseudobolos) velutinervis McAtee and Malloch 1926: 120, 124.
Calphurnioides velutinervis: Wygodzinsky 1966: 353.

Diagnosis.—This species is recognized by the following characters: body brownish yellow, with posterior pronotal lobe dark brown to blackish; pronotum 1.3 times as long as head and 1.4 times as long as humeral width (Figs. 11–12); profemur twice as long as coxa and about 7.5 times as long as its maximum width; submarginal stripe of hemelytron directly connected to vein M, but not connected to vein Cu (Figs. 17–18); hemelytral veins M and Cu not connected to each other before base of discal cell (Figs. 17–18); and hemelytral discal cell with two conspicuous, longitudinal brownish stripes (Fig. 17). Body length ranges from 4.1 to 4.8 mm (n=23).

Material examined.—Java: 2♀, Seyegan, Sleman, Yogyakarta, 7°45′57″S, 110°17′15″E, ca 150 m alt., 19. VIII. 2005, T. Ishikawa; 1♀, Sawo Sajar, Sundeng, Malang, 7°57′59″S, 112°39′23″E, ca 450 m alt., 24. VIII. 2005, T. Ishikawa; 3♀, Buring, Malang, 7°59′41″S, 112°39′39″E, ca 515 m alt., 24. VIII. 2005, T. Ishikawa; 1♂, 1♀, Tumpang Malang, 8°01′39″S, 112°46′26″E, ca 690 m alt., 22. VIII. 2005, T. Ishikawa; 1♂, Malang Sari, Kalibaru, Banyuwangi, 8°18′50″S, 113°57′55″E, ca 410 m alt., 27. VIII. 2005, T. Ishikawa; 2♂, 3♀, Kalibaru, Banyuwangi, 8°18′15″S, 114°00′14″E, ca 440 m alt., 26. VIII. 2005, T. Ishikawa; 2♂ (one shown in Figs. 9–12; another shown in Figs. 17–18), 1♀, Sumber Gondo, Tulung Rejo, Glemor, Banyuwangi, 8°19′28″S, 114°04′00″E, ca 300 m alt., 27. VIII. 2005, T. Ishikawa; 1♂, 4♀, same locality and date as above, T. Ishizaki. Bali: 1♀, Pura Batu Salahan, Bengkel, Tabanan, 8°23′05″S, 115°05′53″E, ca 790 m alt., 3. IX. 2005, T. Ishikawa.

Distribution.—Indonesia (eastern Java, Bali); Philippines.

KEY TO SPECIES OF *CALPHURNIOIDES* FROM EASTERN JAVA AND BALI

1. Body length less than 5 mm; pronotum 1.3 times as long as head; hemelytral veins M and Cu not connected to each other before base of discal cell (Figs. 17–18) . . . . *velutinervis*
– Body length more than 6 mm; pronotum 1.5 to 1.6 times as long as head; hemelytral veins M and Cu connected to each other by a brown spot before base of discal cell (Figs. 13–16) 2
2. Profemur about 11 times as long as its maximum width; submarginal stripe of hemelytron connected to vein Cu by short veinlike markings (Figs. 13–14) . . . . *conjunctus*
– Profemur about 9.5 times as long as its maximum width; submarginal stripe of hemelytron not connected to vein Cu by short veinlike markings (Figs. 15–16) . . . . *emmesius*

ACKNOWLEDGMENTS

We are grateful to K. Sumiartha (Udayana University) and T. Ishizaki (Tokyo University of Agriculture) for kind assistance in the field. This study was financially supported by the Academic Frontier Cooperative Research Project, Tokyo University of Agriculture.

LITERATURE CITED

Distant, W. L. 1913. Rhynchota, Part, I: Suborder Heteroptera. *In* Gardiner, J. S. ed. The Percy Sladen Trust Expedition to the Indian Ocean in 1905 under the leadership of Mr. J. Stanley Gardiner, M. A. Transactions of the Linnean Society of London 16: 139–191.

Ishikawa, T. and T. Yasunaga. 2004. New records of two assassin bug genera (Heteroptera, Reduviidae, Emesinae) from Japan, with description of a new species. Japanese Journal of Systematic Entomology 10: 1–6.

Maldonado Capriles, J. 1990. Systematic catalogue of the Reduviidae of the World (Insecta: Heteroptera). Caribbean Journal of Science (Special edition), x + 694 pp.

McAtee, W. L. and J. R. Malloch. 1926. Philippine and Malayan Ploiariinae (Heteroptera, Reduviidae). Philippine Journal of Science 30: 117–152, pls 1–4.

Wygodzinsky, P. 1954. On some Emesinae from Equatorial Africa (Reduviidae, Hemiptera). Annales du Musée royal du Congo Belge 1: 569–573.

———. 1956. Synopsis of the Australian Emesinae (Hemiptera, Reduviidae). University of California Publications in Entomology 11: 193–246.

———. 1966. A monograph of the Emesinae (Reduviidae, Hemiptera). Bulletin of the American Museum of Natural History 133: 1–616.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 286–294

INTRODUCED LEAF BEETLES OF THE MARITIME PROVINCES, 2: THE CEREAL LEAF BEETLE *OULEMA MELANOPUS* (LINNAEUS) (COLEOPTERA: CHRYSOMELIDAE)

LAURENT LESAGE, ERHARD JOHN DOBESBERGER, AND CHRISTOPHER G. MAJKA

(LL) Agriculture and Agri-Food Canada, ECORC, K.W. Neatby Bldg., 960 Carling Ave., Ottawa, Ontario, Canada K1A 0C6 (e-mail: lesagel@agr.gc.ca); (EJD) Science Advice and Biohazard Division, Canadian Food Inspection Agency, Plant Health Risk Assessment Unit, 3851 Fallowfield Rd., Ottawa, Ontario, Canada K2H 8P9 (e-mail: dobesbergere@inspection.gc.ca); (CGM) Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia, Canada B3H 3A6 (e-mail: c.majka@ns.sympatico.ca)

Abstract.—Voucher specimens of the cereal leaf beetle, *Oulema melanopus* (Linnaeus), from the Maritime Provinces of Canada were examined. This important cereal pest is newly recorded from Prince Edward Island. Most populations established in the Maritime Provinces of Canada probably originated from southern Ontario where *O. melanopus* was first discovered about 1965. Historical information demonstrates that the beetle spread northeastward by natural means and reached Prince Edward Island by 1994. An alternate source of introduction may have been the port of Halifax where *O. melanopus* has been intercepted in cargo originating from Italy. However, it is not possible to distinguish beetles originating from southern Ontario from those introduced directly into Halifax. The introduction of the species into the Canadian Maritimes was probably either domestic or from adjacent portions of the United States. *Oulema melanopus* is likely to continue to spread slowly by natural means throughout Canada. Host availability and climate change are likely to assure survival and establishment in new environments despite phytosanitary measures. Introduction of biological control agents and resistant cereal varieties are likely to maintain populations at or below economic thresholds.

Key Words: Coleoptera, Chrysomelidae, Criocerinae, *Oulema melanopus*, cereal leaf beetle, Canada, Maritime Provinces, adventive species, quarantine pest

The cereal leaf beetle, *Oulema melanopus* (Linnaeus, 1758), is an adventive Palearctic leaf beetle that is now widely established across much of the United States except for the southwest (NAPIS 2005, Riley et al. 2003) and Canada (Campbell et al. 1989, LeSage 1991, Olfert et al. 2004, CFIA 2005).

In the Old World, it is found throughout most of Europe, in North Africa, and across much of Asia from China, Mongolia and central Siberia west through Iran and the Caucasus to Turkey and south to Israel and Syria (Haynes and Gage 1981, Olfert et al. 2004).

In Europe, however, *O. melanopus* has often been mistaken for the closely related *O. duftschmidi* (Redtenbaker, 1874). Berti (1989) discussed the external morphology and genitalia of both species in detail. Both are sympatric, but *O. melanopus* appears more northern in distribution whereas *O. duftschmidi* is more Mediterranean and Oriental. Consequently, the possibility that *O. duftschmidi* has also been introduced into North America is not excluded, but it has not as yet been demonstrated.

Hitherto, most of the available information on *O. melanopus* in Canada consisted of short summaries resulting from Canadian agricultural pest surveys or plant quarantine pest monitoring. In this study, we provide original information obtained directly from voucher specimens of older records, or from new material not previously reported in publications. The dispersal patterns of *O. melanopus* in the Maritime Provinces of Canada are also discussed.

HISTORICAL REVIEW

Oulema melanopus is an invasive pest of small grains and was probably introduced into North America between 1947 and 1949, although it was not identified until 1962 in Berrien Co., Michigan, where it caused significant damage to oats (*Avena sativa* L., Poaceae) (Haynes and Gage 1981). *Oulema melanopus* may have gained entry into the United States via straw originating from Europe that was used as packing material for shipments of brick, although the exact pathway is unknown (Dobesberger 2002). In 1960, at Muskegon, Michigan, *O. melanopus* was found on plants in the trunk of a passenger car originating from Europe (Spears 1964). Numerous interceptions in the USA have been made since the earliest known record in 1936 at Baltimore, Maryland (Spears 1964). Despite pest control and strict quarantine measures (i.e., treatment of hay, straw, corn and sod for movement outside of a quarantine zone), *O. melanopus* continued to spread by natural and various man-made means throughout the Great Lakes Region between 1962 and 1979 (Haynes and Gage 1981).

In Canada, all life stages of the beetle were found for the first time in May 1965, near Harrow, in southern Ontario (Brown 1966). Within two years, the beetle had already infested several fields of Essex County. For this reason, it was expected to spread mostly in a northeasterly direction (McClanahan et al. 1968). To the northwest, the dispersal may have been assisted by additional foreign sources of adults since specimens were intercepted in 1969 at Thunder Bay (Ontario) from agricultural machinery (combines) originating from Germany (Straby 1971). To the east, *O. melanopus* reached the Ontario/Québec border in 1970, and was suspected to be established in Québec (Manson and Boyce 1970). In order to verify this hypothesis, the Division of Plant Protection of Agriculture Canada, Québec section, made several surveys in the southwest of the province in 1972, but no eggs, larvae, or adults were detected although minor damage was observed in some fields of the Vaudreuil-Soulanges counties, west of the Island of Montréal (Dandurand 1976). The quarantine measures ordered by the Division included all Metropolitan Montréal and Vaudreuil-Soulanges counties (Cardinal 1974, Caron 1975). Despite these measures, all life stages of *O. melanopus* were found in 1975 in several localities along the north side of the Ottawa River, from Lachute to Île-aux-Alumettes (Dandurand 1976). Following a small survey in 1981, it was established that the beetle occurred south of the St. Lawrence River from the Ontario border eastward to Nicolet, Drummondville, Acton Vale, and Bedford (Anonymous 1981). In 1982, an attempt was made to define the eastern border of the infestation in Canada. Scattered specimens were found in Richmond, Sherbrooke, and Stanstead counties; the map given in the report also included Québec City (Anonymous 1983). In 1983, 22 fields were checked between Québec City and Mont-Joli, and within the Matapédia Valley; after this survey, *O. melanopus* was considered to have extended its eastern range to Mont-Joli, in the Gaspé Peninsula, and to the border of New Brunswick (Anonymous 1983).

A survey carried out by the Plant Health Division of Agriculture Canada, in 1984, in wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L., Poaceae) and oat fields of Grand Falls, St. Quentin, and Woodstock, New Brunswick, did not detect the cereal leaf beetle (Anonymous 1986). Larvae of the beetle were collected for the first time in 1988, in grain fields located along the St. John River Valley between Hartland (Carleton Co.) and Edmundston (Madawaska Co.) (Finnamore 1988a, Anonymous 1989). It was first detected in Maine (USA) in Ft. Kent, New Canada, and Presque Isle in northern Aroostook Co. (adjacent to Québec and New Brunswick) in 1986 (Dearborn and Donahue 1993).

Oulema melanopus was first noticed in Kings County (Nova Scotia) in 1995, became widespread in 1996, and it was necessary to use chemical controls in 1997 (Crozier 1997a, 1998). *Oulema melanopus* has since been intercepted in Nova Scotia (Halifax) in a wooden container originating from Italy (CFIA 2001).

The search for biological control agents started as early as 1963. Four hymenopteran species were immediately established in Michigan (Haynes et al. 1974): a mymarid egg parasitoid, *Anaphes flavipes* (Foerster), an eulophid larval parasitoid, *Tetrastichus julis* (Walker), a solitary ichneumonid, *Diaparsis carinifer* (Thomson), and a larval ichneumonid parasitoid, *Lemophagus curtus* (Townes). Only *T. julis* was released in Canada, and the targeted area was south-central Ontario (Hartcourt et al. 1977). In 1975, only one year after the parasitoid releases, parasitism rate varied from 15% to 95% (Ellis et al. 1979). In the late 1980s, parasitism held the cereal leaf beetle at a low level throughout Ontario except in west Norfolk County (Bereza 1990). In New Brunswick, *T. julis* was already present when the beetle populations were surveyed (Finnamore 1988b). In Colchester Co. and Kings Co., Nova Scotia, larval parasitism by *Tetrastichus julis* varied from 5 to 50%, and 0 to 12.7% respectively (Crozier 1997b).

These parasitoids succeeded in keeping populations of the cereal leaf beetle in the United States at or below economic thresholds (USDA-APHIS-PPQ 1995). In the absence of natural enemies, yield losses could reach 55% in spring wheat, and 23% in winter wheat. Up to 75% yield loss could be observed in oats and barley (USDA-APHIS-PPQ 1995). The successful introduction of parasitoids into *O. melanopus* populations, which contributed to their decline, probably led to the deregulation of this pest by USDA officials in 1973 and discontinuation of these biological control programs in 1979 (USDA-APHIS-PPQ 1995).

In 1984, *O. melanopus* was reported in Utah and by 1999 had spread to the neighbouring states of Montana, Oregon, Washington, Idaho, Colorado, and Wyoming (Hammon and Peairs 2003). In the Pacific Northwest, *O. melanopus* was found to be a serious problem where the early stages of barley crops were attacked (Buntin et al. 2004). As a result of this western invasion and observation of increased damage compared to central and northeastern North America, APHIS reintroduced its biological control program for *O. melanopus* in 1993 (USDA-APHIS-PPQ 1995). Despite these biological control efforts, *O. melanopus* has been found in the Creston Valley in neighboring British Columbia, Canada in 1998 (CFIA 1999), and in the East Kootenays in 2002

(CFIA 2002). *Oulema melanopus* has since spread to Alberta in 2005 (County of Lethbridge and the Municipal District of Taber) (NAPPO 2005).

Oulema melanopus has been recorded as feeding on a wide variety of grasses in the Poaceae including species in the genera *Agrostis*, *Alopecurus*, *Arrhenatherum*, *Avena*, *Brachypodium*, *Bromus*, *Dactylis*, *Echinochloa*, *Elymus*, *Festuca*, *Hordeum*, *Lolium*, *Oryza*, *Panicum*, *Phalaris*, *Phleum*, *Poa*, *Secale*, *Setaria*, *Sorghum*, *Triticum*, and *Zea* (Campbell et al. 1989, Clark et al. 2004). According to Dandurand (1976), oats are the ideal host, whereas Caron (1975) reported that spring wheat was preferred when he made mid-June surveys in cereal fields of the southeast region of Montréal. Surveys made in Ontario in 1970 ranked oat, barley and wheat in order of preference (Anonymous 1970).

METHODS AND CONVENTIONS

In the course of ongoing research on the Coleoptera fauna of the Maritime Provinces of Canada, specimens of *O. melanopus* in various regional collections, as well as, in the Canadian National Collection (CNC) were examined and determined.

Abbreviations of names of collections referred to in the text are:

ACNS	Agriculture and Agri-Food Canada, Kentville, Nova Scotia.
ACPE	Agriculture and Agri-Food Canada, Charlottetown, Prince Edward Island.
CGMC	Christopher G. Majka Collection, Halifax, Nova Scotia.
CNC	Canadian National Collection, Ottawa, Ontario.
DHWC	David H. Webster Collection, Kentville, Nova Scotia.
JOC	Jeffrey Ogden Collection, Truro, Nova Scotia.
NSNR	Nova Scotia Department of Natural Resources, Shubenacadie, Nova Scotia.
STFX	Saint Francis Xavier University, Antigonish, Nova Scotia.

RESULTS

Identification.—*Oulema melanopus* is a showy beetle with a black head, red pronotum and legs, and deep metallic blue elytra (Fig. 1). Such a color pattern is very uncommon in native Canadian leaf beetles; only *Gastrophysa polygoni* (Linnaeus), another Palearctic species introduced from Eurasia, looks superficially similar. The elytral punctation can be used to separate them easily as it comes in well-defined rows in *O. melanopus*, but it is completely confused in *G. polygoni*. The shape of the pronotum can also help to distinguish these two species, since the pronotum of *G. polygoni* possesses a well-formed bead on both sides whereas such a bead is not found in *O. melanopus*.

Distribution.—*Oulema melanopus* has now been found at a variety of sites in New Brunswick, Nova Scotia, and Prince Edward Island in the Maritime Provinces of Canada (Fig. 2). This is a first record for its presence in Prince Edward Island.

Locality records for the Maritime Provinces.—NEW BRUNSWICK: *Carleton Co.*: Hartland, 20.VII.1987, D.B. Finnamore, (on) grain, (3, CNC). *Victoria Co.*: Grand Falls, VII.1980, L.S. Thompson, (3, CNC). NOVA SCOTIA: *Antigonish Co.*: Antigonish, 14.V.1998, G. Merner, grassland, (1, STFX); Antigonish Landing, 14.V.1998, E.C. Roderick, grassy wetland, (1, STFX). *Colchester Co.*: Bible Hill, 13.V.1998, P. Van Wychen, (20, CNC), 30.VI.1997, L. Crozier (10, CNC); Clifton, 11.V.1998, L. Crozier, (10, CNC); Little Dyke, 4.IX.1996, Lorne Crozier; Masstown, 30,VI.1997, L. Crozier, (10, CNC); Shu-

Fig. 1. Habitus photograph of *Oulema melanopus*.

benacadie, 31.VII, 1997, J. Ogden, (1, JOC); Shubenacadie, 1.VIII, 1997, J. Ogden, (2, NSNR). *Halifax Co.*: Point Pleasant Park, 15.VI. 2001. C.G. Majka, grassy meadow, (1, CGMC); south-end Halifax, 6.VI.2001, C.G. Majka, open area, (1, CGMC). *Kings Co.*: New Minas, 20.V.2001, D.H. Webster, open

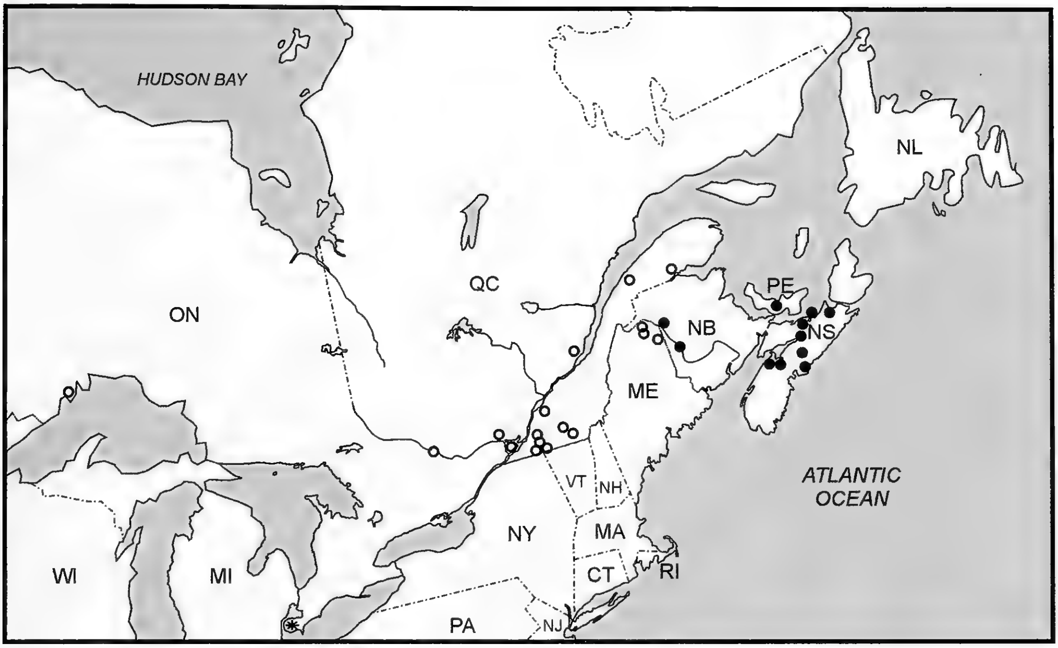


Fig. 2. Distribution of *Oulema melanopus* in the Maritime Provinces and adjacent regions. The asterisk (*) indicates the location of the first Canadian record; open circles indicate localities cited in the paper; closed circles indicate localities based on voucher specimens referred to in the paper.

woods, on *Daphne mezereum* L., (1, DHWC); Sheffield Mills, 17.VII.1996, L. Crosier, (2, CNC); Sheffield Mills, 15.X.1998, M. Trombley, (1, ACNS); Sheffield Mills, 21.V.1997, S. Rigby & C. O'Flaherty, (1, ACNS). *Pictou Co.*: Black River, 13.VII.1998. J. Ogden, (1, NSNR); Pictou Island, 14.VII.1998, J. Ogden, (1, NSNR). PRINCE EDWARD ISLAND: *Queens Co.*: Harrington, Harrington Farm, 2.VIII.1994, M.E.M. Smith, (on) winter wheat, (3, CNC; 3, ACPE).

Discussion

Oulema melanopus has been found in a variety of areas and habitats. Records from Grand Falls (NB), Hartland (NB), Harrington (PE), Sheffield Mills (NS), Shubenacadie (NS), and New Minas (NS) are in agricultural districts, frequently in or adjacent to agricultural sites. The specimens collected in Black River (NS) were along a small stream in a forested area not close to any agricultural areas. Of interest is the specimen collected on Pictou Island in the Northumberland Straits, 7.5 km from the nearest point of mainland Nova Scotia. This island is inhabited and parts are regularly harvested for hay production.

Also of interest are records from Halifax, an important transatlantic seaport. The specimen collected at Point Pleasant Park was less than 500 meters from the container terminal in the port area, while the specimen collected in south-end Halifax was immediately adjacent to the ravine along which the CNR railway lines run from the port. The port of Halifax has a very sizeable annual commerce of grain and related materials through the port facilities. *Oulema melanopus* does not feed on grain, nor is it likely to be moved in grain as adults generally die within about three weeks in such plant material. Adults do not survive long-term storage in grain bins (Morrill et al. 1992), and it is known that beetles may be accidentally found in stored products (Campbell et al. 1989). However, *O. melanopus* adults may "hitch-hike" in solid wood packaging materials (e.g., crating), but interceptions are rare. Farm machinery, Christmas trees, fruit for consumption, and plants with or without soil also are known pathways of movement (Haynes and Gage 1981, Dobesberger 2002).

Point Pleasant Park and the port of Halifax are well-known sites for the introduction of a wide variety of adventive Coleoptera (Majka and Klimaszewski 2004). Majka and LeSage (2006) suggest that the road and rail corridors that lead from Halifax may have been responsible for the introduction and spread of the Palearctic leaf beetle, *Sphaeroderma testaceum* (Fabricius).

In the CLIMEX™ model of the potential distribution of *O. melanopus* generated by Olfert et al. (2004), most of the Maritime Provinces are indicated as being favorable for the establishment of the species with portions of Nova Scotia having EI (Ecoclimatic Index) values in the 35–40 range (values > 20 are considered favorable for establishment). *Oulema melanopus* is likely to continue to spread slowly by natural means throughout Canada. Host availability and climate change are likely to assure survival and establishment in new environments despite phytosanitary measures. Introduction of biological control agents and resistant cereal varieties would maintain cereal leaf beetle populations at or below economic thresholds.

ACKNOWLEDGMENTS

Thanks to Randolph F. Lauff (St. Francis Xavier University), Christine Noronha and Mary Smith (Agriculture and Agri-Food Canada, Charlottetown, PE), Jeffrey Ogden (Nova Scotia Department of Natural Resources), Susan Westby and Cory Sheffield (Agriculture and Agri-Food Canada, Kentville, NS) and David H. Webster for making specimens and records available. Thanks to Alicia Zmudzinska for review of the manuscript, Klaus Bolte for executing the habitus photograph, and Susan Flood for creating the map (Agriculture and Agri-Food Canada, Ottawa, ON). C.G. Majka thanks Calum Ewing and Andrew Hebda (Nova Scotia Museum) for continuing support and encouragement. This work has been assisted by a research grant from the Nova Scotia Museum of Natural History. E.J. Dobesberger thanks D.E. Watler and J.A. Garland (Plant Health Risk Assessment Unit, Canadian Food Inspection Agency, Ottawa) for review of earlier drafts of this manuscript. Two anonymous reviewers read earlier versions of the manuscript and made many constructive suggestions.

LITERATURE CITED

Anonymous. 1970. Pests of small grains—Cereal Leaf Beetles (*Oulema melanopus* (L.)). The Canadian Agricultural Insect Pest Review 48: 3.

———. 1981. Cereal Leaf Beetle, *Oulema melanopus*. Summary of Plant Quarantine Pest and Disease Situations in Canada 1980. 50 pp.

———. 1983. Cereal Leaf Beetle, *Oulema melanopus*. Summary of Plant Quarantine Pest and Disease Situations in Canada 1980. pp. 49–50.

———. 1986. Cereal Leaf Beetle, *Oulema melanopus*. Summary of Plant Quarantine Pest and Disease Situations in Canada 1984–1985. 17 pp.

———. 1989. Cereal Leaf Beetle, *Oulema melanopus* (Linnaeus). Summary of Plant Quarantine Pest and Disease Situations in Canada 1987–88. 20 pp.

Bereza, K. 1990. Insects and related pests of cereal crops—Ontario. The Canadian Agricultural Insect Pest Review 67: 1.

Berti, N. 1989. Contribution à la faune de France. L'identité d'*Oulema* (*O.*) *melanopus* (L.) [Col. Chrysomelidae Criocerinae]. Bulletin de la Société entomologique de France 94: 47–57.

Brown, G. S. 1966. Foreign insects threatening Ontario agriculture and forestry. Proceedings of the Entomological Society of Ontario 96: 11–13.

Buntin, G. D., K. L. Flanders, R. W. Slaughter, and Z. D. DeLamar. 2004. Damage loss assessment and control of the cereal leaf beetle (Coleoptera: Chrysomelidae) in winter wheat. Journal of Economic Entomology 97: 374–382.

Campbell, J. M., M. J. Sarazin, and D. B. Lyons. 1989. Canadian beetles (Coleoptera) injurious to crops, ornamentals, stored products, and buildings. Agriculture Canada, Research Branch, Publication 1826. 490 pp.

Cardinal, J. A. 1974. Les ravageurs faisant l'objet d'une législation fédérale au Québec: leurs conditions en 1973. Annales de la Société entomologique du Québec 19: 115.

Caron, A. 1975. Insectes ravageurs faisant l'objet d'une législation fédérale au Québec: leurs conditions en 1974. Annales de la Société entomologique du Québec 20: 72–73.

CFIA (Canadian Food Inspection Agency). 1999. Summary of Plant Quarantine Pest and Disease Situations in Canada, 1999: Cereal Leaf Beetle: *Oulema melanopus*. Available from http://www.inspection.gc.ca/english/sci/surv/sit99e.shtml#Oulema (accessed 27 January 2006).

———. 2001. Intercepted plant pests 1997–2000. Plant Health Division, Ottawa, Ontario. 152 pp.

———. 2002. Summary of Plant Quarantine Pest and Disease Situations in Canada, 2002: Cereal Leaf Beetle: *Oulema melanopus* (Linnaeus). Available from http://www.inspection.gc.ca/english/sci/surv/sit2002e.shtml#18 (accessed 27 January 2006).

———. 2005. Cereal Leaf Beetle, *Oulema melanopus*. Available from http://www.inspection.gc.ca/english/plaveg/pestrava/oulmel/oulmele.shtml (accessed 27 January 2006).

Clark, S. M., D. G. LeDoux, T. N. Seeno, E. G. Riley, A. J. Gilbert, and J. M. Sullivan. 2004. Host plants of leaf beetle species occurring in the United States and Canada. (Coleoptera: Megalopodidae, Orsodacnidae and Chrysomelidae, excluding Bruchinae). Coleopterists Society Special Publication 2. 476 pp.

Crozier, L. 1997a. Pest management in field crops — Cereals. Nova Scotia Department of Agriculture, Marketing Plant Industry Branch, 1996 Annual Report, pp. 36–39.

———. 1997b. A survey for parasites of the Cereal Leaf Beetle. Available from http://www.gov.ns.ca/nsaf/elibrary/archive/projsum/97/crozierl.htm. (accessed 27 January 2006).

Crozier, L. M. 1998. The Cereal Leaf Beetle in Nova Scotia … problems and possibilities. Pest Management News 9(4): 6.

Dandurand, A. 1976. Première mention du criocère des céréales, *Oulema melanopus* (L.), (Coléoptères: Chrysomelidae), au Québec. Phytoprotection 57: 57–61.

Dearborn, R. G. and C. P. Donahue. 1993. An annotated list of insects collected and recorded by the Maine Forest Service: Order Coleoptera, Beetles. Maine Forest Service, Technical Report 32. August, Maine. 101 pp.

Dobesberger, E. J. 2002. Cereal Leaf Beetle, *Oulema melanopus* (L.): Pest Risk Assessment. Canadian Food Inspection Agency, Science Advice and Biohazard Division, Plant Health Risk Assessment Unit, Ottawa, Ontario. 40 pp.

Ellis, C. R., D. G. Hartcourt, and D. Dubois-Martin. 1979. The current status in Ontario of *Tetrastichus julis* (Hymenoptera: Eulophidae), a parasitoid of the cereal leaf beetle. Proceedings of the Entomological Society of Ontario 109: 23–26.

Finnamore, D. B. 1988a. Insect and related pests of cereal crops—New Brunswick. The Canadian Agricultural Insect Pest Review 65: 1.

———. 1988b. Beneficial insects—New Brunswick. The Canadian Agricultural Insect Pest Review 65: 76.

Hammon, R. W. and F. B. Peairs. 2003. Cereal leaf beetle: Identification, biology and management. Colorado State University Cooperative Extension, Crop Insect series, No. 5.596. 3 pp.

Hartcourt, D. G., J. C. Guppy, and C. R. E. Ellis. 1977. Establishment and spread of *Tetrastichus julis* (Hymenoptera: Eulophidae) a parasitoid of the cereal leaf beetle in Ontario. The Canadian Entomologist 109: 473–476.

Haynes, D. L. and S. H. Gage. 1981. The cereal leaf beetle in North America. Annual Review of Entomology 26: 259–287.

Haynes, D. L., S. H. Gage, and W. Fulton. 1974. Management of the cereal leaf beetle pest ecosystem. Quaestiones Entomologicae 10: 165–176.

LeSage, L. 1991. Family Chrysomelidae: leaf beetles, pp. 301–323. *In* Bousquet, Y. ed. Checklist of Beetles of Canada and Alaska. Agriculture Canada: Research Branch, Publication 1861/E.

Majka, C. G. and J. Klimaszewski. 2004. *Phloeocharis subtilissima* Mannerheim (Staphylinidae: Phloeocharinae) and *Cephennium gallicum* Ganglbauer (Scydmaenidae) new to North America: A case study in the introduction of exotic Coleoptera to the port of Halifax, with new records of other species. Zootaxa 781: 1–15.

Majka, C. G. and L. LeSage. 2006. Introduced leaf beetles of the Maritime Provinces, 1: *Sphaeroderma testaceum* (F.) (Coleoptera: Chrysomelidae). Proceedings of the Entomological Society of Washington 108: 243–247.

Manson, G. F. and H. R. Boyce. 1970. Watch for the Cereal Leaf Beetle. Agriculture Canada Publication 1353. 4 pp.

McClanahan, R. J., H. R. Boyce, and W. R. Code. 1968. The cereal leaf beetle—a new insect in Ontario. Proceedings of the Entomological Society of Ontario 98: 21–26.

Morrill, W. L., G. L. Jensen, D. K. Weaver, J. W. Gabor, and W. T. Lanier. 1992. Cereal leaf beetle (Coleoptera: Chrysomelidae), incidence at harvest and survival in storage in Montana. Journal of Entomological Science 27(1): 1–4.

NAPIS (National Agricultural Pest Information System). 2005. *Oulema melanopus*: Cereal Leaf Beetle. Available from http://www.ceris.purdue.edu/napis/pests/clb/index.html (accessed 27 January 2006).

NAPPO (North American Plant Protection Organization). 2005. Phytosanitary Alert System, September 1, 2005. CFIA Plant Protection Policy Directive related to this insect (D-02-09). Available from http://www.inspection.gc.ca/english/plaveg/protect/dir/d-02-09e.shtml (accessed 27 January 2006).

Olfert, O., R. M. Weiss, S. Woods, H. Philip, and L. Dosdall. 2004. Potential distribution and relative abundance of an invasive cereal crop pest, *Oulema melanopus* (Coleoptera: Chrysomelidae), in Canada. The Canadian Entomologist 136: 277–287.

Riley, E. G., S. M. Clarke, and T. N. Seeno. 2003. Catalogue of the leaf beetles of America north of Mexico (Coleoptera: Megalopodidae, Orsodacnidae and Chrysomelidae, excluding Bruchinae). Coleopterists Society Special Publication 1. 290 pp.

Spears, J. F. 1964. Cereal leaf beetle menaces America's grain producing areas. (reprint) Agricultural Chemicals, October 1964, 4 pp.

Straby, A. E. 1971. List of intercepted plant pests—April 1st to March 31st. Intercepted Plant Pests 1969–1970, Canada Department of Agriculture, Plant Protection Division, Production and Marketing Branch, 25 pp.

USDA-APHIS-PPQ. 1995. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Fact Sheet, Cereal Leaf Beetle, 2 pp. Available from http://www.invasive.org/publications/aphis/fsclb.pdf (accessed 27 January 2006).

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 295–308

GENETIC DIFFERENTIATION BETWEEN THE SIBLING AND SYMPATRIC FLOWER-HEAD INFESTING TEPHRITIDS: THE POLYPHAGE, *TRUPANEA NIGRICORNIS* (COQUILLETT), AND THE NARROWLY OLIGOPHAGOUS, *T. BISETOSA* (COQUILLETT) (DIPTERA: TEPHRITIDAE)

Khouzama M. Knio, Richard D. Goeden, and David H. Headrick

(KMK) Biology Department, American University of Beirut, P.O. Box 11-0236, Riad El Sohl, Beirut, Lebanon (e-mail: kknio@aub.edu.lb); (RDG) Department of Entomology, University of California, Riverside, CA 92521, U.S.A.; (DHH) Horticulture and Crop Science Department, California Polytechnic State University, San Luis Obispo, CA 93407, U.S.A.

Abstract.—*Trupanea nigricornis* and *T. bisetosa* are sibling, cryptic species that occur in sympatry in southern California. *Trupanea nigricornis* is generalist, infesting at least 8 tribes in the Asteraceae while *T. bisetosa* is mainly a specialist on wild sunflowers. Although the two species are very similar in morphology and biology, genetic differentiation between them was possible using isozyme electrophoresis. Among 14 resolved loci, 5 were polymorphic. Significant allele frequency differences were found between the two species for PGI, PGM, ME, and EST-1. Moreover, a fixed allele difference for the locus ACPH was detected, indicating absence of gene flow between *T. nigricornis* and *T. bisetosa* in the sampled sympatric populations. The absence of hybrids could be explained by the results of cross-mating studies, which indicated that the two species did mate in the laboratory, but produced few, if any, viable offspring. Hybrid inviability acted as a post-mating barrier reducing gene flow between sympatric populations of *T. nigricornis* and *T. bisetosa.*

Key Words: Isoenzyme electrophoresis, cross-mating studies, sympatry, Tephritidae, *Trupanea*, post-mating isolating barriers

Trupanea nigricornis (Coquillett) and *T. bisetosa* (Coquillett) are flower head infesting tephritids that occur in sympatry in southern California. They are sibling and cryptic species as both their adult and immature stages show great morphological similarities and are difficult to separate (Foote et al. 1993, Knio et al. 1996a). The males can only be distinguished by the color of the third antennal segment, which is brown in *T. nigricornis* and yellow in *T. bisetosa.* Females are more difficult to separate based on anatomy. Most (ca. 75%) can be recognized by the shape of the Y-shaped apical marking on the wing. This marking is usually thin and distinct in *T. nigricornis* females and broad and short in *T. bisetosa* females (Cavender and Goeden 1983, Foote et al. 1993).

Resource utilization studies showed that the larvae of both species exploited the flower heads of their hosts in a similar manner and they fed on a similar number of achenes, taking into account the size of their host (Knio et al. 2001). However, ecologically, these two sympatric species showed major differences. *Trupanea ni-*

gricornis behaves as a generalist, infesting many Asteraceae hosts belonging to 8 tribes while *T. bisetosa* behaves as a narrowly oligophagous species infesting a few Asteraceae species belonging to only one tribe, the Heliantheae (Goeden 1985, 1992). Moreover, *T. bisetosa* could be considered as a specialist mainly on wild sunflowers, *Helianthus annuus* L., its most common host in southern California (Cavender and Goeden 1983).

Although the oviposition behavior differed between females of *T. nigricornis* and *T. bisetosa*, only subtle differences were detected in the courtship and mating behavior of the two species (Knio et al. 1996b). No apparent physical and temporal barriers seem to keep these two closely related species from meeting and mating in the field. The hosts of *T. nigricornis* bloom for a short period (1–2 months) during the fall or the spring; while the main host of *T. bisetosa*, *H. annuus*, is in bloom throughout the year in southern California, in the absence of frost. Nevertheless, spatial separation appears to be an important factor keeping these two species from meeting in areas of sympatry as adults of both species were observed to meet and mate on their respective host plants, and the timing of courtship displays was different. In the field, males of *T. nigricornis* were observed to exhibit their courtship behavior in the mornings while those of *T. bisetosa* exhibited courtship display in the afternoon (Knio et al. 1996b). However, in the insectary, cross-matings occurred between the two species and resulted in viable and fertile eggs (Cavender and Goeden 1983).

Because *T. nigricornis* and *T. bisetosa* are sympatric and taxonomically close species (Foote et al. 1993), but differ in their mode of herbivory and do not overlap in their host range, it is possible that they diverged from one common ancestor or that one species evolved from the other following host race formation. Biological characteristics permitting the development of new host races in sympatry include mating on the host plant, positive correlation between host and mate selection, and genetic control of host selection (Bush 1975). It is not known whether *T. nigricornis* and *T. bisetosa* meet all the biological criteria proposed by models of sympatric speciation. In addition, it is not known whether these two species hybridize in nature since there are no geographical barriers to isolate them and their host plants very often occur side by side in southern California.

This study investigates, using isoenzyme electrophoresis, whether gene flow occurs between sympatric populations of *T. nigricornis* and *T. bisetosa* in southern California and whether the two species produce viable offspring when crossed in the laboratory. It is one of a series of comparative studies intended to shed light on the attributes that enable *T. nigricornis* to be a successful generalist and *T. bisetosa* a specialist on wild sunflowers.

MATERIALS AND METHODS

Insect collections.—The flies used in electrophoretic studies were reared from mature flower heads containing third instar larvae or puparia. The flower heads were placed in glass-topped, sleeve, insectary cages (34×32×35 cm) at the University of California, Riverside at 60% RH and 12/12 (LD) photoperiod from 0500–1700 h. After emergence, the flies fed on honey striped on the inner glass wall of the cage and water for 2–4 d, and then they were frozen and stored in liquid nitrogen at −180°C. Adults of *T. bisetosa* (N = 231) were reared from heads of wild sunflowers, *Helianthus annuus*; those of *T. nigricornis* were reared from heads of *Encelia farinosa* Gray (N = 252) and, in one instance, from heads of *E. virginensis* A. Nelson (N = 55). All collections were made at locations of sympatry, i.e., where both wild sunflowers and *Encelia* spp. were growing in adjacent patches. The sites of collections were Casa Blanca and Lake Perris (Riverside Co.), CA; and, Wheeler Canyon (Inyo Co.), CA.

Electrophoresis.—Horizontal starch gel electrophoresis was conducted according to the techniques described by Berlocher (1980) and Pasteur et al. (1987). The gels contained 11.16% (48 g starch + 430 ml buffer) potato starch (Sigma Chemical Co.).

Each fly was homogenized with 40 μl 0.1% Triton 100-X grinding buffer using a motorized pestle. The homogenate was absorbed onto a 10×4 mm wick (Whatman #1 filter paper). Electrophoresis was stopped when the marker dye, bromophenol blue (0.1% in water), migrated about 9 cm toward the anode.

Following electrophoresis, the gel was sliced into three to four (2 mm) layers. Each slice was placed in a staining box, incubated at 37°C in a staining solution specific for a certain enzyme for 30–40 min. until the bands became distinct, then fixed in methanol:water:acetic acid (5:5:1) (Berlocher 1980). The alleles were designated according to their Rf value, the distance migrated by the allele divided by the distance migrated by the front or the marker dye.

Buffer systems and staining solutions.—Initial work consisted of resolving 14 enzymes using different buffer systems (Table 1). Five enzymes were found to be polymorphic in *T. nigricornis* and *T. bisetosa* populations. These were phosphoglucose mutase (PGM), phosphoglucose isomerase (PGI), acid phosphatase (ACPH), malic enzyme (ME), and esterases (EST). For this reason, the flies were routinely tested for these enzymes.

Two of these enzymes, PGM and ACPH, were run on aminopropyl morpholine citrate/ tris-citrate-EDTA buffer, pH 8.3: gel buffer containing 6.8 g/l monohydrate citric acid, 0.3 g/l EDTA (disodium salt), and aminopropyl morpholine to pH 8.5; and electrode buffer

Table 1. Enzymes analyzed in *Trupanea nigricornis* and *T. bisetosa* using different buffer systems.

Enzyme	(E.C. #)	Buffers tested[a]	# of major bands per individual[b]	*T. nigricornis*		*T. bisetosa*		
				Polymorphism	N[c]	Polymorphism	N[c]	Polymorphism
Adenylate kinase	(2.7.4.3)	**4**	3	no	35	no	32	no
Alcohol dehydrogenase	(1.1.1.1)	**1**, 2, 3	1	no	35	no	32	no
Aldolase	(4.1.2.13)	**1**, 2	1	no	24	no	20	no
Acid phosphatase	(3.1.3.2)	**1**, 2	1	no	307	no	231	fixed[d]
Esterases: locus 1	(3.1.1.1)	1, **2**, 3	2	yes	107	yes	77	yes
Esterases: locus 2			4	no	107	no	77	no
Fructose 1,6 diphosphate	(3.1.3.11)	**1**	2	no	24	no	20	no
α-Glycerophosphate dehydrogenase	(1.1.1.8)	**1**, 3	2	no	24	no	20	no
Hexokinase	(2.7.1.1)	**2**	1	no	24	no	20	no
Isocitrate dehydrogenase	(1.1.1.42)	**1**, **3**	1	no	24	no	20	no
Malic enzyme	(1.1.1.40)	1, **2**	1	yes	121	yes	95	yes
Malate dehydrogenase	(1.1.1.37)	1, **2**	1	no	121	no	95	no
Phosphoglucose isomerase	(5.3.1.9)	1, **2**	1	yes	307	yes	231	yes
Phosphoglucose mutase	(2.7.5.1)	**1**, 2, **3**	1	yes	307	yes	231	yes

[a] 1 = Aminopropyl morpholine-citrate (pH 8.3) (Clayton and Tretiak 1972); 2 = Poulik (pH 8.7) (Selander et al. 1971); 3 = Tris-citrate-EDTA (pH 6.0); 4 = Phosphate citrate (pH 6.3) (Pasteur et al. 1987). The buffers that gave good resolution are marked in bold.

[b] For homozygous individuals.

[c] N = number of adults tested.

[d] fixed = fixed difference between populations tested.

containing 6.4 g/l monohydrate citric acid, aminopropyl morpholine to pH 5.0, tris to pH 8.3. (Clayton and Tretiak 1972). The enzymes PGI, ME and EST were run on tris-citrate (Poulik) buffer: gel buffer consisting of (0.076 M tris-0.005 M citric acid) 9.21 g tris and 1.05 g monohydrate citric acid/ 1 l distilled water pH 8.7; and electrode buffer consisting of (0.3 M borate) 18.55 g boric acid and 2.4 g sodium hydroxide/ 1 l distilled water, pH 8.2 (Selander et al. 1971). The tris-citrate-EDTA buffer was run for ca. 2.5 h at 120 volts and ca. 40 mA; whereas, the Poulik buffer was run for 3 h at 150 volts and ca. 50 mA.

The enzymes were stained following the recipes described by Pasteur et al. (1987) and Shaw and Prasad (1970).

Statistics.—A chi-square test was used to determine if any significant differences in the allele frequencies existed between or within *T. nigricornis* and *T. bisetosa* populations. It was also used to detect deviations from the Hardy-Weinberg equilibrium. Since some loci had several alleles with low frequencies, the alleles were pooled when it was necessary to ensure that no expected frequency was less than one and that no more than 20% of the expected frequencies was less than five (Zar 1984).

Cross-mating experiments.—The flies used in cross-mating experiments were reared from puparia dissected out of field-collected flower heads, *E. farinosa* for *T. nigricornis* and *H. annuus* for *T. bisetosa*.

After emergence, male and female flies of each species were separated and placed in different glass-topped, sleeved, cages in the insectary. Tightly wrapped cotton strips (ca. 2×1 cm) dipped in a solution of sucrose-yeast hydrolysate-water (7:4:10) (Tsiropoulos 1978) were affixed with adhesive tape to the inner wall surface of the cage as a food source, in addition to stripes of honey and water. The cotton strips were changed every other day. The flies were allowed to feed on the yeast hydrolysate diet for 18 d until the females reached sexual maturity (unpublished data). On day 18 after emergence, the mature flies were paired according to the assigned mate and transferred to smaller cages for the following treatments:

1. *T. nigricornis* females × *T. bisetosa* males (six pairs).
2. *T. nigricornis* males × *T. bisetosa* females (six pairs).
3. *T. nigricornis* females × *T. nigricornis* males (six pairs).
4. *T. bisetosa* males × *T. bisetosa* females (six pairs).
5. Unmated *T. nigricornis* females (six females).
6. Unmated *T. bisetosa* females (six females).

Each pair of flies or single female was placed in 850 ml clear-plastic cage fitted with a basal water reservoir and a screened lid to allow ventilation. The lid of each cage was striped with honey and contained a cotton strip dipped in the yeast hydrolysate solution. Each cage was provided with a bouquet of immature flower heads, the excised peduncles of which were emerged in the water reservoir and held in place by an absorbent cotton wick that also provided a water source for the flies. *Trupanea nigricornis* females were provided with *E. farinosa* heads while those of *T. bisetosa* were provided with *H. annuus* heads. The flower head bouquet was replaced every other day for a period of 2 months (May–June), and was collected from stems that had been covered with a fine mesh cloth to protect them from oviposition in the field.

The caged flower heads were dissected under a stereomicroscope and the number of eggs in each was recorded. The eggs were placed on a filter paper (Whatman #1) moistened with physiological saline in closed glass Petri dishes.

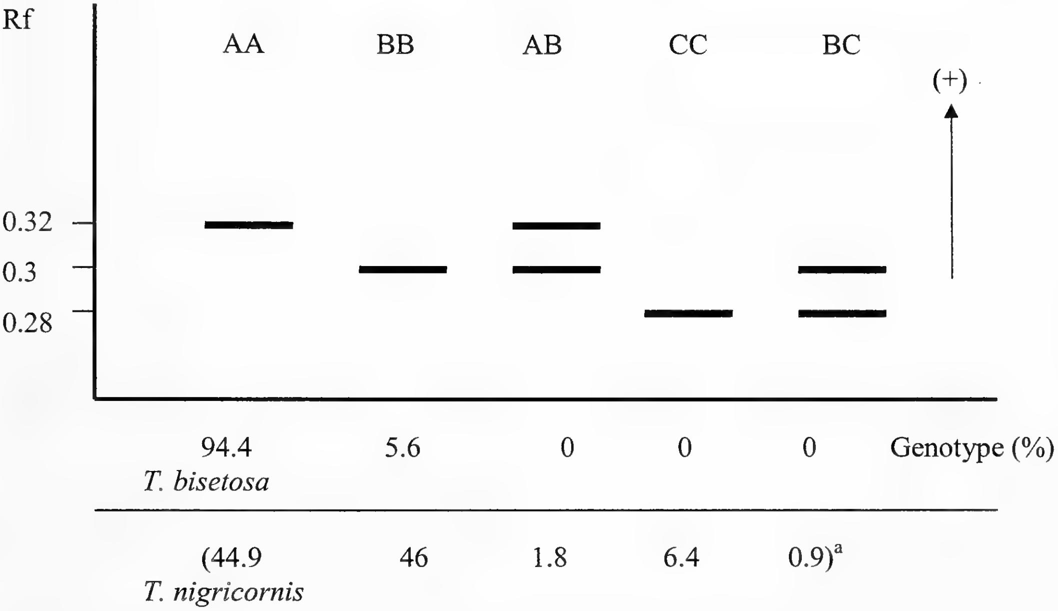


Fig. 1. Zymogram and genotypes (%) found in *Trupanea nigricornis* and *T. bisetosa* populations for malic enzyme (ME).

The Petri dishes were placed in an incubator at 27°C and checked each day for eclosion. The eggs were considered infertile if they did not hatch and remained white with no sign of embryonic development after 2 weeks, i.e., no sign of the cephalopharyngeal skeleton (Cavender and Goeden 1983). On the other hand, the eggs were considered fertile if they hatched into active first instar larvae. The number of fertile and infertile eggs was recorded and percentage eclosion for each treatment was calculated. Analysis of variance was used to compare the mean numbers of eggs laid between the different crosses and their controls.

RESULTS

Isoenzyme electrophoresis was used to test whether gene flow occurs between sympatric populations of *T. nigricornis* and *T. bisetosa.* Table 1 summarizes the isozyme loci resolved in this study, the number of flies analyzed for each locus, the buffer systems used and the number of major bands found per locus. Among 14 resolved loci, only acid phosphatase, phosphoglucose isomerase, phosphoglucose mutase, malic enzyme, and esterases were polymorphic in *T. nigricornis* and *T. bisetosa* populations. The other tested enzymes were monomorphic indicating genetic similarity between the two species.

Among the polymorphic enzymes, ME and EST were not always clearly resolved and therefore were not included in the intraspecific variation analysis. Malic enzyme behaved as a monomer. Two alleles for ME were detected in *T. bisetosa* populations while three were detected for *T. nigricornis* populations (Fig. 1). Allele 0.32 was almost fixed for *T. bisetosa* populations with a frequency of 0.94 (Table 2). There was a significant difference in the allele frequencies of ME between the two species ($X^2 = 89.2$; df = 2; $p < 0.001$). In the esterases, two loci were detected. EST-1 was polymorphic with three common alleles in the two species (Fig. 2); significant allele fre-

Table 2. Allele frequencies of *Trupanea bisetosa* and *T. nigricornis* at the polymorphic loci, ME and EST.

Allele[a]	*T. bisetosa*	*T. nigricornis*
ME**		
0.32	0.94	0.46
0.3	0.06	0.47
0.28	0	0.07
EST-1*		
0.26	0.18	0.09
0.24	0.62	0.78
0.22	0.29	0.04

[a] Each allele is referred to by its Rf value.
* $p < 0.005$; ** $p < 0.001$.

quency differences were also detected between *T. nigricornis* and *T. bisetosa* populations for EST-1 ($X^2 = 18.1$; df = 1; $p < 0.005$) (Table 2).

The most useful enzymes for differentiating between *T. nigricornis* and *T. bisetosa* populations were ACHP, PGI, and PGM. Acid phosphatase was fixed for allele 0.8 in *T. nigricornis* and fixed for allele 0.9 in *T. bisetosa* in all samples analyzed (Fig. 3). The absence of hybrids indicated that mating did not occur between the two species in the populations that were sampled. This locus could be considered diagnostic as it allows discrimination between the two sympatric species.

Two other loci, PGM and PGI, showed genetic differentiation between *T. nigricornis* and *T. bisetosa*. Allele frequencies for PGM and PGI were significantly different between the two species ($p < 0.001$) (Table 3). However, there was no significant allele frequency difference within samples of the same species (Table 3).

The polymorphic locus PGM, which behaved as a monomer, showed greater genetic variability in *T. nigricornis* popu-

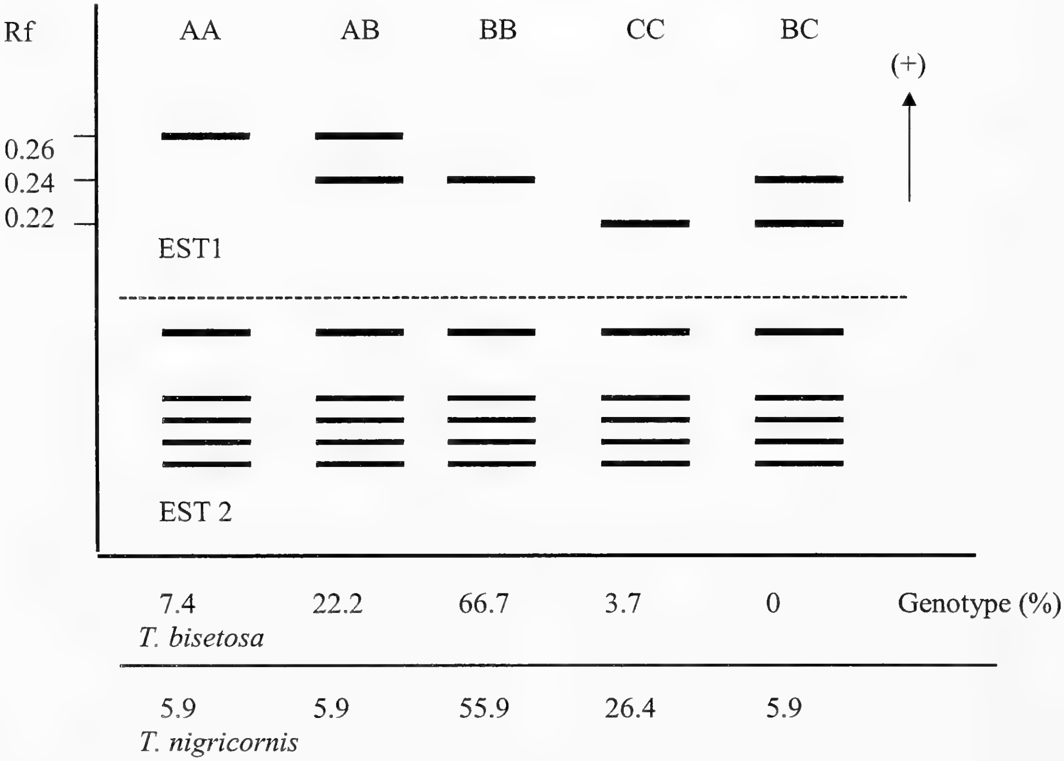


Fig. 2. Zymogram and genotypes (%) found in *Trupanea nigricornis* and *T. bisetosa* populations for esterases (EST), loci 1 and 2.

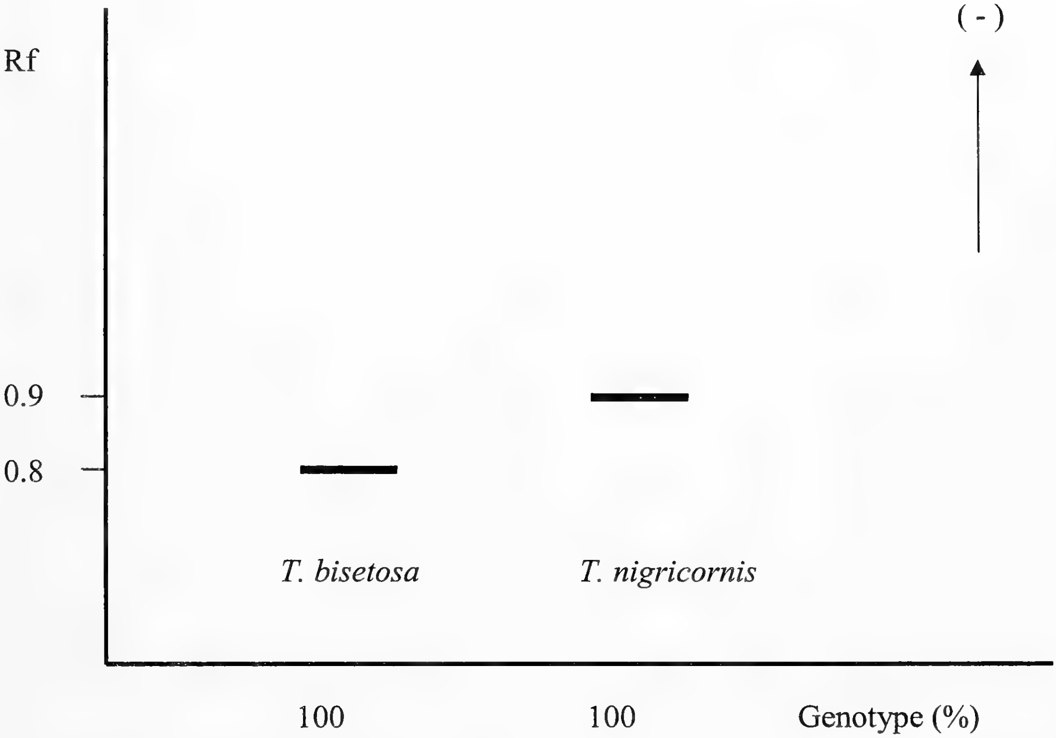


Fig. 3. Zymogram of acid phosphatase (ACPH) in *Trupanea nigricornis* and *T. bisetosa* populations, showing a fixed allele difference between the two species.

lations than in *T. bisetosa* populations. Four alleles for that locus were detected in *T. bisetosa* populations; six alleles were detected in *T. nigricornis* populations. The mean number of alleles was 2.67 in *T. bisetosa* samples and 5.00 in *T. nigricornis* samples. A summary of all PGM phenotypes and their genetic interpretation is presented in Fig. 4. The two species shared the alleles 0.09, 0.12, 0.16, and 0.19. Allele 0.12 was the most common allele in both species, with a total frequency of 0.964 in *T. bisetosa* and 0.609 in *T. nigricornis* (Table 3). Two rare alleles (0.06 and 0.10) were only detected in *T. nigricornis* samples from flies reared from *E. farinosa* flowerheads, but not *E. fructescens* heads. Moreover, PGM was almost fixed in three *T. bisetosa* samples with the frequency of the most common allele (0.12) greater than 0.95 (Table 3).

This greater genetic variation for PGM seemed to be preserved in *T. nigricornis* populations since chi-square tests on expected and observed genotypic frequencies indicated that the PGM locus did not depart from the Hardy-Weinberg equilibrium (Table 4). The Hardy-Weinberg test was not applied to *T. bisetosa* because the locus was almost fixed for the most common allele, leaving the other alleles with genotypic classes having low frequencies (<1), even after pooling.

The polymorphic locus, PGI, behaved as a dimer. It also showed genetic variability between the species. Two alleles were detected in *T. bisetosa*; five were detected in *T. nigricornis*. A mean of 1.33 alleles per locus was found in *T. bisetosa* samples while a mean of 3.33 alleles per locus was found in *T. nigricornis* samples. The phenotypes observed for PGI in the two species are summa-

Table 3. Allele frequencies of *Trupanea bisetosa* and *T. nigricornis* at two polymorphic loci, PGI and PGM.

	Allele frequency in *T. bisetosa*[c]				Allele frequency in *T. nigricornis*[c]			
Allele[a]	Site 1	Site 2	Site 3	Total	Site 1	Site 2	Site 3	Total
N[b]	155	58	18	231	130	142	35	307
PGI								
0.4	0	0	0	0	0	0.004	0	0.002
0.33	0	0	0	0	0	0.007	0	0.003
0.25	0.006	0	0	0.004	0.042	0.049	0.014	0.042
0.17	0.994	1	1	0.996	0.954	0.930	0.986	0.946
0.09	0	0	0	0	0.004	0.011	0	0.007
PGM								
0.19	0.010	0.009	0	0.009	0.027	0.007	0.043	0.020
0.16	0.019	0.034	0	0.022	0.173	0.162	0.129	0.163
0.12	0.952	0.922	0.972	0.946	0.6	0.627	0.571	0.609
0.10	0	0	0	0	0	0.011	0	0.005
0.09	0.019	0.034	0.028	0.024	0.192	0.155	0.257	0.182
0.06	0	0	0	0	0.008	0.039	0	0.021

[a] Each allele is referred to by its Rf value.

[b] Number of adults tested.

[c] Within *T. bisetosa*: $X^2 = 0.99$ (df = 2; $p > 0.05$) for PGI and $X^2 = 2.7$ (df = 4; $p > 0.05$) for PGM. Within *T. nigricornis*: $X^2 = 4$ (df = 2; $p > 0.05$) for PGI and $X^2 = 5.9$ (df = 6; $p > 0.05$) for PGM. Between species: $X^2 = 20.4$ (df = 1; $p < 0.001$) for PGI and $X^2 = 161.2$ (df = 3; $p < 0.001$) for PGM. Alleles were pooled to maintain expected allele frequency >1.

rized in Fig. 5; the frequencies of the PGI alleles are shown in Table 3. The two species shared allele 0.17, the most common allele, and allele 0.25, which occurred at low frequencies (total f = 0.0042) in *T. nigricornis* samples and in lower frequencies (total f = 0.004) in two out of six *T. bisetosa* samples. The locus PGI appears fixed in *T. bisetosa* populations as the frequency of the most common allele ranged from 0.99–1.00 (Table 3). The frequency of the most common allele was also high (0.99) in one *T. nigricornis* sample from flies collected from *E. fructescens* flower heads. Testing for the Hardy-Weinberg equilibrium was not possible for PGI in both species because this locus was almost fixed for the most common allele.

Cross-mating tests between *T. nigricornis* and *T. bisetosa* revealed that the two species did mate in the laboratory, but produced few viable offspring. When *T. nigricornis* females were crossed with *T. bisetosa* males, they produced an average of 66 eggs per female in a period of 2 months; however, only ca. 1% of the eggs were fertile and hatched into first instar larvae (Table 5). When *T. bisetosa* females were crossed with *T. nigricornis* males, they oviposited an average of 16 eggs per female in 2 months, but none of these eggs were fertile, i.e., percent eclosion was zero (Table 5). Eclosion was 100% in the control crosses, *T. nigricornis* × *T. nigricornis* and *T. bisetosa* × *T. bisetosa* (Table 5). Eclosion was 0% when *T. nigricornis* females and *T. bisetosa* females were reared without males. The unmated females produced very few eggs, and none were fertile (Table 5).

Analysis of variance showed significant differences in the mean number of eggs laid by *T. nigricornis* and *T. bisetosa* females in the cross-mating tests (F = 34.65; df = 35; $p < 0.05$). *Trupanea nigricornis* females crossed with either *T. nigricornis* males or *T. bisetosa* males produced significantly (95% level) more

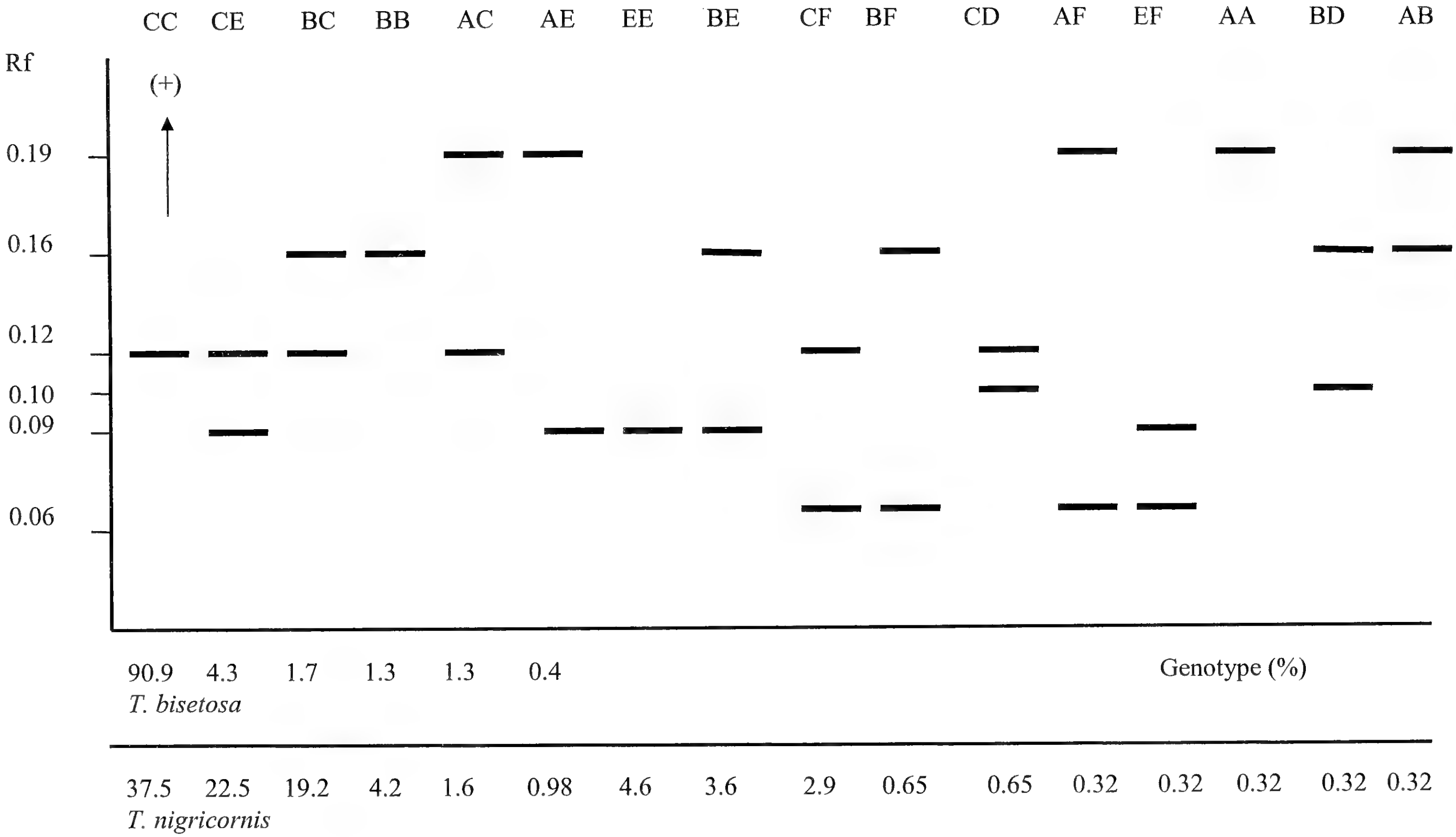


Fig. 4. Zymogram and genotypes (%) found in *Trupanea nigricornis* and *T. bisetosa* populations for the enzyme phosphoglucose mutase (PGM).

Table 4. Test for Hardy-Weinberg equilibrium at the PGM locus in *T. nigricornis* populations. Alleles were pooled to maintain expected genotypic frequency > 1.

Population	Genotypes[a]	Genotypic frequencies: Observed	Genotypic frequencies: Expected	Chi-square
Site 1:				
	CC	46	46.8	0.01
	CE	33	29.95	0.31
	BC	31	32.45	0.07
	BB	8	5.62	1.00
	BE	7	10.38	1.10
	EE	5	4.79	0.01
		130	129.99	2.50[a]
Site 2:				
	CC	59	55.82	0.18
	CE	33	37.75	0.60
	BC	27	28.85	0.12
	EE	10	6.38	2.05
	BE	7	9.75	0.78
	BB	6	3.73	1.39
		142	142.28	5.12[a]
Site 3:				
	CC	10	11.41	0.17
	CE	20	17.15	0.48
	EE	5	6.44	0.32
		35	35	0.97[a]

[a] $p < 0.05$.

eggs than *T. bisetosa* females crossed with *T. nigricornis* males or males of their own species (Table 5). There was no significant difference in the mean number of eggs laid between *T. nigricornis* females crossed with *T. bisetosa* males and the controls. However, *T. bisetosa* females crossed with *T. nigricornis* males produced significantly less eggs than the controls (Table 5). The mean number of eggs produced by the unmated females did not differ between the two species. However, it was significantly lower than the means of mated females of both species in the crosses and the control tests (Table 5).

Discussion

The sympatric and cryptic species, *T. nigricornis* and *T. bisetosa*, showed much genetic similarity. Ten of the 14 resolved loci were monomorphic in the two species. Nevertheless, genetic differentiation between the two species was possible as there was a fixed allele difference for the locus ACPH, and significant allele frequency differences for the loci, PGI, PGM, ME, and EST-1. The fixed allele difference for the diagnostic locus ACPH indicates that the two sympatric species do not hybridize in nature as no hybrids were detected in the populations that were sampled. Hence, there should be some reproductive isolation mechanisms that restrict gene flow between the two species.

Two types of reproductive barriers seem to be involved in the prevention of gene flow between *T. nigricornis* and *T. bisetosa*. These are pre-mating and post-mating isolating barriers. The first type, pre-mating barriers, can operate through ethological isolation and differ-

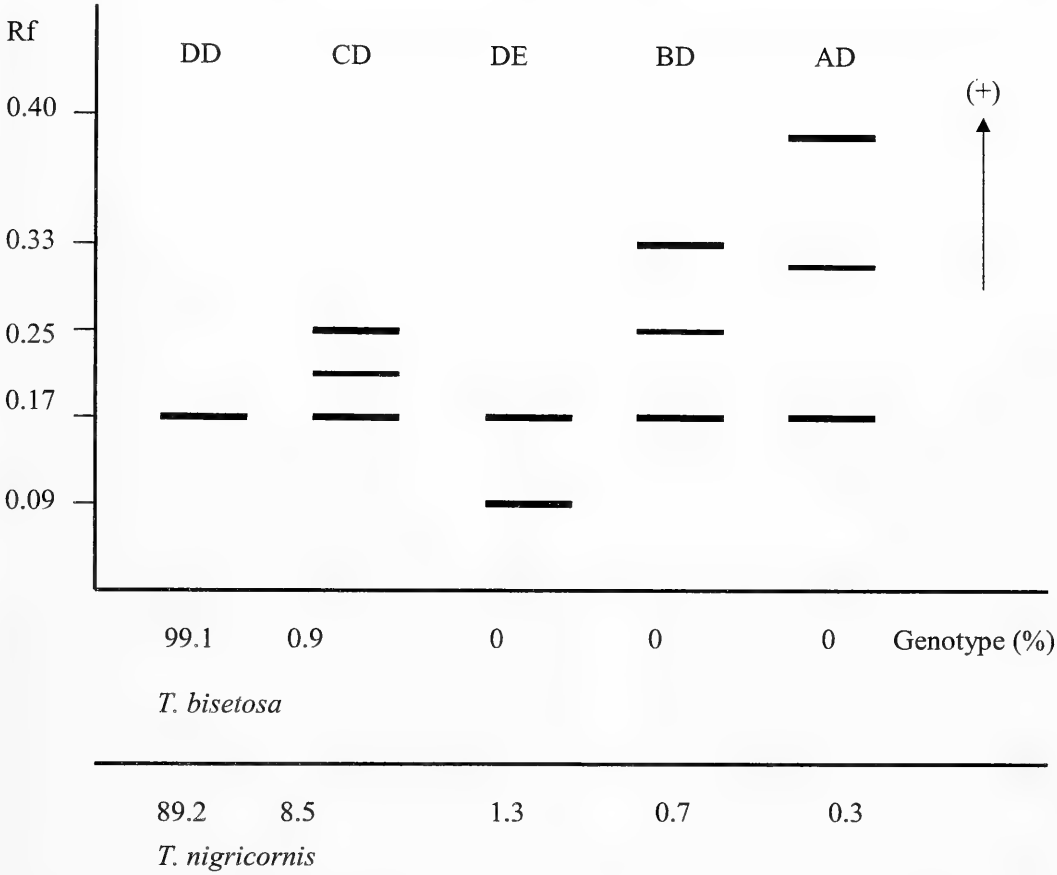


Fig. 5. Zymogram and genotypes (%) found in *Trupanea nigricornis* and *T. bisetosa* populations for the enzyme phosphoglucose isomerase (PGI).

ential host recognition. Ethological mechanisms include a few differences in the courtship behavior of *T. nigricornis* and *T. bisetosa*, especially differences in the wing movements of the males (Knio et al. 1996b). However, because males of both species have very similar wing patterns and because most successful matings are force matings while the females are probing the flower heads

Table 5. Percent eclosion in *T. nigricornis* (T. n.) and *T. bisetosa* (T. b.) crosses and controls.

Crosses (Female × Male)	N[a]	# of eggs laid Mean[b] ± (SE)	Fertile Eggs Mean	Eclosion (%)
T. n. × T. b.	6	99 (12.2) a	1.11	1.69
T. b. × T. n.	6	29.8 (8.3) b	0	0
T. n. × T. n.	6	119.8 (11) a	119.8	100
T. b. × T. b.	6	62 (8.4) c	62	100
T. n. × -	6	2.8 (1.1) d	0	0
T. b. × -	6	2.2 (0.9) d	0	0

[a] N = number of adult pairs.

[b] Means followed by the same letter are not significantly different, $p < 0.05$, as determined by the least significant difference.

(Knio et al. 1996b), differential host recognition is probably more significant than ethological isolation in restricting gene flow. Similarly, in the sibling species *Rhagoletis mendax* Curran and *R. pomonella* (Walsh) (Diptera: Tephritidae) that court and mate on or near their respective host plants (Prokopy et al. 1971, 1972), differences in oviposition preference and in host recognition were the most important pre-mating barriers reducing hybridization between these two sympatric species (Feder et al. 1989). Because *R. mendax* and *R. pomonella* readily mate in the laboratory and field experiments producing viable offspring, differential host usage and host fidelity were found to be more significant in reducing contact between the two species than post-mating and ethological isolation barriers (Feder and Bush 1989). Moreover, in the apple and hawthorn races of *R. pomonella*, differential host recognition by the adult flies together with differences in the timing of adult emergence were responsible for reducing gene flow and causing rapid genetic differentiation between these sympatric races (Feder et al. 1988, Prokopy et al. 1988). In fact, mark-release and recapture experiments demonstrated that host fidelity was an efficient barrier to gene flow between the apple and hawthorn races reducing hybridization to about 6% per generation (Feder et al. 1994). Factors that contributed to this host fidelity were genetically based differences in host preference, adult eclosion under the specific host, and more importantly, allochronic isolation of the adults due to differences in the phenology of their respective plant hosts (Feder et al. 1988, 1994). Contrary to the univoltine *R. pomonella* host races, it is unlikely that seasonal asynchrony is an important factor in reducing gene flow between the multivoltine tephritids, *T. nigricornis* and *T. bisetosa* because there is a large overlap in the flowering period of their different hosts. Although wild sunflowers bloom throughout the year in southern California, the highest densities of the specialist, *T. bisetosa*, are in the spring and in the fall, coinciding with the blooming seasons of the hosts of the generalist, *T. nigricornis*.

Post-mating isolating mechanisms are also involved in restricting gene flow between *T. nigricornis* and *T. bisetosa*. The crosses between the two species yielded eggs with zero to very low eclosion. Since females in these cross-mating tests oviposited significantly more eggs than unmated females of either species, this indicates that the two species cross-mated but produced infertile eggs. Therefore, post-mating barriers are reducing gene flow through hybrid inviability. They also explain why no hybrids for ACPH were detected in the populations analyzed. In case of host identification mistake and mating with a nonconspecific male, post-mating barriers are thus effective in isolating the two species because the hybrids produced are not likely to survive. Post-mating isolating barriers were also found to play a role in limiting hybridization between *R. mendax* and *R. pomonella* through a reduction in the viability of the hybrids (Feder et al. 1989, Feder and Bush 1989). Recently, it was demonstrated that F_1 hybrids resulting from crosses between the apple and hawthorn races of *R. pomonella* in addition to a sister species infesting dogwood showed great fitness disadvantage in finding potential fruit hosts as they failed to respond to fruit volatiles at concentrations causing maximal orientation of their respective parents (Linn et al. 2004).

In conclusion, the electrophoretic data supports the differences in behavior and biology observed in *T. nigricornis* and *T. bisetosa*. The two species are very close morphologically and genetically, but they do not hybridize in nature. The two species meet most of the criteria required for sympatric speciation. Mechanisms that reduce gene flow between these two sympatric species include meeting and mating on different host plants, differences in host recognition, and post-mating sterility through null hybrid viability. The key to host selection in *T. nigricornis* and *T. bisetosa* appears to be in the behavior of adult females rather than in survival of the immatures in suitable hosts. The oviposition behavior of the females coupled with their adaptation to the biophysical features of their host plants are the most important factors determining differences in host uses and host specificity of these species (Knio et al. 1996b, 2001). The trade-off for adopting a narrow host range and specializing on wild sunflowers in *T. bisetosa* seem to be gaining a greater enemy-free space (Knio et al. 2007).

ACKNOWLEDGMENTS

We sincerely thank Dr. R. Stouthammer for initially demonstrating the techniques in starch gel electrophoresis and Dr. D. Kazmer for helping in the statistics and genetic interpretation of the zymograms.

LITERATURE CITED

Berlocher, S. H. 1980. An electrophoretic key for distinguishing species of the genus *Rhagoletis* (Diptera: Tephritidae) as larvae, pupae, or adults. Annals of the Entomological Society of America 73: 131–137.

Bush, G. L. 1975. Sympatric speciation in phytophagous parasitic insects, pp. 187–206. *In* Price, P. W. ed. Evolutionary Strategies of Parasitic Insects and Mites. Plenum Press, New York. 224 pp.

Cavender, G. L. and R. D. Goeden. 1983. On distinguishing *Trupanea bisetosa* (Coquillett) from *T. nigricornis* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 85: 275–281.

Clayton, J. W. and D. N. Tretiak. 1972. Amino citrate buffers for pH control in starch gel electrophoresis. Journal of Fisheries Research Board of Canada 29: 1169–1172.

Feder, J. L. and G. L. Bush. 1989. A field test of differential host plant usage between two sibling species *Rhagoletis pomonella* fruit flies (Diptera: Tephritidae) and its consequences for sympatric models of speciation. Evolution 43: 1813–1819.

Feder, J. L., C. A. Chilcote, and G. L. Bush. 1988. Genetic differentiation between sympatric host races of the apple maggot fly *Rhagoletis pomonella*. Nature 336: 61–64.

———. 1989. Are the apple maggot, *Rhagoletis pomonella*, and blueberry maggot, *R. mendax*, distinct species? Implications for sympatric speciation. Entomologia Experimentalis et Applicata 51: 113–144.

Feder, J. L., S. B. Opp, B. Wlazlo, K. Reynolds, W. Go, and S. Spisak. 1994. Host fidelity is an effective premating barrier between sympatric races of the apple maggot fly. Proceedings of the National Academy of Sciences, USA 91: 7990–7994.

Foote, R. H., F. L. Blanc, and A. L. Norrbom. 1993. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Cornell University Press, Ithaca. 571 pp.

Goeden, R. D. 1985. Host-plant relations of *Trupanea* spp. (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 87: 564–571.

———. 1992. Analysis of known and new hostrecords for *Trupanea* from California (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 94: 107–118.

Knio, K. M., R. D. Goeden, and D. H. Headrick. 1996a. Descriptions of the immature stages of *Trupanea nigricornis* and *T. bisetosa* (Diptera: Tephritidae) from southern California. Annals of the Entomological Society of America 89: 1–11.

———. 1996b. Comparative biologies of the cryptic, sympatric species, *Trupanea bisetosa* and *T. nigricornis* (Diptera: Tephritidae) in southern California. Annals of the Entomological Society of America 89: 252–260.

———. 2001. Resource utilization on the sibling species *Trupanea nigricornis* (Coquillett), a polyphage, and the narrowly oligophagous *T. bisetosa* (Coquillett) (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 103: 946–961.

———. 2007. Natural enemies of the cryptic and sympatric species, *Trupanea nigricorinis* (Coquillett), a polyphage and the narrowly oligophagous *T. bisetosa* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 109: 187–197.

Linn, C. E. Jr., H. R. Dambroski, J. L. Feder, S. H. Berlocher, S. Nojima, and W. L. Roelofs. 2004. Postzygotic isolating factor in sympatric speciation in *Rhagoletis* flies: Reduced response of hybrids to parental host-fruit odors. Proceedings of the National Academy of Sciences, USA 101: 17753–17758.

Pasteur, N., G. Pasteur, F. Bonhomme, J. Catalan, and J. Britton-Davidian. 1987. Manuel Technique de Génétique par Electrophorèse des Protéines. Technique et Documentation, Lavoisier. Paris, France. 217 pp.

Prokopy, R. J., E. W. Bennett, and G. L. Bush. 1971. Mating behavior in *Rhagoletis pomonella* (Diptera: Tephritidae). I. Site of assembly. Canadian Entomologist 103: 1405–1409.

———. 1972. Mating behavior in *Rhagoletis pomonella* (Diptera: Tephritidae). II. Temporal organization. Canadian Entomologist 104: 97–104.

Prokopy, R. J., S. R. Diehl, and S. S. Cooley. 1988. Behavioral evidence for host races in *Rhagoletis pomonella* flies. Oecologia 76: 138–147.

Selander, R. K., M. H. Smith, S. Y. Yang, W. E. Johnson, and J. B. Gentry. 1971. Biochemical polymorphism and systematics in the genus *Peromyscus*. I. Variation in the old-field mouse (*Pteromyscus polionotus*). University of Texas Publication 7103: 46–90.

Shaw, C. R. and R. Prasad. 1970. Starch gel electrophoresis of enzymes—a compilation of recipes. Biochemical Genetics 4: 297–320.

Tsiropoulos, G. L. 1978. Holidic diets and nutritional requirements for survival and reproduction of the adult walnut husk fly. Journal of Insect Physiology 24: 239–242.

Zar, J. H. 1984. Biostatistical Analysis, Second Edition. Prentice Hall, Inc. Englewood Cliffs, New Jersey. 718 pp.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 309–323

CRENOPHYLAX (TRICHOPTERA: LIMNEPHILIDAE), A NEW GENUS TO ACCOMMODATE *RHADICOLEPTUS SPERRYI* BANKS, 1943

David E. Ruiter and Hiroyuki Nishimoto

(DER) 6260 S. Grant Street, Centennial, CO 80121, U.S.A. (e–mail:druiter@msn.com); (HN) 3-104 Mezon-Hikarigaoka II, 1-71-1 Hikarigaoka, Komaki, Aichi, 485-0811, Japan

Abstract.—A **new genus**, ***Crenophylax*** (Trichoptera: Limnephilidae), is proposed for *Radicoleptus sperryi* Banks 1943. Diagnostic characters, description, and figures are provided for larva, pupa, and adults.

Key Words: *Limnephilus*, *sperryi*, Arizona, New Mexico, description, figures

Radicoleptus sperryi Banks (1943) has been a source of confusion since its description. The larva, pupa and female have not been described. Banks (1943) described *R. sperryi* from a pair collected in the Arizona White Mountains (M.C.Z. type 25757) and provided a figure of the male. Ross (1944) placed *R. sperryi* in *Limnephilus* but Ross and Merkley (1952) did not include it in their key to *Limnephilus*. Schmid (1955) listed *L. sperryi* as *incertae sedis* within *Limnephilus*. Flint (1966) provided another figure of the male and pointed out the similarity between *L. sperryi* and *Anisogamus costalis* (Banks) but did not recognize Ross' (1944) placement of *A. costalis* in *Psychoronia*. Wiggins (1975) provided rationale for retention of *Psychoronia* for *P. costalis*, but did not address *L. sperryi*. Weaver (1993) indicated the *L. sperryi* type was missing from the Museum of Comparative Zoology.

Crenophylax sperryi is a very rare species. There were no *C. sperryi* specimens reported, other than the types, until Ruiter (1995) refigured the male from a 1962 collection of three males from near Greer, Arizona, which is also in the White Mountains. Houghton (2001) reared a single male from the White Mountains, about 15 air miles southeast of Greer.

This work is based on the above material as well as new material collected by Dean Blinn, Oliver Flint, Jr., and the senior author over the last several years from several localities in the White Mountains, near Greer, Arizona, and about 30 air miles south-southeast of Greer. These collections are all in the Colorado River drainage. The larval association is based on material reared from a single New Mexico locality, about 220 air miles east-southeast from Greer, east of the continental divide in the Rio Grande River drainage. While collections of *C. sperryi* are known from only six localities, it is found, like *Hesperophylax*, on both sides of the continental divide. To date *Psychoronia* is known only from east of the continental divide.

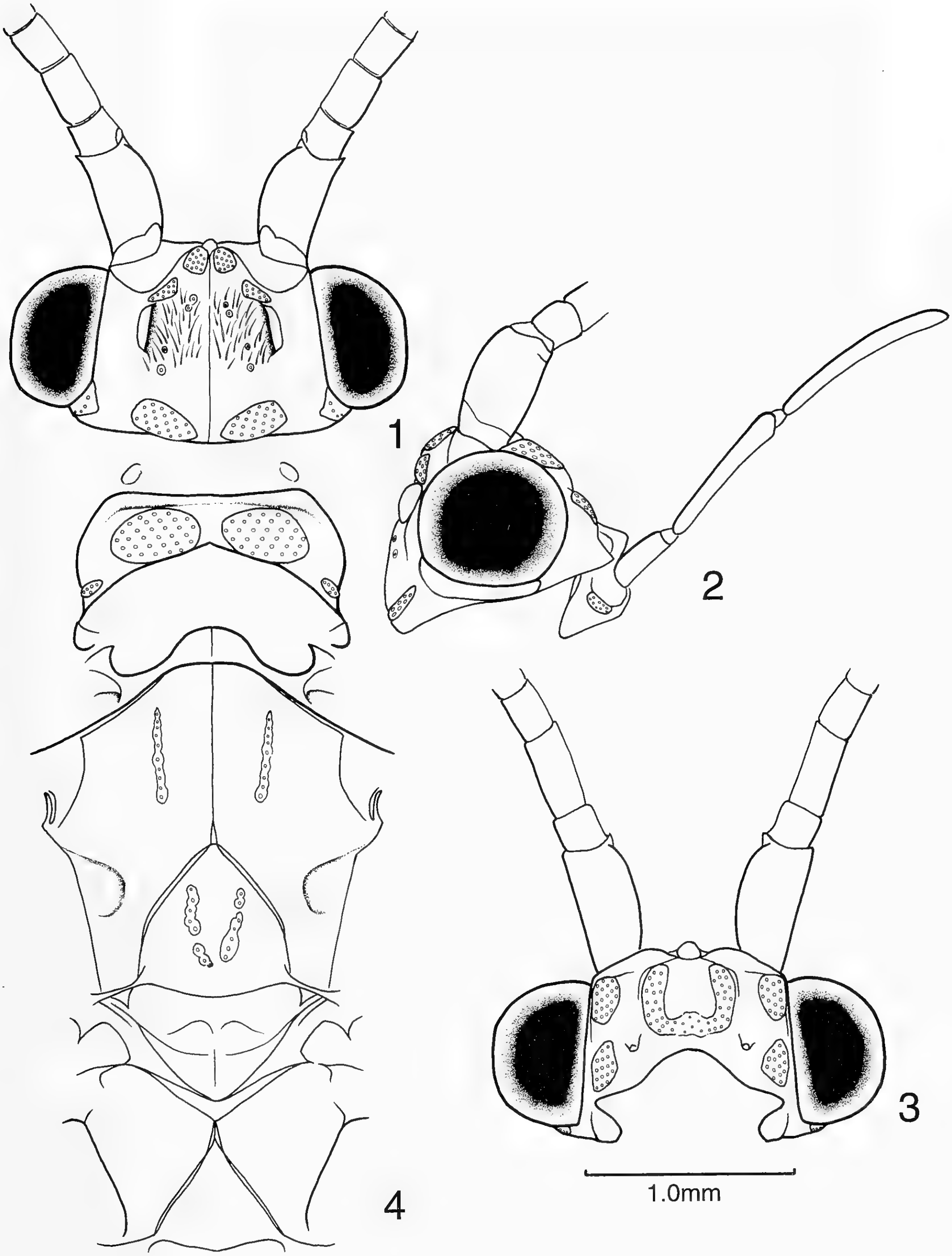
Materials and Methods

Most of the adults for this study were collected via sweepnet or light. During efforts to locate the female and larva in the Arizona White Mountains a special emphasis was placed on examination of headwater springs under the supposition that *C. sperryi* larvae are similar to those of *Psychoronia* and *Hesperophylax* (see Ruiter 1995). While occasional adults were collected (see material examined) a larval population was not located until closed pupae, presumed to be *Hesperophylax*, were reared from a New Mexico stream. Larvae and pupae were collected by hand on May 3, 2003, the pupae were placed in a home refrigerator in a jar with a bit of damp moss from the collection locality. Adults started emerging about 60 d later. The larval/adult association is based on comparison of the larval sclerites in the pupal case with those of larvae collected during the original collection. Emergence was halted for several specimens so that mature larvae, pupae and adults were available from the same collection. Material examined in this study is deposited in the collections of Dean W. Blinn (DWB), Canadian National Collection (CNC), National Museum of Natural History (USNM), and the authors (DER) and (HN).

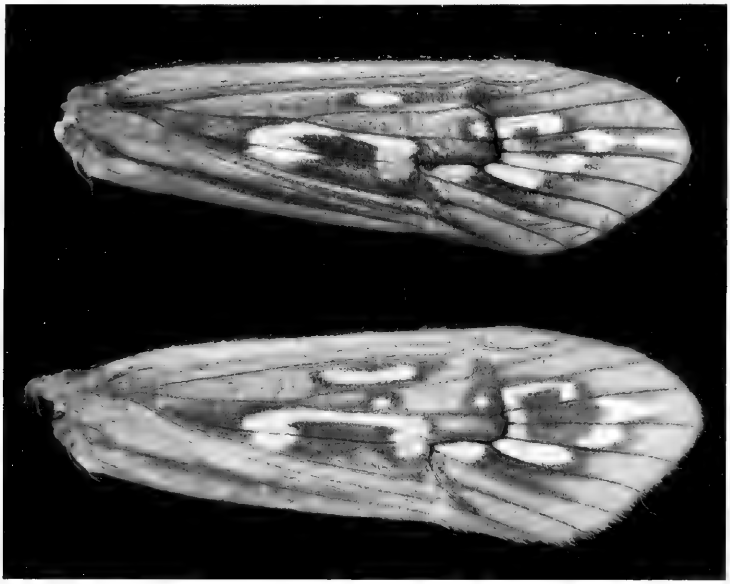
Crenophylax Ruiter and Nishimoto, new genus

Type species: *Radicoleptus sperryi* Banks, 1943.

Adult (Figs. 1–7).—Head yellow; antenna about as long as fore wing, between 60 and 70 segments, scape (Fig. 1) about 3 times length of 2nd segment, 3rd segment about twice length of 2nd, 4th segment about 1.5 length of 2nd segment, remaining segments gradually lengthening to mid-antenna and then gradually decreasing to apex, mid antennal segment length about twice length of 2nd segment; 3 ocelli, lateral ocelli larger than pre-ocellus wart; lateral ocelli located mid-distance between medial suture and eye, located close to anterior margin of head, less than one ocelli length from socket; eye large, width equal to distance between medial suture and eye; medial suture nearly complete, extending anteriorly to anterior margin of ocelli; posterior warts width about 2 times length, covered with 15–20 macrosetae; head surface with numerous small, hairlike setae between and behind lateral ocelli, most setae with small, pale, single, basal warts; maxillary palp three-segmented in male (Fig. 2) and five-segmented in female, male proportions = 0.3:0.8:1, female proportions = 0.3:0.8:1:0.7:0.8; labial palp 3-segmented in both sexes, proportions = 0.3:0.6:1, basal 2 segments flattened ovals, apical segment thin, cylindrical; facial warts (Fig. 3) consisting of two lateral pairs and single U-shaped mesal wart, dorsolateral pair slightly larger than ventrolateral pair; labrum 2.5 times as long as widest portion, widest portion at basal swelling, labial accessory sclerites relatively large, with about 10 macrosetae; postocular wart relatively narrow, widest dorsally, as long as eye height; anterior genal projection present; temporal suture incomplete. Pronotum (Fig. 4) yellow, with two pairs of setae warts, dorsal warts large, oval, with numerous macrosetae; lateral pair small, located at posterolateral apex of pronotum, with 2–6 macrosetae. Mesonotum yellow, with a pair of linear scutal warts, each comprised of 4–8 macrosetae; scutellar setal area with 6–10 macrosetae per side, and a scattering of silky, hairlike setae. Mesopleuron without small setal warts; metapleuron with two setal warts covered in long, silky hairs. Legs yellow, spines black, tibial spurs yellow. Fore- and mesofemora with single, apicomesal, black, spine; hind femur without spines. Tibia and first four tarsal segments with numerous black spines. Foretarsal apical segment without dark spines on ventral surface. Meso- and metatarsal apical segments with 0–2 dark spines on ventral

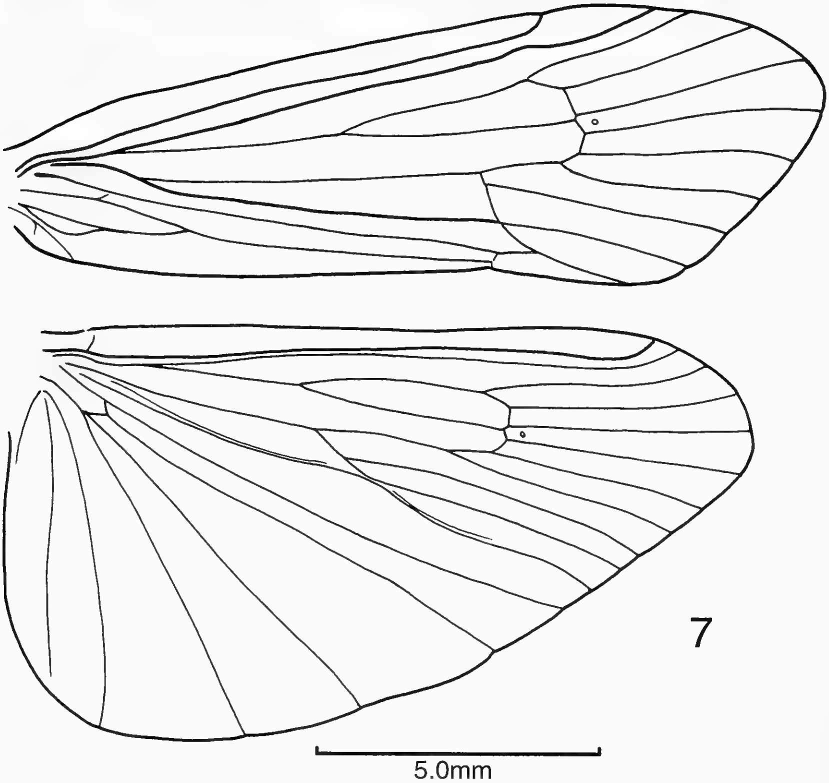


Figs. 1–4. *Crenophylax sperryi*, adult male. 1, Head, dorsal. 2, Head, lateral. 3, Head, frontal. 4, Thorax, dorsal.



5

6



7

Figs. 5–7. *Crenophylax sperryi*, wings. 5, Male fore wing. 6, Female fore wing. 7, Wing venation.

surface. Male foretarsal proportions = 1:0.5:0.4:0.3:0.3. Female foretarsal proportions = 1:0.6:0.5:0.4:0.4. Tibial spurs highly variable in both sexes; usually 1-2-2 or 1-2-3, often bilaterally inconsistent; evidence of a 1-3-4 spur count usually present with reduced basal pits at point of spur attachment; an occasional specimen (n = 16) with full 1-3-4 complement of spurs. Wing length 13–18 mm (n = 16). Fore wing (Figs. 5,6) 3 times as long as widest portion; brightly contrasted coloration, base color yellowish brown; bright white oval areas in subradial, thyridial, radial, and 5 cells beyond chord; 2–3 white ovals in cell V, occasionally merged to nearly fill cell; 1–2 white circles in discoidal cell; areas around white ovals darker brown; anterior chord nearly black, posterior chord yellowish; setae on veins upright, not particularly strong; setae on wing membrane recumbent, fine, hairlike, same color as underlying membrane, i.e., white on white, brown on brown. Hind wing very pale yellow; setae on veins pale, upright, fine, sparse; setae on membrane pale, recumbent, fine, sparse at base, denser towards apex. Venation (Fig. 7) similar in both sexes; distal margins smoothly rounded. Fore wing with R1–R2 separate throughout length, narrowed and slightly curved at pterostigma; apical forks I, II, III, and V sessile; anastomosis staggered, R3-discoidal cell common boundary slightly longer than t1, less than discoidal cell height; discoidal cell about 1.5 length of RS; t1 linear, about twice length t2; t1 and t2 not parallel; t3 long, originating on Cu1, nearly perpendicular to thyridial cell, curved posteriorly; three anal cells, cells A1 and A3 small, A2 about 0.5 length A1+2+3. Hind wing with enlarged anal area; distal margin at Cu not strongly incised; hooked setae along anterior margin absent; R1–R2 separate throughout length, touching near base, separating towards apex, curved at pterostigma; apical forks I, II, III, and V present, all cells sessile; anastomosis staggered; R3-discoidal cell common boundary equal or shorter than t1, less than discoidal cell height; discoidal cell about twice RS; t1 linear, about equal in length t2; t1 and t2 not parallel; t3 long, originating on Cu1, strongly oblique to wing length; posterior 3 anal cells with long, hairlike setae. Abdomen yellowish; 5th segment gland present, small, oval; ventral processes absent.

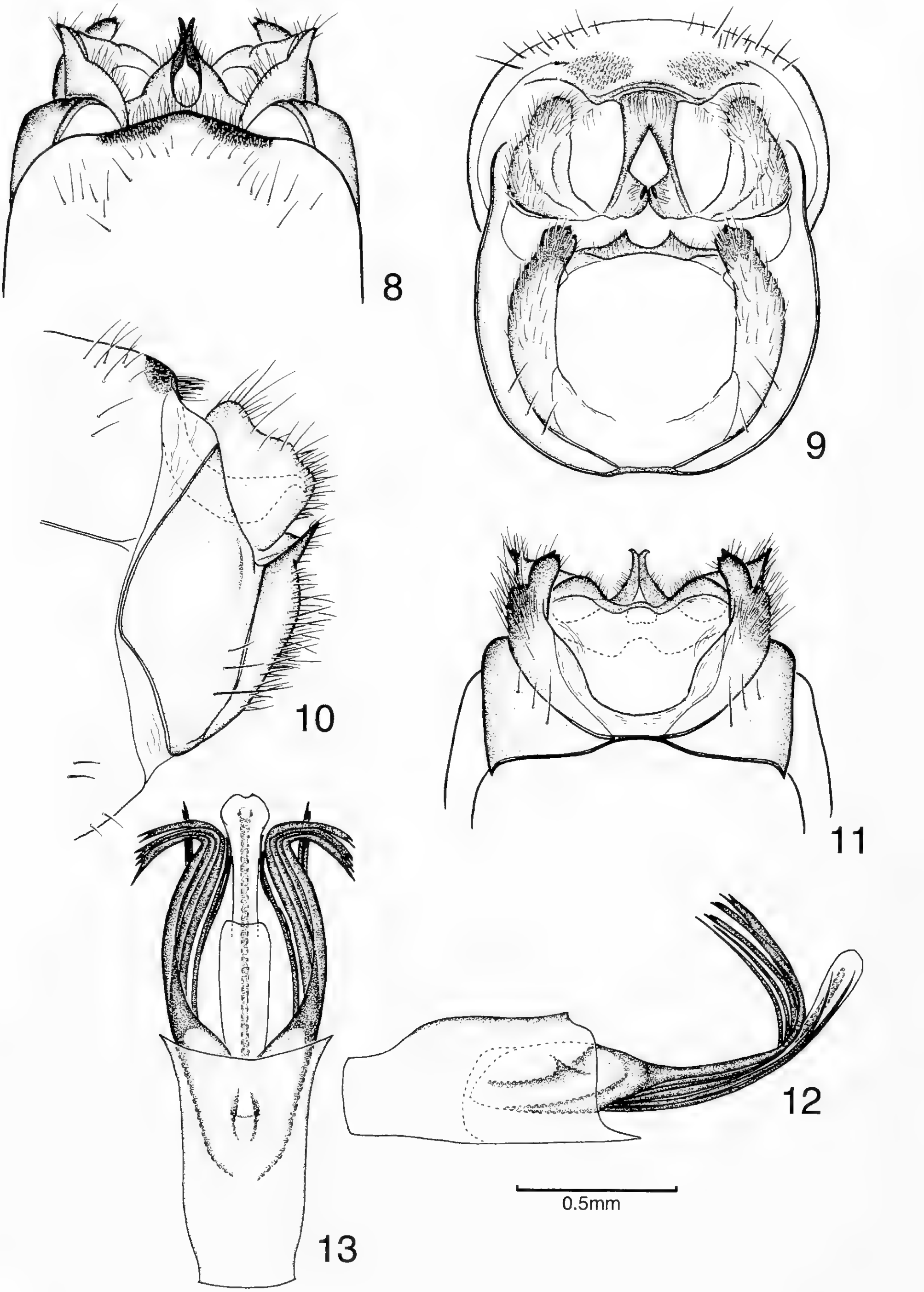
Etymology.—*Crenophylax* (masculine): from the Greek "krene" (spring) and "phylax" (guard), referring to its headwater larval habitat.

Crenophylax sperryi (Banks), **new combination**

Radicoleptus sperryi Banks 1943:346–347, figs. 2, 11, 12. Harvard University, Museum of Comparative Zoology, type No. 25757, types lost. Type locality: White Mountains, Arizona.

Limnephilus sperryi: Ross 1944:298; Schmid 1955:144; Flint 1966:379, 380, figs. 3i, 3j; Ruiter 1995:35, plate 95.

Adult.—*Male genitalia* (Figs. 8–13): Tergite 8 (Fig. 8) with dorsal setae stronger than ventral setae; broad posteromesal spinate patch present; spinate patch broadly concave posteriorly; spines appressed. Segment 9 (Fig. 9) with incomplete, widely separated, tergites; broadest laterally (Fig. 10) at dorsal connection of inferior appendage; connected ventrally by a very thin, sclerotized strap (Fig. 11). Superior appendages nearly quadrate laterally; slightly withdrawn within 9th, widely separated mesally (Fig. 9). Intermediate appendages (Fig. 9) broadly fused dorsally, with dorsal margin distinctly separate from, but touching, 8th tergal spinal patch; appendages broadly concave laterally, reaching mesal margin of superior appendages; ventromesal edges touching, but separate, below anal opening, and

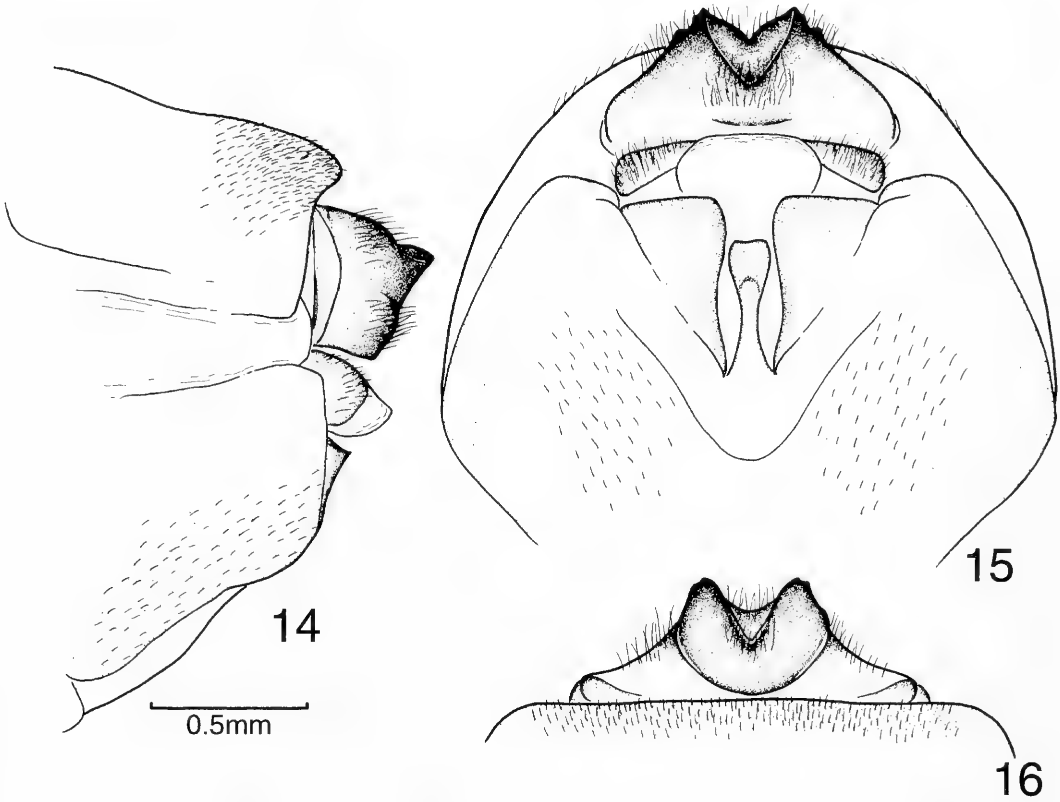


Figs. 8–13. *Crenophylax sperryi*, male genitalia. 8, Dorsal. 9, Caudal. 10, Lateral. 11, Ventral. 12, Phallus, lateral. 13, Phallus, dorsal.

projecting caudoventrally as two, strongly sclerotized hooks. Subanal plate strongly developed, reaching lateral margins of 9th segment; projecting posteriorly nearly to apex of inferior appendages. Inferior appendages broadly separated ventromesally; directed upward; long common boundary with 9th; apex acute, extending caudally equal to superior appendage; in caudal view apex relatively broad with small, acute extension near outer margin. Phallocrypt strips (Fig. 12) sclerotized dorsally, without obvious connection to 9th segment; base of phallocrypt slightly narrower than distal margin. Phallicatal basoventral surface membranous but without linear convolutions; endophallus without endophallic plates; endophallus (Fig. 13) concave dorsally and expanded laterally; phallotremal atrium located dorsally, about midlength of endophallus. Parameres broadly attached laterally to phallicata; apical 3/4ths composed of a broom-like burst of strongly sclerotized, recurved spines; basal, solid portion, a single, undivided, surface with dorsal margin extending beyond ventral margin; spines of paramere reach apex of endophallus.

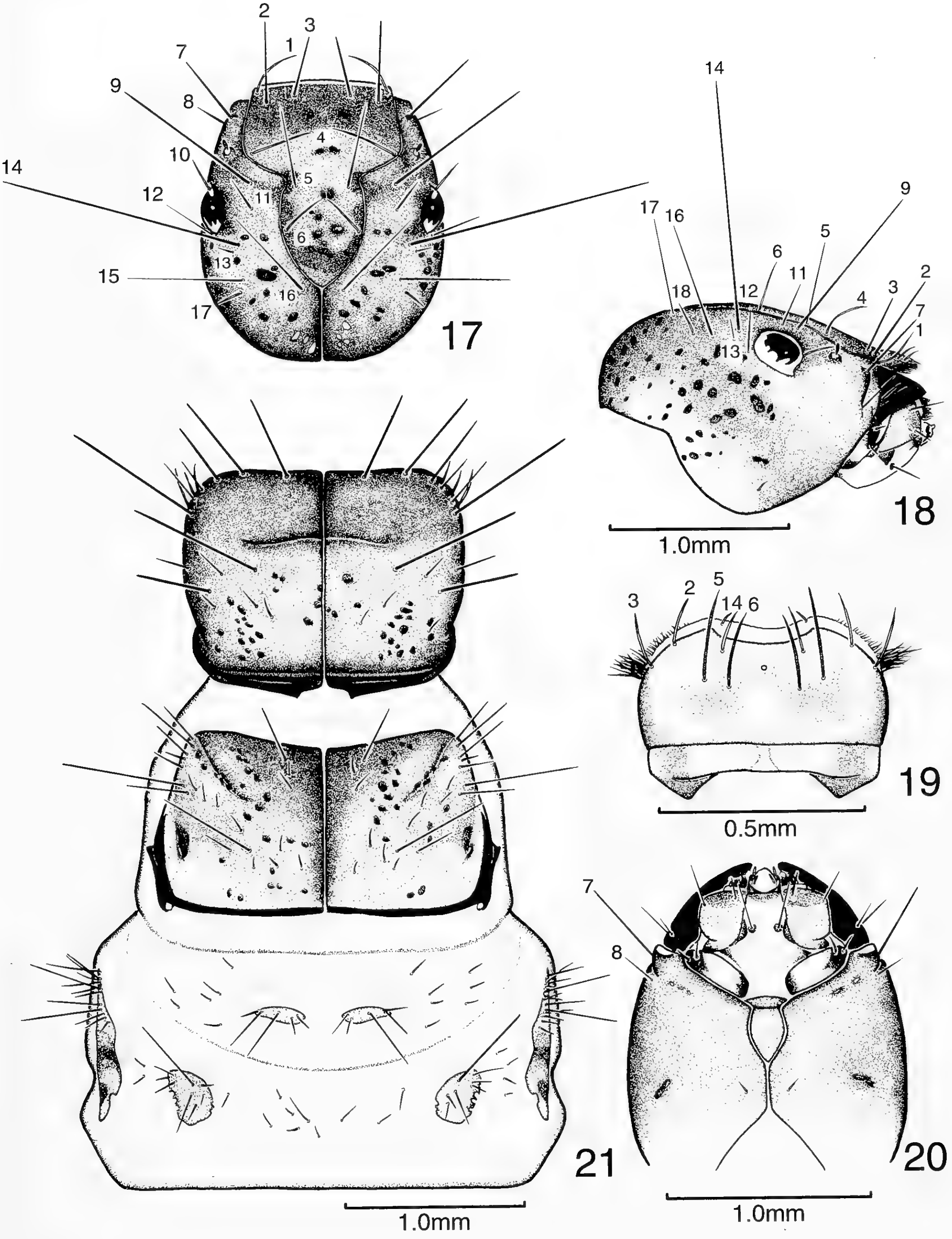
Female genitalia (Figs. 14–16): Segment 8 (Fig. 14) with dorsal setae only slightly stronger than ventral setae. Median lobe (Fig. 15) of subgenital plate about 2/3rds length of lateral lobes; broadest at apex; apical margin slightly concave. Lateral lobes of subgenital plate triangular; broadly connected with 8th segment; wider at apex than base. Subgenital plate broad. Ventral lateral lobes of ninth small, distinctly separated from tergum, widely separated by subgenital plate. Ninth tergum (Fig. 16) narrow dorsally, with slight conical extension between 10th segment appendages; ventrolaterally merged with 10th without obvious suture between two segments. Tenth segment not strongly sclerotized, comprised of a complete cylinder, longer ventrally than dorsally; dorsal lateral appendages fused to tenth, evident by setal patches; short, conical, plates located lateral of anal opening. Spermatheca with spermathecal vestibule narrow, smoothly merged with spermathecal body, without constriction at confluence of vestibule with body; chitinous spermathecal ring tapered, cap-like; no constriction below chitinous ring; additional spermathecal gland located about one width of spermathecal vestibule from spermathecal vestibule; entire inner surface of spermatheca with minute sculpturing, without obvious additional markings.

Final instar larva (Figs. 17–25).—Length 13.0–15.0 mm (N = 2). Head (Fig. 17) dark brown; primary setae 1,4, 6, 10, and 16 almost transparent, setae 1,4, 6, 11, 13, 15, and 16 very thin, seta 2, 3, 7, 9 and 14 thickest; setae 2, 3, 5 subequal in length (Fig. 18), setae 9 and 14 extremely long; seta 18 minute. Labrum (Fig. 19) brown, setae 1, 2, 3, and 4 pale, appressed to labrum, about 1/3 length of dark, upright subequal setae 5 and 6. Labial mentum (Fig. 20) consisting of four distinct sclerites; lateral pair triangular, larger than oval, medial pair. Submental sclerites apparently absent. Mandible with scrapping apex. Anterior ventral apotome vase-shaped; widest portion midlength; about twice as long as wide; about 2/3rds length of ventral ecdysial suture. Posterior ventral apotome absent. All surfaces of head and labrum minutely pebbled, with faint spicules on parietal surface at 60× magnification. Muscle scars darker than surface membrane, few present anterior to setae 14, abundant on posterior, parietal surface. Thorax (Fig. 21) slightly lighter than head. Pronotum darker anteriorly; transversely furrowed in apical third; pebbled, without obvious spines or spicules; long macrosetae along anterior margin, with median pair longest, lengths decreasing to shortest at lateral margin; spaced nearly equidistant; setae 22 longest, setae 2 and 3 slightly

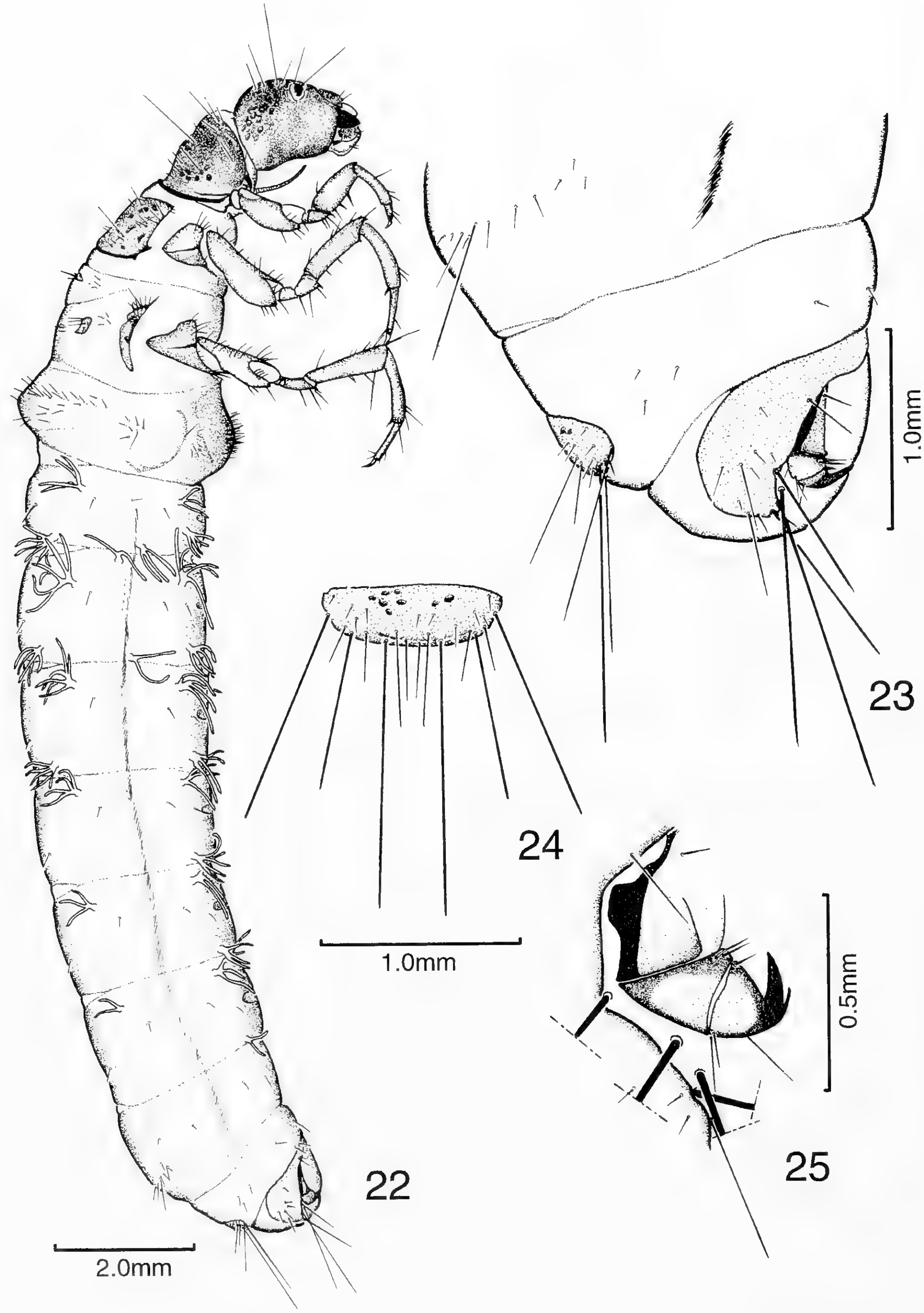


Figs. 14–16. *Crenophylax sperryi*, female genitalia. 14, Segments VIII–X, lateral. 15, Segments VIII–X, ventral. 16, Segments VIII–X, dorsal.

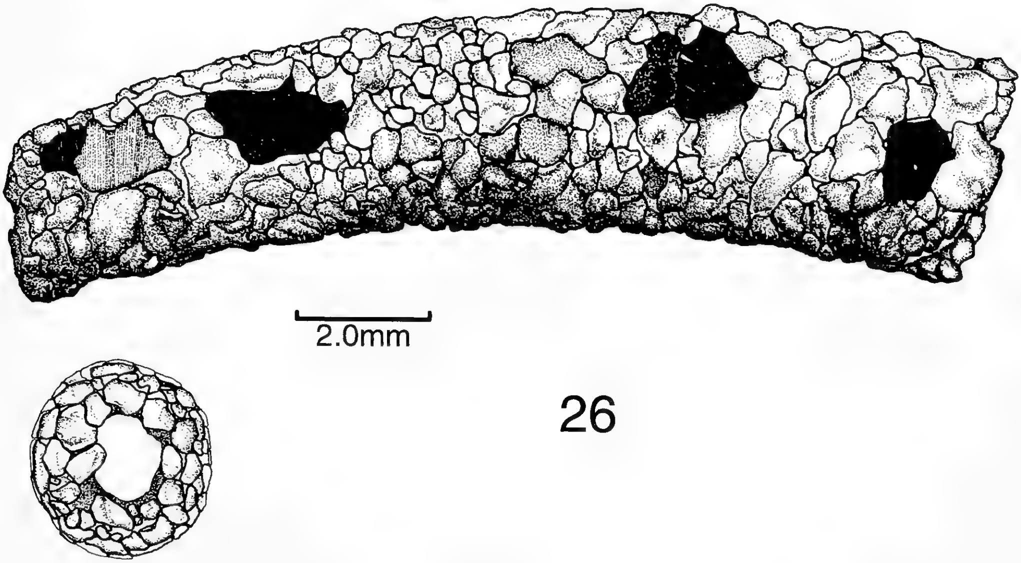
short than 22, all setae dark; muscle scars more obvious posteriorly. Prosternal horn present, about ½ length of coxae. Mesonotum with anterior margin slightly concave; brown, lighter than pronotum; each mesonotal plate slightly wider than long; hind margin black, with blacked area extending anterolaterally to midlength of sclerite; anterior 2/3 portion of mesonotum moderately depressed; muscle scars abundant on anterior half, few on posterior half; setal areas nearly separate. Metanotum with sal, sa2, and sa3 sclerotized; plate of sal linear, plate of sa2 oval. Mesonotal membrane with 10–20 setae around sa1 and sa2. Legs pale brown; trochanters without accessory setae, trochanteral brushes short; femora with only two major setae on ventral edge; profemur with the two major setae hyaline, thickened and flattened, relatively short, distal longer than proximal; mesofemur with hyaline setae located midlength, slightly longer, dark setae located near base of femur; metafemur with hyaline setae located midlength, longer, dark seta located about midway between hyaline setae and apex of femur; lateral surface of all femur without accessory setae; tibial spur count 2-2-2, all spurs hyaline; basal setae of tarsal claw hyaline, relatively stout, about ½ length of claw. Abdominal segment I with 60–80 setae dorsally, 8–10 setae dorsolaterally, 10–12 setae ventrolaterally, 70–90 setae ventrally. Gill arrangement (Fig. 22); most gills with more than 4 filaments; dorsal lateral gills only present at anterior location on segment III, 1 or 2 filaments;



Figs. 17–21. *Crenophylax sperryi*, larva. 17, Head, dorsal. 18, Head, lateral. 19, Labrum, dorsal. 20, Head, ventral. 21, Thorax, dorsal.



Figs. 22–25. *Crenophylax sperryi*, larva. 22, Lateral view. 23, Abdominal segments IX and X, lateral. 24, Dorsal sclerite of segment X, dorsal. 25, Anal proleg, ventrocaudal.

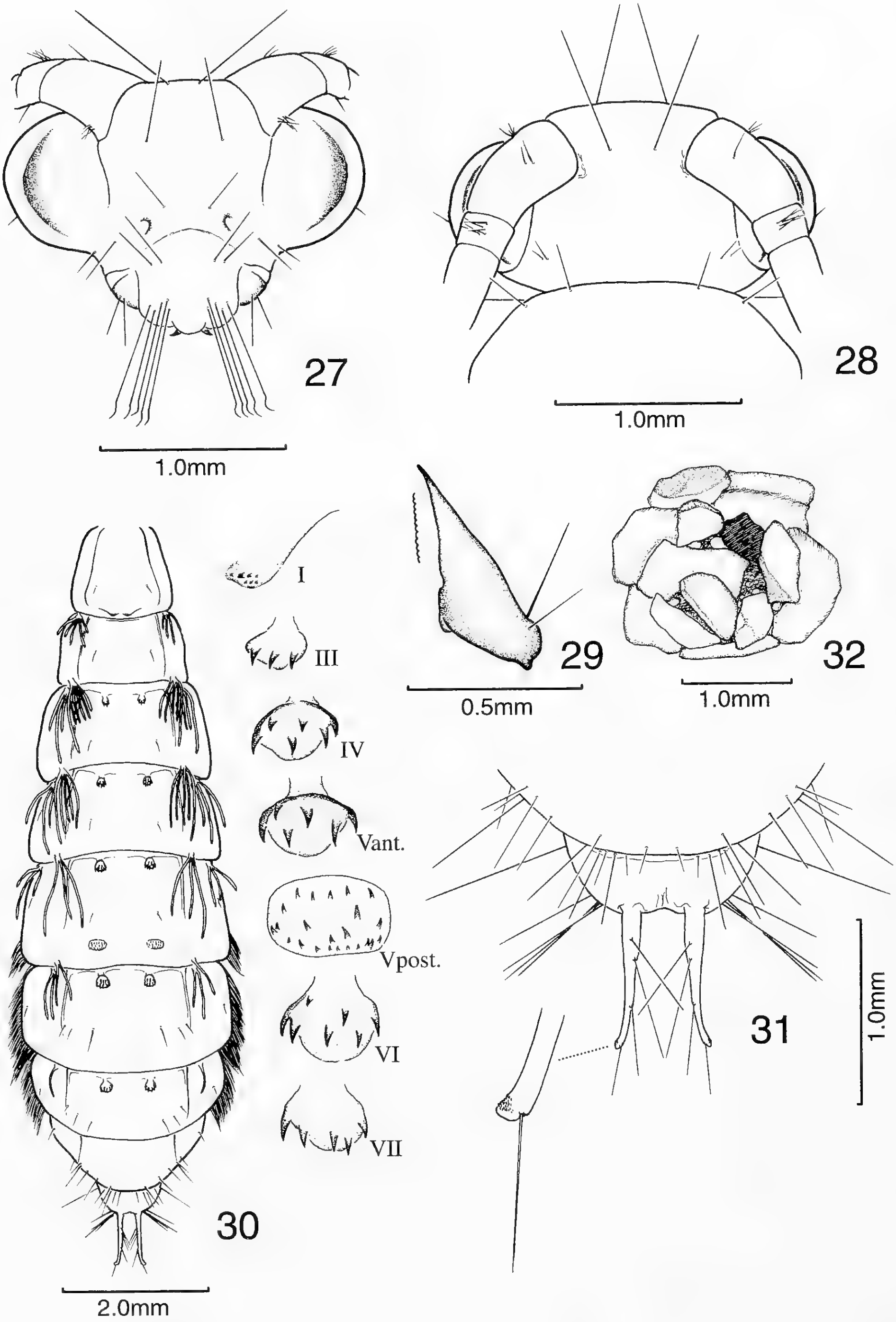


26

Fig. 26. *Crenophylax sperryi*, larval case, lateral and posterior end, caudal.

ventrolateral series only at posterior location of segments II–IV, usually 2 filaments; dorsal gills end on segment VII, ventral gills end on segment VII. Lateral fringe extends from II thru VIII. Forked lamella on II–VIII, 2–5 on segment II, 1–2 on segments III–VII, 4–6 on VIII. Chloride epithelia present ventrally on II–VII, wide and short. VIII segment dorsal setae black (Fig. 23), 16–20, two long, remainder relatively short. Dorsal plate of segment IX (Fig. 24) yellow, with one pair of very long setae mesally, another pair of relatively long setae laterally, and 16–20 additional short setae, all setae black, no spines present. IX with two pair setae ventrally, mesal pair shorter than lateral pair; dorsolateral setae of IX 1–5. Lateral sclerite of X (Fig. 23) with two long setae on dorsomesal edge in addition to several short setae; no spines present, all setae black. Anal claw (Fig. 25) with a short accessory dorsal hook, hook sometimes absent. Immature case constructed of irregular bark and leaves, slightly tapered posteriorly, slightly curved in lateral view, vegetation surface rough; case changed to mineral particles (Fig. 26) prior to pupation.

Pupa (Fig. 27–32).—Length 14–18 mm (N = 3). Head (Figs. 27,28) with three subequal pairs of short setae on face, one pair located mesally, one pair dorsal of base of mandibles, one pair located at eye margin near mandible; one pair slightly longer setae anterior of antennal bases; longest pair between antennal bases; two short setae posteromesal from each eye; all setae black; labrum with five pairs of long, black, apically hooked setae and one pair of short, hyaline setae; two pairs of black setae in area between head and labrum; antenna with tuft of minute setae near base of pedicel, and 1–2 setae about midlength; tuft of 5–6 setae on second segment, all setae black; mandible (Fig. 29) pointed apically, cutting edge with minute blunt serrations; two black setae at base. Pronotum (Fig. 28) with two pairs of black setae, separated by length of setae. Abdominal hook plates as in Fig. 30. Gills generally arranged as in larva, lateral fringe extending from



Figs. 27–32. *Crenophylax sperryi* pupa. 27, Head, frontal. 28, Head, dorsal. 29, Left mandible, ventral. 30, Abdomen, dorsal. 31, Abdominal segments IX and X, dorsal. 32, Posterior closure of pupal case, caudal.

posterior portion of segment posterior portion of V through VIII. Abdominal segment IX (Fig. 31) with four closely appressed setae ventroapically; a liplike slit ventromesally; 6–10 setae located meso- dorsolaterally; all setae black. Anal processes (Fig. 31) slender, longer than segment IX, each with three hyaline setae located dorsomesally; two closer to base, one near apical 1/3rd, all setae long, basal setae extending too, or beyond apex of process; one black setae at apex mesally, apices directed laterally with small spinules on outer surface. Pupal case consists of mineral particles, larger particles anteriorly; anterior and posterior openings closed by silken membrane with perforations (Fig. 32). Length of pupal case 17–20 mm (N = 3).

Material examined.—ARIZONA: Apache County, at light, Greer, White Mountains, E. & I. Munroe, 05 Aug 1962, 2♂ [CNC] ♂ [USNM]; light trap, West Fork Little Colorado River at Sheeps Crossing, Dean W. Blinn, 20 Jun 2001, ♂ [DWB]; light trap, Little Colorado River at Sheeps Crossing, 7 miles SW of Greer on 273, Dean W. Blinn, 02 Jul 2003, ♂ [DER]; light trap, Hall Creek on Highway 373 near Greer, Dean W. Blinn, 03 Jul 2003, ♂ [DER]; Greenlee County, at light, south tributary to Ackre Lake, D.E. Ruiter, 22 Jul 2001, 3♂ [DER], ♂ [USNM]; at light, north end of Ackre Lake, C.M. & O.S. Flint, Jr., 22 Jul 2001, 2♀ [USNM]; Light Trap, K.P. Cienega, 5.5. miles south of Hannagan Meadows on Highway 191, Dean W. Blinn, 02 Jul 2003, 5♀ [DER] 4♂3♀ [HN]; NM: Lincoln County, North Fork Rio Ruidoso, just upstream from Ski Apache Ski Area, D.E. Ruiter, 03 May 2003, 17 larvae 4 pupae [DER] 5 larvae 2 pupae [HN]; stream, at entrance to Ski Apache Ski Area, D.E. Ruiter, 16 Apr 2004, 38 larvae [DER] ; 6 larvae [HN].

DIAGNOSIS

Banks (1943) placed *sperryi* in *Radicoleptus* Wallengren, 1891, a small Palearctic genus of three species (Morse 2005). Banks (1916) had previously placed the North American species *Limnephilus fumosus*, (Banks 1900) and *Clistoronia* (*Clistoroniella*) *flavicollis* (Banks 1900) in *Radicoleptus* based primarily on the presence of ventral spines on the male last hind tarsal segment, lack of large macrochaetae behind/between lateral ocelli, 1-3-4 spur count, and long hind wing discoidal cell. Banks (1916) also placed *Radicoleptus* (and by inclusion *C. sperryi*) near *Hesperophylax*, and *Psychoronia*. Males of *L. fumosus* group, *C.* (*Clistoroniella*) *flavicollis*, *Hesperophylax* (Banks 1916), *Psychoronia* (Banks 1916), and *C. sperryi* all have the dorsal, sclerotized portion of the 9th tergite very reduced, with either a slightly sclerotized connection (*L. fumosus* group, *C.* (*Clistoroniella*)) or a widely separated, non-sclerotized 9th tergite (*Hesperophylax*, *Psychoronia*, *C. sperryi*). *Hesperophylax*, *Psychoronia*, and *C. sperryi* all have the male intermediate appendages variously fused dorsally. Ruiter (2000) also placed *Hesperophylax*, *Psychoronia*, *C. sperryi*, *Limnephilus fumosus* group, and *Clistoronia*, together based on venational characters. Eurasian *Radicoleptus* males have a very strongly sclerotized male 9th tergite, and many other characters different from *C. sperryi*, *Limnephilus fumosus* group and *Clistoronia* (*Clistoroniella*).

Based on an interesting combination of highly derived characters of the adults and larvae, *C. sperryi* belongs to a group very closely related with *Hesperophylax* and *Psychoronia*. Characters which appear to be apomorphic for the group include the brightly colored fore wings, widely separated male 9th tergites; male phallic paramere consisting of groups of strongly sclerotized, spiniform blades; male intermediate appendages fused dorsally above the anal opening; most larval gills with more than 4 branches, and larval gill branches originating from basal branches (see Parker and Wiggins 1985 (*Hesperophylax*), Ruiter 1995 (*C. sperryi*), Ruiter 1999 (*Psychoronia*), Wiggins 1996). The origin of the group appears to be in southern North America (Parker and Wiggins 1985).

The presence of the separate subanal plate in male *C. sperryi*, which has variously fused with intermediate appendages in *Hesperophylax* and *Psychoronia*, may indicate *C. sperryi* is the most primitive of the three genera. Parker and Wiggins (1985) interpreted the intermediate appendages of the sister genera *Hesperophylax* and *Psychoronia* as fused dorsally and connected ventrally by a "sclerotized bridge." We interpret the "sclerotized bridge" to be the subanal plate.

The numerously branched larval gills present an unusual limnephilid character which occurs in few other limnephilid genera. *Hesperophylax*, *Psychoronia*, and *C. sperryi* are all associated with extreme headwater/spring portions of streams which may reflect an increase in gill number to accommodate low dissolved oxygen levels. *Ironoquia* and *Lenarchus* also have numerous gill filaments, although of a slightly different structure consisting of relatively shorter, and more numerous filaments. Their habitats may also be expected to have low dissolved oxygen levels.

Male *Crenophylax* can be readily separated from *Hesperophylax* and *Psychoronia* by the presence of the distinct subanal plate resulting in the intermediate appendages not completely fused below the anus. Female *Crenophylax* have a very short, nearly separated mesally, 9th tergite, much shorter than that of either *Hesperophylax* or *Psychoronia*. *Crenophylax* and *Psychoronia* larvae have a pebbled pronotum, lacking the spicules of *Hesperophylax*, although *Crenophylax* has spicules on the head like *Hesperophylax*, which are absent in *Psychoronia*. *Crenophylax* pupa can be separated from *Hesperophylax and Psychoronia* by the presence of long basal setae on the anal processes, which are short, less than 0.5 length of anal process, in *Hesperophylax* and *Psychoronia*.

ACKNOWLEDGMENTS

We thank Dean Blinn and Oliver Flint, Jr., for providing material for this paper as well as being most enjoyable, and tolerant, collecting companions as the senior author insisted on wandering from spring to spring in the White Mountains. We are also very grateful to Trond Anderson for providing translation of Wallengren's (1918) *Radicoleptus* discussion. We also thank Stephen R. Moulton II and an anonymous reviewer for recommending necessary improvements.

LITERATURE CITED

Banks, N. 1900. New genera and species of Nearctic neuropteroid insects. Transactions American Entomological Society 26: 239–259.

———. 1916. A classification of our limnephilid caddice flies. Canadian Entomologist 48: 117–122.

———. 1943. Notes and descriptions of Nearctic Trichoptera. Bulletin of the Harvard University Museum Comparative Zoology 92: 341–369.

Flint, O. S., Jr. 1966. Notes on certain Nearctic Trichoptera in the Museum of Comparative Zoology. Proceedings of the United States National Museum 118(3530): 373–389.

Houghton, D. C. 2001. Caddisfly (Trichoptera) records from the Apache National Forest, eastern Arizona. Entomological News 112: 85–93.

Morse, J. C. ed. 2005, Trichoptera World Checklist. http://entweb.clemson.edu/database/trichopt/.

Parker, C. R. and G. B. Wiggins. 1985. The Nearctic caddisfly genus *Hesperophylax* Banks (Trichoptera: Limnephilidae). Canadian Journal of Zoology 63: 2443–2472.

Ross, H. H. 1944. The caddis flies or Trichoptera of Illinois. Bulletin of the Illinois Natural History Survey 23(1): 1–326.

Ross, H. H. and D. R. Merkley. 1952. An annotated key to the Nearctic males of *Limnephilus* (Trichoptera, Limnephilidae). American Midland Naturalist 47(2): 435–455.

Ruiter, D. E. 1995. The adult *Limnephilus* Leach (Trichoptera: Limnephilidae) of the New World. Bulletin of the Ohio Biological Survey, New Series, Volume 11, Number 1.

———. 1999. A new species and new synonym in the genus *Psychoronia* (Limnephilidae), with significant records for caddisflies (Trichoptera) from Western North American. Great Basin Naturalist 59(2): 160–168.

———. 2000. Generic key to the adult ocellate Limnephiloidea of the Western Hemisphere (Insecta: Trichoptera). Ohio Biological Survey, Miscellaneous Contributions Number 5, 22 pp.

Schmid, F. 1955. Contribution à l'étude des Limnophilidae (Trichoptera). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 28: 1–245.

Wallengren, H. D. J. 1891. Skandinaviens Neuroptera. Andra afdelningen. Svenska Akademien Handlingar 24(10): 173 pp.

Weaver, J. S. III. 1993. The Trichoptera of the Museum of Comparative Zoology, Harvard University. Braueria 20: 33–50.

Wiggins, G. B. 1975. Contributions to the systematics of the caddisfly family Limnephilidae (Trichoptera). II. Canadian Entomologist 107: 325–336.

———. 1996. Larvae of the North American Caddisfly Genera (Trichoptera). 2nd Edition. University of Toronto Press, 457 pp.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 324–330

A NEWLY DISCOVERED BRAZILIAN SPECIES OF THE STILT BUG GENUS *JALYSUS* (HEMIPTERA: HETEROPTERA: BERYTIDAE) ASSOCIATED WITH MYRMECOPHYTIC PLANTS

THOMAS J. HENRY

Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, P. O. Box 37012, MRC 168, Washington, DC 20013-7012, U.S.A. (e-mail: thomas.henry@ars.usda.gov)

Abstract.—The newly discovered stilt bug ***Jalysus ossesae***, the smallest known species of the genus, is described from specimens collected near Manaus, Amazonas, Brazil, on two myrmecophytic species of the genus *Maeita* (Melastomataceae) associated with two species of ants (Formicidae). A diagnosis, description, photographs of the adult male, scanning electron photomicrographs of selected structures, and illustrations of male genitalia are provided to facilitate recognition. A discussion of the relationship with certain species of the genus is given.

Key Words: Hemiptera, Heteroptera, Berytidae, stilt bug, *Jalysus*, new species, distribution, hosts, *Maeita*

The genus *Jalysus* Stål is a relatively large group of New World stilt bugs, containing 11 species (Henry and Froeschner 1998). Henry (1997b) revised the genus and described four new Neotropical species. *Jalysus* is characterized by the overall yellowish-brown coloration; elongate, slender body; long, slender, legs often brown spotted or banded, with each leg having a combined length of the femur and tibia longer than the body; the unique ostiolar process ending in a distally acute or pointed spine; and the shape of the male parameres. Members of the genus range in length from about 6.00 mm to nearly 10.00 mm (Henry 1997a).

Most stilt bugs prefer glandular-hairy or viscid plants, particularly in the families Geraniaceae, Lamiaceae, Malvaceae, Onagraceae, Scophulariaceae, and Solanaceae (Henry 1997b, 2000), but a few, such as *Gampsocoris decorus* (Uhler), *Jalysus spinosus* (Say), and *Metacanthus tenellus* Stål, specialize in certain, usually pubescent grasses (Wheeler and Henry 1981, 2006). The widespread North American *Jalysus wickhami* Van Duzee has been considered an important predator of hornworm eggs on tobacco (Elsey and Stinner 1971), although occasionally it may become a pest of certain crops, such as tomato, causing serious injury to the fruits (Wheeler and Henry 1981; Henry 2000). Henry (1997b) listed the hosts for species of *Jalysus*, and Henry and Froeschner (1998) summarized the known host plants for the Berytidae of the world. Henry (2000) reviewed their economic importance, emphasizing that many stilt bugs, including *J. wickhami*, have strong predatory tendencies.

In this paper, I describe the newly discovered stilt bug *J. ossesae* from

Manaus, Amazonas, Brazil, to provide a name for Francini Osses and her colleagues, Eduardo Martins and Gustavo Romero, who have studied its habits in association with two species of the plant genus *Maeita* (Melastomataceae). These plants possess domatia or specialized leaf pouches in which two species of symbiotic ants (Formicidae) nest. Provided for *J. ossesae* are a diagnosis, description, illustrations of male genitalia, photographs of the adult male, scanning electron photomicrographs of selected structures, and a discussion of the relationship with certain other species of the genus.

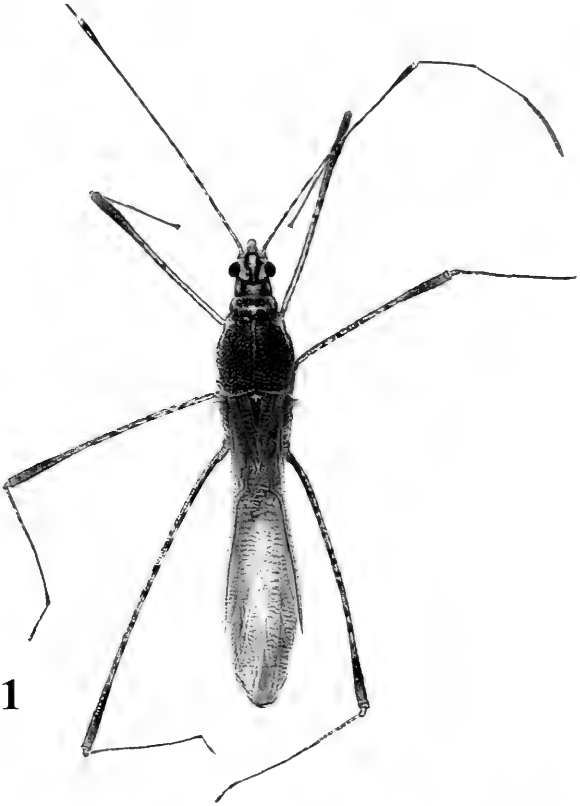
The following acronyms are used for institutions cited in this paper: INPA (Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil); MHNC (Museu de História Natural, Instituto de Biologia, Universidade Estadual de Campinas, Brazil); USNM (National Museum of Natural History, Smithsonian Institution, Washington, DC, USA).

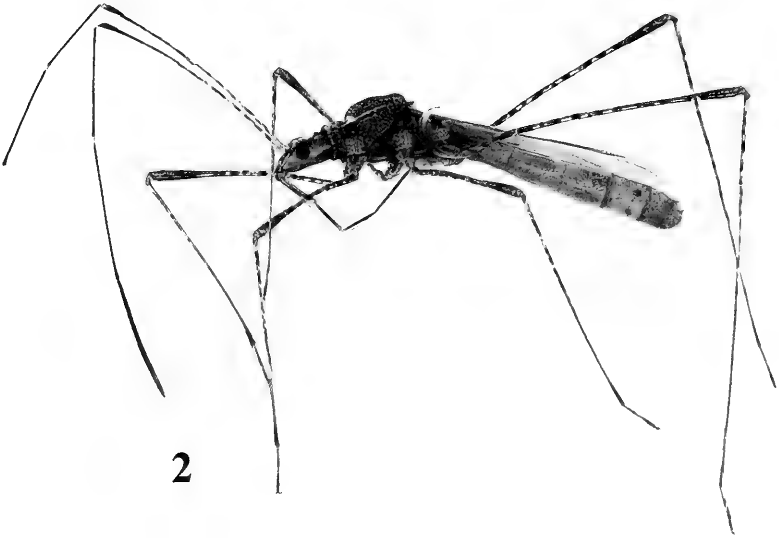
Jalysus ossesae Henry, new species

(Figs. 1–8, 13, 14)

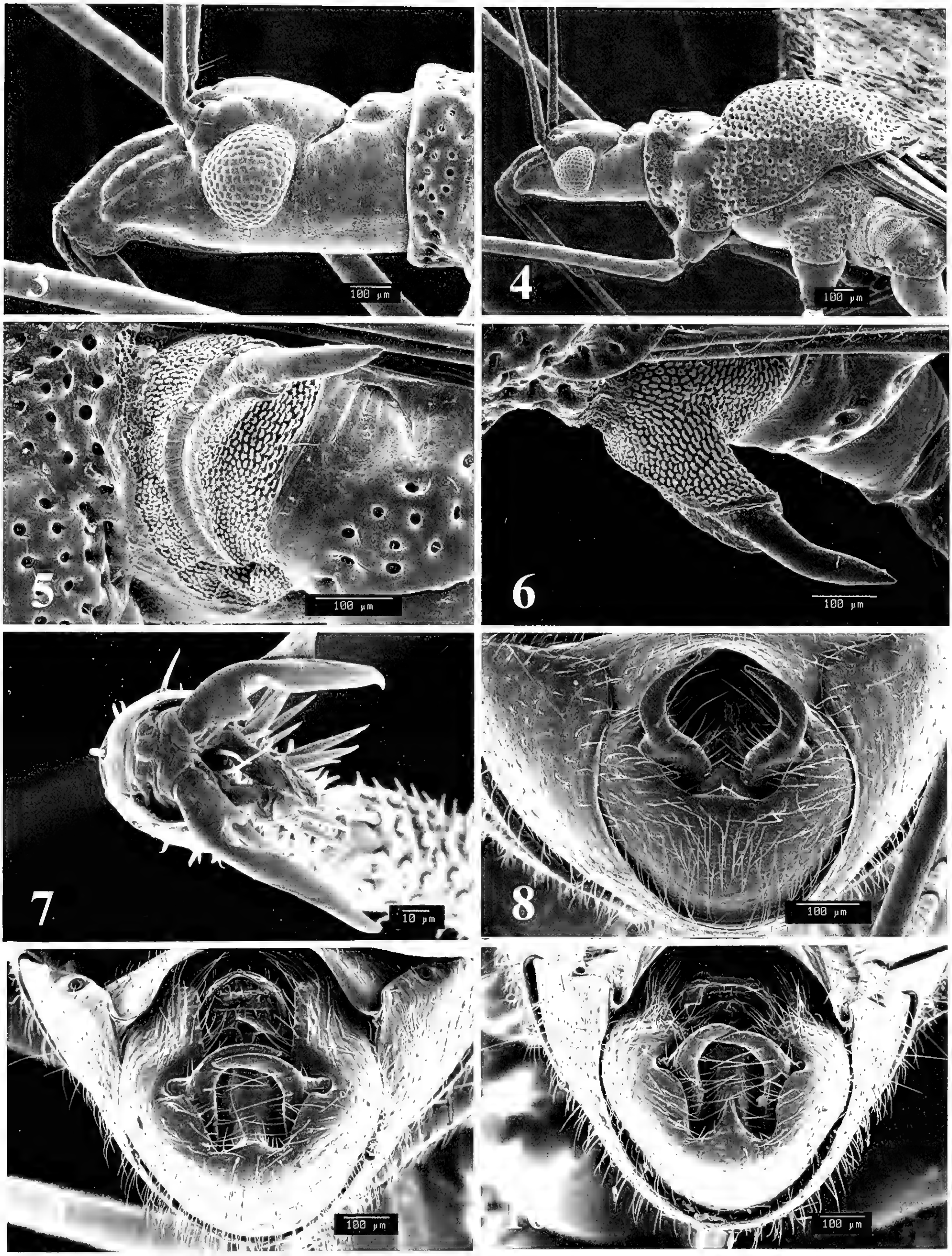
Diagnosis.—*Jalysus ossesae* is distinguished from all other species of *Jalysus* by a combination of the small size (less than 6.00 mm long); the impunctate head (Fig. 3); strongly spotted femora, spots sometimes coalescing to form bands (Figs. 1, 2); long, slender antennal segment IV that is longer than segment II; the very short scutellar spine (Figs. 2, 4); the pale apex of the ostiolar spine; and the shape of the male genital capsule (Fig. 8) and paramere (Fig. 13).

Description.—Male (n=10; holotype measurements in parentheses): Length (from apex of clypeus to apex of hemelytral membrane) 5.38–5.76 mm (5.50 mm); width (across widest area of hemelytra) 0.99 mm (0.99 mm). *Head* (Figs. 3, 4): Length 0.83–0.90 mm (0.85 mm); width across eyes 0.54–0.59 mm (0.58 mm); width of vertex 0.32–0.35 mm (0.32 mm); shiny, impunctate throughout, pale yellowish brown accented with dark brown around base, behind eyes, and on either side of dorsal median line, frons evenly rounded, eyes and ocelli reddish. *Labium:* Length 2.40–2.53 mm (2.43 mm), extending beyond metacoxae to second abdominal segment. *Antenna:* Segment I, length 3.36–3.68 mm (3.68 mm), yellowish brown with 10–12 irregular somewhat broad dark brown bands, swollen apex dark brown; II, 1.44–1.60 mm (1.60 mm), dark brown, base and apex narrowly pale; III, 1.72–1.88 mm (1.88 mm), dark brown to fuscous, base narrowly pale; IV, 1.60–1.68 mm (1.64 mm), uniformly dark brown to fuscous, at most, slightly paler on distal 1/6. *Pronotum* (Figs. 1, 2, 4): Length 1.03–1.16 mm (1.16 mm); basal width 0.74–0.78 mm (0.78 mm); anterior lobe shiny, brown to yellowish brown, calloused anterior angles and transverse ridge pale yellow; posterior lobe dull yellowish brown, calloused anterior angles (at base of anterior lobe) pale yellow, lateral carina yellow, fading on posterior 1/3. *Scutellum* (Fig. 4): Yellowish brown, armed with only a short, stout spine, length about 0.10–0.11 mm (0.11 mm). *Hemelytron:* Shiny yellowish brown; membrane hyaline. *Ventral surface:* Yellowish brown. *Ostiolar evaporative area* (Figs. 5, 6): Uniformly pale yellowish brown, including apical spine. *Legs:* Yellowish brown; femora heavily spotted with small to large dark brown spots, some coalescing to form incomplete bands; tibiae with narrow, sometimes indistinct, dark brown bands, often fading distally, weakly clavate apices dark brown; tarsomeres I and II yellowish brown, last tarsomere and claw dark brown. *Femora:* Length pro- 2.28–2.48 mm (2.44 mm); meso- 2.60–2.80 mm (2.80 mm); meta- 3.44–3.76 mm (3.72 mm). *Tibiae:* Length pro- 2.64–2.80 mm (2.76 mm); meso-

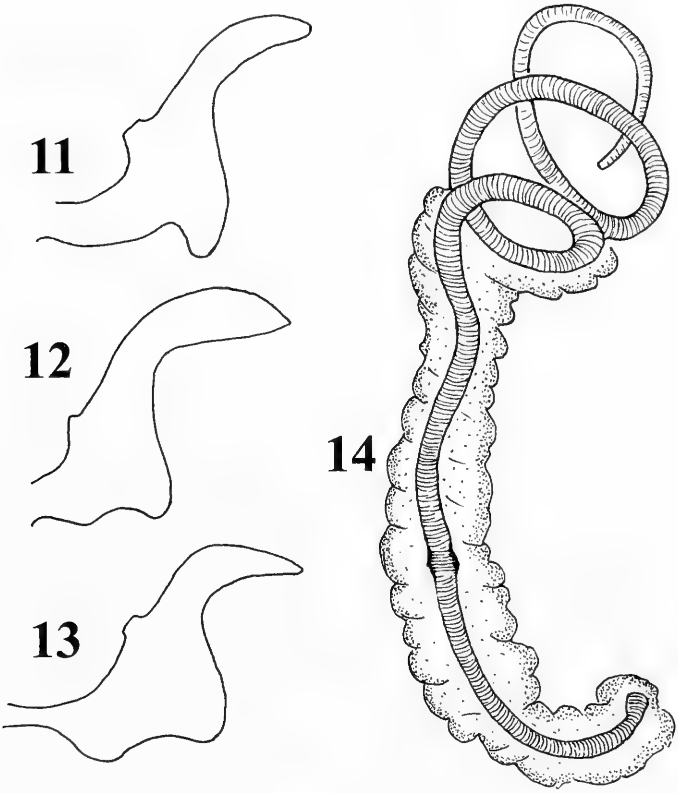

1


2

Figs. 1–2. Photographs of *Jalysus ossesae*, male. 1, Dorsal aspect. 2, Lateral aspect.



Figs. 3–10. Photomicrographs of *Jalysus* spp. 3–8, *Jalysus ossesae*. 3, Head (118×), lateral aspect. 4, Head and pronotum (51.5×), lateral aspect. 5, Ostiolar evaporative area (200×), lateral aspect. 6, Ostiolar evaporative area (117×), dorsal aspect. 7, Claw (695×). 8, Male genital capsule (165×), caudal aspect. 9, *Jalysus albidus*, male genital capsule (120×), caudal aspect. 10, *J. sobrinus*, male genital capsule (118×), caudal aspect.



Figs. 11–14. Male genitalia of *Jalysus* spp. 11–13, Male parameres of *Jalysus* spp. 11, *J. albidus*. 12, *J. sobrinus*. 13, *J. ossesae*. 14, Aedeagus of *J. ossesae*.

3.00–3.20 mm (3.12 mm); meta- 4.80–5.35 mm (5.35 mm).

Genitalia: Capsule (Fig. 8): Oval, basal edge between bilaterally symmetrical parameres with a short pointed process. Paramere (Fig. 13) with a sickle-shape apex and broad, quadrate basal trunk. Aedeagus (Fig. 14) simple, mostly membranous, ductis seminis elongate, with three coils distally and a small scleritized area at middle.

Female (n=6): Length 5.38–5.76 mm; 0.98–1.02 mm. *Head:* Length 0.82–0.88 mm; width across eyes 0.53–0.58 mm; width of vertex 0.32–0.34 mm. *Labium:* Length 2.40–2.50 mm, extending to abdominal segment II. *Antenna:* Segment I, length 3.10–3.42 mm; II, 1.44–1.54 mm; III, 1.72–1.86 mm; IV, 1.60–1.62 mm. *Pronotum:* Length 1.09–1.18 mm; basal width 0.69–0.77 mm. *Legs: Femora:* Length pro- 2.21–2.46 mm; meso- 2.56–2.72 mm; meta- 4.16–5.15 mm. *Tibiae:* Length pro- 2.56–2.69 mm; meso- 2.91–3.10 mm; meta- 4.16–5.15 mm.

Etymology.—I am pleased to name this new species after Francini Osses, one of the discoverers who has made observations on its biology and habits, along with her colleagues Eduardo Martins and Gustavo Romero.

Hosts.—All specimens of *J. ossesae* were taken on the myrmecophytic *Maeita guianensis* Aubl. or *M. poeppigii* Mart. ex Triana (Melastomataceae). See companion article by Osses, Martins, and Romero (2007) describing the association of this stilt bug with these plants and their symbiotic ant species.

Distribution.—Known only from one locality near Manaus, Amazonas, Brazil.

Discussion.—*Jalysus ossesae* runs in my key (Henry 1997b) to *J. clavatus* (couplet 3) based on the impunctate head, spotted legs, and uniformly black fourth antennal segment, or to *J. albidus* and *J. sobrinus* (couplet 4) if the fourth antennal segment is considerd pale apically. All four species share an impunctate head, banded first antennal segments, spotted legs, and similar-shaped genital capsules (Figs. 8–10) and parameres (Figs. 11–13). The pale spined apex of the ostiolar process, the small size, and the long, slender, uniformly dark (i.e., apex not distinctly white on apical 1/3 to 1/6) fourth antennal segment, however, distinguish *J. ossesae* from these species.

Jalysus ossesae is further distinguished from *J. clavatus* by the smaller size (5.38–5.76 mm versus 7.83–8.33 mm); the smoothly rounded frons (versus strongly angulate in *J. clavatus*); the more slender, weakly clavate femora; the more slender and longer antennal segment IV that is longer than segment II; and the shape of the parameres. From *J. albidus* and *J. sobrinus*, it differs by the smaller size, the uniformly dark (with only the apex slightly more pale versus distal 1/2 to 1/3 white in *J. albidus* and *J. sobrinus*), more slender, and longer antennal segment IV (much longer than segment II versus clearly shorter than segment II in *J. albidus* and *J. sobrinus*); the much shorter scutellar spine (Fig. 4) that does not attain the level of the pronotal disc; and the weakly raised basal ridge (Fig. 8) of the male genital capsule (similar to *J. albidus*, fig. 9, versus sharply raised in *J. sobrinus*, fig. 10); and shape of the parameres (Figs. 11–13).

Type specimens.—Holotype ♂, Brazil: Amazonas, PDBFF [Projeto Dinâmica Biológica de Fragmentos Florestais] Reserva 1501, "Reserva Florestal do Km 41" [ca. 70 km north of Manaus], mont. cont. [old growth forest], 2°26.724′S, 59°45.973′W, 4–7. XI. 2005, Coletada em mirmecófita, T. J. Izzo coll. (INPA). Paratypes: 13 ♂♂, 6 ♀♀, same data as for holotype (INPA, MHNC, USNM).

ACKNOWLEDGMENTS

I am grateful to Francini Osses (MNHC) and Thiago Izzo (INPA) for lending specimens of *J. ossesae* for study, and Michele Touchet (Systematic Entomology Laboratory [SEL], ARS, USDA, c/o USNM) for the dorsal and lateral photographs. Julieta Brambila (USDA-APHIS-PPQ, CAPS Program, Gainesville, FL), Mathew Buffington (SEL), Michael G. Pogue (SEL), and A. G. Wheeler, Jr. (Clemson University, Clemson, SC) kindly reviewed the manuscript.

LITERATURE CITED

Elsey, K. D. and R. E. Stinner. 1971. Biology of *Jalysus spinosus*, an insect predator found on tobacco. Annals of the Entomological Society of America 64: 779–783.

Henry, T. J. 1997a. Cladistic analysis and revision of the stilt bug genera of the world (Heteroptera). Contributions of the American Entomological Institute 30(1): 1–100.

———. 1997b. Monograph of the stilt bugs, or Berytidae (Heteroptera), of the Western Hemisphere. Memoirs of the Entomological Society of Washington No. 19, 149 pp.

———. 2000. Chapter 31. Stilt bugs (Berytidae), pp. 725–735. *In* Schaefer, C. W. and Panizzi, A. R., eds. Heteroptera of Economic Importance. CRC Press, Boca Raton, Florida. 828 pp.

Henry, T. J. and R. C. Froeschner. 1998. Catalog of the stilt bugs, or Berytidae, of the world (Insecta: Hemiptera: Heteroptera). Contributions of the American Entomological Institute 50(4): 1–72.

Osses, F., E. G. Martins, and G. Q. Romero. 2007. Association of the stilt bug *Jalysus ossesae* Henry (Hemiptera: Heteroptera: Berytidae) with myrmecophytic plants of the genus *Maieta* (Melastomataceae) in an upland forest area in central Amazon, Brazil. Proceedings of the Entomological Society of Washington 109: 331–337.

Wheeler, A. G., Jr. and T. J. Henry. 1981. *Jalysus spinosus* and *J. wickhami* (Hemiptera: Berytidae): Taxonomic clarification, review of host plants and distribution, and keys to adults and fifth instars. Annals of the Entomological Society of America 74: 606–615.

———. 2006. *Gampscoris decorus* (Uhler) and *Metacanthus tenellus* Stål (Hemiptera: Berytidae): Neotropical stilts bugs as colonists of an African grass, *Urochloa mutica* (Poaceae), in Florida, with a review of berytid-grass associations. Proceedings of the Entomological Society of Washington 108: 1–8.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 331–337

ASSOCIATION OF THE STILT BUG *JALYSUS OSSESAE* HENRY (HEMIPTERA: HETEROPTERA: BERYTIDAE) WITH MYRMECOPHYTIC PLANTS OF THE GENUS *MAIETA* (MELASTOMATACEAE) IN AN UPLAND FOREST AREA IN CENTRAL AMAZON, BRAZIL

Francini Osses, Eduardo G. Martins, and Gustavo Q. Romero

(FO) Programa de Pós-graduação em Ecologia e Conservação de Recursos Naturais, Universidade Federal de Uberlândia, 38400-902, Uberlândia, MG, Brazil (e-mail: franosses@gmail.com); (EGM) Programa de Pós-graduação em Ecologia, Universidade Estadual de Campinas, 13083-970, Campinas, SP, Brazil (e-mail: egmartins@gmail.com); (GQR) Departamento de Zoologia e Botânica, IBILCE, Universidade Estadual Paulista, Rua Cristóvão Colombo, 2265, 15054-000, São José do Rio Preto, SP, Brazil (e-mail: gq_romero@yahoo.com.br)

Abstract.—*Maieta guianensis* Aubl. and *M. poeppigii* Mart. ex. Triana (Melastomataceae) are among the most common myrmecophytic plants in the Amazonian forest understory. These myrmecophytes are colonized exclusively by the ants *Pheidole minutula* Mayr or *Crematogaster* sp. and usually host two other arthropods, the spider *Faiditus subflavus* Exline and Levi and the recently described stilt bug *Jalysus ossesae* Henry. In this study, the association between *J. ossesae* and the myrmecophytic plants *M. guianensis* and *M. poeppigii* in an upland forest area in central Amazon, Brazil, is described. The presence of the stilt bugs on *M. guianensis* and *M. poeppigii* and on plants around these myrmecophytes was recorded in five transects. The number and position of the stilt bugs on the leaf surface (upper or lower) and leaf type (with or without domatia) of these myrmecophytes, as well as their behavioral acts, were recorded. *Jalysus ossesae* was found only on the myrmecophytic plants *M. guianensis* and *M. poeppigii*. The stilt bug occurred at similar frequencies on *M. guianensis* and *M. poeppigii*, and the number of leaves significantly influenced the presence and number of stilt bugs on these myrmecophytes. Feeding, agonistic interaction between males, and mating were observed. Our data indicate that *J. ossesae* uses the myrmecophytes *M. guinanensis* and *M. poeppigii* as reproductive and foraging sites.

Key Words: Hemiptera, animal-plant interaction, host plants, *Maieta guianensis*, *Maieta poeppigii*, trichomes, ant-plants

Myrmecophytes are tropical plants that have specialized structures known as domatia (e.g., hollow stems, leaf pouches, swollen petioles) where ants nest (Beattie 1985; Benson 1985; Davidson and McKey 1993a, b; Heil and McKey 2003). Traditionally, studies on myrmecophytic plants have focused on their mutualistic association with ants and, therefore, have been of paramount importance for our understanding of ant-myrmecophyte mutualisms and mutualistic associations in general (Bronstein 1998). However, myrmecophytes are frequently inhabited by other arthropods (Fowler and Venticinque 1996, Gastreich 1999), and studies have suggested that a better description of ant-myrmecophyte mutualisms should consider the influence of other animals associated with myrmecophytic plants (Price et al. 1986, Jolivet 1991, Letourneau and Dyer 1998, Gastreich 1999).

Myrmecophytic plants are a conspicuous element of central Amazonian forests, where about 16 species are found at relatively high densities (Fonseca and Ganade 1996). Of the many myrmecophytic species studied, *Maieta guianensis* Aubl. and *M. poeppigii* Mart. ex. Triana (Melastomataceae) are among the most common in the Amazonian forest understory (Benson 1985; Vasconcelos 1991, 1993; Christianini and Machado 2004). These myrmecophytes have pubescent (high trichome density on upper leaf surfaces; F. Osses, personal observation), opposite and dimorphic leaves, with the larger leaf of each pair bearing domatia–leaf pouches–inside which ants nest (Vasconcelos 1991, Ribeiro et al. 1999). Both *M. guianensis* and *M. poeppigii* are colonized exclusively by the ants *Pheidole minutula* Mayr or *Crematogaster* sp. (Vasconcelos 1991, 1993; Lapola et al. 2003; Christianini and Machado 2004). Two other arthropods typically are found associated with these plants, namely, the spider *Faiditus subflavus* Exline and Levi (Theridiidae) (Fowler and Venticinque 1996) and the recently discovered stilt bug *Jalysus ossesae* Henry (Berytidae; Henry 2007).

In this study, we describe the association between *J. ossesae* and the myrmecophytic plants *M. guianensis* and *M. poeppigii* in an upland forest of the central Amazon, Brazil. The main questions we address are: 1) Are the stilt bugs strictly associated with *M. guianensis* and *M. poeppigii*? 2) What is the relationship of the stilt bug to these myrmecophytes? 3) What is the relationship of the stilt bug to the ants associated with *M. guianensis* and *M. poeppigii*?

MATERIALS AND METHODS

Study area.—This study was conducted in July 2004 at the Reserva Florestal do Km 41 (2°24′S, 59°44′W), an area of "terra firme" (upland forest) belonging to the Biological Dynamics of Forest Fragments Project (BDFFP), ca. 70 km north of Manaus, central Amazon, Brazil. The altitude of the area ranges between 100 and 150 m and the average total rainfall is 2186 mm. See Lovejoy and Bierregard (1990) for details of the study area.

Data collection.—To verify whether *J. ossesae* is strictly associated with *M. guianensis* and *M. poeppigii* plants, we surveyed four 5 × 100 m transects to inspect 61 myrmecophytes (39 individuals of *M. guianensis* and 22 of *M. poeppigii*) and each herbaceous plant or shrub within 1 m from each myrmecophyte ($n = 244$). We also inspected another common pubescent myrmecophytic species in the study area, *Hirtella myrmecophila* (Chrysobalanaceae) ($n = 30$). We inspected *H. myrmecophila* on four other transects because this plant was absent on transects used to inspect the *Maieta* plants.

For each of the 61 individuals of *Maieta*, we recorded the number of leaves. We also recorded the presence/absence and counted the number of *J. ossesae* on each myrmecophyte in the morning (0800–1100), afternoon (1400–1700), and at night (1900–2200) for two consecutive days. In addition, we recorded the position of the stilt bugs on the leaf surface (upper or lower) and the leaf type (domatia present or absent). All behavioral acts of the stilt bugs were observed and recorded.

Statistical analyses.—To compare the frequency of occurrence of *J. ossesae* between *M. guianensis* and *M. poeppigii*, we used the chi-square test. Logistic

Table 1. Mean (± 1 SD) number of stilt bugs, *Jalysus ossesae*, found on the myrmecophytes *Maieta guianensis* and *M. poeppigii*. Means shown for each period are averages of the total number of stilt bugs found on each myrmecophyte in two days. Means shown for each leaf type and leaf surface are averages of the total number of stilt bugs found on each myrmecophyte across all the periods of the day for two days.

	Period			Leaf surface		Leaf type	
Myrmecophyte	Morning	Afternoon	Night	Upper	Lower	With domatia	Without domatia
M. guianensis	10.0 ± 1.4	6.0 ± 0.0	8.0 ± 1.4	8.7 ±0.3	1.7 ± 0.5	8.0 ± 1.8	1.0 ± 1.0
M. poeppigii	3.0 ± 0.0	4.5 ± 0.7	4.5 ± 0.7	4.2 ± 1.2	0.3 ± 0.5	4.0 ± 0.9	0.5 ± 0.5

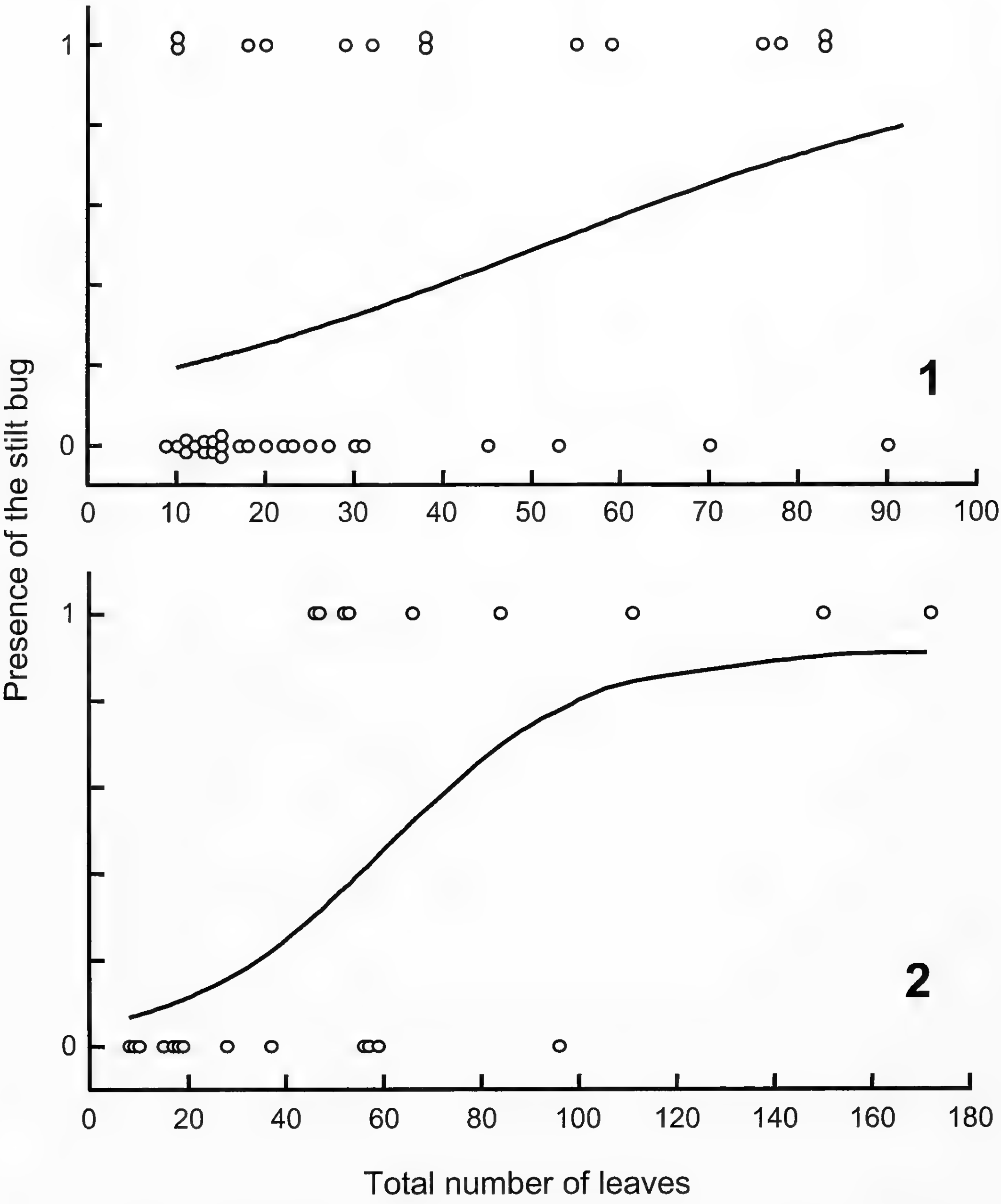
regressions were used to evaluate the influence of the number of leaves on the presence of the stilt bugs, and simple linear regressions were used to evaluate the relation between the number of leaves on the plants and the mean number of stilt bugs on each plant across all the periods of the day for two days.

RESULTS

Jalysus ossesae was found only on the myrmecophytic plants *M. guianensis* and *M. poeppigii*. Stilt bugs were recorded on 14 and 11 individuals of *M. guianensis* and *M. poeppigii*, respectively. These frequencies of occurrence of stilt bugs on the myrmecophytes were not significantly different between the two plants ($\chi^2 = 1.11$; df = 1; $P = 0.29$). The mean number of stilt bugs found on *M. guianensis* and *M. poeppigii* was nearly constant throughout periods of the day (Table 1). On both *M. guianensis* and *M. poeppigii*, the mean number of stilt bugs on the upper surface of leaves tended to be greater than that on the lower surface (Table 1). The mean number of stilt bugs on leaves with domatia also tended to be greater than that on leaves without domatia (Table 1). However, since the leaves bearing domatia of *M. guianensis* and *M. poeppigii* are 7–10 fold larger than those without domatia (mean surface area in mm^2 ± 1 SD; *M. guianensis*: domatia present: 5200.5 ± 359.1; domatia absent: 554.2 ± 69.3; *M. poeppigii*: domatia present: 7438.6 ± 1219.4; domatia absent: 1132.9 ± 384.3; *t*-test: $t = 4.9$, $P < 0.001$), there is no strong support for the tendency of the stilt bugs to occur more frequently on leaves with domatia.

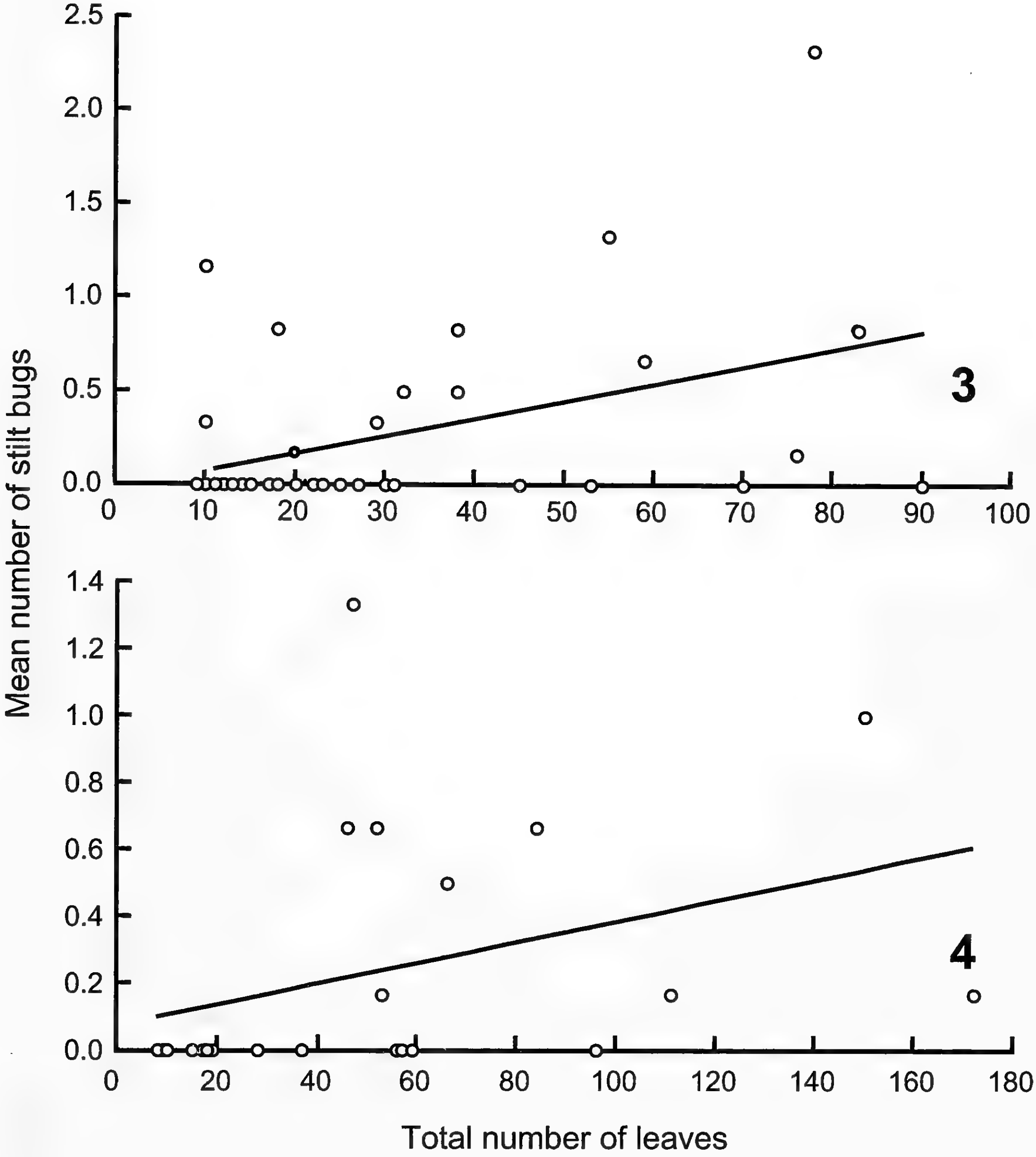
The presence of stilt bugs on the myrmecophytes was significantly influenced by the number of leaves on both *M. guianensis* (logistic regression: $\chi^2 = 6.14$, df = 1, $P = 0.01$, $n = 39$, Fig. 1) and *M. poeppigii* (logistic regression: $\chi^2 = 10.07$, df = 1, $P < 0.01$, $n = 22$, Fig. 2). In general, *M. guianensis* and *M. poeppigii* with fewer leaves had no stilt bugs, whereas the probability of finding a stilt bug on plants with about 95 leaves increased to about 80% (Figs. 1–2). The mean number of stilt bugs on these plants ranged from 0 to 2.3 and from 0 to 1.3 in *M. guianensis* and *M. poeppigii*, respectively, and was positively related to the number of leaves in *M. guianensis* ($r^2 = 0.20$, $F_{1,37} = 9.16$, $P < 0.01$, $n = 39$, Fig. 3) and not related to the number of leaves in *M. poeppigii* ($r^2 = 0.13$, $F_{1,20} = 2.93$, $P = 0.10$, $n = 22$, Fig. 4).

We observed three mating events, all of them in the morning. In all events, the male held the female with its hind legs, positioned the end of its abdomen below that of the female and introduced its copulatory organ. Two feeding events also were observed, one in the morning and one in the afternoon. In both cases, *J. ossesae* was found on leaves with domatia, but one individual was on the upper surface of the leaf and the other on the lower surface. Food items could not be determined because feeding was not observed from the beginning and, when



Figs. 1–2. Relationships between the total number of leaves and the presence/absence of the stilt bug *Jalysus ossesae* on myrmecophytes. 1, *Maieta guianensis*. 2, *Maieta poeppigii*. The presence and absence of stilt bugs are indicated as 1 and 0 on the *y* axis, respectively. Dots are displaced vertically to avoid overlapping.

it was discovered, the food items were too small to be identified. Only one agonistic interaction between two males was observed. In the afternoon, one male moved to a leaf where another male was present. When the intruder reached the middle of the leaf, the resident placed itself in front of the intruder until it was



Figs. 3–4. Relationships between the total number of leaves and the mean number of stilt bugs, *Jalysus ossesae*, found on myrmecophytes. 3, *Maieta guianensis*. 4, *Maieta poeppiggii*.

displaced from the leaf. The agonistic interaction lasted three minutes.

Discussion

We observed *J. ossesae* feeding only on *M. guinanensis* and *M. poeppigii*, suggesting that it is using *Maieta* spp. as a food source. The trichomes in these myrmecophylous plants are apparently important in helping segregate *J. ossesae* from ants; thus, avoiding contact between them and preventing ants from detecting the stilt bugs. Additionally, *J. ossesae* uses these plants as reproductive sites. Other species of *Jalysus* also use pubescent plants as breeding hosts (Wheeler and Henry 1981, Wheeler and Schaefer 1982). In addition to our observations on mating and agonistic interactions between males, we observed fourth- and fifth-instar nymphs, providing further evidence that *J. ossesae* uses *M. guinanensis* and *M. poeppigii* as its main host plants in the study area.

Although species of *Jalysus* feed on sap and reproductive parts of their host plants, they also may require some animal food source for proper development and fecundity (Elsey and Stinner 1971). Because other species of *Jalysus* feed on arthropods associated with their host plants (Elsey and Stinner 1971, Gilmore 1938, Kulash 1949, Wheeler and Henry 1981, Henry 2000), *J. ossesae* might scavenge on prey captured by the ants or even occasionally prey on ants that are, perhaps, injured or dying. Thus, the association between *J. ossesae* and *M. guinanensis* and *M. poeppigii* is likely affected by the presence of ants on these plants.

The above contention is supported by our results showing that the probability of occurrence and the number of stilt bugs on *M. guinanensis* and *M. poeppigii* increases with increasing number of leaves because the number of ants is greater on plants with large numbers of leaves bearing domatia (Christianini and Machado 2004). Consequently, the stilt bugs would be expected to remain on the pubescent surface of these leaves to avoid detection by the ants, as was observed for first-instar lepidopteran caterpillars on *M. guianensis* (Vasconcelos 1991). As expected, our results showed that *J. ossesae* occurs more frequently on the upper surface of leaves, which is densely covered by trichomes, than on the lower surface (low trichome density).

Because we could not identify the food items found with *J. ossesae*, further observations are necessary to evaluate the contention that the stilt bug might occasionally prey on injured or dying ants associated with *M. guinanensis* and *M. poeppigii*. Furthermore, future investigations should focus on the influence, if any, of *J. ossesae* on this ant-myrmecophyte system. Additional data on feeding behavior, egg laying and beneficial or harmful interaction of this stilt bug-ant-myrmecophyte system could be useful for understanding the evolution of the specificity of *J. ossesae* on *M. guinanensis* and *M. poeppigii*.

ACKNOWLEDGMENTS

This work was done during the 10th edition of the course 'Ecologia da Floresta Amazônica' in Manaus, Brazil, which was supported by the Instituto Nacional de Pesquisas da Amazônia (INPA), the Biological Dynamics of Forest Fragments Project (BDFFP), and the Smithsonian Institution. The authors thank the coordinator of the course, Glauco Machado, and all the participants for their help and support during the course. We are grateful to Hélcio Gil-Santana for identifying the family to which *J. ossesae* belongs, Glauco Machado for identifying the ants associated with the myrmecophytes, and Thiago Izzo for collecting additional *J. ossesae* specimens. We are greatly thankful to Thomas J. Henry (Systematic Entomology Laboratory, USDA, Washington, DC) for describing the stilt bug and naming it after Francini Osses and also for his comments and suggestions that greatly improved our manuscript. The clarity of the manuscript also was greatly improved by suggestions made by an anonymous reviewer. Francini Osses and Eduardo G. Martins were supported by a scholarship from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP, 03/10639-7), respectively, and Gustavo Q. Romero was supported by a fellowship and grants from FAPESP (04/13658-5 and 05/51421-0).

LITERATURE CITED

Beattie, A. J. 1985. The Evolutionary Ecology of Ant-Plant Interactions. Cambridge University Press, Cambridge, 182 pp.

Benson, W. W. 1985. Amazon ant-plants, pp. 239–266. *In* Prance, G. T. and T. E. Lovejoy, eds. Amazonia. Pergamon Press, Oxford, 442 pp.

Bronstein, J. L. 1998. The contribution of ant-plant protection studies to our understanding of mutualism. Biotropica 30: 150–161.

Christianini, A. V. and G. Machado. 2004. Induced biotic responses to herbivory and associated cues in the Amazonian ant-plant *Maieta poeppigii*. Entomologia Experimentalis et Applicata 112: 81–88.

Davidson, D. W. and D. McKey. 1993a. Ant-plant symbioses: Stalking the Chuyachaqui. Trends in Ecology and Evolution 8: 326–332.

———. 1993b. The evolutionary ecology of symbiotic ant-plant relationship. Journal of Hymenoptera Research 2: 13–83.

Elsey, K. D. and R. E. Stinner. 1971. Biology of *Jalysus spinosus*, an insect predator found on tobacco. Annals of the Entomological Society of America 64: 779–783.

Fonseca, C. R. and G. Ganade. 1996. Asymmetries, compartments and null interactions in an Amazonian ant-plant community. Journal of Animal Ecology 65: 339–347.

Fowler, H. G. and E. M. Venticinque. 1996. Spiders and understory myrmecophytes of the central Amazon, Brazil. Revista Brasileira de Entomologia 40: 71–73.

Gastreich, K. R. 1999. Trait-mediated indirect effects of a theridiid spider on an ant-plant mutualism. Ecology 80: 1066–1070.

Gilmore, J. U. 1938. Observations on the hornworms attacking tobacco in Tennessee and Kentucky. Journal of Economic Entomology 31: 706–712.

Heil, M. and D. Mckey. 2003. Protective ant-plant interactions as model systems in ecological and evolutionary research. Annual Review of Ecology, Evolution, and Systematics 34: 425–553.

Henry, T. J. 2000. Stilt bugs (Berytidae), pp. 725–735. *In* Schaefer, C. W. and A. R. Panizzi, eds. Heteroptera of Economic Importance. CRC Press, Boca Raton, Florida, 828 pp.

———. 2007. A newly discovered Brazilian species of the stilt bug genus *Jalysus* (Hemiptera: Heteroptera: Berytidae) associated with myrmecophytic plants. Proceedings of the Entomological Society of Washington 109: 324–330.

Jolivet, P. 1991. Ants, plants and beetles: A triangular relationship, pp. 397–406. *In* Huxley, C. R. and D. F. Cutler, eds. Ant-Plants Interactions. Oxford University Press, New York, 601 pp.

Kulash, W. M. 1949. The green pearch aphid as a pest of tobacco. Journal of Economic Entomology 42: 677–680.

Lapola, D. M., E. M. Bruna, and H. L. Vasconcelos. 2003. Contrasting responses to induction cues by ants inhabiting *Maieta guianensis* (Melastomataceae). Biotropica 35: 295–300.

Letourneau, D. K. and L. A. Dyer. 1998. Density patterns of *Piper* ant-plants associated arthropods: Top-predator trophic cascades in a terrestrial system? Biotropica 30: 162–169.

Lovejoy, T. E. and R. O. Bierregard. 1990. Central Amazonian forests and the minimum critical size of ecosystems project, pp. 60–71. *In* Gentry, A. H. ed. Four Neotropical Rainforests. Yale University Press, London, 640 pp.

Price, P. W., M. Westoby, B. Rice, P. R. Atsatt, R. S. Fritz, J. N. Thompson, and K. Mobley. 1986. Parasite mediation in ecological interactions. Annual Review of Ecology and Systematics 17: 487–505.

Ribeiro, J. E. L. S., M. J. G. Hopkins, A. Vicentini, S. A. Sothers, M. A. S. da Costa, J. M. Brito, M. A. D. Souza, L. H. P. Martins, L. G. Lohmann, P. A. C. L. Assunção, E. C. Pereira, C. F. Silva, M. R. Mesquita, and L. C. Procópio. 1999. Flora da Reserva Ducke: Guia de identificação das plantas vasculares de uma floresta de terra-firme na Amazônia Central. INPA-DFID, Manaus, Brazil.

Vasconcelos, H. L. 1991. Mutualism between *Maieta guianensis* Aubl., a myrmecophytic melastome, and one of its ant inhabitants: Ant protection against insect herbivores. Oecologia 87: 295–298.

———. 1993. Ant colonization of *Maieta guianensis* seedlings, an Amazon ant-plant. Oecologia 95: 439–443.

Wheeler, A. G. and T. J. Henry. 1981. *Jalysus spinosus* and *J. wickhami*: Taxonomic classification, review of host plants and distribution, and keys to adults and 5th instars. Annals of the Entomological Society of America 74: 606–615.

Wheeler, A. G. and C. W. Schaefer. 1982. Review of the stilt bug (Hemiptera: Berytidae) host plants. Annals of the Entomological Society of America 75: 498–506.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 338–349

SPECIES OF *APHIS* (HEMIPTERA: APHIDIDAE: APHIDINA) LIVING ON *SCHINUS* (SAPINDALES: ANACARDIACEAE) WITH DESCRIPTION OF A NEW SPECIES

J. Ortego, J. M. Nieto Nafría, and M. P. Mier Durante

(JO) INTA EEA Junín, Casilla de Correo 78, 5570 San Martín (Mendoza), Argentina (e-mail: jortego@junin.inta.gov.ar); (JMNN, MPMD) Departamento de Biología Animal, Universidad de León, E-24071 León, Spain (e-mail: (JMNN) dbajnn@unileon.es; (MPMD) dbammd@unileon.es)

Abstract.—Aphids collected on species of *Schinus* (Anacardiaceae) in Argentina and Chile, mainly in Andean localities, are studied. The variability of *Aphis schinifoliae* Blanchard, 1939, is discussed and males are described. Apterous and alatae viviparous females, oviparous females, and males of a **new species**, ***Aphis schinivora***, are described. A key to Aphidini species that could be found on Anacardiaceae in South America is given.

Resumen.—Se han estudiado los pulgones recogidos en localidades de Argentina y Chile, principalmente andinas, sobre especies de *Schinus* (Anacardiaceae). Se expone la variabilidad de *Aphis schinifoliae* Blanchard, 1939 y se describen los machos. Se describen las hembras vivíparas ápteras y aladas, las hembras ovíparas y los machos de una **nueva especie**, ***Aphis schinivora***. Se presenta una clave para las especies de Aphidini que pudieran encontrarse en Sudamérica sobre especies de Anacardiaceae.

Key Words: *Aphis schinivora*, Aphididae, Aphidina, aphids, new species, Chile, Argentina, South America, Andes, Anacardiaceae

Argentinean entomologist Everard E. Blanchard (1899–1971) described 39 species and subspecies of aphids, 18 of which (15 species and 3 subspecies) are considered available today (Cortés 1973, Nieto Nafría et al. 1994, Seco Fernández et al. 2000, Ortego et al. 2004, Nieto Nafría et al. in press). One species is *Aphis schinifoliae* Blanchard, 1939, which lives on various species belonging to the genus *Schinus* L., 1753 (Anacardiaceae).

Blanchard (1939) described only the apterous viviparous females collected on *Schinus dependens* Ortega, 1798, in Los Cocos (Córdoba province). However, if we take into account the species of *Schinus* present in Argentina and their distribution (Zuloaga and Morrone 1999), the plant may, in fact, be *Schinus fasciculatus* (Griseb) I.M. Johnst., 1938. Remaudière et al. (1991) described the winged viviparous females and the oviparous females, and provided more data on the apterae based on material collected on *Schinus dependens* (we have similar doubts with regard to the identification of the plant) and *Schinus molle* L., 1753, by Bahamondes in Mendoza (Argentina). Hinojosa de Fernández (1964); Blackman and Eastop (1994), and Nieto Nafría et al. (1994) have reported the species in Bolivia, Chile, and Tucumán

Province (Argentina), respectively. It is not present in Brazil, despite the fact that Bertels (1973) recorded it in the State of Rio Grande do Sul (Costa et al. 1993;, Sousa-Silva and Ilharco 1995; Pérez Hidalgo et al. 1998, and Nieto Nafría and Mier Durante 2006).

The genus *Schinus* (Rosidae, Sapindales: Anacardiaceae), with about 30 species, is distributed from southern United States to the southern part of the continent (Argentina and Chile).

According to Blackman and Eastop (1994), three aphid species have been recorded on species of *Schinus: Aphis schinifoliae* (on *S. dependens* and *S. molle*), *Aphis gossypii* Glover, 1877 (on *S. molle* and *S. terebinthifolius* Raddi, 1820), and *Toxoptera aurantii* (Boyer de Fonscolombe, 1841 (on *S. terebinthifolius*). These authors also record aphid species (mostly Fordini, Eriosomatinae) throughout the world on plants belonging to another 12 genera of Anacardiaceae, and amongst them, there are another six species of the tribe Aphidini: *A. spiraecola* Patch, 1914, *A. craccivora* Koch, 1854, *A. fabae* Scopoli, 1763, *A. rhoicola* Hille Ris Lambers, 1954, and another two species in the same tribe Aphidini: *Brachyunguis harmalae* Das, 1918, and *Toxoptera odinae* (van der Goot, 1917). Only the first three of these six species were recorded in South America, and all three are polyphagous.

In recent years, we have carried out expeditions to collect aphids mainly in the Andean area of Argentina to increase our knowledge of the South American aphid fauna. We have studied 11 Argentinean samples and 2 Chilean samples, all collected on *Schinus*.

Material and Methods

Techniques for collecting, preserving, slide mounting and measuring, aphids, as well as terminology, are reported in our previous papers (Mier Durante et al. 2006).

Abbreviations used in the text and figure captions are as follows: AbdI, AbdII, AbdIII, AbdIV, AbdV, AbdVI, AbdVII, AbdVIII = abdominal segments I to VIII; AntI, AntII, AntIII, AntIV, AntV, AntVIb, AntVIpt = antennal segments I to V plus base and processus terminalis of antennal segment VI, respectively; Ars = apical rostral segment; D = basal diameter of antennal segment III; and Ht2 = second segment of hind tarsus. Values in parentheses are exceptional values.

Table 1 shows the collection data for the specimens studied.

Results and Discussion

Using a stereoscopic microscope, viviparous apterous females in alcohol (Table 1) were separated into two groups: 1) specimens collected on various species of *Schinus*, with pale siphunculi at least as long as the cauda, or exceptionally slightly shorter, identified as *A. schinifoliae*; and 2) specimens collected on *Schinus johnstonii* F.A. Barkley, 1944, with very dark, and very short siphunculi (shorter than 2/3 cauda length), considered a new species.

Aphis schinifoliae Blanchard 1939
(Figs. 3B, 4A)

The apterous viviparous females caught in Paso Pehuenche: Las Garzas and in Malargüe: Refugio del Club Andino, differ from the other *A. schinifoliae* specimens (Fig. 4A) in that they have much more voluminous abdominal papillae and slightly longer dorsal abdominal setae. The data obtained in the morphometric study of these females (Table 2) show that there is only one species, *Aphis schinifoliae*, which is more variable than first thought.

Three of the studied samples (Table 1) have sexuals. The oviparous females are similar to those described by Remaudière et al. (1991) and the males, which are

Table 1. Studied material (ap., al., ov., m.: respectively apterous viviparous, alatae viviparous and oviparous females, and males) of *Aphis* (*A.*) *schinifoliae* [*A.sf.*] and *Aphis* (*A.*) *schinivora* [*A.sv.*]; respective samples in alphabetical order for "host plant" and "locality name."

	Locality									
Host plant	Name	Southern Latitude	Western Longitude	Altitude (m)	Andean	Date	*Leg.*	Coll. number	Material	Species
Schinus gracilipes	Tafí del Valle (Tucumán, Argentina)	26° 52′	65° 41′	2015	X	15/09/1985	M.A. Delfino	ARG-6	ap.	*A.sf.*
Schinus molle	Esperanza (Santa Fe, Argentina)	31° 28′	60° 55′	38		20/09/1995	J.M. Nieto	ARG-49	ap.	*A.sf.*
Schinus molle	Mendoza (Mendoza, Argentina)	32° 54′	68° 49′	824	X	8/02/2000	authors	ARG-558	ap.	*A.sf.*
Schinus molle	San Rafael (Mendoza, Argentina)	34° 37′	68° 19′	650		16/10/1995	J. Ortego	ARG-1078	ap.,al.	*A.sf.*
Schinus roigii	Parque Tromen (Neuquén, Argentina)	37° 5′	70° 8′	1785	X	27/01/2000	authors	ARG-507	ap.	*A.sf.*
Schinus sp. (? *roigii*)	Malargüe: Refugio del Club Andino (Mendoza, Argentina)	35° 24′	69° 54′	2183	X	12/03/1994	J. Ortego	ARG-1077	ap.,m.	*A.sf.*
Schinus sp. (? *roigii*)	Malargüe: Refugio del Club Andino (Mendoza, Argentina)	35° 24′	69° 54′	2183	X	7/12/1996	J. Ortego	ARG-1079	ov.,m.	*A.sf.*
Schinus sp. (? *roigii*)	Malargüe: Refugio del Club Andino (Mendoza, Argentina)	35° 24′	69° 54′	2183	X	4/02/2000	authors	ARG-533	ap.	*A.sf.*
Schinus sp.	General Roca (Río Negro, Argentina)	39° 02′	67° 35′	300		8/02/2003	J. Ortego	ARG-938	ap.	*A.sf.*
Schinus sp.	Paso Pehuenche: Las Garzas (Maule, Chile)	~35° 57′	~70° 20′	1160	X	2/02/2000	authors	CHI-122	ap.,ov	*A.sf.*
Schinus johnstonii	Lago Tromen (Neuquén, Argentina)	39° 32′	71° 27′	~1000	X	23/01/2000	authors	ARG-457	ap.,al.,ov.,m.	*A.sv.*
Schinus johnstonii	Paso Pehuenche: La Mina (Maule, Chile)	35° 55′	70° 37′	1542	X	31/01/2000	authors	CHI-95	ap.	*A.sv.*
Schinus johnstonii	San Martín de los Andes (Neuquén, Argentina)	40° 10′	71° 23′	812	X	25/01/1999	J. Ortego	ARG-1023	ap.	*A.sv.*

Table 2. Metric and meristic data of apterous viviparous females and males of *Aphis schinifoliae*. The letters in bold indicate the final limits of each character.

Character	Apterous viviparous females				Males
	Previous data		New data		
	Blanchard 1939 holotype	Remaudière & al. 1991	Small papillae (n=30)	Large papillae (n=20)	New data
Body (mm.)	1.72	1.60–2.23	1.40–**2.25**	**1.08**–2.05	**1.00–1.45**
Antenna (mm.)	0.99	0.85–1.25	0.80–1.25	**0.52–1.33**	**0.80–1.15**
Antenna/Body (times)	0.58	0.5–0.6	0.5–**0.7**	**0.4–0.7**	**0.7–0.9**
AntIII (mm.)	0.26	0.19–0.34	0.18–0.34	**0.15–0.38**	**0.21–0.33**
AntIV (mm.)	0.14	0.13–0.22	0.10–0.22	**0.07–0.24**	**0.13–0.21**
AntV (mm.)	0.18	0.14–0.23	0.14–0.23	**0.11–0.25**	**0.14–0.20**
AntVIb (mm.)	0.11	0.09–0.13	0.09–**0.13**	**0.07–0.13**	**0.09–0.12**
AntVIpt (mm.)	0.15	0.15–0.19	**0.11–0.20**	0.12–0.19	**0.13–0.17**
Ars (mm.)	0.13	0.13–0.14	**0.11–0.16**	0.12–**0.16**	**0.12**
Ht2 (mm.)	0.11	0.12–**0.13**	0.10–**0.13**	**0.08–0.13**	**0.09–0.11**
Ars/Ht2 (times)	1.2	1.1–1.2	**1.0**–1.2	1.2–**1.4**	**1.0–1.3**
Siphunculus (mm.)	0.19	0.18–0.27	0.15–**0.31**	**0.11**–0.30	**0.12–0.16**
Siphunculus/its width at middle (times)		3.4–4.1	**2.5–5.2**	2.6–5.0	**2.7–3.5**
Cauda (mm.)	0.13	0.14–0.18	0.11–0.19	**0.10–0.20**	**0.07–0.11**
Siphunculus/Cauda (times)	1.5	1.2–1.6	1.1–**1.7**	**1.0–1.7**	**1.2–1.5**
Number of setae on cauda	**10**	**4**–9	**4**–7	5–**10**	**5–8**
Papillae on AbdII–AbdVI, total number		6–8	**(2)5–9**	**(2)**7–**9**	**6–8**
Setae on AntIII (μm)		14–17	**10–20**	15–18	**15–20**
Setae on AntIII/D (times)		**0.5**	0.5–0.9	0.7–**1.2**	**0.9–1.2**
Setae on Vertex (μm)			**15**–28	23–**33**	**20–35**
Setae on Vertex/D (times)			**0.8**–1.6	1.1–**1.8**	**1.2–1.9**
Setae on Marginal AbdIII (μm)			18–30	**15–45**	**20–37**
Setae on Marginal AbdIII/D (times)			**0.9**–1.5	**0.9–2.0**	**1.4–1.9**
Setae on Spinal AbIII (μm)		30–33	**18–38**	25–**38**	**27–37**
Setae on Spinal AbdIII/D (times)			**0.9**–1.7	1.3–**2.1**	**1.4–2.0**
Setae on AbdVIII (μm)		48–**57**	**33**–53	40–55	**35–50**
Setae on AbdVIII/D (times)			**1.6**–2.6	2.1–**3.0**	**2.2–2.8**

apterous, are described below. The presence of sexuals, and in particular, the apterous males, demonstrate that the species is monoecious holocyclic on several species of *Schinus,* although it also may be anholocyclic, like other aphid species, should be considered.

Remaudière et al. (1991) were surprised at the presence of oviparous females in November. Our collections in December were just as surprising, but the February and March ones are normal, though somewhat early.

Our data indicate that the species could produce sexuals during the austral summer without interrupting the production of viviparous females, as occurs with *Macrosiphum meixneri* Börner, 1950 (Nieto Nafría and Mier Durante 1991) in the Cantabrian Mountains. Also, the sexuals collected in spring could come from viviparous females that remained on the plants during winter, either in sheltered places or under a layer of snow. Leclant (1978) recorded aphids remaining on the host plant in a place with air and under a layer of snow for *Wahlgreniella ossiannilssoni* Hille Ris Lambers, 1949, on *Arctostaphylos uva-ursi* in the French Alps, and Nieto Nafría and Mier Durante (data not edited) for *Acyrthosiphon* sp. on *Euphorbia flavicoma* subsp. *occidentalis* (perhaps *A. matilei* Remaudière and Leclant 2000) in the Spanish Cantabrian Mountains.

This species, recorded for the first time in Neuquén, Río Negro, and Santa Fe provinces, is widely distributed, known from 60°55′W of Esperanza (Santa Fe, Argentina) in the east to Chile in the west, and from Bolivia in the north to 39°02′S of General Roca (Río Negro, Argentina) in the south.

Males are apterous (Fig. 3B). Slide-mounted specimens have a pigmented head, rostrum, antennae, most of the length of the legs, parameres, anal plate, and cauda, plus sometimes stigmatic and intersegmental sclerites and a band on AbdVIII. AntIII, AntIV, and AntV have 8–16, 4–11, and 4–9 secondary sensoria, respectively. Other metric and meristic characteristic are shown in Table 2.

Aphis schinivora Ortego, Nieto Nafría, and Mier Durante, new species

(Figs. 1, 2, 3B)

Apterous viviparous female (n = 381; 39 measured) (Fig. 1).—Body 0.94–1.38 mm long, 13.1–26.9 times siphunculus, which is very short. Shiny black with partially white legs when alive. Slide-mounted specimens with pigmented head, antenna, partially thorax, partially legs, siphunculi, cauda, and genital and anal plate; see detailed pigmentation in description of each part.

Front margin moderately sinuate or convex. Head, AntI and AntII brown to dark brown. Setae on vertex fine, acute, 15–38 μm long and 1.2–2.4 times D. Antenna 6 segmented, but AntIII and AntIV sometimes coalescent or exceptionally 5 segmented, 0.55–0.78 mm long, 0.47–0.67 times body length and without secondary sensoria. AntIII pale to dark brown, dorsally smooth or very tenuously imbricated and ventrally imbricated, 0.12–0.23 mm long (0.9–1.9 times AntVIpt) and with 3–7 setae, which are 15–30 μm long and 1.0–1.8 times D. Other segments of antennal flagellum brown to dark brown and wrinkly; AntIV and AntV, respectively, 0.06–0.12 and 0.07–0.12 mm long; AntVIpt 0.10–0.16 mm, 0.9–1.5(1.9) times AntIII, and 1.2–1.9 times AntVIb, which is 0.07–0.10 mm long. Rostrum brown reaching or overlapping hind coxae; Ars 0.10–0.12 mm, 1.0–1.3 times Ht2, 1.0–1.5 times AntVIb, 2.0–3.1 times its basal width, and with straight sides and 2 long secondary setae.

Coxae, trochanters, most of femur length, distal one-third of tibiae and tarsi brown to dark brown; other parts of legs not as pigmented, light brown to brown.

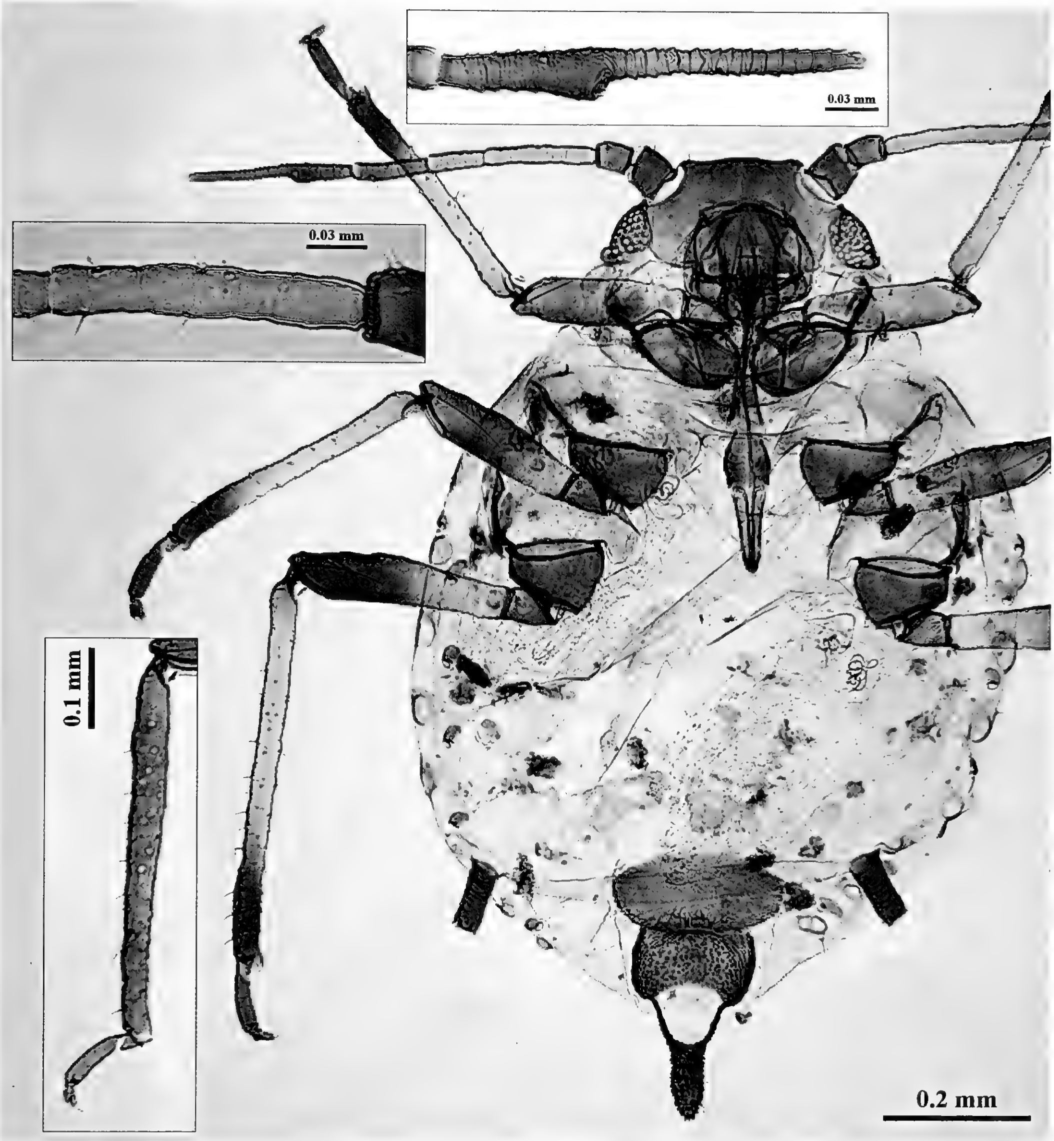


Fig. 1. *Aphis schinivora*, apterous viviparous female, general view and detailed AntIII and AntVI; oviparous female, tibia and tarsus of hind leg.

Inside seta of hind trochanter 33–43 μm, 0.6–1.3 times diameter of trochanter-femoral joint. Longest dorsal setae on hind femur 25–38 μm and 1.3–3.0 times D. Outside setae at mid length of hind tibia 20–38 μm long and 1.1–1.7 diameter of article at its insertion point. First tarsal segment with 3.3.2 setae. Ht2 0.08–0.10 mm long.

Pigmented areas on dorsum of thorax usually restricted to marginal areas and sometimes extended on metathorax, but paler than head. Dorsal abdominal pigmented sclerotized areas very variable: from stigmatic and some intersegmental sclerites and very straight bar on AbdVIII (before hairs) to stigmatic, intersegmental and marginal sclerites,

Fig. 2. *Aphis schinivora*, alatae viviparous female. AntIII and AntVI are detailed.

broken large spinal-pleural on AbdIV, spinal sclerites to small patches on AbdI–AbdIII and AbdV–AbdVI, and bars on AbdVII and AbdVIII; segmental ones tenuously reticulated and paler than coxae or siphunculi.

Marginal papillae on prothorax, AbdI, AbdVII and (5)6–9 on AbdII–AbdVI; prothoracic ones large, longer than triommatidium axis but relatively short, larger than abdominal ones; smallest on AbdVII and, if they exist, on AbdV and AbdVI and AbdVII. Marginal and spinal setae on AbdIII, respectively, 25–48 μm (1.0–2.5 times D) and 18–35 μm (0.7–1.6 times D); setae on AbdVII and AbdVIII, which are 2(4) in number, respectively, 13–25 μm (1.0–2.4 times D) and 10–33 μm (1.7–2.8 times D).

Siphunculus dark brown to black, cylindrical, and very short (0.04–0.10 mm long, 1.1–2.9 times its width at middle, and 0.3–0.7 times cauda), wrinkly and with a small apical flange. Genital plate with 2–4 discal and (4)7–12(19) posterior setae, and dark brown similar to anal plate. Cauda brown to dark brown, more pigmented on margins, 0.09–0.17 mm and (0.8)1.1–1.9 times its basal width, with 4–8 setae.

Alate viviparous female (n = 1) (Fig. 2).—Body 1.33 mm long, and similar to apterous females, although with less sclerotization, a straight bar both on AbdVII (broken) and AbdVIII (complete), and antenna 0,85 mm long. AntIII and AntIV with 5–8 and 0–1 secondary sensoria, respectively.

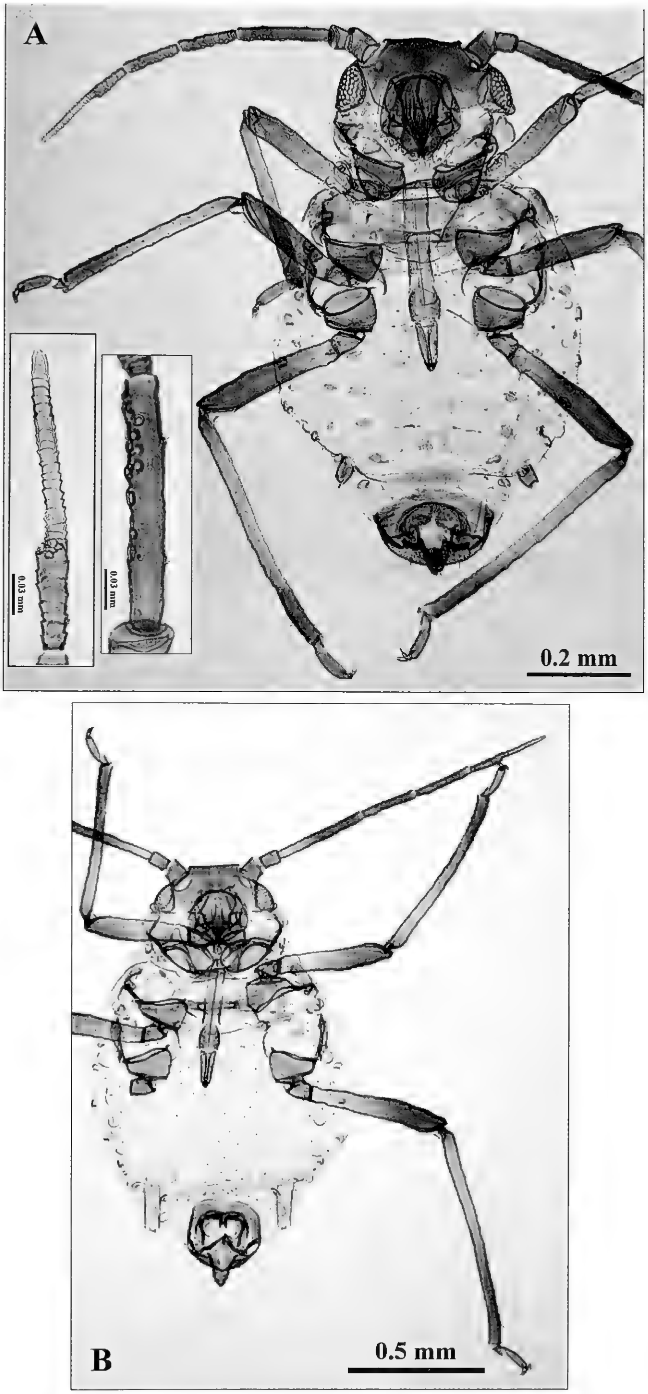


Fig. 3. Apterous males. A, *Aphis schinivora*, AntIII and AntVI are detailed. B, *A. schinifoliae*.

Oviparous female (n = 1) (Fig. 1).—Body 1.12 mm long, similar to viviparous apterous females that have poor dorsal sclerotization and pigmentation; AntIII and AntIV joined and together 0.21 mm long, 11 setae on cauda, bicolored genital plate with 16 discal and 24 posterior setae, and hind tibia brown, gradually enlarged and with 31 scent plates (one hind leg missing).

Male, apterous (n = 3) (Fig. 3A).—Body 0.97–1.07 mm long with antenna and legs brown to dark brown. Dorsal scletorization and pigmentation more extended than apterous viviparous female, with spinal twin plates on AbdII–AbdVI (coalescing to make a spinal complete plate) and bars on AbdVII–AbdVIII. AntIII, AntIV, and AntV, respectively, with 10–13, 2–8, and 3–7 secondary sensoria placed on ventral part of segments. Metric and other meristic features similar those of apterous viviparous female, though antenna 0.6–0.9 times body length, which is 10.5–11.0 siphunculus, and minimal differences in length of some setae.

Type material.—Holotype: apterous viviparous female (ARG-457 measured specimen 11) collected on *Schinus johnstonii* F.A. Barkley at Lago Tromen (Neuquén, Argentina), 23-I-2000. Deposited in collection of the Universidad de León (Departamento de Biología Animal). Paratypes: 117 apterous viviparous females, 1 viviparous alatae female, 1 oviparous female, and 3 males (apterous) found with the holotype, and 263 apterous females caught on the same plant in San Martín de los Andes (Neuquén), 25-I-1999, J. Ortego leg., and in Paso Pehuenche: La Mina (Maule, Chile). Deposited in the collections of the Universidad de León (Leon, Spain), INTA EEA Junín (Junín, Mendoza, Argentina), The Natural History Museum (London, United Kingdom), Muséum Nationale d'Histoire Naturelle (Paris, France), and the National Museum of Natural History, Smithsonian Institution aphid collection (Beltsville, MD, USA).

Etymology.—The specific name, *schinivora*, is an adjective in the feminine gender (as is *Aphis*) derived from the host plant generic name and "vora", that means "eater" in Latin.

Biology and distribution.—The presence of sexual specimens on *Schinus johnstonii* shows that *Aphis schinivora* is monoecious and holocyclic. As the sexuals were collected at the end of January during midsummer and not at a high altitude (approximately 1000 m), we think that their life cycle could well be very short. This species forms very dense colonies on the stems and leaves where it produces abundant honeydew.

The only host plant species of *A. schinivora* is *Schinus johnstonii*, but it is uncertain whether it can live on other shrublike species of *Schinus*. *S. johnstonii* occurs in large areas of western Argentina, from Chubut to San Juan and San Luis provinces and in several areas in Chile (Missouri Botanical Garden 1999; Zuloaga and Morrone 1999); the aphid has been located only in part of this area, but it might live in a more extensive area. In any case, we think that its distribution area is smaller than that of *A. schinifoliae*.

Taxonomic discussion.—The new species is very distinct due to the combination of the following characters: pale and unsclerotized or little sclerotized abdominal dorsum, very short and dark pigmented siphunculi, pigmented antennae and legs, triangular and pigmented cauda, large papillae on the prothorax and AbdI, and very numerous and conspicuous marginal papillae on other abdominal segments. These characters differentiate this species from all other Argentinean and Chilean species.

The following key, partly adapted from those by Remaudière (1994); Blackman and Eastop (1994), and García

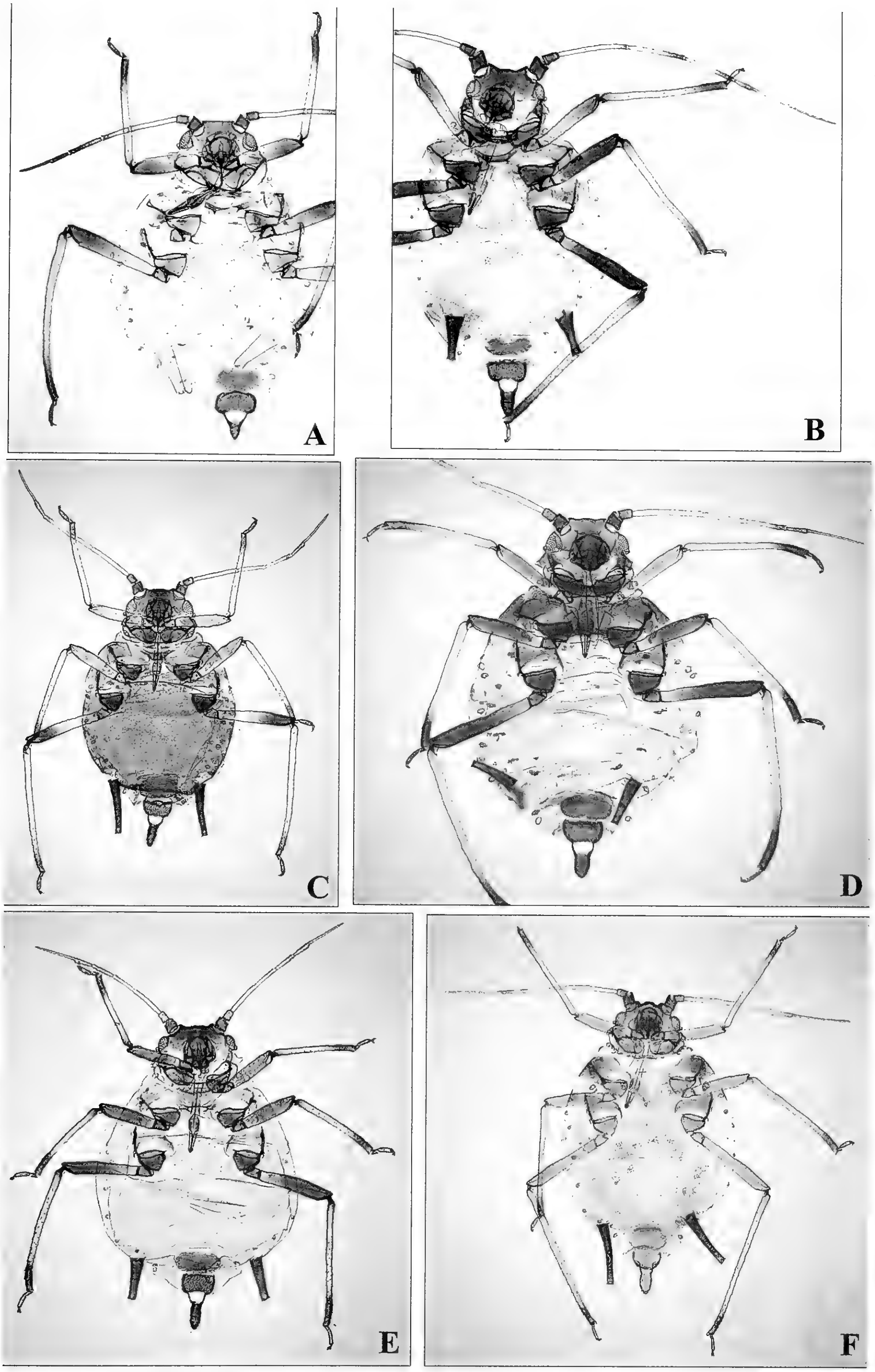


Fig. 4. Apterous viviparous females. A, *Aphis schinifoliae*. B, *Toxoptera aurantii*. C, *A. craccivora*. D, *A. fabae*. E, *A. spiraecola*. F, *A. gossypii*.

Prieto and Nieto Nafría (2006), provides identification of the species of the tribe Aphidini which could be found on *Schinus* spp. in South America; either already recorded (*A. schinifoliae*, *A. schinivora*, *A. gossypii* and *Toxoptera aurantii*) or recorded in other parts of the world on Anacardiaceae (*A.craccivora*, *A. fabae*, and *A. spiraecola*).

1. Siphunculus entirely pale (Fig. 4A). [On several species of *Schinus*] . . . . *Aphis schinifoliae*
– Siphunculus brown to black, sometimes with proximal portion not as dark as distal portion 2
2. Siphunculus 1.1–2.9 times its diameter at middle and at most 0.7 times cauda; femora and tibiae light brown to dark brown, not noticeably dark and pale (Fig. 1) [On *Schinus johnstonii* and perhaps other species] . . . . *Aphis schinivora*
– Siphunculus at least 2.7 times its diameter at the middle and 0.8 times cauda, which is finger shaped; apical parts of femora and tibiae noticeably darker than proximal parts. [Polyphagous or oliphagous species] 3
3. Stridulatory mechanism present, consisting of a conspicuous pattern of ridges on ventrolateral areas of AbdV and AbdVI and a row of short peg like hairs on hind tibia (Fig. 4B) . . . . *Toxoptera aurantii*
– Stridulatory mechanism not present 4
4. AbdI–AbdV (and thoracic) dorsum with discal plate, sometimes broken or partially isolated from marginal sclerites, or partially segmented (Fig. 4C) . . . . . *Aphis craccivora*
– AbdI–AbdV dorsum without discal plate, completely membranous or with isolated small plates and/or sclerites 5
5. Dorsum with variable sclerotic pigmentation, usually consisting of at least dark marginal sclerites plus bands on prothorax, mesothorax, AbdVII (with exceptions), and AbdVIII, and often also with spinal sclerites or small plates; cauda with 12–19 setae (Fig. 4D) . . . . *Aphis fabae*
– Dorsum of prothorax and mesothorax without dark bands, AbdVII and Abd VIII often with small bands or sclerites not deeply pigmented like marginal sclerites if present; cauda at most with 12 setae 6
6. Setae on femora long and fine, longest setae longer than diameter of femur at its base; cauda black, with a distinct constriction about one-third from base and with 6–12 setae (Fig. 4E) . . . . *Aphis spiraecola*
— Setae on femora rather short, not exceeding diameter of femur at its base; cauda clearly paler than siphunculus, tongue-shaped, with a small constriction and bearing 4–7 setae (Fig. 4F) . . . . *Aphis gossypii*

ACKNOWLEDGMENTS

We thank A Dalmasso and E Martínez, "Instituto Argentino de Investigaciones de las Zonas Áridas" (Mendoza, Argentina), for their help in identifying the host plant. This work was funded by grants LE45/02 and LE034A05 from the regional government of Castilla y León (Spain).

LITERATURE CITED

Bertels, S. A. 1973. Revisão de afídeos no Rio Grande do Sul. Instituto de Pesqueisas Agropecuárias do Sul Tim Técnico 84: 1–64.

Blackman, R. and V. F. Eastop. 1994. Aphids on the World's Trees. An Identification and Information Guide. CAB International, Oxon, 8+988 pp. 16 plates.

Blanchard, E. E. 1939. Estudio sistemático de los afidoideos argentinos. Physis 17: 857–1003.

Cortés, R. 1973. Dr. Everard Eels Blanchard. *In* Obituarios. Revista Chilena de Entomología 7: 261–262.

Costa, C. L., V. F. Eastop, and R. L. Blackman. 1993. Brazilian Aphidoidea. I. Key to families and account of Phylloxeridae. Pesquisas Agropecuárias Brasileiras 28(2): 197–215.

García Prieto, F. and J. M. Nieto Nafría. 2006. Género *Aphis*. *In* Nieto Nafría, J. M., M. P. Mier Durante, F. García Prieto, N. Pérez Hidalgo, eds., Hemiptera Aphididae III. *In* Ramos M. A., et al. (2006). Fauna Ibérica 28: 30–173. Museo Nacional de Ciencias Naturales (CSIC). Madrid.

Hinojosa de Fernández, M. L. 1964. Estudio biológico y sistemático de algunos áphidos de Bolivia. Universidad Mayor de San Simón, Facultad de Ciencias Agronómicas, Cochabamba, 68 pp.

Leclant, F. 1978. Étude bioécologique des aphides de la Région Méditerranéenne. Implications Agronomiques. Thése d'Etat. Université des Sciencies et Techniques du Languedoc. 318+43 pp. Montpellier.

Mier Durante, M. P., J. Ortego, and J. M. Nieto Nafría. 2006. A new species of *Aphis* L. (Hemiptera: Aphididae: Aphidina), living on

Urticaceae in Argentina. Proceedings of the Entomological Society of Washington 108(2): 274–284.

Missouri Botanical Garden. 1999. w³TROPICOS. On line: http://mobot.mobot.org/W3T/Search/vast.htlm. Consulted April 3, 2006.

Nieto Nafría, J. M. and M. P. Mier Durante. 1991. Caracterización morfológica y bionomía de *Macrosiphum meixneri* (Homoptera: Aphidinea: Aphididae). Entomologia Generalis 16(2): 123–131.

———. 2006. Three unavailable aphid species by Bertels 1973. Graellsia 62(2): 263–264.

Nieto Nafría, J. M., M. A. Delfino, and M. P. Mier Durante. 1994. La afidofauna de la Argentina, su conocimiento en 1992. Universidad de León (Secretariado de Publicaciones), León, 235 pp.

Nieto Nafría, J. M., M. P. Mier Durante, J. Ortego, and M. V. Seco Fernández. In press. The genus *Uroleucon* (Hemiptera, Aphididae: Macrosiphini) in Argentina, with descriptions of five new species. The Canadian Entomologist.

Ortego, J., M. E. Difabio, and M. P. Mier Durante. 2004. Nuevos registros y actualización de la lista faunística de los pulgones (Hemiptera: Aphididae) de la Argentina. Revista de la Sociedad Entomológica Argentina 63(1–2): 19–30.

Pérez Hidalgo, N., L. M. Bartholdy, and J. M. Nieto Nafría. 1998. Two new aphid records for South America and a list of aphids from Rio Grande do Sul State and Brazil. *In* Nieto Nafría, J. M. and A. F. G. Dixon, eds. Aphids in Natural and Managed Ecosystems, pp. 407–415, Universidad de León (Secretariado de Publicacciones), León.

Remaudière, G. 1994. Revue et clé des espèces sud-américaines d'Aphidina et description d'un *Aphis* nouveau [Homoptera, Aphididae]. Revue Française d'Entomologie (N.S.) 16(3): 109–119.

Remaudière, G. and F. Leclant. 2000. Les espèces d'*Acyrthosiphon* vivant en Europe sur *Euphorbia* spp. [Hemiptera Aphididae]. Revue Française d'Entomologie (N.S.) 22(4): 233–238.

Remaudière, G., N. Weemaels, and J. Nicolas. 1991. Contribution à la connaisance de la faune aphidienne de la Bolivie (Homoptera Aphididae). Parasitica 47(1): 19–46.

Seco Fernández, M. V., J. Ortego, M. P. Mier Durante, and J. M. Nieto Nafría. 2000. Sobre cuatro especies de la tribu Macrosiphini (Hemiptera Aphididae: Aphidinae) de la Argentina. Boletín de la Asociación Española de Entomología 24(3–4): 157–164.

Sousa-Silva, C. R. and F. A. Ilharco. 1995. Afídeos do Brasil e suas plantas hospederas (lista preliminar). Editora da Universidade Federal de São Carlos, São Carlos, 85 pp.

Zuloaga, F. O. and O. Morrone. 1999. Catálogo de las plantas vasculares de la República Argentina. II. On line: http://www.darwin.edu.ar. Consulted April 3, 2006.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 350–358

BIOLOGY AND DAMAGE OF *THAMNURGUS PEGANI* EGGERS (COLEOPTERA: SCOLYTIDAE) FEEDING ON *PEGANUM HARMALA* L. IN EASTERN TURKEY

Coskun Güçlü and Hikmet Özbek

Atatürk University, Agricultural Faculty, Department of Plant Protection, 25240 Erzurum, Turkey (e-mail: cguclu@atauni.edu.tr; hozbek@atauni.edu.tr)

Abstract.—The scolyted beetle, *Thamnurgus pegani* Eggers, was recorded from eastern Turkey in 2002 on *Peganum harmala* L. (Zygophyllaceae), a perennial weed toxic to domestic animals. The beetle's developmental stages, biology, damage, and parasitoids were studied in Igdir Province and in the laboratory at Erzurum during 2003–2005. *Thamnurgus pegani* is univoltine and adults hibernate in the larval galleries, root crown, and soil beneath the host plant. Overwintering beetles appear at the end of April and move to the newly developed stems. Females oviposit eggs singly in the small holes, usually between the stem and lateral shoot. The emergent larvae tunnel downward in the stem pith. A fungus, *Fusarium oxysporium* Schlechtend was detected within the gallery and on the body of *T. pegani*. The fungal-infested tissue became blackishbrown. Larva feed on this infected tissue, pupate in the mined stems, and new adults appear during the first week of August. *T. pegani* attack on *P. harmala* reduces seed crop size and germinability, and thus the beetle is considered to be a potential candidate for biological control of the plant in areas of the world where it has been inadvertently introduced.

Key Words: Thamnurgus pegani, *Peganum harmala*, African rue, biology, biocontrol

The scolytid beetle, *Thamnurgus pegani* Eggers, was first detected on Syrian rue, *Peganum harmala* L. (Zygophyllaceae), 12 km south of the city of Igdir in the foothills of Mt. Ararat in eastern Turkey at an elevation of 1250 m (39° 47′ 46 N; 44° 36′ 44 E) in the summer of 2002 (Fig. 1). This site is towards east 302 km from Erzurum.

Schedl (1981) recorded about 40 species in the genus *Thamnurgus* from Europe, Palearctic Asia, Africa, and Madagascar. Species of *Thamnurgus* feed in the stems of various plant species in the genera of *Euphorbia*, *Peganum*, *Delphinium*, *Tamarix*, and *Labiatae* (Balachowsky 1949, Schedl 1981, Pfeffer 1995).

Peganum harmala L. (African rue) is an erect, 30–70 cm tall, perennial herbaceous perennial with stout stems arising from a woody rootstock. The leaves are alternate, with minute deciduous stipules. The flowers are solitary, usually with opposed leaves (Davis 1967). The flowering period is from March to April. The fruits are globose, three-chambered capsules that contain blackish, angular seeds (Davis 1967, Mahmoudian et al. 2002).

Peganum harmala L. is distributed throughout Turkey, below 1500 m except in the Black Sea Region (Davis 1967). However, it is more common in theeastern and central parts of Turkey

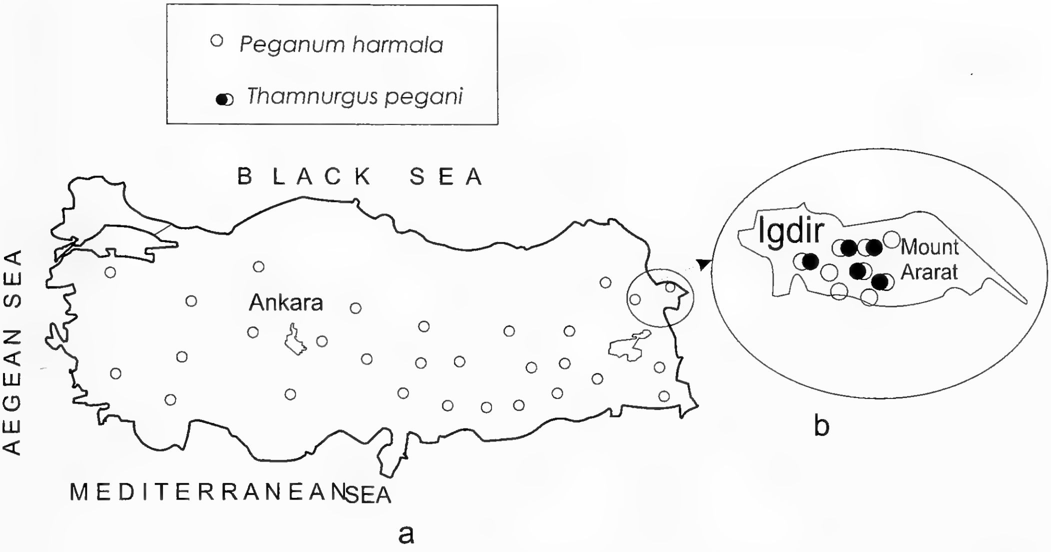


Fig. 1. a) Distribution of *Peganum harmala* in Turkey, b) *Thamnurgus pegani* occurrence in Igdir Province.

(Fig. 1). It is regularly encountered on the outskirts of some villages in the steppe area of eastern Anatolia. The plant has become problematic following its accidental introduction into the western USA.

Peganum harmala L. is known as ‘uzerlik’ or ‘sedefotu’ in Turkish. In villages the fruits of this plant have been used as adornment in the rooms of homes, especially by young women. They believe that these adornments protect the residence occupants against evil eyes. The plant traditionally has been used as an emmenagogue and an abortifacient in the Middle East and North Africa. All parts of the plant contain alkaloids that are toxic upon ingestion and severe intoxication occurs in domestic animals. Animals initially become prostrate and then anorexia, hypersalivation, vomiting and diarrhea occur (Bailey 1986, Bailey and Damn 1981, El-Bahri and Chemli 1991, Mahmoudian et al. 2002, and references therein). The plant usually is not grazed because of its bitter taste. However, when favored forage is sparse, animals may be attracted to and graze intermittently on *P. harmala* (Mahmoudian et al. 2002, and references therein).

Another *Thamnurgus* species, *T. euphorbiae* Küster, was recorded from *Euphorbia characias* L. in Italy, and research was conducted on its host relationships and behavior to determine its potential as a biological control agent for leafy spurge, *Euphorbia esula* L., an invasive weed, which causes over $ 100 million in economic losses in the USA (Anonymous 1992). Christofaro et al. (2000) studied its potential host range at the USDA-ARS-EBCL substation in Rome. Subsequent field and laboratory studies were conducted on the beetle’s biology in Italy. Finally, *T euphorbiae* was approved by the Tecnichal Advisory Group for Biological Control Agents of Weeds for release as a bioagent against leafy spurge in the USA (Campobasso et al. 2004).

In this paper, we report the life history and damage of *T. pegani* and its potential as a biocontrol agent of *P. harmala*.

Material and Methods

Following the discovery of *T. pegani* on *P. harmala*, in Igdir Province in the summer of 2002, we to studied its life history, feeding damage, and parasitoid complex in the field and in the laboratory at Atatürk University from 2003–2005.

Between April and September at about two to three week intervals we made observations in the study area. The plants infested with *T. pegani* were dug up and brought to the laboratory, put in containers with water, and kept in muslin-covered cages (95×45×32 cm) at 24 ± 1°C and approximately 60% RH. Twenty newly hatched larvae were followed to determine the number of larval instars and stadial durations. Infested stems were opened with a razor blade at two-day intervals; the stems were checked until the lavae were ready to pupate. Head capsule widths, larvae lengths, and the lengths and widths of pupae and adults were measured with a Leica MZ 16 FA multi-focusing digital micrometer.

To determine the infestation ratio of *P. harmala* by *T. pegani*, 30 locations were randomly selected and uninfested and infested plants were recorded in 25 m^2 (5×5 m, frame) areas at each location.

Seeds were harvested from uninfested and infested plants at the end of the season and were kept separate for use in 1,000-seed weight, standard germination, and seedling emergence tests.

We counted out 1,000 seeds per sample from collections obtained from both uninfested and infested plants. The experiment was replicated four times per location.

Standard germination tests were conducted in four runs with being four replicates each using 100 seeds for each replicate from uninfested and infested *P. harmala* plants. The seeds were incubated at 23±1°C in 9 cm Petri dishes between two filter paper discs saturated with distilled water containing benlate 1 g/1iter to prevent fungal growth. Seeds with visible radical protrusion were considered germinated. Germination was recorded and germinated seeds were discarded at 24 h-intervals for 15 d (ISTA 1996).

For seedling emergence tests, 100 *P. harmala* seeds were sown into 1 cm deep in a loamy soil in rows in four runs with four different emergence tests with three replicates for each group of seeds germination trays at 23±1°C. Emergence percentages of the seeds were calculated for both uninfested and infested plants for 15 d.

To obtain parasitoids, stems with eggs, larvae and pupae were cut into 15 cm sections and kept in plastic containers provisioned with humid sandy soil and covered with muslin. Distilled water was added daily to keep the soil humid. Emerging parasitoids were collected with a mouth-operated aspirator.

To isolate the fungus, samples were taken from both infested and uninfested areas of stem and the body surface of *T. pegani*. Insects were washed under running tap water in a tub, surface disinfected in 1% sodium hypochlorite for 1 min, crushed in sterile Petri dishes, and then placed on 1.5% water agar (WA) and potato dextrose agar (PDA) containing 50 mg/liter streptomycin sulfate.

Laboratory experiments were conducted as randomized complete block designs, with each treatment replicated four times (% 0.05). Results were subjected to ANOVA and the differences between means were compared using a LSD test. A significance level of $P<0.05$ was used for all experiments.

Results

Description.—Adult (Fig. 2d): Newly emerged adult light brown initially but darkens with age. Color variable, from

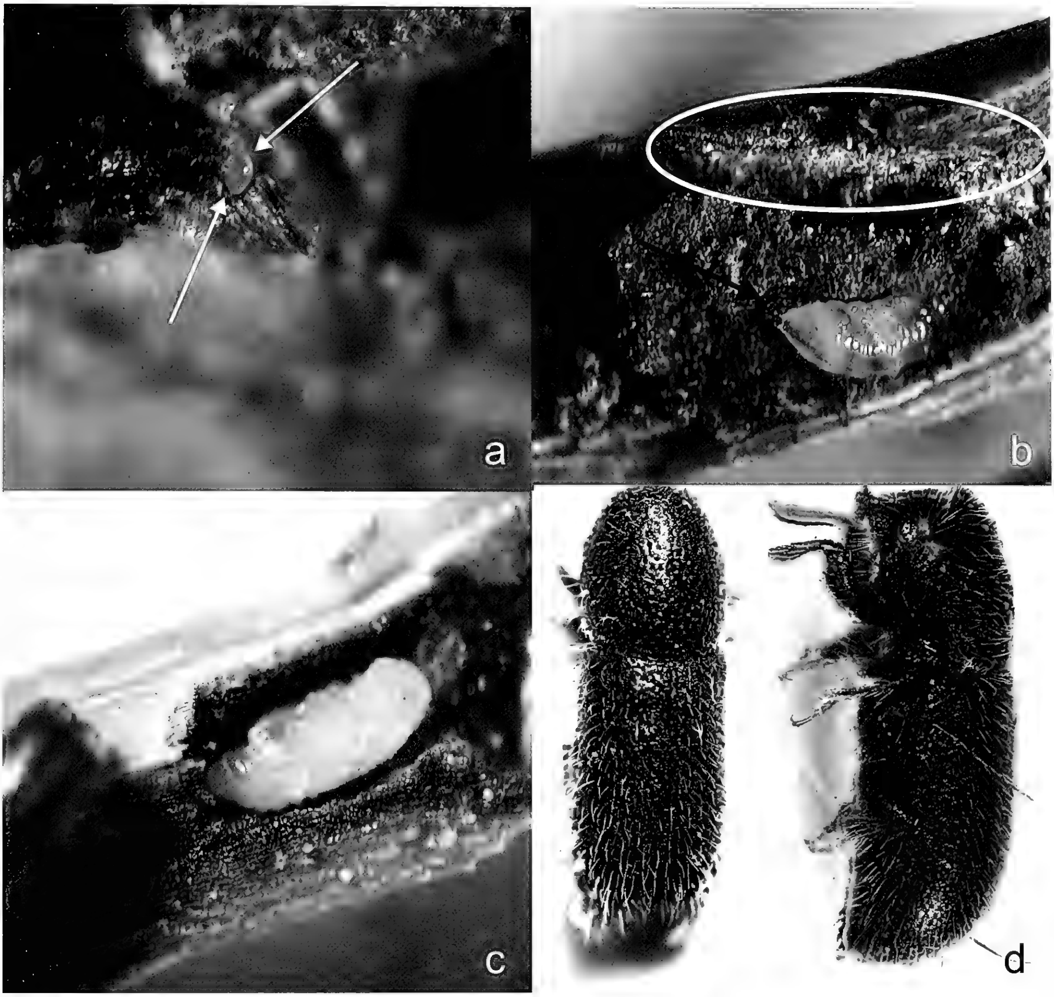


Fig. 2. Stages of *Thamnurgus pegani*. a) Egg, b) Larva in the gallery with *Fusarium oxysporium*, c) Pupa in the gallery, d) Adult.

reddish to blackishbrown. Body elongate and cylindrical, elytra striate, elytral tips truncate. Body covered with golden hairs. Length (mean ± SE) 3.1 ± 0.4 mm (range: 2.8–3.5, n=30) and width 0.9 ± 0.01 mm (range: 0.8–1.0, n=30).

Egg (Fig 2a): Elongate, light yellow, becoming darker with age, and 0.78 ± 0.01 mm (range 0.75–0.81, n=4) long and 0.38 ± 0.01 mm (range 0.35–0.41, n=4) wide.

Larva (Fig. 2b): Mature larva cream colored and elongate. Measurements of first-instar larva (head capsule with body length) 0.27 ± 0.01 (range: 0.24–0.30, n=5), 1.58 ± 0.06 mm (range 1.64–2.79, n=5); second-instar 0.40 ± 0.09 mm (range: 0.35–0.44, n=20), 2.43 ± 0.12 mm (range 1.64–2.79, n=20), and third instar 0.58 ± 0.05 mm (range 0.56–0.61, n= 15), 3.22 ± 0.07 mm (range 2.78–3.51, n= 15). Aksentyev (1991) provided a description of the head capsule.

Pupa (Fig. 2c): Newly emerged pupa cream colored but darkens with age, covered by frass produced by last-instar larva. It measures 4.1 ± 0.1 (range: 3.8–

Fig. 3. a) Distribution of *Peganum harmala* in a meadow, b) *Peganum harmala* infested by *Thamnurgus pegani*, c–d) *Peganum harmala* stems damaged by *Thamnurgus pegani.*

4.5 n=5) mm long and 1.1 ± 0.05 (range:1.1–1.3, n=5) mm wide.

Life history and damage.—From mid-August until early September, some adult beetles leave the galleries and move to the crown of the plant or to the ground, but most adults overwinter in the larval galleries in the damaged stems. Stems harbor from one up to 10 adults, one with as many as 10, but mostly 6 and 7. We also found overwintering adults, with most stems usually containing six to seven. Overwintering beetles appear in the field in late May and move to new stems. In nature, egg-laying started during the last week of May. The female first made a 0.2–0.5 mm diameter cavity in stem with her mouthparts, usually between the stem and lateral branch junction (Fig. 3c) and then inserted an egg. We did not determine the duration of the oviposition period precisely, but we assume that it lasted approximately two weeks. Eggs also are found occasionally in the larval galleries (Fig. 2a). Upon hatching, larvae feed downward along the inside of the stem forming distinctive tunnels. Larvae were first

Table 1. Infestation ratio of *P. harmala* by *T. pegani* in the study area (A: uninfested; B: infested plants).

Year	Mean A/B	Std. Error of Mean A/B	Range A/B	N (Frame)	Sum Plant A/B
2004	4.80/7.46	0.46/0.43	2–11/3–12	30	144/224
2005	5.13/6.53	0.48/051	0–11/1–11	30	154/196

encountered in the galleries at the beginning of June. In July we observed both larvae and pupae in the galleries. Feeding tunnels were 5.24 ± 0.45 mm (range: 5–7 n=5) mm long and 1.5 ± 0.83 mm. (range: 1.4–1.6, n=5) mm wide. In one stem, including all associated side shoots, we counted six tunnels. The color of the feeding tunnel becomes blackish brown due to the presence of the fungus (Fig. 3d). This damage caused plants to lose their normal texture, become dry and fragile, and break easily. Additionally, fruits from infested plants were smaller than those from uninfested plants.

The fungus, *Fusarium oxysporium*, was detected within the larval galleries and on the body of *T. pegani*. This fungus infests the plant tissue and propagates within the galleries and within the stem both above and below the larval galleries (Fig. 2b). Fungal-infested tissue becomes blackish brown. The white mycelia of the fungus on the surface of the blackened tissue are highly visible (Fig. 2b, in circle). We believe that the larvae and adults utilize this infected tissue as a food source. We suspect that since this fungus is a soil inhabitant for a portion of its life cycle, overwintering beetles in the soil bear spores in or on their bodies, and when they make feeding or breeding cavities in the stems, inoculate the stems with the fungus. The other possibility, since beetles feed upon fungal-infected tissue, is that spores may adhere to their bodies and overwintering insects inoculate the stem with the pathogen as a consequence of their feeding activities the following spring. Full-grown larvae pupate in the feeding tunnels. New adults appear during the first week of August and they continue feeding in the larval tunnels until leaving for hibernation. *Thamnurgus pegani* completes only one generation a year.

Under laboratory conditions, the egg incubation period required 9.06 ± 1.57 d (range: 7–11, n=15). The duration of the first larval instar was 8.13 ± 0.83 d (range: 7–9 n=15); second instar 11.85 ± 0.81 d (range 11–13, n=20); and the third instar was 10.05 ± 0.94 d (range7–8, n=20) days. The pupal period lasted 8.46 ± 0.15 d (range: 8–9, n=15).

In the study area in 2004, the number (mean ± SE) of *P. harmala* plants attacked by *T. pegani* was 7.46–0.43 (range 3–12, n=30 frames) and unattacked plants 4.8 ± 0.43 (range 2–11, n=30 frames). The total number of plants sampled was 368 (Table 1). Differences between means of infested versus uninfested plants were statistically significant ($P<0.05$, df: 5, F: 17.56). In 2005, the mean number of infested plants was 6.53 ± 0.51 (range 1–11 n=30 frames) and uninfested plants 5.13± 0.48 (range 0–11 n=30 frames). The total number of plants sampled was 350 (Table 1). These values were statistically significant ($P<0.05$, df: 7, F: 3.8).

The mean weight of 1,000 seeds obtained from uninfested and infested plants was 1.95± 0.29 (range 1.86–2.00, n=4), from uninfested plants and 1.57±0.03 g (range 1.50–1.68, n=4) from infested plants. The difference between means was statistically significant ($P<0.05$, df: 1, F: 63.39).

The germination started to on fourth day and terminated on tenth day

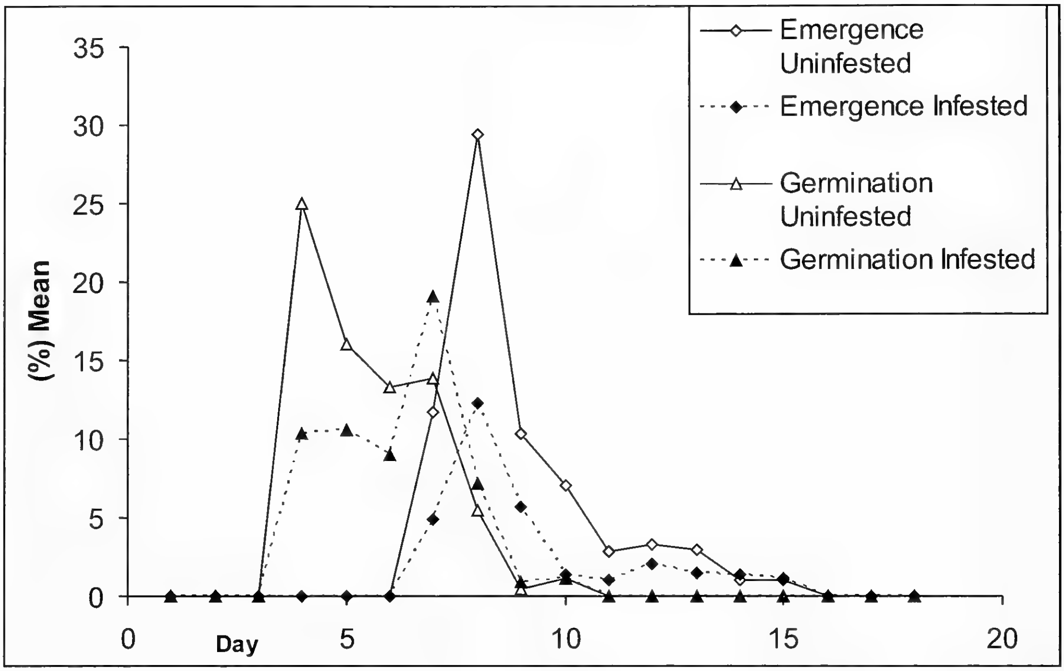


Fig. 4. Germination and emergence of seeds obtained from uninfested and infested plants.

(Fig. 4). Daily mean germinating percentage from infested plants was 8.31 ± 1.30 (%). Daily mean germination percentage from uninfested plants was 10.73 ± 1.84 (Table 2). The difference between seed germination percentage for uninfested and infested plants were statistically significant ($P<0.05$, df: 1, F: 4.1). However, among tests and replications, germination percentage were not significant ($P>0.05$, df: 9, F: 0.20).

The emergence started to on seventh day and terminated on fifteenth day (Fig. 4). Daily mean seedlings emergence of seeds obtained from beetle-infested plants was 3.48 ± 0.73 (%) (Table 2). Daily emergence of seedlings ratio emergence of seeds from uninfested plants was 7.75 ± 1.83 (%) (Table 2). The difference seedling emergence percentage between infested and uninfested plants were significant ($P<0.05$, df: 1, F: 17.08). There is no difference between trials and replications ($P>0.05$, df: 6, F: 0.75).

Parasitoids.—No parasitoids were found during field collections and labo-

Table 2. % Germination and emergence of seeds obtained from uninfested and infested plants.

		Mean (%) ± Std. Error	**Germination from 1600 Seed**	**Total Germination (%)**
Germination (%)	**Uninfested**	10.73* ± 1.84	1202	75.11
	Infested	8.31* ± 1.30	931	58.17
		Mean (%) ± Std. Error	**Emergence from 1200 Seed**	**Total Emergence (%)**
Emergence (%)	**Uninfested**	7.75[q] ± 1.83	836	69.75
	Infested	3.48[q] ± 0.73	276	31.32

* Daily mean germinating percentage; [q] Daily mean emergence percentage.

ratory rearing of eggs, pupae, and adults. In the laboratory, the parasitoids *Coeloides foersteri* Haes (Hymenoptera: Braconidae,), and *Homoporus* sp. and *Trichomalus* sp. (Hymenoptera: Pteromalidae) were obtained from the larvae. *Coeloides foersteri* is an idiobiont parasitoid.

CONCLUSION

In this study, the scolytid, *Thamnurgus pegani* was first detected in Igdır Province in the foothills of Mt. Ararat feeding on *Peganum harmala*, a common and abundant plant especially in the eastern and central part of Turkey and toxic to domestic animals. We also observed the occurrence of this insect in other areas of eastern Turkey.

Thamnurgus pegani is a stem feeder, the adults and larvae feed in the stem forming galleries within the pith of the host. It is notable that the fungus, *Fusarium oxysporum*, develops within these tunnels. Insect feeding and fungal attack weakens the plants. It is remarkable to emphasize that presence of the fungus in stem could increase the biocontrol effect of the beetle. Additionally, the color of the leaves close to the infected area of the stem turns yellow and dry. Fruits from infested plants are smaller than those from uninfested plants. The differences of mean thousand seed weight, standard germination tests, and trial tests of seeds obtained from uninfested and infested plants results from the combined insect and fungus occurrence. *Thamnurgus pegani* is a monophagous species, known only to attack *P.harmala*. In areas occupied by *P.harmala*, *Euphorbia virgata* Woldst et Kit. is abundantly present, but we did not observe *T. pegani* feeding injury to this plant species even though *Thamnurgus* spp. are known to use *Euphorbia* spp. as hosts. *Thamnurgus. pegani* is a potential candidate for the biological control of *P.harmala*, but further research is required to fully assess its role.

ACKNOWLEDGMENTS

We thank B. A. Korotyaev and M. Y. Mandelshtam [Zoological Institute Nauka (ZIN.) St Petersburg, Russia] for their determination of *T. pegani*; S.A. Belekobylskij (ZIN. St Petersburg, Russia) for identifying *C. foersteri*; and M. Doganlar (Mustafa Kemal University., Hatay) for identifying *Homoporus* sp. and *Trichomalus* sp. V. Dorofeev (Komarov Botanical Institute, St Petersburg, Russia) conformed our identification of, *P. harmala* and *E. virgata* and C. Eken and E. Dane (Atatürk University, Erzurum) isolated and identified the pathogen *Fusarium oxysporium*. We also thank two reviewers for their helpful comments.

LITERATURE CITED

Aksentyev, S. I. 1991. Description of larva of *Thamnurgus pegani* and taxonomic status of the genus in the system of bark beetles. Zoological Zhurnal. 70: 147–149 (in Russian with English summary).

Anonymous. 1992. Economic impact of leafy spurge. Leafy Spurge News, Agricultural Experiment Station, North Dakota State University Extension Service 14: 1–4.

Bailey, C. and A. Damn. 1981. Bedouin plant utilization in Sinai and the Negeved. Economical Botany 35: 145–162.

Bailey, M. E. 1986. Principal poisonous plants in the Southwestern United States. *In* Howard, J. L. ed. Current Veterinary Therapy Food Animal Practice. Saunders, Philadelpia, 413 pp.

Balachowsky, A. S. 1949. Faune de France. 50. Coléoptéres Scolytides. Lechevalier, Paris, 320 pp.

Campobasso, G., G. Terragitti, K. Mann, and P. C. Quimby. 2004. Field and laboratory biology of the stem-feeding beetle *Thamnurgus euphorbiae* (Küster) (Col., Scolytidae) in Italy, a potential biological control candidate of leafy spurge in the USA and Canada. Journal Applied Entomology 128: 1–5.

Cristofaro, M., F. Lecce, G. Campobasso, G. Terragitti, N. R. Spencer, and K. D. Mann. 2000. Insect-plant relationships and behavioral observations of the stem-feeding beetle *Tham-*

nurgus euphorbiae Küster (Coleoptera: Scolytidae), a new biocontrol agent from italy to control leafy spurge in the U.S. *In* Spencer, N. R. ed. Proc. X Int. Sym. Biol. Cont. Weeds, 4–14 July 1999, Montana State Univ. Bozeman, MT, USA., 615–619.

Davis, P. H. 1967. Flora of Turkey and the East Aegean islands. Edinburg University Press, Vol: 2. 581 pp.

El-Bahri, L. and R. Chemli. 1991. *Peganum harmala* L: A poisonous plant of North Africa. Veterinary Human Toxicology 33: 276–277.

ISTA, International Rules for Seed Testing. International Seed Testing Association, Zurich, Switzerland, 333 pp.

Mahmoudian, M., H. Jalilpour, and P. Salehian. 2002. Toxicity of *Peganum harmala*. Review and a Case Report. Iranian Journal of Pharmacology & Therapeutics 1: 1–4.

Pfeffer, A. 1995. [Zentral- und westpaläarktische Borken-und Kernkäfer (Coleoptera: Scolytidae, Platypodidae).]. Pro Entomologia, Basel, 310 pp.

Schedl, K. E. 1981. 91. Familie: Scolytidae (Borken-und Ambrosiakäfer) (Ipidae). 310 pp. *In* Freude, H. K., K. W. Harde, and G. A. Lohse, eds. Die Käfer Mitteleuropas Band 10. Bruchidae, Anthribidae, Scolytidae, Platypodidae, Curculionidae. Goecke & Evers, Krefeld.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 359–365

A NEW SPECIES OF *BINODOXYS* (HYMENOPTERA: BRACONIDAE: APHIDIINAE), PARASITOID OF THE SOYBEAN APHID, *APHIS GLYCINES* MATSUMURA, WITH COMMENTS ON BIOCONTROL

K. S. Pike, P. Starý, M. J. Brewer, T. Noma, S. Langley, and M. Kaiser

(KSP) Entomologist, Washington State University, Irrigated Agriculture Research and Extension Center, 24106 N. Bunn Road, Prosser, WA 99350, U.S.A. (e-mail: kpike@wsu.edu); (PS) Entomologist, Institute of Entomology, Academy of Sciences of the Czech Republic, Branišovská 31, 370 05 České Budějovice, Czech Republic; (MJB, TN) Entomologists; and (SL, MK) Research Assistants, Michigan State University, B18 Food Safety and Toxicology Building, East Lansing, MI 48824-1302, U.S.A.

Abstract.—***Binodoxys kelloggensis*** **Pike, Starý, and Brewer, n. sp.** (Hymenoptera: Braconidae: Aphidiinae), is described and illustrated. This aphidiine parasitoid, found in southcentral Michigan, is considered a native species, reared from the exotic soybean aphid, *Aphis glycines* Matsumura, from naturally infested field soybeans and from aphid-infested potted soybeans placed outdoors among assorted plants. It is one of eight parasitoid species now known to attack *A. glycines* in North America.

Key Words: parasitoid, aphidiine, *Binodoxys*, aphid, *Aphis*, soybean, new species, description

A main listing of the aphidiine parasitoids in North America is provided in the Catalog of Hymenoptera in America North of Mexico (Marsh 1979). Research undertaken in the Pacific Northwest (Pike et al. 2000) supplemented this list substantially both in taxonomy and aphid host range information on the group. However, for much of North America, the faunal composition, host range, and ecology of the aphidiines have not been extensively explored. There is a lack of information on the adaptation of local parasitoids to newly introduced pest aphid species, and insufficient or misleading information on the adaptation of accidentally or purposely introduced exotic parasitoids to both native and exotic host aphids.

The new soybean aphid pest, *Aphis glycines* Matsumura (Heimpel and Shelly 2004, Ragsdale et al. 2004, Venette and Ragsdale 2004), which is rapidly expanding its range, affords an opportunity to examine the adaption of local and introduced parasitoids to the new invasive aphid, and to document the unfolding events much the same as was undertaken in North America for the Russian wheat aphid, *Diuraphis noxia* (Kurdjumov) (Pike et al. 2000, Noma et al. 2005).

From field studies on soybean aphids in southcentral Michigan, a native, undescribed species of *Binodoxys* Mackauer was discovered attacking the aphid. The new parasitoid species is herewith named and described. Also provided is a complete listing of all parasitoids, both native and introduced, that to date have been documented to use soybean aphid as a host in North America.

The new parasitoid reared from *A. glycines* was taken from (1) naturally infested soybean field plots at the Michigan State University–Entomology Farm (EF) at East Lansing, Michigan, and (2) naturally infested soybean field plots and artificially infested potted soybeans placed for a time in field plots of assorted plants at the Michigan State University–Kellogg Biological Station, Long-Term Ecological Research plots (KBS) near Hickory Corners, Michigan. Field exposures of potted soybeans at KBS were in or near blocks of alfalfa, corn, clover, poplar, soybean, wheat, and mixed stands of clover, dogbane, goldenrod, Queen Ann's lace, sumac, and timothy. Collections were made by T. Noma, S. Langley, and M. Kaiser, unless otherwise indicated.

PARASITOIDS OF *APHIS GLYCINES* IN MICHIGAN

APHELINIDAE

Aphelinus albipodus (Hayat and Fatima)

Material.—USA, Michigan, EF, 19-Sep-2003; KBS, 1-Aug-2003, 16-Jul & 16-Aug-2004. T. Noma collector.

Aphelinus asychis (Walker)

Material.—USA, Michigan, EF, 8-Aug-2003; 23-Aug & 13-Sep-2004; KBS, 1-Aug-2003; 16-Jul, 16-Aug & 7-Sep-2004. T. Noma collector.

BRACONIDAE: APHIDIINAE

Aphidius colemani Viereck

Material.—USA, Michigan, EF, 9-Jul-2003, 23-Aug-2004; KBS, 27-Jun, 1-Aug, & 12-Sep-2003, 7-Sep-2004. T. Noma collector.

Aphidius ervi Haliday

Material.—USA, Michigan, KBS, 16-Aug & 7-Sep-2004. T. Noma collector.

***Binodoxys kelloggensis* Pike, Starý, and Brewer, new species**

(Figs. 1–8)

Material.—Holotype ♀ (whole mount, dry): USA, Michigan, Kalamazoo Co., near Hickory Corners, Michigan State University–Kellogg Biological Station, Long-Term Ecological Research Plots (N 42.4, W 85.4), 8-Sep-2004, A. Costamagna collector. Reared from *Aphis glycines* Matsmura derived from a naturally-infested field plot of soybeans (*Glycine max*). In the vicinity were 1-hectare blocks of alfalfa, clover, corn, poplar, wheat, and mixed stands of clover, dogbane, goldenrod, Queen ann's lace, sumac, and timothy. Holotype deposited in the National Museum of Natural Hisrtory, Smithsonian Institution, Washington, DC (USNM).

Paratypes: 62 specimens, all from the Kellogg Biological Station, reared from *A. glycines* in August or September 2004. Nine (4 ♀, 5 ♂) were from the same rearings as the holotype, the remainder were derived from *A. glycines* introduced and allowed to multiply on potted soybeans placed outdoors in stands of alfalfa, poplar, and mixed stands of clover, dogbane, goldenrod, Queen Ann's lace, sumac, and timothy. Paratypes deposited in part in collections of USNM (8 ♀, 8 ♂), Michigan State University, East Lansing (8 ♀, 8 ♂), Washington State University, Prosser (12 ♀, 4 ♂), and P. Starý, Czech Republic (9 ♀, 5 ♂).

Diagnosis.—*Binodoxys kelloggensis* is characterized by 11-segmented antenna, by characters on the petiole where the primary (= spiracular) and the secondary tubercles are almost of equal size and their mutual distance of separation is distinctly shorter than the width across the primary tubercles. The prongs bear 2 long setae on the upper side and 6–9 long setae on the lower side; upper and lower marginal setae are of similar length; with

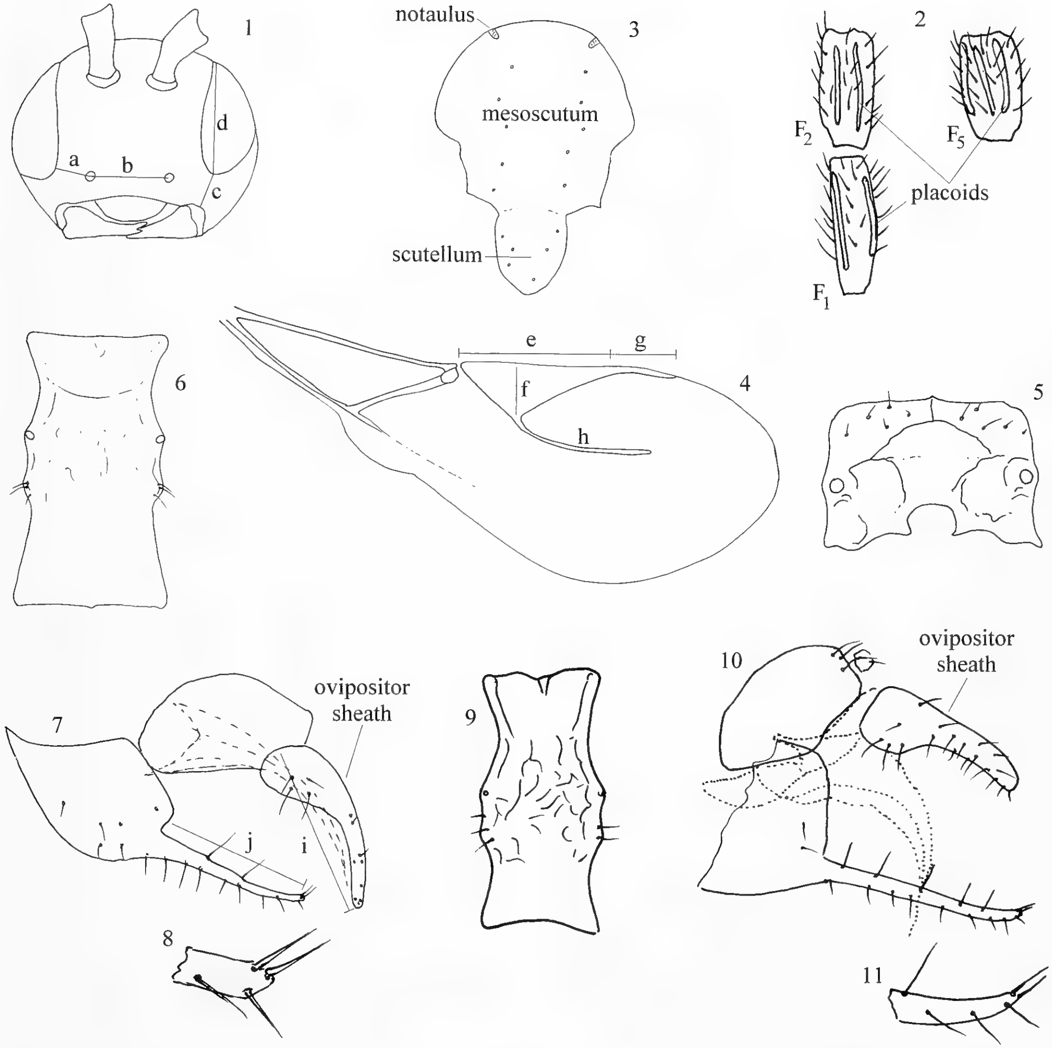


Fig. 1–11. Various morphological features (illustrations not to same scale). 1–8, *Binodoxys kelloggensis*. 1, Head (a, tentorio-ocular distance; b, inter-tentorial distance; c, malar space; d, length of eye). 2, Antennal flagellomeres. 3, Mesonotum (setal number and arrangement shown on mesoscutum [medial-pleural region] and scutellum). 4, Forewing (e, length of stigma; f, width of stigma; g, R1 postmarginal vein (= metacarpus); h, RS vein (radial sector). 5, Propodeum. 6, Petiole. 7, Genitalia (i, length of ovipositor sheath; j, length of prong). 8, Prong apex (close-up). 9–11, *B. carolinensis*. 9, Petiole. 10, Genitalia. 11, Prong apex (close-up).

2 long simple apical setae on the upper side. It is described from *Aphis glycines* from Michigan.

Of the local native species, *B. carolinensis* (Smith 1944), described from *Aphis* sp. in North Carolina (Smith 1944), seems to be the closest relative, characterized as follows: Antenna 11-segmented. The prongs bear 5 long setae on the upper side and 9 setae on the lower side which are about half the length of the opposite upper setae; with 2 long setae at the apex. Also, there are some differences in characters of the petiole and ovipositor between the two species (Figs. 6–7, *B. kelloggensis*—petiole and genitalia; Figs. 9–10 [illustrated by Starý from a slide mounted paratype], *B. carolinensis*—petiole and genitalia).

Certain exotic East Asian *Binodoxys* spp. (Starý et al. unpublished data), if established in North America as control agents of *A. glycines*, might also cause identification problems. Though the East Asian spp. are very similar to *B. kelloggensis*, they are distinguishable by characters on the prongs which bear 4–5 long setae on the upper side, with the upper setae being longer than the lower opposite setae; also, characters on the petiole are different.

Etymology.—The name of the new species is derived from the type location, the Kellogg Biological Station near Hickory Corners, Michigan. The name is attributed to K. Pike, P. Starý and M. Brewer.

Description.—Female. *Head* (Fig. 1): Eyes medium-sized. Malar space equal to 1/4 of eye length. Antenna 11-segmented. Flagellar segment 1 (= F1) (Fig. 2, Table 1) usually slightly >2.5 as long as wide, usually with 2 or 3 placodes, setae semi-erect and equal to 1/3 of segment. F2 (Fig. 2) about 0.8–0.9× F1, approximately twice as long as broad, about 1/5 thicker than F1, with 4–5 placodes. F5 (Fig. 2) slightly wider than F2. *Mesosoma* (Fig. 3): Mesoscutum with notauli distinct in ascendent portion, effaced on disc where traced by a few long setae. Propodeum (Fig. 5) with a broad pentagonal areola, carinae distinct, with a few setae. *Forewing* (Fig. 4, Table 1): Stigma triangular, slightly <3 times as long as broad, R1 (= metacarpus) shorter than stigma length by a factor of 0.4–0.7. RS three times as long as stigma width; lower marginal setae distinctly longer than surface setae. *Metasoma*: Petiole (Fig. 6) about twice as long as width across primary tubercles; distance between primary (= spiracular) and secondary tubercles less than half width across primary tubercles; width across primary tubercles very slightly (about 1/20) shorter than across secondary tubercles; feebly rugose with a short longitudinal carina in second third; with sparse long setae near secondary tubercles. *Genitalia* (Figs. 7–8): Ovipositor sheaths remarkably narrow in distal portion and curved [compare *B. kelloggensis* (Fig. 7) with *B. carolinensis* (Fig. 10)]. Prongs relatively short and strong, slightly arcuate at apex; with 2 long setae on upper side; with 2 long simple setae at apex; with 6–9 long setae on lower side; length of upper side and lower side setae about equal.

Color: Head dark brown, palpi brown. Antenna brown, scape, pedicel and narrow base of F1 light brown. Mesosoma dark brown. Wing venation brown. Legs brown, narrow basal portion of tibiae light brown. Metasoma generally brown. Petiole light brown. Basal spot at tergum 2 light brown. Ovipositor sheaths and prongs dark brown.

Length of body: ca. 1.2 mm.

Male. Antenna 12–13 segmented. Coloration similar to female.

Diaeretiella rapae (M'Intosh)

Material.—USA, Michigan, EF, 17-Jun-2003. T. Noma collector.

Lysiphlebus testaceipes (Cresson)

Material.—USA, Michigan, EF, 8-Aug & 19-Sep-2003, 21-Jun, 23-Aug & 13-Sep-2004; KBS, 27-Jun, 1-Aug & 12-Sep-2003, 16-Aug and 7-Sep-2004. T. Noma collector.

Praon sp.

Material.—USA, Michigan, EF, 21-Jun-2004; KBS, 12-Sep-2003. T. Noma collector.

DISCUSSION

Research on the adaptation of local parasitoids is usually realized within the

Table 1. Feature measurements (μm), counts, and comparison of female and male *Binodoxys kelloggensis* (from paratype series, n = 21 females, n = 14 males).

Features	Female Avg. (range)	Male Avg. (range)
Head		
Antenna flagellomeres		
F1 (length)	92 (73–110)	88 (75–100)
F2 (length)	78 (68–90)	81 (70–90)
F5 (length)	83 (70–100)	85 (78–100)
F1 (width)	33 (28–43)	34 (28–40)
F2 (width)	35 (30–40)	36 (33–40)
F5 (width)	40 (33–45)	45 (38–50)
Antennal placoids		
F1 (no.)	2.9 (2.0–4.0)	4.1 (2.0–5.0)
F2 (no)	3.9 (3.0–5.0)	4.1 (3.0–5.0)
F5 (no.)	4.8 (4.0–5.0)	4.6 (4.0–5.0)
Eye (length)	146 (135–160)	143 (128–160)
Malar space (length)	36 (35–40)	36 (35–40)
Inter-tentorial distance	101 (95–108)	105 (93–113)
Tentorio-ocular distance	41 (35–45)	38 (25–48)
Wing		
Stigma (length)	286 (250–310)	295 (265–315)
Stigma (width)	103 (90–110)	101 (90–110)
Postmarginal vein (R1)	168 (130–200)	172 (150–200)
Mesoscutal pleural setae	10.9 (8.0–14.0)	8.8 (6.0–11.0)
Propodeal setae, anterior area	10.6 (8.0–14.0)	10.5 (9.0–12.0)
Petiole		
length	184 (150–200)	180 (170–188)
width at spiracular tubercles (1°)	94 (80–105)	88 (83–90)
width at secondary tubercles (2°)	87 (75–103)	83 (83–95)
distance betw 1° and 2° tubercles	34 (20–45)	30 (20–40)
Genitalia		
Ovipositor sheath (length)	150 (140–155)	
Prong (length)	143 (115–155)	
Prong lowerside setae (no.)	2.1 (2.0–2.5)	
Prong upperside setae (no.)	7.6 (6.0–9.0)	
Comparisons		
Malar space / eye	0.24 (0.22–0.26)	0.25 (0.22–0.27)
F1 (length / width)	2.75 (2.35–3.18)	2.55 (2.14–3.27)
F2 (length / width)	2.24 (1.69–2.57)	2.23 (2.06–2.46)
F5 (length / width)	2.10 (2.00–2.38)	1.90 (1.70–2.13)
F5 / F2	0.96 (0.94–1.12)	1.06 (1.00–1.11)
Petiole (length / width at 1° tubercle)	1.96 (1.84–2.25)	2.00 (1.90–2.13)
2° / 1° tubercle	0.93 (0.86–1.08)	0.94 (0.91–0.97)
Stigma (length/width)	2.79 (2.48–3.00)	2.91 (2.65–3.33)
Stigma / R1	1.71 (1.35–2.31)	1.71 (1.50–2.07)

framework of post-introduction studies on a target pest aphid. Pike et al. (2000) published extensive information on Northwest USA local parasitoid fauna and tri-trophic associations (plant-aphid-parasitoid), including adaptations of local parasitoids to exotic invasive aphids (e.g., *Diuraphis noxia* and *Brachycorynella asparagi*), and exotic established parasitoids to local and exotic aphids. Noma et al. (2005) found in post-introduction parasitoid studies on *D. noxia* in the northcentral Great Plains that the majority of the parasitoids adapting to and utilizing the invasive aphid were local species.

Aphis glycines, as a new invasive aphid pest in North America, tends to reflect the case of *D. noxia* on small grains – inadvertent pest introduction, subsequent pest expansion, adaptation of local parasitoids combined with foreign searches, importation, and establishment of new exotic parasitoid species.

The presented determinations, eight parasitoids in total, are some of the first records of parasitization of *A. glycines* by local or exotic established parasitoid species in North America (see also Nielsen and Hajek 2005). *Aphelinus albipodus* and *Aphidius colemani* are examples of exotic species. *Aphidius colemani* was introduced against Russian wheat aphid and other aphids in North America and *A. albipodus* against Russian wheat aphid. Both are now established in several states. In addition to the original target pest aphids, they have been found to utilize some alternate aphids, including *A. glycines*. The appearance of *A. colemani* on *A. glycines* as a biocontrol agent was somewhat predictable (see Lin and Ives 2003). *Binodoxys kelloggensis* is apparently a native species which has secondarily adapted to the newly introduced soybean aphid. Its true native aphid hosts have not been determined, but probably they are in the genus *Aphis*. At the type locality, where a mix of plants exists, six local aphid species have been found [*Acyrthosiphon pisum* (Harris), *Aphis* sp., *Nearctaphis bakeri* (Cowen), *Rhopalosiphum padi* (L.), *Therioaphis trifolii* (Monell) and *Uroleucon caligatum* (Richards)], but none of these are directly linked with the parasitoid to date.

A number of other local aphidiines parasitize various *Aphis* spp. and related groups, and we expect in time that some of these will adapt to the congeneric *A. glycines*. North America is rich in species (see Pike et al. 2000) that utilize members of the genus *Aphis*. In general, the aphidine aphids are associated with the highest number of parasitoid species among the subfamilies of aphids (Starý and Rejmanek 1981, Potter and Hawkins 1998). The adaptation of local parasitoids is also in agreement with the Rule of Faunistic Complexes in the biological control of aphids (Starý 1968, 1970).

The value of *A. albipodus* and *A. colemani* as introduced exotics has increased with their parasitization of two exotic aphid pests (*D. noxia*, *A. glycines*). A similar situation has developed with *A. ervi* in Chile (Starý 1996), and with *L. testaceipes* in the Mediterranean region of France (Starý et al. 1988), Portugal (Cecilio 1994) and Spain (Michelena et al. 1994). Such multilateral biocontrol results in added economic savings which unfortunately have not been evaluated.

Aphis glycines, as an exotic, expanding pest in North America, is to some extent a useful model to demonstrate and verify parasitoid dynamics relative to multiple target and nontarget hosts, and their adapation to differing environments across areas of aphid expansion.

ACKNOWLEDGMENTS

We express thanks to A. Costamagna for aphid collections, G. Graf for clearing and mounting specimens, and D. Allison for manuscript review and assistance in illustration formatting and slide labelling. The work was made possible with the support of Michigan State University, Washington State University, and the Academy of Sciences of the Czech Republic. We specifically acknowledge Grant S5007102 and the Entomology Institute project Z50070508 of the Czech Academy of Sciences.

LITERATURE CITED

Cecilio, A. 1994. Faunistic evolution after the introduction of *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Aphidiidae) in Portugal, and its importance for the control of aphids. Boletin de Sanidad Vegetal - Plagas 20: 471–476.

Heimpel, G. E. and T. E. Shelly. 2004. The soybean aphid: A review of its biology and management. Annals of the Entomological Society of America 97: 203.

Lin, L. A. and A. R. Ives. 2003. The effect of parasitoid host-size preference on host population growth rates: an example of *Aphidius colemani* and *Aphis glycines*. Ecological Entomology 28: 542–550.

Marsh, P. M. 1979. Aphidiidae, pp. 295–313. *In* Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. Catalog of Hymenoptera in America North of Mexico, Vol. 1, Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington D. C.

Michelena, J. M., A. Sanchís, and P. González. 1994. Afidíino sobre pulgones de frutales en la Comunidad Valenciana. Boletin de Sanidad Vegetal - Plagas 20: 465–470.

Nielsen, C. and A. E. Hajek. 2005. Control of invasive soybean aphid, *Aphis glycines* (Hemiptera: Aphididae), populations by existing natural enemies in New York state, with emphasis on entomopathogenic fungi. Environmental Entomology 34: 1036–1047.

Noma, T., M. J. Brewer, K. S. Pike, and S. D. Gaimari. 2005. Hymenopteran parasitoids and dipteran predators of *Diuraphis noxia* in the west-central Great Plains of North America: Species records and geographic range. BioControl 50: 97–111.

Pike, K. S., P. Starý, T. Miller, G. Graf, D. Allison, L. Boydston, and R. Miller. 2000. Aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) of Northwest USA. Proceedings of the Entomological Society of Washington 102: 688–740.

Porter, E. E. and B. A. Hawkins. 1998. Patterns of diversity for aphidiine (Hymenoptera: Braconidae) parasitoid assemblages on aphids (Homoptera). Oecologia 116: 234–242.

Ragsdale, D. Q. W., D. J. Voegtlin, and R. J. O'Neil. 2004. Soybean aphid biology in North America. Annals of the Entomological Society of America 97: 204–208.

Smith, C. F. 1944. The Aphidiinae of North America (Braconidae: Hymenoptera). Ohio State University Contributions in Zoology and Entomology 6: 1–154.

Starý, P. 1968. Geographic distribution and faunistic complexes of parasitoids (Hym., Aphidiidae) in relation to biological control of aphids (Hom., Aphidoidea). Acta Universitatis Carolinae - Biologica, Prague 1967: 23–89.

———. 1970. Biology of aphid parasites (Hym., Aphidiidae) with respect to biological control. Series Entomologica 6, Dr. W. Junk., The Hague. 643 pp.

———. 1996. The Aphidiidae of Chile (Hymenoptera, Ichneumonoidea, Aphidiidae). Deutsche Entomologische Zeitschrift, N. F. 42: 113–118.

Starý, P. and M. Rejmánek. 1981. Number of parasitoids per host in different systematic groups of aphids: implications for introduction strategy in biological control (Homoptera: Aphidoidea; Hymenoptera, Aphidiidae). Entomologica Scandinavica, Supplement 15: 341–351.

Starý, P., J. P. Lyon, and F. Leclant. 1988. Post-colonization host range of *Lysiphlebus testaceipes* (Cresson) in the mediterranean France. Zeitschrift für Angewandte Entomologie 105: 74–87.

Venette, R. C. and D. W. Ragsdale. 2004. Assessing the invasion of soybean aphid (Hemiptera: Aphididae): where will it end? Annals of the Entomological Society of America 97: 219–226.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 366–376

THE NON-INDIGENOUS LYCTOCORIDAE AND ANTHOCORIDAE (HEMIPTERA: HETEROPTERA: CIMICOIDEA) OF AMERICA NORTH OF MEXICO

John D. Lattin

Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902, U.S.A.

Abstract.—Eighty-four species of Lasiochilidae, Lyctocoridae and Anthocoridae (Cimicoidea) are known to occur in America north of Mexico. Twenty-six of these are believed to have been introduced (31%). Each non-indigenous species is reviewed and appropriate literature cited. While some species were introduced for possible biological control, others have been introduced accidentally.

Key Words: Lasiochilidae, Lyctocoridae, Anthocoridae, Cimicoidea, Canada and United States species, distribution, and biology

Insects and other organisms have been introduced throughout the world, accidentally or deliberately. The late Charles S. Elton published his pioneer book "The Ecology of Invasions by Animals and Plants" in 1958. Among the insect examples he cited are the winter moth in northeastern North America, elm bark beetle, Japanese beetle, European gypsy moth, sawflies, and even a true bug — *Stephanitis rhododendri*, in this case introduced from North America into Europe, as was the Colorado potato beetle. Other insects have been introduced into Canada and the United States more recently, including the Asian gypsy moth, cereal leaf beetle, blue alfalfa aphid, Russian wheat aphid, and the pine shoot beetle.

Parsons (1983) dealt with the evolution of colonizing species. Mooney and Drake (1984) edited a comprehensive review of some biological invasions, treating the details of invasion and their consequences. The Office of Technology Assessment of the U.S. Congress published "Harmful Non-Indigenous Species in the United States" in 1993. This was a comprehensive treatment of a variety of introductions and their consequences. The use of the term non-indigenous species follows that publication. Some other books published over the past few years on introductions and their consequences include Simberloff et al. (1997), Devine (1998), Cox (1999), Mooney and Hobbs (2000), Ruiz and Carlton (2003), Coombs et al. (2004), Cox (2004) and Mooney et al. (2005). The impact of exotic species on our environments has been enormous. Some of these species have been with us for many years at considerable cost.

Eighty-four species of Lasiochilidae, Lyctocoridae and Anthocoridae (Cimicoidea) are known to occur in America north of Mexico. Twenty-six of these are considered to be non-indigenous (31%). Some were introduced deliberately and others accidentally, usually involving the activities of human beings. Earlier, Lattin (1993) reported 90 species from

America north of Mexico, of which 12.2% were considered to have been introduced, whereas Canada reported 42 species of which 10 (23.8%) were considered introduced. Lattin (1999b, 2000) provided overviews of the Anthocoridae (sensu lato). This publication follows the treatment of families and tribes of the Lasiochilidae, Lyctocoridae and Anthocoridae by Schuh and Štys (1991) and Schuh and Slater (1995). Scudder and Foottit (2006) included the Anthocoridae in their extensive review of the introduced true bugs in Canada. Appropriate references to each species treated here include the date, site of original description, geographic and biological references. Every species that has been reported as a deliberate introduction for biological control purposes has been cited, including those that have not become established. It is the purpose here to record all such species as a data base of past introductions. Stanaway et al. (2001) examined 3,001 empty sea cargo containers in Australia. They recovered over 7,400 living and dead insects from 1174 containers, including 23 specimens of Anthocoridae, 17 of which were still alive. These sea cargo containers now being used world wide have opened yet another pathway of introduction.

LYCTOCORIDAE

Lyctocoris campestris (Fabricius 1794) was described from Europe and first reported from America north of Mexico by Dallas (1852) as *Xylocoris americanus*. Sands (1957) illustrated the egg and nymph, and Anderson (1962b) listed it from the Pacific Northwest. Kelton (1967) recorded it from Alabama, British Columbia, Colorado, Florida, Georgia, Idaho, Illinois, Kansas, Manitoba, Maryland, New York, North Carolina, Ontario, Oregon, Pennsylvania, Quebec, South Carolina, Texas, Utah, Wisconsin and Mexico. Péricart (1972) published an account of *L. campestris* in the western Palearctic, Henry (1988) summarized its occurrence in Canada and the continental United States, and Lattin (2000) reviewed *L. campestris* and its economic importance. This species has been introduced into many parts of the world where it has often been associated with domestic animals, stored-grain, and other products. *Nesidiocheilus hawaiiensis* Kirkaldy, 1902 is considered a synonym of *L. campestris* (Lattin 2006a).

ANTHOCORIDAE

Anthocorini

Acompocoris pygmaeus (Fallén 1807) was described from Europe. Sands (1957) illustrated the egg and nymph and Péricart (1972) published on it in the western Palearctic. Kelton (1977) first reported *A. pygmaeus* from America north of Mexico from New Brunswick and Nova Scotia and later added Ontario and Prince Edward Island (Kelton 1978). Henry (1988) and Maw et al. (2000) cited these provinces. Scudder and Foottit (2006) reported this species from New Brunswick, Nova Scotia, Ontario, and Prince Edward Island. The species is associated with conifers.

Anthocoris confusus Reuter, 1884 was described from Europe. Procter (1946) first reported this species from North America based on specimens from Maine. Sands (1957) illustrated the egg and nymph and Anderson (1962a) described the bionomics of the species in England. Anderson and Kelton (1963) added Ontario and Tennessee. Péricart (1972) published on the species in the western Palearctic. Kelton (1978) reported the species from Maine, Nova Scotia, Ontario, Prince Edward Island, and Tennessee. Scudder (1986) added British Columbia and Henry (1988) summarized the above cited localities. Barnes et al. (2000) cited Nova Scotia and Maw et al. (2000) listed British

Columbia, Nova Scotia, Ontario. Lattin (2000) discussed the economic aspects of this species in detail and Scudder and Foottit (2006) reported this species from British Columbia, Nova Scotia, Ontario, and Prince Edward Island.

Anthocoris nemoralis (Fabricius 1794) was described from Denmark. Sands (1957) illustrated the egg and nymph and Anderson (1962a) published on this species in England. Anderson and Kelton (1963) first reported it from North America from Ontario. McMullen and Jong (1967) recorded it from British Columbia and McMullen (1971) reported the release of 163 specimens from Switzerland in 1963 into British Columbia. Péricart (1972) provided a review of *A. nemoralis* in Europe. Brunner and Burts (1975) raised *A. nemoralis* in the laboratory in Washington. The initial individuals for this rearing came from British Columbia. Henry (1988) reported *A. nemoralis* from British Columbia and Ontario. Hagen and Driestadt (1990) and Driestadt and Hagen (1994) cited its occurrence in California. Lattin (2000) reviewed the activities of the species and Horton et al. (2004) published a detailed discussion of *A. nemoralis* as a biological control agent, particularly as a predator of the pear psylla. Scudder and Foottit (2006) reported this species from British Columbia and Ontario.

Anthocoris nemorum (Linnaeus 1761) was described from Europe. Hill (1957) studied its biology in Scotland, Sands (1957) illustrated the egg and nymph, and Anderson (1962a) reported on this species in England. Péricart (1972) provided an account in the western Palearctic. Two specimens from Switzerland were introduced into British Columbia in 1963 (McMullen 1971), but it did not become established.

Anthocoris pilosus (Jakovlev 1877) was described from Europe. McMullen (1971) reported ten specimens brought to Canada from Switzerland and released but the species failed to become established (L. Humble, Canada, personal communication). Péricart (1972) published on this species under the name *Anthocoris sibiricus* Reuter (1875). Later, he recognized that two species were involved - *A. pilosus* in the western and *A. sibiricus* in the eastern Palearctic (Péricart 1996).

Macrotrachelia nigronitens (Stål 1860) was described from Brazil (Rio Janeiro). It was reported from Panama by Champion (1900). Davis and Krauss (1966) introduced it into the Hawaiian Islands (as *Macrotrachelia thripiformis*) as a possible biological control agent but it failed to become established (Lattin 2007). Lewis et al. (2005) reported finding specimens at Riverside, California on *Ficus* galls. This was the first record of *M. nigronitens* from America north of Mexico.

Temnostethus gracilis Horváth, 1907 was described from Germany and Péricart (1972) published on it in the western Palearctic. Kelton (1977) first reported it from North America, based on specimens collected in Nova Scotia. No additional localities have been recorded (Kelton 1978; Henry 1988; Maw et al. 2000; Scudder and Foottit 2006).

Tetraphleps abdulghani Ghauri, 1964, was described from Pakistan. It was introduced into America north of Mexico as a possible biological control agent against the balsam woolly aphid (*Adelges piceae* (Ratz)). Mitchell and Wright (1967) reported it as *Tetraphleps* sp. and stated that it had been released in Oregon and Washington. Clark et al. (1971) reported that 4622 individuals were released in Nova Scotia and New Brunswick and 1226 in British Columbia from 1962–1965. They indicated that 1436 individuals were released from cages in New Brunswick from 1962–1965. Clausen (1978) cited its introduction into the Pacific Northwest from

Pakistan and India. L.M. Humble, of Canada (personal communication 2 March 1990) stated that no establishment occurred and R.E. Mitchell, retired from the U.S. Forest Service, indicated per personal communication on 22 June 2001 that none of the introductions into United States were successful. Maw et al. (2000) stated that this species was introduced into Canada but failed to become established.

Tetraphleps raoi Ghauri, 1964, was described from Assam. Mitchell and Wright (1967) reported that it had been introduced into Oregon and Washington. Clark et al. (1971) cited the open release of 118 specimens into Nova Scotia and 2,457 specimens were released from cage and laboratory studies in New Brunswick in 1963 and 1965. Maw et al. (2000) stated that the species did not become established.

DUFOURIELLINI

Amphiareus constrictus (Stål 1860) was described from Brazil (Rio Janeiro). Blatchley (1926) first recorded the species from America north of Mexico based on specimens from Dunedin, Florida. Henry (1988) reported it from Florida and considered it transtropical. Lattin and Lewis (2001) stated that it had been intercepted on shipments of orchids at San Francisco, California, and clarified previous citations.

Brachysteles parvicornis (Costa 1847) was described from Italy. Péricart (1972) reviewed it in the western Palearctic. Asquith and Lattin (1990) published the first record from America north of Mexico based on specimens from New Jersey and New York. Lattin and Asquith (1991) added Massachusetts and Maine and Lattin (1993), Nova Scotia, as did Scudder and Foottit (2006). This small predatory bug feeds on mites on conifers in northeastern Canada and the United States.

Buchananiella continua (White 1880) was described from the island of Madeira. It was first reported from California under the name *Cardiastethus cavicollis* Blatchley, 1934, and later synonymized by Lattin et al. (2001) with *Buchananiella continua*. Péricart (1972) reviewed this species in the western Palearctic. Brenner and Lattin (2001) reported it for the first time from the Hawaiian Islands. Kirby (1999) reported *B. continua* from Great Britain for the first time and Verdcourt (2005) stated that specimens were found in sacks of compost in the same country. Whitehead (2005a, b) subsequently reported the further spread of this species in Britain — invasions still occur!

Cardiastethus luridellus Fieber (1860) was described from Pennsylvania. No further localities were listed until Lattin (1999a) reported it from Michigan where it was collected from clusters of dead oak leaves from fallen trees. Lattin and LaBonte (2002) documented its recovery from baited traps at a site handling raw wood at The Dalles, Oregon in 2000. The same species was recovered at Portland, Oregon, from a similar trap in 2004. *Cardiastethus luridellus* is considered to be a non-indigenous species in Oregon — well removed from its natural range. It is not yet known if the species is free-living in the Portland area or periodically reintroduced.

Dufouriellus ater (Dufour 1833) was described from Europe. Van Duzee (1916) first reported it in America north of Mexico ("E."). Blatchley (1928) listed California and Kentucky and Anderson (1962b) added British Columbia and Idaho. Péricart (1972) discussed this species in the western Palearctic. Kelton (1978) added Ontario and Henry (1988) reported North Carolina and New York. Lattin (2000) discussed *D. ater* and included references to its economic role (e.g., Arbogast 1984, Awadallah et al. 1984). It is taken under the bark of trees but also is associated with stored products.

Physopleurella mundula (White 1877) was described from the Hawaiian Islands (as *Cardiastethus mundulus*). Blatchley (1925) first reported it from America north of Mexico (Florida) (as *Physopleurella floridana* Blatchley), and later recorded it from Jamaica (1928). Blatchley's species was synonymized with *Physopleurella mundulus* (White) by Lattin (2005). Thus far, Florida is the only known site in North America.

ORIINI

Macrotracheliella nigra Parshley (1917) was described from Massachusetts. Anderson (1962b) recorded it from British Columbia. Kelton (1978) reported it from British Columbia, Manitoba, Ontario, Quebec and Nova Scotia. Henry (1988) listed Arkansas, Florida, New Jersey, New York and Rhode Island, and Maw et al. (2000) added New Brunswick. Lewis et al. (2005) found it in Montana and Washington. Paine (1992) cited its occurrence in southern California where it was found feeding on thrips on *Ficus*. It is believed to have been introduced earlier into California as a potential biological control agent against the thrips on *Ficus* (Paine 1992). The occurrence out of its normal range, coupled with the likely deliberate introduction, qualifies the species as nonindigenous in California.

Montandoniola moraguesi (Puton 1896) was described from Spain. Carayon and Remade (1962) published an account of the species in France. Herring (1966a) clarified the name for this predator of the Cuban laurel thrips. Davis and Krauss (1966) introduced this bug from Manila, Philippines, into Oahu, the Hawaiian Islands. It quickly became established as a predator of the thrips on *Ficus* and spread to other islands. Péricart (1972) reviewed it in the western Palearctic. Clausen (1978) reported on its introduction into California from Hawaii in 1966–1967 as a potential predator of the Cuban laurel thrips. According to Paine (1992), it did not become established in that state. Reimer (1988) reported that *M. moraguesi* became a predator on a species of thrips introduced into the Hawaiian Islands to help control an introduced weed, and referred to this condition as biotic interference. Recently, Bennett (1995) reported its accidental occurrence in Florida. The bug had been feeding on thrips of an unwanted *Ficus*. He introduced this bug into Texas as possible thrips control on ornamental *Ficus* in shopping malls! Dobbs and Boyd (2006) have provided a detailed study of the distribution of *Montandoniola moraguesi*, its host thrips and their host plants in the United States (Alabama, Florida, Louisiana and Mississippi). This work establishes an excellent base for future work.

Orius insidiosus (Say) (1832) was described from eastern United States. Kelton (1963) reviewed the genus *Orius* for America north of Mexico. Herring (1966b) revised *Orius* for the Western Hemisphere, and indicated that *O. insidiosus* occurred over much of eastern North America, south through Mexico and Central and South America and onto the West Indies. Henry (1988) reported the species from many provinces and states. This is a common species in many agricultural environments (Lattin 1999b, 2000). Scudder and Foottit (2006) stated that *Orius insidiosus* was introduced from eastern North America into greenhouses in British Columbia to control thrips. While this effort was successful, they reported that some bug individuals have escaped the greenhouses. Thus far, there was no evidence that the species had become established in the wild.

Orius (*Heterorius*) *minutus* (Linnaeus 1758) was described from Europe. Tonks (1953) first reported it from America north of Mexico, based on specimens from southern British Columbia, as did

Downes (1957). Anderson (1962b) recorded it from British Columbia, Oregon and Washington as did Kelton (1963, 1978), Herring (1966b) and Henry (1988). Péricart (1972) treated this species in the western Palearctic and Lattin et al. (1989) reviewed the species in the Pacific Northwest, including biology and illustrations of the adult and nymph. Barnes et al. (2000) cited British Columbia, as did Scudder and Foottit (2006). It has been taken on caneberry vines where it feeds on insects and mites (Lattin et al. 1989).

Paratriphleps laeviuscula Champion, 1900, was described from Panama. It is now known from Honduras (Drake and Harris 1926) (see the discussion by Barber, 1939 on some taxonomic problems with *Paratriphleps*). Bacheler and Baranowski (1975) described the biology of the species where it appeared to feed only on flowers. Hambleton (1944) and Wille (1951) had stated that this was a predaceous species in Peru, but Herring (in Bacheler and Baranowski (1975)) stated that the Peru specimens were not *P. laeviuscula*. Henry (1988) reported it from Puerto Rico, Mexico and Panama, besides Florida and Carpentero et al. (1997) added Nicaragua. Lattin (2006b) deleted records of *P. pallida* (Reuter 1884) from America north of Mexico.

XYLOCORINI

Xylocoris (*Arrostelus*) *flavipes* (Reuter 1875) was described from Algeria. Bibby (1961) first reported it from North America (Arizona). Jay et al. (1968) published on its biology in Georgia as did Awadallah and Tawfik (1972) in Egypt. Péricart (1972) provided an account of the species western Palearctic. Arbogast (1975, 1979) wrote on its biology and Henry (1988) reported *X. flavipes* from Arizona, District of Columbia, Georgia, Kansas, Maryland and Texas besides Africa, Asia, Australia, Europe and South America. Lattin (2000) discussed this species from a world perspective. It is commonly associated with food products, likely explaining its widespread distribution.

Xylocoris (*Proxylocoris*) *galactinus* (Fieber 1837) was described from southern Europe. Van Duzee (1905) first recorded this species from America north of Mexico (New York). Anderson (1962b) reported it from Idaho and Oregon. Carayon (1972) included it in his study of *Xylocoris*, and Péricart (1972) reviewed it in the western Palearctic Region. Henry (1988) reported it from Alberta, British Columbia, California, Florida, Georgia, Idaho, Illinois, Manitoba, Missouri, New Jersey, New York, Ontario, Quebec, and Saskatchewan. Dunkel and Ivie (1994) added Montana where specimens of *X. galactinus* were taken in spilled grain. I have identified this species from Oregon. Lattin (2000) included this species in his review of economically important Anthocoridae. This is clearly a non-indigenous species in our area where it is often taken in stored grain.

Xylocoris (*Proxylocoris*) *sordidus* (Reuter 1871) was described from Brazil and Texas. Champion (1900) reported it from Mexico, British Honduras, Guatemala, Panama, Brazil and the Antilles (Grenada and St. Vincent). Van Duzee (1903) recorded this species based on specimens from New Mexico. Arbogast et al. (1983, 1985) provided biological information on the species in stored peanuts in Georgia. Henry (1988) listed this species from Arizona, California, Florida, Georgia, Kansas, Massachusetts, Maryland, New Jersey, New Mexico, New York, Pennsylvania, South Carolina, Tennessee, and Texas besides its natural range in Mexico, Central and South America, and the West Indies. It is associated with stored foodstuff in the United States.

Xylocoris (*Xylocoris*) *cursitans* (Fallén 1807) was described from Sweden. Van

Duzee (1916) first recorded this species in North America from eastern Canada and United States. Sands (1957) figured the egg and a nymph and Anderson (1962b) recorded it from British Columbia, Idaho, and Oregon. Carayon (1972) included this species in his review of *Xylocoris* and Péricart (1972) provided an account of the species in the western Palearctic. Kelton (1978) reported this species from Alberta, British Columbia, Nova Scotia, Ontario, and Quebec and Henry (1988) added Connecticut, Idaho, Indiana, Michigan, New Jersey, New York, and Oregon. Lattin and Stanton (1992) reported it from Washington. Lattin (2000) discussed *Xylocoris cursitans* and suggested that it may occur naturally in the Nearctic but that it also may have been introduced subsequently in international commerce. It occurs in both fully winged and brachypterous individuals in both regions. It is usually found under the bark of dead trees. I have taken both forms under the bark of old conifer logs in western Oregon.

Xylocoris (*Xylocoris*) *vicarius* (Reuter) (1884) was described from Colombia. Van Duzee (1916) first reported it in North America. Torre-Bueno (1930) indicated that the species was found under bark and Anderson (1962b) recorded it from British Columbia with some hesitation, suggesting that his specimen might be a macropterous adult of *X. cursitans*. Henry (1988) recorded it from Florida, Massachusetts, New Jersey and New York besides South America.

ACKNOWLEDGMENTS

My thanks go to N.H. Anderson, A. Asquith, F.D. Bennett, J. Carayon, T.J. Henry, J.L. Herring, D.R. Horton, L.A. Kelton, J. Péricart, and G.G.E. Scudder for their work on these small predators. Special thanks also go to T.M. Lewis for careful review of the manuscript, to A. Christie for assistance with the literature, and to L. Parks for manuscript preparation.

LITERATURE CITED

Anderson, N. H. 1962a. Bionomics of six species of *Anthocoris* (Heteroptera: Anthocoridae) in England. Transactions of the Royal Entomological Society of London 114(3): 67–95.

———. 1962b. Anthocoridae of the Pacific Northwest with notes on distributions, life histories, and habits (Heteroptera). The Canadian Entomologist 94: 1325–1334.

Anderson, N. H. and L. A. Kelton. 1963. A new species of *Anthocoris* from Canada, with distribution records for three other species (Heteroptera: Anthocoridae). The Canadian Entomologist 95: 439–442.

Arbogast, R. T. 1975. Population growth of *Xylocoris flavipes:* influence of temperature and humidity. Environmental Entomology 4: 825–831.

———. 1979. The biology and impact of the predatory bug *Xylocoris flavipes* (Reuter). Proceedings of the Second International Working Conference on Stored-Product Entomology. Ibadan, Nigeria, September 1978. pp. 91–105.

———. 1984. Demography of the predatory bug *Dufouriellus ater* (Hemiptera: Anthocoridae). Environmental Entomology 13: 990–994.

Arbogast, R. T., B. R. Flaherty, and J. W. Press. 1983. Demography of the predaceous bug *Xylocoris sordidus* (Reuter). American Midland Naturalist 109: 398–405.

Arbogast, R. T., B. R. Flaherty, R. V. Byrd, and J. W. Press. 1985. Developmental stages of *Xylocoris sordidus* (Hemiptera: Anthocoridae). Entomological News 96: 53–58.

Asquith, A. and J. D. Lattin. 1990. *Brachysteles parvicornis* (Costa), a species of Anthocoridae new to North America (Hemiptera: Heteroptera). Journal of the New York Entomological Society 98: 352–356.

Awadallah, K. T. and M. F. S. Tawfik. 1972. The biology of *Xylocoris* (= *Piezostethus*) *flavipes* (Reut.) (Hemiptera: Anthocoridae). Bulletin de la Société Entomologique d'Égypte 56: 177–189.

Awadallah, K. T., M. F. S. Tawfik, N. Abou-Zeid, and M. M. El-Husseini. 1984. The life history of *Dufouriellus ater* (Duf.) (Hemiptera: Anthocoridae). Bulletin de la Société Entomologique d'Égypte 63: 191–197.

Bacheler, J. S. and R. M. Baranowski. 1975. *Paratriphleps laeviusculus,* a phytophagous anthocorid new to the United States (Hemiptera: Anthocoridae). Florida Entomologist 58: 157–163.

Barber, H. G. 1939. Insects of Porto Rico and the Virgin Islands. New York Academy of Sciences 14: 263–441.

Barnes, D. I., H. E. Maw, and G. G. E. Scudder. 2000. Early records of alien species of Heteroptera (Hemiptera: Prosorrhyncha) in Canada. Journal of the Entomological Society of British Columbia 97: 95–102.

Bennett, F. D. 1995. *Montandoniola moraguesi* (Hemiptera: Anthocoridae), a new immigrant to Florida: Friend or foe? Vedalia 2: 3–6.

Bibby, F. F. 1961. Notes on miscellaneous insects of Arizona. Journal of Economic Entomology 54: 324–333.

Blatchley, W. S. 1925. Some additional new species of Heteroptera from the southern United States, with characterization of a new genus. Entomological News 36: 45–52.

———. 1926. Heteroptera or True Bugs of Eastern North America with Especial Reference to the Faunas of Indiana and Florida. Nature Publishing Company, Indianapolis. 1116 pp.

———. 1928. Notes on the Heteroptera of eastern North America with descriptions of new species. 1. Journal of the New York Entomological Society 36: 1–23.

———. 1934. Notes on collection of Heteroptera taken in winter in vicinity of Los Angeles, California. Transactions of the American Entomological Society 60: 1–16.

Brenner, G. J. and J. D. Lattin. 2001. Notes on three species of Anthocoridae (Hemiptera: Heteroptera) from Hawaii, including the first record of *Buchananiella continua* (White). Proceedings of the Entomological Society of Washington 103: 386–388.

Brunner, J. F. and E. C. Burts. 1975. Searching behavior and growth rates of *Anthocoris nemoralis* (Hemiptera: Anthocoridae). Annals of the Entomological Society of America 68: 311–315.

Carayon, J. 1972. Le genre *Xylocoris*: Subdivision et espècies nouvelles (Hem. Anthocoridae). Annales de la Société Entomologique France (N.S.) 8: 579–606.

Carayon, J. and F. Remade. 1962. Note sur la présence en France et en Italie de *Montandoniola moraguesi* (Puton) avec quelques observations sur cet Hétéroptère Anthocoridé. Bulletin de la Société Entomologique de France 67: 207–211.

Carpintero, D. L., J. M. Maes, and M. D. del Coscaron. 1997. Catalogo de los Anthocoridae (Heteroptera) de Nicaragua. Revista Nicaraguensis de Entomologia 41: 23–28.

Champion, G. C. 1897–1901. Insecta: Rhynchota (Hemiptera - Heteroptera). Vol. II. *In* Godman and Salvin, eds. Biologica Centrali-Americana. London, 1900: pp. 305–344.

Clark, R. G., D. O. Greenbank, D. G. Bryant, and J. W. E. Harris. 1971. 36. *Adelges picae* (Ratz.) Balsam woolly aphid (Homoptera: Adelgidae), pp. 113–127. *In* Biological control programmes against insects and weeds in Canada 1959–1968. Technical Communication No. 4. Commonwealth Institute of Biological Control, Trinidad. 266 pp.

Clausen, C. P. 1978. Chermidae, pp. 49–55. *In* Clausen, C. P., ed. Introduced parasites and predators of arthropod pests and weeds: A world review. U.S.Department of Agriculture, Agricultural Research Service, Agriculture Handbook No. 480. 545 pp.

Coombs, E. M., J. K. Clark, G. L. Piper, and A. F. Coffrancesco, Jr., eds. 2004. Biological Control of Invasive Plants in the United States. Oregon State University Press, Corvallis. 467 pp.

Costa, A. 1847. Cimicum regni Neapolitant centuria secunda, decas prima, secunda, tertia, quatra et quinta. Napoli. 43 pp.

Cox, G. W. 1999. Alien Species in North America and Hawaii: Impacts on Natural Ecosystems. Island Press, Washington, D.C. 387 pp.

———. 2004. Alien Species and Evolution. Island Press, Washington, D.C. 377 pp.

Dallas, W. S. 1851–1852. List of the specimens of Hemipterous insects in the collection of the British Museum. Taylor and Frances Incorporated, London 1851: 1–368, plates 1–11: 2: 369–592, plates 12–15.

Davis, C. J. and N. L. H. Krauss. 1966. Recent introductions for biological control in Hawaii - XI. Proceedings, Hawaiian Entomological Society 19: 201–207.

Devine, R. S. 1998. Alien Invasion. National Geographic. Washington, D.C. 280 pp.

Dobbs, T. T. and D. W. Boyd, Jr. 2006. Status and distribution of *Montandoniola moragesi* (Hemiptera: Anthocoridae) in the continental United States. Florida Entomologist 89: 41–46.

Downes, W. 1957. Notes on some Hemiptera which have been introduced into British Columbia. Proceedings of the Entomological Society of British Columbia 54: 11–13.

Drake, C. J. and H. M. Harris. 1926. Notes on American Anthocoridae with descriptions of new forms. Proceedings of the Biological Society of Washington 39: 33–46.

Dreistadt, S. H. and K. S. Hagen. 1994. Classical biological control of the Acacia psyllid, *Achizzia uncatoides* (Homoptera: Psyllidae) and predator-prey-plant interactions in the San Francisco Bay Area. Biological Control 4: 319–327.

Dufour, L. 1833. Memoire sur les genres *Xylocoris*, *Leptopus* et *Velia*. Annales de la Société Entomologique de France 2: 104–118, 1 plate.

Dunkle, F. V. and M. A. Ivie. 1994. *Xylocoris galactinus* (Fieber) (Hemiptera: Anthocoridae) newly discovered in Montana stored grain. Pan-Pacific Entomologist 70: 327–328.

Elton, C. S. 1958. The Ecology of Invasions by Animals and Plants. Methuen and Company, LTD, London. 181 pp.

Fabricius, J. C. 1794. Entomologia systematica emendata et aucta, sucundum classes, ordines, genera, species, adjectis synonymis, loci, observationibus. C.G. Proft, Hafniae 4: i–vi, 1–472.

Fallén, C. F. 1807. Monographia Cimicum Sveciae. Apud C.G. Proft, Hafniae. 123 pp.

Fieber, F. X. 1836–1837. Beiträg zur Kenntnis der Schnabelkerfe (Rhychota). *In* Beiträge zur gesammten Natur-und Heilwissenschaft (Weilenweber, W.R.). Barth, Prague, 1(1) 1836: pp. 97–111: 1837: pp. 337–355.

———. 1860. Exegesen in Hemiptera. Wiener Entomologische Monatschrift 4: 257–272.

Ghauri, M. S. K. 1964. Notes on the Hemiptera from Pakistan and adjoining areas. Annals and Magazine of Natural History (13)7: 673–688.

Hagen, K. S. and S. H. Driestadt. 1990. First California record for *Anthocoris nemoralis* (Fabr.) (Hemiptera: Anthocoridae), a predator important in the biological control of psyllids (Homoptera: Psyllidae). Pan-Pacific Entomologist 66: 323–324.

Hambleton, E. J. 1944. *Heliothis virescens* as a pest of cotton, with notes on host plants in Peru. Journal of Economic Entomology 37: 660–666.

Henry, T. J. 1988. Family Anthocoridae, pp. 12–28. *In* Henry, T. J. and R. C. Froeschner, eds. Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States. E.J. Brill, Leiden. 958 pp.

Herring, J. L. 1966a. The correct name for an anthocorid predator of the Cuban laurel thrips (Hemiptera: Anthocoridae). Proceedings of the Entomological Society of Washington 68: 93.

———. 1966b. The genus *Orius* of the Western Hemisphere (Hemiptera: Anthocoridae). Annals of the Entomological Society of America 59: 1093–1109.

Hill, A. R. 1957. The biology of *Anthocoris nemorum* (L.) in Scotland (Hemiptera: Anthocoridae). Transactions of the Royal Entomological Society, London 109: 379–394.

Horton, D. R., T. M. Lewis, and D. A. Broers. 2004. Ecological and geographic range expansion of the introduced predator *Anthocoris nemoralis* (Heteroptera: Anthocoridae) in North America: Potential for non-target effects? American Entomologist 50: 18–30.

Horváth, G. 1907. Hemiptera nova minus cognita e regione palaearctica. Annales Historico-Naturales Musei Nationalis Hungarici 5: 289–323.

Jakovlev, V. E. 1877. True bugs (Heteroptera: Heteroptera) of northern Persia. Trudy Russkogo Entomologicheskogo Obshchestva 10: 67–98. (in Russian and German).

Jay, E., R. Davis, and S. Brown. 1968. Studies on the predaceous habits of *Xylocoris flavipes* (Reuter) (Hemiptera: Anthocoridae). Journal of the Georgia Entomological Society 3: 126–130.

Kelton, L. A. 1963. Synopsis of the genus *Orius* Wolff in America north of Mexico (Heteroptera: Anthocoridae). The Canadian Entomologist 95: 631–636.

———. 1967. Synopsis of the genus *Lyctocoris* in North America and description of a new species from Quebec (Heteroptera: Anthocoridae). The Canadian Entomologist 99: 807–814.

———. 1977. New species of *Cardiastethus* Fieber and *Melanocoris* Champion, and new records of European *Acompocoris* Reuter and *Temnostethus* Fieber in Canada (Heteroptera: Anthocoridae). The Canadian Entomologist 109: 243–248.

———. 1978. The insects and arachnids of Canada. Part 4. The Anthocoridae of Canada and Alaska. Heteroptera: Anthocoridae. Research Branch, Canada Department of Agriculture, Publication 1639. 101 pp.

Kirby, P. 1999. *Buchananiella continua* (B. White). (Hemiptera: Anthocoridae) established in Britain. British Journal of Entomology and Natural History 12: 221–223.

Kirkaldy, G. W. 1902. Hemiptera. Fauna Hawaiiensis 3: 93–174, plates iv–v.

Lattin, J. D. 1993. *Brachysteles parvicornis* (Costa), an Anthocoridae new to Canada (Hemiptera: Heteroptera). The Canadian Entomologist 125: 965–966.

———. 1999a. Dead leaf clusters as habitats for adult *Calliodis temnostethoides* and *Cardiastethus luridellus* and other anthocorids (Hemiptera: Heteroptera: Anthocoridae). Great Lakes Entomologist 32: 33–38.

———. 1999b. Bionomics of the Anthocoridae. Annual Review of Entomology 44: 207–31.

———. 2000. Minute pirate bugs (Anthocoridae), pp. 607–637. *In* Schaefer, C. W. and A. R. Panizzi, eds. Heteroptera of Economic Importance. CRC Press, Boca Raton. 828 pp.

———. 2005. *Physopleurella floridana* Blatchley, 1925, a synonym of *Physopleurella mundula* (White, 1877) (Hemiptera: Heteroptera: Cimicoidea: Anthocoridae). Proceedings of the Entomological Society of Washington 107: 460–462.

———. 2006a. *Nesidiocheilus hawaiiensis* Kirkaldy, 1902, a synonym of *Acanthia campestris* Fabricius, 1794 (Hemiptera: Heteroptera: Lyctocoridae). Proceedings of the Entomological Society of Washington 108: 240.

———. 2006b. Deletion of *Paratriphleps pallida* (Reuter) from the United States fauna (Hemiptera: Heteroptera: Anthocoridae). Proceedings of the Entomological Society of Washington 108: 477–478.

———. 2007. The Lasiochilidae, Lyctocoridae and Anthocoridae (Hemiptera: Heteroptera) of the Hawaiian Islands: Native or Introduced? Proceedings of the Entomological Society of Washington 109: 75–80.

Lattin, J. D. and A. Asquith. 1991. Contemporary records of *Brachysteles parvicornis* (Costa) in the United States (Hemiptera: Heteroptera). Journal of the New York Entomological Society 99: 240–241.

Lattin, J. D., A. Asquith, and S. Booth. 1989. *Orius minutus* (Linnaeus) in North America (Hemiptera: Heteroptera: Anthocoridae). Journal of the New York Entomological Society 97: 409–416.

Lattin, J. D. and J. R. LaBonte. 2002. *Cardiastethus luridellus* Fieber (Hemiptera: Heteroptera: Anthocoridae), a non-indigenous anthocorid in Oregon. Proceedings of the Entomological Society of Washington 104: 1064–1065.

Lattin, J. D. and T. M. Lewis. 2001. *Amphiareus constrictus* (Stål) (Hemiptera: Heteroptera: Anthocoridae) from California: Clarification of previous record and citation. Proceedings of the Entomological Society of Washington 103: 334–338.

Lattin, J. D., T. M. Lewis, and D. R. Horton. 2001. *Buchananiella continua* (White) from California with new synonymy (Hemiptera: Heteroptera: Anthocoridae). Proceedings of the Entomological Society of Washington 103: 558–560.

Lattin, J. D. and N. L. Stanton. 1992. A review of the species of Anthocoridae (Hemiptera: Heteroptera) found on *Pinus contorta*. Journal of the New York Entomological Society 100: 424–479.

Lewis, T. M., D. R. Horton, and D. A. Broers. 2005. New United States records for Anthocoridae (Hemiptera: Heteroptera). Pan-Pacific Entomologist 81(1–2): 59–67.

Linnaeus, C. 1758. Systema naturae per regna tria naturae, secunctum classes, ordines, genera, species, cum characteribus differentiis, synonymus locis. Editio decima reformata. Laurentii Salvii, Holmiae I: 1–823, i–iii. (Hemiptera pp. 434–457).

———. 1761. Fauna Svecica sistems animalia Sveciae regni. 578 pp.

Maw, H. E. L., R. G. Foottit, K. G. A. Hamilton, and G. G. E. Scudder. 2000. Checklist of the Hemiptera of Canada and Alaska. N.R.C. Research Press, Ottawa, Canada. 220 pp.

McMullen, R. D. 1971. 16. *Psylla pyricola* Föster, pear psylla (Hemiptera: Psyllidae), pp. 33–38. *In* Biological Control programmes against insects and weeds in Canada 1959–1968. Commonwealth Institute of Biological Control, Trinidad, Technical Communication No. 4. 266 pp.

McMullen, R. D. and C. Jong. 1967. New records and discussion of predators on the pear psylla, *Psylla pyricola* Förster, in British Columbia. Journal of the Entomological Society of British Columbia 64: 35–40.

Mitchell, R. G. and K. H. Wright. 1967. Foreign predator introductions for control of the balsam woolly aphid in the Pacific Northwest. Journal of Economic Entomology 60: 142–147.

Mooney, H. A. and J. A. Drake, eds. 1984. Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag, New York. 321 pp.

Mooney, H. A. and R. J. Hobbs. 2000. Invasive Species in a Changing World. Island Press, Washington, D.C. 457 pp.

Mooney, H. A., R. N. Mack, J. A. McNeely, L. E. Neville, P. J. Schei, and J. K. Waage, eds. 2005. Invasive Alien Species. Scope 63, Island Press, Washington. 368 pp.

Paine, T. D. 1992. Cuban laural thrips (Thysanoptera: Phlaeothripidae) biology in southern California: Seasonal abundance, temperature dependent development, leaf suitability and predation. Annals of the Entomological Society of America 85: 164–172.

Parshley, H. M. 1917. A species of *Macrotracheliella* found in New England (Hemip. Anthocoridae). Entomological News 28: 37–38.

Parsons, P. A. 1983. The Evolutionary Biology of Colonizing Species. Cambridge University Press, Cambridge. 262 pp.

Péricart, J. 1972. Faune de l'Europe et du Bassin Méditerréen. No. 7. Hémiptères Anthocoridae, Cimicidae et Microphysidae de l'Ouest - Paléarctique. Masson et C^ie^ Editeurs, Paris, France. 402 pp.

———. 1996. Family Anthocoridae Fieber, 1836, pp. 108–140. *In* Aukema, B. and C. Rieger, eds. Catalogue of the Heteroptera of the Palearctic Region. Volume 2. Cimicomorpha 1. 361 pp. Netherlands Entomological Society, Amsterdam, The Netherlands.

Procter, W. 1946. Biological survey of the Mount Desert Region. Part VII. The Insect Fauna. Wistar Institute of Anatomy and Biology, Philadelphia. 566 pp. (Hemiptera: Heteroptera pp. 66–83).

Puton, A. 1896. Hémiptères nouveaux. Revue d' Entomologie 15: 233–234.

Reimer, N. J. 1988. Predation of *Lithothrips urichi* Karney (Thysanoptera: Phlaeothripidae) a case of biotic interference. Environmental Entomology 17: 132–134.

Reuter, O. M. 1871. Acanthiidae americanae, descriptae. Öfversight af Kongliga Svenska Vetenskaps - Akademiens Förhandlinger 28: 557–567. Pl.7.

———. 1875. Genera Cimicadarum Europe. Bihang till Kongliga Svenska Vetenskaps - Akademiens Handlingar 3: 1–66.

———. 1884. Monographia Anthocoridarum Orbis Terrestris. 1–204. Helsingforsiae (also Acta Societatis Scientiarum Fennicae 14(1885): 555–758.

Ruiz, G. M. and J. T. Carlton, eds. 2003. Invasive Species. Island Press, Washington, D.C. 518 pp.

Sands, W. A. 1957. The immature stages of some British Anthocoridae (Hemiptera). Transactions of the Royal Entomological Society of London 109: 295–310, 5 figs.

Say, T. 1832. Descriptions of new species of heteropterous Hemiptera of North America. New Harmony, Indiana. 30 pp.

Schuh, R. T. and J. A. Slater. 1995. True bugs of the world (Hemiptera: Heteroptera): Classification and natural history. Comstock Publishing Associates, Cornell University Press, Ithaca and London. 336 pp.

Schuh, R. T. and P. Štys. 1991. Phylogenetic analysis of cimicomorphan family relationships (Heteroptera). Journal of the New York Entomological Society 99: 298–350.

Scudder, G. G. E. 1986. Additional Heteroptera new to British Columbia. Journal of the Entomological Society of British Columbia 83: 63–65.

Scudder, G. G. E. and R. G. Foottit. 2006. Alien true bugs (Hemiptera: Heteroptera) in Canada: Composition and adaptations. The Canadian Entomologist 138: 24–51.

Simberloff, D., D. C. Schmitz, and T. C. Brown, eds. 1997. Strangers in Paradise. Island Press, Washington, D.C. 467 pp.

Stål, C. 1860–1862. Bidrag till Rio Janeiro trakens Hemipter-fauna. Kongliga Svenska Vetenskaps - Akademiens Handlingar 2(7): 1–84 (1860): 3(6): 1–75 (1862).

Stanaway, M. A., M. P. Zalucki, P. S. Gillespie, C. M. Rodriguez, and G. V. Maynard. 2001. Pest risk assessment of insects in sea cargo containers. Australian Journal of Entomology 40: 180–192.

Tonks, N. V. 1953. Annotated list of insects and mites collected on brambles in the lower Frazer Valley, British Columbia, 1951. Proceedings of The Entomological Society of British Columbia 49: 27–28.

Torre-Bueno, J. R. de la. 1930. Records of Anthocoridae, particularly in New York. Bulletin of the Brooklyn Entomological Society 25: 11–20.

U.S. Congress, Office of Technology Assessment. 1993. Harmful non-indigenous species in the United States, OTA-F-565. Washington, D.C. 391 pp.

Van Duzee, E. P. 1903. Hemiptera of Beulah, New Mexico. Transactions of the American Entomological Society 29: 107–113.

———. 1905. Hemiptera taken in the Adirondack Mountains. New York State Museum Bulletin 97: 546–556.

———. 1916. Checklist of the Hemiptera (excepting the Aphididae, Aleurodidae and Coccidae) of America, North of Mexico. New York Entomological Society, New York. 111 pp.

Verdcourt, B. 2005. Some insects breeding in plastic compost sacks. Entomologist's Monthly Magazine 141: 124.

White, F. B. 1877. Descriptions of new species of heteropterous Hemiptera collected in the Hawaiian Islands by the Rev. T. Blackburn. No. 1. Annals and Magazine of Natural History (4)5: 110–114.

———. 1879–1880. Descriptions of new Anthocoridae. Entomologist's Monthly Magazine 16: 142–148.

Whitehead, P. F. 2005a. *Buchananiella continua* (Buchanan White, 1880) (Hem., Anthocoridae) new to Worcestershire (VC37) and Yorkshire (VC61). Entomologist's Monthly Magazine 141: 166.

———. 2005b. Observations on the invertebrate coenoses of cypress trees in cultivation (Cupressaceae). Entomologist's Monthly Magazine 141: 248.

Wille, J. E. 1951. Biological control of certain cotton insects and the application of new organic insecticides in Peru. Journal of Economic Entomology 44: 13–18.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 377–384

TWO NEW SPECIES OF *LARICOBIUS* (COLEOPTERA: DERODONTIDAE) FROM CHINA, AND A KEY TO *LARICOBIUS* IN THE SOUTHEASTERN PALAEARCTIC

G. M. G. Zilahi-Balogh, J. Jelínek, T. J. McAvoy, S. M. Salom, and L. T. Kok

(GMGZ, TJM, SMS, LTK) Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0319, U.S.A. (GMGZ e-mail: zilahibaloghg@inspection.gc.ca); (JJ) Department of Entomology, National Museum, Golčova 1, CZ-148 00 Prague 4-Kunratice, Czech Republic. GMGZ current address: Canadian Food Inspection Agency, 1905 Kent Road, Kelowna, BC, V1Y 7S6 Canada

Abstract.—***Laricobius baoxingensis*** **Zilahi-Balogh and Jelínek, n. sp.**, and ***Laricobius kangdingensis*** **Zilani-Balogh and Jelínek, n. sp.**, are described from Sichuan Province, China, and the Himalayas. They are compared with other species of the genus from China and a key is provided for the southeastern Palaearctic species. Both species are associated with adelgids of the genus *Adelges* on *Tsuga chinensis*.

Key Words: *Adelges*, description, taxonomy, *Tsuga*

Laricobius Rosenhauer is one of four genera in Derodontidae that occupies cooler temperate regions of both the Northern and Southern hemispheres (Lawrence 1989). Members of this genus are known to be adelgid specialists (Hemiptera: Adelgidae), while the other three genera are mycophagous. (Lawrence and Hlavac 1979, Lawrence 1989). Nine species of *Laricobius* have been described from the Palaearctic and Nearctic regions. Only two species, *Laricobius erichsonii* Rosenhauer and *L. nigrinus* Fender have been studied in any detail as part of larger investigations evaluating their suitability in biological control of *Adelges piceae* Ratzeburg (Clark and Brown 1958; Franz 1958a, b; Brown and Clark 1962) and *Adelges tsugae* Annand (Zilahi-Balogh et al. 2002, 2003a, b, c).

Adelges tsugae is an introduced and destructive pest of *Tsuga canadensis* (L.) Carrière and *T. caroliniana* Engelmann in the eastern United States (McClure and Cheah 1999). A large-scale effort in classical biological control of *A. tsugae* has been on-going since the mid-1990s (Salom et al. 2001). Because of the specialized feeding habit of *Laricobius* on adelgids, an expedition was undertaken in April 2002 to southwestern China, the native range of *A. tsugae*, to survey and collect *Laricobius* and other predators from regions where *Tsuga* naturally occurs. Collected material was returned to the United States alive and evaluated for suitability as biological control agents of *A. tsugae* under quarantine at the Beneficial Insect Laboratory, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Subsequent to Lawrence and Hlavac's (1979) review of the Derodontidae, several new species have been described. These include: *L. kovallevi* Nikitsky and

Figs. 1–2. Pronota. 1, *Laricobius baoxingensis*. 2, *L. kangdingensis*. Scale bars = 0.5 mm.

L. minutus Nikitsky, from Siberia (Nikitsky and Lafer 1992); *L. loebli* Jelínek and Háva (Jelínek and Háva 2001) and *L. schawalleri* Háva and Jelínek from Nepal (Háva and Jelínek 2000); and one species, *L. mirabilis* Háva and Jelínek from China (Háva and Jelínek 1999).

We describe two new species, *L. baoxingensis* and *L. kangdingensis* collected from adelgid-infested *T. chinensis* (Franchet) Pritzel from southwestern China. Biological and habitat information are included as well as a key to *Laricobius* species from the southeastern Palaearctic. Described specimens were compared with *L. erichsonii, L. nigrinus*, and *L. rubidus* Le Conte by GZB and with *L. loebli, L. schawalleri*, and *L. mirabilis* by JJ.

KEY TO SOUTHEASTERN PALAEARCTIC *LARICOBIUS*

1 Sides of pronotum emarginate posterad to anterior angles 2

– Sides of pronotum not emarginate posterad to anterior angles (Figs. 1–2) 3

2 Pronotum with small distinct subrectangular to obtuse posterior angles. Elytra less than 1.5× longer than their combined width 4

– Posterior angles of pronotum indistinct, anterior ones acutely projecting laterally (see fig. 6 in Jelínek and Háva 2001). Elytra 1.53–1.55× longer than their combined width. Red brown with brown yellow appendages, coloration possibly variable. Length 3.0–3.2 mm, width 1.3–1.5 mm. China . . . . . ***L. mirabilis*** Háva and Jelínek

3 Pronotum, 1.32–1.36× wider than long, more strongly narrowed posteriorly than anteriorly, sides of pronotum distinctly emarginate anterad to posterior angles (Fig. 1). First complete elytral stria deeply incised and impunctate in apical one-third. Dark red brown. Head pitchy black. Length 2.5–2.6 mm, width 1.1–1.2 mm. Southwestern China . . . . ***L. baoxingensis***, n. sp.

– Pronotum 1.21–1.25× wider than long, equally narrowed both anteriorly and posteriorly, sides of pronotum hardly emarginate anterad to posterior angles (Fig. 2). First complete elytral stria shallow and distinctly punctate in apical one-third. Yellow brown to piceous. Head and pronotum dark brown to black. Length 2.1–2.4 mm, width 1.0–1.1 mm. Southwestern China . . . . ***L. kangdingensis***, n. sp.

4 Pronotum narrower, less than 1.2× wider than long. Lateral margins of pronotum regularly outcurved in median portion, equally converging both anteriorly and posteriorly (see fig. 4 in Jelínek and Háva 2001). Elytra 1.33× longer than their combined width. Black; appendages brown yellow; femora at least partly black. Length 2.4 mm, width 1.2 mm. Nepal . . . . ***L. loebli*** Jelínek and Háva

– Pronotum wider, more than 1.2× wider than long. Lateral margins of elytra asymmetrically outcurved in median portion, more strongly converging anteriorly than posteriorly (see fig. 2 in Jelínek and Háva 2001). Elytra 1.44× longer than their combined width. Brown yellow; elytra black, suture behind transverse impression and subtriangular apical area brown yel-

Table 1. Characters differentiating *Laricobius baoxingensis* and *Laricobius kangdingensis.*

Laricobius baoxingensis (Fig. 4)	*Laricobius kangdingensis* (Fig. 5)
Pronotum strongly transverse, 1.32–1.36× wider than long, and more strongly narrowed posteriorly, P/A index (ratio distance between posterior angles : distance between anterior angles) 0.88–0.93; sides anterad to posterior angles distinctly concave.	Pronotum less transverse, 1.21–1.25× wider than long, almost equally narrowed both anteriorly and posteriorly, P/A index 0.95–1.07; sides anterad to posterior angles almost rectilinear, at most feebly concave.
Sides of pronotum narrowly explanate, nearly as wide as antennal flagellum.	Sides of pronotum only narrowly bordered, not explanate.
Elytra comparatively shorter, 1.51–1.52× longer than combined width.	Elytra comparatively longer, 1.58–1.65× longer than combined width.
First complete elytral series of punctures in apical portion deeply incised as continuous furrow with indistinct and widely spaced punctures.	First complete elytral series of punctures in apical portion shallowly impressed, with normally developed punctures.

low; appendages brown yellow. Length 2.3 mm, width 1.1 mm. Nepal . . . . *L. schawalleri* Háva and Jelínek

Laricobius baoxingensis Zilahi-Balogh and Jelínek, new species

(Figs. 1, 4)

Diagnosis.—*Laricobius baoxingensis* differs from *L. mirabilis* Háva and Jelínek (1999) especially in the shape of pronotum, which is markedly more transverse and less strongly convex than in *L. mirabilis* (width : length ratio 1.32–1.36 in *L. baoxingensis*, 1.22–1.24 in *L. mirabilis*), with obtuse and not prominent anterior angles (acutely projecting laterally in *L. mirabilis*) and with small but distinctly developed subrectangular posterior angles (indistinct in *L. mirabilis*). Both anterior and posterior pronotal angles are similarly developed in another sympatric species, *L. kangdingensis* (see Table 1 for distinguishing characteristics). In the key to the *Laricobius* species of the Himalaya and China (Jelínek and Háva 2001) *Laricobius baoxingensis* sp. n. agrees with the Himalayan species *L. schawalleri* Háva and Jelínek (2000) and *L. loebli* Jelínek and Háva (2001) in having distinct posterior pronotal angles, but differs from them in having comparatively longer elytra, 1.5× longer than their combined width; it shares the latter character with *L. mirabilis*. However, *L. baoxingensis* sp. n. differs from all species mentioned above in the lack of the constriction (emargination) behind the anterior pronotal corners (see figs. 4–6 in Jelínek and Háva 2001).

Description.—Holotype, female. Body oblong oval, dark red brown. Head, scutellum, scape, ventral surface including elytral epipleura and femora pitchy black, tibiae black brown. Pubescence semierect, red-orange. Length 2.5 mm, width 1.2 mm.

Head: Across eyes narrower than anterior margin of pronotum. Eyes somewhat asymmetrically vaulted dorsally before midlength (dorsal view), finely facetted. Temples almost indistinct. Frons flat with a few large pit-shaped punctures irregularly dispersed, sparsely punctate between large punctures; punctures on clypeus and anterior corners of eyes almost as large as eye facets, separated by one diameter or less of width of eye facet.

Antenna: Nearly as long as anterior pronotal margin; antennomeres 3–5 subequal, longer than wide, antennomeres 6–8 subequal, nearly as long as wide.

Pronotum (Fig. 1): Transverse, widest at its midlength, 1.36× wider than long. Anterior margin subtruncate, anterior angles blunt, not prominent, posterior ones small, subrectangular, protuberant, situated at three-fourths of pronotum length. Lateral margins in anterior portion almost rectilinear, moderately diverging posteriorly, abruptly arcuately curved in median portion and more strongly converging posteriorly, arcuately emarginate before posterior angles. Basal margin arcuate, bordered by deep furrow with series of large punctures separated by less than one diameter puncture width. Disc of pronotum broadly transversely convex, sides with low and broad lateral bulge at midlength, deeply impressed anterior and posterior to bulge. Lateral margins with explanate border almost as wide as antennal flagellum. Pronotal disc with irregularly dispersed large pit-shaped punctures equal to those on frons, interspaces uneven, sparsely and finely, in posterior half indistinctly, punctate. Lateral bulges densely finely punctate. Scutellum small, rounded, finely and densely pubescent.

Elytra: 3.2× longer than pronotum, widest behind midlength, 1.53× longer than combined width and reaching maximum length at suture. Surface seriate-punctate, transversely convex with median portions of lateral margins not visible simultaneously from above, transversely impressed at basal one-fourth. Suture depressed before transverse impression, raised and roof-shaped posteriorly. First (scutellar) stria reaching only to transverse impression. Punctures of each stria separated by nearly one diameter, first complete stria in apical one-third deeply incised as continuous furrow with indistinct and widely spaced punctures smaller than preceding ones. Interstriae (at least 1–4) wider than striae, apparently smooth except for median portion of sutural interstriae, which is distinctly punctate.

Variation.—Body length 2.5–2.6 mm, width 1.1–1.2 mm. Pronotum 1.32–1.36× wider than long.

Types.—Holotype, ♀ China, Sichuan province, Niba Gao Forestry Station (Lat./Long.: 30°41′13″N/102°41′44″E); elevation 2560 m; near Qiagi village, Baoxing county; collected 5–8 April 2002 by TJM and GMG Zilahi-Balogh. Paratypes: 4 ♀, same data as holotype. Holotype and 1 paratype deposited in Institute of Zoology, Academia Sinica (IZAS), Insect Collection, 19 Zhongguancun Lu, Haidian, Beijing, 100080, China; 1 paratype deposited in Czech National Museum (Natural History) (NMPC), Department of Entomology, Kunratice 1, Prague 4, 148 00, Czech Republic, and 1 paratype is deposited in National Museum of Natural History, Smithsonian Institution (NMNH), Washington, DC, USA.

Etymology.—Named after Baoxing, the county in Sichuan province, China, where the type series was collected.

Distribution.—China: Sichuan Province.

Host.—Adults collected in association with *Adelges* (Adelgidae) on *Tsuga chinensis* (Franchet) Pritzel.

Habitat.—Mixed evergreen broadleaf forest; elevation 2600–2900 m, northern aspect; secondary forest; species composition 50% *Picea* sp., 24% *Abies* sp., 18% *Tsuga chinensis*, 5% *Larix potanini* Batalin, 3% *Betula* sp.; understory 40% bamboo, 5% *Rhododendron* sp.

Laricobius kangdingensis **Zilahi-Balogh and Jelínek, new species**

(Figs. 2–3, 5)

Diagnosis.—With obtuse anterior and distinct posterior pronotal angles, sides of pronotum not emarginate behind anterior angles and comparatively long elytra. *Laricobius kangdingensis* is similar

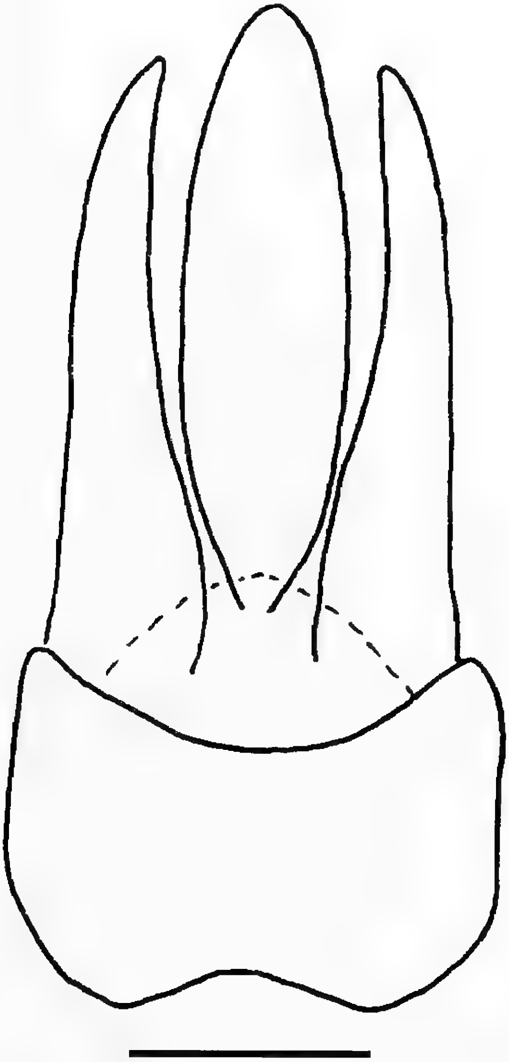


Fig. 3. Aedeagus of *Laricobius kangdingensis*. Scale bar = 0.1 mm.

to *L. Baoxingensis*, but the two species differ in the characters given in Table 1.

Description.—Holotype, male. Body ovate, convex. Head, scutellum, scape, ventral surface, legs, and pronotum black, elytra, rest of antenna and tarsi dark yellow brown. Pubescence erect, tan. Length 2.3 mm, width 1.0 mm.

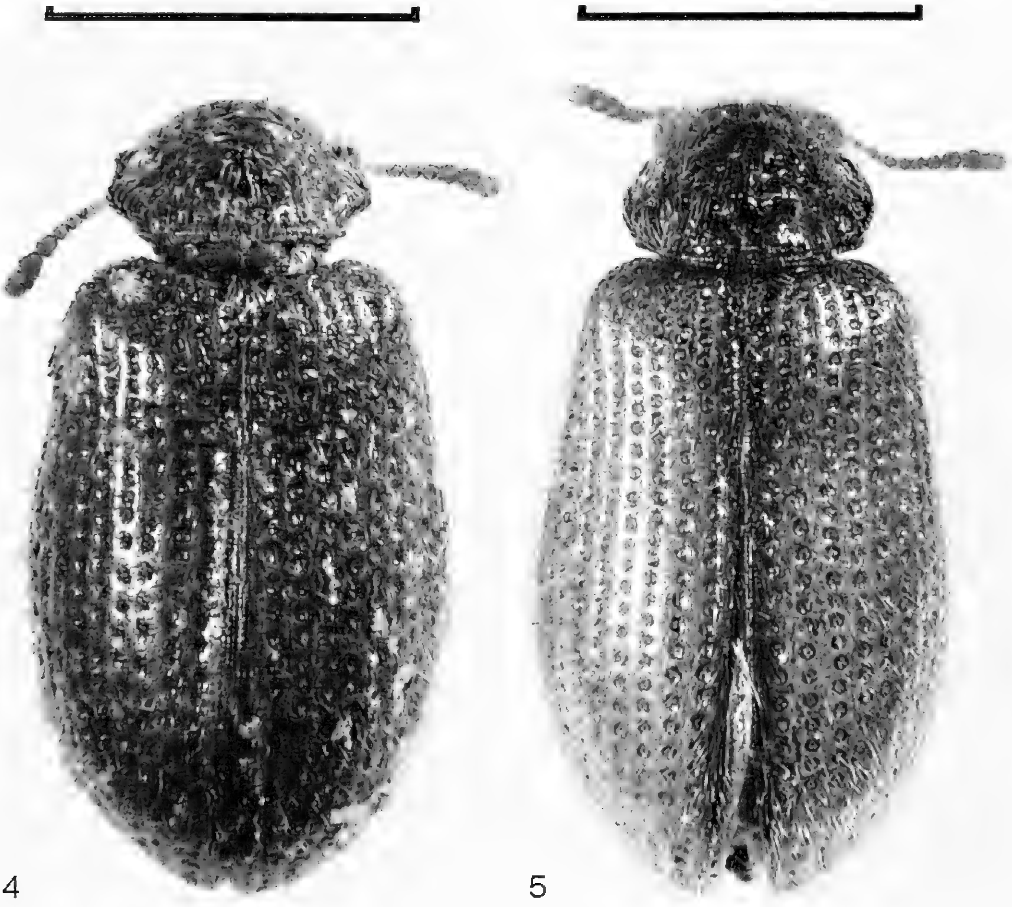
Head: Across eyes narrower than anterior margin of pronotum. Eyes regularly convex. Frons flat with a few deep and large pit-shaped punctures irregularly dispersed besides eyes and on vertex. Median portion flatly vaulted, sparsely and finely punctate, separated from clypeus by arcuate transverse impression. Clypeus densely finely punctate, punctures fairly equal in size to eye facets and separated by one eye facet diameter or less.

Antenna: Nearly as long as width of pronotum; antennomeres 4 and 5 subequal, longer than wide; 6 and 7 subequal, longer than wide, but shorter than preceding ones; 8, nearly as long as wide.

Pronotum (Fig. 2): Transverse, widest at midlength, 1.21× wider than long. Anterior margin broadly arcuate, anterior angles distinct, obtuse, not prominent. Lateral margins arcuate, narrowly bordered, anterior portions almost rectilinear, posterior ones feebly concave. Posterior angles distinct, small, rectangular, nearly as far apart as anterior ones. Basal margin arcuate. Disc transversely convex, at midlength projecting laterally into less convex transverse bulges. Surface with irregularly dispersed large and deep pit-shaped punctures separated by one puncture diameter or less; interspaces indistinctly microscopically punctate.

Elytra: Widest behind their midlength, 1.65× longer than their combined width and 3.05× longer than pronotum, reaching maximum length at suture. Surface strongly transversely convex, seriate-punctate, transversely impressed at one-fourth of elytral length; lateral margins not visible simultaneously from above. Serial punctures large, umbilicate, punctures in same row separated by nearly one puncture diameter; interstries wider than striae, indistinctly microscopically punctate, basal punctures larger. Serial punctures not impressed except for the shallowly impressed apical portion of the first complete stria, interstries flat.

Male genitalia (Fig. 3): Lateral lobes of aedeagus narrower at the apex, while median lobe is not tapered as in *L. erichsonii* Rosenhauer (Brown 1944).



Figs. 4–5. Adults. 4, *Laricobius baoxingensis*. 5, *L. kangdingensis*. Scale bars = 1 mm.

Variation.—Color pattern variable in type series, suture and 2–3 outermost interstries in some specimens black, one male except for antennae and tarsi completely black. *Pronotum*. 1.21–1.25× wider than long, elytra 1.58–1.65× longer than their combined width. Number and pattern of deep large punctures of frons variable and often asymmetrical, but the median subtriangular impunctate bulge as well as the deep arcuate impression separating the bulge from clypeus always distinct.

Types.—Holotype, ♂ China, Sichuan province, Simaqiao Forestry Station (Lat./Long. 29°59′10″N/101°56′46″E), approximately 5 km west of Kangding City, Kangding County; collected 12 April 2002 by G. M. G. Zilahi-Balogh and T. J. McAvoy. Paratypes: 3 ♂, 2 ♀, same data as holotype. Holotype and 1 paratype deposited in IZAS; 1 paratype (♂) deposited in NMPC; and 2 paratypes (♀, ♂) deposited in NMNH.

Etymology.—Named after Kangding, the county in Sichuan Province, China where the type series was collected.

Distribution.—China: Sichuan Province

Host.—Larvae collected in association with *Adelges* (Adelgidae) on *Tsuga chinensis*.

Habitat.—Mixed evergreen broadleaf forest; elevation 2840 m, northwest aspect; secondary forest. Species composition 30% *Pinus armandii* Franchet, 25% *Picea* sp., 10% *Tsuga chinensis* (Franchet) Pritzel, 10% *Betula* sp.; understory 5% Rhododendron sp., 5% Bambusoideae.

Biology.—Larvae collected in association with *Adelges* on *Tsuga chinensis* 12 April 2002, completed their development at 15°C, 12:12 h (L:D) with *Adelges tsugae* Annand on *T. canadensis* under quarantine at Virginia Polytechnic Institute and State University, Blacksburg, Virginia (USA). Mature larvae migrated to the soil to pupate between 29 April and 9 May 2002. Eclosed adults remained in the soil in aestivation, resuming activity on hemlock foliage between 11 September and 1 October 2002, about the same time that *A. tsugae* broke aestival diapause and resumed development. Oviposition in the laboratory was first observed in November 2002. Gatton (2005) determined the fecundity of the parental generation and development of the F_1 generation.

ACKNOWLEDGMENTS

We thank Drs. Ding Jianqing and Zhang Guo–Liang of The Chinese Institute of Biological Control, Chinese Academy of Agricultural Science, Beijing, China for collaboration and logistical support on the foreign exploration expedition, and two anonymous reviewers whose comments improved the quality of the manuscript. TJM took photographs of insect specimens; GZB illustrated the aedeagus of *L. kangdingensis* using the aid of a camera lucida on a compound microscope. This work was supported by USDA Forest Service Grant No. 01-CA-11244225-383 to SMS, LTK, and GZB.

LITERATURE CITED

Brown, N. R. and R. C. Clark. 1962. Studies of predators of the balsam woolly aphid, *Adelges piceae* (Ratz.) (Homoptera: Adelgidae) X. Field identification of *Laricobius erichsonii* Rosen. (Coleoptera: Derodontidae). Canadian Entomologist 94: 191–193.

Brown, W. J. 1944. Some new and poorly known species of Coleoptera, II. Canadian Entomologist 76: 4–10.

Clark, R. C. and N. R. Brown. 1958. Studies of predators of the balsam woolly aphid, *Adelges piceae* (Ratz.) (Homoptera: Adelgidae) V. *Laricobius erichsonii* Rosen. (Coleoptera: Derodontidae), an introduced predator in eastern Canada. Canadian Entomologist 90: 657–672.

Franz, J. M. 1958a. Studies on *Laricobius erichsonii* Rosenh. (Coleoptera: Derodontidae) a predator on chermids Part I, distribution, life-history, and ecology. Entomophaga 3: 109–164.

———. 1958b. Studies on *Laricobius erichsonii* Rosenh. (Coleoptera: Derodontidae) a predator on chermids Part II, external anatomy. Entomophaga 3: 165–196.

Gatton, H. A. 2005. Biology and host-range testing of *Laricobius kangdingensis* sp. n. (Coleoptera : Derodontidae), a newly discovered predator of hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera: Adelgidae), M.S. Thesis, Virginia Polytechnic Institute and State University, 60 pp.

Háva, J. and J. Jelínek. 1999. A new species of the genus *Laricobius* (Coleoptera: Derodontidae) from China. Folia Heyrovskyana 7: 115–118.

———. 2000. *Laricobius schawalleri* sp. nov. from Nepal, and the male of *Laricobius mirabilis* Hava & Jelinek, 1999, from China (Coleoptera: Derodontidae). Entomologische Zeitschrift, Stuttgart 110: 184–185.

Jelínek, J. and J. Háva. 2001. A new species of *Laricobius* (Coleoptera: Derodontidae) from Nepal. Revue Suisse de Zoologie 108: 149–152.

Lawrence, J. F. 1989. A catalog of the Coleoptera of America north of Mexico, Family: Derodontidae. U.S. Department of Agriculture, Agriculture Handbook, 529–65.

Lawrence, J. F. and T. F. Hlavac. 1979. Review of the Derodontidae (Coleoptera: Polyphaga) with new species from North America and Chile. Coleopterists Bulletin 33: 369–414.

McClure, M. S. and C. A. S.-J. Cheah. 1999. Reshaping the ecology of invading populations of hemlock woolly adelgid, *Adelges tsugae* (Homoptera: Adelgidae), in eastern North America. Biological Invasions 1: 247–254.

Nikitsky, N. B. and G. S. Lafer. 1992. Family Derodontidae, pp. 40–44. *In* Ler, P. A., ed. Key to the Identification of Insects of the Far East of USSR, Volume 3, Part 2, St. Petersburg.

Salom, S. M., M. S. McClure, M. E. Montgomery, G. M. G. Zilahi-Balogh, and L. T. Kok. 2001. Hemlock woolly adelgid in the United States: Status of ongoing biological control efforts, pp. 87–97. *In* Alfaro, R. I., K. Day, S. M. Salom, K. S. S. Nair, H. Evans, A. Liebhold, F. Lieutier, M. Wagner, K. Futai, and K. Suzuki, eds. Proceedings XXI International Union of Forestry Research Organizations World Congress, 7–12 August 2000. IUFRO World Series Vol. 11, Kuala Lumpur, Malaysia.

Zilahi-Balogh, G. M. G., L. T. Kok, and S. M. Salom. 2002. Host specificity of *Laricobius nigrinus* Fender (Coleoptera: Derodontidae), a potential biological control agent of the hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera: Adelgidae). Biological Control 24: 192–198.

Zilahi-Balogh, G. M. G., S. M. Salom, and L. T. Kok. 2003a. Development and reproductive biology of *Laricobius nigrinus*, a potential biological control agent of *Adelges tsugae*. Biocontrol 48: 293–306.

Zilahi-Balogh, G. M. G., L. M. Humble, A. B. Lamb, S. M. Salom, and L. T. Kok. 2003b. Seasonal abundance and synchrony between *Laricobius nigrinus* (Coleoptera: Derodontidae) and its prey, the hemlock woolly adelgid (Hemiptera: Adelgidae). Canadian Entomologist 135: 103–115.

Zilahi-Balogh, G. M. G., S. M. Salom, and L. T. Kok. 2003c. Temperature-dependent development of the specialist predator *Laricobius nigrinus* Fender (Coleoptera: Derodontidae). Environmental Entomology 32: 1322–1328.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 385–399

OVIPOSITOR ULTRASTRUCTURE AND OVIPOSITION BEHAVIOR OF THE CRYPTIC AND SYMPATRIC SPECIES, *TRUPANEA NIGRICORNIS* (COQUILLETT), A POLYPHAGE, AND THE NARROWLY OLIGOPHAGOUS *T. BISETOSA* (COQUILLETT) (DIPTERA: TEPHRITIDAE)

KHOUZAMA M. KNIO, RICHARD D. GOEDEN, AND DAVID H. HEADRICK

(KMK) Biology Department, American University of Beirut, P.O. Box 11-0236, Riad El Solh, Beirut, Lebanon (e-mail: kknio@aub.edu.lb); (RDG) Department of Entomology, University of California, Riverside, CA, U.S.A.; (DHH) Horticulture and Crop Science Department, California Polytechnic State University, San Luis Obispo, CA, 93407, U.S.A.

Abstract.—The flower head infesting tephritids, *Trupanea nigricornis* (Coquillett) and *T. bisetosa* (Coquillett) are cryptic and sympatric species. *Trupanea nigricornis* is a polyphagous species while *T. bisetosa* is a specialist on wild sunflowers. The two species showed major differences in their oviposition behavior. Females of *T. nigricornis* oviposited in various developmental stages of open immature heads of *Encelia* spp. and always pierced the plant tissues during oviposition; whereas, *T. bisetosa* females only oviposited in the early stages of closed buds of wild sunflowers and deposited their eggs loosely between the florets without injuring plant tissues. Timing of oviposition without plant tissue injury by *T. bisetosa* was critical because older buds were covered with hard bracts and exuded resin when injured. The period of flower head suitability for oviposition was shorter for *T. bisetosa* than *T. nigricornis*. The differences in oviposition behavior are reflected in the ultrastructure of their ovipositors. The aculeus tip of *T. nigricornis* is pointed, whereas that of *T. bisetosa* is rounded. The acanthae covering the ventral side of the eversible membrane have pointed tips in *T. nigricornis* and are rounded in *T. bisetosa*. *Trupanea nigricornis* has two pairs of central ampulliform sensilla at the apex of the aculeus while *T. bisetosa* has three pairs. Therefore, ovipositor morphology reflects oviposition behavior.

Key Words: Diptera, Tephritidae, *Trupanea*, oviposition behavior, ovipositor structure, acanthae, sensilla, phenology, *Encelia*, *Helianthus annuus*

The flower head infesting tephritids, *Trupanea nigricornis* (Coquillett) and *T. bisetosa* (Coquillett) occur in sympatry in southern California (Foote et al. 1993). They are closely related, cryptic species as they are similar morphologically and genetically, yet they do not interbreed (Knio et al. 1996a, 2007). The immature stages of both species are difficult to separate and are best identified according to their host plants (Knio et al. 1996a). The adults show great morphological similarities. Males can be distinguished by the color of their third antennal segment and most females by the shape of the Y-shaped apical marking on the wing (Cavender and Goeden 1983, Foote et al. 1993). Resource utilization studies demonstrated that the larvae of both species exploited the flower heads of their host in a similar manner and fed on a relatively similar number of achenes (Knio et al. 2001). Nevertheless, the two sympatric species show major ecological differences. *Trupanea nigricornis* behaves as a polyphagous species infesting the heads of 33 genera belonging to at least 8 tribes of the Asteraceae, while *T. bisetosa* is narrowly oligophagous, attacking 6 species of the tribe Heliantheae, and mainly specializing on wild sunflowers in southern California (Goeden 1985, 1992).

Behaviorally, *Trupanea nigricornis* and *T. bisetosa* show a number of differences. Adult males differ subtly in courtship behavior and in the timing of mating in the field. Males of *T. nigricornis* were observed to court in the mornings whereas those of *T. bisetosa* exhibited courtship display in the afternoon (Knio et al. 1996b). On the other hand, females differed greatly in their oviposition behavior. *Trupanea nigricornis* females always pierced the plant tissues during oviposition, such that the posterior end of the egg was inserted into plant tissues. In most cases (ca. 80%), females deposited 1–3 eggs per flower head. On the other hand, *T. bisetosa* females never pierced or injured plant tissues during oviposition and the eggs were vertically aligned loosely atop or among the corollas. In most cases (ca. 70%), *T. bisetosa* females placed 3–8 eggs per flower head (Knio et al. 1996b).

Fecundity studies demonstrated that *T. nigricornis* females had a higher fecundity than *T. bisetosa*. In no-choice experiments, *T. bisetosa* did oviposit in the non-host flower heads of *Encelia farinosa* (Gray); however, *T. nigricornis* could not oviposit in the non-host flower heads of *Helianthus annuus* L. because of the morphological features of this plant (Knio et al., in press). These observations emphasize the importance of the differences in oviposition behavior between the two species and the differences in the ultrastructure of their ovipositors. Sensory structures on ovipositors play an important role in determining host plant suitability in tephritids (Schoonhoven 1983). Further, timing of oviposition by *T. bisetosa* females on their wild sunflower hosts is critical for overcoming the problem of the hard bracts and plant resins. Thus, host plant usage and specialization is not only determined by host plant chemistry, but by other factors like the biophysical features of the plant, the synchronization of adult emergence and female oviposition with host phenology, and availability of buds at stages suitable for egg laying (Berube 1978b, Straw 1991, Zwölfer and Harris 1971).

In this study, we examine the phenology of flower head development of the most common hosts of *T. nigricornis* and *T. bisetosa* in relation to oviposition suitability and we investigate whether the differences in ovipositor morphology relate to differences in oviposition behaviors. This paper is the last of a series aimed at shedding light on the nature of polyphagy/monophagy in closely related sympatric and cryptic tephritids.

MATERIALS AND METHODS

Phenology of flower head development.—The phenology of flower head development of *Encelia farinosa* (Gray) (Asteraceae) and *Helianthus annuus* L. (Asteraceae), the most common hosts of *T. nigricornis* and *T. bisetosa*, respectively, in relation to oviposition was studied in the field. The sites were: University of California, Riverside Co., CA (site 1); Casa Blanca, Riverside Co., CA (site 2), and Lake Perris, Riverside Co., CA (site 3). Only site 3 was observed for *T. bisetosa*. At each location, 10–20 individual flower heads on different spikes were labeled with masking tape attached to the peduncle of each flower head. The flower heads were in the earliest stage of development as 'unopened' buds. The terminal flower heads were not labeled because they developed and matured faster than the apical ones found on different peduncles of the same spike. Development of these labeled flower heads was followed in the field. Flower head diameters at their maximum width and lengths from the base of the receptacle to the tip of the florets were measured using dial calipers at days 1, 3, 5, 10, 15, 18, 22, 28, 33, and 40. At each of these intervals, the labeled flower heads were checked for oviposition wounds, and 20–40 other flower heads at the same developmental stage were collected and dissected in the laboratory to record the number of *T. nigricornis* or *T. bisetosa* eggs.

Insect rearing for scanning electron microscopy.—*Trupanea nigricornis* adults were reared from flower heads of *E. farinosa* while those of *T. bisetosa* were reared from wild sunflower heads, *H. annuus*. The mature flower heads, containing third instar larvae or puparia, were placed in glass-topped, sleeved insectary cages (34×32×35 cm) at the University of California, Riverside, at 60% RH and 12/12 (LD) photoperiod from 0500–1700 h.

Ovipositor ultrastructure.—The ovipositors of *T. nigricornis* females (n = 4) and *T. bisetosa* females (n = 3) were fixed in 2% gluteraldehyde for 12 h, washed twice in distilled water, postfixed in 2% osmium tetroxide overnight, washed twice in distilled water, dehydrated in an increasing series of ethanol, then washed twice in absolute ethanol. The specimens were critically point-dried, mounted on stubs, and coated with a gold-platinum alloy before examination with a scanning electron microscope (SEM), at 15 kV accelerating voltage. Micrographs were taken using Polaroid 55P/N ® films. The micrograph negatives are stored with D. H. Headrick at California Polytechnic State University, San Luis Obispo.

The terminology used in the description of the ovipositor of *T. nigricornis* and *T. bisetosa* follows that of White et al. (1999).

RESULTS AND DISCUSSION

Phenology of flower head development.—The development of *Encelia farinosa* flower heads was divided into the following stages: (1) 'closed bud' stage, in which the bracts cover the immature florets; (2) 'open, green bud' stage, in which the immature florets are exposed, but still green; (3) 'open, light –green bud' stage, in which the immature florets are light-green; (4) 'open, yellow bud' stage, in which the florets are turning yellow, but are not mature, and a few ray florets are starting to develop; (5) 'blossom' stage, in which the florets are at anthesis and the ray florets are fully developed; and (6) 'post-blossom' stage, in which the achenes are mature and hard, the florets begin to dry, and the ray flowers wilt (Fig. 1A–F).

Trupanea nigricornis females oviposited in the immature 'open' buds having a green, light-green, or yellow color (stages 2, 3, and 4; Figs. 1B–D). The flower heads that were suitable for oviposition had mean diameters ranging from 7.1–10.5 mm and mean lengths ranging from 4.3–7.4 mm (Table 1). The period of time that a flower head was suitable for oviposition was about 12 d: 8, 13, and 14 d in sites 3, 2, and 1, respectively. This period of suitability did not correspond to the entire bloom period of *E. farinosa*, as stems continued producing flower heads sequentially as long as there was enough moisture in the soil. The total period of flower-head development of *E. farinosa*, lasted ca. 40 d (5–7 weeks) in the field. The total period of development of *T. nigricornis* from oviposition to adult emergence from the mature heads ranged between

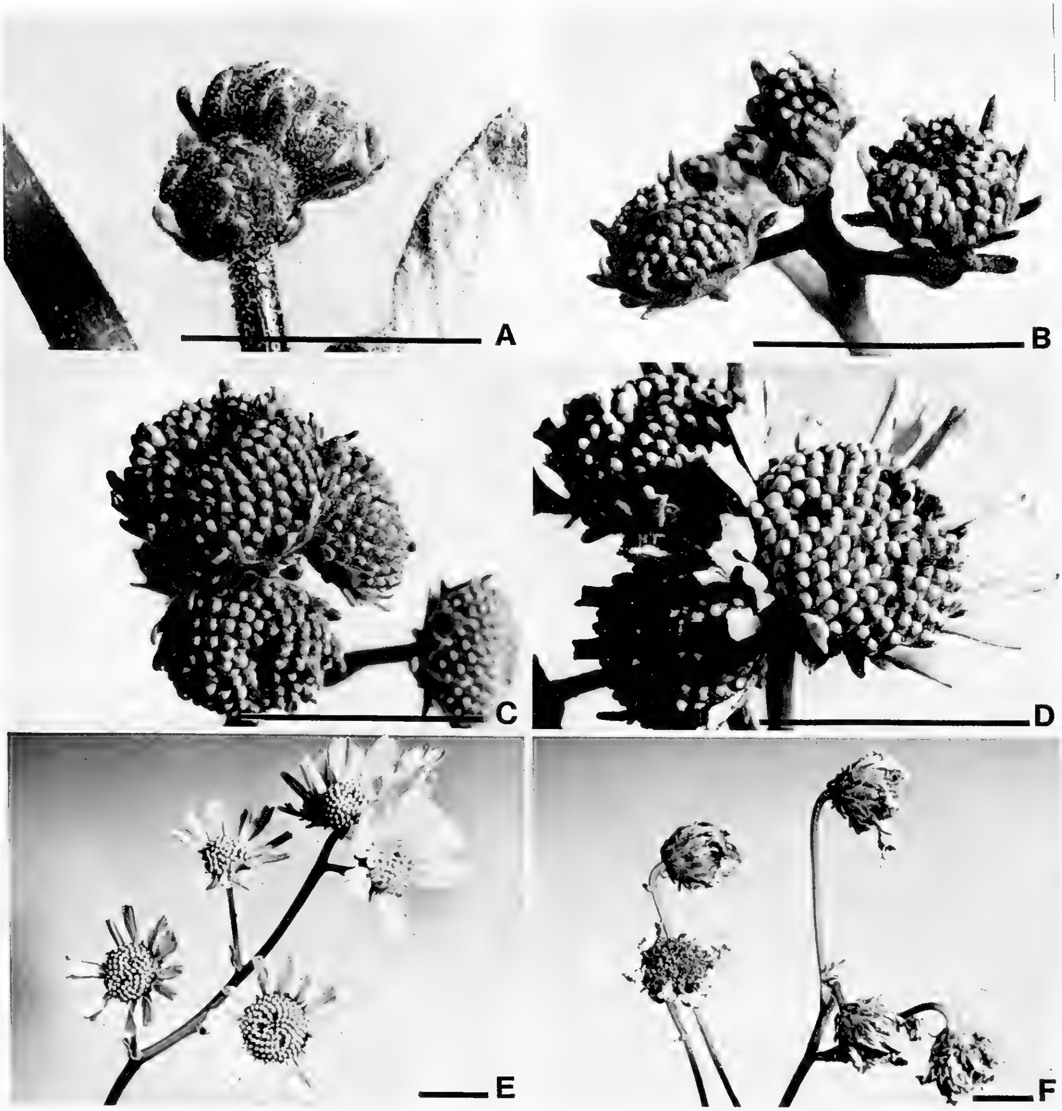


Fig. 1. Stages in flower head development of *Encelia. farinosa* (bar = 1 cm). A, 'Closed bud' stage. B, 'Open green bud' stage'. C, 'Open light-green bud' stage; D, 'Open yellow bud' stage. E, 'Open yellow bud' and 'blossom' stages. F, 'Post-blossom' stage.

25–30 d (ca. 4 weeks) in the field (Table 1).

Dissections of *E. farinosa* flower heads confirmed the results of the field phenology experiment. The flower heads that contained *T. nigricornis* eggs were open buds with green, light-green or yellow florets. These corresponded to the flower head stages 2, 3, and 4. The majority (53%) of the eggs (n = 100) were found in flower heads with light green florets; the rest (26% and 21%) were found in heads with green and yellow florets, respectively (Fig. 2). A correlation existed between flower head size and number of eggs laid per head. The flower heads with yellow florets were the largest and contained the greatest mean number of eggs (2.9) per head. They were closely followed by flower heads with light-

Table 1. Phenology of flower head development of *Encelia farinosa* at three locations in southern California showing the stages in which eggs of *Trupanea nigricornis* are found.

	Site 1		Site 2		Site 3		
Days	D[a] ± SE	L[b] ± SE	D ± SE	L ± SE	D ± SE	L ± SE	Head Stage[c]
1	2.3 ± 0.1	2.1 ± 0.1	3.4 ± 0.2	2.6 ± 0.2	3.2 ± 0.2	2.1 ± 0.1	GC −
3	---------	---------	3.8 ± 0.1	3 ± 0.1	4.4 ± 0.3	2.7 ± 0.1	GC −
5	3.9 ± 0.1	2.3 ± 0	---------	---------	---------	---------	GC −
7	4.8 ± 0.1	3 ± 0.1	6.1 ± 0.2	4 ± 0.4	5.9 ± 0.4	3.7 ± 0.3	GC −
10	6 ± 0.1	3.7 ± 0.1	**7.3 ± 0.5**	**4.3 ± 0.1**	6.8 ± 0.4	4.9 ± 0.4	OG +
15	**7.5 ± 0.1**	**4.4 ± 0.1**	**7.4 ± 0.3**	**4.7 ± 0.2**	**7.1 ± 0.4**	**5.3 ± 0.3**	OG +
18	---------	---------	**7.8 ± 0.3**	**4.9 ± 0.2**	**7.5 ± 0.4**	**6.3 ± 0.3**	OLG +
22	**9.1 ± 0.2**	**5.3 ± 0.2**	**9.3 ± 0.2**	**6.7 ± 0.3**	**8.9 ± 0.5**	**7.4 ± 0.6**	OLG +
28	**10.5 ± 0.2**	**7.2 ± 0.1**	10 ± 0.2	8.1 ± 0.3	8.7 ± 0.4	9.6 ± 0.4	OY +
33	10.8 ± 0.2	8.3 ± 0.1	9.9 ± 0.2	8.3 ± 0.3	8.6 ± 0.5	9.7 ± 0.2	BL −
40	10.3 ± 0.3	9.8 ± 0.2	9.4 ± 0.3	8.5 ± 0.2	8.4 ± 0.5	9.6 ± 0.2	PBL −

[a] Mean widest diameter and [b] mean length (from base of receptacle to tip of florets) ± standard error in mm of n = 10 flower heads for sites 1 and 3 and N = 20 heads for site 2.

[c] Flower head stages: closed green bud (CG); open green bud (OG); open light green bud (OLG); open yellow bud (OY); blossoming head (BL); post-blossoming head (PBL). Eggs found (+); no eggs found (−). The flower heads which contained eggs are marked in bold.

green florets that were intermediate in size and contained a mean of 2.5 eggs per flower head while the smaller heads with green florets contained a mean of 1.5 eggs per flower head (Fig. 2).

The development of wild sunflower heads, the host plant of *T. bisetosa*, was divided into six stages: (1) small 'closed bud' stage, in which the soft, straight, and short green bracts cover the immature florets; (2) advanced 'closed bud'-stage, in which the hard and curved bracts cover the immature florets; (3) 'open yellow bud' stage, in which the bracts are opened and the yellow florets remain immature, but the ray flowers are developing; (4) early 'blossom' stage, in which some of the florets are at anthesis, maturation of the florets has started gradually from the periphery to the center of the flower heads, and the ray flowers are fully developed; (5) advanced 'blossom' stage, in which the florets at the center of the flower head are at anthesis while the rest are at post-anthesis; (6) 'post-blossom' stage, in which the achenes are mature, the florets are at post-anthesis, and the ray flowers are wilting (Fig. 3A–F).

In the field, the females of *T. bisetosa* laid eggs in the immature flower heads of their host. However, unlike *T. nigricornis* females, which laid eggs in the open buds (stages 2–4) of *E. farinosa*, the females of *T. bisetosa* only oviposited in the closed green buds (stage 1) of wild sunflowers, and especially, in the very small closed buds (Fig. 3A). The early stages of closed buds apparently were preferred because they did not exude any resins when accidentally pierced by the female's ovipositor, and they also had softer, straighter, but short bracts (Fig. 3A) compared to the harder and curved bracts of the older closed buds (Fig. 3B). The areas between the elongate bracts that covered the immature florets formed direct channels into the center of the flower head into which females of *T. bisetosa* inserted their ovipositors. In the laboratory, three females out of 10 were observed to oviposit into the open green buds (stage 3) when not given a choice; this led to the death of two of these females because their ovipositors became trapped in the exuding resin. Cavender and Goeden (1982) also reported that in the insectary, *T. bisetosa* females accept-

Fig. 2. Stages in flower head development of *Helianthus. annuus* (bar = 1 cm). A, Small 'closed bud' suitable for oviposition by *T. bisetosa* females. B, Advanced 'closed bud' stage'. C, 'Open yellow bud' stage. D, 'Early blossom' stage. E, 'Late blossom' stage. F, 'Post-blossom' stage.

ed open flower heads, but that in the field they preferred closed flower heads.

The closed green buds that were suitable for oviposition by *T. bisetosa* females had diameters ranging from 5.0–9.8 mm (Table 2). The period of time that a sunflower head was suitable for oviposition in the field was ca. 5 d (Table 2), and much shorter than the suitability period of *E. farinosa* for oviposition by *T. nigricornis*. This suitability for egg laying covered only part of the entire flowering period of wild sunflowers, as some plants flowered throughout the year in southern California under favorable environmental conditions, e.g., mild frost-free winter and ample rainfall. The total period of development for wild sunflower heads was ca. 35–40 d in the field. Like *T. nigri-*

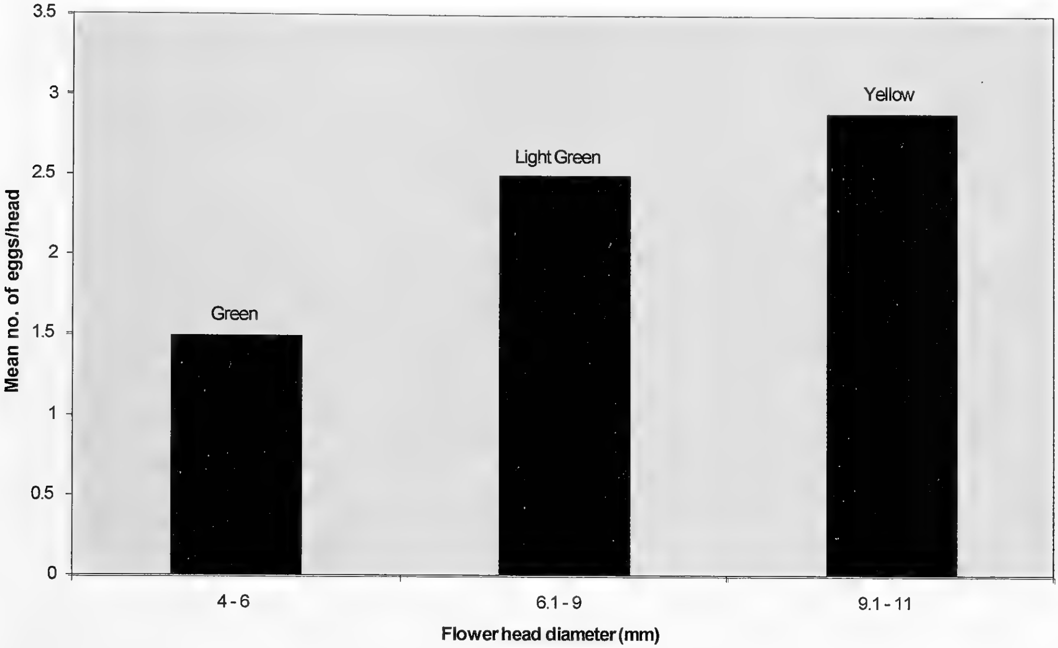


Fig. 3. Mean number of *Trupanea nigricornis* eggs found in three bud stages of *Encelia farinosa* heads (n = 100).

cornis, the period of development of *T. bisetosa* from egg to adult ranged from 30–35 d (ca. 4–5 weeks).

Dissections of field-collected sunflower heads confirmed these findings on phenology. The flower heads that contained *T. bisetosa* eggs (n = 100) were all closed buds with straight bracts (stage 1, Fig. 3A). The mean diameter of these buds ranged from 5.0–7.8 mm and their mean length ranged from 6.5–8.5 mm (Table 2). The dissected buds contained mainly 3–5 eggs as previously reported by Knio et al. (1996b).

Table 2. Phenology of flower head development of *Helianthus annuus* showing the stages suitable for egg laying by *Trupanea bisetosa*.

Days	$D^a \pm$ SE	(Range)	$L^b \pm$ SE	(Range)	Head Stage[c]
1	5 ± 0.1	(4.5–5.8)	6.5 ± 0.1	(5–7.8)	CG +
3	6.3 ± 0.1	(5.7–7)	7.6 ± 0.2	(6.7–9.7)	CG +
5	7.8 ± 0.1	(7–8.8)	8.5 ± 0.1	(7.4–9.8)	CG +
7	10.4 ± 0.2	(8.9–12.8)	10.6 ± 0.2	(9–12.5)	CG −
10	16.7 ± 0.4	(13.5–19.8)	13.6 ± 0.6	(9.5–17.6)	OG −
15	17.6 ± 0.5	(14.2–21)	13 ± 0.7	(8.7–18)	OLG −
18	20.8 ± 0.5	(16.7–24)	12.9 ± 0.4	(9.5–16)	OY −
22	22.4 ± 0.3	(19.3–24.1)	12.7 ± 0.3	(10.6–16.2)	OY −
28	24.3 ± 0.6	(20.1–29.4)	16.6 ± 0.4	(13.3–19.5)	BL −
33	25.2 ± 0.4	(20.5–27)	20.5 ± 0.4	(18.8–22.1)	BL −
40	25.9 ± 0.6	(20.8–29.2)	20.3 ± 0.4	(17.2–23)	PBL −

[a] Mean widest diameter and [b] mean length (from base of receptacle to tip of florets) ± standard error in mm of n = 20 flower heads.

[c] Flower head stages: closed green bud (CG); open green bud (OG); open light green bud (OLG); open yellow bud (OY); blossoming head (BL); post-blossoming head (PBL). Eggs found (+); no eggs found (−).

Similar to *T. bisetosa*, the window for oviposition suitability was narrow and restricted to a short phase, 'unopened buds', in *Trupanea conjuncta* (Adams), *Tephritis dilacerata* Loew and *T. formosa* Loew (Goeden 1987; Berube 1978a, b). *Trupanea conjuncta* females only laid eggs in the small green buds of their host, *Trixis californica* Kellog (Asteraceae) and this stage lasted about 5 d (Goeden 1987). *Tephritis dilacerata* females deposited their eggs in the closed buds of *Sonchus arvensis* L. (Asteraceae) and weaved their ovipositors slowly in between the bracts in order to avoid piercing the host tissues and releasing sticky latex (Berube 1978a). Both *T. dilacerata* and *T. formosa* timed oviposition to coincide with the stage of unopened buds when they were at their maximum growth as this stage was the most suitable for gall induction by the young larvae (Berube 1978b). On the other hand, similar to *T. nigricornis*, the suitability period for oviposition by the tephritids, *Tephritis bardanae* (Schrank) and *Cerajocera tussilaginis* (F.) on *Arctium minus* (Hill) Bernh. (Asteraceae) was 10–11 d; however, there was no overlap in the oviposition suitability periods as *T. bardanae* oviposited early in the smaller unopened buds while *C. tussilaginis* followed a late attack strategy and deposited eggs in the pre-flowering heads. Like *T. nigricornis* and *T. bisetosa*, these flies never laid eggs in flower heads that had started to flower (Straw 1989). Females of *Chaetostomella undosa* (Coquillett) also oviposited in the closed and open buds of their host, *Cirsium cymosum* (Greene) J. T. Howell (Asteraceae), but like *T. nigricornis*, they showed a preference to open buds (Steck 1984).

In selecting heads suitable for oviposition, female tephritids seem to compare their body size and length of their oviscape to flower head dimensions (Straw 1989). The length of the oviscape of several *Urophora* species have been found to be correlated with the diameter of flower heads exploited, implying "evolutionary responses of these phytophages to a particular structure of the host plants"(Zwölfer 1987). Moreover, in addition to the length of the ovipositor, the aculeus tip bears a number of sensilla that are used to guide the female during oviposition. In the following section, we examine the ultrastructure of the ovipositors of *T. nigricornis* and *T. bisetosa* in order to better understand the differences in their oviposition behavior.

Ultra-structure of the ovipositors.—The external anatomy of the ovipositors of *T. nigricornis* consists of the modified seventh abdominal segment or oviscape (syntergosternite 7), an eversible membrane, and an aculeus (Norrbom and Kim 1988, White et al. 1999) composed of three, long, parallel processes, two ventral and one dorsal (Stoffolano and Yin 1987), which are the eighth sternites or ventral flaps, and the eighth tergite, respectively (White et al. 1999) (Fig. 4C, F).

The oviscape of *T. nigricornis* is conical in shape and heavily sclerotized (Fig. 4A). It measured (from tip to base on the ventral side) 1.05 ± 0.014 (range: 0.89–1.16) mm in length (n = 25).

The eversible membrane (0.21 mm as greatest width) of *T. nigricornis* also is heavily sclerotized (Fig. 4B). It is covered with acanthae, scale-like, cuticular projections (Fig. 4D–E). When the ovipositor is retracted only the oviscape is apparent (Fig. 4A–B); the rest of the ovipositor, including the eversible membrane and aculeus, is housed within the seventh abdominal segment.

The retractable eversible membrane connects the oviscape to the aculeus (Fig. 4A–C). The eversible membrane is visible only when the ovipositor is extended. It is covered with acanthae that point anteriad. The acanthae gradually increase in size from the tip of the

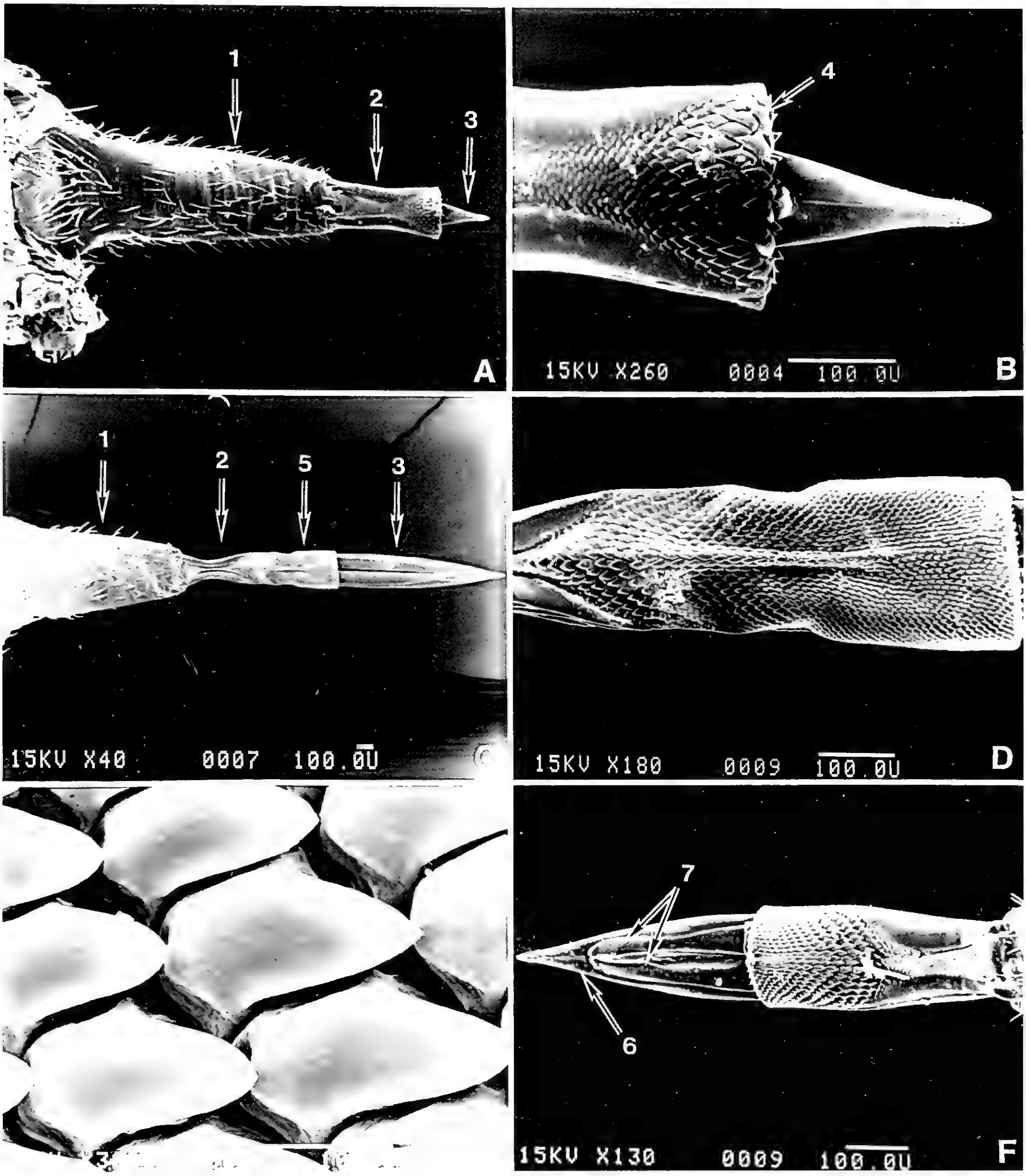


Fig. 4. Scanning electron micrographs of the ovipositor of *Trupanea nigricornis*. A, Ventral view of the ovipositor showing (1) the oviscape, (2) the eversible membrane, and (3) the tip of the aculeus. B, Ventral view of the eversible membrane showing (4) the pointed acanthae. C, Ventral view of the extended ovipositor showing (1) the oviscape, (2) basal region and (5) distal region the eversible membrane, and (3) the aculeus. D, The eversible membrane. E, Pointed acanthae on the eversible membrane. F, Ventral view of the basal part of the eversible membrane, and the aculeus showing (6) the eighth tergite and (7) the ventral flaps or eighth sternites.

distal region to the base of the basal region of the eversible membrane (Fig. 4D). These acanthae are sharply pointed in *T. nigricornis* (Fig. 4E).

The aculeus of *T. nigricornis* has a sharply pointed apex. It bears two ventral sclerites (eighth sternites) and a dorsal sclerite (eighth tergite) (Fig. 4F).

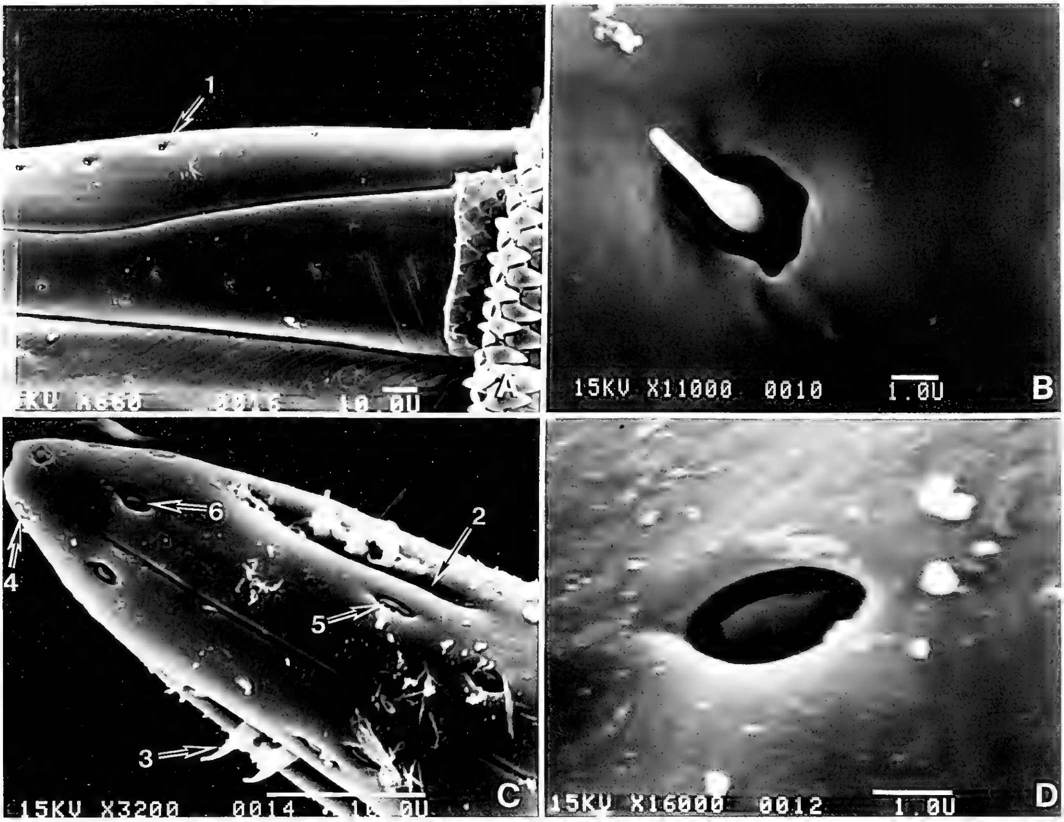


Fig. 5. Scanning electron micrographs of the ovipositor of *Trupanea nigricornis*. A, Lateral aspect of the dorsal process with the row of (1) hair-like sensilla. B, Hairlike sensillum on the dorsal process. C, Apical region of the aculeus showing (2) the two ventrolateral grooves with (3) the elongated sensilla (three per groove), (4) the shallow ampulliform sensilla, (5) the ellipsoidal ampulliform sensilla, and (6) the central ampulliform sensilla. D, Central ampulliform sensillum sunken in an oval socket.

The ventral sclerites appear as two parallel, elongate structures with blunt ends on the ventral side of the ovipositor. They are shorter than the dorsal sclerite and only visible when the ovipositor is extended. The ventral sclerites, which are joined by a flexible, median and infolded membrane, do not completely meet (Stoffolano and Yin 1987, Zacharuk et al. 1986); a ventral groove extends between them and terminates in the cloaca, the common opening to the reproductive and digestive tract. The dorsal sclerite (eighth tergite) measured 0.14 mm at greatest width (n = 4) and 1.27 mm in length (n = 4) (Fig. 4F). It bears a ventrolateral row of hairlike sensilla (Fig. 5A) that have blunt tips. The sensilla are surrounded by a shallow depression (Fig. 5B). Such sensilla also occur on the ventral sclerites (Fig. 5B). These hairlike sensilla are similar to those described for the apple maggot (Stoffolano and Yin 1987). They are numerous (50–60) on the dorsal and (11–12) ventral sclerites of the apple maggot ovipositor; they were identified as mechanoreceptors innervated by a single neuron, and were not associated with chemoreception (Stoffolano and Yin 1987).

The tip of the dorsal sclerite (eighth tergite) of the aculeus of *T. nigricornis* bears different types of sensilla that show

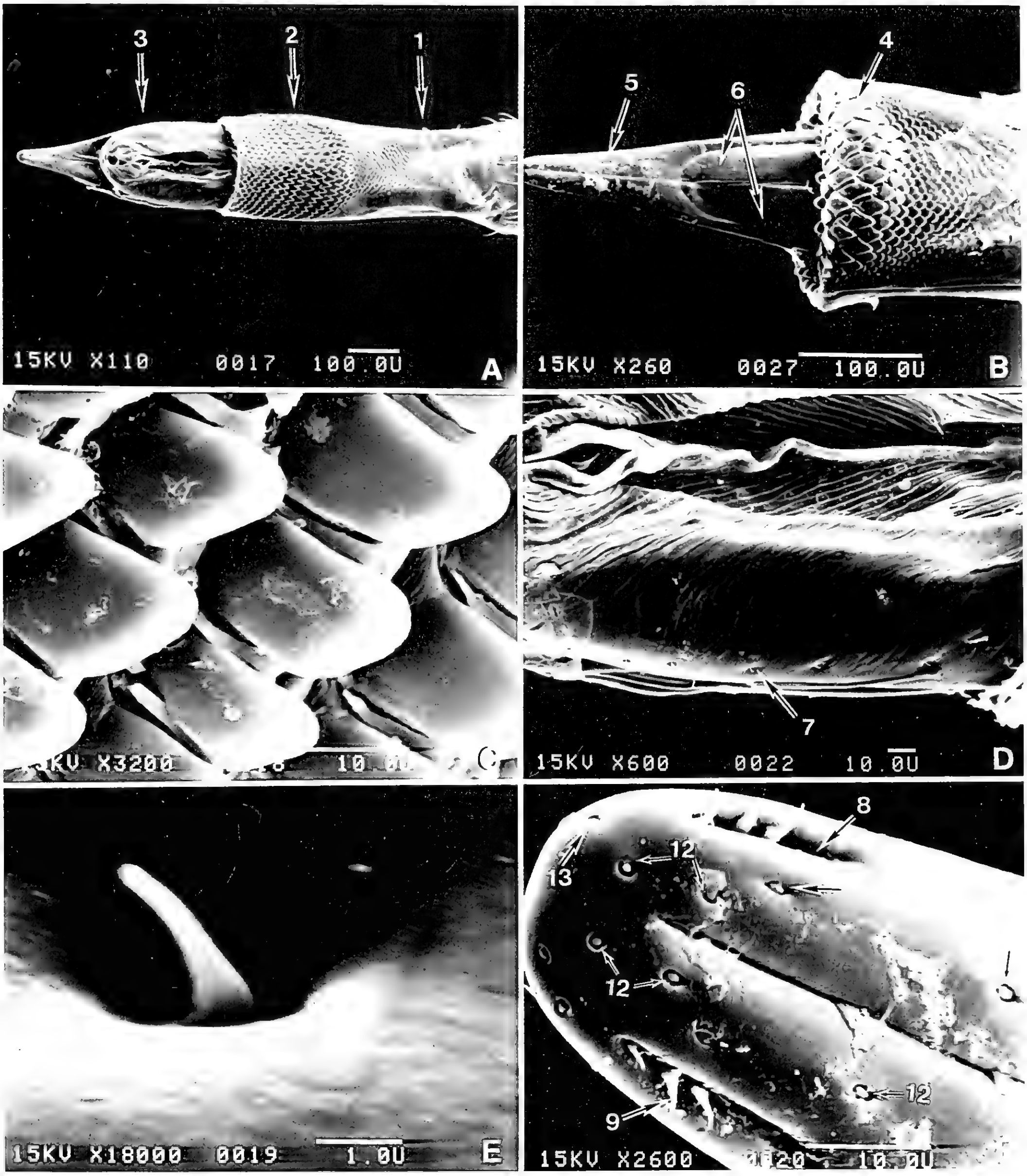


Fig. 6. Scanning electron micrographs of the ovipositor of *Trupanea bisetosa*. A, Ventral view of the ovipositor showing (1) the basal region, (2) the distal region of the eversible membrane, and (3) the aculeus. B, Ventral view of the eversible membrane covered by (4) acanthae, and the aculeus showing the (5) eighth tergite and (6) eighth sternites (ventral flaps). C, Rounded acanthae on the eversible membrane. D, Lateral aspect of the eighth tergite of the aculeus showing the row of (7) hairlike sensilla. E, Hairlike sensillum contained in a shallow socket. F, Apical region of the aculeus showing the rounded tip of the ovipositor, (8) the two lateroventral grooves with (9) the three pairs of elongated sensilla, (11) the shallow ampulliform sensilla, (12) the central ampulliform sensilla, and (13) the ellipsoidal ampulliform sensilla.

bilateral symmetry (Fig. 5C). There are two ventrolateral grooves, each located distad of the ventral sclerites. The ventrolateral grooves bear three pairs of elongated sensilla that probably are chemoreceptors based on comparative morphology (Fig. 5C). The dorsal sclerite also bears several types of ampulliform sensilla. Close to the medial line ventrally dividing the dorsal sclerite are two pairs of ampulliform sensilla that appear to be similar morphologically, but may have different functions. These are short sensilla, referred to as central ampulliform sensilla, sunken in deep, oval sockets (Fig. 5C–D). Another pair of elongated ampulliform sensilla sunken in deep, ellipsoidal sockets is located closer to the ventrolateral grooves than the medial line (Fig. 5C). The lateral sides of the ovipositor tip are also covered by several shallow ampulliform sensilla located in shallow, oval sockets (Fig. 5C).

The gross anatomy of the ovipositor of *T. bisetosa* is similar to that of *T. nigricornis*. It consits of the oviscape, eversible membrane, and aculeus (Fig. 6A). The oviscape is conical and heavily sclerotized (Fig. 6A). Its length is close to that of *T. nigricornis*, measuring 1.08 ± 0.02 (range: 0.92–1.28) mm (n = 25) using light microscopy. The eversible membrane is covered with acanthae that point anteriad; however, contrary to the pointed acanthae of *T. nigricornis*, the acanthae in *T. bisetosa* have rounded tips (Fig. 6C).

The aculeus in *T. bisetosa* also is composed of a long dorsal sclerite and two shorter ventral ones (eighth sternites). Like *T. nigricornis*, the dorsal sclerite of *T. bisetosa* measured 0.15 mm (n = 2) at its greatest width and 1.28 mm (n = 3) in length, and is covered with hairlike sensilla laterally. Each hairlike sensillum is surrounded by a shallow circular socket (Fig. 6D–E). The tip of the aculeus has a rounded shape in *T. bisetosa*, as opposed to the pointed aculeus tip in *T. nigricornis* (Fig. 6F vs. Fig. 5C). Similar to *T. nigricornis*, the apex of the aculeus of *T. bisetosa* bears two ventrolateral grooves with three pairs of elongated sensilla (Fig. 6F), and a pair of ellipsoidal ampulliform sensilla near the ventrolateral grooves (Fig. 6F). Unlike *T. nigricornis*, which has two pairs of central ampulliform sensilla, *T. bisetosa* has three pairs of central ampulliform sensilla sunken in deep, oval sockets close to the medial line of the dorsal sclerite (Fig. 6F).

The gross structure of the ovipositors of *T. nigricornis* and *T. bisetosa* is close to that described for other tephritids (Marchini and Wood 1983, Stoffolano and Yin 1987, Zacharuk et al. 1986). The apices of the ovipositors of *Rhagoletis pomonella* (Walsh) (Stoffolano and Yin 1987), *Urophora affinis* Frauenfeld (Zacharuk et al. 1986), and *Ceratitis capitata* (Wied.) (Marchini and Wood 1983) have two types of mechanosensilla: hairlike and campaniform sensilla, both sunken in shallow pits and lacking a pore to the outside. These hairlike sensilla are similar to those occurring laterally on the dorsal sclerite of the aculeus of *T. nigricornis* and *T. bisetosa*. The campaniform sensilla at the apex of the aculeus of *R. pomonella* and *U. affinis* appear similar to the shallow ampulliform sensilla described for *T. nigricornis* and *T. bisetosa*. Such mechanoreceptors have been found to function in monitoring the hardness of the fruit surface; guiding the ovipositor during piercing and penetrating the fruit pulp; and monitoring the ovipositor position in the fruit, the egg passage, physical contact with the male during copulation, and contact with the fruit during post-ovipositional dragging of the ovipositor (Stoffolano 1989, Stoffolano and Yin 1987). The campaniform sensilla found at the very tip of the aculeus most probably monitor the amount of stress imposed on the cuticle during penetration of the flower head (Zacharuk et al. 1986). The hairlike sensilla or ‘short trichoid hairs’ probably monitor the depth of penetration of the aculeus and its movement in the flower head (Zacharuk et al. 1986).

The apex of the ovipositor of *T. nigricornis* and *T. bisetosa* is also similar to that of *R. pomonella* in having two ventrolateral grooves, each with three elongated sensilla, identified as chemosensilla (Stoffolano and Yin 1987). Similar uniporous chemosensilla located in ventrolateral grooves are also found at the tip of the aculeus of *C. capitata*, but each groove has five sensilla (Marchini and Wood 1983). These chemoreceptors are also found in *U. affinis*; however, there are just two on each side of the aculeus tip and each is located in an individual deep ventrolateral socket (Zacharuk et al. 1986). These serve as mechano-chemosensilla (Zacharuk et al. 1986). In addition to these, the aculeus tip of *U. affinis* and *R. pomonella* contains a fourth type of uniporous mechano-chemosensilla: one pair on each side of the aculeus tip located distally and outside the ventrolateral grooves (Stoffolano and Yin 1987, Zacharuk et al. 1986).

Each of the uniporous chemosensilla in the ventrolateral grooves is associated with three or four chemosensitive neurons and one mechanosensillum (Stoffolano and Yin 1987, Girolami et al. 1986). Possible functions suggested for these chemosensilla are to locate suitable hosts, to assess host suitability and quality, to locate a suitable oviposition site, and to detect conspecific flies or oviposition-deterrent pheromones (Stoffolano 1989, Stoffolano andYin 1987). Zacharuk et al. (1986) noted that since the chemosensilla are located on the ventrolateral aspect of the ovipositor tip, "only the tip of the ovipositor blade 'tastes' or 'smells'...and the egg is deposited just above or at the level of the last 'taste'." Using electrophysiological techniques, it has been found that the contact chemosensilla at the apex of the ovipositor of *R. pomonella* responded to stimulation by various substances like glucose, fructose, and malic acid (Girolami et al. 1986). Also, *R. pomonella* detected the addition of these chemicals to fruits by probing, and they laid more eggs when the fruits were treated with substances like glucose and malic acid. It was also found that the destruction of the chemosensilla affected the ability of the females to discriminate between treated and control fruits. Thus, "the presence of more than one chemosensillum per sensilla may provide the fly with an input that can be used by the fly to discriminate between various types of fruit and/or fruit quality" (Girolami et al. 1986).

Similar to *T. nigricornis* and *T. bisetosa*, the eversible membranes of *R. pomonella* and *Anastrepha* spp. are covered with acanthae, minute 'teeth' or scales (Stoffolano and Yin 1987, Norrbom and Kim 1988). The acanthae 'may hold the base of the aculeus in place during oviposition' (Norrbom and Kim 1988), or may anchor the female's abdomen during the process of fruit penetration (Stoffolano and Yin 1987).

The differences in the shape of the acanthae and the aculeus tip, i.e., pointed in *T. nigricornis* versus rounded in *T. bisetosa*, appear to be related to the different host plants they use and to their specific oviposition behavior. Since females of *T. bisetosa* oviposit in the flower heads of wild sunflowers which exude copious resins when pierced, both the rounded acanthae and rounded aculeus tip allow them to deposit their eggs superficially without injuring the plant tissues and becoming caught in the resins. On the other hand, the hosts of *T. nigricornis* do not exude much resin, and the females lay their eggs deeper in the flower heads by inserting the posterior pole of the egg into the plant tissues (Knio et al. 1996b). In that case, the pointed acanthae may help the females to better anchor themselves and lay the eggs closer to the achene, and the pointed tip of the ovipositor facilitates insertion of the eggs of *T. nigricornis* into the plant tissues. Therefore, it seems that the ovipositor of *T. bisetosa* is adapted for shallow penetration of the plant tissues while that of *T. nigricornis* is adapted for deeper penetration and piercing of host tissues. Moreover, the additional pair of central ampulliform sensilla at the apex of the aculeus observed in *T. bisetosa* might be essential in detecting the suitability of wild sunflower heads for oviposition as well as sensing the position of the florets during egg insertion to avoid piercing the plant tissues.

In conclusion, the basis of host specificity in these closely related and sympatric tephritids appears to be associated with female behavior and related to the biophysical features of the host plants. The specialization on wild sunflowers by *T. bisetosa* required behavioral and morphological adaptation to overcome the problem of hard bracts and resins. Zwölfer (1983, 1987) noted that host adaptation in tephritids frequently involved adaptive changes that are reflected in morphological traits, such as the ovipositor tip and length. "These integrated differentiation processes on the ecological, biological, physiological, and morphological level are consequences of the co-evolution of the tephritid taxon with a given plant taxon" (Zwölfer 1983).

LITERATURE CITED

Berube, D. E. 1978a. Larval descriptions and biology of *Tephritis dilacerata* (Dip.: Tephritidae), a candidate for the biocontrol of *Sonchus arvensis* in Canada. Entomophaga 23: 69–82.

———. 1978b. The basis for host plant specificity in *Tephritis dilacerata* and *T. formosa* (Diptera: Tephritidae). Entomophaga 23: 331–337.

Cavender, G. L. and R. D. Goeden. 1982. Life history of *Trupanea bisetosa* (Diptera: Tephritidae) on wild sunflowers in Southern California. Annals of the Entomological Society of America 75: 400–406.

———. 1983. On distinguishing *Trupanea bisetosa* (Coquillett) from *T. nigricornis* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 85: 275–281.

Foote, R. H., F. L. Blanc, and A. L. Norrbom. 1993. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Cornell University Press, Ithaca, NY, 571 pp.

Girolami, V., R. Crnjar, A. M. Angioy, A. Strapazzon, P. Pietra, J. G. Stoffolano, Jr., and R. J. Prokopy. 1986. Behavior and sensory physiology of *Rhagoletis pomonella* in relation to oviposition stimulants and deterrents in fruit, pp. 183–190. *In* Cavalloro, R., ed. Fruit Flies of Economic Importance 84. A. A. Balkema Publishers, Rotterdam, Netherlands, 221 pp.

Goeden, R. D. 1985. Host-plant relations of *Trupanea* spp. (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 87: 564–571.

———. 1987. Life history of *Trupanea conjuncta* (Adams) on *Trixus californica* Kellog in Southern California. Pan-Pacific Entomologist 63: 284–291.

———. 1992. Analysis of known and new host records for *Trupanea* from California (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 94: 107–118.

Knio, K. M., R. D. Goeden, and D. H. Headrick. 1996a. Descriptions of the immature stages of *Trupanea nigricornis* and *T. bisetosa* (Diptera: Tephritidae) from southern California. Annals of the Entomological Society of America 89: 1–11.

———. 1996b. Comparative biologies of the cryptic, sympatric species, *Trupanea bisetosa* and *T. nigricornis* (Diptera: Tephritidae) in southern California. Annals of the Entomological Society of America 89: 252–260.

———. 2001. Resource utilization on the sibling species *Trupanea nigricornis* (Coquillett), a polyphage, and the narrowly oligophagous *T. bisetosa* (Coquillett) (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 103: 946–961.

———. 2007. Genetic differentiation between the cryptic and sympatric flower-head infesting tephritids: The polyphage, *Trupanea nigricornis* (Coquillett) and the narrowly oligophagous, *T. bisetosa* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 109: 295–308.

———. In press. Fecundity and longevity of the cryptic and sympatric species, *Trupanea nigricornis* (Coquillett), a polyphage, and the narrowly oligophagous *T. bisetosa* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington.

Marchini, L. and R. J. Wood. 1983. Laboratory studies oviposition and on the structure of the ovipositor in the Mediterranean fruit fly *Ceratitis capitata* (Wied.), 113 pp. *In* Cavalloro, R., ed. Fruit Flies of Economic Importance. A. A. Balkema Publishers, Rotterdam, Netherlands, 642 pp.

Norrbom, A. L. and K. C. Kim. 1988. Revision of the *schausi* group of *Anastrepha* Shiner (Diptera: Tephritidae), with a discussion of the terminology of the female terminalia in the Tephritoidea. Annals of the Entomological Society of America 81: 164–173.

Schoonhoven, L. M. 1983. The role of chemoreception in host plant finding and oviposition in phytophagous Diptera, pp. 204–247. *In* Cavalloro, R., ed. Fruit Flies of Economic Importance. Proceedings of the CEC/IOBC International Symposium, Athens, Greece. A. A. Balkema, Rotterdam, 642 pp.

Steck, G. J. 1984. *Chaetostomella undosa* (Diptera: Tephritidae): Biology, ecology, and larval description. Annals of the Entomological Society of America 77: 669–678.

Stoffolano, J. G., Jr. 1989. Structure and function of the ovipositor of the tephritids, pp. 141–146. *In* Cavalloro, R., ed. Fruit Flies of Economic Importance 87. Proceedings of the CEC/IOBC International Symposium, Rome. A. A. Balkema Publishers, Rotterdam, Netherlands, 626 pp.

Stoffolano, J. G., Jr. and L. R. S. Yin. 1987. Structure and function of the ovipositor and associated sensillae of the apple maggot, *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae). International Journal of Insect Morphology and Embryology 16: 41–69.

Straw, N. A. 1989. The timing of oviposition and larval growth by two tephritid fly spp. in relation to host-plant development. Ecological Entomology 14: 443–454.

———. 1991. Resource limitation of tephritid flies on lesser burdock, *Arctium minus* (Hill) Bernh. (Compositae). Oecologia 86: 492–502.

White, I. M., D. H. Headrick, and A. L. Norrbom. 1999. Glossary, pp. 881–924. *In* Aluja, M. and A. L. Norrbom, eds. Fruit Flies (Tephritidae) Phylogeny and Evolution of Behavior. CRC Press, Boca Raton, 968 pp.

Zacharuk, R. Y., R. M. K. W. Lee, and D. E. Berube. 1986. Fine structure of sensilla on the ovipositor of the tephritid fly *Urophora affinis*. Canadian Journal of Zoology 64: 973–984.

Zwölfer, H. 1983. Life systems and strategies of resource exploitation in Tephritids, pp. 16–30. *In* Cavalloro, R., ed. Fruit Flies of Economic Importance. Proceedings of the CEC/IOBC International Symposium, Athens, Greece. A. A. Balkema, Rotterdam, 642 pp.

———. 1987. Species richness, species packing, and evolution in insect plant systems. Ecological Studies 61: 301–319.

Zwölfer, H. and P. Harris. 1971. Host specificity determination of insects for biological control of weeds. Annual Review of Entomology 16: 156–178.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 400–415

KELISIA AND *STENOCRANUS* SPECIES (HEMIPTERA: FULGOROMORPHA: DELPHACIDAE): NEW HOST-PLANT ASSOCIATIONS AND DISTRIBUTIONAL RECORDS OF EIGHT SEDGE-FEEDING PLANTHOPPERS

CHARLES R. BARTLETT AND A. G. WHEELER, JR.

(CRB) Department of Entomology and Wildlife Ecology, 250 Townsend Hall, University of Delaware, Newark, DE 19716-2160, U.S.A. (e-mail: 02542@udel.edu); (AGW) Department of Entomology, Soils, and Plant Sciences, Clemson University, Clemson, SC 29634-0315, U.S.A. (e-mail: awhlr@clemson.edu)

Abstract.—Host-plant associations are poorly known for North American planthoppers of the genera *Kelisia* and *Stenocranus*, whose respective subfamilies – Kelisiinae and Stenocraninae – are considered sister taxa. We report sedges (Cyperaceae) as hosts of the delphacids *K. flava* Beamer, *K. parvicurvata* Beamer, *K. spinosa* Beamer, *K. torquata* Beamer, *K. vesiculata* Beamer, *S. brunneus* Beamer, *S. lautus* Van Duzee, and *S. unipunctatus* Provancher. Collections from the southern Appalachians (North Carolina, South Carolina, and Tennessee) and upper Piedmont (South Carolina) are the first southeastern U.S. records for all of the planthopper species except *K. flava*, *K. parvicurvata*, and *S. lautus*. *Stenocranus lautus* was collected from *Cyperus* spp., but the other seven delphacids were associated with diverse *Carex* spp. representing six sections of the genus. Hosts were generally common, widely distributed sedges. *Stenocranus brunneus*, however, was found on *C. austrocaroliniana* and *C. radfordii*, plant species of limited distribution and special concern. Taxonomic notes on the eight species are provided, as are morphological illustrations and notes on the habitats or communities in which they were found.

Key Words: Auchenorrhyncha, Fulgoroidea, Cyperaceae, *Carex*, *Cyperus*

Kelisia Fieber, a mainly Holarctic genus of the delphacid subfamily Kelisiinae, comprises 45 species, 12 of which occur in North America (Beamer 1945, 1951a). European species of the genus feed mostly on sedges (Cyperaceae), especially *Carex* species (Wilson et al. 1994, Holzinger et al. 2003, Nickel 2003). Specific host associations for the 12 North American species of *Kelisia* (Beamer 1951a) are unknown (Wilson et al. 1994) except for *K. flava* Beamer, which has been collected on *Scirpus cyperinus* (L.) Kunth, a sedge (Denno 1978).

Stenocranus Fieber, belonging to the closely related Stenocraninae (Dijkstra et al. 2003, Bartlett 2006), includes about 66 species, mostly Laurasian in distribution (Metcalf 1943, Calvert and Wilson 1986, Chen and Liang 2005, Bartlett 2006), although it is apparently not monophyletic (Asche and Remane 1982, Asche 1985). In the New World, *Stenocranus* consists of 16 species (Metcalf 1943; Beamer 1946a, b), one of which is not North American, *S. maculipes* (Berg, 1879) from Argentina, plus one species, *S. luteivitta* Walker, 1851, that is *incertae sedis* (Beamer 1946a). In

Europe, *Stenocranus* species feed on grasses (Poaceae) and sedges (Holzinger et al. 2003, Nickel 2003). Of the 14 North American species of *Stenocranus* (Beamer 1946a, b), hosts are known only for *S. arundineus* Metcalf and *S. similis* Crawford, which feed on grasses of the genus *Arundinaria* (*S. similis* also has been found on *Eleocharis quadrangulata* (Michaux) Roem. and Schult. by CRB), and *S. lautus* Van Duzee, which develops on *Carex lurida* Wahl., a sedge (Calvert and Wilson 1986). *Stenocranus lautus* is the only North American species of the two genera whose nymphs have been reported from a specific host.

Here, we provide new host-plant and distributional records of eight delphacids: *Kelisia flava* Beamer, *K. parvicurvata* Beamer, *K. spinosa* Beamer, *K. torquata* Beamer, *K. vesiculata* Beamer, *Stenocranus brunneus* Beamer, *S. lautus* Van Duzee, and *S. unipunctatus* Provancher. For all eight species, we briefly describe the communities or habitats from which they were collected and provide biological and taxonomic notes.

METHODS

Sedges were sampled (by AGW) mainly in the southern Appalachians of North and South Carolina, and the upper Piedmont of South Carolina. The only Tennessee records were from Roan Mountain, whose north-facing slope is in Carter County, Tennessee, and south-facing slope is in Mitchell County, North Carolina; collections from this locality are listed under a combined state header, and both states are indicated on the specimen labels. We tried to sample only pure colonies of *Carex* or *Cyperus* species. Plants were shaken or tapped over a white enamel pan and the dislodged delphacids handpicked from the pan with a shell vial. Adults were sent for identification to CRB, whose collection contains the voucher specimens. The presence of nymphs was noted, and late instars were collected periodically and preserved in ethanol or mounted on points. Hosts are mentioned under "Host plants and habitats" and are not listed under "Material examined" except when a delphacid was found on more than one host at a particular site. In the latter section, "b" denotes brachypterous and "m" macropterous adults; asterisks indicate new state records. All photographs are from specimens taken during this study, except that of *Stenocranus acutus*. Photographs and measurements were taken by CRB using a Nikon SMZ-1500 Digital Imaging Workstation with Nikon DS-U1 digital Camera and Eclipse Net Imaging software (version 1.16.6). Scale bars on all figures represent 0.5 mm.

Kelisia Fieber, 1866

The North American Kelisiinae consist only of the genus *Kelisia*. All 12 described North American species of *Kelisia* were treated by Beamer (1945, 1951a), who described 11 of these species. Beamer's (1951a) key used color features that are generally, but not completely, reliable; male genitalia should be used to confirm species identifications. *Kelisia* individuals are often flightless, with the forewings stenopterous and longer than the abdomen, and the hindwings greatly reduced; individuals are seldom collected, except directly from the host.

Kelisia flava Beamer, 1951
(Fig. 1)

Beamer (1951a) described *K. flava* from a large series (>300 specimens) collected in Connecticut, New Hampshire, New York, North Carolina, and Pennsylvania. This species was later recorded from Maryland (Denno 1978), and Ontario, Canada (Maw et al. 2000), and specimens from Delaware are in the University of Delaware collection. Thirty-four adults were collected from the sedge *Scirpus cyperinus* in Maryland (Denno 1978).

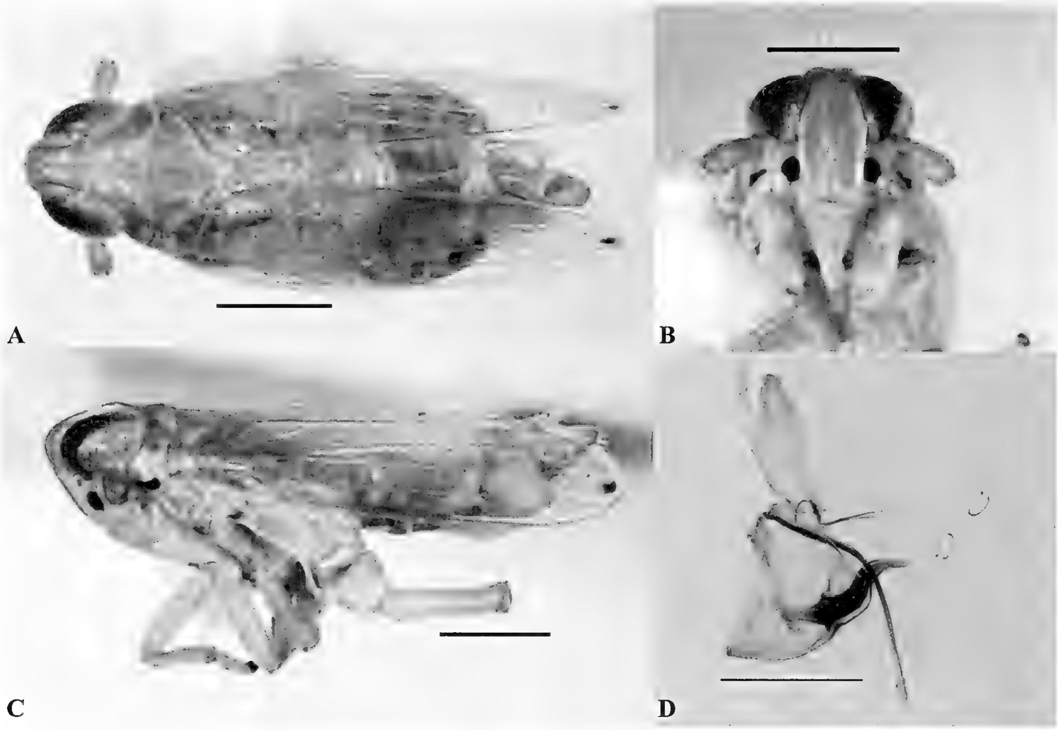


Fig. 1. *Kelisia flava* (NC: Alleghany Co.). A, Dorsal view. B, Frons. C, Lateral view. D, Male pygofer, lateral view.

Host plants and habitats.—*Kelisia flava* was collected from wetlands of the southern Appalachians. Nymphs and adults were found on *Carex bullata* Schkuhr ex Willd. at the edge of ponds in a northern subtype (Schafale and Weakley 1990) of a southern Appalachian bog (Alleghany Co., NC) and on *C. lurida* in a marshy area adjacent to a bog of Schafale and Weakley's (1990) southern subtype (Jackson Co., NC).

Taxonomic notes.—This species is most easily recognized by color, which Beamer (1951a) described as "light stamineous without fumose color anywhere (p. 120)"; however, the specimens we observed from Alleghany Co., NC, uniformly had a dark maculation below the eyes, on the lateral margins of the pronotum, and often on the mesopleuron and apex of the tegmina (Fig. 1A, C). Specimens from Jackson Co., NC (and Delaware), lacked these maculations. All other *Kelisia* have more extensive dark markings on their wings and body. The male genitalia of *K. flava* are most similar to those of *K. axialis* Van Duzee, *K. flagellata* Beamer, and *K. spinosa* in having a pair of elongate hairlike processes arising from the link between the bases of the aedeagus and the anal segment (the presence of processes in this location is a feature of the subfamily; Asche 1990, but see Bartlett 2006). Aside from color, these species differ in the structural details of these processes, the aedeagus, and the pygofer. Most notably, *K. flava* lacks the pygofer spine of *K. spinosa*, and has a pair of dorsal subapical aedeagal teeth instead of the lateral teeth of *K. axialis* and *K. flagellata*.

Material examined.—NORTH CAROLINA: Alleghany Co., ca. 2 km WSW of Cherry Lane, 36°26.53′N, 81°01.86′W, 31 July 2004, 5 b ♂, 1 m ♀; 7–8 Aug.

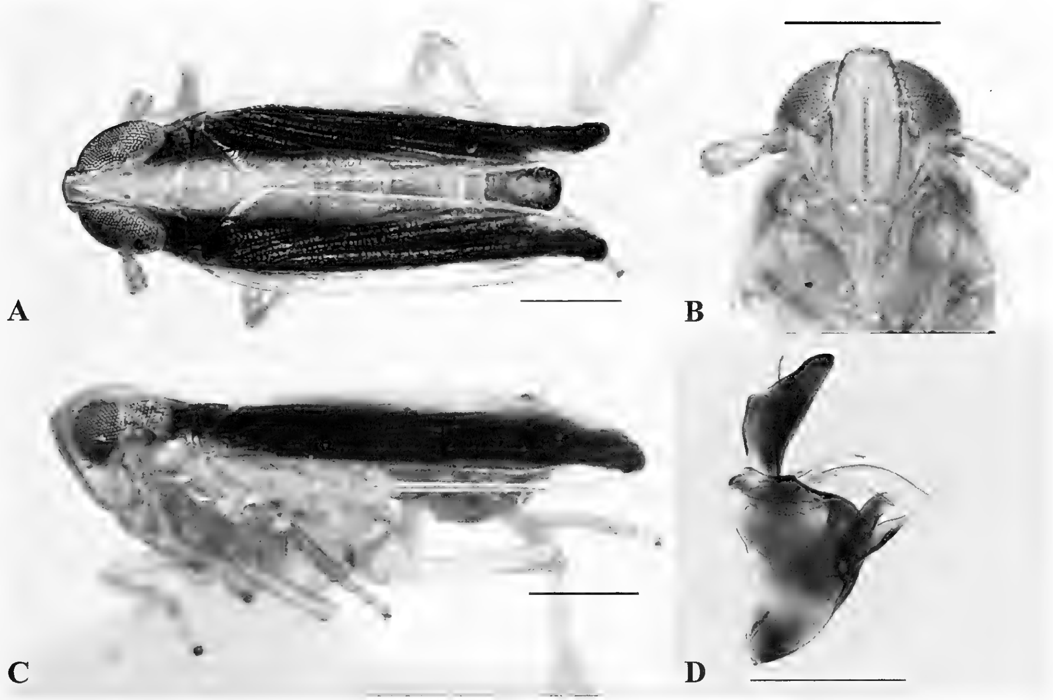


Fig. 2. *Kelisia parvicurvata* (SC: Pickens Co.). A, Dorsal view. B, Frons. C, Lateral view. D, Male pygofer, lateral view.

2004, 12 b ♂, 1 m ♀. Alleghany Co., ca. 4.5 km NE of Cherry Lane, 36°28.87′N, 80°58.73′W, 7–8 Aug. 2004, 10 b ♂, 3 b ♀; 15 Aug. 2004, 7 b ♂, 2 b ♀. Jackson Co., marshy area, Bull Pen Rd. nr. Bull Pen Bog, 35°01.94′N, 83°03.76′W, 4 Sept. 2004, 3 b ♂, 1 b ♀.

Kelisia parvicurvata Beamer, 1951
(Fig. 2)

Beamer (1951a) described this species from 9 brachypterous specimens collected at Palatka, Florida. This species was later reported from Newfoundland, Canada (Maw et al. 2000).

Host plants and habitats.—Adults and nymphs were found on *Carex lurida* growing along Eastatoe Creek in the Piedmont of South Carolina.

Taxonomic notes.—In color pattern, this species resembles *K. spinosa*, *K. torquata*, and *K. curvata*. As noted in Beamer's (1951a) key, the dark wing stripe is narrower in *K. parvicurvata* than in *K. spinosa* (1/3 vs 2/3 wing width); however, in our specimens the dark wing stripe in *K. parvicurvata* measures slightly more than half the wing width at midlength (*K. spinosa* measures very close to 2/3 at wing midlength). Also, the external features used to separate *K. curvata* from *K. parvicurvata* are not reliable and genitalia should be examined to identify these species. The genitalia of *K. parvicurvata* have a unique (Fig 2D), elongate lobe derived from the ventral margin of the aedeagus, which in our specimens is distally free from the aedeagus for a much greater distance than it appears in Beamer's (1951a: 119) illustration.

Material examined.—*SOUTH CAROLINA: Pickens Co., edge of Little Eastatoe Creek, 34°56.93′N, 82°51.01′W, 25 Sept. 2004, 7 b ♂, 6 b ♀.

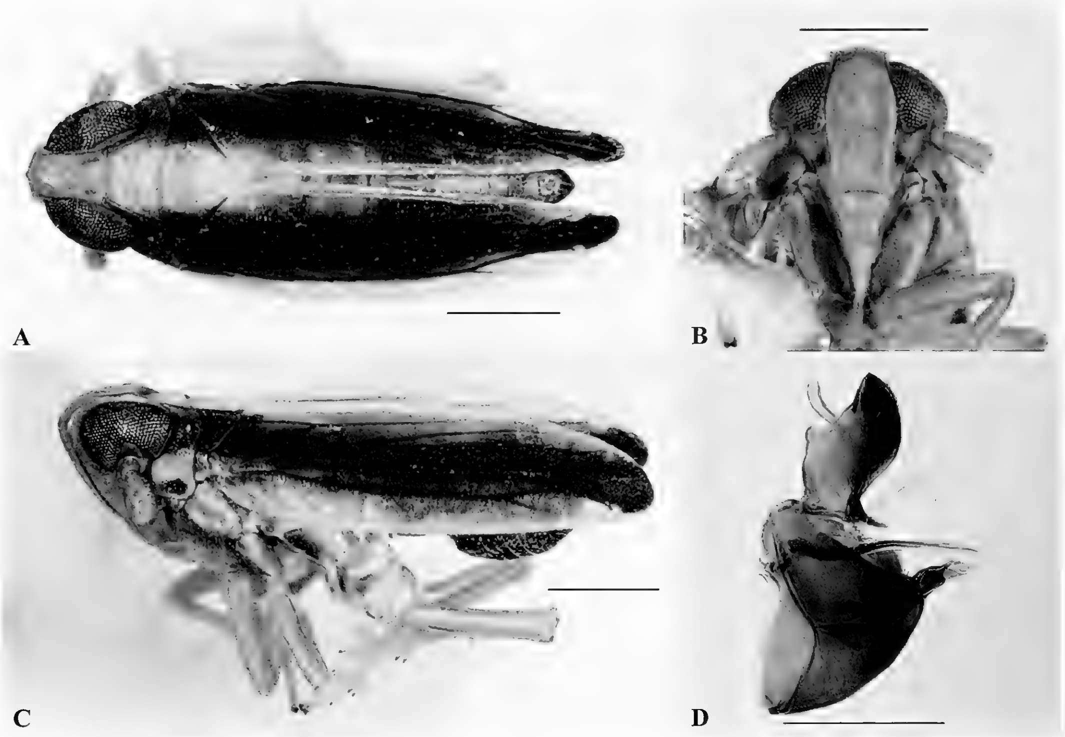


Fig. 3. *Kelisia spinosa* (Roan Mtn., TN & NC). A, Dorsal view. B, Frons. C, Lateral view. D, Male pygofer, lateral view.

Kelisia spinosa Beamer, 1945
(Fig. 3)

Beamer (1945) described *K. spinosa* from brachypterous and macropterous adults taken in the northern United States (Connecticut, Michigan, and Wisconsin) and Manitoba, Canada. All specimens in the type series were collected in August (1934, 1937). Additional state records are Pennsylvania, South Dakota (Beamer 1951a), and Illinois (Wilson and McPherson 1980); subsequent Canadian records include Ontario and Prince Edward Island (Maw et al. 2000).

Host plants and habitats.—Nymphs and adults were found on three species of *Carex*: *C. intumescens* Rudge var. *fernaldii* Bailey, *C. lucorum* Willd. ex Link var. *austrolucorum* Rettig, and *C. pensylvanica* Lam. *Carex lucorum*, once treated as a variety of *C. pensylvanica*, now is considered a distinct species of the *C. pensylvanica* complex (Crins and Ball 1983). *Kelisia spinosa* was collected on *C. intumescens* in a heath bald near Craggy Flats (Buncombe Co., NC) and in grassy balds on *C. intumescens* and *C. pensylvanica* (Black Balsam Knob and Roan Mountain). *Carex pensylvanica* was the host on Whiteside Mountain, a high-elevation granitic dome (Jackson Co., NC); on a granitic outcrop in Alleghany County, NC; and in a *Quercus rubra–Acer rubrum* forest in the upper Piedmont of South Carolina (Oconee Co.). *Carex lucorum* var. *austrolucorum* was the host on a highway embankment (Transylvania Co., NC) and in a shaded area along the road to Sassafras Mountain (Pickens Co., SC). The presence on Whiteside Mountain of adults on the grass *Deschampsia flexuosa* (L.) Trin. probably should be considered incidental (see also Discussion).

Taxonomic notes.—This is the most abundant of the *Kelisia* species observed in this study. Color features place this species as similar to *K. torquata*, *K. parvicurvata*, and *K. curvata*, although the dark longitudinal wing stripe is much broader and uniformly dark in *K. spinosa* than in these other species. This species is most clearly diagnosed by having caudally directed spines on the hind margins of the proximal portion of segment X (Fig. 3D), evidently the feature for which this species was named; *K. spinosa* also has a simple aedeagus, lacking the midventral structures of *K. torquata*, *K. parvicurvata* Beamer, and *K. curvata*.

Material examined.—*NORTH CAROLINA: Alleghany Co., granitic outcrop, ca. 7 km ENE of Laurel Springs, 36°24.4′N, 81°12.0′W, 27 Sept. 2003, 6 b ♂, 2 b ♀. Buncombe Co., nr. Craggy Flats and Blue Ridge Parkway, 14 Sept. 2003, 1 b ♂. Haywood Co., Black Balsam Knob, 35°19.4′N, 82°52.3′W, 10 Sept. 2003, 7 b ♂, 3 b ♀ (ex *C. pensylvanica*) & 25 b ♂, 1 m ♂, 19 b ♀, 1 m ♀ (ex *C. intumescens* var. *fernaldii*); 22 Aug. 2004, 9 b ♂, 3 b ♀ (ex *C. intumescens* var. *fernaldii*). Jackson Co., Whiteside Mountain, ca. 6 km NE of Highlands, 35°04.9′N, 83°08.3′W, 21 Aug. 2002, 2 b ♂, 5 b ♀ (ex *Carex pensylvanica*) & 1 b ♂, 3 b ♀ (ex *Deschampsia flexuosa*); 7 Sept. 2003, 7 b ♂, 8 b ♀, 1 m ♀; 22 Aug. 2004, 9 m ♂, 10 m ♀. Mitchell Co., nr. Round Bald, Roan Mountain, 36°06.6′N, 82°06.3′W, 21 Sept. 2003, 2 b ♂, 2 b ♀; Cloudland and Rhododendron Gardens, 36°06.2′N, 82°07.4′W, 21 Sept. 2003, 12 b ♂, 12 b ♀, 1 m ♀. Transylvania Co., Rt. 276, 1.4 km N of Looking Glass Falls, ca. 12 km NNW of Brevard, 35°20.3′N, 82°47.1′W, 10 Sept. 2003, 5 ♂, 8 ♀; 22 Aug. 2004, 12 m ♂, 6 m ♀. NORTH CAROLINA (Mitchell Co.) / *TENNESSEE (Carter Co.): Carver's Gap, Roan Mountain, 36°06.4′N, 82°06.6′W, 31 Aug. 2003, 11 b ♂, 11 b ♀; 21 Sept. 2003, 5 b ♂, 8 b ♀; 27 Oct. 2002, 1 ♂, 6 ♀ (ex *Deschampsia flexuosa*). *SOUTH CAROLINA: Oconee Co., nr. East Fork Chattooga River, ca. 25 km N of Walhalla, 34°54.06′N, 83°04.31′W, 7 Sept. 2003, 2 b ♂, 2 b ♀. Pickens Co., Sassafras Mountain Rd. (S-19-199), 35°04.1′N, 82°46.9′W, 4 Oct. 2003, 5 ♂, 3 ♀; 24 July 2004, late instars only.

Kelisia torquata Beamer, 1951
(Fig. 4)

Described from Storrs, Connecticut (Beamer 1951a), *K. torquata* previously was known only from the type locality. Beamer's (1951a) description was based on brachypters (6 ♂, 16 ♀) and macropters (1 ♂, 1 ♀) collected in August 1946.

Host plants and habitats.—Adults were collected from *Carex stricta* Lam. in Sparta Bog, a northern subtype (Schafale and Weakley 2004) of a southern Appalachian bog. The nymphs collected with adults might have been those of *K. torquata*, the co-occurring *K. vesiculata* (see below), or both species.

Taxonomic notes.—This species was represented by fewer specimens than the other *Kelisia* species observed in our study. Useful color recognition features include the unmarked head and the weak longitudinal band on the wings, although this species is more strongly marked than *K. vesiculata*. The characteristic genitalia have the basal pair of processes stout and, from caudal view, lyre-shaped, and the aedeagus with a series of ventral fingerlike processes approximately at midlength (Fig. 4D).

Material examined.—*NORTH CAROLINA: Alleghany Co., Sparta Bog, 2.8 km SW of Sparta, 36°26.53′N, 81°01.86′W, 28 Sept. 2003, 2 b ♂, 1 b ♀; 29 Sept. 2005, 3 b ♂, 3 b ♀.

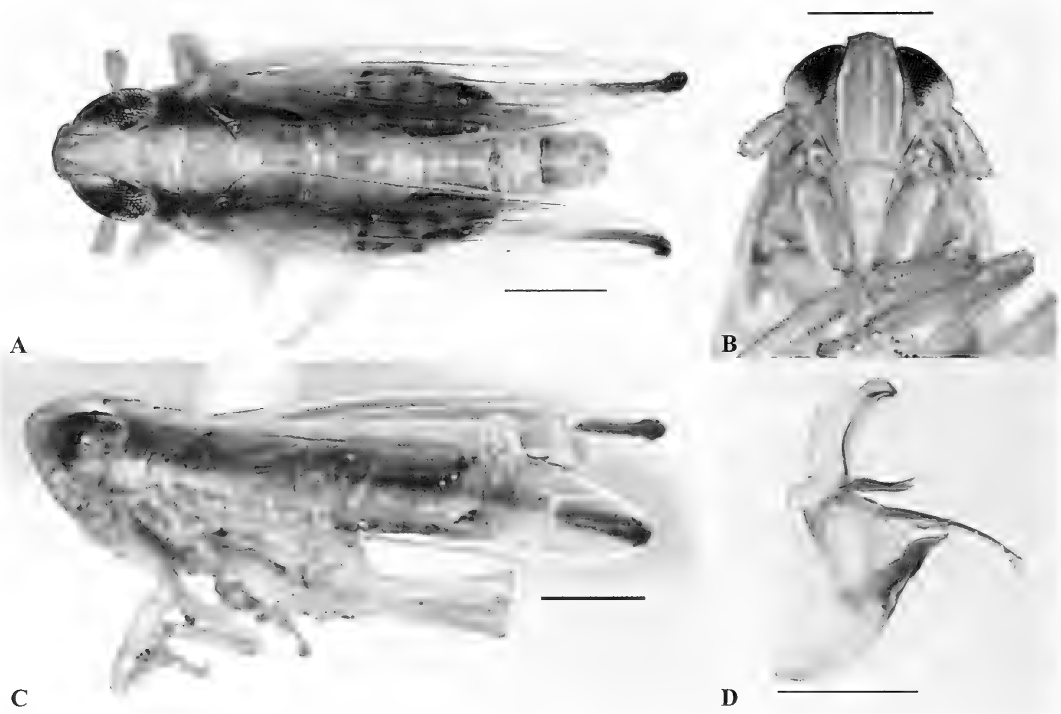


Fig. 4. *Kelisia torquata* (NC: Alleghany Co.). A, Dorsal view. B, Frons. C, Lateral view. D, Male pygofer, lateral view.

Kelisia vesiculata Beamer, 1951
(Fig. 5)

Beamer (1951a) described *B. vesiculata* from a large series collected in Storrs, Connecticut, in August 1946. It since has been reported only from Saskatchewan (Maw et al. 2000).

Host plants and habitats.—Adults were collected on *Carex stricta* in Sparta Bog and in 2003 and 2005 were syntopic with adults of *K. torquata*. In 2004, only *K. vesiculata* was found on *C. stricta* in the same area of the bog. The nymphs observed in mid-August 2004 and late September 2005 might have been those of *K. vesiculata*, *K. torquata*, or both species.

Taxonomic notes.—This species is similar to *K. flava* in being generally pale colored, except that *K. vesiculata* has dark markings on the apex of the wings (Fig 5A), lacking in *K. flava*. *Kelisia vesiculata* is most similar to *K. hyalina* Beamer, differing externally only in that the pygofer is dark in *K. vesiculata* and pale in *K. hyalina*. The aedeagus of *K. vesiculata* is unique in having a large, ventral lobe from mid-length extending proximally nearly to the base of the aedeagus.

Material examined.—*NORTH CAROLINA: Alleghany Co., Sparta Bog, 2.8 km SW of Sparta, 36°26.53′N, 81°01.86′W, 28 Sept. 2003, 3 b ♂, 1 b ♀; 1 Aug. 2004, 7 b ♂, 3 b ♀; 15 Aug. 2004, 3 b ♂, 1 b ♀; 29 Sept. 2005, 2 b ♂.

Stenocranus Fieber, 1866

The North American Stenocraninae consist of the genus *Stenocranus* plus two species recently described in new genera (Bartlett 2006). North American *Stenocranus* were most recently treated by Beamer (1946a, b). The genus is evidently not monophyletic (Asche and

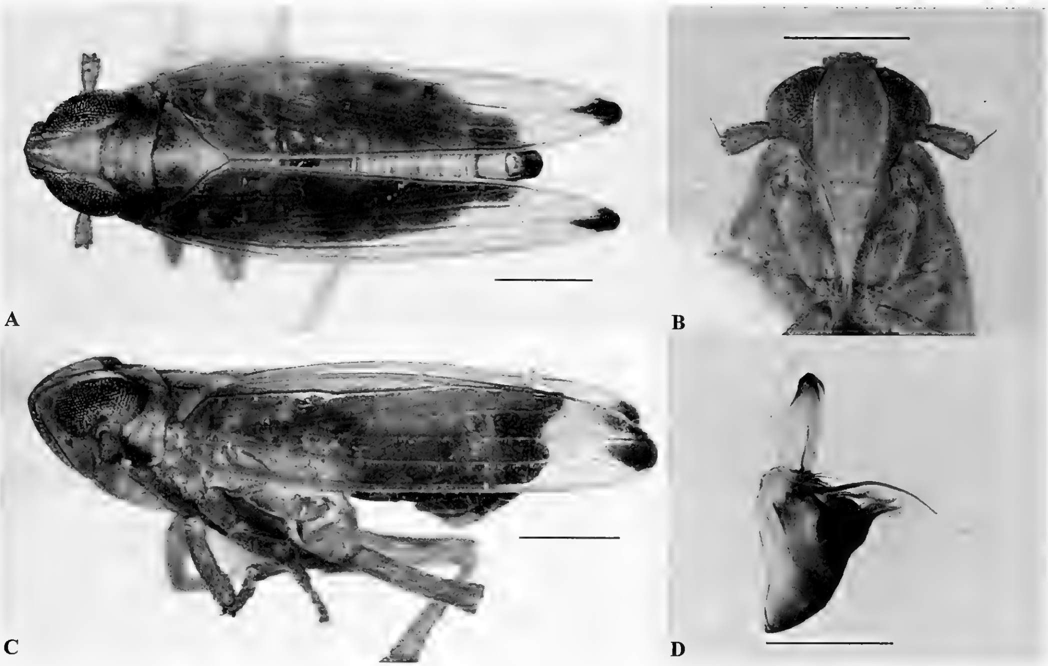


Fig. 5. *Kelisia vesticulata* (NC: Alleghany Co.). A, Dorsal view. B, Frons. C, Lateral view. D, Male pygofer, lateral view.

Remane 1982, Asche 1985) and needs revision on a world basis. Also, Beamer's (1946a) key to North American species is unsatisfactory, as it relies heavily on wing color and venation, neither of which is completely reliable in this genus, making species diagnoses difficult. *Stenocranus* individuals usually are macropterous and often are taken at lights or in general sweeping.

Stenocranus brunneus Beamer, 1946 (Figs. 6, 7A)

No new records have been published since the original description of *S. brunneus* from Illinois and Kansas by Beamer (1946a). The type specimens were collected from June to October 1930–1945 (Beamer 1946a).

Host plants and habitats.—Nymphs and adults were found on six species of *Carex*. In a cove forest in the Jocassee Gorges of South Carolina's upper Piedmont (Pickens Co.), the host was *C. austrocaroliniana* L.H. Bailey. Nymphs and adults were collected from three additional species of *Carex* in another cove forest at Station Cove (Oconee Co.): *C. cumberlandensis* Naczi, Kral and Bryson, *C. gracilescens* Steud., and *C. radfordii* Gaddy. *Stenocranus brunneus* also was found in the upper Piedmont of South Carolina on *C. pensylvanica* growing among lichens and hair-cap moss (*Polytrichum commune* Hedw.) in a granitic outcrop community (Boggs Rock). In North Carolina, single adults were taken on *C. stricta* on each of two dates in Sparta Bog, and nymphs and adults were collected elsewhere in Alleghany County from *Carex intumescens* var. *fernaldii* at the edge of a pond in an area of southern Appalachian bogs. Adults, possibly incidental (see also Discussion), were found on *Cyperus strigosus* in Pickens County, South Carolina.

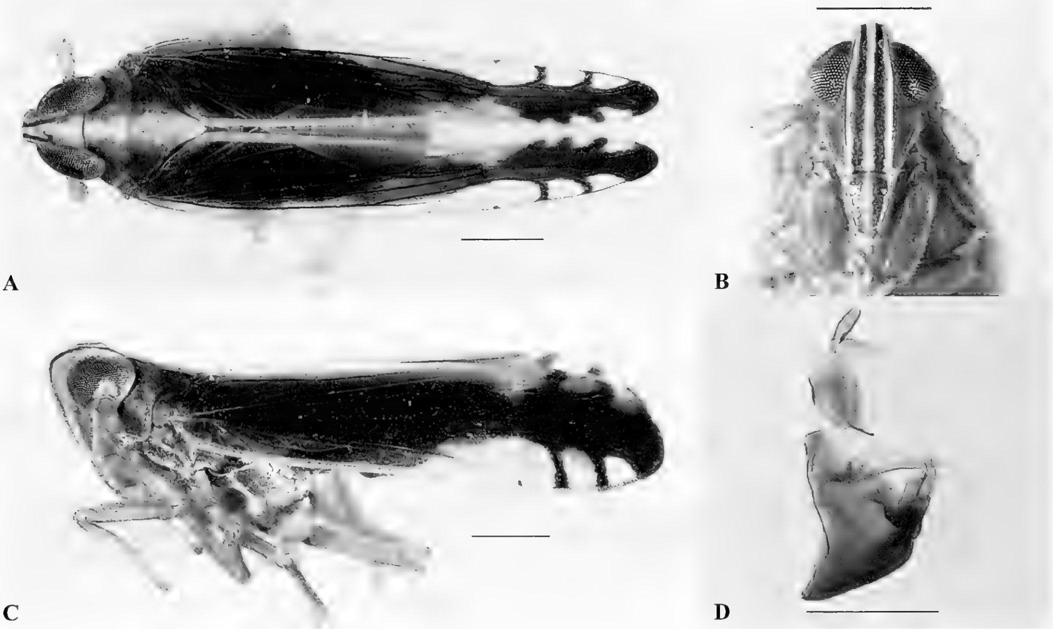


Fig. 6. *Stenocranus brunneus* (A–C, SC: Pickens Co., D, SC: Oconee Co.). A, Dorsal view. B, Frons. C, Lateral view. D, Male pygofer, lateral view.

Taxonomic notes.—This is one of four species that will key in Beamer (1946a:2) as having "M_1 and M_2 usually stemming from R in the front wing," which refers to a proximal fusion of these veins distal to the crossveins (see Dworakowska 1988 for modern interpretation of auchenorrhynchan wing veins). Of these four species, *S. lautus* and *S. unipunctatus* are larger (>5 mm) than *S. brunneus and S. acutus* Beamer (<5 mm). *Stenocranus brunneus* and *S. acutus* can be difficult to distinguish, as the main external differences pertain to relative head proportions. The head of *S. acutus* is narrowed apically (noticeable in both frontal and dorsal views), and projects somewhat in front of the eyes

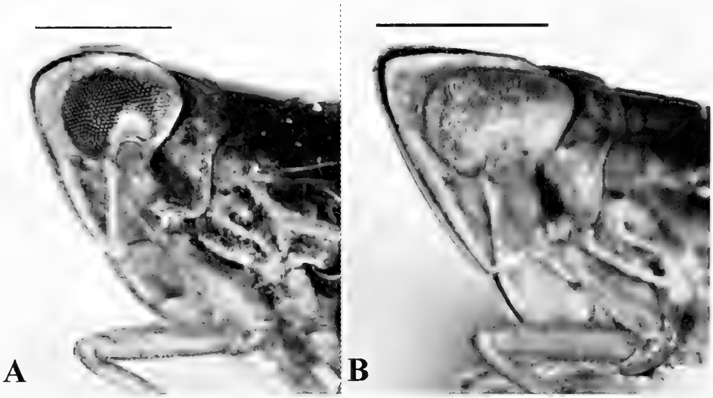


Fig. 7. Lateral view of head. A, *Stenocranus brunneus* (NC: Alleghany Co.). B, *S. acutus* (GA: Okefenokee swamp, paratype).

compared with *S. brunneus* (Fig. 7). In the specimens at hand (males only, n=2 for *S. acutus*), the length of the vertex along the midline is equal to or greater than 0.40 mm in *S. acutus*, less in *S. brunneus*; and the distance between the eye and anterior tip of head is 0.17 or greater in *S. acutus* and 0.14 or less in *S. brunneus*. The head of *S. acutus* also is rather acute in lateral view, versus rounded in *S. brunneus* (Fig. 7). The genitalia of these two species are similar, although the aedeagal process (ventral to curved aedeagus, Fig. 6D) is very broad up to the distal third, but only slightly broadened in *S. acutus*.

Material examined.—*NORTH CAROLINA: Alleghany Co., Sparta Bog, 2.8 km SW of Sparta, 36°26.53′N, 81°01.86′W, 1 Aug. 2004, 1 m ♂; 15 Aug. 2004, 1 b ♂; ca. 4.5 km NE of Cherry Lane, 36°28.87′N, 80°58.73′W, 7–8 Aug. 2004, 5 m ♂, 7 m ♀; 15 Aug. 2004, 4 m ♂, 4 m ♀. *SOUTH CAROLINA: Oconee Co., Station Cove, ca. 7 km WSW of Tamassee, 34°50.96′N, 83°05.11′W, 22 Sept. 2004, 1 m ♂, 5 m ♀ (ex *Carex cumberlandensis*); 25 Sept. 2004, 1 m ♀ (ex *C. cumberlandensis*), 1 m ♂ (*ex C. gracilescens*), 1 m ♀ (ex *C. radfordii*). Pickens Co., Boggs Rock, 2.1 km N of Liberty, 34°48.4′N, 82° 41.6′W, 20 Sept. 2003, late instars & 4 Oct. 2003, 2 m ♂, 5 m ♀; Jocassee Gorges, Cane Creek watershed, 35° 00′04.8″N, 82°52′58.7″W, 15 Sept. 2004, 2 m ♂; NE of CR-143, near Eastatoe Creek, 34°57.66′N 82°50.69′W, 25 Sept. 2005, 3 m ♂, 5 m ♀ (ex *Cyperus strigosus*).

Stenocranus lautus Van Duzee, 1897
(Fig. 8)

Described from New York (Van Duzee 1897), *S. lautus* was recorded from the District of Columbia, Illinois, Kansas, Maryland, New Hampshire, North Carolina, and Virginia by Beamer (1946a). More recent U.S. records are Missouri (Calvert and Wilson 1986) and Tennessee (Bartlett and Bowman 2003). In Canada, it is known from Ontario and Quebec with an uncertain record from British Columbia (Maw et al. 2000). Of the five *Kelisia* and three *Stenocranus* species we treat, *S. lautus* is the only one previously associated with a specific sedge. Calvert and Wilson (1986) reported that nymphs of this bivoltine delphacid develop on *Carex lurida* in central Missouri and described the egg and five nymphal instars.

Host plants and habitats.—Nymphs and adults were found on *Cyperus esculentus* L. in a weedy area of the South Carolina Botanical Garden. Also in the Piedmont of Pickens County, SC, adults were collected from *C. strigosus* L. in a disturbed area along a path in a forested area near Eastatoe Creek. An adult was taken on *Carex cumberlandensis* at Station Cove (Oconee Co., SC) and another on *C. lurida* growing at the edge of a pond in a southern Appalachian bog in Alleghany County, NC.

Taxonomic notes.—This is the most commonly encountered eastern *Stenocranus*, although relatively few specimens were found in our study. *Stenocranus lautus* is most similar to *S. unipunctatus*, and both are larger than *S. acutus* and *S. brunneus*. The key feature of the basal fusion of the R and M veins beyond the crossveins is not consistent for either species, and the "subcosta usually with a black spot" (Beamer 1946a:2) also appears to be inconsistent (see Figs. 8C, 9C). The most consistent features are that *S. unipunctata* is smaller (4.5–5.5 mm) than *S. lautus* (5–6 mm, as reported in Beamer 1946a), and the aedeagal process is apically bifid in *S. unipunctatus*, with the two processes at right angles (Fig. 9D), versus not bifid in *S. lautus*. The latter feature is definitive for these species.

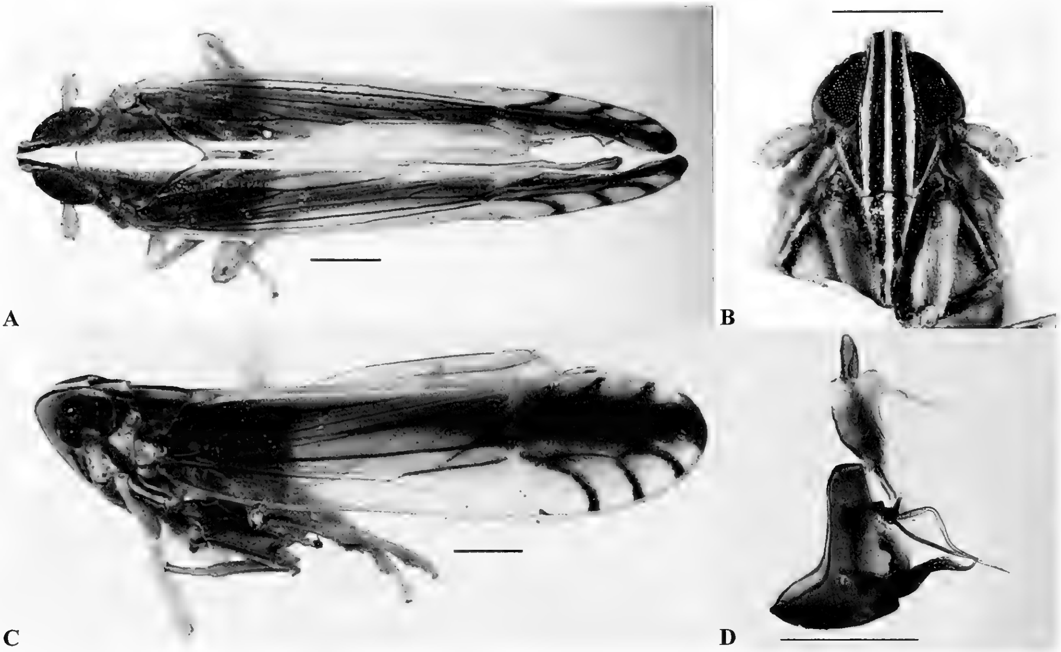


Fig. 8. *Stenocranus lautus* (SC: Pickens Co.). A, Dorsal view. B, Frons. C, Lateral view. D, Male pygofer, lateral view.

Material examined.—NORTH CAROLINA: Alleghany Co., ca. 2 km WSW of Cherry Lane, 36°26.53′N, 81° 01.86′W, 7 Aug. 2004, 1 m ♂. *SOUTH CAROLINA: Oconee Co., Station Cove, ca. 7 km WSW of Tamassee, 34° 50.96′N, 83°05.11′W, 25 Sept. 2004, 1 m ♂. Pickens Co., nr. Eastatoe Creek, 1.3 km N of Rt. 11, 34°57.66′N, 82°50.69′W, 25 Sept. 2004, 1 m ♂. South Carolina Botanical Garden, Clemson, 34°40.49′N, 82°49.21′W, 19 Sept. 2004, 1 m ♀; 25 Sept. 2004, 1 m ♀; 31 Oct. 2004, 1 m ♂,1 m ♀; 31 July 2005, 2 m ♂.

Stenocranus unipunctatus (Provancher 1872)
(Fig. 9)

Described from Quebec by Provancher (1872) (as *Delphax unipunctata*), *S. unipunctatus* was synonymized with *S. dorsalis* Fitch by Van Duzee (1912) before being resurrected as a valid species (Beamer 1946a). The only subsequent Canadian record is Ontario (Maw et al. 2000), and the only previous U.S. record is Illinois (Wilson and McPherson 1980). Dozier (1922) noted that *S. dorsalis* is found nearly throughout the United States and Canada, but the only records assigned to this species are Maine, Illinois (Wilson and McPherson 1980), Ontario, and Quebec (Maw et al. 2000). Dozier's (1922) apparent composite concept of *S. dorsalis* likely included not only that species but also *S. unipunctatus* and other species of the genus.

Host plants and habitats.—Nymphs and adults were collected in Alleghany County, North Carolina, from *Carex intumescens* in the same southern Appalachian bog complex, northern subtype, that harbored *K. flava* and *S. brunneus*. An adult was taken on *C. stricta* in the same northern subtype bog that harbored *K. torquata* and *K. vesiculata*.

Taxonomic notes.—See comments under "Taxonomic notes" for *S. lautus*.

Material examined.—*NORTH CAROLINA: Alleghany County, ca. 4.5 km

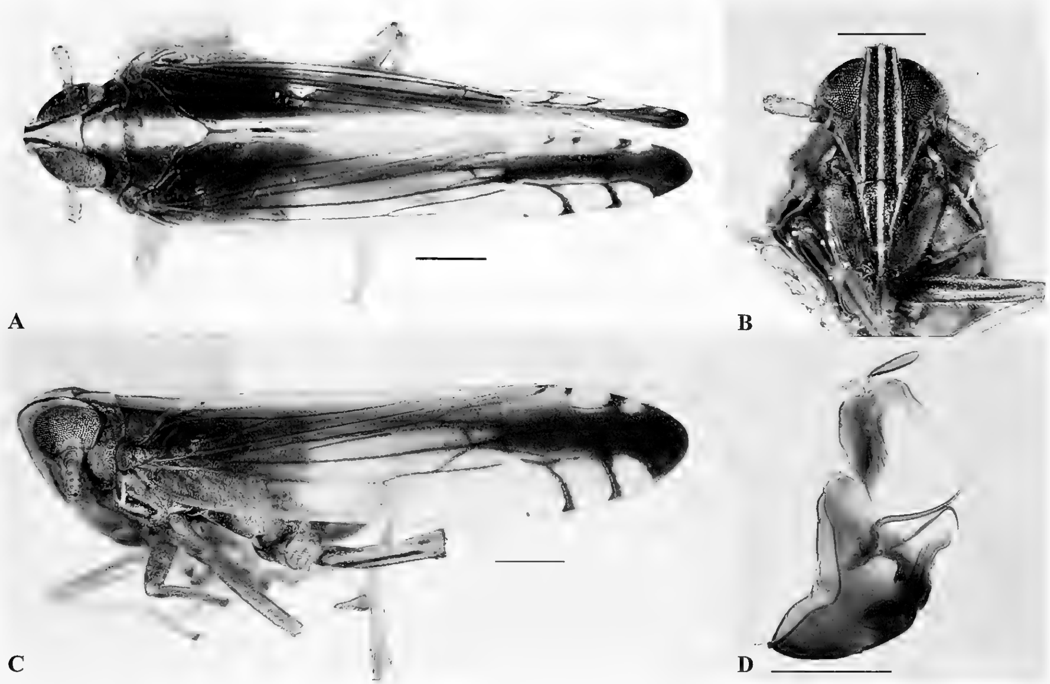


Fig. 9. *Stenocranus unipunctatus* (NC: Alleghany Co.). A, Dorsal view. B. Frons. C, Lateral view. D, Male pygofer, lateral view.

NE of Cherry Lane, 36°28.87′N, 80°58.73′W, 7–8 Aug. 2004, 2 m ♂, 6 m ♀; 15 Aug. 2004, 4 m ♂, 13 m ♀; Sparta Bog, 2.8 km SW of Sparta, 36°26.53′N, 81°01.86′W, 1 Aug. 2004, 1 m ♂.

DISCUSSION

An association with grasses and sedges has long been known for North American species of *Kelisia* and *Stenocranus* (e.g., Dozier 1922, Osborn and Drake 1922, Van Duzee 1923, Osborn 1938). Yet, in a group as host restricted as the Delphacidae (Wilson et al. 1994), the determination of specific host plants is desirable, especially in the case of the speciose sedge genus *Carex*. Delphacid-sedge relationships are incompletely known, even for the relatively well-studied European fauna. Sedges are undercollected because they often grow in bogs, fens, and other hard-to-access communities that field biologists tend to avoid. Sedges also are difficult to identify, particularly when withered or in a vegetative condition (Nickel 2003).

For the eight species of *Kelisia* and *Stenocranus* that we treat, only one specific host association previously has been documented: *S. lautus* on *C. lurida*, a sedge (Calvert and Wilson 1986). *Scirpus cyperinus* apparently is a host of *K. flava* according to Denno (1978).

Raymond Beamer, who described six of the eight delphacids for which we give host plants (and 11 of the 12 North American *Kelisia*), was an excellent collector. Hungerford (1958:60) noted that Beamer "was untiring and enthusiastic in the field and the best collector I ever knew." Beamer's wife Lucy usually accompanied him in the field, and through the years they incorporated new techniques into their collecting repertoire after observing methods used by specialists in other insect groups (L. Beamer 1946). The Beamers collected from sedges (L. Beamer 1946), and they collected nearly all of the new species he described in the mostly sedge-feeding genera *Kelisia* and *Stenocranus* (Beamer 1945, 1946a, b; 1951a). Host relationships, however, were not mentioned in his taxonomic reviews of those genera; rarely did he refer to specific grasses or sedges as delphacid hosts (e.g., Beamer 1947, 1951b).

We observed nymphs of *S. lautus* on *Cyperus esculentus* and adults on *C. strigosus*, in addition to an adult on *Carex cumberlandensis* and one on its previously recorded host, *C. lurida*. Nymphs of the other *Kelisia* and *Stenocranus* species were found only on *Carex*, with the species that served as hosts belonging to six sections of the genus (Flora of North America Editorial Committee 2002). Only in North Carolina at Bull Pen Bog and an adjacent marsh and, especially at Sparta Bog, were we uncertain about a host association—that is, unable to determine that planthoppers at those sites were restricted to *Carex stricta* and not found on syntopic sedges. Nickel (2003) alluded to the difficulty of assigning a particular hopper species to a particular host when sedges occur in mixed stands.

On Whiteside Mountain, several adults of *K. spinosa* were collected from the grass *Deschampsia flexuosa* (L.) Trin. growing about 3 m from a colony of *Carex pensylvanica* harboring nymphs and adults of the delphacid. Nymphs and adults of *S. brunneus* were found only on *Carex* species except for the adults taken on *Cyperus strigosus* in Pickens County, South Carolina. Nickel (2003) mentioned that European delphacids considered strictly monophagous on particular host grasses occasionally are found as adults, or even nymphs, on other grasses. He acknowledged that such occurrences might be more widespread and may potentially enable a herbivore to avoid the constraints of specialization. The presence, however, of *K. spinosa*, whose nymphs have been observed only on sedges, likely is only incidental on the grass *D. flexuosa*. *Kelisia* nymphs were not found during a study of two delphacid species that develop on this grass (Wheeler and Bartlett 2006), nor were nymphs of *Kelisia* found on other grasses at Whiteside Mountain (AGW, personal observation). The relationship of *S. brunneus* to *C. strigosus* might also be incidental.

As is the case for most phytophagous insects (e.g., Strong et al. 1984), planthoppers are associated mainly with plants that are widespread and abundant (Nickel 2003). Host plants of the eight kelisiine and stenocranine planthoppers generally were common, widely distributed sedges typically found in eastern North America from southern Canada south to at least the Carolinas (Flora of North America Editorial Committee 2002). *Cyperus esculentus* and *C. strigosus* often are weedy sedges of disturbed areas (Whitson et al. 2000, Tucker et al. 2002), and *Carex stricta*, on which three delphacid species were collected, might be the most common sedge in wetlands of eastern North America (Standley et al. 2002). We collected *Kelisia* and *Stenocranus* species on one to three hosts, except for *S. brunneus*, nymphs of which were found on six hosts, including the widely distributed *Carex gracilescens* and *C. pensylvanica*, as well as *C. austrocaroliniana*, a species of special concern known only from six states (Kentucky and Tennessee to Alabama and Georgia), and the recently described *C. cumberlandensis* (Naczi et al. 2001) and *C. radfordii* (Gaddy 1995). The latter sedge, recorded only from a few sites near the Blue Ridge escarpment in northeastern Georgia, southwestern North Carolina, and northwestern South Carolina, is a species of conservation concern (Bryson and Naczi 2002).

Knowledge of host relationships among European kelisiine and stenocranine planthoppers is sufficiently mature to discern trends in their diet breadth (Nickel and Remane 2002; Holzinger et al. 2003; Nickel 2003). Any attempt to discuss host-plant specificity among North American kelisiines and stenocranines would be premature. Including the host plants that we report, specific hosts are known for less than one-third of the North American species of *Kelisia* and *Stenocranus* (Wilson et al. 1994). Two of the species we discuss—*K. torquata* and *S. brunneus*—had not been mentioned in the literature since their original descriptions (Beamer 1946a, 1951a). Certain European *Kelisia* species once considered rare have proved common upon discovery of their hosts (Nickel 2003), and that trend also appears to hold for most of the delphacids treated here. Even if uncommon potential hosts are discounted as being unlikely to yield Delphacidae, the sheer number of North American sedges—more than 840 species, with about 480 in *Carex* (Flora of North America Editorial Committee 2002)—will make difficult an inventorying of the Cyperaceae for kelisiines and stenocranines. Much more fieldwork is needed, not only for a better understanding of the host-plant ranges of the eight species we report, but also for discovering the hosts used by the remaining North American species of *Kelisia* and *Stenocranus*.

ACKNOWLEDGMENTS

We are grateful to Patrick McMillan (Department of Biological Sciences, Clemson University) for determining all sedges; his ability to identify even vegetative material greatly enhanced our work. We thank Anthony Gonzon (Department of Entomology and Wildlife Ecology, University of Delaware) for assistance with planthopper specimen preparation and identification. We also thank Peter Adler (Department of Entomology, Soils, and Plant Sciences, Clemson University) and Douglas Tallamy (Department of Entomology and Wildlife Ecology, University of Delaware) for comments that improved an earlier draft of the manuscript. This research was supported by NSF Systematic Biology Program award DEB-0342538 and the University of Delaware Department of Entomology and Wildlife Ecology.

LITERATURE CITED

Asche, M. 1985. Zur Phylogenie der Delphacidae Leach, 1815 (Homoptera: Cicadina: Fulgoromorpha). Marburger Entomologische Publikationen 2(1): 1–910 (in two volumes).

———. 1990. Vizcayinae, a new subfamily of Delphacidae with revision of *Vizcaya* Muir (Homoptera: Fulgoroidea) - a significant phylogenetic link. Bishop Museum Occasional Papers 30: 154–187.

Asche, M. and R. Remane. 1982. Zur Phylogenie der Delphacidae Leach, 1815 (Homoptera Cicadina Fulgoromorpha). Vorläufige Mitteilung. Marburger Entomologische Publikationen 1: 155–182.

Bartlett, C. R. 2006 (2005). Two new genera and species of stenocranine planthoppers (Hemiptera: Delphacidae) from North America. Entomological News 116: 291–303.

Bartlett, C. R. and J. L. Bowman. 2003. Preliminary inventory of the planthoppers (Hemiptera: Fulgoroidea) of the Great Smoky Mountains National Park, North Carolina and Tennessee, U.S.A. Entomological News 114: 246–254.

Beamer, L. 1946. I'll tell you how. Journal of the Kansas Entomological Society 19: 127–129.

Beamer, R. H. 1945. The genus *Kelisia* in America north of Mexico (Homoptera-Fulgoridae-Delphacinae). Journal of the Kansas Entomological Society 18: 100–108.

———. 1946a. The genus *Stenocranus* in America north of Mexico (Homoptera-Fulgoridae-Delphacinae). Journal of the Kansas Entomological Society 19: 1–11.

———. 1946b. A new species of *Stenocranus* and notes on a *Bakerella* (Homoptera-Fulgoridae-Delphacinae). Journal of the Kansas Entomological Society 19: 137–138.

———. 1947. Some new species of *Delphacodes* (continued) with two old ones. Journal of the Kansas Entomological Society 20: 58–71.

———. 1951a. A review of the genus *Kelisia* in America north of Mexico with four new species (Homoptera-Fulgoridae-Delphacinae). Journal of the Kansas Entomological Society 24: 117–121.

———. 1951b. A rare wing deformity in delphacine fulgorids (Homoptera-Fulgoridae-Delphacinae). Journal of the Kansas Entomological Society 24: 55.

Bryson, C. T. and R. F. C. Naczi. 2002. *Carex* Linnaeus sect. *Careyanae* Tuckerman ex Kükenthal in H.G.A. Engler, Pflanzenr. 20[IV, 38]:522. 1909, pp. 443–448. *In* Flora of North America Editorial Committee, ed., Flora of North America North of Mexico. Vol. 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. Oxford University Press, New York.

Calvert, P. D. and S. W. Wilson. 1986. Life history and descriptions of the immature stages of the planthopper *Stenocranus lautus* (Homoptera: Delphacidae). Journal of the New York Entomological Society 94: 118–125.

Chen, X-S. and A-P. Liang. 2005. A taxonomic study of subfamily Stenocraninae (Homoptera, Fulgoroidea, Delphacidae) from China, with description of a new species of the genus *Stenocranus*. Acta Zootaxonomica Sinica 30: 123–129.

Crins, W. J. and P. W. Ball. 1983. The taxonomy of the *Carex pensylvanica* complex (Cyperaceae) in North America. Canadian Journal of Botany 61: 1692–1717.

Denno, R. F. 1978. The optimum population strategy for planthoppers (Homoptera: Delphacidae) in stable marsh habitats. Canadian Entomologist 110: 135–142.

Dijkstra, E., J. M. Rubio, and R. J. Post. 2003. Resolving relationships over a wide taxonomic range in Delphacidae (Homoptera) using the COI gene. Systematic Entomology 28: 89–100.

Dozier, H. L. 1922. A synopsis of the genus *Stenocranus*, and a new species of *Mysidia*. (Homoptera). Ohio Journal of Science 22: 69–82.

Dworakowska, I. 1988. Main veins of the wings of Auchenorrhyncha (Insecta, Rhynchota: Hemelytrata). Entomologische Abhandlungen Staatliches Museum für Tierkunde Dresden 52: 63–108.

Fieber, F. X. 1866. Grundzüge zur generischen Theilung der Delphacini. Verhandlungen der Kaiserlich-Königlichen Zoologish-botanischen Gesellschaft in Wien 16: 517–534.

Flora of North America Editorial Committee, ed., 2002. Flora of North America North of Mexico. Vol. 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. Oxford University Press, New York. 608 pp.

Gaddy, L. L. 1995. *Carex radfordii* (section *Laxiflorae*: Cyperaceae), a new species from the southern Appalachians. Novon 5: 259–261.

Holzinger, W. E., I. Kammerlander, and H. Nickel. 2003. The Auchenorrhyncha of Central Europe. Vol. 1: Fulgoromorpha, Cicadomorpha excl. Cicadellidae. Brill, Leiden. 673 pp.

Hungerford, H. B. 1958. Raymond Hill Beamer. Journal of the Kansas Entomological Society 31: 58–66.

Maw, H. E. L., R. G. Foottit, K. G. A. Hamilton, and G. G. E. Scudder. 2000. Checklist of the Hemiptera of Canada and Alaska. NRC Research Press, Ottawa. 220 pp.

Metcalf, Z. P. 1943. General Catalogue of the Hemiptera. Fascicle IV, Fulgoroidea, Part 3 Araeopidae (Delphacidae). Smith College, Northampton, Mass. 552 pp.

Naczi, R. F. C., R. Kral, and C. T. Bryson. 2001. *Carex cumberlandensis*, a new species of section *Careyanae* (Cyperaceae) from the eastern United States of America. Sida 19: 993–1014.

Nickel, H. 2003. The Leafhoppers and Planthoppers of Germany (Hemiptera, Auchenorrhyncha): Patterns and Strategies in a Highly Diverse Group of Phytophagous Insects. Pensoft Publishers, Sofia: Goecke & Evers, Keltern. 460 pp.

Nickel, H. and R. Remane. 2002. Artenliste der Zikaden Deutschlands mit Angabe von Nährpflanzen, Nahrungsbreite, Lebenszyklus, Areal und Gefährdung (Hemiptera, Fulgoromorpha et Cicadomorpha). Beiträge zur Zikadenkunde 5: 27–64.

Osborn, H. 1938. The Fulgoridae of Ohio. Ohio Biological Survey. Ohio State University, Columbus, 6(6) [Bull. No. 35]: pp. 283–357.

Osborn, H. and C. J. Drake. 1922. An ecological study of the Hemiptera of the Cranberry Lake Region, New York. New York State College of Forestry at Syracuse University. Technical Publication 16: 5–86.

Provancher, L. 1872. Descriptions de plusieurs Hémiptères nouveaux. Naturaliste Canadien 4: 319–320.

Schafale, M. P. and A. S. Weakley. 1990. Classification of the Natural Communities of North Carolina, Third Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources, Raleigh. 325 pp.

Standley, L. A., J. Cayouette, and L. Bruederle. 2002. *Carex* Linnaeus sect. *Phacocystis* Dumortier, Fl. Belg., 146. 1827, pp. 379–401. *In* Flora of North America Editorial Committee, ed., Flora of North America North of Mexico. Vol. 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. Oxford University Press, New York.

Strong, D. R., J. H. Lawton, and [T.]. R. [E.]. Southwood. 1984. Insects on Plants: Community Patterns and Mechanisms. Harvard University Press, Cambridge. 313 pp.

Tucker, G. C., B. G. Marcks, and J. R. Carter. 2002. *Cyperus* Linnaeus, Sp. Pl. 1:44.1753; Gen. Pl. ed. 5, 26.1754, pp. 141–191. *In* Flora of North America Editorial Committee, ed., Flora of North America North of Mexico. Vol. 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. Oxford University Press, New York.

Van Duzee, E. P. 1897. A preliminary review of the North American Delphacidae. Bulletin of the Buffalo Society of Natural Sciences 5: 225–261.

———. 1912. Synonymy of the Provancher collection of Hemiptera. Canadian Entomologist 44: 317–329.

———. 1923. Family Fulgoridae, pp. 24–55. *In* Britton, W. E. ed. Guide to the Insects of Connecticut. Part IV. The Hemiptera or Sucking Insects of Connecticut. Connecticut State Geological and Natural History Survey Bulletin No. 34.

Wheeler, A. G. Jr. and C. R. Bartlett. 2006. *Delphacodes campestris* (Van Duzee) and *D. lutulenta* (Van Duzee) (Hemiptera: Fulgoromorpha: Delphacidae): Association with common hairgrass, *Deschampsia flexuosa* (Poaceae), and notes on habitats, seasonality, and taxonomy. Proceedings of the Entomological Society of Washington 118: 395–403.

Whitson, T. D., et al. (2000). Weeds of the West, 9th ed. Western Society of Weed Science, Newark, CA, in cooperation with the Western U. S. Land Grant Universities Cooperative Extension Services. 626 pp.

Wilson, S. W. and J. E. McPherson. 1980. The distribution of the Fulgoroidea of the eastern United States (Homoptera). Transactions of the Illinois State Academy of Science 73(4): 7–20.

Wilson, S. W., C. Mitter, R. F. Denno, and M. R. Wilson. 1994. Evolutionary patterns of host plant use by delphacid planthoppers and their relatives, pp. 7–113. *In* Denno, R. F. and T. J. Perfect, eds. Planthoppers: Their Ecology and Management. Chapman & Hall, New York. i–x + 799 pp.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 416–426

NEW SPECIES OF LEPTOHYPHIDAE (EPHEMEROPTERA) FROM COSTA RICA

David E. Baumgardner

Department of Entomology, Texas A&M University, College Station, TX 77843-2475, U.S.A. (e-mail: dbaumgardner@tamu.edu)

Abstract.—Three **new species** of leptohyphid mayflies (Ephemeroptera: Leptohyphidae), ***Leptohyphes mandibulus***, ***Tricorythodes kirki***, and ***Tricorythodes primus***, are described from Costa Rica based upon the larval stages. *Leptohyphes mandibulues* can be distinguished from other species in the genus by its unique mandibular morphology and color patterns of the operaulate gill. *Tricorythodes kirk* larvae are distinctive due to their contrasting abdominal coloration. *Tricorythodes primus* is distinguished from other speices of *Tricorythodes* in Central America due to the presence of a distinctive and well developed frontal shelf and genal projections.

Key Words: Ephemeroptera, Leptohyphidae, *Leptohyphes*, *Tricorythodes*, new species

The mayfly family Leptohyphidae is a diverse assemblage of more than 125 species endemic to the Western Hemisphere. The family is most diverse in South America, with fewer species known from Central and North America. The family has received critical attention recently in both South America (Molineri 1999, 2001a,b, 2002, 2003a,b, 2004; Molineri and Zúñiga 2004), and North and Central America (Baumgardner and McCafferty 2000; Wiersema and McCafferty 2000, 2003, 2005; Wiersema et al. 2001; Baumgardner 2003; Baumgardner et al. 2003, 2006; Baumgardner and Ávila 2006). Additional descriptions and revisions of species are still required before generic boundaries and relationships can be fully analyzed. Examination of collections of mayflies made in 2001 from Costa Rica revealed three distinctive new species of leptohyphid mayflies, as described below.

Materials and Methods

Larvae were collected from streams using forceps and by disturbing the sediment using kick nets, then preserved in 70% ethyl alcohol. Legs, gills, and mouthparts were removed and mounted on slides for detailed study. Figures were drawn using a camera lucida. Collection sites are given in longitude/latitude coordinates as degrees, minutes, seconds, and were determined using a handheld global positioning system unit. Setal descriptive terminology follows Baumgardner and Ávila (2006). Gill formula follows Molineri (2003b), and indicates the number of membranous lamellae on abdominal segments two through seven. Collections (and their acronyms) housing materials used in this study include Florida A&M University, Tallahassee (FAMU) and Texas A & M University, College Station (TAMU).

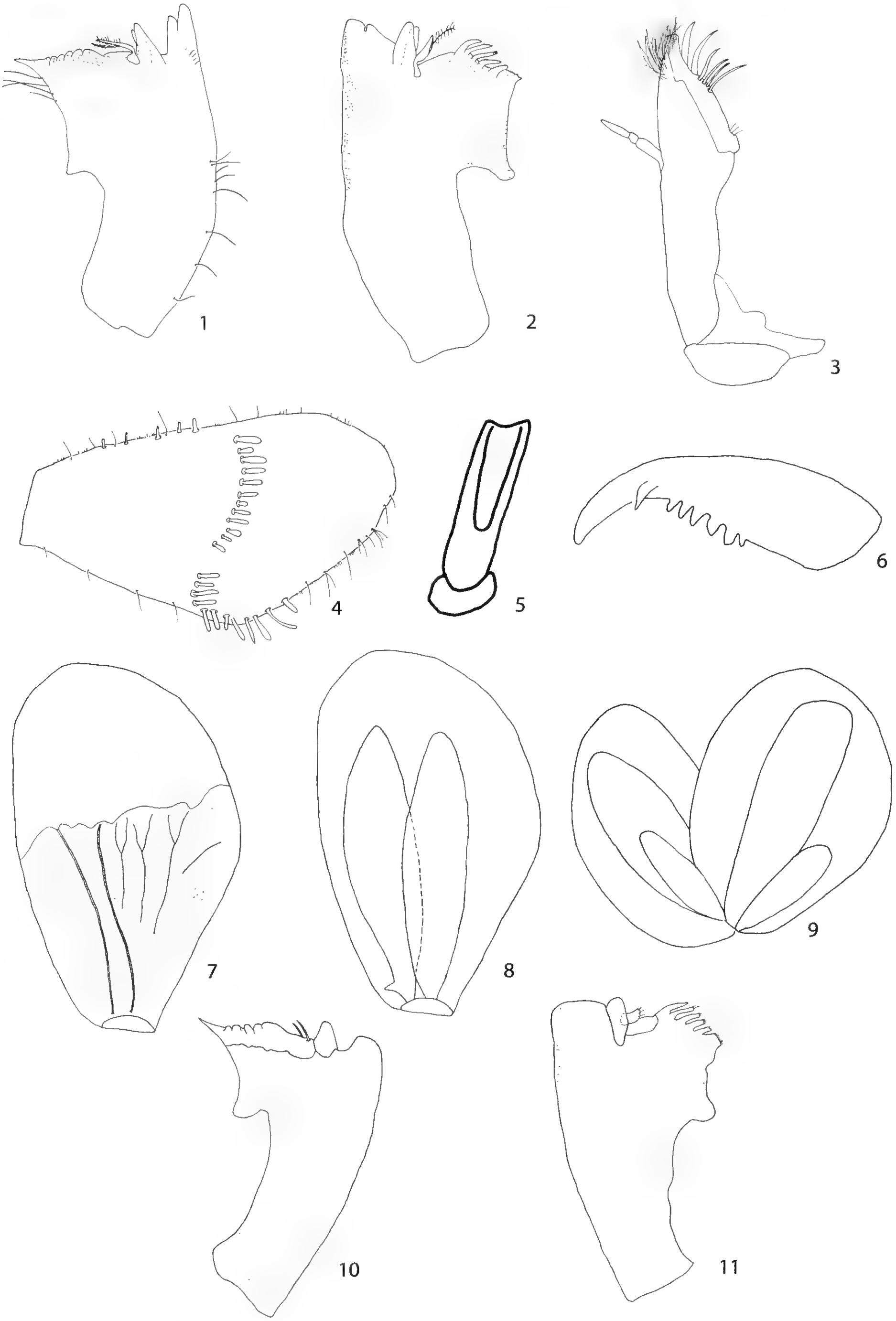
Descriptions

Leptohyphes mandibulus Baumgardner, new species

(Figs. 1–11)

Adult.—Unknown

Mature larva.—Body length 3.0–3.5 mm; caudal filaments 2.0–2.5 mm. General color black. *Head*: Dark reddish brown to black; small genal projections present; tubercles absent; compound eyes small and widely separated; three ocelli present; antenna light brown, approximately two times length of head capsule. *Mouthparts*: Labrum: dorsally with filiform setae along lateral margin; two rows of acuminate setae recessed from anterior margin; ventrally with one longitudinal row of acuminate setae near midline, with interspersed filiform setae; anterior and lateral margins with dense filiform and acuminate setae. Right mandible (Fig. 1): outer and inner incisors two lobed; prostheca arising at base of inner incisor with highly branched, elongate setae projecting towards molar region; molar region mostly fused. Left mandible (Fig. 2): outer incisor two lobed, teeth fused almost their entire distance; inner incisor two lobed; prostheca arising at base of inner incisor, with highly branched setae projecting towards molar region. Hypopharynx: lingua apically rounded; numerous filiform and acuminate setae present on anterior margin; superlinguae oval, with numerous filiform and acuminate setae along anterior and lateral margins. Maxilla (Fig. 3): palp elongate, three segmented, without apical seta; three subapical setae on inner apical margin; cluster of filiform setae on outer apical surface; galealacinia not fused. Labium: submentum moderately developed (approximately twice as wide as long), with regularly spaced acuminate setae along lateral margins; ventrally with numerous robust setae most abundant near midline; prementum ventrally with numerous filiform setae; labial palp three segmented with numerous filiform setae; glossae and paraglossae subequal, fused except distally, with serrate outer margins; glossae slightly recessed, rounded, and with robust setae; paraglossae with numerous filiform setae. *Thorax*: Dorsally dark reddish brown to black; ventrally pale with diffuse black maculae; hindwing pads present in males, absent in females. Foreleg: femur (Fig. 4) pale yellow to pale brown with dorsal, median black spot; anterior and posterior margins with scattered filiform and acuminate setae; dorsal surface with transverse row of elongate setae (Fig. 5). Tibia and tarsus pale brown; anterior margin of tibia with 14–16 evenly spaced, elongate setae; posterior margin with few, scattered filiform setae; margins of tarsus without setae; ventral surface with row of four to six robust setae; tarsal claw with one submarginal denticle, and a single row of four to six marginal denticles, similar in shape and size with equal spacing. Mid- and hind legs: femora pale yellow with dorsal apical and basal black spots; anterior margins with elongate setae; posterior margins with few robust setae (usually on hind femur) or none; dorsal surface with transverse row of robust setae at base of femur. Tibiae: pale brown, with row of approximately 20 evenly spaced elongate setae along anterior margin; posterior margin with few, scattered elongate setae; dorsal surface with elevated, medio-longitudinal ridge. Tarsi pale brown, margins without setae; four to six acuminate setae along inner margin; claws with one submarginal denticle, and a single row of four to six marginal denticles, similar in shape and size with equal spacing (Fig. 6). *Abdomen*: Dark reddish brown to black; posterior margins of terga 1–10 serrate; terga 5–9 each with a pair of elongate setae located medially on posterior margin; tubercles absent; dorsal lamella of operculate gill elongate oval, basal portion black, apical portion pale; scattered acuminate setae



Figs. 1–11. *Leptohyphes mandibulus*, larva. 1, Right mandible. 2, Left mandible. 3, Maxilla. 4, Foreleg femur (dorsal view). 5, Foreleg femoral seta. 6, Hind leg claw. 7, Operculate gill (dorsal view). 8, Operculate gill (ventral view). 9, gill 5 lamellae (ventral view). 10, Right mandible (pre-emergent larva). 11, Left mandible (pre-emergent larva).

present along inner and apical margins (Fig. 7); ventral lamellae of operculate gill transculent-whitish (Fig. 8); gill 5 lamellae as in Fig. 9; gill formula: 3/6/6/6/2. Cercus with whorls of robust and elongate setae at each annulation.

Etymology.—The specific epithet of this species is a noun from the Latin word *mandibula* (f), meaning jaw or mandible. It alludes to the unusual features of the mandibles for this species.

Discussion and diagnosis.—The reduced number of outer incisor denticles on both the left and right mandibles will distinguish this species from others in the genus *Leptohyphes* Eaton. While the vast majority of species within *Leptohyphes* have four denticles on the outer incisor of the left mandible and three on the right mandible, *L. mandibulus* has only two outer incisor denticles on each mandible. In addition, the coloration of the operculate gills (basal half dark, apical half pale), and the contrasting coloration of the body and legs also is distinct for this species. *Leptohyphes cornutus* Allen, known only from South America, also has reduced outer incisors similar to *L. mandibulus*. It can be distinguished from *L. mandibulus* by the presence of distinct thoracic tubercles, which are absent on *L. mandibulus*.

Also of interest for *L. mandibulus* are the changes associated with the mandibles on mature and pre-emergent larvae. Mandibular description in the above species description is based upon relatively mature larvae, but not pre-emergent larvae. In pre-emergent larvae, the outer incisors of the right mandible are reduced to a single, rounded structure, while the inner incisor is reduced to a single denticle (Fig. 10). For the left mandible, the outer incisors are fused into a single, large incisor, while the inner incisor is reduced to a single denticle (Fig. 11). Reduction and fusion of incisors is very rare among leptohyphid mayflies and is usually a result of wear associated with feeding. However, numerous larval paratypes associated with *L. mandibulus* also displayed this condition, indicating it is probably a naturally occurring condition resulting from maturation, and not necessarly a result of feeding.

There does remain the possability that *Leptohyphes mandibulus* could be the undescribed larval stage of at least one of five species of *Leptohyphes* reported from Mexico and Central America, which were described based upon only the adult stage. These species include *Leptohyphes berneri* Traver (1958) described from central Mexico; *Leptohyphes brevissimus* Eaton (1892) described from southern Guatemala based upon female subimagos; *Leptohyphes nigripunctum* Traver 1943 described from a male subimago from Venezuela and later reported from southern Mexico (McCafferty 1985); *Leptohyphes peterseni* Ulmer (1920) described from South America based upon male and female subimagoes, and later reported from Central America (McCafferty 1985); or *Leptohyphes priapus* Traver (1958), which was described from Costa Rica. Based upon geography alone, *L. priapus* would be the most likely species to be the adult stage of *Leptohyphes mandibulus*. Additional research will be required to resolve this situation.

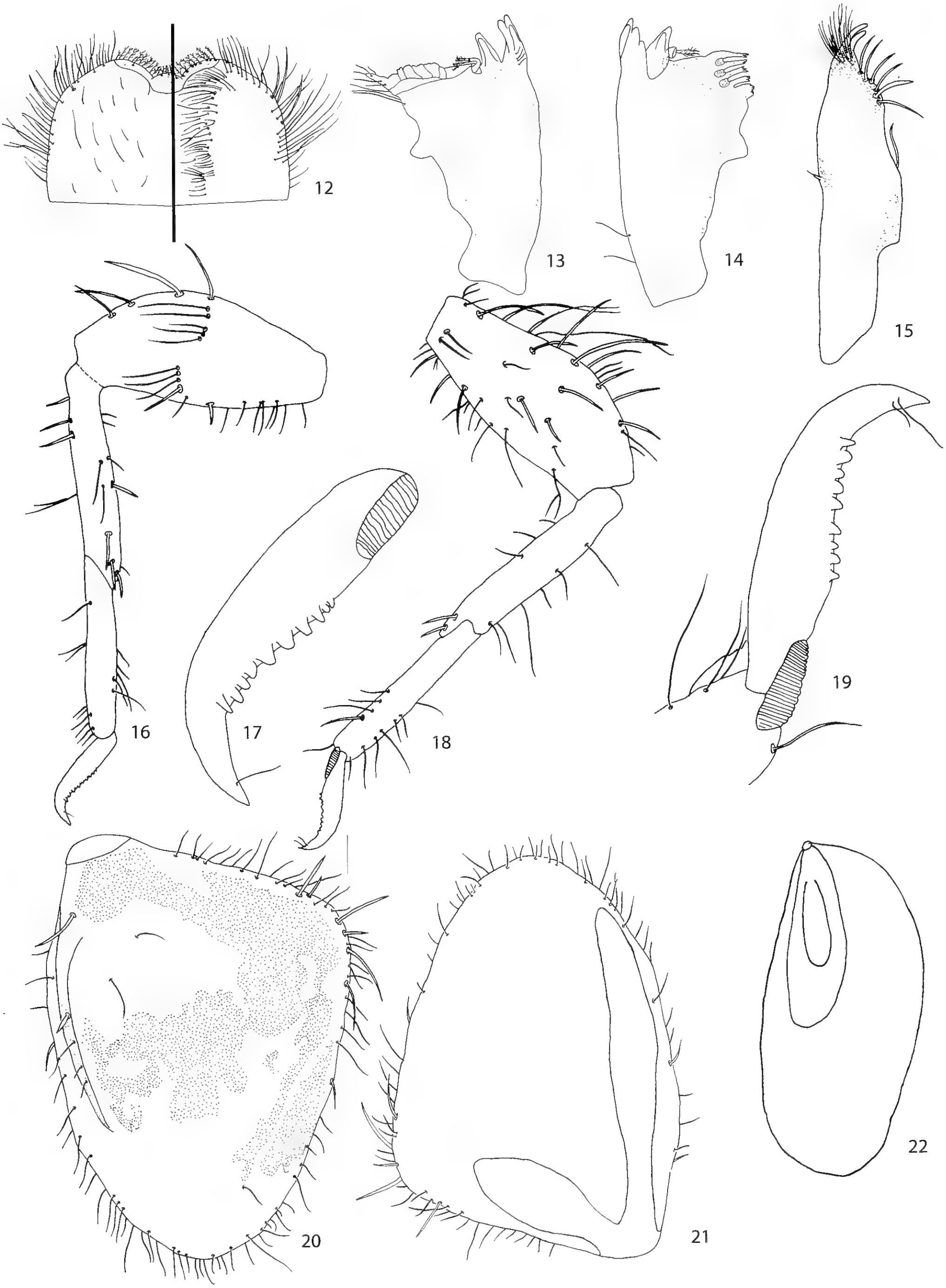
Distribution and biology.—This species is currently known only from the type locality in northwestern Costa Rica. Other species of leptohyphid mayflies collected with it included *Leptohyphes zalope* Traver and *Tricorythodes sordidus* Allen.

Type material.—Holotype: Mature male larva. COSTA RICA: Alajuela Province; NE of Bijagua, nr. Las Flores, Río Areuo (N10°21′06″, W85°21′05″), 07.vi.2000, WD Shepard (WDS-A-1300). Deposited in TAMU. Paratypes: Same data as holotype, 6 larvae (FAMU), 25 larvae (TAMU).

Tricorythodes kirki Baumgardner, new species
(Figs. 12–22)

Adult.—Unknown

Mature larva.—Body length 2.5–3.0 mm; caudal filaments 1.5 mm. General color reddish brown with extensive black maculae. *Head*: Pale reddish brown with variable black maculae on vertex and posterior to compound eyes; tubercles absent; compound eyes small and widely separated; three ocelli present; antenna pale, approximately two times length of head capsule. *Mouthparts*: Labrum (Fig. 12): dorsal surface with scattered filiform setae; lateral margin with numerous filiform and acuminate setae; highly branched robust setae along anterior margin, projecting from ventral surface; ventrally with longitudinal row of acuminate setae near midline, with interspersed filiform setae; lateral margin with numerous filiform and acuminate setae; anterior margin with robust, highly branched setae. Right mandible (Fig. 13): outer incisor three lobed, with elongate setae at base of teeth; inner incisor two lobed; prostheca arising at base of inner incisor with highly branched, elongate setae projecting towards molar region; molar region mostly fused. Left mandible (Fig. 14): outer incisor four lobed, mostly fused; inner incisor two lobed, mostly fused; prostheca arising at base of inner incisor, with branched, elongate setae projecting towards molar region. Hypopharynx: lingua apically truncate; numerous filiform and acuminate setae present on anterior margin; superlinguae oval, with numerous filiform and acuminate setae along anterior and lateral margins. Maxilla (Fig. 15): palp very short, one segmented, with elongate terminal seta; one or two subapical setae on inner apical margin; cluster of dense filiform setae on outer apical surface. Labium: submentum moderately developed, with regularly spaced acuminate and filiform setae along lateral margins; prementum ventrally with numerous filiform setae; labial palp three segmented with numerous filiform setae; glossae and paraglossae subequal, fused except distally, with slightly serrate outer margins; glossae slightly recessed, rounded, and with robust setae; paraglossae with numerous filiform setae. *Thorax*: Pale reddish brown, with extensive black maculae; pro- and mesonota with extensive black shading medially and along margins; forewing pads of mature larvae pale brown; hind wing pads absent; filiform setae present along lateral margin of thorax. Femora pale with limited black maculation along basal, lateral margin; tibiae pale brown with white band at tibia-tarsus articulation; tarsi pale brown with median white band; claws pale brown. Foreleg (Fig. 16): dorsal surface of femur with median transverse row of filiform and acuminate setae; anterior and posterior margins of femur with diffuse filiform and acuminate setae. Tibia and tarsus: margins with scattered acuminate and filiform setae; tarsal claw (Fig. 17) with single row of 10–12 denticles, similar in shape and size with equal spacing. Mid- and hind legs (Fig. 18): dorsal surfaces of femora with few, scattered filiform and acuminate setae; anterior and posterior margins with numerous filiform and acuminate setae. Tibiae: few, scattered filiform and acuminate setae present along anterior and posterior margins, and dorsal surface. Tarsi: filiform and acuminate setae confined to apical margins. Claws (Fig. 19): with single row of 12–14 denticles, similar in shape and size with equal spacing. *Abdomen*: Without tubercles or elevated carina; terga 1–3 white with black lateral margins; terga 4–6 white with limited black meial maculation and lateral black margins; terga 7–9 black with numerous filiform setae along lateral and posterior margins;



Figs. 12–22. *Tricoryhyphes kirki*, larva. 12, Labrum (left: dorsal; right: ventral). 13, Right mandible. 14, Left mandible. 15, Maxilla. 16, Foreleg. 17, Foreleg claw. 18, Hindleg. 19, Hind leg claw. 20, Operculate gill (dorsal view). 21, Operculate gill (ventral view). 22, Gill 3.

tergum 10 brown. Dorsal lamella of operculate gill (Fig. 20) on abdominal segment 2 triangular with margins rounded; narrow, elongate ridge present near inner margin; basal one-half to two-thirds of gills covered with black maculae; apical margin pale; acuminate and filiform setae present along entire outer margin; ventral lamellae of operculate gill pale translucent (Fig. 21); gill 3 as in figure 22; gill formula: 2/3/3/3/2. Cercus with whorls of elongate and robust setae at each annulation.

Etymology.—This species is named for my son, Kirk, in recognition of his support and assistance.

Discussion and diagnosis.—Only three other species of *Tricorythodes* Ulmer are currently known from Central America, south of Mexico. The common and widely-distributed *T. sordidus* Allen, *T. primus*, n. sp. (see discription below), and *T. costaricanus* (Ulmer), known only from the adult stage. *Tricorythodes kirki* larvae can be differentiated from *T. sordidus* larvae by the lack of elongate filiform setae on the body, which are present on *T. sordidus*. In addition, *T. sordidus* larvae possess abdominal terga which are uniformly pale brown in color, while *T. kirki* larvae have contrasting coloration of the abdominal terga as described above. *Tricorythodes kirki* larvae can be distinguished from larvae of *T. pirmus* by the presence of a distinctive and well-developed frontal shelf and genal projections, which are absent in *T. kirki*. There does remain the possability that *T. kirki* could be the undescribed larval stage of *T. costaricanus*. However, considering the very dark brown coloration of *T. costaricanus* adults, and the very limited dark coloration of mature *T. kirki* larvae, the possability appears remote that the two are indeed the same species.

Distribution and biology.—*Tricorythodes kirki* is known only from Alajuela, Heredia, and San José provinces in north-central Costa Rica. Larvae were collected from a very small, shallow first or second order stream at elevations ranging from 200 to 650 m. Substrate of the steams was composed mostly of rock-rubble with little coarse gravel. Other mayflies collected at these sites included *Tricorythodes sordidus* Allen (Leptohyphidae) and *Camelobaetidius warreni* (Traver and Edmunds) (Baetidae).

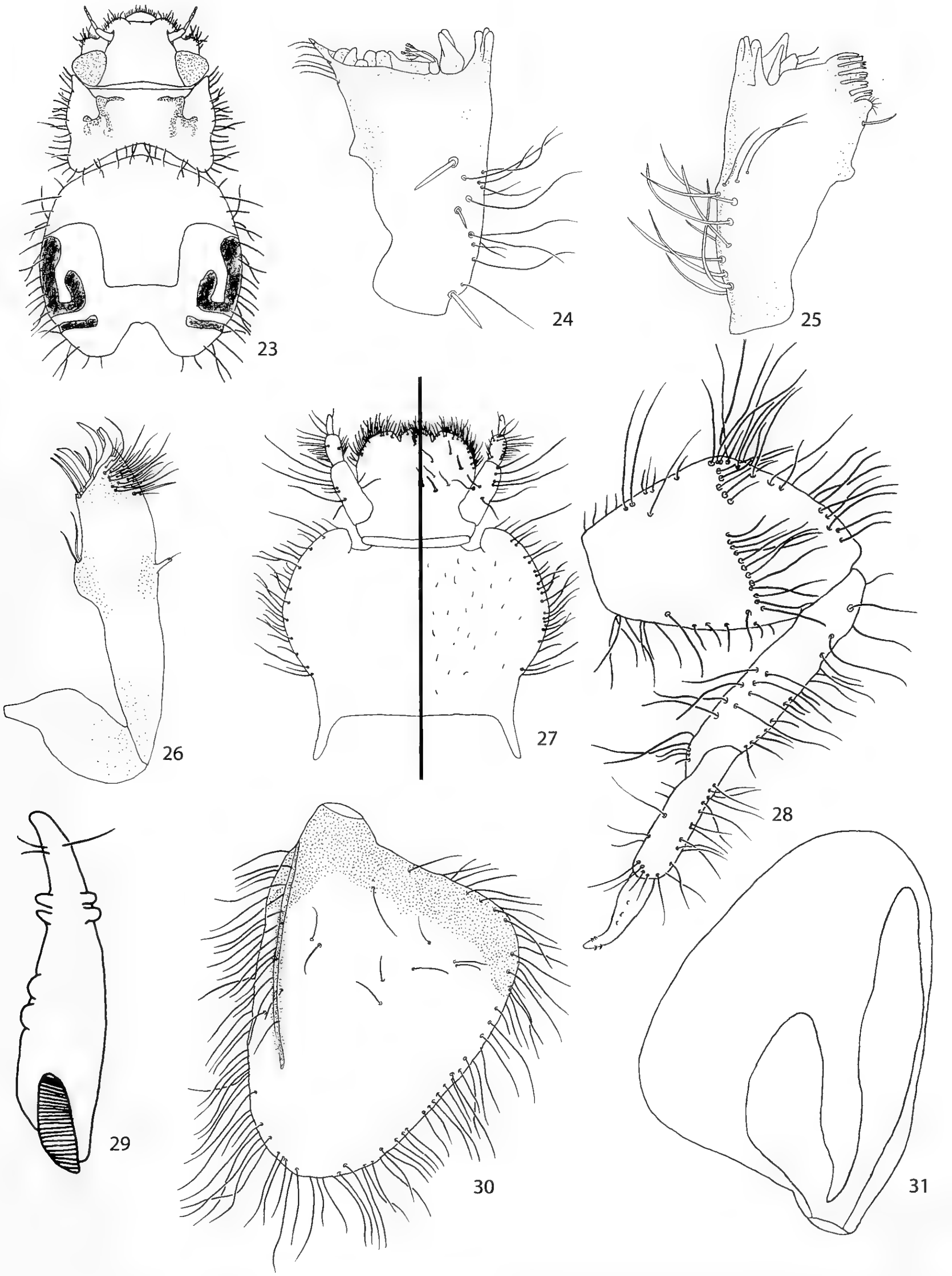
Type material.—Holotype: Mature male larva. COSTA RICA: Alajuela Province, Río Guayabo at Hwy 140, 1.8 km E Venicia (N10°40′45N, W84°15′13″, elev. 460 m), 09.vi.2001, DE Baumgardner (DB 01-25). Deposited at TAMU. Paratypes: Same data as holotype, 5 larvae (3♂, 2♀), 2 slides (DB05012801, DB05xi2208) (4 larvae and slides TAMU, 1 larva FAMU). COSTA RICA: Heredia Province, unnamed creek at Hwy. 4, ca. 3 Km from jct. with Hwy. 32 (N10°15′10″, W83°55′11″; elev. 200 m) 10.vi.2001, DEB (DB 01-28), 2♀ larvae (TAMU); La Selva Biological Station, SW Puerto Viejo, Sura Creek at Rio Puerto Viejo (N10°25′49″; W84°00′06″, elev. 33 m), 09.vi.2001, 8L, DEB (DB 01-26), 8L (5L TAMU, 3L FAMU); Río Isla Grande at Hwy. 4, ca. 5 Km. W. of Rio Frio (N10°23′31″; W 83°58′04″, elev. 65 m), 10.vi.2001, DEB (DB 01-27), 1L (PERC). San José Province; Río Pedregoso at Hwy. 243, ca. 4 Km S. San Isidro de El General (N09° 21′15 W83°43′35″, elev. 660 m), 22.vi. 2001, DEB (DB 01-47), 12L [TAMU].

Tricorythodes primus Baumgardner, new species

(Figs. 23–31)

Adult.—Unknown.

Mature larva.—Body length 3.0–3.5 mm; caudal filaments 3.0 mm. General color yellow with black maculae on thorax and abdomen. *Head*: (Fig. 23) yellow without black maculae; large



Figs. 23–31. *Tricoyrhyphes primus*, larva. Fig. 23, Head and pro- and mesothorax (dorsal view). Fig. 24, Right mandible. Fig. 25, Left mandible. Fig. 26, Maxilla. Fig. 27, Labium (left: dorsal; right: ventral). Fig. 28, Foreleg. Fig. 29, Foreleg claw. Fig. 30, Operculate gill. Fig. 31, Operculate gill (ventral view).

genal and frontoclypeal projections present; tubercles absent; compound eyes small and widely separated; three ocelli present; margins of head with filiform setae; antenna pale, approximately as long as head capsule. *Mouthparts*: Labrum: dorsally with filiform setae along lateral margin; acuminate setae recessed from anterior margin; ventrally with one longitudinal row of acuminate setae near midline, with interspersed filiform setae; anterior margin with filiform setae. Right mandible (Fig. 24): outer incisor three lobed; inner incisor two lobed; prostheca and molar region as in Fig. 17; numerous and very long, thick setae present along outer margin of mandible. Left mandible (Fig. 25): outer incisor four lobed, mostly fused; inner incisor two lobed; prostheca arising at base of inner incisor, with filiform setae projecting towards molar region; numerous and very long, thick setae present along outer margin of mandible. Hypopharynx: lingua apically truncate; numerous filiform and acuminate setae present on anterior margin; superlinguae oval, with numerous filiform and acuminate setae along anterior and lateral margins. Maxilla (Fig. 26): palp one segmented, with terminal seta; two subapical setae on inner apical margin; cluster of filiform setae on outer apical surface. Labium (Fig. 27): submentum moderately developed, with regularly spaced acuminate and filiform setae along lateral margins; ventrally with numerous robust setae; prementum ventrally with numerous acuminate setae; labial palp three segmented with numerous filiform setae; glossae and paraglossae subequal, fused except distally, with slightly serrated margin; glossae serrated with robust setae along margin; paraglossae with numerous filiform and acuminate setae. *Thorax*: (Fig. 23) yellow with extensive black maculae; pronotum with a pair of black inverted "L" shaped markings lateral to midline, and pair of distinctive, sharp projections on anterior lateral margin (Fig. 23); lateral margins with scattered acuminate setae; mesonotum (Fig. 23) yellow with extensive and irregular black maculation, and scattered acuminate setae along lateral margins. Legs: all segments of all legs pale yellow. Foreleg (Fig. 28): dorsal surface of femur with a transverse row of numerous filiform setae; anterior and posterior margins with numerous acuminate and filiform setae. Tibia and tarsus: anterior and posterior margins with numerous acuminate and filiform setae. Claw (Fig. 29): with two or three, minute marginal denticles, and two pair of submarginal denticles. Mid- and hind legs: dorsal surfaces of femora with numerous, irregularly spaced filiform and acuminate setae; anterior and posterior margins with numerous acuminate and filiform setae. Tibiae: filiform setae present along anterior and posterior margins. Tarsi: margins with numerous filiform setae. Claws: with two minute denticles and two pair of submarginal denticles. *Abdomen*: Pale yellow with dorsal and ventral transverse black bands on segments 1–9; posterior margins of terga 1–9 with numerous filiform setae; lateral margins of segments 2–7 expanded outward with filiform setae present along margin. Dorsal lamella of operculate gill (Fig. 30) on abdominal segment two triangular, pale yellow with basal black band at base, and very sparse black maculae over dorsal surface; filiform setae present along entire margin; ventral lamellae of operculate gill pale translucent (Fig. 31); gill formula: 1/3/3/3/2. Cercus with whorls of elongate and robust setae at each annulation.

Etymology.—The specific epithet of this species is a noun from the Latin word *primus* (m), meaning first or original. It refers to the first description of a species of *Tricorythodes* from Central America which possesses a distinctive and well-developed frontal shelf and genal projections.

Discussion and diagnosis.—*Tricorythodes primus* is most similar to *T. condylus* Allen from southwestern United States, and *T. popyanicus* Dominguez from Central America. *Tricorythodes primus* can be distinguished from *T. condylus* by its much smaller size (3.0–3.5 mm for *T. primus* versus 5.0–6.0 mm for *T. condylus*) and more extensive black maculation of the thorax and abdomen. It can be distinguished from *T. popyanicus* by the presence of well-developed antero-lateral projections of the pronotum, which are very weakly developed on *T. popyanicus*. In addition, *T. popyanicus* is known only from southern South America while *T. primus* is known only from Central America.

Tricorythodes popyanicus and *T. condylus* (along with three other species) were recently transferred to the genus *Tricoryhyphes* (Wiersema and McCafferty 2000), which was originally described by Allen and Murvosh (1987) as a subgenus of *Tricorythodes*, and elevated to generic status by Wiersema and McCafferty (2000). Molineri (2002) clearly showed *Tricoryhyphes* to be synonymous with *Tricorythodes*, synonymizing the latter with the former. Unpublished data by D.E. Baumgardner also supports the conclusions of Molineri (2002).

Distribution and biology.—*Tricorythodes primus* was collected from clear flowing streams which were several meters wide, shallow, and with substrate varying from sand to boulders. These low elevation costal streams are located in the extreme southeastern region of the country, near the Panamá border . Other species of mayflies collected with *T. primus* included *Thraulodes brunneus* Koss, *Thraulodes* spp. (Leptophlebiidae), *Leptohyphes zalope* Traver, *Tricorythodes sordidus* Allen, and *Vacupernius packeri* (Allen) (Leptohyphidae).

Type material.—Holotype: Mature larva. COSTA RICA: Puntarenas Province; Río Caracol at CA Hwy. 2, ca. 7.3 Km E. Río Claro (N08°39′47″, W83°00′41″, elev. 80 feet), 23.vi.2001, DE Baumgardner (DB 01-55). Deposited in TAMU. Paratypes: COSTA RICA: Puntarenas: Río Coloradito at CA Hwy. 2, ca. 6.7 Km SE Ciudad Neily (N08°36′09″, W82°52′02″, elev. 180 feet), 23.vi.2001, DE Baumgardner (DB 01-56), 1 larva (legs and mouthparts mounted on slide #05xi2006), slide and specimen deposited in TAMU.

ACKNOWLEDGMENTS

I thank the Institutio Nacional de Biodiversidad, San José, Costa Rica, for arranging collecting permits and assisting with travel while in Costa Rica, and W. D. Shepard for donation of specimens. Funding for field work in Costa Rica was provided by the L.T. Jordan Fellows Program of Texas A&M University. Thanks also to Boris Kondratieff (Colorado State University), Wills Flowers (Florida A&M University), Carlos Molineri (National University of Tucumán, Argentina) and W.P. McCafferty (Purdue University) for reviewing an earlier draft of the manuscript.

LITERATURE CITED

Allen, R. K. and C. M. Murvosh. 1987. Mayflies (Ephemeroptera: Tricorythidae) of the Southwestern United States and Northern Mexico. Annals of the Entomological Society of America 80: 35–40.

Baumgardner, D. E. 2003. New synonyms and stage description for three species of Leptohyphidae (Ephemeroptera). Proceedings of the Entomological Society of Washington 105: 203–208.

Baumgardner, D. E. and Socorro Ávila, A. 2006. *Cabecar serratus*, a new genus and species of leptohyphid mayfly from Central America, and description of the imaginal stages of *Tricorythodes sordidus* Allen (Ephemeroptera: Leptohyphidae). Zootaxa 1187: 47–59.

Baumgardner, D. E. and W. P. McCafferty. 2000. *Leptohyphes zalope* (Ephemeroptera: Leptohyphidae): a polytypic North and Central American species. Entomological News 111: 49–59.

Baumgardner, D. E., S. K. Burian, and D. Bass. 2003. Life stage descriptions, taxonomic notes, and new records for the mayfly family Leptohyphidae (Ephemeroptera). Zootaxa 332: 11–12.

Baumgardner, D. E., M. D. Meyer, and W. P. McCafferty. 2006. A new species of *Asioplax* (Ephemeroptera: Leptohyphidae) from Costa Rica and Nicaragua. Pan-Pacific Entomologist 82: 346–350.

McCafferty, W. P. 1985. New records of Ephemeroptera from Middle America. International Quarterly of Entomology 1: 9–11.

Molineri, C. 1999. Revision of the genus *Tricorythopsis* (Ephemeroptera: Leptohyphidae) with the description of four new species. Aquatic Insects 21: 285–300.

———. 2001a. *Traverhyphes*: a new genus of Leptohyphidae for *Leptohyphes indicator* and related species. Spixiana 24: 129–140.

———. 2001b. El genero *Tricorythopsis* (Ephemeroptera: Leptohyphidae): nuevas combinaciones y descripción de nuevas especies y estadios. Revista de la Sociedad Entomológica Argentina 60: 217–238.

———. 2002. Cladistic analysis of the South American species of *Tricorythodes* (Ephemeroptera: Leptohyphidae) with the description of new species and stages. Aquatic Insects 24: 273–308.

———. 2003a. *Haplohyphes* (Ephemeroptera: Leptohyphidae), new species and stage descriptions with a key to separate the species of the genus. Zootaxa 263: 1–11.

———. 2003b. Revision of the South American species of *Leptohyphes* Eaton (Ephemeroptera: Leptohyphidae) with a key to the nymphs. Studies on Neotropical Fauna and Environment 38: 47–70.

———. 2004. Phylogeny of the *Allenhyphes-Traverhyphes* group (Ephemeroptera: Leptohyphidae), with new subgenera, species and combinations. Tijdschrift voor Entomologie 147: 197–220.

Molineri, C. and M. C. Zúñiga. 2004. *Lumahyphes*, a new genus of Leptohyphidae (Ephemeroptera). Aquatic Insects 26: 19–30.

Wiersema, N. A. and W. P. McCafferty. 2000. Generic Revision of the North and Central American Leptohyphidae (Ephemeroptera: Pannota). Transactions of the American Entomological Society 126: 337–371.

———. 2003. *Ableptemetes*: a new genus of Tricorythodinae (Ephemeroptera: Leptohyphidae) from Mexico and Central America. Entomological News 114: 37–40.

———. 2005. Contribution to the taxonomy of *Asioplax* (Ephemeroptera: Leptohyphidae: Tricorythodinae) in the New World. Entomological News 116: 147–158.

Wiersema, N. A., W. P. McCafferty, and D. E. Baumgardner. 2001. *Asioplax numinuh*, a new species of Ephemeroptera (Leptohyphidae) from Texas and Mexico. Entomological News 112: 301–304.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 427–434

NEW RECORDS OF INTRODUCED SPECIES OF *QUEDIUS* STEPHENS, 1829 (COLEOPTERA: STAPHYLINIDAE) FROM THE MARITIME PROVINCES OF CANADA

Christopher G. Majka and Aleš Smetana

(CGM) Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia, Canada B3H 3A6 (e-mail: c.majka@ns.sympatico.ca); (AS) Agriculture and Agri-Food Canada, Eastern Cereals and Oilseeds Research Centre, K. W. Neatby Building, Ottawa, Ontario, Canada K1P 6P4 (e-mail: smetanaa@agr.gc.ca)

Abstract.—*Quedius fuliginosus* (Gravenhorst) is newly recorded in North America; *Quedius curtipennis* Bernhauer is newly recorded in eastern North America; and *Quedius mesomelinus* (Marsham) is newly recorded in New Brunswick. All three are introduced, Palearctic species of rove beetles. A key to differentiate *Q. fuliginosus* from the related and similar *Q. curtipennis* is provided. Possible modes of introduction of the species are discussed, focusing on historical transport of dry ballast in the maritime trade.

Key Words: Coleoptera, Staphylinidae, *Quedius*, Canada, Maritime Provinces, introduced species, new records, biodiversity

Brown (1940, 1950, 1967) and Lindroth (1957, 1963) were among the pioneers in drawing attention to the large number of species of Coleoptera introduced to North America through ports in Atlantic Canada. One of the pathways of entry they highlighted was the use of dry ballast (bulky rock, sand, and soil) in trans-Atlantic shipping. Brown (1950) noted that large quantities were unloaded at Maritime ports during the Napoleonic Wars (1799–1815) by British vessels in search of timber at a time when Baltic ports were closed to Britain. Lindroth (1957) investigated this topic further, conducting vegetational and faunal surveys in sites in Great Britain known to have been sources of ballast in the trans-Atlantic shipping trade.

There are many species of introduced Staphylinidae found in Atlantic Canada in general, and Nova Scotia in particular. In the first paper to discuss Coleoptera in the province, Kirby (1837) noted the presence of the Palearctic *Philonthus politus* (Linnaeus, 1758) and *Creophilus maxillosus* (Linnaeus, 1758). Subsequently, authors such as Lindroth (1957) added two species, Campbell (1976) three species, Smetana (1982) two species, Klimaszewski (1984) three species, Smetana (1995) 11 species, Hoebeke (1995) one species, Majka and Klimaszewski (2004) two species, Majka et al. (2006) one species, and Klimaszewski et al. (in press) three species. These are 30 of the 68 species of introduced, Palearctic rove beetles found in Nova Scotia. Introduced staphylinids comprise 16% of the province's rove beetle fauna (C. Majka, unpublished data).

Within the subtribe Quediina Kraatz, five introduced species have been reported in North America, all in the genus *Quedius* Stephens: *Q. fulgidus* (Fabricius, 1793), *Q. mesomelinus* (Marsham, 1802), Q. *curtipennis* Bernhauer, 1908, *Q. molochinus* (Gravenhorst, 1806), and *Q. cinctus* (Paykull, 1790) (Smetana 1971). Examination of specimens in collections in the Maritime Provinces of Canada has yielded additional records of introduced species of *Quedius*.

CONVENTIONS

Abbreviations of collections referred to in this study are:

CBU	Cape Breton University, Sydney, Nova Scotia.
CGMC	Christopher G. Majka collection, Halifax, Nova Scotia.
CNC	Canadian National Collection, Ottawa, Ontario.
DHWC	David H. Webster collection, Kentville, Nova Scotia.
NBM	New Brunswick Museum, Saint John, New Brunswick.
NSMC	Nova Scotia Museum, Halifax, Nova Scotia.
NSNR	Nova Scotia Dept of Natural Resources, Shubenacadie, Nova Scotia.
STFX	St. Francis Xavier University, Antigonish, Nova Scotia.

RESULTS

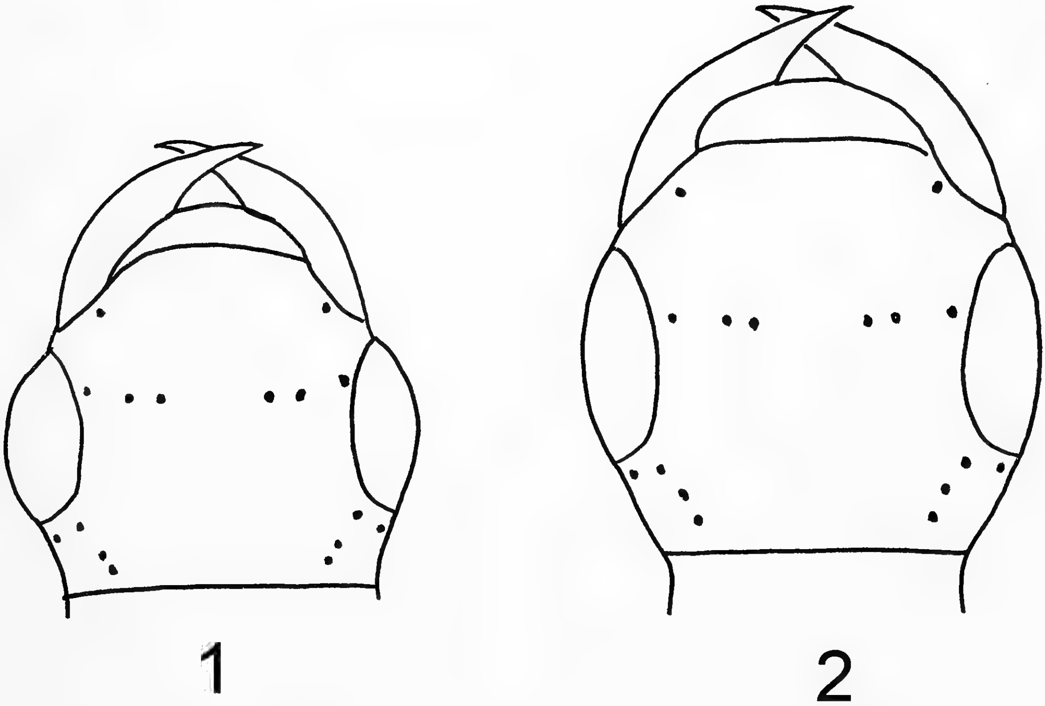
Quedius (Quedius) fuliginosus (Gravenhorst, 1802)

Two specimens of *Quedius fuliginosus* were collected by S. D. Boudreau on 15 May 2001 in St. Andrews, Antigonish County, Nova Scotia (STFX) (Fig. 5). Three specimens were collected by C. G. Majka (18 May 2001, 6 June 2001, and 20 October 2001) in Point Pleasant Park, Halifax Country, NS (CGMC). One specimen was collected by L. A. Hudson (5–11 June 1996) in Irish Cove, Richmond Country, NS (CBU). These reports represent the first record of this species in North America. It closely resembles the Palearctic *Quedius curtipennis* (to where it keys out to in Smetana (1971)) from which it can be separated by characters in the following key:

1. Sensory peg setae on underside of paramere posteriorly distinctly removed from lateral margins toward middle of paramere (Fig. 3). First antennomere at least dorsally, and antennomeres 2 and 3 entirely, piceous to piceous-black. Eyes markedly, evenly convex (Fig. 1) . . . .
. . . *Quedius (Quedius) fuliginosus* (Gravenhorst)
– Sensory peg setae on underside of paramere along entire length situated close to lateral margins (Fig. 4). Antennomeres 1–3 entirely testaceo-brunneous. Eyes less convex, especially posteriorly (Fig. 2) . . . .
. . . . . *Quedius (Quedius) curtipennis* Bernhauer

Quedius fuliginosus, a widely distributed Palearctic species, is found throughout Europe (including Great Britain and Ireland) from Fennoscandia in the north, across Russia, south to Azerbaijan, the Caucasus and Turkey, and west to Tunisia and Algeria in North Africa. It is also known from many islands including Crete and Corsica in the Mediterranean, and the Azores, Faeroe, and Orkney Islands in the Atlantic (Herman 2001; Smetana 2004).

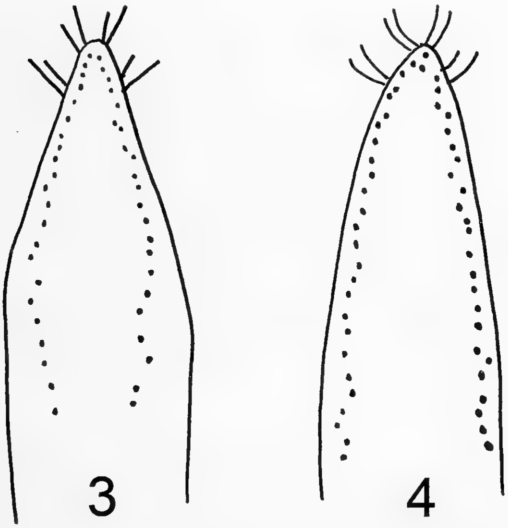
In Europe *Q. fuliginosus* inhabits moist to wet habitats such as moss, leaf litter, decaying plant material, etc. in forests and open areas; less frequently it is found under bark and under stones (Burakowski et al. 1980), in mole nests (Osella and Zanetti 1975), or even in caves (Jeannel and Jarrige 1949). It shows a distinct affinity to bogs, particularly (in Middle Europe) sphagnum bogs (Smetana 1964). In Northern Ireland, it is typically found in sphagnum on cutover bogs, inter-drumlin fen, and similar wetland types (Anderson 1997). It is found throughout the year, in the spring from March to May and in the fall from September to November (Horion 1965).



Figs. 1–2. Profile of eyes. 1, *Quedius fuliginosus.* 2, *Q. curtipennis* (adapted from Szujecki 1980).

Quedius (Quedius) curtipennis Bernhauer, 1908

Quedius curtipennis was previously known in North America solely from British Columbia, Washington, and Oregon from as early as 1939 (Smetana 1971). It now has been found at a number of localities in the Maritime Provinces, the first records from eastern North America (Fig. 5).



Figs. 3–4. Paramere. 3, *Quedius fuliginosus.* 4, *Q. curtipennis* (adapted from Szujecki 1980).

Records.—NEW BRUNSWICK: *Albert Co.:* Mary's Point, 9 August 2002, C.G. Majka, CGMC. NOVA SCOTIA: *Halifax Co.:* Big St. Margaret's Bay, 14 May–2 June 1997, D.J. Bishop, NSMC; McNab's Island, 17 June 2001, J. Ogden, NSNR; Pogwa Lake, 2–15 June 1997, D.J. Bishop, NSMC; *Hants Co.:* Leminister, 2–15 June 1997, D.J. Bishop, NSMC; Smileys Park, 9 June 2005, J. Gordon, NSNR; *Kings Co.:* North Alton, 20 May 2004, D.H. Webster, DHWC.

In North America, this species is found near settlements in various debris, under stones, in greenhouses, etc. Some specimens also have been found in more natural situations away from settlements

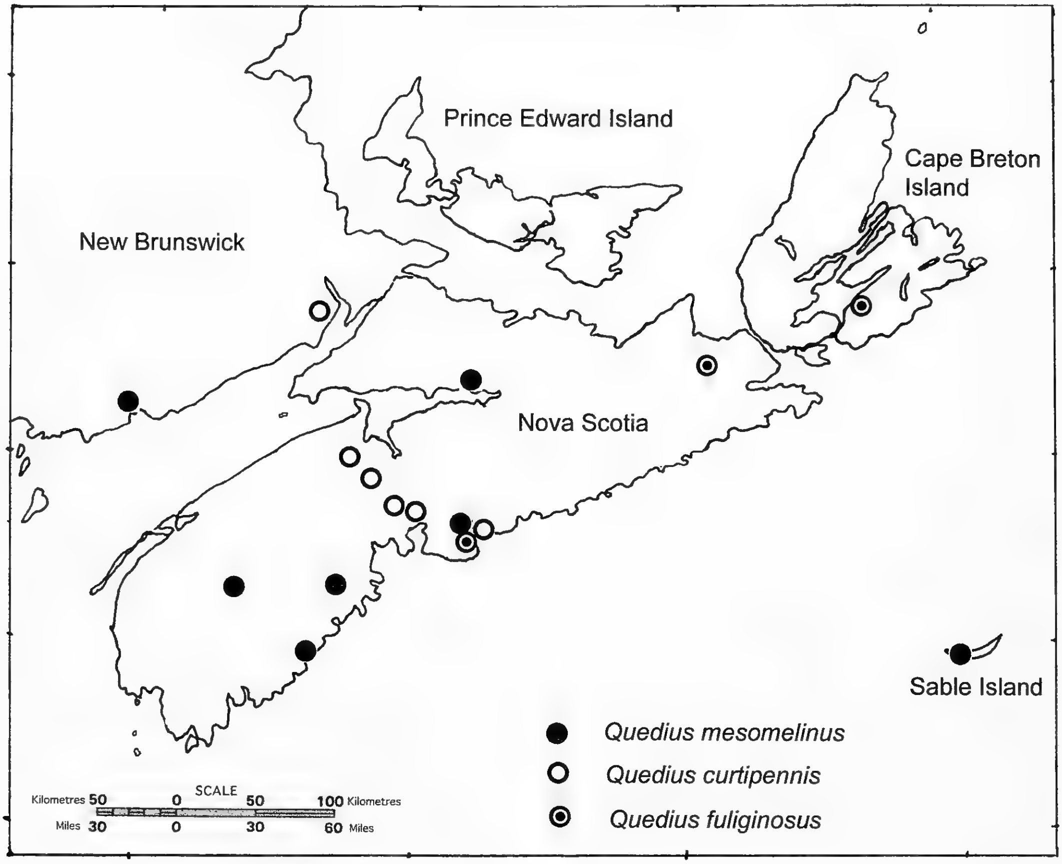


Fig. 5. Distribution of introduced *Quedius* species in the Maritime Provinces of Canada.

in moss, under leaf litter, etc. (Smetana 1971). In the Palearctic region it is found throughout Europe east through Turkey to Uzbekistan, as well as in Morocco and on the Azores (Herman 2001, Smetana 2004).

Quedius (Microsaurus) mesomelinus (Marsham, 1802)

Although Smetana (1971) reported the earliest North American museum specimens of *Quedius mesomelinus* from specimens collected in 1886 in Massachusetts, Bain (1998) found preserved specimens in a seventeenth century latrine in Boston, Massachusetts which dated from 1670, and Prévost and Bain (in press) found preserved remains of this species in a latrine in Ferryland, Newfoundland which date from prior to 1620. It is now widely distributed from Newfoundland south to Florida, west to Nevada and northern California and north to the Alaska Panhandle and along the Aleutian Islands (Smetana 1971). It is found throughout Europe and eastward through western and eastern Siberia to the Russian Far East. It has been unintentionally introduced to Australia, New Zealand, Peru, Tristan da Cunha, and Greenland (Herman 2001, Smetana 2004).

Smetana (1971) recorded it from Sable Island, NS (1 July 1967, H.F. Howden and J.E.H. Martin, 4 specimens, CNC) and Liverpool, NS (24 May 1910, A. Halkett, CNC); however, there are additional records that indicate that the species is more widely distributed in the region and it is newly recorded in New Brunswick (Fig. 5).

Records.—NEW BRUNSWICK: *Saint John Co.:* Saint John, 19 August 1907, G. Morrisey, NBM. NOVA SCOTIA: *Colchester Co.:* Masstown, 6 May 1993, C.J. McPhee, NSNR; Masstown, 14 May 1993, J. Ogden, NSNR; *Halifax Co.:* Armdale, 19 May 1950, D.C. Ferguson, NSMC; Armdale, 31 May 1952, D.C. Ferguson, NSMC; Halifax, January 27 1971, B. Wright, 2 specimens (indoors), NSMC; Halifax, 1 August 1990, M. Leblanc, NSNR; Point Pleasant Park, 15 August 2000, C.G. Majka, CGMC; *Hants Co.*: Hantsport, 17 June 2004, P. Kenrick, NSNR; *Lunenburg Co.:* Bridgewater, 30 June 1965, B. Wright, NSMC; *Pictou Co.*: Pictou, 7 June 2005, A. Jackson, 2 specimens, NSNR; *Queens Co.:* Kejimkujik National Park, 24 August–2 September 1994, B. Wright, 4 specimens, NSMC; Kejimkujik National Park, 21 September–19 October 1994, B. Wright, NSMC; Kejimkujik National Park, 19 September 2001, B. Wright, 2 specimens, NSMC.

In Europe, the species is often found in synanthropic situations in cellars, stables, barns, storehouses, and other farm buildings in various debris and decaying organic matter, especially compost heaps. It is also reported from mammal burrows, tree cavities, and caves, and other similar environments as well as in debris, leaf litter, moss, old mushrooms, etc. in all biotopes (Smetana 1971). In Nova Scotia, most specimens were collected in pitfall traps set in both coniferous and deciduous forests, although some have also been collected in synanthropic situations.

DISCUSSION

These three *Quedius* species join a lengthy list of rove beetles known to have been unintentionally introduced to the Maritime Provinces. The 70 species of introduced Staphylinidae known to occur in Nova Scotia comprise 20% of the 347 species of introduced Coleoptera found in the province (C. G. Majka, unpublished data). The question arises as to how and when these *Quedius* species may have been introduced.

Brown (1950) and Lindroth (1957) drew attention to the importance of the transport of dry ballast in the introduction of many ground-dwelling Coleoptera, particularly those that occur in coastal areas in Great Britain where the preponderance of such materials (bulky rock, sand, and soil) originated. Lindroth (1957) collected *Q. fuliginosus* at the Appledore rock quarry on the River Torridge in North Devon, England – one of eight sites investigated by him as principal sources of trans-Atlantic dry ballast. Lindroth characterized both *Q. fuliginosus* and *Q. curtipennis* as terricolous, mesophilous, occurring on waste ground, polyphagous, and brachypterous – all characteristics favouring the transport of species via such mechanisms.

Brown (1950) and Lindroth (1957, 1963) discussed many species for which they believed there existed strong evidence indicating such transport to Atlantic Canada. Majka (2005) examined the distribution of *Amara communis* (Panzer) in the Maritime Provinces, which is predominantly clustered in coastal locations with a history of maritime commerce. He proposed that this species, whilst only having been discovered relatively recently (in 1988), might nonetheless represent a series of historical introductions via the marine trade.

The town of St. Andrews, where the specimens of *Q. fuliginosus* were collected, was settled in the 1770's by Scottish farmers fleeing the Highland clearances. This site is located along the South River approximately 5.5 km from the head of Antigonish Harbour. Antigonish was itself first settled by Irish Loyalists in

1784 and subsequently grew to become an important community on the Gulf of St. Lawrence shore of Nova Scotia (MacLean 1976). These waves of human settlement, and the associated shipping and nautical trade, could have provided many opportunities for the introduction of *Q. fuliginosus* since the latter part of the eighteenth century.

Similarly, the port of Halifax, where three specimens were collected, has been an important center for trans-Atlantic commerce since 1749 and is a documented center for the introduction of many Palearctic beetles (Majka and Klimaszewski 2004). The collection locale at Irish Cove in Richmond County, on the other hand, is located in a hardwood forest adjacent to a long-term EMAN (Ecological Monitoring and Assessment Network) site which has been undisturbed for over 100 years.

Although *Q. fuliginosus* has only been found in only one area of Nova Scotia, *Q. curtipennis* has been recorded from a number of sites in Nova Scotia and New Brunswick (Fig. 5) indicating that it may have either arrived earlier and had time to expand its distribution, or that it was introduced at multiple locations, or both. The introductions in the Maritime Provinces clearly represent separate introduction events from those on the Pacific coast of the continent.

Mary's Point in New Brunswick, where *Q. curtipennis* has been collected, was first settled by Acadians in the 1740's and later by British Loyalists in the 1780's. It was an important quarry throughout the 19th century with stone being exported to many localities, and a shipbuilding site from the 1850's until 1899. These successive waves of settlement and the extensive maritime traffic at the locality could have provided opportunities for the introduction of *Q. curtipennis*. North Alton, NS, where *Q. curtipennis* has been found, is in an agricultural area where considerable importation of nursery stock has taken place over an extended period of time. Spence and Spence (1988) discuss the importation of nursery stock as a vector for the introduction of exotic ground beetles, a scenario which could also apply in this instance.

The widespread distribution (Fig. 5) of *Quedius mesomelinus* in Nova Scotia and New Brunswick as well as its early records (1907 in New Brunswick and 1910 in Nova Scotia) indicate that this species has been present in the Maritime Provinces for a considerable time. Some records (i.e., Halifax, Liverpool, St. John) are from prominent seaports while others (i.e., Kejimkujik National Park) are from relatively undisturbed sites indicating that the species has been able to successfully colonize native environments, a situation also seen with the introduced *Atheta (Datomicra) celata* (Majka et al. 2006). The specimens from Sable Island, situated on the edge of the continental shelf, 160 km from the nearest land, are particularly noteworthy. The island has, however, been sporadically inhabited during the 1600's and 1700's, and continuously since 1801 (Campbell 1974). During this time period there has been considerable commerce to the island from European ports and those in Atlantic Canada allowing for many opportunities for introduction of introduced species. Forty-five of the 148 (30%) species of beetles recorded on Sable Island are introduced, more than twice the provincial percentage (C. G. Majka, unpublished data).

Additional fieldwork would be desirable to ascertain the range of these species and whether their distribution is changing. Given current concerns with respect to introduced and invasive species, monitoring populations of introduced invertebrates would appear to be a desirable goal given that the effect of introductions on native species and environments is frequently unknown.

ACKNOWLEDGMENTS

Sincere thanks to DeLancey Bishop (North Mountain Old Forest Society), Randolph F. Lauff (St. Francis Xavier University), Donald McAlpine (New Brunswick Museum), Ken Neil, Jeffrey Ogden (Nova Scotia Department of Natural Resources), and David H. Webster for making specimens and records available. Also to Sheilagh Hunt (Kinetic Studio), Jan Klimaszewski (Canadian Forest Service), Rafal Ruta (Zoological Institute, Wroclaw), and Adriano Zanetti (Museo Civico di Storia Naturale, Verona) for their assistance. Margaret Thayer (Field Museum of Natural History) and an anonymous reviewer read earlier versions of the manuscript and made many constructive suggestions. C.G. Majka thanks his colleagues Calum Ewing and Andrew Hebda for continuing support and encouragement. This work has been assisted by a research grant from the Nova Scotia Museum of Natural History.

LITERATURE CITED

Anderson, R. 1997. Species Inventory for Northern Ireland: Rove Beetles (Coleoptera: Staphylinidae). Environment and Heritage Service Publications, 108 pp.

Bain, A. 1998. A Seventeenth-Century beetle fauna from colonial Boston. Historical Archeology 32(3): 38–48.

Brown, W. J. 1940. Notes on the American distribution of some species of Coleoptera common to the European and North American continents. The Canadian Entomologist 72: 65–78.

———. 1950. The extralimital distribution of some species of Coleoptera. The Canadian Entomologist 82: 197–205.

———. 1967. Notes on the extralimital distribution of some species of Coleoptera. The Canadian Entomologist 99: 85–93.

Burakowski, B., M. Mroczkowski, and J. Stefańska. 1980. Chrząszcze. Coleoptera. Kusakowate - Staphylinidae, część 2. Katalog Fauny Polski część XVIII, tom 7. Państwowe Wydawnictwo Naukowe, Warszawa, 272 pp.

Campbell, J. M. 1976. A revision of the genus *Sepedophilus* Gistel (Coleoptera: Staphylinidae) of America north of Mexico. Memoirs of the Entomological Society of Canada No. 99. 89 pp.

Campbell, L. 1974. Sable Island, fatal and fertile crescent. Lancelot Press, Halifax, Nova Scotia, 104 pp.

Herman, L. H. 2001. Catalogue of the Staphylinidae (Insecta: Coleoptera). 1758 to the end of the Second Millenium. Bulletin of the American Museum of Natural History 265, 4218 pp.

Hoebeke, E. R. 1995. Three Palearctic species of *Rugilus* Leach in North America (Coleoptera: Staphylinidae, Paederinae): redescriptions, new synonymy, and new records. Insecta Mundi 9: 69–80.

Horion, A. 1965. Faunistik der Mitteleuropäischen Käfer, Band X: Staphylinidae, 2 Teil Paederinae bis Staphylininae. Verlagsdruckerei Ph. C.W. Schmidt, Neustadt a. d. Aisch, pp. i–xv, pp. 1–335.

Jeannel, R. and J. Jarrige. 1949. Biospeologica. LXVIII. Coléoptères Staphylinides (Première Série). Archives de Zoologie Expérimentale et Générale 86(5): 255–392.

Kirby, W. 1837. *Fauna boreali-Americana* or the Zoology of the northern parts of British America, containing descriptions of the objects of natural history collected on the late northern land expeditions, under the command of Captain Sir John Franklin, RN, by John Richardson. Volume 4. Fletcher, Norwich, England. 325 pp.

Klimaszewski, J. 1984. A revision of the genus *Aleochara* Gravenhorst of America north of Mexico (Coleoptera: Staphylinidae, Aleocharinae). Memoirs of the Entomological Society of Canada No. 129. 211 pp.

Klimaszewski, J., V. Assing, C. G. Majka, G. Pelletier, R. P. Webster, and D. Langor. In press. New records of adventive aleocharine beetles from Canada (Coleoptera, Staphylinidae, Aleocharinae). The Canadian Entomologist.

Lindroth, C. H. 1957. The faunal connections between Europe and North America. Almqvist & Wiksell, Stockholm, Sweden, 344 pp.

———. 1963. The fauna history of Newfoundland illustrated by carabid beetles. Opuscula Entomologica Supplementum 23. Lund, Sweden, 112 pp.

MacLean, R. A. 1976. The History of Antigonish, volumes 1 & 2. Casket Printing & Publishing, Antigonish, NS, 500 pp.

Majka, C. G. 2005. The Palearctic species *Bembidion femoratum* and *Amara communis* (Coleoptera: Carabidae): new records and notes on modes of introduction to North America. The Canadian Entomologist 137: 532–538.

Majka, C. G. and J. Klimaszewski. 2004. *Phloeocharis subtilissima* Mannerheim (Staphylinidae: Phloeocharinae) and *Cephennium gallicum* Ganglbauer (Scydmaenidae) new to North America: a case study in the introduction of exotic Coleoptera to the port of Halifax, with new records of other species. Zootaxa 781: 1–15.

Majka, C. G., J. Klimaszewski, and R. F. Lauff. 2006. New Coleoptera records from owl nests in Nova Scotia, Canada. Zootaxa 1194: 33–47.

Osella, G. and A. Zanetti. 1975. La coleotterofauna dei nidi di *Talpa europaea* L. nell'Italia settentrionale a nord del fiume Po. Bollettino di Zoologia agraria e di Bachicoltura 2(12): 41–200.

Prévost, M.-A. and A. Bain. In press. L'implantation d'une colonie terre-neuvienne au XVIIe siècle: l'apport des analyses archéobotanique et archéoentomologique. *In* Bain, A., J. Chabot and M. Moussette, eds. La mesure du passé: contributions à la recherche en archéométrie (2006). British Archaeological Reports.

Smetana, A. 1964. Die Staphylinidenfauna des Moores Hájek (Soos) in Westböhmen (Col., Staphylinidae). Acta Faunistica Entomologica Musei Nationalis Pragae 10: 412–123.

———. 1971. Revision of the tribe Quediini of America north of Mexico (Coleoptera: Staphylinidae). Memoirs of the Entomological Society of Canada No. 79. 303 pp.

———. 1982. Revision of the subfamily Xantholininae of America north of Mexico (Coleoptera: Staphylinidae). Memoirs of the Entomological Society of Canada No. 120. 389 pp.

———. 1995. Rove beetles of the subtribe Philonthina of America north of Mexico (Coleoptera: Staphylinidae) classification, phylogeny and taxonomic revision. Associated Publishers, Gainesville, Florida, 946 pp.

———. 2004. Staphylinidae, pp. 237–698. *In* Löbl, I. and A. Smetana, eds. Catalogue of Palaearctic Coleoptera. Vol. 2. Apollo Books, Stenstrup, 942 pp.

Spence, J. R. and D. H. Spence. 1988. Of groundbeetles and men: introduced species and the synanthropic fauna of western Canada. Memoirs of the Entomological Society of Canada 144: 151–168.

Szujecki, A. 1980. Kusakowate – Staphylinidae, kusaki – Staphylininae. Klucze do oznaczenie owadów Polski [Keys for the identification of Polish insects]. XIX, 24 e. 164 pp.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 435–439

A NEW SPECIES OF *HYPERXIPHIA* MAA (HYMENOPTERA: XIPHYDRIIDAE) FROM JAPAN, REARED FROM WOOD OF *MACHILUS THUNBERGII* SIEB. AND ZUCC. AND *ARDISIA SIEBOLDII* MIQ.

ICHIJI TOGASHI

1-chome, Tsurugihonmachi, Hakusan-shi, Ishikawa Prefecture 920-2121, Japan

Abstract.—***Hyperxiphia tabunokii*, n. sp.**, from Amani-Oshima, Kagoshima Prefecture, Kyushu, Japan, is described and illustrated. Specimens emerged from wood of *Machilus thunbergii* Sieb. and Zucc. (Lauraceae) and *Ardisia sieboldii* Miq. (Myrsinaceae). A key is provided for the four Japanese species of *Hyperxiphia*.

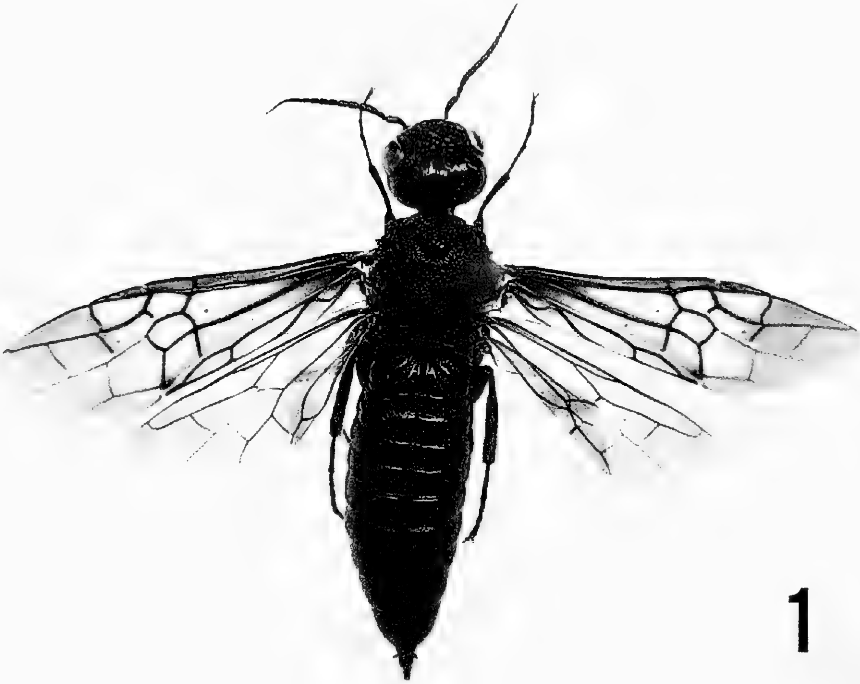
Key Words: Symphyta, Xiphydriidae, *Hyperxiphia*, food plants, *Machilus*, *Ardisia*

Hyperxiphia Maa is a small genus of 10 species that occur in the eastern Palaearctic and Oriental regions. Three species, *H. leucopoda* (Takeuchi 1938), *H. nakanishii* (Takeuchi 1938), and *H. nodai* Togashi, 1982 (in Togashi and Hirashima 1982) are known in Japan. Recently, I received five specimens (two females and three males) of *Hyperxiphia* which emerged from wood of *Machilus thunbergii* Sieb. and Zucc. and *Ardisia sieboldii* Miq. collected at Mt. Yui, Amami-Oshima, Kagoshima Prefecture, Kyushu, Japan. These specimens are close to *H. nodai* , but they are distinguished from the latter by the number of antennal segments, by having a white ring at the apical portion of the forecoxa (Fig. 13), by the lengths of the third antennal segment and the hind basitarsus (Fig. 18), and by having an appendiculate vein at the base of vein 2A+3A of the forewing (Fig. 11). Also, these specimens do not key to any of the known species of *Hyperxiphia* in Maa (1949). Therefore, I concluded that these specimens represent a new species. In this paper, I describe and illustrate the new species and give a key to the Japanese species.

This species is placed in *Hyperxiphia* based on Maa's (1949) classification. *Hyperxiphia* is distinguished by the following: Propleuron in profile much longer than high; cells Rs and M present in the hindwing; maxillary palpus 5-segmented with last segment slightly longer than segments 3 and 4 together; labial palpus 4-segmented; and tarsal claws each with a small tooth near middle or base of claw.

KEY TO JAPANESE SPECIES OF *HYPERXIPHIA*

1. Head rufous; wings hyaline; legs entirely yellowish white . . . . . . *leucopoda* (Takeuchi)
– Head black; wings slightly infuscte or hyaline (Fig. 1); legs black or yellowish . . 2
2. Legs entirely yellowish white; wings hyaline; antenna 12- or 13-segmented . . . . *nakanishii* (Takeuchi)
– Legs brownish black or entirely black; forewing evenly infuscate; antenna 14- or 18-segmented 3
3. Antenna 14-segmented; forecoxa black; base of 2A+3A of forewing without appendiculate vein . . . . *nodai* Togashi
– Antenna 18-segmented; forecoxa with white ring at apex (Fig. 13); base of vein 2A+3A of forewing with appendiculate vein (Fig. 11) . . . . *tabunokii*, n. sp.



1

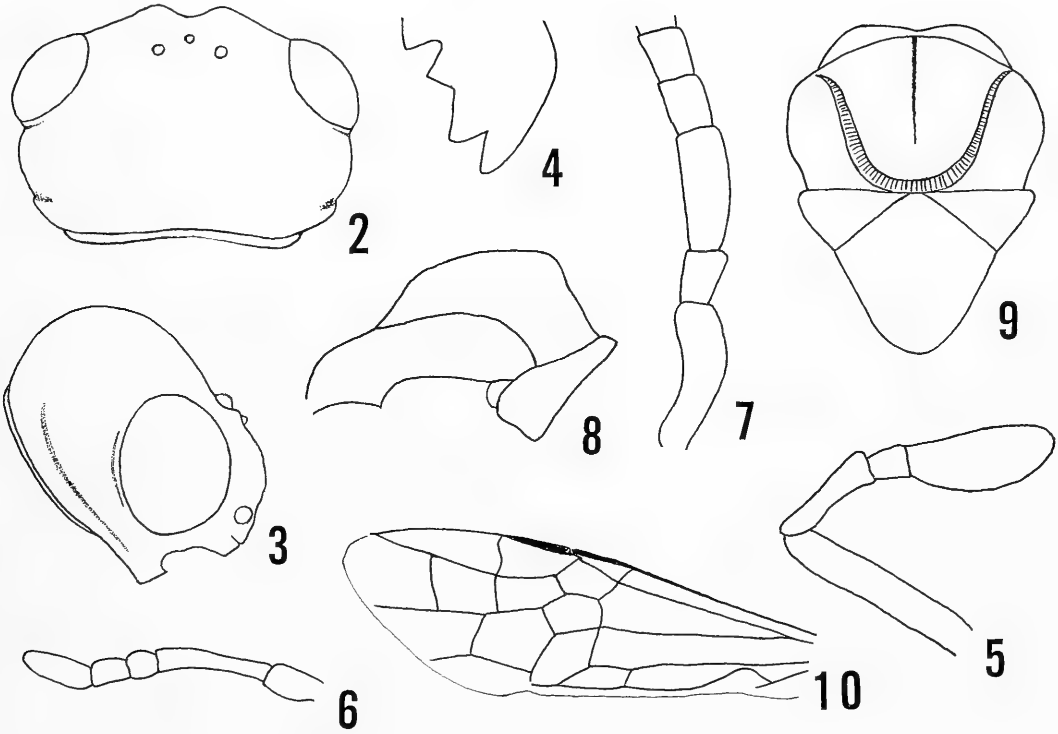
Fig. 1. *Hyperxiphia tabunokii*, holotype.

Hyperxiphia tabunokii Togashi, new species
(Figs. 1–20)

Female.—Length, 16 mm. Antenna, head, and body black. Wings evenly infuscate, stigma and veins dark brown to black. Legs black, but apex of forecoxa with white ring (Fig. 13).

Head (Fig. 2): Postocellar area slightly raised; OOL:POL:OCL = 1.1:1.0:3.5; interocellar, postocellar, and lateral furrows absent; frons raised; median fovea deep, elongate; lateral fovea deep and circular; antenno-ocular distance shorter than distance between antennal sockets (ratio 1.0:2.1); clypeus with a central tooth; malar space (including malar depression) nearly as long as diameter of front ocellus; occipital carina distinct; genal carina distinct to top of eye; postorbital groove distinct (Fig. 3); labial palpus 4-segmented (Fig. 5); maxillary palpus 5-segmented (Fig. 6); mandible quadridentate (Fig. 4). Antenna 18-segmented, slightly shorter than costa of forewing (ratio 1.0:1.2); scape curved (Fig. 7), slightly longer than third antennal segment (ratio 1.0:0.8) (Fig. 7); relative lengths of basal five segments about 2.8:1.0:2.3:1.0:1.0.

Thorax: Anterior half of mesoprescutum distinctly angulated in lateral view (Fig. 8); median suture of mesoprescutum distinct but posterior portion indistinct (Fig. 9); mesoscutellum rather flattened; cenchrus small, distance between them about four times breadth of one (ratio 1.0:4.0). Venation of forewing as in Fig. 10; base of vein 2A+3A of forewing with appendiculate vein (Fig. 11); venation of hindwing as in Fig. 12; petiole of anal cell of hindwing slightly shorter than



Figs. 2–10. *Hyperxiphia tabunokii*, holotype. 2, Head, dorsal. 3, Head, profile. 4, Mandible, front. 5, Labial palpus, ventral. 6, Maxillary palpus, ventral. 7, Basal 5 antennal segments, lateral. 8, Mesoprescutum, lateral. 9, Mesoprescutum, dorsal. 10, Forewing.

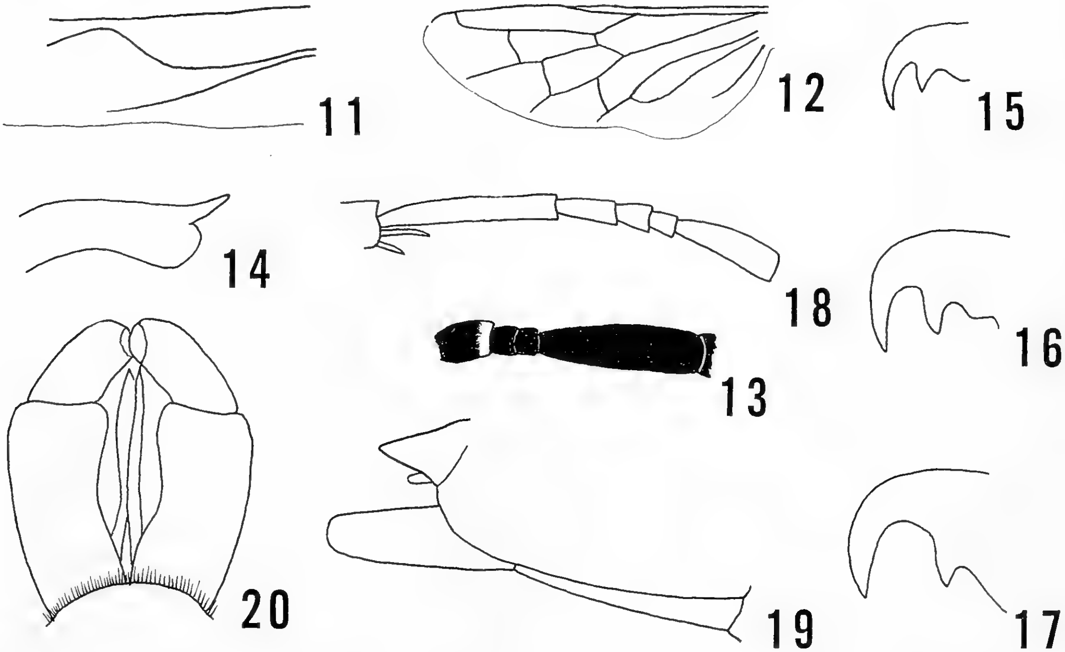
nervulus (cu-a) (ratio 1.0:1.3. Legs: Hind basitarsus longer than following three segments combined (ratio 1.0:0.7); foretibial spur as in Fig. 14; each taral claw with inner tooth, as in Fig. 15–17. Mid- and hind claws larger than foreclaw.

Abdomen: Propodeum with an oblique furrow along central line; length of sheath nearly as long as length of basal plate (Fig. 19); sheath as in Fig. 19.

Punctation: Vertex, postocellar area, and upper half of postocellar area impunctate, shining; lower half of postocellar area distinctly and rather closely punctured, interspaces between punctures nearly impunctate, shining; frons, inner orbits, supraclypeal area, clypeus, and malar space distinctly, coarsely, and irregularly sculptured; pronotum, mesoscutum, meso- and metascutellum, axilla, mesoscutellar appendate, and mesopleuron strongly, irregularly, and rugoso-subreticulately sculptured, but posterior portion of mesoprescutum nearly impunctate, shining; scrobiculate area separates median and lateral lobes (Fig. 9); central portion of propodeum nearly impunctate, shining; oblique furrow distinctly, rather closely punctured; second to last tergites covered with many transverse wrinkles.

Male.—Length, 12.0 mm. Structure and coloration similar to female, except for tarsal claw and male genitalia. Male genitalia as in Fig. 20; black but apical portion of harpes white. Posterior margin of subgenital plate nearly truncate. Claws of each leg similar in size.

Type material.—Holotype: Female, Mt. Yui, Amami-Oshima, Kagoshima Pref., 13.V.2005, bred from Machilus thunbergii, H. Makihara, leg. Paratypes: Female, same locality as for holotype, 26.VII.2004, bred from Ardisia sieboldii, H. Makihara, leg; 2 males, same locality



Figs. 11–20. *Hyperxiphia tabunokii*, holotype. 11, Appendiculate vein of forewing. 12, Hindwing. 13, Forecoxa, trochanters, and femu, lateral. 14, Foretibial spur, lateral. 15, Foretarsal claw, lateral, female. 16, Midtarsal claw, lateral, female. 17, Hind tarsal claw, lateral, female. 18, Hind tarsus, lateral. 19, Sawsheath and basal plate, lateral. 20, Male genitalia, dorsal.

as for holotype, 14.IX.2004, bred from Machilus thunbergii, H. Makihara, leg.; 1 male, same locality as for holotype, 6.V.2005, bred from Machilus thunbergii, H. Makihara, leg. Holotype and two paratypes (males) deposited in the collection of the National Science Museum (Nat. Hist.), Tokyo; 2 paratypes (female and male) deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC.

Distribution.—Japan (Kagoshima Prefecture, Amami-Oshima).

Food plants.—*Machilus thunbergii* (Lauraceae) (Japanese name: Tabunoki) and *Ardisia sieboldii* (Myrsinaceae) (Japanese name: Mokutachibana).

Etymology.—The names is the genitive form of the Japanese name of the food plant.

Remarks.—This new species is close to *Hyperxiphia nodai*, but it is distinguished from the latter by the 18-segmented antenna (14-segmented in *H. nodai*), by the antennal scape slightly longer than the third antennal segment (slightly shorter in *H. nodai*), by the hind basitarsus longer than the following three segments combined (shorter in *H. nodai*), by having a white ring on the apical portion of the forecoxa (entirely black in *H. nodai*), and by having an appendiculate vein at the base of 2A+3A of the forewing (absent in *H. nodai*). According to Maa's (1949) key, this new species goes to *H. melanaria* (Mocsáry) from Tonkin, but it is distinguished from the latter by the black tergites (8th to 9th tergites white in *H. melanaria*).

Acknowledgments

I express my thanks to Dr. David R. Smith, USDA, Washington, DC, for reading through this manuscript and for his kind service. I am indebted to Mr. H. Makihara, Forestry and Forest Products Research Institute, Taskuba

City, for his kindness in giving me the opportunite to examine the specimens.

Literature Cited

Maa, T. 1949. A synopsis of Asiatic Siricoidea with notes on certain exotic and fossil forms. Notes d'Entomologie, Chinoise 8: 11–189.

Takeuchi, K. 1938. A systematic study on the suborder Symphyta (Hymenoptera) of the Japanese Empire (1). Tenthredo 2: 173–229.

Togashi, I. and Y. Hirashima. 1982. Wood wasps or horn-tails of the Amami-oshima Island, with description of a new species (Hymenoptera: Siricoidea). Esakia 19: 185–189.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 440–453

THE GENUS *PHYSOPLEURELLA* REUTER (HEMIPTERA: HETEROPTERA: ANTHOCORIDAE) FROM SOUTHEASTERN ASIA

KAZUTAKA YAMADA AND TOSHIYA HIROWATARI

Entomological Laboratory, Graduate School of Life and Environmental Sciences, Osaka Prefecture University, Sakai, Osaka 599-8531, Japan (e-mail: (KY) kazu2000@plant.osakafu-u.ac.jp; (TH) hirowat_t@envi.osakafu-u.ac.jp)

Abstract.—The flower bug genus *Physopleurella* Reuter 1884 of southeastern Asia is revised. Six species are recognized from this region, including three new species: ***P. malayana*, n. sp.**, ***P. nigrifemora*, n. sp.**, and ***P. striata*, n. sp.** *Physopleurella armata* Poppius 1909, *P. pessoni* Carayon 1956, and *P. flava* Carayon 1956 are recorded from southeastern Asia for the first time. Keys are provided to distinguish species.

Key Words: Heteroptera, Anthocoridae, Dufouriellini, *Physopleurella*, new species, new records, Southeast Asia

---

Physopleurella Reuter, belonging to the tribe Dufouriellini, is a small flower bug genus, previously including 13 world species: *P. africana* Carayon 1956; *P. armata* Poppius 1909; *P. australis* Gross 1954; *P. bribiensis* Gross 1954; *P. flava* Carayon 1956; *P. indica* Muraleedharan 1978; *P. loyala* Muraleedharan 1978; *P. mundula* (White 1877); *P. pacifica* Gross 1954; *P. pessoni* Carayon 1956; *P. signata* (Distant 1913); *P. typica* (Distant 1913); *P. vichitravarna* Muraleedharan 1977 (Poppius 1909; Distant 1913; Gross 1954; Carayon 1956; Muraleedharan 1977, 1978; Ford 1979). Members of this genus are distributed predominantly over the tropics and subtropics, including southeastern Asia. The fauna of this region requires a great deal of further investigation. Prior to this study, there were no records of the genus from southeastern Asia, except for *P. indica, P. loyala*, and *P. vichitravarna*, from southern India (Muraleedharan 1977, 1978).

Recent surveys in the southeastern Asia by the authors, our colleagues, and other entomologists have resulted in the recognition of six species in this genus, three of which are new. Here, three new species are described and three previously known species, *P. armata*, *P. pessoni*, and *P. flava*, are first recorded from southeastern Asia. The biology of species of this genus is briefly documented based on our field observations. Keys are provided to assist in distinguishing species.

MATERIALS AND METHODS

Most specimens were preserved in 70% ethyl alcohol, then dried and mounted for observation of their various structures. The examination and illustration of the detailed external structures were made from specimens macerated in 5% hot KOH solution for 3–5 minutes. They were dissected with micro-pins in glycerin on a well glass slide under a Nikon Stereoscopic Zoom Microscope SMZ1500 binocular microscope.

Examined specimens are deposited in the Entomological Laboratory, Osaka

Prefecture University, Sakai (OPU) and the Department of Zoology, National Science Museum, Tokyo (NSMT). All measurements in the text are given in millimeters and terminology for descriptions generally follows Carayon (1972) and Péricart (1972). An asterisk is placed after the name of new localities.

TAXONOMY

Genus *Physopleurella* Reuter

Physopleurella Reuter 1884: 124. Type species: *Cardiastethus mundulus* White, 1877, by monotypy.

Ostorodiasoides Distant 1913: 187. Type species: *Ostorodiasoides typicus* Distant 1913, by original designation. Synonymized by Carayon 1972: 339.

Diagnosis.—Recognized by the following characters: Body oblong ovate, covered with long, silky, reclining setae on dorsum; rostrum short, robust, hardly surpassing anterior margin of prosternum; pronotal callus with longitudinal grooves; ostiolar peritreme curved posteriorly, not joining fine carina which extends to anterior margin of metapleuron; fore femur enlarged, much thicker than mid- and hind femora, bearing series of spines on ventral surface; fore tibia arched, bearing a row of short reclining setae on all of the ventral surface (Reuter 1884, Blatchley 1925, Gross 1954).

Remarks.—*Physopleurella* is apparently a distinct genus and can be distinguished easily from the other genera of the tribe Dufouriellini by the pronotal callus with longitudinal grooves, the enlarged fore femur bearing series of spines on ventral surface, and arched fore tibia, all of which are considered to support the monophyly of the genus.

Biology.—Species of *Physopleurella* are known to be found in dead plant materials, such as dead leaves and branches, banana leaves, harvested stems and leaves, and the nests of weaverbirds (Usinger 1946; Carayon 1958; Hiura 1959). In Malaysia, most individuals were collected by beating dead-leaf clusters of evergreen trees, together with other Dufouriellini species of the genera such as *Amphiareus* Distant, *Buchananiella* Reuter, and *Cardiastethus* Fieber. Five species, excluding *P. armata*, were found sympatrically in a similar habitat in Selangor, Malaysia, and the largest number of individuals was *P. malayana*. Zimmerman (1948) reported psocids and small leaf hoppers as preys of *P. mundula*. In contrast, Malaysian specimens were collected together with many nymphs and adults of unidentified tuburiferan thrips that possibly serve as prey of *Physopleurella* species.

Physopleurella armata Poppius
(Figs. 1, 17, 18)

Physopleurella armata Poppius 1909: 12, 13. Syntypes: ♂, Bukenji, Japan; housed in the Hungarian Natural History Museum, Budapest. Haveri, New Guinea; Museo Civico di Storia Naturale "Giacomo Doria," Genoa.

Physopleurella obscura Poppius 1909: 13. Holotype: ♀, Ighibirei, New Guinea; Museo Civico di Storia Naturale "Giacomo Doria," Genoa. Synonymized by Esaki 1926: 170.

Scoloposcelis japonicus Esaki 1931: 263, 264, fig. 4. Holotype: ♂, Fukuoka-Hirao, Japan; Kyushu University, Entomological Collection, Fukuoka. Synonymized by Hiura 1959: 7.

Diagnosis.—Recognized by the following characters: Head (Fig. 1) light brown; vertex tinged with dark brown; antenna pale yellow, with apex of segment I and II dark brown; antennal segment II longer than head width across eyes; rostrum pale yellow; pronotum (Fig. 1) unicolorously yellowish brown; scutellum (Fig. 1) reddish brown to brown; hemelytra (Fig. 1) yellowish

Figs. 1–6. *Physopleurella* spp. in dorsal view. 1, *P. armata*, female. 2, *P. pessoni*, male. 3, *P. flava*, female. 4, *P. malayana*, male, holotype. 5, *P. nigrifemora*, male, holotype. 6, *P. striata*, male, holotype. Scale bars: 1.0 mm.

brown with innermost portion of corium narrowly darkened; cuneus broadly darkened; legs pale yellow; abdomen dark reddish brown; pygophore (Fig. 17) with a nearly straight paramere extending laterad and slightly bent anteriorly at apex.

Measurements [♂ (n=7) /♀ (n=20)]. Body length 3.00–3.25/3.05–4.13; head length (excl. neck) 0.42–0.45/0.40–0.46; head width across eyes 0.47–0.48/0.46–0.54; vertex width 0.18–0.20/0.18–0.20; width between ocelli 0.07–0.08/0.10–0.15; length of antennal segments I–IV 0.14/0.13–0.16, 0.53–0.58/0.44–0.59, 0.34–0.38/0.30–0.39, and 0.31–0.33/0.25–0.35; length of rostral segments II–IV 0.08–0.09/0.06–0.08, 0.21–0.25/0.21–0.25, and 0.16–0.19/0.16–0.20; anterior pronotal width 0.33–0.35/0.33–0.35; mesal pronotal length 0.43–0.45/0.45–0.50; basal pronotal width 0.90–1.00/0.90–1.10; length of embolial margin 0.92–0.98/0.90–1.13; length of cuneal margin 0.60–0.65/0.64–0.75; maximum width across hemelytra 1.04–1.13/1.02–1.28.

Specimens examined.—VIETNAM: 1♀, Ba Be, 230 m alt., Bac Kan Prov., 12.v.1998, M. Tomokuni (NSMT). 1♀, Trung Yen, 900 m alt., Moc Chau, Son La Prov., 20.vi.1997, light trap, M. Tomokuni (NSMT). 1♂1♀, Tam Dao, 900 m alt., Vinh Phuc Prov., 17–18.vi.1999, Y. Nakatani (OPU). THAI-

LAND: 1♂4♀, Mae Sa, 400–450 m alt., Mae Rim, Chiang Mai, 1–4.viii.2001, S. Nagashima (OPU); 5♂ (Figs. 17, 18) 8♀ (Fig. 1), same locality, 15–17.v.2002, T. Ishikawa (OPU); 2♀, Mae Sa, 450 m alt., Mae Rim, Chiang Mai, 18.viii.2001, light trap, T. Ishikawa (OPU). 1♀, Khao Luang National Park, H. Q., 120 m alt., Nop Pi Tam, Nakhon Si Thammarat, 9.viii.1987, M. Sato (NSMT); 1♀, Khao Luang, National Park, H. Q., 450 m alt., Nop Pi Tam, Nakhon Si Thammarat, 6.viii.1997, T. Yamasaki (NSMT). PHILIPPINES: 1♀, Puerto Princera, Palawan Is., 26.viii.1985, M. Sakai (NSMT).

Distribution.—Vietnam*, Thailand*, Philippines*, China (central and southeastern territories), Taiwan, Japan, New Guinea, Australia, Hawaii.

Remarks.—This species was described from Japan and New Zealand by Poppius (1909). It is now known to be widely distributed in eastern Asia and the Australian Region (Cassis and Gross 1995, Péricart 1996, Bu and Zheng 2001). Vietnam, Thailand, and the Philippines represent new distributional records for this species in southeastern Asia.

Physopleurella pessoni Carayon (Figs. 2, 19, 20)

Physopleurella pessoni Carayon 1956: 104, 106, figs. 1, 2. Holotype: ♂, Adiopodoumé, Côte-d'Ivoire; Muséum National d'Histoire Naturelle, Paris.

Diagnosis.—Recognized by the following characters: Head (Fig. 2) yellowish brown; vertex widely darkened; antenna pale yellow with apex of segment I and II dark brown; antennal segment II about as long as head width across eyes; rostrum pale yellow; pronotum (Fig. 2) yellowish brown with widely darkened posterior angles; scutellum (Fig. 2) dark brown; hemelytra (Fig. 2) yellowish brown, clavus narrowly darkened at apex, cuneus widely darkened; legs unicolorously pale yellow; abdomen blackish brown, laterally yellowish brown; pygophore (Fig. 19) with a short paramere extending laterad, gradually tapering toward apex and slightly constricted near apex.

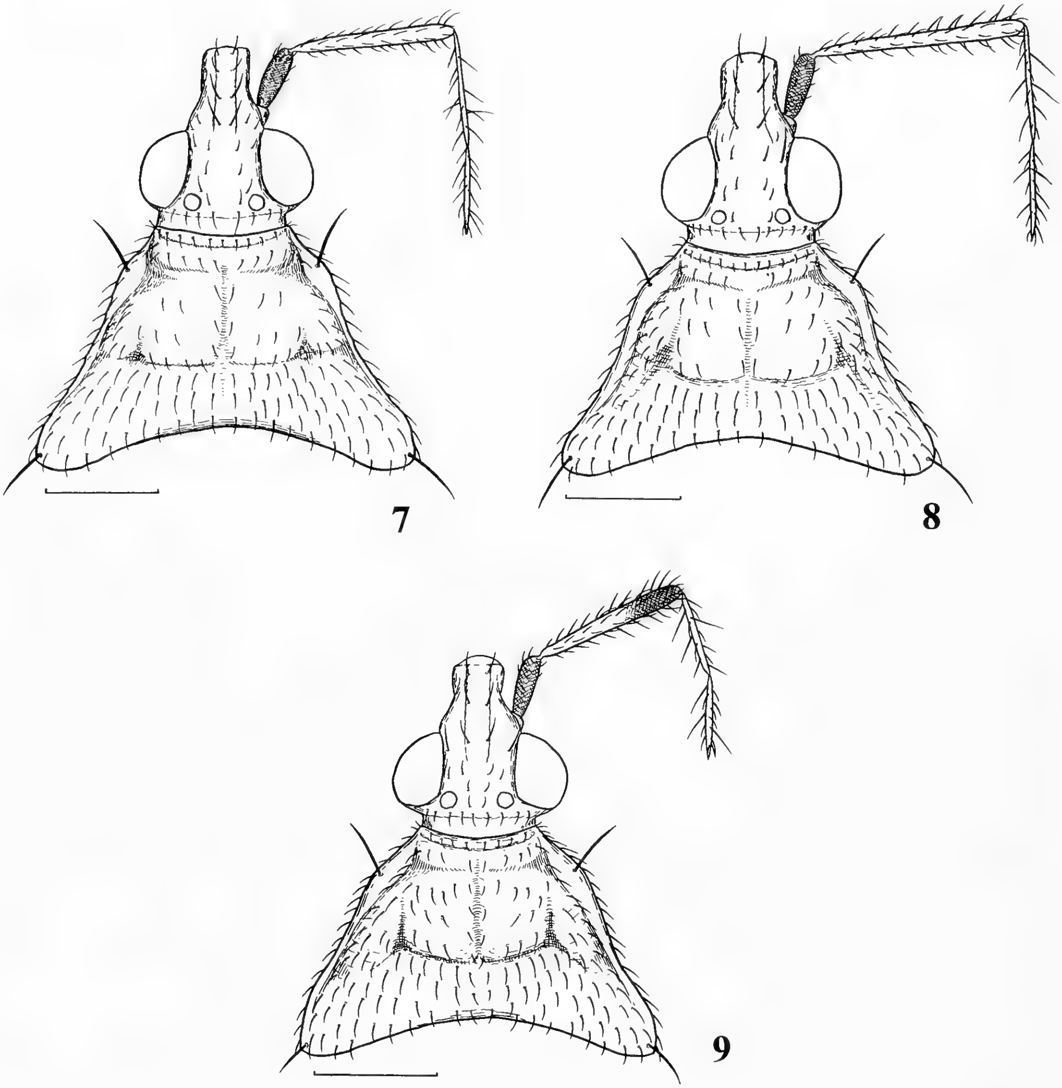
Measurements [♂ (n=2) /♀ (n=4)]. Body length 2.75/3.18–3.38; head length (excl. neck) 0.40/0.40–0.44; head width across eyes 0.45/0.48–0.50; vertex width 0.17/0.19–0.20; width between ocelli 0.09/0.10–0.12; length of antennal segments I–IV 0.13/0.15–0.16, 0.50/0.50–0.52, 0.31/0.31–0.33, and 0.29/0.29–0.31; length of rostral segments II–IV 0.06/0.08, 0.22/0.23–0.25, and 0.17/0.17–0.19; anterior pronotal width 0.31/0.33–0.34; mesal pronotal length 0.41/0.46–0.48; basal pronotal width 0.85/1.05–1.07; length of embolial margin 0.76/0.90–1.00; length of cuneal margin 0.60/0.68–0.70; maximum width across hemelytra 0.96/1.15–1.20.

Specimens examined.—MALAYSIA: 1♂2♀, Ulu Gombak, Selangor, 9.v.2005, K. Yamada. 1♂ (Figs. 2, 19, 20) 1♀, nr. Endau-Rompin, Pahang, 12.v.2005, light trap, K. Yamada. 1♀, Kampung Peta, Endau-Rompin, Johor, 15.v.2005, light trap, K. Yamada. All in OPU.

Distribution.—Malaysia*, Mauritius (Mascarene Isls.), Madagascar, Cameroon, Côte-d'Ivoire.

Remarks.—*Physopleurella pessoni* was described by Carayon (1956) based on specimens from Côte-d'Ivoire and Cameroon. Subsequently, he recorded this species from Madagascar and Mauritius, together with *P. flava* (Carayon 1958). Malaysia represents a new country record.

The shape of male genitalia and other external structures of specimens from Malaysia agree with those of *pessoni* Carayon, judging from the original description of Carayon (1956). However Malaysian specimens have a rather larger body than those of the African specimens (2.32–2.58 in male, 2.54–3.05 in female).



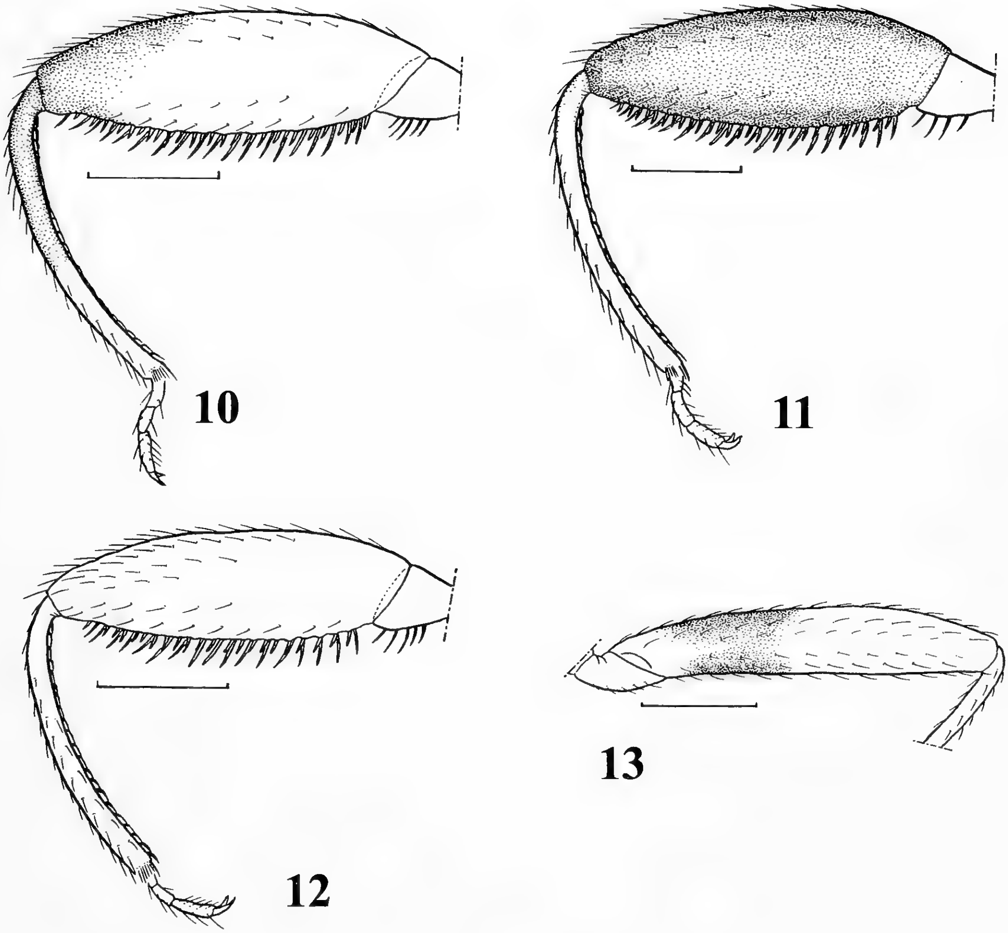
Figs. 7–9. Heads and pronota in dorsal view. 7, *Physopleurella malayana*, female. 8, *P. nigrifemora*, male. 9, *P. striata*, male, holotype. Scale bars: 0.3 mm.

Physopleurella flava Carayon
(Figs. 3, 21, 22)

Physopleurella flava Carayon 1956: 107, 108. Holotype: ♀, Dahomey; Muséum National d'Histoire Naturelle, Paris.

Diagnosis.—Recognized by the following characters: Body (Fig. 3) unicolorously yellowish brown to light brown; antenna pale yellow with segment I slightly darkened; antennal segment II about as long as head width across eyes; rostrum pale yellow; legs pale yellow to yellowish brown; abdomen brown tinged with fuscous; pygophore (Fig. 21) wide, rounded at bottom, apex of left side with dense, short, stout setae; paramere (Figs. 21, 22) stout, moderately rounded anteriorly, abruptly bent near apex.

Measurements [♂ (n=4) /♀ (n=14)]. Body length 2.75/2.80–3.08; head length (excl. neck) 0.36–0.37/0.35–0.40; head width across eyes 0.41–0.42/0.41–0.44;



Figs. 10–13. Fore legs (10–12) and hind femur (13). 10, *Physopleurella malayana*, male. 11, *P. nigrifemora*, male. 12, 13, *P. striata*, male. Scale bars: 0.05 mm.

vertex width 0.16–0.18/0.19–0.20; width between ocelli 0.08–0.10/0.13; length of antennal segments I–IV 0.11–0.13/0.11–0.13, 0.41/0.41–0.43, 0.25/0.24–0.25, and 0.25/0.25; length of rostral segments II–IV 0.06–0.08/0.06–0.09, 0.22/0.22–0.23, and 0.17–0.18/0.16–0.20; anterior pronotal width 0.29–0.30/0.30–0.34; mesal pronotal length 0.40–0.42/0.45; basal pronotal width 0.82–0.84/0.90; length of embolial margin 0.80/0.80–0.90; length of cuneal margin 0.60/0.67–0.70; maximum width across hemelytra 0.95–1.00/0.94–1.08.

Specimens examined.—THAILAND: 1♀, Mae Sa, 400–450 m alt., Mae Rim, Chiang Mai, 1–4.viii.2001, S. Nagashima; 1♀, same locality, 1.viii.2001, T. Ishikawa; 1♂1♀, same locality, 13.viii.2001, T. Ishikawa; 1♂ (Figs. 21, 22) 5♀ (Fig. 3), 16–17.v.2002, T. Ishikawa. 2♀, Mae Choe, N17-45' E100-01', Uttaradit, Y. Nakatani (without collection date). MALAYSIA: 2♂4♀, Ulu Gombak, Selangor, 8.v.2005, K. Yamada. All in OPU.

Distribution.—Thailand*, Malaysia*, Mauritius (Mascarene Isls.), Madagascar, Congo, Benin, Côte-d'Ivoire.

Remarks.—Previously, this species was known to be widely distributed in tropical Africa. Thailand and Malaysia represent new country records.

According to Carayon (1958), the shape of male genitalia differed very little between the specimens from the Côte-d'Ivoire and those from Mauritius (Mascarene Isls.). Judging from the male genitalia of specimens from Thailand and Malaysia, the shape of the paramere resembles that of the Mauritius specimens. Carayon (1958) indicated that these differences could represent subspecific distinction or geographic variability. Besides the male genitalia, however, no differences in external characters were found between the African and southeastern Asian specimens. Therefore, the male genitalic differences are considered to represent intraspecific variation.

Physopleurella malayana Yamada and Hirowatari, new species

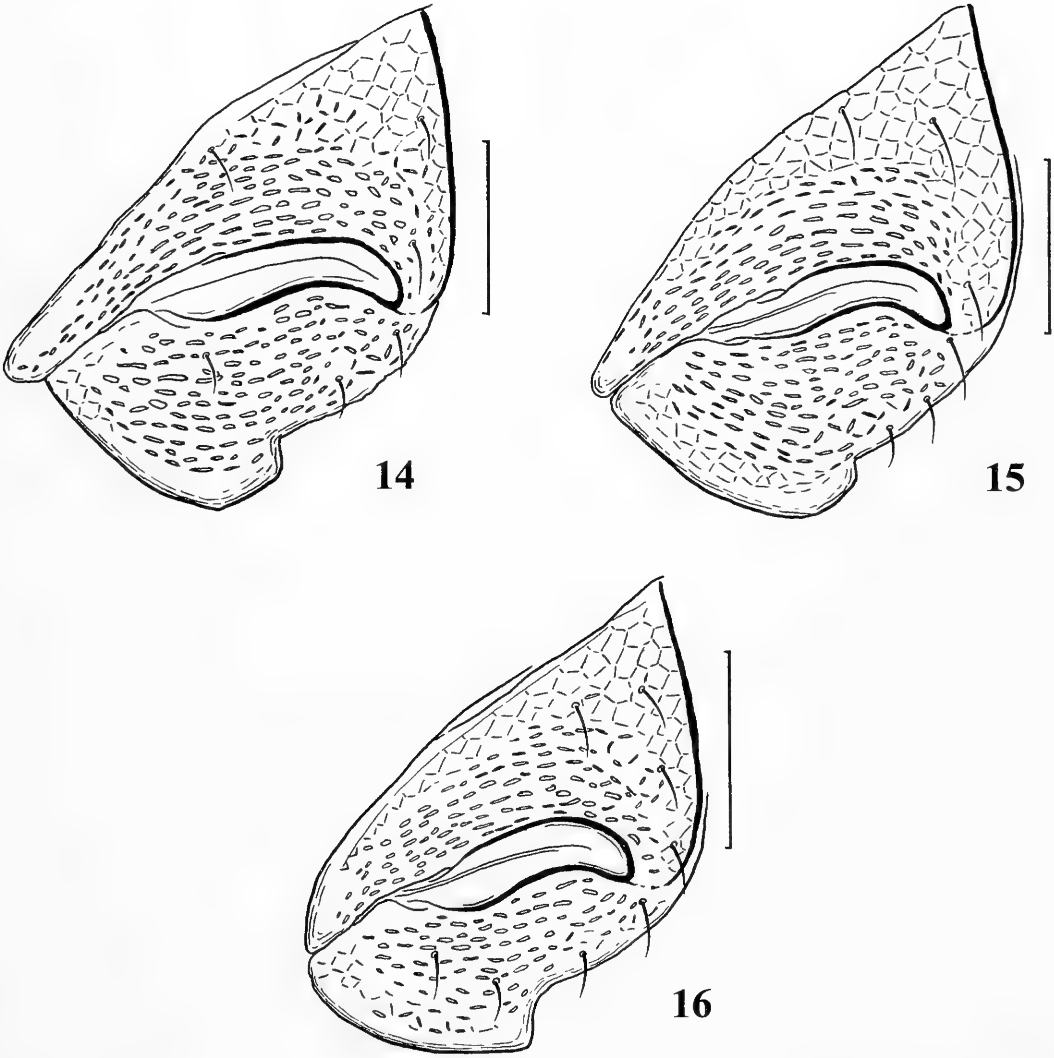
(Figs. 4, 7, 10, 14, 23, 24)

Diagnosis.—Recognized by the following characters: Head (Figs. 4, 7) dark brown; antenna pale yellow, with segment I dark brown; antennal segment II about as long as head width across eyes; pronotum (Fig. 4) dark brown; apical 1/3 of dorsal surface of fore femur (Fig. 10) and basal half of fore tibia (Fig. 10) darkened; abdomen blackish brown; paramere (Figs. 23, 24) stout, bent and swollen at base in lateroposterior view, notched near apex, abruptly acute apically.

Description.—Body (Fig. 4) generally brown. Head (Figs. 4, 7) dark brown, slightly shorter than its width across eyes; dorsal surface shiny, sparsely covered with long, silky, erect setae; anteocular portion about as long as length of the eye; vertex tinged with blackish brown, about 1.3 times as wide as width of eye; ocelli red. Antenna (Figs. 4, 7) pale yellow, covered with yellow, suberect, setae; segment I dark, reaching apex of head; segment II thickened toward apex, about as long as head width across eyes; segment III about 0.6 times as long as segment II; segment IV slightly shorter than segment III, flattened. Rostrum pale yellow, with sparse, short setae; segment I and II darkened; segment II bearing a pair of long erect setae at base; segment III distinctly swollen, 1.3 times as long as segment IV.

Pronotum (Figs. 4, 7) dark brown, sometimes tinged posteromedially with light brown, shiny, covered with long, silky, reclining setae; collar longitudinally narrow, with some furrows and short setae; anterior margin slightly curved, 0.68 times as long as mesal length; lateral margin slightly sinuate, carinate on anterior 2/3; posterior margin 2.9 times as wide as anterior margin. Scutellum (Fig. 4) paler than color of pronotum, weakly shiny, with two distinct foveae at middle. Hemelytra (Fig. 4) light brown, covered with yellow, reclining setae; cuneus narrowly darkened at apex, sometimes obscure; apical part of corium three times as wide as embolium; cuneal margin about 0.75 times as long as embolial margin; membrane smoky dark brown, with three veins, innermost vein distinctly bifurcated at base, remainder veins slightly curved; venter of thorax blackish brown. Legs pale yellow, densely covered with yellow, short setae; coxa dark brown; apical 1/3 of dorsal surface of fore femur (Fig. 10) and basal half of fore tibia (Fig. 10) darkened; trochanter with 5–6 spine like setae ventrally; fore femur ventrally with two series of spines composed of 18–20 long and 26 short spines. Ostiolar peritreme and evaporative area black to blackish brown, as shown in Fig. 14. Abdomen blackish brown, ventrally with dense, short, silky setae; scissure on abdominal tergite nearly reaching to middle of segment III.

Male genitalia (Figs. 23, 24): Pygophore (Fig. 23) posteroventrally covered with stout setae longer than length of pygophore, bottom of pygophore rounded; paramere (Fig. 23, 24) stout, extend-

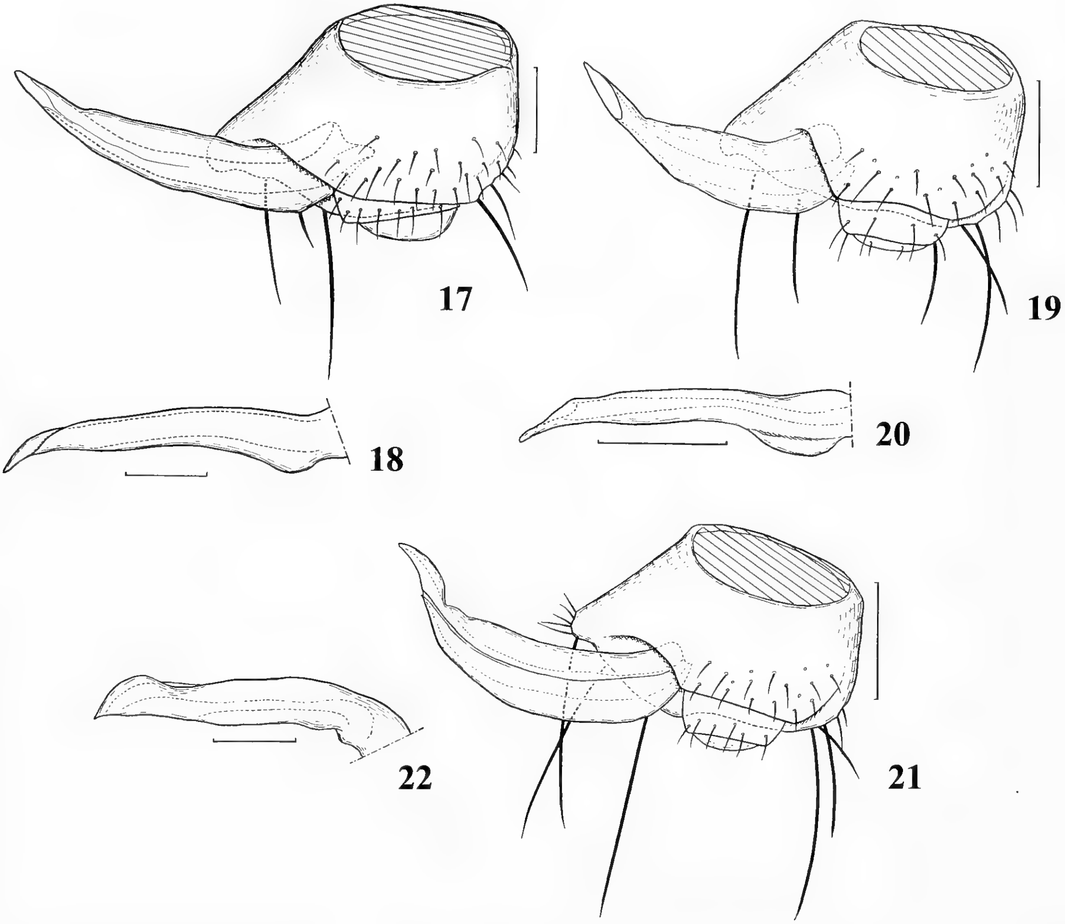


Figs. 14–16. Ostiolar peritremes and evaporative areas in left lateroventral view. 14, *Physopleurella malayana*, male. 15, *P. nigrifemora*, male. 16, *P. striata*, male. Scale bars: 0.1 mm.

ing anteriorly, bent and swollen at base in lateroposterior view, notched near apex, abruptly acute at apex.

Measurements [♂ (n=45) /♀ (n=20)]. Body length 2.55–2.83/2.60–3.25; head length (excl. neck) 0.36–0.40/0.38–0.42; head width across eyes 0.40–0.44/0.42–0.46; vertex width 0.16–0.17/0.17–0.20; width between ocelli 0.09–0.10/0.09–0.12; length of antennal segments I–IV 0.13/0.13–0.15, 0.41–0.44/0.41–0.47, 0.23–0.25/0.25–0.28, and 0.23–0.24/0.25–0.26; length of rostral segments II–IV 0.05–0.06/0.06–0.07, 0.23–0.25/0.24–0.26, and 0.16–0.19/0.18–0.19; anterior pronotal width 0.30–0.34/0.29–0.31; mesal pronotal length 0.44–0.47/0.43–0.51; basal pronotal width 0.83–0.90/0.90–1.04; length of embolial margin 0.76–0.82/0.73–0.95; length of cuneal margin 0.55–0.63/0.56–0.74; maximum width across hemelytra 0.89–1.00/0.90–1.14.

Holotype.—♂ (with glass slide No. OPU-KY135 for genitalia), "MA-



Figs. 17–22. Male genitalia. 17, 18, *Physopleurella armata*. 19, 20, *P. pessoni*. 21, 22, *P. flava*. 17, 19, 21, Pygophores in dorsal view. 18, 20, 22, Parameres in posterior view. Scale bars: 0.05 mm.

LAYSIA, Selangor, Ulu Gombak, 9.v.2005, K. Yamada" (OPU).

Paratypes.—MALAYSIA: 43♂ (Figs. 10, 14) 19♀ (Fig. 7), same locality as for holotype, 7-10.v.2005, K. Yamada; 1♂, same data as for holotype. 1♀, Kampung Peta, Endau-Rompin, Johor, 14.v.2005, K. Yamada. All in OPU.

Distribution.—Malaysia.

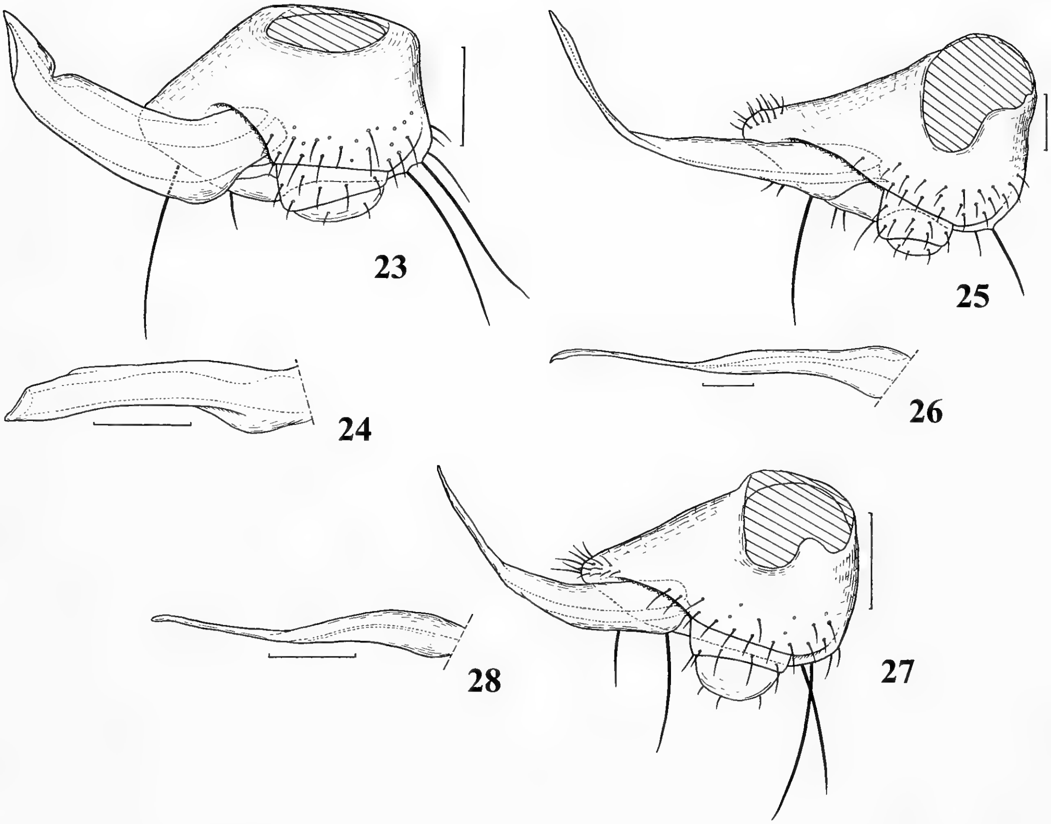
Etymology.—Named after the type locatlity, Malaysia; an adjective.

Remarks.—In general, habitus of this new species is allied to *P. africana* from Cameroon. It may be distinguished from the latter by the larger body size (male: 2.28; female: 2.33 in *P. africana*); the antennal segment II as long as head width across eyes (definitely shorter than head width across eyes in *P. africana*); the innermost vein of membrane distinctly bifurcate at base (not bifurcate in *P. africana*); the darkened apical 1/3 of dorsal surface of fore femur and basal half of fore tibia (brown or clear yellow femur and tibia in *P. africana*); and the stout paramere notched near apex and abruptly acute at apex (gradually acute toward apex in *P. africana*).

Physopleurella nigrifemora **Yamada and Hirowatari, new species**

(Figs. 5, 8, 11, 15, 25, 26)

Diagnosis.—Recognized by the following characters: Head (Figs. 5, 8)



Figs. 23–28. Male genitalia. 23, 24, *Physopleurella malayana*, holotype (glass slide No. OPU-KY135). 25, 26, *P. nigrifemora*, holotype (glass slide No. OPU-KY137). 27, 28, *P. striata*, holotype (glass slide No. OPU-KY141). 23, 25, 27, Pygophores in dorsal view. 24, 26, 28, Parameres in posterior view. Scale bars: 0.05 mm.

black to brownish black; antenna pale yellow with segment I entirely darkened; antennal segment II apically tinged with fuscous, about 1.2 times as long as head width across eyes; pronotum (Fig. 5) unicolorously black; femur (Fig. 11) entirely black or brownish black; abdomen overall blackish brown, with central area pale brown; paramere (Figs. 25, 26) slender, extending laterally and abruptly bent anteriorly near middle, gradually tapered toward apex in posterior view.

Description.—Body (Fig. 5) brown to blackish brown. Head (Figs. 5, 8) black to brownish black, 0.92 times as long as width across eyes; dorsal surface shiny, sparsely covered with long, silky, erect setae and small punctures; anteocular portion as long as length of eye; vertex 1.28 times as wide as width of eye; ocelli red; neck tinged with pale brown. Antenna (Figs. 5, 8) pale yellow, slender, covered with yellow, suberect setae; segment I entirely darkened, reaching apex of head; segment II apically tinged with fuscous, slightly thickened toward apex, about 1.2 times as long as head width across eyes; segment III 0.55 times as long as segment II; segment IV slightly shorter than segment III, weakly flattened. Rostrum pale yellow, with sparse short setae; segment I to and basal of II darkened; segment II bearing a pair of long erect setae at base; segment III distinctly swollen, about 1.2 times as long as segment IV.

Pronotum (Figs. 5, 8) uniformly black, densely covered with long, silky, reclining setae; and small punctures; anterior margin slightly curved, about 0.7 times as long as mesal length; lateral margin sinuate, strongly carinate on anterior half; posterior margin three times as wide as anterior margin. Scutellum (Fig. 5) dark with apex paler, sometimes pale brown, with two distinct foveae at middle. Hemelytra (Fig. 5) unicolorously pale brown, densely covered with yellow, reclining setae; apical portion of corium about 2.7 times as wide as embolium; cuneal margin 0.75 times as long as embolial margin; membrane dark ochre, narrowly darkened at base, with three veins, innermost vein distinctly bifurcated at base, remaining veins slightly curved; venter of thorax black to blackish brown. Legs densely covered with short, silky setae; coxa mostly dark brown; trochanter, tibia, and tarsus pale yellow; trochanter with 5–6 spine-like setae ventrally; femur (Fig. 11) entirely black or brownish black, venter with two series of spines composed of 18–19 long and 27 short spines. Ostiolar peritreme and evaporative area black, as shown in Fig. 15. Abdomen overall blackish brown, with central area pale brown, ventrally with short, silky setae; scissure on abdominal tergite nearly reaching to middle of segment III.

Male genitalia (Figs. 25, 26): Pygophore (Fig. 25) strongly narrowed at base, basal opening very wide, strongly produced on left margin and bearing dense, short setae; paramere (Figs. 25, 26) slender, extending laterally and abruptly bent anteriorly near middle, gradually tapered toward apex in posterior view.

Measurements [♂ (n=9) /♀ (n=5)]. Body length 2.88–3.20/2.85–3.13; head length (excl. neck) 0.43–0.45/0.40–0.46; head width across eyes 0.46–0.49/0.44–0.49; vertex width 0.19–0.20/0.18–0.20; width between ocelli 0.10–0.11/0.11–0.14; length of antennal segments I–IV 0.14–0.16/0.14–0.16, 0.50–0.55/0.51–0.54, 0.30–0.31/0.28, and 0.28/0.26; length of rostral segments II–IV 0.08/0.08, 0.25/0.26, and 0.19/0.22; anterior pronotal width 0.32–0.36/0.30–0.36; mesal pronotal length 0.46–0.54/0.45–0.53; basal pronotal width 0.95–1.02/0.92–1.05; length of embolial margin 0.85–0.90/0.85–1.00; length of cuneal margin 0.64–0.68/0.62–0.75; maximum width across hemelytra 1.00–1.15/1.07–1.25.

Holotype.—♂ (with glass slide No. OPU-KY137 for genitalia), "MALAYSIA, Selangor, Ulu Gombak, 10.v.2005, K. Yamada" (OPU).

Paratypes.—VIETNAM: 1♂2♀, Dhu An, Tan Phu, Dong Nai Prov., 29.xii.2001, T. Ishikawa (OPU). MALAYSIA: 5♂ (Figs. 8, 11, 15), same locality as for holotype, 7-8.v.2005, K. Yamada (OPU). 1♂1♀, Batu Niah, Sarawak, 12.xii.1968, M. Sato (NSMT-I-He 7811 and 7813); 1♀, same locality, 15.xii.1968, M. Sato (NSMT-I-He 7812). PHILIPPINES: 1♀, Bagio, 1440 m alt., Benguet Prov., Luzon Is., 28.vii.1985, M. Sakai (NSMT-I-He 7814); 1♂, Eagle Centre, 1100 m alt., Baracatan, north slope of Mt. Apo, Mindanao Is., 7.viii.1985, M. Sakai (NSMT-I-He 7815).

Distribution.—Vietnam, Malaysia, Philippines.

Etymology.—From Latin *nigra* (= black) in combination with *femora* (= femur), referring to the entirely blackish brown femora.

Remarks.—This new species is similar to *P. malayana*, from which it can be distinguished easily from the latter by the black to brownish black head and pronotum; the antennal segment II being 1.2 times as long as head width across eyes; the unicolorously pale brown hemelytra; the entirely black or brownish black femora; the pygophore being strongly narrowed at base, with strongly produced at its left margin and bearing dense short setae; and the paramere extending laterally and abruptly bent anteriorly near middle. The male genitalia somewhat resemble those of *P. mundula* from Pacific islands, southern part of America, and Central America, but *P. nigrifemora* differs from it in the general coloration and the paramere is abruptly bent anteriorly near middle (nearly straight but curving anteriorly at the tip in *P. mundula*).

Physopleurella striata Yamada and Hirowatari, new species

(Figs. 6, 9, 12, 13, 16, 27, 28)

Diagnosis.—Recognized by the following characters: Head (Figs. 6, 9) dark brown, with pale brown apex and neck; antenna yellowish brown, with segment I darkened; antennal segment II apically tinged with dark brown, slightly shorter than width of head across eyes; pronotum (Fig. 6) dark brown, broadly pale brown posterior margin; hemelytra (Fig. 6) yellowish brown, with cuneus narrowly darkened at apex; hind femur (Fig. 13) pale brown with darkened annulation basally; paramere (Figs. 27, 28) long, slender, anteriorly curved, abruptly narrowing at apical 1/3.

Description.—Body (Fig. 6) generally brown. Head (Figs. 6, 9) dark brown, with apex and neck pale brown, 0.89 times as long as width across eyes; dorsal surface roughened, clothed with long, silky, erect setae; anteocular portion slightly shorter than length of eye; vertex about 1.4 times as wide as eye; ocelli red, large. Antenna (Figs. 6, 9) yellowish brown, sparsely clothed with yellow, suberect setae; segment I dark, reaching apex of head, apically with short setae; segment II apically tinged with dark brown, thickened toward apex, slightly shorter than head width across eyes; segment III 0.58 as long as segment II; segment IV equal to segment III, slightly flattened. Rostrum pale yellow, with sparse short setae; segment I to II darkened; segment II with a pair of long erect setae at base; segment III about 1.2 times as long as segment IV.

Pronotum (Figs. 6, 9) dark brown, broadly pale brown posterior margin, shiny, densely clothed with long, reclining, yellow setae and small punctures; anterior margin nearly straight, 0.72 times as long as mesal length; lateral margin nearly straight, carinate on anterior 2/3; posterior margin 2.8 times as wide as anterior margin. Scutellum (Fig. 6) yellowish brown, with two distinct foveae at middle. Hemelytra (Fig. 6) yellowish brown, cuneus narrowly darkened at apex, clothed with long, reclining, yellow setae; apical part of corium slightly wider than 2.5 times of that of embolium; cuneal margin 0.8 times as long as embolial margin; membrane smoky ochre, with three veins, innermost vein distinctly bifurcated at base, other veins slightly curved; venter of thorax blackish brown. Legs pale yellow, densely pubescent; coxa tinged with dark brown; fore tibia (Fig. 12) tinged with dark brown at base; hind femur (Fig. 13) pale brown with a darkened annulation basally; trochanter with 4–5 spine-like setae ventrally; fore femur ventrally with two series of spines composed of 15–16 long and 22–23 short spines. Ostiolar peritreme and evaporative area reddish brown, as shown in Fig. 16. Abdomen blackish brown, centrally and laterally pale brown, ventrally clothed with dense reclining setae; scissure on abdominal tergite nearly reaching to middle of segment III.

Male genitalia (Figs. 27, 28): Pygophore (Fig. 27) strongly narrowed at base, very wide at basal opening, left margin produced, apex of left side bearing dense, short, stout setae; paramere (Fig. 28) long, slender, anteriorly curved, abruptly narrowing at apical 1/3.

Measurements [♂ (n=7) /♀ (n=1)]. Body length 2.63–2.80/2.83; head length (excl. neck) 0.36–0.38/0.36; head width across eyes 0.41–0.42/0.41; vertex width 0.17–0.18/0.18; width between ocelli 0.10–0.12/0.10; length of antennal segments I–IV 0.11–0.12/0.11, 0.38–0.39/

0.39, 0.22–0.23/0.23, and 0.22–0.23/0.23; length of rostral segments II–IV 0.05–0.06/0.06, 0.20–0.21/0.22, and 0.17–0.18/0.18; anterior pronotal width 0.30–0.32/0.30; mesal pronotal length 0.42–0.44/0.42; basal pronotal width 0.86–0.87/0.87; length of embolial margin 0.78–0.81/0.80; length of cuneal margin 0.62–0.64/0.65; maximum width across hemelytra 0.98–1.02/1.02.

Holotype.—♂ (with glass slide No. OPU-KY141 for genitalia), "MALAYSIA, Selangor, Ulu Gombak, 11.v.2005, K. Yamada" (OPU).

Paratypes.—MALAYSIA: 6♂ (Figs. 12, 13, 16) 1♀, same locality as for holotype, 8-11.v.2005, K. Yamada. All in OPU.

Distribution.—Malaysia.

Etymology.—From Latin *striata* (= striate), referring to broad, pale brown posterior margin of the pronotum; an adjective.

Remarks.—This new species is closely similar to *P. malayana* in general appearance and coloration. It may be distinguished from the latter by the broad, pale brown posterior margin of the pronotum; the unicolorously pale yellow femur; the pale brown hind femur with a darkened annulation basally; the apex of left side with dense, short, stout setae; and the rather longer and slender paramere abruptly narrowing at apical 1/3. This new species is also similar to *P. nigrifemora*, based on the male genitalia, but it is distinguished from *P. nigrifemora* by the coloration of head, pronotum, and legs, and the shorter paramere.

Key to Southeastern Asian Species of *Physopleurella*

Coloration

1. Head and pronotum unicolorous or mostly black or dark brown (Figs. 4–6); antennal segment I entirely darkened (Figs. 7–9) . . 2

– Head and pronoum mostly brown to pale yellow (Figs. 1–3); antennal segment I not entirely darkened, brown or pale yellow . . 4

2. Cuneus not darkened at apex; femora entirely black or brownish black (Fig. 11) . . . . *P. nigrifemora*, n. sp.

– Cuneus narrowly darkened at apex; femora pale yellow or only partly darkened (Figs. 10, 12) 3

3. Apical 1/3 of dorsal surface of fore femur and basal half of fore tibia darkened (Fig. 10); hind femur without a darkened basal annulation . . . . . . *P. malayana*, n. sp.

– Fore femur and tibia uniformly brown to pale brown (Fig. 12); hind femur with a darkened basal annulation (Fig. 13) . . . . *P. striata*, n. sp.

4. Scutellum and hemelytra uniformly yellowish brown or pale brown (Fig. 3) . . *P. flava*

– Scutellum reddish brown or dark brown (Figs. 1, 2); hemelytra yellowish brown with extensively darkened cuneus (Figs. 1, 2) 5

5. Pronotum with widely darkened posterior angles (Fig. 2); abdomen overall blackish brown with laterally areas yellowish brown . . . . *P. pessoni*

– Pronotum without darkened posterior angles (Fig. 1); abdomen uniformly dark reddish brown . . . . *P. armata*

Morphological Characters

1. Antennal segment II longer than head width across eyes (Fig. 8) 2

– Antennal segment II about as long as or shorter than head width across eyes (Figs. 7, 9) 3

2. Paramere nearly straight, extending laterad (Figs. 17, 18) . . . . *P. armata*

– Paramere slender, abruptly bent anteriorly near middle (Figs. 25, 26) . . . . *P. nigrifemora*, n. sp.

3. Pygophore with dense, short setae on produced left margin (Figs. 21, 27) 4

– Pygophore without dense, short setae on produced left margin (Figs. 19, 23) 5

4. Paramere stout, moderately rounded anteriorly, abruptly bent near apex (Figs. 21, 22) . . . . *P. flava*

– Paramere slender, anteriorly curved, abruptly narrowing at apical 1/3 (Fig. 28) . . . . *P. striata* n. sp.

5. Paramere gradually tapering toward apex, extending laterad, slightly constricted near apex (Figs. 19, 20) . . . . *P. pessoni*

– Paramere stout, extending anteriorly, notched near apex, abruptly acute at apex (Fig. 23, 24) . . . . *P. malayana*, n. sp.

Acknowledgments

We are grateful to Dr. T. J. Henry (U.S. Department of Agriculture, Washington D. C.) and Dr. J. D. Lattin (Department of Botany and Plant Pathology, Oregon State University) for reviewing the manuscript with useful comments and suggestions. We express our cordial thanks to Dr. T. Yasunaga (JICA-SV, c/o Natural History Museum, Tribhuvban University, Swayambhu, Kathmandu) and to Dr. M. Tomokuni (NSMT) for their valuable advice and critical comments on our study. We are also indebted to the following entomologists for the loan or donation of material, and/or kind assistance in the field: Dr. M. Tomokuni (NSMT), Dr. R. Hashim (University of Malaya, Kuala Lumpur), Dr. Y. Nakatani (National Institute for Agro-Environmental Sciences, Tsukuba), Dr. T. Ishikawa (Tokyo University of Agriculture, Atsugi), and Mr. S. Nagashima (Itami City Museum of Insects, Itami). Yamada also thanks Prof. M. Ishii and Dr. N. Hirai (Osaka Prefecture University) for their encouragement and advice during this study.

Literature Cited

Blatchley, W. S. 1925. Some additional new species of Heteroptera from the southern United States, with characterization of a new genus. Entomological News 36: 45–52.

Bu, W. J. and L. Y. Zheng. 2001. Heteroptera. Lasiochilidae. Lyctocoridae. Anthocoridae. Fauna Sinica, Insecta 24: i–vii, 1–267.

Carayon, J. 1956. Trois espèces africaines de *Physopleurella* (Hémipt. Anthocoridae) dont l'une présente un nouveau cas de viviparité pseudoplacentaire. Bulletin du Muséum National d'Histoire Naturelle (2) 28(1): 102–110.

———. 1958. Quelques Hemipteres Anthocoridae des Iles Mascareignes. Mémoires de l'Institut Scientifique de Madagascar (E) 9: 335–348.

———. 1972. Caractères systématiques et classification des Anthocoridae (Hemipt.). Annales de la Société Entomologique de France (N.S.) 8: 309–349.

Cassis, G. and G. F. Gross. 1995. Hemiptera: Heteroptera (Coleorrhyncha to Cimicomorpha) Anthocoridae, pp. 23–42. *In* Houston, W. W. K. and G. V. Maynard, eds. Zoological Catalogue of Australia 27. 3A: 1–506. CSIRO, Melbourne

Distant, W. L. 1913. Rhynchota. Part I: Suborder Heteroptera (of the Seychelles). Transactions of the Linnean Society of London 16: 139–191.

Esaki, T. 1926. Verzeichnis der Hemiptera-Heteroptera der Insel Formosa. Annales Historico-Naturales Musei Nationalis Hungarici 24: 136–189.

———. 1931. Undescribed Hemiptera from Japan and Formosa. Annotatioes Zoologicae Japonenses 13: 259–269.

Ford, L. J. 1979. The phylogeny and biogeography of the Cimicoidea (Insecta: Hemiptera). Thesis, M. S. Degree, University of Connecticut, vii + 138 pp.

Gross, G. F. 1954. A revision of the flower bugs (Heteroptera: Anthocoridae) of the Australian and adjacent Pacific Regions. Part I. Records of the South Australian Museum 11: 129–164.

Hiura, I. 1959. Contribution to the knowledge of Anthocoridae from Japan and its adjacent territories (Hemiptera-Heteroptera). 1. Bulletin of the Osaka Museum of the Natural History 11: 1–15.

Muraleedharan, N. 1977. Notes on a collection of Lyctocorinae (Hemiptera: Anthocoridae) from Garo Hills (Meghalaya). Records of the Zoological Survey of India 73: 239–246.

———. 1978. On the tribes Cardiastethini and Almeidini from South India (Hemiptera: Anthocoridae). Bulletin of the Zoological Survey of India 1: 65–70.

Péricart, J. 1972. Hémiptères Anthocoridae, Cimicidae et Microphysidae de l'Ousest-Paléarctique. *In* Faune de l'Europe et du Bassin Méditerranéen 7: i–iv, 1–402. Masson, Paris.

———. 1996. Family Anthocoridae Fieber, 1836 — Flower bugs, minute pirate bugs, pp. 108–140. *In* Aukema, B. and C. Rieger, eds. Catalogue of the Heteroptera of the Palaearctic Region Vo. 2. Cimicomorpha I. The Netherlands Entomological Society, Amsterdam. 361 pp.

Poppius, B. 1909. Beiträge zur Kenntnis der Anthocoriden. Acta Societatis Scientiarum Fennicæ 37: 1–43.

Reuter, O. M. 1884. Monographia Anthocoridarum Orbis Terrestris. Helsingforsiae, 204 pp. (Also Acta Societatis Scientiarum Fennicae 14 (1885): 555–758.)

Usinger, R. L. 1946. Hemiptera, pp. 11–103. *In* Insects of Guam-II. Bernice P. Bishop Museum. Bulletin 189, 237 pp.

Zimmerman, E. C. 1948. Insects of Hawaii, Vol. 3 Heteroptera. University of Hawaii Press, Honolulu, 255 pp.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 454–462

INTRODUCED LEAF BEETLES OF THE MARITIME PROVINCES, 3: THE VIBURNUM LEAF BEETLE, *PYRRHALTA VIBURNI* (PAYKULL) (COLEOPTERA: CHRYSOMELIDAE)

CHRISTOPHER G. MAJKA AND LAURENT LESAGE

(CGM) Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia, Canada B3H 3A6 (e-mail: c.majka@ns.sympatico.ca); (LL) Agriculture and Agri-Food Canada, ECORC, K.W. Neatby Building, 960 Carling Avenue, Ottawa, Ontario, Canada K1A 0C6

Abstract.—*Pyrrhalta viburni* (Paykull), the viburnum leaf beetle, is an introduced Palearctic leaf beetle established in northeastern and northwestern North America. It was first reported in Ontario in 1947 but did not create problems until 1978 when destruction of European varieties of viburnums was observed. It has subsequently been found in a number of Canadian provinces and northeastern United States. It is herein newly reported from Prince Edward Island and Newfoundland. In Nova Scotia, several localities are reported for the first time, while specimens collected in Annapolis Royal, in 1924, establish a new timeline for its occurrence on the continent. Two possible scenarios with respect to the origin and dispersal of *P. viburni* in the Maritimes are proposed and discussed. The systematic history of the genus is briefly recounted and the diagnostics of the genus and species are given. The occurrence of *P. viburni* on native and exotic species in the plant genus *Viburnum* is examined. and concerns are expressed with respect to its impact on native and cultivated varieties.

Key Words: Coleoptera, Chrysomelidae, Galerucinae, *Pyrrhalta viburni*, viburnum leaf beetle, Canada, Maritime Provinces, introduced species

Pyrrhalta viburni (Paykull) is an accidentally introduced Palearctic leaf beetle, which is now established in northeastern and northwestern North America. In the Old World, it is found throughout much of Europe (including Ireland and Great Britain) north to Fennoscandia and east across Russian Karelia to the Urals, Orenburg, and Kazan. The southern limit of its distribution ranges from the Pyrenees east through Liguria and the southern Carpathians to the Black Sea, Crimea, Georgia, and Dagestan in the Caucasus (Warchalowski 1994, Borowiec 2005)

Pyrrhalta viburni was first reported on the North American continent from specimens collected in Fonthill in the Niagara Peninsula of Ontario in 1947 (Sheppard 1955). In 1978, Becker (1979) found the species established on the southern side of the Ottawa River in Ottawa (Ontario), and on the northern side in Hull (Québec). Old scars on twigs of infested bushes indicated that the beetle had been present for several years before the infestations were noticed. In 1993, it was reported in Halifax and Dartmouth, Nova Scotia (Wheeler and Hoebeke 1994), and in 1994 it was found in Maine (Weston and Hoebeke 2003). It was recorded in New York (1996), Vermont (2000), Pennsylvania (2000), and Ohio (2002) by Weston and Hoebeke (2003). In 2001, it was recorded in British Columbia (Gillespie 2001). More recently it has been reported in Connecticut (2004), Massachusetts (2004), New Hampshire (2005) and Vermont (2004) (Anonymous 2005). Weston and Diaz (2005) predicted that "given its broad distribution in Europe, it seems likely that this pest will become widely distributed in the United States, given the abundance of suitable native host plants such as *Viburnum dentatum* and *V. opulus* variety *americanum* throughout the eastern and northern halves, respectively, of the United States."

Pyrrhalta viburni has been recorded from a large variety of hosts whose susceptibility to the beetle varies considerably. Based on field observations, Weston and Desurmont (2002) reported that *V. trilobum* Marshall, *V. opulus* L., *V. sargentii* Koehne, *V. rafinesquianum* Schultes, *V. recognitum* Fernald, and *V. dentatum* L. were the most susceptible hosts. In laboratory trials, they found *V. trilobum, V. sargentii,* and *V. prunifolium* L. susceptible in varying degrees to larval feeding, while *V. wrightii* Miq., *V. plicatum* (Thunb.), *V. rhytidophylloides* J. Sur., *V. carlesii* Hemsl., and *V. sieboldii* Miq were resistant. Adults additionally fed to a substantial degree on *V. wrightii, V. rhytidophylloides*, and *V. carlesii.* Clark et al. (2004) additionally record *P. viburni* from *V. acerifolium* L., *V. dilatatum* Thnb., *V. lantana* L., *V. lentago* L., *V. x pragense* Decker, and *V. tinus* L., although they did not specify susceptibility nor larval versus adult consumption for these species. Concern has been expressed by a number of authors about the potential impact of *P. viburni* on populations of *Viburnum* in North America (Weston and Desurmont 2002, Weston et al. 2002, Weston and Hoebeke 2003, Weston and Diaz 2005). Small and Catling (2005: 50) wrote that, "Biologists have speculated that certain species of *Viburnum* may become extirpated over parts of their range. The situation has been described as verging on ecological disaster."

In this context, we examined the published records of this species from the Maritime Provinces of Canada. We also studied recent and historical specimens housed in various collections (see below). Our survey reveals that *P. viburni* is more broadly distributed in this region than hitherto known, and it has been present for a significantly longer period than previously reported.

SYSTEMATICS

Pyrrhalta has a complicated taxonomic history. De Joannis (1866) originally created it as a subgenus of *Galeruca* Geoffroy, 1792. In the first edition of the *Coleopterorum Catalogus*, Weise (1924) considered *Pyrrhalta* as monotypic, including only *P. viburni.* Wilcox (1965) enlarged the genus considerably by including the subgenera *Galerucella* Crotch, *Neogalerucella* Chûjô, *Xanthogaleruca* Laboissièrre, and *Tricholochmaea* Laboissière. He maintained roughly the same conception in the second edition of the *Coleopterorum Catalogus* (Wilcox 1971). Ten years later, however, he included in *Pyrrhalta* only the Palearctic species and elevated to generic level the subgenera of his first contribution (Seeno and Wilcox 1982). LeSage (1991) adopted these changes but Downie and Arnett (1996) continued to use the broad conception of *Pyrrhalta.*

Recently Riley et al. (2002) largely followed the generic arrangement of Seeno and Wilcox (1982), with only slight modifications regarding *Galerucella* Crotch and *Neogalerucella* Chûjô. This new classification which was adopted for the *Catalog of Leaf Beetles* *of America North of Mexico* (Riley et al. 2003) reaches a broad consensus among those interested in leaf beetles in North America.

IDENTIFICATION

The genus *Pyrrhalta* can be identified using a combination of external characters: antennomere 4 longer than 2, the front coxae closed and not separated by the prosternum, tibial spurs present on hind tibiae in both sexes, the inner margin of epipleuron is distinct to apex, elytra without distinct vittae, and elytral punctation fine.

At a specific level, *P. viburni* is distinguished by a golden pubescence on the head, pronotum, and elytra. Species in the genus *Tricholochmaea* Laboissière are also pubescent, but the hairs are never golden. On the pronotum of *P. viburni*, the pair of dark markings reach the lateral margins, but not in *Tricholochmaea*. In addition, the pronotum is twice as wide as long in *Pyrrhalta*, whereas it is only 1.5 as wide as long in *Tricholochmaea*. The elytral punctures are coarse in *Tricholochmaea* but fine in *Pyrrhalta*. There are no vittae on the elytra as in most specimens of *Ophraella* Wilcox, although the shoulders are often darkened (Fig. 1).

CONVENTIONS

Abbreviations of collections referred to in the text are:

ACNS	Agriculture and Agri-Food Canada, Kentville, Nova Scotia
ACPE	Agriculture and Agri-Food Canada, Charlottetown, Prince Edward Island
CGMC	Christopher G. Majka Collection, Halifax, Nova Scotia
CNC	Canadian National Collection, Ottawa, Ontario
CUIC	Cornell University Insect Collection, Ithaca, New York
DHWC	David H. Webster Collection, Kentville, Nova Scotia
GSC	Gary Selig Collection, Bridgewater, Nova Scotia
NSAC	Nova Scotia Agricultural College, Bible Hill, Nova Scotia
NSMC	Nova Scotia Museum Collection, Halifax, Nova Scotia
NSNR	Nova Scotia Department of Natural Resources, Shubenacadie, Nova Scotia

LOCALITY RECORDS

Pyrrhalta viburni has now been found in the four Maritime Provinces: New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland (Fig. 2). In total, 76 specimens were examined. Unless otherwise indicated, specimens are adults. In addition to the locality records obtained from the specimens examined by the authors, the list below includes localities reported in the literature.

NEW BRUNSWICK: *Charlotte Co.*: St. Stephen, 1995–2001, R.E. Hoebeke and A.G. Wheeler, (Hoebeke and Wheeler 2003); *Saint John Co.*: Saint John, 1995–2001, R.E. Hoebeke and A.G. Wheeler, (Hoebeke and Wheeler 2003); *York Co.*: Fredericton, 1995–2001, R.E. Hoebeke and A.G. Wheeler, (Hoebeke and Wheeler 2003). NEWFOUNDLAND: St. John's, Long Pond, IX–X.2001, D.J. Larson (4, CNC); St. John's, 2002, D.J. Larson (2, CNC). NOVA SCOTIA: *Annapolis Co.*: Annapolis Royal, 19.IX.1924, J.P. Spitall (1, ACNS); 1.X.1924, J.P. Spitall (4, ACNS); *Halifax Co.*: Halifax, 26.VI.1993, R.E. Hoebeke & A.G. Wheeler, (on) *Viburnum opulus* (1, CUIC); Dartmouth, 26.VI.1993, R.E. Hoebeke & A.G. Wheeler, (on) *Viburnum opulus*, (1, CUIC); Point Pleasant Park: 9.IX.2001, C.G. Majka, swamp, low vegetation (1, CNC); ibid., 23.IX.1993, Barry Wright, (on) *Viburnum nudum* (9, NSMC); ibid., 25.IX.1993, Barry Wright, (on) *Viburnum*

Fig. 1. Habitus photograph of *Pyrrhalta viburni.*

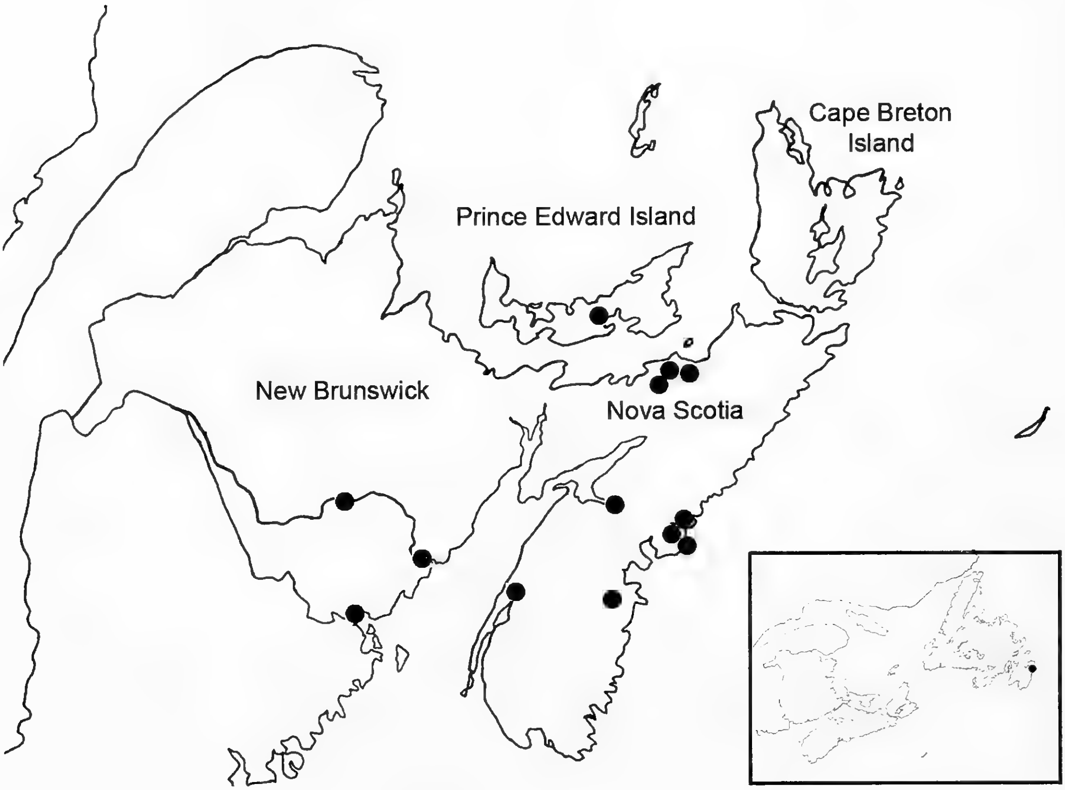


Fig. 2. Distribution of *Pyrrhalta viburni* in the Maritime Provinces. Closed circles indicate collection localities. Inset map: collection locality in Newfoundland.

nudum (3, NSMC); ibid., 1.IX.2000, C.G. Majka, C.G. Majka, (on) *Viburnum nudum* (1, CGMC); ibid., 10.VIII.2001, C.G. Majka, (on) *Viburnum nudum* (2, CGMC); ibid., 9.IX.2001, C.G. Majka, boggy area, deciduous vegetation (3, CGMC); ibid., 21.IX.2001, C.G. Majka, deciduous forest (3, CGMC); Herring Cove: 29.IX.2002, C.G. Majka, coastal barrens (2, CGMC); *Hants Co.*: Windsor, 28.VII.1999, J. Ogden (2, NSNR); *Pictou Co.*: New Glasgow, 22.VIII.2002, S. Wallis (8, NSNR); Lyons Brook, 30.VIII.2002, E. Georgeson (1, NSNR); Salt Springs, 16.VIII.2006, C.G. Majka, defoliating *Viburnum opulus* (20, CGMC); *Lunenburg Co.*: Bridgewater, 23.IX.2002, G.D. Selig, defoliating *Viburnum opulus* (2, GSC). PRINCE EDWARD ISLAND: *Queens Co.*: Charlottetown, 6.VIII.1997, M.E.M. Smith, on *Viburnum* (2, ACPE); Charlottetown, 1995–2001, R.E. Hoebeke and A.G. Wheeler, (Hoebeke and Wheeler 2003); Cornwall, 28.VI.2005, defoliating snowballs, M.E. Smith (36 larvae, CNC).

Discussion

An examination of Fig. 2 reveals that *P. viburni* has now been recorded from a number of widely distributed localities in the southern portions of the Maritime Provinces and in Newfoundland. On the mainland, it has not been recorded in northern New Brunswick (although collecting effort in this area has been slight) nor on Cape Breton Island. Of particular note and interest are specimens collected by J.P. Spitall (a researcher with the Dominion Entomological Station [1911–52] in Annapolis Royal) in Annapolis Royal, NS in 1924. These specimens extend by 23 years the known timeline of this species in North America. The question thus arises as to the possible origin of this population. In this context two possibilities present themselves.

1) Annapolis Royal is the site of one of the earliest European settlements in North America, established by French settlers in 1605. It was the military and administrative center of Acadia during parts of 17th century, and between 1710 and 1749 (until the establishment of Halifax) was the capital of Nova Scotia (which then included much of the Maritime Provinces). During this period, there was an extensive trans-Atlantic commerce between Annapolis Royal and (particularly) French seaports (Calnek 1897). Indirect evidence indicates that this commerce had an effect on the fauna of the area. Of 161 species of beetles which have been collected in the Annapolis Royal area (ACNS, CNC, CGMC, DHWC, NSAC, NSMC), 47 species (29.2%) are introduced, Palearctic species, double the 14.8% overall ratio of introduced species in Nova Scotia (C. Majka, unpublished data). Many of these are synanthropic species or those associated with agriculture and/or horticulture. In many instances these specimens represent some of the earliest known records of these species in the province (Table 1), indicating an early and extensive history of introductions to the area. Thus, it is possible that *P. viburni* may have been imported to the Annapolis Royal area sometime during this early history of settlement.

2) Annapolis Royal was also the site (from 1885 to ~ 1945) of the Annapolis Royal Nurseries, the largest and most comprehensive horticultural nursery in eastern Canada (Clarke 1927). This nursery imported horticultural stock from throughout the world, propagated it, and sold plants throughout the Maritime Provinces (A. Wilson, pers.

Table 1. Early records (date first recorded) of adventive Coleoptera from Annapolis Royal, NS.

Anobiidae	
Lasioderma serricorne Fabricius	1929
Ptinus fur Linné	1912
Bostrichidae	
Lyctus linearis (Goeze)	1932
Cantharidae	
Cantharis rufa Linné	1930
Carabidae	
Agonum muelleri Herbst	1909
Amara familiaris Duftschmid	1909
Pterostichus melanrius (Illiger)	1909
Clivinia fossor (Linné)	1935
Cerambycidae	
Callidium violaceum Linné	1929
Chrysomelidae	
Longitarsus luridus (Scopoli)	1924
Pyrrhalta viburni (Paykull)	1924
Cryptophagidae	
Cryptophagus subfumatus Kraatz	1941
Curculionidae	
Sitophilus granarius (Linné)	1910
Otiorhynchus ovatus (Linné)	1932
Otiorhynchus sulcatus (Fabricius)	1928
Sitona flavenscens Gyllenhal	1928
Sitona hispidulus (Fabricius)	1928
Sciaphilus asperatus (Bonsdorff	1910
Strophosoma melanogrammum (Forster)	1924
Trachyphloeus asperatus (Beck)	1924
Hypera zoilus (Scopoli)	1924
Dermestidae	
Attagenus pellio Linné	1930
Dermestes lardarius Linné	1909
Latridiidae	
Corticaria saginata Mannerheim	1924
Cortinicara gibbosa (Herbst)	1928
Melyridae	
Malachius aeneus Linné	1928
Oedemeridae	
Nacerdes melanura (Linné)	1935
Scarabaeidae	
Aphodius prodromus (Brahm)	1915
Staphylinidae	
Tasgius ater (Gravenhorst)	1938
Tenebrionidae	
Tenebrio molitor Linné	1913

comm.). In the nursey's catalogue (Clarke 1927) three exotic Palearctic species of *Viburnum* were offered for sale (*V. opulus* L., *V. tomentosum* Shasta, and *V. plicatum* Thunb.), suggesting the possibility that *P. viburni* could have been imported in association with nursery stock of one of these species. Whether this early introduction to Annapolis Royal was responsible for the subsequent occurrence of *P. viburni* at other locations in the Maritime Provinces is uncertain.

Pyrrhalta viburni is one of a substantial number of introduced leaf beetles known in the Maritime Provinces. In Nova Scotia, 25 of the 178 species of Chrysomelidae (14%) recorded in the province are introduced species, similar to the 14.8% of the overall beetle fauna which is introduced (C. Majka, unpublished data). *Chrysolina staphylea* L. (Evans 1899), *Cassida rubiginosa* Müller (Brown 1940), *Longitarsus luridus* (Goeze) (Brown 1967, LeSage 1988), *L. ferrugineus* (Foudras) (LeSage 1988), *L. pratensis* (Panzer) (LeSage 1988), *Sphaeroderma testaceum* (Fabricius) (Hoebeke and Wheeler 2003, Majka and LeSage 2006) and *Oulema melanopus* (Linné) (LeSage et al. 2007) are all introduced Palearctic chrysomelids whose presence in the region has been discussed in publications. The impact of this substantial number of introduced species on the native fauna and the environment in general has been rather little investigated. Species such as *Lilioceris lilii* (Scopoli), *Crioceris duodecimpunctata* (L.), *C. asparagi* (L.), and *Oulema melanopus* are all potentially serious pests.

In the Maritime Provinces, the native *Viburnum alnifolium* Marsh., *V. edule* (Michx.) Raf., and *V. nudum* L. are common, generally distributed species. *Viburnum acerifolium, V. lentago*, and *V. recognitum* have been found in New Brunswick. Exotic species such as *V. dentatum, V. lantana*. and *V. opulus* grow as naturalized shrubs, and other species of *Viburnum* are grown in horticultural contexts (Roland 1998, Hinds 1986). In the Maritime Provinces *P. viburni* has been recorded on *V. opulus* and *V. nudum*, and *V. acerifolium, V. dentatum, V. lanata, V. lentago*, and *V. recognitum* are recorded hosts (Clark et al. 2004), indicating that a substantial proportion of species in this region could be affected by this beetle.

Thus far, the impact of *P. viburni* in this region has not been noted to be significant, although occasional significant defoliation of shrubs has been reported (G. Selig pers. comm.). Weston and Desurmont (2002) wrote that, "Viburnum leaf beetle has the potential to become a major landscape pest because of its ability to kill susceptible viburnums if allowed to defoliate shrubs for several years in succession." Young (2004) wrote that, "Heavy infestations … could defoliate shrubs, cause dieback, and eventually kill plants. Costs to homeowners, parks, arboretums, municipalities, and nurseries to manage heavy infestations … and to replace killed plants could be high. Quarantines imposed … would represent an economic burden to the many growers who export nursery stock …." Given such concerns, ongoing monitoring of populations of *P. viburni* in the region would not be imprudent.

ACKNOWLEDGMENTS

Thanks are extended to Christine Noronha and Mary Smith (Agriculture and Agri-Food Canada, Charlottetown, PEI), Susan Westby and Cory Sheffield (Agriculture and Agri-Food Canada, Kentville, NS), Gary Selig, Jean-Pierre LeBlanc (Nova Scotia Agricultural College), and Jeffrey Ogden (Nova Scotia Department of Natural Resources) for making specimens and records available, to Klaus Bolte for executing the habitus photograph, and to Alex Wilson (Nova

Scotia Museum) for his assistance. Shawn Clark (Brigham Young University) read an earlier draft of this manuscript and made many constructive suggestions. C. G. Majka thanks Calum Ewing and Andrew Hebda (Nova Scotia Museum) for continuing support and encouragement. This work has been assisted by a research grant from the Nova Scotia Museum of Natural History.

LITERATURE CITED

Anonymous. 2005. Pest Tracker Invasive Insect: Viburnum Leaf Beetle, *Pyrrhalta viburni.* Available from http://ceris.purdue.edu/napis/pests/vlb/ (accessed 12 May 2006).

Becker, E. C. 1979. *Pyrrhalta viburni* (Coleoptera: Chrysomelidae), a Eurasian pest of *Viburnum* recently established in Canada. The Canadian Entomologist 111: 417–419.

Borowiec, L. 2005. Chrysomelidae: The Leaf Beetles of Europe and the Mediterranean Subregion (Checklist and Iconography). University of Wroclaw, Wroclaw, Poland, Available from http://culex.biol.uni.wroc.pl/cassidae/European%20Chrysomelidae/index.htm (accessed 12 May 2006).

Brown, W. J. 1940. Notes on the American distribution of some species of Coleoptera common to the European and North American continents. The Canadian Entomologist 72: 65–78.

———. 1967. Notes on the extralimital distribution of some species of Coleoptera. The Canadian Entomologist 99: 85–93.

Calnek, W. A. 1897. History of the County of Annapolis. Mika Studio, Bellville, Ontario, (reprint). 660 pp.

Clarke, E. R. 1927. Catalogue, spring 1927: Annapolis Royal Nurseries. Annapolis, Nova Scotia. 51 pp.

Clark, S. M., D. G. LeDoux, T. N. Seeno, E. G. Riley, A. J. Gilbert, and J. M. Sullivan. 2004. Host plants of leaf beetle species occurring in the United States and Canada (Coleoptera: Megalopodidae, Orsodacnidae and Chrysomelidae, excluding Bruchinae). Coleopterists Society Special Publication 2. 476 pp.

de Joannis, M. L. 1866. Monographie des Galérucides d'Europe, du Nord de l'Afrique et de l'Asie. L'Abeille 3: 1–168.

Downie, N. M. and R. H. Arnett, Jr. 1996. The Beetles of Northeastern North America. Sandhill Crane Press, Gainesville, Florida. 1721 pp.

Evans, J. D. 1899. List of Coleoptera from Halifax. The Canadian Entomologist 31: 32–321.

Geoffroy, E. L. 1792. Histoire abrégée des insectes qui se trouvent aux environs de Paris dans laquelle les animaux sont rangés suivant un ordre méthodique. Durand, Paris, Vol. 1, 523 pp.

Gillespie, D. R. 2001. Arthropod introductions into British Columbia – the past 50 years. Journal of the Entomological Society of British Columbia 98: 91–97.

Hinds, H. R. 1986. Flora of New Brunswick. Primrose Press, Fredericton, N.B. 460 pp.

Hoebeke, E. R. and A. G. Wheeler, Jr. 2003. *Sphaeroderma testaceum* (F.) (Coleoptera: Chrysomelidae), a Palearctic flea beetle new to North America. Proceedings of the Entomological Society of Washington 105: 990–994.

Kerzhner, I. M. 1991. Histoire abrégée des insectes qui se trouvent aux environs de Paris (Geoffroy, 1792): proposed conservation of some generic names (Crustacea and Insecta). Bulletin of Zoological Nomenclature 48: 107–134.

LeSage, L. 1988. Notes on European *Longitarsus* species introduced in North America (Coleoptera: Chrysomelidae: Alticinae). The Canadian Entomologist 120: 1133–1145.

———. 1991. Family Chrysomelidae leaf beetles. pp. 301–322. *In* Y. Bousquet ed. Checklist of beetles of Canada and Alaska. Research Branch, Agriculture Canada, Publication 1861/E, 430 pp.

LeSage, L., E. J. Dobesberger, and C. G. Majka. 2007. Introduced leaf beetles of the Maritime Provinces, 2: The cereal leaf beetle *Oulema melanopus* (Linnaeus) (Coleoptera: Chrysomelidae). Proceedings of the Entomological Society of Washington 109: 286–294.

Majka, C. G. and L. LeSage. 2006. Introduced leaf beetles of the Maritime Provinces, 1: *Sphaeroderma testaceum* (F.) (Coleoptera: Chrysomelidae). Proceedings of the Entomological Society of Washington 108: 243–247.

Riley, E. G., S. M. Clark, R. W. Flowers, and A. J. Gilbert. 2002. Chrysomelidae Latreille 1802. pp. 617–691. *In* R. H. Arnett, Jr., M. C. Thomas, P. E. Skelley, and J. H. Frank, (eds). American Beetles, Volume 2: Polyphaga: Scarabaeoidea through Curculionoidea. CRC Press, Boca Raton, USA.

Riley, E. G., S. M. Clark, and T. N. Seeno. 2003. Catalog of the leaf beetles of America north of Mexico. Coleopterists Society Special Publication No. 1. 290 pp.

Roland, A. E. 1998. Roland's Flora of Nova Scotia. Revised by M. Zinck. Nova Scotia Museum, Halifax, Nova Scotia. 1297 pp.

Seeno, T. N. and J. A. Wilcox. 1982. Leaf beetles genera (Coleoptera: Chrysomelidae). Entomography 1: 1–221.

Sheppard, R. W. 1955. New entries of insects to the Niagara Peninsula. Annual Report of the Entomological Society of Ontario 86: 31–33.

Small, E. and P. M. Catling. 2005. Poorly known economic plants of Canada – 47: American cranberry bush (*Viburnum opulus* var. *americanum*). The Canadian Botanical Association Bulletin 38(4): 48–54.

Warchalowski, A. 1994. Chrysomelidae. Stonkowate (Insecta: Coleoptera). Part IV (subtribes: Chrysomelina, Gonioctenina, Phratorina and Entomoscelina and subfamily Galerucinae. Fauna Poloniae, Vol. 16. Museum and Institute of Zoology PAS, Warszawa. 302 pp.

Weise, J. 1924. *Coleopterorum Catalogus*. Chrysomelidae: 13. Galerucinae. W. Junk, ’s-Gravenhage. 225 pp.

Weston, P. A. and G. Desurmont. 2002. Suitability of various species of *Viburnum* as hosts for *Pyrrhalta viburni*, an introduced leaf beetle. Journal of Environmental Horticulture 20(4): 224–227.

Weston, P. A. and M. D. Diaz. 2005. Thermal requirements and development of immature stages of viburnum leaf beetle, *Pyrrhalta viburni* (Paykull) (Coleoptera: Chrysomelidae). Physiological Ecology 34: 985–989.

Weston, P. A. and E. R. Hoebeke. 2003. Viburnum leaf beetle, *Pyrrhalta viburni* (Paykull) (Coleoptera: Chrysomelidae): dispersal pattern of a Palearctic landscape pest in New York and its distribution status in the northeastern U.S. and eastern Canada. Proceedings of the Entomological Society of Washington 105: 889–895.

Weston, P. A., B. Eshenaur, J. M. Baird, and J. S. Lamboy. 2002. Evaluation of insecticides for control of larvae of *Pyrrhalta viburni*, a new pest of viburnums. Journal of Environmental Horticulture 20: 82–85.

Wheeler, A. G. and E. R. Hoebeke. 1994. First record from Canadian Maritime Provinces of three European insects injurious to ornamental plants. Proceedings of the Entomological Society of Washington 96: 749–756.

Wilcox, J. A. 1965. A synopsis of the North American Galerucinae (Coleoptera: Chrysomelidae). New York State Museum and Science Service, Bulletin 400. 226 pp.

———. 1971. *Coleopterorum Catalogus* Supplementa. Pars 78, Fasc. 1 (Editio seconda). Chrysomelidae: Galerucinae Oidini, Galerucini, Metacyclini, Sermylini. Dr. W. Junk, ’s-Gravenhage. pp. 1–220.

Young, C. E. 2004. The viburnum leaf beetle in Ohio. Ohio State University Extension Research, Special Circular 195: 13. Available from http://ohioline.osu.edu/sc195/pdf/0195_13.pdf (accessed 12 May 2006).

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 463–468

ANOPHELES (*CELLIA*) *KOKHANI*, N. SP. (DIPTERA: CULICIDAE) FROM KAPIT, SARAWAK, EAST MALAYSIA

I. Vythilingam, J. Jeffery, R. E. Harbach, S. T. Chan, C. H. Tan, and M. Asmad

(IV, STC, CHT) Institute for Medical Research, Jalan Pahang, 50588 Kuala Lumpur, Malaysia (e-mail: indra@imr.gov.my); (JJ) Department of Parasitology and Medical Entomology, Faculty of Medicine, Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia; (REH) Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K. (e-mail: r.harbach@nhm.ac.uk); (MA) Sarawak Medical and Health Department, Kuching, Sarawak, Malaysia

Abstract.—***Anopheles kokhani*** **Vythilingam, Jeffery, and Harbach, n. sp.**, a member of the Neomyzomyia Series of subgenus *Cellia* Theobald (Diptera: Culicidae) is described from females collected in Sarawak, Malaysia, during studies to identify the mosquitoes responsible for transmitting simian malaria to humans. The species is distinguished from sympatric members of the Neomyzomyia Series, including *An. saungi* Colless, *An. stookesi* Colless, *An. tessellatus* Theobald, and *An. watsonii* (Leicester), with which it shares one or more key features. The wing and legs of the new species are illustrated.

Key Words: *Anopheles kokhani*, mosquito, new species, Neomyzomyia Series

The present paper describes a new species of *Anopheles* mosquito (Diptera: Culicidae) that was collected (along with 11 other species of the genus) during the course of studies to identify the vector(s) of *Plasmodium knowlesi*, a simian malarial protozoan recently found in humans (Singh et al. 2004). The study was conducted in Kapit, Sarawak, Malaysia, from June 2005 to April 2006. Bare leg catch (BLC) and monkey baited trap (MBT) methods were used to capture mosquitoes in forest, and BLC only inside and outside a longhouse (a dwelling used by local people) and in a farm at the forest fringe. The collections included 144 females of an unknown *Anopheles* species that could not be identified using the keys of Reid (1968) for the "Anopheline Mosquitoes of Malaya and Borneo." The specimens also could not be identified using keys for neighboring areas, including continental Southeast Asia (Rattanarithikul et al. 2006), the Philippines (Cagampang-Ramos and Darsie 1970) and the Australasian Region (Lee et al. 1987). Based on available character data, the specimens appear to be conspecific with the single female collected in the 3rd division of Sarawak that Cheong and Pillai (1965) recognized as a possible new species. Reid (1968) examined the single female, which was "reared from a larva found in a forest swamp," and stated "Probably this is a new species but until specimens with larval and pupal skins are available it is not possible to be sure." Although efforts to obtain progeny broods from blood-fed females and to find the immature stages of this species were unsuccessful, there is no doubt that the specimens

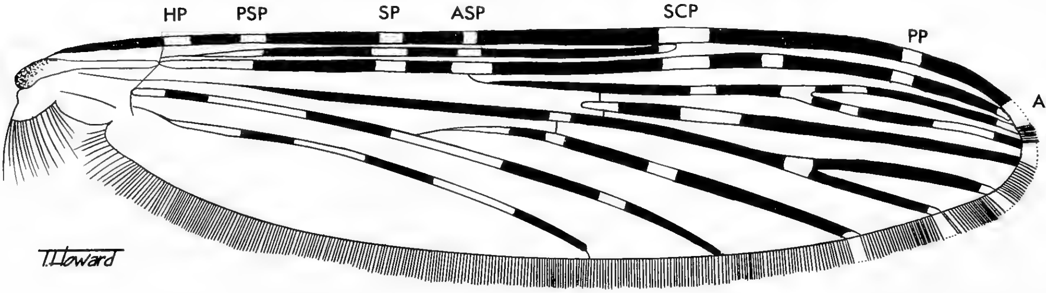


Fig. 1. Schematic outline drawing showing the pattern of pale and dark markings on the wing (dorsal surface) of *Anopheles* (*Cellia*) *kokhani* (female). Abbreviations for costal wing spots: AP, apical pale; ASP, accessory sector pale; HP, humeral pale; PP, preapical pale; SCP, subcostal pale; SP, sector pale. See the text, Reid (1968), and Harbach and Knight (1980) for the nomenclature applied to veins.

captured at Kapit represent a morphologically distinct species that is new to science. Consequently, this species is formally described and named *An. kokhani* n. sp. in this report. It is a pleasure to dedicate this species to Dr. Ng. Kok Han, Director of the Institute for Medical Research, Kuala Lumpur, in recognition of his tremendous support for the Institute's research activities.

Materials and Methods

This study is based on the specimens mentioned above, 129 of which were subsequently dissected during vector incrimination studies. Specimens were examined under artificial and simulated natural light. Except for wing spot nomenclature (Wilkerson and Peyton 1990), the morphological terminology used in the species description follows Harbach and Knight (1980, 1982). Reid's (1968) system of numbering wing veins is used along with standard terms to aid workers in Malaysia. Diagnostic and differential characters were confirmed in all available specimens.

Taxonomic Treatment

Anopheles (*Cellia*) *kokhani* Vythilingam, Jeffery, and Harbach, n. sp.

(Figs. 1–2)

Diagnosis.—Females of *An. kokhani* are distinguished from other members of the Neomyzomyia Series in the Oriental Region in having four pale bands on the maxillary palpus [distinction from *An. kolambuganensis* Baisas], anal vein of the wing with three dark marks [distinction from *An. tessellatus* Theobald; members of the Leucosphyrus Group], speckled legs [distinction from *An. aurirostris* (Watson)], hindleg without broad pale band covering the tibio-tarsal joint [distinction from members of the Leucosphyrus Group], hindtarsi mainly dark-scaled with narrow apical pale bands [distinction from *An. kochi* Dönitz, *An. watsonii* (Leicester), *An. stookesi* Colless; *An. saungi* Colless], abdominal terga without scales [distinction from *An. kolambuganensis*], abdominal sterna without scale-tufts [distinction from *An. kochi*].

Female.—*Head*: Vertex with white erect scales behind frontal tuft, black erect scales posteriorly; frontal tuft with 9 or 10 long white sinuous setae. Clypeus bare. Antenna slightly longer than proboscis; pedicel without scales; flagellomere 1 with inconspicuous elongate gray to black scales on mesal surface, setae of flagellar whorl 2–3 times as long as flagellomeres. Proboscis 1.60–1.75 mm, about same length as forefemur; prementum entirely dark-scaled, scales semi-erect at base; labella pale. Maxillary palpus slightly shorter than proboscis, length 1.50–1.65 mm, with 4 narrow pale

Fig. 2. Legs (anterior aspects) of *Anopheles* (*Cellia*) *kokhani* (female) showing the pattern of pale markings: A, foreleg; B, midleg; C, hindleg.

bands, apical pale band about length of preapical dark band, other bands at apices of palpomeres 2, 3 and 4; palpomere 2 with semi-erect scales imparting a shaggy appearance to proximal portion of palpus. *Thorax*: Integument dark brown to black, scutum with mottled pattern of gray pruinose and darker areas, scutellum pruinose with median dark area contiguous with similar spot on prescutellar area of scutum; anterior promontory and antedorsocentral areas with white semierect scales that grade into yellowish to golden fusiform scales on anterior acrostichal area, some scattered pale scales on scutal fossa; bronze to black setae on acrostichal, dorsocentral, fossal, antealar, supraalar and prescutellar areas; sparse rather inconspicuous pale scales among antealar and supraalar setae. Scutellum with posterior row of long bronze to black setae interspersed with few fine golden setae, with cluster of fine golden setae medially. Mesopostnotum and postpronotum bare. Antepronotum with or without few pale scales ventrally among few rather short golden-brown setae and few dark scales dorsally among long dark setae. Pleura dark with variable pruinose areas, with few golden-brown to black setae on proepisternum (1–3), prespiracular area (1–3), prealar knob (2–4), upper (2–4) and lower (3–5) mesokatepisternum and upper mesepimeron (3–5); lower mesepimeral setae absent. *Wing* (Fig. 1): Length about 3.2 mm; dark scaling black, pale scaling pale yellow, pattern of spots well defined, pale spots fairly narrow except on cubitus (veins 5 and 5.2 of Reid 1968) and anal vein (vein 6); costa with or without prehumeral pale spot, with humeral, presector, sector, accessory sector, subcostal, preapical and apical pale spots; remigium pale-scaled; vein R + R_1 (vein 1) like costa except presector pale spot extends to humeral crossvein, sector dark spot slightly shorter, subcostal pale spot slightly longer and preapical dark spot with pale interruption; R_s + R_{2+3} (vein 2) mainly dark-scaled with indefinite pale spots at radiomedial crossvein (cv 2-3) and middle and apex of R_{2+3}, R_2 and R_3 (veins 2.1 and 2.2) with indefinite postbasal pale spots, R_2 with small apical pale spot and R_3 with relatively large subapical pale spot; R_{4+5} (vein 3) with small basal and slightly larger postbasal pale spots; M + M_{2+3} (vein 4) dark-scaled with pale spot at fork of M_1 and M_2 (veins 4.1 and 4.2), M_1 and M_2 each narrowly pale at apex; mediocubital crossvein (base of vein 5.1) bare proximally, with dark scales distally; M_{3+4} (vein 5.1) with small pale spots at mediocubital crossvein, near midlength and at apex; CuA (veins 5 and 5.2) with 4 dark spots: small well-defined spot near base, large spot before mediocubital crossvein and 2 large narrowly separated distal spots (distal spots sometimes fused to form a line of dark scales to wing fringe); 1A (vein 6) with 3 dark marks, apex without scales; apical pale fringe spot present between apices of veins R_3 and R_{4+5} and faint pale fringe spots usually visible at apices of M_1, M_2, M_{3+4} and sometimes CuA. *Halter*: Pedicel bare, pale; scabellum and base of capitellum with narrow white spatulate scales, dome of capitellum with smooth shiny covering of minute decumbent black scales that contrast sharply with adjacent white scaling. *Legs* (Fig. 2): Coxae without scales; trochanters with mixture of pale and dark (mainly or all dark) scales on ventral surfaces; femora, tibiae and first tarsomeres with speckles and blotches of pale yellow scaling, hindfemur and all tibiae with narrow knee spots; tarsomeres 1–4 of all legs with narrow apical pale bands, bands usually faint or obsolete ventrally on fore- and midlegs. *Abdomen*: Integument dark with long dark setae; scales absent except for narrow golden scales on posterior area of tergum VIII and dorsal and lateral surfaces of cerci; sternum VIII with 2 or 3 narrow pale spatulate scales.

Male, pupa, larva, and egg.—Unknown.

Systematics.—*Anopheles kokhani* belongs to the Neomyzomyia Series of subgenus *Cellia* Theobald. Females key to couplet 17 in Reid's (1968) key to the anopheline mosquitoes of Malaya and Borneo. This couplet distinguishes *An. tessellatus* from *An. saungi*, *An. stookesi*, and *An. watsonii*, but *An. kokhani* cannot be identified as any one of these species based on key characters. *Anopheles kokhani* resembles *An. tessellatus* in having narrow apical pale bands on the hindtarsomeres, but differs in having the proboscis completely dark-scaled. These species also exhibit significant differences in characteristics of the maxillary palpus, proboscis, wings, and halteres, and do not appear to be closely related. *Anopheles kokhani* resembles the other three species in having a dark-scaled proboscis, but differs in having hindtarsomeres 3–5 mainly dark-scaled. These tarsomeres are pale-scaled in *An. stookesi* and *An. watsonii*, and hindtarsomere 3 is largely pale-scaled in *An. saungi*. *Anopheles kokhani* otherwise closely resembles these three species in overall habitus. It appears to share a closer relationship with *An. watsonii* than to *An. saungi* and *An. stookesi* based on shared features of the wings. Whereas vein R_{4+5} (vein 3 of Reid 1968) is nearly completely dark-scaled in *An. kokhani* and *An. watsonii*, it is largely pale-scaled in the other two species. Other characters, e.g., a pale fringe spot at the apex of vein CuA (veins 5 and 5.2 of Reid 1968), are too variable to distinguish the species or suggest possible evolutionary affinities.

Reid (1968) indicated that the Philippine *An. kolambuganensis* might be found in Borneo. Females of this species also run to couplet 17 in Reid's key, but are distinguished from *An. tessellatus*, *An.*

saungi, *An. stookesi*, and *An. watsonii*, as well as *An. kokhani*, by the presence of broad pale and dark scales that form "incipient" lateral tufts on the posterior corners of abdominal terga V–VII.

Bionomics.—*Anopheles kokhani*, *An. stookesi*, and *An. watsonii* all occur in Sarawak. Whereas *An. watsonii* was collected at the type locality of *An. kokhani*, *An. stookesi* is a highland species, having been collected above 610 m (Reid 1986, as 2,000 feet), and may not occur in sympatry with the other two species. *Anopheles saungi* is also unlikely to occur in sympatry with *An. kokhani* and *An. watsonii* as it has only been found above 1070 m in the Crocker Range of Sabah (Reid 1986, as 3,500 feet).

Females of *An. kokhani* and *An. watsonii* were collected at the same sites, albeit in different numbers, during the vector incrimination studies mentioned above. Collections in forest yielded 17 *An. kokhani* (15 in BLC and two in MBT collections) and 190 *An. watsonii* (121 BLC; 69 MBT). Collections made inside and outside a longhouse located about 5 km from the forest fringe on land cleared of original forest and now supporting fruit trees and secondary vegetation, included 46 *An. kokhani* (19 captured indoors and 27 outdoors) and only two *An. watsonii* (one indoors; one outdoors). Although the larval habitats of *An. kokhani* are unknown and may be more numerous outside forest than those occupied by *An. watsonii*, the collection data suggest that *An. kokhani* is the more endophilic species. BLC collections at a farm located closer to forest yielded 81 *An. kokhani* and one *An. watsonii*. Although both species are attracted to humans, the results show that *An. kokhani* is more peridomestic and anthropophilic than *An. watsonii*, which appears to be mainly a forest species. Most of the *An. kokhani* females (129) collected during the field studies noted above were dissected for possible vector incrimination, but no sporozoites or oocysts of *Plasmodium* species, and no microfilariae, were found (unpublished observations).

According to Reid (1968), the presumed female of *An. kokhani* reported by Cheong and Pillai (1965) was reared from a larva found in a forest swamp. In contrast, larvae of *An. watsonii* are "usually found in fallen split, or cut-open bamboo, sometimes in collections of water on fallen tree trunks" (Reid 1968). This clearly indicates a demarcation in the habitat requirements of the two species.

Type series.—Fifteen females. *Holotype*, ♀ (no. 33), MALAYSIA: *Sarawak*, Kapit, 20 Apr 2006 (Vythilingam et al.). *Paratypes* (same locality and collectors as holotype), 14 ♀ (nos. 1, 10, 12, 16, 17, 24, 44, 55, 57a, 57b, 64, 68, 69, 90) collected between Jun 2005 and Apr 2006. The holotype female and two paratypes (nos. 12 and 24) are deposited in The Natural History Museum (NHM), London; two females (nos. 1 and 16) are to be deposited in National Museum of Natural History, Washington, D.C.; two females (nos. 10 and 57a) are to be deposited in Sarawak Biodiversity Council, Kuching, Sarawak, Malaysia; and the remaining 8 paratypes (55, 17, 68, 69, 90,64, 44, 57b) are retained in the Institute for Medical Research, Kuala Lumpur, Malaysia.

ACKNOWLEDGMENTS

The support of the staff of the respective departments is greatly appreciated. We gratefully acknowledge Theresa Howard (NHM) for preparing the figures, Bruce A. Harrison (Public Health Pest Management, North Carolina Department of Environment and Natural Resources, Winston-Salem, North Carolina) for reviewing the manuscript and providing constructive comments, the Sarawak Biodiversity Center for permission to carry out the work, and the Director, Institute for Medical Research, Kuala Lumpur, for permission to publish. This project was funded by the Ministry of Health Malaysia, grant MRG2005-4.

LITERATURE CITED

Cagampang-Ramos, A. and R. F. Darsie, Jr. 1970. Illustrated keys to the *Anopheles* mosquitoes of the Philippine Islands. USAF Fifth Epidemiological Flight, PACAF, Technical Report 70-1: 1–49.

Cheong, W. H. and A. G. Pillai. 1965. A new species of *Anopheles* from Malaysia. Singapore Medical Journal 6: 44.

Harbach, R. E. and K. L. Knight. 1980. Taxonomists' Glossary of Mosquito Anatomy. Plexus Publishing, Inc., Marlton, New Jersey. xi + 415 pp.

———. 1982. Corrections and additions to *Taxonomists' Glossary of Mosquito Anatomy*. Mosquito Systematics (for 1981) 13: 201–217.

Lee, D. J., M. M. Hicks, M. Griffiths, M. L. Debenham, J. H. Bryan, R. C. Russell, M. Geary, and E. N. Marks. 1987. The Culicidae of the Australasian Region. Volume 5. Nomenclature, synonymy, literature, distribution, biology and relation to disease. Genus *Anopheles*. Subgenera *Anopheles*, *Cellia*. Monograph Series, Entomology Monograph No. 2. Australian Government Publishing Service, Canberra. ix + 315 pp.

Rattanarithikul, R., B. A. Harrison, R. E. Harbach, P. Panthusiri, and R. E. Coleman. 2006. Illustrated Keys to the Mosquitoes of Thailand. IV. *Anopheles*. Southeast Asian Journal of Tropical Medicine and Public Health 37(Suppl. 2): ii + 128 pp.

Reid, J. A. 1968. Anopheline mosquitoes of Malaya and Borneo. Studies from the Institute for Medical Research, Malaya 31: 1–520.

Singh, B., K. S. Lee, A. Matusop, A. Radhakrishnan, S. S. Shamsul, J. Cox-Singh, A. Thomas, and D. J. Conway. 2004. A large focus of naturally acquired *Plasmodium knowlesi* infections in human beings. Lancet 363: 1017–1024.

Wilkerson, R. C. and E. L. Peyton. 1990. Standardized nomenclature for the costal wing spots of the genus *Anopheles* and other spotted-wing mosquitoes (Diptera: Culicidae). Journal of Medical Entomology 27: 207–224.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 469–488

SYSTEMATICS OF A NEW GENUS AND CAVERNICOLOUS SPECIES OF THE MOSQUITO TRIBE AEDINI (DIPTERA: CULICIDAE) FROM THAILAND

RALPH E. HARBACH, RAMPA RATTANARITHIKUL, THERESA M. HOWARD,
YVONNE-MARIE LINTON, AND IAN J. KITCHING

(REH, TMH, YML, IJK) Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K. (e-mail: r.harbach@nhm.ac.uk); (RR) Museum of World Insects, 72 Nimanhemin 13, Huay-Kaeo Road, Chiangmai 50200, Thailand

---

Abstract.—***Borichinda*** **Harbach and Rattanarithikul, n. gen.**, is introduced as a new mosquito genus of tribe Aedini for a previously unknown cave-dwelling species, ***Borichinda cavernicola*** **Rattanarithikul and Harbach, n. sp.**, in Thailand. A diagnosis of the genus is provided that features unique anatomical characters of the adult, pupal, and larval stages of the type species. The affinities of *Borichinda* and *Bc. cavernicola* are discussed in terms of their position in the phylogeny of Aedini. The male and female genitalia, pupa, fourth-instar larva, and terminal abdominal segments of the third-instar larva of the new species are illustrated. Sequence data are provided for the second nuclear internal spacer region (ITS2) and a 522-bp fragment of the mitochondrial cytochrome c oxidase I (COI) gene. Cladistic analysis of morphological data indicates that *Borichinda* is more closely related to *Isoaedes* and *Ayurakitia* than to other genera of tribe Aedini. Salient differences that distinguish these three genera are contrasted.

Key Words: new genus, new species, ITS2, COI, mosquito, taxonomy, systematics

---

Larvae of the new species described in this paper were discovered in a cave while sampling a wide range of larval mosquito habitats in Doi Inthanon National Park in Chiangmai Province of northern Thailand. Adults reared from the larvae were initially identified as a species of genus *Isoaedes* (sensu Reinert et al. 2004) using unpublished keys (Rattanarithikul et al.) for the aedine fauna of Thailand. Upon closer examination of the adults and their associated larval and pupal exuviae, it became obvious that the species was very different from *Isoaedes*, suggesting that it belonged to a hitherto unrecognized phyletic line of tribe Aedini. Consequently, character data for the new species were coded for the characters described by Reinert et al. (2004) and the combined data set analyzed to objectively assess the placement of the new species in the classification of the tribe. The results of this analysis indicate that the species does not fall within any currently recognized genus-level taxon of Aedini, and therefore a new genus-species combination is proposed and described herein.

MATERIALS AND METHODS

This study is based on larvae and adults reared individually from larvae and pupae collected from a rimstone pool in a cave in northern Thailand (see Material examined following the species description). Pinned adults were examined under simulated natural light; dissected genitalia, larvae, and larval and pupal exuviae were studied with differential interference contrast optics. Measurements and counts were taken from 10 specimens of each life stage. Numbers in parentheses represent modes of the reported ranges. Anatomical terminology and abbreviations used in the descriptions and illustrations, respectively, follow Harbach and Knight (1980, 1982). The symbols ♀, ♂, Le, Pe, L^4, and L^3 used in the material examined section represent female, male, larval exuviae, pupal exuviae, fourth-instar larva, and third-instar larvae, respectively.

A number of fourth-instar larvae were killed and preserved in 95% ethanol for DNA extraction. DNA was extracted from three larvae using the commercially available QIAgen DNAeasy Kit (QIAgen Ltd, Sussex, England) following the manufacturer's recommended protocol. A 522-bp fragment of the mitochondrial cytochrome oxidase subunit I locus (COI) was amplified using the universal insect primers C1-J-1718 and C1-N-2191 (Simon et al. 1994). The last five digits of these codes indicate the position and orientation of the 3′ end of the primers with respect to the mtDNA genome of *Drosophila yakuba* (X03240) (Clary and Wolstenholme 1985). Amplification of the 393-bp amplicon of the second nuclear ribosomal spacer region (ITS2), including flanking portions of the 5.8S and 28S genes, was carried out using the 5.8SF and 28SR primers recommended by Collins and Paskewitz (1996). PCR products were amplified using the following reaction mix (50 µl): 2 µl DNA, 25.5 µl ddH_2O, 2.5 µl 2.5 mM $MgCl_2$ (BioLine, London, England), 0.1 µl Taq polymerase (BioLine), and 5 µl each of primers at 5 µM, 2 mM dNTPs (PE Applied Biosystems, Warrington, England), and 10× NH_4 buffer (BioLine). The PCR thermocycler program consisted of a 2-min denaturation at 94°C, 34 cycles at 94°C, 53°C (ITS-2)/57°C (COI), and 72°C for 30 sec each, followed by a 10-min extension at 72°C. Sequence data were obtained following PCR purification using a commercially available PCR purification kit (QIAgen Ltd, Sussex, England), and products diluted to 3 ng /µL /200 bp of product for sequencing. Cycle sequencing reactions were prepared using one-eighth reactions of the Big Dye Terminator Kit (PE Applied Biosystems) and read by an ABI 3730 robotic sequencer (PE Applied Biosystems). Sequence data were edited and aligned using Sequencher™ 4.5 (Genes Codes Corporation, Ann Arbor, Michigan). After sequencing, the DNA was dried and retained at −70°C in the Molecular Systematics Laboratory, The Natural History Museum, for future reference.

The phylogenetic relationship of *Borichinda* to other aedine taxa was examined by including character data for *Borichinda* in the parsimony analysis of Reinert et al. (2004), which should be consulted for the methods describing the cladistic analysis. Briefly, 172 characters derived from eggs, fourth-instar larvae, pupae, and adult males and females (Appendix) were coded for 120 species: *Borichinda cavernicola*, n. sp., plus the 119 exemplar species representing the 12 genera and 56 subgenera of tribe Aedini that were recognized prior to the changes to aedine classification proposed by Reinert et al. The coding by Reinert et al. of character 38 for *Isoaedes cavaticus* was changed from state (1) to (2) (see Reinert 1979: fig. 5). The data were analyzed using both equal weights, implemented by WinClada version 1.0000 (Nixon 1999–2002), and implied weights, implemented by PIWE version 3.0 (for Windows) (Goloboff 1997) with the default value of the concavity constant, *K* = 3. The former applied the Parsimony Ratchet (Nixon 1999) (50,000 replications with 17 characters sampled and one tree held per replicate). The latter was performed by heuristic search, using 5,000 replications (mult*5,000) and holding 10 cladograms per replicate (hold/10). To determine whether the Ratchet and PIWE had found all most parsimonious or fittest cladograms (MPCs), respectively, the results were checked by searching for successively less parsimonious or fit cladograms using the commands "sub *n*" (where *n* is the increase in length in steps of 1 (equal weighting) or decrease in fit, in steps of 0.1 (implied weighting)) and "find*" (to search for all cladograms of length + n or best fit − *n*, respectively), up to a maximum of 100,000 cladograms. The "best" command was then applied to this set of 100,000 cladograms to confirm that the included set of MPCs was the same as that obtained in the initial analyses. Agreement in grouping within a set of MPCs was summarized using a strict consensus tree (SCT). A SCT of the combined EW and IW analyses was generated to reveal those taxa whose composition and relationships are weighting independent.

TAXONOMIC TREATMENT

Borichinda Harbach and Rattanarithikul, new genus

Type species: *Borichinda cavernicola* Rattanarithikul and Harbach, n. sp.

Adults.—Medium-sized mosquitoes. Moderately ornamented, principally dark-scaled with pale-scaled areas and markings; setae of head, antepronotum, scutum and scutellum strongly developed, prominent, long and dark; setae of thoracic pleura and coxae lighter in color and not so prominent. *Head*: Narrow pale decumbent scales and darker erect forked scales on occiput and vertex; ocular line narrow, with sparse narrow pale scales; interocular scales extend between eyes to postfrons; eyes narrowly separated by space equal to diameter of 1–2 eye facets. Maxillary palpus of females with 3 palpomeres; palpus of males with 5 palpomeres, palpomeres 2 and 3 ankylosed. *Thorax*: Scutum with pattern of long narrow dark and pale falcate scales covering all but inner dorsocentral areas at anterior promontory and prescutellar area; setae as follow: complete acrostichal line, complete dorsocentral line contiguous with lateral prescutellar line, anterior, lateral, median and posterior areas of scutal fossa, antealar and supraalar areas; scutellum with broad pale spatulate scales on middle lobe and narrower scales on lateral lobes; paratergite and mesopostnotum bare. Antepronota widely separated, not enlarged, with cluster of 3–6 strong dorsally projecting setae on upper margin and scattered setae below. Postpronotum with variable number of pale falcate scales along dorsal margin. Pleura with small patches of pale spatulate scales on upper proepisternum, postspiracular and subspiracular areas, upper and lower mesokatepisternum and upper (anterior) mesepimeron. *Wing*: Dark-scaled; remigial setae absent; alula with row of narrow scales on margin; upper calypter with row of setae on dorsal half of margin. *Legs*: Dark-scaled, femora with narrow apical pale rings; fore- and midungues of females each with tooth, hindungues simple; posterior foreunguis of males large, with tooth, anterior foreunguis smaller, without tooth, midungues each with tooth, hindungues simple. *Abdomen*: Terga with basal pale bands that become obsolescent medially on posterior segments. *Female genitalia*: Tergum and sternum VIII with numerous broad spatulate scales; tergum VIII with setae on posterior 0.6, basolateral seta absent; sternum VIII with median caudal emargination, seta 2-S noticeably posterior to seta 1-S; tergum IX relatively narrow, width about 1.7× length, roughly cordate in outline, posterolateral corners with group of several fine setae; insula tonguelike, without setae; upper vaginal sclerite weakly developed (not illustrated); lower vaginal sclerite absent; spermathecal eminence membranous, poorly defined; postgenital lobe moderately long and wide, apex with relatively deep emargination, caudal half of ventral surface with scattered setae; cercus moderately long, scales absent; one large and 2 smaller spermathecal capsules. *Male genitalia*: Tergum IX with slightly produced lobe on either side of narrow median bridge, each lobe with cluster of relatively slender stiff setae; sternum IX long, with median posterior group of fine setae; gonocoxite long and relatively narrow, mesal surface entirely membranous; gonostylus attached at apex of gonocoxite, single gonostylar claw at apex; basal mesal lobe elongate, free of mesal membrane of gonocoxite; proctiger long, paraproct simple, without sternal arm; cercus membranous, setae absent; aedeagus moderately long, comprised of 2 lateral plates (aedeagal sclerites).

Pupae.—*Cephalothorax*: Seta 1-CT similar in development to 3-CT; 5-CT longer than 4-CT; 6,7-CT subequal; 10,11-CT on small tubercles, closer to one another than to 12-CT, 11 CT single; 13-CT absent. *Trumpet*: Tracheoid present, weakly developed. *Abdomen*: Seta 6-I,II longer than 7-I,II respectively; 2-II–VII inserted anterior and slightly mesad of setae 3 and 4, laterad of seta 1; 6-II–VI long, single (infrequently double on II and III), inserted posterior to setae 4 and 9, 6-VII inserted anterior to seta 9; seta 9-II–VI comparatively long, single, inserted near midlength of lateral margin considerably anterior to seta 6, 9-VII longer than 6-VII; 10-II present, long, single; 5-IV–VI long, usually single, longer than following tergum; 4-V inserted on line directly mesad of seta 5, 4-VI in line with seta 5; 3-VI inserted lateral to 1-VI. *Paddle*: Longer than wide, outer part slightly broader than inner part; midrib indistinct distally; apex slightly emarginated; without marginal fringes, outer part with minute serrations proximal to midlength. Seta 1-Pa single, rarely distally forked; 2-Pa absent.

Larvae, fourth-instars.—*Head*: Median labral plate not apparent or absent. Occipital foramen more or less oval, longer in ventral view than posterior view, collar more strongly developed dorsolaterally. Hypostomal sclerite triangular, narrowly attached to lateralia. Labiogula short; hypostomal suture complete, gently curved, extending to posterior tentorial pit at margin of collar. Setae 5,6,8,9,10,13-C single, 9-C rarely double; 4-C with multiple thin branches, inserted much closer to 6-C than to 5-C; 7-C inserted more or less on level with 4-C, far anterior to 5-C; 8,10-C inserted more or less at same level; 9-C inserted posterior to 8,10-C; 11,12-C more or less equal distance from 13-C, 12-C mesal to 13-C, 13-C in line with 11-C; 15-C relatively long, single, occasionally double; 19-C absent; ventromedian cervical sclerite present. *Antenna*: Long, slender, smooth, curved mesad; seta 1-A relatively long, normally double, borne dorsolaterally at midlength. *Thorax*: Setae 0,1,3,8,14-P, 1,13,14-M and 1,5,8,13-T stellate; 0-P more or less directly posterior to 4-P; 1–3-P not attached to common setal support plate; 2-P single, longer than 1,3,4-P; 13-P absent; 7-M shorter than 5-M; 2-T single. *Abdomen*: Setae 1,2,5,9,13-I–IV, 7-II–VI, 11-I and 1,5-VIII well developed, stellate, minutely aciculate; 2-I–VII inserted anterolateral to seta 1; 6-I–VI long, branched aciculate; 3-I single; 7-I nearly as long as 6-I, with 2–4 branches; 12-I absent; 7-II much smaller than 6-II; 9-II–V inserted far anterior to seta 7; 10-II–V slightly mesad of setae 11,12. *Segment VIII*: Comb with relatively large spinelike scales in single row. Seta 5-VIII noticeably ventral to comb. *Siphon*: Slightly swollen just beyond midlength; acus present, small, detached; pecten with evenly spaced spines; seta 1-S inserted distal to pecten. *Segment X*: Saddle incomplete, relatively large, extending below lateral midline of segment X, posterior margin lined with spinelike spicules, acus absent. Seta 1-X well developed, inserted on and longer than saddle; 3-X normally single, rarely double on one side; 4-X with 4 pairs of setae on grid (with only transverse bars) and 2 stellate precratal setae, cratal setae include 2 short normally single setae anteriorly and 6 long setae with 1–4 branches posteriorly.

Eggs.—Unknown.

Etymology.—*Borichinda* is the name of the cave where the type species of the genus was discovered (see below). The cave bears the surname of Mr. Thanom Borichinda, the 11th chief of Chomthong District (1927–1929) in Chiangmai Province, Thailand, where the cave is located. Hence, the gender of *Borichinda* is masculine in agreement with Article 30.2.2 of the *International Code of Zoological Nomenclature* (International Commission on Zoological Nomenclature 1999). The two-letter abbreviation *Bc.* is recommended for this genus.

Systematics.—The generic status and phylogenetic relationships of *Borichinda* were assessed objectively by including character data for *Borichinda* in the parsimony analyses of Reinert et al. (2004). The characters used in the analyses and their states observed in *Borichinda* are listed in the Appendix. Analysis of the data set under equal weights (EW) produced 128 most parsimonious cladograms (MPCs) with a length of 1853 steps (CI = 0.12, RI = 0.65). *Borichinda* was placed in an unambiguous sister-group relationship with *Isoaedes* in the strict consensus tree (SCT) of these cladograms. Analysis of the data under implied weights (IW) yielded 56 MPCs of fit 595.0, in which *Borichinda* was placed in two alternative clades: *Isoaedes* + (*Borichinda* + *Ayurakitia*) and *Isoaedes* + *Borichinda*. The former clade occurred in 38 MPCs and the latter occurred in 18 MPCs. The sister relationship of *Borichinda* + *Ayurakitia* is supported by seven homoplastic characters (19:0, 33:1, 34:0, 36:1, 55:1, 137:1, 159:2) and that between *Borichinda* + *Isoades* is supported by seven different homoplastic characters (5:1, 45:1, 60:1, 68:0, 85:1, 103:0, 135:0). Three of the characters that support the sister relationship of *Borichinda* + *Isoades* also support *Isoades* as the sister of *Borichinda* + *Ayurakitia* (5:1, 68:0, 103:0). *Borichinda* emerged as a separate lineage in an unresolved basal polytomy along with 30 other taxa (see fig. 7 of Reinert et al. 2004) when the SCTs of the EW and IW analyses were combined. Incidentally, all the taxa that Reinert et al. (2004) treated as genera were recovered here as monophyletic groups, and groups comprising two or more genera exhibited identical or very similar patterns of interrelationships.

Borichinda clearly falls within the *Aedes* genus-group of Reinert et al. (2004), but is not consistently placed either within a genus or as sister to any of the genera recognized by those authors. Because *Borichinda* is paired with *Isoaedes* in both the EW and IW analyses, it could be argued that *Borichinda* might be considered a subgenus of *Isoaedes*. However, the autapomorphic differences of *Borichinda* in comparison to both *Ayurakitia* and *Isoaedes* are so great that it cannot be readily accommodated within either. The many salient differences between these three taxa that are not reflected in the data set used in the cladistic analyses are contrasted in Table 1. These differences

Table 1. Salient anatomical differences that distinguish the adults, pupae, and fourth-instar larvae of *Borichinda*, *Isoades*, and *Ayurakitia*. Characters that distinguish *Borichinda* from *Isoaedes* are indicated with an asterisk (*).

Character	*Borichinda*	*Isoaedes*	*Ayurakitia*
Adults			
Vertex, decumbent scales	Narrow	Narrow	Broad
Ocular scales	Narrow	Narrow	Broad
Compound eyes*	Narrowly separated	Continguous	Continguous
Interocular setae	Present	Present	Absent
Interocular space	Narrow	Narrow	Broad
Scutum, pale scaling*	Present	Absent	Absent
Scutellum, scales on midlobe*	Broad	Narrow	Narrow and broad
Antepronotal scales	Present	Present	Absent
Postpronotal scales	Present	Present	Absent
Postspiracular setae	Present	Present	Absent
Postspiracular scales*	Present	Absent	Absent
Subspiracular scales*	Present	Absent	Absent
Remigial setae*	Absent	Present	Present
Foreungues (males)*	One toothed	Both toothed	One toothed
Midungues (males)	Both toothed	Both toothed	Both simple
Female genitalia			
Insular setae	Absent	Absent	Present
Male genitalia			
Sternum IX (males)*	Long	Shorter	Long
Sternum IX setae*	Present	Absent	Present
Gonostylus	Long, cylindrical	Long, cylindrical	Short, bilobed
Claspette*	Apex expanded with numerous setae	Apex narrow with few setae	Apex narrow with few setae
Pupae			
Seta 7-CT*	About length of 6-CT	Longer than 6-CT	Longer than 6-CT
Seta 3-III*	Single	Multiple branches	Single
Seta 6-III*	Single	Branched	Branched
Seta 6-VII*	Anterior to seta 9	Posterior to seta 9	Posterior to seta 9
Seta 9-IV–VI*	Anterior to seta 8	Posterior to seta 8	Posterior to seta 8
Paddle*	Apex slightly concave	Apex produced	Apex longer on mesal side
Fourth-instar larvae			
Seta 4-C*	Short, 7–11 branches	Short, 3–6 branches	Long, multibranched
Setae 5,6,8-C	Single	Single	Multiple branches
Seta 13-C	Single	Single	Branched
Seta 14-C*	Branched	Single	Branched
Cervical sclerite	Present	Present	Absent
Seta 1-P*	Shorter than 2-P	Longer than 2-P	Shorter than 2-P
Setae 1,3-P*	Stellate	Single	Stellate
Seta 5-P*	Double	Single	Multibranched
Seta 5-T*	Large, stellate, multibranched	Small, single	Small, branched
Seta 2-I–VII*	Large, stellate, far anterolateral to seta 1	Small, single, near seta 1	Large, stellate, far anteromesal to seta 1
Seta 11-I*	Large, stellate	Small, 1–2 branches	Large, stellate
Seta 5-II–VI*	Large, stellate	Small, single	Large, stellate
Seta 7-II*	Short, stellate	Long, 1–2 branches	Short, stellate
Seta 9-II–VI*	Far anterior to seta 7	Near seta 7	Near seta 7

Table 1. Continued

Character	*Borichinda*	*Isoaedes*	*Ayurakitia*
Seta 10-II–V*	Mesal to setae 11,12	Lateral to setae 11,12	Lateral to setae 11,12
Seta 13-III–V*	Stellate	Single	Stellate
Seta 5-VII*	Large, stellate	Small, 1–2 branches	Large, stellate
Comb scales*	Spinelike, in single row	Scalelike, in patch	Spinelike, in single row
Siphon acus	Present	Present	Absent
Pecten spines*	Evenly spaced	Distal spine more widely spaced	Evenly spaced
Seta 1-X*	Large, branched	Small, single	Large, branched
Precratal setae*	Present	Absent	Present

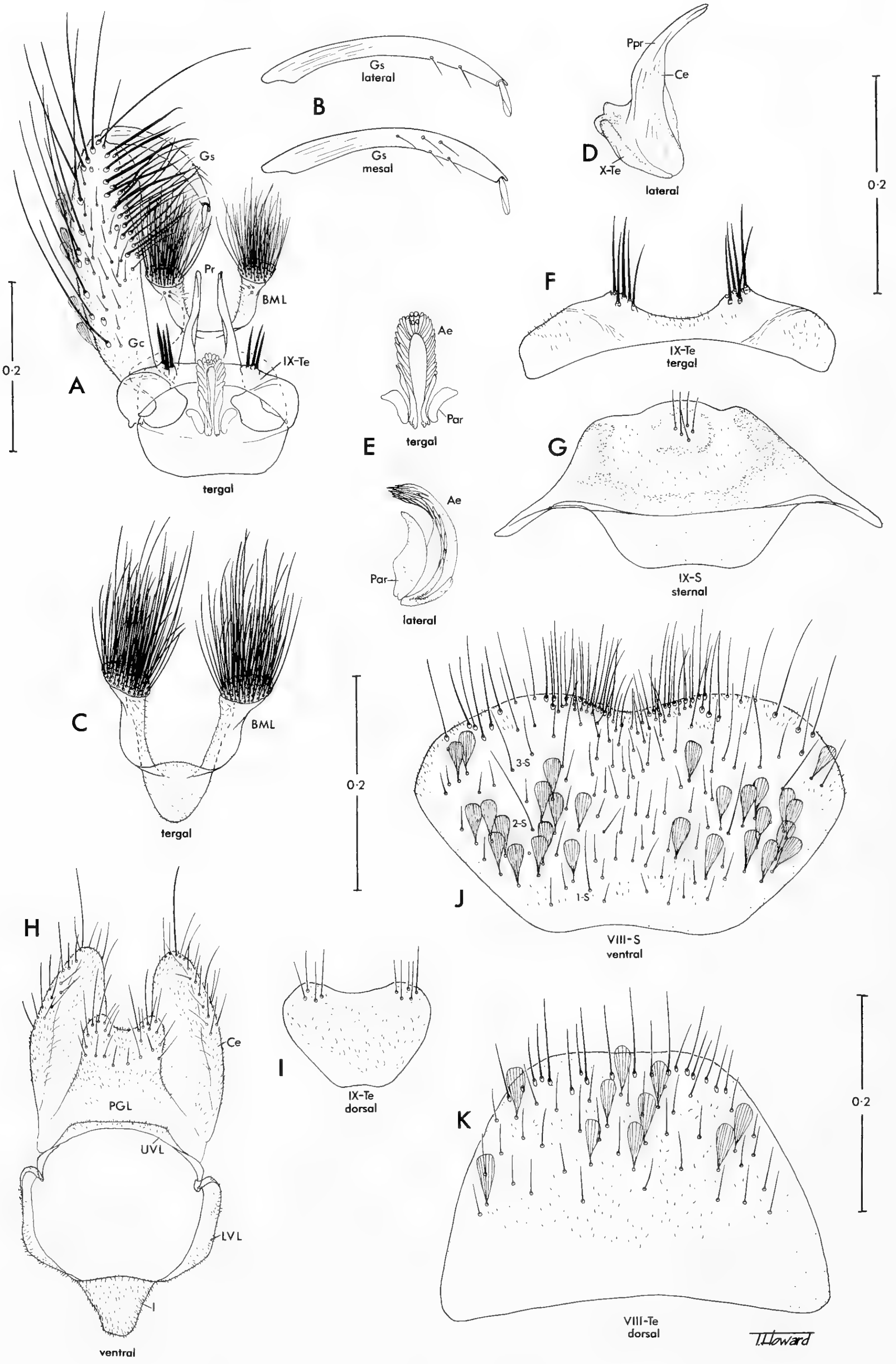
clearly support the recognition of *Borichinda* as a new polythetically diagnosed genus of tribe Aedini.

Despite the results of the cladistic analyses, the affinities of *Borichinda* are somewhat enigmatic. The fourth-instar larvae resemble some species of *Stegomyia* with stellate setae and precratal setae (e.g., the eastern Palaearctic *St. chemulpoensis* Yamada), but exhibits significant differences in adult ornamentation (e.g., scutal scaling and leg markings), male genitalia (e.g., development of the claspette and paraproct) and pupal chaetotaxy (e.g., placement of seta 6-VII relative to 9-VII). Similar types of differences also distinguish the adult, larval, and pupal stages of *Borichinda* from all other genera of the *Aedes* genus-group (Reinert et al. 2004) in Southeast Asia, which, in addition to *Ayurakitia*, *Isoaedes* and *Stegomyia*, include *Aedimorphus*, *Alanstonea*, *Armigeres*, *Belkinius*, *Bothaella*, *Diceromyia*, *Edwardsaedes*, *Heizmannia*, *Lorrainea*, *Paraedes*, *Scutomyia*, *Udaya*, *Verrallina*, and *Zeugnomyia*.

Borichinda cavernicola Rattanarithikul and Harbach, new species

(Figs. 1–4)

Female.—As described for genus. Dark scaling dark brown to black, pale scaling white. *Head*: Dorsum with narrow pale decumbent scales that become broader anteriorly and especially laterally, with narrow pale to dark brown erect forked scales that become sparser anteriorly. Antenna length 1.76–1.97 mm (mean 1.86 mm); pedicel and flagellomere 1 with small pale spatulate scales on mesal surface. Proboscis (except labella) and maxillary palpus dark-scaled; proboscis length 1.78–2.03 mm (mean 1.88 mm), essentially same length as forefemur; maxillary palpus bare beneath, with relatively few setae dorsally, laterally and apically, length 0.28–0.43 mm (mean 0.37 mm). *Thorax*: Integument dark brown, sutures, membranes, lower mesokatepimeron, metapleuron and metameron paler. Scutum with pattern of coarser pale scales on background of finer dark scales, pale scaling as follows: narrow acrostichal line bifurcating into lateral prescutellar lines, patch anteriorly on scutal fossa and dorsocentral area, posterior fossal line bifurcating into posterior dorsocentral and supraalar lines that converge posteriorly, small patch on antealar area; pleural setae as follow: 4–6(6) upper proepisternal, 7–12(10) antepronotal, 2–4(3) postpronotal, 4–6(5) postspiracular, 5–8(6) prealar, total of 8,9 upper and lower mesokatepisternal in continuous line above lower mesokatepisternal scale patch, 1,2(1) small lower mesokatepisternal below patch, 2,3(2) anterior mesepimeral, 4–7(5) upper mesepimeral. *Wing*: Length 2.84–3.46 mm (mean 3.13 mm). *Halter*: Integument pale, scabellum and capitellum with pale scales. *Legs*: Anterolateral surface of


Gs
Pr
BML
Gc
IX-Te
0·2
A
tergal
B
Gs
lateral
Gs
mesal
D
Ppr
Ce
X-Te
lateral
0·2
E
Ae
Par
tergal
Ae
Par
lateral
F
IX-Te
tergal
G
IX-S
sternal
C
BML
tergal
0·2
J
3-S
2-S
1-S
VIII-S
ventral
H
Ce
PGL
UVL
LVL
I
ventral
I
IX-Te
dorsal
K
0·2
VIII-Te
dorsal
T.Howard

forecoxa with pale spatulate scales and prominent dark setae, midcoxa with pale spatulate scales on anterior side of mid-lateral row of prominent setae, hindcoxa without scales, with posterolateral row of prominent setae; ventral surface of trochanters with pale scales and setae distally; femora with distinct apical pale rings and subdued posterolateral pale stripes on proximal 0.5–0.8; forefemur length 1.81–1.03 mm (mean 1.90 mm). *Abdomen*: Basal pale bands become obsolescent medially on segments V–VII in females and usually on segment VII in males; sterna progressively more dark-scaled from segment II to segment VII, sterna VI,VII and sometimes VI entirely dark-scaled. *Genitalia* (Fig. 1H–K): Tergum VIII broad anteriorly, narrower posteriorly, anterior margin slightly convex, index about 0.65; sternum VIII narrow anteriorly, broadened laterally in distal 0.6, index about 0.55, with close-set line of setae on either side of posterior emargination; tergum IX index about 0.70; upper and lower vaginal lips narrow, lightly to moderately pigmented; postgenital lobe (PGL) with lateral margins slightly depressed, dorsal index about 0.88, ventral index about 1.25, ventral length about 0.1 mm; cercus with smoothly rounded apex, distal area of dorsal and lateral surfaces with scattered setae, length about 0.18 mm, width about 0.06 mm, index about 3.0, cercus/dorsal PGL index about 2.5; spermathecal capsules (not illustrated) heavily pigmented, with few small pores near orifice.

Male.—Smaller but otherwise similar to female except for obvious sexual differences. *Head*: Antenna with strongly developed whorls of numerous long setae, 2 terminal flagellomeres disproportionately long compared to other flagellomeres; length 1.27–1.43 mm (mean 1.37 mm). Proboscis proportionately shorter, length 1.67–1.84 mm (mean 1.77 mm), very slightly shorter to same length as forefemur, proximal 0.75 of ventral surface with subdued and indistinct pale scaling. Maxillary palpus slightly shorter than proboscis, length 1.62–1.78 mm (mean 1.70 mm), dark-scaled, palpomeres 1–3 without scales ventrally, apices of palpomeres 3–5 with few relatively short rather inconspicuous setae, palpomeres 4 and 5 short and bent laterad. *Wing*: Generally paler, veins with fewer scales; length 2.57–2.73 mm (mean 2.66 mm). *Abdomen*: Tergum VIII with dark scales dorsally, pale-scaled laterally; sternum VIII pale-scaled. *Genitalia* (Fig. 1A–G): Gonocoxite with patch of long mesally projecting setae on distal half of tergomesal margin, some more distal setae flattened and lanceolate; dorsal surface with short setae, lateral and ventral surfaces with long setae and spatulate scales; gonostylus moderately long and narrow, slightly longer than half length of gonocoxite, tergomesal surface with scattered setae beyond midlength, gonostylar claw shoehorn-shaped; basal mesal lobe with flattened tergally directed head bearing numerous long close-set caudally projecting setae; proctiger nearly half as long as gonocoxite, paraproct distally tapered and bend tergally, without apical teeth; tergum X poorly defined, fused caudally with base of paraproct; aedeagus with lateral plates bent tergally, joined distally, tergolateral margin of

←

Fig. 1. Male (A–G) and female (H–K) genital structures of *Borichinda cavernicola*. Aspects as indicated. Scales in mm. Ae = aedeagus; BML = basal mesal lobe; Ce = cercus; Gc = gonocoxite; Gs = gonostylus; I = insula; LVL = lower vaginal lip; Par = paramere; PGL = postgenital lobe; Ppr = paraproct; Pr = proctiger; UVL = upper vagina lip; VIII-S = sternum VIII; VIII-Te = tergum VIII; IX-S = sternum IX; IX-Te = tergum IX; X-Te = tergum X; 1–3-S = numbered setae of sternum VIII.

Table 2. Range (mode) of numbers of branches for pupal setae of *Borichinda cavernicola*.

Seta	Cephalothorax CT	Abdominal Segments I	II	III	IV	V	VI	VII	VIII	Paddle Pa
0	—	—	1	1	1	1	1	1	1	—
1	1	≈120	7–13(9)	4–9(6)	4–8(6)	2–5(3)	3–5(3)	1–3(2)	—	1,2(1)
2	1	1,2(2)	1,2(1)	1,2(1)	1	1	1	1	—	—
3	1,2(1)	1,2(1)	1,2(1)	1,2(1)	2–5(4)	1	1	1	—	—
4	1,2(1)	2–5(3)	1,2(1)	1,2(1)	1	1,2(2)	1	1	1	—
5	1,2(1)	1–3(1)	2,3(2)	1–3(2)	1,2(1)	1	1,2(1)	1,2(1)	—	—
6	1	1	1,2(1)	1,2(1)	1	1	1	1,2(2)	—	—
7	1,2(1)	1	1,2(1)	1–3(2)	1–3(2)	2–4(3)	1,2(1)	1	—	—
8	1–3(2)	—	—	1	1	1	1,2(1)	1–3(2)	—	—
9	1	1,2(1)	1	1	1	1	1	1–3(2)	4–7(5)	—
10	2–5(3)	0*,1(1)	1	1	1	1	1	1,2(1)	—	—
11	1,2(1)	—	—	1	1	1	1	1	—	—
12	1–3(1)	—	—	—	—	—	—	—	—	—
14	—	—	—	1	1	1	1	1	1	—

each lined with short teeth to apex; paramere moderately long, about 0.7 length of aedeagus; basal piece large, broadly sickle-shaped.

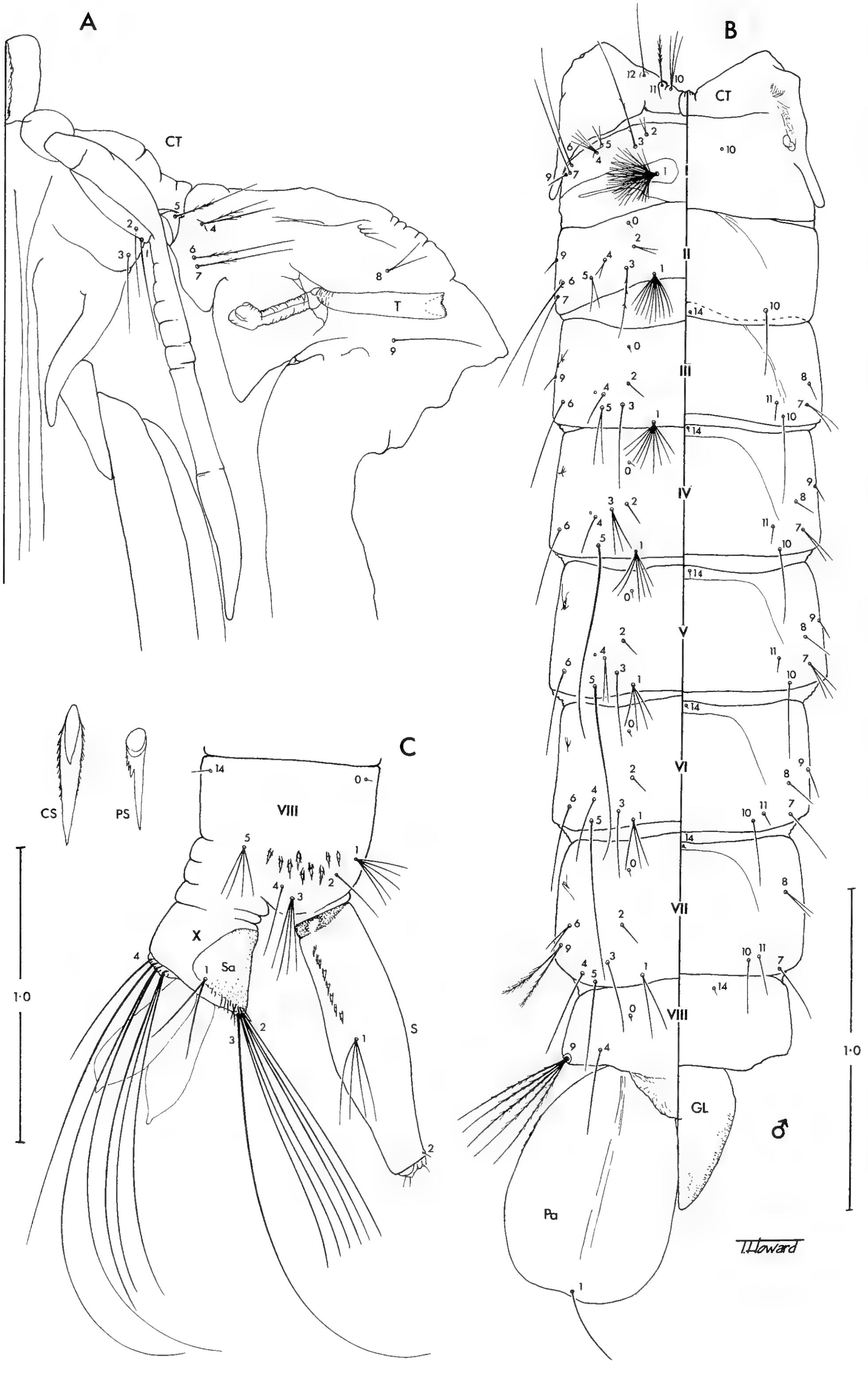
Pupa (Fig. 2A,B).—As described for genus; character and positions of setae as illustrated, numbers of branches in Table 2. *Cephalothorax*: Lightly to moderately pigmented, scutum slightly darker, becoming progressively darker onto metanotum. Setae 1–3,5–7,9-CT single, 3,5,7-CT rarely double; 4-CT usually double, rarely single; 8-CT double or triple, rarely single; 11-CT single or double more often single, noticeably aciculate distally. *Trumpet*: Moderately and evenly pigmented; length 0.33–0.41 mm (mean 0.41 mm), tracheoid 0.03–0.05 mm (mean 0.04 mm), pinna 0.04–0.09 mm (mean 0.07 mm), width at midlength 0.06–0.08 mm (mean 0.07 mm), index 4.13–7.50 (mean 5.54). *Abdomen*: Moderately pigmented, posterior area of tergum I darker, posterior areas of terga and sterna II–VII and their fold lines darker; length 2.96–3.68 mm (mean 3.19 mm). Seta 1-I bushlike, with thick stem and numerous (approximately 120) thin branches; seta 1-II–VII multiple branched, with progressively fewer branches on succeeding posterior terga; 6-II–VI relatively long, single, occasionally double on segments II and III; 10-II long, single (apparently homologous with short seta in same position on other aedine species interpreted as seta 11); normally double, branches usually noticeably aciculate distally, 9-VIII with 4–7(5) long aciculate branches, slightly longer than half length of paddle. *Genital lobe*: Moderately pigmented; length 0.45–0.47 mm in male; 0.24–0.27 mm in female. *Paddle*: Lightly and evenly pigmented, margins and midrib slightly darker, midrib distinct to distal area before seta 1-Pa; length 0.67–0.82 mm (mean 0.75 mm), width 0.41–0.55 mm (mean 0.50 mm), index 1.39–1.63 (mean 1.49).

Larva, fourth-instar (Fig. 3).—As described for genus; form and placement of setae as figured, range and modal number of branches in Table 3. *Head*: Nearly round in dorsal view, length 0.63–0.88 mm (mean 0.81 mm), width 0.72–0.76 mm (mean 0.76 mm); moderately pigmented, collar darker. Dorsomentum with 10 or 11 teeth on either side of larger median tooth. Setae 14-C and 6-Mx with thick stiff branches; 18-C single, inserted posterior to cervical sclerite. *Antenna*: Moderately to darkly pigmen-

Table 3. Range (mode) of numbers of branches for fourth-instar larval setae of *Borichinda cavernicola*.

	Head	Thorax			Abdominal Segments								
Seta	C	P	M	T	I	II	III	IV	V	VI	VII	VIII	X
0	1	6–10(7)	—	—	—	1	1	1	1	1	1	1	—
1	1	3–5(5)	5–10(6)	9–14(12)	11–15(13)	9–13(10)	8–11(9)	5–11(9)	7–10(9)	8–12(8)	6–9(8)	4–6(5)	3,4(3)
2	—	1	1	1	10–14(11)	6–12(10)	7–12(10)	5–12(8)	6–12(9)	6–10(7)	5–9(7)	1	3–5(4)
3	1	5–12(7)	1	1–3(2)	1,2(1)	1	1	1	1	1	1	4–7(5)	1,2(1)
4	7–11(9)	1	1	3–5(4)	2,3(3)	1–3(2)	1	1,2(1)	1–3(2)	1	1	1,2(1)	1–4*
5	1	2	3–5(3)	6–12(10)	4–8(6)	8–12(10)	7–13(10)	8–13(11)	6–11(9)	6–12(9)	6–9(6)	5–8(6)	—
6	1	1,2(1)	1	1	3–6(5)	3–6(5)	3–6(4)	2–5(3)	2,3(3)	2,3(3)	3–6(4)	—	—
7	5–8(7)	2,3(2)	2–4(3)	2–6(4)	2–4(2)	4–6(4)	5–8(6)	4–8(6)	5–10(6)	3–5(4)	1	1-S,	2–4(4)
8	1	5–13(9)	4–7(5)	5–11(6)	—	1	1	1	1	2	5–7(5)	2-S,	1
9	1,2(1)	1,2(1)	1	4–6(5)	2–4(3)	4–8(6)	6–12(8)	6–12(8)	5–10(8)	6–8(8)	4–6(4)	6-S,	1
10	1	1	1	1,2(1)	1	1	1,2(1)	1	1	1	1,2(1)	7-S,	1
11	6–11(7)	1,2(2)	1	1,2(1)	8–15(8)	1	1	1	1	1	1	8-S,	1
12	1,2(2)	1	5–10(7)	1	—	1,2(1)	1,2(1)	1	1,2(1)	1	1	9-S,	1
13	1	—	6–10(7)	6–12(11)	8–11(8)	6–9(8)	6–8(6)	5–7(6)	5–8(6)	7–10(8)	5–10(9)	—	—
14	3–6(4)	6–9(8)	4–8(6)	—	—	—	1	1	1	1	1	1	—
15	1,2(1)	—	—	—	—	—	—	—	—	—	—	—	—
18	1	—	—	—	—	—	—	—	—	—	—	—	—

* Cratal setae: anterior setae normally single, rarely double; posterior seta 3- or 4-branched. Posterior precratal seta with 2–4(4) branches; anterior precratal seta with 2,3(3) branches.


A
CT
T
B
CT
I
II
III
IV
V
VI
VII
VIII
GL
Pa
♂
1·0
C
VIII
X
Sa
S
CS
PS
1·0
T.Howard

ted; length 0.28–0.38 mm (mean 0.34 mm). *Thorax*: Integument hyaline, smooth. Setae 3-P and 1-T minutely aciculate; 5–7-P,M, 9-M,T and 7-T aciculate proximally; 5,7-P double, 7-P rarely triple; 6-P single or double, more often single; 14-P relatively strongly developed, multiple branched, similar to 14-M; 5-T also relatively strongly developed, multiple branched, similar to 8-T. *Abdomen*: Integument hyaline, smooth. Seta 3-I usually and 3-II–VII always single, moderately long, 3-I–V noticeably longer than seta 4, 3-VI,VII subequal to seta 4; 6-I–VI multiple branched, branches long, stout, aciculate proximally, 6-VI noticeably shorter than 6-I–V; 8-II–V single, 8-VI double; 10-I–VII normally single, moderately long, 10-II–V approach length of following segment. *Segment VIII*: Comb comprised of 8–12(10) spinelike scales with minute basolateral denticles. *Siphon*: Moderately to darkly pigmented, surface with minute rows of scalelike etching; length 0.70–0.83 mm (mean 0.78 mm); width at base 0.21–0.30 mm (mean 0.26 mm); index 2.50–3.33 (mean 3.00); pecten with 9–16(13) spines with few denticles basally on ventral margin. *Segment X*: Saddle moderately pigmented; dorsal length 0.24–0.28 mm (mean 0.27 mm); siphon/saddle index 2.88–3.08 (mean 2.95). Seta 1-X usually with 3, occasionally 4, stout rather stiff branches that diverge in single plane from base; 2 precratal setae of ventral brush stellate with short stiff branches. Dorsal and ventral anal papillae equally long, longer than saddle, length 0.31–0.53 mm (mean 0.45 mm), thick, abruptly tapered apically.

Larva, third-instar (Fig. 2C).—Like fourth-instar but smaller; large setae generally with slightly fewer branches; comb scales shorter, broader, in partially double row; acus larger, attached to base of siphon; spines on posterior margin of saddle larger, especially prominent dorsally; precratal setae of ventral brush absent.

DNA sequence.—The ITS2 and COI sequences generated during the study are available in GenBank under the following accession numbers: ITS2 (EF370409–EF307411) and COI (EF370412, EF370413). Considering the taxonomic breadth of Aedini, DNA sequence data are available for very few species of the tribe, which precludes comparisons with allied taxa. Among sequences recorded in GenGank, the 393-bp ITS2 fragment of *Bc. cavernicola*, which includes a short portion of the flanking 5.8S and 28S genes, is most similar (84.4%) to that of *Stegomyia simpsoni* (AF158208, registered as *Aedes simpsoni*). Thus, of the species available for comparison, *Bc. cavernicola* and *St. simpsoni* are the most closely, albeit distantly, related species. The nucleotide bases of the ITS2 fragment consist of 24.4%A, 25.7%T, 26.5%C and 23.4%G. No intraspecific variation was detected between the ITS2 sequences generated for the three larvae, and only two unique mtDNA haplotypes were detected in the 522-bp COI fragment, which varied by only a singleton polymorphism at base 459 (C↔T) in one specimen. The most common COI haplotype comprised 28.1%A, 37.5%T, 19.1%C and 15.3%G. Although based on a small sample size ($n=3$), this level of genetic homogeneity denotes a closely

←

Fig. 2. A,B, Pupa of *Borichinda cavernicola*. A, Left side of cephalothorax, dorsal to right. B, Dorsal (left) and ventral (right) aspects of metathorax and abdomen. C, Terminal abdominal segments of third-instar larva. Scales in mm. CS = comb scale; CT = cephalothorax; GL = genital lobe; Pa = paddle; Ps = pecten spine; S = siphon; Sa = saddle; T = trumpet; I–VIII,X = abdominal segments I–VIII,X; 0–11, 14 = setal numbers for specified areas, e.g., seta 3-I.

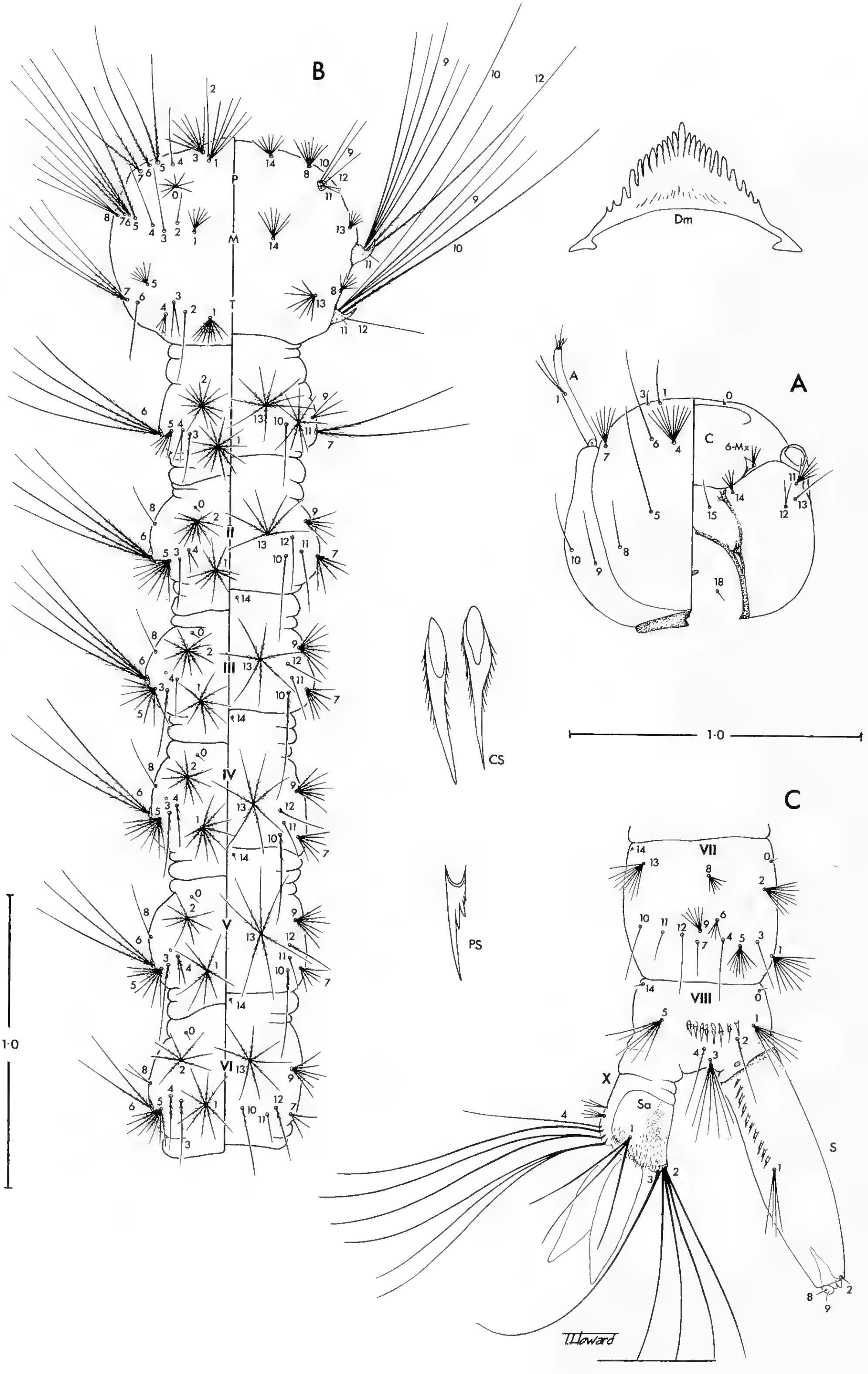

B
P
M
T
I
II
III
IV
V
VI
1·0
Dm
A
C
6-Mx
CS
PS
1·0
C
VII
VIII
X
Sa
S
T.Howard

Fig. 4. Rimstone pool in Borichinda Cave – the larval habitat and type locality of *Borichinda cavernicola*. The pool is fed by seepage from a single point (arrow) in the wall of the cave.

related, potentially inbreeding population. Among sequences available in GenBank, the COI gene of *Bc. cavernicola* proved to be most similar (87.4%) to that of *Anopheles funestus* (AY423059), which tells us nothing about the affinities of *Borichinda*.

Etymology.—The name *cavernicola* is a Latin common noun (masculine or feminine) meaning "cave-dweller." It was chosen because the species was discovered in and only known to inhabit Borichinda Cave in northern Thailand (see below).

Bionomics.—Larvae and pupae of *Bc. cavernicola* were collected on three occasions from a single rimstone pool (Fig. 4) located approximately 150 m into Borichinda Cave. Other than limited areas of seepage, no other sources of water were found in the cave. The collections were made in October 2004, September 2005, and November 2005 during the latter part of the rainy season. The water in the

---

←

Fig. 3. Fourth-instar larva of *Borichinda cavernicola*. A, Head, dorsal (left) and ventral (right) aspects of left side. B, Thorax and abdominal segments I–VI, dorsal (left) and ventral (right) aspects of left side. C, Abdominal segments VII–X, left side. Scales in mm. A = antenna; C = cranium; M = mesothorax; P = prothorax; S = siphon; Sa = saddle; T = metathorax; I–VIII,X = abdominal segments I–VIII,X; 0–15, 18 = setal numbers for specified areas, e.g., seta 5-C.

pool was crystal clear, 20–30 cm deep and devoid of vegetation and plant matter. A layer of silt covered the bottom of the pool. There was no water in the pool when the cave was visited in February 2005, but the silt bottom was slightly moist. Samples of silt were collected and later inundated with water, but eggs were apparently absent as no larvae emerged. The walls of the cave were searched for resting adults, but none were found. The cave harbours an enormous number of bats that are likely to be the primary source, perhaps the sole source, of food for adult females. The floor of the cave was covered with bat droppings, but none were observed in the rimstone pool. Since the rimstone pool appears to be the only larval mosquito habitat in Borichinda Cave, and in view of the very long period of time it takes the wall of a rimstone pool to develop, it is hypothesized that *Bc. cavernicola* evolved as countless generations developed in the same habitat.

Distribution.—*Borichinda cavernicola* is only known from Borichinda Cave in Chiangmai Province in northern Thailand.

Type series.—One hundred and seventy-four specimens: 38 ♀, 16 ♂, 45 Le, 51 Pe, 20 L^4, 4 L^3. *Holotype*, ♂ (TH122-25), with LePe and dissected genitalia on separate microscope slides, THAILAND: *Chiangmai Province*, Chomthong District, Borichinda Cave (18° 29′ 59.5″ N 98° 40′ 40″ E, on shared border of Doi Inthanon and Mae Wang National Parks), rimstone pool, 13.x.2004 (Rampa et al.). *Paratypes* (same data as holotype except collection TH343 collected 29.ix.2005 by Harbach et al.; specimens with dissected genitalia are indicated with an asterisk*), 1 ♀ (TH122-11); 32 ♀LePe (TH122-4, -8, -9, -10, -12, -13, -15, -16, -17, -18, -19, -20*, -21, -22, -23, -24, -26, -27, -28; TH343-1b, -2, -4, -7, -11, -12, -15, -16, -18, -20, -22, -24, -26); 1♀Le (TH343-14*); 4 ♀Pe (TH122-1*, -2, -3; TH343-3); 1♂ (TH343-19); 11 ♂ LePe (TH122-4*, -6*; TH343-1a*, -5, -6, -9, -10, -13, -17, -21, -23); 3 ♂Pe (TH343-5, -8, -25*); 20 L^4 (TH122a, b, c, d; TH343e-t); 4 L^3 (TH343a, b, c, d).

The holotype (TH122-25) and the following paratypes are deposited in the NHM: TH122-1 through -10, -12 through -15, -18 through -28. The remaining paratypes are deposited in the Queen Sirikit Botanic Garden, Chiangmai, Thailand (TH122-11, -16, -17; all of collection TH343).

Acknowledgments

We greatly appreciate the efforts of Jumnongjit Pusak, Mark Isenstadt, Raewat Sawkord, Wirat Sommit, Wichai Srisuka, and Pisan Tongson (Darwin Initiative project, Queen Sirikit Botanic Garden, Chiangmai, Thailand) for participating in the collection, rearing, and preservation of the mosquitoes that made this study possible. Bruce A. Harrison (Public Health Pest Management, North Carolina Department of Environment and Natural Resources, Winston-Salem, North Carolina) and John F. Reinert (Center for Medical, Agricultural, and Veterinary Entomology, USDA, ARS, Gainesville, Florida) are gratefully acknowledged for reviewing the manuscript and providing constructive comments. The work in Thailand was conducted as part of a Darwin Initiative project (no. 13-003), funded by the U.K. Department for Environment, Food and Rural Affairs, entitled "Taxonomic capacity building in support of biodiversity conservation in Thailand."

Literature Cited

Clary, D. O. and D. R. Wolstenholme. 1985. The mitochondrial DNA molecule of *Drosophila yakuba*: nucleotide sequence, gene organisation and genetic code. Journal of Molecular Evolution 22: 252–271.

Collins, F. H. and S. M. Paskewitz. 1996. A review of the use of ribosomal DNA (rDNA) to differentiate among cryptic *Anopheles* species. Insect Molecular Biology 5: 1–9.

Goloboff, P. 1997. Pee-Wee: a program for parsimony analysis under implied weights. Program and documentation, available at ftp.unt.edu.ar/pub/parsimony.

Harbach, R. E. and K. L. Knight. 1980. Taxonomists' Glossary of Mosquito Anatomy. Plexus Publishing, Marlton, New Jersey. xi + 415 pp.

———. 1982. Corrections and additions to *Taxonomists' Glossary of Mosquito Anatomy*. Mosquito Systematics (for 1981) 13: 201–217.

International Commission on Zoological Nomenclature. 1999. International Code of Zoological Nomenclature. Fourth Edition. International Trust for Zoological Nomenclature, London. xxix + 306 pp.

Nixon, K. C. 1999. The Parsimony Ratchet, a new method for rapid parsimony analysis. *Cladistics* 15: 407–414.

———. 1999–2002. Winclada version 1.0000, published by the author. Ithaca, New York. Available at http://www.cladistics.org.

Reinert, J. F. 1979. A description of *Isoades*, a new subgenus of *Aedes* Meigen, and its type-species, *Ae.* (*Isa.*) *cavaticus* new species (Diptera: Culicidae). Mosquito Systematics 11: 144–162.

Reinert, J. F., R. E. Harbach, and I. J. Kitching. 2004. Phylogeny and classification of Aedini (Diptera: Culicidae) based on morphological characters of all life stages. Zoological Journal of the Linnean Society 142: 289–368.

Simon, C., F. Frati, A. Beckenbach, B. Crespi, H. Lui, and P. Flook. 1994. Evolution, weighing and phylogenetic unity of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. Annals of the Entomological Society of America 87: 651–701.

APPENDIX

Anatomical characters used in the cladistic analysis. See Reinert et al. (2004) for character coding and discussions of the characters. Character states observed in *Borichinda cavernicola* are listed with the numerical character code of Reinert et al. in parentheses.

Eggs

1. *Deposition*: unknown (?).
2. *Shape*: unknown (?).
3. *Outer chorion*: unknown (?).

Larvae (fourth-instars)

4. *Labiogula*: short, length < width (0).
5. *Antenna*: moderate to long, ≥0.42 median length of dorsal apotome (1).
6. *Seta 1-A, development*: single or 2-branched (0).
7. *Seta 1-A, length*: short, ≤3.0× antennal width at point of attachment (0).
8. *Setae 2,3-A, position*: apical or nearly apical (0).
9. *Seta 1-C, development*: single, thinner, distal part thin (1).
10. *Seta 4-C, position*: at same level or posterior to seta 6-C (1).
11. *Seta 4-C, length*: moderate to long (1).
12. *Seta 6-C, position*: anterior to seta 7-C (0).
13. *Seta 7-C, position*: anterior to seta 5-C (0).
14. *Seta 12-C, position*: mesad of or at same level as seta 13-C (0).
15. *Seta 13-C, development*: single (0).
16. *Seta 19-C*: absent (0).
17. *Ventromedian cervical sclerite*: present (1).
18. *Setae 1-3-P*: not attached to a common setal support plate (0).
19. *Seta 1-P, length*: ≤length of seta 2-P (0).
20. *Seta 3-P, length*: < length of seta 2-P (0).
21. *Seta 5-P, length*: ≤length of seta 6-P (0).
22. *Seta 5-P, development*: branched (1).
23. *Seta 8-P, length*: ≤1.2 length of seta 4-P (0).
24. *Seta 13-P*: absent (0).
25. *Seta 4-M, development*: single (0).
26. *Seta 7-M, length*: < length of seta 5-M (0).
27. *Seta 2-T, development*: single (0).
28. *Seta 3-I, development*: single (0).
29. *Seta 7-I, length*: ≥0.55 length of seta 6-I (1).

30. *Seta 7-I, development*: single to ≥4 branches (0,1).
31. *Seta 12-I*: absent (0).
32. *Seta 6-II, development*: branched (1).
33. *Seta 7-II, development*: different than seta 7-I (1).
34. *Seta 8-II, development*: single (0).
35. *Seta 3-V, length*: ≥1.90× length of seta 5-V (1).
36. *Seta 2-VII, development*: branched (1).
37. *Seta 3-VII, length*: short to moderately long (0).
38. *Seta 12-VII, position*: posterior to seta 13-VII (2).
39. *Seta 12-VII, development*: single (0).
40. *Setae 1,2-VIII:* not attached to common setal support plate (0).
41. *Seta 2-VIII, development*: single (0).
42. *Seta 4-VIII, development*: single (0).
43. *Comb*: few to several scales in 1 or 2 irregular rows (0).
44. *Comb plate*: absent (0).
45. *Siphon, acus*: present (1).
46. *Pecten*: present, spines evenly spaced (1).
47. *Seta 1-S*: one seta some distance from base of siphon (1).
48. *Seta 6-S, development*: short (1).
49. *Seta 8-S, length*: short (0).
50. *Saddle, acus*: absent (0).
51. *Sclerotization of segment X*: dorsal saddle (0).
52. *Seta 1-X, position*: inserted on saddle (0).
53. *Seta 3-X, development*: single (0).
54. *Sclerotization supporting seta 4-X (ventral brush)*: grid with only transverse bars (1).
55. *Precratal/preboss setae* (i.e., 2 or more setae anterior to grid/boss): present (1).
56. *Seta 4a-X of ventral brush*: long (1).

Pupae

57. *Cephalothorax with clear unpigmented spots*: absent (0).
58. *Tracheoid area of trumpet*: present at base, weakly developed (1).
59. *Seta 1-CT, development*: similar in development to seta 3-CT (0).
60. *Seta 5-CT, length*: >1.3× length of seta 4-CT (1).
61. *Seta 7-CT, length*: ≤length of seta 6-CT (0).
62. *Seta 11-CT, development*: single or branched (0,1).
63. *Seta 13-CT*: absent (0).
64. *Seta 6-I, length*: ≤length of seta 7-I (0).
65. *Seta 2-II, position*: lateral to seta 1-II (1).
66. *Seta 2-II, length*: < length of seta 1-II (0).
67. *Seta 3-II, position*: lateral to seta 2-II (1).
68. *Seta 3-II, length*: ≤length of seta 6-II (0).
69. *Seta 3-III, development*: single, stout (0).
70. *Seta 5-II, position*: lateral to or at same level as seta 4-II (0).
71. *Seta 6-II, length*: > length of seta 7-II (1).
72. *Seta 6-III, development*: single (0).
73. *Seta 6-VII, position*: anterior to seta 9-VII (0).
74. *Seta 5-V, length*: ≥medial length of tergum VI (1).
75. *Seta 2-VI, position*: lateral to seta 1-VI (1).
76. *Seta 3-VI, position*: lateral to seta 1-VI (1).
77. *Seta 9-VII, length*: > length of seta 6-VII (1).
78. *Seta 9-VIII, development*: ≥3 branches (1).
79. *Paddle midrib*: well developed, extending to or near apex of paddle (1).
80. *Paddle, fringe of long hairlike spicules*: absent (0).
81. *Paddle, apical margin*: sharply or broadly rounded, flat or very slightly concave (0).
82. *Seta 1-Pa, development*: single, rarely 2-branched (0).
83. *Seta 2-Pa*: absent (0).

Adults (females except where otherwise noted)

84. *Erect scales of head*: on occiput and vertex (2).
85. *Decumbent scales of vertex*: narrow (1).
86. *Ocular line*: narrow (0).
87. *Ocular scales*: narrow (1).
88. *Eyes, immediately above antennal pedicels*: narrowly to moderately separated (1).
89. *Interocular setae*: present (1).
90. *Interocular space, scales*: narrow (1).
91. *Antennal pedicel, mesal surface*: with scattered scales and/or setae (0).
92. *Antennal pedicel, lateral surface*: bare (0).
93. *Apical flagellomeres* (males): both apical flagellomeres disproportionately long compared with other flagellomeres (0).
94. *Antenna, development of flagellar whorls* (males): numerous long setae, directed normally dorsally and ventrally (2).
95. *Maxillary palpomeres* (males): 5, palpomeres 2 and 3 fused/ankylosed (0).
96. *Antepronota*: more widely separated (1).
97. *Acrostichal setae*: present (1).
98. *Dorsocentral setae*: present (1).
99. *Prescutellar area, median and/or posterior parts*: bare (0).
100. *Prescutellar setae*: present (1).
101. *Scutellum, scales on midlobe*: broad (1).
102. *Scutellum, scales on lateral lobes*: narrow (0).
103. *Paratergal scales*: absent (0).
104. *Parascutellar scales*: absent (0).
105. *Antepronotal scales*: present (1).
106. *Postpronotal scales*: present (1).
107. *Prespiracular setae*: absent (0).
108. *Postspiracular setae*: present (1).
109. *Postspiracular scales*: present (1).
110. *Hypostigmal scales*: absent (0).
111. *Subspiracular area*: with scales and/or setae (1).
112. *Upper proepisternal setae*: 5–19 (1).
113. *Upper proepisternum, scales*: present (1).
114. *Lower proepisternum, scales*: absent (0).
115. *Upper mesokatepisternal setae*: present (1).
116. *Prealar setae*: ≤20 (0).
117. *Lower prealar area, scales*: absent (0).
118. *Upper prealar area, scales*: absent (0).
119. *Mesepimeron, scales*: present (1).
120. *Lower anterior mesepimeral setae*: present (1).
121. *Mesepimeron, fine setae on ventral, posterior or both areas*: absent (0).
122. *Metameron*: bare (0).
123. *Upper calypter, setae or hairlike scales*: present, several or numerous (1).
124. *Upper calypter, setae or hairlike scales* (males): present, several to numerous (1).
125. *Alula, marginal scales*: narrow (1).
126. *Alula, dorsal moderately broad or broad scales*: absent (0).
127. *Remigial setae, dorsal*: absent (0).
128. *Remigial setae, ventral*: absent (0).
129. *Anal vein of wing*: ending noticeably distal to intersection of mcu and cubitus (1).
130. *Vein R_2, length*: ≥length of vein R_{2+3} (1).
131. *Anteprocoxal scales*: absent (0).
132. *Postprocoxal scales*: absent (0).
133. *Base of hindcoxa*: well below dorsal margin of mesomeron (0).
134. *Fore-, mid- and hindfemora, subapical white-scaled band*: absent (0).
135. *Hindtarsomere 1, pale-scaled area*: absent (0).
136. *Foreungues*: both toothed (2).
137. *Foreungues* (males): one simple, other toothed (1).
138. *Midungues* (males): both toothed (2).
139. *Hindungues* (males): both simple (0).

140. *Hindungues*: both simple (0).
141. *Laterotergite, scales*: present (1).
142. *Terga, lateral setae* (males): numerous, short to moderately long (1).
143. *Abdominal segment VII, shape*: laterally compressed (0).

Female genitalia

144. *Intersegmental membrane between segments VII and VIII*: intermediate (1).
145. *Tergum VIII*: entirely sclerotized (rarely with only small median nonsclerotized area), without lateral rod-shaped structures (2).
146. *Tergum VIII, setae*: on distal 0.6 or less (0).
147. *Tergum VIII, scales*: numerous, ≥9 scales (2).
148. *Sternum VIII, position of seta 2-S*: noticeably posterior to seta 1-S (0).
149. *Sternum VIII, scales*: numerous, ≥10 scales (2).
150. *Tergum IX*: narrower, width ≤1.9× length (1).
151. *Tergum IX, setae*: present distally (1).
152. *Postgenital lobe, position of ventral setae*: distal (0).
153. *Upper vaginal sclerite*: present (1).
154. *Lower vaginal sclerite*: absent (0).
155. *Insula*: tonguelike (2).
156. *Insular setae*: absent (0).
157. *Spermathecal capsule(s)*: 3 (1).

Male genitalia

158. *Tergum IX, setae*: slender (1).
159. *Sternum IX , length*: long (2).
160. *Sternum IX, setae*: present (1).
161. *Gonocoxite, lateral setae*: mostly long (1).
162. *Gonocoxite, mesal surface*: entirely membranous (0).
163. *Gonocoxite, scales*: present (1).
164. *Gonostylus, attachment to gonocoxite*: apical (1).
165. *Gonostylus, scales*: absent (0).
166. *Gonostylus, development*: moderately long to long, relatively narrow throughout length but distal part narrower and usually somewhat curved mesally (0).
167. *Gonostylar claw*: one (1).
168. *Claspette*: with basal, setose plaque variously developed (setae simple, specialized or both) or with relatively short, thin or thick stem with slender or stout seta(e) or spiniform(s) (1).
169. *Opisthophallus*: absent (0).
170. *Aedeagus*: comprised of 2 lateral plates (1).
171. *Proctiger, sternal arm*: absent (0).
172. *Proctiger, cercal setae*: absent (0).

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 489–492

NOTE

Asian Tiger Mosquito, *Aedes albopictus* (Skuse) (Diptera: Culicidae), Larvae in Pitchers of *Nepenthes ventricosa* Blanco (Nepenthaceae) in Virginia

Cultivating unusual exotic plants has been popular with horticulturists since Darwin's time. These include Old World tropical pitcher plants belonging to the genus *Nepenthes* (Nepenthaceae). Since their discovery by Europeans in Madagascar in the 17th century, over 60 species of *Nepenthes* have been described (Clark 1997). Many of the species are restricted to the tropical rain forests of Malaysia and Borneo where their vines attach to trees and extend vertically above the ground (Clark 1997, 2001). Others are found in drier open areas where they are non-climbers. Because *Nepenthes* is dioecious, species sometimes hybridize in nature. Nurserymen and collectors also create dozens of hybrids and cultivars.

The modified traps or pitchers of *Nepenthes* form at the ends of tendrils emanating from the tips of the leaves and they vary considerably in size and shape. Not all leaves form traps. The pitcher is a cuplike structure with a lip. It has a ribbed upper rim, a waxy zone and a pool of fluid which assists in the breakdown of prey items (Adams and Smith 1977). Prey are attracted to the traps by a combination of cues including the release of extrafloral nectar, purple markings on the body and rim of the trap, odors released by the decaying matter in the fluid-filled traps, and leaf morphology. Some insects attracted to the traps crawl along the lip of the cuplike leaves and fall into and drown in the liquid contents. In time they are degraded by a combination of leaf-produced enzymes, microorganisms, and associated invertebrates. The invertebrates include rotifers, protozoa, crustaceans, and larvae of several families of Diptera including mosquitoes (Kitching 2000).

Meadowview Biological Research Station (MBRS) in Caroline County, Virginia, maintains living collections of many species of pitcher plants. One of the species that is maintained in large numbers in the collections is the purple pitcher plant, *Sarracenia purpurea* L., which occurs naturally in Virginia. Found living in *S. purpurea* leaves are larvae of the species-specific mosquito, *Wyeomyia smithii* (Coq) (Buffington 1970). During the summer at MBRS in the area of the *S. purpurea* plant beds, several *Nepenthes* plants are suspended from a chainlink fence. Although *Wy. smithii* larvae were not expected to be found in the *Nepenthes* leaves, we decided to test this by sampling water from leaves of *N. ventricosa* Blanco. We found that several leaves contained mosquito larvae. To determine the species, we reared the immature specimens to adults. To broaden the scope of the initial observation, we contacted some local *Nepenthes* growers to see if other species of *Nepenthes* contained mosquito larvae.

The plants studied in this investigation were maintained outdoors during the warmer months and indoors during the winter months. Seventeen leaves were sampled from two *N. ventricosa* plants at the MBRS and leaves from one plant at Fredericksburg, Spotsylvania County, Virginia. At that location six additional species of *Nepenthes* were also sampled including *N. ampullaria* Jack., *N. alata* Blanco, *N. rafflesiana* Jack., *N. coccinea* [(*N. rafflesiana* × *N. ampularia*) × *N.*

mirabilis (Lour.) Druce], *N. albomarginata* Lobb & Lindl, and *N. truncata* Macfarlane.

All samples were collected in October, 2004. Fluid in each leaf was stirred with a tapered spatula to re-suspend debris and organisms. The suspended contents were removed using a pipette (0.4 cm internal diameter) with an attached rubber bulb. This material was placed in a 50 ml conical plastic tube and transported to the laboratory.

Samples were processed within 24 h of collection. In the laboratory, each sample was assigned an accession number and was examined for mosquito larvae using a dissecting stereo microscope. The water was also checked for rotifers, copepods, and other invertebrates.

Samples containing mosquito larvae were transferred to 40 ml glass Syracuse dishes that contained 20 ml of leaf water. The larvae were fed brewers yeast. Each day the samples were checked and pupae were removed. Each pupa was reared individually in a 50 ml. screw cap, conical centrifuge tube that contained 1 ml of leaf water. All specimens were labeled with individual accession numbers. The dates of pupation and emergence were recorded. Adult mosquitoes were removed and frozen.

Voucher specimens were preserved and labeled *N. ventricosa* study [2004-IX-27-(76 & 77; 2004-X-10-27]. They are deposited at the Georgia Museum of Natural History, University of Georgia, Athens, Georgia.

From the two *N. ventricosa* plants at the MBRS Station, out of 17 leaves sampled, five leaves contained 34 mosquito larvae and pupae. A total of 19 adults were reared out of this material, and the remaining larvae and pupae were preserved 70% ethyl alcohol. From the twelve leaves sampled from Fredericksburg, one contained 16 mosquito larvae. Twelve adults were reared from this material. All reared mosquitoes were identified as *Aedes albopictus* (Skuse), the Asian tiger mosquito (Darsie and Ward 2005).

In addition to *N. ventricosa*, six other species were sampled at the Fredericksburg site, namely *N. ampullaria, N. alata, N. rafflesiana, N. coccinea, N. albomarginata*, and *N. truncata*. None of the water samples from these six species contained mosquito larvae.

Aedes albopictus was first documented in the United States in Harris County, Texas, in 1985 (Sprenger and Wuithiranyagool 1986). The following year this mosquito was detected throughout the southeastern states. Authorities believe the mosquito entered the United States several years before its first detection based on its distribution and subsequent spread. *Aedes albopictus* and other exotic mosquito species were intercepted in shipments of used tires entering the United States from Asia (Moore et al. 1988). Today this mosquito is well established in the United States and has been documented in 26 states (Moore 1999).

In temperate climates, *Ae. albopictus* overwinters in the egg stage (Lyon and Berry 1991). The eggs are laid singly on the sides of water holding containers. The eggs usually hatch upon submersion. The larvae feed on fine organic matter in the water. At room temperature and with adequate food supply, the larval stage lasts five to ten days and another two days in the pupal stage.

The Asian tiger mosquito is a major pest species. Adults feed opportunistically and aggressively during the daytime on humans, as well as a wide variety of mammalian species, including natural hosts for several arboviruses of humans and animals. For example, *Ae. albopictus* has been shown to be a competent vector of La Crosse virus and dengue. Although not the primary epidemic vector of dengue, it may be involved in the maintenance cycle of dengue (Moore et al. 1988).

Nepenthes ventricosa is native to the Philippine Islands (Cheers 1992). The natural distribution of *Ae. albopictus* includes the Philippine Islands (Knight and Hull 1952). If the two species occur naturally in the same area, they might be associated together when introduced into a new region of the world.

Aedes albopictus is primarily found along the edges of forests. In North America, it has quickly adapted to breeding in both natural and artificial containers. In some situations, *Ae. albopictus* displaces existing species. For example, interspecific experimental studies by Livdahl and Willey (1991) between the eastern tree-hole mosquito, *Ae. triseriatus* (Say) and *Ae. albopictus*, showed the latter always prevailed.

The presence of *Ae. albopictus* larvae in the leaves of *N. ventricosa* documents the adaptability of this species to exploit a variety of phytotelmata (structures formed by non-aquatic plants that impound rainwater). Lounibos et al. (2003) reported that *Ae. albopictus* occurs in the water-holding tanks and axils of ornamental bromeliads found in gardens in Florida. The numbers of *Ae. albopictus* in ornamental bromeliads were significantly higher in northern Florida sites than southern sites.

It is interesting that leaves from *N. ventricosa* plants from two different locations contained *Ae. albopictus* larvae. We have no explanation why none of the water-filled leaves of the other species of *Nepenthes* contain mosquito larvae. One hypothesis would be that there are chemical cues that attract *A. albopictus* to *N. ventricosa* or that the other species exhibit some surface compound, possibly a wax, that is a deterrent to the Asian tiger mosquito. While collecting samples we did observe that many samples smelled putrid. Closer inspection of the leaves revealed that they contained large numbers of dead insects primarily earwigs (Dermaptera). It appeared the leaves were eutrophic.

Nepenthes can be started from cuttings or from seed. Collectors frequently amass large living collections of multiple species and they are placed around patios and backyards during the summer months. Unfortunately cultivated *Nepenthes* may provide breeding sites for the *Ae. albopictus* as well as other container-breeding species. In the fall, local plants have to be brought indoors to protect them from freezing. Trimming the pitchers off is one easy method to prevent bringing mosquitoes indoors during the winter months.

We express our thanks to Al Gustin and Mike Hammond for allowing us to collect water samples from their living collections of *Nepenthes* species. We extend our appreciation to F. Christian Thompson, Systematic Entomology Laboratory, ARS, USDA for identifying the mosquitoes.

LITERATURE CITED

Adams, R. M. and G. W. Smith. 1977. An SEM survey of the five carnivorous pitcher plant genera. American Journal of Botany 64: 265–272.

Buffington, J. 1970. Ecological considerations of the cohabitation of pitcher-plants by *Wyeomyia smithii* and *Metriocnemus knabi*. Mosquito News 30: 89–90.

Cheers, G. 1992. Letts Guide to Carnivorous Plants of the World. Charles Letts & Co. Ltd, London, England. 172 pp.

Clarke, C. M. 1997. Nepenthes of Borneo. Natural History Publications (Borneo), Kota Kinabalu. 207 pp.

———. 2001. Nepenthes of Sumatra and Peninsular Malaysia. Natural History Publications (Borneo), Kota Kinabalu. 326 pp.

Darsie, R. F. Jr. and R. A. Ward. 2005. Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico. University Press of Florida, 383 pp.

Kitching, R. L. 2000. Food Webs and Container Habitats: The Natural History and Ecology of Phytotelmata. Cambridge University Press, 431 pp.

Knight, K. L. and W. B. Hull. 1952. The *Aedes* mosquitoes of the Philippine Islands. II. Subgenera *Skusea*, *Christophersiomyia*, *Geoskusea*, *Rhinoskusea*, and *Stegomyia* (Diptera: Culicidae). Pacific Science 6: 157–189.

Livdahl, T. P. and M. S. Willey. 1991. Prospects of an invasion: competition between *Aedes albopictus* and native *Aedes triseriatus*. Science 253: 189–91.

Lounibos, L. P., G. F. O'Meara, N. Nishimura, and R. L. Escher. 2003. Interactions with native mosquito larvae regulate the production of *Aedes albopictus* from bromeliads in Florida. Ecoogical Entomology 28: 551–558.

Lyon, W. F. and R. L. Berry. 1991. Asian tiger mosquito. Ohio State University Extension Fact Sheet HYG-2148-98.

Moore, C. G. 1999. *Aedes albopictus* in the United States: current status and prospects for future spread. Journal of the American Mosquito Control Association 15: 221–227.

Moore, C. G., D. B. Francy, D. A. Eliason, and T. P. Monath. 1988. *Aedes albopictus* in the United States: rapid spread of a potential disease vector. Journal of the American Mosquito Control Association 4: 356–361.

Sprenger, D. and T. Wuithiranyagool. 1986. The discovery and distribution of *Aedes albopictus* in Harris County, Texas. Journal of the American Mosquito Control Association 2: 217–219.

Richard M. Duffield and Phil Sheridan. *(RMD) Department of Biology, Howard University, Washington, DC 20059, U.S.A. (e-mail: rduffield@howard.edu); (PS) Meadowview Biological Research Station, 8390 Fredericksburg Turnpike, Woodford, VA 22580, U.S.A. (e-mail: meadowview@pitcherplant.org)*

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 493–495

NOTE

The Second Record of the Genus *Eumerus* Meigen, 1822 (Diptera: Syrphidae) for the Neotropical Region and the First for Brazil

Eumerus Meigen is a genus of Old World origin. In recent times, it has been introduced into the Nearctic and Neotropical regions. There are 280 species of *Eumerus*: Palaearctic (163), Afrotropical (77), Oriental (34), Australian / Oceania (18), Nearctic (3), and now Neotropical (2). In the Nearctic Region, three species, *E. funeralis* Meigen, 1822 [= *tuberculatus* Rondani, 1857], *E. strigatus* (Fallén 1817), and *E. narcissi* Smith, 1928, were introduced from Europe by commerce with onion, narcissus, and related bulbs.

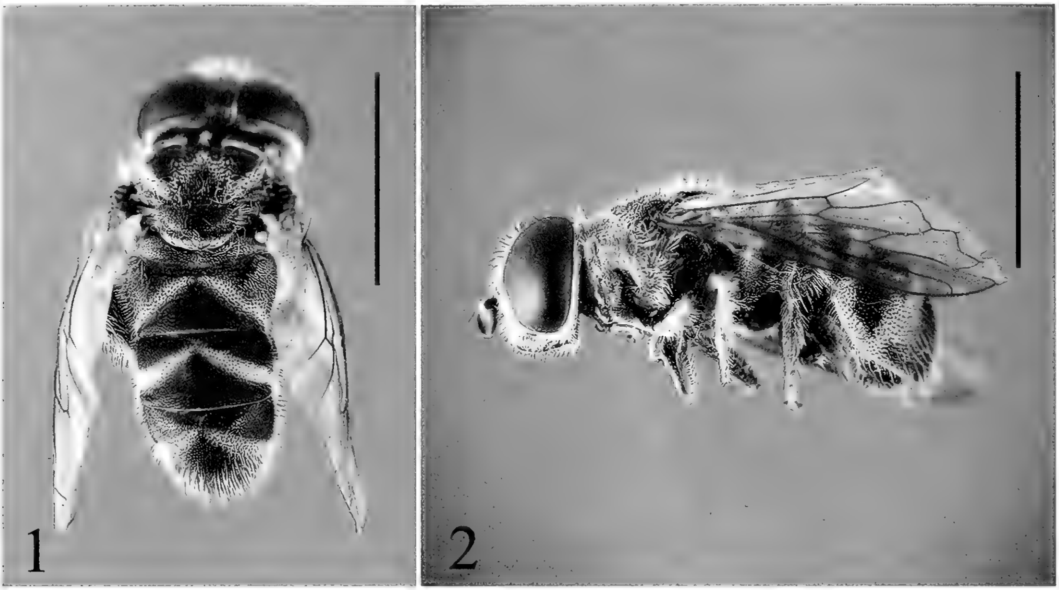
Larvae have been found on a variety of host plants of economic importance: bulbs of Liliaceae (onion and hyacinth); Amaryllidaceae (narcissus); Iridaceae (iris); stems of Umbelliferae (parsnip and carrot); tubers of Solanaceae (potato); roots of Compositae (salsify); and bulbs and roots of Orobanchaceae (Pérez-Bañón and Marcos-Garcia 1998).

Larvae of *Eumerus* may be identified by the following characters: mouth hooks and fleshy mandibular lobes outside the mouth; dorsal lip with a setal fringe; antenno-maxillary organs on flattened, oval-shaped lobes; middle pair of lappets divided into two small projections; locomotor organs barely projecting from ventral surface; and posterior respiratory process at tip of slightly extended anal segment (Rotheray and Gilbert 1999).

Adults are small to medium-sized, black or black and red, and with characteristic wing venation: crossvein r-m apical to middle of cell dm and vein M1 strongly angulate with spurs. The hind femur is often swollen and armed in the male of some species. The face is also characteristically pilose, without a tubercle, and the mouth edge only slightly projecting. Most are thermophilous and may be found in grasslands and at the borders of woods and bushes, often near the larval food plants. Most species fly quickly near the ground, which makes them difficult to spot (Hull 1949). The genus can be keyed out in Thompson (1999).

This is the second record of *Eumerus* in the Neotropical Region. Previously, *Eumerus funeralis* Meigen [as *tuberculatus* Rondani] was reported from Magdalena, Colombia (Thompson et al. 1976). This is the first record of the genus in Brazil and the first record of *E. obliquus* (Fabricius) (Figs. 1, 2) for the Neotropical Region. A single female of *E. obliquus* was collected in a Malaise trap in the vicinity of Ponta Grossa, Paraná, southeastern Brazil. The collecting was carried out as part of the project PROVIVE (Projeto de Levantamento da Fauna Entomológica de Vila Velha, Ponta Grossa, Paraná, Brasil – Survey of the Entomological Fauna of Vila Velha State Park, Ponta Grossa, Paraná, Brazil). The specimen was caught during the week of 06-13.IX.1999 in a forest that has been in a natural process of regeneration for about 20 years. The locality, once used for seasonal crops such as beans and corn, is about 335 m from the edge of the forest.

Another female of *E. obliquus* was collected with a hand net in the State of São Paulo, in Ribeirão Preto, 15.VII.2003, on *Cajanus cajan* (L.) Mill. (Fabaceae). The Brazilian common name for this crop is Guandu-anão. This is



Figs. 1–2. *Eumerus obliquus*, female. 1, Habitus, dorsal view. 2, Habitus, lateral view. Scale bar = 3 mm.

a very common plant in central Brazil that was introduced from Africa through Guyana by slaves. It is edible and considered a good source of protein (Morton et al. 1982).

The distribution of *E. obliquus* includes southern Europe, widespread in Africa including St. Helena and Madagascar, and Australia (introduced). These first records for Brazil confirm the presence of this species in the Neotropical Region. Because of the wide range of host plants (Moor 1973), this species probably has been introduced with various agriculturally important plants. Once introduced, it can adapt to native plant species (Pérez-Bañón and Marcos-Garcia 1998).

Pérez-Bañón and Marcos-Garcia (1998) studied the larvae of *Eumerus purpurariae* Baez, 1982, and found some morphological similarities with those of *E. obliquus*. According to these authors, the morphological similarities between the two species probably are due to their similar food preferences such as decaying fluids from plant tissues.

The specimen collected in the state of Paraná was identified by F.C. Thompson, Systematic Entomology Laboratory, USDA, Washington, D.C., and the specimen from São Paulo State, by comparison to the first one. Both specimens are deposited in the Entomological Collection Pe. Jesus Santiago Moure, Department of Zoology, Curitiba, Paraná, Brazil.

We are grateful to F.Christian Thompson (Systematic Entomology Laboratory, USDA, Washington, D.C.) for the identification of the material and critical review of the manuscript; to Ángeles Marcos-García (Centro Iberoamericano de la Biodiversidad, Universidad de Alicante, Spain) and Wayne N. Mathis (National Museum of Natural History, Smithsonian Institution, Washington, D.C.) for critical review; to Ana Maria de Faria (Secretaria de Agricultura e Abastecimento, Ribeirão Preto, São Paulo, Brazil) for donation of the specimen to the Entomological Collection Pe. Jesus Santiago Moure, DZUP; and to CNPq for financial support. This is contribution number 1641 from the Department of Zoology of Federal University of Paraná, Curitiba, Paraná, Brazil.

LITERATURE CITED

Hull, F. M. 1949. The morphology and interrelationship of the genera of syrphid flies, recent and fossil. Transactions of the Zoological Society of London 26(4): 257–408.

Moor, F. C. de. 1973. Notes on a syrphid fly, *Eumerus obliquus* (Fabricius) (Diptera: Syrphidae). Arnoldia 6(15): 1–7.

Morton, J. F., R. E. Smith, M. A. Luco-Lopez, and R. Abrans. 1982. Pigeon-peas *Cajanus cajan* Millsp): A Valuable Crop of the Tropics. Mayaguez, University of Puerto Rico - Department of Agronomy and Soils, Puerto Rico, 122 pp.

Pérez-Bañón, C. and A. Marcos-Garcia. 1998. Life history and description of the immature stages of *Eumerus purpurariae* (Diptera: Syrphidae) developing in *Opuntia maxima*. European Journal of Entomology 95(3): 373–382.

Rotheray, G. and F. Gilbert. 1999. Phylogeny of Palaearctic Syrphidae (Diptera): evidence from larval stages. Zoological Journal of the Linnean Society 127: 1–112.

Thompson, F. C. 1999. A key to the genera of the flower flies (Diptera: Syrphidae) of the Neotropical Region including descriptions of new genera and species and a glossary of taxonomic terms. Contributions on Entomology, International 3(3): 322–378.

Thompson, F. C., J. R. Vockeroth, and Y. S. Sedman. 1976. A Catalogue of the Diptera of the Americas South of the United States. Museu de Zoologia da Universidade de São Paulo, São Paulo. 46, 195 pp.

Luciane Marinoni and Mírian Nunes Morales, *Departamento de Zoologia, Universidade Federal do Paraná, Caixa Postal 19020, 81531-980, Curitiba, Paraná, Brazil (e-mail: lmarinoni@ufpr.br; mirian_nm@yahoo.com.br)*

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 496–498

NOTE

First Record of the Raspberry Pest *Priophorus brullei* (Dahlbom) (Hymenoptera: Tenthredinidae: Nematinae: Cladiini) in South America

Sawflies are economically important insects that include major agricultural, forest, and horticultural pests (Raffa and Wagner 1993). The family Tenthredinidae is the largest of the Symphyta, with approximately 5000 species worldwide. Throughout the Neotropical Region there are more than 400 species in about 32 genera (Smith 2003). The subfamily Nematinae is a diverse and widespread group, reaching its maximum diversity in arctic and subarctic Eurasia and North America, with more than 1000 species in 35 genera. In South America, however, only two genera are known, *Pristiphora* Latreille with nine endemic species from México to Brazil and *Nematus* Panzer with a single introduced species in Argentina and Chile (Smith 2003). *Priophorus* Dahlbom was not known in South America at the time of Smith's (2003) treatment of Neotropical Nematinae.

We found and collected six adults and nine larvae of *Priophorus brullei* (Dahlbom) [= *Priophorus morio* (Lepeletier)] (Fig. 1) feeding on leaves of *Rubus idaeus* L. (var. Tulameen, which has one annual

Fig. 1. Adult female of *Priophorus brullei* from El Bolsón, Río Negro, Argentina.

Fig. 2. Area of study site in Argentina.

bloom) in a commercial planting in El Bolsón, Río Negro, Argentina (Fig. 2). This constitutes the first record of this crop pest for South America. There is also a record of this species feeding on raspberry (*Rubus* sp.) in Chile, Osorno, Jan/Feb 2002, E. Cisternas A. (Smith, unpublished). The collected individuals were identified by DRS and agree with the treatment of this species in the identification keys of Smith (1974) and Naumann et al. (2002). According to Smith (1974), the female of this species is recognized by the sheath that is broadened at its base in dorsal view (Smith 1974: fig. 11); the lancet with the annuli distinctly slanted (Smith 1974: fig.14); an average length of 5.5 mm; the black coloration with brownish maxillary and labial palpi, the brownish to whitish tegulae, the entirely white extreme apex of each femur, tibia, and basitarsus; and the uniformly, lightly infuscated wings. Males are seldom found. Mature larvae are usually light green with three brown spots on the head and a broad, dorsal longitudinal brown stripe on the body and measure approximately 12 mm in length. Voucher specimens of *P. brullei* from Argentina are deposited in the Museo de La Plata, La Plata, Argentina.

In Smith's (2003) key to the subfamilies of Neotropical Nematinae, *Priophorus* will run to couplet 3 from which it may be distinguished from the Selandriinae and other subfamilies leading to couplet 4 by the following characteristics of the forewing: vein 2r-m absent, base of Rs+M near Sc+R straight; vein 2A+3A complete, fused with 1A at center; veins M and 1m-cu divergent; and veins M and Rs+M meeting Sc+R at about the same point. The forewing venation can be compared with Fig. 1.

The source of introduction of *P. brullei* is unknown because of its widespread, Holarctic distribution. It was accidentally introduced in Australia and New Zealand (Callan 1978, Valentine and Walker 1991) and was intentionally introduced as a biological control agent for blackberry in Hawaii (Nakao 1967, Davis 1976).

The larvae feed on the undersides of the basal leaves of several species of *Rubus* spp. (raspberries) and *Sorbus* spp. (mountain ash) (Smith and Kido 1949, Bruzzese 1980, Raspé et al. 2000), causing serious damage. In North America and Australia, the species reproduces by thelytokous parthenogenesis (Callan 1978) and has as many as three generations a year (Smith and Kido 1949, Smith 1974). The female oviposits in the leaf petioles or the tender bark of new shoots. Larvae consume the entire leaf tissue leaving circular holes between the veins. Mature larvae burrow into the soil or beneath or within ground litter and pupate within silken cocoons.

The reproductive strategy and number of generations per year are not known for populations found in southern South America. Further study is needed to monitor this raspberry pest and evaluate its economic impact in Argentina.

We thank Nacho Siemmersi and Graciela Maregiani for kindly helping with this study.

Literature Cited

Bruzzese, E. 1980. The phytophagous insect fauna of *Rubus* spp. (Rosaceae) in Victoria, a study on the biological control of blackberry (*Rubus fruticosus* L. agg). Journal of the Australian Entomological Society 19: 1–6.

Callan, E. McC. 1978. Biological notes on the introduced sawfly *Priophorus morio* (Lepeletier) (Hymenoptera: Tenthredinidae). Journal of the Australian Entomological Society 17: 23–24.

Naumann, I. D., M. A. Williams, and S. Schmidt. 2002. Synopsis of the Tenthredinidae (Hymenoptera) in Australia, including two newly recorded, introduced sawfly species associated with willows (*Salix* spp.). Australian Journal of Entomology 41: 1–6.

Davis, C. J. 1976. *Priophorus morio* (Lepeletier). Notes and exhibitions. Proceedings of the Hawaiian Entomological Society 22: 178.

Nakao, H. R. 1967. Releases of blackberry insects: *Priophorus morio* (Lepeletier). Proceedings of the Hawaiian Entomological Society 19: 339.

Raspé, O., C. Findlay, and A. L. Jacquemart. 2000. *Sorbus aucuparia* L. Journal of Ecology 88: 910–930.

Raffa, K. F. and M. R. Wagner, eds. 1993. Sawfly Life History Adaptations to Woody Plants. Academic Press, Inc., San Diego, New York etc. XX +581 pp.

Smith, D. R. 1974. Sawflies of the tribe Cladiini in North America (Hymenoptera: Tenthredinidae: Nematinae). Transactions of the American Entomological Society 100: 1–28.

———. 2003. A synopsis of the sawflies (Hymenoptera: Symphyta) of America south of the United States: Tenthredinidae (Nematinae, Heterarthrinae, Tenthredininae). Transactions of the American Entomological Society 129: 1–45.

Smith, L. M. and G. S. Kido. 1949. The raspberry leaf sawfly. Hilgardia 19: 46–54.

Valentine, E. W. and A. K. Walker. 1991. Annotated Catalogue of New Zealand Hymenoptera. DSIR Plant Protection Report 4. DSIR Plant Protection, Auckland.

Mariano Lucia, Alberto Horacio Abrahamovich, Eleonora Trejo, and David R. Smith, *(ML, AHA) División Entomología, Museo de La Plata, Universidad Nacional de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina (e-mail: mlucia@fcnym.unlp.edu.ar); (ET) Sede FAUBA, El Bolsón, Río Negro, Argentina; (DRS) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, DC 20013-7012, U.S.A. (e-mail: dave.smith@ars.usda.gov)*

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 499

NOTE

Species Numbers of Cecidomyiidae (Diptera) by Zoogeographical Region

Since *A Catalog of the Cecidomyiidae of the World* (Gagné 2004) appeared I have been asked several times to provide the number of species that occur in each of the larger zoogeographic regions. This information should have been given in the catalog, so it is belatedly provided in the following table, additionally divided by subfamily.

Fossil species were not counted for the table and some species occur in more than one region, with the result that the totals in the bottom line here add up to more than the 5,451 species listed in the catalog. For example, the Nearctic and Palearctic Regions share 53 Lestremiinae, 12 Porricondylinae, and 46 Cecidomyiinae.

The comparative disparity in numbers of species among the regions reflects taxonomic opportunity, effort, and interest, rather than the actual numbers that must occur. Gall midges all over the world, least so in Europe, are generally poorly known. I once wondered how that great unknown could be grasped more quickly, but I see now that nothing can replace careful and contextual study. In fact, a great part of the fauna that is already named was insufficiently described and requires revision before any meaning can be drawn from it. We should learn from past work that there are no shortcuts.

LITERATURE CITED

Gagné, R. J. 2004. A catalog of the Cecidomyiidae (Diptera) of the world. Memoirs of the Entomological Society of Washington No. 25, 408 pp.

Raymond J. Gagné, *Systematic Entomology Laboratory, PSI, Agricultural Research Service, U. S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, NHB 168, P.O. Box 37012, Washington, DC 20013-7012, U.S.A. (e-mail: raymond.gagne@ars.usda.gov)*

	Nearc.	Neotr.	Palearc.	Afrotr.	Orient.	Austral.	Oceanian
Catotrichinae	2		3			1	
Lestremiinae	90	7	417	3	66	15	8
Porricondylinae	94	9	418	15	50	10	1
Cecidomyiinae	983	517	2219	147	219	221	23
Totals	1169	533	3057	165	335	247	32

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 500–502

BOOK REVIEW

Olethreutinae Moths of Australia, Monographs on Australian Lepidoptera, Volume 10, by Marianne Horak, with contributions by Furumi Komai. 528 pages, 984 black-and-white photographs; 7″ × 10″; ISBN 0-643-09093-2. AU $160.00 (ca. $120.00 US) hardback. CSIRO Publishing. Publication date: July 2006.

For over two decades, Marianne Horak has been one of the world's leading experts in tortricid systematics, with seminal contributions to van der Geest and Evenhuis' *Tortricid Pests, their Biology, Natural Enemies and Control* (Horak 1991, Horak and Brown 1991), to Neilsen, Edwards, and Rangsi's *Checklist of Australian Lepidoptera* (Horak et al. 1996), and to Kristensen's *Handbook of Zoology* (Horak 1998). Her systematic work is thorough, her morphological investigations are meticulous, and her knowledge of the world fauna is unparalleled. Her recently published monograph on Australian Olethreutinae, the subject of this book review, is the crowning achievement in a highly productive career focused primarily on Tortricidae.

Most of us tortricid systematists impatiently apply our craft to taxa and regions of various sizes, inevitably leaving a trail of papers, each of which addresses a different species group, genus, country, or geographic region, but rarely fully treating an entire fauna or larger taxon in a single tome. Horak has shown the patience and perseverance to complete a thorough taxonomic study of the entire subfamily Olethreutinae for the entire continent of Australia. In this volume she reviews the 90 olethreutine genera and 249 described species (and provides comments on an additional 200 undescribed species) occurring in Australia. Because much of the fauna is derived from that of the Oriental Region, biogeographically and phylogenetically, the treatment has significant impact on the classification of the Olethreutinae of a geographic area much broader than Australia alone. Each genus is described in detail, diagnosed and defined by synapomorphies, and discussed in the context of biogeography and phylogenetic relationships; in addition, all the constituent species of the Australian fauna are listed.

The text of this monograph is presented in 8 major sections, not including the standard front material (i.e., abstract, introduction, materials and methods, and acknowledgments): 1. Phylogeny of the Olethreutinae, 2. Morphology, 3. Biology, 4. Diversity and Distribution, 5. Australian Olethreutinae Genera, 6. References, 7. Appendices, and 8. Index.

The first section, Phylogeny of the Olethreutinae, presents a detailed list of 126 morphological characters for 73 of the included genera plus two outgroups, along with the results of a cladistic analysis using WinClada. As Horak concludes, the results portrayed in the consensus tree should be viewed as preliminary and somewhat inconclusive since several widely accepted groupings based on synapomorphies are not recovered in the analysis. It is likely that additional characters are required to more accurately identify relationships among the genera. Nonetheless, the data matrix represents an important first step in the development of a phylogeny for the Australian and Oriental members of the subfamily upon which a stable classification can begin to be built.

The Morphology section is thorough and rich in details. The 20 pages of wing venation provide an outstanding visual summary of the variation in shape, venation, and male secondary structures found in the Australian and Oriental Olethreutinae. The Biology section presents a brief overview of tortricid life histories and larval food plants. And the Diversity and Distribution section likewise presents a brief analysis of different olethreutine tribes within Australia and comparisons with other well-documented faunas.

Section 5, Australian Olethreutinae Genera, is the meat of the monograph, with over 400 pages of diagnoses, descriptions, and illustrations of the included taxa. For each tribe there are "status remarks," "evidence for monophyly," "diagnosis," "distribution," "biology," and "remarks." The text in this section reveals the depth of Horak's knowledge of the fauna. Included are the kinds of details and factoids that experts accumulate over a career of working on a taxon but seldom find the right medium in which to convey them. Of particular interest to me are the myriad host-plant records based on Horak's personal experience, the card file at CSIRO (compiled primarily by the late I. F. B. Common), and the work of her colleagues in Australia and elsewhere. In this section she describes 12 new genera and 16 new species along with proposing 121 new combinations (41 for the Australian fauna and 80 for non-Australian species). For the tribe Grapholitini, Horak enlisted the assistance of the highly regarded Japanese tortricid taxonomist Furumi Komai, and the results are outstanding.

The final three sections, References, Appendices (morphological character matrix and host plants by tortricid genus), and Index, are thorough as one would expect in a professional taxonomic treatment. While the last two are listed in the Table of Contents as sections "7" and "8," respectively, their title pages in the text lack the numbering system used for other major sections - an extremely trivial format oversight that does not detract from the presentation.

Like other CSIRO publications, the physical aspects of the book are very good - strong binding, high quality paper, and no wasted space. Fonts are highly legible, headings are clear and well defined, and illustrations are nicely organized, distributed throughout the text rather than clustered at the back or middle.

This book is in a vein similar to Diakonoff's (1973) classic South Asiatic Olethreutini, and it is destined to become the new reference for all systematic work on Olethreutinae of Indo-Australia and southern Asia. But it has broader geographic implications as well, because many of the treated genera are distributed in various continents around the globe: e.g., *Megalota*, with its southern continental distribution; *Crocidosema*, with its nearly cosmopolitan distribution; and *Spilonota*, with its Palaearctic-Oriental-Australian range. This book is undoubtedly one of the most significant and original contributions to tortricid systematics to appear in the last few decades, and its impact likely will be felt by generations of tortricid systematists. Anyone working on tortricid moths at the global level in any context (e.g., biogeography, taxonomy, host plants) absolutely will have to consult this volume.

Horak is to be congratulated for her tenacity in finishing this overwhelming project and creating a masterpiece in the process. She has set the bar high for her fellow tortricid taxonomists and Lepidoptera systematists in general.

LITERATURE CITED

Diakonoff, A. 1973. The South Asiatic Olethreutini (Lepidoptera: Tortricidae). Zoologische Monographieen van het Rijksmuseum van Natuurlijke Historie 1. 699 pp.

Horak, M. 1991. 1.1 Morphology, pp. 1–22. *In* van der Geest, L. P. S. and H. H. Evenhuis, eds. Tortricid Pests, Their Biology, Natural Enemies and Control. Elsevier Science Publishers B. V., Amsterdam.

———. 1998. Tortricoidea, pp. 199–215. *In* Kristensen, N., ed. Lepidoptera, Moths and Butterflies. Volume 1: Evolution, Systematics, and Biogeography. Handbook of Zoology 4 (35), Arthropoda: Insecta. Walter de Gruyter, Berlin & New York.

——— and R. L. Brown. 1991. 1.2 Taxonomy and phylogeny, pp. 23–48. *In* van der Geest, L. P. S. and H. H. Evenhuis, eds. Tortricid Pests, Their Biology, Natural Enemies and Control. Elsevier Science Publishers B. V., Amsterdam.

———, I. F. B. Common, and F. Komai. 1996. Tortricidae, pp. 123–136. *In* Neilsen, E. S., E. D. Edwards and T. V. Rangsi, eds. Checklist of Australian Lepidoptera. Monographs on Australian Lepidoptera 4. CSIRO, Canberra, Australia.

John W. Brown, *Systematic Entomology Laboratory, P.S.I., Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Washington, DC 20013-7012, U.S.A. (e-mail: john.brown@ars.usda.gov)*

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 503–505

REPORTS OF OFFICES FOR 2007

PRESIDENT

Serving as President of the Entomological Society of Washington for 2006 has been a rewarding endeavor. During this past year, we had diverse and interesting speakers at our well-attended meetings in the National Museum of Natural History. Our society continues to be among the preeminent entomological societies in the world.

The annual banquet and lecture, also held again in the National Museum of Natural History, was well-received and a great success. This year it was organized by Michael Gates, and I thank him for his hard work.

During 2006, it was necessary to relocate and redistribute all the back issues of memoirs and special publications that had been accumulating for decades in Beltsville, Maryland. This was estimated at over 5,000 copies. I am pleased to report that in one day, after they were transported to the museum and frozen, all were distributed among the ordinal units, except for a requisite amount of copies for sale. I thank all the officers for their help to efficiently solve this storage problem.

This past June, our society gave a $500 contribution to the Nature Conservancy to support the Potomac Gorge Bioblitz, an intensive 2–3 d survey of arthropods in the National Park along the Potomac River. This survey greatly increased our understanding of the local fauna and arthropod distribution and our society received some well-deserved positive press.

In November, our society was pleased to recognize the tireless efforts of Dave Smith, Editor, for his work to consistently produce a quality journal in a prompt fashion. In this regard, the officers approved a $1,000 honorarium for his dedication to the Society during 2006.

I thank the following members of the Audit Committee for reviewing the Treasurer books: Norman Woodley (Chair), Alexander Konstantinov, and Jens Prena. I thank the following members of the Nominating Committee for selecting a slate of candidates for officer positions for 2007: F. Christian Thompson (Chair), Thomas Henry, and Warren Steiner. Thanks to all the officers for their efforts to maintain the society as one of the most significant entomological societies in the world.

Respectfully submitted,
Steven W. Lingafelter, *President*

EDITOR

Volume 108 of the *Proceedings* included four issues with a total of 1,028 pages. Ninety-six regular papers, 10 notes, and 7 book reviews were published. Also included were minutes of the Society meetings, membership list, reports of officers, instructions for authors, list of speakers at regular meetings, notice of a new publication, and the table of contents for volume 108. About 105 manuscripts (regular papers and notes) were submitted for consideration for publication from November 1, 2005 through October 31, 2006.

The Miscellaneous Publication "A Phylogenetic Revision of the Napaeina (Lepidoptera: Riodinidae: Mesosemiini)" by Jason P. W. Hall was published in December 2005.

I extend thanks to members of the Publications Committee – Ray Gagné, Tom Henry, and Wayne Mathis – for their advice, encouragement, and support. Ray Gagné, as Book Review Editor, has provided excellent book reviews for publication. I am especially grateful to the many reviewers for their time-consuming efforts and constructive reviews of manuscripts. Their contributions are essential to help maintain the quality of papers published in the *Proceedings*.

Respectfully submitted,
David R. Smith, *Editor*

TREASURER

SUMMARY FINANCIAL STATEMENT FOR 2006

	General Fund	Special Publication Fund	Total Assets
Assets: November 1, 2005	$42,658.57	$131,860.74	$190,315.75
Total Receipts for 2006	$76,827.00	$ 5,909.10	$ 82,736.10
Total disbursements for 2006	$84,454.78	$ 16,602.00	$101,056.78
Assets: October 31, 2006	$35,030.79	$121,167.84	$156,198.63
Net Changes in Funds	$ (7,627.78)	$ (10,692.90)	$ (18,320.68)

Audited by the Auditing Committee, December 5, 2006, consisting of Norman E. Woodley, Chair, Alex S. Konstantinov, and Jens Prena. Presented to the membership at the meeting of December 7, 2006.

Respectifully submitted,
Michael G. Pogue, *Treasurer*

CUSTODIAN

Mailings from 1 November 2005 through 31 October 2006:

Proceedings of the Entomological Society of Washington:

2003 Volume 105(1) – 3; (2) – 3; (3) – 3; (4) – 4.
2004 Volume 106(1) – 3; (2) – 3; (3) – 3; (4) – 6.
2005 Volume 107(1) – 13; (2) – 11; (3) – 15; (4) – 28.
2006 Volume 108(1) – 44; (2) – 29; (3) – 13; (4) 7.

Miscellaneous Publications:

A Phylogenetic Revision of the Napaeina by J.P.W. Hall – 9.
A Handbook of the Families of Nearctic Chalcidoidea, Second Edition, Revised, by E.E. Grissell & M.E. Schauff – 15.

Revision of *Anoplophora* by S.W. Lingafelter & E.R. Hoebeke – 2
Revision of the Oriental Species of *Aphthona* Chevrolat by A.S. Konstantinov & S.W. Lingafelter – 1.

Memoirs of the Entomological Society of Washington:

Memoir 1 – 1; Memoir 4 – 1; Memoir 5 – 1; Memoir 14 – 4; Memoir 15 – 2; Memoir 17 – 1; Memoir 18 – 2; Memoir 19 – 2; Memoir 20 – 2; Memoir 21 – 1; Memoir 23 – 1; Memoir 24 – 1; Memoir 25 – 7.

Respectfully submitted,
Jon A. Lewis, *Custodian*

Membership Secretary

In 2006 the Society received applications for membership from 26 people:

Roy J. Beckmeyer
Irina Brake
Mignon Davis
Anil Kumar Dubey
Dimitri Forero
Ali Gök
Coskun Güclü
Levent Gultekin
Tadashi Ishikawa
Daniel Kjar
Khouzama Knio
Chiun-Cheng Ko
James E. Korechi
Catherine P. Murphy
Carlos Eduardo Nasraui
Charles E. Olsen
Gary Ouellette
Gustavo Quevedo Romero
John A Rumph
Justin Runyan
John W. Sharpe, II
Jae-Chen Sohn
Jeffrey Sosa-Calvo
Betty Thompson
Timothy Tomon
Thomas Zavortink

Each applicant was sent a letter of welcome to the Society and his/her name was read at a regular monthly meeting. The number of applications increased 215% from 2005. Other letters from the Membership Secretary included six letters to guest speakers, seven letters to special fund contributors, and five replies to requests for information.

Respectfully submitted,
Holly B. Williams,
Membership Secretary

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 506–509

SOCIETY MEETINGS

1,101st Meeting – May 4, 2006

The 1,101st meeting of the Entomological Society of Washington was held in the Cathy Kerby room of the National Museum of Natural History. The minutes of this meeting have been misplaced. However, the speaker for the evening was Dr. Cole Gilbert, Department of Entomology, Cornell University, Ithaca, NY, whose presentation was entitled "All the Better to See You with My Dear: Visually-Guided Aerial Pursuit of Females by Male Flies."

Dr. Gilbert presented behavioral, physiological, and anatomical results from his studies of the way in which male flesh flies aerially pursue females. Compared to females, males have a special area of the retina that has higher visual acuity and is served by sexually-dimorphic neurons in the optic lobe. In flight, males may change the position of their head to look at the females and they monitor head position with a propriosensory organ in the neck. The organ, however, is not present in all groups of flies. It first appears in the higher nematocerous flies and was modified gradually in the Brachycera.

1,102nd Meeting – June 6, 2006

The 1,102nd meeting of the Entomological Society of Washington (ESW) consisted of the Annual Banquet, held on the first floor of the National Museum of Natural History, Washington, D. C., in conjunction with the Maryland Entomological Society and the Botanical Society of Washington. After an open bar starting off at 6:30 p.m., and dinner, the group of about 85 moved to the Baird Auditorium for the main event: the presentation "Tricksters, Hypnotists, and Puppeteers: the Strategies and Tools of Parasitoid Hymenoptera," delivered by Dr. Michael Sharkey, of the University of Kentucky. This was an overview of the interesting life histories of the microhymenoptera, and a discussion of the "ovipositor clip" that enables them to lock onto their host while injecting their lethal spawn.

The meeting was adjourned at 9:00 p.m.

Respectfully submitted,
Stuart H. McKamey
Recording Secretary

1,103rd Regular Meeting – October 5, 2006

The 1,103rd regular meeting of the Entomological Society of Washington (ESW) was called to order in the Rose room of the National Museum of Natural History, Washington, D. C., by President Steve Lingafelter at 7:05 p.m. The meeting was packed with 28 members and 20 guests. Minutes of the 1,102nd meeting were approved as read.

President Lingafelter announced his appointment of Chris Thompson as the chair of the nominating committee, noted that the officers of the Society had approved another Miscellaneous publication by Jason Hall, and suggested that the society provide $1,000 to $2,000 for PESW editor Dave Smith as a small token of our appreciation of his many years of effort.

There were seven new applicants for membership: Levent Gultekin, Thomas Zavortink, Tadashi Ishikawa, Gustavo Quevedo Romero, Catherine Murphy, John Rumph, and Daniel Kjar. No new members were present. Eight visitors were introduced.

In miscellaneous business, President Lingafelter suggested that we update the ESW website, which hasn't been done for three years. Art Evans discussed the success of the ESW – subsidized Virginia Bioblitz this past June, which observed and/or collected over 1,000 species of invertebrates and announced an upcoming Virginia BeetleBlitz in June, 2007.

For exhibits, Stu McKamey had the bilingual book "*Treehoppers of Tropical America*" and a new CD "*Bibliography of the Hemiptera*." Charlie Stains had "*The Hispine Beetles of America North of Mexico (Chrysomelidae: Cassidinae)*," Art Evans brought "*Dragonfly Genera of the New World*," "*Field Guide to Beetles of California*," and the magnificently photograph-endowed "*Insects. Their Natural History and Diversity, with a Photographic Guide to Insects of Eastern North America*," by S.A. Marshall, who was humbly present at the meeting. Dave Furth brought an example of the phenomenon of ants nesting in electrical devices. He brought five new books: "*Verbreitungsatlas der Libellen des Grossherzogtums Luxemburg*" [dragonflies of Luxemburg], and two 2-volume publications, "*Lepidoptera Pupae of Central Europe*" and "*Handbook of the Bruchidae of the United States and Canada (Insecta: Coleoptera)*." Each set had text in one volume and figures in the other.

Dave Furth introduced the speaker, Akito Kawahara, a student at the University of Maryland, Department of Entomology. His presentation was entitled "Thirty-foot Telescopic Nets, Bug-collecting, Videogames, and $1,000 Beetle Pets: Entomology in Modern Japan." The crux of the talk was that the Japanese populace is inundated from an early age by a positive portrayal of insects in a wide variety of ways, as suggested by the title. Insect supplies, live insects, and insect food is typically available in department stores, TV shows on insects feature identification contests, documentaries, and cartoons, and children's toys and books often feature taxa not considered charismatic in the United States, such as *Polistes* wasps and dung beetles. There are also a wide variety of guides for adults that give extensive information on precisely when and where to find particular species. Akito also admitted that the pervasive interest in entomology in Japan has caused problems, as well, such as permitless collection in foreign countries, a Japanese law allowing importation of such specimens, the sale of type specimens, and important collections held privately and seldom available for research.

The meeting was adjourned at 8:40 p.m. Refreshments were provided by the Society.

Respectfully submitted,
Stuart H. McKamey
Recording Secretary

1,104th Regular Meeting –
November 2, 2006

The 1,104th regular meeting of the Entomological Society of Washington (ESW) was called to order in the Cathy Kerby room of the National Museum of Natural History, Washington, D. C., by President Steve Lingafelter at 7:02 p.m. The meeting was attended by 16 members and 8 guests. Minutes of the 1,103rd meeting were approved with modification.

President Lingafelter announced that Gary Oulette and Jerry Louten had volunteered to help update the Society's website and that by unanimous vote the ESW Executive Committee approved a token $1,000 for PESW editor Dave Smith in appreciation of his many years of effort.

There was one new applicant for membership, Betty Thompson, who was present. One visitor was introduced.

Chris Thompson, Warren Steiner, and Tom Henry obtained a slate of officers to be voted on at the December meeting, unless additional nominations are obtained from the floor.

For exhibits, Edd Barrows had his book, "*Nature, Gardens, and Georgetown*" and some carpenter bee nest holes. Chris

Thompson had three items: the "*National Academy Report, Synopsis on Native Pollinators*," noting that many species are declining significantly in the USA and elsewhere, "*On the Fly*," a CD with a LUCID key to Australian families, and the bilingual book from INBio, "*Diptera of Costa Rica*." Matt Buffington invited members to use his GT Vision automontage system. Warren Steiner had two books: Cahiers Scientifiques, Lyon, Fascicle 10, "*Proceedings of the Second International Symposium on Tenebrionidae*," and the Bulletin of the Biological Society of Washington, "*Vascular Plant Checklist of Plummer's Island, Maryland*." Dave Furth had only two books, "*Things Great and Small*," a natural collections policy book, and a National Geographic with a mantid photo. He also noted that he has supplies of the Smithsonian entomology department T-shirts available for purchase in adult and children sizes.

Dave Furth introduced the speaker, Dr. Faith Deering of the University of Massachusetts, Amherst, whose presentation was entitled "Lac, from Forest to Factory." Dr. Deering and colleagues were sent on an expedition to get the story of the scale insect *Kerria lacca* in Thailand. These sessile female insects occur in colonies of hundreds of thousands and occur naturally on a variety of hosts, but are raised on, and harvested from only one species, the fabaceous monkeypod tree. Use of the lac insect for color and resin date back to Roman times (250 A.D.) and despite the invention of synthetic resin in 1856, still has a wide variety of uses, including red lipstick and slow-release pills, and approximately 260,000,000 records between 1907 and the invention of vinyl. Dr. Deering described the many steps involved in harvesting and processing, and their rearing of many predators captured in the colonies, though perhaps not all on lac.

The meeting was adjourned at 8:07 p.m. Refreshments were provided by the Society.

Respectfully submitted,
Stuart H. McKamey
Recording Secretary

1,105th Regular Meeting – December 7, 2006

The 1,105th regular meeting of the Entomological Society of Washington (ESW) was called to order in the Cathy Kerby room of the National Museum of Natural History, Washington, D. C., by President Steve Lingafelter at 7:04 p.m. The meeting was attended by 17 members and 10 guests. Minutes of the 1,104th meeting were approved as read.

There were four new applicants for membership, Timothy Tomon, Mignon Davis, Chiun-Cheng Ko, and Anil Kumar Dubey. Five visitors were introduced.

President Lingafelter presided over the 2006 elections for each office. All of the following candidates were approved unanimously: President, Michael Gates; President-elect, Gary Hevel; Treasurer, Michael Pogue; Recording Secretary, Robert Kula; Membership Secretary, Hollis Williams; Custodian, Jon Lewis; Editor, David Smith; and Program Committee Chair, Mathew Buffington.

For exhibits, Mike Gates had the cover sheet of a publication so new that it hasn't yet escaped the Colombian ports, "*Introducción a los Hymenoptera de la Región Neotropical*," by F. Fernández and M. J. Sharkey, and the 1,000-page "*Hymenoptera de la Región Neotropical*," by P. Hanson and I. Gauld, whose reference list alone is close to 200 pages. David Furth had the latest issue of Nature Conservancy, featuring the Potomac Gorge Bioblitz organized by ESW member Art Evans.

Dave Furth introduced the speaker, Dr. Molly Rightmeyer of the University of Kansas and the Smithsonian Institution, who presented her work on the "Phylogenetics and Special Adaptations for Cleptoparasitism in the Bee Tribe Epeolini, with Emphasis on the Genus *Triepeolus* (Apidae)." The tribe is cosmopolitan, except absent in Australia. All of its approximately 300 species are cleptoparasites of solitary ground-nesting bees and have a specialized sixth sternum thought to facilitate insertion of their eggs into the soil walls of their host's nest cells. They lay their eggs in the provisioned cell of the host bee, their first instar immatures actively kill the host egg or larva, then revert to the immobile, stereotypical bee larvae to continue development. The generic diversity is greatest in the Neotropics, whereas 50% of the species occur in the arid Southwestern United States and Northern Mexico. There are only two speciose genera in the tribe: the species of one all parasitize species of one host genus, whereas the species of the other attack species of many apoid families.

Outgoing President Steve Lingafelter passed the gavel to incoming President Michael Gates, who adjourned the meeting at 7:54 p.m. Refreshments were provided by the Society and Ralph Eckerlin.

Respectfully submitted,
Stuart H. McKamey
Recording Secretary

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 510

CORRECTIONS

CORRECTION TO: Grissell, E. E.—Two new species of *Torymoides* Walker (Hymenoptera: Torymidae) from the American southwest, with a key to Nearctic species. Proceedings of the Entomological Society of Washington 108(3): 765–773.

In couplet 4 (p. 773) the following changes should be made:
Left column, line 9: change Fig. 12 to Fig. 20.
Left column, line 20: change Fig. 10 to Fig. 21.
Left column, line 23: change Fig. 10 to Fig. 21.
Left column, line 25: change Fig. 8 to "as in Fig. 14."

CORRECTION TO: Furth, David G.—A new genus and species of flea beetle (Coleoptera: Chrysomelidae: Alticinae) from the rainforest canopy of Costa Rica. Proceedings of the Entomological Society of Washington 109(1):90–101. The correct epithet for this new genus and species is *Laselva triplehorni* as cited throughout the text; however, the figure captions (Figs. 1, 2–3, 4–10) on pages 93, 94, 95, respectively, are incorrectly cited as *Laselvia. Laselva* is the correct spelling.

PROC. ENTOMOL. SOC. WASH.
109(2), 2007, pp. 511–512

Instructions for Authors

General policy.—Articles for publication are accepted from members and non-members. However, non-members pay a higher publication charge and cannot apply for a waiver of page charges. Only one author of an article needs to be a member for member rates. Articles must be in English, but an abstract in French, German, Spanish, Portuguese, Russian, and some other languages is acceptable. Such an abstract should be placed immediately after the English abstract and may be a translation of that abstract.

Manuscripts of 15 printed pages or less are encouraged, but longer manuscripts are acceptable and considered. Publication charges for pages over 15 are at a higher rate and are never waived. About two and one-half double-spaced typewritten pages equal one printed page. Manuscripts are peer reviewed before acceptance. Final acceptance is the responsibility of the Editor. Articles are published in the order received, not the date of acceptance. Immediate publication ahead of schedule is available with payment of full page charges. Notes, book reviews, and obituaries are published as space is available.

Manuscript submittal.—Manuscripts may be submitted as hard copy or electronically. For electronic submittal, send as an attachment to the editor: dave.smith@ars.usda.gov. Illustrations sent electronically should be in TIFF format. When submitting printed copies, please include three copies to the Editor. It is not necessary to send original illustrations until requested after the manuscript has been accepted. After acceptance, the editor will give instructions on sending the final copy and illustrations.

Format for manuscripts submitted should fit letter-sized paper. The entire manuscript should be double spaced, allowing adequate (1–1½″) margins. Words to be italicized may be indicated in italic form or underlined. Do not use bold face; the editor will mark what is to be in bold. Manuscript contents should be in the following sequence, and items 1–6 should begin a new page:

1. Title page with title, author(s), and author(s) byline. The corresponding author and address, telephone and fax numbers, and e-mail should be in the upper left corner. Title must include order and family placement, e.g., "… (Hymenoptera: Xyelidae)." Taxa of the genus- and species-group levels may have the author's name.
2. Abstract; key words. Key words should include those that do not appear in the title.
3. Text of paper; acknowledgments at end.
4. Literature cited (see below).
5. Figure legends.
6. Appendix; footnotes (if any).
7. Copies of tables; legends for tables are placed at the top of each table.
8. Copies of plates arranged in final form by author.

Illustrations.—There is no extra charge for line drawings or half tones. Authors should plan illustrations for reduction to dimensions of the printed page and allow room for legends at the bottom. Illustrations may be submitted on disk or CD, and should be in TIFF format with a resolution of 400–600 dpi; however, a printout of each illustration/plate should be provided. Illustrations also may be submitted mounted on suitable board which will be scanned by the printer. These should be trimmed, grouped together, abutted, and numbered when mounted, i.e., the author is responsible for preparation of the final plate. Consecutive figure numbers are preferred (not 1a, 1b, . . ., 2a, 2b, . . ., etc.), numbered consecutively in the sequence in which they are referred to in the text,

and positioning of the numbers for the figures at the lower right of each is preferred. Reference in the text should be as "Fig. 1," "Figs. 2, 3," "Figs. 2–5," and for Tables, "Table 1," etc. See recent *Proceedings* for style of figure legends.

Literature cited.—Cite only papers referred to in the text; list alphabetically by author; spell out references (e.g., journal names) completely, including conjunctions and prepositions. Do not italicize journal names or titles of books. See recent *Proceedings* for style of journals, books, and book chapters.

When referring to references in text, format as follows: Henry (1990), (Henry 1990), (Henry 1987, 1990), (Smith 1990, Henry 1991), (Smith 1990; Henry 1991, 1995), (Miller 1990a, 1990b), (Gagné et al. 1999). Do not italicize "et al." Citations "in press" should be cited as "in press," not with the expected year of publication. Cite as "in press" those papers that have been accepted for publication.

Names of persons providing unpublished information should include initials and be referenced in the text as: W. Mathis (personal communication) [information obtained orally] or W. Mathis (in litt.) [information obtained in writing].

Names of organisms.—The first mention of a plant or animal should include the full scientific name including the authority, spelled in full (authorities for plant names may be abbreviated). Generic names may be abbreviated after first use but should always be spelled out at the beginning of a sentence or if two or more genera being discussed have the same first letter. Within sentences use the generic name or initial preceding a species name.

Taxonomic papers.—Taxonomic papers must conform to requirements of the *International Code of Zoological Nomenclature* (1999). Holotypes must be designated for new species described, type depositories must be clearly indicated, and new taxa must be clearly differentiated from existing taxa by means of keys or differential diagnoses. An etymology section should provide the derivation of name(s), and the gender should be stated for all new genus-group names. In short, papers must conform to good taxonomic practices.

Book reviews.—Send to Dr. Raymond J. Gagné, Book Review Editor, or Editor at the address of the Society on the inside front cover. Electronic transmission is acceptable, to: rgagne@sel.barc.usda.gov, or dsmith@sel.barc.usda.gov. See recent issues of the *Proceedings* for format.

Charges.—Authors will be assessed a charge to cover editing and publication expenses. The current charges are $40.00 per printed page up to 15 pages for members and $60.00 per printed page for non-members, for all pages over 15, and for immediate publication. Charges for reprints, if ordered, and for author's corrections in proof are extra.

Member authors who are retired or not affiliated with an institution may request to have charges partially or completely waived *and should do so when the manuscript is submitted.* A maximum of 15 pages of an article may be waived. A complete or partial waiver may delay publication. Waiver of publication charges do not include cost of reprints, if ordered, or author's corrections in proof.

Acceptance of papers in based only on scientific merit without regard to the author's financial support.

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

MISCELLANEOUS PUBLICATIONS

A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera): Second Edition, Revised, by E. Eric Grissell and Michael E. Schauff. 87 pp. 1997	15.00
Revision of the Oriental Species of *Aphthona* Chevrolat (Coleoptera: Chrysomelidae), by Alexander S. Konstantinov and Steven W. Lingafelter. 349 pp. 2002	40.00
Revision of the Genus *Anoplophora* (Coleoptera: Cerambycidae), by Steven W. Lingafelter and E. Richard Hoebeke. 236 pp. 2002	30.00
A Phylogenetic Revision of the Napaeina (Lepidoptera: Riodinidae: Mesosemiini), by Jason P. W. Hall. 233 pp. 2005 Softcover 18.00, Hardcover	25.00

MEMOIRS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Memoirs 1, 2, 3, and 9 are no longer available.

No.4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No.5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No.6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No.7.	Ant larvae: Review and Synthesis, by George C. and Jeanette Wheeler. 108 pp. 1976	11.00
No.8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No.10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky, edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No.11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kammiya, 370 pp. 1983	18.00
No.12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No.13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton, 98 pp. 1987	18.00
No.14.	Biology and Phylogeny of Curculionoidea, edited by R. S. Anderson and C. H. C. Lyal. 174 pp. 1995	25.00
No.15.	A Revision of the Genus *Ceratopogon* Meigen (Diptera: Ceratopogonidae), by A. Borkent and W. L. Grogan, Jr. 198 pp. 1995	25.00
No.16.	The Genera of Beridinae (Diptera: Stratiomyidae), by Norman E. Woodley. 231 pp. 1995	25.00
No.17.	Contributions on Hymenoptera and Associated Insects, Dedicated to Karl V. Krombein, edited by B. B. Norden and A. S. Menke. 216 pp. 1996	25.00
No. 18.	Contributions on Diptera, Dedicated to Willis W. Wirth, edited by Wayne N. Mathis and William L. Grogan, Jr. 297 pp. 1997	25.00
No. 19.	Monograph of the Stilt Bugs, or Berytidae (Heteroptera), of the Western Hemisphere, by Thomas J. Henry. 149 pp. 1997	18.00
No. 20.	The Genera of Elaphidiini Thomson 1864 (Coleoptera: Cerambycidae), by Steven W. Lingafelter. 118 pp. 1998	12.00
No. 21.	New World *Blepharida* Chevrolat 1836 (Coleoptera: Chrysomelidae: Alticinae), by David G. Furth. 110 pp. 1998	12.00
No. 22.	Systematics of the North American Species of *Trichogramma* Westwood (Hymenoptera: Trichogrammatidae), by John D. Pinto. 287 pp. 1999	28.00
No. 23.	Revision of the Net-Winged Midges of the Genus *Blepharicera* Macquart (Diptera: Blephariceridae) of Eastern North America, by Gregory W. Courtney. 99 pp. 2000	14.00
No. 24	Holcocerini of Costa Rica (Lepidoptera: Gelechioidea: Coleophoridae: Blastobasinae), by David Adamski. 147 pp. 2002	18.00
No. 25	A Catalog of the Cecidomyiidae (Diptera) of the World, by Raymond J. Gagné. 408 pp. 2004	50.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $60.00 per volume to non-members and $25.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra on all orders. Dealers are allowed a discount of 10 percent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Treasurer, Entomological Society of Washington, ℅ Department of Entomology, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, D.C. 20013-7012.

CONTENTS

(Continued from front cover)

NOTES

BOOK REVIEW

MISCELLANEOUS

VOL. 109 JULY 2007 NO. 3
(ISSN 0013-8797)

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY
of **WASHINGTON**

PUBLISHED
QUARTERLY

CONTENTS

(Continued on back cover)

THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

ORGANIZED MARCH 12, 1884

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168.

MEETINGS.—Regular meetings of the Society are held in the Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 7:00 P.M. Minutes of meetings are published regularly in the *Proceedings*.

MEMBERSHIP.—Members shall be persons who have demonstrated interest in the science of entomology. Annual dues for members are $25.00 (U.S. currency).

PROCEEDINGS.—The *Proceedings of the Entomological Society of Washington* (ISSN 0013-8797) are published quarterly beginning in January by The Entomological Society of Washington. POSTMASTER: Send address changes to the Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember U.S. subscriptions are $60.00 per year and foreign subscriptions are $70.00 per year, payable (U.S. currency) in advance. Foreign delivery cannot be guaranteed. All remittances should be made payable to *The Entomological Society of Washington*.

The Society does not exchange its publications for those of other societies.

PLEASE SEE PP. 511–512 IN THE APRIL ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Editor: David R. Smith, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Books for Review: David R. Smith, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 28 June 2007

Periodicals Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 513–521

THREE NEW SPECIES OF CHEWING LICE (PHTHIRAPTERA: ISCHNOCERA: PHILOPTERIDAE) FROM AUSTRALIAN PARROTS (PSITTACIFORMES: PSITTACIDAE)

Roger D. Price and Kevin P. Johnson

(RDP) 1409 Burnham Court, Fort Smith, AR 72903-2579, U.S.A. (e-mail: rpricelice2@aol.com); (KPJ) Illinois Natural History Survey, 1816 South Oak Street, Champaign, IL 61820-6970, U.S.A. (e-mail: kjohnson@inhs.uiuc.edu)

Abstract.—Three new Australian philopterid chewing louse species from parrots are described and illustrated. They and their type hosts are ***Neopsittaconirmus vincesmithi*** from Bourke's parrot, *Neopsephotus bourkii* (Gould), from Western Australia and ***Neopsittaconirmus bushae*** and ***Echinophilopterus claytoni***, both from the Bluebonnet, *Northiella haematogaster* (Gould), from New South Wales. A portion of the mitochondrial COI gene was sequenced for these species and other parrot lice to evaluate their genetic distinctiveness.

Key Words: chewing lice, *Neopsittaconirmus*, *Echinophilopterus*, Phthiraptera, Philopteridae, parrots, Australia

The chewing louse philopterid genus *Neopsittaconirmus* Conci has been thoroughly treated by Guimarães (1974), with two subsequent works by Price and Emerson (1978, 1985) having expanded slightly on his findings. The checklist of Price *et al.* (2003) recognizes 30 species from this genus, all restricted to 40 species of parrots. A second genus, *Echinophilopterus* Ewing, is smaller regarding the number of included species, with only eight recognized by Price *et al.* (2003) from 25 species of parrots and one from a species of coraciiform host. This genus, as with *Neopsittaconirmus*, also has received a comprehensive treatment by Guimarães (1980). As a result of recent collecting of chewing lice in Australia by the junior author and his colleagues, we have obtained three series of lice from parrots, each representing a new species: two of *Neopsittaconirmus* and one of *Echinophilopterus*. It is our purpose to describe and illustrate them herein. For these species and other parrot lice, we sequenced a portion (379 base pairs) of the mitochondrial cytochrome oxidase I (COI) gene to evaluate the genetic distinctiveness of these species.

For the following descriptions, all measurements were made with an ocular micrometer and are given in millimeters. All lice used in this study were slide-mounted in Canada balsam following the procedure given in Price *et al.* (2003: 8). Abbreviations for dimensions are: TW, temple width; HL, head length at midline; PW, prothorax width; MW, metathorax width; AWV, abdomen width at segment V; TL, total length; and GL, male genitalia length. Host classification below that of order follows Dickinson (2003). Holotypes are deposited in the insect collection of the Illinois Natural History Survey, Champaign;

paratypes are deposited there and in the collection of The Field Museum, Chicago, Illinois.

Genus *Neopsittaconirmus* Conci

Neopsittaconirmus Conci 1942: 37. Type species: *Neopsittaconirmus borgiolii* Conci, by original designation.

The members of this genus are elongate slender lice with head evenly rounded anteriorly (Fig. 1); preantennal region with pair of circular dark guttate sclerotizations; temple only slightly wider than preantennal portion; antennae with or without sexual dimorphism. Pronotum with single short seta near each lateroposterior corner; metanotal margin with 4 long to very long setae on each side. All abdominal tergites complete for both sexes, with possible exception of tergite I; without anterior tergal or sternal setae. Sternites usually weakly developed. Female subgenital plate with posterior margin having number of short spiniform setae. Male genitalia with prominent projecting parameres and variable complex of medioposterior structures.

***Neopsittaconirmus vincesmithi* Price and Johnson, new species**

(Figs. 1–5)

Type host.—*Neopsephotus bourkii* (Gould), the Bourke's parrot.

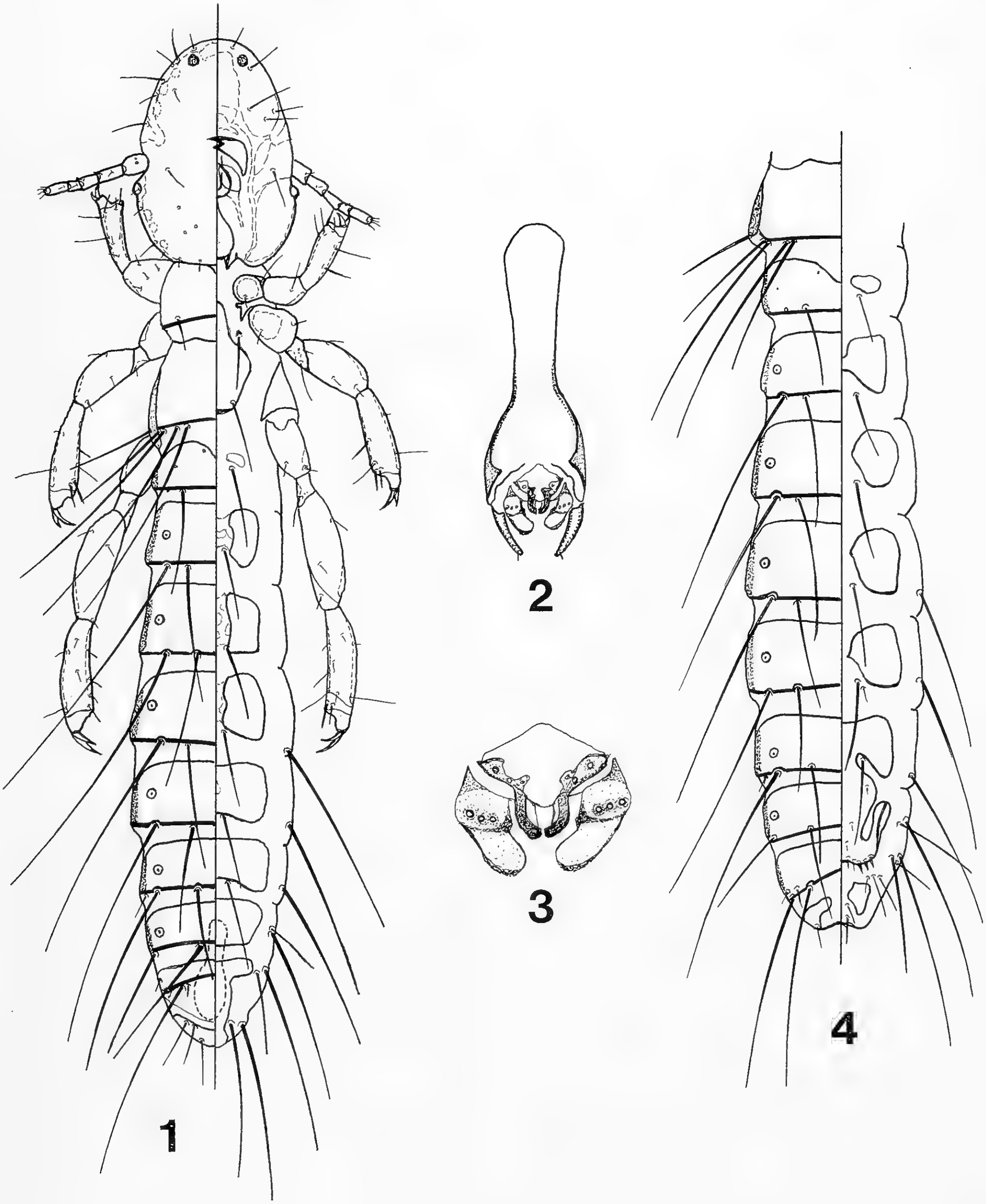
Male.—As in Fig. 1. Very long median pair of tergal setae on II–VIII; extremely long tergolateral seta on III–VII; with shorter such seta on VIII. Median pair of sternal setae on II–VII. Lateral margin of abdomen with no setae on II–IV, single very long seta on V–VII, and very long and shorter setae on VIII–IX. Posterior chaetotaxy as in Fig. 1. Genitalia as in Fig. 2; parameres slender, gently rounded, with slight incurving; median structures with detail as in Fig. 3. Dimensions: TW, 0.27–0.28; HL, 0.36–0.39; PW, 0.16–0.18; MW, 0.24–0.28; AWV, 0.27–0.29; TL, 1.53–1.70; GL, 0.15–0.16.

Female.—Metanotum and dorsoventral abdomen as in Fig. 4. Chaetotaxy much as for male, except for details associated with posteriormost segments. Ventral subgenital plate as in Fig. 5, with posterior margin of plate essentially transverse, bearing 4–5 short spiniform setae on each side with 4–6 fine short setae centrally between them and an occasional such seta inserted within row of spiniforms; broad bridge connecting sternite VII with sternal plate on VIII; lateral margins of sternite VII strongly defined. Dimensions: TW, 0.31–0.32; HL, 0.41–0.44; PW, 0.20–0.21; MW, 0.28–0.34; AWV, 0.26–0.32; TL, 1.76–1.94.

Type material.—Holotype ♀, ex *Neopsephotus bourkii*, Australia: Western Australia, 90 km N of Kumarina Roadhouse, N of Mekkatharra, 7 May 2002, T. Chesser, ANWC (=Australian National Wildlife Collection) 33003. Paratypes: Ex *N. bourkii*, 3 ♂, 1 ♀, same data as holotype; 1 ♂, 1 ♀, same except 12 km N of Overland Roadhouse, S of Carnarvon, 22 May 2002, ANWC 33374.

Other material.—1 ♀, ex *Psephotus haematonotus* (Gould), Australia: New South Wales, E Mount Hope, 24 July 2001, K. P. Johnson, ANWC 29297.

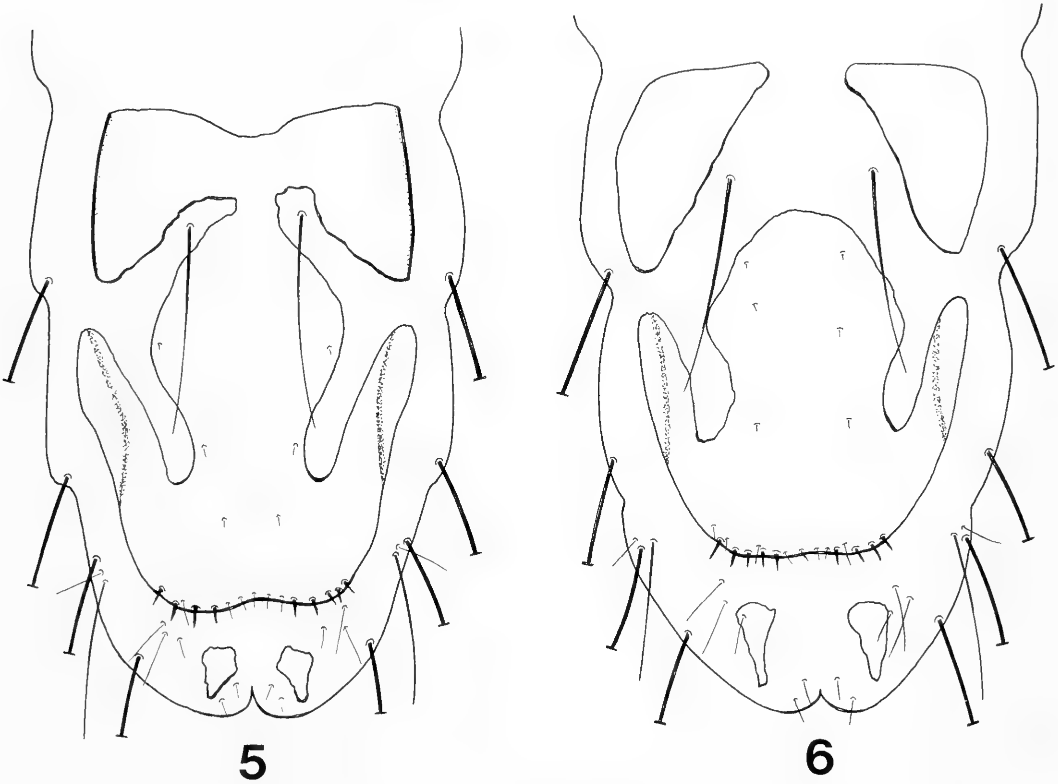
Remarks.—This new species is readily separable from all other described species in the genus by the female subgenital plate having a predominantly transverse posterior margin (Fig. 5); the posterior portion of the plates of the other species is typically a broad "V"- or "W"-shape. The male is distinctive by its alignment and shape of the parameres (Fig. 2) and the details of the median genitalic features (Fig. 3); most other species have outwardly-curved or straight parameres of a quite different shape. Only *N. anodis* (Neumann) and *N. abnormis* Guimarães have parameres approaching the type for



Figs. 1–4. *Neopsittaconirmus vincesmithi.* 1, Dorsoventral entire male. 2, Male genitalia. 3, Male medioposterior genitalic details. 4, Female metanotum and dorsoventral abdomen.

N. vincesmithi, but both sexes of these differ profoundly by a number of other features. The chaetotaxy of the abdominal tergites will also support separation of this species from others.

Etymology.—*Neopsittaconirmus vincesmithi* is named for our colleague Vincent S. Smith, The Natural History Museum, London, in recognition of numerous contributions to understand-



Figs. 5–6. Ventral female terminalia. 5, *Neopsittaconirmus vincesmithi.* 6, *N. bushae.*

ing the systematics of lice and to the electronic infrastructure for louse taxonomic data.

Neopsittaconirmus bushae Price and Johnson, new species

(Fig. 6)

Type host.—*Northiella haematogaster* (Gould), the Bluebonnet.

Male.—Much as in Fig. 1, apparently inseparable from *N. vincesmithi* except for tendency for *N. bushae* to have larger dimensions. Dimensions: TW, 0.30–0.33; HL, 0.41–0.45; PW, 0.20–0.22; MW, 0.28–0.33; AWV, 0.31–0.36; TL, 1.68–1.95; GL, 0.16–0.18.

Female.—Likewise very close to *N. vincesmithi*, with metanotum and dorsoventral abdomen much as in Fig. 4. However, details of subgenital plate as in Fig. 6, with posterior margin of plate essentially transverse, bearing 4–5 short spiniform setae on each side with interspersed fine short setae; sternite VII with distinct separation from sternal plate on VIII and without strongly defined lateral margins. Dimensions: TW, 0.31–0.36; HL, 0.41–0.47; PW, 0.21–0.24; MW, 0.33–0.36; AWV, 0.27–0.37; TL, 1.84–2.12.

Type material.—Holotype ♀, ex *Northiella haematogaster*, Australia: New South Wales, E Mount Hope, 24 July 2001, K. P. Johnson, ANWC 29300. Paratypes: 2 ♀, 3 ♂, same data as holotype.

Other material.—3 ♀, 2 ♂, ex *Psephotus varius* Clark, Australia: South Australia, Pootnoura Creek, 1 May 2002, T. Chesser, ANWC 32736 and ANWC 32737.

Remarks.—Both sexes of *N. bushae* are separable from all previously described species of this genus by the same features as given for *N. vincesmithi*. While *N. bushae* is admittedly quite close morphologically to *N. vincesmithi*, the well defined differences associated with the female subgenital plate (Fig. 6 vs. Fig. 5) and the generally larger dimensions of both sexes of the former will afford separation.

Neumann (1890: 65) described "*Lipeurus forficuloides*" from a host now known as *Psephotus varius*. Guimarães (1974) commented on the status of this species, currently recognized as *Psittaconirmus forficuloides* (Neumann), concluding that it must be referred to as a "*species inquirenda*". The description of *P. forficuloides* is clearly that of a *Psittaconirmus* louse, but little can be said beyond that, as opposed to the distinctly different genus *Neopsittaconirmus*. Guimarães (1974) believed the host association was in error and the type specimens in Neumann's collection at Toulouse had been lost, thus making positive identification of this species impossible. We concur with that action, citing this here so as to avoid any confusion between the Neumann *Psittaconirmus* name and our inclusion of *P. varius* lice as *Neopsittaconirmus bushae*.

Etymology.—*Neopsittaconirmus bushae* is named for our colleague Sarah E. Bush, The Natural History Museum, University of Kansas, Lawrence, in recognition of her numerous contributions to understanding the ecology of avian chewing lice.

Genus *Echinophilopterus* Ewing

Echinophilopterus Ewing 1927: 92. Type species: *Echinophilopterus chapini* Ewing, by original designation.

The members of this genus are broad lice with head usually markedly narrowed anteriorly; medioanterior margin with forceps-like modification (Fig. 9); distinctly widest across temples; well-defined dorsoanterior plate present; antennae without sexual dimorphism. Pronotum with single short seta at each lateroposterior corner; each side of metanotal margin with variable number of long setae. Abdomen broad, with tergites I–VII having wide median separation for both sexes; without anterior tergal or sternal setae. Sternites usually reduced. Ventral surface of abdomen often with prominent patch of spiniform setae on anterior three segments. Male genitalia with prominent parameres and variable complex of medioposterior structures.

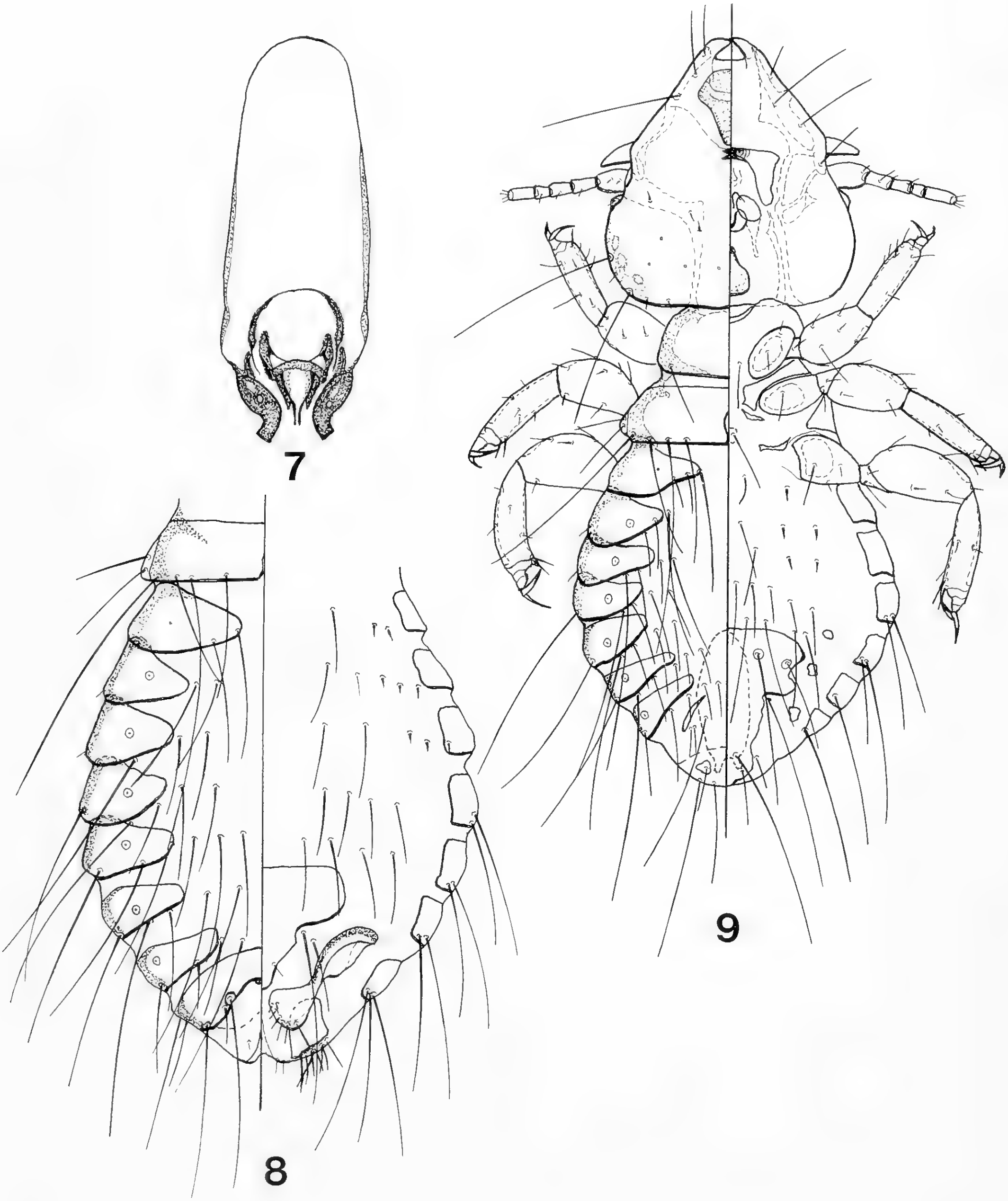
***Echinophilopterus claytoni* Price and Johnson, new species**

(Figs. 7–9)

Type host.—*Northiella haematogaster* (Gould), the Bluebonnet.

Male.—As in Fig. 9. Preantennal portion of head with straight converging margins. Metanotal margin with 4 long setae on each side. Each tergum II–VI with total of 6–8 setae positioned between spiracles; VII–VIII with 9–11 such setae; tergite IX weakly developed. Sterna II–IV with median pair of setae accompanied by several short lateral spiniform setae; sterna on V to end of abdomen as shown in Fig. 9. Lateral margin of abdomen with no setae on II, very short seta on III–IV, very long seta on V–VII, and shorter seta on VIII. Genitalia as in Fig. 7; parameres stout, recurved, with truncated posterior margin; median structures with detail as in Fig. 7. Dimensions: TW, 0.42; HL, 0.39 (from anterior margin of dorsoanterior plate); PW, 0.24; MW, 0.36; AWV, 0.54; TL, 1.16; GL, 0.22.

Female.—Metanotum and dorsoventral abdomen as in Fig. 8. Chaetotaxy of abdomen much as for male, except for details associated with posteriormost segments; tergite IX complete across abdomen, with very long marginal setae as shown. Dimensions: TW, 0.48; HL, 0.45 (from anterior margin of dorsoanterior plate); PW, 0.28; MW, 0.43; AWV, 0.66; TL, 1.45.



Figs. 7–9. *Echinophilopterus claytoni.* 7, Male genitalia. 8, Female metanotum and dorsoventral abdomen. 9, Dorsoventral entire male.

Type material.—Holotype ♂, ex *Northiella haematogaster*, Australia: New South Wales, E Mount Hope, 24 July 2001, K. P. Johnson, ANWC 29301. Paratype: 1 ♀, same data as holotype.

Remarks.—This species is readily recognized from all other known species of *Echinophilopterus* by the unique shape of the head with its broadly tapered preantennal portion, by the structure of the

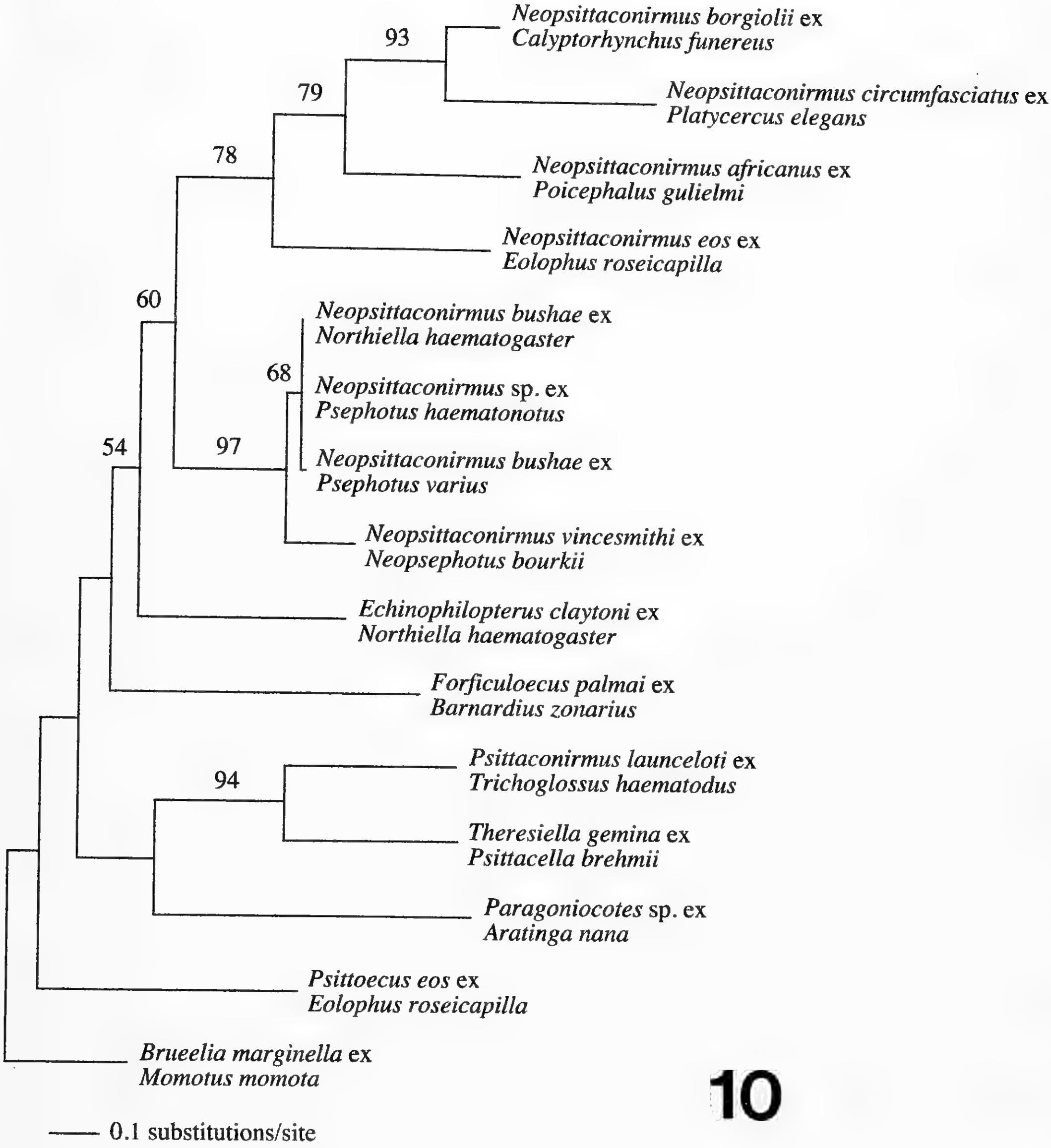


Fig. 10. Phylogenetic tree of parrot louse genera (Ischnocera) based on maximum likelihood (ML) analyses of partial mitochondrial COI sequences. Numbers above branches are support from 100 ML bootstrap replicates. Branch lengths proportional to substitutions per site (scale indicated). Tree rooted on *Brueelia marginella*, a parasite of a motmot.

male genitalia, especially the distally truncated parameres, and by the absence of a dense patch of short spiniform setae on the first three abdominal sterna.

Of the described species of *Echinophilopterus*, the head shape and lack of spiniform setae on the anterior abdominal sternal area for *E. buphthalmus* (Piaget) are reminiscent of *E. claytoni*. However, *E. buphthalmus* has markedly different male genitalia with elonate tapered parameres and the ventral female terminalia with a quite different chaetotaxy. The only non-psittaciform louse of this genus, *E. inexpectatus* Guimarães, whose type host is the long-tailed ground roller, *Uratelornis chimaera* Rothschild (Coraciiformes: Brachypteraciidae), has similar male genitalia and female ventral terminalia as for *E. claytoni*. However, the much smaller dimensions, the broader anterior head, and the denser abdominal chaetotaxy easily characterize *E. claytoni*. Both of these "near" relatives of *E. claytoni* are African, whereas *E. claytoni* is Australian.

Etymology.—*Echinophilopterus claytoni* is named for our colleague Dale H. Clayton, Department of Biology, University of Utah, Salt Lake City, in recognition of his numerous contributions to understanding the ecology of avian chewing lice and of his taxonomic work on parrot lice.

DISCUSSION

Sequences from the mitochondrial COI gene (GenBank Accession numbers EF058159–62) generally support the taxonomic conclusions of this paper. *Neopsittaconirmus vincesmithi* and *N. bushae* are indeed very closely related species, and separated from other species of *Neopsittaconirmus* (Fig. 10). However, these two species are 10% divergent from each other, on par with other divergences between closely related louse species (Johnson and Price 2006). Divergence between *N. bushae* from *Northiella haematogaster* and *Psephotus varius* was 0.5%, consistent with other reported within-species divergences. However, one surprising result was that the sequence of *Neopsittaconirmus* from *Psephotus haematonotus* was identical to that of *N. bushae* from *Northiella haematogaster*, the type host. Unfortunately the individual sequenced from *P. haematonotus* was a nymph so a firm morphological identification could not be made. Further collecting is needed to determine whether this represents dual infestation of this host species by multiple *Neopsittaconirmus* species, or is a case of contamination, or highlights the difficulty in distinguishing *N. bushae* from *N. vincesmithi*. Only one adult from *Psephotus haematonotus* was available for study and this individual was not sequenced. Only the present species of *Echinophilopterus* was available for sequencing, so no comment can be made on its genetic distinctiveness from other species of this genus.

Phylogenetic analysis of the COI sequences supports the monophyly of *Neopsittaconirmus* as distinct from other genera of parrot lice (Fig. 10), and this is supported by bootstrapping (60%). Other species of this genus also show pronounced genetic divergences from each other (ranging from 17% to 23%). *Theresiella* is strongly supported as the sister to *Psittaconirmus*, and *Echinophilopterus* may be sister to *Neopsittaconirmus*, though weakly supported (bootstrap 54%). More work is needed to determine the relationships among the other parrot louse genera.

ACKNOWLEDGMENTS

We thank Terry Chesser, Ian Mason, Robert Palmer, and John Wombey for assistance in collecting the specimens used in this study. This work was supported by NSF PEET DEB-0118794 to KPJ.

LITERATURE CITED

Conci, C. 1942. I Mallofagi degli Psittaciformes. Bollettino della Società Entomologica Italiana 74: 33–41.

Dickinson, E. C., ed. 2003. The Howard and Moore complete checklist of the birds of the world. 3rd edition. Princeton University Press, Princeton, New Jersey. 1039 pp.

Ewing, H. E. 1927. Descriptions of new genera and species of Mallophaga, together with keys to some related genera of Menoponidae and Philopteridae. Journal of the Washington Academy of Sciences 17: 86–96.

Guimarães, L. R. 1974. Ischnocera (Mallophaga) infesting parrots (Psittaciformes) I. Genera *Neopsittaconirmus* Conci, 1942, and *Psittaconirmus* Harrison, 1915. Arquivos de Zoologia, São Paulo 25: 121–201.

———. 1980. Ischnocera (Mallophaga) infesting parrots (Psittaciformes) IV. Genus *Echinophilopterus* Ewing, 1927. Papéis Avulsos de Zoologia, São Paulo 33: 127–156.

Johnson, K. P. and R. D. Price. 2006. Five new species of *Myrsidea* Waterston (Phthiraptera: Menoponidae) from bristlebills and greenbuls (Passeriformes: Pycnonotidae) in Ghana. Zootaxa 1177: 27–37.

Neumann, L. G. 1890. Contribution à l'étude des Ricinidae parasites des oiseaux de la famille des Psittacidae. Bulletin de la Société d'Histoire Naturelle de Toulouse 24: 55–69.

Price, R. D. and K. C. Emerson. 1978. The *Neopsittaconirmus* (Mallophaga: Philopteridae) from *Cacatua* (Aves: Psittaciformes). Pacific Insects 18: 33–36.

———. 1985. The identity of *Nirmus eos* Giebel (Mallophaga: Philopteridae) from the rose-breasted cockatoo (Psittaciformes). Journal of the Kansas Entomological Society 58: 173–175.

Price, R. D., R. A. Hellenthal, and R. L. Palma. 2003. World checklist of chewing lice with host associations and keys to families and genera. *In* Price, R. D., R. A. Hellenthal, R. L. Palma, K. P. Johnson, and D. H. Clayton. The chewing lice: World Checklist and Biological Overview. Illinois Natural History Survey Special Publication 24, x + 501 pp.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 522–529

A TAXONOMIC REEVALUATION OF *OVATUS MENTHARIUS* (VAN DER GOOT) (HEMIPTERA: APHIDIDAE)

Gary L. Miller, Susan E. Halbert, and Robert G. Foottit

(GLM) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, Bldg. 005, BARC-West, Beltsville, MD 20705, U.S.A. (e-mail: gary.miller@ars.usda.gov); (SEH) Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL 32614, U.S.A. (e-mail: halbers@doacs.state.fl.us); (FGF) Agriculture and Agri-Food Canada, Canadian National Collection of Insects, Ottawa, ON K1A 0C6, Canada (e-mail: foottitrg@agr.gc.ca)

Abstract.—We reevaluate the status of *Ovatus mentharius* (van der Goot) in North America which was previously misidentified as *Ovatus crataegarius* (Walker). Detailed keys for separating *O. crataegarius* and *O. mentharius* on Labiatiae, descriptions of apterous viviparae and the alatae of *O. mentharius*, morphometric analysis, distribution records, and illustrations of *O. mentharius* are presented.

Key Words: aphid, mint, adventive species

The genus *Ovatus* was proposed by van der Goot in 1913. Some species of this genus host alternate between *Craetaegus* or other woody Pomaceae and Labiatae while other species are monoecious, associated with Labiatae or other herb families (Heie 1994). A systematic evaluation of *Ovatus* (sensu Remaudière and Remaudière 1997) in North America by Jensen and Stoetzel (1999) resulted in its revision and subsequent placement of four endemic North American species into the genus *Abstrusomyzus* Jensen and Stoetzel. Their revision left a single species of *Ovatus* in North America, *Ovatus crataegarius* (Walker), which is considered Palearctic in origin but has a worldwide distribution (Jensen and Stoetzel 1999).

Adventive aphid species represent approximately 18% of the North American aphid fauna (Foottit et al. 2006). Recent interceptions of *Ovatus mentharius* (van der Goot) identified by us (GLM and SEH) and others (e.g., Floren 2004) at various ports-of-entry and greenhouse facilities within the United States have brought our attention to this Palearctic species. It also raised concerns that yet another adventive aphid species may represent an ecological threat. All holdings of *O. mentharius* within the National Museum of Natural History Aphidoidea Collection (USNM), Beltsville, MD, were from port interceptions originating from Europe. Further examination of holdings of *O. crataegarius* revealed intermittent collections of *O. mentharius* that had been previously misidentified as *O. crataegarius* from as far back as 1935. Some of these collections represented border interceptions, but the earliest record of this species (California in 1935) was possibly not an interception. In addition to the recent port interceptions, discovery (and subsequent eradication) of *O. mentharius* within experimental plots containing mint (*Mentha spicata* L., *M. suaveolens* Ehrh., and *Mentha* sp.) and basil (*Ocimum basilicum* L.) and on *Mentha* spp. at an organic greenhouse operation in Florida raised our concern that this species could be pestiferous. *Ovatus mentharius* in Florida represents the easternmost distribution of the species in the U.S.A.

Ovatus mentharius is holocyclic and monoecious on *Mentha* spp. while *O. crataegarius* is holocyclic and heteroecious with *Mentha* spp. serving as secondary hosts (Heie 1994). Mixed infestations of the two species and morphological similarities sometimes make identification difficult. The current study was undertaken to reevaluate the status of *O. mentharius* in America North of Mexico by providing descriptions, illustrations, keys for separating *O. crataegarius* and *O. mentharius*, distribution records of *O. mentharius*, and morphometric analysis of *O. crataegarius* and *O. mentharius* for additional species clarification.

Materials and Methods

Synoptic descriptions are taken from original descriptions and specimens from The Florida State Collection of Arthropods (FSCA), Gainesville, FL, U.S.A. and the National Museum of Natural History Aphidoidea Collection (USNM), Beltsville, MD, U.S.A. Measurements are in micrometers (μm) as minimum and maximum ranges of representative specimens. Table 1 also includes summary statistics (range, mean, and standard deviation) for *O. crataegarius* and *O. mentharius*. Drawings were begun using a camera lucida and completed either by hand or by computer-aided illustration programs (Adobe Photoshop®). Most specimens had been cleared and mounted or remounted in Canada balsam.

Morphological terms and structures adapted from Foottit and Richards (1993) are used in this work. Abbreviations herein for body length, antennal segment(s), aptera/apterae (=wingless viviparous female(s)), alata/ alatae (=winged viviparous female(s)), and immature(s) are listed as: b.l., a.s., ap., al., and imm., respectively. If a collection was made at the same locality, but on a different date as a previously listed collection, duplicated information is not repeated. Months are designated as roman numerals. For example, the documentation provided for a particular locality may be recorded as: FLORIDA: Tallahassee, VI-6-1989, on *Ocimum basilicum*, D. C. Beard coll., (2 ap.) USNM; V-10-1990, VI-29-1991, I-21-1992, on mint [*Mentha* sp.], (5 ap. on 5 sl.) USNM. In this hypothetical example, the second collection was also found at Tallahassee, even though "Tallahassee" was not repeated. Collection data that are the same except for collection date are simply listed sequentially. In examples where microscope slides record a county, they are listed first within each state then chronologically. Other collection localities are listed chronologically. When specimens are mounted on a single slide (sl.), it is not written as such but is assumed. Bracketed ([ ]) text represents supplemental information by the current authors for clarification purposes.

Specimens of the adult apterous viviparous morph were used for morphometric analysis. Bracketed letters (e.g., {A}) in the "Specimens examined" section for *O. mentharius* indicate those specimens that were used in the analysis. Seventy-three slides of *O. crataegarius* were examined from the USNM. Single representative specimens of *O. crataegarius* that were measured and used in the analysis are as follows. MEXICO: [intercepted at San Ysidro, CA [?] interception # 2536], II-27-1961, on *Mentha* sp., J. Spear coll., USNM; [intercepted at Chicago, IL, interception # 4785], III-28-1963, on *Mentha* sp., Rood coll., USNM;

Table 1. Summary statistics (range, mean and standard deviation) for measurements of *Ovatus crataegarius* and *Ovatus mentharius* in μm, and standardized total sample coefficient (loadings) for variables used in canonical discriminant analysis.

	O. crataegarius n=10			*O. mentharius* n=11			
Variable	Range	Mean	Std Dev	Range	Mean	Std Dev	Standardized CVA Coefficient
body length	1235–1910	1528.5	218.44	1060–1790	1390.5	270.61	−0.12
head width	325–475	386.5	49.44	300–400	345.9	36.93	−3.40
a.s. III length	315–490	424.0	58.16	300–490	375.9	60.78	−9.66
a.s. IV length	235–355	297.5	41.98	210–390	290.5	62.51	
a.s. V length	225–315	275.0	31.45	180–350	265.0	56.26	3.25
a.s. VI base length	95–135	107.0	12.95	85–115	99.1	11.14	−3.98
a.s. VI terminal process	405–590	492.0	49.51	425–590	495.5	50.67	−2.10
ultimate rostral segment length	110–140	120.0	10.80	100–135	116.8	10.79	−3.15
ultimate rostral segment width	35–70	46.0	10.22	35–50	41.4	5.95	3.42
fore femur length	265–475	351.0	69.63	235–375	315.0	53.95	
fore tibia length	460–825	627.0	122.07	450–715	570.5	92.15	
fore tarsus segment II length	60–100	74.5	12.12	60–80	70.5	7.23	−2.07
mid femur length	275–470	362.5	66.89	240–400	323.2	59.84	
mid tibia length	495–855	641.5	114.02	450–765	590.9	107.35	0.54
mid tarsus segment II length	65–100	76.0	11.01	65–80	72.3	6.47	−5.06
hind femur length	350–610	458.5	86.89	300–515	390.5	72.27	
hind tibia length	650–1175	860.0	167.88	590–935	768.2	111.63	15.28
hind tarsus segment II length	60–100	77.5	11.61	60–95	74.5	10.36	1.07
siphunculus length	260–460	334.0	58.96	265–455	345.5	63.58	10.27
intersiphuncular distance	240–475	340.5	71.16	215–385	286.4	56.04	−2.13
cauda length	125–210	160.0	23.09	125–190	148.6	22.92	−6.01

[intercepted at Hidalgo, TX, interception # 6845], VIII-4-1986, on *Mentha* sp., A. Munoz coll., USNM. UNITED STATES: IDAHO, New Plymouth, III-22-1973, on mint, A. M. Finley coll., USNM. INDIANA, Warsaw, VIII-8-1933, on peppermint, G. E. Gould coll., USNM. MARYLAND, Beltsville, X-6-1975, on [?], S. W. T. Batra coll.; X-7-1997, on *Mentha* sp., A. Jensen coll., USNM. NEW YORK, Ludlowville, VIII-22-1974, on *Mentha spicata*, L. L. Pechuman coll., USNM. UTAH, Brigham, VIII-18-1973, on *Mentha spicata*, G. F. Knowlton coll., USNM. WASHINGTON, Prosser, VII-30-1956, on peppermint, K. E. Frick coll., USNM.

Each specimen was measured for the following 21 variables (Table 1) (operational dimensions for most variables are as indicated in Foottit and Mackauer, 1990): b.l., head–width (through eyes), a.s. III–length, a.s. IV–length, a.s. V–length, a.s. VI base–length, a.s. VI processus terminalis–length, ultimate rostral segment–length, ultimate rostral segment–width, fore femur–length, fore tibia–length, fore tarsus segment II–length, mid femur–length, mid tibia–length, mid tarsus segment II–length, hind femur–length, hind tibia–length, hind tarsus segment II–length, siphunculus–length, intersiphuncular distance, cauda–length.

We used principal component analysis to investigate relationships among specimens and variables and we used canonical variates analysis to determine those variables which best separated groups of specimens (Foottit and Mackauer 1990). All statistical analyses were carried out using SAS version 9.1 for Windows® (SAS Institute Inc., Cary, North Carolina).

RESULTS

Ovatus van der Goot 1913

Ovatus van der Goot 1913:84. Type species: *Myzus mespili* van der Goot, 1912: 64; (=*Aphis insitus* Walker, 1849: xxxix). By original designation.

North American diagnosis.—Small to medium aphids (b.l. 1,000–2,500). Antennae 6-segmented, longer than body in apterae and alatae; apterae without secondary sensoria, alatae with numerous secondary sensoria on a.s. III, fewer on a.s. IV, and frequently on a.s.V. Head spiculated, lateral frontal tubercles well developed with prominent convergent rounded processes on the inner sides. Apical rostral segments longer than hind tarsus II. Forewing length of alatae ca.1.5 times body length. First tarsal segment with 3-3-3 hairs. Dorsal body setae shorter than those on venter; abdomen with irregularly-shaped sculpturing separated by smooth space, without large dorsal patch although smaller faint sclerites present. Siphunculi longer than cauda, with imbrications and distinct flange. Cauda elongate, spiculated with 5–7 setae.

Notes.—Various authors (e.g., Eastop and Hille Ris Lambers 1976, Remaudière and Remaudière 1997) have erroneously recorded "*Ovatus mespili* van der Goot (1913)" as the original combination of the type species. In fact, *Ovatus* was described by van der Goot (1913) with *Myzus mespili* van der Goot (1912) (= *Ovatus insitus* (Walker)) as the type species. Jensen and Stoetzel (1999) provided characters for separating *O. crataegarius* in North America from similar taxa in the genera *Abstrusomyzus* Jensen and Stoetzel, *Hyalomyzus* Richards, *Myzus* Passerini, and *Phorodon* Passerini. *Ovatus* species can be either holocyclic and heteroecious or holocyclic and monoecious. For example, *O. crataegarius* has primary hosts *Crataegus* and other Rosaceae and secondary hosts *Mentha* spp., while *O. mentharius* is holocyclic and monoecius on *Mentha* spp. (Heie 1994).

Ovatus mentharius (van der Goot 1913)
(Figs. 1–9)

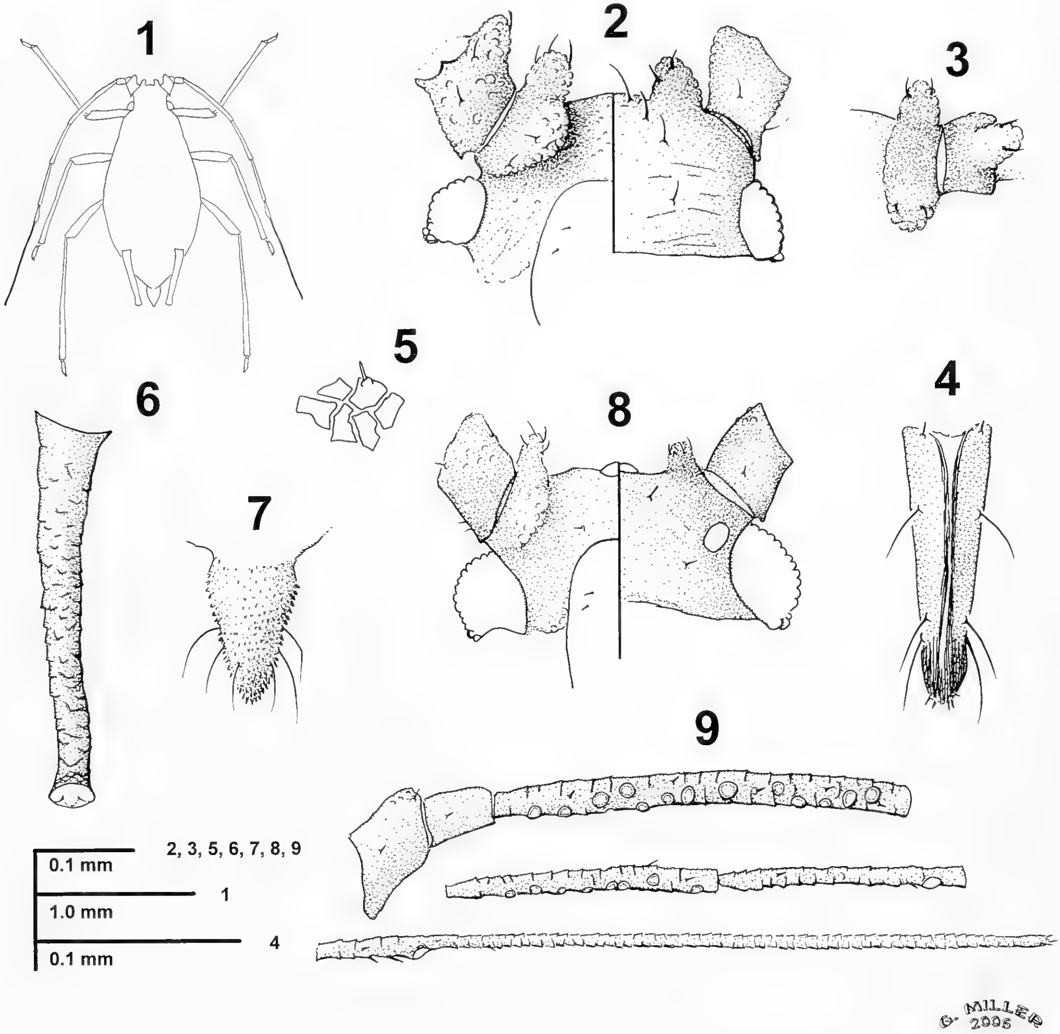
Phorodon mentharius van der Goot 1913: 82.

Ovatus menthastri Hille Ris Lambers 1947: 303.

Ovatus mentharius (van der Goot): Eastop and Hille Ris Lambers 1976: 329; Remaudière and Remaudière 1997: 135.

Field features.—Fundatrices and apterae "pale whitish green" (Hille Ris Lambers 1947). Alatae "green" (Hille Ris Lambers 1947) or more specifically, head and thorax brownish green, abdomen green, antenna black, siphunculus brownish with paler bases, wings with brown-borderd veins (Heie 1994); oviparae "pale greenish yellow" (Hille Ris Lambers 1947).

Recognition characters.—*Apterous vivipara* (Fig. 1): b.l. 1,060-1,790; width through eyes, 300-400 Head (Fig. 2) sclerotized and scabrous; antennal tubercles well developed, converging and bearing setae (Figs. 2, 3); tips of dorsal head setae blunt. Antenna (Fig. 1) longer than body, a.s. I (Figs. 2, 3) with anterior projection, occasionally obscured on some specimens due to orientation in mounting medium, a.s. VI and tip of V darker than other segments on mature specimens, setae less than half width of



Figs. 1–9. *Ovatus mentharius*. 1, Apterous vivipara dorsal habitus. 2, Right side, apterous vivipara dorsum of head and a.s. I; left side, apterous vivipara venter of head and a.s. I.. 3, Lateral view of heade and a.s.I of apterous vivipara. 4, Utimate rostral segment. 5, Dorsal abdominal reticulation. 6, Siphunculus of apterous vivipara. 7, Cauda of apterous vivipara. 8, Right side, alata dorsum of head and a.s. I; left side, alata venter of head and a.s. I. 9, Alata a.s. I-VI.

segment; a.s. III 300-490 long without secondary sensoria; a.s. IV 210-390 long without sensoria; a.s.V 180-350 without secondary sensoria; base of a.s.VI 85-115 long; terminal process, 425-590 long. Rostrum extending past metacoxae; ultimate segment (Fig. 4) 100-135 long, approximately 3 times as long as wide at base, with 2 accessory setae. Fore femur 235-375, fore tibia 450-715 long, fore tarsus II 60-80 long; mid femur 240-400, mid tibia 450-765, mid tarsus II 65-80 long; hind femur 300-515, hind tibia 590-0.935, hind tarsus II 60-95 long. Abdomen dorsally with distinct irregular reticulations separated by smooth areas (Fig. 5), occasionally with small faint lateral sclerites, dorsal setae stout with blunt tips, ventral setae longer with pointed tip, segment VIII with 4-6 setae; ventrally spiculose; anal plate with 6-8 setae, genital plate with normal configuration of setae. Siphunculus (Fig. 6) 265-455 long, scabrous, tapering slightly and occasionally slightly curved with several rows of hexagonal cells below apical flange. Cauda (Fig. 7) 125-190 long, elongate, tongue-shaped with 2-3 pairs of lateral setae.

Alata (Fig. 8): Similar to apterous female except: b.l. 1,175-1,675; width through eyes 310-375. A.s. I (Fig. 9) protuberance not as pronounced as in apterae, a.s. III 350-425 long, with 19-26 sensoria; a.s. IV 225-390 long, with 4-15 secondary sensoria; a.s. V 205-330 long, with 0-1 secondary sensoria; base of a.s. VI 90-110 long; terminal process 490-600 long. Ultimate rostral segment 115-125 long. Forewing length 1,650-2,500, 550-860 at widest point; hindwing 900-1,475 long, 250-420 at widest point. Fore femur 330-455, fore tibia 650-835 long, fore tarsus II 60-80 long; mid femur 300-400, mid tibia 600-825 mid tarsus II 60-80 long; hind femur 375-535, hind tibia 810-1,100, hind tarsus II 70-90 long. Siphunculus 225-350 long. Cauda 125-140 long.

Morphometric analysis (Table 1).—Initial principal component analysis indicated that a large component (75%) of the morphological variation within the specimens was the result of size-related influences. We reduced the number of variables to 16 from 21 by eliminating a.s. IV–length, fore tibia–length, and the three femur–length measures as these variables were highly correlated (over 95%) with other variables. Two specimens of *O. crataegarius* (Idaho, III-22-1973 and Maryland, X-6-1975) were eliminated from further analysis as they were likely distorted by compression from the slide-mounting process.

Further principal component analysis showed that there was a broad distribution of specimens of both species along a size-related axis which still accounted for approximately 70% of the total variation. This trend indicated that many of the variables would be sufficiently influenced by size variation as to be ineffective as species-level discriminators. The analysis indicated that among the specimens of *O. mentharius* there is less variation in the a.s. VI, base -length and the ultimate rostral segment–length, than in *O. cratagarius*.

The canonical variates analysis, which incorporates the overall variation among the specimens, completely separated the two sets of species representatives on the basis of significant contributions from a number of variables. *Ovatus crataegarius* is characterized by a longer cauda and a longer antennal segment III compared to those of *O. mentharius*. *Ovatus mentharius* is characterized by longer legs and a longer siphunculus.

Notes.—Identification should consist of a series of specimens when possible. This is especially true when certain characters such as antennal projections can be obscured or altered during the slide-mounting process. In addition, there is variability within such characters as secondary sensoria. For example, one specimen had 21 and 26 secondary sensoria on left and right side a.s.III, respectively. This upper count of secondary sensoria is even higher than the upper range (21) Heie (1994) recorded for *O. mentharius* .

Specimens examined.—MEXICO: Juarez [intercepted at El Paso, TX, interception #'s 66434, 69197, 00865], V-20-1966 {A}, VIII-19-1967 {B}, IX-14-1970, on *Mentha* sp., [various collectors include] D. S. Cambell, J. Kline, C. Oliver colls., (5 ap. on 3 sl.) USNM; Torrean, [intercepted at El Paso, TX, interception # 001508], IX-2-1970 {C}; on *Mentha* sp., D. Mayer coll. (4 ap. and 1 imm.) USNM; [interception at San Ysidro, interception # 2535], II-27-1961 {D}, on *Mentha* sp., J. Spear coll. (3 ap.) USNM; [interception at Chicago, IL, interception # 4540], X-18-1962, on *Mentha* sp., Rood coll. (1 ap.) USNM;

[interceptions at El Paso, TX, interception #'s 61498, 71850, 70484], X-13-1962, III-12-1968, XII-15-1968 {E}, on *Mentha* sp., [and] mint, [and] "misc. mosses" [dubious host association],[various collectors include] G. Dunn, J. W. Green, McClain , C. Oliver colls., (10 ap., 2 al. 1 imm. on 5 sl.) USNM; [interception at Atlanta, GA, interception # 0502015], VI-20-2004 {F}, on *Mentha* sp., P. Haney coll. (3 ap. on 3 sl.) FSCA, USNM; [interception at San Francisco, CA, interception # 0505031], V-30-2005 {G}, on *Mentha* sp., J. Iniguez coll. (3 ap.) USNM. UNITED STATES: CALIFORNIA, Berkeley, III-30-1935 {H}, on *Mentha spicata*, E. O. Essig coll., (7 ap., 4 al., 2 imm. on 8 sl.) USNM. FLORIDA, Orange Co., Apopka, III-1-2006 {I}, on *Mentha* sp., L. Osborne coll., (2 al. on 2 sl.) FSCA, USNM; Suwannee Co., Live Oak, VI-1-2006, on *Mentha* sp., L. L. Davis coll., (2 ap. on 2 sl.) FSCA, USNM. NEW MEXICO, Mesilla Park, IV-25-1956 {J}, on mint, J. J. Durkin coll., (2 ap.) USNM. UNDETERMINED [labeled "Ariz to Juarez to El Paso] V-12-1964 {K}, on *Mentha* sp., Overmiller coll., (1 ap., 1 al., 1 imm.) USNM.

KEY TO NORTH AMERICAN *OVATUS* VIVIPARAE ON MINTS

1. Antennal segment tip V and VI dark in mature adults; apterous viviparous a.s. I with forward projecting process on inner side (Figs. 2, 3) (on slide-mounted specimens this is sometimes difficult to see); siphunculus often longer than distance between inner bases (Fig. 1); alatae a.s. III with 19-24 secondary sensoria (occasionally more), a.s. IV with 4-13 (occasionally more) secondary sensoria . . . . *Ovatus mentharius* (van der Goot)

– Antennal segments I-VI predominantly dark in mature adults; apterous viviparous a.s. I without forward projecting process on inner side; siphunculus usually shorter to subequal (occasionally longer) than distance between inner bases; alatae a.s. III with 27-34 secondary sensoria (occasionally less), a.s. IV with 12-17 (occasionally less) secondary sensoria . . . . *Ovatus crataegarius* (Walker)

Conclusions

Identification of *O. mentharius* in North America has been problematic due to morphological similarities with *O. crataegarius* and a partial overlap of host plants. However, current morphometric analysis supports the contention that they are indeed separate species. This separation is especially critical not only taxonomically but also from an economic standpoint. The economic importance of the mint hosts (e.g., *Mentha spicata*) could be a major concern in the spearmint growing region of the Pacific Northwest. In addition, our report of basil as a host represents an additional concern for the fresh herb industry. On a positive note, even though *O. mentharius* had been recorded from California as early as 1935, there have been apparently no major populations collected since that time. This also is borne out through the absence of *O. mentharius* in extensive collecting of one of us (SJH) in this region of the continent.

Adventive species of sternorrhynchous Hemiptera in North America have been the subjects of concerted efforts recently (e.g., Miller et al. 2002, Miller and Miller 2003, Miller et al. 2005, Foottit et al. 2006). The numbers and rates of introductions of the Coccoidea and Aphidoidea have nearly mirrored each other for the past two centuries (Miller et al. 2005, Foottit et al. 2006). Foottit et al. (2006) determined that 262 species of aphids should be considered adventive to America North of Mexico. It is possible that *O. mentharius* could represent an addition to this tally. However, with the exception of the recent collection and eradication of *O. mentharius* in Florida, it seems as though establishment is suspect except in a greenhouse situation.

ACKNOWLEDGMENTS

We thank Eric Maw (Agriculture and Agri-Food Canada, Ottawa) for assistance with the morphometric analyses. Thanks also to D. Miller (SEL, Beltsville, MD), S. Lingafelter (SEL, Washington, DC), W. Dixon (Gainesville, FL), C. Favret (Beltsville, MD) and A. S. Jensen (Moses Lake, WA), for their reviews of the manuscript. This is Entomology Contribution No. 1071, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Bureau of Entomology, Nematology, and Plant Pathology.

LITERATURE CITED

Eastop, V. F. and D. Hille Ris Lambers. 1976. Survey of the World's Aphids. Dr. W. Junk, b.v., The Hague. 573 pp.

Floren, K. E. 2004. Los Angeles County 2004 agricultural crop report. http://acwm.co.la.ca.us/pdf/2004cropreport.pdf 17pp. [accessed 14 March 2006].

Foottit, R. G. and M. Mackauer. 1990. Morphometric variation within and between populations of the pine aphid, *Cinara nigra* (Wilson) (Homoptera: Aphidoidea: Lachnidae), in western North America. Canadian Journal of Zoology 68: 1410–1419.

Foottit, R. G. and W. R. Richards. 1993. The genera of the aphids of Canada, Homoptera: Aphidoidea and Phylloxeroidea. The Insects and Arachnids of Canada Part 22. Agriculture Canada Research Branch Publication 1885: 766 pp.

Foottit, R. G., S. E. Halbert, G. L. Miller, H. E. Maw, and L. M. Russell. 2006. Adventive aphids (Hemiptera: Aphididae) of America North of Mexico. Proceedings of the Entomological Society of Washington 108(3): 583–610.

Heie, O. E. 1994. The Aphidoidea (Hemiptera) of Fennoscandia and Denmark. V. Family Aphididae: Part 2 of tribe Macrosiphini of subfamily Aphidinae. Fauna Entomologica Scandinavica 28: 1–242.

Hille Ris Lambers, D. 1947. On some mainly Western European aphids. Zoologische Mededeelingen 28: 291–333.

Jensen, A. S. and M. B. Stoetzel. 1999. An examination of the North American aphid species currently placed in *Ovatus* van der Goot (Hemiptera: Aphididae) with the description of a new genus. Proceedings of the Entomological Society of Washington 101(1): 39–56.

Miller, D. R., G. L. Miller, and G. W. Watson. 2002. Invasive species of mealybugs (Hemiptera: Pseudococcidae) and their threat to U.S. agriculture. Proceedings of the Entomological Society of Washington 104(4): 825–836.

Miller, D. R., G. L. Miller, G. S. Hodges, and J. A. Davidson. 2005. Introduced scale insects (Hemiptera: Coccoidea) of the United States and their impact on U.S. Agriculture. Proceedings of the Entomological Society of Washington 107(1): 123–158.

Miller, G. L. and D. R. Miller. 2003. Invasive soft scales (Hemiptera: Coccidae) and their threat to U.S. agriculture. Proceedings of the Entomological Society of Washington 105(4): 832–846.

Remaudière, G. and M. Remaudière. 1997. Catalogue of the World's Aphids. INRA, Paris. 473 pp.

van der Goot, P. 1912. Uber einige noch nicht oder nur unvollstandig beschriebenen Blattlausarten's Gravenhag. Tijdschrift Entomologie 55: 58–96.

———. 1913. Zur systematik der Aphiden. Tijdschrift Entomologie 56: 69–155.

Walker, F. 1849. Descriptions of new British aphides. Zoologist 7: xxxi–xl.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 530–540

A NEW NEARCTIC SPECIES OF BITING MIDGE IN THE SUBGENUS *METAFORCIPOMYIA* SAUNDERS OF *FORCIPOMYIA* MEIGEN (DIPTERA: CERATOPOGONIDAE)

William L. Grogan, Jr. and Elizabeth A. Sigrist

Department of Biological Sciences, Salisbury University, Salisbury, MD 21801, U.S.A. (e-mail: wlgrogan@salisbury.edu); EAS current address: Department of Entomology and Wildlife Ecology, University of Delaware, Newark, DE 19716, U.S.A.

Abstract.—The biting midge, ***Forcipomyia (Metaforcipomyia) fehrerorum* Grogan and Sigrist, new species**, is described and illustrated from specimens collected in Maryland and Florida and compared with its only Nearctic congener, *F. (M.) pluvialis* Malloch, which is redescribed and illustrated.

Key Words: Diptera, Ceratopogonidae, *Forcipomyia*, biting midge, new species, Maryland, Florida

The biting midges of the genus *Forcipomyia* Meigen are common inhabitants of wet and semi-moist habitats in all regions of the world except Antarctica. Currently, there are some 1,100 species in this extremely diverse genus in 36 subgenera (A. Borkent, personal communication). In their World Catalog of Biting Midges, Borkent and Wirth (1997) listed 13 species in the subgenus *Metaforcipomyia* Saunders, 11 of which are from the Old World, mainly Australia and Papua New Guinea. Their World Catalog included only two New World species, *F. (M.) pluvialis* Malloch, 1923, from the eastern United States and extreme southern Ontario, Canada (Wirth 1965) and *F. (M.) cerifera* Saunders, 1957, from Brazil.

After the publication of the World Catalog by Borkent and Wirth (1997), Marino and Spinelli (1999) recorded *F. cerifera* from Argentina and described two new species in the subgenus *Metaforcipomyia* from the northeastern portion of that country, *F. galliardi*, from Misiones Province, and, *F. williamsi*, from Buenos Aires Province and Martin Garcia Island. Marino and Spinelli (2003) described three new species from Patagonian Argentina, provided a key to the New World species of *Metaforcipomyia* and reassigned *F. maculosa* Ingram and Macfie (1931) to *Metaforcipomyia* (included in the subgenus *Forcipomyia* by Borkent and Wirth 1997). Finally, Liu et al. (2001) described two new species of *Metaforcipomyia* from China, thereby raising the world total to 21 species (A. Borkent, personal communication). Spinelli and Borkent (personal communication) are currently studying a large series of *F. (Metaforcipomyia)* from Costa Rica in the collection at the Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (INBio) as well as Neotropical material from the National Museum of Natural History, Washington D. C. (USNM).

John R. Malloch collected the type series of *F. pluvialis* on 14 August 1921 during a collecting trip to Cabin John, Montgomery Co., Maryland while trying to avoid a summer thunderstorm by seeking shelter under a beech tree. On the trunk of this tree he noticed "a few dry spots and my attention was attracted to some minute white dots on these areas. A close scrutiny disclosed that they were small ceratopogonine flies and a series was bottled for a more detailed inspection later. This inspection disclosed the fact that the species is undescribed and one of the most strikingly colored occurring in this country. It is so very small that it was not at any time seen in the net nor elsewhere during the summer though I collected at the same spot frequently." (Malloch 1923). Malloch's original description of both sexes of this species is very brief and contains mainly notations of its coloration, but, no illustrations of any anatomical features of this beautiful elfin midge. Bill Wirth (1951) provided details of females and an illustration of the male genitalia, as well as new records of this species from Louisiana, Virginia, and Panama.

Herein, we describe and provide detailed illustrations of a second species in the subgenus *Metaforcipomyia* from North America that is radically different in coloration, body form and anatomical details from its relative, *F. pluvialis*. We also provide redescriptions and illustrations of both sexes of *F. pluvialis*. For general terms of structures of Ceratopogonidae, see Downes and Wirth (1981); for characters distinguishing members of the subgenus *Metaforcipomyia* from other subgenera of *Forcipomyia*, see Saunders (1957) and Debenham (1987). Terms for general structures including genitalia and wing venation are those in the Manual of Nearctic Diptera by McAlpine (1981) except for recent modifications of wing veins and cells as proposed by Szadziewski (1996) which were summarized in a table by Spinelli and Borkent (2004). Numerical data are presented as mean, range, followed by sample size.

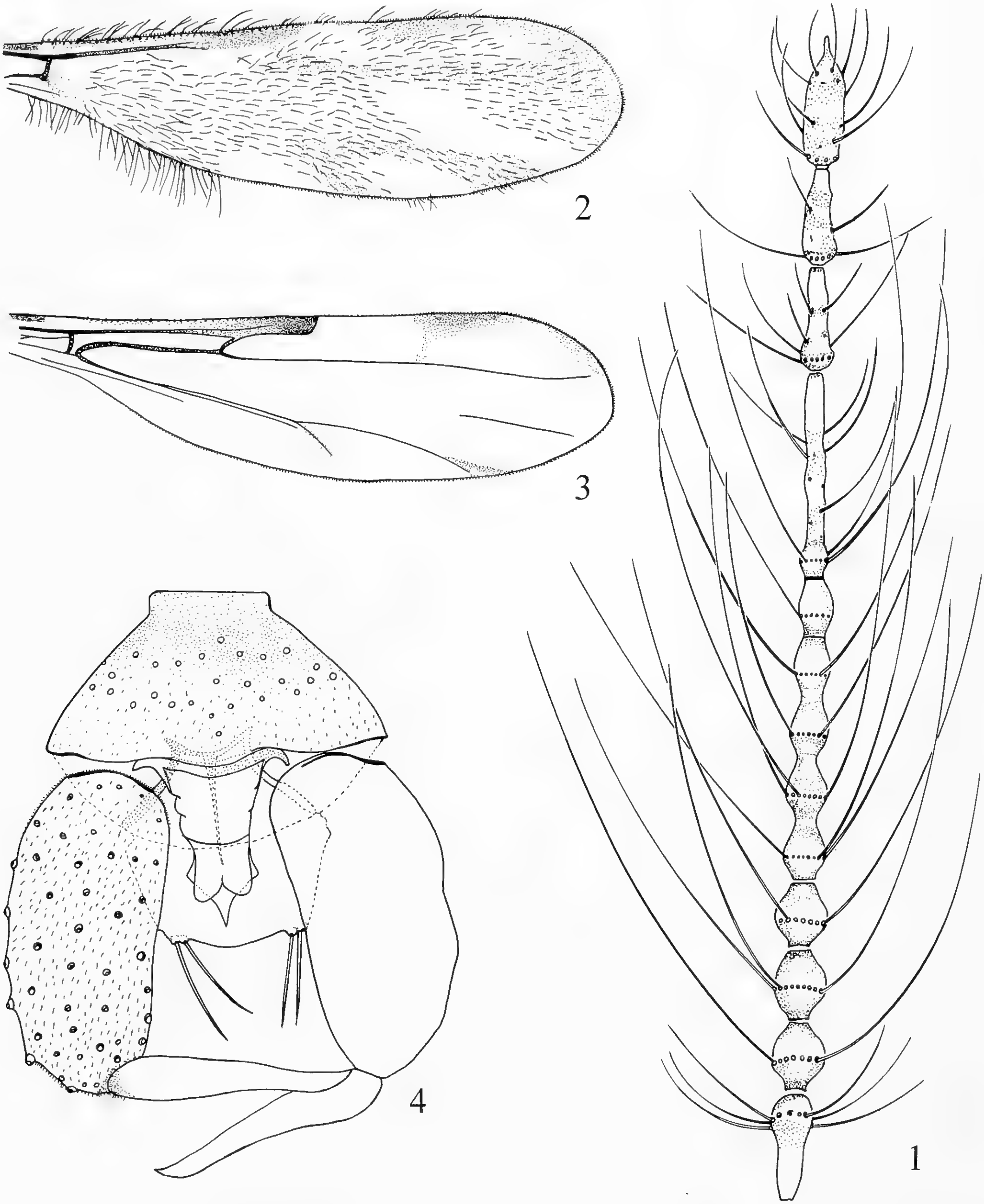
All specimens examined are mounted onto microscope slides in phenol-balsam by the methods described by Wirth and Marston (1968). Measurements and other data are presented as mean, minimum-maximum values, followed by sample size. The holotype, allotype, and most paratypes of our new species are deposited in the USNM. Other paratypes are deposited in the Academy of Natural Sciences, Philadelphia; Canadian National Collection, Ottawa; Florida State Collection of Arthropods, Gainesville; Museo de La Plata, Argentina; Collection of Arthropods with Medical Importance of the Instituto Nacional de Diagnostico y Referencia Epidemiologicos, Mexico City; and Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica.

Forcipomyia (Metaforcipomyia) fehrerorum Grogan and Sigrist, new species

(Figs. 1–10)

Diagnosis.—Distinguished from its only Nearctic relative, *F. (M.) pluvialis*, by its black to dark brown coloration; male parameres with medioposterior rod like extension and aedeagus arrowhead-shaped with broad, triangular, pointed tip; female with unequal-sized spermathecae with short, stout necks.

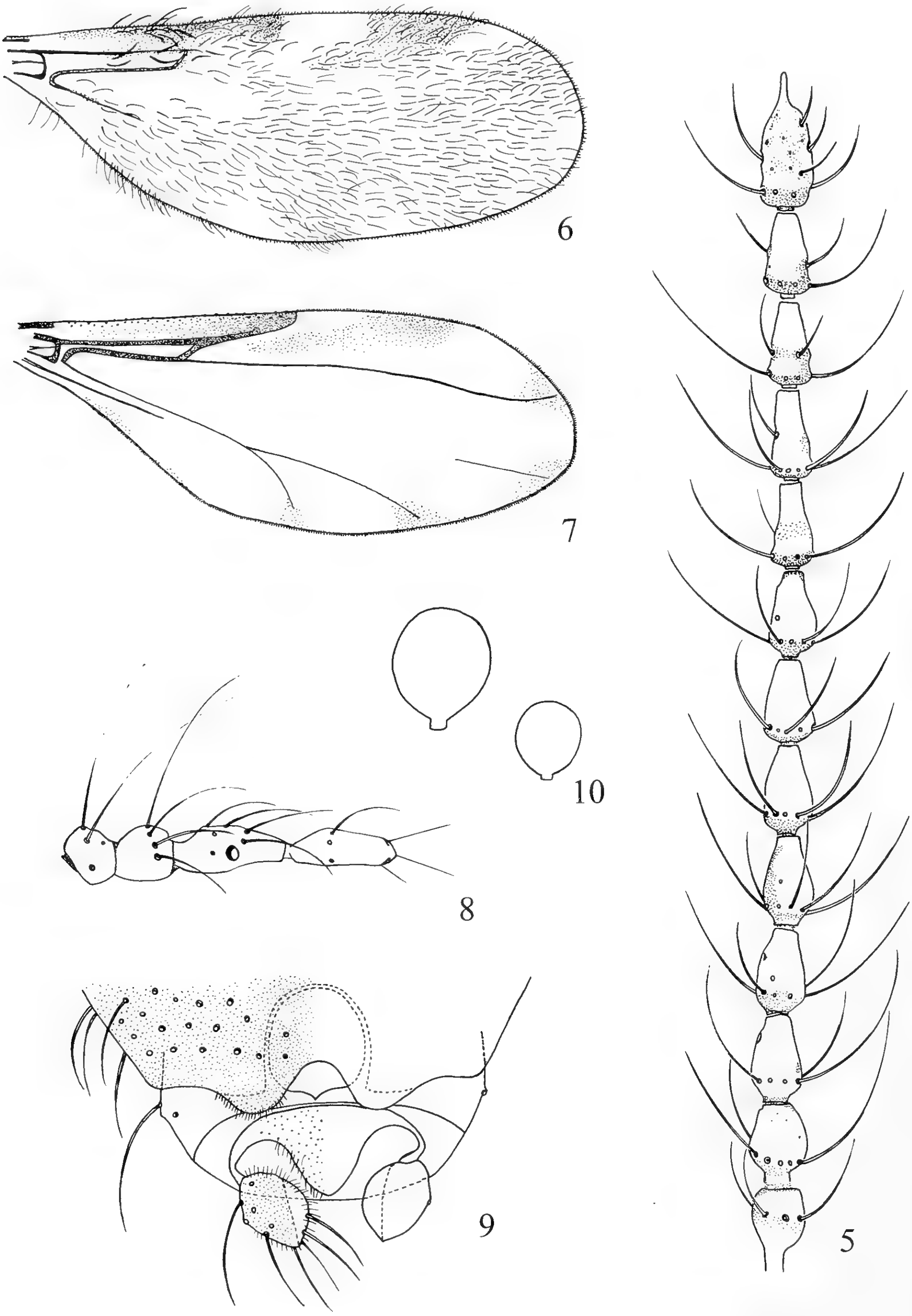
Male.—*Head:* Dark brown. Vertex, clypeus, palpus, flagellomeres with large, coarse setae with minute spicules on distal portions. Eyes contiguous, bare. Antennal flagellum (Fig. 1) light brown; flagellomeres 1–12 more or less vasiform, flagellomere 13 broader with narrow tip; flagellomeres 1–4 or 1–5 separate, 5–8 or 6–9 fused, 10–13 always separate; all flagellomeres with subbasal ring of sensilla chaetica, those on flagellomeres 2–10 very long, forming the dense plume, flagellomeres 10–13 with additional scat-



Figs. 1–4. *Forcipomyia (Metaforcipomyia) fehrerorum*, male. 1, Antennal flagellum. 2, Wing, macrotrichia intact. 3, Wing, macrotrichia removed. 4, Genitalia.

tered sensilla chaetica and sensilla basiconica; antennal ratio 0.42 (0.35–0.46, n=26). Palpus brown, 4-segmented (segment 4 = fused segments 4+5); apex of segment 4 with apical smaller, nonspiculate setae; segment 3 moderately slender with single small pit and smaller opening, rarely with 2 small pits (as on right palpus of holotype); palpal ratio 2.52 (2.00–2.86, n=33). Mandible vestigial, without teeth. *Thorax*: Dark brown; with dense large, coarse setae bearing minute spicules. Scutum with 4 moderately defined rows of large setae, additional scattered large and smaller setae; scutellum with 8 more or less centrally located large setae. Legs dark brown except for tarsomeres 3–5 which are pale; tarsi with shorter, broader, flattened setae with central striations; hind tibial comb similar to *F. pluvialis* (Fig. 18); claws small, equal-sized, curved and bent 90° at mid-length, tips slender, apices sharply pointed, entire or barely bifid. Wing (Figs. 2–3) membrane hyaline, covered with microtrichia and dense, coarse macrotrichia bearing minute spicules, those on costa, radius, broader, flattened with medial striations; distribution of macrotrichia generally densest on major veins, with pattern of pale spots due to absence of macrotrichia (Fig. 2); venation and pigmentation as illustrated (Fig. 3) from a wing devoid of macrotrichia; radial cells obliterated; vein M_1 curving upward on extreme distal portion, apex not reaching wing margin, M_2 obsolete on proximal 2/3, distal 1/3 not reaching wing margin; vein CuA_1 and CuA_2 forking at level just beyond fusion of costa and radius, CuA_2 obsolete on distal 1/3; anal lobe very poorly developed; wing length 0.89 (0.81–0.97, n=29) mm, breadth 0.28 (0.22–0.30, n=29) mm; costal ratio 0.43 (0.41–0.45, n=29). Halter pale; knob pale to white. *Abdomen*: Slender, dark brown, intersegmental areas, pleurae yellowish to grayish; surface with dense large, coarse setae bearing minute spicules. Genitalia as in Fig. 4. Sternite 9 broader than long, with smaller, finer setae, posterior margin nearly straight; tergite 9 tapering abruptly distally on proximal 1/3, distal 2/3 nearly parallel sided, with pair of large setae on extreme distolateral margins, cercus poorly developed, flattened, covered with fine setae. Gonocoxite twice as long as broad, nearly straight, covered with long coarse and fine setae as on sternite 9; gonostylus pale in color except for extreme base, nearly straight, tapering slightly distally, apex barely curved, tip sharply pointed. Aedeagus longer than broad; extreme proximal portion heavily sclerotized, basal arm recurved 60°, tip pointed; distal portion lightly sclerotized, hyaline, with few marginal wrinkles, apex broad, bifid with an underlying triangular, arrowhead-shaped, sharply pointed tip. Parameres fused, heavily sclerotized; basal apodemes curved distally, fused into a posteriorly curved median bridge bearing a slender elongate, medioposterior rodlike extension.

Female.—Similar to male with the following notable sexual differences. *Head*: Antennal flagellum (Fig. 5) with flagellomere 13 distinctly longer than proximal 12, terminal papilla more basally constricted; flagellomeres with basal whorl of shorter sensilla chaetica; flagellomeres 8–13 with additional, scattered, shorter sensilla chaetica; antennal ratio 0.75 (0.63–0.88, n=35). Palpus (Fig. 8) similar to male; segment 3 broader than male, with single small pit, rarely with two smaller pits; palpal ratio 2.00 (1.89–2.38, n=40). *Thorax*: Legs similar to male but tarsomeres 2–5 pale; claws more rounded, tips entire. Wing (Figs. 6–7) similar to male but broader; with pattern of pale spots due to absence of macrotrichia as illustrated (Fig. 6); venation, pigmentation as illustrated (Fig. 7) from a wing devoid of macrotrichia; wing length 0.80 (0.73–0.92, n=36) mm, breadth 0.33 (0.31–0.40, n=36) mm; costal ratio 0.43 (0.39–0.47, n=36). *Abdomen*: Stout, broader with narrower pale pleurae, intersegmental areas. Genitalia as in Fig. 9. Posterior margin of sternite 8 with slender, circular, sclerotized marking with thicker basal arms; sternite 9 very short medially; sternite 10 with fine setae only. Spermathecae (Fig. 10) subspherical,



Figs. 5–10. *Forcipomyia (Metaforcipomyia) fehrerorum*, female. 5, Antennal flagellum. 6, Wing, macrotrichia intact. 7, Wing, macrotrichia removed. 8, Palpus. 9, Genitalia. 10, Spermathecae.

heavily sclerotized, unequal-sized with short, broad necks; one aberrant paratype with only a single small spermatheca.

Type material.—Holotype ♂, allotype ♀, 9 ♂ and 13 ♀ paratypes labeled: MD, Wicomico Co., Wango, pitcher plant bog on TNC prop S junct. of Fooks Rd & Twilleys Bridge Rd., 14-21-VI-2004, W.L. Grogan, Malaise trap. Other paratypes: 1 ♂, same data except 4-11-V-2004; 2 ♀, same data except 11-17-V-2004; 4 ♀, same data except 17-24-V-2004; 1 ♂, same data except 7-14-VI-2004; 1 ♂, 6 ♀, same data except 21-28-VI-2004; 2 ♂, 3 ♀, same data except 28-V/5-VII-2004; 4 ♂, 7 ♀, 19-26-VII-2004; 2 ♂, 2 ♀, same data except 26-VII/2-VIII-2004; 3 ♂, 3 ♀, same data except 2-9-VIII-2004; 5 ♂, 4 ♀ same data except 26-VIII-2004. MD, Wicomico Co., Salisbury, 17-23-VIII-1982, Wm. L. Grogan, Jr., Malaise trap, 1 ♀; 1 ♂, same data except 3-10-VIII-1992; 2 ♀, same data except 29-VI-6-VII-1993. MD, Wicomico Co., Wango, Nassawango Creek at Waste Gate Rd., 1-7-V-2006, Wm. L. Grogan, Jr., Malaise trap, 1 ♂; 2 ♂, 1 ♀, same data except 22-29-V-2006; 3 ♀, same data except 27-VI/4-VII-2006; 2 ♀, same data except 4-11-VII-2006; 1 ♀, same data except 11-18-VII-2006; 1 ♀, same data except 18-25-VII-2006; 2 ♀, same data except 1-7-VIII-2006; 2 ♀, same data except 8-15-VIII-2006; 3 ♂, 2 ♀, same data except 15-22-VIII-2006; 1 ♂, same data except 22-29-VIII-2006; 3 ♀, same data except 29-VIII/7-IX-2006. FL, Highlands Co., Sebring, Highlands Hammock St. Park, 15-IV-1970, W. W. Wirth, light trap, 1 ♀; Wakulla Co., Wakulla Springs St. Pk., 25-26-V-2004, S. Murphree, CDC LT, swamp on Lodge Rd., 1 ♂, 2 ♀.

Distribution.—Known only from Florida and Maryland, but this species probably occurs throughout the southeastern Atlantic Coastal Plain.

Etymology.—We are pleased to name this new species in honor of the Joseph Fehrer, Sr. (deceased) family, including his wife Ilia and their children Joe, Jr. and Melissa, in recognition of their family's long dedicated efforts to preserving the floodplain of Nassawango Creek in both Wicomico and Worcester counties, Maryland.

Discussion.—This new species is most similar to *F. (M.) cerifera* from Brazil and extreme northeastern Argentina in coloration and morphologically. This Neotropical species differs from the new Nearctic species by its wing with a narrow 1st radial cell and lacking vein M_2 (Marino and Spinelli 1999). The male genitalia of *F. cerifera* are very similar to those of *F. fehrerorum*, but its aedeagus has a much deeper basal arch and lacks an apical point, the parameres have a straight, non-convex base, and the distomedial extension reaches the tip of the aedeagus. Females of *F. cerifera* differ from our new species in having subequal sized spermathecae with narrow necks and the genital sclerotization is more ovoid in shape with a posteromedial extension.

Despite collecting by WLG with Malaise and light traps since 1979 in the environs of Salisbury, MD, only a few individuals of this species were obtained during1982 and 1993. However, the large series collected during 2004 and 2006 indicates that this strikingly different relative of the more common and apparently more widespread *F. pluvialis*, can also be common in certain, optimal microhabitats. All specimens collected during 2004 were from the margin of a purple pitcher plant (*Sarracenia purpurea* L.) bog in an open power-line cut that is fed by a small tributary of Nassawango Creek. This bog also contains small Red maple (*Acer rubrum* L.), Buttonbush (*Cephalanthus occidentalis* L.), cattails (*Typha* sp.) and sedges. Conversely, all specimens collected during 2006 came from the flooded, swampy headwaters of Nassawango Creek that is several kilometers upstream and quite different from the 2004 collection site. This latter site is dominated by Baldcypress (*Taxodium distichum* (L.) Richard.), Red maple, Buttonbush, Greenbrier (*Smilax* sp.), Nettle (*Urtica* sp.) and Jewelweed (*Impatiens capensis* Meerb.).

The discovery of this new species in the subgenus *Metaforcipomyia* of *Forcipomyia* in the southeastern United States was unexpected. Well known as a well-traveled, tireless collector, Willis Wirth apparently only collected and/or slide mounted a single specimen of this species from FL, which we discovered during our examination of some 800 slide-mounted specimens of unidentified *Forcipomyia* in the USNM collection. We predict that future collections will yield further specimens of this new species from other states in the southeastern Atlantic and possibly Gulf Coastal plains.

Forcipomyia (Metaforcipomyia) pluvialis Malloch
(Figs. 11–21)

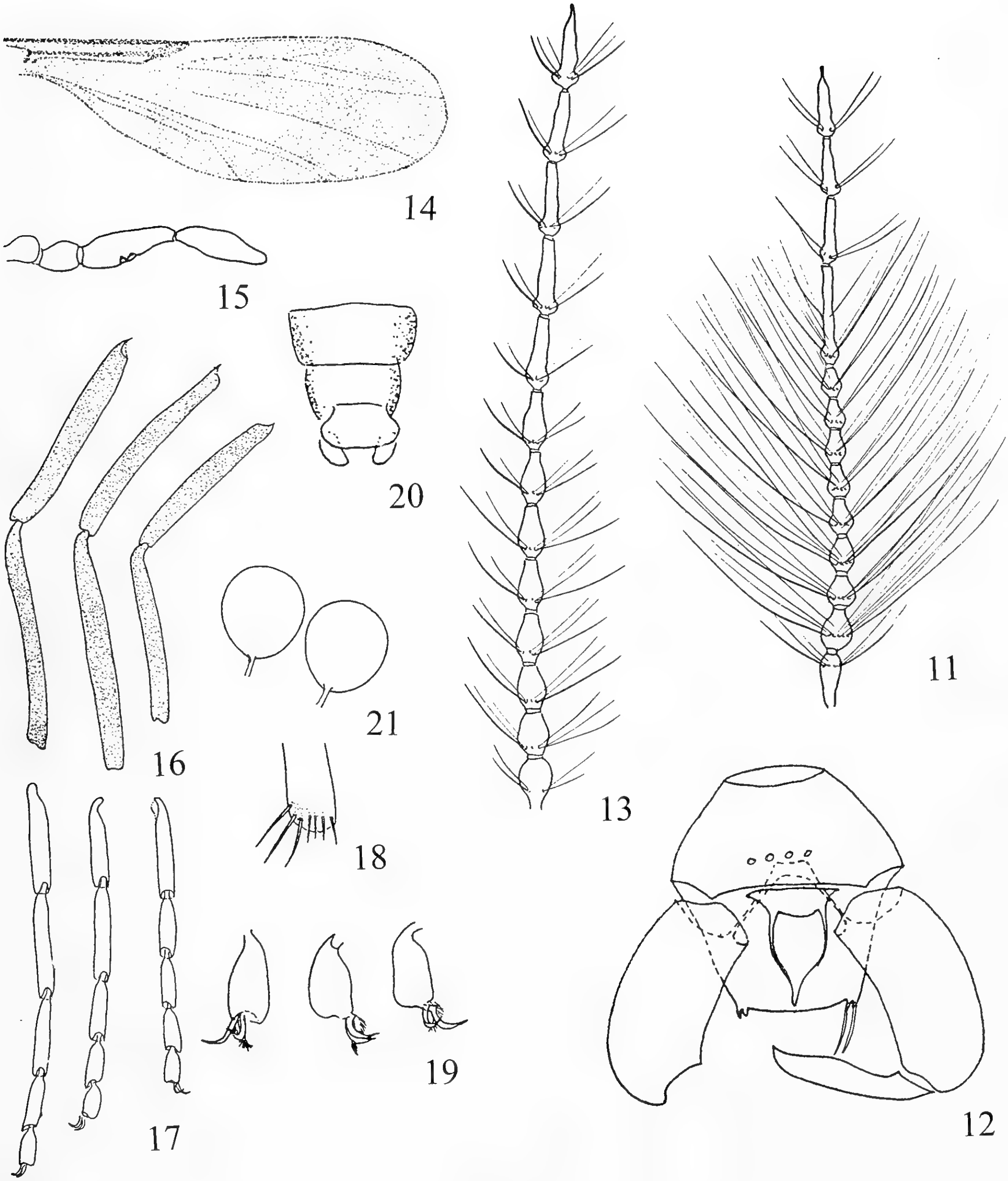
Forcipomyia pluvialis Malloch 1923: 4 (♂, ♀; Maryland).

Forcipomyia (Forcipomyia) pluvialis: Johannsen 1943: 778 (in list of North American species); Wirth 1951: 314 (♀; description; fig. ♂ genitalia; Virginia, Louisiana, Panama).

Forcipomyia (Metaforcipomyia) pluvialis: Wirth 1965: 125 (in North American catalog; distribution); Borkent and Wirth 1997: 42 (in world catalog).

Diagnosis.—Distinguished from its only Nearctic relative, *F. (M.) fehrerorum*, by its whitish or yellowish coloration; male with mediobasal bar of parameres curved anteriorly, straight posteriorly, without posterior or anterior extensions and proximal half of aedeagus shield-shaped, distal portion elongate, slender, tapering to a narrow pointed tip; female with broad, heavily sclerotized sternite 8 and spherical, equal-sized spermathecae with long, slender necks.

Male.—*Head:* Brown on vertex, golden brown on frons, clypeus, palpus grayish brown. Vertex, clypeus, palpus, antennal pedicel, flagellomere 1 with coarse setae, distal portions spiculate. Eyes bare, broadly contiguous. Antennal pedicel dark brown; flagellum (Fig. 11) with proximal 10 flagellomeres golden, distal 3 grayish brown; flagellomeres 1–9 more or less vasiform, 10–13 more elongate; all flagellomeres with sub-basal whorl of sensilla chaetica, those on flagellomeres 2–10 longer, forming dense, golden plume, 10–13 with scattered shorter sensilla chaetica and sensilla basiconica; flagellomeres 1, 2, 11–13 separate, 2–4, 9–10 semi-fused, 5–8 fused; antennal ratio 0.46 (0.41–0.54, n=10). Palpus light brown, 4-segmented; segment 3 moderately slender with 1–3 small, shallow, round sensory pits bearing large capitate sensilla with most of their lengths extending outside pit; segment 4 (fused 4+5) with apical setae; palpal ratio 3.04 (2.63–3.43, n=10). Mandible slender, reduced, without teeth. *Thorax*: Golden yellow; anterior margin of scutum, scutellum, postscutellum, ventral sclerites brown. Legs covered with dense, coarse, flattened, spiculate setae; femora, tibiae light brown, tarsi pale brown; hind tibial comb similar to female (Fig. 18); claws small, gently curved, bent 90° at midlength, tips narrow, pointed with apices very sharp, apparently entire. Wing similar to female (Fig. 14) but more narrow; membrane pale transparent with fine microtrichia and much larger, coarse, spiculate, flattened macrotrichia that are dense over radial sector, which appears as a "stigma"; both radial cells obliterated; cell r_3 with weak intercalary vein, upper fork much shorter than lower fork; vein M_1 nearly complete to wing margin, M_2 obsolete; CuA_1, CuA_2 forking at level beyond end of costa; anal lobe very



Figs. 11–21. *Forcipomyia (Metaforcipomyia) pluvialis*. 11–12, Male 13–21, Female. 11, 13, Antennal flagella. 12, Genitalia. 14, Wing, macrotrichia removed. 15, Palpus. 16, Femora and tibiae, from right to left, fore, mid, hind. 17, Tarsi, from right to left, fore, mid, hind. 18, Hind tibial comb. 19, 5th tarsomeres and claws, from right to left, fore, mid, hind. 20, Terminal abdominal segments, ventral view. 21, Spermathecae.

poorly developed; wing length 0.85 (0.78–0.92, n=10) mm; breadth 0.25 (0.21–0.28, n=9) mm; costal ratio 0.39 (0.36–0.45, n=10). Halter light brown.

Abdomen: Golden to light brown; posterior margins of sternites, tergites brown; surface with long, slender setae which are apparently non-spiculate. Genitalia as in

Fig. 12; brown, except gonostyli pale. Sternite 9 broadening distally from base, conical, posterior margin straight, 2–6 large setae in more or less single row near level of base of parameres; tergite 9 tapering gradually distally to more or less truncate distal margin, distolateral margins with 2 or more large setae. Gonocoxite slightly curved, twice as long as broad; gonostylus curving slightly distally, tapering distally from mid-portion to hooked, sharply pointed tip. Aedeagus with slightly curved basal arms; basal arch very shallow; proximal half shield-shaped, well sclerotized on margin and basal arm; distal half lightly sclerotized, tapering abruptly to narrow pointed tip that extends to or beyond posterior margin of tergite 9. Parameres fused, moderately sclerotized; basal portion a narrow bridge that is slightly curved on anterior margin; distal arm slender, straight, connecting to dorsal base of gonocoxite.

Female.—Similar to male with the following notable sexual differences. *Head*: Golden brown. Antennal flagellum (Fig. 13) brown, with all flagellomeres more or less vasiform, 9–13 longer than 1–8, 13 with tapering, terminal papilla; bases with shorter, less dense whorl of sensilla chaetica; antennal ratio 0.90 (0.83–0.94, n=10). Palpus (Fig. 15) brown; segment 4 (fused 4+5) moderately broad at mid-portion, tapering slightly distally to rounded tip; papal ratio 3.38 (2.50–3.86, n=9). *Thorax*: Golden, anterior portion of scutum, scutellum, postscutellum, fore coxa brown. Legs (Figs. 16, 17) with large setae densest on tibiae, tarsi; hind tibial comb (Fig. 18) with 3 large lateral setae and 4 smaller apical setae; 5th tarsomeres light brown, claws (Fig. 19) more rounded, tips entire. Wing (Fig. 14) slightly broader than male; veins very pale, often not discernable; anal lobe slightly better developed than in male; wing length 0.81 (0.66–0.94, n=10) mm, breadth 0.28 (0.23–0.34, n=10) mm; costal ratio 0.36 (0.33–0.39, n=10). *Abdomen*: Golden to light brown, lateral edges of sternites, tergites brown (Fig. 20); sternite 8 enlarged, broadest on distal half, shield-shaped; sternite 9 with small, poorly sclerotized circular marking on distal margin; sternite 10 with fine setae and subapical apical pair of larger setae. Spermathecae (Fig. 21) lightly sclerotized, globular, equal-sized with long, narrow necks.

Distribution.—Extreme southeastern Canada and the United States east of the Mississippi River, south to Central America and northern Brazil.

Specimens examined.—FLORIDA: Alachua Co., Gainesville, Chantilly Acres, VI-1967, F. S. Blanton, light trap, 1 ♀, same data except 16-VII-1967, F. S. Blanton, 1 ♂, same data except 25-VIII-1967,1 ♂, same data except Oak Crest, 27-X-1986, W. W. Wirth, UVLT, 1 ♂, 1 ♀; Indian River Co., Vero Beach, Ent. Res. Cntr., light trap, Mar. 1958, 1 ♂, same data except III-1960, 1 ♂, same data except, April 1960, 1 ♂; Levy Co., Yankeetown, X-1981, Alan Wilkening, light trap with CO_2, 1 ♂, 7 ♀; Monroe Co., Big Pine Key, 3 June 1971, D. G. Young, B. L. Trap, 1 ♂, Middle Torch Key, 13 Feb. 1978, W. W. Wirth, light trap, 3 ♂, 1 ♀. LOUISIANA: Baton Rouge Parish, Baton Rouge, Audubon Hall, May 1947, W. Wirth, LT, 1 ♀. MARYLAND: Montgomery Co., Glen Echo, 14-VIII-1921, J. R. Malloch, ♂ genitalia (paratype); Prince Georges Co., Patuxent Wildlife Refuge, 16-VII-1978, W. W. Wirth, Malaise trap, 1 ♀; Wicomico Co., Salisbury, 23–31 May 1979, Wm. L. Grogan, Jr., Malaise trap, 1 ♂, 2 ♀, same data except 21-28-VII-1993, 1 ♀, same data except 8-14-VIII-2003, 1 ♂, 1 ♀, same data except 24-31-VIII-2003, 1 ♀, Wango, pitcher plant bog on TNC Prop. S junct. of Fooks Rd. & Twilleys Bridge Rd., 11-17-V-2004, W. L. Grogan, Malaise trap, 2 ♂, same data except 17-24-V-2004, 1 ♂, same data except 24-31-V-2004, 2 ♂, 1 ♀, same data except 28-VI/5-VII-2004, 1 ♂, same data except 5-12-VII-2004, 1 ♂, same data except 12-19-VII-2004, 1 ♀, same data except 26-VII/2-VIII-2004, 1 ♀, same data except 2-9-VIII-2004, 1 ♀, same data except 16-23-VIII-2004, 3 ♂, 2 ♀, Wango, Nassawango Creek at Waste Gate Rd., 22-29-V-2006, Wm. L. Grogan, Jr., Malaise trap, 1 ♀, same data except 20-27-VI-2006, 1 ♂, 1 ♀, same data except 27-VI/4-VII-2006, 1 ♂, 2 ♀, same data except 4-11-VII-2006, 1 ♂, same data except 25-31-VII-2006, 1 ♀, same data except 8-15-VIII-2006, 1 ♂, same data except 22-29-VIII-2006, 1 ♂; Worcester Co., Snow Hill, 30-VI-1968, W. H. Anderson, light trap, 2 ♂. MASSACHUSETTS: Middlesex Co., Concord, 27 July 1961, W. W. Wirth, marshy pond, 5 ♂. NORTH CAROLINA: Highlands Co., July 1965, P. M. Marsh, Malaise trap, 1 ♂, 2 ♀; Transylvania Co., Lake Toxaway, 9-20-VII-1989, W. W. Wirth, UVlt, 1 ♂. VIRGINIA: Warren Co., Howellsville, 4 July 1974, P. G. Bystrak, at yellow light, oak woods, 1 ♂; Fairfax Co., Falls Church, 29 July 1950, W. W. Wirth, 5 ♂, same data except 6-VIII-1950, 1 ♂, 1 ♀, same data except Holmes Run, 17-VII-1958, 1 ♂, 1 ♀, same data except 10 Aug. 1958, 6 ♂, same data except 15-VI-1960, 1 ♂, same data except 17-VI-1960, 6 ♂, same data except 26 June 1960, 1 ♂, same data except 14 Sept. 1960, 1 ♂, same data except 17 Oct. 1960, 1 ♂, 1 ♀, same data except 17-VI-1960, 1 ♂, 3 ♀, same data except 19 Oct. 1960, 1 ♂, same data except 5 Sept. 1961, 1 ♀, same data except 10 Oct. 1961, 1 ♂. WEST VIRGINIA: Hardy Co., Lost River St. Pk., 8–14 July 1963, K. V. Krombein, tent trap, 7 ♂, 2 ♀. ONTARIO: Kemptville, 5 June 1960, W. Wirth, 1 ♂.

Discussion.—The original description by Malloch (1923) was brief and dealt mainly with coloration and some external characteristics of both sexes. Wirth (1951) briefly characterized the female hind tarsal ratio, antennal flagellomeres, and spermathecae, which he noted as "…the ducts not sclerotized." However, our examination of some 50 slide-mounted specimens revealed that the spermathecal necks are long, slender and lightly sclerotized (Fig. 21).

The male genitalia were illustrated by Wirth (1951), but not described. His illustration (Wirth 1951: Fig. 2) is fairly accurate except for the aedeagus, which he depicts as shorter, shield-shaped with a rounded apex that has a shallow median notch. Our examination of some 70 slide mounted specimens revealed that the aedeagus is indeed shield-shaped, but only on its proximal half. The extremely hyaline, narrow, and sharply pointed distal portion of the aedeagus (Fig. 12) is often difficult to discern unless this structure is viewed with high contrast at 100–400×.

ACKNOWLEDGMENTS

This article presents results of an undergraduate research project in the Department of Biological Sciences, Salisbury University by EAS who prepared all of the illustrations, mounted the majority of specimens onto microscope slides and recorded all meristic data of this new species. We gratefully acknowledge the Department of Biological Sciences, Henson School of Science, Salisbury University, for offsetting publication expenses. We thank David Furth, Wayne Mathis, and Holly Williams for the loan of specimens in the USNM collection. We are indebted to The Nature Conservancy for permission to collect on their property within the Nassawango Creek watershed. Thanks are also extended to Steve Murphree, who collected the specimens from Wakulla Co., FL, for donating his material to this study. We also thank N. C. Ratanaworabhan for preparing the illustrations of *F. pluvialis* that we have slightly modified in a few cases. Finally, we extend special thanks to Art Borkent and an anonymous individual for reviewing an earlier draft of the manuscript.

LITERATURE CITED

Borkent, A. and W. W. Wirth. 1997. World species of biting midges (Diptera: Ceratopogonidae). Bulletin of the American Museum of Natural History, No. 233, 257 pp.

Debenham, M. L. 1987. The biting midge genus *Forcipomyia* (Diptera: Ceratopogonidae) in the Australasian Region (exclusive of New Zealand). I. Introduction, key to subgenera, and the *Thyridomyia* and *Trichohelea* groups of subgenera. Invertebrate Taxonomy 1: 35–119.

Downes, J. A. and W. W. Wirth. 1981. Chapter 28. Ceratopogonidae, pp. 393–421. *In* McAlpine, J. F., B. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood, eds. Manual of Nearctic Diptera. Vol. 1. Agriculture Canada Monograph, 27, 274 pp.

Ingram, A. and J. W. S. Macfie. 1931. Ceratopogonidae. *In* Diptera of Patagonia and South Chile. Part II. Fasc. 4: 155–232.

Johannsen, O. A. 1943. A generic synopsis of the Ceratopogonidae (Heleidae) of the Americas a bibliography, and a list of the North American species. Annals of the Entomological Society of America 36: 763–791.

Liu, J.-H., G. Yan, G.-P. Liu, B.-S. Hao, Z.-J. Liu, and Y. X. Yu. 2001. Forcipomyiinae of China (Diptera: Ceratopogonidae) II. The genus Forcipomyia *Meigen.* Fauna of China 3: 3–256.

Malloch, J. R. 1923. A new species of *Forcipomyia* from the eastern United States (Ceratopogonidae, Diptera). Entomological News 34: 4–5.

Marino, P. I. and G. R. Spinelli. 1999. The subgenus *Forcipomyia (Metaforcipomyia)* in Argentina (Diptera: Ceratopogonidae). Iheringia, série Zoologia 86: 3–8.

———. 2003. The Patagonian species of the subgenus *Forcipomyia (Metaforcipomyia)* (Diptera: Ceratopogonidae), with a key to the New World species. Insect Systematics & Evolution 34: 21–28.

McAlpine, J. F. 1981. Chapter 2. Morphology and terminology – adults, pp. 9–63. *In* McAlpine, J. F., B. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood, eds. Manual of Nearctic Diptera. Vol. 1. Agriculture Canada Monograph, 27, 274 pp.

Saunders, L. G. 1957. Revision of the genus *Forcipomyia* based on characters of all stages (Diptera, Ceratopogonidae). Canadian Journal of Zoology 34: 657–705.

Spinelli, G. and A. Borkent. 2004. New species of Central American *Culicoides* Latreille (Diptera: Ceratopogonidae) with a synopsis of species from Costa Rica. Proceedings of the Entomological Society of Washington 106: 361–395.

Szadziewski, R. 1996. Biting midges from Lower Cretaceous amber of Lebanon and Upper Cretaceous Siberian amber of Taimyr (Diptera: Ceratopogonidae). Studia Dipterologica 3: 23–86.

Wirth, W. W. 1951. New species and records of Virginia Heleidae (Diptera). Proceedings of the Entomological Society of Washington 53: 313–326.

———. 1965. Family Ceratopogonidae (Heleidae). pp. 121–142. *In* Stone, A. et al., eds. A Catalog of the Diptera of America North of Mexico. U. S. Department of Agriculture, Agriculture Handbook No. 276, 1,696 pp.

Wirth, W. W. and N. Marston. 1968. A method for mounting small insects on microscope slides in Canada balsam. Annals of the Entomological Society of America 61: 783–784.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 541–546

A NEW SPECIES OF *TRIOXYS* (HYMENOPTERA: BRACONIDAE: APHIDIINAE) PARASITIC ON THE BIRD CHERRY-OAT APHID, *RHOPALOSIPHUM PADI* (L.) (HEMIPTERA: APHIDIDAE) IN THE PACIFIC NORTHWEST

J. L. Fulbright and K. S. Pike

Entomologists, Washington State University, Irrigated Agriculture Research and Extension Center, 24106 N. Bunn Road, Prosser, WA 99350, U.S.A. (e-mail: kpike@wsu.edu)

Abstract.—***Trioxys sunnysidensis* Fulbright and Pike, n. sp.,** is described and illustrated. This aphidiine parasitoid, found in central Washington, is considered a native species, reared from the bird cherry-oat aphid, *Rhopalosiphum padi* (L.), on potted wheat placed outdoors in reed canary grass, *Phalaris arundinacea* L. It is one of two *Trioxys* species known to attack *Rhopalosiphum* in North America.

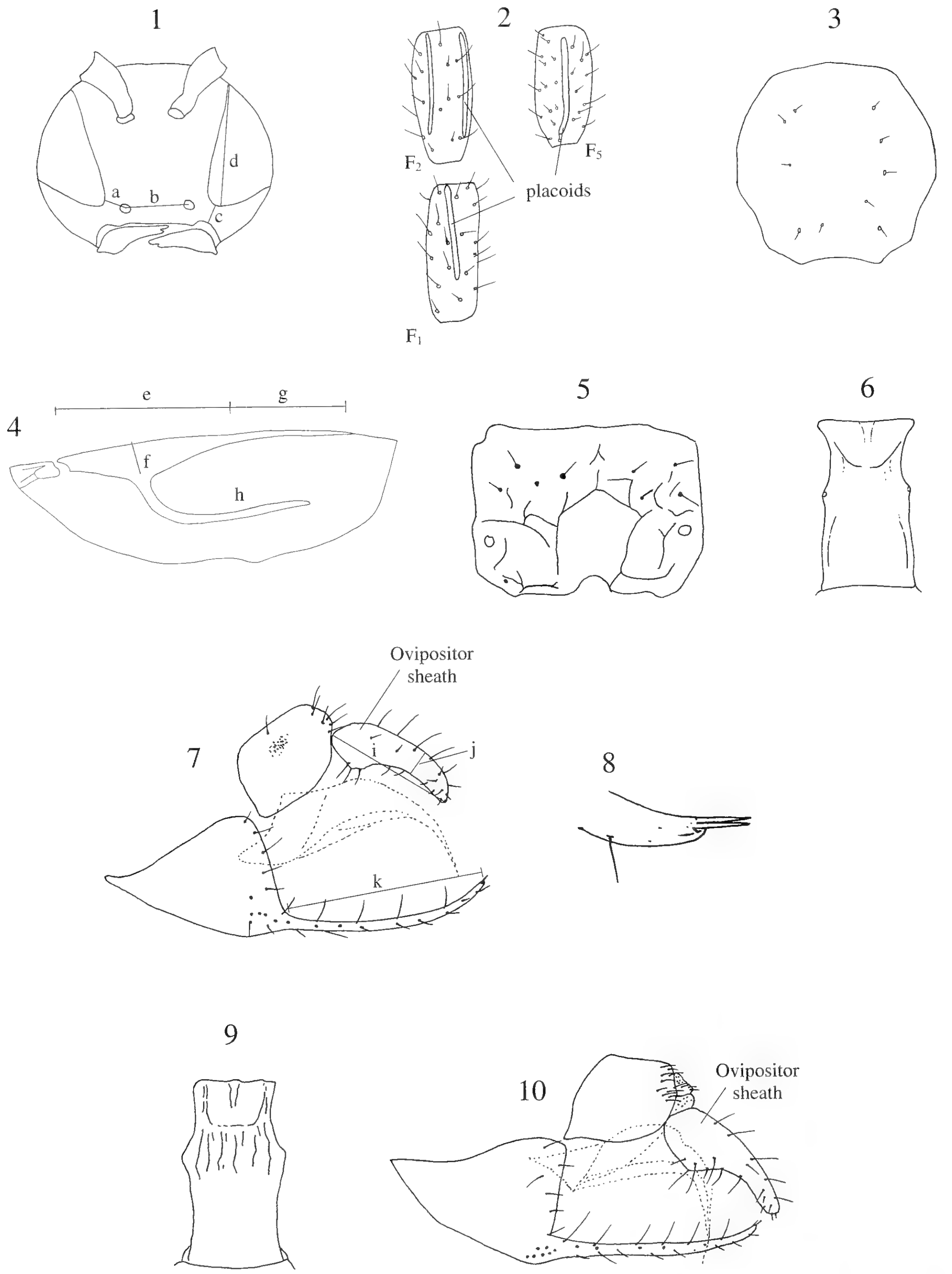
Key Words: parasitoid, aphidiine, aphelinid, *Trioxys*, aphid, *Rhopalosiphum*, wheat, new species, *Phalaris*

Parasitic wasps have been used to control pest aphids in various crop settings (van den Bosch et al. 1959, 1970; Starý 1973; Starý and Remaudière 1993; AliNiazee and Hagen 1995; AliNiazee and Messing 1995; González et al. 1995; Miller and Pike 1997). These beneficial wasps, known as aphidiids and aphelinids, are highly mobile insects that can move between habitats (Starý 1972, Starý and Pike 1999). In the authors' studies of canal bank grasses (primarily reed canary grass, *Phalaris arundinacea* L.) as a refuge for aphid parasitoids in proximity to agricultural lands, an undescribed aphidiid parasitoid of *Trioxys* Haliday attacking the bird cherry-oat aphid, *Rhopalosiphum padi* (L.), was discovered. It is herewith named and described. A brief summary of the reported native and introduced parasitoids of *R. padi* in North America is also provided.

Materials and Methods

Reed canary grass, *Phalaris arundinacea*, grows naturally and abundantly along many roadside ditches, canals, and riverbanks in Washington State. Wheat, artificially infested with *R. padi*, was placed for four days in reed canary grass habitats along the Sunnyside Valley Irrigation District main canal in central Washington's lower Yakima Valley. Exposures to naturally occurring parasitoids were undertaken in June, July, and August of 2005 and 2006. Following exposure, infested plants were held in-lab in screened containers at temperatures of approximately 20–23°C for 30 days for parasitoid development and recovery. No other aphids, other than *R. padi* were observed in any of the exposed wheat recoveries.

Descriptive morphology is after Sharkey and Wharton 1997. Specimens were



Figs. 1–10. Morphological features (not to scale). 1–8, *Trioxys sunnysidensis.* 1, Head (a, tentorio-ocular distance; b, intertentorial distance; c, malar space; d, eye length). 2, Antennal flagellomeres. 3, Mesoscutum (setal number and arrangement shown). 4, Forewing (e, stigma length; f, stigma width; g, R1 [= metacarpus]; h, RS vein [radial sector]). 5, Propodeum. 6, Petiole. 7, Ovipositor sheath, seventh metasomal sternite prong and genitalia (i, ovipositor sheath length; j, ovipositor sheath width at narrower

slide mounted whole or dissected (after techniques by P. Starý, modified by G. Graf of Washington State University) and measured as follows:

Whole mount.—1) specimen immersed in 95 % ETOH; 2) specimen transferred to test tube of water and inverted several times; 3) water decanted, 10% KOH added and tube placed in heating block for approximately 2 minutes at 98°C; 4) specimen transferred to test tube of water and inverted several times; 5) specimen placed in 3 drops of mounting medium (200 g gum arabic, 550 g chloral hydrate, 60 ml glycerin, and 400 ml distilled water, mixed and filtered through glass wool) and positioned; 6) coverslip placed over specimen; 7) collection code written on slide; 8) slide placed on slide warmer for 2–3 weeks at 50°C to allow mounting medium to harden; 9) mount sealed around coverslip with glyptal to prevent dehydration and crystallization; 10) slide fully labeled.

Dissected mount.—1) specimen placed in a mounting medium; 2) head separated from body using fine, sharply pointed insect pins; 3) mesonotum, wings (sometimes left attached to mesonotum), propodeum, petiole (sometimes left attached to propodeum or metasoma), hind legs, and genitalia with ovipositor sheath and prongs (sometimes left attached to metasoma if protruding) separated; and 4) parts positioned in medium (e.g., dorsal view of mesonotum, lateral view of genitalia).

Measurements.—Whole and dissected mounts were reticle measured using a Zeiss Axiolab™ dissecting microscope at magnifications of 50–400×.

Trioxys sunnysidensis Fulbright and Pike, new species

Figs. 1–8

Diagnosis.—*Trioxys sunnysidensis* is characterized by a 12-segmented antenna, rarely 11-segmented, with flagellar segments 1, 2, and 5 each of similar length and width, and by its current host range. The prongs of the seventh metasomal sternite bear 4–5 dorsal setae, 6–8 ventral setae, and 2 straight, simple bristles on the upper side of the apex.

A Eurasian species, *Trioxys auctus* (Haliday 1833) is the only other *Trioxys* species in North America known to attack species of *Rhopalosiphum* (Starý and Remaudière 1977). It is similar to *T. sunnysidensis* (Figs. 6, 7) but *T. auctus* may be distinguished by the following features: dorsal striations on the petiole and differences in the shape of the ovipositor sheath (see Figs. 9, 10).

Description.—Female. *Head.* (Fig. 1): Eyes averaging 161 μm in length, range: 135–175 μm. Malar space equal to 1/5 of eye length. Antenna usually 12-segmented, rarely 11-segmented. Flagellar segment 1 (=F1) (Fig. 2, Table 1) averaging 2.5× as long as wide, usually with 1 or 2 placoids; F2 (Fig. 2) approximately equal in width and length to F1, with 1 or 2 placoids; F5 (Fig. 2) approximately equal in width and length to F2. *Mesosoma* (Fig. 3): Mesoscutum with 6–11 pleural setae. Propodeum (Fig. 5) carinate with pentagonal areola (sometimes open posteriorly), and 7–12 anterior propodeal setae. *Forewing* (Fig. 4, Table 1): Stigma triangular, tapering into R1 (Fig. 4). Radial sector 3× as long as stigma width. *Metasoma*: Petiole (Fig. 6) about twice as long as width across

←

distal region; k, length of prong). 8, Apical bristles of seventh metasomal sternite prong. 9–10, *Trioxys auctus* (redrawn after Starý 1976). 9, Petiole. 10, Ovipositor sheath, seventh metasomal sternite prong and genitalia.

Table 1. Feature measurements (μm), counts, and comparisons of female and male *Trioxys sunnysidensis* (from paratype series, n = 19 females, n = 9 males).

	Female		Male	
	Avg.	(Range)	Avg.	(Range)
Head				
Antenna flagellomeres				
F1 (length)	79	(70–90)	85	(75–100)
F2 (length)	79	(70–95)	92	(75–110)
F5 (length)	81	(70–95)	98	(80–110)
F1 (width)	32	(25–40)	37	(30–45)
F2 (width)	33	(25–40)	33	(25–40)
F5 (width)	36	(30–40)	36	(30–45)
Antennal placoids				
F1 (no.)	1.4	(1.0–2.0)	2.0	(2.0–2.0)
F2 (no.)	1.9	(1.0–2.0)	2.0	(2.0–2.0)
F5 (no.)	2.0	(2.0–2.0)	2.0	(2.0–2.0)
Eye (length)	161	(135–175)	144	(130–165)
Malar space (length)	32	(25–40)	36	(30–40)
Inter-tentorial distance	92	(80–100)	89	(80–95)
Tentorio-ocular distance	30	(25–35)	33	(30–40)
Mesosoma				
Mesoscutal pleural setae (no.)	8.0	(6.0–11.0)	7.8	(5.0–11.0)
Wing				
Stigma (length)*	299	(280–320)	297	(260–325)
Stigma (width)	78	(75–90)	77	(60–90)
R1 (length)*	159	(130–180)	148	(120–180)
Radial sector vein	252	(210–280)	245	(210–275)
Propodeal setae, anterior area (no.)	9.3	(7.0–12.0)	7.5	(5.0–9.0)
Metasoma				
Petiole				
length	191	(150–225)	164	(145–185)
width at spiracular tubercles (1°)	97	(80–120)	81	(75–90)
Genitalia				
Ovipositor sheath (length)	170	(150–185)		
Ovipositor sheath (width)	29	(25–35)		
Prong (length)	237	(225–265)		
Prong dorsal setae (no.)	4.6	(4.0–5.0)		
Prong ventral setae (no.)	7.0	(6.0–8.0)		
Comparisons				
Malar space / eye	0.2	(0.1–0.3)	0.3	(0.2–0.3)
F1 (length / width)	2.5	(2.0–3.4)	2.3	(2.1–3.3)
F2 (length) / F1 (length)	1.0	(0.9–1.1)	1.1	(1.0–1.1)
F2 (length / width)	2.4	(2.1–3.0)	2.8	(2.3–3.4)
F5 (length / width)	2.2	(1.9–2.8)	2.8	(2.3–3.7)
F5 (length) / F2 (length)	1.0	(0.9–1.1)	1.1	(1.0–1.2)
Petiole (length /width at 1° tubercle)	2.0	(1.6–2.4)	2.0	(1.9–2.1)
Stigma (length / width)	3.8	(3.3–4.2)	3.9	(3.5–4.3)
Stigma (length) /R1 (length)	1.9	(1.7–2.3)	2.0	(1.8–2.5)
Ovipositor (length / width)	6.0	(4.9–7.2)		

* Troublesome to define, as stigma tapers into R1; measurements should be viewed as estimates – R1 measured from a point of roughly constant thickness.

spiracular tubercles. Ovipositor sheath length slightly < 6× sheath width at midpoint of narrower distal region of sheath (Fig. 7). Sheaths distinctly emarginate ventrally. Prongs relatively long and narrow with 2 straight, simple bristles at apex (Fig. 8); with 4–5 dorsal and 6–8 ventral setae. *Color:* Head black to dark brown, palpi brown. Antenna dark brown, except scape, pedicel, and narrow base of F1 light brown. Mesosoma black to dark brown. Wing venation light brown. Legs brown to light brown. Metasoma blackish brown to brown. Petiole light brown. Ovipositor sheaths dark blackish brown to brown. Seventh metasomal sternite prongs brown. Body 1.6–2.1 mm.

Male. Antenna 13-segmented. Coloration similar to female. Body 1.2–1.4 mm.

Material examined.—Holotype ♀ (whole mount, dry): USA, Washington, Yakima Co., Sunnyside Valley Irrigation District main canal, 6 July 2006, J. Fulbright, collector. Reared from *Rhopalosiphum padi* (L.) on artificially infested wheat plants (*Triticum aestvum* L. var. Alpowa) placed in stands of reed canary grass, *Phalaris arundinacea* L. on the canal bank. Deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM). Paratypes: 40 specimens, from the same location as holotype, reared from *R. padi* in June and July 2005 and 2006. Paratypes deposited in collections of USNM (5 ♀, 3 ♂), Washington State University, Prosser (15 ♀, 11 ♂), and P. Starý, Czech Republic (5 ♀, 1 ♂).

Etymology.—The name is derived from the type locality, the Sunnyside Valley Irrigation District main canal in central Washington's lower Yakima Valley.

DISCUSSION

As previously stated, *T. sunnysidensis* and *T. auctus* both attack species of *Rhopalosiphum*. *Trioxys auctus*, of Eurasian origin, has been reported in Québec to attack *Rhopalosiphum nymphaeae* (L.) (Starý and Remaudière 1977), while in the Mediterranean region it is known to attack *R. padi* (Starý 1976).

The bird cherry-oat aphid, *Rhopalosiphum padi*, has a wide distribution in the temperate zones of the northern and southern hemispheres (Pike 1985). It is common on small grains and a wide array of grasses. Within the Pacific Northwest, *R. padi* is attacked by a diversity of aphidiine parasitoids: *Diaeretiella rapae* (M'Intosh) (Pike et al. 1997); *Monoctonus washingtonensis* Pike and Starý and *Praon yakimanum* Pike and Starý (Pike and Starý 1995); *Aphidius ervi* Haliday, *Lysiphlebus testaceipes* (Cresson), *Praon occidentale* Baker, and *Praon unicum* Smith (Pike et al. 1996, Pike et al. 2000); and *Aphidius avenaphis* (Fitch) and *A. matricariae* Haliday (Pike et al. 2000).

The appearance of *R. padi* on *Phalaris arundinacea* is relatively common (Pike et al. 2000). Stands of *P. arundinacea* in Washington State, when infested with aphids, generally carry higher densities of *R. padi* than all other aphids combined (Pike unpublished data). However, it is not yet known whether *R. padi* is the premier host of *T. sunnysidensis*. Research to determine other hosts of *T. sunnysidensis* is in progress.

Although *R. padi* was parasitized by *T. sunnysidensis* on wheat plants placed in reed canary grass along the canal, there have been no records of *R. padi* being parasitized as such in agricultural wheat fields. The parasitoid is apparently more closely linked with the reed canary grass habitat. This habitat is common along waterways and roadsides where runoff water collects. Many of the areas lie adjacent to small grains, but the absence of *T. sunnysidensis* on grain crops as a whole, and its lack of movement into such fields limits its value as a biological control agent.

Acknowledgments

We express thanks to the Sunnyside Valley Irrigation District for canal access; G. Graf for clearing and mounting specimens and collection assistance; A. Allison, C. Fulbright, D. Graf, and R. Potter for collection assistance; D. Allison and P. Starý for manuscript review; and R. L. Zuparko, Essig Museum of Entomology, University of California, Berkeley, for specimen loan of *Trioxys auctus*. The work was made possible with the support of Washington State University, Department of Entomology.

Literature Cited

AliNiazee, M. T. and K. S. Hagen. 1995. Walnut aphid-part 1, pp. 140–141. *In* Nechols, J. R., L. A. Andres, J. W. Beardsley, R. D. Goeden, and C. G. Jackson, eds. Biological Control in the Western United States. University of California, Division of Agriculture and Natural Resources, Publication 3361, 356 pp.

AliNiazee, M. T. and R. H. Messing. 1995. Filbert aphid, pp. 123–126. *In* Nechols, J. R., L. A. Andres, J. W. Beardsley, R. D. Goeden, and C. G. Jackson, eds. Biological Control in the Western United States. University of California, Division of Agriculture and Natural Resources, Publication 3361, 356 pp.

González, D., K. S. Hagen, P. Starý, G. W. Bishop, D. W. Davis, and K. S. Pike. 1995. Pea aphid and blue alfalfa aphid, pp. 129–135. *In* Nechols, J. R., L. A. Andres, J. W. Beardsley, R. D. Goeden, and C. G. Jackson, eds. Biological Control in the Western United States. University of California, Division of Agriculture and Natural Resources, Publication 3361, 356 pp.

Haliday, A. H. 1833. An essay on the classification of the parasitic Hymenoptera of Britain, which correspond with the Ichneumones minuti of Linnaeus. Entomological Magazine 1: 259–276.

Miller, S. and K. S. Pike. 1997. Biological control of Russian wheat aphid. Wheat Life 40(7): 72–73.

Pike, K. S. 1985. A bibliography of the bird cherry-oat aphid (*Rhopalosiphum padi*). Washington State University Research Bulletin 957, 40 pp.

Pike, K. S. and P. Starý. 1995. New species of parasitic wasps attacking cereal aphids in the Pacific Northwest (Hymenoptera: Braconidae: Aphidiinae). Journal of the Kansas Entomological Society 68(4): 408–414.

Pike, K. S., P. Starý, R. Miller, D. Allison, L. Boydston, G. Graf, and T. Miller. 1996. New species and host records of aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) from the Pacific Northwest, U.S.A. Proceedings of the Entomological Society of Washington 98(3): 570–591.

Pike, K. S., P. Starý, T. Miller, D. Allison, L. Boydston, G. Graf, and R. Gillespie. 1997. Small-grain aphid parasitoids (Hymenoptera: Aphelinidae and Aphidiidae) of Washington: distribution, relative abundance, seasonal occurrence, and key to known North American species Environmental Entomology 26(6): 1299–1311.

Pike, K. S., P. Starý, T. Miller, G. Graf, D. Allison, L. Boydston, and R. Miller. 2000. Aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) of Northwest U.S.A. Proceedings of the Entomological Society of Washington 102(3): 688–740.

Sharkey, M. J. and R. A. Wharton. 1997. Morphology and Terminology, pp. 19–37. *In* Wharton, R. A., P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World genera of the family Braconidae (Hymenoptera). Special Publication of the International Society of Hymenopterists No. 1, 439 pp.

Starý, P. 1972. Host range of parasites and ecosystem relations, a new viewpoint in multilateral control concept (Homoptera, Aphididae; Hymenoptera, Aphidiidae). Annales de la Société Entomologique de France, N.S. 8: 351–358.

———. 1973. The fate of released parasitoids (Hymenoptera: Braconidae, Aphidiinae) for biological control of aphids in Chile. Bulletin of Entomological Research 83: 157–163.

———. 1976. Aphid Parasites (Hymenoptera, Aphidiidae) of the Mediterranean Area. Dr. W. Junk, The Hague, 95 pp.

Starý, P. and K. S. Pike. 1999. Uses of beneficial insect diversity in agroecosystem management, pp. 49–67. *In* Collins, M. and C. O. Qualset, eds. Importance of Biodiversity in Agroecosystems. Advances in Agroecology Series, CRC Press LLC Publishers.

Starý, P. and G. Remaudière. 1977. Some aphid parasitoids (Hymenoptera: Aphidiidae) from Nearctic America. Annales de la Société Entomologique de France, N.S. 13(4): 669–674.

———. 1993. Arrivée spontanée enregion Parisienne de l'Hyménoptère aphidiide *Pauesia cedrobi*, parasite du puceron du cèdre *Cedrobium laportei*. Revue Française d'Entomologie 15: 157–158.

van den Bosch, R., E. I. Schlinger, E. J. Dietrick, K. S. Hagen, and J. K. Holloway. 1959. The colonization and establishment of imported parasites of the spotted alfalfa aphid in California. Journal of Economic Entomology 52(1): 136–141.

van den Bosch, R., B. D. Frazer, C. S. Davis, P. S. Messenger, and R. Hom. 1970. *Trioxys pallidus*: An effective new walnut aphid parasite from Iran. California Agriculture 24(11): 8–10.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 547–571

A REVISION OF THE GENUS *PRIOCNEMICORIS* COSTA WITH THE DESCRIPTION OF EIGHT NEW SPECIES (HEMIPTERA: HETEROPTERA: COREIDAE: CLORESMINI)

HARRY BRAILOVSKY AND ERNESTO BARRERA

Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, Apdo Postal No. 70153, México 04510 D.F., México (HB e-mail: coreidae@servidor.unam.mx)

Abstract.—The genus *Priocnemicoris* Guérin-Méneville of the tribe Cloresmini (Coreidae) is revised. Prior to this work only one species, *P. flaviceps* (Guérin-Méneville), was known. Eight **new species** from Irian Jaya and Papua New Guinea are described (**P. antennatus**, **P. bicoloripes**, **P. cyclops**, **P. doesburgi**, **P. kiungensis**, **P. morobe**, **P. nigrellus**, and **P. papuensis**), and the species **P. diversipes** (Fallou) is resurrected from the synonymy of **P. flaviceps**; new records for the previously known species are added; habitus illustrations and drawings of the male genital capsule and parameres, as well as female genital plates are provided; and a key to the known species is presented.

Key Words: Hemiptera, Heteroptera, Coreidae, Cloresmini, revision, *Priocnemicoris*, new species, Irian Jaya, Papua New Guinea

The tribe Cloresmini, restricted to the Eastern Hemisphere (China, India, Philippine Republic, Malaysia, Indonesia, and Papua New Guinea), is characterized by having the body more or less shining, usually with green metallic iridescence, the abdomen almost parallel-sided, not dilated laterally; abdominal sterna III and IV lacking tubercles; the male hind femora not curved or curved only at the very basal third and ventrally armed with long spines; the hind tibiae not expanded; the head short, shorter than width and abruptly bending downward at the antenniferous tubercle level; rostrum not extending to base of abdomen; and antenniferous tubercle protruding forward.

The genus *Priocnemicoris* was proposed by Costa (1863) to include only the species *P. refulgens* Costa ("Patria Ignota"). Stål (1873) transferred the species *Nematopus flaviceps* (Guérin-Méneville 1832) described from Papua New Guinea to *Priocnemicoris*, and synonymyzed *P. refulgens* with *P. flaviceps*. In the same paper, Stål transferred the species *Nematopus albithorax* Boisduval (1835), described from New Guinea, to *Priocnemicoris*. Fallou (1891) described a new species *Notobitus diversipes* from New Britain (Papua New Guinea), and a year later Bergroth (1892) synonymized it with *Priocnemicoris flaviceps*. Lethierry and Severin (1894) in their catalogue considered *albithorax*, *diversipes*, and *refulgens* synonyms of *Priocnemicoris flaviceps*. Blöte (1936) reported *P. flaviceps* from New Guinea and included several new localities.

Previously, only one species of *Priocnemicoris*, *P. flaviceps*, was known. In this contribution, the genus is redescribed, one species, *P. diversipes* (Fallou) is resurrected from the synonymy of *P. flaviceps*, new records for *P. diversipes* and *P. flaviceps* are given, and eight new species from Irian Jaya and Papua New Guinea are described.

The following abbreviations indicate institutions where specimens are deposited or from where they were generously lent: American Museum of Natural History, New York (AMNH); Australian National Insect Collection, Canberra (ANIC); The Natural History Museum, London (BMNH); Bernice P. Bishop Museum, Honolulu, Hawaii (BPBM); Brigham Young University, Monte L. Bean Life Sciences Museum, Provo, Utah (BYU); California Academy of Sciences, San Francisco (CAS); Field Museum of Natural History, Chicago, Illinois (FMNH); Institut Royal des Sciences Naturelles, Bruxelles, Belgium (IRNB); Natural History Museum of Los Angeles County, California (LACM); Queensland Museum, Brisbane, Australia (QMBA); South Australian Museum, Adelaide (SAMA); Texas A & M University, College Station (TAMU); University of California, Davis (UCDA); University of Minnesota, Insect Collection, St. Paul (UMSP); Colección Entómologica, Instituto de Biología, Universidad Nacional Autónoma de México (UNAM); National Museum of Natural History, Smithsonian Institution, Washington D. C. (USNM); Zoological Institute, St. Petersburg, Russia (ZMAS); Zoologische Staatssammlung Münich, Germany (ZSMC).

All measurements are given in millimeters.

Priocnemicoris Costa

Priocnemicoris Costa 1863: 253–254; Stål 1873: 66; Lethierry and Severin 1894: 41.

Type species: *Nematopus flaviceps* Guérin-Méneville 1832: 177. Designated by Stål 1873.

Myrsilus Stål 1865: 3; Walker 1871: 75.

The tribe Cloresmini contains four genera: *Cloresmus* Stål (1859), *Notobitus* Stål (1859), *Notobitella* Hsiao (1963), and *Priocnemicoris* Costa (1863).

The genus *Priocnemicoris* contains several of the most brightly colored species of Coreidae. It is characterized by having the fore femora ventrally unarmed or with one subapical spine; abdominal sternite VII of the female is complete, lacking plica or fissura; the post-tylar depression deep, forming a single sulcus; the middle third of the pronotal disk with a low, longitudinal groove, running behind the calli laterally to the posterior margin; the mesosternum with a median sulcus at the anterior third; and the buccula situated after the insertion of antenna and not produced anteriorly.

For the other three genera, the fore femur is armed with two rows of ventral spines; abdominal sternite VII of female has a plica and fissura; the post-tylar depression is absent, or weakly impressed; the middle third of the pronotal disk lacks a median groove; and the buccula is situated before the antennal insertions of the antennae, and clearly produced anteriorly.

According to the characters discovered in this study, *Priocnemicoris* can be divided into two groups of species. The first group, characterized by having the propleura, mesopleura, and metapleura clothed with numerous very short yellowish-white sericeous hairs giving a woolly appearance, includes six species: *P. antennatus*, *P. cyclops*, *P. diversipes*, *P. flaviceps*, *P. nigrellus*, and *P. papuensis*. The second group includes four species *P. bicoloripes*, *P. doesburgi*, *P. kiungensis*, and *P. morobe*, all of which lack yellowish-white sericeous setae on the propleura, mesopleura, and metapleura.

Redescription.—*Head:* Wider than long, shorter than pronotal length, dorsally flat, declivant, suddenly bending downward at antenniferous tubercles level; tylus blunt, rounded, unarmed, thickened, slightly exceeding juga; antenniferous tubercles protruding forward, widely separated, unarmed, inner margins with large lobe apically rounded; post-tylar depression deep, forming a single median longitudinal sulcus; antennal segment IV longer than head and pronotum combined; antennal segment I slender, thicker than succeeding segments and slightly curving; segments II and III cylindrical, IV fusiform; antennal segment IV longest, III shortest, and I longer than II; preocellar pit deep, nearly circular; ocelli prominent, not raised; eyes hemispherical, conspicuously prominent and clearly removed from anterior pronotal angles; buccula short, elevated, situated after insertion of antennae, not produced anteriorly; rostrum reaching anterior or middle third of mesosternum; rostral segment III shortest, I and IV subequal, and II shorter than I and IV; rostral segment I reaching hind margin of eyes; neck short; postocular tubercle absent; mandibular plate unarmed.

Thorax: Pronotum wider than long, trapeziform, gradually declivant; collar wide; anterolateral border obliquely straight, smooth: frontal angles blunt; humeral angles obtuse or slightly exposed; posterolateral borders sinuate, entire; posterior border entire, concave or straight across base of scutellum; triangular process absent; calli weakly and uniformly elevated, separated along midline by a longitudinal mesial furrow; middle third of pronotal disk with low longitudinal groove running behind calli until posterior margin; posterior margin with low transverse carina; prosternum with deep excavation; mesosternum with median sulcus at anterior third, and deep longitudinal groove reaching middle third of the sternum; posterior border of metasternum straight, slightly sinuate, or conspicuously concave; anterior lobe of metathoracic peritreme elongate, raised, located far apart from the anterior margin of metapleura, posterior lobe auriculiform. Legs of male with coxae and trochanters unarmed; distance between procoxae and mesocoxae two times diameter of mesocoxae; distance between mesocoxae and metacoxae one times diameter of mesocoxae; fore and middle femora slender, unarmed, or with short single subapical spine; hind femur not curved, relatively incrassate, conspicuously exceeding apex of abdomen, ventrally with two large acute spines, one near middle third, second one subdistal, and two rows of short spines running from middle third to apex; fore and middle tibiae sulcate, unarmed; hind tibia curved at very basal third, sulcate, inner face with one row of short stout spines, or very stout spines; length of tarsal segment I longer than total length of segments II and III together. Female legs similar to male except hind femur not curved, less incrassate than male, reaching but not exceeding apex of abdomen, ventrally with one large acute subdistal spine, and two rows of short spines running from middle third to apex; hind tibia not curved, unarmed, sulcate.

Scutellum: Triangular, flat, longer than wide, apically subacute.

Hemelytra: Macropterous, extending beyond apex of last abdominal segment; apical margin weakly concave; apical angle narrowed, long, extending beyond middle third of hemelytral membrane.

Abdomen: Almost parallel-sided, not dilated laterally; posterior angle of connexival segments III to VII extended into large, acute spine; abdominal spiracle closer to anterior border; distance between spiracle and upper margin of abdomen greater than distance between spiracle and anterior margin of sternum.

Integument: Body surface shining, with or withtout green metallic iridescence; head, calli, connexivum, prosternum, mesosternum, metasternum, anterior and middle third of mesopleuron and metapleuron, abdominal sterna, male genital capsule, and female genital plates smooth, impunctate; pronotal disk transversely striated, with few tiny punctures at humeral angles; scutellum transversely striated, with one row of punctures along lateral margins; clavus and corium densely punctate, punctures larger than those of pronotum and scutellum; propleuron, and posterior margin of mesopleuron and metapleuron striated, and weakly to coarsely punctate; yellowish longitudinal stripe on propleura, mesopleura and metapleura clothed with numerous very short yellowish-white sericeous setae, giving a clearly woolly appearance (sometimes lacking); surface clothed with short decumbent to erect silver or golden bristle-like pilosity; abdominal sterna with few moderately long and conspicuous silver to golden bristle like setae; pubescence of antennae and femora short, mainly suberect; pubescence of tibiae and tarsi longer and rather dense; abdominal sterna III to VII usually with an ovate or obovate patch of silver to golden bristle like hairs located below each abdominal spiracle.

Male genital capsule: Posteroventral edge with lateral angles exposed into large, and broad arms, or large and subacute to subtruncate arms, between them with deeply U-shaped concavity with large, stout mesial projection or short, slender mesial projection or lacking a median projection; the latter condition with the mesial concavity wide open or clearly angulate, V-shaped.

Female genitalia: Abdominal sternite VII complete, without plica or fissura; gonocoxae I broad, enlarged anteroposteriorly with inner margins contiguous; upper border wide, straight, truncate, and outer border weakly convex, or upper border rounded, and outer border obliquely straight or upper border short, straight and truncate, and outer border obliquely straight; paratergite VIII triangular, with spiracle visible, and larger than paratergite IX; paratergite IX squarish, not overlapping at middle third, with posterior third angulate, exposed and directed backward.

Key to Species of *Priocnemicoris*

1\. Fore and middle legs entirely dark reddish brown to black . . . . *P. nigrellus*, n. sp.
– Fore and middle legs entirely yellow or pale yellowish orange 2
2\. Corium bicolorous, yellowish, with costal and apical margins dark castaneus orange; abdominal sterna tricolorous . . . . *P. bicoloripes*, n. sp.
– Corium concolorous; abdominal sterna bicolorous, yellowish with pale castaneus marks below abdominal spiracle 3
3\. Upper margin of propleuron, and posterior third of mesopleuron and metapleuron with a green metallic iridescence 4
– Upper margin of propleuron, and posterior third of mesopleuron and metapleuron lacking a green metallic iridescence 6
4\. Pronotal disk clothed with short, dense erect setae . . *P. flaviceps* (Guérin-Méneville)
– Pronotal disk clothed with short, sparse almost, decumbent setae 5
5\. Anterior lobe of pronotal disk pale castaneus orange, and posterior lobe shiny reddish castaneus; posteroventral edge of male genital capsule without mesial projection (Figs. 5, 10) . . . . . . *P. cyclops*, n. sp.
– Pronotal disk uniformly reddish castaneus; posteroventral edge of male genital with short and stout or acute mesial projection (Figs. 3, 6) . . . . *P. diversipes* (Fallou)
6\. Propleuron, mesopleuron, and metapleuron clothed with numerous very short, yellowish-white sericeous setae giving a clear woolly appearance 7
– Propleuron, mesopleuron, and metapleuron clothed with fine and sparse decumbent setae, lacking yellowish-white sericeous setae 8
7\. Antennal segment I shiny reddish orange, with basal third black; antennal segment I relatively slender. . . *P. papuensis*, n. sp. (in part)
– Antennal segment I entirely reddish orange; antennal segment I robust . . . . *P. antennatus*, n. sp.

8. Antennal segment I shiny reddish orange, with basal third black . . . . *P. papuensis*, n. sp. (in part)
– Antennal segment I entirely shiny reddish orange 9
9. Posterior margin of metapleuron conspicuously concave; propleuron entirely pale yellow; mesopleuron and metapleuron entirely castaneus orange . . . . *P. doesburgi*, n. sp.
– Posterior margin of metapleuron straight or slightly sinuate; propleuron, mesopleuron, and metapleuron uniformly shiny yellowish orange 10
10. Male genital capsule trilobate (Fig. 11); pronotal disk clothed with short and sparse almost decumbent setae . . *P. morobe*, n. sp.
– Male genital capsule with V or U opening (Fig. 2); pronotal disk clothed with short, dense erect setae . . . . . . *P. kiungensis*, n. sp.

Priocnemicoris flaviceps (Guérin-Méneville)

(Figs. 4, 9, 21, 35–37)

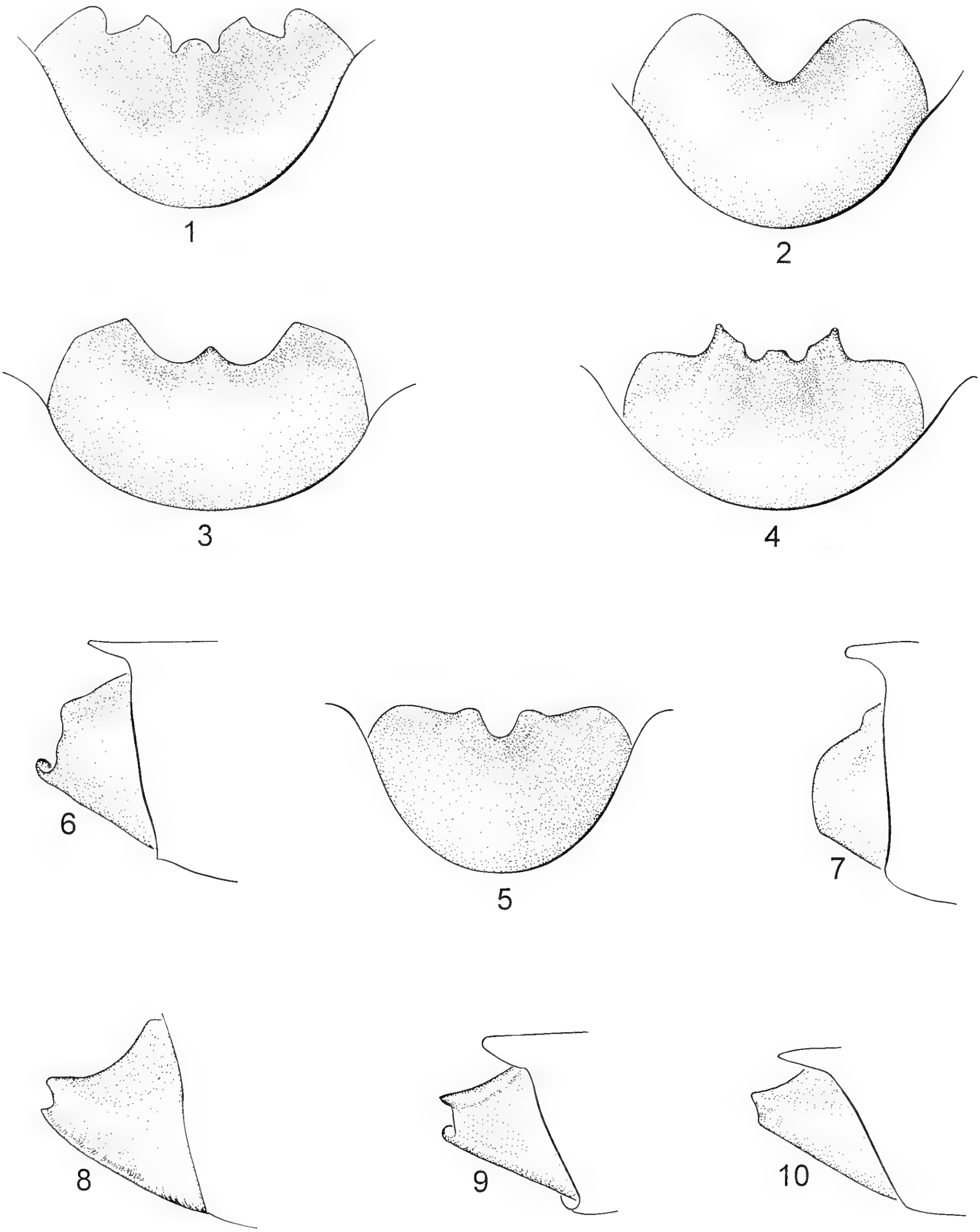
Nematopus flaviceps Guérin-Méneville 1832: 177.
Nematopus albithorax Boisduval 1835: 635.
Priocnemicoris refulgens Costa 1863: 254.
Myrsilus flaviceps: Walker 1871: 75.
Myrsilus albithorax: Walker 1871: 75.
Priocnemicoris flaviceps: Stål 1873: 66.
Priocnemicoris flaviceps: Lethierry and Severin 1894: 41.
Priocnemicoris flaviceps: Blöte 1936: 53.

Redescription.—Measurements: Male: Head length including the apex of antenniferous tubercle 1.80; width across eyes 2.45; interocular distance 1.10; length of antennal segments: I, 4.25; II, 3.90; III, 2.90; IV, 7.40. Pronotum: Length 3.45; maximum width across anterior lobe 2.75; maximum width across humeral angles 4.45. Scutellar length 2.60; width 2.08. Body length 16.70. Female: Head length including the apex of antenniferous tubercle 2.00; width across eyes 2.67; interocular distance 1.15; length of antennal segments: I, 4.50; II, 4.10; III, 3.11; IV, 7.65. Pronotum: Length 4.00; maximum width across anterior lobe 3.10; maximum width across humeral angles 5.15. Scutellar length 2.75; width 2.30. Body length 18.90.

Male: *Dorsal coloration:* Head, anterior lobe of pronotal disk, and apex of scutellum yellow; antennal segment I shiny reddish brown with basal third at ventral surface yellow; antennal segments II to III shiny reddish brown, and IV dull reddish brown; collar, anterolateral margins of pronotum, posterior lobe of pronotal disk, scutellum, clavus, and corium shiny reddish brown with green metallic iridescence; hemelytral membrane dark yellow with basal third pale brown; connexivum yellow with posterior angles brown; dorsal abdominal segments reddish orange suffused with scattered yellow marks. *Ventral coloration:* Head, rostral segments (apex of IV brown), thorax, fore and middle legs, and anterior and posterior lobe of metathoracic peritreme yellow to shiny orange yellow; propleuron, mesopleuron, and metapleuron with wide pale yellowish longitudinal stripe; hind leg with coxa, trochanter and tarsus yellow to shiny orange yellow, femur shiny reddish brown with basal third yellow, and tibia pale orange castaneus with apical third yellow; middle and hind acetabulum and upper margin of propleuron, mesopleuron, and metapleuron shiny reddish castaneus with green metallic iridescence; abdomen yellow with pale castaneus or reddish castaneus marks below abdominal spiracle; genital capsule yellow, scattered with reddish-castaneus marks.

Thorax: Posterior border of metapleuron nearly straight.

Genital capsule: Posteroventral edge at middle third with some degree of variability, and frequently concave and trilobate, with lateral arms short and rounded to subtruncated, and mesial projection short, stout, truncate or slightly triangular (Fig. 4), and eventually bilobate with lateral arms subtruncate (Fig. 9). Parameres, Figs. 35, 36.



Figs. 1–10. *Priocnemicoris* spp., male genital capsule. 1–5, Caudal view. 1, *P. papuensis*. 2, *P. kiungensis*. 3, *P. diversipes*. 4, *P. flaviceps*. 5, *P. cyclops*. 6–10, Lateral view. 6, *P. diversipes*. 7, *P. kiungensis*. 8, *P. papuensis*. 9, *P. flaviceps*. 10, *P. cyclops*.

Integument: Pronotal disk clothed with short, dense, clearly erect, silvery, bristlelike pilosity; yellowish longitudinal stripe on propleuron, mesopleuron and metapleuron clothed with numerous very short yellowish-white sericeous hairs, giving a clearly woolly appearance.

Female: Color similar to male. Connexival segments VIII and IX shiny dark reddish brown with posterior angle black; dorsal abdominal segments VIII and IX shiny dark reddish brown; genital plates dark yellow with orange reflections.

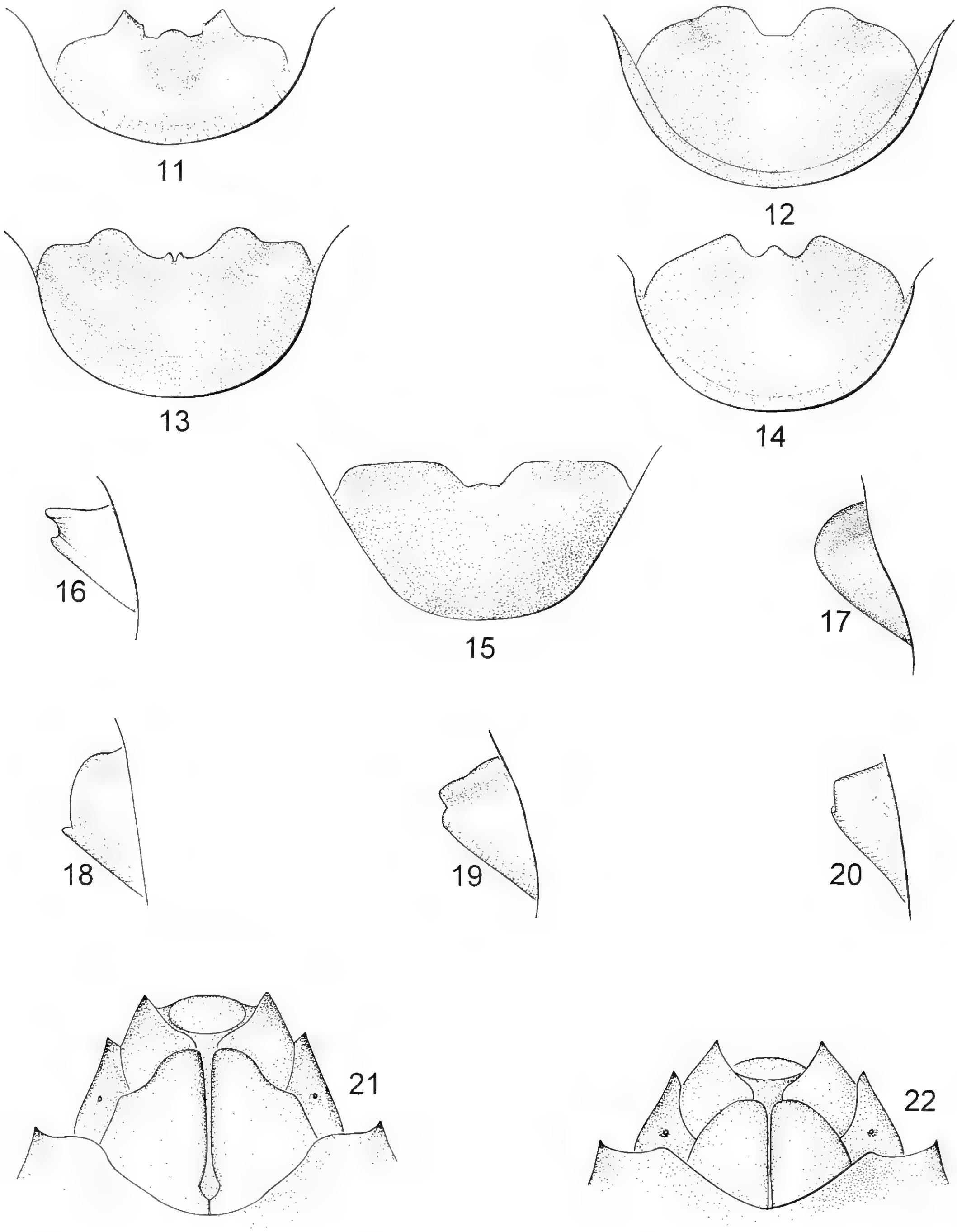
Variation.—1, Head dorsally with two dark to pale brown longitudinal stripes. 2, Ocelli surrounded by a pale brown halo. 3, Shiny metallic green iridescense in pronotal disk, scutellum, clavus and corium, sometimes difficul to see. 4, Lateral margins of mesosternum with dark brown longitudinal stripes. 5, Fore acetabulum pale orange castaneus. 6, Hind femur uniformly pale orange yellow. 7, Hind tibia yellow with basal joint reddish brown to black. 8, Posterior margin of connexivum dark brown.

Distribution.—This species was originally described from Papua New Guinea (Offak), and included it in the genus *Nematopus* (Guérin-Méneville 1832). Later Stål (1873) and Walker (1871) recorded it from the Islands of Aru, Mysol, Sula, and Wagiou, and Blöte (1936) added several new localities to New Guinea (Doreh, Andai, Arfak, Waigeu, Salawatti, Fakfak, Zoutbron, Begoure, Kaiserin on the Augusta River, and Sentani).

Material examined.—INDONESIA: Irian Jaya (Dutch New Guinea): 2 ♂, Waris, S. of Hollandia, 450–500 m, 8–23 August 1959, T. C. Maa (BPBM); 1 ♂, W Sentani, Cyclops Mts., Hollandia Area, 150–250 m, 17 April 1959, J. L. Gressitt (BPBM); 2 ♂, 2 ♀, Hollandia, 10 November 1944, 2 April 1945, 4 May 1945, H. Hoogstraal (FMNH); 1 ♀, Waigeo Island, Urbinas Pen., G. N. Susu, 0–450 m, 25 January 2001, A. Riedel (UNAM); 1 ♂, Wasior DMP, km 38 Sararti, 100–200 m, 7–9 January 2001, A. Riedel (UNAM); 1 ♂, Manokwari, Vogelkop, 75 m, 23 July 1957, D. Elmo Hardy (BPBM); 2 ♂, Jayawijaya Prov., Salawatti Island, Kalobo, ca 10–30 m. 19–22 October 1996, A. Riedel (UNAM); 2 ♂, 2 ♀, Japen, Servi, Mantembo, Ambaiditu, 200–1150 m, 7–9 September 1991, A. Riedel (USNM ex. Ullrich coll.); 1 ♀, Manokwari, G. N. Meja, ca 300 m, 23–24 September 1990 A. Riedel (USNM, ex Ullrich coll.); 2 ♀, Jayawijaya Prov., Kec., Waigeo, Sel. Yembeser, Gaman Island, 0–100 m, 16 November 1996, A. Riedel (ZSMC). PAPUA NEW GUINEA: 1 ♂, NE, Torricelli Mts., Mobitei, 750 m, 5–15 March 1959, W. W. Brandt (BPBM); 1 ♂, Fly R., Olsobip, 400–600 m, August 1969, J. & M. Sedlacek (BPBM); 1 ♀, NE, Madang Province, Gogol (Loggin Area), 80 m, 8 February 1978, W. C. Gagne (BPBM).

Discussion.—This is the type species of the genus *Priocnemicoris* and is diagnosed mostly on the basis of the shape of the posteroventral edge of the male genital capsule (Figs. 4, 9), the shape of the parameres (Figs. 35, 36), the green metallic iridescence on the upper margin of propleura, mesopleura, and metapleura, by the yellow longitudinal stripe on the propleura, mesopleura, and metapleura, the yellowish-white, bristlelike setae covered with wax, that give a woolly appearance, and the short, dense, erect, silvery, bristlelike pilosity on the pronotal disk.

In *Priocnemicoris flaviceps*, the anterior lobe of pronotal disk usually exhibits a yellow pattern clearly in contrast with the rest of the pronotal surface, whereas the other species of the genus have an almost uniformly-colored pronotum, with sparse decumbent pilosity on the disk, and the shape of posteroventral edge of male genital capsule is distinct (Figs. 1–3, 11–15).



Figs. 11–22. *Priocnemicoris* spp., male genital capsule. 11–15, Caudal view. 11, *P. morobe*. 12, *P. nigrellus*. 13, *P. doesburgi*. 14, *P. bicoloripes*. 15, *P. antennatus*. 6–10, Lateral view. 16, *P. morobe*. 17, *P. nigrellus*. 18, *P. doesburgi*. 19, *P. antennatus*. 20, *P. bicoloripes*. 21–22, *Priocnemicoris* spp., female genital plates. 21, *P. flaviceps*. 22, *P. morobe*.

Priocnemicoris cyclops Brailovsky and Barrera, new species
(Figs. 5, 10, 23–24, 38)

Description.—Measurements: Male: Head length including apex of antenniferous tubercle 1.75; width across eyes 2.65; interocular distance 1.32; length of antennal segments: I, 5.35; II, 5.10; III, 3.65; IV, 6.90. Pronotum: Length 4.25; maximum width across anterior lobe 3.25; maximum width across humeral angles 5.80. Scutellar length 2.65; width 2.40. Body length 19.95. Female: Head length including apex of antenniferous tubercle 2.05; width across eyes 2.77; interocular distance 1.25; length of antennal segments: I, 5.35; II, 5.10; III, 3.65; IV, 7.90. Pronotum: Length 4.40; maximum width across anterior lobe 3.25; maximum width across humeral angles 5.80. Scutellar length 2.65; width 2.40. Body length 20.00.

Male: *Dorsal coloration:* Head pale orange yellow; ocelli surrounded by reddish halo; antennal segments I to III shiny reddish orange, and IV dull reddish orange; anterior lobe of pronotal disk pale castaneus orange, and posterior lobe shiny reddish castaneus with green metallic iridescence; scutellum (apex yellow or pale orange), clavus and corium shiny reddish castaneus with green metallic iridescence; hemelytral membrane dark yellow, with basal third pale brown; connexivum yellow with posterior angles of each segment brown; dorsal abdominal segments shiny, pale, reddish orange. *Ventral coloration:* Head, rostral segments (apex of IV brown), prosternum, mesosternum, and metasternum, fore and middle legs, abdominal sterna, rim of abdominal spiracles, and genital capsule pale orange yellow; anterior and posterior lobe of metathoracic peritreme yellow; propleuron, mesopleuron, and metapleuron with a wide, pale, yellowish, longitudinal stripe; hind acetabulum pale reddish castaneus; hind leg with coxae, trochanters and tarsi pale orange yellow, femur reddish orange with basal joint pale orange yellow, and tibia pale orange yellow with basal joint darker; mesosternum laterally pale brown; upper margin of propleuron, mesopleuron and metapleuron shiny reddish castaneus with green metallic iridescence; abdominal sterna laterally and below abdominal spiracles irregularly pale castaneus.

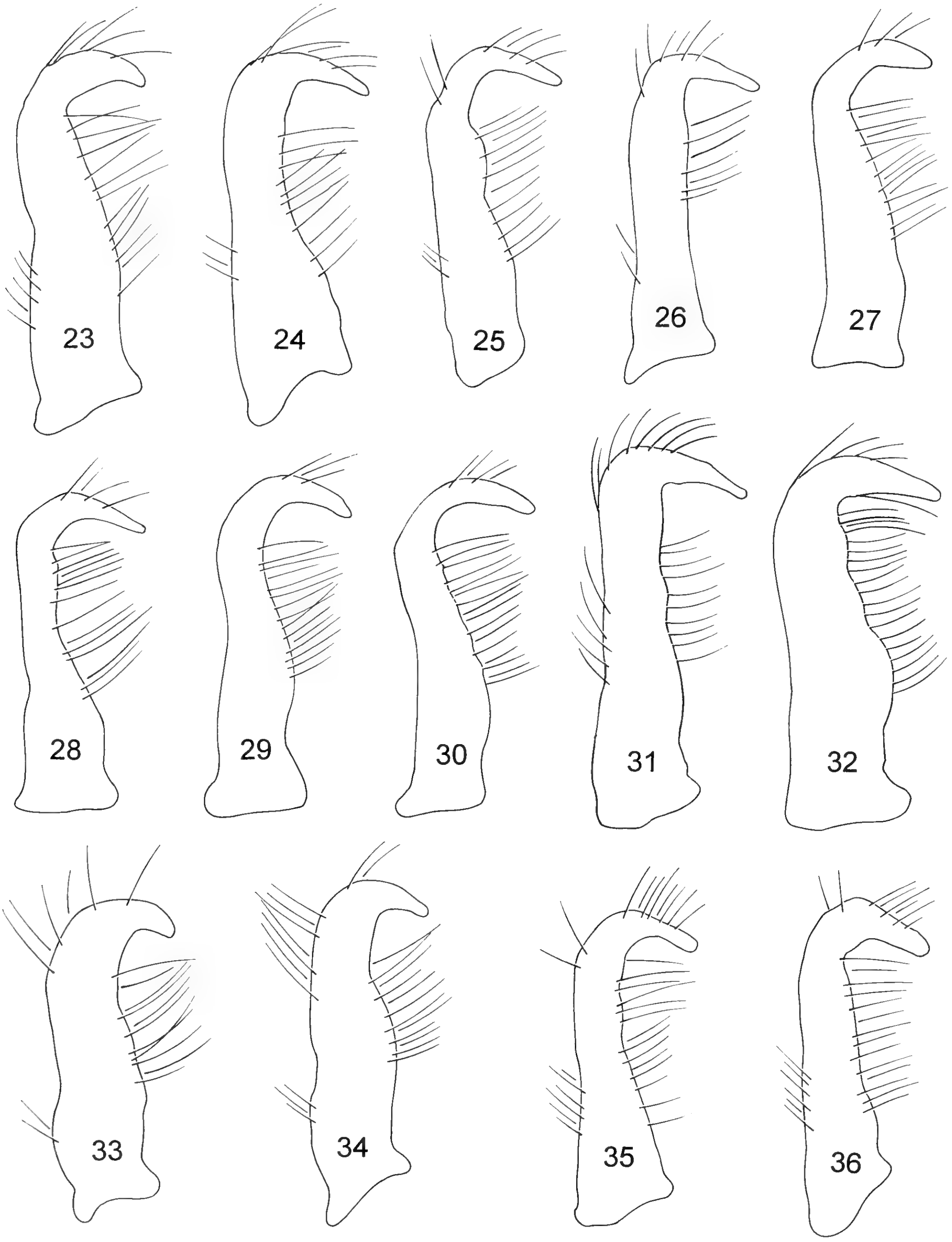
Thorax: Posterior border of metapleura slightly sinuate.

Genital capsule: Posteroventral edge with wide opened U-shaped concavity (Figs. 5, 10). Parameres. Figs. 23–24.

Integument: Pronotal disk clothed with short, sparse, almost exclusively decumbent silvery, bristlelike pilosity; yellowish longitudinal stripe on propleuron, mesopleuron, and metapleuron clothed with numerous, very short, yellowish-white sericeous setae, giving a clearly woolly appearance.

Female: Color similar to male. Connexival segments and dorsal abdominal segments VIII and IX shiny, dark reddish brown; genital plates dark yellow with orange reflections.

Type material.—Holotype: ♂, Indonesia: Irian Jaya (Dutch New Guinea): Ifar, Cyclops Mts., 300 m, 4 November 1958, J. L. Gressitt (BPBM). Paratypes: INDONESIA: Irian Jaya (Dutch New Guinea): 1 ♂, NW Ifar, Cyclops Mts., 300–500 m, 26–28 June 1962, J. L. Gressitt (BPBM); 1 ♂, Genjam, 40 km W of Hollandia, 100–200 m, 1–10 March 1960, T. C. Maa (BPBM); 1 ♂, Sattelberg, H. Rolle (whitout date) (IRNB); 1 ♂, Manokwari, Ransiki, Mayuby-Benyas, ca 200–400 m, 27–28 September 1990, A. Riedel (USNM, ex. Ullrich coll.); 1 ♂, 1 ♀, Japen, Serui, Mantembo, 200–700 m, 6 September 1991, A. Riedel (USNM, ex. Ullrich coll.); 1 ♀, Jayawijaya Prov., angguruk Membahan, c 1700 m, 23 September 1991, A. Riedel (USNM, ex. Ullrich coll.); 4 ♂, 3 ♀,



Figs. 23–36. *Priocnemicoris* spp., paramere. 23–24, *P. cyclops*. 25–26, *P. bicoloripes*. 27–28, *P. morobe*. 29–30, *P. papuensis*. 31–32, *P. diversipes*. 33–34, *P. kiungensis*. 35–36, *P. flaviceps*.

Waena Bakair (Water Res.), Cyclops Mts., 18 km W Jayapura, 300 ft, 1–2 November 1990, P. J. Clausen (UMSP); 1 ♂, Lae, December 1944, W. Harden (LACM); 1 ♀, Jayawijaya Prov., Bime, 1600–2000 m, 10 September 1993, A. Riedel (ZSMC). Papua New Guinea: 1 ♂, Morobe Province, Ana-Pose, 21 October 1987, G. P. Lifsey (TAMU); 2 ♂, Morobe District, Wau, 1050 m, 5 January 1961, G. Monteith (QMBA), 6 October 1969, J. E. Tobler (CAS); 1 ♀, Wau, 1200 m, 10 November 1972, Tawi Bukman (BPBM) (collected on *Erodia* sp.); 1 ♂, NE Torricelli Mts., Mobiiei, 750 m, 16–31 March 1959, W. W. Brandt (BPBM); 1 ♂, Torricelli, Gebirge, Kais Wilhelmslandt (ZMAS); 1 ♂, NE Torricelli Mts., Sugoitel, 900 m, 6–9 February 1959, W. W. Brandt (BPBM); 1 ♂, 1 ♀, Finisterre Range, Saidor, Gabumi, 11 June- 1–21 July 1958, W. W. Brandt (BPBM); 1 ♂, Owen Stanley Range, Goilala, Loloipa, 25 November–10 December 1975, W. W. Brandt (BPBM); 1 ♀, Samoro Area Rd., 850 m, 12 May 1975, J. L. Gressitt (BPBM); 1 ♀, Koitaki, 1500 ft., October–November 1928, Pemberton (ANIC); 1 ♂, 2 ♀, Gulf Ivinka Res., Station, Lake Lakekamu, 07°44′S–146°30′E, 120 m, 1–10 March 2000, 6 April 2000, 19–25 November 2000, T. A. Sears (UCDA); 1 ♀, Kakoro, 07°51′S–143°31′S, 24 April 2000, T. Sears & Binatung Brigade (UCDA); 1 ♂, Morobe Province, Gulf, Lakekamu Basin, 23 March–5 April 2000, T. Sears & Binatung Brigade (UCDA); 1 ♂, 3 ♀, Morobe Province, Tekadu, 07°38′S–146°34′E, 25 March 2000, 1–20 April 2000, T. A. Sears & Binatung Brigade (UCDA); 1 ♀, Anglican Mission, Agenehambo via Popondetta, April (without date), A. Chilllebourough (SAMA); 1 ♂, 1 ♀, Aru Island, 1911, Elzner (Froggatti coll.) (CSIRO); 2 ♂, 1 ♀, rossell Island, Abaleti, 2 October–2 November 1963, W. W. Brandt (CSIRO); 1 ♂, 1 ♀, Rossell Island, Abaleti, Fifth Archbold Expedition to New Guinea, 2–11 October 1956, L. J. Brass (AMNH).

Distribution.—Irian Jaya, Indonesia.

Discussion.—This species is similar to *P. flaviceps* with the yellowish, longitudinal stripe on the propleuron, mesopleuron, and metapleuron clothed with yellowish-white sericeous setae, giving it a clearly woolly appearance, the upper margin of the propleura, mesopleura, and metapleura with green metallic iridescence, the anterior lobe of the pronotal disk usually paler than posterior pronotal disk, and the pronotum, scutellum, clavus, and corium with green metallic iridescence.

Priocnemicoris cyclops is recognized by having the pronotal disk clothed with sparse, almost decumbent pilosity, the shape of posteroventral edge of male genital capsule simple with a wide open U-shaped concavity (Figs. 5, 10), and the shape of the parameres (Figs. 23, 24). *Priocnemicoris flaviceps* has the pronotal disk clothed with dense, erect pilosity, the posteroventral edge of male genital capsule with some of variabily, but never with a wide open concavity (Figs. 4, 9), and the parameres are distinct (Figs. 35, 36).

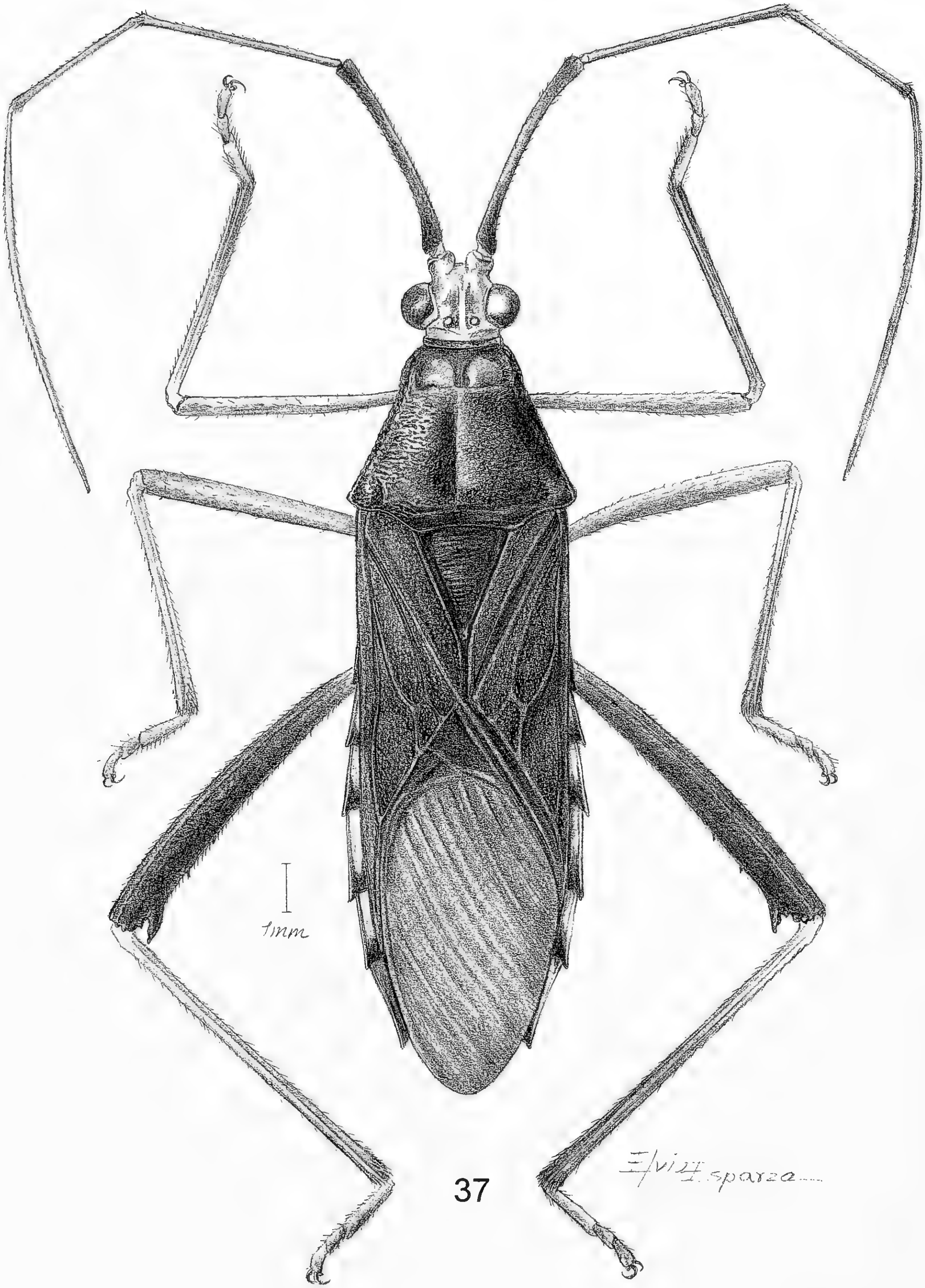
Etymology.—Named for the Cyclops Mts., in Irian Jaya; a noun in apposition.

Priocnemicoris diversipes (Fallou), **New combination**

(Figs. 3, 6, 31–32)

Notobitus diversipes Fallou 1891: 7.
Notobitus diversipes: Bergroth 1892: 262–264.

Redescription.—Measurements: Male: Head length including apex of antenniferous tubercle 1.90; width across eyes 2.60; interocular distance 1.07; length of antennal segments: I, 4.85; II, 4.35; III, 2.95; IV, 7.25. Pronotum: Length 3.95; maximum width across anterior lobe 2.85; maximum width across humeral



37

Fig. 37. Dorsal view of *Priocnemicoris flaviceps*, female.

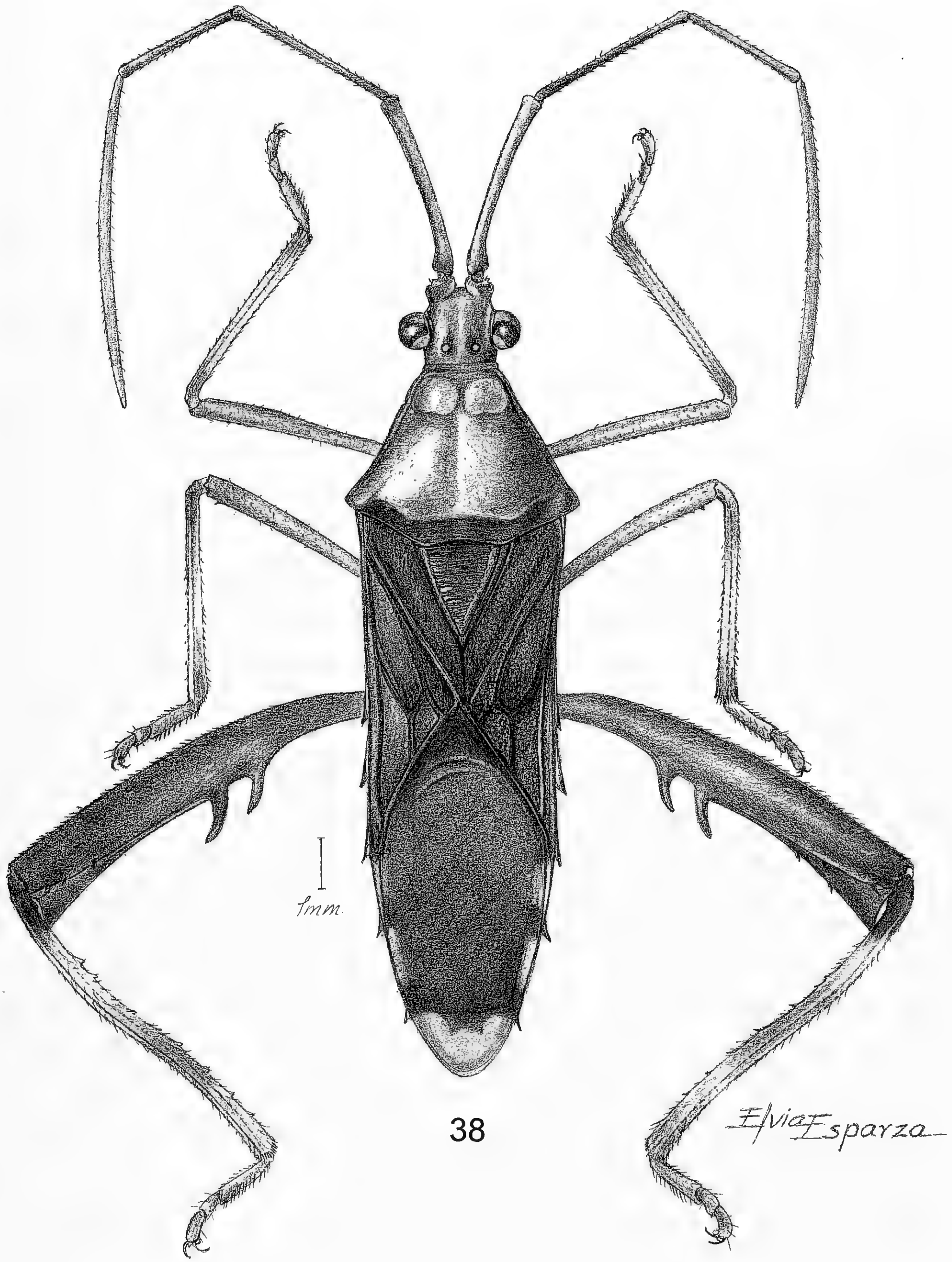


Fig. 38. Dorsal view of *Priocnemicoris cyclops*, male.

angles 5.00. Scutellar length 2.45; width 2.10. Body length 18.43. Female: Head length including apex of antenniferous tubercle 1.90; width across eyes 2.60; interocular distance 1.10; length of antennal segments: I, 4.50; II, 4.20; III, 3.05; IV, 6.95. Pronotum: Length 3.90; maximum width across anterior lobe

3.00; maximum width across humeral angles 5.05. Scutellar length 2.55; width 2.20. Body length 18.15.

Male: *Dorsal coloration:* Head pale orange yellow; ocelli surrounded by reddish halo; antennal segments I to III shiny reddish orange, and IV dull reddish orange; pronotum, scutellum (apex yellow), clavus and corium shiny reddish castaneus with green metallic iridiscence; hemelytral membrane dark yellow with basal third pale brown; connexivum yellow with posterior angles brown; dorsal abdominal segments reddish orange. *Ventral coloration:* Head, rostral segments (apex of IV brown), prosternum, mesosternum, and metasternum, fore and middle legs, anterior and posterior lobe of metathoracic peritreme, rim of abdominal spiracle, and male genital capsule pale orange yellow; propleuron, mesopleuron and metapleuron with wide yellowish longitudinal stripe; hind leg with coxae, trochanter and tarsi pale orange yellow, femur shiny red with basal joint pale orange yellow, and apex black, and tibiae pale castaneus with basal joint black, and apical third orange yellow; hind acetabulum shiny reddish castaneus; upper margin of propleura, mesopleura, and metapleura shiny reddish castaneus with green metallic iridescence; abdominal sterna yellow to pale orange yellow with pale castaneus marks below abdominal spiracle.

Thorax: Posterior border of metasternum nearly straight.

Genital capsule: Posteroventral edge with wide open U-shape concavity, and at mesial third with short, stout or acute projection (Figs. 3, 6). Parameres, Figs. 31, 32.

Integument: Pronotal disk clothed with short, sparse, almost exclusively decument silvery bristlelike pilosity; yellowish longitudinal stripe on propleuron, mesopleuron, and metapleuron clothed with numerous, very short, yellowish-white sericeous setae giving a clearly woolly appearance.

Female: Color similar to male. Connexival segments VIII and IX and dorsal abdominal segments VIII and IX shiny reddish orange; genital plates pale orange yellow.

Variation.—1, Basal joint of antennal segment I dark yellow. 2, Lateral margins of mesosternum pale castaneus orange. 3, Posterior angle of metapleura yellow. 4, Connexivum yellow with posterior borders brown.

Distribution.—Previously known only from the type locality, New Britain (Papua New Guinea) without a definite locality. The new records listed below show that it occurs extensively in New Guinea.

Material examined.—PAPUA NEW GUINEA: Bismarck Arch.: New Britain: 1 ♂, 2 ♀, Silanga, Nakanai, 150 m, 31 July 2 August 1956, E. J. Ford Jr. (BPBM); 1 ♂, Gazelle Pen., Gaulim, 140 m, 21–26 October 1962, J. Sedlacek (BPBM); 1 ♂, 1 ♀, Gazelle Pen., Upper Warangoi, Illugi, 230 m, 8–11 December 1952, J. Sedlacek (BPBM); 1 ♀, Nakanai Mts., 28 July 1956, E. J. Ford Jr. (BPBM); 1 ♀, Cape Gloucester, 14–15 August 1966, Y. Kondo (BPBM); New Ireland: 1 ♂, SW Gilingil Pl'c, 2 m, 6 July 1956, J. L. Gressitt (BPBM); 1 ♀, 30 mi S of Kavieng, 12 February 1966, G. Monteith (QMBA); 2 ♂, 4, ♀, Knogogo Road, near Karu Plateau, 40 km N of Mamatanai, 10–11 December 1969, J. E. Tobler (CAS); 1 ♀, Kaselok, 16 km S of Kavieng, 17 December 1969, J. E. Tobler (CAS); 1 ♂, Namatanai, 5 December 1969, J. E. Tobler (CAS); 2 ♂, 1 Jacquinot Bay, 1 December 1969, J. E. Tobler (CAS); 1 ♀, Oast First Village, along trail from Danum to Lelet Plateau, 14 December 1969, J. E. Tobler (CAS).

Discussion.—This species is nearly identical in coloration with *P. flaviceps*, and the two were considered conspecific until now. Both species have a yellowish longitudinal stripe on propleuron, mesopleuron, and metapleuron clothed with yellowish-white sericeous setae giving it a woolly appearance, and the upper margin of propleuron, mesopleuron, and metapleuron have a green metallic iridescence. There are distinct differences in the male genital capsule, as well as a several fairly consistent somatic characters.

Priocnemicoris diversipes has the pronotal disk entirely shiny reddish castaneus, the pronotal disk clothed with sparse, decumbent pilosity, and the posteroventral edge of male genital capsule distinct (Figs. 3, 6). In *P. flavipes*, the anterior lobe of pronotum is pale to dark yellow, contrasting with the shiny reddish-brown posterior lobe, and the pronotal disk is clothed with dense, erect pilosity.

***Priocnemicoris papuensis* Brailovsky and Barrera, new species**

(Figs. 1, 8, 29–30)

Description.—Measurements: Male: Head length including apex of antenniferous tubercle 1.70; width across eyes 2.45; interocular distance 0.98; length of antennal segments: I, 4.00; II, 3.85; III, 2.47; IV, 6.68. Pronotum: Length 3.70; maximum width across anterior lobe 2.75; maximum width across humeral angles 5.25. Scutellar length 2.60; width 2.25. Body length 17.05. Female: Head length including apex of antenniferous tubercle 1.65; width across eyes 2.40; interocular distance 1.12; length of antennal segments: I, 4.30; II, 4.10; III, 2.90; IV, 6.65. Pronotum: Length 4.00 maximum width across anterior lobe 3.25; maximum width across humeral angles 5.80. Scutellar length 2.80; width 2.55. Body length 19.03.

Male: *Dorsal coloration.* Head pale castaneus orange, with two dark brown longitudinal stripes; antennal segment I reddish brown with basal third black, and segments II to IV dark orange; pronotum, clavus and corium pale castaneus orange; hemelytral membrane dark yellow with basal third pale brown; scutellum reddish brown with apex yellowish white; connexivum yellow with posterior margin black; dorsal abdominal segments shiny reddish orange. *Ventral coloration:* Head, rostral segments (apex of IV brown), prosternum, mesosternum, metasternum (laterally pale reddish), anterior and posterior lobe of metathoracic peritreme, fore and middle legs, and posterior angle of metapleuron yellow; propleuron, mesopleuron, and metapleuron pale castaneus orange; hind leg with coxa pale castaneus orange, trochanter yellow, femur pale castaneus orange with basal joint yellow and apex including the subapical spine black, tibia pale reddish orange with basal joint black and apical third yellow, and tarsus yellow; abdomen yellow with rim of abdominal spiracles, two longitudinal and irregular stripes lateral to midline, posterior margin of abdominal sternite VII, and genital capsule pale castaneus orange.

Thorax: Posterior border of metapleura almost straight.

Genital capsule: Posteroventral edge trilobate, lateral arms exposed, subtriangular to nearly truncate, and mesial projection stout, weakly subtruncate (Figs. 1, 8). Parameres, Figs. 29, 30.

Integument: Pronotal disk clothed with short, sparse, almost exclusively decumbent silver bristlelike pilosity; propleuron, mesopleuron, and metapleuron clothed with numerous very short, yellowish-white sericeous setae, giving clearly woolly appearance.

Female: Color similar to male. Connexival segments VIII and IX shiny reddish orange, with posterior spinelike projections, black; abdominal segments VIII and IX shiny reddish orange with posterior margin black; genital plates dark yellow with inner margin of gonocoxae I and paratergite IX pale brown.

Variation.—1, Apex of antenniferous tubercles yellow with green metallic iridescence. 2, Humeral angles and tarsi with green metallic iridescence. 3, Hind tibia pale castaneus orange with basal joint black, and apical third yellow with green metallic iridescence. 4, Rim of abdominal spiracles yellow.

Type material.—Holotype: ♂, Papua New Guinea: Morobe, Tekadu, 07°38′S–146°34′E, 26 April 2000, T. Sears & T. David (UCDA). Paratypes: PAPUA NEW GUINEA: 1 ♂, 2 ♀, same data as for holotype (UCDA, UNAM); 1 ♂, Gulf, Ivimka Res. Station, Lakekamu, 120 m, 07°44′S–146°30′E, March–April 2000, T. Sears & Binatung Brigade (UCDA); 1 ♀, SE: S. Highlands District, Pimaga, 900 m, (on *Ficus* sp.), 9–10 February 1978, J. L. Gressitt (BPBM); 1 ♀, Kerema, Brown River, Central District, 09°12′S–147°14′E, 24 April 1971, Balderson & Baker, trip 171, stop 27961.2 (UCDA); 1 ♂, Daradae nr., Javarere, Musgrove R., 100 m, 2 October 1958, J. L. Gressitt (BPBM); 1 ♂, 1 ♀, Owen, Stanley Range, Goilala, Tapini, 975 m, 16–25 November 1957, W. W. Brandy (BPBM); 1 ♂, Rigo District, September 1928, Pemberton (ANIC).

Distribution.—Widespread in Papua New Guinea.

Discussion.—Like *P. flaviceps* (Guérin-Méneville) the propleuron, mesopleuron and metapleuron has a fine set of yellowish-white sericeous setae occurring in large numbers, forming a woolly longitudinal stripe, the fore and middle legs are yellow, and the male genital capsules are similar (Figs. 1, 4, 8, 9).

Priocnemicoris papuensis has antennal segment I reddish brown with basal third black, the pronotal disk clothed with short almost exclusively decumbent silvery bristlelike setae, and the pronotum (some specimens with green metallic iridescence at humeral angles), clavus, corium, scutellum, upper margin of propleura, and posterior margin of mesopleura and metapleura lacking green metallic iridescence, similar to *P. flaviceps* which has antennal segment I reddish brown with basal third at ventral face yellow, and pronotal disk clothed with short, clearly erect, silvery, bristle-like setae.

Etymology.—Named for its occurrence in New Guinea.

Priocnemicoris antennatus Brailovsky and Barrera, new species

(Figs. 15, 19)

Description.—Measurements: Male: Head length including apex of antenniferous tubercle 1.70; width across eyes 2.45; interocular distance 1.12; length of antennal segments: I, 4.30; II, 4.00; III, 2.85; IV, 7.50. Pronotum: Length 4.10; maximum width across anterior lobe 3.00; maximum width across humeral angles 5.25. Scutellar length 2.70; width 2.30. Body length 17.30. Female: Head length including apex of antenniferous tubercle 1.72; width across eyes 2.47; interocular distance 1.15; length of antennal segments: I, 4.45; II, 3.90; III, 2.70; IV, 7.10. Pronotum: Length 4.12; maximum width across anterior lobe 3.50; maximum width across humeral angles 5.70. Scutellar length 2.85; width 2.50. Body length 19.17.

Male: *Dorsal coloration:* Head yellowish-orange with two dark brown, diffused, longitudinal stripes; ocelli surrounded by pale brown halo; antennal segments I to IV reddish orange; pronotum, clavus, and corium shiny, pale, castaneus orange; scutellum reddish castaneus with apex yellow; hemelytral membrane dark yellow with basal third pale brown; connexivum yellowish orange with posterior margins brown; dorsal abdominal segments shiny orange with pale brown marks. *Ventral coloration:* Head, rostral segments (apex of IV brown), prosternum, mesosternum, fore acetabulum, fore and middle legs, and abdominal sterna pale yellowish orange; anterior and posterior lobe of metathoracic peritreme yellow; metasternum pale yellowish orange, and laterally pale reddish orange; propleuron, mesopleuron, and metapleuron with wide, pale, yellowish longitudinal stripe; upper margin of propleuron, mesopleuron, and metapleuron and middle and hind acetabulae castaneus orange; hind leg with coxa, trochanter, and tarsi pale yellowish orange, femur dark castaneus orange with basal third pale yellowish orange and tibia dark castaneus orange with apical third pale yellowish orange; abdominal sterna with two longitudinal and irregular stripes pale castaneus orange below abdominal spiracles.

Thorax: Posterior border of metapleuron slightly sinuate.

Genital capsule: Posteroventral edge trilobate, lateral arms broad and exposed, mesial projection wide and truncated (Figs. 15, 19).

Integument: Pronotal disk clothed with short, sparse, almost exclusively decumbent, silvery, bristlelike pilosity; yellowish longitudinal stripe on propleuron, mesopleuron, and metapleuron clothed with numerous very short, yellowish white, sericeous setae, giving a clearly woolly appearance.

Female: Color similar to male. Connexival segments VIII and IX dark reddish orange with posterior angles black; dorsal abdominal segments VIII and IX dark reddish orange; genital plates pale yellow with inner margin of gonocoxae I pale brown, and posteior angle of paratergite VIII and IX reddish.

Variation.—1, Fore acetabulum pale castaneus. 2, Dorsal abdominal segments shiny reddish orange. 3, Middle third of abdominal sternite III reddish orange.

Type material.—Holotype: ♂, Papua New Guinea: Middlefly, 250–300 m, July–August 1928, Pemberton (ANIC). Paratypes: PAPUA NEW GUINEA: 1 ♂, same data as for holotype (UNAM); 1 ♀, SE: S Highlands District, Pimaga, 900 m, 9–10 February 1978, J. L. Gressitt (BPBM); 1 ♀, 1891, Finschhafen (without data) (IRNB). INDONESIA: Irian Jaya (Dutch New Guinea): 1 ♀, Lae, December 1944, W. Harden (LACM). Indonesia: Dutch East Indies: 1 ♂, Molucca Island: Morotai, 1944, E. Reimschiissel (BYU).

Distribution.—Only known from New Guinea.

Discussion.—This species is recognized by the dimensions of antennal segment I and IV which are always longer than 4.20 (male), 4.40 (female) and 7.40 (male) 7.00 (female) respectively. Like *P. papuensis* with a yellowish longitudinal stripe on the propleura, mesopleura, and metapleura clothed with yellowish-white sericeous setae giving a clearly woolly appearance, and with the upper margin of propleura, mesopleura, and metapleura lacking a green metallic iridescence. *Priocnemicoris antennatus* has antennal segment I entirely shiny reddish orange whereas in *P. papuensis* it is shiny reddish orange with the basal third black, and always shorter than 4.05 (male), 4.30 (female) and more slender, and antennal segment IV shorter than 6.70 (male), 6.75 (female).

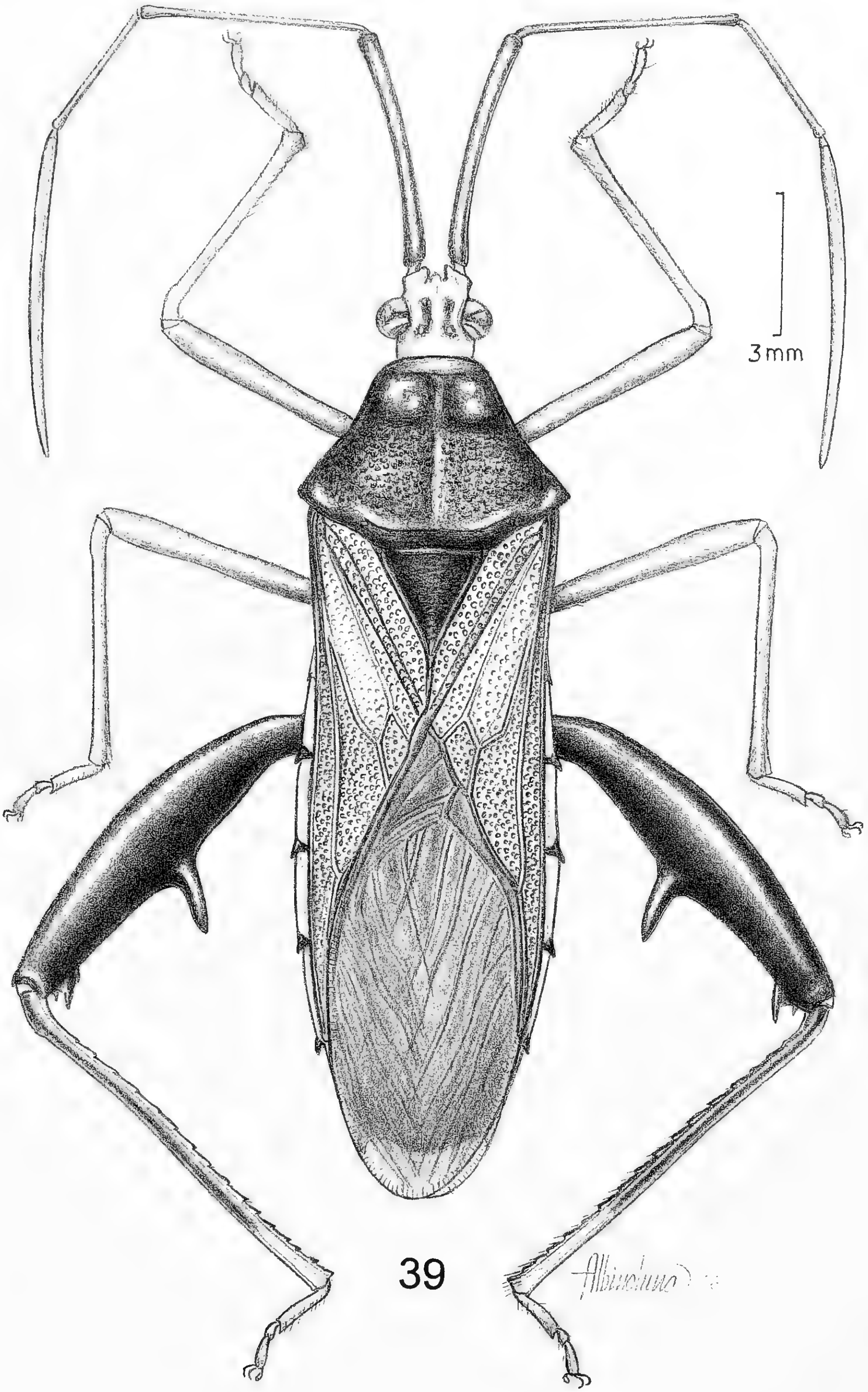
The posteroventral edge of the male genital capsule is similar to *P. morobe* (Figs. 11, 15, 16, 19) and in both species the propleura, mesopleura and metapleura lack a sericeous setae.

Etymology.—Named for the shape of antennal segment I.

Priocnemicoris bicoloripes Brailovsky and Barrera, new species

(Figs. 14, 20, 25–26, 39)

Description.—Measurements: Male: Head length including apex of antenniferous tubercle 1.92; width across eyes



39

Fig. 39. Dorsal view of *Priocnemicoris bicoloripes*, male.

2.40; interocular distance 1.17; length of antennal segments: I, 4.65; II, 4.20; III, 3.00; IV, 7.15. Pronotum: Length 4.00; maximum width across anterior lobe 3.30; maximum width across humeral angles 5.70. Scutellar length 2.75; width 2.40. Body length 18.67. Female: Head length including apex of antenniferous tubercle 1.85; width across eye 2.45; interocular distance 1.10; length of antennal segments: I, 4.32; II, 3.85; III, 2.70; IV, 7.80. Pronotum: Length 4.15; maximum width across anterior lobe 3.55; maximum width across humeral angles 5.95. Scutellar length 2.85; width 2.60. Body length 19.38.

Male: *Dorsal coloration:* Head yellow with two dark brown longitudinal stripes; ocelli surrounded by dark brown halo; antennal segment I dark reddish brown, segments II and III dark reddish orange, and IV pale orange; pronotum shiny dark reddish brown, with green metallic iridescence; scutellum dark reddish brown with apex yellow and lateral margins with green metallic iridescence; clavus yellow with green metallic iridescence; corium yellow, costal and posterior margins dark castaneus orange, and punctures tinged with green metallic iridescence; hemelytral membrane dark yellow with basal third brown; connexivum yellow with posterior border, including spine dark brown; dorsal abdominal segments dark reddish brown. *Ventral coloration:* Head and rostral segments (apex of IV brown) yellow; prosternum, mesosternum, metasternum, and fore and middle legs pale yellowish orange; anterior and posterior lobe of metathoracic peritreme yellow; fore and middle acetabulum, and space between them black; propleuron, mesopleuron, and metapleuron dark reddish brown with green metallic iridescence; hind leg with coxa, trochanter, and tarsus pale castaneus orange, femur shiny reddish brown with basal joint pale yellowish orange, and tibia pale castaneus orange with basal third shiny reddish brown, and apical third pale yellowish orange; abdominal sterna tricolorous, midline shiny yellowish orange, pleural margins pale yellow and in between a shiny dark reddish-brown longitudinal stripe running below abdominal spiracles; genital capsule dark castaneus orange.

Thorax: Posterior border of metapleuron slightly sinuate.

Genital capsule: posteroventral edge trilobate, lateral arms exposed and rounded, and mesial projection short and subtruncate (Figs. 14, 20). Parameres, Figs. 25, 26.

Integument: Pronotal disk clothed with short, sparse, almost exclusively decumbent silvery, bristlelike setae; propleuron, mesopleuron and metapleuron clothed with very fine, sparse, decumbent setae.

Female: Color similar to male. Connexival segments and dorsal abdominal segments VIII and IX dark reddish brown; genital plates dark reddish brown with outer margin of gonocoxae I and inner margin of paratergite VIII and IX shiny orange.

Variation.—1, Antennal segments II and III dark reddish brown. 2, Dorsal and ventral surface lacking the green metallic iridescence.

Type material.—Holotype: ♂, Indonesia: Irian Jaya (Dutch New Guinea): Jayawijaya Province, Bommela, ca 1700–1900 m, 4 October 1996, A. Riedel (ZSMC). Paratypes: INDONESIA: Irian Jaya (Dutch New Guinea): 3 ♂, 1 ♀, Sama date as for holotype (UNAM, USNM ex. Ullrich coll.).

Distribution.—Known only from the type material.

Discussion.—This is the only known species in the genus *Priocnemicoris* with the corium bicolorous, the clavus entirely yellow, and the abdominal sterna tricolorous. For the other species the corium and clavus are usually dark reddish brown to black, and the abdominal sterna yellow with an irregular, castaneus-orange longitudinal stripe running below each abdominal spiracle. Additionally, the propleura, mesopleura, and metapleura of *P. bicoloripes* lacks a wide, yellowish, longitudinal stripe clothed with sericeous setae.

Etymology.—Named for bicolored of corium.

Priocnemicoris morobe Brailovsky and Barrera, new species

(Figs. 11, 16, 22, 27–28)

Description.—Measurements: Male: Head length including apex of antenniferous tubercle 1.75; width across eyes 2.40; interocular distance 1.08; length of antennal segments: I, 4.25; II, 4.10; III, 2.75; IV, 7.45. Pronotum: Length 3.88; maximum width across anterior lobe 2.75; maximum width across humeral angles 4.90. Scutellar length 2.30; width 2.20. Body length 16.95. Female: Head length including apex of antenniferous tubercle 1.80; width across eyes 2.30; interocular distance 0.97; length of antennal segments: I, 3.75; II, 3.50; III, 2.40; IV, 6.15. Pronotum: Length 3.90; maximum width across anterior lobe 3.00; maximum width across humeral angles 5.55. Scutellar length 2.60; width 2.30. Body length 18.70.

Male: *Dorsal coloration:* Head dark yellow; ocelli surrounded by dark brown halo; antennal segments I to III shiny reddish orange, and IV dull orange; pronotum dark castaneus orange with anterolateral margins and humeral angles dark yellow; scutellum shiny reddish orange, and apex yellow; clavus and corium pale to dark castaneus orange; hemelytral membrane dark yellow with basal third pale brown; connexivum yellow with posterior margin dark brown; dorsal abdominal segments dark yellow with shiny reddish-orange marks. *Ventral coloration:* Head, rostral segments (apex of IV brown), prosternum, mesosternum, metasternum, anterior and posterior lobe of metathoracic peritreme, fore and middle acetabulae, fore and middle legs, and posterior angle of metapleuron yellow; propleuron, mesopleuron, metapleuron, and hind acetabulum pale castaneus orange; hind femur with coxae pale castaneus orange with yellow marks, trochanter yellow, femur reddish orange with basal joint dark yellow, lateral and apical angles, and subdistal spine dark brown to black, tibia pale castaneus orange with basal joint shiny reddish orange, and tarsus pale castaneus orange; abdominal sterna dark yellow with two longitudinal and irregular reddish-orange stripes lateral to midline; rim of abdominal spiracle yellow; genital capsule pale castaneus orange.

Thorax: Posterior border of metapleuron nearly straight.

Genital capsule: Middle third of posteroventral edge trilobate, with lateral arms broad and exposed, and mesial projection wide and truncate or bilobate, lacking mesial projection (Figs. 11,16). Parameres, Figs. 27, 28.

Integument: Pronotal disk clothed with short, sparse, almost exclusively decumbent, silvery, bristlelike pilosity; propleuron, mesopleuron, and metapleuron clothed with very fine, sparse, decumbent setae.

Female: Color similar to male. Connexival segments VIII and IX shiny reddish orange, with posterior angle black; dorsal abdominal segments VIII and IX shiny reddish orange with posterior margin darker; genital plates dark yellow with reddish reflections on paratergite VIII and IX (Fig. 22).

Variation.—1, Head dorsally with two pale brown longitudinal stripes. 2, Dorsal surface of hind femur pale castaneus orange and ventrally, including the basal joint yellow.

Type material.—Holotype: ♂, Papua New Guinea: NE Wau, 1200 m, 7 March

1968, J. & M. Sedlacek (BPBM). Paratypes: PAPUA NEW GUINEA: 4 ♂, 1 ♀, NE Wau, 18 December 1965, G. Monteith (QMBA), 7 March 1968, J. & M. Sedlacek (UNAM), 3 July 1971, J. Sedlacek (BPBM), 6–13 March 1974, on *Hibiscus* sp., Szent-Ivany (BPBM); 1 ♀, Wau, Ecology Center, 17 February 1978, E. I. Schlinger (CAS); 1 ♀, Morobe District, Wau, Big Wau Creek, 1400 m, 15 September 1979, P. J. Shanahan (CAS); 2 ♂, 3 ♀, Morobe District, Wau, 3–4 February 1966, G. Monteith (QMBA), 23 October 1969, J. E. Tobler (UNAM), 9 August 1972, G. G. E. Scudder (BPBM), 22 January 1974, G. Otaweto (BPBM); 1 ♂, NE Boana Mission, Huon Pen., 900 m, 4–5 September 1956, E. J. Ford Jr. (BPBM); 1 ♀, NE Huon Pen., Pindiu, 600–850 m, 19 April 1963, J. Sedlacek (BPBM); 1 ♀, SE Mt. Lamington, Amboga R.,500 m, April 1966, P. Shanahan (BPBM); 1 ♂, Morobe Province, Wau, Wau Ecol. Inst., 1200 m, 1–10 August 1983, S. E. & P.M. Miller (USNM).

Distribution.—Widespread in Papua New Guinea.

Discussion.—This species resembles *P. papuensis* in lacking green metallic iridescence on the pronotum, scutellum, clavus, corium, upper margin of propleura and posterior margin of mesopleura and metapleura. The pronotal disk is clothed with short, sparse, almost exclusively decumbent pilosity, the anterior lobe of pronotal disk is dark castaneus orange, not yellow, and connexivum is bicolored.

Priocnemicoris morobe is characterized by having the antennal segment I entirely shiny reddish orange, the anterolateral margins of pronotum dark yellow, clearly in contrast with the dark castaneus orange disk, and the propleuron, mesopleuron, and metapleuron lack a yellowish longitudinal stripe clothed and numerous very short yellowish-white sericeous setae giving a clearly woolly appearance. In contrast, *P. papuensis* has antennal segment I reddish brown, with basal third black, the anterolateral margins pale castaneus orange, and a uniformly colored pronotal disk.

Etymology.—Named for Morobe Province, Papua New Guinea; a noun in apposition.

Priocnemicoris doesburgi Brailovsky and Barrera, new species

(Figs. 13, 18)

Description.—Measurements: Male: Head length including apex of antenniferous tubercle 1.95; width across eyes 2.60; interocular distance 1.17; length of antennal segments: I, 3.70; II, 3.80; III, 2.75; IV, 7.82. Pronotum: Length 4.40; maximum width across anterior lobe 3.30; maximum width across humeral angles 5.70. Scutellar length 2.75; width 2.43. Body length 19.32. Female: Head length including apex of antenniferous tubercle 1.92; width across eyes 2.62; interocular distance 1.18; length of antennal segments: I, 3.85; II, 3.81; III, 2.77; IV, 7.83. Pronotum: Length 4.42; maximum width across anterior lobe 3.30; maximum width across humeral angles 5.73. Scutellar length 2.76; width 2.45. Body length 19.50.

Male: *Dorsal coloration.* Head pale orange yellow; ocelli surrounded by pale brown halo; antennal segment I pale castaneus orange, segments II and III shiny dark castaneus orange, and IV dull castaneus orange; pronotum shiny pale orange yellow with posterior margin shiny reddish orange; humeral angles with green metallic iridescence; scutellum shiny reddish orange with apex yellow; clavus and corium shiny castaneus orange with green metallic iridescence; hemelytral membrane dark yellow with basal third pale brown; connexivum yellow with posterior third reddish brown; dorsal abdominal segments shiny dark reddish orange with yellow marks and laterally as well as the posterior margin of abdominal segment VII almost black. *Ventral coloration:* Head, rostral segments (apex of IV black), prosternum, propleuron, middle third of mesosternum, fore and middle acetabulae, fore and middle legs, and posterior margin of metapleuron pale yellow; anterior and posterior lobe of metathoracic peritreme dark yellow; lateral surface of mesosternum pale brown; mesopleuron, metapleuron, metasternum, and hind acetabulae shiny reddish castaneus; hind leg with coxa yellow with castaneus reflections, trochanter yellow, femur reddish orange with basal third yellow, tibia yellow with basal third reddish orange, and tarsus yellow; abdominal sterna yellow with two irregular, longitudinal, reddish orange stripes lateral to midline, behind each abdominal spiracle; rim of abdominal spiracle yellowish orange; genital capsule pale castaneus and laterally yellow.

Thorax: Posterior border of metapleuron strongly concave.

Genital capsule: Posteroventral edge with wide open U-shaped concavity, laterally rounded (Figs. 13, 18).

Integument: Pronotal disk clothed with short, clearly erect, silvery, bristle-like pilosity; propleuron, mesopleuron, and metapleuron with very fine, sparse decumbent hairs.

Female: Color similar to male. Connexival segment VIII yellow with posterior third reddish brown, and IX reddish brown; dorsal abdominal segments VIII and IX reddish brown; genital plates pale orange yellow with inner margin of gonocoxae I pale brown.

Variation.—1, Antenniferous tubercle, tibiae and tarsi with green metallic iridescence.

Type material.—Holotype ♂, Papua New Guinea: Western District, Rouku, Morehead River, 19 March–28 May 1962, W. W. Brandt (BPBM). Paratype: PAPUA NEW GUINEA: 1 ♀, same data as for holotype (UNAM).

Distribution.—Only recorded from the type locality.

Discussion.—*Priocnemicoris doesburgi* is the only known species in the genus with the posterior border of metapleura strongly concave. In the other species, the metapleura are straight or slightly sinuate. In *P. morobe* and *P. doesburgi*, the propleura, mesopleura, and metapleura lack a woolly longitudinal stripe of sericeous setae, and lack a green metallic iridescence. In *P. morobe*, the posteroventral edge of male genital capsule is trilobate (Figs. 11, 16), and the propleura, mesopleura, and metapleura exhibit a pale castaneus orange color. In *P. doesburgi*, the posteroventral edge of male genital capsule has a wide, open U-shaped concavity (Figs. 13, 18), and the mesopleura and metapleura are shiny reddish castaneus, contrasted with the pale yellow propleura.

Etymology.—Named in honor of the distinguished Dutch heteropterist Pieter H. van Doesburg Jr.

Priocnemicoris kiungensis Brailovsky and Barrera, new species

(Figs. 2, 7, 33–34)

Description.—Measurements: Male: Head length including apex of antenniferous tubercle 1.80; width across eyes 2.40; interocular distance 1.07; length of antennal segments: I, 4.00; II, 3.75; III, 2.65; IV, 7.65. Pronotum: Length 4.00; maximum width across anterior lobe 2.80; maximum width across humeral angles 4.90. Scutellar length 2.50; width 2.25. Body length 17.85.

Male: *Dorsal coloration:* Head shiny pale orange with two pale brown longitudinal stripes; antennal segments I to III shiny reddish orange, and IV dull orange; pronotum dark castaneus orange, with green metallic iridescence at humeral angles; scutellum shiny reddish brown with apex yellow; clavus and corium dark castaneus orange with green metallic iridescence; hemelytral membrane dark yellow with basal third pale brown; connexivum yellow with posterior margin dark brown; dorsal abdominal segments shiny reddish orange suffused with irregular brown marks. *Ventral coloration:* Head, rostral segments (apex of IV brown), prosternum, mesosternum, metasternum, and fore and middle legs pale orange yellow; anterior and posterior lobe of metathoracic peritreme, and posterior angle of metapleuron yellow; propleuron, mesopleuron, metapleuron, and hind acetabula shiny castaneus orange; hind leg with coxa shiny castaneus orange, trochanter pale orange yellow, femur shiny reddish orange with basal joint pale orange yellow, tibia pale orange yellow with basal joint reddish orange, and tarsus pale orange yellow; abdominal sterna, pale orange yellow with two longitudinal, irregular stripes pale to dark castaneus orange lateral to midline; rim of abdominal spiracle, and genital capsule pale orange yellow.

Thorax: Posterior border of metapleuron nearly straight.

Genital capsule: Posteroventral edge with wide, open U-shaped concavity, laterally convex (Figs. 2, 7). Parameres, Figs. 33, 34.

Integument: Pronotal disk clothed with short, clearly erect, silvery, bristlelike hairs; propleuron, mesopleuron, and metapleuron clothed with very fine, sparse decumbent setae.

Variation.—1, Green metallic iridescence at humeral angles, clavus, and corium sometimes difficult to see.

Female: Unknown.

Type material.—Holotype: ♂, Papua New Guinea: Kiunga Fly River, 11–13 August 1957, W. W. Brandt (BPBM). Paratypes: PAPUA NEW GUINEA: 1 ♂, Kiunga Fly river, 11–13 August 1957, W. W. Brandt (UNAM); 2 ♂, Amazon Bay Area, Deria, 700 ft, 11 Dic 1962–9 Jan 1963 W. W. Brandt (ANIC); 1 ♂, Morobe District, Tekadu, 07°36′S–146°34′E, 18 March 2000, T. Sears & Binatung Brigade (UCDA).

Distribution.—Only known from the type material.

Discussion.—This species appears to be most closely related to *P. morobe*, in having the propleura, mesopleura, and metapleura clothed with very fine, sparse, decumbent setae, in lacking yellowish-white, sericeous setae, and lacking a green metallic iridescence on the upper margin of propleura, and posterior margin of mesopleura and metapleura.

Priocnemicoris kiugensis has the pronotal disk clothed with short, clearly erect, silvery, bristlelike setae, the pronotum, clavus and corium have a green metallic iridescence, and the posteroventral edge of male genital capsule has a wide opened U-shaped concavity (Figs. 2, 7). *Priocnemicoris morobe* has the pronotal disk clothed with short and almost decumbent bristlelike pilosity, the pronotum, clavus and corium lack a green metallic iridescence, and the posteroventral edge of male genital capsule is trilobate (Figs. 11,16).

Etymology.—Named for its occurrence in Kiunga, Papua New Guinea; a noun in apposition.

***Priocnemicoris nigrellus* Brailovsky and Barrera, new species**

(Figs. 12, 17)

Description.—Measurements: Male: Head length including apex of antenniferous tubercle 2.15; width across eyes 2.75; interocular distance 1.25; length of antennal segments: I, 4.70; II, 4.65; III, 3.50; IV, 8.50. Pronotum: Length 4.50; maximum width across anterior lobe 3.55; maximum width across humeral angles 5.70. Scutellar length 2.95; width 2.60. Body length 20.00. Female: Head length including apex of antenniferous tubercle 1.95; width across eyes 2.70; interocular distance 1.27; length of antennal segments: I, 4.40; II, 4.30; III, 3.35; IV, 8.00. Pronotum: Length 4.40; maximum width across anterior lobe 3.25; maximum width across humeral angles 5.35. Scutellar length 2.85; width 2.35. Body length 19.20.

Male: *Dorsal coloration:* Head dark castaneus orange with vertex and frons dark brown; antennal segments I to III shiny dark reddish brown, and IV dull dark reddish brown; pronotum dark reddish brown; humeral angles tinged with green metallic iridescence; scutellum dark reddish brown with apex yellow; clavus and corium dark reddish brown; hemelytral membrane dark yellow with basal third dark brown; connexivum yellow with posterior margin dark reddish brown; dorsal abdominal segments dark reddish brown. *Ventral coloration:* Head dark castaneus orange with pale yellowish longitudinal stripe near eyes; rostral segments dark castaneus orange; thorax, including anterior and posterior lobe of metathoracic peritreme, acetabulae, and legs dark reddish brown; acetabulae, propleuron, and posterior margin of mesopleuron and metapleuron tinged with green metallic iridescence; prosternum and mesosternum at midline yellow; propleuron, mesopleuron, and metapleuron with wide, yellowish, longitudinal stripe; abdominal sterna and genital capsule dark reddish brown; pleural margins yellowish with posterior border pale to dark reddish brown.

Thorax: Posterior border of metapleuron slightly concave.

Genital capsule: Posteroventral edge with wide open U-shaped concavity (Figs. 12, 17).

Integument: Pronotal disk clothed with short, dense, clearly erect, silvery, bristlelike pilosity; yellowish longitudinal stripe on propleuron, mesopleuron and metapleuron clothed with numerous, very short, yellowish-white sericeous setae, giving a woolly appearance.

Female: Color similar to male. Connexival segments, dorsal abdominal segments VIII and IX, and genital plates black to dark reddish brown, with inner angle of paratergite VIII yellow.

Variation.—1, Dark reddish-brown color of dorsal and ventral surface replaced by ashiny black tint. 2, Pleural abdominal margin yellow with posterior margin reddish brown to black.

Type material.—Holotype: ♂, Indonesia: Irian Jaya (Dutch New Guinea): Japen, Servi, Mantembo, 200–700 m, 6 September 1991, A. Riedel (UNAM). Paratype: INDONESIA: Irian Jaya (Dutch New Guinea): 1 ♀, same data as for holotype (ZSMC).

Distribution.—Only recorded from the type localities.

Discussion.—*Priocnemicoris nigrellus* is the only known species in the genus with the fore and middle legs including the acetabulum entirely dark reddish brown to black. In other species, the fore and middle legs are always pale yellow to pale yellowish orange.

Etymology.—From the Latin *nigra*, meaning black, referring to the color of the body.

Acknowledgments

We thank to the following individuals and institution for loans and other assistance: Randall T. Schuh (AMNH), Tom Weir (ANIC), Mick Webb (BMNH), Al Samuelson and Keith Akakari (BPBM), Richard W. Baumann (BYU), Vincent Lee and Keve Ribardo (CAS), P. P. Parrillo (FMNH), Jerome Constant (IRNB), Brian Harris (LACM), Geoffrey B. Monteith and Geoff Thompson (QMBA), Jan Forrest (SAMA), Joseph C. Schaffner (TAMU), S. L. Heydon (UCDA), Philip J. Clausen (UMSP), Thomas J. Henry (USNM), Izya M. Kerzhner (ZMAS), and Klaus Schonitzer (ZSMC). We also are indebted to Alexander Riedel. Comments on the manuscript from Thomas J. Henry (USNM) and anonymous reviewers are greatly appreciated. Support for the research reported in this paper was provided by UNAM-DGAPA. IN 220135 project.

LITERATURE CITED

Bergroth, E. 1892. Notes synonymiques. Revue d'Entomologie, Caen 12: 262–264.

Blöte, H. C. 1936. Catalogue of the Coreidae in the Rijksmuseum van Natuurlijke Histoire, Part III. Coreinae, Second Part. Zoologische Mededeelingen 19: 23–66.

Boisduval, J. B. A. 1835. Voyage de decouvertes de L'Astrolabe faune entomologique de L'Ocean Pacifique. Part 2. Paris: J. Tastu, 716 pp.

Costa, A. 1863. Illustrazione di alguni emitteri stranieri all' Europa. Nota Seconda. Nuovi Generi e Nouve specie di Coreidei. Rendiconto della advanze e de lavori della Reale Academia della Scienzi di Napoli 2(6): 250–261.

Fallou, G. 1891. Diagnoses D'Hémiptéres nouveaux. Revue d'Entomologie, Caen 10: 5–10.

Guérin-Méneville, F. E. 1832–1838. Histoire Naturelle des crustaces, arachnides et insectes recueillis dans le voyage autour du monde de la corvette de su Majeste, La Coquille execute pendant les annees 1822, 1823, 1824 et 1825, son le commandement du capitaine Duperrey. Part II. Paris. Arthus Bertrand, Libraire, 154–180.

Hsiao and Tsai Yu. 1963. Results of the zoologico-botanical expedition to southwest China, 1955–1957. Acta Entomologica Sinica 12(3): 310–344.

Lethierry, L. and G. Severin. 1894. Catalogue Général des Hémiptéres. Tome II. Hétéroptéres Coreidae, Berytidae, Lygaeidae, Pyrrhocoridae. F. Hayez, Bruxelles. 277 pp.

Stål, C. 1859. Till kannedomen om Coreida. Öfversigt af Kongliga Svenska-Akademiens Förhandlingar 16(10): 449–475.

———. 1865. Hemiptera Africana II. Norstedtiana, Stockholm. 200 pp.

———. 1873. Enumeratio Hemipterorum III. Enumeratio Coreidarum Africae, Asiae et Australiae. Kongliga Svenska Vetenskaps-Akademiens Handlingar 2(2): 33–163.

Walker, F. 1871. Catalogue of the specimens of Hemiptera Heteroptera in the collection of the British Museum Part IV. London. 211 pp.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 572–578

THE GENUS *TOMOCERUS* NICOLET (COLLEMBOLA: TOMOCERIDAE) FROM SICHUAN, CHINA, WITH DESCRIPTIONS OF TWO NEW SPECIES

YUAN SUN, AI-PING LIANG, AND FU-SHENG HUANG

(YS) Institute of Zoology, Chinese Academy of Sciences, Beisihuanxilu, Beijing 100080, P. R. China (e-mail: sunyuan@ioz.ac.cn), Graduate School of Chinese Academy of Sciences, Beijing 100039, P. R. China; (A-pL; F-sH) Institute of Zoology, Chinese Academy of Sciences, Beisihuanxilu, Beijing 100080, P. R. China. Corresponding author: Ai-ping Liang (e-mail: liangap@ioz.ac.cn)

Abstract.—Three species of the genus *Tomocerus* Nicolet are described from Sichuan, China, ***Tomocerus (Tomocerina) tridentatus*, n. sp.**, ***Tomocerus (Tomocerus) wushanensis*, n. sp.** and *Tomocerus* (*Tomocerus*) *kinoshitai* Yosii, 1954. The new species are described and illustrated. A key to the species of *Tomocerus* from Sichuan, China, is provided.

Key Words: Collembola, Tomoceridae, *Tomocerus*, new species, Sichuan, China

---

The family Tomoceridae is divided into two weakly defined subfamilies, Tomocerinae and Lepidophorellinae. The former is largely limited to the Northern Hemisphere while the latter is limited to Australia, New Zealand, and the Antarctic Region. There are nine genera in the Tomocerinae: *Aphaenomurus* Yosii, 1956, *Lethemurus* Yosii, 1970, *Monodontocerus* Yosii, 1955, *Plutomurus* Yosii, 1956, *Pogonognathellus* Paclt, 1944, *Tomocerina* Yosii, 1955, *Tomocerus* Nicolet, 1842, *Tomolonus* Mills, 1949, and *Tritomurus* Frauenfeld, 1854. Many of these genera were treated as subgenera of *Tomocerus* by earlier authors.

Yosii (1967) made a comprehensive study on the family Tomoceridae with special reference to the Japanese fauna. Based on mucronal morphology, Yosii redefined the genera (treated as subgenera) *Tomocerus, Monodontocerus*, and *Tomocerina*. Until now, 63 species have been described of the subgenus *Tomocerus*, with 30 species described or recorded from China (Sun et al. 2006a, b, c).

Nine species of *Tomocerus* have been reported from Sichuan Province (Li 1987, Liu and Li 2003, Liu et al. 1999). In the subgenus *Tomocerina*, eleven world species are known. Six species have been described or recorded in China (Ma et al. 2003a, b), among which four species have been reported from Sichuan Province and two from Xinjiang Province. The percentage of species reported in Sichuan makes it obvious that *Tomocerus* is rich in this region.

This study on the genus *Tomocerus* of Sichuan reveals two new species belonging to two subgenera, *Tomocerus* and *Tomocerina*. They are *Tomocerus (Tomocerina) tridentatus*, n. sp., and *Tomocerus* (*Tomocerus*) *wushanensis*, n. sp. A key to the species of *Tomocerus* from Sichuan, China, is provided.

MATERIALS AND METHODS

The specimens studied in this work are deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing, China (IZCAS).

Abbreviations used include: Ant. III = Antennal segment III; Th. II = Thoracic segment II; Abd. I = Abdominal segment I. The terminology and morphological interpretations follow Yosii (1967). Measurements are in millimeters (mm).

KEY TO THE SPECIES OF *TOMOCERUS* FROM SICHUAN, CHINA

1. Outer basal tooth of mucro without toothlet (Fig. 12) (subgenus *Tomocerina*) 2
– Outer basal tooth of mucro normally with a small toothlet (Fig. 24) (subgenus *Tomocerus*) 6
2. Unguis with 4 inner teeth . . . . *T. (Tomocerina) minutus* Tullberg, 1876
– Unguis without or with 1 inner tooth 3
3. Unguis without inner tooth . . . . *T. (Tomocerina) calceus* Liu, Hou, and Li, 1999
– Unguis with 1 inner tooth 4
4. Distal dental spine arranged as I . . . . *T. (Tomocerina) purpurithorus* Liu, Hou, and Li, 1999
– Distal dental spines arranged as I, 1, I . . . 5
5. Dental spines simple . . . . *T. (Tomocerina) wanglangensis* Liu and Li, 2003
– Dental spines compound, tridentate (Fig. 11) . . . . *T. (Tomocerina) tridentatus*, n. sp.
6. Distal dental spines arranged as I or II . . 7
– Distal dental spines arranged as I, 1–2, I . . 10
7. Unguiculous with 1 outer tooth . . . . *T. (Tomocerus) parvus* Huang and Yin, 1981
– Unguiculous without outer tooth 8
8. Mucro with at least 4 intermediate minute teeth (Fig. 24) 9
– Mucro with 0–3 intermediate minute teeth . . . *T. (Tomocerus) kinoshitai* Yosii, 1954
9. Corpus with 7 setae (Fig. 20); unguis with 1 inner tooth . . . . *T. (Tomocerus) wushanensis*, n. sp.
– Corpus with 15 setae; unguis with 4–5 inner teeth . . . *T. (Tomocerus) ocreatus* Denis, 1948
10. Distal dental spines arranged as I, 2, I . . . . *T. (Tomocerus) vulgaris* (Tullberg, 1871)
– Distal dental spines arranged as I, 1, I . . 11
11. Unguiculous with 1 inner tooth . . . . *T. (Tomocerus) minor* Lubbock, 1862
– Unguiculous without inner tooth 12
12. Dental spines simple without plication . . 13
– Dental spines compound with plications. . . 14
13. Unguis with 1 inner tooth . . . . *T. (Tomocerus) maximus* Liu, Hou, and Li, 1999
– Unguis with 4–5 inner teeth . . . . *T. (Tomocerus) sibiricus* Reuter, 1891
14. Unguiculous with 1 inner tooth; tibiotarsus with 5, 5, 5 blunt spiny setae . . . . *T. (Tomocerus) emeicus* Liu, Hou, and Li, 1999
– Unguiculous without inner tooth; tibiotarsus with 1, 2, 2 blunt spiny setae . . . . *T. (Tomocerus) shuense* Liu, 2003

For a key to the species of *Tomocerus* Nicolet from China, see Sun et al. 2006b.

***Tomocerus (Tomocerina) tridentatus* Sun, Liang, and Huang, new species**

(Figs. 1–12, Table 1)

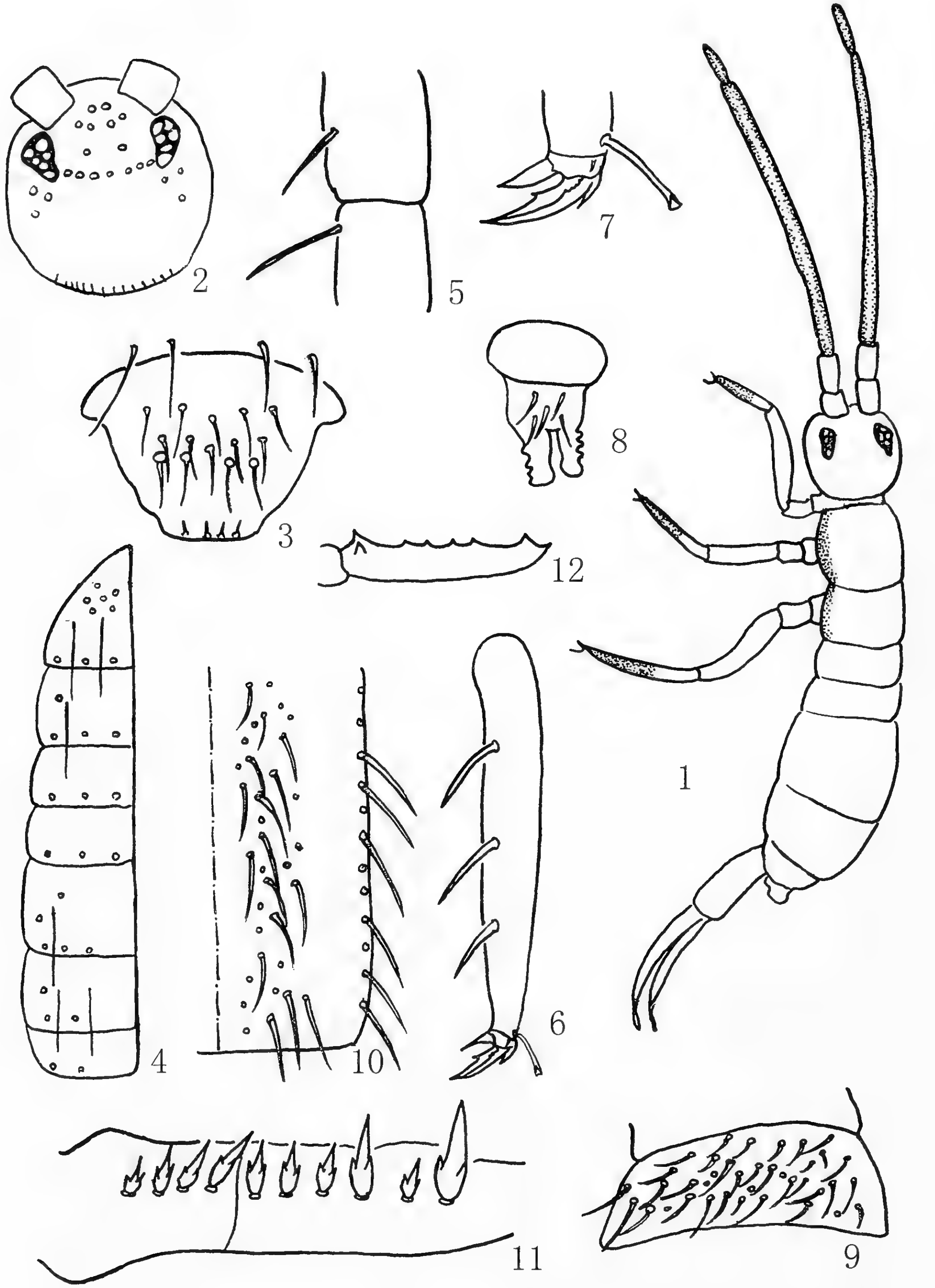
Description.—Body length 2.1–2.5 mm.

Color: Ground color pale yellow. Eye patches black. Ant. I and II brown. Ant. III and Ant. IV purple. Lateral margin of Th. II and III with bluish-black pigment. Purple pigment scattered on distal 2/3 of tibiotarsi.

Head: Eyes 6+6, almost subequal. Antenna 0.89 times as long as body and 4.21 times as long as head. Ratios of Ant. I: II: III: IV = 1.0: 1.5: 10.0: 1.5. About 14 setae present on posterior head (Fig. 2). Labral setae 4/5, 5, 4, all smooth; each of distal 3 rows beset on papilla. Anterior margin of labrum with 4 recurved spines (Fig. 3).

Thorax: Macrochaetae and bothriotricha of thorax and abdomen as shown in Fig. 4. Tibiotarsi with numerous pointed smooth setae of different sizes; ventral side with 0, 0, 3 large blunt spiny setae respectively on leg I–III (Fig. 6). Unguis slender; a pair of well-developed pseudonychia, 0.33–0.40 times as long as inner edge of unguis; inner tooth 1, 1 and 1 respectively on leg I–III. Unguiculus lanceolate without outer tooth or inner tooth. Tenent hair thick, 1.0–1.07 times as long as inner edge of unguis, apex spatulate (Fig. 7). Trochanteral organ reduced to 1, 1 seta (Fig. 5).

Abdomen: Tenaculum unscaled, 4+4 teeth, with 5 smooth setae on corpus



Figs. 1–12. *Tomocerus (Tomocerina) tridentatus.* 1, Habitus. 2, Dorsum of head. 3, Labrum. 4, Dorsal chaetotaxy of body (Th. II-Abd. V). 5, Trochanteral organ. 6, Hind tibiotarsus and hind claw. 7, Detail of hind foot complex. 8, Tenaculum. 9, Lateral flap of ventral tube. 10, Distal part of manubrium (dorsal view). 11, Dental spines. 12, Mucro.

Table 1. Comparison between *T. (Tomocerina) tridentatus*, *T. (Tomocerina) wanglangensis*, and *T. (Tomocerina) simplex*.

Characters	*T. (Tomocerina) tridentatus*	*T. (Tomocerina) wanglangensis*	*T. (Tomocerina) simplex*
Dental spines formula	4/3–4, I, 1, I	2/1, I, 1, I	4/3, I
Dental spine pattern	Compound, tridentate	Simple, unplicated	Simple, unplicated
Mucronal intermediate teeth	3–4	2	1

(Fig. 8). Ventral tube unscaled, lateral flap with about 38 smooth setae in different sizes (Fig. 9). Ratios of manubrium/dens/mucro = 2.86–3.14/4.57–4.72/1.0. Manubrium scaled, with 12 large setae on each dorsolateral side, all mildly ciliate and sharply tapered near apex; dorsally with 2 setaceous stripes (Fig. 10). Dentes without large setae on outer edge and basal scalelike spine on inner edge. Dental spines formula as 4/3–4, I, 1, I, pale brown, tridentate (Fig. 11). Mucro elongate covered with numerous ciliate setae; outer basal tooth without a corner toothlet. Outer dorsal lamella bearing 3–4 intermediate minute teeth; apical and anteapical teeth subequal (Fig. 12). Upper anal valve of Abd. VI with 12 large ciliate cylindrical setae arranged in 2 irregular transverse rows.

Types.—Holotype: ♀, China, Sichuan, Guanxian, Lidui (31.0°N, 103.6°E), 800 m, 8 May 1986, collected by Huang Fu-Sheng (IZCAS). Paratypes: 2 ♀, all on slides, same data as holotype (IZCAS).

Etymology.—The new species is named after the dental spine pattern.

Remarks.—This species is similar to *T. (Tomocerina) wanglangensis* Liu and Li, 2003, and *T. (Tomocerina) simplex* Yosii, 1966, but it can be separated from them by the characters listed in Table 1.

***Tomocerus* (*Tomocerus*) *wushanensis* Sun, Liang, and Huang, new species**

(Figs. 13–24, Table 2)

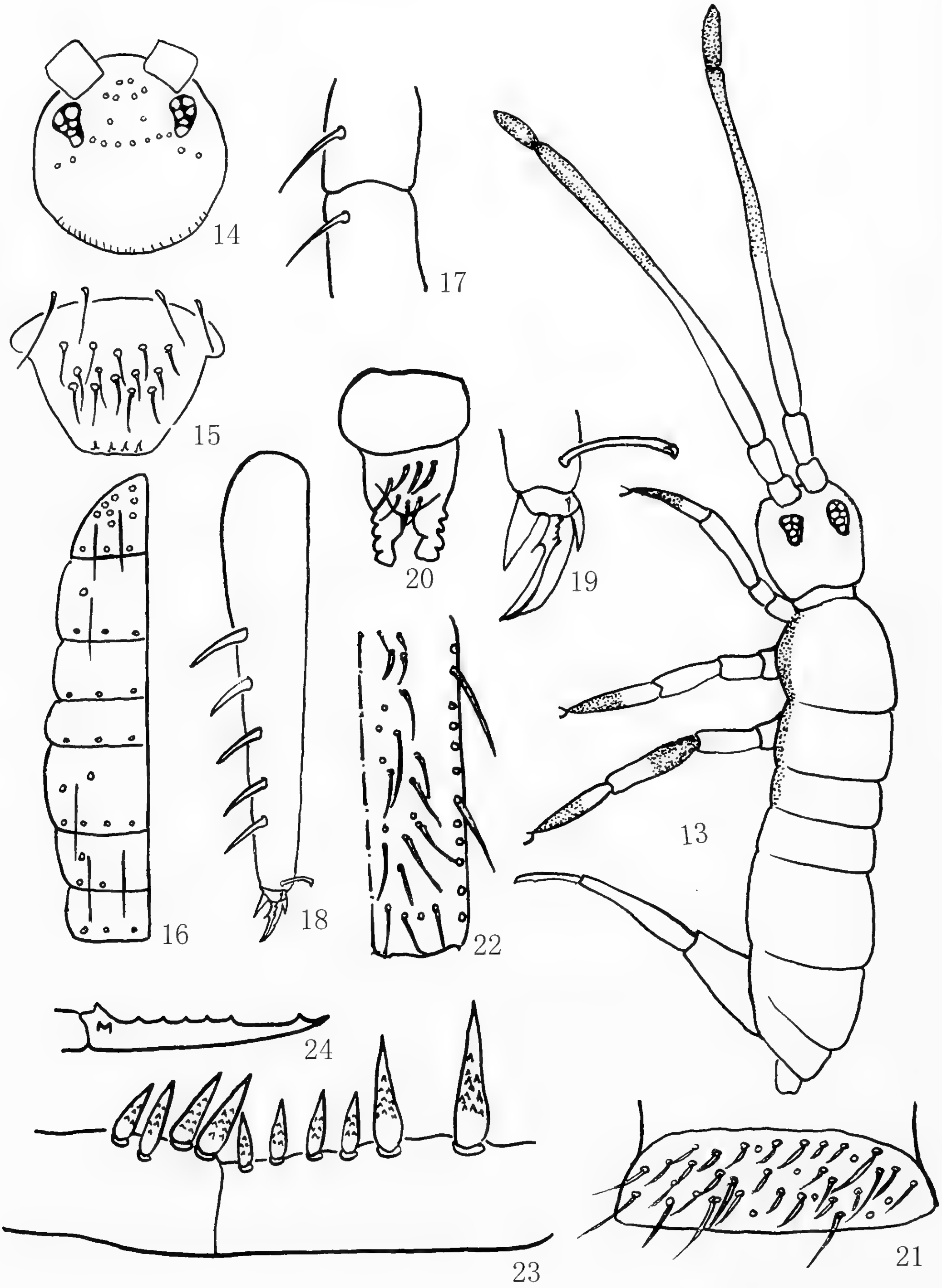
Description.—Body length 2.8–2.9 mm.

Color: Ground color pale yellow. Eye patches black. Distal 1/2 of Ant. III pale purple. Ant. IV dark purple. Lateral margin of Th. II and III and Abd. I with black pigment. Distal 1/2 part of tibiotarsi pale purple. Basal 1/2 of hind femur dark purple.

Head: Eyes 6+6, almost subequal. Antenna 0.68–0.89 times as long as body and 3.8–4.8 times as long as head. Ratios of Ant. I–IV = 1.0:1.5:10.75–11.25:1.75. Twenty-three setae present on dorsal posterior head (Fig. 14). Labral setae 4/5, 5, 4, all smooth; each of distal 3 rows beset on papilla. Anterior margin of labrum with 4 recurved spines (Fig. 15).

Thorax: Macrochaetae and bothriotricha as shown in Fig. 14. Tibiotarsi with numerous pointed smooth setae of varying lengths; ventral side with 5, 5, 5 large blunt spiny setae respectively on leg I–III (Fig. 18). Unguis slender; a pair of well-developed pseudonychia, 0.5 times as long as inner edge of unguis; inner tooth 1, 1 and 1 respectively on leg I–III. Unguiculus lanceolate without outer tooth or inner tooth. Tenent hair thick, same length as length of inner edge of unguis, apex spatulate (Fig. 19). Trochanteral organ reduced to 1, 1 seta (Fig. 17).

Abdomen: Tenaculum unscaled, 4+4 teeth, with 7 smooth setae on corpus (Fig. 20). Ventral tube unscaled, lateral flap with about 26 smooth setae of different sizes (Fig. 21). Ratios of manubrium/dens/mucro = 2.67–3.5/4.0–4.63/1.0. Manubrium scaled, with 12 large setae on each dorsolateral side, all mildly ciliate and sharply tapered near apex; dorsally with 2 setaceous stripes



Figs. 13–24. *Tomocerus* (*Tomocerus*) *wushanensis*. 13, Habitus. 14, Dorsum of head. 15, Labrum. 16, Dorsal chaetotaxy of body (Th. II-Abd. V). 17, Trochanteral organ. 18, Hind tibiotarsus and hind claw. 19, Detail of hind foot complex. 20, Tenaculum. 21, Lateral flap of ventral tube. 22, Distal part of manubrium (dorsal view). 23, Dental spines. 24, Mucro.

Table 2. Comparison between *T.* (*Tomocerus*) *wushanensis*, *T.* (*Tomocerus*) *ocreatus*, and *T.* (*Tomocerus*) *ishibashi*.

Characters	*T.* (*Tomocerus*) *wushanensis*	*T.* (*Tomocerus*) *ocreatus*	*T.* (*Tomocerus*) *ishibashi*
Color pattern on head, body, and legs	Distal 1/2 of Ant. III pale purple. Ant. IV dark purple. Lateral margin of Th. II and III and Abd. I with black pigment. Distal part of tibiotarsi pale purple. Basal 1/2 of hind femur dark purple.	Thorax often diffusely violet. Antennae violet distally. Leg pale, but tibiotarsus often diffusely violet.	Head and Ant. I, II intensely pigmented to purple. Antennae violet distally. No pigment upon other places.
Length ratio of antennae to body	<1	>1	=1
Unguis inner teeth	1, 1, 1	4–5, 4–5, 4–5	6, 6, 6

(Fig. 22). Dentes without large setae on outer edge and basal scalelike spine on inner edge. Dental spines arranged as 4/3–4, II, pale yellow, spines with smaller teeth on surface (Fig. 23). Mucro elongate covered with numerous ciliate setae; outer basal tooth with a corner toothlet. Outer dorsal lamella with 4–5 intermediate minute teeth; apical and anteapical teeth subequal (Fig. 24). Upper anal valve of Abd. VI with 16 large ciliate cylindrical setae arranged in 2 irregular transverse rows.

Types.—Holotype ♀, China, Sichuan, Wushan, Liziping (31.0°N, 109.9°E), 1800 m, 4 August 1993, collected by SUN Bao-Wen (IZCAS). Paratypes: 2 ♀, all on slides, same data as holotype (IZCAS).

Etymology.—The name refers to the type locality.

Remarks.—This species is similar to *T.* (*Tomocerus*) *ocreatus* Denis, 1948, and *T.* (*Tomocerus*) *ishibashi* Yosii, 1954, but it can be separated from them by the characters listed in Table 2.

Tomocerus (*Tomocerus*) *kinoshitai* Yosii, 1954

Tomocerus kinoshitai Yosii 1954: 814, fig. 29; 1956: 90; 1967: 20, fig. 10; Martynova 1969: 307, fig. 7; Lee 1975: 951; Park and Lee 1995: 439; Liu and Hou 1998: 1; Huang and Liu 1999: 20, fig. 2–3.

Specimens examined.—China: 1 ♂, Sichuan, Qingcheng Shan (30.9°N, 103.5°E), 600 m, 8 May 1975; 2 ♀, Jiangxi, Lu Shan (29.4°N, 115.9°E), 1,000 m, 23 April 1978; 4 ♀, Jilin, Changbai Shan (42.0°N, 128.1°E), 1100 m, 3 August 1980, collected by Huang Fu-Sheng (IZCAS).

Remarks.—This species can be separated from the others by the following characters: short antennae, often less than half the body length; mucro typical in structure often with 0–3 intermediate minute teeth; corpus unscaled with only 1 seta; and dental spine formula 3–4/1–2, II, with 3–5 spikes near the basis. While examining the specimens, we find that this species is widely distributed in mideastern China, both in the north (Jilin Province) and south (Chongqing, Fujian Province, Hunan Province, Sichuan Province, Jiangxi Province). It is not endemic to Japan according to Yosii (1967). This species was reported from soil and litter as well as from a cave environment in Korea (Park and Lee 1995).

Distribution.—China (Chongqing, Fujian, Hunan, Sichuan, Jiangxi, Jilin) Japan, Korea, Russia.

Acknowledgments

This work was supported by the Hundred Talent Program and an Innovation Program, both from the Chinese Academy of Sciences and the National Science Fund for Fostering Talents in Basic Research (NSFC-J0030092), all awarded to Ai-Ping Liang. We thank Byung-Hoon Lee and Kyung-Hwa Park from Chonbuk National University (Korea) for providing us with literature. Thanks are also given to K. A. Christiansen of Grinnell College (USA) for reviewing the manuscript.

Literature Cited

Denis, J. R. 1948. Collemboles d'Indochine. Notes d' Entomologie Chinoise XII(17): 220–221.

Huang, F.-S. and H. Liu. 1999. Collembola, pp. 19–21. *In* Huang, B.-K., ed. Fauna of Insects in Fujian Province of China. Fujian Science and Technology Press, Fuzhou.

Lee, B.-H. 1975. Étude de la faune coréenne des Insectes Collemboles VI. Sur la famille des Tomoceridae, édaphiques, avec la description de quatre nouvelles espèces et d'une nouvelle sous-espèce. Bulletin du Muséum National d'Histoire Naturelle 317: 945–961.

Li, Z.-C. 1987. Springtails of the genus *Tomocerus* from Sichuan (Collembola, Entomobryidae). Journal of Mianyang Agricultural College 14(2): 1–7 (in Chinese).

Liu, Y.-Q. and D.-B. Hou. 1998. A new recorded species of the Genus *Tomocerus* (Collembola: Tomoceridae) from China. Journal of Mianyang College of Economy and Technology 15(4): 1–2 (in Chinese).

Liu, Y.-Q. and Z.-C. Li. 2003. A new species of the genus *Tomocerus (Tomocerina)* (Collembola: Tomoceridae) from China. Entomotaxonomia 25(4): 249–251.

Liu, Y.-Q., D.-B. Hou, and Z.-C. Li. 1999. Four new species of *Tomocerus* (Collembola: Tomoceridae) from China. Entomotaxonomia 21(4): 239–245.

Ma, Y.-T., J.-X. Chen, and K. A. Christiansen. 2003a. A new species of the genus *Tomocerus (Tomocerina)* from China (Collembola: Tomoceridae) with a discussion of the subgenera of *Tomocerus*. Entomological News 114(1): 41–46.

———. 2003b. A new Chinese species of the genus *Tomocerus (Tomocerina)* from Xinjiang (Collembola: Tomoceridae) with a discussion of *Tomocerina*. Journal of Entomological Science 38(4): 511–518.

Martynova, E. F. 1969. Springtails of the family Tomoceridae (Collembola) from the fauna of USSR. Revue Entomologique USSR 68(2): 299–314.

Park, K.-H. and B.-H. Lee. 1995. Tomocerid Collembola (Insecta) from Korean caves including a new species. The Korean Journal of Systematic Zoology 11: 435–445.

Sun, Y., A.-P. Liang, and F.-S. Huang. 2006a. Descriptions of two new Tibetan species of *Tomocerus* (s.str.) Nicolet, 1842 (Collembola, Tomoceridae). Acta Zootaxonomica Sinica 31(3): 559–563.

———. 2006b. The subgenus *Tomocerus* (s.str.) Nicolet (Collembola: Tomoceridae) from Gansu, China. Oriental Insects 40: 327–338.

———. 2006c. Descriptions of two new species of the genus *Tomocerus* (Collembola, Tomoceridae) from Shanxi, China. Acta Zootaxonomica Sinica 31(4): 803–806.

Yosii, R. 1954. Springschwänze des Ozé-Naturschutzgebietes. Scientific Researches of the Ozegahara Moor Tokyo, pp. 777–830.

———. 1956. Monographie zur Höhlencollembolen Japans. Contributions from the Biological Laboratory Kyoto University 3: 1–109.

———. 1966. Collemola of Himalaya. Journal of the College of Arts and Sciences, Chiba University 4(4): 508.

———. 1967. Studies on the Collembolan family Tomoceridae, with special reference to the Japanese forms. Contributions from the Biological Laboratory Kyoto University 20: 1–54.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 579–595

FECUNDITY AND LONGEVITY OF THE SIBLING AND SYMPATRIC SPECIES, *TRUPANEA NIGRICORNIS* (COQUILLETT), A POLYPHAGE, AND THE NARROWLY OLIGOPHAGOUS *T. BISETOSA* (COQUILLETT) (DIPTERA: TEPHRITIDAE)

KHOUZAMA M. KNIO, RICHARD D. GOEDEN, AND DAVID H. HEADRICK

(KMK) Biology Department, Faculty of Arts & Sciences, American University of Beirut, P.O. Box 11-0236, Riad El Solh, Beirut, Lebanon (e-mail: kknio@aub.edu.lb); (RDG) Department of Entomology, University of California, Riverside, CA 92521, U.S.A.; (DHH) Horticulture and Crop Science Department, California Polytechnic State University, San Luis Obispo, CA 93407, U.S.A. (e-mail: dheadric@calpoly.edu)

Abstract.—The sibling species, *Trupanea nigricornis* (Coquillett) and *Trupanea bisetosa* (Coquillett) are not sexually mature when they emerge from puparia, and must feed to attain sexual and reproductive maturity. In both species, males matured earlier than females and gonadal maturation was independent of diet. Females of *T. nigricornis* and *T. bisetosa* required an extrinsic source of proteins, in addition to sugar and water, to mature eggs. They showed similar pre-oviposition periods (18–20 d) on protein diets. Omission of vitamins to a protein diet did not inhibit ovarian maturation in both species, but lengthened their pre-oviposition periods. Addition of the host plant to a protein diet did not affect the pre-oviposition period, but prevented egg resorption and led to successful mating. No significant differences were detected in longevity between the two species fed on carbohydrate or protein diets, and between males and females of the same species, with the exception of *T. nigricornis* females fed on yeast hydrolysate diet. When given the choice, females of each species preferred to oviposit in flower heads of its natural host. In non-choice experiments, *T. nigricornis* could not successfully oviposit in the flower heads of wild sunflowers, the host of *T. bisetosa*, but *T. bisetosa* females did oviposit in the non-host heads of *Encelia farinosa*. On their natural hosts, the fecundity of *T. nigricornis* (244 eggs/female) was higher than that of *T. bisetosa* (158 eggs/female). Mating influenced egg production in both species. The fecundity of unmated *T. nigricornis* (14 eggs/female) and *T. bisetosa* (8 eggs/female) females on their host plants, *E. farinosa* and *H. annuus*, respectively, was much lower than the fecundity of mated females on their host plants.

Key Words: adult food, fruit flies, ovarian maturation, survival

Trupanea nigricornis (Coquillett) and *Trupanea bisetosa* (Coquillett) are flower-head infesting tephritids that occur in sympatry in southern California. They are sibling and cryptic species showing great similarities in their morphology, biology and behavior (Knio et al. 1996a, b). Immatures of both species are difficult to separate and can only be recognized by their host plant (Knio et al. 1996a). Adult males can be easily separated by the color of the third antennal segment, brown in *T. nigricornis* and yellow in *T. bisetosa* However, females are more difficult to identify; about 75% can be recognized by the shape of the Y-apical marking on the wings: short and broad in *T. nigricornis* vs. distinct and thin in *T. bisetosa* (Cavender and Goeden 1983, Foote et al. 1993). Ecologically, the two species show major differences in their mode of herbivory and host plant specificities. *Trupanea nigricornis* behaves as a generalist, infesting plants belonging to 8 tribes of the Asteraceae while *T. bisetosa* is a narrow oligophage, specializing mainly on the flower heads of *Helianthus annuus* L. (Asteraceae).

Resource utilization studies showed that the larvae of both species exploited the flower heads of their hosts in a similar manner and they damaged a similar number of achenes (Knio et al. 2001). Such studies did not provide clues to why these two sister and sympatric species have diverged in their mode of herbivory. Comparisons of the types and densities of natural enemies attacking these two species showed that the generalist, *T. nigricornis*, suffered mortality by more species of parasitoids (5 vs. 1) than the specialist, *T. bisetosa*. Moreover, percentage parasitism was much higher in samples infested with *T. nigricornis* (21.5–58.2%) than *T. bisetosa* (4.5–16.1%). Therefore, it seems that by specializing on wild sunflowers, *T. bisetosa* gained an enemy-free space (Knio et al. 2007). It is not known whether *T. nigricornis* can compensate for the higher mortality caused by parasitoids by having a higher fecundity than *T. bisetosa*. Moreover, studying demographic parameters of the adult populations, such as fecundity and longevity, might shed further light on the different strategies adopted by these two species.

In tephritids, adult survival and reproduction are affected by nutrition and temperature (Hendrichs et al. 1993, Jácome et al. 1999, Vargas et al. 2000). There have been extensive studies on the effect of diets on the longevity and fecundity of fruit-infesting and economic important species, but no information exists on the flower-head infesting species, which cannot be reared in the laboratory on artificial diets. Studies on fruit-infesting tephritids showed that newly emerged adults of most species are not sexually mature and females need, under optimum conditions, several days to maturate eggs. Although adult tephritids differ in their nutritional requirements as there are differences among individuals and species in the amount and quality of metabolites transferred from the larval to the adult stage, most species need an extrinsic source of sugars and water for survival, and regular ingestion of proteins, vitamins and minerals for adequate egg production (Tsiropoulos 1977, 1978, 1980). In nature, food sources for adult fruit flies included damaged fruits, plant exudates, plant sap, pollen, nectar, honey dew, microorganisms, and bird droppings (Bateman 1972, Fletcher 1987, Hendrichs et al. 1993).

Relatively few demographic and life history studies have been conducted on the flower-head infesting tephritids, and more specifically on *T. nigricornis* and *T. bisetosa*. The pattern of reproduction and effect of adult nutrition on survival and fecundity have not been studied in those species. In this study, we aim to compare the influence of different diets, including the host plants of *T. nigricornis* and *T. bisetosa*, on gonadal maturation, and longevity of the adults, and to determine the fecundities of *T. nigricornis* and *T. bisetosa* females on host and non-host plants. The effect of mating on fecundity is also investigated. These life history studies constitute one of a series intended to shed light on the nature of polyphagy/oligophagy in the sibling and sympatric species, *T. nigricornis* and *T. bisetosa*.

MATERIALS AND METHODS

Study insects.—*Trupanea nigricornis* adults were reared from *Encelia farinosa*

Gray (Asteraceae) heads while *Trupanea bisetosa* adults were reared from flower heads of wild sunflowers, *Helianthus annuus* L. (Asteraceae) collected from four interior valley sites in southern California. The collected flower heads were placed in separate glass-topped, sleeve cages (34×32×35 cm) in the insectary at 60% RH and a 12/12 h LD photoperiod from 0500–1700 h to monitor for the emergence of adult tephritids. Newly emerged (one day old) adults were used for the following experiments.

Effect of diets on ovary maturation.—*Effect of sugar, proteins and host:* Insectary cages were provisioned with six different diets: (1) control diet: water and honey (as a source of carbohydrates mainly); (2) water, honey, and flower heads of *E. farinosa* for *T. nigricornis* or *H. annuus* for *T. bisetosa*; (3) water, honey and casein hydrolysate (as a source of proteins mainly); (4) water, honey, casein hydrolysate and *E. farinosa* flower heads; (5) water, honey, and yeast hydrolysate (as a source of proteins mainly); and (6) water, honey and yeast hydrolysate and *E. farinosa* flower heads.

Yeast and casein hydrolysates, two commonly used, rich protein diets on fruit-infesting species, were tried as extrinsic source of proteins for *T. nigricornis*. Since they both gave similar results, only yeast hydrolysate as protein diet was adopted for *T. bisetosa*. Therefore, only diets (1), (2), and (5) were tested for *T. bisetosa* adults.

The yeast and casein hydrolysate solutions were prepared by mixing the protein hydrolysate: sucrose: water in the ratio of 4: 7: 10 (Tsiropoulos 1978). Tightly wrapped, absorbent sterile cotton wicks (ca 2×1 cm) were dipped in the protein solutions and hung from the glass top of the sleeve cage with scotch tape. The cotton wicks were changed every other day. On the second day, they were moistened with ca. 1 ml of distilled water added with a pipette. The immature flower heads of *E. farinosa* and *H. annuus* were attached to stems which were immersed in water. They were changed every 2–3 d. In each cage, honey was streaked on the underside of the glass and water was provided in a glass bottle with a cotton wick. Every cage initially contained 40 females and ten males newly recovered (one day old) from the flower heads. Each treatment was replicated twice. Subsamples of three females (six females per treatment) were taken from each cage 5, 10, 15, 20, 30 and 50 d after emergence. The females were chilled for 30 min then placed in 70% ethanol and dissected under a stereomicroscope to examine the condition of the ovaries. Ovary size was measured with an ocular micrometer. The preoviposition periods of the females given different diets were estimated by monitoring the presence of mature eggs in (i) dissected ovaries, and (ii) in flower heads of *E. farinosa* or *H. annuus*. For the latter step, three females were taken at each sampling interval from the cages provided with diets lacking the host plant, and placed for 3–4 h in Petri dishes (100×15 mm) with excised immature *E. farinosa* or *H. annuus* flower heads to allow oviposition. The females were not returned to their cages to avoid variables caused by probing or feeding on the flower heads.

Effect of vitamins: To separate the effect of protein and vitamins on ovarian maturation, newly emerged (one day old) flies were fed on a diet of water, sucrose and protein devoid of vitamins (Vitamin Assay Casamino Acids dehydrated, Difco Laboratories, Detroit, Michigan) (10: 7: 4). Newly emerged adults of both species were placed in separate cages (40 females and 10 males per cage), as described above. The control diet was yeast hydrolysate, sucrose, and water. A subsample of six females was taken from each treatment at day 10, 15, 18, 20, 25, 30, 35, and 50 after adult emergence. The females were dissected and the size and conditions of the ovaries were recorded as described above.

Effect of diets on male gonadal maturation.—Newly emerged adults (one day old) of *T. nigricornis* (20 females and 20 males) and *T. bisetosa* (20 females and 20 males) were paired, and each pair was placed in a small plastic cage. For every species, 10 pairs were offered a diet of water and honey, and 10 other pairs were offered water, honey and yeast hydrolysate. The first time a male started to exhibit courtship display was recorded.

Effect of diets on adult longevity.—Newly emerged adults (one day old) of *T. nigricornis* and *T. bisetosa* were divided into three subsamples and provided with the following diets: (1) water, (2) water and honey, (3) water, honey and yeast hydrolysate diet, (4) water, honey, yeast hydrolysate and immature flower heads of *E. farinosa* or *H. annuus*, depending on the tephritid species. For every treatment, male and female flies of the same species were placed in the same cage. Longevity of the flies under these different diets was determined by recording, daily, the date of natural death.

Fecundity.—*Initial experiments (group fecundity):* Initial fecundity experiments were carried out to determine whether *T. nigricornis* and *T. bisetosa* would oviposit under artificial conditions in host and non-host flower heads and to determine the stage of the flower heads suitable for oviposition. Newly emerged adults of both species were placed in separate glass-topped sleeve cages (34×32×35 cm) in the insectary and given a yeast hydrolysate diet, honey, and water. Adults of each species were divided into three subsamples of 20 flies. Adults in the first subsamples were provided with bouquets of immature *H. annuus* flower heads. Adults in the second subsamples were provided with *E. farinosa* flower heads; those in the third subsamples were provided with *E. farinosa* and *H. annuus*. The flower heads were changed every three days and dissected under a stereomicroscope to determine whether oviposition had occurred. The time the females started to oviposit was also recorded as well as the plant host that was preferred by each species under laboratory conditions.

Individual fecundity experiment: One-day old, sexed adults were given yeast hydrolysate, honey and water. At day 18 after emergence (as determined from the previous experiments on the effect of diets on timing of flies' sexual maturity), the flies were paired (female × male of *T. nigricornis* or female × male of *T. bisetosa*) and transferred to a smaller cage: 850 ml clear plastic cage with a basal water reservoir and a screened lid for ventilation (Cavender and Goeden 1983). The lid of each cage was striped with honey and pinned with a cotton wick dipped in the yeast hydrolysate diet. Each cage was provided with a bouquet of immature flower heads, the peduncles of which were immersed in the basally attached water reservoir and held in place by a moist absorbent cotton plug that also provided a water source for the flies. To study the flies' fecundity on their host plants, adults of *T. nigricornis* were provided with bouquets of *E. farinosa* (open buds). Adults of *T. bisetosa* were provided with bouquets of sunflowers (very small closed buds). To test the fecundity of these flies on the other species host plants, *T. nigricornis* adults were provided with bouquets of wild sunflowers (very small closed buds) while *T. bisetosa* adults were provided with bouquets of *E. farinosa* (open buds). To be certain that the flower heads collected were not infested, the immature heads were previously covered with a fine-mesh cloth to prevent fly from oviposition or they were collected while free of oviposition wounds and placed in water at room

Table 1. Pre-oviposition period and ovarian size of *Trupanea nigricornis* females on different diets.

Days After Emergence	Mean Ovary Size (Diameter × Length in mm; n = 6) of Females Given[a]:					
	W+H	W+H+Y	W+H+Y+F	W+H+F	W+H+C	W+H+C+F
5	0.18×0.23	0.23×0.36	0.21×0.32	0.16×0.25	0.21×0.32	0.19×0.29
10	0.18×0.27	0.23×0.38	0.24×0.38	0.17×0.27	0.24×0.43	0.3×–0.4
15	-----------	-----------	**0.42×0.72**[c]	-----------	-----------	-----------
20	0.18×0.26	**0.43×0.79**[b]	**0.56×0.93**	0.18×0.3	**0.5×0.86**	**0.49×0.92**
30	0.18×0.27	**0.46×0.77**	**0.59×0.97**	**0.62×1.04**	**0.52×0.87**	**0.57×1.01**
50	0.21×0.33	**0.53×0.84**	**0.52×0.99**	**0.5×0.7**	**0.49×0.87**	**0.51×0.79**
Pre-oviposition Period	-----------	20	15–20	30	20	20

[a] Diets: water and honey (W+H) (control); yeast hydrolysate diet (Y); casein hydrolysate diet (C); *Encelia farinosa* flower heads (F).

[b] The presence of mature eggs in the ovaries of all sampled females is indicated in bold face.

[c] Only in this sample, three out of six females had mature ova in their ovaries.

temperature for 2 d before using them, so that any eggs still present would have shriveled if infertile or hatched into first instars. The bouquets of the immature flower heads were changed every 2–3 d, and then dissected under a stereomicroscope to determine the number of eggs laid. All the eggs that were found were placed on a filter paper (Whatmann #1) moistened with physiological saline in closed glass Petri dishes, and incubated at 27°C. The eggs were checked every day for eclosion.

Effect of mating on fecundity: To study the effect of mating on fecundity, individual newly emerged *T. nigricornis* (n = 10) and *T. bisetosa* (n = 10) females were placed in small cages and given a yeast hydrolysate diet as described above. At day 18 after emergence, *T. nigricornis* females were provided, every 3 d, with a bouquet of *E. farinosa* flower heads while *T. bisetosa* females were provided, every 3–4 d, with wild sunflower heads. The number of eggs oviposited by each female and percentage egg hatch were recorded as described above. This data was then compared and plotted against the number of eggs oviposited by *T. nigricornis* and *T. bisetosa* females from the individual fecundity experiments.

Statistics.—Statistical differences in the mean timing of reaching sexual maturity of *T. nigricornis* and *T. bisetosa* males fed on yeast hydrolysate or water and honey were tested by performing two-tailed *t*-tests for independent variables. Tukey's test for pairwise comparison of means was conducted to test differences between average longevity of *T. nigricornis* and *T. bisetosa* adults on different diets tested. All statistical tests were performed at 95% confidence level using SPSS (13.0).

RESULTS

Effect of diets on ovary maturation.—*Effect of sugar, proteins and host:* The conditions of the ovaries and pre-oviposition periods of *T. nigricornis* and *T. bisetosa* females given different diets are summarized in Tables 1 and 2. The control diet, which was honey and water, did not support ovary maturation in either species. Honey, which is composed of a high proportion of sugars, of which 40–50% is sucrose, water, and traces of proteins (Chapman 1982), provided mainly a source of carbohydrates. Sugars alone were not sufficient to support egg production in *T. nigricornis* and *T. bisetosa* females. Thus, the ovaries in females of neither species matured on

Table 2. Pre-oviposition period and ovarian size of *Trupanea bisetosa* females on different diets.

	Mean Ovary Size (Diameter × Length in mm; n = 6) of Females Given[a]:		
Days After Emergence	(W+H)	(W+H+Y)	(W+H+Y+F)
5	0.17×0.24	0.19×0.39	0.20×0.30
10	0.20×0.28	0.24×0.33	0.25×0.36
15	0.20×0.27	0.26×0.52	----------
20	0.18×0.30	**0.51×0.73**[b]	**0.50×0.75**
40	0.22×0.30	**0.42×0.65**	**0.55×0.83**
50	0.20×0.30	**0.43×0.65**	**0.50×0.70**
Preoviposition Period	----------	20	20

[a] Diets: water and honey (W+H) (control); yeast hydrolysate diet (W+H+Y); excised sunflower heads (F).

[b] The presence of mature eggs in the ovaries of all sampled females is indicated in bold face.

a sugar and water diet, and the follicles in the immature ovaries became resorbed between 40 and 50 d after female emergence. The resorbed ova were translucent and yellowish.

All protein hydrolysate diets tested supported ovigenesis in *T. nigricornis* females. With all these diets, the ovaries matured, and they each contained six to eight mature ova (0.20 mm in diam.; 0.70 mm in length). There was no difference in the diets containing casein or yeast hydrolysates, with or without the host plant, with respect to the pre-oviposition period, which was about 20 d for all the protein diets tested (Table 1). Thus, both casein and yeast hydrolysate provided the essential nutrients required for the production of mature eggs.

The addition of the host plant to the protein hydrolysate diet did not affect the pre-oviposition period of *T. nigricornis* females, but it affected two phenomena: egg resorption and mating. When *T. nigricornis* adults were fed on protein diets but were not offered flower heads of their hosts, most (90%) of the females had the ova in their ovaries resorbed by days 40 and 50, as they had no access to oviposition sites.

Egg resorption did not occur in *T. nigricornis* and *T. bisetosa* provided with protein diets and flower heads of their hosts. At day 50 after emergence, the females that were given protein diets and *E. farinosa* heads contained expanded, empty ovaries, resembling two large, opaque sacs (mean of four empty ovaries: 0.66 mm in diameter; 1.21 mm in length). These females had laid most of the eggs produced in their ovaries. Also, the presence of the host plants, together with the protein diet, provided cues for mating, since successful matings were only recorded in the cages provided with protein hydrolysate and *E. farinosa* heads.

Similar to *T. nigricornis*, the females of *T. bisetosa* also required a protein source for their ovaries to mature (Table 2). They developed mature ova on day 20 on yeast hydrolysate diets, with or without their host plant (Table 2).

The diet comprising water, honey, and *E. farinosa* heads also supported ovigenesis in *T. nigricornis* females. Females showed mature ova on this diet at day 30 compared to day 20 with the protein hydrolysate diets (Table 1).

Effect of vitamins: The absence of vitamins in the diet did not inhibit ovarian maturation in *T. nigricornis* and *T. bisetosa*, but affected their pre-oviposition period (Table 3). Both *T. nigricornis* and *T. bisetosa* females matured eggs when fed proteins devoid of vitamins, sugar, and water. The pre-oviposition period, however, varied among females; not all sampled females

Table 3. Ovarian maturation and pre-oviposition period of *Trupanea nigricornis* and *Trupanea bisetosa* with protein alone, sucrose, and water diet (A) and with yeast hydrolysate diet (control) (B).

	Number of Mature Females[a] from n = 6:			
	T. nigricornis		*T. bisetosa*	
Days After Emergence	A	B	A	B
10	0	0	0	0
15	0	0	0	0
18	0	5 (83.3%)	0	4 (66.7%)
20	2 (33.3%)	6 (100%)	2 (33.3%)	6 (100%)
25	1 (16.7%)	6 (100%)	3 (50%)	6 (100%)
30	2 (33.3%)	6 (100%)	3 (50%)	6 (100%)
35	6 (100%)	6 (100%)	6 (100%)	6 (100%)
50	6 (100%)	6 (100%)	6 (100%)	6 (100%)

[a] A female was considered mature if the ovaries contained fully developed eggs.

reached reproductive maturity during the same week after emergence (Table 3). Few females of both species had mature ova in their ovaries at days 20 and 30 after emergence. All females matured ova at day 35 after emergence compared to day 20 with yeast hydrolysate (control) diet (Table 3).

Effect of diets on male gonadal maturation.—*Trupanea nigricornis* and *T. bisetosa* males reached sexual maturity about 5–10 d after emergence: 7.2 ± 0.4 (5–10) days for *T. nigricornis* (n =10) and 8.2 ± 0.4 (6–10) days for *T. bisetosa* (n = 10). No difference in the mean timing of reaching sexual maturity was detected for *T. nigricornis* and *T. bisetosa* males fed on yeast hydrolysate or water and honey ($t = 0.73$; $P > 0.05$ and $t = 0.35$; $P > 0.05$, respectively). Unlike the females, the males did not need an extrinsic source of nitrogen for gonadal development since they became mature on the yeast hydrolysate diet as well as the carbohydrate diet, and at the same time.

Effect of diets on adult longevity.—*Trupanea nigricornis* and *T. bisetosa* adults survived in the insectary for 2–3 months on the diets tested, including the water and honey diet. They survived on water alone for only 2–4 d (Table 4). This shows that at least carbohydrates and water are essential for survival. The role of proteins in prolonging longevity is not very clear, as there was little difference in longevity between the carbohydrate and protein diets for both species (Table 4). Only the females of *T. nigricornis* showed a significantly greater mean longevity on yeast hydrolysate diet than on water and honey diet. There was no significant difference in longevity between male and female flies for either species fed on yeast hydrolysate or water and honey diet, with the exception of *T. nigricornis* females on the yeast hydrolysate diet, which survived longer than the males (Table 4). Hence, both *T. nigricornis* and *T. bisetosa* survived for a period of 2–3 months, and sometimes up to 4 months on diets of yeast hydrolysate or honey and water in the insectary.

When *T. nigricornis* and *T. bisetosa* females were fed on yeast hydrolysate diets, but were also given flower heads of their host for oviposition, they lived a maximum of 2 months (Table 4). The longevity of ovipositing females was significantly lower than that of females deprived of oviposition sites, but fed on the same protein hydrolysate diet (Table 4). This could be due to the exhaustion of nutrients and energy needed for continual egg production and egg-laying in the ovipositing females.

Unlike the females, the longevity of *T. nigricornis* and *T. bisetosa* males did not

Table 4. Longevity (in days) of *Trupanea nigricornis* (T. n.) and *Trupanea bisetosa* (T. b.) on different diets.

Diet[a]	Species	N	Mean[b] Longevity ± SE (range) Males	Mean[b] Longevity ± SE (range) Females
W	T. n.	10	2.6 ± 0.27a (1–4)	2.9 ± 0.22a (2–4)
	T. b.	10	2.5 ± 0.26a (1–4)	2.4 ± 0.24a (1–3.5)
W+H	T. n.	40	87.4 ± 2.3c (65–116)	91.6 ± 2.6c (60–118)
	T. b.	15	84.5 ± 3.42c (65–102)	87 ± 3.5c (65–102)
W+H+Y	T. n.	40	89.1 ± 2.7c (65–120)	98.4 ± 3.2d (65–124)
	T. b.	20	91.1 ± 3.7c (65–120)	95.3 ± 4c, d (68–122)
W+H+Y+F	T. n.	17	84.8 ± 4.1c (64–124)	64.7 ± 4.2b (30–86)
	T. b.	17	86.6 ± 3.4c (58–119)	65.6 ± 4.3b (30–88)

[a] Diet: water (W); water and honey (W+H); water, honey and yeast hydrolysate (W+H+Y); water, honey, yeast hydrolysate and flower heads of *Encelia farninosa* for *T. nigricornis* or sunflowers for *T. bisetosa* (W+H+Y+F).

[b] Means followed by the same letter were not significantly different using Tukey's test at 95% confidence level.

change on protein hydrolysate diet with or without flower heads of their host plants (Table 4). The presence of the flower heads did not change the behavior and activities of the males that exhibited their courtship behavior in the presence and the absence of their host plants.

Fecundity.—*Initial experiments (group fecundity):* Initial experiments showed that the females of *T. nigricornis* oviposited only on their host, *E. farinosa*, and that the females of *T. bisetosa* preferred to oviposit on their host, *H. annuus*, but could also oviposit on the non-host, *E. farinosa* under artificial conditions. Females of both species started to oviposit 16–20 d after emergence. When given a choice between host and non-host flower heads, the females of *T. bisetosa* oviposited in wild sunflower heads if they were at the right stage for oviposition (very small 'closed' buds'). If the sunflower heads were in a stage barely suitable for oviposition (medium 'closed' buds), they preferred to oviposit in the non-host, *E. farinosa*. When given the choice, the females of *T. nigricornis* only oviposited in the flower heads of their host, *E. farinosa*; they did not attempt to oviposit in wild sunflower heads. In non-choice situations, only a few females of *T. nigricornis* attempted to oviposit in sunflower heads.

Individual fecundity experiment: Fecundity studies showed that the females of *T. nigricornis* oviposited a large number of eggs in the flower heads of their host plant, *E. farinosa*, during their life span (ca. 2 months in the insectary). The mean number of eggs laid per 15 females during a period of 8 weeks was 243.7 ± 16.1 (range: 147–377) (Fig. 1). The mean number of eggs laid during the first week was very high (73), then declined progressively to reach a mean of 3.5 eggs during the eighth week (Fig. 2A). The oviposition curve showed a peak during the first week, then a smooth decline with time.

The fecundity of *T. bisetosa* on its host plant, *H. annuus*, was significantly lower than that of *T. nigricornis* on its host plant. The mean number of eggs oviposited by 10 *T. bisetosa* females was 157.8 ± 21.8 (range: 89–268) (Fig. 1). The oviposition curve showed a high peak in the first week (mean of 35 eggs/female), followed by a slow decrease in the number of eggs laid (18–24 eggs/female/week) during weeks 2 to 6, and

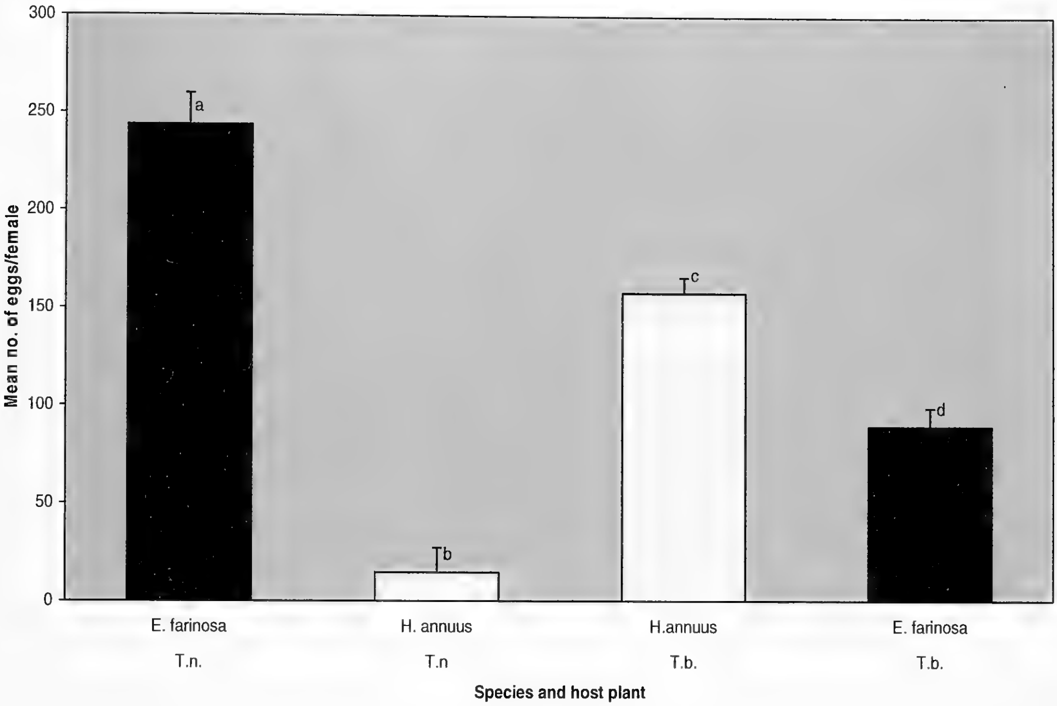


Fig. 1. Fecundity of *Trupanea nigricornis* (T. n.) females on their host plant, *E. farinosa*, and non-host plant, *H. annuus*, compared to the fecundity of *T. bisetosa* (T. b.) females on their host plant, *H. annuus*, and the non-host plant, *E. farinosa*.

a sharp decline in oviposition after week 6 to reach a mean of 5.1 eggs during the eighth week (Fig. 2B).

The fecundity of *T. nigricornis* females on the non-host flower heads of wild sunflowers was very low. The mean number of eggs oviposited by 10 females in 8 weeks was 12.6 ± 6.4 (range: 0–64) (Fig. 1). This mean was significantly lower than the mean number of eggs laid by *T. bisetosa* on the non-host plant, *E. farinosa*. Four *T. nigricornis* females did not lay eggs on the non-host flower heads of *H. annuus*. The other females did not lay any eggs in the first week, then started ovipositing a few eggs as they do in their host plant heads, i.e., by piercing the plant tissues. However, the females of *T. nigricornis* could not successfully oviposit in sunflower buds, which, unlike *E. farinosa* heads, are covered by hard bracts and exude much resins when pierced. Instead of placing the eggs underneath the bracts and among the florets (Knio et al. 1996b) like *T. bisetosa* females do, the females of *T. nigricornis* pierced the hard tissues of the outer bracts while ovipositing, inserting the basal end of the egg in the tissues of the outer bract. This manner of placing the eggs prevented the first instar from hatching, as the basal part of the egg was covered with resins; it also caused the exposed eggs to dry quickly, and resulted in the death of some females when their ovipositors and hind legs became trapped in the exuding resins.

Oviposition by *T. bisetosa* in the non-host flower heads of *E. farinosa* was significantly less than oviposition on their host plant. The females laid a mean number of 89.5 ± 9.4 (58–145) eggs during a period of 8 weeks (Fig. 1). They did not oviposit every day. Plots of the intervals of time (2–5 d) between ovipositions declined slowly during the first

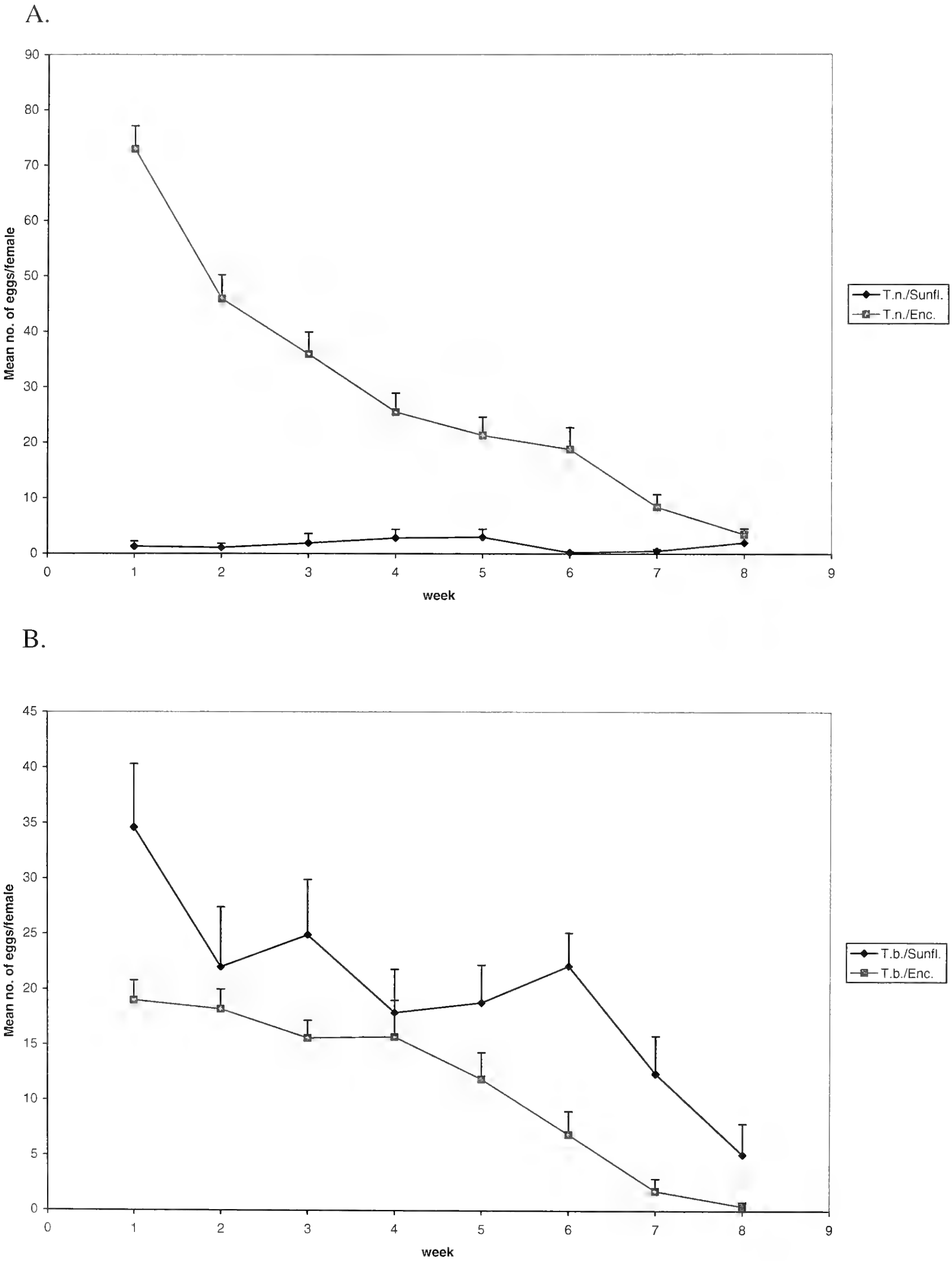


Fig. 2. Fecundity curves, showing the mean number of eggs (± SE) laid per female (n = 15) per week, during a period of 8 weeks, for: (A) *T. nigricornis* (T. n.) on *E. farinosa* (Enc.) and the non-host, *H. annuus* (Sunfl.); (B) *T. bisetosa* (T. b.) on *H. annuus* and the non-host, *E. farinosa*.

4 weeks; then sharply declined after the fourth week (Fig. 2). The eggs oviposited by the females in *E. farinosa* heads had a 95% eclosion; however, it was not possible to know whether the larvae of *T. bisetosa* could develop in the heads of *E. farinosa* as excised *E. farinosa* bouquets did not last more than a week in the insectary and no artificial diet has yet been developed for rearing the larvae of flower head-infesting tephritids. Under insectary conditions, oviposition by *T. bisetosa* in the non-host plant, *E. farinosa* was more successful than oviposition of *T. nigricornis* on non-host plant, *H. annuus*. Unlike *T. nigricornis* females, the fecundity of *T. bisetosa* females was not drastically reduced when ovipositing in the non-host plant, *E. farinosa* (Fig. 2).

Effect of mating on fecundity: The fecundity of unmated *T. nigricornis* and *T. bisetosa* females on their host plants, *E. farinosa* and *H. annuus*, respectively, was much lower than the fecundity of mated females on their host plants. The mean total number of eggs laid by 10 unmated females *T. nigricornis* was 13.8 ± 1.2 (8–20) during a period of eight weeks. The same mean for 8 females of *T. bisetosa* was 8.0 ± 1.5 (4–17). Thus, unmated females of both species did mature and oviposit eggs, but the eggs did not hatch and the fecundity of the females was greatly reduced.

DISCUSSION

The data showed that newly emerged adults of *T. nigricornis* and *T. bisetosa* were not sexually mature, but must feed before attaining reproductive and sexual maturity. Carbohydrate diet did not support egg production in *T. nigricornis* and *T. bisetosa*. Females of both species needed an extrinsic source of proteins for egg maturation.

Both *T. nigricornis* and *T. bisetosa* had matured ova on day 20 when fed protein hydrolysate diets, which contain vitamins and peptides, both essential for ovarian maturation of tephritids (Fytizas 1973). This period needed for egg maturation on protein hydrolysate diets was shorter than the pre-oviposition period of *Rhagoletis completa* Cresson (30 d) (Tsiropoulos 1978), but longer than the period reported for *Bactrocera oleae* (Gmelin) (5–6 d) (Tsiropoulos 1977), (4 d) (Fytizas 1973); *Rhagoletis pomonella* (Walsh) (ca. 10 d) (Webster and Stoffolano 1978, Hendrichs et al. 1993), (6–12 d for wild females) (Webster et al. 1979), *Anastrepha serpentina* (Wiedemann) (16 d) (Jácome et al. 1999), and *A. sororcula* (Zucchi) (14–16 d) (Joachim-Bravo et al. 2003). The pre-oviposition periods of tephritids were also found to vary with different temperature regimes; they were longer at 24°C than at 29°C (Vargas et al. 2000).

The addition of the host plant to the protein hydrolysate diets had no effect on the pre-oviposition period of the flies but prevented egg resorption. Ova resorption was also observed in other flower head infesting tephritids such as *Trupanea conjuncta* (Adams) and *Eutreta simplex* Thomas when deprived of oviposition sites in the insectary (Goeden 1987, 1990). Apparently, this phenomenon helps conserve egg metabolites while the female continues searching for suitable oviposition sites (Goeden 1987).

Females of *T. nigricornis* also matured ova when kept on a sugar diet but were offered *E. farinosa* flower heads. Apparently, they were able to get some sources of vitamins and nitrogen from heads of their host plant, either by feeding on the plant sap flowing from oviposition wounds, on secretions from insects like aphids or thrips that fed on the flower heads, from microorganisms on the flower head surface, or from a combination of these. The amount of nutrients offered by these plant parts was probably low, so that the females needed a longer pre-oviposition period than when they were given protein hydrolysates.

Absence of vitamins in a protein hydrolysate diet did not affect egg maturation of *T. nigricornis* and *T. bisetosa* but resulted in a longer and varied pre-oviposition period. The role of vitamins in the development of the reproductive system of tephritid females is not clearly defined, partly because some transfer of vitamins can occur from the larval to the adult stage (Tsiropoulos 1978, 1980). This could help to explain the variability in the time of ovarian maturation observed in *T. nigricornis* and *T. bisetosa*, because accumulated vitamin reserves obtained from the larval stage could vary among individuals. Similarly, in the walnut husk fly, *Rhagoletis completa*, omission of different vitamin groups was found to influence the pre-oviposition period differently. Omission of vitamin B–mixture or vitamin E did not change the pre-oviposition period, but omission of vitamin C lengthened this period. Both vitamin B-mixture and vitamin C were necessary for fertility in the walnut husk fly (Tsiropoulos 1978).

The effects of diet and proteins on ovarian maturation have been studied almost exclusively in the fruit infesting tephritids. Similar to *T. nigricornis* and *T. bisetosa*, most female tephritids have been found to be anautogenous, requiring an extrinsic source of proteins for ovarian maturation. Carbohydrate diets failed to support egg production by *Bactrocera tryoni* (Froggatt) (Drew 1987), *R. completa* (Tsiropoulos 1978), and *R. pomonella* (Hendrichs et al. 1993). On the other hand, a few species such as *B. oleae*, *A. serpentina* and *C. capitata* could achieve a low fertility when kept on a sucrose diet (Jácome et al. 1999; Tsiropoulos 1977, 1980; Fytizas 1973). This low egg production could have been facilitated by metabolites transferred from the larval stage, and possibly by nutrients synthesized by symbionts (Jácome et al. 1999; Tsiropoulos 1977, 1980). In all cases, protein ingestion in the adult phase significantly increased egg production (Jácome et al. 1999, Cangussu and Zucoloto 1995, Tsiropoulos 1977). However, this increase in fertility in *B. oleae* occurred only when minerals were also added to the protein diet (Tsiropoulos 1980). Analysis of the nutritional requirements of the walnut husk fly revealed that carbohydrates were necessary for the utilization of the dietary proteins and salts were required for protein and vitamin utilization (Tsiropoulos 1978). Furthermore, amino acids have been found to act as phagostimulants for adult tephritids, and those that stimulated feeding by the females proved to be nutritionally necessary for egg production (Tsiropoulos 1986).

The sources of nutrients required for reproduction and survival of fruit flies in the field have been little documented. *Trupanea nigricornis* and *T. bisetosa* were observed feeding on sap exuding from oviposition wounds, honey dew, pollen, and most probably microorganisms found on the flower-head surfaces, as the flies have been observed to constantly extend and retract their proboscis while slowly walking on flower heads. In general, natural food sources of tephritids include fruit juices and pulp, plant exudates, plant sap, pollen, nectar from flowers, honey dew, bacteria and bird droppings (Bateman 1972, Fletcher 1987, Hendrichs et al. 1993). In *R. pomonella*, bird droppings and honey dew as adult food sources resulted in a moderate egg production (Hendrichs et al. 1993). Honey dew lacks some essential amino acids and other nutrients needed for high egg production in tephritids (Hagen and Tassan 1972). Bacteria, on the other hand, offer an important source of proteins to adult tephritids. In *B. tryoni*, adults ingested non-symbiotic bacteria from fruit surfaces, and diets consisting of bacteria, sugar and water resulted in an increased fecundity comparable to yeast hydrolysate diets (Drew et al. 1983, Courtice and Drew 1983). These bacteria colonizing the alimentary canal of *B. tryoni* belonged to the Enterobacteriaceae, and they were spread during feeding by regurgitation and reingestion processes. They were isolated from fruit surfaces, oviposition wounds, and larval induced fruit rots, but not from leaf surfaces, indicating that these bacteria can be considered as potential food for adults flies (Drew and Lloyd 1987). As for the 'invisible' substances that tephritids are commonly seen grazing on leaves, they are nutrient leachates, mainly carbohydrates, found on the upper surface of foliage and seem important in sustaining survival of the flies (Hendrichs et al. 1993).

Unlike the females, *T. nigricornis and T. bisetosa* males did not need to feed on proteins to reach sexual maturity. Similarly, males of *Bactrocera* sp. required little or no protein for gonadal maturation (Drew 1987). Reproductive maturation of *R. pomonella* males was also independent of diet; the males required little protein for accessory gland development (Webster and Stoffolano 1978). However, in *C. capitata* males, protein nutrition following adult eclosion was found to enhance male maturation and reproductive success (Blay and Yuval 1997, Yuval et al. 2002). When wild *C. capitata* males were fed on a yeast hydrolysate diet, they called more frequently and started sexual calling before those fed on sugar alone (4 vs. 6 d) (Papadopoulos et al. 1998). Protein-fed males were more likely to join leks, emitted more pheromones, and mated more frequently than sugar fed males (Blay and Yuval 1997, Kaspi and Yuval 2000).

Similar to other tephritids, the males of *T. nigricornis* and *T. bisetosa* matured earlier than the females. Two weeks after emergence, they were seen expanding their abdominal pleura and displaying courtship behavior toward the unreceptive females. Male tephritids, in general, become sexually mature earlier than the females (Williamson 1989). Males of *R. pomonella* had active sperms after emergence and became sexually mature 5 d after emergence while females had mature oocytes 10 d after emergence (Webster and Stoffolano 1978). Males of the olive fruit fly also matured 1 to 2 d before the females. Laboratory reared males became sexually mature 3–5 d after emergence, while field-collected males matured 4–15 d after emergence (Zervas 1983). In *C. capitata*, significant differences were also detected in the timing of sexual maturation of wild and laboratory-reared flies. Greater mating activity occurred between 3–5 d after emergence in laboratory reared flies vs. 7–13 d after emergence in wild flies (Liedo et al. 2002). This earlier sexual maturation of laboratory reared flies was also observed in females of *A. suspensa* (Loew). Maturation of oocytes was earlier in mass-reared flies, followed by semi-wild flies adapted for a year to laboratory conditions, and then by wild flies. Moreover, in the semi-wild and wild females, male presence was found to accelerate ovarian maturation (Pereira et al. 2006).

Adults of *Trupanea nigricornis* and *T. bisetosa* survived 2–3 months on the different diets tested, but just a few days on water alone. Carbohydrates were essential for their survival. Similarly, adult nutrition has been found to influence survival of fruit infesting tephritids. Two components essential for tephritid diets were carbohydrates and water (Tsiropoulos 1978); sucrose, as a source of energy, was the most important ingredient for maintaining adult longevity (Tsiropoulos 1980, Jácome et al. 1999). Like *T. nigricornis* and *T. bisetosa*, adults of *Anastrepha serpentina* (Wiedemann) could survive up to

5 d on diets lacking sucrose, such as intact fruits or bird feces (Jácome et al. 1999). The addition of proteins to a carbohydrate diet further increased longevity in *B. tryoni, A. serpentina* and *R. completa* (Drew 1987, Tsiropoulos 1980, Jácome et al. 1999). Contrary to *T. nigricornis* and *T. bisetosa, B. tryoni* and *B. cacuminatus* (Hering) survived longer, 4–5 months, on diets containing carbohydrates and proteins, such as autolyzed brewer's yeast or bacteria, compared to ca. 2 months with sucrose and water (Drew et al. 1983). Similar to *T. nigricornis* and *T. bisetosa*, no difference in longevity was detected between males and females of *A. serpentina* (Jácome et al. 1999). On the other hand, females of *R. completa* lived longer than males (Tsiropoulos 1980). But in *C. capitata, Bactrocera dorsalis* Hendel, and *B. cucurbitae* Coquillett, male longevity was greater than that of females and adult longevity was found to be influenced by temperature regimes (Vargas et al. 2000).

On protein hydrolysate diets, the longevity of ovipositing females of *T. nigricornis* and *T. bisetosa* was lower than that of females who had no access to oviposition sites. Egg production and egg laying were therefore exhausting stored nutrients and imposing a cost on survival. Similarly, in *C. capitata* females, egg production as well as mating were demonstrated to impose independent costs on survival (Chapman et al. 1998). Moreover, in *Anastrepha* spp., fertility and longevity seemed to be inversely related; species with higher fertility had lower longevity (Joachim-Bravo et al. 2003).

The fecundities of *T. nigricornis* (244 eggs) and *T. bisetosa* (158 eggs) on their natural hosts were close to that estimated for some of the fruit infesting species on sucrose plus yeast hydrolysate diets, *B. oleae* (200–250 eggs) (Christenson and Foote 1960), *Anastrepha obliqua* (Macquart) (274 eggs) (Joachim-Bravo et al. 2003), *A. serpentina* (164 eggs) (Jácome et al. 1999), slightly lower than *C. capitata* (300 eggs for wild flies), but much lower that *Anastrepha ludens* (Loew) (*ca.* 1400 eggs for reared flies) (Christenson and Foote 1960). The oviposition curve of *T. nigricornis* and *T. bisetosa* showed a high peak during the first week, then a smooth decline with time. Similarly, oviposition of different *Anastrepha* spp. was mainly concentrated in the first weeks of egg laying (Joachim-Bravo et al. 2003).

In non-choice experiments, *T. bisetosa* females could oviposit in the non-host heads of *E. farinosa*; however, *T. nigricornis* females could not successfully oviposit in the flower heads of wild sunflowers, the host of *T. bisetosa*, and their fecundity was greatly reduced. This was due to the physical features of wild sunflowers, which unlike the hosts of *T. nigricornis*, are covered by hard bracts and exude copious resins when pierced.

Unmated *T. nigricornis* and *T. bisetosa* females showed a drastically reduced fecundity (8–10 eggs) on their host plants. Similarly, virgin females of *B. oleae* matured eggs at the same time as mated females; however, their daily oviposition rates were lower than those of mated females (5–7 vs. 10–12 eggs/day). This suggested that mating offered a stimulus to oviposition and that high egg production was initiated once mating took place (Zervas 1983). Nevertheless, repeated matings did not stimulate oviposition of the apple maggot females. There was no significant difference in the number of eggs laid by females with frequent matings (395 eggs) and females with few matings (360 eggs) during the first two weeks. However, virgin females had a lower fecundity (ca. 100 eggs) compared to mated females (Nielson and McAllan 1965). Contrary to most tephritid species, no difference in egg production was detected between virgin and non-virgin females of *C. capitata*. Mating was not necessary to induce egg production in this species, but it imposed a cost on the longevity of mated females (Chapman et al. 1998).

In conclusion, the sympatric and sibling species, *T. nigricornis* and *T. bisetosa* appear to have similar adult longevity, male maturation, and preoviposition periods. Females of both species required an extrinsic source of proteins to mature eggs. However, the fecundity of the specialist species *T. bisetosa* was significantly lower than that of the polyphagous *T. nigricornis*. Similarly, in the dacine flies, the fecundities of most oligophagous species were lower than those of the polyphagous species, and this was reflected in their survival strategies, which were much more r-selected than in the oligophagous species (Fletcher 1987). The higher fecundity of *T. nigricornis* probably facilitates the maximum use of its available hosts, which bloom for short periods (1 to 3 months) in the spring or in the fall. On the other hand, wild sunflowers, the main host of *T. bisetosa* which does not seem to diapause, bloom nearly throughout the year in southern California.

Apparently, these two sibling species, which show close morphological and ecological affinities (Knio et al. 1996a, b, 2001), have adopted different life history strategies. *Trupanea nigricornis* infests many plant species, has a wide incidence in the field, exists at higher densities, mainly in the spring and fall seasons, and has a higher fecundity than *T. bisetosa*, but it also suffers more mortality due to parasitism (Knio et al. 2007). On the other hand, the oligophagous species, *T. bisetosa*, exists at lower densities throughout the year on wild sunflower in southern California, it has a clumped distribution in the field, it suffers less pressure from natural enemies, but it has a lower fecundity than *T. nigricornis*. Thus, this high mortality due to parasitism is compensated by a high fecundity in *T. nigricornis*.

LITERATURE CITED

Bateman, M. A. 1972. The ecology of fruit flies. Annual Review of Entomology 17: 493–519.

Blay, S. and B. Yuval. 1997. Nutritional correlates of reproductive success of male Mediterranean fruit flies (Diptera: Tephritidae). Animal Behavior 54: 59–66.

Cangussu, J. A. and F. S. Zucoloto. 1995. Self-selection and perception threshold in adult females of *Ceratitis capitata* (Diptera: Tephritidae). Journal of Insect Physiology 41: 223–277.

Cavender, G. L. and R. D. Goeden. 1983. On distinguishing *Trupanea bisetosa* (Coquillett) from *T. nigricornis* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 85: 275–281.

Chapman, R. F. 1982. The Insects: Structure and Function. Third Edition. Harvard University Press, Cambridge, Massachusetts. 919 pp.

Chapman, T., T. Miyatake, H. K. Smith, and L. Partridge. 1998. Interactions of mating, egg production and death rates in females of the Mediterranean fruit fly, *Ceratitis captitata*. Proceedings of the Royal Society of London. Series B. 265: 1879–1894.

Christenson, L. D. and R. H. Foote. 1960. Biology of fruit flies. Annual Review of Entomology 5: 171–192.

Courtice, A. C. and R. A. I. Drew. 1983. New attractants for fruit flies. HortScience 18: 805.

Drew, R. A. I. 1987. Behavioral strategies of fruit flies of the genus *Dacus* (Diptera: Tephritidae) significant in mating and host-plant relationships. Bulletin of Entomological Research 77: 73–81.

Drew, R. A. I. and A. C. Lloyd. 1987. Relationship of fruit flies (Diptera: Tephritidae) and their bacteria to host plants. Annals of the Entomological Society of America 80: 629–636.

Drew, R. A. I., A. C. Courtice, and D. S. Teakle. 1983. Bacteria as a natural source of food for adult fruit flies (Diptera: Tephritidae). Oecologia 60: 279–284.

Fletcher, B. S. 1987. The biology of dacine fruit flies. Annual Review of Entomology 31: 115–144.

Foote, R. H., F. L. Blanc, and A. L. Norrbom. 1993. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Cornell University Press, Ithaca, New York. xii + 571 pp.

Fytizas, E. 1973. Influence d'une seule administration de levure hydrolysée sur la fecondité des femelles de *Dacus oleae* Gmel. (Diptera: Trypetidae). Annales de la Zoologie-Écologie Animale 5: 39–44.

Goeden, R. 1987. Life history of *Trupanea conjuncta* (Adams) on *Trixus californica* Kellogg in southern California. Pan-Pacific Entomologist 63: 284–291.

———. 1990. Life history of *Eutreta simplex* Thomas on *Artemesia ludoviciana* Nuttall in southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 66: 33–38.

Hagen, D. S. and R. L. Tassan. 1972. Exploring nutritional roles of extracellular symbiotes on the reproduction of honey dew feeding adult chrysopids and tephritids, pp. 232–351. *In* Rodriquez, J. G. ed. Insect and Mite Nutrition. Nort-Holland, Amsterdam.

Hendrichs, J., C. R. Lauzon, S. S. Cooley, and R. J. Prokopy. 1993. Contribution of natural food sources to adult longevity and fecundity of *Rhagoletis pomonella* (Diptera: Tephritidae). Annals of the Entomological Society of America 86: 250–264.

Jácome, I., M. Aluja, and P. Liedo. 1999. Impact of adult diet on demographic and population parameters of the tropical fruit fly *Anastrepha serpentina* (Diptera: Tephritidae). Bulletin of Entomological Research 89: 165–175.

Joachim-Bravo, I. S., T. C. Magalhães, A. M. da Silva Neto, A. N. Guimarães, and A. S. Nascimento. 2003. Longevity and fecundity of four species of *Anastrepha* (Diptera: Tephritidae). Neotropical Entomology 32: 543–549.

Kaspi, R. and B. Yuval. 2000. Post-teneral protein feeding improves sexual competitiveness but reduces longevity of mass-reared sterile male Mediterranean fruit flies (Diptera: Tephritidae). Annals of the Entomological Society of America 93: 949–955.

Knio, K. M., R. D. Goeden, and D. H. Headrick. 1996a. Descriptions of the immature stages of *Trupanea nigricornis* and *T. bisetosa* (Diptera: Tephritidae) from southern California. Annals of the Entomological Society of America 89: 1–11.

———. 1996b. Comparative biologies of the cryptic, sympatric species, *Trupanea bisetosa* and *T. nigricornis* (Diptera: Tephritidae) in southern California. Annals of the Entomological Society of America 89: 252–260.

———. 2001. Resource utilization on the sibling species *Trupanea nigricornis* (Coquillett), a polyphage, and the narrowly oligophagous *T. bisetosa* (Coquillett) (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 103: 946–961.

———. 2007. Natural enemies on the sibling and sympatric species, *Trupanea nigricornis* (Coquillett), a polyphage, and the narrowly oligophagous *T. bisetosa* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 109: 187–197.

Liedo, P., E. De Leon, M. I. Barrios, J. F. Valle-Mora, and G. Ibarra. 2002. Effect of age on the mating propensity of the Mediterranean fruit fly (Diptera: Tephritidae). Florida Entomologist 85: 94–101.

Nielson, W. T. A. and J. W. McAllan. 1965. Effects of mating on fecundity of the apple maggot, *Rhagoletis pomonella* (Walsh). Canadian Entomologist 97: 276–279.

Papadopoulos, N. T., B. I. Katsoyannos, N. A. Kouloussis, A. P. Economopoulos, and J. R. Carrey. 1998. Effect of adult age, food, and time of day on sexual calling incidence of wild and mass-reared *Ceratitis capitita* males. Entomologia Experimentalis et Applicata 89: 175–182.

Pereira, R., P. E. A. Teal, J. Sivinski, and B. D. Dueben. 2006. Influence of male presence on sexual maturation in female Caribbean fruit fly, *Anastrepha suspensa* (Diptera: Tephritidae). Florida Entomologist 19: 31–43.

Tsiropoulos, G. J. 1977. Survival and reproduction of *Dacus oleae* (Gmelin) fed on chemically defined diets. Zeitschrift für Angewandte Entomologie 84: 192–197.

———. 1978. Holidic diets and nutritional requirements for survival and reproduction of the adult walnut husk fly. Journal of Insect Physiology 24: 239–242.

———. 1980. Major nutritional requirements of adults *Dacus oleae*. Annals of the Entomological Society of America 73: 251–253.

———. 1986. Effect of phagostimulants on *Dacus oleae* feeding behavior, pp. 85–90. *In* Cavalloro, R. ed. Fruit Flies of Economic Importance, Proceedings of the CEC/IOBC International Symposium, Athens, Greece, 1982. A. A. Balkema, Rotterdam.

Vargas, R. I., W. A. Walsh, D. Kanehisa, J. D. Stark, and T. Nishida. 2000. Comparative demography of three Hawaiian fruit flies (Diptera: Tephritidae) at alternating temperatures. Annals of the Entomological Society of America 93: 75–81.

Webster, R. P. and J. G. Stoffolano, Jr. 1978. The influence of diet on the maturation of the reproductive system of the apple maggot, *Rhagoletis pomonella*. Annals of the Entomological Society of America 71: 844–849.

Webster, R. P., J. G. Stoffolano, Jr., and R. J. Prokopy. 1979. Long-term intake of protein and sucrose in relation to reproductive behavior of wild and laboratory cultured *Rhagoletis pomonella*. Annals of the Entomological Society of America 72: 41–46.

Williamson, L. D. 1989. Oogenesis and spermatogenesis, chapter 3.2, pp. 141–151. *In* Robinson, A. S. and G. Hooper, eds. World Crop Pest: Fruit Flies, their Biology, Natural Enemies and Control. Elsevier, New York.

Yuval, B., R. Kaspi, S. A. Field, S. Blay, and P. Taylor. 2002. Effects of post-teneral nutrition on reproductive success of male Mediterranean fruit flies (Diptera: Tephritidae). Florida Entomologist 85: 165–170.

Zervas, G. A. 1983. Sexual and reproductive maturation in wild and lab cultured olive fruit flies *Dacus oleae* (Gmelin) (Diptera: Tephritidae), pp. 429–438. *In* Cavalloro, R. ed. Fruit Flies of Economic Importance, Proceedings of the CFC/IOBC International Symposium. Balkema, Rotterdam.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 596–604

FIRST RECORDS OF INVASION BY THE MYRMICINE JAPANESE ANT *VOLLENHOVIA EMERYI* W. M. WHEELER (HYMENOPTERA: FORMICIDAE) IN THE UNITED STATES

Daniel S. Kjar and Theodore W. Suman

(DSK) Division of Mathematics and Natural Sciences, Elmira College, 1 Park Place, Elmira, NY 14901, U.S.A. (e-mail: dkjar@elmira.edu); (TWS) Department of Entomology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, Washington, DC 20013-7012, U.S.A.

Abstract.—*Vollenhovia emeryi* W. M. Wheeler was found at two sites over 2 yr in the Dyke Marsh Preserve, part of the George Washington Memorial Parkway, a National Park in Fairfax County, Virginia. This ant was also found at two locations along the shore of the Potomac River in Maryland: Fort Washington National Park, Prince George's County, and Glen Echo Park, Montgomery County. These are the first records for their respective states. A live colony of *V. emeryi* was collected from the campus of Georgetown University in the District of Columbia and is maintained at the Smithsonian Institution. Previous records for this ant in the United States are: Rock Creek Park, a National Park in the District of Columbia (1986), and Philadelphia, Pennsylvania (1993). These records indicate that this species has spread beyond areas of its initial introduction. This ant species may have entered the U.S. with imported Japanese cherry trees in the District of Columbia, and Philadelphia, Pennsylvania.

Key Words: *Vollenhovia emeryi* W. M.Wheeler, introduced species, alien, Japanese ant

Introduced ant species are some of the more destructive and expensive pests in the U.S. as well as worldwide (Crowell 1968, Porter and Savignano 1990, Cole et al. 1992, Morrison 2002, Breton et al. 2003, Hill et al. 2003). However, the majority of ant species are not likely to be introduced through human activities because of habitat preferences and specialization on specific prey. Alien, invasive ant species tend to be habitat and prey generalists, often with polygynous colonies, and with nesting habits that increase their likelihood of transportation through human trade (Holway et al. 2002).

Linepithima humile (Mayr) (Argentine ant), an aggressive alien ant introduced into southern California and Louisiana from South America in the 1890s, is rapidly spreading into most of the southwestern U.S. (Cole et al. 1992, Holway 1998). *Solenopsis invicta* Buren (red imported fire ant) is one of the more notorious alien invasives in the U.S. (Porter and Savignano 1990). This ant spread rapidly after its introduction in Mobile, Alabama, during the 1930s and its range extends through most of the southern U.S. *Solenopsis invicta* quickly decimated local arthropod populations and has caused human injuries and deaths due to its venomous sting. Recently, and for reasons yet unknown, this ant appears to be declining behind its invasion line in natural habitats, although it is dominant and abundant in disturbed areas (Morrison 2002). Many alien ant species become agricultural pests by protecting crop-damaging arthropods and creating mounds in agricultural fields. Other aggressive alien ant species in the U.S. include: *Anoplolepis gracilipes* (Smith), *Paratrechina flavipes* (Smith), *Pheidole megacephala* (Fabricius), *Solenopsis geminata* (Fabricius), *Technomyrmex albipes* Smith, and *Wasmannia auropunctata* (Roger) (Wheeler 1929, McGlynn 1999, Trager 1984, Deyrup 1991, Trager 1991, Wetterer and Porter 2003, Wetterer 2005)

Some introduced ant species do not appear to displace native species or greatly disrupt native ant communities, and are predominately found in habitats altered by human activity. *Monomorium pharaonis* (Linnaeus) (Pharaoh ant) lives in dry, warm habitats, and a colony of these 1.5 mm-long ants can travel great distances in crates, luggage, or machinery. Such travel has resulted in this species' worldwide distribution. *Tetramorium caespitum* (Linnaeus) (pavement ant) forms large colonies and lives in pavement cracks and building foundations throughout the eastern U.S.

Stefan P. Cover first found *Vollenhovia emeryi* in the U.S. in 1986 while sampling for ants in Washington, D.C., and its presence in North America is briefly mentioned by Hölldobler and Wilson (1990). *Vollenhovia* spp. are generalists and are distributed throughout Asia and the Pacific Islands (Wheeler 1907, Bolton 1995, Terayama and Kinomura 1997). There are no known *Vollenhovia* species native to the Western Hemisphere. The behavior and natural history of *V. emeryi* is relatively unknown. In its native habitat, polygyne colonies nest in decaying wood in riparian forests, have reduced wings (brachypterous), and a high rate of gynandromorphy (a condition where part of the individual is female and the other part male). Monogyne colonies are found in upland areas, nest in wood, and have queens with fully-developed wings (macropterous) and infrequent gynandromorphy (Kubota 1984, Kinomura and Yamauchi 1994). Reproductives eclose in the fall and overwinter in their nests. Wheeler (1906) described taxonomic details and more recent work has focused on queen morphology and gynandromorphy (Kubota 1984; Kinomura and Yamauchi 1994).

We give the first record of this ant in Virginia, and describe previously unpublished records of *V. emeryi* in Maryland, Philadelphia, and Washington D.C. We include observations made on a captive *V. emeryi* colony. We hypothesize that *V. emeryi* is spreading along the riparian corridors of Washington, D.C., and suggest that gifts of Japanese cherry trees during the early 20th century may have resulted in the introduction of this ant into the U.S. on two separate occasions.

MATERIALS AND METHODS

Study Sites.—*Dyke Marsh Preserve:* Dyke Marsh Preserve (DMP) is part of the George Washington Memorial Parkway (GWMP) in Fairfax County, Virginia. The GWMP is a national park bordering the west shore of the Potomac River. The DMP is 3.5 km long, 500 m wide at its widest point on an east-west transect, and located 15 km south of the Ronald Reagan Washington National Airport. The DMP has areas of flood-plain forests, open tidal freshwater marsh, and swamp forests (Johnston 2000; Barrows et al. 2005). All sampling sites were within the DMP flood-plain forest.

The flood-plain forest is dominated by *Liquidambar styraciflua* L. (sweetgum) and a dense under story of *Lindera benzoin* (L.) Blume (spicebush) and *Viburnum molle* Michx. (smooth arrowwood). Other trees common in the forest include *Acer negundo* L. (boxelder), *Acer rubrum* L. (red maple), *Fraxinus americana* L. (white ash), *Liriodendron tulipifera* L. (tulip tree), *Nyssa sylvatica* Marshall (tupelo), *Quercus palustris* Münchh. (pin oak), *Quercus phellos* L. (willow oak), *Quercus rubra* L. (red oak), *Sassafras albidum* (Nutt.) Nees (sassafras), and *Ulmus americana* L. (american elm).

Fort Washington: Fort Washington National Park (FWNP) is located 20 km south of Washington, D.C. in Prince George's County, Maryland. The current structure dates to 1824, and previous forts on this site date to 1808. The park and surrounding area is greatly impacted by human activities. Trees species found around the park are *Quercus* sp., *L. styraciflua*, *U. americana*, *L. tulipifera*, *Platanus occidentalis* L. (eastern sycamore), and various *Prunus* cvs. (cherries). Open areas are dominated by grass and edge vegetation. Areas along the Potomac River are dominated by young *A. negundo* and *U. americana*. Most areas along the river were used as warfs and contain concrete, drift wood, and other beach debris.

Glen Echo Park: Glen Echo Park (GEP) is part of the GWMP on the Maryland side of the Potomac River 7 km north of Washington, D.C. The area has been used as an amusement park since the late 19th century. Currently the park is operated by the National Park Service for education and various family oriented activities. The forest around the GEP is second growth eastern deciduous and primarily consisting of *A. negundo*, *L. tulipifera*, *U. americana*, *P. occidentalis*.

Observatory Hill: Observatory Hill, on the Main Campus of Georgetown University, Washington, D.C., is adjacent to Glover-Archbold Park, part of Rock Creek Park (a national park). Observatory Hill is a manicured landscape with *Asimina triloba* (L.) Dunal (pawpaw), *Ilex* spp. (hollies), *Metasequoia glyptostroboides* Hu and W. C. Cheng (dawn redwood), *Prunus* cvs., *Quercus* spp. (oaks), *Robinia pseudoacacia* L. (black locust), and other trees.

Site Selection.—*Dyke Marsh Preserve:* As part of a larger study on the ant community of the DMP forest, 60 random sites were selected within the DMP using a geographical information system (ESRI Inc. 2001), the National Park Service's AlaskaPak extension (National Park Service 2002), and high-resolution aerial photography with the cooperation of the National Park Service GIS Coordinator of the GWMP. Sites were in a predefined area of the forest whose borders were at least 5 m from trails or roads. A Trimble™ backpack global positioning system (GPS) was used to locate each of the sites in the forest.

Fort Washington: Three areas within the FWNP were sampled during March through September, 2002; and during May and November, 2003. Sampling in the southeastern part of the park included open grass areas, young upland woods, gullies, and areas around and on Bunker B. Sampling in the western part of the park included public fishing areas near the shoreline and near the lighthouse. Sampling in the northeast of the park was done in wooded areas, picnic grounds, and along trails.

Glen Echo Park: Ant sampling in GEP occurred as part of a Bioblitz sponsored by the National Park Service, The Nature Conservancy, and the Virginia Museum of Natural History on June 24 and 25, 2006. Sampling was done along a short stretch of path leading down to a gully near the Clara Barton Parkway (38° 58′02″ N, 77° 08′47″ W).

Observatory Hill: A pitfall trap was placed on Observatory Hill in an open area below a large oak tree (*Quercus rubra* L.) and near a grove of small pawpaw (*A. triloba*) at 38° 54′28″ N, 77° 04′39″ W. The area was open with pieces of bricks and pavement, loose gravel, and grass.

Ant collection.—*Dyke Marsh Preserve:* Soil cores (70 × 70 mm) were collected from each site in the third week of June, August, and October in 2002 and 2003. Arthropods were extracted from the soil with the use of Berlese funnels. A single collar and funnel pitfall trap of the design described in Kjar and Barrows (2004) was used at each study site. The pitfall traps were run for 24 h, in the last week of June, August, and October during 2002 and 2003.

Fort Washington: Sites at FWNP were sampled using Berlese funnels, pitfall traps, and Winkler extraction (Suman 2004).

Glen Echo Park: Hand sampling was done for 30 minutes along the gully by turning over stones, searching tree limbs and leaf litter, and breaking up decomposing tree limbs and stumps.

Observatory Hill: A single pitfall trap of identical design to the DMP site was left for 48 h starting on 14 September 2004. Hand sampling near the pitfall trap location was performed 7 June 2005.

Ant Identification.—Ants were identified using Bolton (1994), Creighton (1950), the National Museum of Natural History ant collection, and verified by Dr. David R. Smith (USDA), and Mr. Terry P. Nuhn (USDA). Voucher specimens are in the arthropod collection of the Laboratory of Entomology and Biodiversity at Georgetown University, Washington, D.C. Specimens collected from Fort Washington National Park are deposited with the National Park Service under catalog number 13651 (Suman 2004).

RESULTS

Ant Collection at the Dyke Marsh Preserve.—*Vollenhovia emeryi* was found at two locations in the DMP: site 33 (38° 46′27″N, 77° 03′01″ W); site 58 (38° 46′26″ N, 77° 03′01″ W). Workers were found in pitfall trap samples during both 2002 and 2003. One was collected in June of 2002, and another was collected August 2002, both at site 33. This site is dominated by the alien vine *Ampelopsis brevipedunculata* (Maxim.) Trautv. and is 15 m from the banks of the Potomac River. Other alien plants in this site include *Celastrus orbiculatus* Thunb. (Asian bittersweet), *Clematis terniflora* Dc. (Asian clematis), *Lonicera japonica* Thunb. (Japanese honeysuckle), and *Rosa multiflora* Thunb. (multiflora rose). The only native plant in site 33 was a small *Prunus serotina* Ehrh. (wild black cherry) seedling.

During August 2003, one worker was found in a pitfall sample from site 58, approximately 30 m south of site 33. Site 58 is 15 m from the river and located below a 132-cm-dbh *A. rubrum*, a 64-cm-dbh *L. styraciflua*, and a 51-cm-dbh *U. americana*. The plant community in this site was dominated by the alien vine *L. japonica*, and also contained *A. brevipedunculata*. Native plants in site 58 included all three tree species mentioned above and the monocot vine *Smilax rotundifolia* L. (greenbrier).

Ant Collection at Fort Washington.—Twenty-four workers of *V. emeryi* were found in FWNP on June 26, 2003. The ants were found in debris along the shore of the Potomac River near the lighthouse. A Berlese funnel was used to extract arthropods from the debris.

Ant Collection at Glen Echo Park.—One *V. emeryi* worker was collected by hand at the beginning of the trail surveyed. The worker was found on the surface of the leaf litter layer.

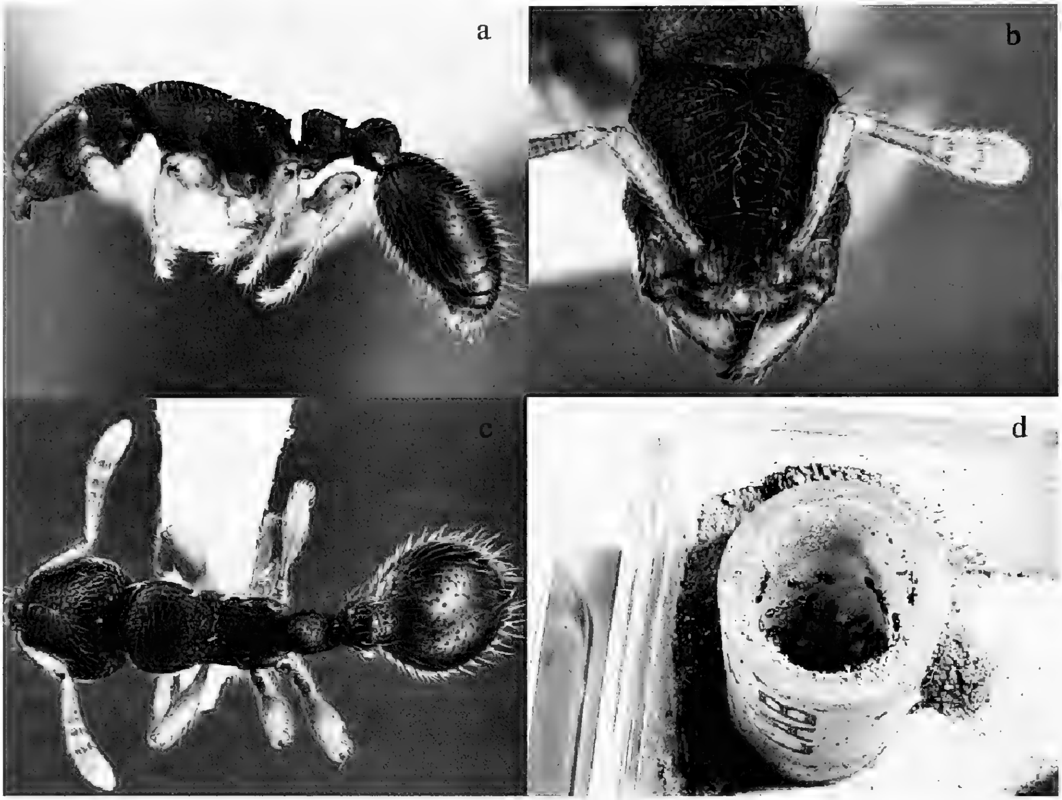


Fig. 1. Three images of a *V. emeryi* worker, and an image of the *V. emeryi* nest at the U.S. National Museum of Natural History. The frames are images of: a, profile view; b, head view; c. dorsal view; d. the nest of the colony taken from Observatory Hill, Georgetown University, Washington, D.C.

Ant Collection on Observatory Hill.—The 14 September 2004 pitfall-trap sample from Observatory Hill contained 10 *V. emeryi* workers along with several common ant species: *Camponotus pennsylvanicus* (De Geer), *Lasius alienus* (Foerster), and *Prenolepis imparis* (Say).

On 7 June 2005, a colony of *V. emeryi* was hand-collected from the same area of Observatory Hill. The colony had 28 workers, three dealate (queens that have lost their wings) females, five larvae, and 10 eggs. The colony's nest was located in soil mixed with bricks, gravel, and wood. The nest was 2 cm below the soil surface with slightly mounded soil around the opening.

Members of the colony collected from Observatory Hill were slow moving on a warm day. After the colony was disturbed, workers quickly moved all exposed eggs and larvae under soil or within the moistened paper used to transport them. When hand collected, workers attempted to move away from an aspirator and forceps and did not have the 'crouch-and-freeze' behavior of such small myrmicines as *Cyphomyrmex* spp. and *Temnothorax* spp. (Wheeler 1907, Cole 1940, Fellers 1987). If a worker was pushed onto her dorsal surface, she struggled to right herself. These ants have short legs with inflated femora, although they are relatively elongate for their small overall length of about 2.5 mm (Fig. 1). The 28 workers from the colony showed no readily visible variation in coloration or size.

The live colony was taken to Ted R. Schultz and Eugenia Okonski at the

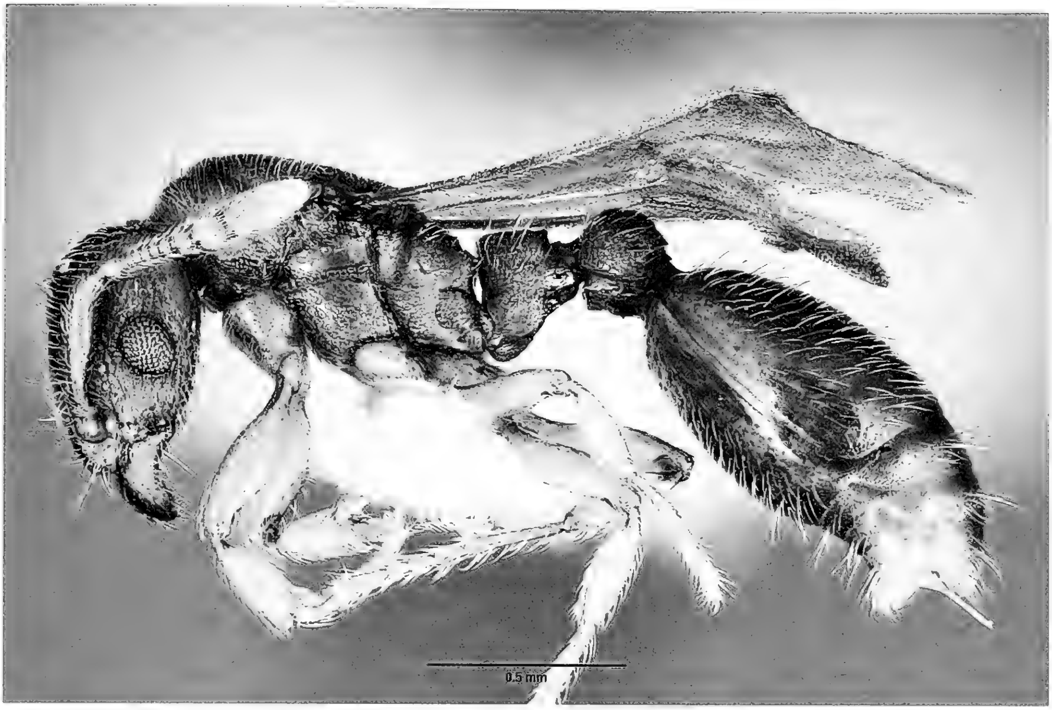


Fig. 2. Image of a brachypterous *V. emeryi* alate queen. This queen is from Stefan Cover's 1986 survey of Rock Creek Park, Washington, D.C. (Photograph used with permission of and taken by April Nobile, California Academy of Sciences, www.antweb.org).

National Museum of Natural History and Okonski is maintaining it at the Museum. After the colony was placed in the artificial habitat it moved its larvae, eggs, and queens into the small hose used to add water to the porous clay base of the nest container. Within two weeks the colony moved into the small gap between this hose and the plastic wall of the container, and built a small chamber with two openings from the small amount of soil that was introduced into the container with the colony (Fig. 1d). Foragers frequently enter and leave the chamber. Queens have not been observed outside of this chamber.

Discussion

Vollenhovia emeryi is a recently discovered alien myrmicine ant from Japan and may be spreading across the mid-Atlantic region of the U.S. This ant is native to Japan (30–45° N) (Wheeler 1906, Bolton 1995), and therefore may have little problem acclimating from southern Virginia north to southern New England along the U.S. East Coast.

The June 2002 collection in DMP is the first record of this ant in Virginia, and the June 2003 collection at FWNP is the first record of this ant in Maryland. The Observatory Hill collections (September 2004 and June 2005) are the second and third collections of this ant in the District of Columbia. Previous records of this ant include the first record of this ant in the U.S. from a 1986 survey of the ants of Rock Creek Park in Washington, D.C. (Hölldobler and Wilson 1990); and Philadelphia, Pennsylvania, in 1993 (King and Green 2005). The alate reproductive females found in the U.S. have reduced wings (brachypterous) (Fig. 2), and therefore mating flights, especially ones of any distance may not be possible. In view of this information, it seems likely that *V. emeryi* was independently introduced into Philadelphia and Washington, D.C.

An intriguing hypothesis on the introduction of *V. emeryi* in the U.S. concerns the Japanese gift of cherry trees that were planted along the Tidal Basin by the Jefferson Memorial in Washington, D.C., and at Fairmont Park in Philadelphia. The first 2,000 trees intended for Washington, D.C. were imported in 1910. This first shipment was destroyed due to the numerous insects and other pests inhabiting them (National Park Service 2005). After the U.S. received a second gift of 3,020 cherry trees from Japan, the trees were planted in 1912. More cherry trees were planted in 1965 and 1986 around the Tidal Basin and the area around the Washington Monument (National Park Service 2001). The fact that Japan gave 2,000 cherry trees to Philadelphia in honor of the 150th anniversary (1926) of the U.S. Declaration of Independence provides further support to the cherry tree hypothesis.

Transport in the root balls of these trees would be ideal for ants with a wet nesting habitat preference. There were no exhaustive surveys of the District of Columbia's ant fauna after Theodore Pergande's (1840–1916) time at the National Museum of Natural History until Stefan Cover's work in the mid-1980s. This small ant could have easily spread throughout the Washington, D.C., area unnoticed during this 70-yr lapse of myrmecological survey data.

The potential ecological impact of this alien ant is entirely unknown. Cover's observations in Rock Creek Park did not reveal displacement of native ant species by this species, and few ant species in this area, with the exception of *Ponera pennsylvanica* Buckley, share this species' nesting preference of extremely hydric rotting wood. The location of *V. emeryi* at Georgetown University, a sunny southern slope under an oak tree approximately 1 km from the Potomac River, indicates that this species is not confined to wet habitats as previously thought, although the Georgetown colony at the National Museum of Natural History showed an obvious preference for an extremely moist nest location (Fig. 1d). The polygynous nest from an upland dry area suggests the habitat range of polygyne colonies in the introduced population should be investigated, as it may differ from what has been reported for this species in Japan.

Long-distance dispersal by wind is unlikely in this epigaeic ant with putatively brachypterous reproductives. The presence of this ant in the DMP forest and Fort Washington National Park is probably the result of its rafting in wood. This ant's preference for wet rotting wood may result in queens' founding nests in wood that has been left when tides go out and picked up again and moved down river during subsequent high tides. Most flooding events would send *V. emeryi* from the City downstream to DMP and FWNP with the exception of hurricane associated storm surges. However, the Potomac River is tidal in the Washington, D.C., Area and therefore they could raft up and down the river depending on conditions. However, the GEP record of *V. emeryi* 7 km north of the city adds support to a gradual spread and an early introduction.

Vollenhovia emeryi was found in moist stream bottoms in Rock Creek Park. Rock Creek empties into the Potomac River 2 km upstream of the Tidal Basin. It is possible that *V. emeryi* traveled along the river banks and the Chesapeake and Ohio Canal spreading throughout Rock Creek Park, Georgetown University, and GEP which are all connected directly to the river and canal by forested park land. Human introduction of *V. emeryi* to each of the five Washington, D.C., area locations is possible, but the apparently restricted regional distribution of this ant species suggests that it had a single introduction in this city and another in Philadelphia. If this species were commonly introduced by humans through agricultural or horticultural products, it likely would have come to the attention of myrmecologists sooner and have a much wider known distribution. *Vollenhovia emeryi* is not a cryptic ant species and is morphologically distinct from other ant species in the eastern U.S., and areas around the Mid-Atlantic Region have been extensively studied for decades by myrmecologists.

CONCLUSIONS

Vollenhovia emeryi is present in at least two locations in the DMP forest. It has also been found in a national park within Washington, D.C., and in three locations within two national parks along the Potomac River in both Maryland and Virginia, and may be common along riparian water ways in the Mid-Atlantic Region. It appears likely that this species was introduced in the early 20th century in Washington, D.C. and Philadelphia through the import of Japanese cherry trees. If the trees are the vehicle of introduction, other cities in the U.S. with suitable nesting areas may also have this alien ant due to the popularity of such cherry trees. The impact of *V. emeryi* on local ant communities is unknown, but its preference for extremely wet nesting sites, and lack of a painful sting, this ant's effect on most native biota and humans may be low. However, to verify that this ant will not become destructive to the eastern riparian forest biota, the ecology and behavior of *V. emeryi* in the U.S. and Japan should be examined in depth.

ACKNOWLEDGMENTS

We thank Edward M. Barrows and our reviewers for their suggestions on improving this manuscript, the National Park Service, Georgetown University, Discoverlife.org, Stefan P. Cover for providing the cherry tree hypothesis, David R. Smith, Terry P. Nuhn, Maya Patel, John Pickering, Ted Schultz and his ant lab, and the National Museum of Natural History, Smithsonian Institution.

LITERATURE CITED

Barrows, E. M., A. M. McIntyre, and O. S. FlintJr. 2005. Alderfly (Neuroptera: Sialidae) flight periods, sex ratios, and habitat use in a Virginia freshwater tidal marsh, low forest, and their ecosystems. Proceedings of the Entomological Society of Washington 107: 693–699.

Bolton, B. 1994. Identification Guide to the Ant Genera of the World. Harvard University Press, Camridge, MA. 222 pp.

———. 1995. A New General Catalogue of the Ants of the World. Harvard University Press, Cambridge, MA. 504 pp.

Breton, J. L., J. Chazeau, and H. Jourdan. 2003. Immediate impacts of invasion by *Wasmannia auropunctata* (Hymenoptera: Formicidae) on native litter ant fauna in a New Caledonian rainforest. Austral Ecology 28: 204–210.

Creighton, W. S. 1950. The Ants of North America. Bulletin of the Museum of Comparative Zoology 104. 569 pp.

Crowell, K. L. 1968. Rates of competitive exclusion by the Argentine ant in Bermuda. Ecology 49: 551–555.

Cole, A. C. 1940. A guide to the ants of the Great Smoky Mountains National Park, Tennessee. American Midland Naturalist 24: 1–88.

Cole, F. R., A. C. Medeiros, L. L. Loope, and W. W. Zuehlke. 1992. Effects of the Argentine Ant on arthropod fauna of Hawaiian high-elevation shrubland. Ecology 73: 1313–1322.

Deyrup, M. 1991. *Technomyrmex albipes*, a new exotic ant in Florida (Hymenoptera: Formicidae). Florida Entomologist 74: 147–148.

ESRI, Inc, Version 3.1.380. ESRI, Inc., New York Street, Redlands, CA.

Fellers, J. H. 1987. Interference and exploitation in a guild of woodland ants. Ecology 68: 1466–1478.

Hill, M., K. Holm, T. Vel, N. J. Shah, and P. Matyot. 2003. Impact of the introduced yellow crazy ant *Anoplolepis gracilipes* on Bird Island, Seychelles. Biodiversity and Conservation 12: 1969–1984.

Hölldobler, B. and E. O. Wilson. 1990. The Ants. Harvard University Press, Cambridge, MA. 732 pp.

Holway, D. A. 1998. Effect of Argentine ant invasions on ground-dwelling arthropods in northern California riparian woodlands. Oecologia 116: 252–258.

Holway, D. A., L. Lach, A. V. Suarez, N. D. Tsutui, and T. J. Case. 2002. The causes and consequences of ant invasions. Annual Review of Ecology and Systematics 33: 181–233.

Johnston, D. W. 2000. The Dyke Marsh Preserve ecosystem. Virginia Journal of Science 51: 223–272.

King, T. G. and S. A. Green. 2005. Ants (Hymenoptera: Formicidae) collected in Philadelphia. Pennsylvania, USA. Website. http://biodiversity.georgetown.edu/searchfiles/infosearch.cfm?view=all&IDNumber=2819 (23 September 2005).

Kjar, D. S. and E. M. Barrows. 2004. Arthropod community heterogeneity in a mid-Atlantic forest highly invaded by alien organisms. Banisteria 23: 26–37.

Kinomura, K. and K. Yamauchi. 1994. Frequent occurrence of gynandromorphs in the natural population of the ant *Vollenhovia emeryi* (Hymenoptera: Formicidae). Insectes Sociaux 41: 273–278.

Kubota, M. 1984. Anomalous female wings in *Vollenhovia emeryi* Wheeler. Ari 12: 2–3 (in Japanese).

McGlynn, T. P. 1999. The worldwide transfer of ants: Geographical distribution and ecological invasions. Journal of Biogeography 26: 535–548.

Morrison, L. W. 2002. Long-term impacts of an arthropod-community invasion by the imported fire ant, *Solenopsis invivta*. Ecology 83: 2337–2345.

National Park Service, The National Park Service's Cultural Landscapes Inventory: Thomas Jefferson Memorial. Website. http://www.nps.gov/thje/cli/ (22 September 2005).

———. 2002. AlaskaPak: Functions pack extensions for ArcView 3× National Park Service Alaska Support Office. Retrieved from http://www.nps.gov/akso/gis/av31/akpak.htm on 3 June 2005.

———. 2005. History of the cherry trees in Washington, D.C. Website. http://www.nps.gov/nacc/cherry/history.htm (22 September 2005).

Porter, S. D. and D. A. Savignano. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology 71: 2095–2106.

Suman, T. W. 2004. An annotated list of the ants (Hymenoptera: Formicidae) found in Fort Washington and Piscataway Parks, Maryland. A report to the National Park Service. United States Department of the Interior/National Park Service, Washington, DC. 13 pp. (unpublished report).

Terayama, M. and K. Kinomura. 1997. Taxonomic studies of Japanese Formicidae part 3: Genus *Vollenhovia* Mayr. Nature and Human Activities 2: 1–8.

Trager, J. C. 1984. A revision of the genus *Paratrechina* (Hymenoptera: Formicidae) of the continental United States. Sociobiology 9: 51–162.

———. 1991. A revision of the fire ants, *Solenopsis geminata* group (Hymenoptera: Formicidae: Myrmicinae). Journal of the New York Entomological Society 99: 141–198.

Wetterer, J. K. and S. D. Porter. 2003. The little fire ant, *Wasmannia auropunctata*: Distribution, impact, and control. Sociobiology 42: 1–41.

Wetterer, J. K. 2005. Worldwide distribution and potential spread of the long-legged ant, *Anoplolepis gracilipes* (Hymenoptera: Formicidae). Sociobiology 45: 77–97.

Wheeler, W. M. 1906. The ants of Japan. Bulletin of the American Museum of Natural History 22: 301–328.

———. 1907. The fungus-growing ants of North America. Bulletin of the American Museum of Natural History 23: 669–807.

———. 1929. Two Neotropical ants established in the United States. Psyche 36: 89–90.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 605–610

THE LASIOCHILIDAE AND ANTHOCORIDAE (HEMIPTERA: HETEROPTERA) OF THE GALÁPAGOS ISLANDS, ECUADOR: INTRODUCED OR NATIVE?

JOHN D. LATTIN

Department of Botany and Plant Pathology, Oregon State University, Corvallis OR 97331-2902, U.S.A.

Abstract.—Eight species of Lasiochilidae and Anthocoridae have been reported from the Galápagos Islands, Ecuador, 970 km west of mainland Ecuador. Six of the species are considered to be non-indigenous and one species, *Nidicola mazda* Herring, may be the only native species on the islands. An unidentified species of *Xylocoris* Dufour awaits identification before further consideration can be made. The history of each species is presented.

Key Words: Hemiptera: Heteroptera, Lasiochilide, Anthocoridae, Galápagos Islands, Ecuador, introduced species

Charles Darwin left England on the Beagle on December 27, 1831, at the age of 22, and returned on October 2, 1836, after an extended voyage around the world. The main purpose of this trip was to continue coastal surveys of South America. Darwin had ample opportunity to examine the fauna, flora, and geology wherever the ship stopped. One such stop was at the Galápagos Islands, some 970 km (600 mi) west of the coast of mainland Ecuador. The visit lasted from mid-September to mid-October, 1835. Darwin (1839) commented on the general paucity of the insect fauna and their drab appearance. He collected 25 species of beetles (his special interest) "…excluding a species of *Dermestes* (Dermestidae) and *Corynetes* (Cleridae) imported wherever a ship touches." This was a very early statement on the accidental introduction of non-indigenous insects. This paper concerns a group of true bugs of the Galápagos Islands.

Books that provide a useful background on the Galápagos Islands include: Darwin (1839), *The Voyage of the Beagle*; Weiner (1995), *The Beak of the Finch*; Thomson (1995), *HMS Beagle*; Quamen (1996), *The Song of the Dodo*; Larson (2001), *Evolution's Workshop*; Peck (2001), *Smaller Orders of Insects of the Galápagos Islands, Ecuador: Evolution, Ecology and Diversity*; Nicholes (2003), *Evolution's Captain*; papers by Peck et al. (1998), Introduced insect fauna of an oceanic archipelago; The Galápagos Islands, Ecuador; and Causton et al. (2006), Alien insects: threats and implications for the conservation of Galápagos Islands.

The former family Anthocoridae is now considered to be three families: Lasiochilidae, Lyctocoridae, and Anthocoridae (Schuh and Štys 1991). The families Lasiochilidae and Anthocoridae were first reported from the Galápagos Islands (as Anthocoridae) by Herring

(1966a). The species were Lasiochilidae: *Lasiochilus pallidulus*, Anthocoridae: Dufouriellini: *Alofa sodalis, Amphiarus constrictus, Cardiastethus limbatellus*; Oriini: *Orius tristicolor*; Scolopini: *Nidicola mazda*; and Xylocorini: *Xylocoris sordidus*. Linsley (1977) reported six of these species (except *Lasiochius pallidulus*) and Schaefer et al. (1980) added information on *L. pallidulus*. Froeschner (1981) cited references to five of these species but did not mention *Orius insidiosus* (Say) or *Xylocoris sordidus*. Froeschner (1985) covered all seven species previously published. Peck et al. (1998) reported 292 species of insects in 16 orders likely to have been introduced into the Galápagos Islands. Their list included two species of Anthocoridae: *Alofa sodalis* and *Amphiareus constrictus*, both from Santa Cruz Island. Peck (2001) treated all known species of Lasiochilidae and Anthocoridae (as Anthocoridae), added an unidentified species of *Xylocoris* Dufour, and added many new localities for all other species. The status of all species reported from the Galápagos Islands follows.

Lasiochilidae

Lasiochilus pallidulus Reuter (1871) was described from South Carolina. Herring (1966a) reported it from Academy Bay, Isla Santa Cruz, and stated that the species also was known from Guatemala and Brazil. Schaefer et al. (1980) added information on this species from "Puerto Ayora / Indefatigable I. Galápagos / Dec.–Mar., 1971–2 / J. Vagvolgyi / at lights." Froeschner (1981, 1985) repeated these records. Henry (1988) reported this species from Florida, South Carolina, and Texas, besides Mexico, Central America and the West Indies. Carpentero et al. (1997) cited the species from Nicaragua. Peck (2001) reported this species from Isla Isabela, Isla Marchena, Isla Pinta, Isla Santa Cruz, and Isla Santiago. Based upon the broad distribution records, I consider this species to be introduced into the Galápagos Islands.

Anthocoridae

Dufouriellini

Alofa sodalis (White) was described from the Hawaiian Islands in 1878 (as *Cardiastethus sodalis*). Herring (1966a) reported it as *Buchananiella sodalis* from the Galápagos Islands (Academy Bay, Isla Santa Cruz) based on a single male and cited its occurrence in Africa, many islands in the Pacific, North, Central and South America, and the West Indies. It is thought to be a native species in the Hawaiian Islands. It is a non-indigenous species in the Galápagos Islands and was so reported by Peck et al. (1998), and Causton et al. (2006). Peck (2001) recorded Isla Islabela and Isla Santa Cruz.

Amphiareus constrictus (Stål) was described from Brazil in 1860 (as *Xylocoris constrictus*). Herring (1965) clarified the taxonomy of *Amphiareus constrictus* and later (Herring 1966a) reported it from Academy Bay, Isla Santa Cruz, and indicated that the species occurred in Africa, the Orient, many of the islands in the Pacific Ocean, North, Central and South America, and the West Indies. As with *A. sodalis*, it is regarded as an introduction into the Galápagos Islands and was so reported by Peck et al. (1998, 2001), and Causton et al. (2006). Peck (2001) listed Isla Isabela and Isla Santa Cruz.

Cardiastethus limbatellus (Stål) was described from Brazil in 1860. Herring (1966a) first reported it from the Galápagos Islands (Academy Bay, Isla Santa Cruz, ex. *Scalesia affinis* Hook.f. (as *Scaleia affinis*)) and several other sites on the island, as well as from Guatemala and Brazil. These records were repeated by Linsley (1977) and Froeschner (1981, 1985). Peck (2001) recorded Isla Baltra, Isla Floreana, Isla Isabela, and Isla Santa Cruz. Peck (2001) and Peck et al. (1998) and Causton et al. (2006) did not consider this species in their charts of introductions. I consider this a non-indigenous species based upon the original site of description, in addition to the activities on Isla Baltra that was converted into an airport many years ago.

Oriini

Orius tristicolor (White) was described from California in 1880 (as *Triphleps tristicolor*). Herring (1966a) reported it from the Galápagos Islands (Isla Santa Cruz) and stated it was common in western United States, south through Mexico to South America, and the West Indies. He included this species in his revision of *Orius* (1966b). Linsley (1977) repeated Herring's (1966a) record, as did Froeschner (1985), but not in his Heteroptera of Ecuador (Froeschner 1981). Froeschner (1999) reported it from Panama based on the record of Champion (1900). Henry (1988) provided detailed province and state localities for *O. tristicolor*. Peck (2001) reported this species from Isla Española, Isla Fernandina, Isla Isabela, Isla Marchena, Isla Pinta, Isla Pinzón, Isla Santa Cruz and Isla Santago. Based upon its widespread occurrence, I consider this species non-indigenous in the Galápagos Islands.

Xylocorini

Xylocoris sordidus (Reuter) was described from Texas and Brazil in 1871 (as *Piezostethus sordidus*). Herring (1966a) first reported it from the Galápagos Islands (Isla Baltra and Isla Santa Cruz). He stated that it occurred in the southern United States, south through Mexico to Central America and South America, and the West Indies. Froeschner (1985) repeated previously published records. Henry (1988) provided detailed distribution of it in the United States. Peck (2001) reported this species from Isla Baltra, Isla Isabela, Isla Pinta, Isla San Cristóbal, Isla Santa Cruz, and Isla Santa Fé. *Xylocoris sordidus* is found at many locations in the United States (Henry 1988) and is widely distributed in Mexico, Central and South America (Lattin 2007). It is often associated with stored foodstuff (Arbogast et al. 1983, 1985) and thus, is easily introduced. Peck et al. (1998); Peck (2001), and Causton et al. (2006) have provided detailed information on the import of commercial goods, the very activities that would allow *X. sordidus* to have been introduced into the Galápagos Islands. It is here considered to be introduced in these islands.

Scolopini

Nidicola mazda Herring (1966a) was described from Academy Bay, Isla Santa Cruz, based upon a single female. The illustration of the type shows that the individual is submacropterous. Linsley (1977) and Froeschner (1981, 1985) included this record in their publications. Peck (2001) reported this species from Isla Fernandina, Isla Isabela, Isla Marchena, Isla Rábida, Isla Santa Cruz, and Isla Wolf. Earlier, Drake and Herring (1964) published a revision of *Nidicola* Harris and Drake that included five species with illustrations. The forewing of *N. mazda* by Herring shows a reduced membrane, similar to that of submacropterous *N. engys* Drake and Herring. Peet (1979) reported the same condition for *N. jaegeri* Peet from southern California. Ford (1979) listed seven species in the genus *Nidicola*. Peet (1973, 1979) provided detailed biological information on *N. marginata* Harris and Drake and *N. jaegeri*. Specimens were taken from woodrat nests, bat guano, and grain bins where they fed on small insects. He also stated that species of *Nidicola* had been intercepted from shipments of flowers and other plant materials at inspection centers in Arizona and Texas (Peet 1979). Species of the genus *Nidicola* are found from Arizona and California south through Mexico to Guatemala and Nicaragua (Ford 1979; Carpintero et al. 1997). No records exist as yet for any species of *Nidicola* in mainland Ecuador (Froeschner 1981) or Panama (Froeschner 1999). Peck (2001) considered this species to be the only endemic Anthocoridae on the Galápagos Islands. He reported it as occurring in the "littoral to transition zones." No mention was made of the condition of the wings of the additional specimens collected. Considering the amount of traffic to the islands, especially Isla Santa Cruz (Peck et al. 1998), there is a possibility this species is introduced. Despite this, comparison with all other known species of *Nidicola* supports the validity of it being a distinct species.

In summary, seven species of Lasiochilidae and Anthocoridae were reported from the Galápagos Islands, Ecuador, by Herring (1966a). These are Lasiochilidae: *Lasiochilus pallidulus* and Anthocoridae: *Alofa sodalis, Amphiareus constrictus, Cardiastethus limbatellus, Orius tristicolor, Xylocoris sordidus*, and *Nidicola mazda*. I consider the first six nonindigenous to the islands, whereas the last, *Nidicola mazda*, is perhaps the only endemic species. All other species of *Nidicola* occur from Arizona and California, south through Mexico to Guatemala and Nicaragua. Most of the described species have been intercepted at the United States border in Arizona and Texas in shipments of plant material, especially flowers, from Mexico. It is possible that *N. mazda* was introduced into the Galápagos Islands the same way. Peck (2001) treated all previously known species of Lasiochilide and Anthocoridae (as Anthocoridae), added many new island records, and included an unidentified species of *Xylocoris*.

Peck et al. (1998) reported 292 species of introduced insects from the Galápagos Islands and their possible modes of introduction, including two species of Anthocoridae (*Alofa sodalis* and *Amphiareus constrictus*). Table 4 was of particular interest, listing the various islands and the number of species introduced on each island. They reported 165 species introduced onto Santa Cruz - by far the greatest number cited. All of the true bugs reviewed by Herring were reported from Santa Cruz Island, only *Xylocoris sordidus* was also recovered from another island - Baltra. Baltra Island was converted into an air base during World War II and was a major site for introduction of all types of materials. Peck (2001) published a study of the smaller insect orders besides providing an extensive overview of the origin, arrival and evolution of the insect fauna of the islands. Many additional localities of the included insects were given, including the true bugs. Henry and Wilson (2004) reported eleven species of Hemiptera: Heteroptera not previously recorded from the Galapágos Islands. Causton et al. (2006) reported 463 species, up from 292 cited in Peck et al. (1998). Peck and his associates have provided an excellent study of the Galápagos insects. Their treatment of the extraordinary number of introduced species is particularly relevant to the present paper.

Dedication

This paper is dedicated to my friend and colleague, the late Jon L. Herring. Jon was the first to publish on the Anthocoridae of the Galápagos Islands in 1966, including the description of a new species (*Nidicola mazda*). He also published the only major work on the Anthocoridae of Micronesia in 1967.

ACKNOWLEDGMENTS

My thanks to former colleagues R.C. Froeshner, J.L. Herring, and E.G. Linsley, and to G.J. Brenner, D.L. Carpintero, R. R. Halse, T.J. Henry, S.B. Peck, W.B. Peet, Jr., and C.W. Schaefer. A. Christie provided assistance in locating critical literature and L. Parks took special care in preparing the manuscript.

LITERATURE CITED

Arbogast, R. T., B. R. Flaherty, and J. W. Press. 1983. Demography of the new predaceous bug *Xylocoris sordidus* (Reuter). American Midland Naturalist 109: 398–405.

Arbogast, R. T., B. R. Flaherty, R. V. Byrd, and J. W. Press. 1985. Developmental stages of *Xylocoris sordidus* (Hemiptera: Anthocoridae). Entomological News 96: 53–58.

Carpintero, D. L., J.-M. Maes, and M. del C. Coscarón. 1997. Catalogo de los Anthocoridae (Heteroptera) de Nicaragua. Revisa Nicareguense de Entomologia, No. 41, pp. 23–26.

Causton, C. E., S. E. Peck, B. J. Sinclair, L. Roque-Albelo, C. J. Hodgson, and B. Landry. 2006. Alien insects: threats and implications for conservation of Galápagos Islands. Annals of the Entomological Society of America 99: 121–143.

Champion, G. C. 1897–1901. Insecta: Rhynchota (Hemiptera - Heteroptera). Vol. II. *In* Godman and Salvin, Biologia Centrali-Americana, London. 416 pp. (1897:1–32; 1898: 33–192; 1899: 193–304; 1900: 305–344; 1901: i–xvi + 345–416).

Darwin, C. 1839. The Voyage of the Beagle. (2001, Modern Library Paperback Edition, New York, N.Y. 468 pp.).

Drake, C. J. and J. L. Herring. 1964. The genus *Nidicola* (Hemiptera: Anthocoridae). Proceedings of the Biological Society of Washington 77: 53–64.

Ford, L. J. 1979. The phylogeny and biography of the Cimicoidea (Insecta: Hemiptera). M.S. Degree, University of Connecticut, i–vii + 138 pp.

Froeschner, R. C. 1981. Heteroptera or true bugs of Ecuador - a partial catalog. Smithsonian Contributions to Zoology, No. 322, 147 pp.

———. 1985. Synopsis of the Heteroptera or true bugs of the Galápagos Islands. Smithsonian Contributions to Zoology, No. 407, 84 pp.

———. 1999. True bugs (Heteroptera) of Panama: a synoptic catalog as a contribution to the study of Panama biodiversity. Memoirs of the American Entomological Institute, Vol. 61, 393 pp.

Henry, T. J. 1988. Family Anthocoridae Fieber, 1837, pp. 12–28. *In* Henry, T. J. and R. C. Froeschner, eds. Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States. E.J. Brill, Leiden. 958 pp.

Henry, T. J. and M. R. Wilson. 2004. First records of eleven true bugs (Hemiptera: Heteroptera) from the Galápagos Islands, with miscellaneous notes and corrections to published reports. Journal of the New York Entomological Society 112: 75–86.

Herring, J. L. 1965. The status of *Amphiareus* Distant, *Buchananiella* Reuter and *Poronotellus* Kirkaldy (Hemiptera: Anthocoridae). Proceedings of the Entomological Society of Washington 67: 202–203.

———. 1966a. The Anthocoridae of the Galápagos and Cocos Islands (Hemiptera). Proceedings of the Entomological Society of Washington 68: 127–130.

———. 1966b. The genus *Orius* of the Western Hemisphere. (Hemiptera: Anthocoridae). Annals of the Entomological Society of America 59: 1093–1109.

———. 1967. Insects of Micronesia Heteroptera: Anthocoridae. Bernice P. Bishop Museum, Insects of Micronesia 7(8): 390–414.

Larson, E. J. 2001. Evolution's Workshop. Basic Books, New York, N.Y.. 320 pp.

Lattin, J. D. 2007. The non-indigenous Lyctocoridae and Anthocoridae (Hemiptera: Heteroptera: Cimicoidea) of America north of Mexico. Proceedings of the Entomological Society of Washington 109: 366–376.

Linsley, E. G. 1977. Insects of the Galápagos (Supplement). Occasional Papers of the California Academy of Sciences, No. 125, 50 pp.

Nicholes, P. 2003. Evolution's Captain. Perennial, Harper Collins, New York, N.Y. 336 pp.

Peck, S. B. 2001. Smaller Orders of Insects of the Galápagos Islands, Ecuador: Evolution, Ecology, and Diversity. NRC. CNRC, NRC Research Press, Ottawa. 278 pp.

Peck, S. B., J. Heaty, B. Landry, and B. J. Sinclair. 1998. Introduced insect fauna of an oceanic archipelago: the Galápagos Islands, Ecuador. American Entomologist, Winter, 1998, pp. 218–237.

Peet, W. B. Jr. 1973. Biological studies of *Nidicola marginata* (Hemiptera: Anthocorodae). Annals of the Entomological Society of America 66: 344–348.

———. 1979. Description and biology of *Nidicola jaegeri*, n.sp., from southern California (Hemiptera: Anthocoridae). Annals of the Entomological Society of America 72: 430–437.

Quamen, D. 1996. The Song of the Dodo. Scribner, New York, N.Y. 702 pp.

Reuter, O. M. 1871. Acanthiidae americanae, descriptae. Öfversight af Kongliga Svenska Vetenskaps - Academiens Förhandlinger 28(5): 557–567, 1 plate.

Schaefer, C. W., J. Vagvolgya, and P. D. Ashlock. 1980. On a collection of Heteroptera (Hemiptera) from the Galápagos Islands. Pan-Pacific Entomologist 56: 43–50.

Schuh, R. T. and P. Štys. 1991. Phylogenetic analysis of cimicomorphan family retionships (Heteroptera). Journal of the New York Entomological Society 99: 298–350.

Stål, C. 1860–1862. Bidrag till Rio Janeiro traktens Hemipter - fauna. Kongliga Svenska Vetenskaps - Academiens Handlingar 2(7): 1–84 (1860); 1–75 (1862).

Thomson, K. S. 1995. HMS Beagle. Phoenix, Great Britain, London. 320 pp.

Weiner, J. 1995. The Beak of the Finch. Vantage Books, New York, N.Y. 332 pp.

White, F. B. 1878. Descriptions of new species of heteropterous Hemiptera collected in the Hawaiian Islands by the Rev. T. Blackburn. No. 2. Annals and Magazine of Natural History (V) 1: 365–374.

———. 1880. Descriptions of new Anthocoridae. Entomologist's Monthly Magazine 16: 142–148.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 611–627

SEVEN NEW SPECIES AND ONE NEW RECORD OF *GERGITHUS* STÅL (HEMIPTERA: FULGOROIDEA: ISSIDAE) FROM CHINA

YANLI CHE, YALIN ZHANG, AND YINGLUN WANG

(YC, YZ, YW) Key Laboratory of Plant Protection Resources and Pest Management, Ministry of Education, Entomological Museum, Northwest A & F University, Yangling, Shaanxi 712100, China; (YC) College of Plant Protection, Southwest University, Beibei, Chongqing 400716, China (e-mails: (YC) shirleyche@sohu.com; (YZ) yalinzh@yahoo.com.cn. Corresponding author: Yalin Zhang (yalinzh@yahoo.com.cn)

Abstract.—Eight Chinese species of the genus *Gergithus* Stål are treated. *Gergithus gravidus* Melichar is reported for the first time from China, and the following seven **new species** are described: ***G. quinquemaculatus, G. spinosus, G. chelatus, G. parallelus, G. multipunctatus, G. pseudotessellatus, G. yunnanensis***. The eight species are described and illustrated, and a key is provided for their identification. *Ishiharanus* Hori, 1969, is proposed as a **new synonym** of *Gergithus* Stål, 1870.

Key Words: Hemiptera, Issidae, *Gergithus*, new species, new synonym, China

---

The planthopper issid genus *Gergithus* was established by Stål in 1870. Melichar (1906) placed it in the Hemiphaerrinae of Issidae. Forty species are listed by Metcalf (1958). Subsequently, Hori (1969) reported on four species from Taiwan, China; Chou and Lu (in Chou et al. 1985) described one species, *Gergithus esperanto*, a junior synonym of *Hemisphaerius lysanias* Fennah (Che et al. 2006); and Chan and Yang (1994) described six species from Taiwan and raised two subspecies to specific level. Currently, fifty-two world species are known. In this paper, seven new species from China are described and illustrated, one new generic synonym is proposed (*Ishiharanus* Hori, a junior synonym of *Gergithus* Stål), and *Gergithus gravidus* Melichar is reported for the first time from China.

All type specimens are kept in the Entomological Museum, Northwest A & F University (NWAFU) except the holotype of *Gergithus yunnanensis*, n. sp. which is deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS).

Gergithus Stål, 1870

Gergithus Stål 1870: 756. Type species: *Hemisphaerius schaumi* Stål, by original designation.

Ishiharanus Hori 1969: 49–64. Type species: *Gergithus iguchii* Matsumura, 1916, by original designation. **New synonym**.

Description.—Body hemispherical. Head with eyes distinctly narrower than pronotum. Vertex broader than long, approximately quadrangular without carina. Ocelli present or absent. Frons with disc coarse or smooth, slightly elevated. Frontoclypeal suture nearly straight or slightly arched. Clypeus distinctly produced downward. Rostrum long, reaching metatrochanter. Pronotum short and wide, with two pits on disc, anterior margin distinctly convex and posterior margin nearly truncate, disc depressed. Mesoscutellum nearly triangular, with two pits along lateral margin, disc slightly elevated, with spots or stripes. Tegmen nearly elliptical, coarsely reticulate, claval suture absent. Wing translucent, longer than half of tegmen, veins distinctly netlike. Legs relatively long, not dilated, lateral margin of hind tibia with 2 teeth. Spinal formula of hind leg (6–7)–(8–12)–2, indicating number of spines at apex of hind tibia and hind tarsomeres I and II.

Male genitalia symmetrical or asymmetrical, anal segment subtriangular or mushroom-shaped, pygofer with or without spines; aedeagus tubular, symmetrical or asymmetrical, with spiniform processes near apex or at base, or without process.

Remarks.—Hori (1969) designated *G. iguchii* Matsumura as the type species of *Ishiharanus* Hori by distinct color, short pronotum and smooth frons, but all these three characters also appear in species of *Gergithus*; thus we synonymize *Ishiharanus* with *Gergithus*.

Gergithus differs from other genera in Hemisphaeriinae by the hemispherical body, vertex not projected, frons without tubercles and wings longer than half of tegmen.

Distribution.—Oriental Region (China, Japan, Vietnam, Philippines, India, Singapore, Thailand, Myanmar, Sri Lanka); Palaearctic Region (Japan).

KEY TO CHINESE SPECIES OF *GERGITHUS*

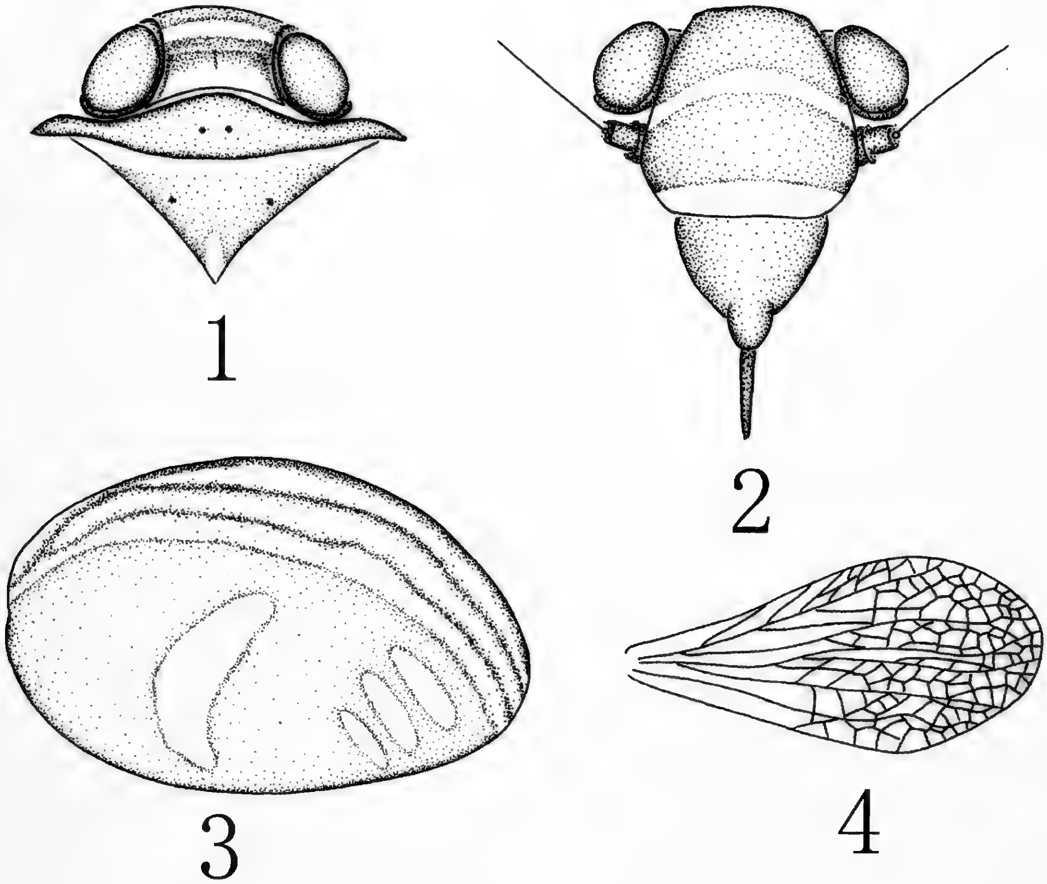
1. Frons with 2 fasciae, 1 between eyes and 1 against frontoclypeal suture (Figs. 2, 15, 25, 34, 52) 2
– Frons without or with 1 fascia (Figs. 6, 43, 61) 6
2. Tegmen with 3 subparallel yellow stripes along costal margin from base to apex, 1 lunate macula on disk, and 3 nearly elliptical subapical spots (Fig. 3) . . . . *G. gravidus* Melichar
– Tegmen not as above 3
3. Pygofer produced but without spine (Fig. 38) . . . . *G. parallelus*, n. sp.
– Pygofer strongly produced into large black spine (Figs. 19, 29, 56) 4
4. Anal segment with apical margin strongly convex (Fig. 28); aedeagus with 2 cheliform processes near base and 2 hatchet-like processes near apex (Figs. 30, 31) . . . . *G. chelatus*, n. sp.
– Anal segment with apical margin truncate or slightly convex; aedeagal processes spiniform 5
5. Aedeagus with laterobasal processes symmetrical (Figs. 57, 58) . . . . *G. pseudotessellatus*, n. sp.
– Aedeagus with laterobasal processes asymmetrical (Figs. 20, 21, 22) *G. spinosus*, n. sp.
6. Tegmen dark brown with 5 or 10 distinct yellow spots (Figs. 7, 44) 7
– Tegmen yellowish hazel with dark brown stripe along costal margin and dark brown spot near apex (Fig. 62) . . . . *G. yunnanensis*, n. sp.
7. Tegmen with 5 spots (Fig. 7); aedeagus without spiniform processes (Figs. 11, 12) . . . . *G. quinquemaculatus*, n. sp.
– Tegmen with 10 spots (Fig. 44); aedeagus with 2 spiniform processes at base and long spiniform processes fused with nearly quadrate process near apex (Figs. 48, 49) . . . . *G. multipunctatus*, n. sp.

Gergithus gravidus Melichar
(Figs. 1–4)

Gergithus gravidus Melichar 1906: 61.

Description.—Female. Length (including tegmen): 6.5 mm. Length of tegmen: 5.2 mm.

Vertex black with 2 yellow transverse fasciae at base and at apex. Eyes dark brown. Frons piceous brown with 2 yellow transverse fasciae, 1 between eyes, and 1 beyond frontoclypeal suture. Clypeus piceous black. Rostrum brown. Pronotum piceous black. Mesoscutellum piceous black with yellow fascia at



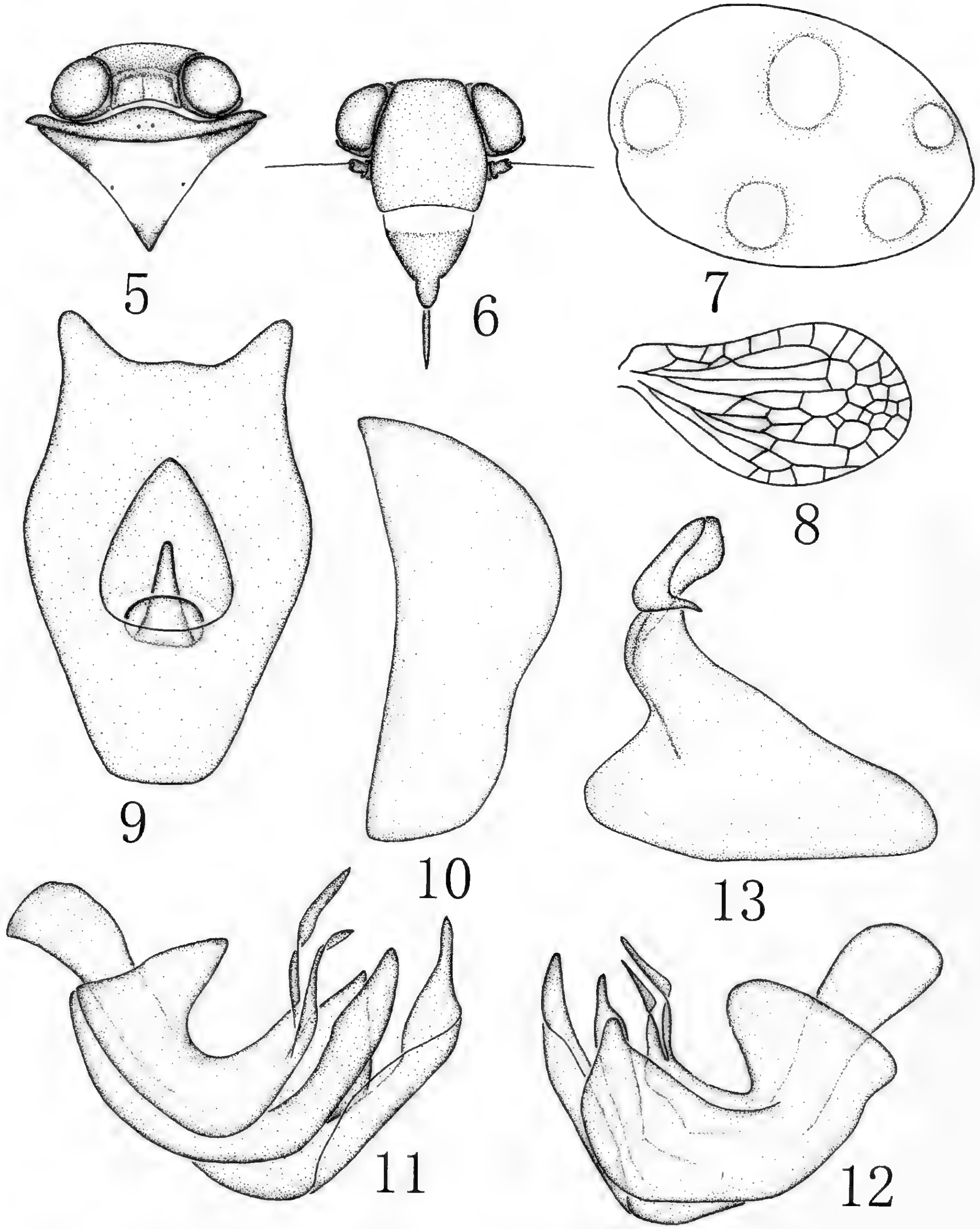
Figs. 1–4. *Gergithus gravidus* (♀). 1, Vertex and throax, dorsal view. 2, Frons and clypeus. 3, Tegmen. 4, Wing.

anterior margin and longitudinal yellow short stripe at posterior angle. Tegmen piceous black with 3 subparallel yellow stripes along costal margin from base to apex, 1 lunate macula on disk, and 3 nearly elliptical subapical spots (Fig. 3). Wings and legs hazel. Femora with black fasciae, two sides of femora and tibiae black. Venter piceous black, apex yellow. Dorsum of abdomen hazel.

Vertex wide and ecarinate, disc slightly depressed. Frons slightly convex, broader than long, midlength 0.8× longer than greatest width, 1.7× wider at widest part than at base. Frontoclypeal suture nearly straight. Pronotum wide posteriorly, roundly sinuate. Mesoscutellum broad and short, 2.1× wider at widest part than long in middle. Tegmen nearly elliptical, 1.5× longer than widest part; veins protruding. Wing large, 0.8× length of tegmen. Spinal formula of hind leg 6–9–2.

Material examined.—1♀, China, Guangxi Zhuang Autonomous Region, Lingtian, 3 June 1984, coll. Wu Zhengliang and Lu Xiao-Lin; 1♀, China, Guangxi Zhuang Autonomous Region, Longzhou, Nonghu, 13 June 1980, coll. Mao Ji-Zhen.

Distribution.—China (Guangxi); Vietnam. This is a new record for China.



Figs. 5–13. *Gergithus quinquemaculatus* (♂). 5, Vertex and throax, dorsal view. 6, Frons and clypeus. 7, Tegmen. 8, Wing. 9, Anal segment, dorsal view. 10, Pygofer, lateral view. 11, Aedeagus, left side. 12, Aedeagus, right side. 13, Genital style, lateral view.

Gergithus quinquemaculatus Che, Zhang, and Wang, new species

(Figs. 5–13)

Description.—Male length (including tegmen): 5.1 mm; length of tegmen: 4.7 mm. Female length (including tegmen): 5.3 mm; length of tegmen: 4.9 mm.

Vertex, frons, and eyes dark brown. Clypeus dark brown with yellow fascia against frontoclypeal suture. Rostrum brown. Pronotum dark brown. Mesoscutellum yellow. Tegmen shiny brown, with 5 distinct yellow spots arranged 1, 2, 2 from base to apex of tegmen (Fig. 7). Wings hazel, veins dark brown. Legs hazel. Forefemur black at base, fore- and midtibiae with black stripes. Venter dark brown, apex of venter slightly black. Abdominal dorsum dark brown.

Vertex lightly wrinkled, wide and nearly quadrangular, 2.1× wider at apex than long in middle line, disc slightly depressed. Frons slightly convex, narrower than long, midlength 1.25× longer than greatest width, 1.1× wider at widest part than at base. Frontoclypeal suture arched. Pronotum narrow and posteriorly roundly sinuate. Mesoscutellum broad and short, 2.5× wider at widest part than medial length. Tegmen nearly elliptical, 1.8× longer than widest part. Wing large, 0.8× length of tegmen. Spinal formula of hind leg 6–9–2.

Male genitalia: Anal segment moderately long in dorsal view, longer than medial width. Lateral margin strongly convex, apical margin strongly concave; in lateral view basal margin almost straight, ventral margin strongly convex, angles tapering. Anal tube situated about in middle of anal segment. Pygofer in profile slightly longer ventrally than dorsally; dorsocaudal angle strongly produced. Connective fused with aedeagus, U-shaped, asymmetrical, with lateral, ventral and dorsal lobes; in dorsal view, dorsal lobes long and narrow, right and left dorsal lobes asymmetrical, left lobe distinctly longer than right; in lateral view, lateral lobes robust with apex slender, asymmetrical, left lobe distinctly longer than right; in ventral view, ventral lobe tortuous and very long, apex tapering, spinelike. Aedeagus stout, strongly curved downward medially, without spiniform processes. Genital styles with apical margin wider than median, subtriangular and rounded at ventrocaudal margin, process short and stout, hooked near base, inner apical angle incised in caudal view, 1 long carina along ventrocaudal margin; dorsal and ventral margins not parallel.

Types.—Holotype ♂, China, Guangxi Zhuang Autonomous Region, Longzhou county, Sanlian, 13 June 2000, coll. Chen Jun. Paratypes: 1♀, China, Guangxi Zhuang Autonomous Region, Longzhou county, Sanlian, 14 June 2000, coll. Zhu Chao-Dong; 1♀, China, Guangxi Zhuang Autonomous Region, Longzhou county, Xiangshui, 8 June 1980, coll. Liang Xian-Fa (NWAFU)

Diagnosis.—This species is similar to *Gergithus iguchii* but differs from the latter by the dark brown tegmen with five yellow spots and the spinal fomula of the hind tibia as 6–9–2.

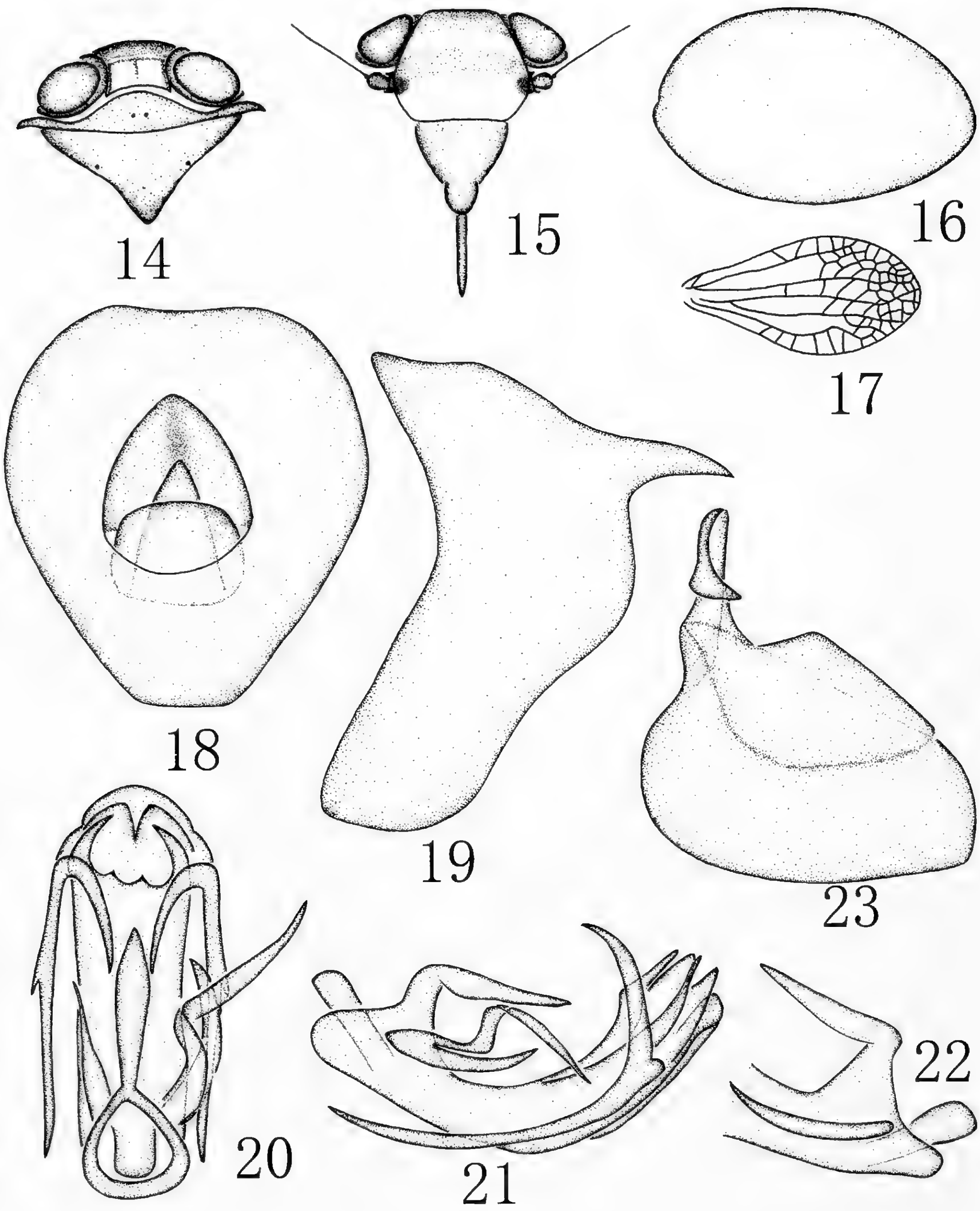
Etymology.—The Latin word "*quinquemaculatus*" refers to the five distinct yellow spots on the tegmen.

Gergithus spinosus Che, Zhang, and Wang, new species

(Figs. 14–23)

Description.—Male length (including tegmen): 6.0 mm; length of tegmen: 4.9 mm. Female length (including tegmen): 6.2 mm; length of tegmen: 5.1 mm.

Vertex dark yellowish green. Eyes black. Frons hazel with 2 pale green fasciae, 1 narrow, between eyes and 1 broad, against frontoclypeal suture; black spot on each side of frons near antenna. Clypeus piceous black, apex and base pale green. Rostrum brown.



Figs. 14–23. *Gergithus spinosus* (♂). 14, Vertex and throax, dorsal view. 15, Frons and clypeus. 16, Tegmen. 17, Wing. 18, Anal segment, dorsal view. 19, Pygofer, lateral view. 20, Aedeagus, dorsal view. 21, Aedeagus, left side. 22, Basal part of aedeagus, right side. 23, Genital style, lateral view.

Pronotum hazel with anterior margin and disc pale green. Mesoscutellum dark yellowish green. Tegmen yellowish hazel (female with irregular dark brown spot on disc of tegmen). Wing brown. Legs hazel, fore- and midfemora with black fasciae, hind femur black, fore- and midtibiae with black stripes. Venter dark brown, apex of venter yellowish. Abdominal dorsum dark brown.

Vertex slightly wrinkled, disc slightly depressed, wide and nearly quadrangular, 1.3× wider at apex than midlength. Frons slightly convex, narrower than long, midlength 1.1× longer than width at widest part, 1.6× wider at widest part than at base. Frontoclypeal suture nearly straight. Pronotum narrow and posteriorly almost straight. Mesoscutellum broad and short, 2.1× wider at widest part than medial length. Tegmen nearly elliptical, 1.9× longer than widest part. Wing large, 0.8× length of tegmen. Spinal formula of hind leg 6–10–2.

Male genitalia: Anal segment moderately long, in dorsal view nearly trapezoid, about equal in length to medial width; lateral margin strongly convex, apical margin slightly concave, basal margin almost straight, in profile ventral margin strongly convex. Anal tube near middle of anal segment. Pygofer in profile almost equal ventrally to dorsally, dorsocaudal angle strongly produced, spinelike. Connective fused with aedeagus, U-shaped, asymmetrical, with lateral, ventral, and dorsal lobes; in dorsal view, dorsal lobes bilobate, tapering to apex, long, apical margin undulate; in lateral view lateral lobes bilobate, apex tapering; in ventral view, ventral lobe distinctly shorter than dorsal and lateral lobes, apex broad and rounded. Aedeagus stout, strongly curved downward medially, with 5 spiniform proecesses, 2 lanciform processes near apex and 3 short spiniform processes near base 1 dorsally and 2 laterally, asymmetrical. Genital styles with apical margin wider than median, subtriangular and rounded at ventrocaudal margin, process short and stout, hooked near base, inner apical angle incised in caudal view, ventrocaudal margin with subapical process below a nearly quadrate carina; dorsal and ventral margins not parallel.

Types.—Holotype ♂, China, Hainan Prov., Jianfeng Mountain, 7 June 1984, coll. Lin You-Dong. Paratypes: 2♀, same data as holotype; 1♀, China, Hainan Prov., Jianfeng Mountain, 4 December 1974, coll. Yang Chi-Kun; 1♂, China, Hainan Prov., Jianfeng Mountain, 13 August 1981, coll. Gu Mao-Bin; 1♀, China, Hainan Prov., Jianfeng Mountain, 26 June 1981, coll. Gu Mao-Bin (NWAFU)

Diagnosis.—This species resembles *Gergithus formosanus* Metcalf, but differs from the latter by the frons with two transverse fasciae and two black spots near the antenna, and the aedeagus with five processes.

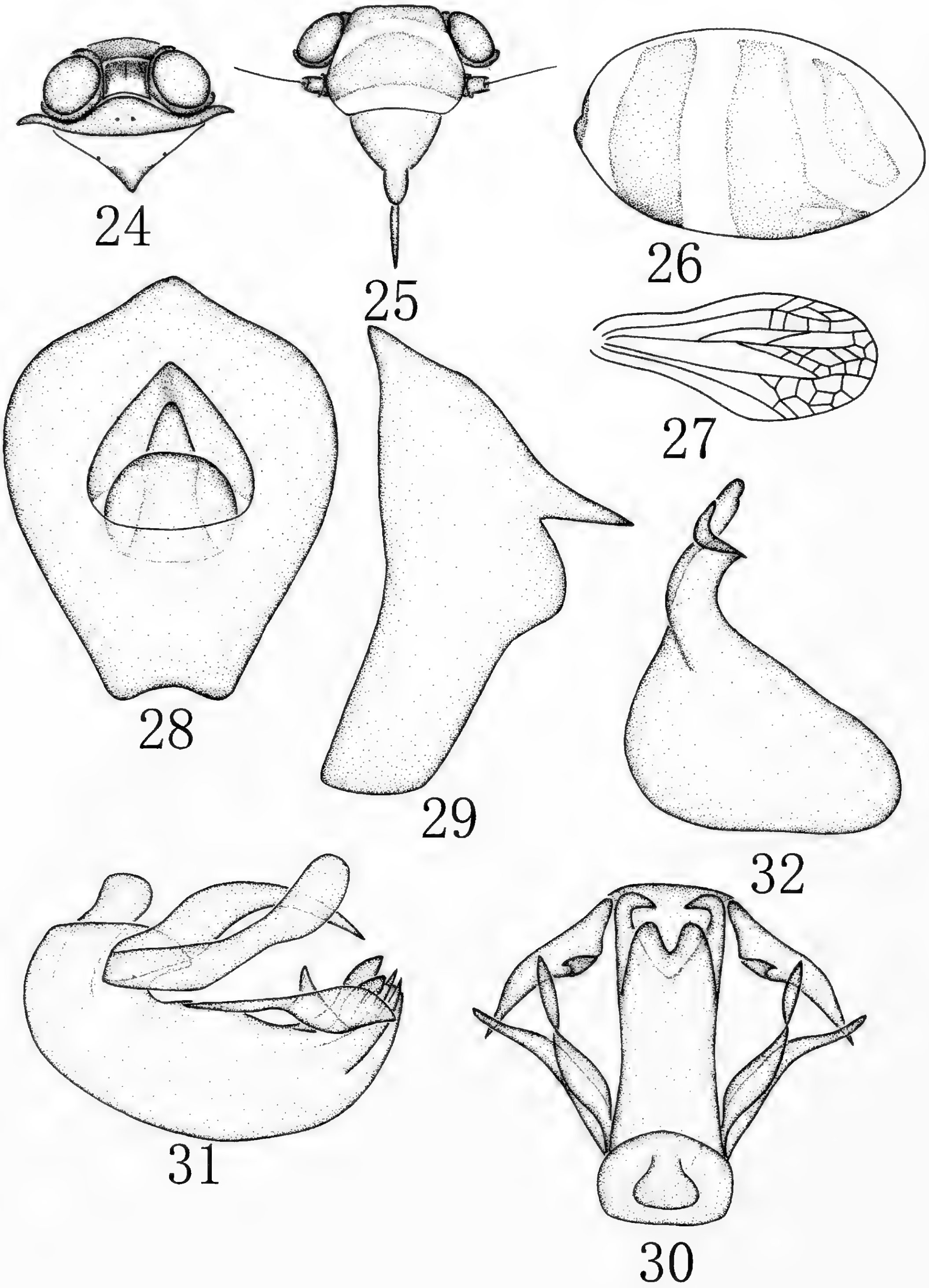
Etymology.—The Latin species name "*spinosus*" refers to the spiniform dorsocaudal angle of the pygofer.

Gergithus chelatus Che, Zhang, and Wang, new species

(Figs. 24–32)

Description.—Male length (including tegmen): 4.8–5.0 mm; length of tegmen: 3.9–4.1 mm. Female length (including tegmen): 5.1 mm; length of tegmen: 4.2 mm.

Vertex dark brown, basal part pale green. Eyes black. Frons dark brown with 2 narrow pale green fasciae, 1 between eyes and 1 against frontoclypeal suture. Clypeus and pronotum piceous black. Rostrum brown. Mesoscutellum pale green, posterior angle dark brown. Tegmen brown, with 4 pale-green transverse fasciae and pale-green subapical spot. Wing hazel. Legs hazel, fore- and midfemora and tibiae with black stripe, hind femur black. Venter dark brown, apex pale green. Abdominal dorsum dark brown.



Figs. 24–32. *Gergithus chelatus* (♂). 24, Vertex and throax, dorsal view. 25, Frons and clypeus. 26, Tegmen. 27, Wing. 28, Anal segment, dorsal view. 29, Pygofer, lateral view. 30, Aedeagus, dorsal view. 31, Aedeagus, left side. 32, Genital style, lateral view.

Vertex wrinkled, 1.2× wider at apex than medial length, disc distinctly depressed. Frons convex, narrower than long, 1.1× longer medially than greatest width, 1.6× wider at widest part than at base. Frontoclypeal suture nearly straight. Pronotum wide and posteriorly roundly sinuate. Mesoscutellum narrow and short, 2.1× wider at widest part than medial length. Tegmen 1.6× longer than widest part. Wing large, 0.8× length of tegmen. Spinal formula of hind leg 6–9–2.

Male genitalia: Anal segment moderately long, in dorsal view nearly oval, longer than medial width. Lateral margin strongly convex, apical margin convex, basal margin slightly concave, in profile ventral margin strongly convex. Anal tube near middle of anal segment. Pygofer in profile slightly longer ventrally than dorsally, dorsocaudal angle strongly produced, spinelike. Connective fused with aedeagus, U-shaped, symmetrical, with lateral, ventral, and dorsal lobes; dorsal lobes bilobate in dorsal view, tapering with apex rounded; in lateral view lateral lobes bilobate, tapering to acute apex; in ventral view, ventral lobe distinctly shorter than dorsal and lateral lobes, apex rounded. Aedeagus stout, slightly curved downward medially, with 4 spiniform processes, 2 cheliform processes near base, and 2 hatchetlike processes near apex. Genital styles with apical margin wider than median, subtriangular and rounded at ventrocaudal margin, process short and stout, hooked near base, inner apical angle incised in caudal view, process short and tapering, a short carina along dorsalcaudal margin, dorsal and ventral margins not parallel.

Types.—Holotype ♂, China, Hainan Prov., Jianfeng Mountain, 25 July 1983, coll. Hua Li-Zhong. Paratypes: 1♂, China, Hainan Prov., Jianfeng Mountain, 8 July 1982, coll. Liu Yuan-Fu; 2♀, China, Hainan Prov., Jianfeng Mountain, 15 July 1981, coll. Liu Yuan-Fu; 1♀, China, Hainan Prov., Jianfeng Mountain, 5 August 1982, coll. Liang Cheng-Feng (NWAFU)

Diagnosis.—This species is similar to *Gergithus lineatus* Kato, but differs from the latter by the tegmen with four fasciae and one spot, and the frons with two transverse stripes.

Etymology.—The species name is derived from the Latin word "*chelate*," referring to the aedeagus with chelate processes.

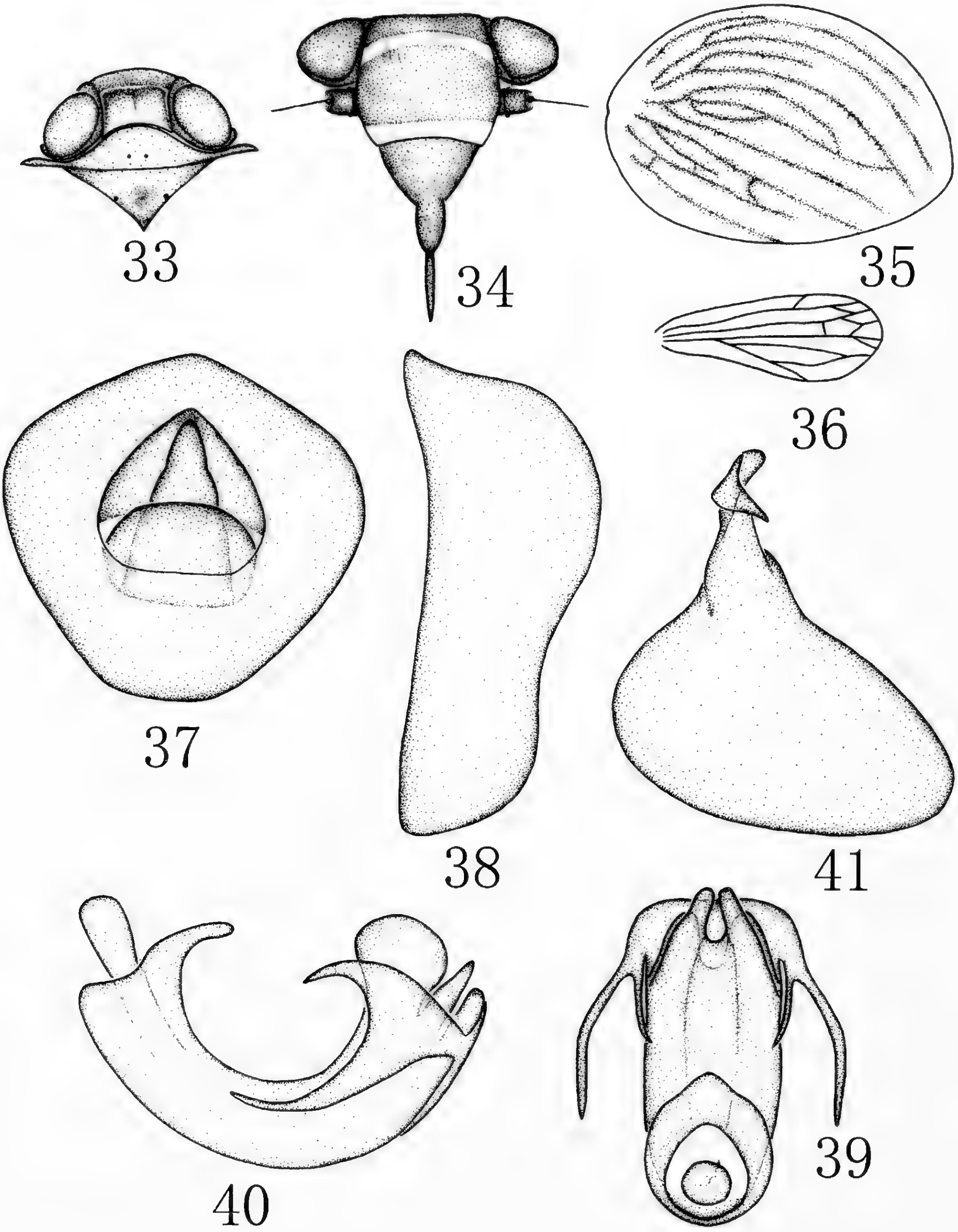
Gergithus parallelus Che, Zhang, and Wang, new species

(Figs. 33–41)

Description.—Male length (including tegmen): 3.9 mm; length of tegmen: 3.4 mm. Female length (including tegmen): 4.3 mm; length of tegmen: 3.8 mm.

Vertex dark brown, basal half pale yellowish green. Eyes dark brown. Frons brown with 2 narrow pale-green fasciae, 1 between eyes and 1 against frontoclypeal suture. Clypeus brown with base pale brown. Rostrum and pronotum brown. Mesoscutellum yellowish green, posterior angle dark brown. Tegmen yellowish hazel with veins dark brown. Wing brown. Legs hazel, fore- and midfemora and tibiae with black stripes. Venter dark brown, apex slightly hazel. Dorsum of abdomen pale yellowish green.

Vertex wrinkled, twice as wide at apex than medial length, disc distinctly depressed. Frons slightly convex, about as broad as long, 1.1× longer medially than greatest width, 1.5× wider at widest part than at base. Frontoclypeal suture slightly arched. Pronotum wide, posteriorly almost straight. Mesoscutellum narrow and short, 2.9× wider at widest part than medial length. Tegmen 1.5× longer than widest part; veins distinct and thickened, forming concentric arcs. Wing small, 0.65× length of tegmen. Spinal formula of hind leg 6–9–2.



Figs. 33–41. *Gergithus parallelus* (♂). 33, Vertex and throax, dorsal view. 34, Frons and clypeus. 35, Tegmen. 36, Wing. 37, Anal segment, dorsal view. 38, Pygofer, lateral view. 39, Aedeagus, dorsal view. 40, Aedeagus, left view. 41, Genital style, lateral view.

Male genitalia: Anal segment moderately long, in dorsal view nearly square, lateral margin strongly convex, apical margin convex, basal margin almost straight, and ventral margin in profile strongly convex. Anal tube near base of anal segment. Pygofer in profile distinctly longer ventrally than dorsally, dorsocaudal angle slightly produced. Connective fused with aedeagus, U-shaped, symmetrical, with lateral, ventral, and dorsal lobes; dorsal lobes bilobate in dorsal view, tapering to rounded apex; in lateral view, lateral lobes bilobate, tapering to rounded apex; in ventral view, ventral lobe apex nearly truncate, shorter than dorsal and lateral lobes. Aedeagus stout, slightly curved downward medially, and with 2 spiniform processes, V-shaped near apical part. Genital styles with apical margin wider than median, subtriangular and rounded at ventrocaudal margin, process short and slender, hooked near base, inner apical angle incised in caudal view, dorsal and ventral margins not parallel.

Types.—Holotype ♂, China, Hainan Prov., Nada, 1 June 1983, coll. Zhang Ya-Lin. Paratypes: 1♂1♀, China, Hainan Prov., Jianfeng Mountain, 3 June 1983, coll. Gu Mao-Bin; 1♀, same data as holotype; 1♀, China, Yunnan Prov., Xishuangbanna, Mengla, 20 April 1982, coll. Zhou Jing-Ruo and Wang Su-Mei (NWAFU)

Diagnosis.—This species resembles *Gergithus chelatus*, but differs from the latter by the tegmen without transverse bars and only the apex of the aedeagus with a V-shaped processes.

Etymology.—The Latin word "*parallelus*" refers to the dark lines (veins) of the tegmen.

Gergithus multipunctatus Che, Zhang, and Wang, new species

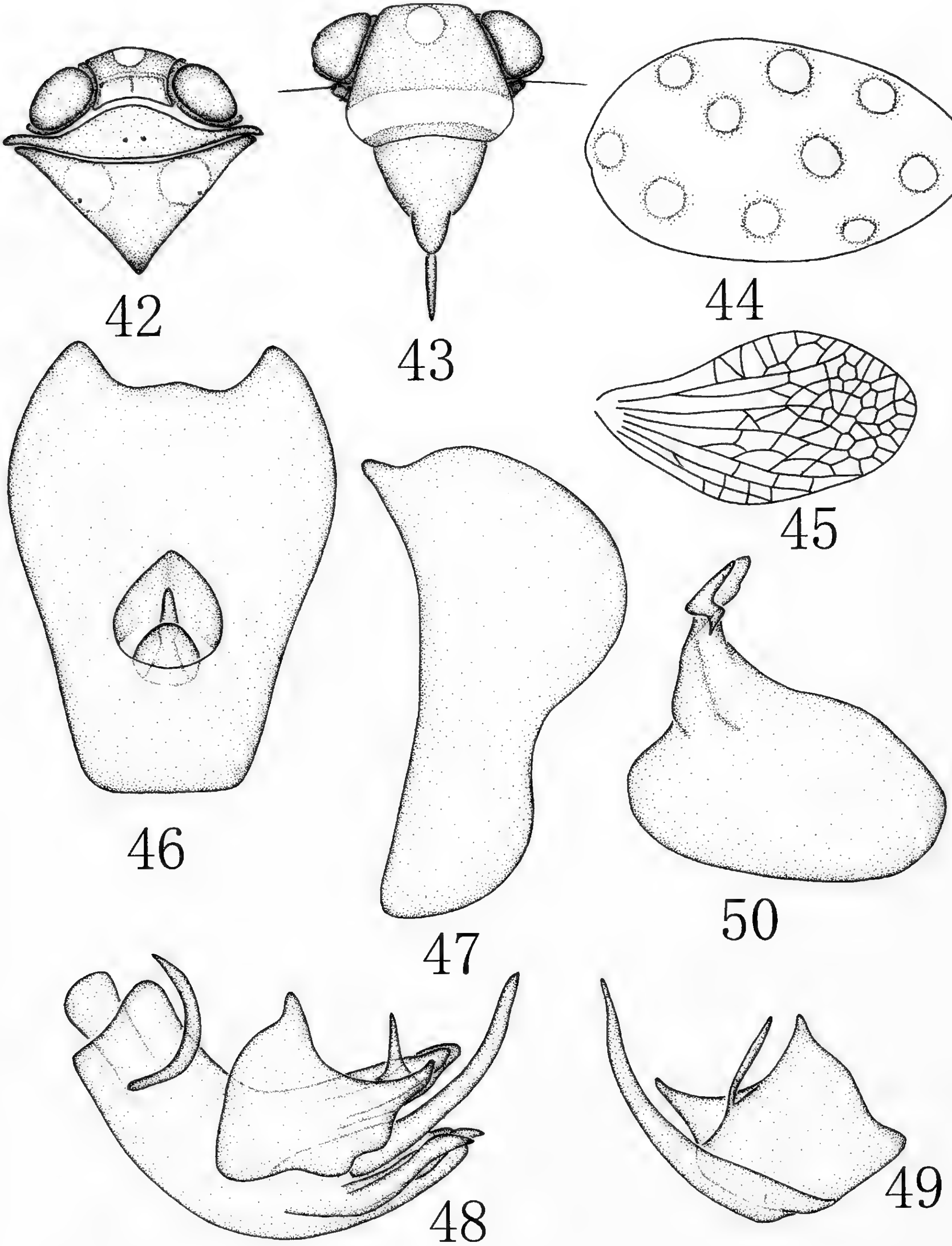
(Figs. 42–50)

Description.—Male length (including tegmen): 6.2 mm; length of tegmen: 5.2 mm. Female length (including tegmen): 7.1 mm; length of tegmen: 6.2 mm.

Vertex brown. Eyes black. Frons dark brown with yellow fascia near frontoclypeal suture, and yellow spot near apex. Clypeus dark brown. Rostrum brown. Pronotum dark brown. Mesoscutellum brown, with 2 yellow lateral spots. Tegmen dark brown with 10 yellow spots arranged 1, 2, 1, 2, 1, 2, 1 from base to apex of tegmen. Wing hazel, veins dark brown. Legs, abdominal dorsum and venter hazel; apex of fore- and midfemora black, fore- and midtibiae black, and apex of venter black.

Vertex wrinkled, wide, nearly quadranglar, 2.5× wider at apex than medial length, disc distinctly depressed. Frons convex, narrower than long, 1.2× longer medially than greatest width, 1.6× wider at widest part than at base. Pronotum narrow and posteriorly roundly sinuate. Mesoscutellum twice as wide at widest part as medial length. Tegmen 1.6× longer than widest part. Wing large, 0.9× length of tegmen. Spinal formula of hind leg 6–7–2.

Male genitalia: Anal segment large, nearly trapeziform in dorsal view, longer than medial width. Lateral margin slightly convex, apical margin strongly concave, basal margin slightly concave, ventral margin in profile almost straight. Anal tube between midlength and base of anal segment. Pygofer in profile similar in length ventrally to dorsally, dorsocaudal angle strongly produced. Connective fused with aedeagus, U-shaped, asymmetrical, with lateral, ventral and dorsal lobes; dorsal lobes bilobate in dorsal view, tapering to rounded apex; lateral lobes bilobate in lateral view, tapering to acute apex; in ventral view, apex of ventral lobe truncate, shorter than dorsal and lateral lobes. Aedeagus with 2 short spiniform processes near base and long spiniform process fused with nearly quadrate process near apex (Figs. 48, 49). Genital



Figs. 42–50. *Gergithus multipunctatus* (♂). 42, Vertex and throax, dorsal view. 43, Frons and clypeus. 44, Tegmen. 45, wing. 46, Anal segment, dorsal view. 47, Pygofer, lateral view. 48, Aedeagus, left side. 49, Processes of aedeagus, right side. 50, Genital style, lateral view.

styles with apical margin wider than median, subtriangular and rounded at ventrocaudal margin, process short and stout, hooked near base, apex tapering in caudal view, inner apical angle incised, carina along ventrocaudal margin, dorsal and ventral margins nearly parallel.

Types.—Holotype♂, China, Hainan Prov., Jianfeng Mountain, 19 June 1983, coll. Gu Mao-Bin. Paratypes: 1♂, China, Hainan Prov., Jianfeng Mountain, 27 August 1981, coll. Gu Mao-Bin; 1♀, China, Hainan Prov., Jianfeng Mountain, 25 June 1981, coll. Gu Mao-Bin; 1♀, China, Hainan Prov., Jianfeng Mountain, 4 August 1983, coll. Liu Yuan-Fu; 1♀, China, Hainan Prov., Jianfeng Mountain, 2 August 1982, coll. Liang Cheng-Feng (NWAFU)

Diagnosis.—This species is similar to *Gergithus iguchii*, but differs from the latter by the dark brown tegmen with ten yellow spots arranged 1, 2, 1, 2, 1, 2, 1 from base to apex and mesoscutellum dark brown with two yellow spots.

Etymology.—The specific name "*multipunctatus*" refers to the 10 yellow spots on the tegmen.

Gergithus pseudotessellatus Che, Zhang, and Wang, new species

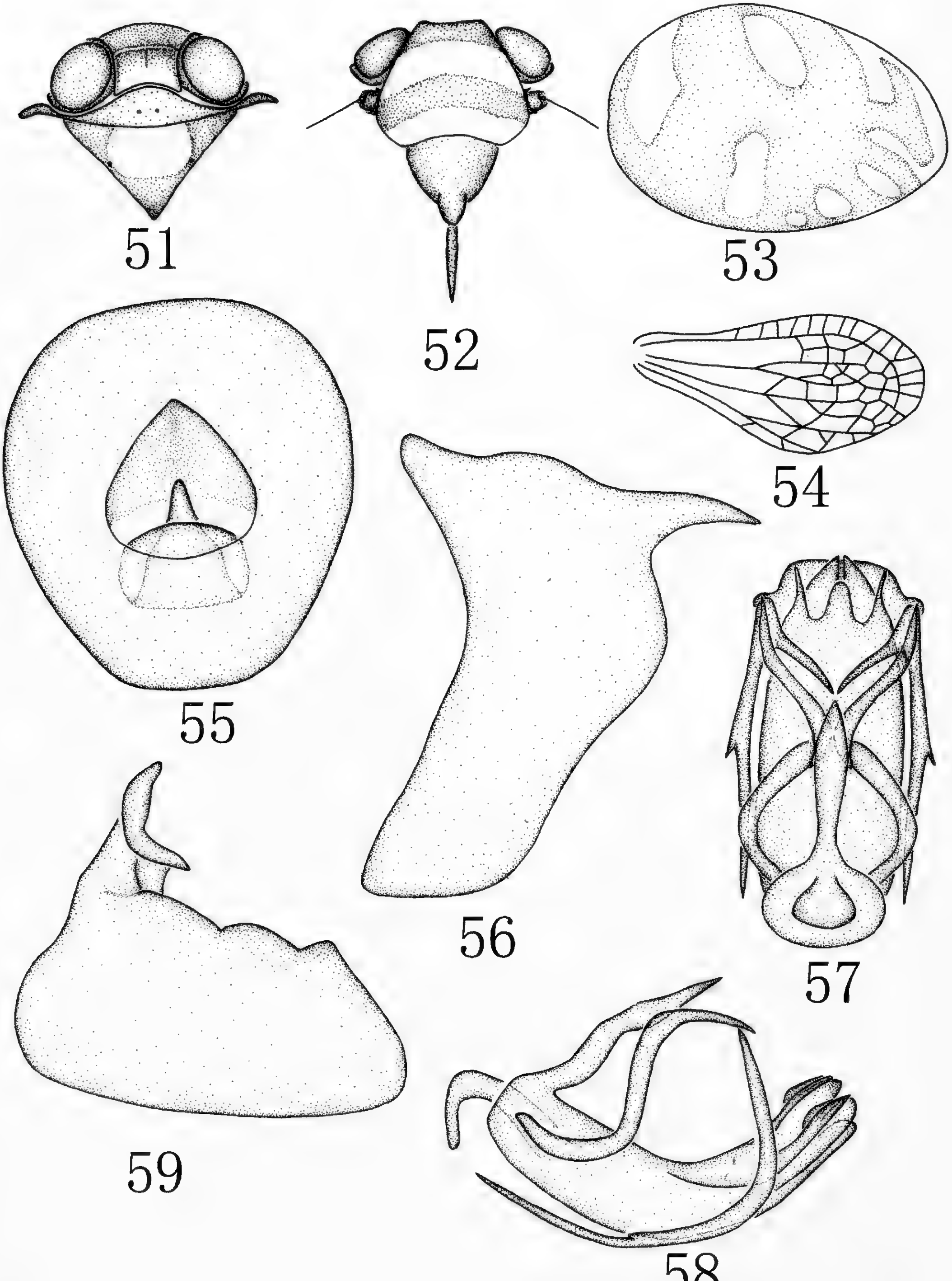
(Figs. 51–59)

Description.—Male length (including tegmen): 6.2 mm; length of tegmen: 5.2 mm. Female length (including tegmen): 6.4 mm; length of tegmen: 5.3 mm.

Vertex brown with basal part yellow. Eyes black. Frons dark brown with 2 yellow fasciae, 1 between eyes and 1 against frontoclypeal suture. Clypeus dark brown. Rostrum brown. Pronotum brown. Mesoscutellum dark brown with large medial spot. Tegmen dark brown, basal half with 3 large elongate spots, apical half with 6 or 7 smaller elongate spots at apical margin. Wing hazel, veins dark brown. Legs brown, fore- and midfemora with dark brown fasciae, fore-, mid- and hindtibiae with dark brown stripes. Venter hazel, apex yellow. Abdominal dorsum dark brown.

Vertex wrinkled, 1.3× wider at apex than medial length, disc distinctly depressed. Frons slightly convex, narrower than long, midlength 1.1× longer than greatest width, 1.8× wider at widest part than at base. Frontoclypeal suture slightly arched. Pronotum wide and posteriorly arched. Mesoscutellum narrow and short, 2.1× wider at widest than medial length. Tegmen 1.6× longer than wide at widest part. Wing large, 0.8× length of tegmen. Spinal formula of hind leg 6–10–2.

Male genitalia: Anal segment moderately large, in dorsal view nearly oblong, about equal in length to medial width. Lateral margin convex, apical margin nearly truncate, basal margin almost straight, and ventral margin in profile strongly convex. Anal tube near middle of anal segment. Pygofer in profile slightly longer ventrally than dorsally, dorsocaudal angle strongly produced into large black spine. Connective fused with aedeagus, U-shaped, symmetrical, with lateral, ventral, and dorsal lobes; dorsal lobes bilobate in dorsal view, tapering, angle acute and apical margin distinctly convex; lateral lobes bilobate in lateral view, tapering, apex acute; in ventral view, apex of ventral lobe nearly truncate, shorter than dorsal and lateral lobes. Aedeagus symmetrical, stout, slightly curved downward medially, with 5 spiniform processes (Figs. 57, 58), 2 long near apex, 1 dorsal and 2 S-shaped lateral processes. Genital styles with apical margin wider than medial, subtriangular and rounded at ventrocaudal margin, process short and stout, hooked near base, inner apical angle incised in caudal view, dorsal margin undulate, dorsal and ventral margins not parallel.



Figs. 51–59. *Gergithus pseudotessellatus* (♂). 51, Vertex and throax, dorsal view. 52, Frons and clypeus. 53, Tegmen. 54, Wing. 55, Anal segment, dorsal view. 56, Pygofer, lateral view. 57, Aedeagus, dorsal view. 58, Aedeagus, left side. 59, Genital style, lateral view.

Types.—Holotype♂, China, Hainan Prov., Diaoluo Mountain, 4 May 1965, coll. Liu Si-Kong. Paratypes: 1♂, China, Hainan Prov., Limu Mountain, 21 May 1963, collector unknown; 5♀, China, Hainan Prov., Diaoluo Mountain, 18/27 May 1964, 4 April 1964, 8/14 May 1964, coll. Liu Si-Kong; 1♀, China, Hainan Prov., Limu Mountain, 1 August 2002, coll. Che Yan-Li and Wang Zong-Qing (NWAFU)

Diagnosis.—This species resembles *Gergithus tessellatus* Matsumura, but it can be distinguished from the latter by the frons with two fasciae and the aedeagus complex with five spiniform processes.

Etymology.—The Latin prefix "*pseudo*" refers to the similarity of this species with *Gergithus tessellatus.*

Gergithus yunnanensis Che, Zhang, and Wang, new species

(Figs. 60–67)

Description.—Male length (including tegmen): 4.6 mm; length of tegmen: 3.7 mm.

Vertex brown. Eyes dark brown. Frons dark yellow with yellow fascia against frontoclypeal suture. Clypeus hazel, with dark brown fascia against frontoclypeal suture. Rostrum brown. Pronotum and mesoscutellum hazel. Tegmen yellowish hazel with dark brown stripe against costal margin and dark brown spot near apex. Wing hazel. Legs hazel, fore- and hindfemora with dark brown fasciae, fore- and hindtibiae with dark brown stripes. Venter hazel, apex dark brown. Abdominal dorsum hazel.

Vertex 2.1× wider at apex than medial length, disc slightly depressed. Frons broader than long, midlength 0.9× longer than greatest width, 1.2× wider at widest part than at base. Frontoclypeal suture nearly straight. Mesoscutellum broad and short, 2.2× wider at widest part than medial length. Tegmen 1.3× longer than wide at widest part. Wing large, 0.8× length of tegmen. Spinal formula of hind leg 6–7–2.

Male genitalia: Anal segment small, nearly oval in dorsal view, longer than medial width. In dorsal view, lateral margin slightly convex, apical margin strongly concave, basal margin concave; in lateral view, ventral margin strongly convex. Anal tube near middle of anal segment. Pygofer in profile slightly shorter ventrally than dorsally, dorsocaudal angle produced. Connective fused with aedeagus, U-shaped, asymmetrical, with dorsal, lateral, and ventral lobes; in dorsal view, dorsal lobes deflected to left side of aedeagus and ventral lobe to right side; dorsal lobes bilobate with apex tapering, 2 knifelike processes near middle; in lateral view, lateral lobes bilobate, apices obtuse; in ventral view, ventral lobe asymmetrical, apical margin slightly concave and right angle tapered to apex. Aedeagus stout, slightly curved downward medially, with 2 spiniform processes near midlength. Genital styles with apical margin wider than median, subtriangular, and rounded at ventrocaudal margin, process short and stout, apex tapering, hooked near base; in caudal view, inner apical angle incised, dorsal and ventral margins not parallel, genital style with a carina below process.

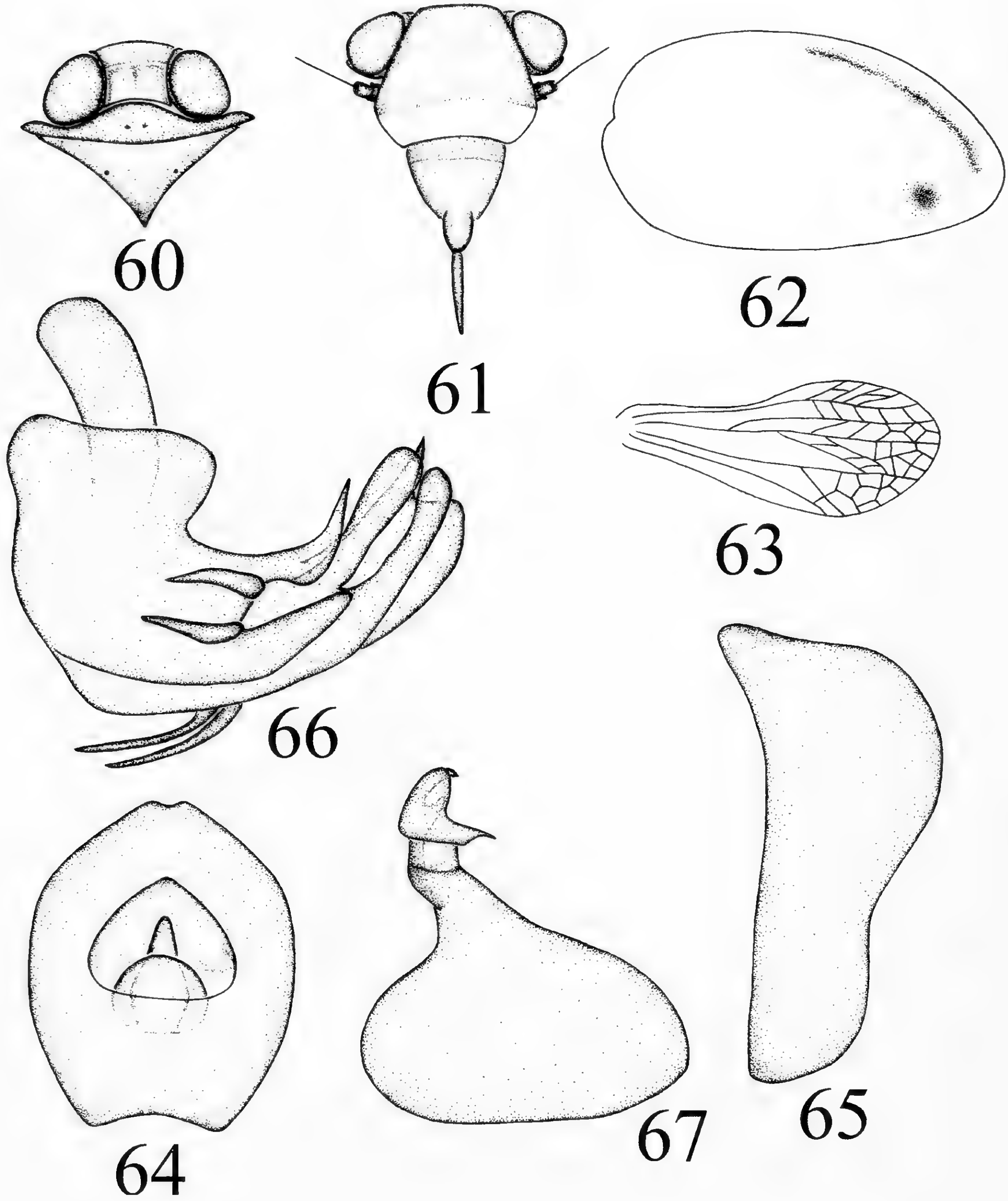
Type.—Holotype♂, China, Yunnan, Xishuangbanna, Kongming Mountain, 21 September 1957, coll. Zang Ling-Chao (IZCAS)

Diagnosis.—This species is similar to *Gergithus rotundus* Chan and Yang, but differs from the latter by the tegmen with one dark brown spot and stripe, and the spinal formula of hind leg 6–7–2.

Etymology.—The name of the new species refers to the type locality, Yunnan, China.

ACKNOWLEDGMENTS

We thank M. D. Webb (The Natural History Museum, London) for revising



Figs. 60–67. *Gergithus yunnanensis* (♂). 60, Vertex and throax, dorsal view. 61, Frons and clypeus. 62, Tegmen. 63, Wing. 64, Anal segment, dorsal view. 65, Pygofer, lateral view. 66, Aedeagus, left side. 67, Genital style, lateral view.

the manuscript. This project is supported by "Northwest A&F University Grant for Outstanding Faculty Members," and the Pilot Project of Standardized Curation, Data Integration and Resource Sharing of Zoological Collections by Ministry of Science and Technology of China (2005DKA21402).

LITERATURE CITED

Chan, M. L. and C. T. Yang. 1994. Issidae of Taiwan (Homoptera: Fulgoroidea). Taichung, Taiwan. 168 pp.

Che, Y. L., Y. L. Zhang, and Y. L. Wang. 2006. Two New Species of the Oriental Planthopper Genus *Hemisphaerius* Schaum (Hemiptera, Issidae). Acta Zootaxonomica Sinica 31(1): 160–164.

Chou, I., J. S. Lu, J. Huang, and S. Z. Wang. 1985. Economic Insect Fauna of China. Fasc. 36. Homptera, Fulgoroidea. Science Press, Beijing. 152 pp.

Hori, Y. 1969. Hemisphaeriinae of the Japan Archipelago (Hemiptera: Issidae). Transactions of the Shikoku Entomological Society 10(2): 49–64.

Melichar, D. L. 1906. Monographie der Issiden (Homoptera). Abhandlungen der K. K. Zoologisch-Botanisch Gesellschaft in Wien 3: 1–327.

Metcalf, Z. P. 1958. General Catalogue of the Homoptera, Fascicle IV Fulgoroidea Part 15 Issidae. Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C. 561 pp.

Stål, C. 1870. Hemiptera insularum Philippinarum Bidrag till Philippinska oarnes Hemiptera-Fauna. Ofversigt af Kongliga Svenska Vetenskaps Akademiens Förhandlingar 27: 607–776.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 628–642

NEW SPECIES OF *ELEODES* (COLEOPTERA: TENEBRIONIDAE)

CHARLES A. TRIPLEHORN

Department of Entomology, Museum of Biological Diversity, The Ohio State University, 1315 Kinnear Road, Columbus, OH 43212, U.S.A.

Abstract.—Twelve species of *Eleodes* Eschscholtz from the United States and Mexico are described as new: ***Eleodes aalbui*** (California), ***E. spiculiferus*** (Texas). Mexico: ***E. bidens*** (Durango), ***E. brucei*** (Durango), ***E. corrugans*** (Michoacán), ***E. mirabilis*** (Nuevo León), ***E. muricatulus*** (San Luis Potosí), ***E. platypennis*** (Jalisco), ***E. reddelli*** (Nuevo León), ***E. samalayucae*** (Chihuahua), ***E. scyropterus*** (Hidalgo), and ***E. watrousi*** (Durango).

Key Words: *Eleodes*, United States, Mexico

The genus *Eleodes* Eschscholtz is one of the largest, if not the largest genus of the family Tenebrionidae in the Western Hemisphere. There are approximately 230 described species divided into 13 subgenera, all confined to western United States and Mexico. The subgeneric classification is based largely on the female genitalia, which thus far has not proven to be totally satisfactory. Blaisdell (1909) in his monumental revision of *Eleodes* has seven plates illustrating female genitalia, yet in the large number of his subsequent papers in which many new species were described, not a single illustration of genitalia was provided. In the half century in which I have been studying these beetles, I have found no more reliable characters than the female genitalia for dividing this difficult genus into subgenera.

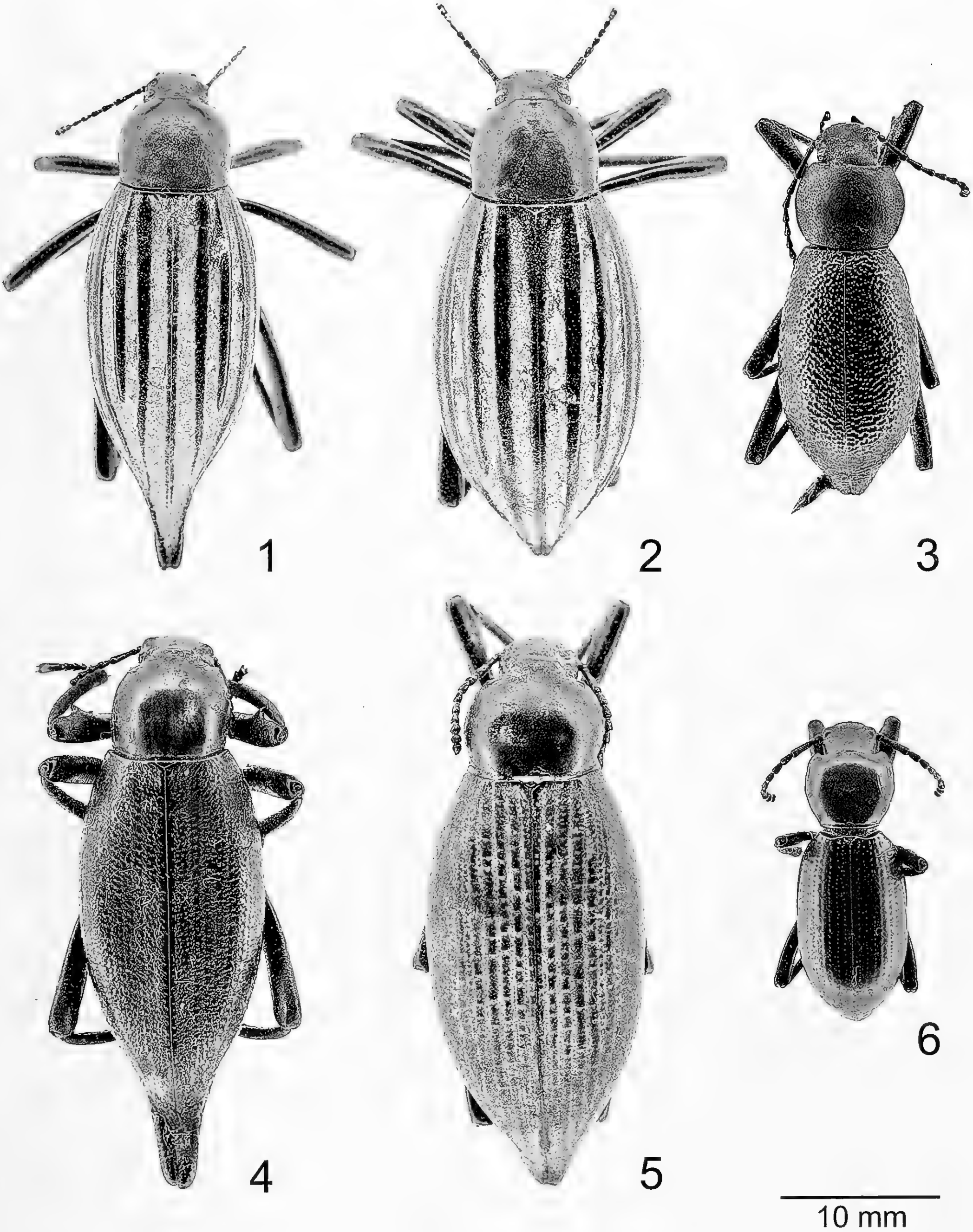
All species of *Eleodes* are wingless and there is a bewildering array of recognizable sedentary populations, many of which have been named, causing considerable synonymy. There are 26 names associated with the common and widespread *E. carbonarius (Say)*, some of which I am recognizing as subspecies, and others I am reducing to synonymy.

Species of *Eleodes* are a conspicuous component of the western beetle fauna, and a few have become economically important in arid land agriculture where they are known as "false wireworms," damaging root crops and other commodities.

In anticipation of a major revision of the genus *Eleodes*, I wish to make known the following new species.

Eleodes aalbui Triplehorn, new species
(Fig. 6)

Description.—Holotype female: Narrowly elongate, glossy, pronotum slightly darker than elytra. Head alutaceous, clypeus rounded, rugosely punctured, punctures becoming smaller and farther apart on frons which is slightly concave, sides reflexed and prominent over antennal insertions, fronto-clypeal suture scarcely evident; eyes narrow, elongate, antenna extending slightly beyond pronotal base. Pronotum slightly broader than long, widest near middle, sides rapidly narrowing toward base, smooth-



Figs. 1–6. *Eleodes* species, habitus. 1, *E. mirabilis*, male, Ciudad del Maiz, S. L. P. 2, *E. mirabilis*, female, same data. 3, *E. bidens*, male holotype, 9 mi E El Palmito, Durango. 4, *E. scyropterus*, male, 5 mi S Galeana, N. L. 5, *E. scyropterus*, female, 7 mi W Pachuca, Hdg. 6, *E. aalbui*, male, Inyo Co., CA, Inyo Mts.

ly rounded, anterior margin excavate with angles prominent, basal margin straight, marginal bead fine, visible from above, surface minutely and sparsely punctate. Elytra punctate-striate, punctures fine, closely spaced, not in grooves, intervals with a single row of minute punctures. Ventral surface concolorous with dorsum, prosternum coarsely and densely punctate, prosternal process rugose, its apex deflexed between procoxae, hypomera impunctate laterally; mesosternum rugosely punctured, abdominal sterna scarcely punctate medially, punctures coarser and denser laterally; legs stout, finely and sparsely punctate, profemur with blunt tooth at apical fifth. Length: 18.3 mm; width: 6.0 mm.

Allotype male: Similar to holotype but with profemoral tooth stronger.

Variation.—There is very little variation in the type series in terms of shape, size, and coloration. Size ranges from 16.0 to 18.3 mm. in length.

Types.—Holotype ♀: California, Inyo County, Inyo Mts., Willow Springs Canyon, 4600 ft., 1.5 mi n, 6.5 mi e of Independence, VI-1 to VIII-24-1984, D. Giuliani (CASC). Allotype ♂: Inyo County, Saline Valley, Grapevine Canyon, 4000', V-23 to XI-23-1983, D. Giuliani (CASC). Paratypes: 5, same locality as holotype, except dates (6-XII-1984 to 20-XII-1986; 3-I to 1-VI-1984; 2, Inyo County, Inyo Mts., Lead Canyon, 21-XII to 12-VIII-1982, D. Giuliani; 1, same data as allotype; 9, Inyo County, Inyo-White Mts., Westgate Pass, Poleta Cave, V-21 to XI-5-1988, R. L. Aalbu. All were collected in antifreeze pitfall traps. Paratypes in CASC, OSUC, and RLAC.

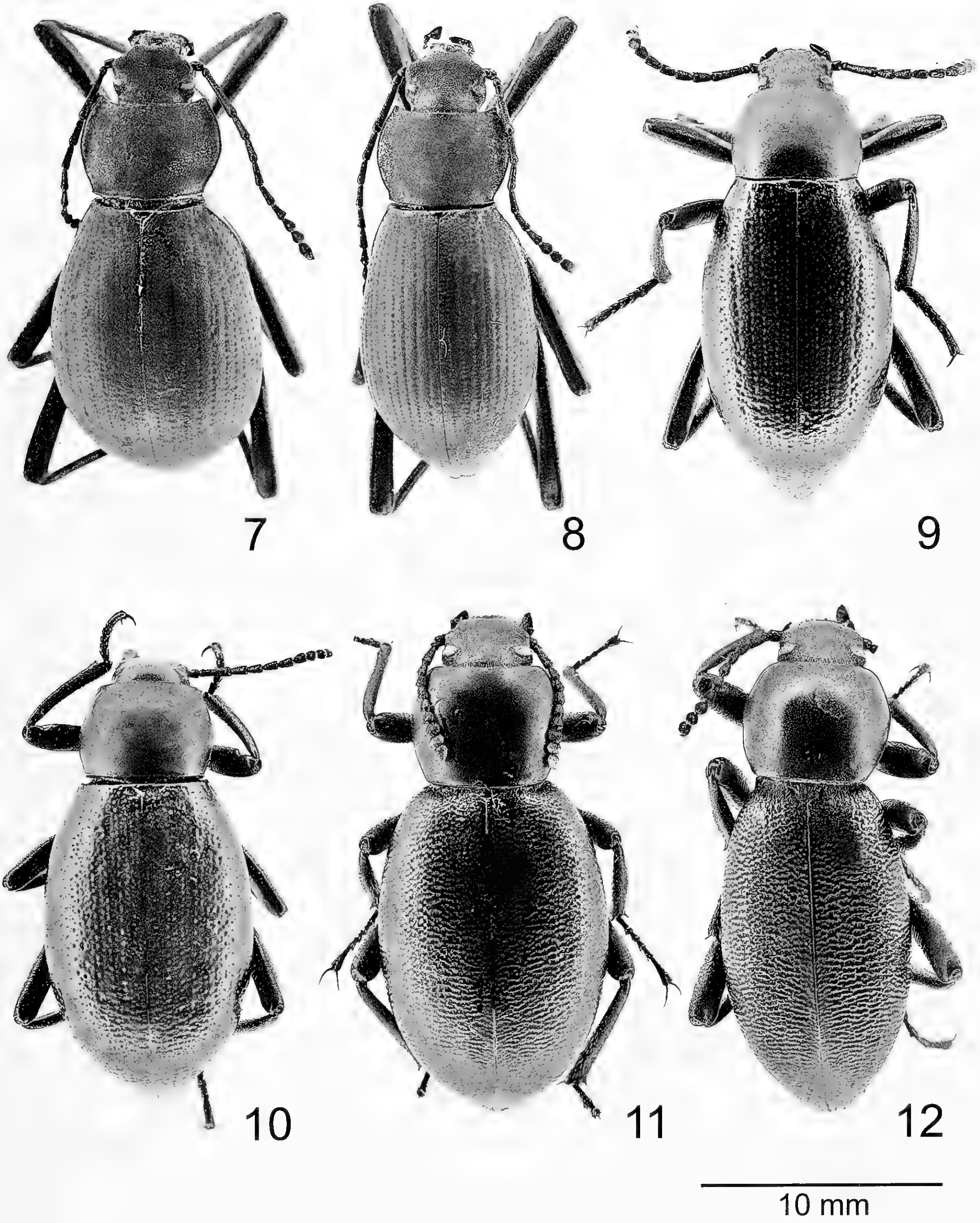
Discussion.—This species is most like *Eleodes dissimilis* Blaisdell, except that the body is more cylindrical, the pronotum is more convex from side to side, its anterior margin arcuate, with angles prominent, and the frons is concave. It belongs to the subgenus *Metablapylis.*

Etymology.—I take pleasures in naming this species in honor of Dr. Rolf L. Aalbu, an accomplished collector, outstanding tenebrionid specialist, and good friend who collected part of the type series and provided all of the specimens known to me.

Eleodes corrugans Triplehorn, new species
(Figs. 11, 12)

Description.—Holotype female: Elongate-oval, robust, black, shining. Head finely and densely punctured, epistomal margin broadly, shallowly arcuate; clypeus coarsely punctured with conspicuous amber setae; eyes narrow; elongate, antenna stout, attaining pronotal base, antennomere 3 subeqeual to 4 and 5 combined; mentum trapezoidal, coarsely sculptured; ventral surface coarsely and densely punctured, each puncture bearing a short, dark seta. Pronotum one-fourth broader than long, sides moderately rounded with fine marginal bead, anterior margin broadly emarginate, angles obtusely rounded, not prominent, base subtruncate, angles obtusely rounded, convex from side to side, widest slightly anterior to middle; surface minutely and densely punctate, each puncture separated by several times its diameter; hypomera finely wrinkled laterally. Elytra narrowly elongate, sides subparallel, narrowing toward both base and apex, humeri obsolete, surface with fine transverse wrinkles. Abdominal sterna finely longitudinally wrinkled, legs, moderately long, femora finely and sparsely punctured, tibiae moderately coarsely punctured, each puncture with pale, stout seta, basal protarosmere prolonged, acute, longer than protibial spurs, all tarsal claws long and slender. Length: 20.3 mm; width: 11.5 mm.

Allotype male. Similar to female but much more slender, basal protarsomere clothed beneath with fine, dense, golden setae, basal mesotarsomere with dense



Figs. 7–12. *Eleodes* species, habitus. 7, *E. reddelli*, female holotype, 2.4 km S Minas Viejas, N.L. 8, *E. reddelli*, male allotype, same data. 9, *E. brucei*, male, 2 mi NW Nombre de Dios, Dgo. 10, *E. brucei*, female, same data. 11, *E. corrugans*, female holotype, Uruapán, Mich. 12, *E. corrugans*, male allotype, Morelia, Mich.

golden setae; metatarsomeres bearing dense stout spines (as in female). Length: 20.2 mm; width: 8.2 mm.

Types.—Holotype ♀: Mexico, Uruapán [Michoacán] , 28-5-72, no collector (OSUC). Allotype ♂: Sierra de Durango (from Oberthur collection, MNHN). Paratype: 1 ♀, Mexico, Morelia [Michoacán], 15-VIII-1993, no collector, from the collection of P. Leo, sent to me for determination by Daniele Sechi (OSUC).

Remarks.—This species belongs to the subgenus *Steneleodes* and is similar to *E. compressitarsus* Blaisdell, except for the transversely wrinkled elytra.

Etymology.—The name refers to the corrugated sculpture of the elytra which resembles ripple marks in sand.

Eleodes spiculiferus Triplehorn, new species

(Figs. 15, 16)

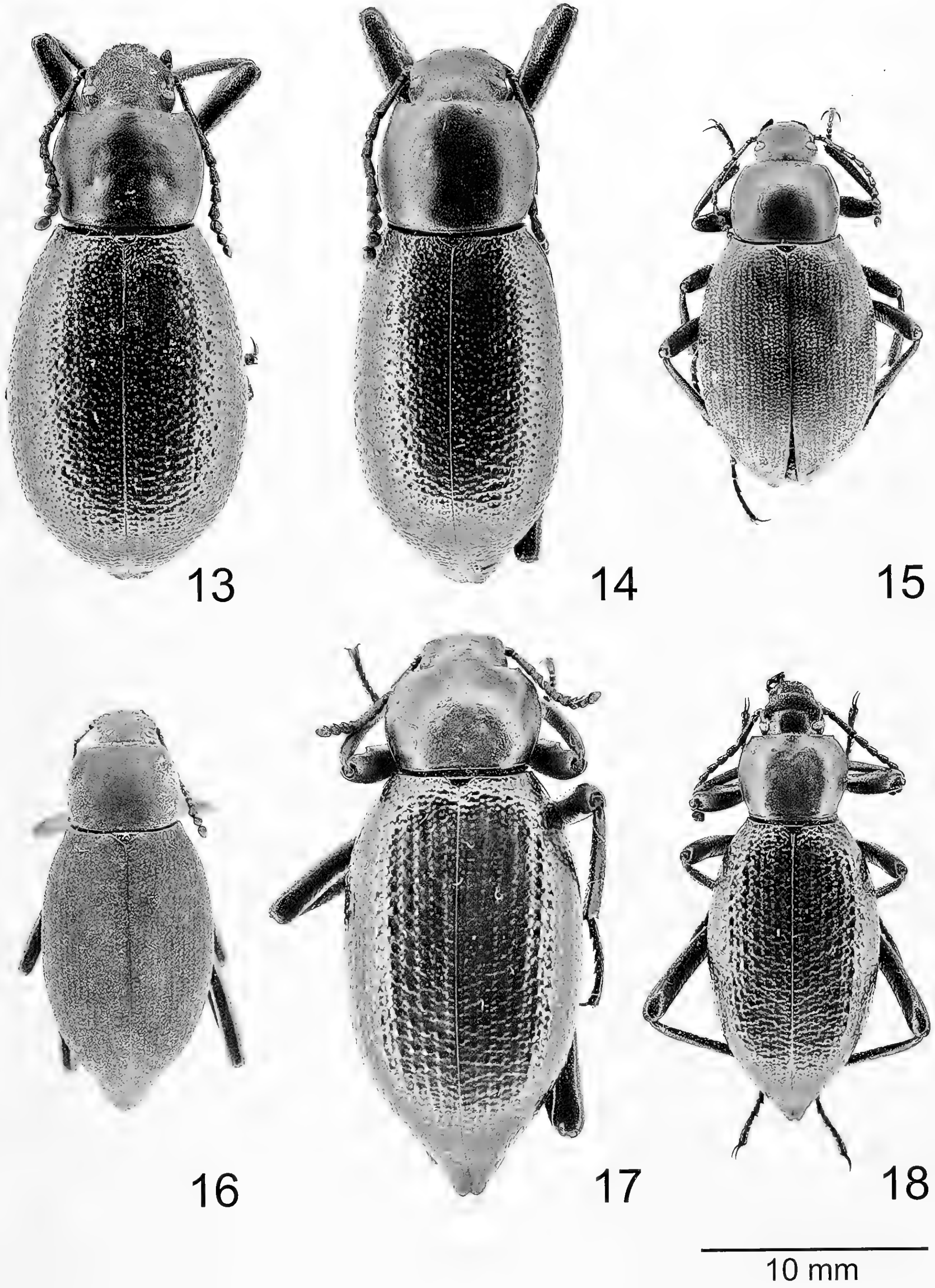
Description.—Holotype female: Oblong-oval, dull, piceous. Head moderatly densely punctate, most punctures separated by several times their diameters; epistomal margin truncate; eyes narrow, elongate, scarcely emarginate anteriorly; antenna short, third antennomere subequal to 4–6 combined; mentum trapezoidal, rugose. Pronotum broader than long, sides slightly rounded from base to apex with very fine marginal bead, widest at middle, basal margin arcuate, angles obtusely rounded; anterior margin almost truncate, angles obtuse, not prominent; surface finely and muricately punctate, punctures subequal to those of head. Elytra with sides evenly rounded from base to apex, not margined laterally, humeri prominent, embracing base of pronotum; striae absent, surface finely and densely papillose, each papilla bearing a short, pale, recumbent seta; hypomera and prosternum smooth with a few scattered muricate punctures, prosternal process convex between procoxae, apex secondarily reflexed, moderately prominent; ventral surface, including abdominal sterna, coarsely. muricately punctate; legs coarsely and densely punctate. Length: 14.8 mm; width: 7.8 mm.

Allotype, male: Similar to female but with dentate profemur (mutic in female), a dense pad of short, golden setae on basal protarsomere (coarse spines in female), and antenna stouter, with third antennomere slightly longer than 4 and 5 combined. Length: 17.0 mm; width: 7.0 mm.

Types.—Holotype ♀ allotype ♂ (TAMU) and one ♀ paratype (OSUC): Texas, Anderson County, Engeling Wildlife Management Area, V-31-2001, E. G. Riley (TAMU). Paratypes: 2 ♀, 2.5 mi. sw of Forestburg, Montague County, 30-V-1951, B. Patterson (FMNH); 1 ♀, same data except 22-29-IV-50 (FMNH); 1 ♂, Anderson County, Gus Engeling Wildlife Management Area, mv+bl, 29 May, 1998, R. Turnbow (RHTC); 1 ♂, Forestburg, VIII-15-1949 (NMNH); 1 ♂, Oakwood [Freestone County], V-4-1956, H. Howden (OSUC); 1 ♂, Freestone Co. Old Spring Seat Church, nr. Donie, V-6-1995, E. Riley (TAMU); 1 ♀, Leon County, 5 mi. n of Flynn, VIII-13-1994, E. G. Riley (TAMU).

Remarks.—It seems incredible that so few specimens of this unusual species are known and from such widely separated localities. It appears to belong to the subgenus *Promus*, but does not seem closely related to any other species in the subgenus. The elytral setae are similar to those of *E. opacus* Horn, the only other setose member of the subgenus, but lacks the sharp lateral margins of the elytra so characteristic of that species. The dense pad of golden setae on the basal protarsomere of the male is also diagnostic.

According to Robert Turnbow, his specimen was collected at the Gus Engeling Wildlife Management Area, Tennessee Colony, Texas. There the soils are mostly light colored, rapidly perme-



Figs. 13–18. *Eleodes* species, habitus. 13, *E. watrousi*, female holotype, 2 mi NW Nombre de Dios, Dgo. 14, *E. watrousi*, male allotype, same data. 15, *E. spiculiferus*, female, 2.5 m SW Forestburg, TX. 16, *E. spiculiferus*, male, Anderson, Co., TX, Engeling W.M.A. 17, *E. muricatulus*, female holotype, El Refugio, S.L.P. 18, *E. muricatulus*, male, El. Obligato, Zac.

able sands and the vegetation consists of deciduous forest with an overstory of oak hickory, sweetgum, and elm.

Riley's specimens from Engeling WMA, and from the localities of "Old Spring Seat Church," and "5 mi n of Flynn," are also areas of deep sand. All of these exposed sands are part of a narrow band of Eocene sand outcrops that extend diagonally across the eastern half of Texas, from the Rio Grande into northeastern Texas. Vegetation of these areas often differs markedly from surrounding Texas coutryside, and is characterized by sparsely vegetated patches that include blue jack oak (*Quercus incana* Bartr.), hickory (*Carya* sp.), and *Yucca* sp. The Howden locality of "Oakwood, Freestone Co." is also part of this sand outcrop (E. G. Riley, personal communication).

Etymology.—The specific epithet refers to the small spicules adorning the elytra.

Eleodes mirabilis Triplehorn, new species
(Figs. 1, 2)

Description.—Holotype female: Elongate, robust, fusiform, moderately convex, black, shiny. Head finely and sparsely punctured except where punctures are coarser and almost contiguous along epistomal margin, clypeal suture distinct; eyes narrow, elongate; antenna short, scarcely extending caudad beyond pronotal base. Pronotum almost as long as broad, broadest about middle, lateral margins slightly arcuate, subparallel, briefly sinuate just before acute and prominent apical angles, marginal bead indicated only at base and apex, basal angles obtuse, anterior margin truncate; disc convex, surface minutely and sparsely punctate , strongly shining; hypomera smooth, impunctate. Elytra elongate, tapering gradually behind, forming a distinct cauda; each elytron with sutural, marginal and three discal costae, all of which reach elytral base, first and third costae joined shortly before apex, central discal costa ending about 2/7 distance from apex, all costae smooth and shiny, with a row of widely spaced muricate punctures; area between costae flat, clothed with short, black, not very densely spaced setae. Legs long, slender, all tarsi with planter grooves not interrupted by fine setae; profemur with distinct obtuse tooth one third from apex; abdominal sterna finely and sparsely punctate, faintly wrinkled, shiny; prosternal process deflexed behind, secondarily reflexed and acute apically; mesosternum slightly concave, coarsely sculptured. Length; 32 mm; width: 12.5 mm.

Allotype male: Similar to female but more slender, with longer cauda, and with profemoral tooth acute. Length: 30.2 mm width: 10.7 mm.

Variation.—In several males, the second and third discal costae are joined apically at about 5/12 elytral length from apex. A female has the same two costae joined on the right elytron with the left elytron as in holotype. In two specimens, the discal costae are only slightly indicated.

Types.—Holotype ♀, allotype ♂, and 4 ♂ paratypes: MEXICO: Nuevo León, 42 km n, 3 km. w of Doctor Arroyo, 25 July, 1981, Allan Chaney (TAIU). Paratypes: MEXICO: 1 ♂, 4 ♀, San Luis Potosí, 12 mi. nw of Ciudad del Maiz, 20 November, 1948, H. B. Leech and E. S. Ross (CASC); 1 ♂, Nuevo León, 5 mi. W of Doctor Arroyo (6200'), 22 September, 1976, J. A. Chemsak, J. Powell, A. and M. Michelbacher (CISC); 1 ♂, San Luis Potosí, 3 mi. w of Cedral (6000'), 21 September, 1976, Chemsak, Powell, A. and M. Michelbacher (CISC); 1 ♀, San Luis Potosí, 31 km s. of San Luis Potosí (1950 m), 4–5 August, 1974, E. M. and J. L. Fisher (CISC); 1 ♀, San Luis Potosí, Rio Verde, 3 mi. e (nr Rio Verde River), 25 August. 1969, J. Doyen, J .K. Haddock (CISC); 1 ♀, S. L. P., 4 mi. E of Rio Verde, 29 August, 1969, J. Doyen (CISC); 2 ♂, Tamaulipas, Hwy 80× k101, 10 August, 1975, G. Merkord (TAIU); 2 ♂, S. L. P., Valles, 22 May, 1972, V.C. Allman (BYUC); 1 ♂, 1 ♀, San Luis Potosí, Yucca Flat, 3-VIII-1977, P. Blom, A. Allen (ACIC); 3 ♂, 1 ♀, San Luis Potosí, km 54 on Hwy. 80 w of Ciudad del Maiz, 5-X-1980, P. Blom (ACIC); 1 ♀, Nuevo León, 29 km n San Cayentano de las Vacas, 31-V-1981, W. E. Steiner (USNM); 1 ♂, S. L. P., 11 mi n. Matahuala, 2-IX-1958, H. F. Howden (CNCI). UNITED STATES: Texas, 1 ♂, Comstock (Val Verde Co.) 20 July, 1972, S. M. Benbow (TTCC).

Remarks.—This is one of the largest and most easily recognized species in the genus *Eleodes*. The flat areas between the elytral costae are usually coated with argillaceous material of varying thickness which causes the shiny elytral costae to stand out in bold relief. Both external morphology and male and female genitalia place this species in the subgenus *Eleodes*, section B of the *E. dentipes* group as defined by Blaisdell (1909: 234), but it is not very closely related to any species heretofore described.

Etymology.—From Latin: wonderful, strange.

Eleodes scyropterus Triplehorn, new species

(Figs. 4, 5)

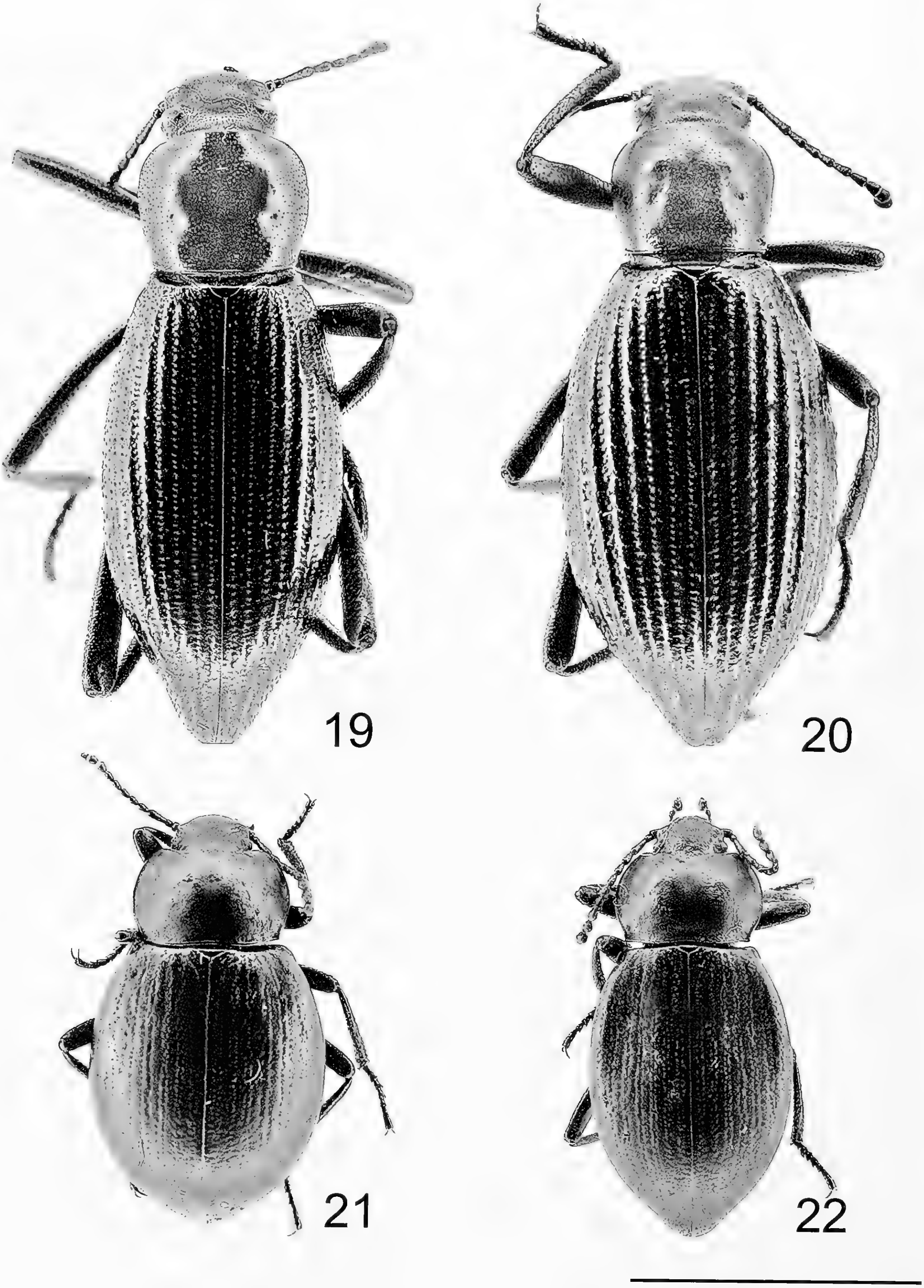
Description.—Holotype female: Similar to preceding species, differing principally in elytral sculpture, consisting of a series of moderately large muricate tubercles, with smaller, more closely spaced tubercles between, causing entire surface of elytra to be rough, almost filelike; both large and small tubercles each with a short, dark, semierect seta arising from posterior side Length: 32.5 mm; width: 11.5 mm.

Allotype male: Similar to female but more slender and with a much longer cauda, profemoral teeth acute. Length: 34.4 mm; width: 11.4 mm.

Variation.—The punctation of a male from near Galeana is distinctly finer and more sharply defined. Also, the cauda of this same specimen is angled rather abruptly upward for its entire length. In the three Galeana specimens, the lateral bead of the pronotum is very fine but distinct.

Types.—Holotype ♀: MEXICO, Hidalgo, 7 mi w Pachuca, 24-VI-1975, CA, WE, BW Triplehorn (OSUC). Allotype ♂ : Nuevo León, 5 mi s Galeana, 8-VIII-1959, B. & B.Valentine (OSUC). Paratypes: 1 ♀, Nuevo León, 10 mi. west of San Roberto (7000'), 15 IX-1976, J. A. Chemsak, J. Powell, A & M Michelbacher (CISC); 1 ♂, Nuevo León, 8 mi. e of Estancia Roberto, Hwy 85 (1800 m), 11-VIII-1977. E. L. Schlinger (CISC); 2 ♂, 1 ♀, Guanajuato, Hwy 57, km 306, Rancho Jardin, 10-VIII-1965, Cornell Field Party, desert scrub (CUIC); 1 ♂, Nuevo León, Rt. 58, 8 km. e junction Rt. 57, 17-VII-1988, R. Turnbow (RHTC); 1 ♂, 1 ♀, Queretaro, 10 mi. n Vizarron at km 90 (5300'), 19-VI-1971, A. O. Allen; 1 ♂, Nuevo León, Monterey, IX-1-1957, S. G.Wellso (MSUC); 1 ♂, Durango, Graceros, (6000'), 7-VII-1961, R.A Scheibner (MSUC); 1 ♀:, Zacatecas, Sombrerete, 3-V-1961, Howden and Martin, under rocks (CNCI); 1 ♀, Aguascalientes, I-1892 (DEUN); 1 ♂, Zacatecas, 30 mi sw Concepción del Oro, 9-VII-1983, Kovarik, Harrison, Schaffner (TAMU); 1 ♀, Aguascalientes City, Höge (BMNH). This last paratype was incorrectly determined by Champion as *E. glabricollis* and listed in the *Biologia Centrali-Americana* (Champion 1892: 515).

Remarks.—*Eleodes scyropterus* and *E. mirabilis* appear to be very closely related. Further collecting in northern Mexico is needed to establish relationships. Since the elytral sculpturing is so radically different in the two (see figures), and since no intermediate forms were encountered, I



Figs. 19–22. *Eleodes* species, habitus. 19, *E. samalayucae*, male, Samalayuca, Chih. 20, *E. samalayucae*, female, same data. 21, *E. platypennis*, female, Sierra de Manantlan, Jal. 22, *E. platypennis*, male, same data.

choose to consider them distinct species at this time. It belongs to the nominate subgenus *Eleodes*.

Etymology.—From Greek: scyro (rough), ptero (wing).

Eleodes platypennis Triplehorn, new species

(Figs. 21, 22)

Description.—Holotype female: Broadly oval, flattened, dull, opaque. Head with epistomal margin truncate, frontoclypeal suture scarcely evident; surface finely and densely punctate; eyes narrow, elongate, antenna short, stout, extending just past base of pronotum, antennomere 3 subequal to 4–5 combined; mentum small, rounded, rugosely punctured. Pronotum 2/5 broader than long, sides broadly and uniformly rounded, widest at middle, with strong marginal bead, basal margin subtruncate, with strong bead, basal angles obtuse; anterior margin broadly emarginate, with fine bead, angles obtuse; surface minutely and sparsely punctate. Elytra broadly rounded, sharply deflexed laterally, finely punctate-striate, punctures not in grooves, intervals flat, with rows of punctures slightly smaller than those of striae. Ventral surface, hypomera smooth, longitudinally wrinkled near procoxae; prosternum coarsely, rugosely punctured, prosternal process deflexed between procoxae, apex not prominent; mesosternum coarsely punctured, scarcely excavate anteriorly; metasternum coarsely punctured; abdominal sterna almost smooth (except for terminal one with distinct punctures), finely wrinkled, especially laterally; legs short, metafemora extending only to middle of third visible abdominal sternum; all femora finely and sparsely punctate, tibiae with fine muricate punctures, each bearing a short, pale seta, protibial spurs short, thin; tarsi with short, stout setae. Length 11.8 mm; width: 7.0 mm.

Allotype male: Almost identical to female, sexes separable only by dissection. Length: 12.5 mm; width: 6.7 mm.

Variation.—In several specimens the elytral intervals are subconvex, otherwise the series is quite uniform in size, shape, luster, and punctation.

Types.—Holotype ♀, allotype ♂, and 3 paratypes: Mexico, Jalisco, Sierra de Manantalan, Bosque Mesofilo, 1899–1900 m, 18-VII-1985, J. Doyen (CISC). Two paratypes, same data (OSUC); one ♂ paratype, same locality, but 21-III-1990, J. Pal (HNHM).

Remarks.—This species bears a superficial resemblance to *E. tesselatus* Champion, but the female genitalia are quite different. I am unwilling to assign either of these species to any known subgenus at this time.

Etymology.—The specific epithet refers to the flat elytra.

Eleodes muricatulus Triplehorn, new species

(Figs. 17, 18)

Description.—Holotype female: Elongate, slender, fusiform, subconvex, black, shining. Head with frons finely and sparsely punctate, frontoclypeal suture indistinct, clypeus moderately densely punctured, eyes small, narrow, elongate, antenna moderately long, extending three antennomeres beyond base of pronotum. Pronotum slightly broader than long, broadest slightly anterior to middle, lateral margins arcuate, narrowing rapidly toward base, basal margin rounded, angles obtusely rounded, apical margin shallowly emarginate, apical angles acute, prominent, marginal bead fine and entirely visible from above; disc subconvex, surface minutely and sparsely punctate, glossy. Elytra elongate, widest near middle, sides subparallel, narrowing gradually to apex, not meeting at midline, but each separately rounded, apex bifid; surface with uniform longitudinal rows of muricate punctures with shiny crests, intervals microreticulate, glossy. Ventral surface shiny, propleura almost impunctate, prosternal process deflexed between procoxae, abdominal sterna shiny, finely wrinkled; legs long, profemur with blunt tooth at outer 1/5, metafemur attaining elytral apex. Length: 24.8 mm; width: 9.5 mm.

Allotype male: Similar to female, but with strong profemoral tooth at outer 1/5. Length: 19.7 mm; width: 7.8 mm.

Variation.—The size and sculpture of the seven available specimens is very constant. Both sexes have very similar body proportions and it is necessary to check the profemoral teeth to distinguish between them.

Types.—Holotype ♀: MEXICO, San Luis Potosí, El. Refugio, 2-IX-1958, H. F. Howden, roadside flowers (CNCI). Allotype ♂: San Luis Potosí, 3 mi w Cedral (6000'), 21-IX-1976, J. A. Chemsak, J. Powell, A. and M. Michelbacher (CASC). Paratypes: 1 ♂, San Luis Potosí, 7.6 mi ne San Luis Potosí on Mex. Rt. 30 (6075'), 8 IX-1964, W L. Nutting and sons (UAZC); 1 ♂, San Luis Potosí, Ft. Huizache, 22-VIII-1954, J. G. Chillcott (CNCI); 1 ♀, Coahuila, 20 mi se Saltillo, 10-VII-1963, H. and A. Howden (CNCI); 1 ♂, Zacatecas, 7 mi e Sombrerete, 31-VIII-1965, Gertsch and Hastings (AMNH); 1 ♀, Zacatecas, El Obligado, (2100 m), 2-VII-1990 leg. Heinz (SMNS)

Remarks.—This species belongs to the nominate subgenus *Eleodes* and resembles *E. scyropterus* in elytral sculpture, but males are not caudate as in that species.

Also, the pronotum is quadrate in *E. muricatulus* and longer than broad in *E. scyropterus*

Etymology.—The specific epithet refers to the muricate sculpture of the elytra.

Eleodes brucei Triplehorn, new species
(Figs. 9, 10)

Description.—Holotype female: Oblong, ovate, robust, head and pronotum dull, elytra shiny. Head finely and densely punctate; antenna stout, extending caudad two antennomeres beyond base of pronotum. Pronotum quadrate, widest anterior to middle, sides feebly arcuate, slightly narrowed to base, marginal bead fine and sharp, basal margin straight, basal angles obtuse, apical margin arcuate, apical angles right, not prominent, surface dull, very finely, somewhat irregularly punctate; elytra with three distinct striae on either side of suture, composed of large, well-separated, deep punctures, intervals with much finer more closely spaced, slightly irregular punctures; remander of elytra confusedly punctured, with punctures of two sizes, tending to coalesce laterally, forming transverse plicae. Ventral surface glossy black, hypomera impunctate, smooth, with a few wavy lines along upper margin and laterad of procoxae; prosternum smooth, prosternal process rugosely sculptured between procoxae, strongly prolonged caudad, acute and horizontal, a slight depresson on face of mesosternum for its reception. Abdominal sterna finely and very sparsely puncate, except terminal sternum on which punctures become coarser and denser from base to apex. Legs moderate in length, stout, profemur with distinct anteapical notch, protibial spurs subequal, mesothoracic and metathoracic legs without modifications; all tarsi with only coarse setae on plantar surfaces (no setae in plantar grooves). Length: 19.0 mm; width: 8.4 mm.

Allotype male: Similar in punctation to female, much more slender. Profemur strongly dentate anteriorly, basal protarsomere with conical tuft of dense golden setae interrupting plantar groove. Length: 17.8 mm width: 7.0 mm.

Variation.—The type series is relatively homogeneous. In a few specimens, the serial arrangement of punctures is evident over the entire elytra, in some, even the striae bordering the suture have lost the serial arrangement. In the more strongly punctured individuals, the entire elytra are somewhat rugose due to coalescence of punctures. The shape of the pronotum is somewhat variable, the sides are often subparallel and widest at the middle. Females range from 16.4–19.4 mm in length; males 14.6–18.0 mm.

Types.—Holotype ♀, allotype ♂, and 89 paratypes (52 ♀, 37 ♂): MEXICO, 2 mi. NW of Nombre de Dios, 12-VII-1975, CA, WE, and BW Triplehorn, L. E. Watrous, D. S. Chandler, F. W. Fisk, and Q. D. Wheeler. Holotype, allotype, and paratypes in OSUC. Paratypes in BMNH, MNHN, FMNH, CUIC, and DSCC. Additional specimens seen, but not designated paratypes: 1 ♀, Nombre de Dios, Durango (5900'), 13-VIII-1947, W. Gertsch; 5 ♀, same location, 4 VIII-1954, M. Cazier, W. Gertsch, Bradts (AMNH); 1 ♂, 5 ♀, Zacatecas, 1 km S of Tropic of Cancer on Rt 45, 29-IX-1982, B.W. Triplehorn (OSUC); 1 ♂, Zacatecas, Guadeloupe, 16-VIII-1947, M. Cazier (AMNH).

Remarks.—*Eleodes brucei* belongs to the subgenus *Promus* as indicated by the female genitalia. It most closely resembles *E. montanus* Champion which is known from only a few specimens collected in the Alvarez Mountains (presumably in the state of San Luis Potosí, see Selander and Vauri 1962: 201). Both have relatively coarse, simple elytral punctures which are subserial in arrangement with smaller punctures on the intervals.

Both males and females of *E. brucei* have the prosternal process subhorizontal with the apex prolonged and acute; in *E. montanus*, the process is deflexed behind the procoxae with the apex secondarily reflexed and mucronate. The lateral marginal bead of the pronotum is extremely fine and scarcely visible from above, whereas in *E. montanus*, the bead is much more strongly developed, slightly reflexed, and entirely visible from above. In males of *E. brucei*, only the basal protarsomere has a tuft of fine golden setae interrupting the plantar groove; *E. montanus* has such setal tufts on the two basal protarsomeres.

The entire type series was collected on a single night with the aid of battery-operated headlamps. It was the most abundant species of *Eleodes* in the area at that time.

Etymology.—I take pleasure in naming this species for my son, Dr. Bruce Wayne Triplehorn, a diligent and enthusiastic collector, who helped collect the type series.

Eleodes reddelli Triplehorn, new species
(Figs. 7, 8)

Description.—Holotype female: Obovate, robust, black, opaque. Head finely and sparsely punctate, frontoclypeal suture well defined, epistomal margin feebly emarginate; eyes very narrow; elongate, antenna long, slender, extending about 5 antennomeres beyond pronotal base, antennomeres 3–8 cylindrical, 9–10 about as long as wide, 11 larger and acuminate apicaly; mentum trapezoidal, longitudinally rugose, ventral surface coarsely and densely punctured. Pronotum 1/3 broader than long, sides strongly rounded, widest at middle, slightly sinuate near base, lateral marginal bead extending around both basal and apical angles, basal angles obtusely rounded, apical margin broadly emarginate, angles acute, prominent; surface minutely and sparsely punctate; elytra strongly inflated behind, abruptly declivous, humeri obsolete, epipleura broad, smooth basally, slightly reflexed near apex, surface punctate-striate, strial punctures, not in grooves, individual punctures separated by several times their diameters, intervals with a single row of very minute punctures; hypomera almost smooth with a few wrinkles and scattered minute punctures; prosternal process rugosely punctured, mesosternum coarsely and densely punctured, scarcely excavate anteriorly; metasternum and abdominal sterna practically smooth, with feeble longitudinal wrinkles laterally; legs long and slender, tibiae clothed with short, stout setae, plantar surfaces of tarsi with stout setae. Length: 19.2 mm; width: 8.7 mm.

Allotype male: Similar in color, size, and sculpture to female, but much more slender and with profemur strongly dentate in apical ¼.

Variation.—The three females and one male comprising the type series are very uniform in size and scultpture.

Types.—Holotype ♀: MEXICO, Nuevo León, Cueva de Cuchillo, 2.5 km s of Minas Viejas, 1270 m, 22 April, 1998, Peter Sprouse. Allotype ♂: same locality but 24 Nov., 1995, G. Veri. Paratypes: 1 ♀, Mexico, N. L. Gruta del Palmetto, 4 mi S of Bustamente, 12-30-64, F. McKenzie; 1 ♀, same locality, but 15-IX-1942, C. Bolivar. Holotype and allotype deposited in TAMU. Paratypes in TMMC and CNIC.

Remarks.—This species is a member of the subgenus *Caverneleodes* as indicated by the long, slender antennae, small eyes, and the female genitalia. It is by far the largest member of the subgenus. The large size, long, slender legs, and inflated elytra are distinctive.

Etymology.—This species is named in honor of James Reddell, who has collected many unusual beetles and other arthropods in caves.

Eleodes watrousi Triplehorn, new species
(Figs. 13, 14)

Description.—Holotype female: Elongate-oval, robust, piceous, head and pronotum dull, elytra shining. Head finely and densely punctured, epistomal margin shallowly emarginate, clypeolabial suture scarcely evident; eyes narrow, elongate, upper lobes slightly larger than ventral; antenna stout, extending about four antennomeres beyond pronotal base, antennomere 3 subequal to 4–6 combined; mentum trapezoidal, about as long as broad; gular area longitudinally finely wrinkled. Pronotum ¼ broader than long, widest just anterior to middle, sides moderately rounded, narrowing toward base, basal margin round, angles obtuse, anterior margin shallowly emarginate, angles rectangular, slightly prominent, lateral marginal bead very fine; surface minutely and sparsely punctate; hypomera strongly sculptured, especially adjacent to procoxae; prosternum strongly sculptured, prosternal process horizontal, its apex acute and prominent. Elytra convex, sides strongly rounded, apical declivity steep; humeri obsolete; punctures coarse, not in rows, tending to coalesce into horizontal rugae. Mesosternum rugose, feebly excavate anteriorly; metasternum and abdominal sterna smooth, almost impunctate but with conspicuous wrinkles, terminal abdominal sternum more coarsely punctate. Legs slender, finely and densely punctate; profemur with slight emargination at apical 1/5, protibial spurs very short, metafemora not quite attaining elytral apex, all tarsi clothed beneath with short dark setae. Length: 23.5 mm; width: 10.3 mm.

Allotype male: Similar to female, but slightly more slender and with profemur strongly dentate at anterior 1/5, and basal protarsomere with dense, fine, pale setae in plantar groove. Length: 22.0 mm; width: 8.7 mm.

Types.—Holotype ♀, allotype ♂, and five paratypes: Mexico, Durango, 2 mi. NW of Nombre de Dios, 12- VII-1975, C. A., W. E., B.W. Triplehorn, L. E. Watrous, collectors (OSUC).

Remarks.—This species is known only from the type series. It belongs to the subgenus *Promus* and differs from all other members of that subgenus in having the elytra rugosely punctured and without striae.

Etymology.—I am pleased to name this interesting species in honor of Dr. Larry E. Watrous, a skilled and dedicated companion in the field and an accomplished beetle systematist who collected part of the type series.

Eleodes bidens Triplehorn, new species

(Fig. 3)

Description.—Holotype male: Similar to *E. watrousi*, but with pro- and mesofemora bearing denticles at apical 1/5 on both upper and lower surfaces, and metafemur slightly dentate. Head and lateral portion of pronotum more densely punctate than in that species. Prosternal process deflexed between procoxae, its apex not prolonged; ventral surface, especially abdominal sterna, rugosely punctured. Length: 22.8 mm; width: 8.5 mm.

Holotype.—♂, Mexico, Durango, 9 mi E of El Palmito (7500'), 15-VI-1971, H. F. Howden (CNCI).

Remarks.—This is the only species of *Eleodes* I have seen with double teeth on the pro- and mesofemora, a very unique character. It belongs to the nominate subgenus *Eleodes*.

Etymology.—The specific epithet refers to the double teeth on the pro- and mesofemora.

Eleodes samalayucae Triplehorn, new species

(Figs. 19, 20)

Description.—Holotype female: Elongate, slender, black, shining. Head finely and sparsely punctate, epistomal margin subtruncate, clypeus small, transverse, deeply emarginate, sparsely punctate, each puncture bearing a black seta; eyes narrow, elongate, feebly emarginate anteriorly; antenna moderately stout, third antennomere almost as long as next three combined. Pronotum 2/5 wider than long, widest in anterior third, smoothly converging to base, anterior margin truncate, angles obtuse, not prominent, basal margin rounded, angles obtusely rounded, marginal bead extremely fine, surface finely and sparsely punctate, hypomera smooth, impunctate, feebly wrinkled, prosternum with fine, transverse rugae, prosternal process deflexed between procoxae, apex not prolonged. Elytra elongate-oval, rather slender, slightly rounded from base to apex, humeri obsolete, surface punctate-striate, strial punctures finely muricate, not in grooves, intervals convex, with widely spaced muricate punctures, stronger laterally and apically; legs long, slender, hind femora extending beyond last visible abdominal suture, femora sparsely, muricately punctured, tibiae densely spiny, tarsi clothed beneath with coarse, dark setae, tibial spurs and claws unusually long on all legs, ventral surface finely wrinkled and sparsely punctate. Length: 19.8 mm; width: 7.5 mm.

Allotype male: Similar to female but slightly more robust and with a very slight suggestion of a profemoral tooth. Length: 22.2 mm; width: 7.4 mm.

Types.—Holotype ♀ and allotype ♂: Mexico, Chihuahua, Samalayuca, 24-VI-1947, Cazier, D. Rockefeller Exp. (AMNH). Paratypes: 1 ♂, same data as holotype (AMNH); 1 ♂, 1 ♀, same locality, but 15-V-1947, C. M. Bogart (OSUC); 2 ♂, 5 mi S of Samalayuca, 31-VII-1974, R. L. Mangan, D. S. Chandler (DSCC).

Remarks.—This species is apparently confined to the dry lake Samalayuca, south of Juarez, Chihuahua, Mexico. It superficially resembles *E. hispilabris* (Say), but differs in not having the profemora dentate in the male, and in the narrow and sparsely punctate pronotum with apical angles obtusely rounded, not prominent. The tibial spurs and tarsal claws are likewise much longer than in *E. hispilabris*. It belongs to the nominate subgenus *Eleodes*.

Etymology.—This species is named for the type locality, Samalayuca in Chihuahua, Mexico.

ACKNOWLEGMENTS

The specimens upon which this paper is based are from many individuals and institutions. I am indebted to the following for their patience in allowing me to retain their specimens for many years, in some instances for decades: Albertson College of Idaho (ACIC), Caldwell, ID (W. Clark, P. Blom); American Museum of Natural History (AMNH), New York, NY (Lee Herman); The Natural History Museum (BMNH), London, UK (Martin Brendell); Brigham Young University (BYUC), Provo, UT (Richard Baumann); California Academy of Sciences (CASC), San Francisco, CA (David Kavanaugh); California Department of Food and Agriculture (CDFA), Sacramento, CA (Fred Andrews); California Insect Survey (CISC), Berkeley, CA ((John Doyen); Cornell University (CUIC), Ithaca, NY (Richard Hoebeke); Canadian National Collection (CNCI), Ottawa, Ontario, Canada (Edward C. Becker); University of Nebraska (DEUN), Lincoln, NE (B. C. Ratcliffe); Rolf L. Aalbu private collection (RLAC), Sacramento, CA; Donald S. Chandler private collection (DSCC), Durham NH; Field Museum of Natural History (FMNH), Chicago, IL (Alfred Newton); Hungarian Natural History Museum (HNHM), Budapest, Hungary (Otto Merkl) Michigan State University (MSCU), East Lansing, MI (Roland Fischer); Muséum National d' Histoire Naturelle (MNHN), Paris, France (Claude Girard); The Ohio State University (OSUC), Columbus, OH; Robert H. Turnbow private collection (RHTC), Fort Rucker, AL; Stattlisches Museum für Naturkunde (SMNS), Stuttgart, Germany (Wolfgang Schawaller); Texas A. & I. University (TAIU) Kingsville, TX (J. E. Gillaspy); Texas Memorial Museum, University of Texas (TMMC), Austin, TX (J. Reddell}; Texas Tech University (TTCC), Lubbock, TX (David Foster); Texas A&M University (TAMU), College Station, TX (Edward Riley); University of Arizona (UAZC), Tucson, AZ (Carl Olson); Collección Nacional de Insectos, Instituto de Biología, Universdad Nacional Autónoma de México (CNIC), Mexico, D. F. (Paulina Cifuentes Ruiz, Victor H. Toledo); National Museum of Natural History, Smithsonian Institution (USNM), Washington, DC (Warren E. Steiner, Jr.). I am especially grateful to Todd Gilligan for the excellent habitus photographs of these beetles, which add immeasurably to the value of the paper, and to Robert H. Turnbow and Edward G. Riley for providing information on the ecology of *Eleodes spiculiferus*.

LITERATURE CITED

Blaisdell, F. E. 1909. A monographic revision of the Coleoptera belonging to the tenebronide tribe Eleodiini inhabiting the United States, Lower California, and adjacent islands. Bulletin of the United States National Museum 63: 524. 13 plates.

Champion, G. C. 1892. Insecta, Coleoptera, pp. 477–524. *In* Godman and Salvin, eds., Biologia Centrali-Americana, Insecta, Coleoptera (supplement to Heteromera), vol. 4, pt. 1.

Selander, R. B. and P. Vaurie. 1962. A gazetteer to accompany the Insecta volumes of the Biologia Centrali-Americana. American Museum Novitates, No. 2099, 70 pp.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 643–648

NEW SPECIES OF *DAMALIS* FABRICIUS AND *OMMATIUS* WIEDEMANN (DIPTERA: ASILIDAE) FROM INDIA

AUBREY G. SCARBROUGH

Visiting Scholar, Department of Entomology, The University of Arizona, Tucson, AZ 85741, U.S.A. (e-mail: saubrey05@comcast.net)

Abstract.—Two **new species** of asilids, ***Damalis anamaliensis*** (Trigonomiminae) from Kerala State and ***Ommatius disparis*** (Ommatiinae) from Maharashtra State, India, are described, illustrated, and compared with congeners. This is the first report of a species of *Ommatius* from this region of India.

Key Words: Asilidae, Trigonomiminae, Ommatiinae, *Damalis*, *Ommatius*, new species, India

Damalis Fabricius, 1805 and *Ommatius* Wiedemann, 1821 are widely distributed asilid genera in the Oriental Region (Oldroyd 1975). Presently, India has the larger number of species of these genera with 23 and 52, respectively (Joseph and Parui 1984a, b, 1987a, b, 1990a, b, 1995, 1998, 1999). Recently, two undescribed species from southern and south-central India were found in the Institut Royal des Sciences Naturalles de Belgique (IRSNB) and in the University Museum of Natural History, Oxford (UMO). The species are described, the terminalia illustrated, and compared with congeners, increasing the number of species of *Damalis* to 24 and *Ommatius* to 53.

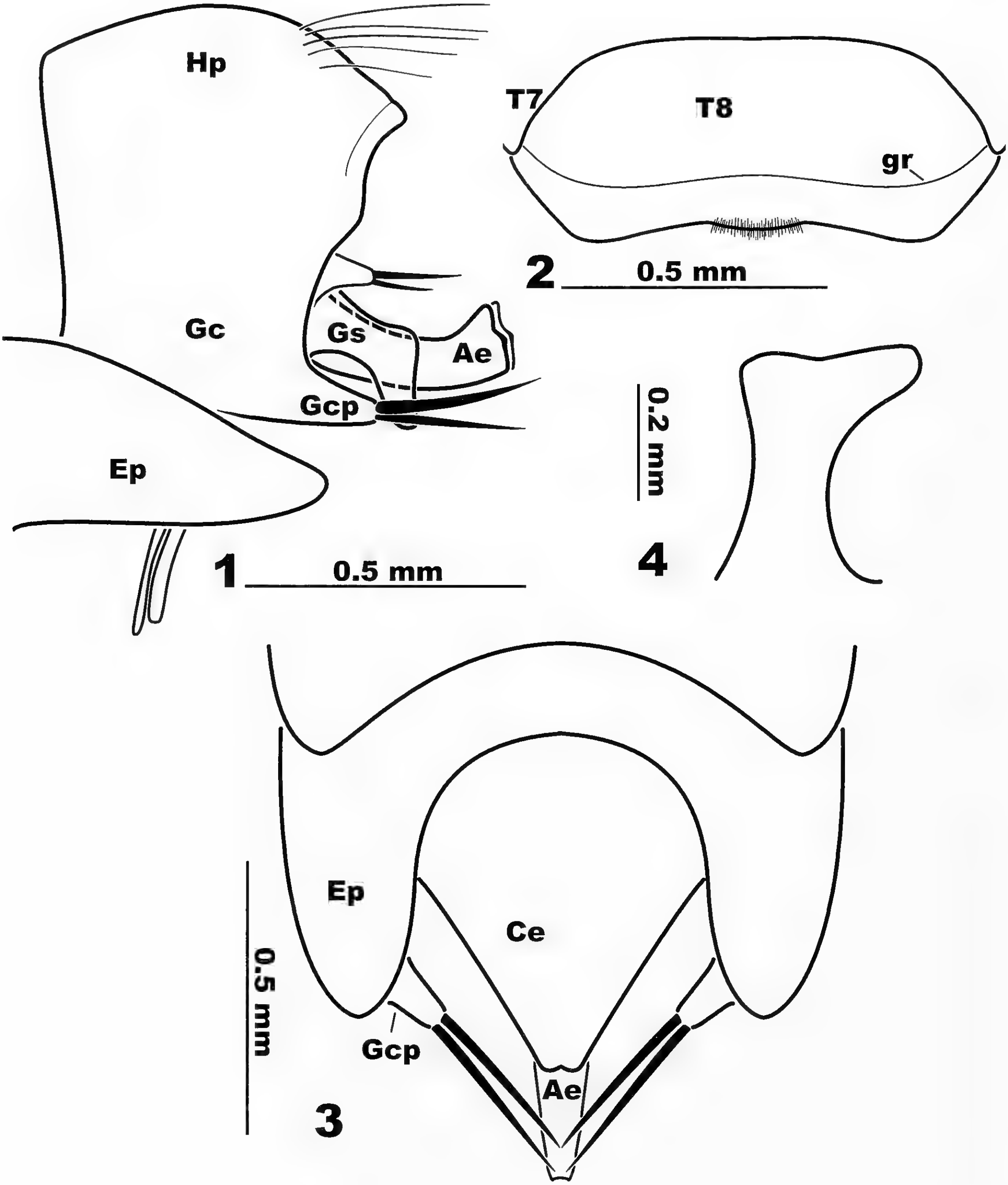
Morphological terminology follows McAlpine (1981). Measurements were made using an ocular micrometer in a Meiji dissecting microscope. Terminalia were prepared for study, illustrated, and permanently stored following Scarbrough (2005) and Scarbrough and Costantino (2005). *Damalis* terminalia are illustrated in their normal rotated (180°) position with the hypandrium and epandria in dorsal and ventral positions, respectively. That of *Ommatius* is illustrated in the normal dorsal-ventral position. A single measurement bar is used for terminalia illustrated in different positions. Data are recorded as they appear on labels with each line denoted by a slash [/]. Dates are recorded as Roman numerals.

Damalis anamaliensis Scarbrough, new species

(Figs. 1–4)

Male.—Body black. Measurements, body 8.0–13.0 mm, wings 7.9–11.5 mm. *Head*: Face and frons brown tomentose, dense except dorsal 1/2 of face sparse, subshiny; face, frons, antenna, ocellar tubercle, palpus, and proboscis black setose, that of face especially abundant; bristles absent. Occiput dusty gray tomentose, slightly brownish or yellowish along margin of eye; white setose except black across vertex, continuing to midlateral margin of eye. Palpus brown apically, brownish yellow basally, yellowish setose.

Thorax: Black, mostly dusty gray tomentose, brownish yellow above postalar callus; obvious longitudinal stripes



Figs. 1–4. Male terminalia of *Damalis anamaliensis*. 1–3, Lateral, dorsal, and ventral views. 4, Gonostylus, lateral view. Abbrevations, Ae=aedeagus, Ce=cercus, Ep=epandrium, Gc=gonocoxite, Gcp=gonocoxal process, gr=groove, Gs=Gonostylus, Hp=hypandrium, T7=tergite 7, T8=tergite 8.

absent dorsally; black setose, especially long and abundant medially and posteriorly, bristles absent. Scutellum yellowish gray or gray tomentose, with short black setae; marginal setae contrastingly long, black; preapical groove present. Pleuron yellowish gray to yellowish tomentose, setae mostly black, katatergite with sparse whitish setae dorsally. Halter dull brownish yellow or yellow.

Wing: Mostly blackish microtrichose, bm cells posteriorly mostly bare; slightly brownish anteriorly, subcostal and costal cells darkest. Crossvein r-m at apical 1/3 of cell d, slightly longer than width of cell m_1 basally. Cell m_1 narrow basally, sides divergent on basal 1/3, constricted preapically; base about 1/3 as wide as cell at its widest point. Five posterior cells present.

Legs: Black setose, stout bristles absent. Coxae, trochanters, and femora black except basal 1/4–1/3 of hind femur yellow or yellowish brown; middle and hind coxae yellow setose laterally; hind trochanter without spiny bristles apically. Hind femur moderately swollen medially, 2.2 times wider than base; apical 1/3 with only 3 bristles in each ventral row. Tibiae yellow, narrow apices blackish; front and middle tibiae blackish anteriorly. Tarsi with all tarsomeres yellow, at least basally, apices black, black becoming more widespread on apical 2–3 tarsomeres; pulvillus yellow, claws yellow basally, black apically.

Abdomen: Black, shiny dorsally, slender with basal 5 segments of equal widths, lateral margins of tergites partly or entirely yellowish-gray tomentose; sternites yellowish-gray tomentose, sternite 1 entirely and 2–6 with large atomentose spots laterally. Setae mostly whitish, usually long, scattered on sternites, abundant on all tergites laterally; tergites 1–2 whitish setose dorsally; tergites 3–8 dorsally with black, short setae.

Terminalia (Figs. 1–4): Reddish or yellowish brown with mostly blackish vestiture. Cercus elongate, triangular, apex pointed, yellow setose. Epandrium short, wide, triangular; epandrial notch wide, U-shaped in dorsal view. Gonostylus flat, footlike, apex asymmetrically capitate. Gonocoxal process short, not projecting beyond epandrium. Aedeagus tubular apically, flattened and wider than preapically, slightly triangular in lateral view. Apical margin of hypandrium simple, not produced medially.

Female.—Unknown.

Types.—Holotype ♂, INDIA: S. India [Kerala State], Anamalai Hills / Cinchona 3500f / ix.1969 (IRSNB). Paratype ♂, same data as holotype (IRSNB).

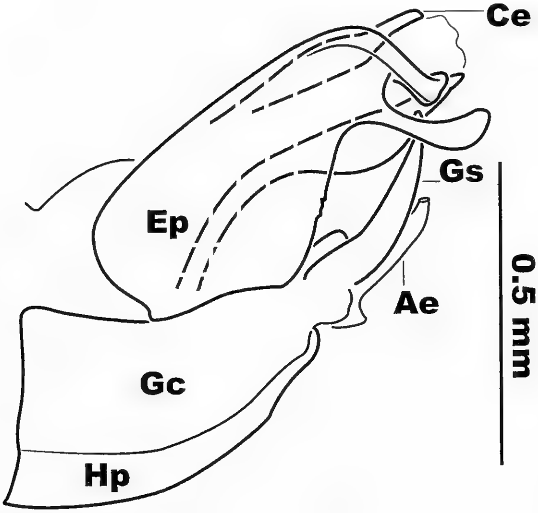
Etymology.—The name *anamaliensis* refers to the type locality (Anamalai Hills).

Remarks.—*Damalis anamaliensis* is distinguished from congeners by the abundant facial setae, absence of facial bristles, dusty grayish tomentum of the thoracic dorsum, blackish legs, yellowish tarsomeres, and combined characters of the terminalia (Figs. 1–4). *Damalis anamaliensis* will run to couplet 11 in Joseph and Parui's (1984b) key but is distinguished from *D. artigasi* Joseph and Parui and *D. rufoabdominalis* Joseph and Parui by the absence of a medially produced projection along the apical margin of the hypandrium. It is further distinguished from *D. artigasi* by the largely black hind femur whereas it is yellow with a black median band ('ring') in the latter species. It is also distinguished from *D. rufoabdominalis* in the black abdomen whereas it is brownish yellow in the latter species. *Damalis anamaliensis* is distinguished from *D. pseudoartigasi* Joseph and Parui (1987b) by the abundant black setae of the face, black femora, and characters of the terminalia (Figs. 1–4), especially the footlike gonostylus, and the shape of the aedeagus, and absence of a prominently produced apical margin of the hypandrium and a median process along the apical margin of the gonocoxa.

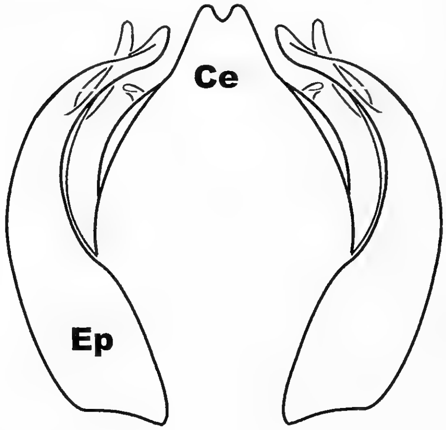
Ommatius disparis Scarbrough, new species

(Figs. 5–9)

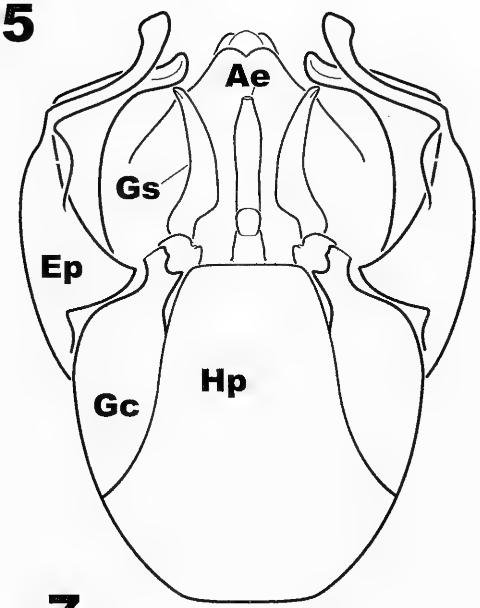
Male.—Body 10.8 mm; wing 9.3 mm. *Head*: Yellowish tomentose, yellow setose. Face narrow, 1/10 as wide as head



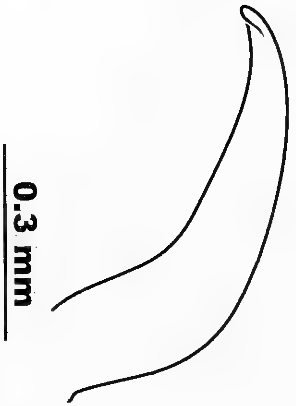
5



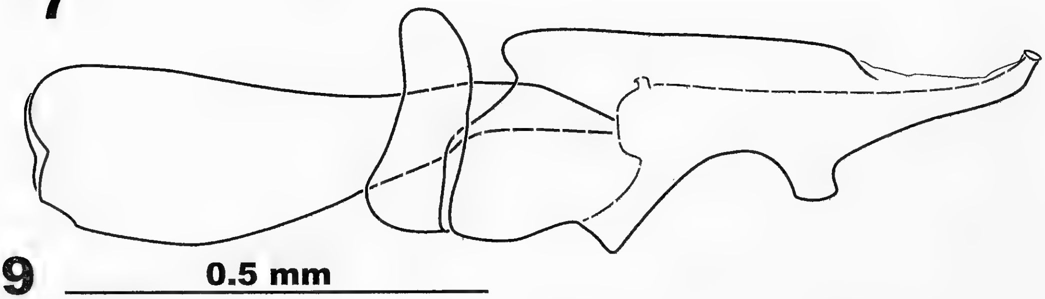
6



7



8



9

Figs. 5–9. Male terminalia of *Ommatius disparis* Scarbrough. 5–7, Lateral, dorsal, and ventral views. 8, Gonostylus, lateral view. 9, Aedeagus, lateral view. Abbrevations, Ae=aedeagus, Ce=cercus, Ep=epandrium, Gc=gonocoxite, Gs=Gonostylus, Hp=hypandrium.

at antennae; setae sparse dorsally, 5–6 thin brown bristles and long setae on lower 1/3. Palpus, proboscis, frons, and ocellar tubercle yellow setose. Antenna brown setose, 1 seta below scape long, extending to apex of flagellum; scape and pedicel yellowish brown; flagellum black, about 1/3 longer than wide basally, longer than combined length of scape and pedicel; style sparsely setose, 1–2 at apex, 3 on apical 1/2 ventrally. Frons narrow, sides converge slightly dorsally. Occiput yellowish to white tomentose, whitish setose; postocular bristles yellow, proclinate, those dorsally with tips just beyond posterior margin of eye.

Thorax: Black, postalar callus reddish. Pronotum white setose, 4 yellowish bristles dorsally. Scutum with sparse, yellow setae; dorsocentral bristles thin, setalike, 2 posterior bristles black; notopleural bristles yellow, supra-alar and postalar bristles black. Scutellum with sparse yellow setae and shallow preapical groove, stout marginal bristles absent. Pleuron yellowish-gray tomentose, sparsely white setose; anepimeral and katatergal bristles white. Halter yellow.

Wing: Costal margin straight, not dilated anteriorly; apical 1/3 densely microtrichose. Base of cell r_4 just beyond apex of cell d; R_5 slightly concave. Crossvein r-m well beyond middle of cell d, about 1/2 as long as CuA_1+M_3. Cell m_1 narrow basally, 1/3 as wide as cell at basal 1/3, constricted preapically.

Legs: Coxae and trochanters black, yellowish-gray tomentose, vestiture yellowish. Front and middle femora yellow with slight tint of brown dorsally, yellow setose ventrally, setae below middle femur moderately thick. Hind femur normal, about 6 times longer than wide; apical 1/3–1/2 and venter except narrow base and apex brown, remaining yellow; anteroventral bristles absent; 7–8 yellow posteroventral bristles present. Tibiae yellow, apical 1/4–1/3 of hind tibia brown; bristles mostly brown, lateral bristles of front tibia yellow. Tarsi mostly reddish brown with apical tarsomeres darkest; basal tarsomere yellow, narrow apex reddish brown; hind basitarsomere yellowish brown basally; bristles brown.

Abdomen: Largely yellowish brown, segment 1 entirely, segment 2 and tergite 3 largely black, wide apical margins of tergites 1–2 yellowish brown. Setae mostly yellow, tergite 4 and sternite 5 sparsely brown setose, tergites 5–8 and sternites 6–8 entirely black setose.

*Terminalia (*Figs. 5–9*):* Yellowish brown, mostly yellow setose. Epandrium angular ventrobasally, bent downward apically, with deep, narrow, notch. Gonostylus sickleshaped, tapered apically. Aedeagus linear, distiphallus slightly curved upward apically. Hypandrium wide, truncate apically.

Female.—Unknown.

Holotype.—♂, INDIA: Poona [modern-day Pune, Maharashtra State, south-central India] / Ghauts of. [Western Ghaut Mountains] / Coll. abt. 1888 / by T. B. Fry, Pres. 1905 by / J. W. Yerbury / 1905 /1365 (UMO).

Etymology.—Latin *disparis* meaning ‘different or unequal’ referring to the different lengths of the epandrial lobes.

Remarks.—*Ommatius disparis* is the first species of *Ommatius* recorded from the Indian State of Maharashtra. It distinguished from congeners by the yellow setae and bristles of the body, style with sparse setae, bare basally, flagellum as long as scape and pedicel combined, hind femur brown except basal 1/2 dorsally and narrow apex and narrow base ventrally yellow, basal 3 segments of abdomen mostly black, remaining yellow brown, and combined characters of the terminalia (Figs. 5–9).

Ommatius disparis runs to couplet 46 in the Joseph and Parui (1998) key. The modified key below separates the three species.

46. Antenna black; femora black except yellowish apex of front femur (Andhra Pradesh) . . . .
. . . . . .*pseudojabalpurensis* Joseph and Pauri
- Pedicel and scape brownish yellow or yellowish, flagellum brown; femora partly yellow 46a

46a. Front and middle femora yellowish brown, apices black; hind femur mostly black, basal 1/3 yellowish brown; hind basitarsomere and terminalia black; epandrium with dorsal lobe flat, bladelike, 4–5 times as long as ventral lobe, ventral lobe spinelike (Andaman Island) . . . .
. . . . *rajani* Joseph and Parui
- Front and middle femora yellow, pale brownish yellow dorsally; hind femur yellowish on basal 1/2–2/3; hind basitarsomere and terminalia yellowish brown; lobes of epandrium long and slender, ventral lobe slightly longer than dorsal lobe (Figs. 5–7) (Western Ghaut Mountains, Maharashtra State) . . *disparis*, n. sp.

ACKNOWLEDGMENTS

I thank the following colleagues and institutions for the loan of specimens and other assistance relevant to this study: J. Constant and Pol Limbourg (IRSNB); Darren Mann, John Ismay, and Adrian Pont (UMO). Torsten Dikow (American Museum of Natural History, New York) is thanked for reviewing the manuscript and providing useful suggestions.

LITERATURE CITED

Joseph, A. N. T. and P. Parui. 1984a. On some Asilidae (Diptera) from India and adjoining countries present in the British Museum (Natural History). Oriental Insects 18: 53–71.

———. 1984b. New and little-known Indian Asilidae (Diptera) VII. Ten new *Xenomyza* Wiedemann and *Microstylum* Macquart and keys to Indian species. Entomologia Scandinavica 15(4): 443–453.

———. 1987a. On some Asilidae (Diptera) from India. Bulletin of the Zoological Survey of India 8(1–3): 89–109.

———. 1987b. On some Asilidae (Diptera) present in the B. P. Bishop Museum, Honolulu I. Bulletin of the Zoological Survey of India 8(1–3): 223–235.

———. 1990a. Four new species of Asilidae (Diptera) from India. Hexapoda 2: 51–56.

———. 1990b. On some Asilidae (Diptera) present in the B. P. Bishop Museum, Honolulu II. Record of the Zoological Survey of India 86(2): 261–273.

———. 1995. On Asilidae (Diptera) from India and adjacent countries present in the California Academy of Science. Wasmann Journal of Biology 50(1–2): 1–38.

———. 1998. The Fauna of India and Adjacent Countries. Diptera (Asilidae) part I. Zoological Survey of India, Calcutta. pp. 1–278.

———. 1999. Asilidae (Diptera) from Andwra Pradesh, India. Record of the Zoological Survey of India 97(1): 1–25.

McAlpine, J. F. 1981. Morphology and terminology - adults, pp. 9–63. *In* McAlpine, J. F., B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood, eds. Manual of Nearctic Diptera. Vol. 1. Agriculture Canada. Monograph 27, Ottawa.

Oldroyd, H. 1975. Family Asilidae, pp. 99–156. *In* Delfindo, M. D. and D. E. Hardy, eds. A catalog of Diptera of the Oriental Region. Volume 2. University of Hawaii Press, Honolulu.

Scarbrough, A. G. 2005. Synopsis of *Aireina* Frey and *Damalis* Fabricius (Diptera: Asilidae) from Southeast Asia and a new name for *D. dimidiata* Joseph & Parui. Journal of the New York Entomological Society 113: 129–158.

Scarbrough, A. G. and J. E. Costantino. 2005. The genus *Ommatius* Wiedemann (Diptera: Asilidae), *dilatipennis* species group. Proceedings of the Entomological Society of Washington 107: 789–807.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 649–655

LONGIOCULUS BURMENSIS, N. GEN., N. SP. (ORTHOPTERA: ELCANIDAE) IN BURMESE AMBER

George Poinar, Jr., Andrej V. Gorochov, and Ron Buckley

(GP) Department of Zoology, Oregon State University, Corvallis, OR 97331, U.S.A. (e-mail: poinarg@science.oregonstate.edu); (AG) Zoological Institute, Russian Academy of Sciences, S. Petersburg 199034, Russia (e-mail: gryllus@front.ru); (RB) 9635 Sumpter Road, Florence, KY 41042-8355, U.S.A. (e-mail: ronbuckley@fuse.net)

Abstract.—An adult orthopteran in Early Cretaceous Burmese amber is described as a **new genus and species, *Longioculus burmensis* Poinar, Gorochov, and Buckley**. On the basis of its tegminal venation, three-segmented tarsi, and large spines on the hind tibia, it is placed in the extinct family Elcanidae. This fossil differs from previously described members of the family by its relatively small and slender body, protruding eyes, enlarged scapes and antennal cavities, short pronotum, and unique venational and leg armament characters.

Key Words: Orthoptera, Elcanidae, *Longioculus*, *Longioculus burmensis*, Burmese amber, Early Cretaceous

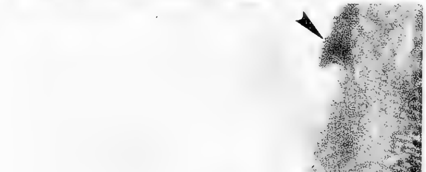
Adult orthopterans in amber are rare, since these insects are usually strong enough to free themselves from the resin. A well-preserved Burmese amber orthopteroid previously depicted in Poinar et al. (2005) is the topic of this paper. The specimen has three-segmented tarsi, a short pronotum, enlarged hind femora, and venational characters that align it with members of the family Elcanidae (Sharov 1968, Carpenter 1992, Gorochov 1995, Gorochov and Rasnitsyn 2002).

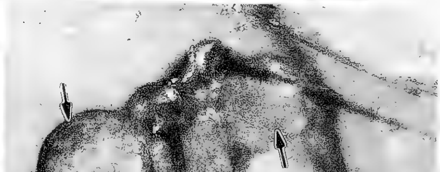
MATERIALS AND METHODS

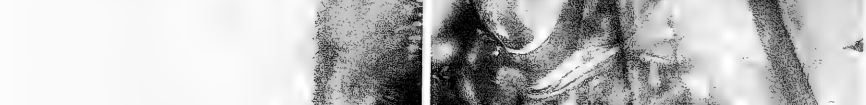
Amber from Burma occurs in lignitic seams in sandstone-limestone deposits in the Hukawng Valley, southwest of Maingkhwan in the state of Kachin (26°20′N, 96°36′E). Nuclear magnetic resonance (NMR) spectra of amber samples taken from the same locality as the fossils indicated an araucarian (possibly *Agathis*) source of the amber (Lambert and Wu, unpublished research 2002). Palynomorphs from the amber beds where the fossil originated have been assigned to the Upper Albian of the Lower Cretaceous (~100 mya) (Cruickshank and Ko 2003); however, since the amber is secondarily deposited, the age could be older.

The piece of amber containing the specimen is rectangular in shape, measuring 13 mm in length, 10 mm in width and 6 mm in depth. The fossil is well preserved and complete except for the tips of the antennae and wings, one side of the apex of the abdomen (including one cercus and the genital apparatus), the left metatibia and metatarsus and the apical portion of the right metatibia. Other fossils in the same amber piece are three small adult beetles, one mite, one adult nematoceran and several branched plant hairs. Observations and photographs were made with a Nikon SMZ-10 stereoscopic microscope and Nikon


1


2


3


4

Optiphot optical microscope (with magnifications up to 650×).

Family Elcanidae Handlirsch, 1906

Longioculus Poinar, Gorochov, and Buckley, new genus

Description.—Body relatively small and slender; scapes and antennal cavities greatly enlarged, occupying entire area between compound eyes; compound eyes large, protruding from head; ocelli lacking; pronotum short, hind tibia with dorsal row of denticles and row of much larger spines in middle part (and possibly in distal part); ventral surface of hind basitarsus with row of rather long spines; tegmina with both branches of false costa ("C") meeting within short distance of each other on anterior wing margin; tegminal area between "C" and Sc narrow; tegminal crossveins in visible area between R+ RA reduced (most proximal crossvein in the area, possibly basal part of RS, situated between bases of third and fourth branches of RA).

Etymology.—"*Longioculus*" is from the Latin "oculus" for eye and "longus" for long, in reference to the protruding eyes. The gender is masculine.

Diagnosis.—On the basis of the narrow, large spines on the hind tibiae, the new genus may belong to the Late Jurassic-Early Cretaceous subfamily Elcaninae (= Baisselcaninae). *Longioculus* is similar in size to the Early Cretaceous genus *Minelcana* Gorochov, Jarzembowsky, and Coram (Gorochov et al. 2006) and the smallest species of the Early Cretaceous genus *Panorpidium* Westwood (Westwood 1854), but can be distinguished from both these genera as well as from other genera of Elcanidae, except the Early Cretaceous *Cratoelcana* Martins- Neto (Martins-Neto 1991), by the apices of the branches of tegminal "C" positioned within a short distance of each other and the most proximal crossvein in the area between R+ RS (possibly the basal part of RS) situated near the bases of the third and fourth branches of RA. From *Cratoelcana*, with species over 20 mm in length, the new genus differs in being much smaller (under 8 mm in length).

Type species.—*Longioculus burmensis*, n. sp.

Longioculus burmensis Poinar, Gorochov, and Buckley, new species

(Figs. 1–12)

Description.—Characters as listed under generic description. Alate male; body brown with transparent wing; length body, 7.14 mm; length pronotum, 2.4 mm; length hind femur, 6.4 mm.

Head: Narrow; without rostral tubercles between antennal cavities; ocelli not observed; antennal cavities in contact with each other, with edges prominent; antennal scapes enlarged; antennal flagellum longer than body (both antennae cut off at edge of amber piece); filiform; antennomeres short, equal or subequal in size; each antennomere bears one to several spines; genae narrow; clypeus and mouthparts more or less normal for Ensifera (only lower edge of labrum exposed).

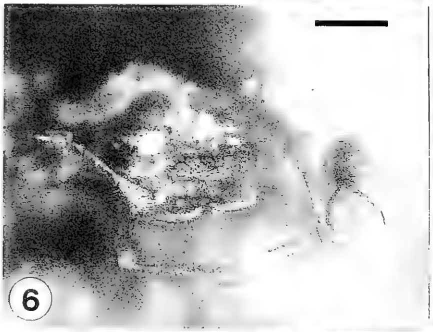
Thorax: Pronotum saddle-shaped, with anterior margin convex; pronotal dorsum with seven circular light blotches with dark borders located in depressions symmetrically positioned on each side; hind part of pronotum convex, not prolonged over abdomen; legs covered with short hairs; fore- and midfemora with pair of

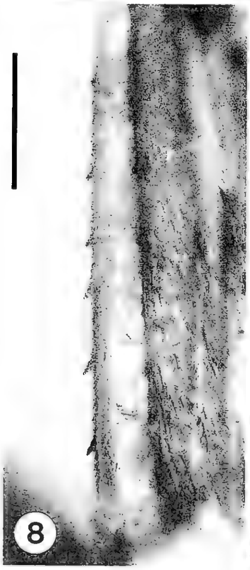
←

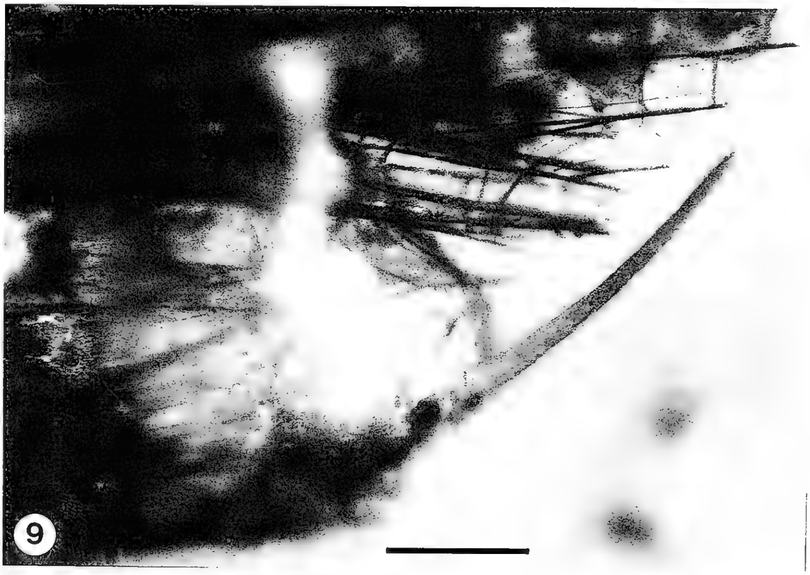
Figs. 1–4. *Longioculus burmensis* in Burmese amber. 1, Lateral view of entire specimen. Bar = 1.6 mm. 2, Metatarsus showing long spine (arrow) and two denticles (arrowheads). Bar = 88 μm. 3, Dorsal view of anterior portion showing protruding eyes (arrows) and round colored areas on pronotum. Bar = 542 μm. 4, Portion of antenna showing scattered setae. Bar = 63 μm.

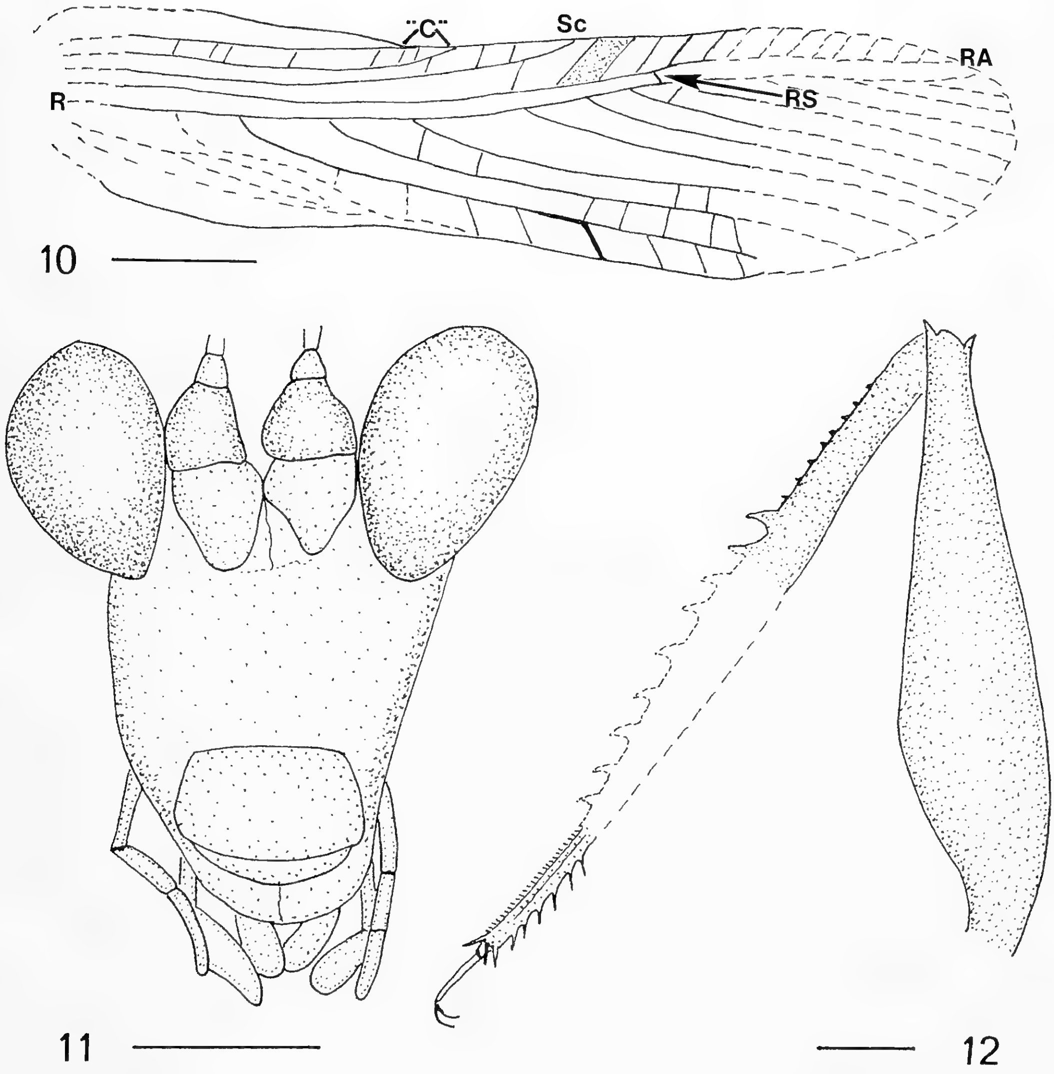

5


7


6


8


9



Figs. 10–12. *Longioculus burmensis* in Burmese amber. 10, Venation of tegmina. Dotted portions represent reconstructed areas. Bar = 1 mm. 11, Frontal view showing protruding eyes, prominent antennal cavities and enlarged antennal scapes. Bar = 1 mm. 12, Hind leg showing denticles and spines on dorsal surface of metatibia and spines on ventral surface of basitarsus. Dotted portions represent reconstructed areas. Bar = 1 mm.

rounded apical lobules, lacking denticles; fore tibia with single apical outer spine; mid- and hind tibiae with pair of apical spines; basal portion of hind tibia on dorsal surface bearing single row of small denticles from 25–31 μm in height and 25–31 μm in width at base; distance between denticles 201–246 μm; denticles

---

←

Figs. 5–9. *Longioculus burmensis* in Burmese amber. 5, Frontal view. Bar = 375 μm. 6, Mouthparts. Bar = 700 μm. 7, Metatarsus (arrow points to small spines on first tarsal segment of metatarsus) and mesotarsus (arrowhead). Note rows of large spines opposite small spines on ventral surface of basimetatarsus. Bar = 800 μm. 8, Denticles on proximal portion of metatibia. Bar = 575 μm. 9. Portion of abdomen showing remaining cercus. Bar = 800 μm.

replaced on middle part (and possibly on distal part) of dorsal surface of hind tibia by large spines (only one complete spine, 265 μm long and 63 μm wide, and one partial second spine visible); distance between first and second large tibial spines, 315 μm; all tarsi with first segment longer than 2nd and 3rd combined; apex of all basitarsi with 2 pairs of apical spines; midtarsus very short, less than ¼ as long as basitarsus; third tarsal segments with well- developed, simple, slightly curved claws; arolium absent; fore- and midbasitarsi with 2 rows of short spines on dorsal and ventral surfaces; hind basitarsus with two rows of spines, dorsal row composed of 27 short spines and ventral row with 7 large spines; midtarsus without spines; tegmina membranous (wings folded); venation as shown in Fig. 10; tegmina coloration light (transparent) with dark veins and clear area between first and second branches of RA.

Abdomen: Short, robust; cercus slender, pointed, approximately 1/3 length of abdomen; base of cercus with single, small, outer sensilla; anal plate, subgenital plate, and genital apparatus missing.

Material examined.—Holotype male in Burmese amber from the Hukawng Valley, southwest of Maingkhwan in the state of Kachin (26°20′N, 96°36′E), northern Myanmar (Burma), deposited in the amber collection of Ron Buckley, Florence, Kentucky (accession # ab 307). The specimen is available for study by contacting R. Buckley.

Etymology.—The specific name "burmensis" indicates the place of origin of the fossil.

Comments.—Unfortunately, the left hind tibia is missing and only the proximal half of the right hind tibia is present (the remainder is obliterated by a cavity in the amber) but the right midtarsus is present on the other side of the cavity. One complete and a second partial spine positioned at the distal end of the remaining portion of the hind tibia suggests that the entire distal portion contained a row of large spines, which is typical for elcanids. The depressed colored areas on the dorsum of the pronotum probably served as camouflage.

DISCUSSION

Fossils of the superfamily Elcanoidea first appeared in the Early Permian and extended into the mid-Cretaceous. Members of the grasshopper-appearing family Elcanidae first appeared in the Early Jurassic and representatives of the subfamily Elcaninae, which ranged from Siberia to England and Brazil, were rather common in Lower Cretaceous localities (Martins-Neto 1991; Gorochov 1995; Gorochov and Rasnitsyn 2002). The small size of *Longioculus* may indicate how it became entrapped in amber.

ACKNOWLEDGMENTS

We thank Jim Davis for supplying the amber, J. B. Lambert and Y. Wu, Department of Chemistry, Northwestern University, for their analysis of the amber, and Roberta Poinar for comments on an earlier draft of this manuscript.

LITERATURE CITED

Carpenter, F. M. 1992. Superclass Hexapoda. *In* Kaesler, R. L. ed. Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, Volume 3. The Geological Society of America and The University of Kansas, Boulder and Lawrence. 277 pp.

Cruickshank, R. D. and K. Ko. 2002. Geology of an amber locality in the Hukawng Valley, northern Myanmar. Journal of Asian Earth Sciences 21: 441–455.

Gorochov, A. V. 1995. System and evolution of the suborder Ensifera (Orthoptera). Part 1. Proceedings of the Zoological Institute, Russian Academy of Sciences [Trudy Zoologicheskogo Instituta RAN], v. 260: 1–224 (in Russian).

Gorochov, A. V. and A. P. Rasnitsyn. 2002. Superorder Gryllidea. Laicharting, 1781 (= Orthopteroidea Handlirsch, 1903). pp. 293–303. *In* Rasnitsyn, A. P. and D. L. J. Quicke, eds. History of Insects. Kluwer Academic Publishers, Dordrecht.

Gorochov, A. V., E. A. Jarzembowski, and R. A. Coram. 2006. Grasshoppers and crickets (Insects: Orthoptera) from the Lower Cretaceous of southern England. Cretaceous Research 27: 641–662.

Martins-Neto, R. G. 1991. Sistemática dos Ensifera (Insects, Orthopteroida) da Formaçâo Santana, Cretáceo Inferior do nordeste do Brasil. Estudio Technológicos, Acta Geologica Leopoldensia 32: 3–162.

Poinar, Jr., G. O., R. Buckley, and A. Brown. 2005. The secrets of Burmese amber. Mid Atlantic Paleontology Society 29: 20–29.

Sharov, A. G. 1968. Phylogeny of orthopteroid insects. Proceedings of the Paleontological Institute, Academy of Sciences of the USSR 118: 1–216 (in Russian).

Westwood, J. D. 1854. Contributions to fossil entomology. Quarterly Journal of the Geological Society of London 10: 378–396.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 656–660

AN ADDITIONAL SPECIES OF THE GENUS *AGLAOSTIGMA* KIRBY (HYMENOPTERA: TENTHREDINIDAE) FROM JAPAN

Ichiji Togashi

1-chome, Tsurugihonmachi, Hakusan-shi, Ishikawa Prefecture 920-2121, Japan

Abstract.—***Aglaostigma kawazoei*, n. sp.**, from Japan is described and illustrated. A key is provided for the nine Japanese species of *Aglaostigma*.

Key Words: Symphyta, Tenthredinidae, *Aglaostigma*, new species, Japan

Aglaostigma Kirby is a Holarctic and Oriental genus containing about 52 species (Taeger and Blank 2005). In Japan, *A. albicinctum* (Takeuchi 1953), *A. amoorense* (Cameron 1876), *A. helvicinctum* Togashi 1970, *A. naitoi* Togashi 1972, *A. nebulosum* (André 1881), *A. occipitosum* (Malaise 1931), *A. sapporonis* (Matsumura 1912), and *A. yasumatsui* Togashi 1970, are known. The Japanese species were first revised by Togashi (1970), with a subsequent species added by Togashi (1972). Recently, I obtained four specimens (two females and two males) of this genus collected by A. Kawazoe and M. Inagaki in Mie Prefecture. These specimens are very close to *A. amoorense* in body color, but they can be separated from the latter by the two middle cells in the hindwing (Figs. 4, 5, 7), the straight radial crossvein (2r) of the forewing (Figs. 3, 6), the shape of the tarsal claws (Figs. 10, 17), the shape of the inner tibial spur (Figs. 9, 16), and the color of the mesopleura. I concluded that these specimens represent a new species, and I describe and illustrate them and give a key to the Japanese species of *Aglaostigma*.

KEY TO JAPANESE SPECIES OF *AGLAOSTIGMA* (FEMALES)

1. Hindwing without middle cell; postocellar furrow indistinct; hind tibia and tarsus black of blackish . . . . . *yasumatsui* Togashi
– Hindwing with one or two middle cells; postocellar furrow distinct; hind tibia and tarsus reddish yellow or black 2
2. First abdominal tergite black or blackish . 3
– First abdominal tergite yellow or reddish yellow 7
3. Abdomen black or black with a white band on 4th segment 4
– Abdomen yellow or reddish yellow 5
4. Fourth abdominal segment with a white band; radial crossvein (2r) of forewing slightly curved . . . . *albicinctum* (Takeuchi)
– Abdomen entirely black; radial corssvein (2r) of forewing nearly straight . . . *naitoi* Togashi
5. Supra-antennal tubercles distinctly elevated, free standing and abruptly cut off from frontal ridges; postocellar area nearly quadrate; 2nd to 6th abdominal segments reddish yellow . . . . *nebulosum* (André)
– Supra-antennal tubercles and frontal ridges confluent; postocellar area nearly transverse; narrow band on anterior margin of 2nd to 6th abdominal segments black 6
6. Mesopleuron with yellowish-white macula; hind wing with one middle cell (Fig. 7); anal cell of hind wing with a petiole (Fig. 7); tarsal claw as in Fig. 17 . . . . *amoorense* (Cameron)
– Mesopleuron entirely black; hind wing with two middle cells (Fig. 4); anal cell of hind wing sessile (Fig. 4); tarsal claw as in Fig. 10 . . . . *kawazoei*, n. sp.
7. OOL = 3POL; OCL = 2POL; hind margin of pronotum, posterior corner of mesoprescutum, mesoscutellum, and mesoscutellar appendage yellow . . . *occipitosum* (Malaise)
– OOL = 2POL; OCL slightly longer than POL; thorax with mesoscutellum and mesoscutellar appendage nearly black . . . 8

Fig. 1. *Aglaostigma kawazoei*, holotype.

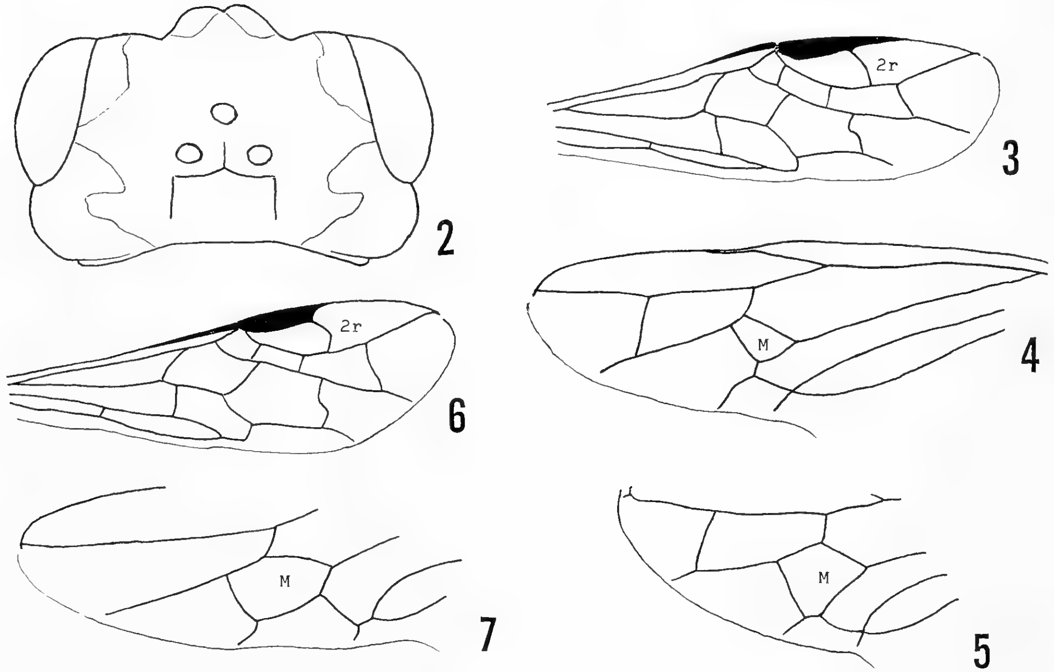
8. Antenna shorter than costa + stigma of forewing; hind wing with two middle cells . . . . *helvicinctum* Togashi
– Antenna as long as costa of forewing; hind wing with one middle cell . . . . *sapporonis* (Matsumura)

Aglaostigma kawazoei Togashi, new species

(Figs. 1–5, 8–15)

Female.—Length, 8–9 mm. *Color*: Head and thorax black with following yellow: postocellar area, inner orbits, supraclypeal area, antennal sockets, clypeus, labrum, basal half of mandible, labial and maxillary palpi, posterior half of pronotum, and tegula. Abdomen yellow with following black: 1st tergite, narrow band on anterior margin of 2nd to 6th tergites, posterior 1/3 of 6th tergite, triangular macula of posterior margin of 8th tergite, central portion of 9th tergite, and circus. Antenna pale yellow with black stripe on dorsal side. Wings hyaline, basal half of stigma and veins dark brown to black with apical half of stigma and costa of forewing yellow; forewing with a dark band below stigma (Fig. 1). Legs yellow with following black: coxae, hind femur except for basal 1/3, and apical 1/3 of hind tibia.

Head: Transverse (Fig. 2); postocellar area transverse with ratio of width to length about 2:1, convex; OOL:POL:OCL = 2.4:1.0:1.6; interocellar, postocellar, and lateral furrows distinct; frontal area concave with raised frontal ridges; median fovea large, deep, and circular in outline; lateral fovea small and circular in outline; supraclypeal area slightly convex; supra-antennal tubercles confluent with frontal ridges; clypeus rather flattened, subtruncate in front; labrum nearly flattened; antenno-ocular distance nearly as long as distance



Figs. 2–7. 2–5, *Aglaostigma kawazoei*. 6–7, *A. amoorense*. 2, Head, dorsal. 3, Forewing. 4, Hindwing of female. 5, Hindwing of male. 6, Forewing. 7, Apical portion of hindwing.

between antennal sockets (ratio about 1.0:1.0); eyes rather small and slightly converge below, distance between them nearly as long as 1.3× height of each; occipital carina defined below and obsolete above; malar space nearly as long as diameter of front ocellus, nearly as long as 0.7× length of pedicel. Antenna neary as long as costa of forewing, about 2× head width; relative lengths of segments about 1.5:1.0:3.1:2.6:2.1:1.8:1.6:1.5:1.5, pedicel longer than wide.

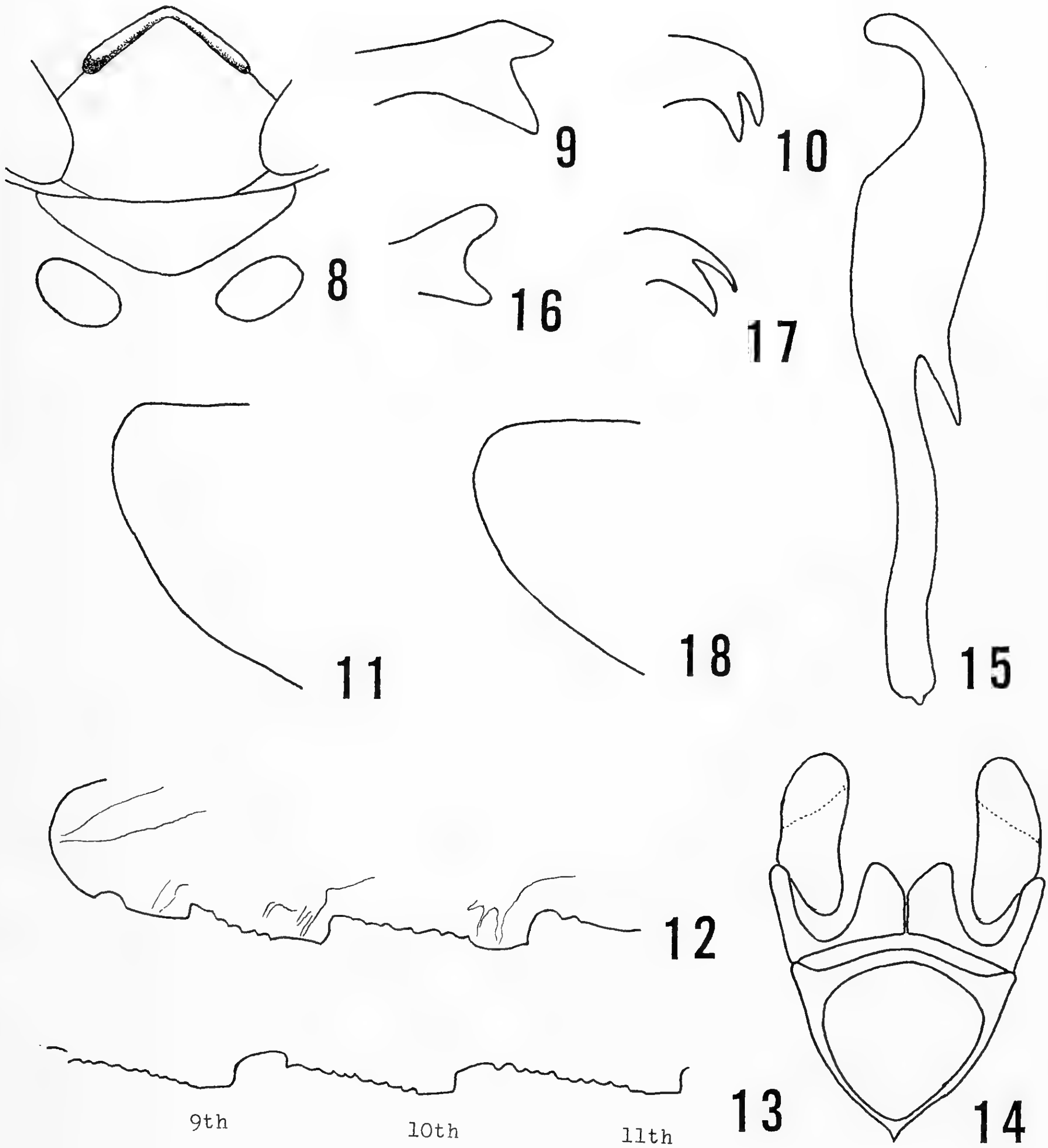
Thorax: Normal. Mesoscutellum convex, front margin acute (Fig. 8); cenchrus large, distance between cenchri nearly as long as breadth of one (Fig. 8). Wing venation as in Figs. 3, 4; radial crossvein (2r) of forewing nearly straight; hind wing with two middle cells; discoidal cell (M) small (Fig. 4); anal cell of hindwing sessile. Fore inner tibial spur as in Fig. 9; tarsal claws as in Fig. 10; hind basitarsus nearly as long as following 3 segments combined.

Abdomen: Normal. Sawsheath as in Fig. 11. Lancet with 20 serrulae; apical portion and 9th to 11th serrulae as in Figs. 12, 13.

Punctation: Head matt, with rather coriaceous sculpture; pronotum and mesoscutum covered with medium-sized punctures; mesoscutellum and mesopleuron covered with setigerous punctures; abdominal tergites shagreened.

Male.—Length, 8 mm. Color as in female, but 7th to 9th tergites black; structure same as female except for size of middle cell (Fig. 5) and sexual characters; hind wing without marginal vein. Genitalia as in Fig. 14, black but apical half of harpe milky white; penis valve as in Fig. 15.

Types.—Holotype ♀, 21.IV.2005, Mt. Noto, Kameyama City, Mie Prefecture, Honshu, Japan, M. Inagaki leg. Paratypes: 1 ♀, 2 ♂, same data as for holotype except collectors, M. Inagaki and A. Kawazoe. All types deposited in



Figs. 8–18. 8–15, *Aglaostigma kawazoei.* 16–18, *A. amoorense.* 8, Mesoscutellum and mesoscutellar appendage, dorsal. 9, Fore inner tibial spur, lateral. 10, Tarsal claw. 11, Sawsheath, lateral. 12, Apical portion of lancet. 13, 9th to 11th serrulae of lancet. 14, Male genitalia, ventral. 15, Penis valve. 16, Fore inner tibial spur, lateral. 17, Tarsal claw, lateral. 18, Sawsheath, lateral.

the National Science Museum (Natural History), Tokyo.

Distribution.—Japan (Honshu).

Food plant.—Unknown.

Etymology.—Named in honor of Mr. Akio Kawazoe, Kuwana City, Mie Prefecture, Japan.

Remarks.—This new species is close to *A. amoorense*, but it is distinguished from the latter by the black mesopleuron (with yellowish white macula in *A. amoorense*); by having two middle cells in the hind wing (one in *A. amoorense*) (Figs. 4, 7); by the sessile anal cell of the hind wing (with petiole in *A. amoorense*) (Figs. 4, 7); by the nearly straight radial crossvein of the forewing (curved in *A. amoorense*) (Figs. 3, 6); by the shape of the tarsal claws (Figs. 10, 17); by the shape of the fore inner tibial spur (Figs. 9, 16); and by the shape of the sawsheath (Figs. 11, 18).

About 20 other species of *Aglaostigma* have been described from eastern Asia, other than Japan. From the descriptions (e.g., Malaise 1937; Wei and Nie 1998) and material available to me, the new species does not fit any of them. From *A. nigrocorne* Wei, *A. flatoposttrgitium* Wei, *A. zigzaga* Wei, and *A. qinlingium* Wei from China, *A. kawazoei* is distinguished by the broad and rounded apex of the sawsheath in lateral view (narrow and truncated in lateral view in the abovementioned four species). From *A. birmanicum* (Malaise) from Myanmar, *A. kawazoei* is distinguished by the color of the antenna (black in *A. birmanicum*), and by having two middle cells in the hindwing (one middle cell in the female of *A. birmanicum*). From *A. ruficorne* (Malaise) from Myanmar, *A. kawazoei* is separated by the color of the stigma of the forewing (fulvous in *A. ruficorne*) and by the color of the second and third tergites (black in *A. ruficorne*).

ACKNOWLEDGMENTS

I thank D. R. Smith, Systematic Entomology Laboratory, USDA, Washington, D.C. for kind help with the manuscript, and S. M. Blank, Deutsches Entomologisches Institute, Müncheberg, Germany, for review and comments. I am much indebted to A. Kawazoe, Mie Prefecture, for bringing these specimens to my attention.

LITERATURE CITED

Malaise, R. 1937. New Tenthredinidae mainly from the Paris Museum. Revue Française d'Entomologie, Paris 4: 43–53.

Togashi, I. 1970. The Japanese sawflies of the genus *Aglaostigma* Kirby (Hym., Tenthredinidae). Mushi 44: 1–9.

———. 1972. Description of a new species of the genus *Aglaostigma* Kirby from Japan (Hymenoptera: Symphyta, Tenthredinidae). Transactions of the Shikoku Entomological Society 11: 81–83.

Wei, H. and H. Nie. 1998. Five new species of *Aglaostigma* from Mt. Funise (Hymenoptera: Tenthredinidae), pp. 146–151. *In* The Fauna and Taxonomy of Insects in Henan. China Agricultural Scientific Press, Beijing, Volume 2.

Taeger, A. and S. M. Blank. 2005. ECatSym-Electronic World Catalog of Symphyta (Insecta, Hymenoptera). Version 1.0 (August 1, 2005). ECatSym Online Service Müncheberg – http://www.zalf.de/homezalf/institute/dei/phpe/ecatsym/index.html.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 661–683

STUDY OF THE MORPHOLOGY OF *ALTICA FRAGARIAE* (NAKANE) (COLEOPTERA: CHRYSOMELIDAE: ALTICINAE), WITH FIRST DESCRIPTIONS OF THE LARVAE AND PUPAE

YONG ZHANG, SIQIN GE, AND XINGKE YANG

(YZ, SG, XY) Institute of Zoology, Chinese Academy of Sciences, 36 box, 25 Bei SiHuanXiLu, Haidian, Beijing 100080, China; (YZ) Graduate School, Chinese Academy of Sciences, Yuquanlu, Shijingshan, Beijing 100039, China (e-mail: zhangy@ioz.ac.cn). Corresponding author: Xingke Yang (e-mail: yangxk@ioz.ac.cn)

Abstract.—*Altica fragariae* (Nakane) (Coleoptera: Chrysomelidae: Alticinae) is an oligophagous insect whose host plants are Rosaceae. It is distributed in China and Japan. The first descriptions of the larvae and pupae and detailed morphological study of the eggs and adult are presented. Illustrations and descriptions are provided for the morphology of the adult, larva, pupa, and egg. Additionally, the taxonomic history, distribution, and biological notes of the species are reviewed, including associations with host plants and laboratory studies. Comparisons are made with the other species of *Altica* Geoffroy. The main differences between *Altica fragariae* and other species of *Altica* are the morphology of male and female genitalia, punctures of the pronotum in the adult, color, body length, and chaetotaxy of the larvae and pupae. Sensilla of the antennae and the setae of the tarsus of males and females are discussed.

Key Words: *Altica fragariae* (Nakane), morphology, egg, larvae, pupae, adult, biology

Altica fragariae (Nakane) belongs to the genus *Altica* Geoffroy (Coleoptera: Chrysomelidae: Alticinae). The genus *Altica* was established by Geoffroy in 1762, the type species is *Chrysomela oleracea* Linnaeus, 1754, from Sweden. It is a large genus of flea beetles with over 300 known world species (Konstantinov and Vandenberg 1996). Among them, 28 species are distributed in China, and six of them are endemic species. The classification of this genus is not easy because of their similar color and morphology.

There have been several important works on Chinese species of *Altica*, including Ogloblin (1921, 1925), Chen (1936), Ohno (1960), Gressitt and Kimoto (1963), Scherer (1969), Lopatin (1977), Chen and Wang (1981), Wang (1992, 1996), and Gruev and Döberl (1997). There also have been some studies on the morphology of *Altica*, such as Kangas and Rutanen (1993), Konstantinov (1987, 1998, 2002), Konstantinov and Lopatin (1987), Lee and Furth (2000), and LeSage and Denis (1999). *Altica fragariae* was first described by Nakane from Japan in 1955 and was placed in the genus *Haltica*. There are also some studies by Ohno (1960), Kimoto (1966), Wang (1996), Guo et al. (1996), and Wang et al. (2005), but there are no detailed morphological study on this species.

---

*Corresponding Author: e-mail: yangxk@ioz.ac.cn

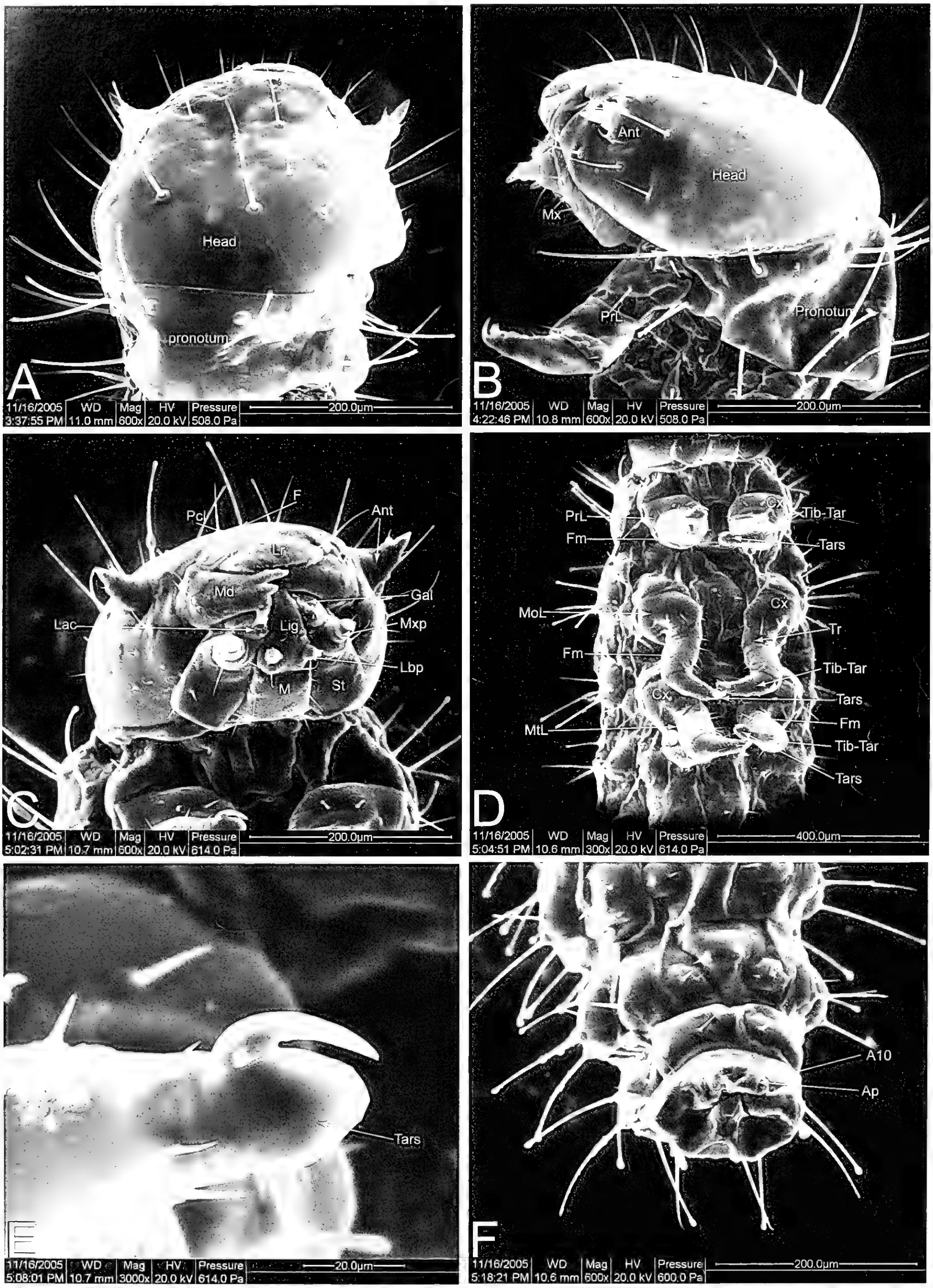


Fig. 1. *Altica fragariae*: first instar larva. A, Drosal view of head. B, Lateral view of head. C, Frontolateral view of head. D, Ventral of thorax. E, Apex of foreleg. F, Ventral view of apical abdomen. Abbreviations: A10: Abdominal segment 10; Ap: Anal plate; Ant: Antennae; Cx: Coxae; F: Frons; Fm: Femur; Gal: Galea; Lac: Lacinia; Lbp: Labium palpi; Lig: Ligula; Lr: Labrum; M: Mentum; Md: Mandible; MoL: Mesoleg; MtL: Metaleg; Mx: Maxillae; Mxp: Maxillary palpi; Pcl: Post clypeus; PrL: Proleg; St: Stipe; Tars: Tarsungulus; Tib-Tar: Tibia-Tarsus.

Concerning the larvae and pupae, very little work have been done. LeSage et al. (2004) gave a thorough introduction to the history of the North America species from Riley (1870) to Lawson (1991). LeSage et al. (2004) also gave a detailed descriptions of larvae, eggs, and pupae of *Altica chalybea* Illiger and *A. woodsi* Isely, and compared the differences between these two species. The only treatment for China is Kimoto and Takizawa (1995) who described the larvae of *Altica birmanensis* Jacoby, *A. caerulescens* (Baly), *A. cyanea* (Weber), *A. cirsicola* Guérin-Méneville, *A. coerulea* (Olivier), *A. japonica* Ohno, and *A. himalayensis* (Chen) from Taiwan.

In this paper, a morphological study of eggs, larvae, pupae, and adults of *Altica fragariae* is presented, including illustrations and descriptions. Distribution and biological notes also are given. Further study of the functional morphology should be done to explain differentiation of the morphology as related to the differentiation of their feeding habits.

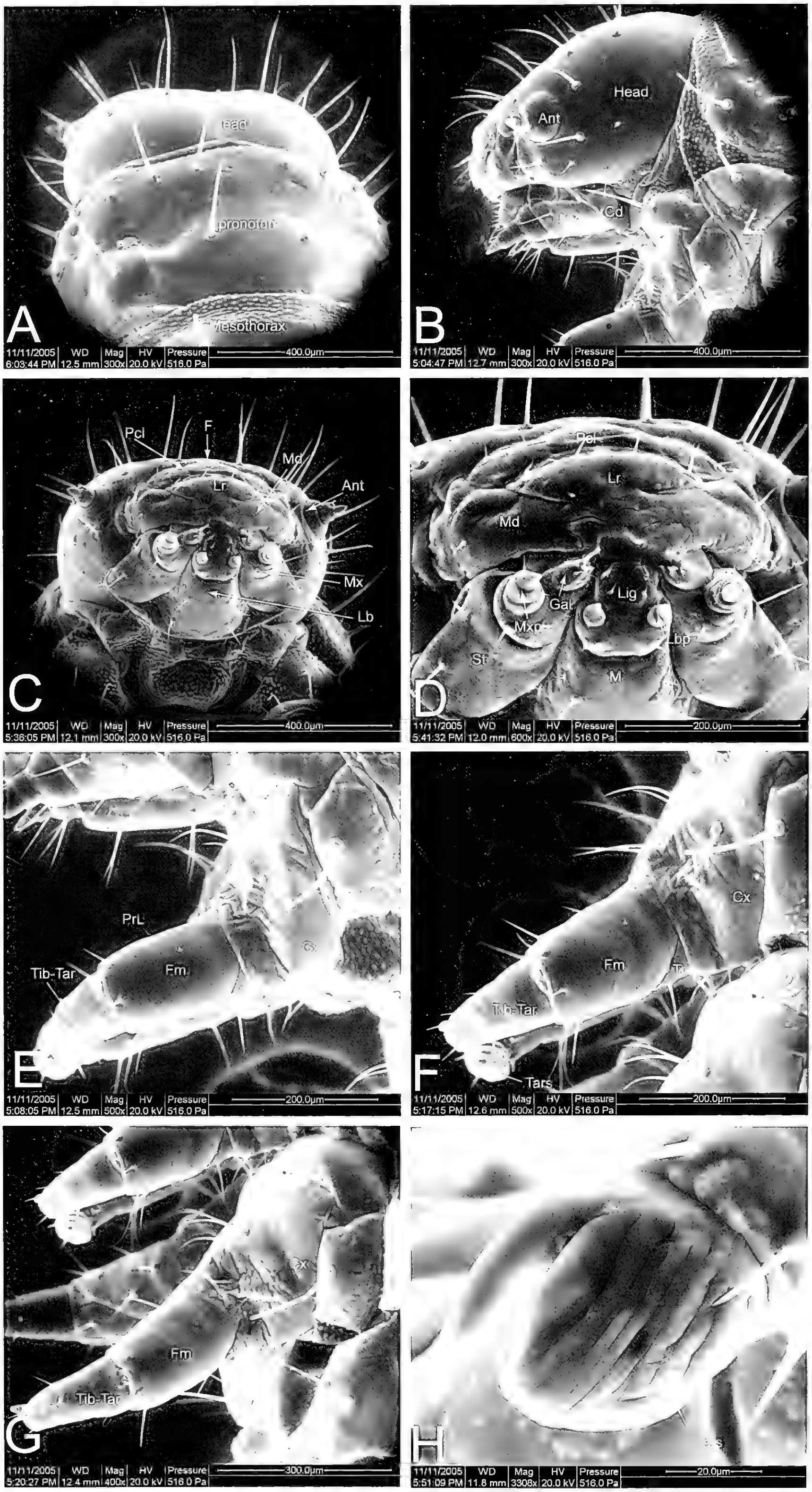
Distribution

Altica is distributed throughout the world. Among them, 28 species occur in China, and six of them are endemic species. *Altica fragariae* is mainly distributed in China, Russia, Korea, and Japan. In China, it is recorded from Jilin, Beijing, Shandong, Jiangsu, Hunan, Hubei, Fujian, and Guizhou. They are always on the forest floor at altitudes less than 800 m.

Biological Notes

Altica fragariae is an oligophageous species of flea beetle. Based on field observations by Wang et al. (2005), *A. fragariae* feeds on *Agrimonia pilosa* Ledeb., *Potentila flagellaris* Willd. ex Schlecht, *Geum aleppicum* Jacq., and *Fragaria ananassa* Duchesne besides its primary host plant, *Duchesnea indica* (Andrews) Focke. All belong to the family Rosaceae. Based on our field observations, *Altica fragariae* is the predominant population among the species of *Altica* in the mountainous region of Beijing. It lives in shady, moist, and concealed conditions of the forest floor. Adults and larvae always live on the underside of the leaves and are difficult to find. Females deposit eggs singly or more usually in clusters on the underside of leaves, usually along the central and tributary veins, and occasionally along leaf edges. Normally, they prefer to oviposit on the more withered and yellow last two leaves at the bottom of the host plants. Females consistently smear each egg with a thin layer of excrement, but its biological significance is not known. Philips (1977a, 1997b) suggested that the smear contains a deterrent to arthropod predators or parasites. The first two instars of the larvae feed on the underside of the leaves, and the veins and upper surface are left intact. The third-instar larvae and adults also feed on the underside of the leaves, making the leaf surface appear as a sieve.

This species usually completes two or three generations per year in Beijing and with an overlap of generations. Overwintering adults emerge in early spring and are first observed on the host plants in mid-March, after which a period of feeding, and mating occurs. Oviposition is in May; after about 7–14 d the first-instar larvae hatch. There are three larval instars each lasting about seven days. Before winter, the overwintering adults burrow about three to five cm below the dead wood and dead leaves for hibernation. We observed a few adults in late October. In addition, the beetle overwinters with noticeable aggregation behavior. We have found a big group of thousands of hibernating individuals gathered in about one square meter of dead leaves in early spring. As a result, feeding damage was often


A
Head
pronotum
Mesothorax
11/11/2005 6:03:44 PM WD 12.5 mm Mag 300x HV 20.0 kV Pressure 516.0 Pa 400.0µm
B
Head
Ant
Cd
11/11/2005 5:04:47 PM WD 12.7 mm Mag 300x HV 20.0 kV Pressure 516.0 Pa 400.0µm
C
Pcl
F
Md
Lr
Ant
Mx
Lb
11/11/2005 5:36:05 PM WD 12.1 mm Mag 300x HV 20.0 kV Pressure 516.0 Pa 400.0µm
D
Pcl
Lr
Md
Gal
Lig
Mxp
Lbp
St
M
11/11/2005 5:41:32 PM WD 12.0 mm Mag 600x HV 20.0 kV Pressure 516.0 Pa 200.0µm
E
PrL
Tib-Tar
Fm
Cx
11/11/2005 5:08:05 PM WD 12.5 mm Mag 500x HV 20.0 kV Pressure 516.0 Pa 200.0µm
F
Cx
Fm
Tr
Tib-Tar
Tars
11/11/2005 5:17:15 PM WD 12.6 mm Mag 500x HV 20.0 kV Pressure 516.0 Pa 200.0µm
G
Cx
Fm
Tib-Tar
11/11/2005 5:20:27 PM WD 12.4 mm Mag 400x HV 20.0 kV Pressure 516.0 Pa 300.0µm
H
11/11/2005 5:51:09 PM WD 11.8 mm Mag 3308x HV 20.0 kV Pressure 516.0 Pa 20.0µm

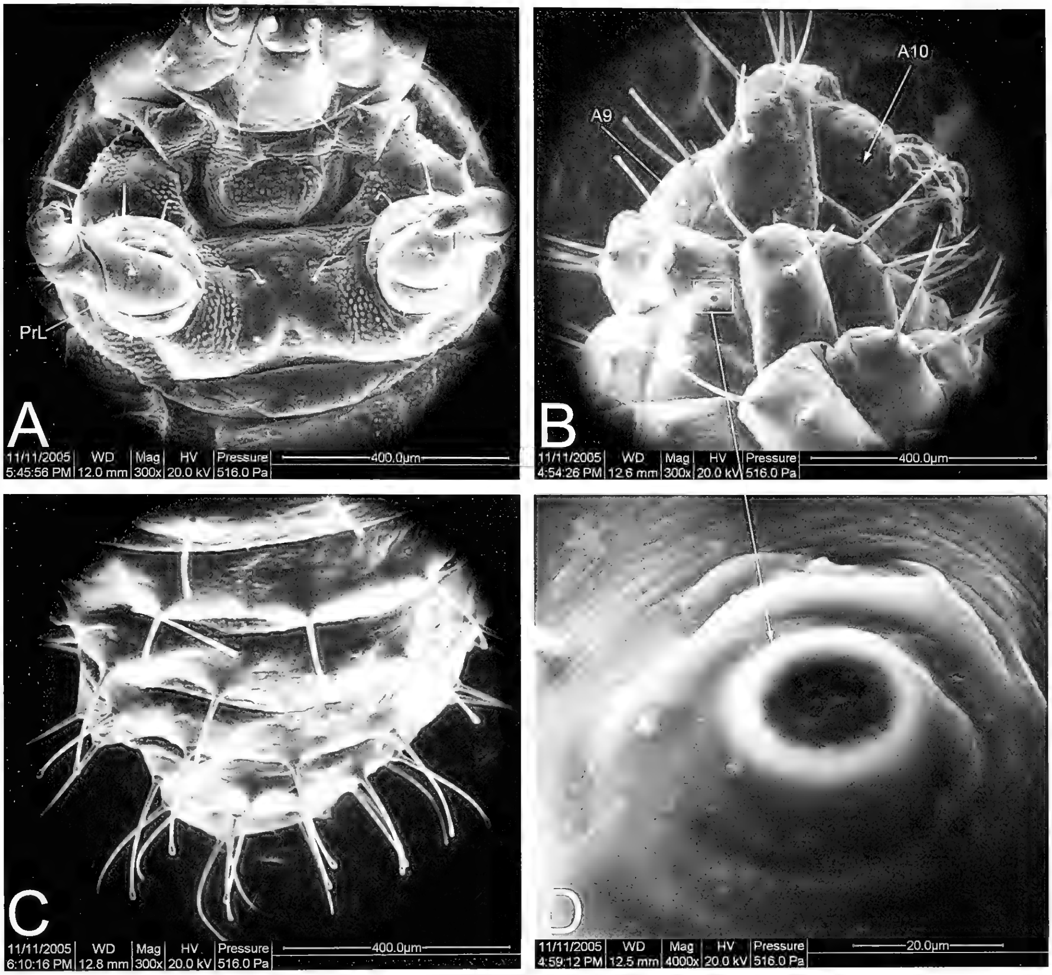


Fig. 3. *Altica fragariae*: mature larva. A, Ventral view of prothorax. B, Lateral view of apical segment of abdomen. C, Dorsal view of apical segments of abdomen. D, Spiracle. Abbreviations: A9: Abdominal segment 9; A10: Abdominal segment 10; PrL: Proleg.

localized by post-hibernating adults in spring.

MATERIAL AND METHODS

All stages of *Altica fragariae* are described. Ten individuals of each stage were observed, each three times.

All specimens were collected in Badaling Forestry Centre (40.3°N, 116.0°E), Beijing, China in June and July, 2005, and were reared in 12 × 11.5 cm glass jars with sand on the bottom and with host plants. Fresh leaves were added every day and wilted leaves removed.

←

Fig. 2. *Altica fragariae*: mature larva. A, Dorsal view of head. B, Lateral view of head. C, Frontal view of head. D, Mouthpart. E, Proleg. F, Mesoleg. G, Metaleg. H, Apex of proleg. Abbreviations: A10: Abdominal segment 10; Ap: Anal plate; Ant: Antennae; Cd: Cardo; Cx: Coxae; Fm: Femur; Gal: Galea; Mx: Maxillae; F: Femur; Lac: Lacinia; Lig: Ligula; Lr: Labrum; Md: Medible; MoL: Mesoleg; MtL: Metaleg; Mxp: Maxillary palpi; St: Strip; M: Mentum; Lbp: Libium palpi; Pcl: Post clypeus; PrL: Proleg; Fm: Femur; Tr: Trochanter; Tib-Tar: Tibia-Tarsus; Tars: Tarsungulus.

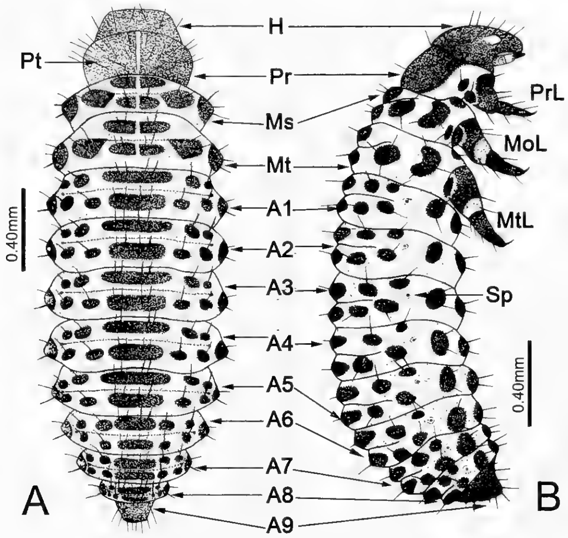


Fig. 4. *Altica fragariae*: mature larva. A, Habitus, dorsal view. B, Habitus, lateral view. Abbreviations: A1, A2, A3, A4, A5, A6, A7, A8, A9: Abdominal segment 1, 2, 3, 4, 5, 6, 7, 8, 9; Ant: Antenna; H: Head; Mol: Mesoleg; Ms: Mesothorax; Mt: Metathorax; MtL: Metaleg; Pr: Pronotum; Pt: Prothorax; PrL: Proleg; Sp: Spiracle.

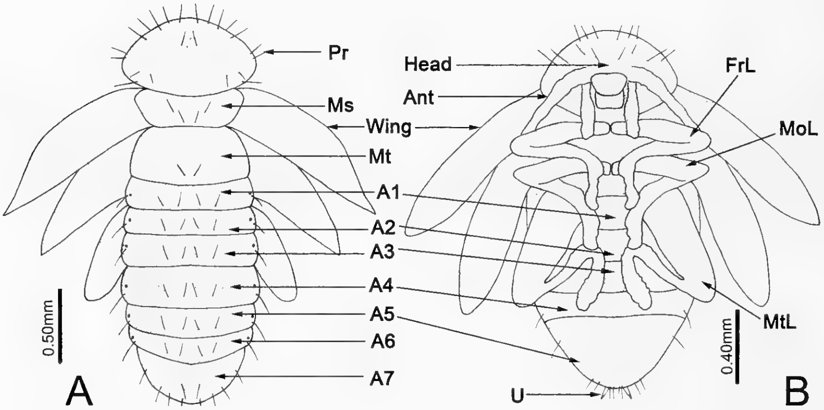
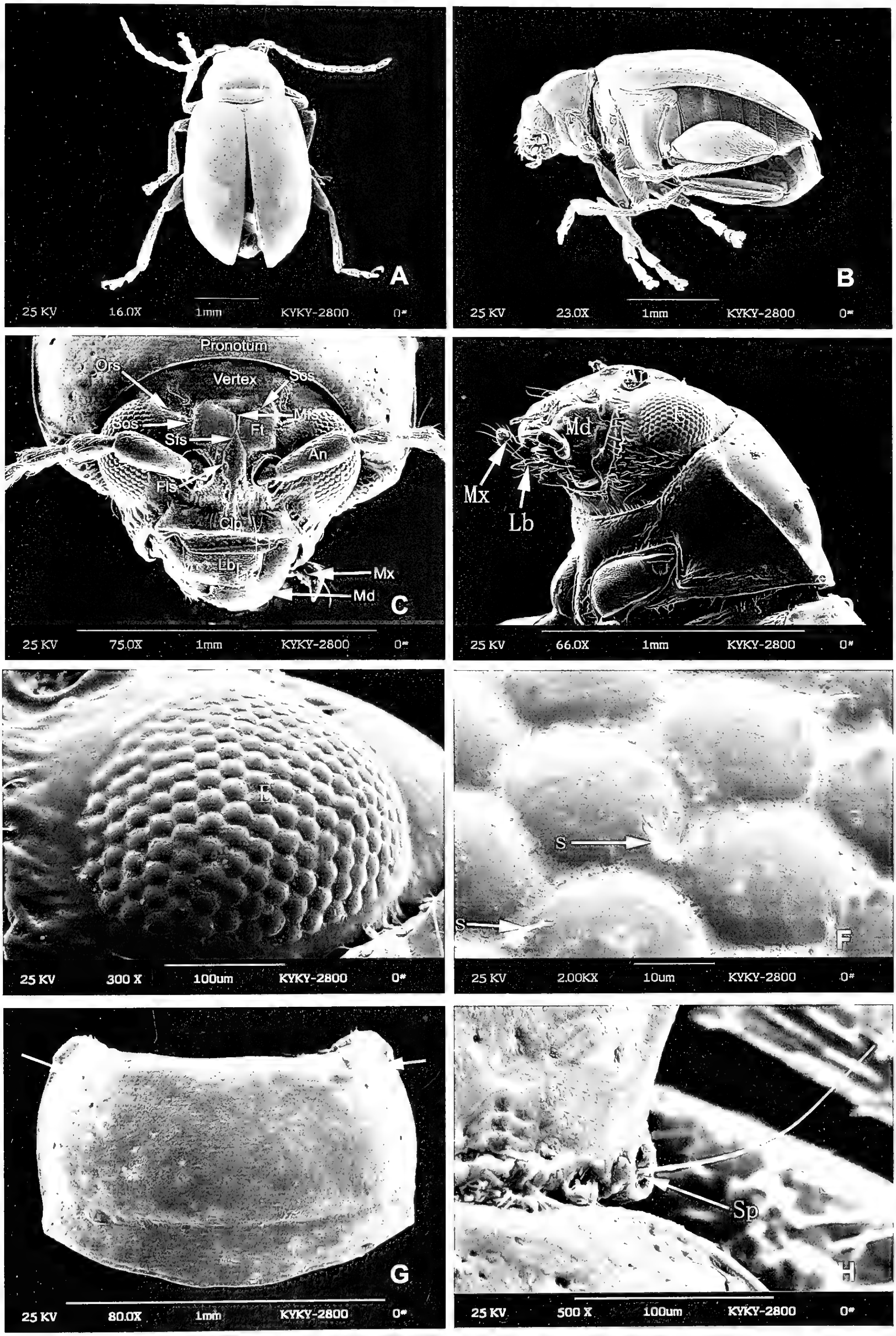
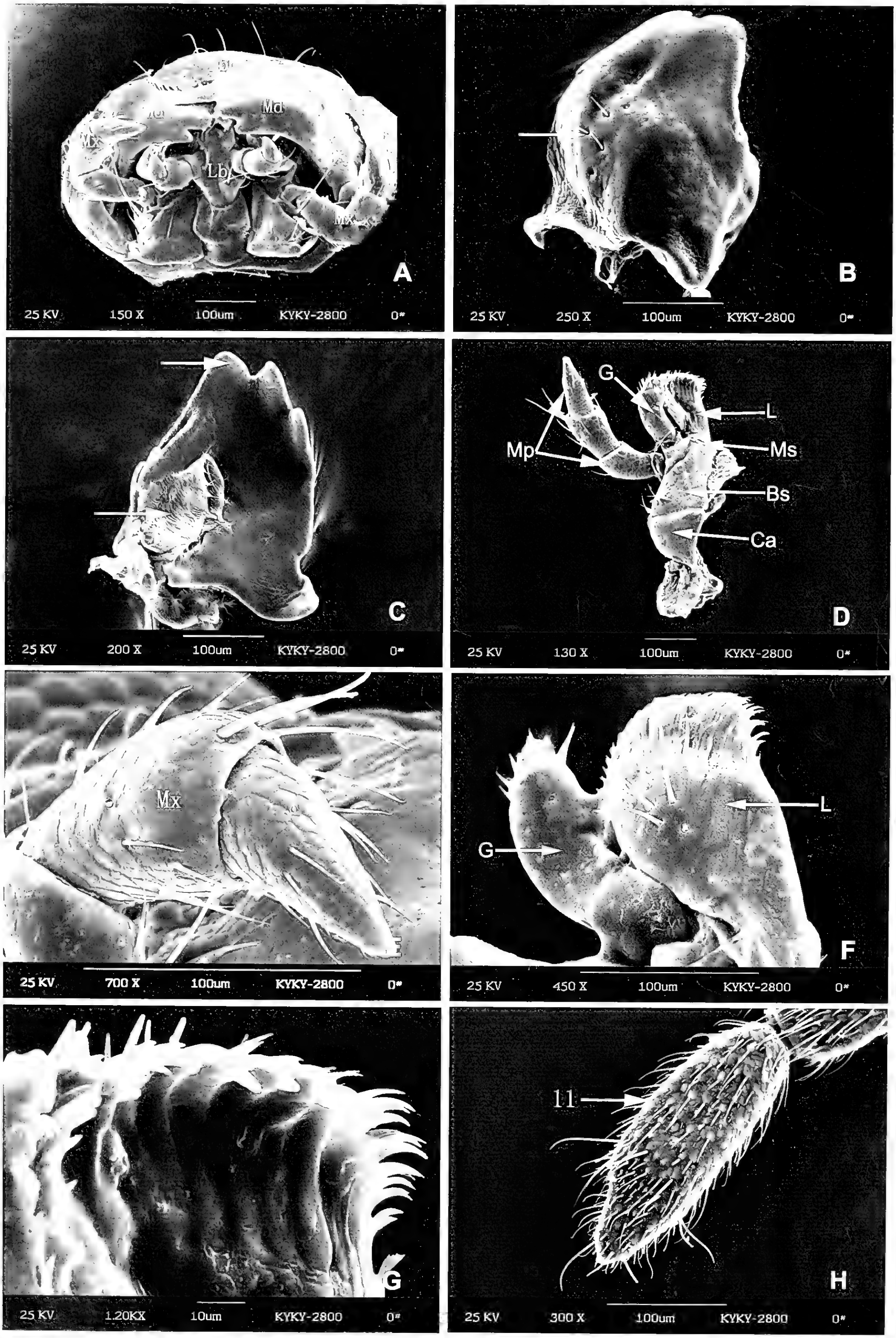


Fig. 5. *Altica fragariae*, Pupa. A, Habitus, dorsal view. B, Habitus, ventral view. Abbreviations: A1, A2, A3, A4, A5, A6, A7: Abdominal segmenets 1, 2, 3, 4, 5, 6, 7; FrL: Foreleg; MoL: Mesoleg; MtL: Metaleg; Ms: Mesothorax; Mt: Metathorax; Pr: Pronotum; U: Urogomphi.

→

Fig. 6. *Altica fragariae*, adult. A, Habitus, dorsal view. B, Habitus, lateral view. C, Frontal view of head. D, Lateral view of head. E, Eyes. F, Partial view of eyes. G, Pronotum. H, Posterior setigerous pore of pronotum. Abbreivations: An: Antennae; Clp: Clypeus; E: Eye; Fls: Frontolateral sulcus; Ft: Frontal tubercle; Lb: Labium; Lbr: Labrum; Md: Mandible; Mfs: Midfrontal sulcus; Mx: Maxilla; Ors: Orbital sulcus; S: Setae; Scs: Supracallinal sulcus; Sfs: Suprafrontal sulcus; Sos: Supraorbital sulcus; Sp: Setigerous pore.


A
25 KV 16.0X 1mm KYKY-2800 0#
B
25 KV 23.0X 1mm KYKY-2800 0#
Pronotum
Ors
Vertex
Sos
Mfs
Sos
Ft
Sfs
An
Fis
Clp
Lb
Mx
Md
C
25 KV 75.0X 1mm KYKY-2800 0#
Md
E
Mx
Lb
25 KV 66.0X 1mm KYKY-2800 0#
E
25 KV 300 X 100um KYKY-2800 0#
S
S
F
25 KV 2.00KX 10um KYKY-2800 0#
G
25 KV 80.0X 1mm KYKY-2800 0#
Sp
H
25 KV 500 X 100um KYKY-2800 0#


Md
Mx
Lb
Mx
A
25 KV 150 X 100um KYKY-2800 0*
B
25 KV 250 X 100um KYKY-2800 0*
C
25 KV 200 X 100um KYKY-2800 0*
G
L
Ms
Mp
Bs
Ca
D
25 KV 130 X 100um KYKY-2800 0*
Mx
25 KV 700 X 100um KYKY-2800 0*
L
G
F
25 KV 450 X 100um KYKY-2800 0*
G
25 KV 1.20KX 10um KYKY-2800 0*
11
H
25 KV 300 X 100um KYKY-2800 0*

Jars were kept closed except when adding leaves and removing dead materials. Rearing was at 25°C, 16: 8 LD, and 80% humidity. Intervals of egg laying and eclosion, different instars, and pupation were recorded.

Adults were dissected and stored in pure alcohol, and some put in a 10% solution of potassium hydroxide for study of the head, mouthparts, and internal skeleton. All materials, including adults and larvae, were put into an ultrasonic cleaner before studying them under the SEM. Adult samples were dehydrated in different percentages of alcohol followed by air drying and gold-sputter coating. Specimens were photographed with a KYKY 2800 SEM. Larvae were transferred directly from pure alcohol onto an SEM-stub and into the microscope with XL20 ESEM-TMP without prior fixation or coating at low vacuum. This technique gave a much better result than the traditional method of fixation and gold-sputter coating. However, because larvae degrade rapidly, they should not be removed from alcohol until immediately before study under the microscope. They can be retrieved and stored again in alcohol after being studied. In order to study the mandibles that are normally covered by the clypeus and labrum, we removed them from the larvae by dissection in alcohol. In the SEM microscope, we photographed the front, lateral, and dorsal views of the larval head, and closeups of the anterior view of the mouthparts and legs. Drawings of the skeleton were made with a camera lucida on a Leica MZ 125. For the female genitalia a Zeiss Axioplan microscope and AnalySIS® software were used. All pictures were evaluated and assembled with Adobe Photoshop® CS 8.0 and Illustrator® CS software.

The terminology follows Suzuki (1988, 1994), Konstantinov and Vandenberg (1996), Cox (1998), and Cox et al. (1999).

The specimens studied are deposited in Institute of Zoology, Chinese Academy of Sciences, Beijing, P. R. China (IZAS).

DESCRIPTION OF EGGS, LARVAE AND PUPAE

Egg (Figs. 11G, H).—*Color:* Usually yellowish. *Morphometrics*: Length: 0.48–0.52 mm, width: 0.20–0.23 mm. *Form*: Cylindrical, rounded at both apices (Fig. 11G), widest at middle and narrowing towards base and micropyle region (narrowest below micropyle region), sometimes symmetrical, apex flattened, with a shell and strip of excrement on surface, and with many air holes and some separated irregular polygon loops (Fig. 11H).

Eggs are laid in star-shaped clusters perpendicular to the substrate with end opposite the micropyle affixed to the back of the leaves.

First-instar larva (Fig. 1).—*Shape:* Eruciform. *Color:* Living specimens dark yellowish; alcohol specimens deep dark yellowish. *Morphometrics:* Length: 0.08–0.12 mm.

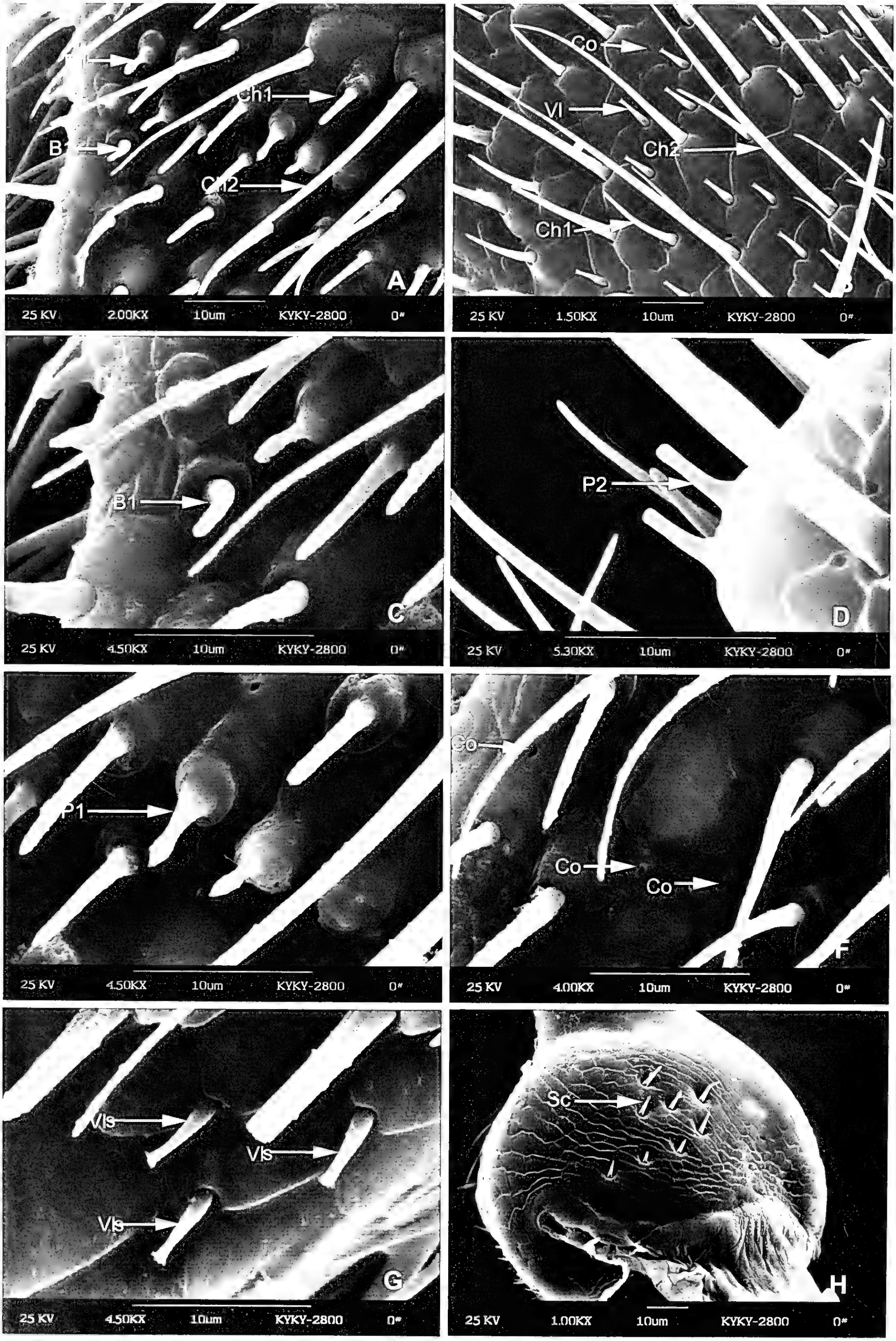
The morphology of first-instar larva is similar to the mature larva. We do not give a detailed description, but illustrate the morphology to show the basic morphological features.

Mature larva (Figs. 2–4).—*Habitus*: Eruciform (Figs. 4A, B); slightly curved when preserved.

Color: Living specimens bright yellow, sclerites dark. Alcohol specimens dark yellow, with head, pronotum, legs, and

←

Fig. 7. *Altica fragariae*, adult. A, Ventral view of mandible. B, Dorsal view of maxillae. C, Ventral view of mandible. D, Ventral view of Maxilla. F, Ventral of lacinia and galea. G, Setae of lacinia. H, Apical segment of antennae. Abbreviations: G: Gelea; L: Lacinia; Lb: Labium; Lbr: Labrum; Md: Mandible; Mp: Maxillary palpi; Mx: Maxilla.

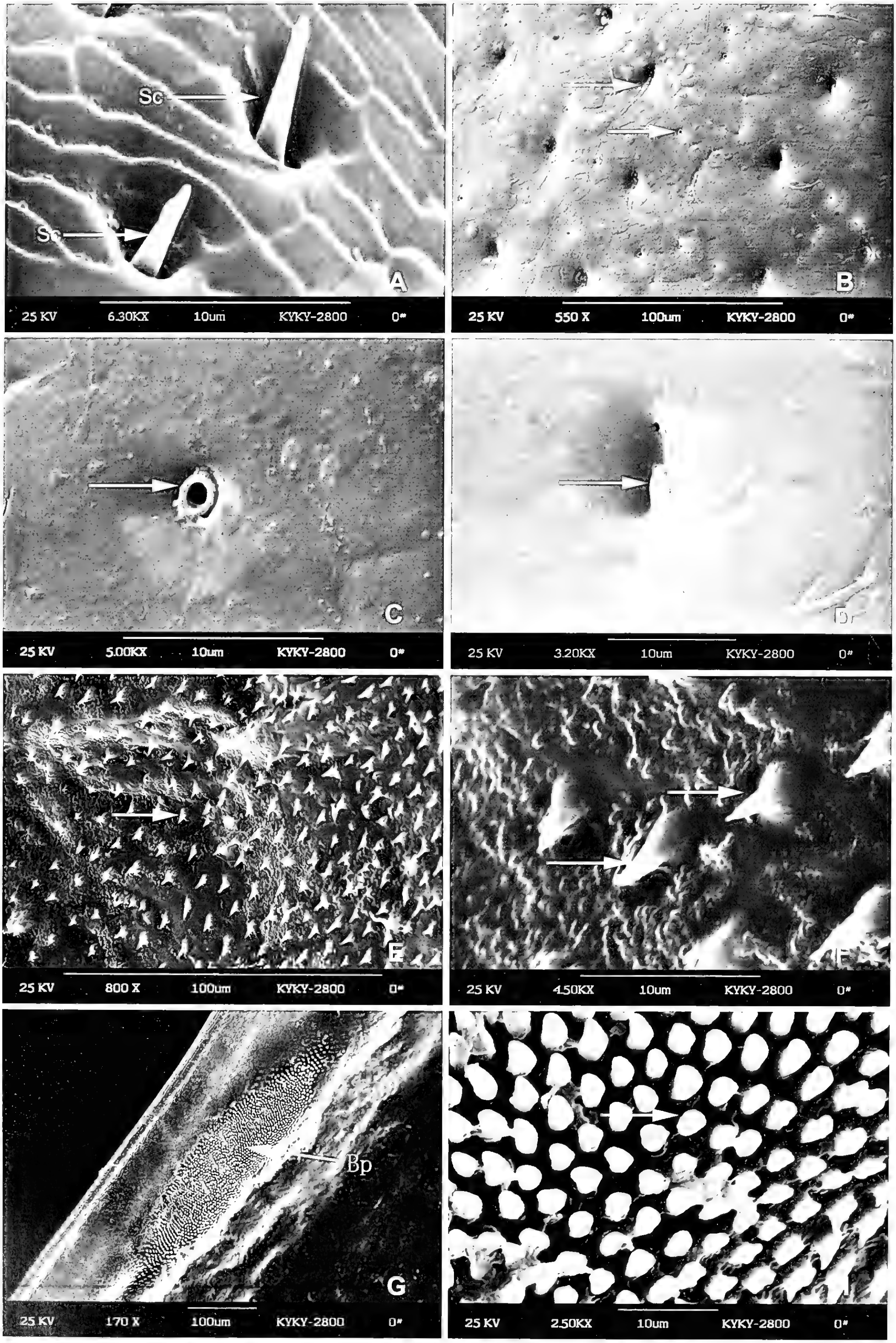

Ch1
B1
Ch2
A
25 KV 2.00KX 10um KYKY-2800 0#
Co
Vl
Ch2
Ch1
B
25 KV 1.50KX 10um KYKY-2800 0#
B1
C
25 KV 4.50KX 10um KYKY-2800 0#
P2
D
25 KV 5.30KX 10um KYKY-2800 0#
P1
25 KV 4.50KX 10um KYKY-2800 0#
Co
Co
Co
F
25 KV 4.00KX 10um KYKY-2800 0#
Vls
Vls
Vls
G
25 KV 4.50KX 10um KYKY-2800 0#
Sc
H
25 KV 1.00KX 10um KYKY-2800 0#

sclerites dark brown. *Morphometrics:* Length: 3.70–4.05 mm.

Head: Rounded, hypognathous, heavily sclerotized; Y-shaped, bowing outwards towards antennal sockets (Figs. 2A, B). Epicranial stem short; endocarina robust, extending from base of frontal arms to clypeus. Frons bearing 5 pairs of long setae (4 dorsal, 1 ventrolateral) and 1 pair of sensory pores close to frontal suture. Vertex highly convex, each epicranial half bearing 3 long setae (2 dorsal, 1 ventrolateral) and 2 sensory pores along with endocarina. Stemmata absent. Antenna 2-segmented (Fig. 2B); antennal socket pronounced, located at ends of frontal arms; basal segment partially membranous bearing 2 sensory pores (1 ventral, 1 dorsal), membranous area bearing 2 peglike sensilla dorsally; distal segment conical, slightly sclerotized basally. Postclypeus (Figs. 2C, D) transverse, edges rounded laterally, bearing 2 pairs of sensilla and 1 pair of scamiform setae. Labrum (Figs. 2C, D) transverse, sclerotized, lateral edges rounded, with pronounced anterior median invagination; dorsal surface bearing 2 pairs of long setae and 1 pair of sensory pores; anterior margin bearing 2 pairs of stout pedunculate setae laterally and 1 pair of short setae medially. Epipharynx with central apical patch of microtrichia grouped in a short transverse row, 1 sensillum lateral to microtrichia, and 3 patches of campaniform sensilla (each composed of 5 sensilla) in a straight longitudinal line (each composed of 3 sensilla) in a straight longitudinal line. Mandibles (Figs. 2C, D) symmetrical, robust, 5-toothed, dentae 1 and 2 bearing small serrations; external face bearing 2 prominent setae and 1 sensory pore; penicillus formed of a single row of diagonally oriented thickened setae; mola absent. Maxilla (Figs. 2C, D) with cardo transverse, highly sclerotized bearing 2 short seta laterally; stipes elongate with two sclerotized areas, one basal bearing 1 lateral and 1 ventrolateral seta and 1 sensory pore anterior to ventrolateral seta and mesad to lateral seta, other sclerotized area smaller near palp bearing 1 seta verntrally; mala with lightly sclerotized basal area bearing 1 seta ventrally, highly sclerotized apex with 8 setae arranged in a circle around 1 stout pedunculate seta (appearing 2-segmented), dorsally bearing straight longitudinal row of long stout setae; maxillary palp 3-segmented, first segment bearing 2 ventromesal and 1 dorsolateral sensory pore, second segment bearing 1 dorsal and 1 ventrolateral seta and 2 ventral sensory pores, distal segment bearing 1 dorsal seta and 2 sensory pores and 1 seta ventrally. Labium (Figs. 2C, D) with submentum sclerotized, basal portion clearly melanized, bearing ventrally 2 pairs of long median setae and 1 short seta at each ventrolateral corner; mentum lightly sclerotized, bearing 2 well-developed and 1 sensory pore on each side; labial palp 2-segmented, basal segment with 2 ventromedial sensory pores and 2 ventrolateral setae, distal segment with 1 ventrolateral sensory pore, 2 lateral setae (hidden in a groove), and 1 lateral elongate placoid sensillum. Hypopharynx heavily covered with microtrichia; apically bearing 2 campaniform sensilla, 2 short setae, and 1 peglike sensillum, entire array forming a circle on ingestion surface. Gula absent.

←

Fig. 8. *Altica fragariae*, adult. A, Antennae sensilla of last segment. B, Antennae sensilla of 10th segment. C, Sensilla basiconica. D, Sensilla petioliform 2. E, Sensilla petioliform 1. F, Sensilla coeloconica. G, Vase-like sensilla. H, Scape. Abbreviations: B1: Basiconica sensilla 1; Ch1: Chaetonica sensilla 1; Ch2: Chaetonica sensilla 2; Co: Sensilla coeloconica; P1: P1-Petioliform sensilla 1; P2: Petioliform sensilla 2; Sc: Scape setae; Vls: vase-like sensilla.


Sc
Sc
A
25 KV 6.30KX 10um KYKY-2800 0#
B
25 KV 550 X 100um KYKY-2800 0#
C
25 KV 5.00KX 10um KYKY-2800 0#
D
25 KV 3.20KX 10um KYKY-2800 0#
E
25 KV 800 X 100um KYKY-2800 0#
F
25 KV 4.50KX 10um KYKY-2800 0#
Bp
G
25 KV 170 X 100um KYKY-2800 0#
H
25 KV 2.50KX 10um KYKY-2800 0#

Thorax (Figs. 4A, B): Prothorax narrower than other thoracic segments; pronotum with 2 transverse tubercles, each with 5 setae, and 2 lateral unisetose tubercles; prosternum with 2 pairs of medial setae. Meso- and metathorax (Figs. 4A, B) subequal, wider than prothorax; both nota with 2 anterior and 2 posterior unisetose tubercles arranged in a transverse row, 2 large lateral bisetose tubercles, and 2 large lateral trisetose tubercles. Meso- and metasterna with 1 anterior median bisetose tubercle, 2 posterior bisetose medial tubercles and 2 bisetose tubercles laterally. Mesothoracic spiracle annuliform.

Legs (Figs. 2E–H, 3A): Increasing in size from pro- to metathorax, 5-segmented, all setae on legs filiform; coxae largely trapezoidal bearing 8 setae (5 short, 3 long); trochanters largely membranous distally, with 4 setae (4 long) and 2 sensilla; femur strongly sclerotized dorsally but membranous ventrally, with 6 setae (3 short, 3 long); tibia with 7 setae (5 long, 2 short) and 1 sensory pore; tarsungulus bearing setiform pulvillus with long, setalike, basiconic sensillum at base (Fig. 2H).

Abdomen (Figs. 3B, C, 4A, B): Segments I–VII bearing well-defined sclerites, arranged dorsally into two transverse rows, with similar chaetotaxy (Fig. 4A, B); dorsally 1 anteromedian tubercle with 4 setae, posterior tubercles parallel to anterior one with 4 setae, and 8 long dorsolateral unisetose tubercles; laterally with 2 unisetose tubercles; ventrally with 1 anteromedian bisetose tubercle, 2 posterior bisetose tubercles arranged in a transverse row, and 2 ventrolateral bisetose tubercles. Segment VIII similar to previous abdominal segments, except for fusion of interior and exterior scutoscutellar sclertites into single scutoscutellar sclerite, with 4 (2 pairs) of large capitate scutoscutellar setae. Segment IX dorsally fused together into semicircular pygidium; with 5 pairs of large capitate pygidial setae. Ventral sclerites fused together into narrow tranverse band baring 2 pairs of filiform setae. Segment X not visible in dorsal view, in form of fleshy pygopod with 1 anterior lobe, 1 posterior lobe, and 1 pair of lateral lobes, and a weakly slcerotized narrow transverse sclertite at anterior portion.

Pupa (Fig. 5).—*Morphometrics:* Length: 3.70–3.91 mm. *Color*: Grayish yellow. With dark brown tubercules at base of spiracles.

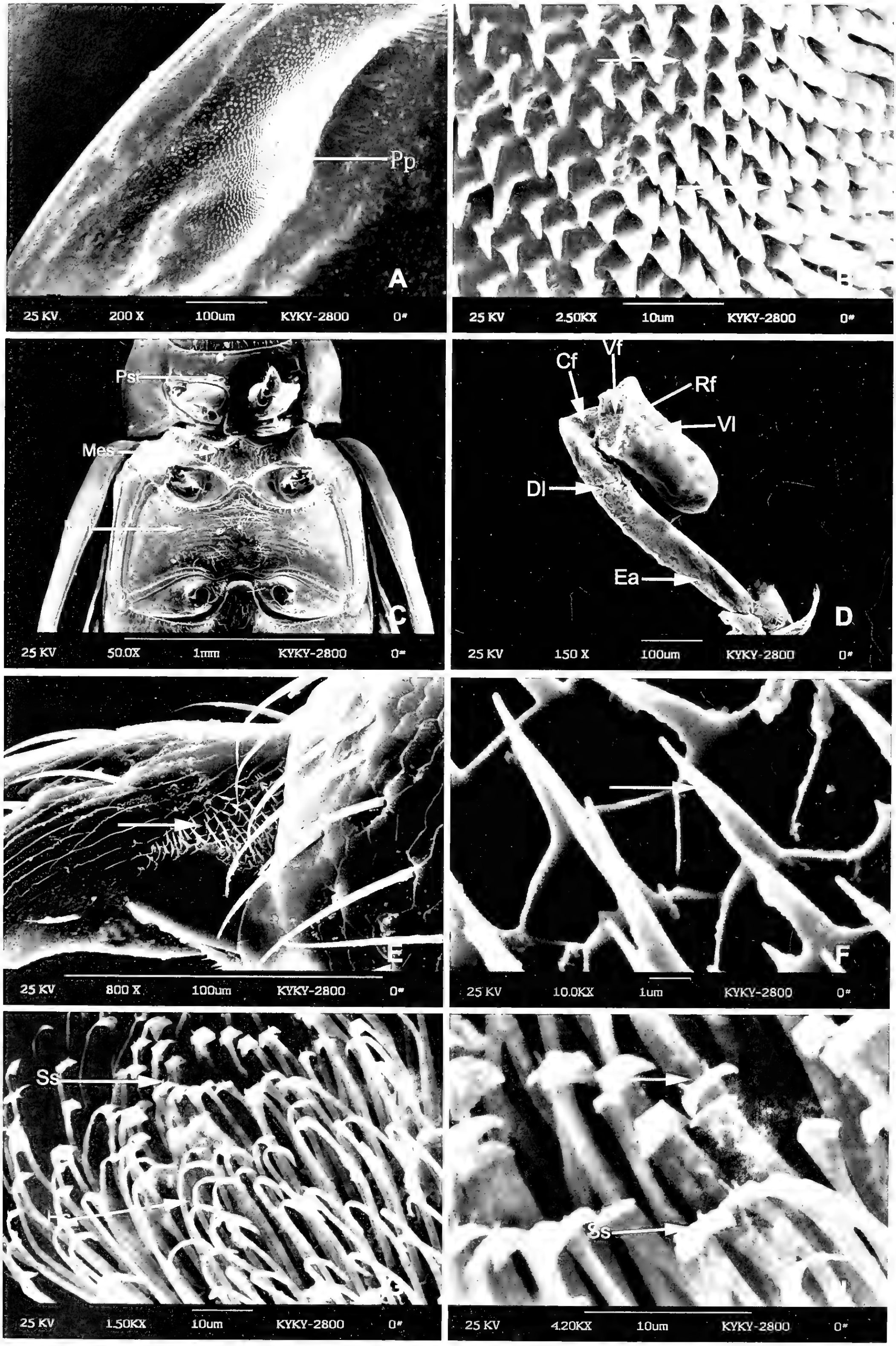
Head (Figs. 5A, B): Rounded, not visible in dorsal view, bearing 1 pair of long setae on eyes, 1 pair of setae above eyes, and 1 pair subantennal setae, situated on frons near midline. Mouthparts well developed and distinct. Labrum subquadrate, apex emarginated medially. Mandible and maxillary and labial palpi subglobose.

Thorax (Figs. 5A, B): Pronotum trapezoidal, twice as wide as long, bearing 10 pairs of setae: anterior area bearing 5 pairs of setae (2 pairs located close to midline) and 3 pairs of setae anterolaterally, 1 pair centrally on disk, and 5 posterolateral pairs of setae (2 setae at 1/4th of posterior pronotal margin and 3 seta at posterior corner of pronotum).

Abdomen: Abdominal segments I–VI bearing dorsally 2 pairs of long setae evenly spaced across dorsal surface, setae borne on small conical tubercles; segments I–V bearing 1 pair of sclerotized annular spiracles and 1 pair of pleural

←

Fig. 9. *Altica fragariae*, adult. A, Scape setae. B, Punctures of elytra. C, Puncture without setae. D, Puncture with setae. E, Ventral surface of elytra. F, Setae of elytra ventral surface. G, Basal patch. H, Setae of basal patch. Abbreviations: Bp: Basal patch; Sc: Scape setae.


Pp
A
25 KV 200 X 100um KYKY-2800 0#
B
25 KV 2.50KX 10um KYKY-2800 0#
Pst
Mes
C
25 KV 50.0X 1mm KYKY-2800 0#
Vf
Cf
Rf
Vl
Dl
Ea
D
25 KV 150 X 100um KYKY-2800 0#
E
25 KV 800 X 100um KYKY-2800 0#
F
25 KV 10.0KX 1um KYKY-2800 0#
Ss
Hs
G
25 KV 1.50KX 10um KYKY-2800 0#
Ss
25 KV 4.20KX 10um KYKY-2800 0#

setae, originating from a small tubercle vertroposterior to each spiracle; segment VI bearing dorsally 2 pairs of setae and 1 pair of pleural setae appearing ventral; segment VII semicircular; with 5 pairs of dorsal setae. Segment VIII reduced, bearing 1 pair of sharp black urogomphi. Segments IX and X reduced, hidden under segment VII.

MORPHOLOGY OF ADULT

(Figs. 6, 7, 8, 9, 10, 11, 12, 13)

General features.—Dark blue, shiny metallic, convex in lateral view (Figs. 6A, B). Body length: 3.50–4.00 mm; width: 1.80–2.20 mm.

Head.—*External structures* (Figs. 6C–F): Subprognathous, vertex smooth, almost impunctate; each side with a setigerous pore and a moderately long seta near eyes (Fig. 6C). Frontal tubercles more distinct and quadrate, separated by a shallow longitudinal furrow; interantennal space somewhat broad and very convex, with basal part acute, inserted between two tubercles and anterior part narrower, each side with several punctures (Fig. 6C). Orbital sulcus well developed, supracallinal sulcus absent, midfrontal sulcus well developed, antennal calli almost completely separated, supra-antennal sulcus extremely deep, suprafrontal sulcus poorly developed, antennal calli and top of frontal ridge meet, separated by shallow groove, frontolateral sulcus well developed, anterofrontal ridge convex and well separated from clypeus, frontoclypeal suture well developed, clypeus usually with anterior margin straighter, subgenal suture poorly developed, gena with some setigerous pores (Fig. 6C). Compound eyes large, rounded and protruding, with sharp setae between ommatidia (Figs. 6E, F).

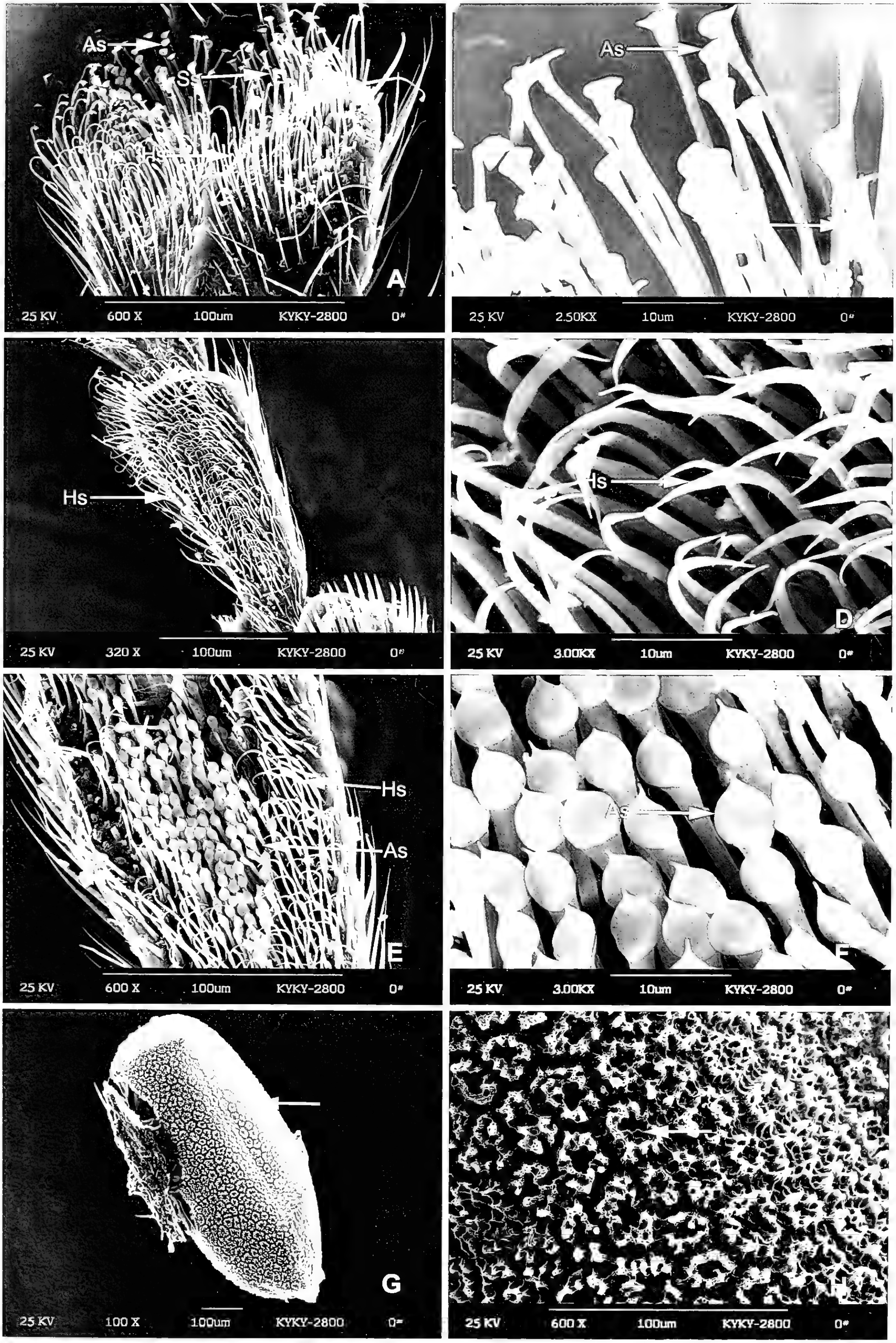
Labrum (Figs. 6C, D, 7A, 13A): Trapezoidal, with strongly rounded anterolateral edges. Flat, sclerotized, with 2 posterolateral elongated tormae and numerous marginal setae on anterior, medially sinuate margin, upper surface with 6 symmetrically placed setigerous pores.

Mandibles (Figs. 6D, 7A–C): Highly sclerotized, broadly triangular, with rounded lateral margins and well-developed apex, mostly symmetrical. External side broad at base and narrowing towards apex. Proximal half slightly inclined dorsomedially (Fig. 7B). Ridge on anterolateral dorsal side of mandible slightly bent externally (Fig. 7B). Basal half of dorsal side slightly convex, with 3 distinct denticles on distal part; outer surface very convex with 5 setae and very complicated sculpturing (Fig. 7B), inner surface strongly concave with a membranous prostheca covered by many small setae (Fig. 7C).

Maxilla (Figs. 6D, 7D–G): Consisting of a basal segment (cardo), basistipes, mediastipes, galea, and lacinia. Cardo subtriangular, with several long setae or spines. Basistipes elongate triangular, surface with several short spines. Mediastipes firmly connected with lacinia, surface with several short setae. Mesal edge of lacinia continuous with a semimembranous lamella, densely covered and with hairs anteriorly. Distal margin of lacinia with a row of large, finger-shaped blunt thorns (Fig. 7G). Galea composed of 2 galeomeres. Galeomere I

←

Fig. 10. *Altica fragariae*, adult. A, Posterior patch. B, Setae of posterior patch. C, Ventral surface of thorax. D, Metafemoral spring. E, Setae of basal tibiae. F, Amplificatory setae. G, Female third tarsus. H, Spatulate setae. Abbreviations: Cf: Central furrow; Dl: Dorsal lobe; Ea: Extended arm; Hs: Hooked setae; Mes: Mesosternum; Met: Metasternum; Pp: Posterior patch; Pst: prosternum; Rf: Recurve flange; Ss: Spatulate setae; Vf: Ventral furrow; Vl: Ventral lobe.


As
S
Hs
A
25 KV 600 X 100um KYKY-2800 0#
As
25 KV 2.50KX 10um KYKY-2800 0#
Hs
25 KV 320 X 100um KYKY-2800 0#
Hs
D
25 KV 3.00KX 10um KYKY-2800 0#
Hs
As
E
25 KV 600 X 100um KYKY-2800 0#
As
F
25 KV 3.00KX 10um KYKY-2800 0#
G
25 KV 100 X 100um KYKY-2800 0#
H
25 KV 600 X 100um KYKY-2800 0#

subquadrangular in dorsal view. Galeomere II elongate-ovid, distal part covered with rows of short hairs (Figs. 7D, F). Maxillary palp elongate, 4-segmented. Palpomere I very short. Palpomeres II and III distally widening and bent inwards. Ultimate palpomere elongate and spindle-shaped, longer than wide, shorter than palpomere III (Figs. 7D, E).

Labium (Figs. 6D, 13B): Prementum broad, subquadrangular. Hind margin not clearly separated from gular suture. Mentum and hypopharynx forming a morphological and functional unit. Mentum large, heavily sclerotized. Anterior margin with prominent process; surface of mentum uneven, with a regular but sparse vestiture of short hairs. Labial palp 3-segmented, inserted on distal part of palpiger below paired mentum sclerites. Palpomere I long, palpomere II approximately cylindrical, longest, lateral margin with small spine. Palpomere III shorter than II, apex pointed. Internal and external margins with setae.

Antenna (Figs. 7H, 8A–H, 9A): 11-segmented, posteriorly almost reaching middle of elytra, first segment club-shaped, dorsomedial part with several setae, long and almost same length as last segment, second segment shortest, third segment longer than second, fouth segment slightly longer than third, from fourth segment more piligerous, last segment with apex acute (Fig. 7H); proportion of each segment: 1.2: 0.7: 0.9: 1.0: 1.1: 0.9: 0.9: 1.0: 1.0: 0.9: 1.2. Ultrastructure of 2 types of sensilla chaetonica (Figs. 8A, B), 1 type of sensilla basiconica (Figs. 8A, C), 1 type of sensilla coeloconica (Figs. 8B, F), 2 types of sensilla petioliform (Figs. 8A, D, E), and 1 type of vaselike sensilla (Fig. 8G).

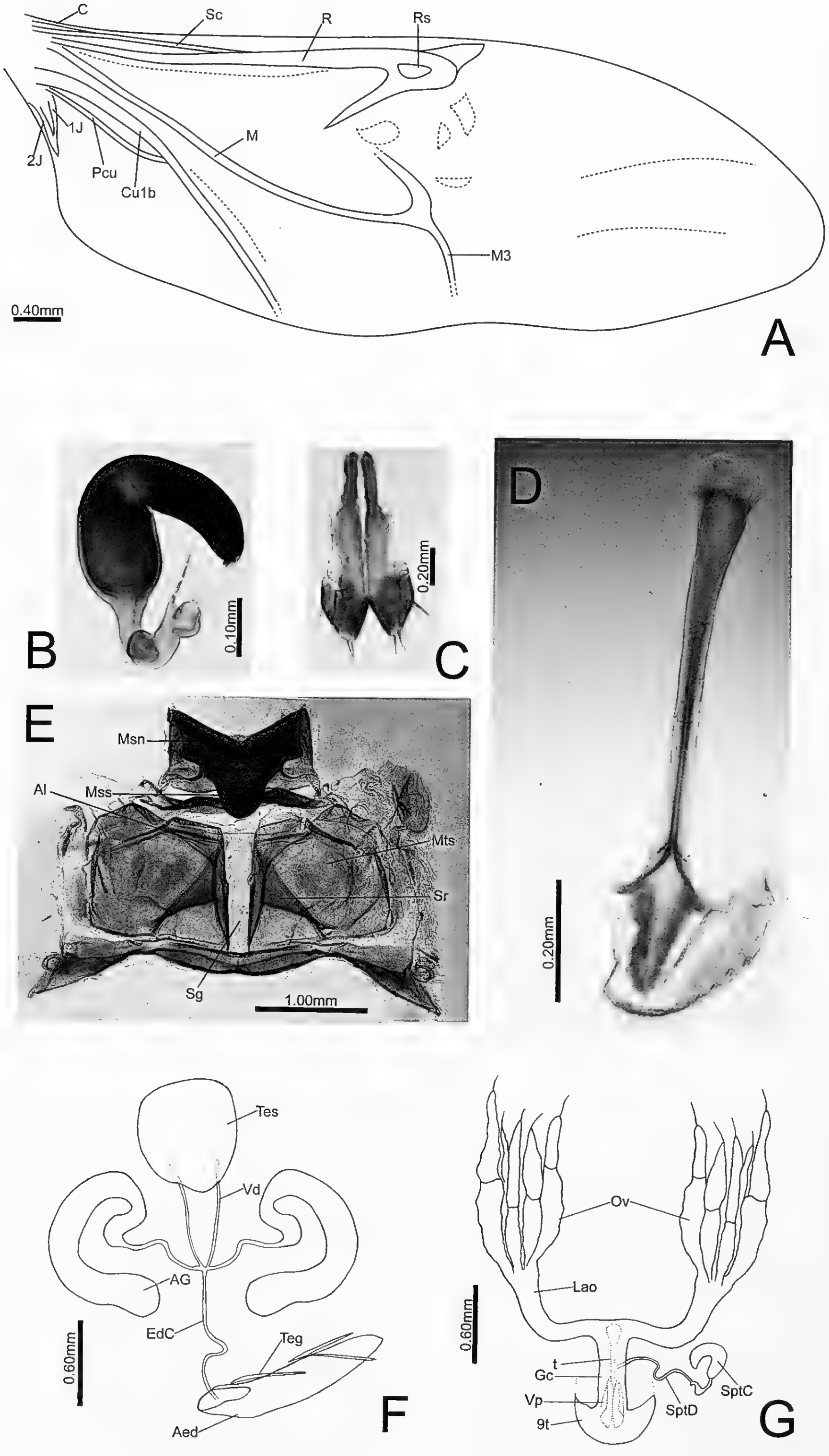
Thorax.—*Prothorax* (Figs. 6D, G, H): Length: 1.20–1.40 mm; width: 0.80–1.00 mm; each corner with setigerous pore and anterior seta much longer than posterior one (Fig. 6H). Anterior margin straighter, lateral margin slightly arched, basal margin slightly more arched in middle; anteriorlateral angle acute, incrassate, posteriorlateral angle obtuse; surface almost smooth, with sparse and fine punctures, disc impunctate especially with some strong punctures near anterior angle; with a transverse groove before basal margin, almost straight, each side almost reaching lateral margin. Lateral wall of prothorax exclusively formed by hypomeron. Hypomeron broad and impunctate (Fig. 6D). Pleuron fused with trochantinus; trochantinopleuron not visible externally. Prosternum well developed. Prosternal process triangular, broader and protruding behind between two coxal cavities, slightly constricted between procoxae, apex truncate. Surface without punctures and pubescences. Procoxal cavities open hehind (Fig. 6D).

Mesothorax (Fig. 10C): Scutellum subtriangular, smooth and impuntate. Ventral side somewhat broad and concave, including anepisternum and epimeron with pubescence and with some wrinkles.

Elytra (Figs. 6A, B, 9B–H, 10A, B): Length: 2.20–2.40 mm; width: 2.80–3.20 mm; completely concealing abdomen (Fig. 6A). Elytra broader than pronotum at base, with close and confused punctures, more distinct than on

←

Fig. 11. *Altica fragariae*, adult. A, Male third tarsus. B, Amplificatory of male third tarsus. C, Female first tarsus. D, Hooked setae. E, Male first tarsus. F, Acetabula setae. G, Egg. H, Surface of egg. Abbreviations: As: Acetabula setae; Hs: Hooked setae; Ss: spatulate setae.


C
Sc
R
Rs
1J
2J
Pcu
Cu1b
M
M3
0.40mm
A
B
0.10mm
C
0.20mm
D
0.20mm
E
Msn
Al
Mss
Mts
Sr
Sg
1.00mm
Tes
Vd
AG
EdC
Teg
Aed
0.60mm
F
Ov
Lao
t
Gc
Vp
9t
SptD
SptC
0.60mm
G

pronotum, and posterior part with sparser punctures, with some fine punctures between larger ones, also with some slightly shagreened wrinkles between punctures (Figs. 9B–D). Ventral surface composed of microtrichia (Figs. 9E, F). Ventral surface of elytral suture with two patches (basal and posterior) for connection. Basal patch forms metascutal interlocking device, composed of scalelike microtrichia (Figs. 9G, H). Posterior patch composed of stalklike microtrichia (Figs. 10A, B). Epipleura widened anteriorly, without punctures and wrinkles (Fig. 6B).

Metathorax (Figs. 10C, 12E, 13C, D): Ventral side including anepisternum and epimeron with sparse pubescence and wrinkles (Fig. 10C). Metanotum well pigmented and sclerotized, about 2 times as wide as long, slightly arched, except for vertical anterior part. Scutum with distinct anterolateral bulges and ridges (Fig. 10C). Alacristae long and distinct, extending from anterior margin of horizontal part of scutum to hind margin. Scutoscutellar ridge crossing alacristae anteriorly, thus lowered area between alacristae composed of a very large scutellar portion and a very small anterior scutal portion. Scutellar groove narrow (Fig. 12E). Exposed part of anepisternum nearly parallel-sided, rather elongate. Epimeron largely covered by elytra. Metasternum evenly convex, anteromedially projecting between mesocoxae. Transverse suture separating mesosternum from katepisternum. Katepisternum exposed in total length, but narrowed close to median line. Metacoxae separated, slightly narrowed laterally, almost reaching lateral metathoracic margin (Fig. 10C). Metendosternite well developed (Figs. 13C, D), stalk with narrow sulcus arising from base of metasternal processes, without basal extention, arms with small, medially fused triangular extension, apical part with small extension, ventral process narrower and stalk longer than wide.

Hindwing (Fig. 12A): Well developed, venation as typical *Altica* morphology. Vein C short and strong, Sc close to and below C, R very strong forming a small cell Rt apically, M_{1+2} and r-m absent, Cu1a also absent, Cu1b and Pcu coalesce apically. Hind wing venation developed in about 1/2 of wing.

Legs (Figs. 6A, B, 10D–H, 11A–F): Procoxae cone-shaped. Trochanters of moderate size, femora very inflated, tibiae slender, basal part with microtrichia composed of triangular area (Figs. 10E, F). Third segment of tarsi bilobed. Claws appendiculate. Ultrastructure of first and third tarsi different between male and female. Female always with one type of hooklike setae (Figs. 10G, 11A, C, D, E), male always with two types of setae, the former same as female, the latter acetabula-like setae (Figs. 11A, B, E, F). Metafemoral spring with straight dorsal lobe, a rather long extended arm, obtuse, often small, basal angle of ventral lobe, and significant sclerotized recurve flange (Fig. 10D).

Abdomen (Figs. 6B, 12B, C, D, F, G, 13E–G).—Abdominal sternite 5-seg-

←

Fig. 12. *Altica fragariae*, adult. A, Hindwing. B, Spermatheca. C, Vaginal palpi. D, Tignum. E, Metanotum, dorsal view. F, Male reproductive system. G, Female reproductive system. Abbraviations: 1J: 1st jugal vein; 2J: 2nd jugal vein; 9t: 9th tergits; Aed: Aedeagus; AG: Accessory gland; Al: Allocrista; C: Costa; Cu1b: Cubital vein 1b; Edc: Ejaculatory; Gc: Genitalia chamber; Lao: Lateral oviduct; M: Medial vein; M_3: Medial vein 3; Msn: Mesonotum; Mss: Mesoscutellum; Mts: Metascutum; Ov: Ovary; Pcu: Precubital vein; R: Radial vein; Rs: Radial sector; Sc: Subcosta; Sg: Scutellar groove; SptC: Spermatheca capsule; SptD: Spermatheca duct; Sr: Scutoscutellar ridge; T: Tignum; Teg: Tegmen; Tes: Testis; Vd: Vas deferens; Vap: Vaginal palpi.

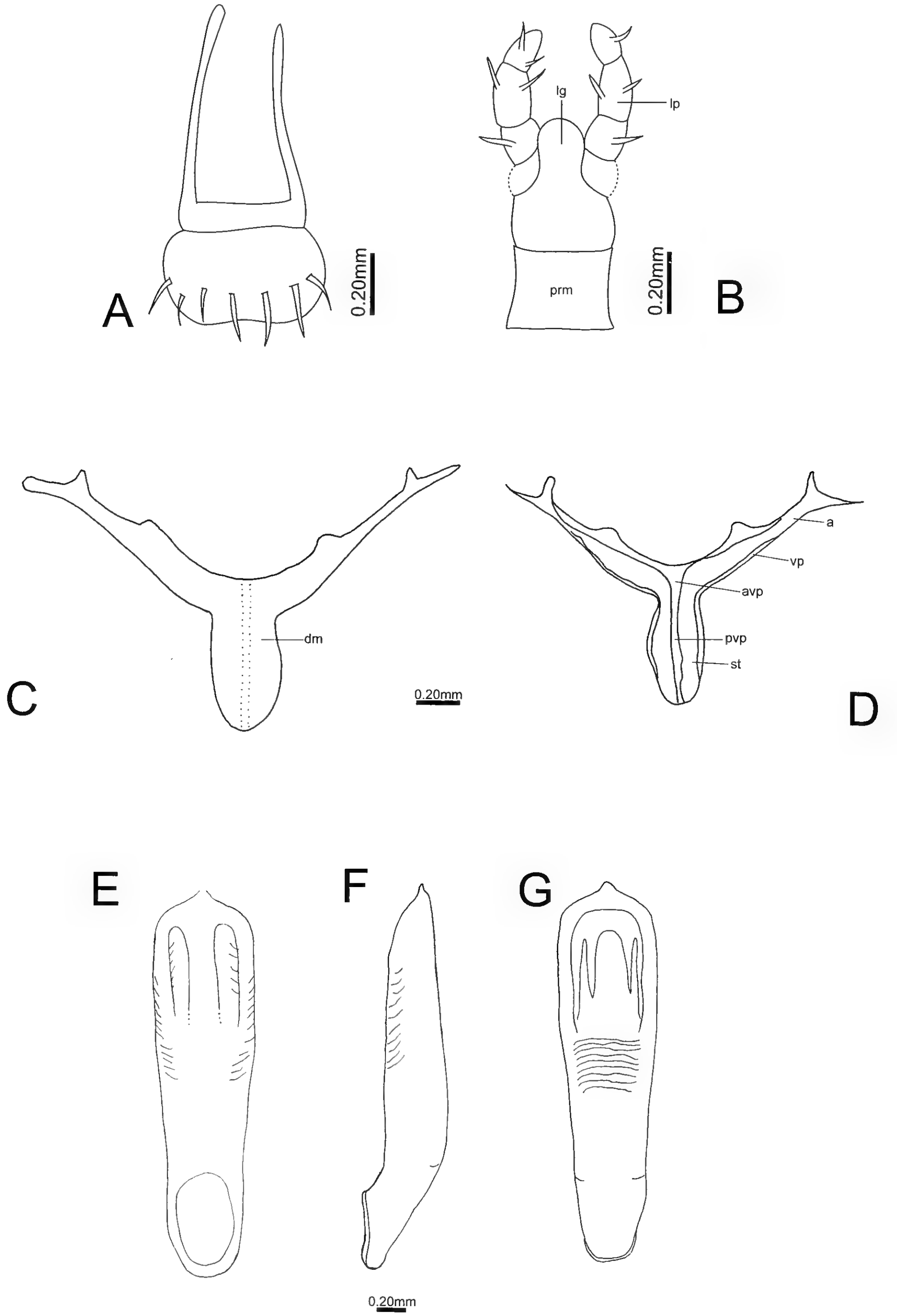


Fig. 13. *Altica fragariae*, adult. A, Labrum. B, Labium. C, Metendosternite, dorsal view. D, Metendosternite, verntral view. E, Aedeagus, ventral view. F, Aedeagus, lateral view. G, Aedeagus, dorsal view. Abbreviations: A: Arm; Avp: Anterior part of ventral process; Dm: Dorsal membrane; Lg: Ligule; Lp: Labial palpi; Prm: Promentum; Pvp: Posterior part of ventral process; St: Stalk; Vep: Ventral projection.

mented, with dense pubescence and shallow punctures. Last sternite of male trilobed, unconspicuous, that of female rounded.

Male reproductive system (Fig. 12F).—Internal reproductive system with spherical testis; a pair of tubular vas deferens, almost uniform in width but somewhat expanded at middle; ejaculatory duct connected with vas deferens at anterior part and opens into internal sac, inner chamber of aedeagus invaginated at apex; accessory glands are secretory organs of mucous substances and connected with anterior end of ejaculatory duct, length and width always varied.

Aedeagus (Figs. 13E–G.): With a very small denticle at apex. In ventral view, convex in middle, each side with a short longitudinal groove near apex, surface of lateral part of groove and lateral side of aedeagus with some transverse wrinkles (Fig. 13E). In lateral view, almost straight and slightly acute at apex, slightly concave about 1/3 length from apex and with some oblique wrinkles (Fig. 13F). In dorsal view, with a narrow longitudinal sclerotized part medially, each side with bifurcate, median part with transverse winkles (Fig. 13G).

Female reproductive system (Fig. 12G).—Consisting of a pair of ovaries, varying in shape; lateral oviduct short and uniform in width; common oviduct extends from opening of lateral oviduct to genital opening; genital chamber connected with common oviduct at anterior part and with spermatheca in lateral part; vaginal palpi and tignum at end of genital chamber.

Spermatheca (Fig. 12B): With receptacle longer than pump, internal side of receptacle convex, external side almost straight, receptacle elongate, longer than wide, maximum width at base, pump moderately narrow, horizontal part curved; vertical part shorter than horizontal part, duct not exceeding middle of receptacle, making a very narrow loop away from receptacle.

Vaginal palpi (Fig. 12C): With middle of membranous part nearly as long as sclerotized part, lateral margin almost parallel to medial, pointed apically, median margin almost straight.

Tignum (Fig. 12D): Nearly straight, slightly broadened at base and acute at apex, well sclerotized.

DISCUSSION

The taxonomy of *Altica* is very difficult because of their similar morphology. Although there are some important works on *Altica fragariae*, most only emphasize taxonomy. In this paper, we describe and treat the morphology in detail. We draw the following conclusions:

Adults.—The main differences between *Altica fragariae* and other species are the morphology of the male and female genitalia, punctures of the pronotum, and color. In the ultrastructure of the antennae, 2 types of sensilla chaetonica, 1 type of sensilla basiconica, 1 type of sensilla coeloconica, 2 types of sensilla petioliform, and 1 type of vaselike sensilla were found. These characters should be closely related to choosing host plants. The ventral setae of the tarsus in the male and female could be related to mating behavior.

Eggs.—LeSage (2004) described the egg shell as a two-level structure in two species of *Altica*. We also observed that the outermost layer is made of more or less well-defined and symmetrical polygons whereas the second level consists of larger polygons and smaller polygons.

Larvae.—Three larval instars are present in *Altica fragariae*, as previously reported (Woods 1917, 1918; Isely 1920; Paterson 1943; Dirks-Edmunds 1965; Barstow and Gittins 1973; LeSage et al. 2004). The morphology of three instars is similar, but they can be distinguished by color and body size. Also the first instar has egg bursts on the meso- and metathorax.

Pupae.—The difference of *Altica* species can be found in the chaetotaxy, body size, and color.

Though the morphology is dealt with in detail in this paper, several aspects should be described in much more detail with function, such as the setae of the antennae and tarsi. Also, internal skeletal structure should be studied.

ACKNOWLEDGMENTS

First and foremost, we are grateful to Huai-Jun Xue, Shu-Yong Wang, and Wen-Zhu Li for collecting and rearing *Altica fragariae* and for providing useful information on biology and for comments on manuscript. We cannot fully express our gratitude to Hua Gu of Tsinghua University and Shi-Yi Guo of Nankai University for their assistance with SEM. Thanks especially to Laurent LeSage of Agriculture and Agri-Food Canada, Ottawa, for mailing some useful reprints. The project was supported by the National Natural Science Foundation of China (Grant No. 30330100, 30470202).

LITERATURE CITED

Barstow, D. A. and A. R. Gittins. 1973. Descriptions of the life stages of *Altica bimarginata* Say (Coleoptera: Chrysomelidae). Journal of the Kansas Entomological Society 46: 55–510.

Cabrera, N. C. and S. P. Durante. 2003. Comparative morphology of mouthparts in species of the genus *Acalymma* Barber (Coleoptera, Chrysomelidae, Galerucinae). Coleopterists Bulletin 57(1): 5–16, 41 figs.

Chen, S. H. 1936. Notes on some flea-beetles from Tropical Asia (2). Sinensia 7(1): 80–88.

Chen, S. H. and S. Y. Wang. 1981. Coleoptera: Chrysomelidae: Alticinae, pp. 491–508. *In* Huang, F. Sh., ed. Insects of Xizang, Science Press, Beijing, China, vol. 1.

Cox, M. 1998. The pupae of Chrysomeloidea and their use in phylogeny (Coleoptera), pp. 73–90. *In* Biondi, M., M. Daccordi, and D. G. Furth, eds. Fourth International Symposium on the Chrysomelidae, Torino.

Cox, M. and S. M. Windsor. 1999. The first instar larva of *Aulacoscelis appendiculata* s. sp. (Coleoptera: Chrysomelidae: Aulacoscelinae) and its value in the placement of the Aulacoscelinae. Journal of Natural History 33: 1049–1067.

Dirks-Edmunds, J. C. 1965. Habits and life history of the bronze flea beetle, *Altica tombacina* (Mannerheim) (Coleoptera-Chrysomelidae). Northwest Sciences 39: 148–158.

Gressitt, J. L. and S. Kimoto. 1963. The Chrysomelidae (Coleoptera) China and Korea. Part 2. Pacific Insects Monograph 1B: 739–893.

Gruve, B. and M. Döberl. 1997. General Distribution of the flea Beetles in the Palaearctic subregion (Coleoptera: Chrysomelidae: Alticinae). Scopolia 37: 1–496.

Isely, D. 1920. Grapevine flea-beetles. Bulletin of the United States Department of Agriculture, No. 901, 27 pp.

Kangas, E. and I. Rutanen. 1993. Identification of females of the Finnish species of *Altica* Müller. Entomologica Fennica 31(5): 115–128.

Konstantinov, A. S. 1987. On the morphological structures used for identification of female of *Altica* (Coleoptera, Chrysomelidae). Zoological Journal 54(1): 42–50.

———. 1998. On the structure and function of the female genitalia in flea beetles (Coleoptera: Chrysomelidae: Alticinae). Proceedings of the Entomological Society of Washington 100(2): 353–360, 3 figs.

———. 2002. New data on the structure of the female genitalia of flea beetles (Coleoptera: Chrysomelidae). Proceedings of the Entomological Society of Washington 104(1): 237–239.

Konstantinov, A. S. and I. K. Lopatin. 1987. Comparative morphological study of the metendosternite in the leaf-beetles of the subfamily Alticinae (Coleoptera, Chrysomelidae). Revue d'Entomological'URSS 66(2): 247–255, 37 figs.

Kontantinov, A. S. and N. J. Vandenberg. 1996. Handbook of Palearctic Flea Beetles (Coleoptera: Chrysomelidae: Alticinae). Associated Publishers, Ganesville, Florida. 439 pp.

Lee, J. E. and D. G. Furth. 2000. Larval morphology and biology of a North American and an Israeli *Altica* species (Coleoptera: Chrysomelidae: Alticinae). Florida Entomologist 83(3): 276–284, 20 figs.

LeSage, L. and J. Denis. 1999. The flea-beetle *Altica corni* Woods in North America (Coleoptera: Chrysomelidae, Alticinae), pp. 533–544. *In* Cox, M. L. ed. Advances in Chrysomelidae Biology 1. Backhuys Publishers, Leiden.

LeSage, L. and A. Zmudzinska-Krzesinska. 2004. The immature stages of the grape flea beetles *Altica chalybea* Illiger and *A. woodsi* Isely (Coleoptera: Chrysomelidae), pp. 503–528. *In* Jolivet, P., J. A. Santiago-Blay, and M. Schmitt, eds. New development in the Biology of Chrysomelidae.

Lopatin, I. K. 1977. Leaf beetles of Central Asia and Kazakhstan. Opredeliteli Faune SSSR 113: 4–268.

Ogloblin, D. A. 1921. Espèces nouvelles de la tribu Halticina de la region Palearctique (Coleoptera: Chrysomelidae). Revue Russe d'Entomologie 17: 20–40.

———. 1925. Einige neue *Haltica*-Formen aus der paläarktischen Region. Revue Russe d'Entomologie 19: 91–96.

Ohno, M. 1960. On the species of the genus *Altica* occuring in Japan. Bulletin of the Department of Liberal Arts, Tokyo University 1: 77–95.

Patersin, N. F. 1943. Early stages of two species of Halticinae (Chrysomelidae, Coleoptera). Journal of the Enomological Society of South Africa 6: 29–36.

Phillips, W. M. 1977a. Observation on the biology and ecology of the chrysomelid genus *Haltica* Geoffroy in Britain. Ecological Entomology 2: 205–216.

———. 1977b. Some aspects of the host plant relations of the Chrysomelid genus *Haltica* with special reference to *Haltica lythri*. Entomologia Experimentalis et Applicata 21: 261–274.

Riley, C. V. 1870. Insects injurious to the grapevine. The American Entomologist and Botanist 2: 327–328.

Scherer, G. 1969. Die Alticinae des Indischen Subcontinents (Coleoptera: Chrysomelidae). Pacific Insects Monograph 22: 1–251.

Suzuki, K. 1988. Comparative morphology of the internal reproductive system of the Chrysomelidae (Coleoptera), pp. 317–355. *In* Jolivet, P. H., E. Petitpierre, and T. H. Hsiao, eds. Biology of the Chrysomelidae. Kluwer Academic Publishers, Dordrecht.

———. 1994. Comparative morphology of the hindwing venation of the Chrysomelidae (Coleoptera), pp. 337–354. *In* Jolivet, P. H., M. L. Cox, and E. Petitpierre, eds. Novel aspects of the Biology of Chrysomelidae. Kluwer Academic Publishers, The Netherlands.

Kimoto, S. and H. Takizawa. 1994. Leaf Beetles (Chrysomelidae) of Japan. Tokai University Press, 539 pp.

Wang, S. Y. 1992. Coleoptera: Chrysomelidae: Alticinae, pp. 675–753. *In* Chen, S. H. ed. Insects of the Hengduan Mountains Regions. Science Press, Beijing, China.

———. 1996. Alticinae, pp. 196–299. *In* Yu, P. Y., S. Y. Wang, and X. K. Yang, eds. Economic Insect Fauna of China, Science Press, Beijing, China, Fasc., vol. 54.

Wang, S. Y., J. Z. Cui, W. Z. Li, and Y. Zhang. 2005. The feeding habits of the genus *Altica* Geoffroy and biological significance. Chinese Bulletin of Entomology 42(4): 385–390.

Woods, W. C. 1917. The biology of the alder flea-beetle. Bulletin of the Maine Agricultural Experiment Station 265: 249–284.

———. 1918. The biology of Maine species of *Altica*. Bulletin of the Maine Agriculatural Experiment Station 273: 149–204.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 684–688

TAXONOMY AND ECOLOGY OF THE PITCHER PLANT MOSQUITO, *WYEOMYIA SMITHII* (COQUILLETT) (DIPTERA: CULICIDAE), IN MISSISSIPPI

Jerome Goddard, Gretchen Waggy, Wendy C. Varndo, and Bruce A. Harrison

(JG, WCV) Mississippi Department of Health, P.O. Box 1700, Jackson, MS, 39215, U.S.A. (e-mail: jgoddard@msdh.state.ms.us); (GW) Grand Bay National Estuarine Research Reserve, 6005 Bayou Heron Rd., Moss Point, MS 39562, U.S.A.; (BAH) North Carolina Department of Environment and Natural Resources, 585 Waughtown St., Winston-Salem, NC 27107, U.S.A.

Abstract.—During 2005, a population of the Gulf Coast race of *Wyeomyia smithii* (Coquilett) was studied in the purple pitcher plant, *Sarracenia purpurea* L. and one hybrid plant in the Grand Bay National Wildlife Refuge located in extreme southeastern Mississippi. Twenty-nine larval specimens of *Wy. smithii* were collected during this study from two clusters of plants approximately 100 m apart. A short review is provided of the changing taxonomic concept for *Wy. smithii* in the United States. Mississippi populations of *Wy. smithii* represent a Gulf Coast race of the species, but current evidence does not support providing a subspecies name for this race. Also provided are ecological observations of the affects of a controlled burn of the pitcher plant field as well as the storm surge caused by Hurricane Katrina on the plants and *Wy. smithii* population densities.

Key Words: *Wyeomyia smithii*, pitcher plant mosquito, ecology, taxonomy

Wyeomyia smithii (Coquillett) is one of only three species of *Wyeomyia* Theobald in North America that are phytotelmic. *Wyeomyia vanduzeei* Dyar and Knab from Florida, and *Wy. mitchellii* (Theobald) from Florida and southern Georgia, are found in bromeliads, while *Wy. smithii* is associated with the purple pitcher plant, *Sarracenia purpurea* L. (Sarraceniaceae), from the Gulf Coast northward into Canada. Recently, the southern form of the pitcher plant *S. purpurea* was proposed to be a new species named *S. rosea* (Naczi and Soper 1999); however, we are retaining the name *S. purpurea* for this study. According to Bradshaw (1983), *Wy. smithii* may be found occasionally in other pitcher plants such as *S. flava* L., *S. leucophylla* Rafinesque, *S. rubra* Walt., and *S. alata* Wood, but cannot overwinter in these other species because the leaves die back during winter. Further, *Wy. smithii* larvae also may be found in hybrids between *S. purpurea* and *S. flava*, *S. alata*, *S. leucophylla*, and others, and in warm southern areas they may survive in the hybrid leaves through the winter months (Bradshaw 1983).

No major mosquito taxonomic publications list *Wy. smithii* as occurring in Mississippi (Carpenter and LaCasse 1955, King et al. 1960, Darsie and Ward 2005); however, papers published in the journal *Evolution* present Mississippi collection data (Bradshaw and Lounibos

1977, Armbruster et al. 1998). The species is rare in Mississippi and little is known of its habitat, distribution, and ecology in the state. In this paper, we present ecological, biological, and taxonomic information gathered thus far about *Wy. smithii* in Mississippi.

METHODS

Larval specimens were collected by aspirating water from pitcher plants with a turkey baster. Some larvae were fixed in hot water and preserved in 80% ETOH, while others were reared to the adult stage in the laboratory. Otherwise, no adult specimens were collected in this study. For vouchers, adults were glued to pinned paper points and labeled with collection information. All collections were made in the Grand Bay National Wildlife Refuge (GBNWR), which is an undisturbed area along the extreme southeastern coast of Mississippi containing mesic palustrine forests (slash pine flatwoods/ savannah with wiregrass, oak-mixed hardwood ridge bottom forest), wet palustrine forests (disturbed wet savannah habitat, old settlement wet forest/savannah habitat, wet pine – pond cypress savannah, wet slash, longleaf, pine savanna with broomsedge), shrub wetlands, inland freshwater marshes, swamp forests, upland maritime communities, estuarine fringe wetlands, and intertidal estuarine communities. All specimen identifications, adults and larvae, were confirmed by the fourth author. Specimens have been deposited in the Mississippi Entomological Museum, Mississippi State University, Starkville, MS, the Public Health Pest Management mosquito collection, Winston-Salem, NC, and the National Museum of Natural History, Smithsonian Institution, Washington, DC.

RESULTS

Notes on the taxonomic status.—Since its original description (Coquillett 1901) and until 1947, populations ascribed to *Wy. smithii* from Florida to Canada were considered representatives of one taxon. Dodge (1947) altered this consensus when he described *Wyeomyia haynei* from South Carolina. Dodge separated *Wy. haynei* from *Wy. smithii* based primarily on the former having the following larval characters: (1) a small pair of dorsal anal papillae above the long ventral pair (*Wy. smithii* only has a ventral pair), (2) more comb scales, (3) seta 14-M equal to or smaller than 14-P (14-M is larger than 14-P on *Wy. Smithii*), and (4) setae 3, 4-X usually bifid (usually trifid on *Wy. smithii*). Dodge also described adults of *Wy. haynei* with silver scales on the mid-lobe of the scutellum while those of *Wy. smithii* are dark, but was unable to find differences in the male genitalia of the two species. Darsie and Williams (1976), comparing northern and southern specimens, re-examined the 4 larval characters identified by Dodge, and also found that setae 2-IV-VI would separate *Wy. haynei* from *Wy. smithii*. During the period 1947–77, taxonomists accepted the two species concept, although the male genitalia of the two species continued to be described as "indistinguishable" (Carpenter and LaCasse 1955). Two species in *Wyeomyia* having identical male genitalia is very unusual, as species of this genus typically have male genitalia with very distinct morphological characters. Darsie and Ward (1981) documented *Wy. haynei* as occurring in Alabama, Florida, Georgia, South Carolina, North Carolina, Virginia, and Maryland, while the distribution of *Wy. smithii* included more northern states, from Delaware west to Illinois and more northern states, and Canada. Unknown to Darsie and Ward, during the 1970s considerable research was conducted and published in non-taxonomic journals that focused on *Wy. smithii* as an inquiline of the purple pitcher plant host, *S. purpurea*. This research addressed the taxonomy, biology, distribution, morphological variations, hybridization, competition with other inquilines of the pitcher plant, photoperiod, dormancy, diapause, altitude and latitude relationships, and other biological aspects of different populations of *Wy. smithii.* Bradshaw and Lounibos (1977) documented and studied representative specimens of 33 populations of *Wy. smithii* from Mississippi, Alabama, and Florida, more northern states in the U.S., to the Canadian provinces of Nova Scotia, New Brunswick, and Quebec. This represented the first record of *Wy. smithii* from Mississippi. They conducted laboratory cross-mating studies and found complete hybridization among the populations (northern, southern, high elevation, low elevation) that were crossed and backcrossed. The hybrids and backcrosses of the extremes (north-south, high-low elevations) were fully viable and expressed intermediate characters in the anal papillae, branching of setae 3, 4-X, expression of silver scales on the midlobe of the scutellum, and photoperiodic effects on initiation and depth of larval diapause along a cline from south to north, or from low to high elevation in North Carolina. They concluded that *Wy. smithii* is a polytypic species with three geographic races, i.e., *Wy. smithii* in the north and at high elevations in North Carolina, *Wy. haynei* in the mid-Atlantic and Georgia area as a geographic subspecies, and a newly recognized and more southern geographic race along the Gulf coast (Mississippi, Alabama, and Florida) with dorsal anal papillae nearly equal the length of the ventral anal papillae. Of interest, Bradshaw and Lounibos (1977) found high elevation populations in North Carolina that are morphologically identical to specimens of *Wy. smithii* found in northern states, while coastal North Carolina populations were identical to the geographical race called *Wy. haynei.* Upon learning of this published research, Ward and Darsie (1982) suggested more work (cross-mating studies) was needed to resolve the species status of *Wy. haynei*; however, the suggested cross-mating studies had already been accomplished in Bradshaw and Lounibos (1977). Darsie and Morris (2000) declared that *Wy. haynei* was a junior synonym of *Wy. smithii.* Now there is a consensus again; only a single species, *Wy. smithii,* is recognized as inhabiting the purple pitcher plant, *S. purpurea,* and also hybrids of *S. purpurea* and certain other *Sarracenia* species in North America. The Mississippi populations represent the Gulf Coast race of Bradshaw and Lounibos (1977); however, because of the south to north cline of morphological, biological, and physiological traits from the Gulf Coast to Canada, Bradshaw (unpublished personal communication) does not see a need for recognizing subspecies.

Biological notes.—Major mosquito publications for the North American fauna (Carpenter and LaCasse 1955, Wood et al. 1979) have commented on the lack of blood feeding by *Wy. smithii,* although the mouthparts are developed for blood feeding (Hudson 1970). Bradshaw (1980) resolved this enigma when he was bitten by *Wy. smithii* at low elevations in North Carolina and along the Gulf Coast. Furthermore, he observed a female taking blood from a box turtle in Florida. These observations led to further research where he determined that females from the northern and high elevation populations of *Wy. smithii* are always autogenous, while those from the low elevations in the Carolina Coast Plain and Piedmont and Gulf Coast populations are autogenous for the first oviposition, then anautogenous for later ovipositions. Accordingly, mosquito collectors should be alert for specimens attracted to light traps and coming to hosts for a blood meal.

Distribution and plant associations.—A total of 29 specimens of *Wy. smithii* were collected during this study (27 specimens in May and 2 specimens in Aug). Larvae were collected from one primary breeding site, a cluster of approximately 48 *S. purpurea* plants within a 5 m diameter circle. Later, another cluster of about 100 *S. purpurea* plants was located approximately 175 m from there, and larvae were observed living in those plants, but no collections were made. In addition, on July 26th, *Wy. smithii* larvae were observed in a cluster of *S. purpurea* × *S. alata* hybrids located approximately 100 m from the primary collection site. Nine days later, two larval specimens were collected from the hybrid plants and confirmed as *Wy. smithii.*

To date, *Wy. smithii* has been collected in only two locations in Mississippi, the GBNWR during this study (Jackson County, approximately 7 mi. east of Moss Point) and Movella, MS, reported earlier (Bradshaw and Lounibos 1977; George County, approximately 15 mi. south of Lucedale). There is one other unpublished collection report of 7 adult specimens by a mosquito control technician using CO_2 baited CDC light traps in a pitcher plant field in Gautier, MS (Jackson County) during a West Nile mosquito survey. Numerous attempts by the senior author to verify this finding have proven unfruitful. If confirmed, the Gautier site would be the most western report of *Wy. smithii* in the southern United States.

Effects of a controlled burn.—The entire 960 acre field containing the pitcher plants with *Wy. smithii* underwent a controlled burn by refuge personnel on April 14, 2005. A few water-filled *S. purpurea* leaves survived the burn, but were badly damaged. No living *Wy. smithii* were seen in any leaves a day after the burn. The area was observed weekly for new pitcher plant growth and subsequent repopulation of the leaves with *Wy. smithii.* Regrowth of pitcher plant leaves occurred within 2 weeks. All new patches of over three or more individual plants were there prior to the fire. No mosquito larvae were seen in the new leaves for approximately 16 weeks (July 25th), after which leaves were thoroughly repopulated. How and from where the pitcher plants were repopulated is unknown. No other patches of *S. purpurea* have been found in the immediate area.

Effects of a hurricane.—Hurricane Katrina hit the coasts of Louisiana, Mississippi, and Alabama on August 29, 2005, causing widespread catastrophic destruction. The 145 km Mississippi coastline was especially hit hard, although power outages and wind damage occurred as far as 322 km inland. The hurricane storm surge inundated many areas along the Mississippi gulf coast, and virtually 100% of the area south of Highway 90 in the proximity of the Grand Bay National Estuarine Research Reserve (GBNERR) was hit with a 6 m storm surge, recorded by GBNERR personnel (S. Christine Walters, personal communication). The GBNERR is partially contained within the GBNWR. The pitcher plant field in this study was located south of Highway 90 and was flooded by the surge. There was direct observation by a GBNERR staff member of approximately 1 m of water covering the entire pitcher plant savannah on the afternoon of the storm (Chris May, personal communication). Interestingly, neither the pitcher plants nor the mosquito larvae were apparently harmed by this inundation with salt water. Two visits to the site after the hurricane (Sept. and Nov.) revealed numerous *Wy. smithii* larvae living inside the leaves of *S. purpurea.*

CONCLUSIONS

The Gulf Coast race of *Wyeomyia smithii* extends into southeastern Mississippi where it is associated with populations of the purple pitcher plant and a hybrid between the purple pitcher plant and the pale pitcher plant. Taxonomic analysis of Mississippi *Wy. smithii* does not support naming the Gulf Coast race a subspecies at this time. Based on data from one controlled burn, burning pitcher plant fields apparently decimates pitcher plant mosquito larvae residing in the plants, but repopulation occurs within weeks or months. Preliminary evidence suggests that short-term exposure to salt water from the tidal surge of Hurricane Katrina did not affect pitcher plants or their mosquito larvae.

Acknowledgments

Bill Bradshaw, University of Oregon, provided information and helpful comments concerning this manuscript. Christine Walters and Chris May, Grand Bay National Estuarine Research Reserve, provided information about the effects of Hurricane Katrina on our study site.

Literature Cited

Armbruster, P., W. E. Bradshaw, and C. M. Holzapfel. 1998. Effects of postglacial range expansion on allozyme and quantitative genetic variation of the pitcher plant mosquito, *Wyeomyia smithii*. Evolution 52: 1697–1704.

Bradshaw, W. E. 1980. Blood-feeding and capacity for increase in the pitcher plant mosquito, *Wyeomyia smithii*. Environmental Entomology 9: 86–89.

———. 1983. Interaction between the mosquito *Wyeomyia smithii*, the midge *Metriocnemus knabi*, and their carnivorous host *Sarracenia purpurea*, pp. 161–189. *In* Frank, J. H. and L. P. Lounibos, eds. Phytotelmata: Terrestrial Plants as Hosts for Aquatic Insect Communities. Plexus Publishing, Inc., Medford, NJ.

Bradshaw, W. E. and L. P. Lounibos. 1977. Evolution of dormancy and its photoperiodic control in pitcher plant mosquitoes. Evolution 31: 543–565.

Carpenter, S. and W. LaCasse. 1955. Mosquitoes of North America. University of California Press, Berkeley, CA. 360 pp.

Coquillett, D. W. 1901. Three new species of Culicidae. Canadian Entomologist 33: 258–260.

Darsie, R. F. Jr. and C. D. Morris. 2000. Keys to the adult females and fourth-instar larvae of the mosquitoes of Florida. Florida Mosquito Control Association, Technical Bulletin Number 1(revised): 1–159.

Darsie, R. F. Jr. and R. A. Ward. 1981. Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico. Mosquito Systematics Supplement 1: 1–313.

———. 2005. Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico. University Press of Florida, Gainesville.

Darsie, R. F. Jr. and R. M. Williams. 1976. First report of *Wyeomyia haynei* in Georgia, with comments on identification of larvae. Mosquito Systematics 8: 441–444.

Dodge, H. R. 1947. A new species of *Wyeomyia* from the pitcher plant. Proceedings of the Entomological Society Washington 49: 117–122.

Hudson, A. 1970. Notes on the piercing mouthparts of three species of mosquitoes viewed with the scanning electron microscope. Canadian Entomologist 102: 501–509.

King, W. V., G. H. Bradley, C. N. Smith, and W. C. McDuffie. 1960. A handbook of the mosquitoes of the southeastern United States. U.S. Department of Agriculture, Washington, D.C., Agricultural Handbook No. 173, 188 pp.

Naczi, R. F. C. and E. M. Soper. 1999. *Sarracenia rosea* (Sarraceniaceae), a new species of pitcher plant from the southeastern United States. Sida 18: 1183–1206.

Ward, R. A. and R. F. DarsieJr. 1982. Corrections and additions to the publication, Identification and geographic distribution of mosquitoes of North America, north of Mexico. Mosquito Systematics 14: 209–219.

Wood, D. M., P. T. Dang, and R. A. Ellis. 1979. The Mosquitoes of Canada. Canadian Department of Agriculture, Biosystematics Research Institute, Publication Number 1686 (part 6), 390 pp.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 689–695

EFFECTS OF TEMPERATURE ON THE DEVELOPMENT AND SURVIVAL OF THE CREEPING WATER BUG *ILYOCORIS CIMICOIDES EXCLAMATIONIS* (SCOTT) (HEMIPTERA: NAUCORIDAE)

H. KANEDA AND Y. YOSHIYASU

Laboratory of Applied Entomology, Graduate School of Agriculture, Kyoto Prefectural University, Shimogamo, Kyoto 606-8522, Japan (e-mail: great_muta0312@hotmail.com)

Abstract.—The effects of temperature on the development and survival of *Ilyocoris cimicoides exclamationis* (Scott) were investigated under two photoperiods (15, 18, 20, 22.5, 25, and 28°C under 15L-9D; and 18 and 25°C under 10L-14D). Eggs did not hatch at 15°C and its development was delayed at 28°C. The survival rate of nymphs was significantly lower at 18 and 20°C than those at 22.5, 25, and 28°C. No nymphs reached adults at 18°C under either 15L-9D or 10L-14D. The developmental thresholds for the egg and 1st–5th instars were 11.8°C and 13.3°C, respectively. The thermal constants for the egg and 1st–5th instars were 270.3 and 626.5 degree-days, respectively. These results suggest that *I. c. exclamationis* is univoltine and the development of the immature stages is restricted to May to October in Kyoto, Japan.

Key Words: aquatic insect, Naucoridae, *Ilyocoris cimicoides exclamationis*, immature stage, life cycle

The family Naucoridae occurs worldwide and contains 413 described species in 39 genera (Sites 2000). Naucorids are oval, flattened aquatic bugs with raptorial front legs that are used for predation, and hairy middle and hind legs that are used for swimming (Polhemus 1979, Polhemus and Polhemus 1988).

The creeping water bug *Ilyocoris cimicoides exclamationis* (Scott 1874) is the only naucorid species in Japan. The adult is about 12 mm long and mostly brown, except for a greenish head, pronotum and scutellum; and reddish compound eyes. It occurs in China, Korea and Japan, and lives in submerged vegetation near the banks of fresh-water ponds and lakes (Ichikawa 1996, Hayashi and Miyamoto 2005). This insect is listed as one of the near-threatened species on the Red List of Japan (Ministry of the Environment 2000) because of recent decreases in local population numbers.

Rawat (1939) reported that the nymphal developmental period of the nominotypical subspecies *I. c. cimicoides* (L., 1758) is about 95 d at an ambient temperatures that varied from 14°C to 23°C. Japanese *I. c. exclamationis* require about 61 d from egg laying to adult emergence in an aquarium in greenhouse under natural photoperiod conditions during summer (Ichikawa 1996). However, thermal effects on developmental traits of *I. cimicoides* have not been investigated.

We study the effects of temperature and photoperiod on the development and survival of *I. c. exclamationis* to

Fig. 1. Adult female of *Ilyocoris cimicoides exclamationis* ovipositing into the root of *M. trifoliata* in aquarium.

obtain a better understanding of the life cycle of this endangered subspecies. This knowledge may be important for the conservation of this subspecies.

Materials and Methods

Laboratory rearing.—The laboratory culture of *I. c. exclamationis* was established using three male and three female adults collected at Midorogaike Pond, Kyoto (135°46′E, 35°3′N) in summer 2003. The adults were paired in three aquaria (21 cm long, 13 cm wide, 13 cm deep) at 25°C under a 15 h, light and 9 h, dark (15L-9D) photoperiod. Each aquarium was filled with dechlorinated water (about 10 cm deep) and covered on the bottom with aquarium gravel. A section of the plant *Ceratophyllum demersum* L. (Ceratophyllaceae) was provided as a perching substrate. Because the females insert their eggs into the tissue of aquatic plants (Fig. 1), the root or stem of *Menyanthes trifoliata* L. (Menyanthaceae) was provided as an ovipositional site. Larvae of *Chironomus* spp. (Diptera: Chironomidae) were supplied as prey. Water in each aquarium was changed every 2 to 3 d. Plant sections were replaced daily and examined for eggs under a binocular microscope.

Plant sections with eggs were transferred within 24 h to a 250 ml plastic cup and kept at temperatures of 15, 18, 20, 22.5, 25, or 28°C under a 15L-9D photoperiod. Each cup was filled with dechlorinated water that was changed daily.

Newly emerged nymphs were placed individually in plastic cups (1st–3rd instar, 90 ml; 4th–5th, 250 ml) and kept at temperatures of 18, 20, 22.5, 25, or 28°C under a photoperiod of 15L-9D or at 18 or 25°C under 10L-14D photoperiod. Each cup was filled with dechlorinated water and a plant section provided as a perching substrate. Larvae of *Chironomus* spp. were supplied as prey and water was changed daily. The developmental period and survival of each individual was recorded daily. Developmental thresholds (T_0) for the egg and nymphal instars were estimated from the regression between developmental rate ($1/D$) and temperatures, and the thermal constant (K) was calculated from T_0 and the regression equation [$K = D(T - T_0)$].

Statistical analyses.—The Kruskal-Wallis test was used to test for differences in the developmental periods of the egg and each instar among temperature treatments. When a significant difference was detected, a comparison between two temperatures in each combination was performed using the Mann-Whitney's *U*-test corrected by the Ryan method. A Tukey-type multiple comparison test was conducted for comparing the survival rate of instars between the five temperature treatments. A chi-square test was used to analyze differences in the survival of instars between two photoperiods at 25°C. The Mann-Whitney's *U*-test was used to compare differences between males and females in developmental periods of nymphs at each temperature and photoperiod, and between the photoperiods at 18 or 25°C.

Voucher specimens.—Selected samples of adults and nymphs have been deposited in the Laboratory of Applied Entomology, Graduate School of Agriculture, Kyoto Prefectural University.

RESULTS

All eggs kept at 15°C failed to hatch (n=45). Viability could not be determined because some ovipositional substrates rotted before eclosion in each treatment, especially at higher temperatures. The developmental period of eggs decreased significantly as temperature increased from 18°C (39.7 d) to 25°C (20.3 d), but was equal between 28 (25.2 d) and 22.5°C (23.9 d). Mean stadia periods for nymphs under each rearing condition were not significantly different between males and females (15L-9D: 20°C, P=0.31; 22.5°C, P=0.51; 25°C, P=0.63; 28°C, P=0.27. 10L-14D: 25°C, P=0.48). The 1st–5th mean stadium was significantly shorter at 25°C and 10L-14D than at 25°C and 15L-9D (Table 1). It developed significantly in 15L-9D as temperature increased from 20°C to 28°C (20°C, 92.4 d; 22.5°C, 73.3 d; 25°C, 50.8 d; 28°C, 43.6 d) (Table 1).

The survival rate of nymphs under 15L-9D was significantly lower at 18°C and 20°C than at 22.5, 25, and 28°C (Table 2). At 18°C under 15L-9D and 10L-14D, only 6.3% and 24.2% completed the 1st stadium, respectively, and no nymphs reached to the adults. About half of the nymphs died during first instar at 20°C (15L-9D). Survival of nymphs at 25°C under 15L-9D was significantly higher than under 10L-14D (χ^2=4.31, df=1, P=0.0379).

The relationship between temperature and developmental rate for the egg and nymph is linear, but with an outline at each temperature extream (Fig. 2). Data pertaining to 15°C and 28°C for the egg and 18°C for the nymph were not included in the calculation of the re-

Table 1. Developmental periods (days) of *I. c. exclamationis* in relation to temperature and photoperiod (mean ± S.E.).

Temperature (°C)	Photoperiod	Egg	Nymphal stage (instar)					
			First	Second	Third	Fourth	Fifth	Total† (First–Fifth)
18	15L-9D	39.7 ± 0.6 (31) d	25, 35 (2)	21.0 (1)	21.0 (1)	31.0 (1)	—	—
20		36.4 ± 0.5 (29) c	16.2 ± 0.4 (25)	13.7 ± 0.2 (24)	14.5 ± 0.2 (23)	17.4 ± 0.2 (22)	31.0 ± 0.7 (16)	92.4 ± 1.0 (16) d
22.5		23.9 ± 0.2 (34) b	11.3 ± 0.2 (39)	10.1 ± 0.1 (39)	11.2 ± 0.1 (39)	15.0 ± 0.2 (39)	25.7 ± 0.2 (35)	73.3 ± 0.4 (35) c
25		20.3 ± 0.3 (34) a	8.2 ± 0.1 (35)	7.1 ± 0.1 (35)	7.8 ± 0.1 (34)	9.9 ± 0.1 (34)	17.9 ± 0.1 (34)	50.8 ± 0.3 (34) b
28		25.2 ± 0.9 (11) b	6.7 ± 0.1 (31)	5.7 ± 0.1 (30)	6.7 ± 0.1 (30)	8.4 ± 0.1 (30)	16.1 ± 0.3 (28)	43.6 ± 0.4 (28) a
18	10L-14D	not examined	18.4 ± 0.4 (8)	15.0 ± 0.3 (8)	14, 15 (2)	—	—	—
25		not examined	8.2 ± 0.2 (27)	6.3 ± 0.1 (27)	7.0 ± 0.1 (27)	9.0 ± 0.1 (26)	16.6 ± 0.3 (23)	47.2 ± 0.5 (23)‡

Values in parentheses represent the number of individuals examined.

Values in the same column followed by the same latter are not significantly different using the Mann-Whitney's U-test corrected by the Ryan method (P>0.05).

† Means are not significantly different between males and females in each rearing condition using the Mann-Whitney's U-test (P>0.05).

‡ Mean is significantly different in comparison to value at 25°C, 15L-9D using the Mann-Whitney's U-test (P<0.05).

Table 2. Survival rate (%) of *I. c exclamationis* in relation to temperature and photoperiod.

Temperature (°C)	Photoperiod	Number of individuals examined	Nymphal stage (instar)				
			First	Second	Third	Fourth	Fifth
18	15L-9D	32	6.3 (2)	3.1 (1)	3.1 (1)	3.1 (1)	0 a
20		51	49.0 (25)	47.1 (24)	45.1 (23)	43.1 (22)	31.4 (16) b
22.5		40	97.5 (39)	97.5 (39)	97.5 (39)	97.5 (39)	87.5 (35) c
25		44	79.5 (35)	79.5 (35)	77.3 (34)	77.3 (34)	77.3 (34) c
28		35	88.6 (31)	85.7 (30)	85.7 (30)	85.7 (30)	80.0 (28) c
18	10L-14D	33	24.2 (8)	24.2 (8)	6.1 (2)	0	0
25		41	65.9 (27)	65.9 (27)	65.9 (27)	63.4 (26)	56.1 (23)†

Values in the parentheses represent the number of surviving individuals.

Values in the same column followed by the same letter are not significantly different using the Tukey-type multiple comparison test ($P>0.05$).

† Survival rate is significantly different in comparison to that at 25°C, 15L-9D.

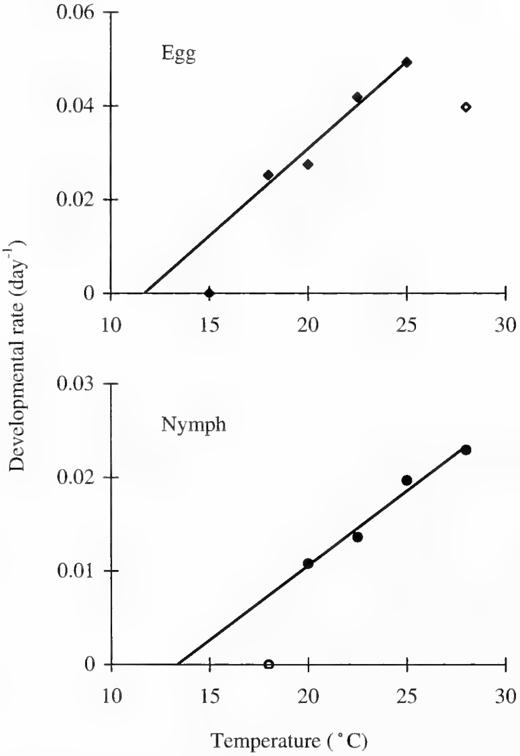


Fig. 2. Relationship between temperature and developmental rate of *Ilyocoris cimicoides exclamationis*. Open symbols represent data not included in the calculation of the regression equation.

gression equation because of developmental delay at these temperatures. The developmental thresholds (T_0) were 11.8°C for the egg and 13.3°C for the nymph (Table 3). The thermal constants *K* were 270.3 degree-days (DD) for the egg and 626.5 DD for the 1st–5th instars (Table 3).

Discussion

We found marked effects of temperature on development and survival of *Ilyocoris cimicoides exclamationis*. There also is earlier information on the developmental periods of other naucorid species under laboratory conditions. For example, the developmental period from egg to adult in the naucorid *Ambrysus lunatus lunatus* Usinger, a lotic species occurring in the United States of America, at 30°C was 114.3 d (egg, 20.7 d; first instar nymph, 11.0 d; second, 11.7 d; third, 19.0 d; fourth, 20.6 d; fifth, 31.3 d) (Sites and Nichols 1990). The lentic naucorid *Pelocoris femoratus* (Palisot de Beauvois) of the United States, under 16L-8D and at about 26.7°C, required 81.0 d (egg, 17.7 d; first instar nymph, 10.5 d; second, 9.7 d; third, 11.0 d; fourth, 12.6 d; fifth, 19.5 d) (McPherson et al. 1987). *Ilyocoris c. cimicoides*, at a room temperature that varied between 14°C and 23°C, required about 95 d (first instar, 12–13 d; second, 6–8 d; third, 7–9 d; fourth, 14–16 d; fifth, 21–23 d) (Rawat 1939). These reports and the result of our study suggest that the stadium at the fifth

Table 3. Developmental threshold (T_0) and thermal constant (K) of immature stages of *I. c. exclamationis*.

Developmental stage	Regression equation	r^2	T_0 (°C)	K (degree-days)
Egg	$y=0.0037x-0.0435$	0.956	11.8	270.3
First instar	$y=0.0111x-0.1606$	0.995	14.5	96.8
Second	$y=0.0132x-0.1922$	0.993	14.6	75.1
Third	$y=0.0105x-0.1420$	0.977	13.5	95.6
Fourth	$y=0.0083x-0.1109$	0.956	13.4	119.4
Fifth	$y=0.0040x-0.0481$	0.953	12.0	250.4
First–Fifth	$y=0.0016x-0.0213$	0.974	13.3	626.5

instar is about 1.5 times that of the fourth instar. In the other species of Nepomorpha, it was reported that the stadia at later instars, especially fifth instar, were longer than at earlier instars in *Aphelocheirus vittatus* Matsumura (Ichiyanagi 2000; Ishida and Yoshiyasu 2004), *A. nawae* Nawa (Ishida and Yoshiyasu 2004), *Lethocerus colossicus* Stål (Macías-Ordóñez 2003), and *Ranatra fusca* Palisot de Beauvois (Packauskas and McPherson 1986)

Eggs of *I. c. exclamationis* did not hatch at 15°C and developed more slowly at 28°C compared to 25°C (Table 1). In contrast, nymphs developed successfully at 28°C but failed to reach adults at 18°C. These results suggest that low temperature tolerance is higher in eggs than nymphs, and that nymphs are more tolerant of high temperature than are eggs.

Although the developmental threshold of total nymphal stages was 13.3°C, no nymph developed to adult at 18°C, and 93.7% and 51.0% of nymphs died during the first instar at 18 and 20°C, respectively (Table 2). In addition, developmental thresholds of early instars (first, 14.5°C; second, 14.6°C) were higher than those of later instars, especially the 5th (12.0°C) (Table 3). Therefore, early instars apparently are more sensitive to low temperature than are later instars.

Ichiyanagi (2000) reported the effects of temperature on the development of a Japanese aphelocheirid species *A. vittatus*, and Ishida and Yoshiyasu (2004) also noted thermal effects for development of *A. nawae*, together with the former species. The developmental threshold of nymphs of *I. c. exclamationis* (13.3°C) was higher than those of these two aphelocheirids (7.5–11.1°C) (Table 4). Both aphelocheirid species are lotic and their nymphs are found all year round according to the field surveys (Ichiyanagi 2000; Ishida and Yoshiyasu 2004). In contrast, the nymphs of *I. c. exclamationis* are discovered during late June to mid September (Ban 1985). These results indicate the breeding season of this naucorid is shorter than those of the aphelocheirids. Consequently, the higher developmental threshold of *I. c. exclamationis* will also explain their shorter and restricted breeding season.

On the basis of fragmented information derived from laboratory rearing and field surveys conducted in central Hon-

Table 4. Developmental threshold (T_0) and thermal constant (K) of immature stages of *Aphelocheirus vittatus* and *A. nawae* (Ichiyanagi 2000; Ishida and Yoshiyasu 2004).

		T_0 (°C)		K (degree-days)	
Species	Population	Egg	Nymph	Egg	Nymph
A. vittatus	Yoro River	11.5	9.4	374	1326
	Niizaki River	11.4	9.0	388	1436
	Kamo River	8.9	11.1	476	1433
A. nawae	Muko River	10.6	7.5	401	1666

Table 5. Water temperature (°C) at a depth of 0.5 m at Midorogaike Pond in 2004 (Takemon, unpublished data).

	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Min.	11.2	15.8	19.7	25.7	24.7	21.8	13.2	10.4
Max.	23.1	26.6	30.7	35.1	37.4	34.7	30.7	20.1
Mean†	15.9	20.5	24.9	29.7	28.9	26.2	19.6	14.3

† Calculation based on temperatures recorded at intervals of 30 min.

shu, Japan, Ban (1985) and Ichikawa (1996) suggested this bug is univoltine, reproduces from late spring to early summer, and overwinters as adults. The mean water temperatures at a depth of 0.5 m at Midorogaike Pond in April and November were 15.9 and 14.3°C, respectively (Table 5), so the development of eggs and nymphs probably occurred from May (20.5°C) to October (19.6°C). In our study, total duration of the eggs and nymphs at 20, 25, and 28°C under a 15L-9D photoperiod was about 129, 71, and 69 d, respectively. Eggs of *I. c. exclamationis* that begin developing in May should reach adults in August to early September. Temperatures during September and October decrease progressively and are not high enough for immatures of a second generaion to reach adults based on the results of our study under laboratory condition. The results of our study, therefore, suggest that *I. c. exclamationis* also is univoltine in Kyoto, Japan. However, the life cycle of this species should be confirmed in the future by field observations at regular intervals throughout a year.

ACKNOWLEDGMENTS

We thank F. Goto, Kyoto Prefectural University, for providing us with the culture stock of *I. c. exclamationis*; Y. Takemon, Kyoto University, for offering water temperature data for Midorogaike Pond; and the staff of the Board of Education, Kyoto City, for allowing us to study this insect in Midorogaike Pond, a natural conservation area.

LITERATURE CITED

Ban, Y. 1985. Comparison of life history of aquatic insect, lentic versus lotic 1. *Ilyocoris exclamationis* Scott (Hemiptera: Naucoridae) and *Aphelocheirus vittatus* Matsumura (Hemiptera: Aphelocheiridae). Rostria 37: 526–532 [in Japanese].

Hayashi, M. and S. Miyamoto. 2005. Nepomorpha, pp. 295–330. *In* Kawai, T. and K. Tanida, eds. Aquatic Insects of Japan: Manual with Keys and Illustrations. Tokai-Daigaku Syuppankai [in Japanese], 1342 pp.

Ichikawa, N. 1996. Observation of the creeping water bug *Ilyocoris exclamationis*. Insectarium 33: 360–365 [in Japanese].

Ichiyanagi, H. 2000. Life history of the stream-dwelling bug *Aphelocheirus vittatus* (Heteroptera: Aphelocheiridae) in central Japan. Entomological Science 3: 603–610.

Ishida, N. and Y. Yoshiyasu. 2004. Life cycles of two *Aphelocheirus* species (Hemiptera: Aphelocheiridae) in Kinki District, with notes on their developments and habitats. Japanese Journal of Entomology (n.s.) 7: 55–68 [in Japanese].

Macías-Ordóñez, R. 2003. On the reproductive behavior and population ecology of *Lethocerus colossicus* Stål (Heteroptera: Belostomatidae). Folia Entomologica Mexicana 42: 161–168.

McPherson, J. E., R. J. Packauskas, and P. P. Korch. 1987. Life history and laboratory rearing of *Pelocoris femoratus* (Hemiptera: Naucoridae), with descriptions of immature stages. Proceedings of the Entomological Society of Washington 89: 288–295.

Ministry of the Environment, Red list of threatened wild animals in Japan: Invertebrates. Insecta. (online; URL:http://www.env.go.jp/) [in Japanese].

Pakauskas, R. J. and J. E. McPherson. 1986. Life history and laboratory rearing of *Ranatra fusca* (Hemiptera: Nepidae) with descriptions of immature stages. Annals of the Entomological Society of America 79: 566–571.

Polhemus, D. A. and J. T. Polhemus. 1988. Family Naucoridae Leach, 1815. The creeping water bugs, pp. 521–527. *In* Henry, T. J. and R. C. Froeschner, eds. Catalog of the Heteroptera, or true bugs, of Canada and the continental United States. Brill, Leiden. 958 pp.

Polhemus, J. T. 1979. Family Naucoridae, pp. 131–138. *In* Menke, A. S. ed. The semiaquatic and aquatic Hemiptera of California (Heteroptera: Hemiptera). Bulletin of the California Insect Survey; Vol. 21, University of California Press, Berkeley. 168 pp.

Rawat, B. L. 1939. On the habits, metamorphosis and reproductive organs of *Naucoris cimicoides* L. (Hemiptera-Heteroptera). Transactions of the Royal Entomological Society of London 88: 119–138.

Sites, R. W. 2000. Creeping Water Bugs (Naucoridae), pp. 571–576. *In* Schaefer, C. W. and A. R. Panizzi, eds. Heteroptera of Economic Importance. CRC Press, 828 pp.

Sites, R. W. and B. J. Nichols. 1990. Life history and descriptions of immature stages of *Ambrysus lunatus lunatus* (Hemiptera: Naucoridae). Annals of the Entomological Society of America 83: 800–808.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 696–699

MORIBAETIS MIMBRESAURUS, NEW SPECIES (EPHEMEROPTERA: BAETIDAE): FIRST REPRESENTATIVE OF THE GENUS NORTH OF MEXICO

W. P. McCafferty

Department of Entomology, Purdue University, West Lafayette, IN 47907, U.S.A. (e-mail: mccaffer@purdue.edu)

Abstract.—Unusually large baetid mayfly adults from Coconino County, Arizona, USA are described as ***Moribaetis mimbresaurus*, new species**. The new species represents the first known occurrence of the genus *Moribaetis* Waltz and McCafferty north of the Neotropical Region. It is distinguished from Central American congeners by having double cubito-anal intercalary veins and limited pigmentation in the forewings, and a non-forked second longitudinal vein in the hindwing.

Key Words: mayflies, new species, new USA generic record, Baetidae

---

While working on the identification of an extensive collection of alate mayflies made by M. S. Sanderson in parts of Arizona during the 1980s and kindly donated by him to the Purdue Entomological Research Collection, I came upon highly unusual Baetidae adults that were not readily identifiable to any known genus from the USA. Their relatively large size was not known for any Nearctic small minnow mayflies (Baetidae) other than some *Callibaetis* Eaton, and they clearly did not belong to that group (e.g., they lacked both crossvenation in the hindwings and body speckling). The largest non-*Callibaetis* baetids in the USA have included *Baetis magnus* McCafferty and Waltz (throughout much of the western USA) and the little-known *B. palisadi* Mayo (only from California), but the Arizona mayflies in question were considerably larger than those species. The combination of large size, membrane pigmentation in the forewing, the basally margined, distally oriented, sharp costal process of the hindwing, short stalk of the turbinate eye, and small terminal segment of the genital forceps indicated that the mayflies in question represented a new species with an obvious affinity with Central American species of the genus *Moribaetis* Waltz and McCafferty.

Moribaetis has been known as a Western Hemisphere group ranging from tropical South America to southern Mexico, with three well-described nominal species common to Central America (Waltz and McCafferty 1985, Lugo-Ortiz and McCafferty 1996). Nominal South American species are poorly known and dubius (see below). *Moribaetis* represents a relatively plesiotypic genus among the *Baetodes* complex of genera (Lugo-Ortiz and McCafferty 1996, McCafferty and Baumgardner 2003), a distinctive clade of Baetidae restricted to the Western Hemisphere and of Neotropical origin (McCafferty 1998).

The purpose of this paper is to describe the newly discovered species of *Moribaetis*. This discovery is significant because the new species represents a disjunct country record for the genus, is exceptionally large for USA baetines, and is possibly rare because presumably it would be difficult to overlook such a mayfly if it were common in Arizona, a state whose mayfly fauna has been relatively well studied (see Lugo-Ortiz and McCafferty 1995).

Moribaetis mimbresaurus McCafferty, new species

(Figs. 1–5)

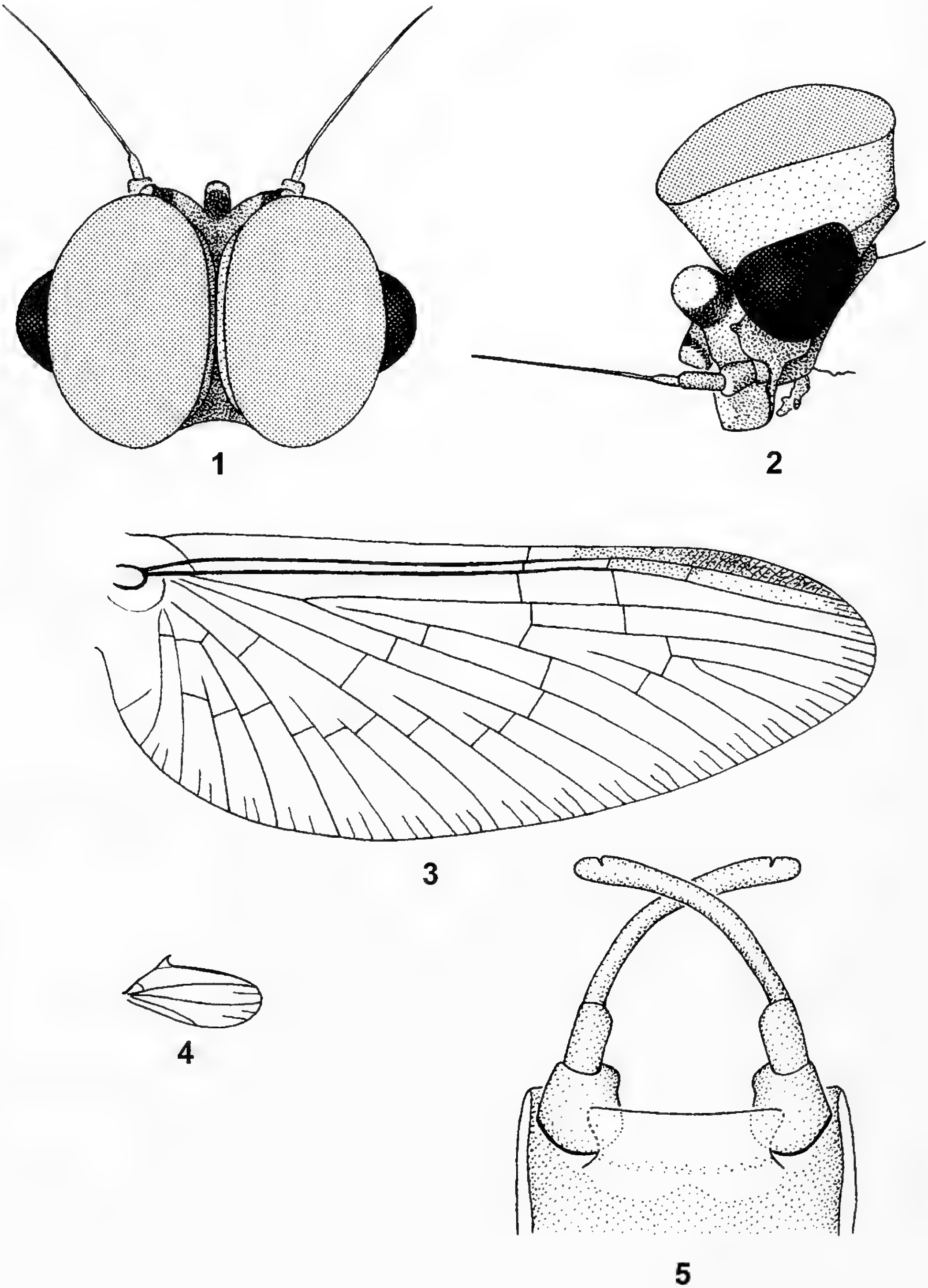
Male adult.—Body length 9.3–9.5 mm. Forewing length 9.6–10.0 mm. Hindwing length 1.2 mm. Cercus length 19.0 mm. General coloration light to medium brown. Head with turbinate eyes ovoid, yellow, and approximate (Fig. 1); stalk of turbinate eye relatively short and yellow (Fig. 2). Scape and pedicel somewhat darkened basally. Thorax with all nota medium brown (pronotum somewhat darker). Mesonotum with some highlights posteriorly. Mesopleurum pale with profuse medium and dark brown markings. Forefemur light brown with medium brown cloud apically on both surfaces. Foretibia and foretarsus somewhat darker than forefemur and with distinct markings. Mid- and hindlegs pale throughout except femora with brown cloud apically as per foreleg. Forewing (Fig. 3) with tan infuscation limited to distal half of costal and subcostal areas; costal crossveins profuse and somewhat anastomose; marginal intercalary veins double throughout (very difficult to see in anal region). Hindwing (Fig. 4) with distally pointed, sharp costal process with basal margination, and with three longitudinal veins; second longitudinal vein not forked; one marginal intercalary vein between first and second longitudinal veins; two marginal intercalary veins following second longitudinal vein and ending in distal margin; third longitudinal vein shorter and ending in anal margin. Abdomen with terga light brown and unmarked, with terga 7–10 somewhat darker, and with some dark brown infuscation distally on tergum 10. Sterna pale cream; sterna 2–7 submedially with pair of short, oblique, light brown dashes followed posteriorly by pair of small, light brown dots. Genitalia as in Fig. 5: forceps bases very well demarcated and with some distomedial development; apical forceps segment short and set off by lateral indentation only; subgenital plate prominent and with straight distal border for entire distance between forceps. Cercus uniformly light brown.

Female adult.—Body length 10.1 mm. Forewing length 10.1 mm. Hindwing length 1.2 mm. Cercus length unknown. Coloration as per male, except markings not as apparent in some. Wing venation as described for male, although in some, basal margin of hindwing costal process not as distinct as in male and marginal intercalary veins of hindwing not as distinctive.

Material examined.—Holotype: ♂ adult, Arizona, Coconino Co, Oak Cr at pumphouse wash (floating on water), 3-III-1984, M. W. Sanderson (deposited in the Purdue Entomological Research Collection, West Lafayette, Indiana). Other material: 1 ♂ adult (some parts dissected, in microvial and on slide), and 2 ♀ adults (some parts dissected on slide), same locale and depostion data as holotype.

Etymology.—The specific epithet is a compound noun in apposition and an allusion to the lizard shape typified in drawings of the ancient Mimbres culture of the Southwest.

Discussion.—*Moribaetis mimbresaurus* represents the sixth currently recognized species of the genus *Moribaetis*, although the two recognized South American species, *M. aneto* (Traver) and *M. comes* (Navás), remain poorly known and provisional at this time (Lugo-Ortiz and McCafferty 1999, McCafferty 2000). The only other South American name



Figs. 1–5. *Moribaetis mimbresaurus*, male adult. 1, Head (dorsal). 2, Head (lateral). 3, Forewing. 4, Hindwing. 5, Genitalia (ventral).

referred to *Moribaetis, M. socius* (Needham and Murphy), is a *nomen dubium* and not counted among the six recognized species.

The new species differs from the other species of *Moribaetis* in having the pigmented infuscation of the membrane of the forewing limited to the distal costal and subcostal area, and crossventation in the distal costal area somewhat anastomose. Central American species are known to have various degrees of patterned pigmentation in the forewing. The two recognized South American species are devoid of wing pigmentation except perhaps at the wing base, and they differ also from the North-Central American forms in that they have a less distinct costal process of the hindwing that is not set off or distally oriented, and are considerably smaller in body size. The new species also differs from the other *Moribaetis* adults, except for the South American *M. aneto* (Traver), in not having the second longitudinal vein of the hindwing forked, although otherwise the hindwing venation is quite similar. In addition, although it is common for the Central American species to have triple marginal intercalaries in the cubito-anal cells of the forewing, these veins are double in *M. mimbresaurus*. This character is not resolved for the two South American species. For comparisons, the other pertinent adult descriptions of Central American *Moribaetis* species, including figures of the wings, are as follows: *M. salvini* (Eaton): Eaton (1885, plate 16, fig. 29a); *M. maculipennis* (Flowers): Flowers (1979, figs. 1–5); and *M. macaferti* Waltz: McCafferty and Lugo-Ortiz (1998, figs. 1–8).

The venational traits of *M. mimbresaurus* (double marginal intercalaries in the cubito-anal cells of the forewing and non-forked main veins in the hindwing) are apparently plesiomorphic with respect to the Central-North American species of *Moribaetis*, whereas the anastomose distal costal crossvenation could be viewed as autapomorphic within the group. This could suggest that *M. mimbresaurus* is a basal lineage among the Central-North American species, and furthermore based on its geographic distribution that it is relictual in Arizona, possibly having been much more widespread in Mexico and Central America at one time. Future discovery of the larval stage of the species should shed considerable light on these possibilities.

LITERATURE CITED

Eaton, A. E. 1883–88. A revisional monograph of recent Ephemeridae or mayflies. Transactions of the Linnaean Society of London, Second Series in Zoology 3: 1–352.

Flowers, R. W. 1979. A new species of *Baetis* from Panama (Ephemeroptera: Baetidae). Pan-Pacific Entomologist 55: 187–191.

Lugo-Ortiz, C. R. and W. P. McCafferty. 1995. Annotated inventory of the mayflies (Ephemeroptera) of Arizona. Entomological News 106: 131–140.

———. 1996. Phylogeny and classification of the *Baetodes* complex (Ephemeroptera: Baetidae), with description of a new genus. Journal of the North American Benthological Society 15: 367–380.

———. 1999. Revision of South American species of Baetidae (Ephemeroptera) previously placed in *Baetis* and *Pseudocloeon* Klapálek. Annales de Limnologie 35: 257–262.

McCafferty, W. P. 1998. Ephemeroptera and the great American interchange. Journal of the North American Benthological Society 17: 1–20.

———. 2000. Notations on South American Baetidae (Ephemeroptera). Entomological News 111: 375–397.

McCafferty, W. P. and D. E. Baumgardner. 2003. *Lugiops maya*, a new genus and species of Ephemeroptera (Baetidae) from Central America. Proceedings of the Entomological Society of Washington 105: 397–406.

McCafferty, W. P. and C. R. Lugo-Ortiz. 1998. The adult of *Moribaetis macaferti* (Ephemeroptera: Baetidae). Entomological News 109: 117–121.

Waltz, R. D. and W. P. McCafferty. 1985. *Moribaetis*: a new genus of Neotropical Baetidae (Ephemeroptera). Proceedings of the Entomological Society of Washington 87: 239–251.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 700–714

TAXONOMY OF THE SPECIES OF *AMPHIGERONTIA* (PSOCOPTERA: PSOCIDAE) OF THE ROCKY MOUNTAINS OF THE UNITED STATES AND CANADA

Edward L. Mockford and Johannes E. Anonby

(ELM) Department of Biological Sciences, Campus Box 4120, Illinois State University, Normal, IL 61790–4120, U.S.A. (e-mail: elmockf@ilstu.edu); (JEA) Sognefjordvegen 138, N–6863 Leikanger, Norway (e-mail: Johannes.anonby@fm-sf.sta.no)

Abstract.—Five species of psocids of the genus *Amphigerontia* Kolbe 1880, are recorded from the Rocky Mountains of the United States and Canada. ***Amphigerontia longicauda*, n. sp.**, is described. *Amphigerontia petiolata* (Banks) is recorded from the Rocky Mountains for the first time. The holotype of *Amphigerontia infernicola* (Chapman) is re-examined and described in detail. New characters for the separation of females of *Amphigerontia bifasciata* (Latreille) and *Amphigerontia montivaga* (Chapman) resulted in many new records of the latter species, previously known in the Rocky Mountains from only a single locality. Species-level characters are reviewed and several new ones are added. A key to the species known from North America north of Mexico is included.

Key Words: Psocoptera. Psocidae, *Amphigerontia*, new species, Rocky Mountains

Psocids of the genus *Amphigerontia* are found throughout the Rocky Mountains of the United States and Canada. These relatively large psocids sometimes become abundant locally in late summer and autumn on the foliage and branches of coniferous trees. The species are much alike in superficial appearance and accurate identification of the Rocky Mountain species is not possible with the existing literature. In this paper we attempt to resolve this problem with a new evaluation of characters, new diagnoses, and a revised key to the species. It should be noted that the term "Rocky Mountains" as used here includes the desert ranges of New Mexico, Arizona, and Utah and also an area west of the mountains in British Columbia.

Five species are now known from the Rocky Mountains. One of these is new and is here named and described from material collected in Arizona, New Mexico, and Colorado. *Amphigerontia infernicola* (Chapman) remains known only from the holotype male, collected at West Thumb, Yellowstone National Park. Our restudy of the type makes known several additional characters for recognition of this species. The other three species have fairly wide distributions elsewhere in North America (Mockford 1993). *Amphigerontia petiolata* (Banks) is recorded for the first time from the Rocky Mountains, with localities in New Mexico and southern Arizona. *Amphigerontia montivaga* (Chapman) was previously known in the Rocky Mountains from a single locality in west-central Colorado. Prior to the present study, many females of this species were misidentified as *Amphi-*

gerontia bifasciata (Latreille) and the fact that it is well represented in the central and northern Rocky Mountains went unnoticed. *Amphigerontia bifasciata* occurs throughout the Rocky Mountains and north of the mountains in the Yukon and Northwest Territories (Mockford 1993). Without presenting its copious collection data, we summarize its geographic, seasonal, altitudinal, and habitat distribution in the study area.

A key to the species of *Amphigerontia* known from the U.S. and Canada is presented in which *Amphigerontia contaminata* (Stephens) is included. This European species has become established on conifers at Vancouver, B.C. *Amphigerontia* continues southward through the mountains of Mexico and Central America, but the fauna of that area is too poorly known for proper systematic treatment at present.

MATERIALS AND METHODS

Collecting by ELM was done in the field seasons of 1963, 1966, 1969, 1987, 2001, 2002, and 2003. His former student, D.M. Sullivan, collected in Arizona, New Mexico, and Colorado in the field seasons of 1984 and 1985. JEA collected at two localities in central British Columbia in August, 1993. Other material, primarily from Utah, is on loan from Utah State University. Approximately 3,000 adult specimens were examined.

Major types as well as some paratypes of the single new species will be deposited in the collection of the Illinois Natural History Survey (INHS) Champaign, Illinois. The remaining paratypes will be retained in the collection of ELM, currently housed in the Department of Biological Sciences, Illinois State University, Normal, Illinois. The type of *A. infernicola* is in the collection of the Department of Entomology, Cornell University, Ithaca, New York (CUIC).

Illustrations were made with the aid of a drawing tube (body parts) and micro projector (wings). Measurements (expressed in μm) were made on slide-mounted parts with a filar micrometer. Color descriptions are based on observations through a dissecting microscope with direct light on specimens preserved in 80% or 95% ethyl alcohol for various periods of time.

Abbreviations used in the descriptions and measurements are as follows: FW = forewing, HW = hindwing, F = hind femur, T = hind tibia, t1 and t2 = hind first and second tarsomeres, t1ct = number of ctenidiobothria (comb-based setae) on hind first tarsomere, f1–f3 = first to third antennal flagellomeres, IO = least distance between compound eyes, d = lateral diameter of a compound eye, IO/d = index thus obtained, v1–v3 = first to third valvulae (ventral, dorsal, and lateral valvulae or gonapophyses respectively).

All measurements except those of the type of *A. infernicola* represent a mean of two measurements from two individuals from different localities.

Evaluation of Characters

Species-level characters for the North American species have not been evaluated thoroughly, and some new ones have been found in the present study. A review and evaluation of characters for species discrimination follows.

1) Head characters.
   a) Male IO/d. This index is relatively constant except in *A. bifasciata*. In that species, much inter-populational variation is seen, resulting in overlap with *A. montivaga*.
   b) Extent of sexual dimorphism in eye size. Female eyes are of a relatively constant small size. The eyes of the male *A. petiolata* are nearly the same size as those of the female. In the other species

males have much larger eyes than females. The greatest difference is in some populations of *A. bifasciata*. IO and d are indicated separately and as an index in the descriptions.

2) Forewing characters.

   a) Relative length of rs-m crossvein (Fig. 28). This crossvein, found throughout the genus, tends to be shortest in *A. montivaga*, longest in *A. infernicola*, and intermediate in the other species, with *A. bifasciata* towards the longer end and *A. longicauda* n. sp. towards the shorter end and overlapping with *A. montivaga*.

   b) Extent of development of the nodal band (cf. Lienhard, 1998: fig. 7c). This character is highly sexually dimorphic and is useful as an identification aid primarily for females. It is consistently wide and well-pigmented in *A. montivaga* (Fig. 21), variable but overlapping with *A. montivaga* in *A. bifasciata* (Fig. 2), somewhat narrower than in *A. montivaga* but well-pigmented in *A. longicauda* (Fig. 12), and very poorly developed in *A. petiolata* (Fig. 29). Chapman (1930) mentioned this band as "inconspicuously marked" in *A. infernicola* but did not illustrate it.

3) Abdominal characters.

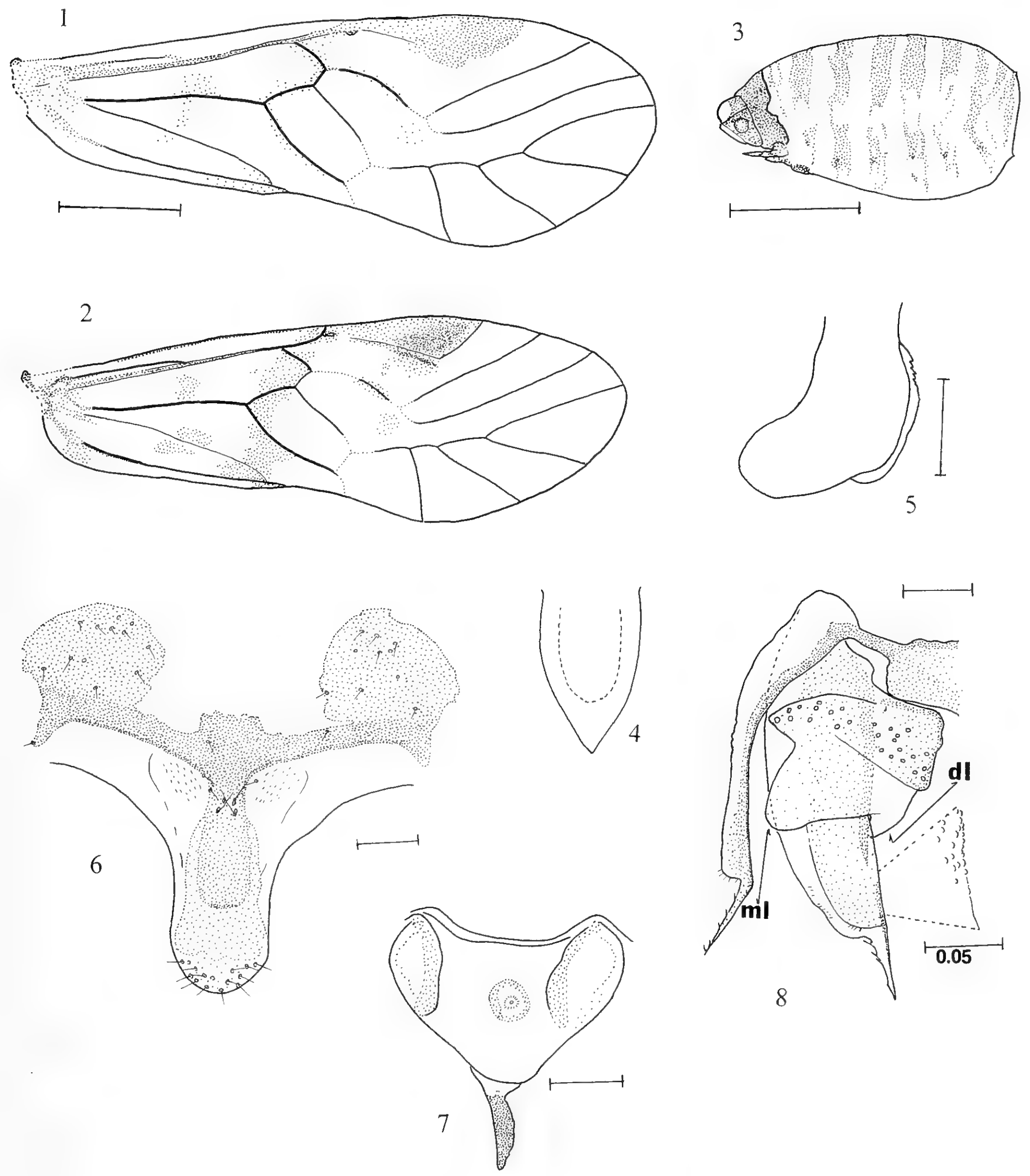
   a) Color pattern of the preclunial segments (Figs. 3, 16, 22, 30). These patterns are in subcuticular pigment and do not maintain their positions well in specimens that have been much handled. Although they are essentially the same in both sexes, they are more easily seen in females due to the larger abdomen. The pattern of each species is included in the descriptions.

   b) Male terminal abdominal characters. The epiproct and paraprocts appear to offer no useful characters at the light-microscopic level.

      (1) Median distal hypandrial process, (Figs. 4, 9, 14, 23, 31). This structure terminates distally in a single point in *A. bifasciata* and *A. petiolata*, but is slender throughout in the former and broad-based and tapering distally in the latter species. In the others, it ends in two points and slight differences in shape may be observed. Caution must be exercised in the case of *A. montivaga*, where variation in the shape of this structure is notable. On its dorsal surface the median distal process bears a lobe, here termed the dorsal lobe (Fig. 14, d), apposing the outer (ventral) surface of the process. This lobe appears to be relatively much shorter in *A. infernicola* than in *A. bifasciata, A. montivaga*, and *A. longicauda*. In *A. petiolata*, it is a short rim, forming a shallow cavity enclosed ventrally by the ventral wall of the process.

      (2) Lateral distal hypandrial processes (Figs. 5, 10, 15, 24, 31). Shape of this structure and extent of its outer crest are constant within and differ among the species in this study. Care must be taken to orient the structure uniformly in a temporary preparation.

      (3) Phallomeres (paired skeletal elements of the phallosome, joined by membrane). These



Figs. 1–8. *Amphigerontia bifasciata.* 1, Male, forewing. 2, Female, forewing. 3, Female, abdomen, lateral view. 4, Male, median distal hypandrial process, scale of Fig. 5. 5, Male, right distal hypandrial process. 6, Female, subgenital plate. 7, Female, spermapore plate. 8, Female, ovipositor valvulae (ml = median lobe, dl = distal lobe). Scale for wings and abdomen = 1.0 mm; all other scales = 0.1 mm unless indicated otherwise.

are of very limited value in the group of species under study. A rounded crest on the distal end bearing large denticles (Fig. 32) separates *A. petiolata* from the other species, but among the others no reliable differences were found.

c) Female terminal abdominal characters. As in the male there appear to be no reliable epiproctal or paraproctal characters.

(1) Subgenital plate. Three categories of characters may be distinguished:

(1 a) Length and shape of the distal lobe or egg guide. This structure readily separates *A. longicauda* from the others (Fig. 17 vs. Figs. 6, 25, and 33). Although some intraspecific variation exists in this structure in both *A. bifasciata* and *A. montivaga*, it can be used to separate these two species (Figs. 6, 25).

(1 b) Pigmentation pattern of the basal region. Beyond a major difference in shape between *A. petiolata* and the other species, only the relative length and shape of the median pigment band (Fig. 25, mpb) is important in distinguishing species, and even in this character some intraspecific variation occurs.

(1 c) Fine setae arising from elongate follicles on the neck or base of the egg guide (Figs. 6, 17, 25 fs, 33). These have not been observed previously, and they have not been reported in other genera. Differences among species may exist in their number, follicular size, and arrangement.

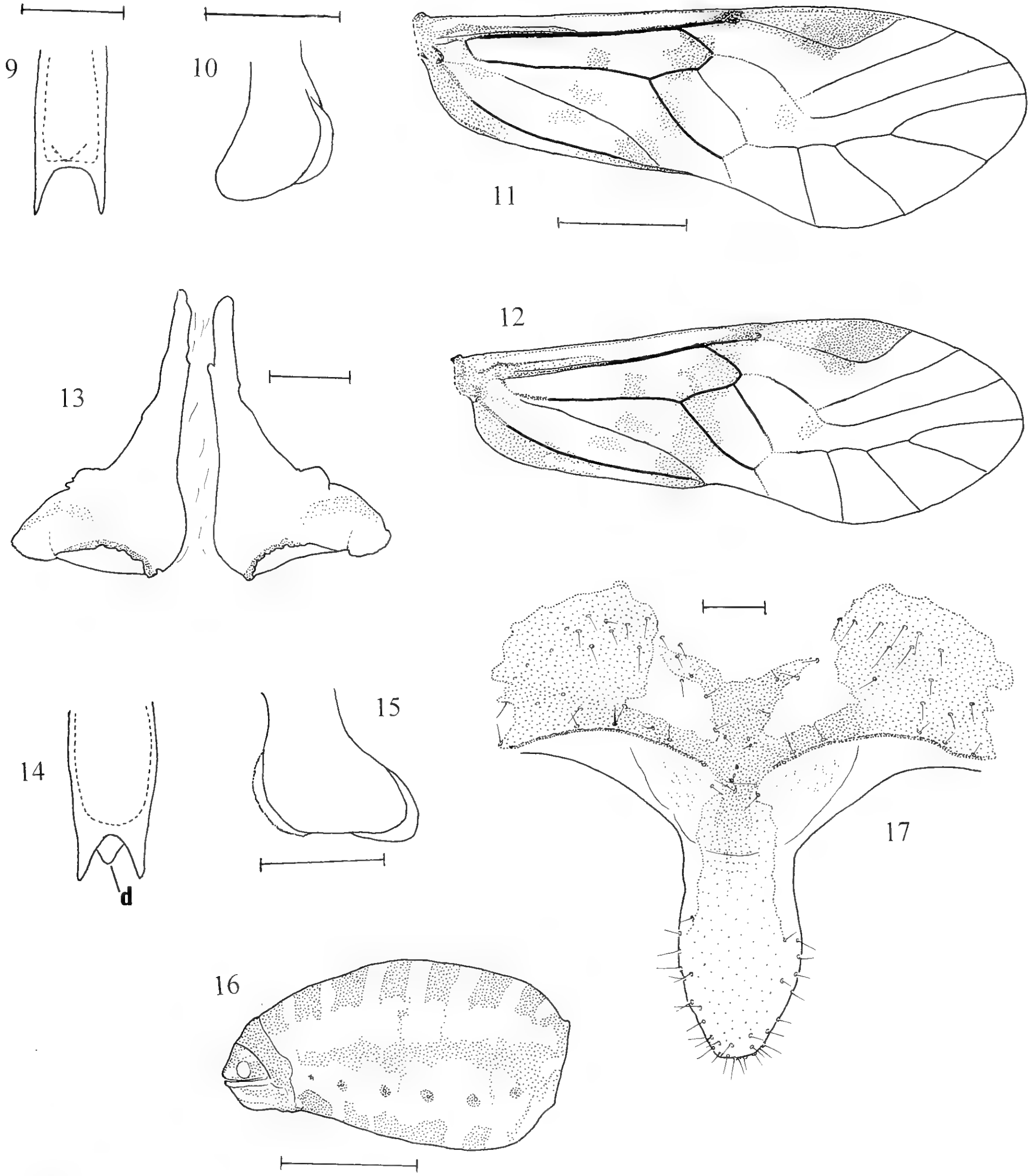
(2) Spermapore plate. No reliable difference is found between *A. bifasciata* and *A. montivaga*, but in *A. longicauda* and *A. petiolata* the shape and/or extent of pigmentation of this structure separate each from the other species. We have illustrated the structure for each species (Figs. 7, 18, 26, 34).

(3) Ovipositor valvulae.

(3 a) v1. Except for its relatively greater length in *A. longicauda*, this structure offers no other information.

(3 b) v2. In *A. petiolata* the outer surface bears tubercles reminiscent of barnacles (Fig. 35). These structures are present, but less obvious, on the other species. In *A. longicauda*, v-2 is relatively much longer than in the other species.

(3 c) v3. This is a complex structure in *Amphigerontia*, consisting of a basal, setose region separated by a line and an indentation on the medial face, from a glabrous distal region. The distal region consists of a large median lobe (Fig. 8, m1) and a smaller distal lobe (Fig. 8, d1) protruding perpendicular to the median lobe near its outer surface. In *A. bifasciata*, the median lobe is relatively large and its apex is oriented at a decided angle to the basal region (Fig. 8). In the other species, it is relatively smaller and sits more nearly parallel to the basal region. The distal lobe shows some differences in length among the species.



Figs. 9–17. *Amphigerontia* spp. 9–10, *A. infernicola*, male. 9, Median distal hypandrial process. 10, Right distal hypandrial process. 11–17, *A. longicauda*. 11, Male, forewing. 12, Female, forewing. 13, Male, phallomeres. 14, Male, median distal hypandrial process, scale of Fig. 9 (d = dorsal lobe). 15, Male, left distal hypandrial process. 16, Female, abdomen, lateral view. 17, Female, subgenital plate. Scale for wings and abdomen = 1.0 mm; all other scales = 0.1 mm.

Diagnoses and Descriptions

A diagnosis of the genus and a key to the North American genera of the subfamily Amphigerontiinae were presented by Mockford (1993:293–297). The species dealt with here are all essentially alike in color of the head, thorax, antennae, and legs, so that these features are described only for the single new species. Any notable differences in other species are mentioned. Synonymies are shortened to include only the original description and first use of the present combination. Complete synonymies may be found in Lienhard and Smithers (2002).

Amphigerontia bifasciata (Latreille 1799)

Psocus bifasciatus Latreille 1799: 144.
Amphigerontia bifasciata: Ball 1926: 332.

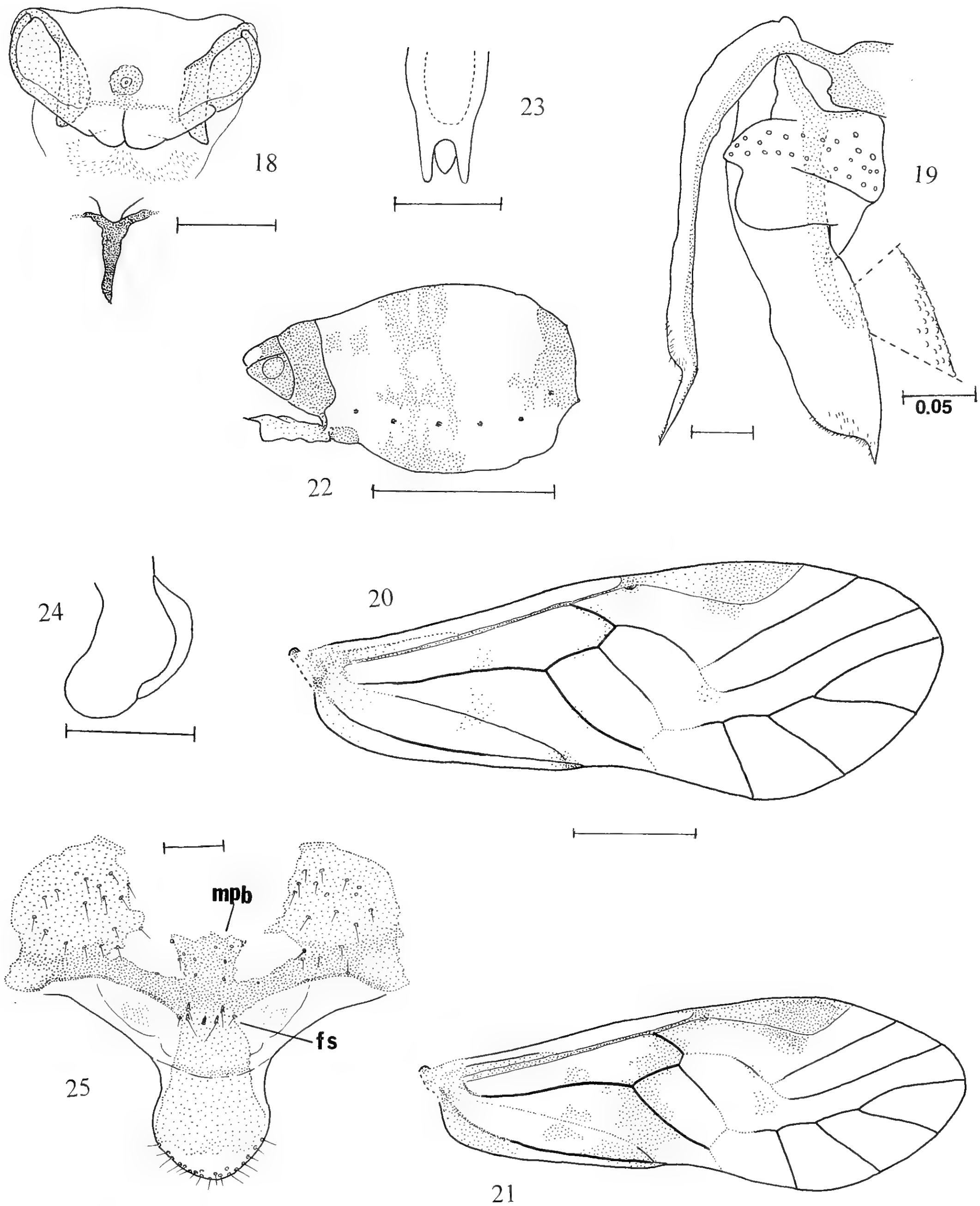
Descriptive notes.—Male eyes large, IO/d ≈ 1.44. Sexual dimorphism in eye size marked; female IO/d ≈ 3.10. In forewing, (Figs. 1, 2) rs-m crossvein relatively long. Nodal band in male consisting only of faint pigmentation along vein Rs before crossvein, along crossvein, continuing along vein M before crossvein, along vein Cu1 in its basal half, and at nodulus. In female, nodal band broken between base of pterostigma and vein Rs, otherwise complete but rather narrow in middle and sometimes broken in cell Cu1b. Preclunial abdominal color pattern (Fig. 3): ground color white; segments 2–6 each with an incomplete ring of reddish brown, absent ventrally; highly gravid females usually with a break in each pigment band dorsolaterally, thus forming on each side a pale longitudinal line. Median distal process of hypandrium slender, terminating in a single point (Fig. 4). Lateral distal hypandrial process (Fig. 5) with long "muzzle," crest with relatively large denticles basally. Phallomeres as in Fig. 13. Subgenital plate (Fig. 6): egg guide relatively short but somewhat variable in length; median pigment band short, sometimes slightly bifid at apex. Spermapore plate (Fig. 7). Ovipositor valvulae (Fig. 8): v2 with faint tubercles on outer surface; v3 with large median lobe projecting at a decided angle to basal region.

Measurements: Male: FW = 5558; HW = 4420; F = 817; T = 1723; t1= 550; t2 = 176; t1ct = 24; f1 = 805; f2 = 628; f3 = 529; IO = 403; d = 283. Female: FW = 5445; HW = 3972; F = 800; T = 1707; t1 = 478; t2 = 186; t1ct = 21, f1 = 736; f2 = 554; f3 = 496; IO = 616; d = 200.

Distribution (summary).—At the southern end of the Rocky Mountains, the Chiricahua Mountains of southern Arizona, large numbers of adults were collected in early September (1984, 1985) at elevations of 2225–2804 m on *Pinus flexilis* James, *Pinus ponderosa* Lawson, *Abies concolor* Gordon and Glendinning, *Pseudotsuga menziesii* (Mirbel), *Acer negundo* Linneaus, *Populus* sp., and *Quercus rugosa* Née. Numerous nymphs (species identification based on abdominal color pattern) were still present at that time on *P. ponderosa* at 2560 m. In Teller County, Colorado, (ca. 840 km north), many adults and nymphs were collected in late July and early August (1984, 1985) at elevations of 2073–3170 m, on *Pinus aristata* Engelmann, *Pinus cembroides* Zuccarini, *P. ponderosa, Populus angustifolia* James, *Populus tremuloides* Michaux, *Ribes* spp., scrub oak (*Quercus* sp.), *Salix amygdaloides* Andersson, and *Salix* sp. Adults and a few nymphs persisted through mid-September. North of central Colorado, sparse collecting has found the species from Teton County, Wyoming, Shoshone County, Idaho, and Jefferson and Glacier counties, Montana. These collections were made from late July through late August, 1966, and consisted almost entirely of adults. At present, we know of no records from the Canadian Rockies, but since records exist from north of the mountains in the Northwest and Yukon Territories (Mockford 1993: 298), it is reasonable to assume that the species occurs in those mountains.

Amphigerontia infernicola (Chapman 1930)

Psocus infernicolus Chapman 1930: 240.
Amphigerontia infernicola: Mockford 1993: 299.



Figs. 18–25. *Amphigerontia* spp. 18–19, *A. longicauda*. 18, Female, spermapore plate. 19, Female, ovipositor valvulae. 20–25, *A. montivaga*. 20, Male, forewing. 21, Female, forewing. 22, Female, abdomen, lateral view. 23, Male, median distal hypandrial process. 24, Male, right distal hypandrial process. 25, Female, subgenital plate (fs = fine setae, mpb = median pigment band). Scale for wings and abdomen = 1.0 mm; all other scales = 0.1 mm unless indicated otherwise.

Descriptive notes.—Known from male holotype only. Eyes relatively large. IO/d = 1.38. Right forewing missing and distal half of left also missing, but remainder showing a long rs-m crossvein. Nodal band consisting only of light clouding along vein Rs before crossvein, along crossvein, along vein M before crossvein, and at nodulus. Median distal process of hypandrium (Fig. 9) ending in pair of points relatively widely separated; dorsal lobe of median process relatively short. Lateral distal hypandrial process (Fig. 10) with short muzzle, slender neck, relatively short crest.

Measurements: FW = ca. 6.0 mm (estimate based on ratios of FW to HW length in other species and HW length in this specimen; agrees with figure in original description); HW = 4556; F = 920; T = 1900; t1 = 640; t2 missing; t1ct = 26.

Distribution.—Known only from the holotype, collected at West Thumb, Yellowstone National Park, Wyoming, 28 August 1927 (CUIC type no. 4838).

Amphigerontia longicauda Mockford and Anonby, new species

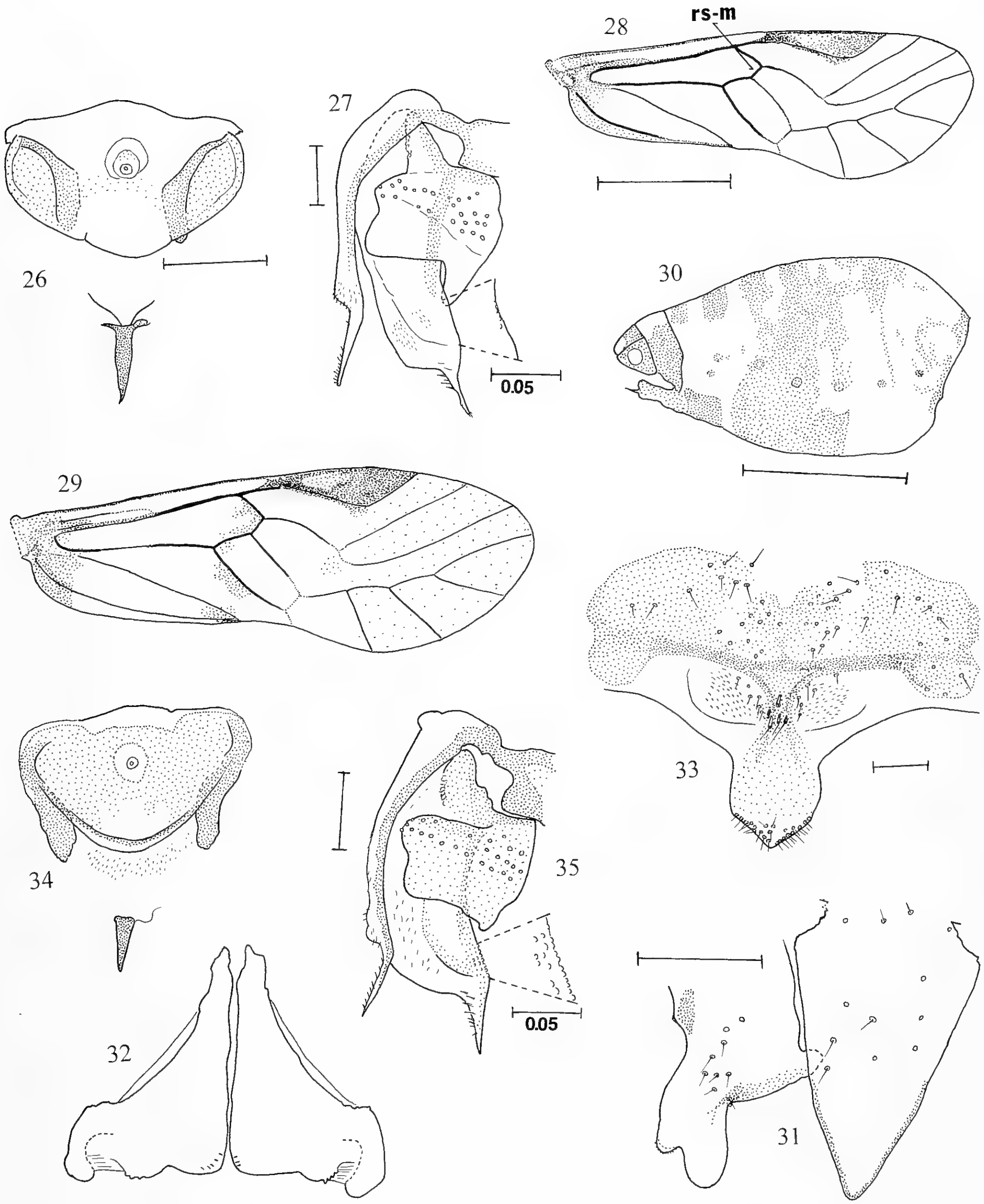
Diagnosis.—Median distal process of hypandrium (Fig. 14) terminating in pair of points, its dorsal lobe relatively long. Male eyes relatively small, IO/d ≈ 2.09. Lateral distal hypandrial process (Fig. 15) with two crests, one on the muzzle. Subgenital plate (Fig. 17) with egg guide long, ca. 1.15 × length of lateral pigmented arm.

Description.—*Male color* (in 80% ethyl alcohol): Eyes black; rest of head cream marked with chestnut brown, the latter in broad band bordering ecdysial line, broadening posteriorly to include entire hind margin of vertex, an aggregate of small spots mesad to each eye, a v-shaped mark open anteriorly on frons before ocellar field, and slender vertical lines on postclypeus. Antenna black. Thorax chestnut brown with streak of cream between lateral lobes of meso- and metanotum. Legs: coxae chestnut brown, trochanters white, femora brown dorsally, paler ventrally; tibiae and tarsi dark brown. Forewing (Fig. 11): pterostigma and stigmasaum brown throughout except narrow pale distal margin, but darker in distal three-fifths than in basal region; antenodal band of three pale spots, one in cell R, one in cell Culb, and one in cell Cu2; nodal band developed mostly as cloudy brown spot along vein Rs before crossvein, along crossvein, and along vein M before crossvein and a spot at nodulus, mostly in cell Cu2; a pale brown spot in cell R5 behind radial fork; cell IA faintly brown; remainder of wing clear. Hindwing clear. Abdomen: preclunial segments with ground color creamy white, pale pink, or grayish white; sterna pale purplish brown throughout; each of segments 2–7 with a transverse dorsal band of pale purple above a broad longitudinal band of ground color running entire length of preclunial region; latter band above a slenderer band of pale purple also running length of preclunial region; latter band subtended by another lengthwise band of ground color including spiracles. Terminal segments dark brown.

Male structural characters: See diagnosis, also following. Antenna somewhat longer than body; flagellomeres with sparse upright setae ca. 2 × as long as width of a segment. Median and frontal ecdysial lines distinct. Ocellar field conspicuous. Forewing venation (Fig. 11) typical of genus; rs-m crossvein slightly shorter than Rs segment before it. Phallomeres (Fig. 13).

Male measurements: FW = 4914; HW = 3703; F = 792; T = 1670; t1 = 493; t2 = 169; t1ct = 22; f1 = 769; f2 = 579; f3 = 500; IO = 481; d = 231.

Female color: Head, thorax, antenna, and legs as in male. Forewing (Fig. 12) as in male except spots of antenodal band darker, nodal band continuous but



Figs. 26–35. *Amphigerontia* spp. 26–27, *A. montivaga*. 26, Female, spermapore plate. 27. Female, ovipositor valvulae. 28–35, *A. petiolata*. 28, Male, forewing (rs-m = rs-m crossvein). 29, Female, forewing, scale of Fig. 28. 30, Female, abdomen, lateral view. 31, Male, median and left distal hypandrial processes. 32, Male, phallomeres. 33, Female, subgenital plate. 34, Female, Spermapore plate. 35, Female, ovipositor valvulae. Scales for wings and abdomen = 1.0 mm; all other scales = 0.1 mm unless indicated otherwise.

for a break between base of pterostigma and Rs, spot in cell R5 darker. Abdomen (Fig. 16) as described for male except preclunial sterna usually with transverse segmental bands of pale purplish brown.

Female structural characters: As in diagnosis plus following. Antenna, head ecdysial lines, and ocellar field as in male, but antennal setae much shorter and slanting distad. Eyes relatively smaller than in male, IO/d ≈ 2.86. Forewing (Fig. 12): rs-m crossvein variable but tending to be shorter than in male. Subgenital plate (Fig. 17) with median pigmented band strongly bifid at apex. Spermapore plate (Fig. 18) with broad, bilobed apex of basal region. Ovipositor valvulae (Fig. 19): v1 and v2 elongate; v2 with rather conspicuous tubercles on outer surface; distal process of v2 short; v3 with a relatively short, rounded median lobe and a relatively long distal lobe.

Female measurements: FW = 4883; HW = 3594; F = 781; T = 1665; t1 = 451; t2 = 175; t1ct = 18; f1 = 719; f2 = 539; f3 = 438; IO = 583; d = 204.

Material examined.—All collected by D. M. Sullivan. ARIZONA: Cochise Co.: Chiricahua Mountains, el. 2804 m, 9 September 1984, on *P. flexilis* and *P. ponderosa*, holotype ♂, allotype ♀, (INHS). Paratypes: ARIZONA: 5 ♂ same data as holotype, (INHS); 6 ♀ Rustler Park Campground, el. 2560 m, 9 September 1984, on *P. ponderosa*, 1 ♂, 4 ♀ (ELM); Graham Co.: Pinaleño Mts., Webb Peak, el. 3048 m, 27 October 1985, beating *Ps. menziesii*, 1 ♀ (ELM). COLORADO: Conejos Co.: ca. 8.05 km S. Lake Fork, Rio Grande National Forest, el. 2743 m, 25 September 1985, beating *Ps. menziesii*, 1 ♂, 2 ♀ (ELM); El Paso Co.: Gold Camp Rd., ca. 24.1 km E. Victor, el. 2895 m, 24 August 1984, beating *P. flexilis*, 1 ♀ (ELM); ca. 16.1 km S. Del Norte, el. 2850 m, 21 September 1985, beating *Ps. menziesii* and *P. ponderosa*, 1 ♂, 13 ♀ (ELM); Saguache Co.: ca. 16.1 km S. Poncha Springs, el. not noted, 19 August 1983, beating *P. ponderosa*, 1 ♀ (ELM); Teller Co.: ca. 4.02 km S.E. Goldfield, el 3246 m, 12 September 1985, beating *P. aristata*, 1 ♀ (ELM); ca. 16.1 km S. Victor, Phantom Canyon, el. 2743 m, 9 September 1985, beating *P. aristata*, 3 ♂, 3 ♀ (INHS); ca. 32.2 km S. Victor, el. 2499 m, 9 September 1985, beating *P. ponderosa*, 1 ♀ (ELM). NEW MEXICO: Catron Co.: Elk Mtn., U.S. forest Service Rd. 143a, el. 2560 m, 18 September 1984, beating *P. ponderosa*, 2 ♀ (ELM); Rio Arriba Co.: Upper Canjilon Lake, el. 2987 m, 30 September 1985, on dead aspen trunk, 1 ♀ (ELM).

Amphigerontia montivaga
(Chapman 1930)

Psocus montivagus Chapman 1930: 225.
Amphigerontia montivaga: Mockford 1950: 201.

Descriptive notes.—Male eyes relatively small, IO/d ≈ 1.69. Sexual dimorphism in eye size moderate; female IO/d ≈ 3.30. In forewing (Figs. 20, 21) rs-m crossvein relatively short. Nodal band in male consisting only of a cloudy brown spot bordering vein Rs before crossvein, on crossvein, and on vein M before crossvein, and a faint brown spot at nodulus. In female, band broad throughout except for a break between base of pterostigma and Rs. Preclunial abdominal color pattern (Fig. 22): ground color white; segments 1–2 brown; segments 3–4 usually each with a transverse brown band dorsally (not seen in Fig. 22); segments 5–6 each with a complete brown ring broken only at spiracles; segment 7 with a transverse brown band dorsally. Median distal hypandrial process (Fig. 23) terminating in two points, with a relatively long dorsal lobe. Lateral distal hypandrial process (Fig. 24) with short muzzle, long crest with only minute denticles on its edge. Phallomeres as in Fig. 13. Subgenital plate (Fig. 25): egg guide short; median pigment band relatively long but variable, occasionally bifid at apex. Spermapore plate (Fig. 26). Ovipositor valvulae (Fig. 27): v2 with a few small tubercles on outer surface; v3 with median lobe of moderate size, oriented nearly parallel to basal region.

Measurements: Male: FW = 5699; HW = 4236; F = 899; T = 1817; t1 = 550; t2 = 181; t1ct = 24; f1 = 817; f2 = 591; f3 = 523; IO = 440; d = 261. Female: FW = 4500; HW = 3266; F = 696; T = 1454; t1 = 446; t2 = 176, t1ct = 21; f1 = 640; f2 = 561; f3 = 428; IO = 574; d = 171.

Distribution.—The species occurs from central New Mexico (Catron and Lincoln counties) north in the mountains to eastern British Columbia, with records between from Colorado, Utah, Wyoming, Montana, and Idaho. There are at present no clearly verifiable records from Arizona, but a small series of teneral adults from the North Rim of Grand Canyon probably represents this species.

Material examined.—Collections by D.M. Sullivan indicated as "coll. DMS". U.S.A. COLORADO: Conejos Co.: Conejos River at USFS Magote Campground, el. 2530 m, 26 September 1985, beating blue spruce (*Picea pungens* Engelmann), *Cornus stolonifera* Michaux, and *Juniperus monospermum* Sargent, coll. DMS, 14 ♀; El Paso Co.: ca. 9.7 km W. Colorado Springs, el. 2713 m, 17 September 1985, beating *Betula papyrifera* Marsh, coll. DMS, 1 ♀; Rattlesnake Gulch NW Manitou Springs, el. 2118 m, 26 August 1984, beating *Quercus gambelii* Nutall, coll. DMS, 4 ♀, 1 nymph; ca. 40.2 km E. Victor, Gold Camp Rd., el 2515 m, 24 August 1984, beating *A. concolor*, coll. DMS, 5 ♀; Gunnison Co.: Agate Campground, Gunnison Nat. Forest, el. 2438 m, 21 July 1969, beating *Pinus contorta* Loudon and *P. pungens*, coll. ELM, 7 ♂, 1 ♀; Huerfano Co.: Cucharas River, ca. 4.2 km SW Cucharas, el. 2957 m, 19 September 1985, beating aspen (*Populus* sp.), coll DMS, 1 ♂; ca. 40.2 km W. Walsenburg, el. 2499 m, 19 September 1985, beating aspen, coll. DMS, 2 ♀; Montrose Co.: Uncompahgre Nat. Forest, Spruce Mtn., NF Rd. 600, el. 2957 m, 24 July 1985, beating *Abies lasiocarpa* Nutall, coll. DMS, 1 ♀, 12 nymphs; Uncompahgre Nat. Forest, Iron Springs, el. 2957 m, 5 September 1985, beating *Abies lasiocarpa* (Hooker), coll. DMS, 14 ♀; Teller Co.: ca. 48.3 km SE Cripple Creek, el. 3048 m, 17 September 1985, beating aspen (*Populus* sp.), coll. DMS, 3 ♀; ca. 3.2 km SE Goldfield, el. 3170 m, 12 September 1985, beating *P. aristata*, 2 ♀, beating *Picea engelmannii* Parry, 1 ♂, 1 ♀, coll. DMS. IDAHO: Boundary Co.: U.S. Hwy. 2, 1.6 km W. Montana State line, 19 August 1966, beating coniferous trees, coll. ELM, 2 ♀; Idaho Co.: Clearwater Nat. Forest: Wendover Campground, Hwy. 12, el. 1036 m, 28 July 1987, beating *Abies* sp. and *Tsuga mertensiana* Sargent, coll. ELM, 1 ♂. MONTANA: Flathead Co.: Tally Lake Campground, Flathead Nat. Forest, el. 1067 m, 29 July 1987, beating *Ps. menziesii* and *P. contorta*, coll. ELM, 4 ♂, 9 ♀. NEW MEXICO: Catron Co.: Negrito Creek and USFS Rd. 141, Gila Nat. Forest, el. 2286 m, 17 September 1984, beating dead branches of *P. engelmannii*, coll. DMS, 1 ♀; Lincoln Co.: Capitan Mountain., el. 2438–2987 m, 3–4 September 1984, beating *Ps. menziesii* and *P. flexilis*, coll. DMS, 8 ♂, 12 ♀, 12 nymphs; Rio Arriba Co.: ca. 16.1 km NE Chama, el. 2499 m, 27 September 1985, beating *Q. gambelii*, coll. DMS, 1 ♀; ca. 8.0 km S. Tierra Amarilla, Hwy. 84, el. 2377 m, beating *Pinus edulis* Engelmann, coll. DMS, 1 ♀. UTAH: Cache Co.: Tony Grove Canyon, 25 August–2 September 1976, coll. Knowlton and Hanson, 1 ♂; Tony Grove Junction, 1–7 September 1984, Malaise trap, 1 ♂; Rich Co.: Logan Canyon Summit, 22–29 August 1980, Malaise trap, 1 ♂; Utah Co.: Alpine Loop Rd. off Hwy. 189 nr. Heber City, el. 1768 m, 24 August 1953, coll. ELM, 5 ♀, 2 nymphs. Wyoming: Teton Co.: U.S. Hwy. 26, 22.5 km N. Jackson, 5 August 1966, beating *Ps. menziesii*, coll. ELM, 5 ♂, 6 ♀. CANADA: BRITISH COLUMBIA: Burns Lake, el. ca. 700 m, 2 August 1993, beating young *Picea glauca* Voss, coll. JEA, 1 ♀; Cariboo Regional District: Kersley, el. ca. 600 m, 1 August 1993, beating *Pseudotsuga*, coll. JEA, 1 ♀; Nakusp village, el. 450 m, 22 July 1993 beating young *Tsuga* in mature secondary forest, coll. JEA, 1 ♂, 1 ♀.

Amphigerontia petiolata (Banks 1918)

Psocus petiolatus Banks 1918: 4.
Amphigerontia petiolata: Mockford 1950: 201.

Descriptive notes.—Male eyes small, IO/d ≈ 2.28. Sexual dimorphism in eye size slight. Female IO/d ≈ 3.34. Eyes bicolored in both sexes: pale greenish gray in upper two-fifths, black in lower three-fifths. In forewing (Figs. 28, 29), rs-m crossvein relatively long. Nodal band absent in male; in female continuous but weakly pigmented and thin from vein Rs nearly to nodulus then as a spot at nodulus. A basal band also present in female. Preclunial abdominal color pattern (Fig. 30): ground color chalky white; segments 1–2 dark brown laterally, white dorsally except for a longitudinal brown dorsolateral streak on each side; segment 3 white laterally and ventrally, brown dorsally; segments 4–6 dark brown throughout (or with some white spots on sides); segment 7 white with two dorsolateral brown spots. Median distal process of hypandrium (Fig. 31) broad basally, tapering to single point distally. Lateral distal hypandrial process (Fig. 31) with long muzzle, short denticulate crest occupying prominence. Phallomeres (Fig. 32) each with short row of denticles distally near lateral margin. Subgenital plate (Fig. 33) with short egg guide tapered to blunt point at apex; median pigment band diffuse. Spermapore plate (Fig. 34). Ovipositor valvulae (Fig. 35): v2 with large tubercles on outer surface; v3 with median and distal lobes relatively small, the median parallel with basal region.

Measurements: Male: FW = 3606; HW = 2755; F = 613; T = 1331; t1 = 369; t2 = 119; t1ct = 16; f1 = 628; f2 = 477; f3 = 401; IO = 424; d = 186. Female: FW = 4129; HW = 3264; F = 607; T = 1242; t1 = 319; t2 = 122; t1ct = 16; f1 = 625; f2 = 433; f3 = 334; IO = 517; d = 155.

Distribution.—The Rocky Mountain records represent a range extension (from eastern Texas) westward in the U.S. of ~ 1045 km. to Arizona. The species appears to be restricted in the Rocky Mountains to southern New Mexico and southern Arizona.

Material examined (collected by ELM except where otherwise noted). ARIZONA: Cochise Co.: Chiricahua Mountains: South Fork Road of Cave Creek Area, Coronado National Forest, 6 September 2002, beating broad-leaf trees along creek, 11 ♂, 11 ♀, 18 nymphs; Pinery Canyon Rd. at North Fork Rd., 22 September 2002, beating dead branches of oak, sumac, and *Bumelia*, 1 ♂, 2 ♀; Huachuca Mountains: Miller Peak Trail, el. 1585–1646 m, 18 August 2001, beating dead branches of trees, 2 ♀; Santa Cruz Co.: Santa Rita Mountains: Madera Canyon, 21 August 1959, on *Quercus* sp., coll. G.H. Nelson, 4 ♀. NEW MEXICO: Lincoln Co.: ca 3.2 km S. Nogal on State Hwy. 37, 10 August 1983, beating piñon pines, 6 ♂, 2 ♀.

KEY TO THE SPECIES OF *AMPHIGERONTIA* OF NORTH AMERICA NORTH OF MEXICO

1. Abdomen terminating ventrally in a 2-segmented, heavily sclerotized plate, the hypandrium, ending posteriorly in three processes; male 2

– Termination of abdomen very different, a partially-sclerotized subgenital plate bearing posteriorly a single process, egg guide, latter closely flanked by ovipositor valvulae; female 7

2. Median process of hypandrium terminating in a single point (Figs. 4, 31) 3

– Median process of hypandrium terminating in a pair of points (Figs. 9, 14, 23) 4

3. Median process of hypandrium slender, tapering beyond middle to single point (Fig. 4) . . . . *A. bifasciata* (Latreille)

– Median process of hypandrium long-arrowhead shaped, tapering from broad base to single point (Fig. 31) . . . . *A. petiolata* (Banks)

4. Forewing length ca. 6 mm; eyes relatively large, IO/d = 1.38 . . . . *A. infernicola* (Chapman)

– Forewing shorter, rarely over 5.8 mm; eyes smaller, IO/d ranging from 1.46–2.22 5

5. Lateral process of hypandrium lacking a crest on muzzle (Fig. 24); preclunial abdominal segments with a belt of pigment in segments 5 and 6, as in Fig. 22. *A. montivaga* (Chapman)

– Lateral process of hypandrium with a crest on muzzle (Fig. 15); preclunial abdominal segments lacking belt of pigment in segments 5 and 6 6

6. Median process of hypandrium greatly widened in middle; (cf., Mockford 1993, fig. 380) . . . . *A. contaminata* (Stephens)

– Median process of hypandrium only slightly widened in middle (Fig. 14) . . . . *A. longicauda*, n. sp.

7. Egg guide as well as v1 and v2 elongate (Figs. 17, 19), former ca. 1.15 × length of a lateral pigmented arm of subgenital plate; median pigmented band of subgenital plate usually strongly bifid at its apex (Fig. 17) . . . . *A. longicauda*, n. sp.

– Egg guide as well as v1 and v2 shorter, former shorter than length of a lateral pigmented arm of subgenital plate; median pigmented band of subgenital plate either not bifid at apex or only slightly so 8

8. Median pigmented band of subgenital plate diffuse; egg guide tapered distally (Fig. 33) . . . . *A. petiolata* (Banks)

– Median pigmented band of subgenital plate with distinct limits, at least at its base; egg guide rounded distally (Figs. 6, 25) 9

9. Median pigmented band of subgenital plate short, usually not longer than its basal width (Fig. 6); median lobe of v3 at a decided angle to basal region (Fig. 8) . . . . *A. bifasciata* (Latreille)

– Median pigmented band of subgenital plate usually longer than its basal width (Fig. 25); median lobe of v3 nearly parallel to basal region (Fig. 27) 10

10. Preclunial abdominal sterna unpigmented; v2 with prominent tubercles on outer surface . . . . *A. contaminata* (Stephens)

– Two preclunial abdominal sterna before subgenital plate usually pigmented (Fig. 22); tubercles of outer surface of v2 small and inconspicuous . . . . *A. montivaga* (Chapman)

ACKNOWLEDGMENTS

We thank J. Liebherr (Cornell University) for arranging the loan of the type of *A. infernicola* and W.J. Hanson (Utah State University) for arranging the loan of Utah material. Collecting in Colorado, New Mexico, and Arizona by D.M. Sullivan and ELM in 1984–85 was supported by a National Science Foundation grant BSR-8219659, to Illinois State University. We thank S. Sakaluk and K. Yoshizawa for critical reading and important comments on this manuscript. ELM thanks J. Kessell for his company on several collecting excursions in the mountains of southern Arizona.

LITERATURE CITED

Ball, A. 1926. Les Psocidae de Belgique. Bulletin et Annales de la Société entomologique de Belgique 66: 331–349, 3pls.

Banks, N. 1918. New Neuropteroid Insects. Bulletin of the Museum of Comparative Zoology, Harvard College 62: 1–22, 2 pls.

Chapman, P. J. 1930. Corrodentia of the United States of America. I. Suborder Isotecnomera. Journal of the New York Entomological Society 38: 219–290, 319–403, pls. XII–XXI.

Kolbe, H. J. 1880. Monographie der deutschen Psociden mit besonderer Berücksichtigung der Fauna Westfalens. Jahresbericht des Westfälischen Provinzial-Vereins für Wissenschaft und Kunst 8: 73–142, pls. I–IV.

Latreille, P. A. 1799. Le genre *Psocus*, pp. 8–14. *In* Coquebert de Montbret, A. J. ed. Illustratio Iconographica Insectorum quae in Musaeis parisinis observavit et in lucem edidit Joh. Christ. Fabricius, etc., Paris.

Lienhard, C. 1998. Faune de France 83. Psocoptères Euro-Mediterranéens. Fédération Française des Sociétés de Sciences naturelles. Paris. 517 pp. pls. 1–11.

Lienhard, C. and C. N. Smithers. 2002. Psocoptera (Insecta), World Catalogue And Bibliography. Instrumenta Biodiversitatis V, Geneva. 745 pp.

Mockford, E. L. 1950. The Psocoptera of Indiana. Proceedings of the Indiana Academy of Science 60: 192–204.

———. 1993. North American Psocoptera (Insecta). Sandhill Crane Press, Gainesville, FL, and Leiden, Netherlands. 455 pp.

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 715–717

NOTE

Eremocoris borealis Dallas (Hemiptera: Lygaeoidea: Rhyparochromidae): A Litter-Inhabiting Seed Bug in Cones of Pitch Pine (*Pinus rigida*)

The family Rhyparochromidae is the most speciose of families that formerly composed the diverse Lygaeidae. Though long suspected to represent a paraphyletic group (e.g., Leston 1958, Southwood and Leston 1959, Schuh and Slater 1995), the Lygaeidae in its traditional sense was not formally reconstituted until Henry (1997) proposed family status for Rhyparochrominae and 10 other subfamilies, including the nominate Lygaeinae.

Rhyparochromids live almost exclusively at the interface of the ground and litter where they feed on fallen seeds (Sweet 1960, 1964). They are most efficiently collected by a "scratch and search" of dead leaves and other ground litter (Barber 1928, Sweet 1964, Slater and Baranowski 1978). With few exceptions, drymine rhyparochromids are typical litter inhabitants. Among North American drymines, *Eremocoris depressus* Barber (Wheeler 1996) and species of the Holarctic genus *Gastrodes* Westwood (Usinger 1933, 1938; Sweet 1964; Ashlock 1979) are arboreal, feeding on seeds in the cones of pines (*Pinus* spp.) and other conifers.

Eremocoris Fieber, a Holarctic genus, has twelve species in Canada and the United States and nine additional species in Mexico (Slater 1964; Slater and O'Donnell 1995). Eastern North American species, in addition to *E. depressus*, are *E. borealis* Dallas, *E. ferus* Say, and *E. setosus* Blatchley. Bionomics of the seldom-collected *E. setosus* are little known, whereas those of the common *E. borealis* and *E. ferus* have been studied in the field and laboratory by Sweet (1964), who included data for both species under *E. ferus* even though he considered them to represent cryptic species. Based on behavioral, distributional, ecological, morphological, and reproductive evidence, Sweet (1977) elevated *E. borealis* from synonymy with *E. ferus*. He recognized *E. borealis* as more northern, ranging in eastern North America from Newfoundland south along the Appalachians to North Carolina and Tennessee; in the Midwest, its southern limits are Michigan and Wisconsin. The distribution of *E. ferus* is Austroriparian-Carolinian: southern New York and lowland areas of New England south to the Gulf of Mexico, with Illinois, Indiana, and Ohio marking the northern range limit in the Midwest. Relictual populations are found in the Edwards Plateau of Texas (Sweet 1977). Both species are bivoltine, overwinter as adults, and feed on seeds of coniferous and hardwood trees in loose ground litter in cool or shaded habitats (Sweet 1964).

On 14 August 1993, on a ca. 15-m pitch pine (*Pinus rigida* Mill.) in Maine, I encountered not only the arboreal *E. depressus* but also *E. borealis* when cones within reach (up to ca. 2.5 m) were tapped with an ax handle over a shallow beating net. Six ♂ and 4 ♀ of *E. borealis* and 9 ♂ and 4 ♀of *E. depressus* were collected (additional adults of both species were observed in cones) in Cumberland Co., 8 km NNE of Gray at the intersection of Mayall Rd. and Bluff Circle (formerly Blueberry Bluff Circle), 43° 55.74′N, 70° 19.45′W. Specimens of both species have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC.

Ashlock and A. Slater (1988), in the most recent catalog of North American Heteroptera, did not record *E. borealis* from Maine but referred to Sweet's (1977) comment that old northern records of *E. ferus* pertain to the former species. Thus, Parshley's (1914) records of *E. ferus* from Maine should be considered the first for *E. borealis* in the state.

Nymphs of *E. depressus*, in contrast to those of the litter-inhabiting *E. borealis* (Sweet 1964), feed on seeds in second-year, partially opened cones of pitch pine in northeastern states (Wheeler 1996). The occasional movement of rhyparochromines from the litter biotope is assumed to represent dispersal. *Eremocoris ferus*, for example, disperses in early spring (Sweet 1964), and *E. borealis* and *E. ferus* can become household nuisances in summer when they enter houses or congregate on porches or siding (Wheeler 1989). But the presence of seeds in cones that yielded *E. borealis* and *E. depressus*, including nymphs of the latter species, suggests that in mid-August adults of *E. borealis* were not merely resting in the tree or seeking shelter in cones, but feeding on seeds.

Although *E. borealis* and *E. ferus* feed in the field and laboratory on seeds of various woody plants, they show a marked tendency for those of conifers (Sweet 1964, 1977); western North American species of the genus feed on fallen conifer seeds (Sweet 2000). The presence of multiple adults of *E. borealis* in cones of pitch pine in Maine might not indicate a shift to arboreal seed feeding. The collection of adults, however, reinforces an association with conifers and illustrates behavioral plasticity that allows a litter inhabitant to move opportunistically into cones of a pine tree where it might feed on seeds.

Slater et al. (1993) suggested that arboreal habits in the myodochine rhyparochromid *Slaterobius quadristriatus* (Barber), which also feeds on seeds in pitch pine (and jack pine, *P. banksiana* Lamb.) cones, represent a recent niche shift in an otherwise litter-inhabiting genus. The arboreal habits and flattened body of *E. depressus* presumably reflect derived characters (Wheeler 1996). Phylogenetic analysis of *Eremocoris* should help determine if colonization of an arboreal microhabitat by *E. depressus* actually is a derived condition.

I thank Thomas J. Henry (Systematic Entomology Laboratory, ARS, USDA, c/o National Museum of Natural History, Washington, DC) for verifying the identification of *E. borealis*, Scott Baldwin (U.S. Postal Service, Gray, ME) for information on the change of street name at the collection site, and Peter H. Adler (Department of Entomology, Soils, and Plant Sciences, Clemson University) for his constructive review of an earlier draft of the manuscript.

LITERATURE CITED

Ashlock, P. D. 1979. A new *Eremocoris* from California with a key to North American genera of Drymini (Hemiptera-Heteroptera: Lygaeidae). Pan-Pacific Entomologist 55: 149–154.

Ashlock, P. D. and A. Slater. 1988. Family Lygaeidae Schilling, 1829 (= Infericornes Amyot and Serville, 1843; Myodochidae Kirkaldy, 1899; Geocoridae Kirkaldy, 1902). The seed bugs and chinch bugs, pp. 167–245. *In* Henry, T. J. and R. C. Froeschner, eds. Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States. E.J. Brill, Leiden.

Barber, H. G. 1928. Some quantitative results in collecting Hemiptera. Entomological News 39: 193–194.

Henry, T. J. 1997. Phylogenetic analysis of the family groups within the infraorder Pentatomomorpha (Hemiptera: Heteroptera), with emphasis on the Lygaeoidea. Annals of the Entomological Society of America 90: 275–301.

Leston, D. 1958. Chromosome number and the systematics of Pentatomomorpha (Hemiptera). Proceedings of the Tenth International Congress of Entomology 2: 911–918.

Parshley, H. M. 1914. List of the Hemiptera-Heteroptera of Maine. Psyche 21: 139–149.

Schuh, R. T. and J. A. Slater. 1995. True Bugs of the World (Hemiptera: Heteroptera): Classification and Natural History. Cornell University Press, Ithaca, NY. 336 pp.

Slater, J. A. 1964. A Catalogue of the Lygaeidae of the World. 2 volumes. University of Connecticut, Storrs. 1668 pp.

Slater, J. A. and R. M. Baranowski. 1978. How to Know the True Bugs (Hemiptera-Heteroptera). W.C. Brown, Dubuque, IA. 256 pp.

Slater, J. A. and J. E. O'Donnell. 1995. A Catalogue of the Lygaeidae of the World (1960–1994). New York Entomological Society, New York. 410 pp.

Slater, J. A., M. H. Sweet, and H. Brailovsky. 1993. Two new species of *Slaterobius* Harrington with comments on the ecology and distribution of the genus (Hemiptera: Lygaeidae). Proceedings of the Entomological Society of Washington 95: 590–602.

Southwood, T. R. E. and D. Leston. 1959. Land and Water Bugs of the British Isles. Frederick Warne, London. 436 pp.

Sweet, M. H. 1960. The seed bugs: a contribution to the feeding habits of the Lygaeidae (Hemiptera: Heteroptera). Annals of the Entomological Society of America 53: 317–321.

———. 1964. The biology and ecology of the Rhyparochrominae of New England (Heteroptera: Lygaeidae). Parts I, II. Entomologia Americana 43: 1–124, 44: 1–201.

———. 1977. Elevation of the seedbug *Eremocoris borealis* (Dallas) from synonymy with *Eremocoris ferus* (Say) (Hemiptera: Lygaeidae). Entomological News 88: 169–176.

———. 2000. Seed and chinch bugs (Lygaeoidea), pp. 143–264. *In* Schaefer, C. W. and A. R. Panizzi, eds. Heteroptera of Economic Importance. CRC Press, Boca Raton, FL.

Usinger, R. L. 1933. A new species of *Gastrodes* from California (Lygaeidae-Hemiptera). Pan-Pacific Entomologist 9: 127–128.

———. 1938. Review of the genus *Gastrodes* (Lygaeidae, Hemiptera). Proceedings of the California Academy of Sciences (Fourth Series) 23: 289–301.

Wheeler, A. G., Jr. 1989. *Eremocoris borealis* and *E. ferus* (Heteroptera: Lygaeidae) as household pests in Pennsylvania and Connecticut. Entomological News 100: 165–168.

———. 1996. *Eremocoris depressus* Barber: hosts, seasonality, and first New England records of a pine seed specialist (Heteroptera: Lygaeidae). Proceedings of the Entomological Society of Washington 98: 767–773.

A. G. Wheeler, Jr., *Department of Entomology, Soils, and Plant Sciences, Clemson University, Clemson, SC 29634-0315, U.S.A. (e-mail: awhlr@clemson.edu)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 718–720

NOTE

Trichogramma Species (Hymenoptera: Trichogrammatidae) Egg Parasitoids of Lepidoptera in the Eastern Mediterranean Region of Turkey

Trichogramma can parasitize a wide range of insects but mostly attack Lepidoptera, including a large number of important agricultural pests. However, worldwide commercial use of *Trichogramma* is still limited to a small number of species. For effective commercial use, it is essential to select suitable species to control the target insect pests. Success or failure in the use of egg parasites in biological control depends on the choice of species. Toward this goal, the species of *Trichogramma* not previously known and observed in Lepidoptera eggs, except those on corn, in the eastern Mediterranean region of Turkey were determined.

Surveys were carried out in cultivated areas [cotton (June–September), corn (April–October), citrus (April–June), wine (April–August), apple and the other fruits (May–September), vegetables and weeds (throughout the year)] and noncultivated areas in Adana (35.16°E, 37.00°N), Mersin (34.36°E, 36.51°N), and Hatay (36.10°E, 36.14°N) provinces, in the eastern Mediterranean region of Turkey, during 2000–2001. Eggs of Lepidoptera on these crops were collected and placed in refrigerated plastic boxes to bring to the laboratory. Collections were labeled with date, place and name of host plant. Each sample was prepared and cultured at 25±1°C, 65±10% RH, and 16:8 L:D. Samples were controlled daily until adult emergence. Some of the *Trichogramma* adults were kept in 70% alcohol and the others kept dry. The dry samples were kept in 7 drops of glacial acetic acid and 5 drops of lactophenol or chloral-phenol in small petri dishes for 1–3 d, then specimens were mounted in hoyers (Rosen and DeBach 1979). Prepared samples were identified by a specialist.

Six species of *Trichogramma* were determined: *Trichogramma embryophagum* Hartig, *Trichogramma cacoeciae* Marchal, *Trichogramma pintoi* Voegele, *Trichogramma evanescens* Westwood (= *Trichogramma turkestanica* Meyer), *Trichogramma brassicae* (Bezdenko), and *Trichogramma dendrolimi* Matsumura (Table 1). The hosts of *Trichogramma* were determined as *Trichoplusia ni* (Hübner) (Lepidoptera: Noctuidae) on lettuce, *Chrysodeixis chalcites* (Esper) (Lepidoptera: Noctuidae) on black nightshade, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on cotton, tomato and cabbage, *Ostrinia nubilalis* (Hübner) (Lepidoptera: Crambidae) on corn, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) on apple, *Cydia molesta* (Busck) (Lepidoptera: Tortricidae) on peach, *Archips rosanus* (Linnaeus) (Lepidoptera: Tortricidae) on cherry, *Thaumetopoea pityocampa* (Denis and Schiffermüller) (Lepidoptera: Thaumatopoeidae) on pine, and *Idaea bractilineata* (Zeller) (Lepidoptera: Geometridae) on castor oil (Table 1). Parallel results also were obtained from Spain (Cabello-Garcia and Vargas-Piqueras 1985), Russia (Livshits and Mitrofanov 1986), Germany (Hassan 1989), Bulgaria (Tsankov et al. 1996; Karadjov 1996), Portugal (Silva et al. 1999), and Holland (Rijswijk et al. 2000).

Based on the 2000 and 2001 records, six *Trichogramma* species were found on 11 host plants and nine various Lepidoptera pests, and, except for corn, these species are new records in the Mediterranean region of Turkey. *Trichogramma*

Table 1. *Trichogramma* species and host records in the Eastern Mediterranean Region of Turkey in 2000–2001.

Place	Date	Host Plants	Lepidoptera Hosts	*Trichogramma* Species
Hatay	12.09.2001	*Zea mays*	*Ostrinia nubilalis*	*T. brassicae*
Hatay	21.04.2000	*Rucumis communis*	*Idaea bractilineata*	*T. brassicae*
Hatay	10.04.2001	*Rucumis communis*	*Idaea bractilineata*	*T. brassicae*
Mersin	16.06.2000	*Malus communis*	*Cydia pomonella*	*T. embryophagum*
Mersin	11.07.2000	*Malus communis*	*Cydia pomonella*	*T. embryophagum*
Mersin	21.06.2001	*Malus communis*	*Cydia pomonella*	*T. embryophagum*
Mersin	04.07.2001	*Malus communis*	*Cydia pomonella*	*T. embryophagum*
Mersin	30.06.2000	*Prunus persicae*	*Cydia molesta*	*T. embryophagum*
Mersin	16.06.2000	*Prunus avium*	*Archips rosanus*	*T. cacoeciae*
Adana	18.01.2001	*Lactuca sativa*	*Trichoplusia ni*	*T. pintoi*
Mersin	16.02.2000	*Solanum nigrum*	*Chrysodeixis chalcites*	*T. evanescens*
Mersin	15.02.2001	*Solanum nigrum*	*Chrysodeixis chalcites*	*T. evanescens*
Adana	02.08.2000	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	03.08.2000	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	09.08.2000	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	14.08.2000	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	24.08.2000	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	31.08.2000	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	08.08.2001	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	23.08.2001	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	05.09.2001	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	18.09.2001	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	26.09.2001	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Mersin	15.08.2000	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Mersin	28.08.2000	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Mersin	16.08.2001	*Zea mays*	*Ostrinia nubilalis*	*T. evanescens*
Adana	20.01.2000	*Brassica oleracea*	*Helicoverpa armigera*	*T. evanescens*
Adana	24.08.2000	*Gossypium* sp.	*Helicoverpa armigera*	*T. evanescens*
Adana	05.09.2001	*Solanum lycopersicum*	*Helicoverpa armigera*	*T. pintoi*
Adana	05.09.2001	*Pinus* sp.	*Thaumetopoea pityocampa*	*T. embryophagum*
Adana	18.09.2001	*Pinus* sp.	*Thaumetopoea pityocampa*	*T. embryophagum*
Adana	05.09.2001	*Pinus* sp.	*Thaumetopoea.pityocampa*	*T. dendrolimi*
Adana	18.09.2001	*Pinus* sp.	*Thaumetopoea pityocampa*	*T. dendrolimi*
Adana	26.09.2001	*Pinus* sp.	*Thaumetopoea pityocampa*	*T. dendrolimi*

evanescens was the dominant species detected on three host plants (corn, cotton, and weed) in the eggs of *H. armigera*, *O. nubilalis* and *C. chalcites*. *Trichogramma evanescens* was reported from *Pieris rapae* (L.) (Lepidoptera: Pieridae), *O. nubilalis*, and *C. pomonella* eggs, and was the dominant species within the total of nine on corn, fruit, and vegetable (Uzun et al. 1996).

All species were recorded from more then a few eggs, but of 241 eggs of *H. armigera* collected on cotton, only 14 were parasitized by *T. evanescens*. However, in maize fields thousands of eggs were collected and most of them were parasitized by *T. evanescens*. With regard to apple orchards, hundreds of eggs were parasitized by *T. embryophagum*. Only on pine and maize were two different species of *Trichogramma* determined. *Trichogramma cacoeciae* and *T. dendrolimi* were found only in one host, *T. embryophagum*, *T. pintoi*, and *T. brassicae* were found in two different hosts, and *T. evanescens* was found in three different hosts.

Specimens have been deposited in the insect museum unit of the Plant Protection Research Institute in Adana, Turkey.

My thanks to Dr. Bernard Pintureau (INSA/INRA de Lyon Lab. Biologie Applique'-Bat. 406 20, Avenue Albert Einstein 69621-Villeur banne Cedex-France), Dr. Americo Ioria Ciociola (ESALQ/USP Entomologia AV. Padua Dias, 11 Caixa, Postal, 9 Piracicaba-SP, Brazil), and Dr. Viktor Fursov (Institute of Zoology, National Ukranian Academy of Sciences, Bogdan Khmel'nitsky Street 15, 01601, Kiev-30, Ukraine) for identification the *Trichogramma* species; Dr. M.A. Badr (Agriculture Research Center, Plant Protection Research Institute, 7 Nadi El-Seid Street-Dokki-Egypt) for the microlepidoptera; and Prof. Dr. Serpil Kornosor (University of Çukurova, Faculty of Agriculture, Department of Plant Protection, 01330, Balcali/Adana) for the Lepidoptera hosts.

LITERATURE CITED

Cabello-Garcia, T. and P. Vargas-Piqueras. 1985. Olfactometer studies of the influence of the plant and of the insect host in the searching activity of *Trichogramma cordubensis* Vargas & Cabello and *T.* sp. near *buesi* (Hym.:Trichogrammatidae). Boletin del Servicio de Defensa contra Plagas e Inspeccion Fitopatologica 11(2): 237–241.

Hassan, S. A. 1989. Selection of suitable *Trichogramma* strains to control the Codling Moth *Cydia pomonella* and the two summer fruit tortrix moths *Adoxophyes orana, Pandemis heperana* (Lep.: Tortricidae). Entomophaga 34: 19–27.

Karadjov, S. 1996. Data on the known species of *Trichogramma* and other egg parasitoids that occur regularly (native and imported in the field). Trichogramma News 9: 10.

Livshits, I. Z. and V. I. Mitrofanov. 1986. Hymenopterous egg parasitoids of fruit tree pests. Zashchita Rastenii Moskva 9: 46–47.

Rijswijk, M. van, R. van der Heijden, Y. Jongema, R. Stouthamer, M. J. Sommeijer, and F. Meeuwsen. 2000. Occurrence and molecular identification of the Dutch *Trichogramma* species. Proceedings of the 11th Meeting of Experimental and Applied Entomologists in the Netherlands, Wageningen, Netherlands, 17 December 1999. Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological-Society 2000 11: 67–71.

Rosen, D. and P. Debach. 1979. Species of *Aphytis* of the World. Keter Publishing House, Jerusalem Ltd. 801 pp.

Silva, I. M. M. S., J. Honda, F. van Kan, J. G. Hu, L. Neto, B. Pintureau, and R. Stouthamer. 1999. Molecular differentiation of five *Trichogramma* species occurring in Portugal. Biological Control 16(2): 177–184.

Tsankov, G., G. H. Schmidt, and P. Mirchev. 1996. Structure and parasitism of egg batches of a processionary moth population different from *Thaumetopoea pityocampa* (Den. & Schiff.) (Lep., Thaumetopoeidae) found in Bulgaria. Bollettino di Zoologia Agraria e di Bachicoltura 28(2): 195–207.

Uzun, S., H. Bulut, A. Ozpinar, N. Kilincer, C. Oncuer, and S. Kornosor. 1996. *Trichogramma* species associated with some lepidopterous pests in Turkey. Trichogramma News 9: 16.

Sevcan Oztemiz, *Plant Protection Research Institute, 01321 Adana, Turkey (e-mail: s_oztemiz@hotmail.com)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 721–724

NOTE

Comments on the Conservation Status of the Tiger Beetle *Cicindela ancocisconensis* T. W. Harris (Coleoptera: Carabidae: Cicindelinae)

The tiger beetle *Cicindela ancocisconensis* T. W. Harris has long been considered an uncommon species. Although this beetle was discovered about 1850 and formally named in 1852, very few specimens were known to science until the early twentieth century, when E. D. Harris (son of T. W. Harris) undertook a more systematic investigation of riparian and riverine habitats around the type locality in New Hampshire's White Mountains. Over a period of several years, Harris collected a large number of specimens of this beetle at sites in both New Hampshire and New York (Harris 1911, 1916, 1917, 1918). Some of Harris's collecting localities in New Hampshire were resurveyed by Wilson and Larochelle (1979), who likewise found the species to be abundant. These authors described the habitat conditions at the type locality (large sand bars and sandy islands on the Saco River) and summarized museum specimen records which indicated a broad but somewhat patchy distribution from Quebec south to Georgia and west to Illinois.

The first indication that this tiger beetle might be of conservation concern was a short publication by John Stamatov (1970) noting a lack of recent collections at historic sites in New York and New Hampshire. However, this note was published before the more intensive survey efforts described by Wilson and Larochelle (1979), which resulted in the discovery of large populations in the latter state. Further concerns were expressed by Graves and Brzoska (1991) in their review of the Ohio tiger beetle fauna. These authors inferred a general decline in *C. ancocisconensis* from the absence of recent records across much of its historic range, including Ohio. They recommended that any surviving populations of *C. ancocisconensis* in Ohio be considered for designation as an endangered species, and that steps be taken to protect these populations and their habitats.

Such comments helped to set the stage for conservation actions involving this tiger beetle, including its formal protection under Maryland state law (Glaser 1992, Maryland Department of Natural Resources 2003). As with other rare tiger beetles, *C. ancocisconensis* is actively tracked by the state Natural Heritage Programs throughout its range, and is currently listed as having a status of "S1" (critically imperiled within the state) in the states of Maryland, New York, Ohio, Pennsylvania, and Vermont (NatureServe 2006).

Having had recent field experiences with this species in New Hampshire and West Virginia, I suspect that it occurs at more sites within its known range than these state Natural Heritage rankings would indicate. Certain attributes of *C. ancocisconensis* suggest that this species is probably often overlooked. The adult beetles are cryptically colored and may be difficult to locate when at rest on certain sand or cobble substrates. The adults are also quite wary and, in my experience, are faster to fly when disturbed than adults of other tiger beetle species found in the same riparian habitats. Finally, adults in areas that I have surveyed tend to be found in slightly different microhabitats than adults of other sympatric riparian tiger beetles (small vegetated patches of silty sand for *C. ancocisconensis* versus areas of open sand or cobble for *C. repanda* and *C. duodecimguttata*). Given the abundance of apparently suitable sand bar habitat within the known range of *C. ancocisconensis*, and the relatively small number of experienced workers who have actively searched for this beetle, there is a strong possibility that many more populations await discovery.

In September, 2004, and May, 2006, I searched for *C. ancocisconensis* at sites in New Hampshire. I found adults to be common and occasionally even abundant at multiple localities along both the Saco and Ammonoosuc rivers in the White Mountains. On these rivers, *C. ancocisconensis* is associated with large sand and cobble bars in river channels which flow through areas of unconsolidated glacial till (both morainal and outwash deposits). Unlike adults of the associated species *C. duodecimguttata* Dejean and *C. repanda* Dejean, adults of *C. ancocisconensis* are seldom found out on the open sand or cobble. Rather, the beetles spend most of their time foraging and basking within small vegetated patches, which are typically located on areas of silty sand along the bankside edge of the bar, or in sandy pockets within a larger cobble bar. Vegetation in these patches consists of low, sparse grasses, perennial herbs (including species of the genera *Conyza, Erigeron, Solidago* (all family Asteraceae) and *Monarda* (family Lamiaceae)), or low shrubs (principally *Salix* species, family Salicaceae). The adult beetles are quite wary and take flight at the slightest disturbance. Escape flights of this species are long and straight, with flights of 10 meters or more not uncommon. Such flights often take the beetles well out onto the bar, or even across the river to an adjacent bar. The brown and white coloration of this tiger beetle is strongly cryptic on the sand and cobble of its habitat, and adults are not easily located either when at rest or after they have taken flight.

In New Hampshire, I also observed (but did not survey) extensive areas of apparently suitable habitat for this species along the Pemigewasset River. Philip J. Darlington, Jr., collected large series of specimens of *C. ancocisconensis* along this river in the early twentieth century (Wilson and Larochelle 1979), and populations probably still occur there.

During a short trip to West Virginia in September, 2005, I found adults of *C. ancocisconensis* to be common along the North River in Hampshire County, a locality which was first noted by Glaser (1984). This habitat consisted of small areas of silty sand along a shallow, bedrock-dominated river channel. Adults were found basking on the sand and on the exposed bedrock. As in New Hampshire, this species was more wary and difficult to approach than either *C. duodecimguttata* or *C. repanda*, both of which were abundant along this river.

Acciavatti et al. (1992) conducted a much more extensive survey of riparian habitats in West Virginia. These authors concluded that *C. ancocisconensis* is "not uncommon and may be abundant" along the major river systems in that state.

Similar in-depth surveys have yet to be conducted in major portions of the historic range of this species. States where additional effort could be focused include Maine, New York, Pennsylvania, and Vermont. There are very few historic or recent records from Maine, although Wilson and Larochelle (1979) and Wilson and Brower (1983) indicated that *C. ancocisconensis* is likely to be widespread in the state (but see remarks on habitat alteration by Nelson and LaBonte 1989). In New York, historic records span much of the state, from Buffalo and Cazenovia in the west to the Catskills and Adirondacks in the east and north (Wilson and Larochelle 1979). Recent work by P. Novak, W. Gall, J. Huether, and K. Will has resulted in the discovery of previously unknown populations at sites in New York such as the Zoar Valley of Cattaraugus County and Letchworth State Park (Rising 1998, K. Will, personal communication). Given the large size of New York State and the abundance of glacial till over much of its area, additional populations of *C. ancocisconensis* probably await discovery. In Pennsylvania, there are very few historic records of *C. ancocisconensis* (Wilson and LaRochelle 1979). However, I recently examined series of specimens in two major museum collections that were collected in the 1980s at sites on the Clarion River in Jefferson County, Penns Creek in Centre County, and Pine Creek in Tioga County. These records suggest a fairly broad distribution for this species within Pennsylvania. Finally, there are very few records from Vermont, although areas of apparently suitable habitat are found in the more mountainous regions of this state (Leonard and Bell 1999, Bell no date).

More comprehensive surveys in these and other states will undoubtedly provide a clearer picture of the overall conservation status of *C. ancocisconensis*. However, the evidence presented here suggests that this species is probably not rare and likely will be found at more sites than are currently known. This is not to imply that the species may not be of local or even regional conservation concern: it is evidently extirpated from Massachusetts (NatureServe 2006) and few extant populations are known from Ohio (Acciavatti 1992). While conservation actions may be appropriate in some parts of its range, overall this species is probably secure at present.

I thank Terry L. Erwin of the National Museum of Natural History, Smithsonian Institution, and Lee Herman of the American Museum of Natural History, New York, for permission to examine specimens in their care. Corinne M. Carter provided helpful assistance with the field portions of this study, while C. Barry Knisley and Michael A. Valenti provided valuable comments on the manuscript. I thank Kipling W. Will for introducing me to this tiger beetle during our graduate student days at Cornell University.

LITERATURE CITED

Acciavatti, R. E. 1992. More new Ohio county records for Cicindelidae including the rediscovery of *Cicindela ancosisconensis* [sic] Harris. The Ohio Coleopterist 1(3), World Wide Web document at http://www.ohiocoleo.org/members/issues/iss1~3.asp (accessed May 25, 2006).

Acciavatti, R. E., T. J. Allen, and C. Stuart. 1992. The West Virginia tiger beetles (Coleoptera: Cicindelidae). Cicindela 24(3–4): 45–78.

Bell, R. T. No date. Zadock Thompson Invertebrate Collection: Tiger Beetles of Vermont. World Wide Web document at: http://www.uvm.edu/~rtbell/Tigers.html (accessed May 25, 2006).

Glaser, J. D. 1984. The Cicindelidae (Coleoptera) of Maryland. Maryland Entomologist 2(4): 65–76.

Glaser, J. R. 1992. *Cicindela ancocisconensis* Harris (Coleoptera: Cicindelidae) in Maryland. Maryland Entomologist 4: 145–146.

Graves, R. C. and D. W. Brzoska. 1991. The tiger beetles of Ohio (Coleoptera: Cicindelidae). Bulletin of the Ohio Biological Survey (new series) 8: 1–42.

Harris, E. D. 1911. List of the North American Cicindelidae in the Harris Collection. Truan Press, Yonkers, New York. 68 pp.

———. 1916. Proceedings. Meeting of October 3, 1916. Journal of the New York Entomological Society 24(4): 309–311.

———. 1917. Proceedings. Meeting of February 20, 1917. Journal of the New York Entomological Society 25(2): 136–138.

———. 1918. Proceedings. Meeting of November 5, 1917. Journal of the New York Entomological Society 26(3–4): 236–238.

Leonard, J. G. and R. T. Bell. 1999. Northeastern Tiger Beetles: A Field Guide to Tiger Beetles of New England and Eastern Canada. CRC Press, Boca Raton, Florida. xii + 176 pp.

Maryland Department of Natural Resources. 2003. Rare, threatened, and endangered animals of Maryland, December 12, 2003. World Wide Web document at http://dnrweb.dnr.state.md.us/download/rteanimals.pdf (accessed May 25, 2006).

NatureServe, *Cicindela ancocisconensis*, March 31, 2004. World Wide Web document at http://www.natureserve.org (accessed May 25, 2006).

Nelson, R. E. and J. R. LaBonte. 1989. Rediscovery of *Cicindela ancocisconensis* T. W. Harris and first records for *C. scutellaris lecontei* Haldeman in Maine. Cicindela 21(3–4): 49–54.

Rising, G. 1998. Tiger Beetles, column in the September 21, 1998, Buffalo News. World Wide Web document at http://www.acsu.buffalo.edu/~insrisg/nature/nw98/tigerbeetles.html (accessed May 25, 2006).

Stamatov, J. 1970. Collecting one-a-year tigers. Cicindela 2(2): 11–12.

Wilson, D. A. and A. E. Brower. 1983. The Cicindelidae of Maine. Cicindela 15(1–4): 1–33.

Wilson, D. A. and A. Larochelle. 1979. *Cicindela ancocisconensis* T. W. Harris. Cicindela 11(3): 33–48.

Jonathan R. Mawdsley, *Research Associate, Department of Entomology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 187, Washington, DC 20013-7012 U.S.A. (e-mail: mawdsley@heinzctr.org)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 725–726

NOTE

A New County Record for the Tiger Beetle *Cicindela patruela* Dejean (Coleoptera: Carabidae: Cicindelinae) from West Virginia, with Notes on Habitat and Other Upland Tiger Beetle Species

Cicindela patruela Dejean is an uncommon or rare tiger beetle throughout much of its range. As with many rare cicindelid species, *C. patruela* has become the subject of conservation concern in recent years. Extirpations of populations of this tiger beetle have been reported from the District of Columbia, Maryland, and New York (Glaser 1984, McCabe 1995, Mawdsley 2005), and populations are formally protected by state law in Maryland and Massachusetts (Maryland Department of Natural Resources 2003, Massachusetts Division of Fisheries and Wildlife 2004).

West Virginia is one of the few states where *C. patruela* remains fairly common in suitable habitats. Acciavatti et al. (1992) reviewed the tiger beetle fauna of West Virginia and noted that populations of this species could be found "where sandstone strata create natural forest openings, and along woodland roads and at the edges of abandoned sand quarries." In the latter habitat, they noted that this species could even be "locally abundant." These authors reported *C. patruela* from nine West Virginia counties: Barbour, Berkeley, Lincoln, Mineral, Monongalia, Pendleton, Preston, Randolph, and Wyoming.

During my first visit to Morgan County in September, 2005, it quickly became apparent that there was ample habitat to support populations of *C. patruela*. The dominant geological features of the county are two ridges, Cacapon Mountain and Warm Springs Ridge, both of which have actively eroding exposures of white sandstones (the Tuscarora and Oriskany Sandstones, respectively). Mining of these formations for sand has occurred in Morgan County for at least a century (West Virginia Geological and Economic Survey 2004), and there are several abandoned sand pits and one large active sand quarry just north of the village of Berkeley Springs.

Following these initial observations, I conducted more extensive surveys in May, 2006, which resulted in the discovery of a small population of *C. patruela* along a ridgetop trail near Berkeley Springs. Adults were found basking in sunny spots along several hundred meters of trail. The ridge in this area consists of eroded outcrops of white sandstone. The substrate of the trail consists of unconsolidated fine white sand which had eroded from the bedrock. The principal tree species at the site included *Quercus castanea* Née (Fagaceae) and *Pinus virginiana* Miller (Pinaceae), with *Kalmia latifolia* L. and species of *Vaccinium* (both Ericaceae) present in the understory. Mosses, lichens, and sedges (*Carex* spp., Cyperaceae) were common along the margins of the trail. This population of *C. patruela* was evidently quite small, as the maximum number of adults observed per visit was eight.

The only other tiger beetle present at this site during my visits was the closely related *C. sexguttata* F. In Morgan County, *C. sexguttata* is found in a wide variety of xeric and mesic habitats associated with diverse soil types (clay, sand, cobble, shale, and organic forest soils). It is interesting to note the differences in ecological tolerances between these two species which are very closely related, according to the latest molecular analyses (Barraclough and Vogler 2002).

During my surveys in Morgan County, I found another upland tiger beetle species, *C. purpurea purpurea* Olivier, only on shale or clay substrates, at sites where *C. patruela* was absent. *Cicindela sexguttata* was consistently found in the same habitats as *C. purpurea.* It is interesting to contrast these findings with my recent observations in the Pine Barrens of New Jersey, where *C. purpurea* is a common associate of the endemic subspecies *C. patruela consentanea* Dejean. In New Jersey, adults of both species are found at approximately the same times of year on sandy substrates, often at the same sites (Mawdsley 2007). Comparison of these observations suggests that different populations of *C. purpurea* may exhibit associations with different substrate types.

I thank Terry L. Erwin who graciously permitted the examination of specimens in the collection of the National Museum of Natural History. Corinne M. Carter accompanied me on trips to West Virginia. Michael A. Valenti provided valuable comments on the manuscript.

LITERATURE CITED

Acciavatti, R. E., T. J. Allen, and C. Stuart. 1992. The West Virginia tiger beetles (Coleoptera: Cicindelidae). Cicindela 24(3–4): 45–78.

Barraclough, T. G. and A. P. Vogler. 2002. Recent diversification rates in North American tiger beetles estimated from a dated mtDNA phylogenetic tree. Molecular Biology and Evolution 19(10): 1706–1716.

Glaser, J. D. 1984. The Cicindelidae (Coleoptera) of Maryland. Maryland Entomologist 2(4): 65–76.

Maryland Department of Natural Resources, Rare, threatened, and endangered animals of Maryland, December 12, 2003. World Wide Web document at http://dnrweb.dnr.state.md.us/download/rteanimals.pdf (accessed September 13, 2005).

Massachusetts Division of Fisheries and Wildlife, Massachusetts List of Endangered, Threatened, and Special Concern species. June 18, 2004. World Wide Web document at http://www.mass.gov/dfwele/dfw/nhesp/nhrare.htm (accessed September 13, 2005).

Mawdsley, J. R. 2005. Extirpation of a population of *Cicindela patruela* Dejean (Coleoptera: Carabidae: Cicindelinae) in suburban Washington, D.C., USA. Proceedings of the Entomological Society of Washington 107(1): 64–70.

———. 2007. Ecology, distribution, and conservation biology of the tiger beetle *Cicindela patruela consentanea* Dejean (Coleoptera: Carabidae: Cicindelinae). Proceedings of the Entomological Society of Washington 109: 17–28.

McCabe, T. L. 1995. The changing insect fauna of Albany's Pine Barrens. World Wide Web document at http://biology.usgs.gov/s+t/noframe/f124.htm (accessed September 13, 2005).

West Virginia Geological and Economic Survey. 2004. History of West Virginia Mineral Industries – Sandstone. World Wide Web document at http://www.wvgs.wvnet.edu/www/geology/geoldvss.htm (accessed July 18, 2006).

Jonathan R. Mawdsley, *Research Associate, Department of Entomology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 187, Washington, DC 20013-7012 U.S.A. (e-mail: mawdsley@heinzctr.org)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 727–729

NOTE

A New Maryland Record for *Cicindela splendida* Hentz (Coleoptera: Carabidae: Cicindelinae), with Notes on Taxonomic Status and Phylogenetic Relationships

Cicindela splendida Hentz has long been considered one of the rarest tiger beetles in the state of Maryland. In a review of the state's tiger beetle fauna, Glaser (1984) reported that he could only find two valid records of *C. splendida*. These records were based on collections from Calvert and Prince George's counties, of which the most recent was from 1948. With no recent records, Glaser (1984) concluded that *C. splendida* might actually be extirpated from Maryland.

Recent survey work by the author and colleagues at sites along the Patuxent River in Anne Arundel County, Maryland, has identified many previously unknown populations of tiger beetle species. Most recently, surveys by the author at the U.S. Fish and Wildlife Service's Patuxent Research Refuge identified a small population of *C. splendida* on Refuge property. On April 15, 2006, adults of this species were observed foraging and ovipositing in an area of bare, eroded red clay soil within an abandoned sand and gravel pit. The area where the beetles were observed was heavily eroded into a series of small (1–2 m deep) gullies. Other tiger beetle species present at this site on this date included *C. sexguttata* Fabricius and *C. tranquebarica tranquebarica* Herbst. Two voucher specimens of *C. splendida* were collected for deposition in the collection of the National Museum of Natural History, Smithsonian Institution (NMNH).

Cicindela splendida is closely associated with exposed, eroded red clay substrates throughout its range (Knisley and Schultz 1997, Pearson et al. 2006). Such exposures are still common at this writing in central Maryland, in settings such as roadsides, railroad cuts, power line rights-of-way, drainage ditches, gullies, abandoned sand or gravel quarries, and abandoned clay pits. Comparison with the geological map of Maryland (Maryland Geological Survey 1968) indicates that the red clays in central Maryland, including those at Patuxent Research Refuge, are part of the Cretaceous Potomac Group. Specific formations within the Potomac Group which may include red clays are the Raritan and Patapsco Formations, as well as the Arundel Clay. These Potomac Group sediments underlie much of central Maryland, particularly in the corridor between Washington, D.C. and Baltimore. Given the abundance of suitable habitat, it is likely that additional populations of *C. splendida* exist in Maryland.

The apparent scarcity of *C. splendida* in Maryland is particularly surprising given the large number of specimens of this species collected during the first decades of the twentieth century at sites in the District of Columbia and northern Virginia, as demonstrated by the following records from NMNH. For completeness, I also include the few Maryland records from the NMNH collection.

District of Columbia: Rock Creek, 14.V.1899 (2 ♂, 1 ♀), 2.VI.1901 (1 ♂, 1 ♀), 14.IX.1902 (1 ♂).

Maryland: Prince George's County, Bladensburg, 21.IV.1920 (1 ♂); Fort Washington, on clay bank, steep ravine, 8.IV.1943 (1 ♂, 1 ♀), 6.IX.1943 (1 ♂, 1 ♀), 15.IX.1943 (1 ♀). Glaser (1984) also reports a collection from: Calvert County, Solomons, 20.IV.1948.

Virginia: Alexandria, 28.IV.1889 (1 ♀); 2.VI.1902 (1 ♀). Arlington County: Four Mile Run, 28.IX.1913 (1 ♂); Glencarlyn, 8.IV.1929 (1 ♂), 18.IV.1931 (1 ♂). Fairfax County: Barcroft, IX. 1914 (1 ♂); Falls Church, 20.V.1917 (2 ♂), 5.V.1917 (1 ♂); Mount Vernon, 21.IX.1910 (1 ♀), 20.V.1917 (1 ♂), 21.IX.1919 (4 ♂, 5 ♀), 23.IX.1920 (2 ♀), 6.IV.1929 (5 ♂), 5.IV.1930 (1 ♂, 2 ♀), 24.IX.1930 (1 ♀), 30.IV.1931 (1 ♀), 15.IV.1933 (2 ♂), 11.IX.1936 (3 ♂, 2 ♀), 24.IX.1939 (1 ♂, 1 ♀); locality not specified, 21.IX.1919 (1 ♀), 19.IX.1920 (1 ♀).

Maryland, Virginia, and District of Columbia populations of *C. splendida* are readily separated from other sympatric tiger beetle species by the combination of 1) uniformly green or blue-green head and pronotum with 2) reddish or purplish elytra with green lateral margins and variable (but often highly reduced) white markings (Knisley and Schultz 1997). However, from a broader taxonomic perspective, the separation of *C. splendida* from a closely-related group of similar North American species has long been problematic. In the most comprehensive treatment to date, Schincariol and Freitag (1991) studied the adult morphology of taxa in their "*C. splendida* group" and concluded that three valid species were represented: *C. splendida, C. limbalis* Klug, and *C. denverensis* Casey. This conclusion has generated considerable discussion, because the three forms share similarities in coloration, are partially sympatric, and are known to mate with each other (Johnson 1979, Kippenhan 1994, Knisley and Schultz 1997, Pearson et al. 2006).

A recent molecular phylogenetic analysis of North American species of the genus *Cicindela* L. (Barraclough and Vogler 2002) provides an interesting resolution to these longstanding taxonomic questions. As expected, *C. splendida, C. limbalis*, and *C. denverensis* are close relatives, part of a monophyletic group of similar species. However, these three species do not themselves form a monophyletic group. Rather, *C. limbalis* is the sister-species of *C. decemnotata* Say, while *C. splendida* is the sister-species of *C. purpurea* Olivier. These two lineages in turn form an unresolved trichotomy with *C. denverensis*. In the context of this analysis, Schincariol and Freitag's "*C. splendida* group" is clearly non-monophyletic.

More interestingly, this analysis suggests that *C. splendida, C. limbalis*, and *C. denverensis* have all existed as separate species for at least one million years. Barraclough and Vogler (2002) estimated divergence times for each lineage in their analysis, using nonparametric rate smoothing of branch lengths which had been estimated using maximum likelihood methods applied to DNA sequence data. The divergence of *C. denverensis* from the other two lineages is estimated to have occurred approximately 2 million years ago, the divergence of *C. limbalis* and *C. decemnotata* approximately 1.8 million years ago, and the divergence of *C. splendida* and *C. purpurea* approximately 1.0 million years ago. These estimates serve to bolster the conclusions of Schincariol and Freitag (1991) that *C. splendida, C. limbalis*, and *C. denverensis* are each separate and valid species.

I thank Holliday Obrecht and Brad Knudson of the U.S. Fish and Wildlife Service for permission to survey tiger beetles at the Patuxent Research Refuge. For assistance with projects along the Patuxent River, I thank Sam Droege of the U.S. Geological Survey and Warren Steiner of the Smithsonian Institution. C. Barry Knisley and Michael A. Valenti provided valuable comments on the manuscript. Terry Erwin graciously permitted the examination of specimens in the collection of the National Museum of Natural History.

LITERATURE CITED

Barraclough, T. G. and A. P. Vogler. 2002. Recent diversification rates in North American tiger beetles estimated from a dated mtDNA phylogenetic tree. Molecular Biology and Evolution 19(10): 1706–1716.

Glaser, J. D. 1984. The Cicindelidae (Coleoptera) of Maryland. Maryland Entomologist 2(4): 65–76.

Johnson, W. N. 1979. Sympatric population of *Cicindela limbalis transversa* and *Cicindela splendida cyanocephalata*. Cicindela 11(2): 26.

Kippenhan, M. G. 1994. The tiger beetles (Coleoptera: Cicindelidae) of Colorado. Transactions of the American Entomological Society 120(1): 1–86.

Knisley, C. B. and T. D. Schultz. 1997. The Biology of Tiger Beetles and a Guide to the Species of the South Atlantic States. Virginia Museum of Natural History, Martinsville, Virginia. 210 pp.

Maryland Geological Survey, Geologic Map of Maryland. Baltimore, Maryland.

Pearson, D. L., C. B. Knisley, and C. J. Kazilek. 2006. A Field Guide to the Tiger Beetles of the United States and Canada: Identification, Natural History, and Distribution of the Cicindelidae. Oxford University Press, New York. vi + 227 pp. + 24 pls.

Schincariol, L. A. and R. Freitag. 1991. Biological character analysis, classification, and history of the North American *Cicindela splendida* Hentz group taxa (Coleoptera: Cicindelidae). The Canadian Entomologist 123: 1327–1353.

Jonathan R. Mawdsley, *Research Associate, Department of Entomology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 187, Washington, DC 20013-7012 U.S.A. (e-mail: mawdsley@heinzctr.org)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 730–732

NOTE

Reinstatement of *Serratella serratoides* (McDunnough) and Status of *Ephemerella molita* (McDunnough) (Ephemeroptera: Ephemerellidae)

Recent global study of Ephemerellinae (Ephemeroptera: Ephemerellidae) (sensu McCafferty and Wang 2000) has revealed that the status and synonymies of two nominal species should be adjusted. *Ephemerella molita* McDunnough is designated here to be a *nomen dubium*, and *Serratella serratoides* (McDunnough) is removed from synonymy with *E. molita*. Jacobus and McCafferty (2002) considered the two species to be equivalent, based on their observation that the female adult holotype of *E. molita* has sternal markings similar to those of *S. serratoides* and that the coloration of its caudal filaments fall within the range of color variation of *S. serratoides*. We now recognize that the holotype of *E. molita* is also indistinguishable from variants of several other Ephemerellinae species that were not examined as part of the Jacobus and McCafferty (2002) study. These species each have rows of dark maculae on their abdominal sterna and include, for example, the Nearctic species *E. needhami* McDunnough (e.g., McDunnough 1931, Traver 1935, Burks 1953, Allen and Edmunds 1965) and the widespread Palearctic, and possibly Holarctic, species *E. notata* Eaton (e.g., Eaton 1887, Schoenemund 1930: fig. 101, Ulmer 1932: fig. 44, Landa 1969, Elliot and Humpesch 1983: fig. 33, Studemann et al. 1992: fig. 341, Ishiwata 2001). Although the presence of sternal maculations on these *Ephemerella* Walsh species has been documented extensively, no comparisons to them were made by Jacobus and McCafferty (2002), because at that time *E. molita* was thought to be part of the *Ephemerella serrata* Morgan species group (McDunnough 1931, Traver 1935, Allen and Edmunds 1963), which is recognized widely now as the genus *Serratella* Edmunds (Edmunds 1959, Tshernova 1972, Allen 1980). The confusion surrounding *E. molita* is due in part to the historical lack of global comparisons of Ephemerellinae species and to difficulties surrounding proper identification of female adult Ephemerellinae. Many female adults are indistinguishable from one another using traditional external morphological characteristics. Examination of eggs could contribute to the resolution of the identity of *E. molita* (Jacobus and McCafferty, unpublished), but such action would require destruction of the holotype, the only *bona fide* specimen associated with the name *E. molita* (McDunnough 1930). McDunnough (1931) mistakenly reported a paratype from New Brunswick (Jacobus and McCafferty 2002), and Traver's (1932) discussion appears to be an inadvertent error because no male adult has been associated with the species. *Ephemerella molita* should not be confused with *E. mollitia* Seemann, a species name that is synonymous with *Ephemerella dorothea infrequens* McDunnough (Jacobus and McCafferty 2003).

Unfortunately, *E. molita* has been reported several times since Jacobus and McCafferty (2002) modified its concept. In most of these instances (e.g., Kluge 2004, DeWalt and Heinold 2005, Chandler et al. 2006, DeWalt et al. 2007, Parker et al. in press), specimens are representatives of *S. serratoides*. McCafferty et al. (2006) discussed a report of *E. molita* from Iowa that was based instead on a misidentification of *E. needhami* (McCafferty et al. 2003). An Arkansas record of *S. sordida* (McDunnough) (Peters and Warren 1966) that Jacobus and McCafferty (2003) treated as a misidentification of *E. molita* is referrable to *S. serratoides*.

LITERATURE CITED

Allen, R. K. 1980. Geographic distribution and reclassification of the subfamily Ephemerellinae (Ephemeroptera: Ephemerellidae), pp. 71–91. *In* Flannagan, J. F. and K. E. Marshall, eds. Advances in Ephemeroptera Biology. Plenum, New York. 552 pp.

Allen, R. K. and G. F. Edmunds, Jr. 1963. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VI. The subgenus *Serratella* in North America. Annals of the Entomological Society of America 56: 583–600.

———. 1965. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae) VIII. The subgenus *Ephemerell*a in North America. Miscelaneous Publications of the Entomological Society of America 4: 244–282.

Burks, B. D. 1953. The mayflies, or Ephemeroptera, of Illinois. Bulletin of the Illinois Natural History Survey 26(Art. 1): 1–216.

Chandler, D. S., G. D. Whitmore, S. K. Burian, and J. F. Burger. 2006. The mayflies (Ephemeroptera) of New Hampshire: Seasonality and diversity of the stream fauna. Transactions of the American Entomological Society 132: 25–73.

DeWalt, R. E. and B. D. Heinold. 2005. Summer emerging Ephemeroptera, Plecoptera, and Trichoptera of Abrams Creek, Great Smoky Mountains National Park. Proceedings of the Entomological Society of Washington 107: 34–48.

DeWalt, R. E., L. M. Jacobus, and W. P. McCafferty. 2007. Summer Ephemeroptera, Plecoptera and Trichoptera of Southwestern Drainages in Great Smoky Mountains National Park. Proceedings of the Entomological Society of Washington 109: 136–154.

Eaton, A. E. 1883–1888. A revisional monograph of recent Ephemeridae or mayflies. Transactions of the Linnean Society, London, Zoological Series 3: 1–352.

Edmunds, G. F., Jr. 1959. Subgeneric groups within the mayfly genus *Ephemerella* (Ephemeroptera: Ephemerellidae). Annals of the Entomological Society of America 52: 543–547.

Elliott, J. M. and U. H. Humpesch. 1983. A key to the adults of the British Ephemeroptera with notes on their ecology. Scientific Publications of the Freshwater Biological Association No. 47. Freshwater Biological Association, 101 pp.

Ishiwata, S.-I. 2001. A checklist of Japanese Ephemeroptera, pp. 55–84. *In* The 21st Century and Aquatic Entomology in East Asia: Proceedings of the 1st Symposium of Aquatic Entomologists in East Asia. The Korean Society of Aquatic Entomology, Korea. 146 pp.

Jacobus, L. M. and W. P. McCafferty. 2002. Analysis of some historically unfamiliar Canadian mayflies (Ephemeroptera). The Canadian Entomologist 134: 141–155.

———. 2003. Revisionary contributions to North American *Ephemerella* and *Serratella* (Ephemeroptera: Ephemerellidae). Journal of the New York Entomological Society 111: 174–193.

Kluge, N. 2004. The Phylogenetic System of Ephemeroptera. Kluwer Academic Publishers, Dordrecht. 442 pp.

Landa, V. 1969. Jepice-Ephemeroptera. Fauna CSSR 18: 1–352.

McCafferty, W. P. and T.-Q. Wang. 2000. Phylogenetic systematics of the major lineages of Pannote mayflies (Ephemeroptera: Pannota). Transactions of the American Entomological Society 126: 9–101.

McCafferty, W. P., T. Hubbard, and J. M. Webb. 2006. Insecta, Ephemeroptera: range extensions and new Iowa state records. Check List 2(1): 40–41.

McCafferty, W. P., T. Hubbard, T. H. Klubertanz, R. P. Randolph, and M. Birmingham. 2003. Mayflies (Ephemeroptera) of the Great Plains. II: Iowa. Transactions of the American Entomological Society 129: 77–105.

McDunnough, J. 1930. The Ephemeroptera of the north shore of the Gulf of St. Lawrence. The Canadian Entomologist 62: 54–62.

———. 1931. The eastern North American species of the genus *Ephemerella* and their nymphs (Ephemeroptera). The Canadian Entomologist 63: 187–197, 201–216.

Parker, C. R., O. S. Flint, Jr., L. M. Jacobus, B. C. Kondratieff, W. P. McCafferty, and J. C. Morse. In Press. The Ephemeroptera, Plecoptera, Megaloptera and Trichoptera fauna of Great Smoky Mountains National Park. Southeastern Naturalist.

Peters, W. L. and L. O. Warren. 1966. Seasonal distribution of adult Ephemeroptera in northwestern Arkansas. Journal of the Kansas Entomological Society 39: 396–401.

Schoenemund, E. 1930. Eintagsfliegen oder Ephemeroptera. Die Tierwelt Deutschlands 19: 1–106.

Studemann, D., P. Landolt, M. Sartori, D. Hefti, and I. Tomka. 1992. Ephemeroptera -Insecta. Helvetica Fauna 9, 175 pp.

Traver, J. R. 1932. Mayflies of North Carolina. Journal of the Elisha Mitchell Scientific Society 47: 85–236.

———. 1935. Part II: Systematic. North American mayflies order Ephemeroptera, pp. 237–739. *In* Needham, J. G., J. R. Traver, and Y.-C. Hsu, eds. The Biology of Mayflies. Comstock, Ithaca, New York. 759 pp.

Tshernova, O. A. 1972. Some new species of mayflies from Asia (Ephemeroptera, Heptageniidae, Ephemerellidae). Entomologicheskoye Obozrenie 51: 604–614 [English translation 1972 Entomological Review 51: 364–369].

Ulmer, G. 1932. Ordung: Eintagsfleigen, Ephemeroptera (Agnatha). Tierwelt Mitteleuropas 4: 1–43.

Luke M. Jacobus and W. P. McCafferty, *Department of Entomology, Purdue University, West Lafayette, IN, 47907, U.S.A. (e-mail:(LMJ)konchu@tls.net; (WPM)mccaffer@purdue.edu), LMJ current address: Department of Biology, Indiana University, Bloomington, IN, 47405, U.S.A.*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 733–734

NOTE

Frankliniella intonsa (Trybom) (Thysanoptera: Thripidae), An Invasive Insect in North America

Frankliniella intonsa (Trybom) (Thysanoptera: Thripidae) is a polyphagous, florivorous thrips species currently established in North America west of the Cascade Mountains in Washington State and near Portland, Oregon in the United States (U.S.); and in southern British Columbia, Canada. Its natural distribution is the Palaearctic and part of the Oriental regions (Nakahara 1997). The species has been intercepted numerous times from various countries in Europe and the Orient at U.S. ports during agricultural quarantine inspections of cut flowers carried by airline passengers, in quarters of passenger aircrafts and in commercial importations by Plant Quarantine Division, Agricultural Research Service, U.S. Department of Agriculture (ARS, USDA), Plant Protection and Quarantine-Animal and Plant Health Inspection Service (PPQ-APHIS, USDA), and by Customs Border Protection, Department of Homeland Security. The origin of the founder population in the Pacific Northwest has not been resolved, and we do not know whether the populations in Canada and the U.S. were from two or more unrelated introductions from either Europe or the Orient.

The earliest detection in Canada at Vernon, British Columbia, was reported on *Prunella vulgaris* L. (Chiasson 1986). However, Chiasson did not cite the source of the record. The original publication and the collection on which this report was based have not been found and the date of detection can not be established. During 1994–1996, infestations were found in several nurseries in the Vancouver area, Barnhartvale, Chilliwack, Salmon Arm, and Nelson in southern British Columbia. Further surveys by the Canadian Food Inspection Agency in 2003 and 2004 found this thrips well established in the Vancouver area.

The earliest record for the U.S. is April 27, 1972 at Nugents Corner, Whatcom Co., Washington, on bush beans. In September of 1989, it was recollected in this state south of Seattle on baby's breath (*Gypsophila paniculata* L.) plants in a nursery with other native and invasive thrips that are common in the Pacific Northwest. Apparently there has not been any report of damage by this thrips to agricultural crops in the Pacific Northwest.

During 2002 and 2003, specimens were intercepted in several shipments of cut flowers from British Columbia at U.S. ports. Quarantine actions where taken based on the limited distribution in the U.S. and because this species is a pest of several agricultural crops in Asia and Europe (Lewis 1997). It is also a vector of plant disease-causing tospoviruses (Wijkamp et al. 1995), which can be transmitted only by a few thrips species. In the latter part of 2003, surveys by PPQ-APHIS found infestations in four counties in Washington State (Whatcom, Skagit, Snohomish, and King) and near Portland, Oregon, on flowers, weeds, and other plants. Discovery of wider distribution of this species in the Pacific Northwest led to rescinding the quarantine requirements for this thrips. This case illustrates the importance of a survey system to detect and track invasive pests in North America.

We thank Paul Courneya, PPQ-APHIS, USDA, for information on quarantine activities and surveys, and for reviewing the manuscript; Eric Maw, National Science Program-Environmental Health, Agriculture and Agri-Food Canada, Ottawa. for collection data from the surveys conducted by the Canadian Food Inspection Agency, and for reviewing the manuscript; and Gary Miller and Norman Woodley, Systematic Entomology Laboratory, ARS, USDA, for reviewing the manuscript.

LITERATURE CITED

Chiasson, H. 1986. A synopsis of the Thysanoptera (Thrips) of Canada. Lyman Entomological Museum and Research Laboratory Memoir 17: 1–115.

Lewis, T. 1997. Thrips as crop pests. CAB International, Wallingford, UK. 740 pp.

Nakahara, S. 1997. Annotated list of the *Frankliniella* species of the world. Contributions on Entomology, International 2(4): 355–389.

Wijkamp, I., N. Almarza, and D. Peters. 1995. Median latent period and transmission of tospoviruses vectored by thrips, pp. 53–57. *In* Parker, B. L., M. Skinner, and T. Lewis, eds. Thrips Biology and Management, NATO ASI, Series A, 276. Plenum Press, New York.

Sueo Nakahara and Robert G. Foottit, *(SN) Systematic Entomology Laboratory, Plant Sciences Institute, Agricultural Research Service, U.S. Department of Agriculture, Room 137, Building 005, BARC-West, 10300 Baltimore Avenue, Beltsville, MD 20705-2350, U.S.A. (e-mail: steve.nakahara@ars.usda.gov); (RGF) National Science Program-Environmental Health, Agriculture and Agri-Food Canada, K. W. Neatby Building, Room 3048, 960 Carling Avenue, Ottawa, Ontario, Canada K1A 0C6 (e-mail: foottitrg@agr.gc.ca)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 735–736

NOTE

Two New Species Synonyms in North American *Baetis* Leach (Ephemeroptera: Baetidae)

Baetis parallelus Banks was described by Banks (1924) from male adults taken in Nevada. It has remained an unfamiliar and tenuous North American species, only being reported subsequently from Alberta and British Columbia by Walley (1927) in a list of Canadian mayflies. That list contained numerous junior synonyms of a variety of *Baetis* species and many other genera, as we now understand the species composition in North America. Traver (1935) correctly noted that the male genitalia of *B. parallelus* were of the *Moffati* [*sic*] (*rhodani*) type, shared by several Holarctic species of *Baetis*, including the ubiquitous *B. tricaudatus* Dodds. In addition, putative diagnostic color pattern characteristics and hindwing venation characteristics associated with the species have been shown by workers to be variable within species. Its color pattern fits closely that of *B. intermedius* Dodds, a synonym of *B. tricaudatus* with morphologically similar larvae (Morihara and McCafferty 1979); and as can be seen by the rearing studies of Durfee and Kondratieff (1993, 1999), its hindwing venation is similar to that associated with *Baetis moffatti* Dodds, another synonym of *B. tricaudatus* that falls within the demonstrated range of hindwing variability in *B. tricaudatus*. Although I have been unable to see the type material of *B. parallelus*, there can be little doubt that *B. parallelus* is a junior subjective synonym of *B. tricaudatus*, **n. syn.**, in all respects falling within the range of adult variation known for the latter. Furthermore, I have recently seen, in the Purdue Entomological Research Collection (PERC), larvae of *B. tricaudatus* taken from the Truckee River, at Reno, where the types of *B. parallelus* had been collected.

Baetis caurinus Edmunds and Allen was described by Edmunds and Allen (1957) from male adults taken near Alsea, Oregon. It also has been a tenuous and unfamiliar species, and has not been reported since its description. I have studied the holotype and numerous paratypes, deposited in PERC, and can find no consistent difference from variants of the ubiquitous North American species *B. flavistriga* McDunnough. Edmunds and Allen (1957) stated that *B. caurinus* differed from other species with the *intercalaris* (*fuscatus*) type genitalia as defined by Traver (1935) (including *B. flavistriga* and several other species recognized at that time) by the hyaline abdominal segments 1–6. Edmunds and Allen (1957) did not believe that other species with similar male genitalia occurred in western North America. I have recently seen significant collections of larval and adult *B. flavistriga* from Washington, Oregon, Idaho, California, and Nevada (all records to be formally published elsewhere). The abdominal segments of male adult *B. flavistriga* grade from distinctly tinted to hyaline in both western and eastern populations. I therefore place *B. caurinus* as a subjective junior synonym of *B. flavistrga*, **n. syn.** Although no larvae had been associated with *B. caurinus*, *Baetis levitans* McDunnough and *B. quebecensis* Hubbard are other synonyms of *B. flavistriga* (see Morihara and McCafferty 1979) that were based on light-abdomen variants, and in these cases, associated larvae of all have been shown to be morphologically similar.

Literature Cited

Banks, N. 1924. Descriptions of new neuropteroid insects. Bulletin of the Museum of Comparative Zoology 12: 421–455.

Durfee, R. and B. C. Kondratieff. 1993. Description of adults of *Baetis magnus* (Ephemeroptera: Baetidae). Entomological News 104: 227–232.

———. 1999. Notes on North American *Baetis* (Ephemeroptera: Baetidae): *Baetis moffatti* new synonym of *B. tricaudatus* and range extension for *B. bundyae*. Entomological News 110: 177–180.

Edmunds, G. F. and R. K. Allen. 1957. A new species of *Baetis* from Oregon. Journal of the Kansas Entomological Society 30: 57–58.

Morihara, D. K. and W. P. McCafferty. 1979. *Baetis* larvae of North America (Ephemeroptera: Baetidae). Transactions of the American Entomological Society 105: 139–221.

Traver, J. R. 1935. Part III, Systematic, pp. 239–739. *In* Needham, J. G., J. R. Traver, and Y.-C. Hsu, eds. The Biology of Mayflies. Comstock Publishing Co., Ithaca, New York.

Walley, G. S. 1927. Ephemeroptera, pp. 59–61. *In* Criddle, N. ed. The entomological record, 1926. Annual Report of the Entomological Society of Ontario 57: 47–62.

W. P. McCafferty, *Department of Entomology, Purdue University, West Lafayette, IN 47907, U.S.A. (e-mail: mccaffer@purdue.edu)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 737–738

NOTES

An Extreme Range Extension and Disjunction for the Ephemeroptera Family Potamanthidae in North America

As part of our inventory of mayflies of far western North American, we have studied materials held in several important collections. In a small California collection borrowed from the Illinois Natural History Survey, we identified larvae of *Anthopotamus verticis* (Say) (Potamanthidae) [2 larvae, El Dorado County, Upper Truckee River, Route 299, 2-X-1976, Furnish]. This is an important and unexpected discovery, because the family previously has been known in North America only from one genus and four species restricted to far eastern and east-Central North America (Bae and McCafferty 1991). *Anthopotamus verticis* along with *A. myops* (Walsh) are the most widespread of the species, with *A. verticis* having been known from 20 U.S. states and Canadian provinces, only as far west as Minnesota, Iowa, Missouri, and far eastern Oklahoma.

Life history, riverine habitat preferences, filter feeding, and interstitial burrowing behavior for *A. verticis* have been investigated by McCafferty and Bae (1992, 1994); Bae and McCafferty (1994), and Yanoviak and McCafferty (1995). The Upper Truckee River in east-central California would predictably provide an adequate environment for the larval development of this species.

Bae and McCafferty (1991) hypothesized that the origin of the North American genus *Anthopotamus* McCafferty and Bae within the Laurasian family Potamanthidae coincided with vicariance of North America and Eurasia in the Northern Hemisphere (probably the Eocene event). Whereas the resultant Eastern Hemisphere clade involving the genus *Potamanthus* Pictet is widespread across Eurasia, it was hypothesized that *Anthopotamus* also may have been widespread in North America at one time (Bae and McCafferty 1991). The discovery of *A. verticis* in California now supports that hyposthesis, with the highly disjunct occurrence in California possibly an isolated relict of a historically more widespread continental pattern. Although widespread transcontinental distribution patterns in today's mayfly fauna are becoming known for a growing number of species as central areas are investigated, extreme east-west disjunct patterns are evidently rare in mayflies at the species level. *Cinygmula subeaqualis* (Banks) (Heptageniidae), *Attenella attenuata* (McDunnough) (Ephemerellidae), and *A. verticis* are representative of the latter.

LITERATURE CITED

Bae, Y. J. and W. P. McCafferty. 1991. Phylogenetic systematics of the Potamanthidae (Ephemeroptera). Transactions of the American Entomological Society 117: 1–143.

———. 1994. Microhabitat of *Anthopotamus verticis* (Ephemeroptera: Potamanthidae). Hydrobiologia 288: 65–78.

McCafferty, W. P. and Y. J. Bae. 1992. Filter–feeding habits of the larvae of *Anthopotamus* (Ephemeroptera: Potamanthidae). Annales de Limnologie 28: 27–34.

———. 1994. Life history aspects of *Anthopotamus verticis* (Ephemeroptera: Potamanthidae). The Great Lakes Entomologist 27: 57–67.

Yanoviak, S. P. and W. P. McCafferty. 1995. Stream size and the distribution of selected Ephemeroptera, pp. 225–236. *In* Corkum, L. and J. Ciborowski, eds. Current directions in research on Ephemeroptera. Canadian Scholars' Press, Toronto.

W. P. McCafferty and M. D. Meyer, (WPM) *Department of Entomology,* *Purdue University, West Lafayette, IN 47907, U.S.A. (e-mail: mccaffer@purdue.edu);* (MDM) *Department of Biology, Chemistry, and Environmental Science, Christopher Newport University, 1 University Place, Newport, VA 23606 U.S.A. (e-mail: michael.meyer@cnu.edu)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 738

Kivuiops: A New Name for a Generic Homonym of Afrotropical Baetidae (Ephemeroptera)

Lugo-Ortiz and McCafferty (1996) proposed the generic name *Kivua* for two distinct Afrotropical species previously assigned to *Cloeon* Leach and *Rhithrocloeon* Gillies (Ephemeroptera: Baetidae). Forsius (1934), however, previously used the same generic name for certain sawfly species (Hymenoptera: Tenthredinidae) from Africa. Because our generic name was therefore preoccupied, we propose the replacement name *Kivuiops* (**new name**) [= *Kivua* Lugo-Ortiz and McCafferty 1996 (**new homonym**), nec *Kivua* Forsius 1934]. The two species included in *Kivuiops* are *K. elouardi* (Gillies) (**new combination**) and *K. insuetum* (Kopelke) (**new combination**)..—

We sincerely thank Andreas Taeger (Deutsches Entomologisches Institut, Müncheberg, Germany) for kindly informing us about the sawfly genus *Kivua*.

Literature Cited

Forsius, R. 1934. On some Tenthredinoidea from the Belgian Congo Museum at Tervueren. Revue de Zoologie et de Botanique Africaines 25: 389–406.

Lugo-Ortiz, C. R. and McCafferty, W. P. 1996. The *Bugilliesia* complex of African Baetidae (Ephemeroptera). Transactions of the American Entomological Society 122: 175–198.

C. R. Lugo-Ortiz and W. P. McCafferty, *(CRL) Department of Biology, Chemistry, and Environmental Sciences, Interamerican University, San Germán, PR 00683, U.S.A. (e-mail: crlo122@hotmail.com); (WPM) Department of Entomology, Purdue University, West Lafayette, IN 47907, U.S.A. (e-mail: mccaffer@purdue.edu)*

PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 739–740

NOTE

Synonymy of Some Eastern North American Species of *Apatania* (Trichoptera: Apataniidae)

Apatania incerta was described by Banks (1897) as *Enoicyla incerta*, based on examples from Sherbrooke, Canada, Franconia, N.H., and Sea Cliff, N.Y. Ross (1938) designated and illustrated a male lectotype from the Sea Cliff locality. Schmid (1953, 1954) produced a world wide revision of the family (then a subfamily), illustrating both sexes, recording it from Canada to Virginia and west to Wisconsin, and transferring the species to *Apatania* Kolenati. More recently Morse (1971) described two species, *A. rossi* and *A. praevolans* from North Carolina, and South Carolina and Tennessee, respectively. Sykora and Weaver (1978) described *A. blacki* from western Pennsylvania. The illustrations of the male genitalia of all these species show virtually no differences. Chen (1992) produced a key purported to distinguish between the larvae of *A. incerta*, *A. blacki*, and *A. praevolans*. I have used this key with the few larvae available and find those determined as *A. blacki* and *A. praevolans* are identical, but there does seem to be a difference between this pair and the larvae of *A. incerta* in the shape and setation of the ninth tergite. However, very little material is available and virtually none has been reared rendering this factor inconclusive at a specific level.

Working with adults on the Trichoptera of Virginia, I was puzzled by identifications of what seemed to be *A. incerta* as *A. rossi*, *A. praevolans* and *A. rossi X praevolans*. In an attempt to clarify their status I visited the Museum of Comparative Zoology and studied the lectotype of *A. incerta*, comparing it to examples from southern Connecticut (the nearest locality I had to Sea Cliff, Long Island, NY), and various examples from Virginia, including some identified as *A. rossi* and *A. praevolans*. Purportedly these species differ in the lengths and shapes of a series of processes from the tenth tergum of the male genitalia. However, I found a great deal of variation in the length, width, curvature and apical shape of these processes from specimen to specimen and even from one side to the other. The lectotype of *A. incerta* was more nearly identical to some examples from Virginia identified as *A. rossi* than the one from Connecticut. Schmid (1953, 1954) even illustrated a variation in the tenth tergum of this species and variants of this structure in another widespread species, *A. zonella* (Zetterstedt). Considering the overall similarity and seeming plasticity in detail of the tenth tergum and identity in other parts of the male genitalia, I am formally proposing the **new synonymy** of *Apatania blacki* Sykora and Weaver, 1978, *A. praevolans* Morse, 1971, and *A. rossi* Morse, 1971, with *A. incerta* (Banks, 1897).

LITERATURE CITED

Banks, N. 1897. New North American neuropteroid insects. Transactions of the American Entomological Society 24: 21–31.

Chen, Y. E. 1992. The larva and pupa of *Apatania praevolans* Morse (Trichoptera: Limnephilidae), with a key to described larvae of North American species of *Apatania*. Aquatic Insecta 14: 49–55.

Morse, J. C. 1971. New caddisflies (Trichoptera) from the southeastern United States. Journal of the Georgia Entomological Society 6: 77–84.

Ross, H. H. 1938. Lectotypes of North American caddis flies in the Museum of Comparative Zoology. Psyche 45: 1–61.

Schmid, F. 1953. Contribution a l'étude de la sous-famille des Apataniinae (Trichoptera, Limnophilidae). I. Tijdschrift voor Entomologie 96: 109–167.

———. 1954. Contribution a l'étude de la sous-famille des Apataniinae (Trichoptera, Limnophilidae). II. Tijdschrift voor Entomologie 97: 1–74.

Sykora, J. L. and J. S. Weaver III. 1978. Three new species of Trichoptera from Western Pennsylvania. Annals of Carnegie Museum 47: 1–12.

Oliver S. Flint, Jr., *Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20013-7012, U.S.A. (e-mail: flinto@si.edu)*

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

MISCELLANEOUS PUBLICATIONS

A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera): Second Edition, Revised, by E. Eric Grissell and Michael E. Schauff. 87 pp. 1997	15.00
Revision of the Oriental Species of *Aphthona* Chevrolat (Coleoptera: Chrysomelidae), by Alexander S. Konstantinov and Steven W. Lingafelter. 349 pp. 2002	40.00
Revision of the Genus *Anoplophora* (Coleoptera: Cerambycidae), by Steven W. Lingafelter and E. Richard Hoebeke. 236 pp. 2002	30.00
A Phylogenetic Revision of the Napaeina (Lepidoptera: Riodinidae: Mesosemiini), by Jason P. W. Hall. 233 pp. 2005 Softcover 18.00, Hardcover	25.00

MEMOIRS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Memoirs 1, 2, 3, and 9 are no longer available.

No.4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No.5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No.6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No.7.	Ant larvae: Review and Synthesis, by George C. and Jeanette Wheeler. 108 pp. 1976	11.00
No.8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No.10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky, edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No.11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kammiya, 370 pp. 1983	18.00
No.12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No.13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton, 98 pp. 1987	18.00
No.14.	Biology and Phylogeny of Curculionoidea, edited by R. S. Anderson and C. H. C. Lyal. 174 pp. 1995	25.00
No.15.	A Revision of the Genus *Ceratopogon* Meigen (Diptera: Ceratopogonidae), by A. Borkent and W. L. Grogan, Jr. 198 pp. 1995	25.00
No.16.	The Genera of Beridinae (Diptera: Stratiomyidae), by Norman E. Woodley. 231 pp. 1995	25.00
No.17.	Contributions on Hymenoptera and Associated Insects, Dedicated to Karl V. Krombein, edited by B. B. Norden and A. S. Menke. 216 pp. 1996	25.00
No. 18.	Contributions on Diptera, Dedicated to Willis W. Wirth, edited by Wayne N. Mathis and William L. Grogan, Jr. 297 pp. 1997	25.00
No. 19.	Monograph of the Stilt Bugs, or Berytidae (Heteroptera), of the Western Hemisphere, by Thomas J. Henry. 149 pp. 1997	18.00
No. 20.	The Genera of Elaphidiini Thomson 1864 (Coleoptera: Cerambycidae), by Steven W. Lingafelter. 118 pp. 1998	12.00
No. 21.	New World *Blepharida* Chevrolat 1836 (Coleoptera: Chrysomelidae: Alticinae), by David G. Furth. 110 pp. 1998	12.00
No. 22.	Systematics of the North American Species of *Trichogramma* Westwood (Hymenoptera: Trichogrammatidae), by John D. Pinto. 287 pp. 1999	28.00
No. 23.	Revision of the Net-Winged Midges of the Genus *Blephariccra* Macquart (Diptera: Blephariceridae) of Eastern North America, by Gregory W. Courtney. 99 pp. 2000	14.00
No. 24	Holcocerini of Costa Rica (Lepidoptera: Gelechioidea: Coleophoridae: Blastobasinae), by David Adamski. 147 pp. 2002	18.00
No. 25	A Catalog of the Cecidomyiidae (Diptera) of the World, by Raymond J. Gagné. 408 pp. 2004	50.00

Back issues of the Proccedings of the Entomological Society of Washington are available at $60.00 per volume to non-members and $25.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra on all orders. Dealers are allowed a discount of 10 percent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Treasurer, Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, D.C. 20013-7012.

CONTENTS

(Continued from front cover)

NOTES

VOL. 109 OCTOBER 2007 NO. 4
(ISSN 0013-8797)

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY
of **WASHINGTON**

PUBLISHED
QUARTERLY

CONTENTS

(Continued on back cover)

THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

Organized March 12, 1884

OFFICERS FOR 2007

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168.

MEETINGS.—Regular meetings of the Society are held in the Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 7:00 P.M. Minutes of meetings are published regularly in the *Proceedings*.

MEMBERSHIP.—Members shall be persons who have demonstrated interest in the science of entomology. Annual dues for members are $25.00 (U.S. currency).

PROCEEDINGS.—The *Proceedings of the Entomological Society of Washington* (ISSN 0013-8797) are published quarterly beginning in January by The Entomological Society of Washington. POSTMASTER: Send address changes to the Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember U.S. subscriptions are $60.00 per year and foreign subscriptions are $70.00 per year, payable (U.S. currency) in advance. Foreign delivery cannot be guaranteed. All remittances should be made payable to *The Entomological Society of Washington*.

The Society does not exchange its publications for those of other societies.

PLEASE SEE PP. 978–979 IN THIS ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Editor: David R. Smith, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Books for Review: David R. Smith, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168.

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 05 October 2007

Periodicals Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 741–764

NEOTROPICAL TINEIDAE, V: A NEW GENUS AND SPECIES OF TINEIDAE ASSOCIATED WITH SOCIAL HYMENOPTERA AND RE-EXAMINATION OF TWO POORLY KNOWN GENERA WITH SIMILAR BIOLOGY (LEPIDOPTERA: TINEIDAE, LYONETIIDAE)

Donald R. Davis and Mignon M. Davis

Department of Entomology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 105, Washington, D.C. 20013-7012, U.S.A. (e-mail: davisd@si.edu)

Abstract.—The larva and adult of a **new genus** and **species** of tineid moth, ***Sphecioses acignathus* D. and M. Davis**, are described from the Neotropical Region. The case-bearing larva of this species is believed to feed primarily as a scavenger within the nests of certain social bees and wasps (Apidae and Vespidae). The comparative morphology and family relationships of two other Neotropical and monobasic genera, *Antipolistes* Forbes and *Taeniodictys* Forbes, with similar biology and previously assigned to the Tineidae are also reviewed. The family placement of *Antipolistes* within Tineidae has been reconfirmed, with *Taeniodictys* now reassigned to Lyonetiidae.

Key Words: Lyonetiidae, Tineidae, adult and larval morphology, larval biology, scavenger, bee/wasp associate, Apidae, Vespidae

More than 11 genera and 20 species of Tineidae have been discovered living in the nests of social Hymenoptera, including Apidae, Formicidae, and Vespidae (Rau 1941, Hinton 1951, Petersen 1963, Hölldobler and Wilson 1990, Pierce 1995, Yamane 1996). This is the largest number of species reported utilizing this association for any moth family. Unfortunately, the precise biological interactions that have evolved between the moths and Hymenoptera remain unknown for more than a third of the reported instances. Most species are known or believed to be detritovores, feeding upon the papery nest material, pollen, organic waste, and possible chitinous remains within abandoned nests. A few may be mycetophagous, feeding upon fungal remains in the nests of leafcutting ants. A few species have been observed to be both detritivorous on wasp meconia and carnivorous on the sealed brood of Vespidae. The larva of *Hypophrictis dolichoderella* (Roepke 1925) has been observed to be predaceous on the ant brood of *Dolichoderus thoracicus* (F. Smith) in central Java.

A new genus and species of tineid moth, *Sphecioses acignathus* D. and M. Davis, is described herein from the Neotropical Region. Nearly 200 adults of this species were reared by DRD from a single vacant nest of *Chartergus* species (Vespidae) collected at a lowland Amazonian rainforest site in southern Venezuela. The case-bearing larva of this species was observed feeding primarily as a detritovore within the nests of its host.

Also reviewed are the morphology and classification of two genera previously described by Forbes (1933) and assigned to the Tineidae. Examination of their adult morphology has reconfirmed *Antipolistes* Forbes as a member of Tineidae (possibly Meessiinae) and *Taeniodictys* Forbes is tentatively assigned to Lyonetiidae.

TINEIDAE

Sphecioses D. and M. Davis, new genus

Type species.—*Sphecioses acignathus*, new species

Adult (Fig. 1).—Small moths with forewing length 3.8–6.0 mm.

Head (Figs. 2–3): Vestiture rough; vertex and frons densely covered with erect, piliform scales with acute apices. Antenna simple, ~0.85–0.9× length of forewing; scape slightly flattened, without pecten; flagellum with a single row of slender, appressed scales encircling each segment. Eye well developed; vertical diameter ~2× length of scape; frons narrow, interocular index ~1.25. Pilifer well developed, bilobed. Mandible absent. Galea reduced, ~0.8× length of maxillary palpus. Maxillary palpus elongate, 5-segmented, with apical segment the shortest; length ratio of segments from base: 1.0:1.2:1.4:2.5:0.9. Labial palpus well developed; length ratio of segments from base: 1.0:3.1:1.4; vestiture smooth dorsally, moderately short, rough ventrally with 5–7, dark, elongate bristles arising mostly lateroventrally along segment 2; apical segment slightly flattened.

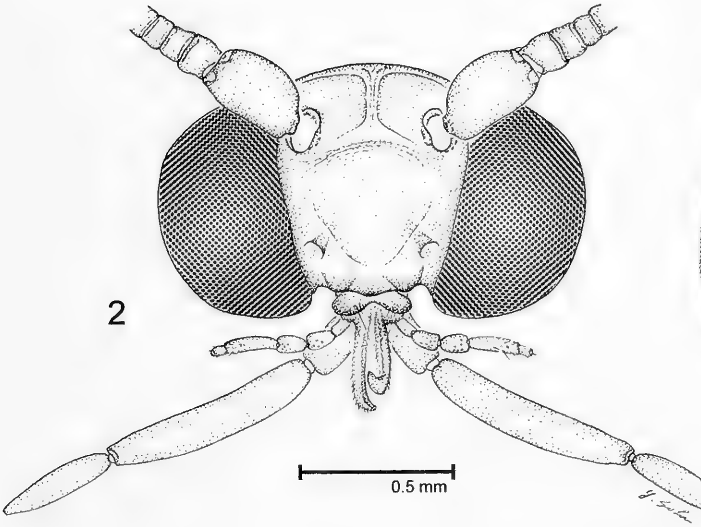
Thorax: Forewing (Fig. 4) moderately slender, W/L ratio ~0.33, apex moderately rounded. Venation well preserved with most veins distinct. Forewing with all 5 branches of R present and separate; accessory cell indistinct, open; M1-3 all separate; CuA1-2 well preserved; CuP indistinct; A1 and 2 with basal fork, then fused ~2/3 their length; male retinaculum strongly curved; female retinaculum consisting of a loose concentration of elongate hairs from ventral base of Sc. Hindwing W/L ratio ~0.35; M1-3 all separate; CuA1 and 2 well developed; 1A + 2A well preserved; 3A faint; frenula a single stout bristle in male, 2 bristles in female. Legs with tibial spur pattern of 0-2-4; epiphysis well developed, ~3/5× length of foretibia.

Abdomen: Without specialized structures; S2 apodemes slender, nearly straight, elongate, ~0.5× length of S2. Male coremata and female corethrogyne absent.

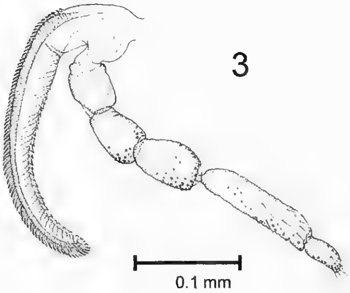
Male genitalia (Figs. 5–9): Uncus broad, extended caudally as a pair of relatively elongate, spatulate lobes united across caudal apex by strong membrane, well separated laterally from tegumen by a deep constriction. Junction of tegumen with vinculum indistinct; vinculum extending ventrally as a narrow, transverse sclerite, abruptly constricted to a slender saccus nearly 0.4× length of valva. Gnathos well developed, fused laterally with tegumen, forming a relatively broad, ventral band which tapers medially to form an elongate, slender, acute rod. Valva moderately broad, divided apically into two rounded lobes, a larger cucullar lobe and a smaller saccular lobe about half the size of the former. Juxta a slender rod from vinculum firmly connected to bases of valvae. Aedoeagus a slender, elongate, slightly curved cylinder about equal to length of genital capsule (excluding saccus), with a single, elongate, inverted V-shaped cornutus near apex.

Female genitalia (Fig. 10): Ovipositor moderately elongate, telescoping. Posterior apophysis ~1.7× length of anterior pair. Anterior apophysis moderately short and stout. Ventral pseudapophysis absent. Ostium bursae a sclerotized ring located near anterior margin of sternum 8. Ductus bursae about equaling length of anterior apophysis, with completely sclerotized, cylindrical walls. Corpus

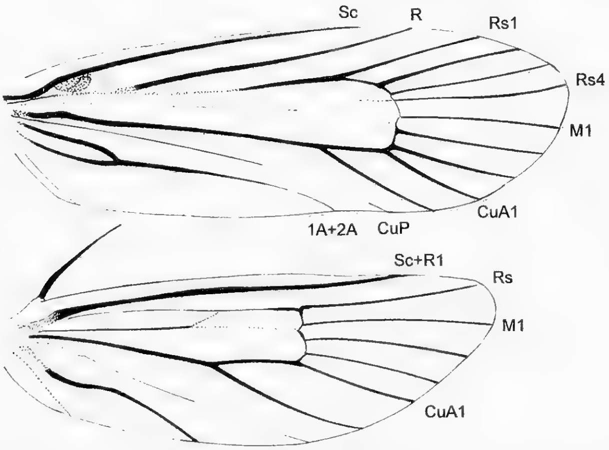
1



2

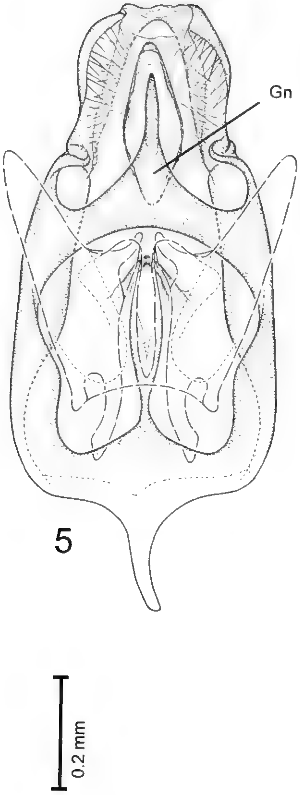


3

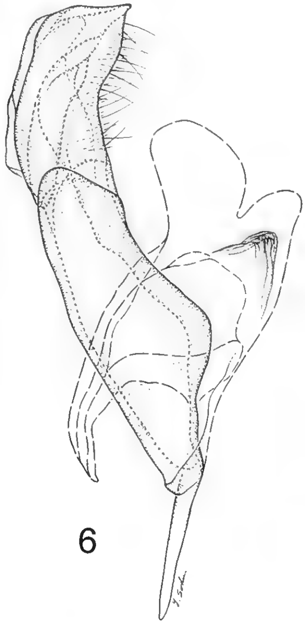


4

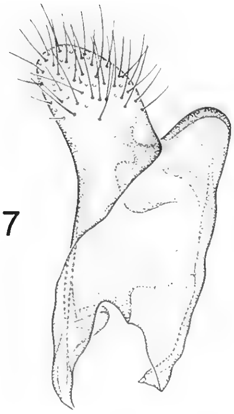
Figs. 1–4. *Sphecioses acignathus*. 1, Adult male, forewing length 4.8 mm. 2, Adult head, frontal view. 3, Right maxilla of Fig. 2. 4, Wing venation.



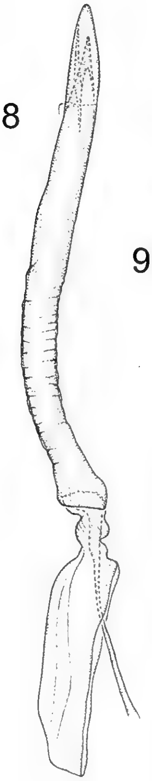
5



6

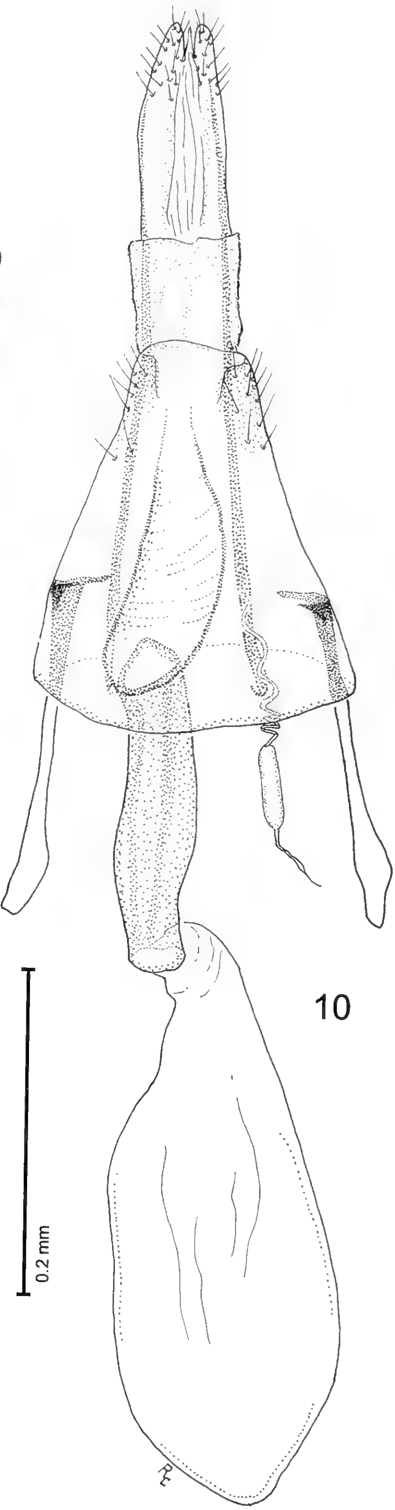


7



8

9



10

bursae relatively large, about equaling length of posterior apophysis, elliptical, membranous, without signum.

Etymology.—The generic name is derived from the Greek *sphekia* (wasp nest) and *ses* (moth), in reference to the larval habit. It is masculine in gender.

Discussion.—*Sphecioses* generally agrees with other members of the subfamily Tineinae except for the prominently lobed valvae and uncus of the male genitalia, which is broader and partially divided. The larva of *Sphecioses* is similar to those of Tineinae in possessing a bisetose SV setal group on the meso- and metathorax and in lacking stemmata (reduced to 0–1 pair in Tineinae, Hinton 1956, Robinson and Nielsen 1993). The detritivorous larval feeding biology of *Sphecioses* is also similar to that of several Tineinae.

***Sphecioses acignathus* D. and M. Davis, new species**

(Figs. 1–26)

Adult (Fig. 1).—*Head*: Cream colored with fuscous shading laterally around rim of eye. Antenna dark fuscous to black dorsally, slightly paler, more gray ventrally. Maxillary palpus mostly fuscous; apical segment pale gray. Labial palpus with segments 1–2 mostly fuscous except for an irregular mid-dorsal streak of cream; apical segment cream except for basal half of lateral and ventral surfaces; segment 2 with slightly rough scaling ventrally and bearing ~6–8 slender, mostly lateral bristles.

Thorax: Dark fuscous to black dorsally over pro- and mesonota, golden cream on metanotum and entire venter. Forewing golden cream, variably irrorated with dark brown to black scales, becoming most dense along costal margin; two small fuscous spots present at base and apex of discal cell, another, more elongated, small fuscous spot along anal margin; fringe banded with light and dark brown. Hindwing and fringe uniformly light shiny gray. Fore- and midlegs generally dark brown to fuscous dorsally, golden cream to light brown ventrally; apices of tibiae and most tarsomeres tipped with dark brown; hindleg paler, mostly golden cream to light brown, with suffusion of dark brown dorsally on tibia and tarsomeres.

Abdomen: Light, shiny brown dorsally, golden cream ventrally.

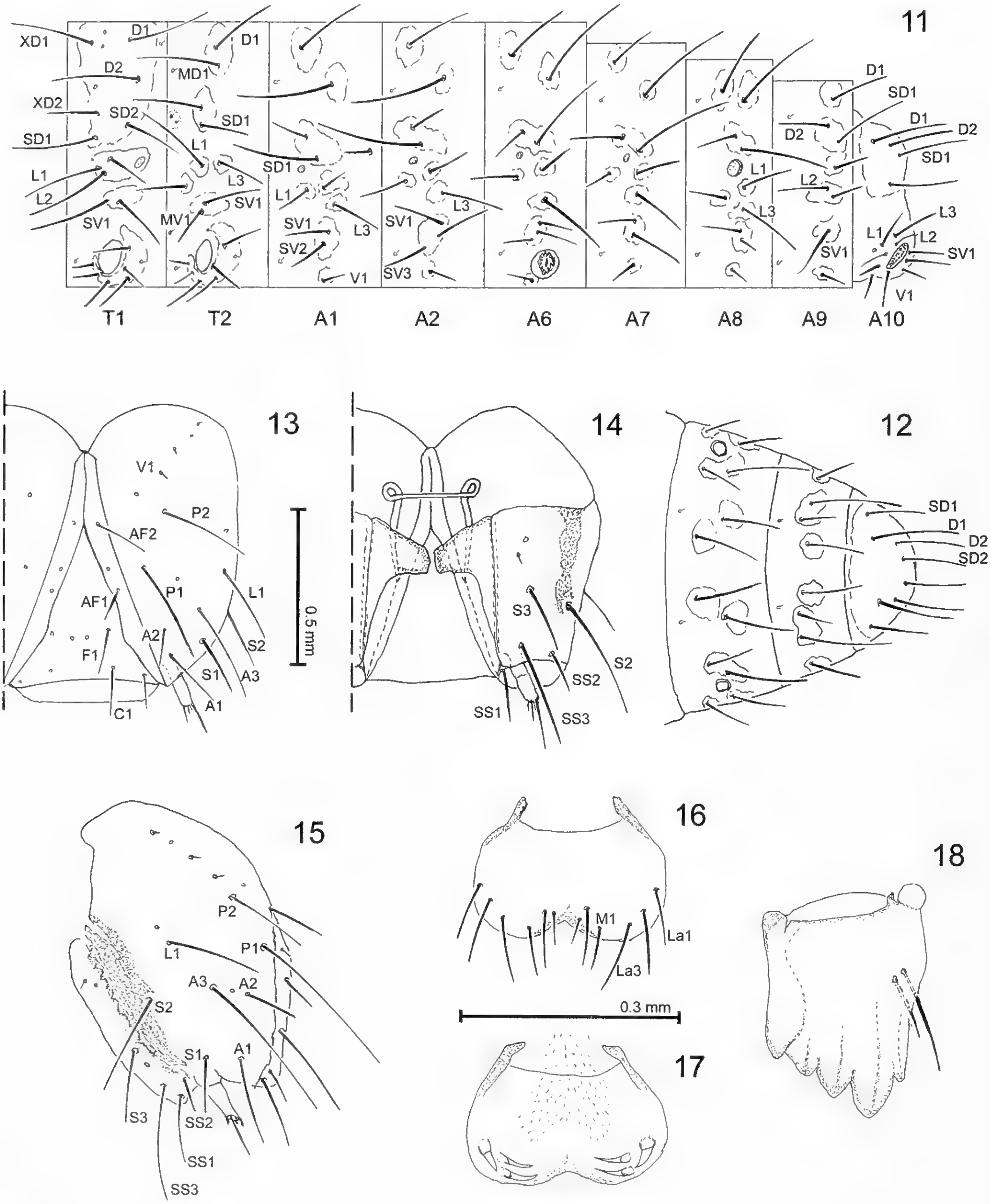
Male genitalia (Figs. 5–9): As described for genus.

Female genitalia (Fig. 10): As described for genus.

Larva (Figs. 11–22).—Length of largest larva 16.5 mm; maximum diameter 1.5 mm. Body generally pale cream; pinacula indistinct (in alcohol). *Head:* Maximum width 1.0 mm. Color light reddish brown, with an elongate, irregular, black streak extending laterally much of length of head from slightly below antennal base to rear margin of head. Chaetotaxy as illustrated (Figs. 11–18); labrum with 6 pairs of dorsal setae and 3 pairs of stout epiphryngeal setae along anterior-ventral margin. Stemmata absent. Mandible with 4–5 cusps with middle 3 of relatively uniform width but gradually decreasing in length from lateral to mesal, except for smallest and most lateral and mesal lobes. *Thorax:* Pronotum pale brown; other pinacula indistinct (in alcohol). Lateral setae trisetose and together on same pinaculum with spiracle. Meso- and metathorax with L1-3 all arising from separate

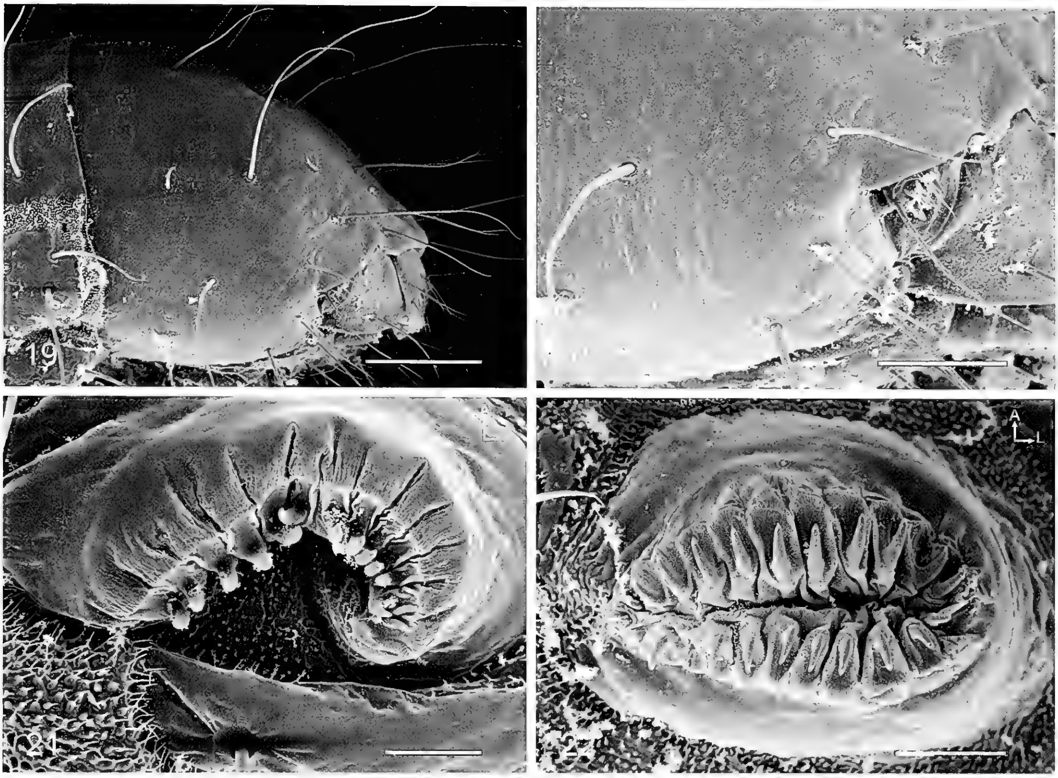
←

Figs. 5–10. *Sphecioses acignathus*. 5, Male genitalia, ventral view, Gn = gnathos. 6, Lateral view of Fig. 5. 7, Lateral (mesal) view of valva. 8, Aedoeagus, lateral view. 9, Apex of aedoeagus, dorsal view. 10, Female genitalia, ventral view.



Figs. 11–18. *Sphecioses acignathus*, chaetotaxy of late instar larva. 11, Lateral schematic of prothorax, mesothorax, metathorax, and abdominal segments 1, 2, 6–10. 12, Dorsal view of abdominal segments 8–10. 13, Head, frontal view. 14, Ventral view. 15, Lateral view. 16, Labrum, dorsal view. 17, Labrum, ventral view. 18, Mandible.

pinacula. Legs well developed; coxae nearly contiguous on T1, progressively more widely separated on T2 and 3. Pretarsal claw relatively short and stout; apical half moderately curved. *Abdomen*: D1 and 2 on separate pinacula on A1-8, A9 with D2 on same pinacula as SD1. SD 1 and 2 together on same pinacula on



Figs. 19–22. *Sphecioses acignathus*, larval morphology. 19, Head, lateral view (200 μm). 20, Head, detail of stemmatal region (100 μm). 21, Right anal proleg (40 μm). 22, Right ventral proleg (100 μm), A6. A = anterior; L = lateral. (scale lengths in parentheses).

A1-8; SD 2 absent on A9, SD1 together with D2. L1-3 on separate pinacula on A1-8; L2-3 together on same pinacula separate from L1 on A9. Subventral setae bisetose on A1, A7-9; trisetose on A2-6. Dorsal plate of A10 with 4 pairs (D1, D2, SD1, SD2) of elongate setae. Prolegs present on A3-6, 10; crochets A3-6 uniordinal, uniserial, and arranged in a complete ellipse of ~18–20 hooks; prolegs smooth, not covered with minute spines; crochets on A10 consisting of a single row of ~12–14 hooks along anterior edge of planta.

Larval case (Fig. 25).—Maximum length 12 mm, width 4 mm, relatively flat with a maximum depth of 2.5 mm. Light to dark brown in color; texture rough, covered primarily with small, cylindrical balls of dark frass and irregular pieces of nest detritus, including minute insect fragments. The dried frass pellets ranged in size to a maximum length of 0.7 mm and width of 0.5 mm.

Holotype.—♂; VENEZUELA: Territorio Amazonas: Cerro de la Neblina, basecamp, 0°50′N, 66°9′44″, 140 m, 10 Feb 1984, em. 24 Feb 1984 ex nest of *Chartergus* sp. probably *chartarius* (Olivier), DRD 501, D. R. Davis, (USNM).

Paratypes.—COSTA RICA: HEREDIA: Estación Biológica La Selva, Puerto Viejo de Sarapiqui, 50–150 m: 1 ♂, 1 Dec 2000, E. F. Smith, ex nest of *Mischocyttarus collarellus*, nest P.33A, (USNM). VENEZUELA: TERRITORIO AMAZONAS: Cerro de la Neblina, basecamp, 0°50′N, 66°9′44″, 140 m: 6 ♂, 2 ♀, 10 Feb 1984, em. 24 Feb 1984 ex nest of *Chartergus* sp. probably *chartarius* (Olivier), DRD 501, D. R. Davis; same data except: 13 ♂, 11 ♀, em. 25 Feb 1984; 7 ♂, 8 ♀, em. 26–29 Feb 1984; 4 ♂, 3 ♀, em. 29 Feb 1984; 3 ♂, 3 ♀, em. 1 Mar 1984; 4 ♂, 4 ♀, em. 2 Mar 1984; 2 ♂, 5 ♀, em. 4 Mar 1984; 4 ♂, 9 ♀, em. 5 Mar 1984; 6 ♂, 6 ♀, em. 6 Mar 1984; 7 ♂, 5 ♀, em. 8 Mar 1984; 7 ♂, 7 ♀, em. 10 Mar 1984; 4 ♂, 8 ♀, em. 12 Mar 1984; 7 ♂, 12 ♀, em. 13 Mar 1984; 3 ♂, 2 ♀, em. 18–21 Mar 1984; 1 ♂, 2 ♀, em. 1–2 Apr 1984; 1 ♀, em. 7–8 Apr 1984; 1 ♂, em. 12 Apr 1984; (BMNH, INBIO, UCVM, USNM). Cerro de la Neblina, basecamp, 0°50′N, 66°9′44″, 140 m: 1 ♀, 31 Jan 1984, light trap, 1 ♂, 10–20 Feb 1985, malaise trap in rainforest, P. J. & P. M. Spangler, R. A. Faitoute, & W. E. Steiner, (USNM); 1 ♂, 13–15 Mar 1984, Malaise trap over small stream at east side of basecamp, O. Flint & J. Louton, (USNM).

Host.—Apidae: Nests of *Bombus atratus* Franklin and *B. transversalis* (Olivier) (Whitfield et al. 2001). Vespidae: Nest of *Chartergus* sp. probably *chartarius* (Olivier); nest of *Mischocyttarus collarellus* Richards, Polistinae (Smith 2005).

Parasitoid.—Braconidae: *Apanteles nidophilus* Whitfield and Cameron.

Flight period.—Adults collected from December to March.

Distribution.—Probably widespread through the lowland Neotropical Region from Costa Rica to Brazil (Whitfield et al. 2001).

Etymology.—The species name is derived from the Greek *akis* (point, beak) and gnathos (jaw) in reference to the diagnostic, pointed gnathos in the male genitalia.

Discussion.—This species was first discovered by DRD during a 1984 expedition to Cerro de la Neblina, Amazonas, Venezuela. Nearly 200 adults were reared from a single vacant nest of *Chartergus* sp. (probably *chartarius* (Olivier), Figs. 23–24) collected 10 Feb 1984 at a site near the Rio Baria and adjacent to the Neblina Expedition basecamp. The nest was immediately opened, and numerous larval cases were observed suspended from the undersides of the transverse combs. The larvae appeared to be feeding on detritus in the combs (probably on meconia within the cells) as well as the cell walls of the comb. The remains of minute, chitinized insect fragments attached to the larval case also suggest that the larvae of *S. acignathus* feed on the remains of various stages of the wasps within the nest. Even more significant were the abundant insect remains found tightly packed within the larval frass of *acignathus* (also attached to the larval case, Fig. 25).

More recently other entomologists working on various groups of Hymenoptera have reared this moth and sent specimens or images to DRD for identification. Whitfield et al. (2001) reared *S. acignathus* from underground nests of Neotropical bumble bees, *Bombus atratus* Franklin and *B. transversalis* (Olivier) in Colombia, Brazil, and Ecuador. They reported that the moth appeared to be a scavenger which destroyed the nest cells while foraging. They also discovered *S. acignathus* to be parasitized by a braconid that differed from those described previously from *Bombus* nests. While studying the ecology of the paper wasp *Mischocyttarus collarellus* at the La Selva Biological Station, Puerto Viejo, Costa Rica, E. Smith (2004, 2005) reared *S. acignathus* from the nests (Fig. 26) of that wasp. The larvae of the moth were observed to have burrowed through the nest and cell walls of its host, leaving frass and silk, and possibly devouring brood.

Antipolistes Forbes

Antipolistes Forbes 1933: 91.—Davis 1984: 20.—Nye and Fletcher 1991: 22.

Type species.—*Antipolistes anthracella* Forbes 1933; by monotypy.

Adult (Fig. 27).—Very small moths with forewing length 2.3–2.7 mm.

Head (Figs. 28, 29): Vestiture rough; Vertex and frons densely covered with erect, piliform scales with acute apices. Antenna simple, ~0.75× length of forewing; scape slightly flattened, without pecten; flagellum with a single row of slender, appressed scales encircling each segment. Eye reduced; vertical diameter ~1.3× length of scape; frons very broad, interocular index ~0.5. Pilifer undeveloped. Mandible and galea absent. Maxillary palpus greatly reduced, normally not visible on uncleared head, 2-segmented, with a minute, apical spine projecting from segment 2 (Fig. 29). Labial palpus well developed, widely divergent from base of head; length ratio of segments from base: 1.0:1.5:1.4; vestiture generally smooth, with numerous (>12), elongate bristles arising laterally and apically along segment 2; apical segment cylindrical.

Thorax: Forewing (Fig. 30) relatively slender, W/L ratio ~0.26, apex subacute. Venation generally reduced; base of most veins indistinct. Forewing with Rs1 and 2 fused; Rs3 & 4 variably stalked 1/4–1/2 their length; accessory cell absent; M2 absent, possibly fused with M1 which is variably stalked to Rs4; CuA2 absent; CuP indistinct; 1A and 2A completely fused; male retinaculum a strongly curved process. Hindwing W/L ratio ~0.18; M1 vestigial, present only near margin; M2 absent, possibly fused with M1; M3 almost completely preserved; CuA1 and 2 variable, either completely fused or minutely branched in male, more divided in female; anal veins undeveloped; frenulum a single stout bristle in male, 2 bristles in female. Legs with tibial spur pattern of 0-2-4; epiphysis absent.

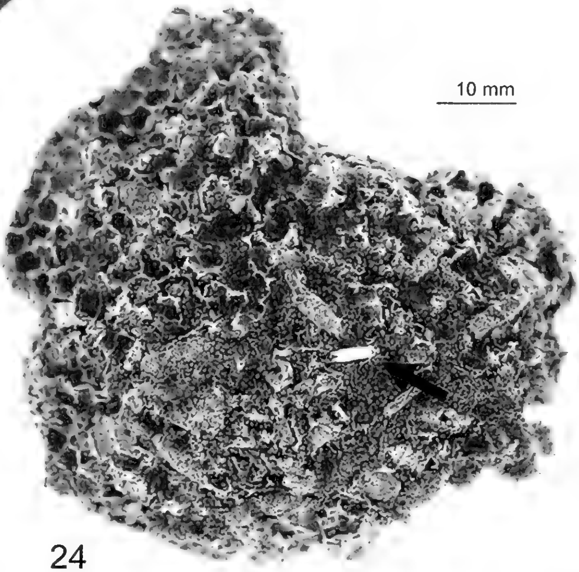
Abdomen: Without specialized structures; S2 apodemes relatively elongate and slender, slightly curved. Male coremata and female corethrogyne absent.

Male genitalia (Figs. 31–34): Uncus fused with tegumen, deeply bilobed, with a broad U-shaped cavity separating lobes; apices of uncus setose. Gnathos absent. Tegumen—vinculum forming a narrow ring. Valva simple, without secondary lobes; dorsal and ventral margins subparallel; apex asymmetrically rounded; mesal surface with a dense concentration of relatively enlarged setae near base. Aedoeagus a relatively simple, straight cylinder, gradually enlarging slightly to base; apex slightly produced dorsally; cornuti absent. Juxta a moderately slender, lightly sclerotized band firmly attached to aedoeagus (Fig. 33).

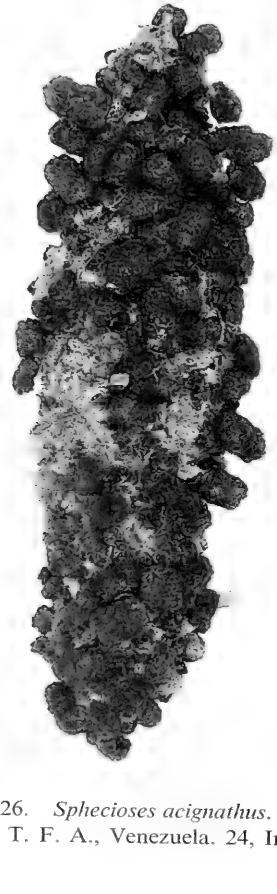
Female genitalia (Fig. 35): Ovipositor elongate, telescoping. Posterior apophysis ~1.65× length of anterior pair. Ventral pseudapophysis absent. Ostium bursae moderately broad, U-shaped, located near middle of sternum 8. Ductus bursae short, membranous, antrum V-shaped, gradually constricting to corpus bursae. Corpus bursae relatively large, nearly as long as anterior apophysis, elliptical in form, membranous, without signum.

Discussion.—The family placement of *Antipolistes* within Tineidae is supported by such adult characters as the erect, piliform setae of the head, erect bristles arising from the second segment of the maxillary palpus, and elongate, telescoping ovipositor. Subfamily affinities for the genus are uncertain but appear nearest to Meessiinae, a probably polyphyletic group of more than 20 genera whose known larvae are predominantly lichenivorous (Davis and Robinson 1998). Adults of Meessiinae often possess relatively simple forewing patterns of large spots or transverse bands, with slender wings and reduced venation (loss or stalking of Rs and M branches, 3A rarely present). The mouthparts of most genera of Meessiinae are typically fully developed but may be greatly reduced

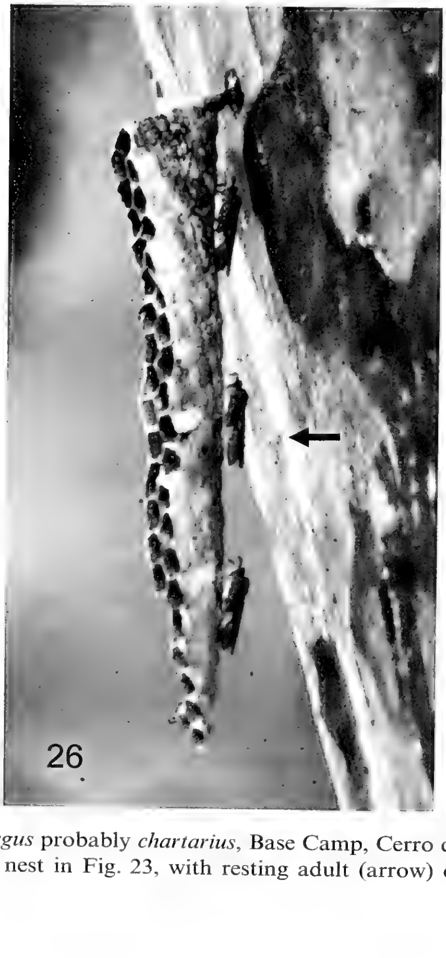
23



24



25



26

Figs. 23–26. *Sphecioses acignathus*. 23, Nest of *Chartergus* probably *chartarius*, Base Camp, Cerro de la Neblina, T. F. A., Venezuela. 24, Internal comb from nest in Fig. 23, with resting adult (arrow) of (without maxillae) in some genera (e.g., *Tenaga*, Robinson and Nielsen 1993).

Future studies involving all taxa currently associated with Meessiinae will probably result in the restriction of this subfamily to just those genera allied to the type genus, *Eudarcia*. The larvae of *Eudarcia* are unusual among what little we know of the immature stages of Tineidae in possessing an extremely long subdorsal seta (SD1) extending anteriorly from the pronotum and sometimes a similarly elongated SD1 from the anal plate, in addition to an anal comb for flicking frass (Dominguez 1996, Davis unpub.). None of these specializations are present in *Antipolistes.*

Antipolistes anthracella Forbes
(Figs. 27–59)

Antipolistes anthracella Forbes 1933: 92.—Davis 1984: 20.

Tinea latebrivora Meyrick, 1935: 575.—Davis 1984:20 (synonym of *Antipolistes anthracella* Forbes).

Tinea latebricola [sic] Vesey-Fitzgerald 1938:182.—Nelson 1968: 1530.—Jeanne 1979: 306.—Makino 1985:20.

Adult (Fig. 27).—*Head*: Uniformly light brown. Antenna shiny light brown to gray. Labial palpus shiny light brown to gray. *Thorax*: Dark fuscous to black dorsally, shiny light brown to gray ventrally. Forewing dark fuscous to black, with 4 irregular whitish spots; one pair along middle and distal 3/4 of costa; another pair at basal 1/3 and distal 2/3 of dorsal margin; fringe fuscous to black. Hindwing dark fuscous with faint purplish luster. Legs generally dark fuscous dorsally, shiny light brown to gray ventrally, with faint whitish apices to tibiae and tarsomeres. *Abdomen*: Dark fuscous dorsally, shiny light gray ventrally.

Male genitalia (Figs. 31–34): As described for genus.

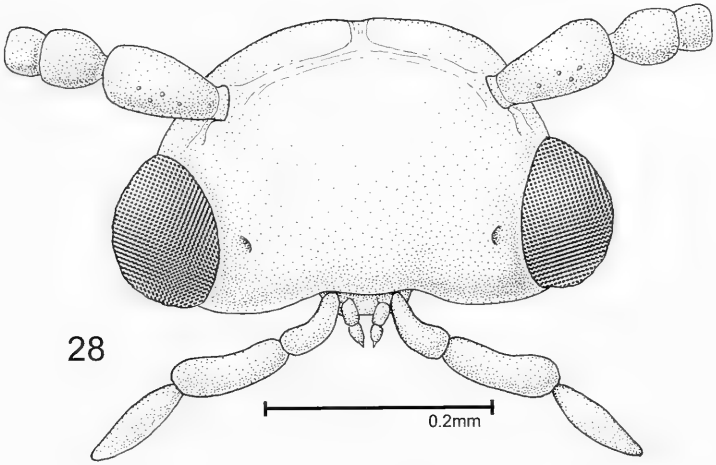
Female genitalia (Fig. 35): As described for genus.

Larva (Figs. 36–59).—Maximum length examined 4.3 mm; maximum body width 0.5 mm. Vesey-Fitzgerald (1938) briefly described the larva as 5 mm long at maturity, and "white with a few white hairs on the body and light brown heads"; pinaculae indistinct (in alcohol). *Head*: Maximum width 0.4 mm. Chaetotaxy as illustrated (Figs. 36–43); labrum with 6 pairs of dorsal setae and 3 pairs of stout epiphryngeal setae along anterior-ventral margin. Stemmata absent. Antenna with sensilla as shown (Figs. 49–52). Mandible with 3–4 cusps along distal margin with lateral cusp the longest and most acute; a small, subapical dorsal cusp also present (Fig. 43). *Thorax*: Pronotum and pinacula indistinct (in alcohol). Lateral setae trisetose and together on same pinaculum with spiracle. Meso- and metathorax with L1-3 all arising from separate pinacula. Legs moderately well developed; procoxae narrowly separated; meso- and metacoxae well separated. Pretarsal claw with relatively slender basal half; apical half only slightly curved (Fig. 54). *Abdomen*: D1 and 2 on separate pinacula on A1-8, together on same pinacula on A9. SD 1 and 2 on separate pinacula on A1-8; SD 2 absent on A9. L1-3 on separate pinacula on A1-9; L3 together with SV1 on same pinacula on A9. Subventral setae bisetose on A1-2, A7-8; trisetose on A2-6; only SV1 present on A9. Dorsal plate of A10 with 4 pairs (D1, D2, SD1, SD2) of elongate setae. Prolegs present on A3-6,

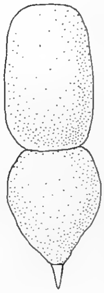
←

S. acignathus. 25, Larval case (length 11 mm). 26, Nest of *Mischocyttarus collarellus* with 3 wasps (arrow), La Selva, Heredia, Costa Rica.

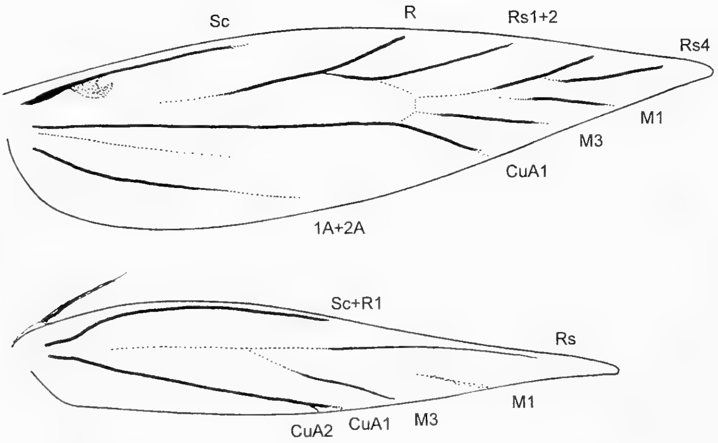
27



28

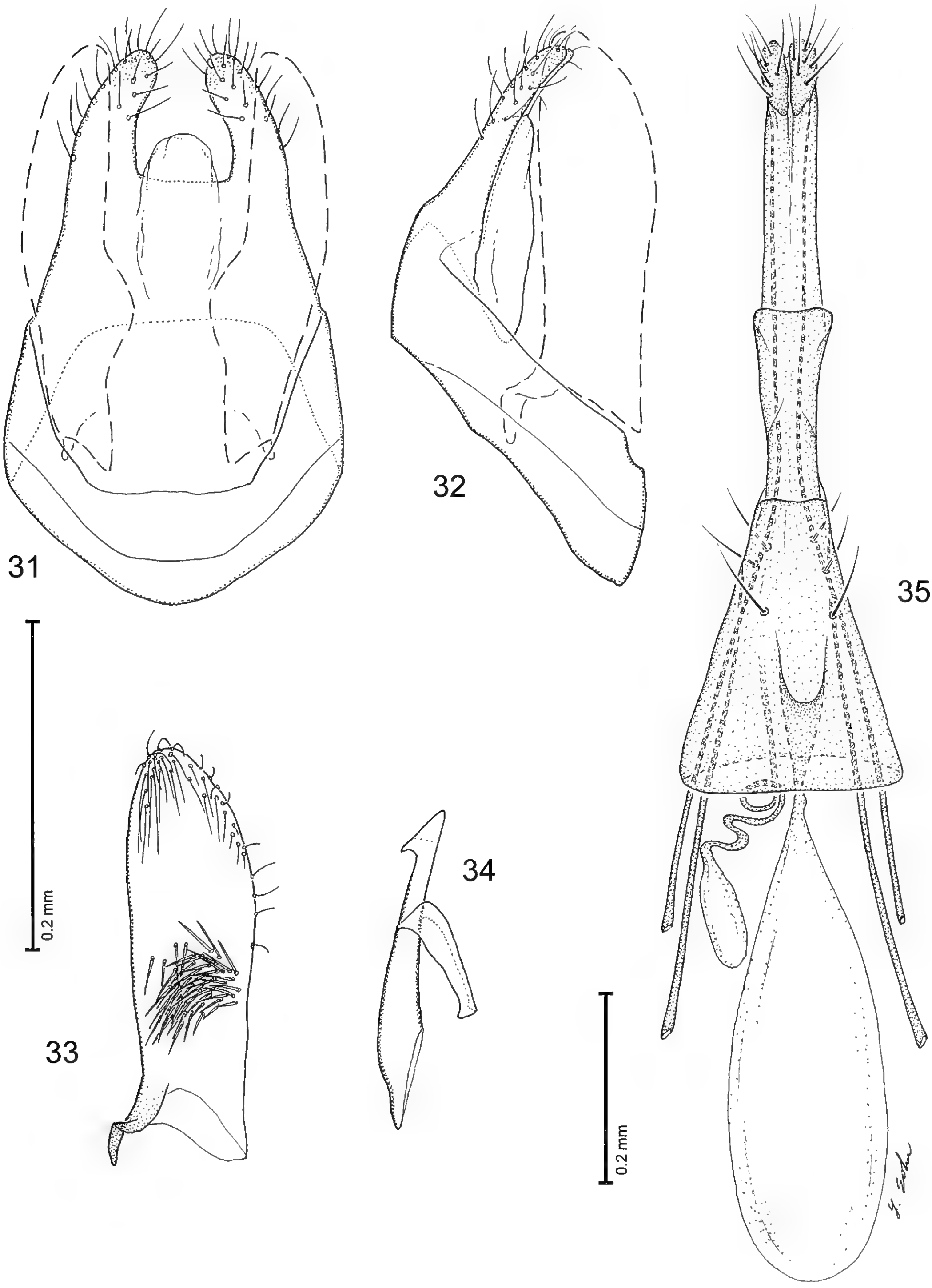


29

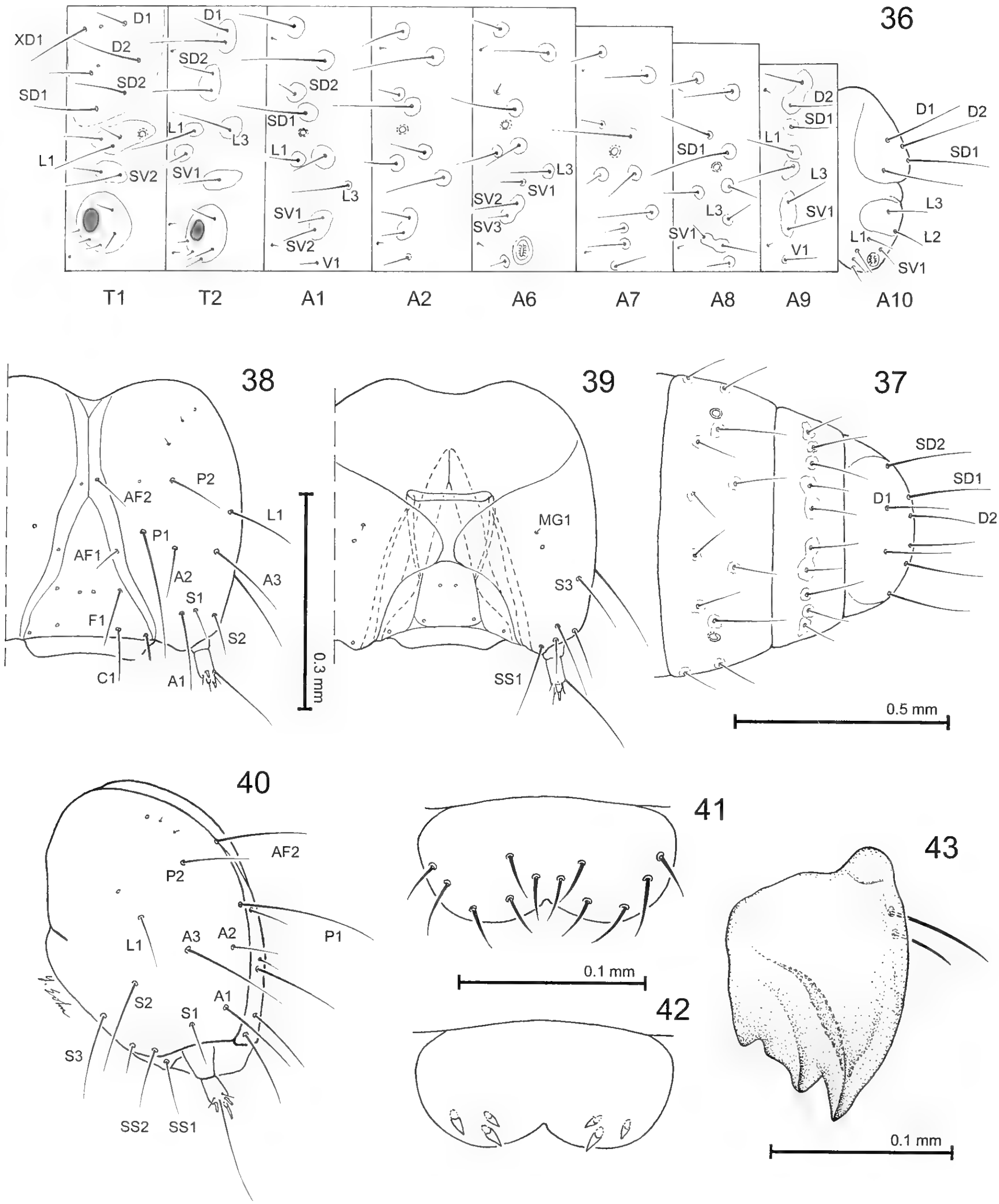


30

Figs. 27–30. *Antipolistes anthracella*. 27, Adult male, forewing length 2.5 mm. 28, Head, frontal view. 29, Right maxilla of Fig. 28. 30, Wing venation.

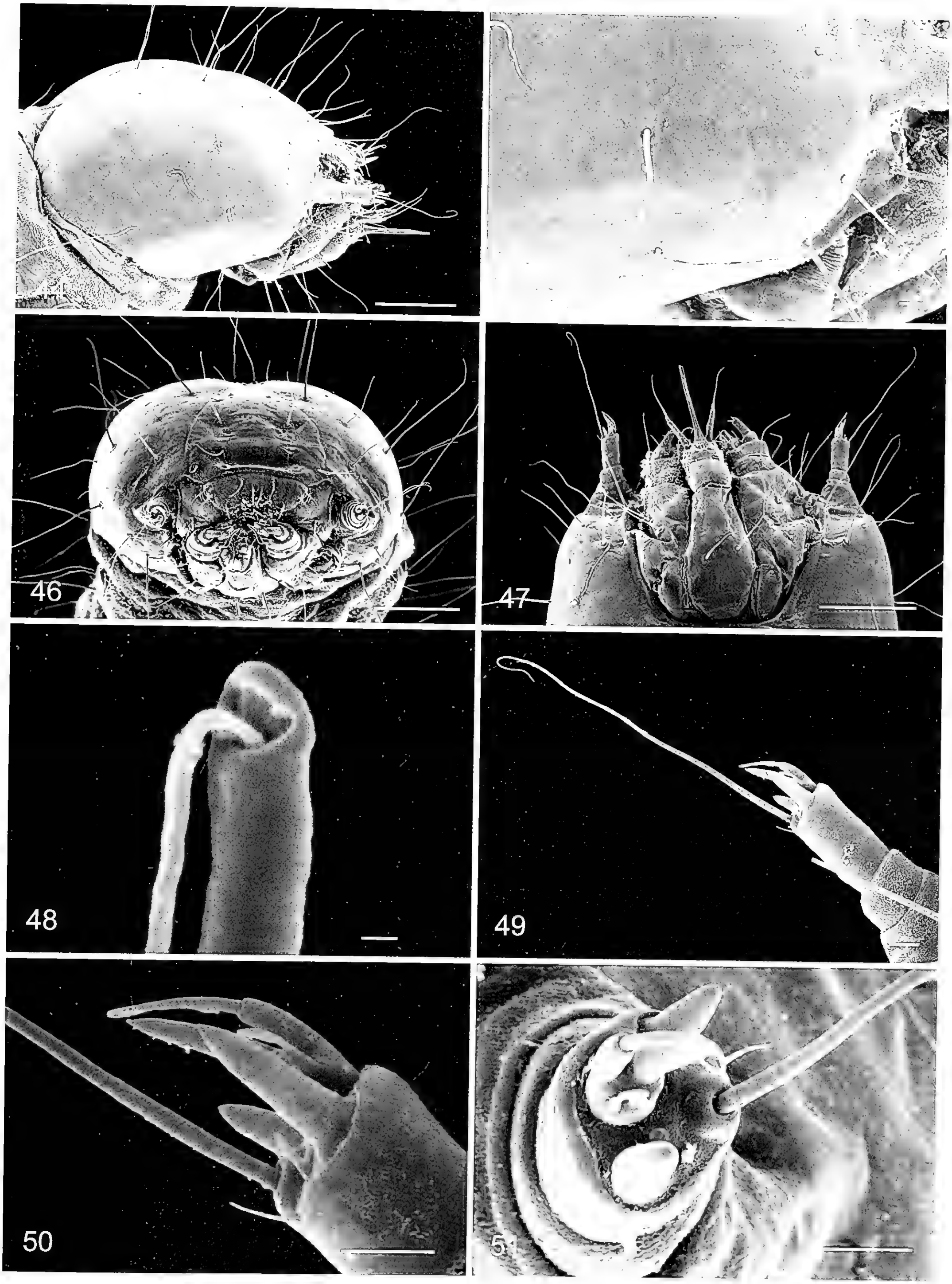


Figs. 31–35. *Antipolistes anthracella.* 31, Male genitalia, ventral view. 32, Lateral view of Fig. 31. 33, Lateral (mesal) view of valva. 34, Aedoeagus, lateral view. 35, Female genitalia, ventral view.

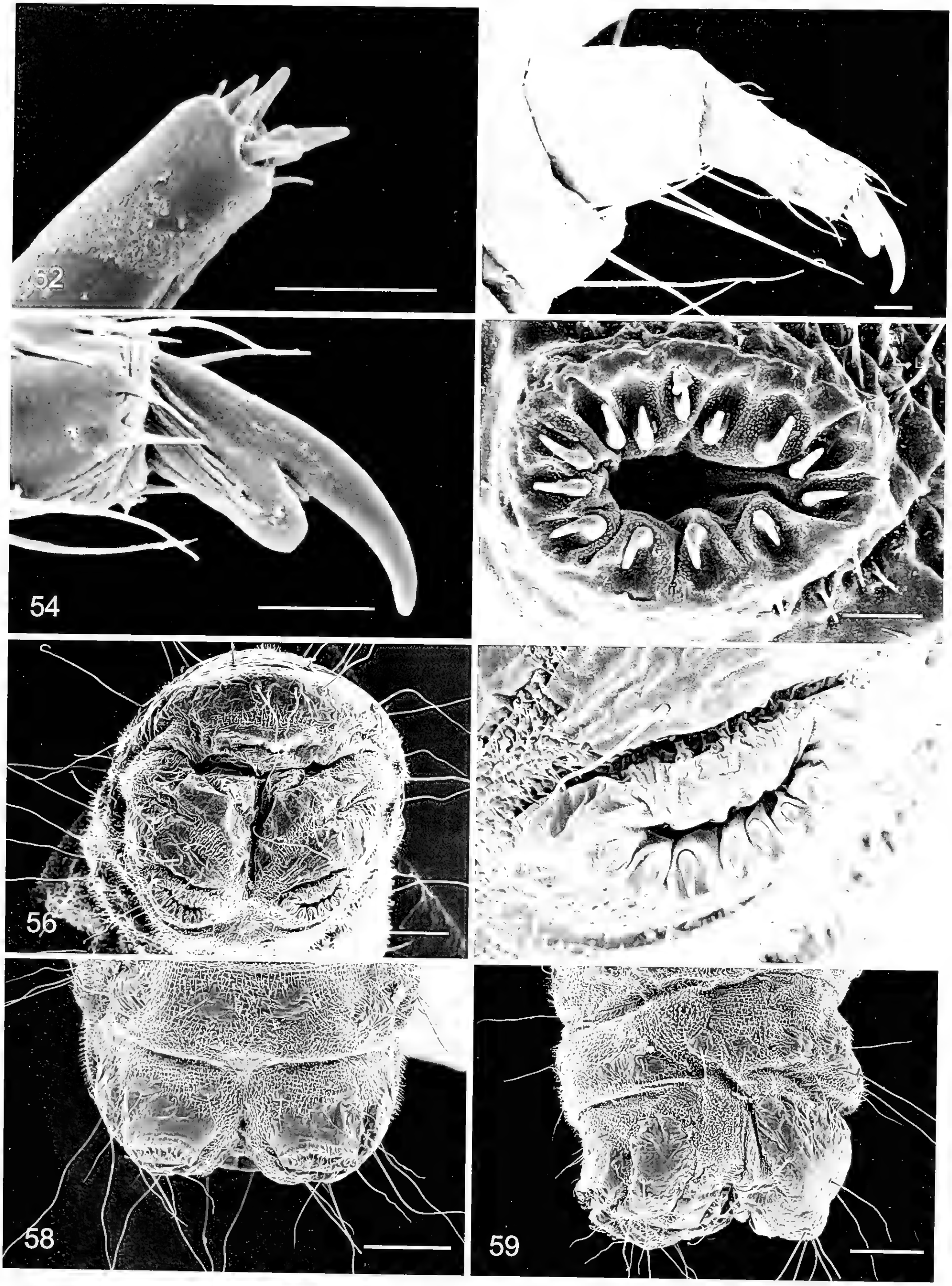


Figs. 36–43. *Antipolistes anthracella*, chaetotaxy of late instar larva. 36, Lateral schematic of prothorax, mesothorax, metathorax, and, abdominal segments 1, 2, 6–10. 37, Dorsal view of abdominal segments 8–10. 38, Head, frontal view. 39, Ventral view. 40, Lateral view. 41, Labrum, dorsal view. 42, Labrum, ventral view. 43, Mandible.

10; crochets A3-6 uniordinal, uniserial, and arranged in a complete ellipse of ~13 hooks (Fig. 55); prolegs sparsely covered with minute spines anteriorly, less so ventrally; crochets on A10 consisting of a single row of ~7–8 hooks along anterior edge of planta (Fig. 57).



Figs. 44–51. *Antipolistes anthracella*, larval morphology. 44, Head, lateral view (100 μm). 45, Head, detail of stemmatal region (10 μm). 46, Head, anterior view (100 μm). 47, Head ventral view (100 μm). 48, Apex of spinneret with silk thread emerging, ventral view (1 μm). 49, Right antenna, ventral view (10 μm). 50, Antennal sensilla, ventral view (10 μm). 51, Antennal sensilla, anterior view (10 μm). (scale lengths in parentheses).



Figs. 52–59. *Antipolistes anthracella*, larval morphology. 52, Left maxillary palpus, dorsal view (10 μm). 53, Left prothoracic leg (10 μm). 54, Detail of pretarsus in Fig. 53 (10 μm). 55, Crochets of right proleg of abdominal segment 6 (A = anterior; L = lateral; 10 μm). 56, Caudal end of abdomen (100 μm). 57, Crochets of right anal proleg (10 μm). 58, Ventral view of abdominal segments 9 and 10 (100 μm). 59, Lateral view of Fig. 58 (100 μm). (scale lengths in parentheses).

Pupa.—Not examined. Description from Forbes (1933): "Pupa (from Sein) similar to *Tinea pellionella* as figured by Miss Mosher (Bull. Ill. State Lab. Nat. Hist. xii, pl. 20, figs. 30, 31), sutures not clearly seen, prothorax depressed dorsally, maxillae shorter, nearly obsolete, but maxillary palpi large and transverse; antennae barely longer than fore wings; angulations of terminal segment ventral rather than lateral. The small round eyes are also more completely visible below the antennae. Abdomen dorsally with first three segments unarmed; fifth and sixth with anterior rows of fine spinules; 7th and 8th also with coarser rows near the mid-segments, the latter rather sparse; ninth segment with two subdorsal clusters of about three spinules each and last with small pointed subdorsal cones."

Types.—♂ (holotype, *Antipolistes anthracella*); Puerto Rico: Lares, (CU). ♀ (lectotype, *Tinea latebrivora*, present designation); bearing following labels: "Lectotype/Trinidad 1990, 24.vi.33, D.V.F.G./BM 1934-614/*Tinea latebrivora* Meyr., Type" (BMNH). A lectotype has been designated to ensure the stability of the name.

Material examined.—BRAZIL: Pernambuco: Parnambuco: 2 ♂, 1 ♀, 1983 [USDA lot 1983:3631], M. Arcanjo, reared from beehives, (USNM). Pará: Fazenda Taperinha, 2°32′S, 54°20′W, ~40 km E of Santarém [on lower Amazon River]: 4 ♂, 6 ♀, slides USNM 20794, 21565, 21566, 22156, 22157, 22169, 33181; Santarém, Taperinha, 2°54′S, 54°20′W: 5 larvae, 23 Jul 1977, R. Jeanne, larval slides USNM 33726, 33727 (USNM). CUBA: Cienfuegos: Guabairo, Central Soledad: 1 ♀ (paratype), 1 Sep 1930, R. Dow, reared from nest of *Polistes cubensis*, (USNM). PUERTO RICO: Lares: 1 ♂ (holotype, *Antipolistes anthracella*), (CU); (CU); 4 ♂, 2 ♀, (paratypes), Dec 1931, bred from nest of *Polistes crinitus*, slides USNM 22198, 33180; 1 ♂, 1 ♀, (USNM). TRINIDAD: 1 ♀ (lectotype, *Tinea latebrivora*), 24 Jun 1933; 2 ♀ (paralectotypes, *Tinea latebrivora*), 24 May 1933; 3 ♀ (paralectotypes), bred May 1933; D.V.F., (BMNH); 3 ♀, Dec 1934, Fitzgerald, reared from refuse at bottom of cells of *Polistes canadensis*; 1 ♂, Jan 1935, Fitzgerald, reared from old *Polistes* nest, (BMNH).

Host.—Scavenger/predator in nests of *Polistes canadensis* (L.), *Polistes canadensis panamensis* Holmgren, *Polistes crinitus* (Felton), *Polistes cubensis* Lepeletier, beehives [? *Apis mellifera* L.].

Flight period.—Adults are probably active most of the year, with records in January, May, June, September, and December.

Distribution.—Greater Antilles south to Brazil.

Discussion.—*Antipolistes anthracella* was first reared from *Polistes* nests by F. Sein, Jr. in Puerto Rico (Forbes 1933). Vesey-Fitzgerald (1938) later reared the moth in Trinidad from nests of *Polistes canadensis*, where *anthracella* larvae were reported to be an important pest of this wasp. Unaware that Forbes had already described the species, Meyrick redescribed it as *Tinea latebrivora* (later misspelled *latebricola* by Vesey-Fitzgerald) two years later. The larvae were believed by Vesey-Fitzgerald to feed primarily as scavengers within the wasp nest, but were seen to feed on living *Polistes* pupae just prior to the emergence of the wasp. *Antipolistes* larvae were reported to enter the body of its host through the tip of its abdomen. Live pharate *Polistes* adults were observed to still be able to move their legs and antennae although their abdomens were full of feeding *Antipolistes* larvae. Three moths in the collections of the USNM bear labels as being "reared from beehives".

The most complete account of the biology of this species is by Jeanne

(1979), who reported this moth to be present in 56% of the colonies of *P. canadensis canadensis* L. surveyed at Fazenda Taperinha, a site on the lower Amazon River approximately 40 km east of Santarém, Pará. Jeanne reports the moth to lay its eggs in clusters of two or more under the edge of the wasp meconium. As the larvae mature, their feeding and tunneling activities break down the meconium, and the larvae begin to spin silken tunnels throughout the frass and remains of the meconium. Larvae were observed to penetrate the paper walls of their cell to feed on meconia in adjacent cells. Jeanne also noted the larvae to feed occasionally on the wasp brood. Pupation occurs in the lower parts of the cells amidst the tangles of silk webbing and frass. The total development from egg to adult was estimated to require between 25–30 days.

Jeanne hypothesized that several behaviors exhibited by the wasp, including multiple comb building, were adaptations that reduced brood loss to these moths. It was noted that colonies infested by the moth did not use their combs to rear a second batch of brood, while uninfested colonies did. Since a comb cannot be invaded by moths until a meconium is exposed by the production of the first adult, dividing the brood into many small isolated periods of short age range reduces the risk that a given pupa will be attacked by moth larvae. It also reduces the risk that brood will be lost due to the nest-weakening effects of moth infestation.

Antipolistes anthracella probably is widely distributed over the Neotropical Region as suggested by its occurrence in both Brazil and the greater Antilles. Rau (1933) refers to a 'minute Lepidopteron' that emerged from webbed, empty cells of *Polistes canadensis panamensis* in Panama. The moths were examined by August Busck, who could not identify them except to suggest that they might be a species of *Antispila* (Heliozelidae). No specimens of what Busck examined are known to exist. Considering the predominantly leaf-mining biology of *Antispila* and general similarity in size and color pattern (a black forewing with 3–4 small whitish spots) between most *Antispila* and *Antipolistes anthracella*, we conclude that the latter insect is what Rau actually collected and sent to Busck for identification.

LYONETIIDAE

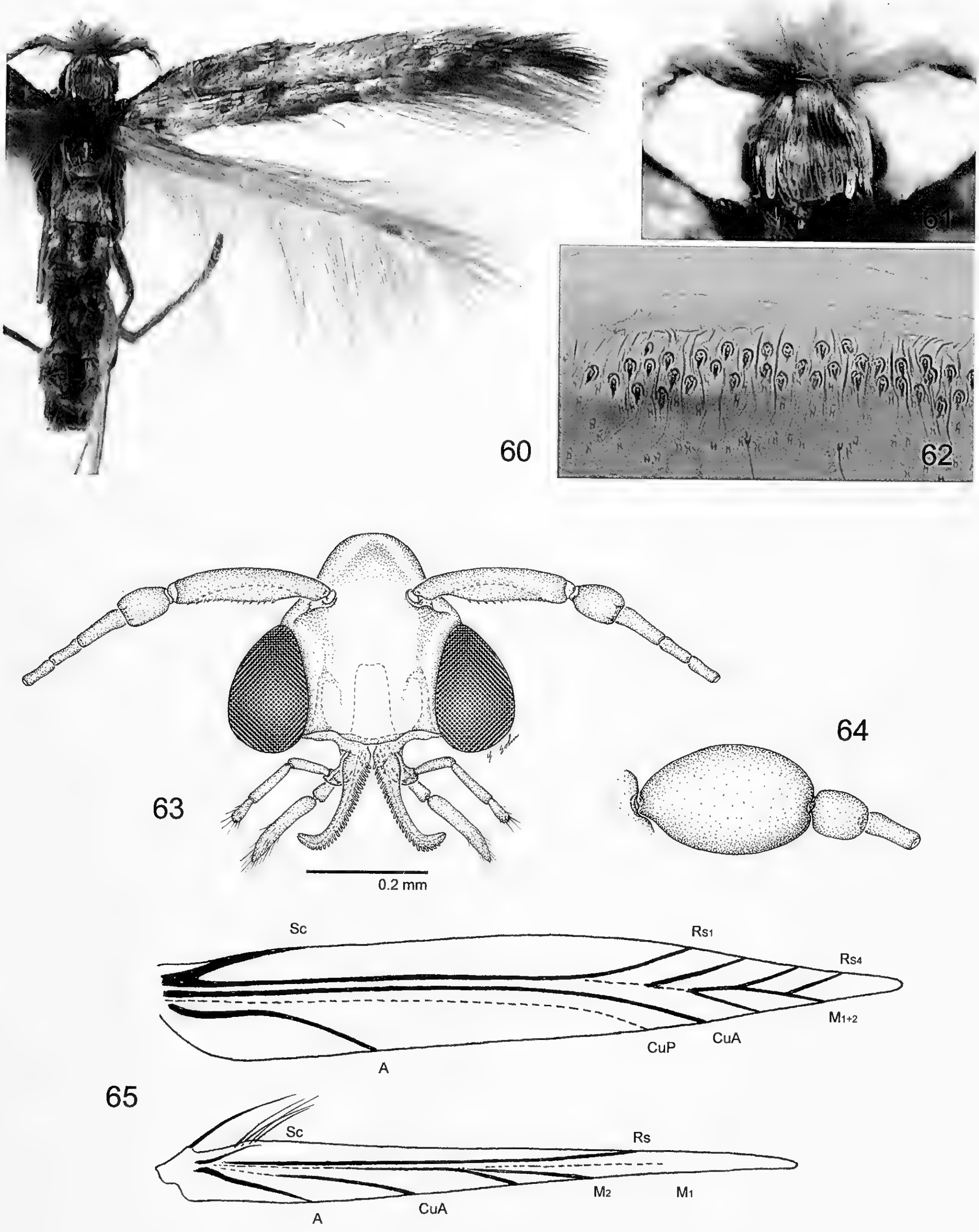
Taeniodictys Forbes

Taeniodictys Forbes 1933: 89.—Davis 1984: 5, 23.—Nye and Fletcher 1991: 295.

Type species.—*Taeniodictys sericella* Forbes 1933; by monotypy.

Adult (Figs. 60).—Very small moths with lanceolate wings; forewing length 3.0–3.4 mm.

Head (Figs. 61, 63): Frons strongly inclined; vestiture of frons and occipital area smooth, with moderately broad scales. Vertex of cranium produced, broadly subconical, with a prominent, erect tuft of piliform scales bearing acute apices. Antenna simple, ~0.65× length of forewing; scape elongate, broadly flattened, maximum width ~0.7× vertical diameter of eye, forming an eyecap in repose; pecten absent but with dorsal scales projecting over anterior margin; flagellum with a single row of slender, appressed scales encircling each segment. Eye moderately developed; vertical diameter ~0.8× length of scape; frons broad, interocular index ~1.0. Ocelli absent. Pilifer undeveloped. Mandible absent. Galea naked, reduced, ~0.9× length of maxillary palpus. Maxillary palpus well developed, exceeding length of labial palpus, 4-segmented; length ratio of segments from base: ~1.0:1.0:1.5:0.7. Labial palpus moderately developed; length ratio of segments from base: ~1.0:0.8:2.5; vestiture smooth.



Figs. 60–65. *Taeniodictys sericella*. 60, Adult male, forewing length 3.0 mm. 61, Head, dorsal view. 62, Tergal spines of 4th abdominal tergum. 63, Head, frontal view. 64, basal three segments of antenna, dorsal view. 65, Wing venation.

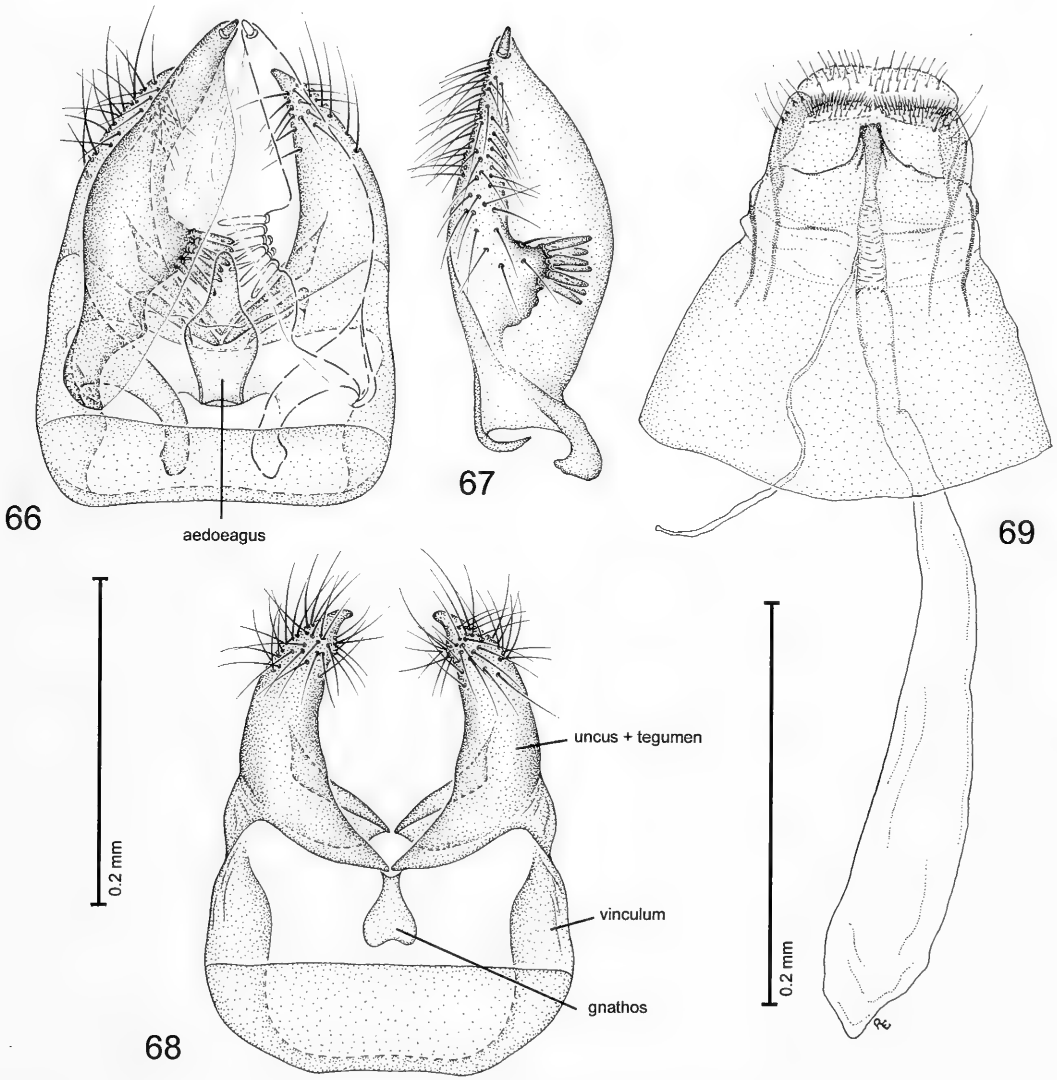
Thorax: Forewing (Fig. 65) lanceolate, W/L ratio ~0.15, apex extended, acute. Venation reduced; discal cell indistinct, very narrow and compressed, open; base of most veins indistinct. Forewing with R absent; Rs with 4 branches; Rs3 & 4 partially stalked with M1; M2 absent, perhaps fused with M1; CuA undivided to margin; CuP indistinct; 1A and 2A completely fused, without basal fork; male retinaculum a shallow ridge along venter of Sc. Hindwing W/L ratio ~0.09; Sc a short spur to base of costal margin; M2 and 3 distinct; M1 barely evident as a vestigial branch toward apex of wing; CuA undivided, present near basal third of dorsal margin; anal vein simple; frenulum a single stout bristle in male, 2 bristles in female. Legs with tibial spur pattern of 0-2-4; tibial spurs elongate, of unequal length with one member of a pair about twice the length of shorter member; epiphysis very slender, ~0.4× length of foretibia;.

Abdomen (Fig. 62): Terga 2–7 in male and 2–6 in female with 3–4 scattered rows of minute, sharp spines across anterior margin of tergite. S2 apodemes elongate and slender, slightly curved. Male coremata and female corethrogyne absent. Eighth segment of male without pleural lobes.

Male genitalia (Figs. 66–68): Uncus fused with tegumen, deeply bilobed, forming a pair of stout, inwardly curved, acute lobes, separated by a broad V-shaped cavity which deeply separates the lobes; apices of uncus setose. Gnathos reduced, consisting of a small, basally lobed sclerite immediately dorsal to aedoeagus (Fig. 68). Vinculum in the form of a narrow, ventral ring. Valva elongate, acute, with costal half thickened, bearing a relatively stout tubercule near middle of valva bearing ~6–7 stout spines; ventral half of valva much thinner, with entire margin; a single, short stout spine arising subapically; basal process of valva enlarged, stout, and curved. Aedoeagus a relatively simple, short cylinder with swollen sides and relatively broad base; cornuti absent. Juxta absent.

Female genitalia (Fig. 69): Ovipositor very short, not telescoping; apex broadly subtruncate. Apophyses short, slender; posterior apophysis with caudal third thickened; total length ~1.6× that of anterior pair. Ventral pseudapophysis absent. Ostium bursae arising at apex of small tubercular projection located at caudal margin of sternum 8 near caudal end of abdomen. Ductus bursae relatively elongate, membranous, gradually expanding to elongate, slender, membranous corpus bursae, without signum. Ductus seminalis joining ductus bursae near its caudal third.

Discussion.—When describing *Taeniodictys*, Forbes was uncertain as to its family relationships, a problem that still persists largely because of how little is known about many genera currently assigned to the Lyonetiidae. Primarily on the basis of the well developed maxillary palpi and "semi-scavenger" habits, Forbes tentatively associated the genus with the Oinophilidae (now considered within Hieroxestinae, a subfamily of Tineidae). Forbes also realized that this insect possessed some features more typical of the family Lyonetiidae, as characterized by Meyrick at that time. Because this genus was never studied again until now, later authors (Davis 1984: 23) retained the taxon in Tineidae as originally suggested by Forbes. Our examination has determined the relationship of *Taeniodictys sericella* to be more allied to the Lyonetiidae, subfamily Cemiostominae (Dugdale et al. 1998). Characters supporting this placement include: 1) frons smooth and strongly inclined; 2) vertex with prominent tuft of piliform scales; 3) antennal scape well developed, flattened and forming a partial eyecap; 4) wings lanceolate with



Figs. 66–69. *Taeniodictys sericella*. 66, Male genitalia, ventral view. 67, Lateral (mesal) view valva. 68, Male genitalia, ventral view with valvae removed. 69, Female genitalia, ventral view.

reduced venation; and particularly 4) abdomen with 3–4 transverse rows of tergal spines. Major features possessed by *Taeniodictys* that are atypical of most Lyonetiidae are the 4-segmented maxillary palpi, absence of pleural lobes in the male, presence of greatly reduced, nonpiercing ovipositor, and detritivorous larval biology. To resolve such incongruencies, a review of all genera currently assigned to the Lyonetiidae is needed.

Taeniodictys sericella Forbes
(Figs. 60–69)

Taeniodictys sericella Forbes 1933: 90.—Davis 1984: 23.—Nye and Fletcher 1991: 295.

Taeniodictys servicella [sic] Nelson 1968: 1530.—Makino 1985: 25.—Yamane 1996: 85.

Adult (Figs. 60, 61).—*Head*: Frons shiny white; vertex mostly white with cream suffusion; occiput shiny light brown. Antenna mostly shiny white to cream. Labial palpus white basally, apical third brown. *Thorax*: Shiny light brown dorsally, more white ventrally. Forewing uniformly shiny light brown; fringe very pale brown. Hindwing and fringe mostly cream. Legs generally very pale brown dorsally, cream ventrally; hindtibia with long cream hairs dorsally. *Abdomen*: Pale brown dorsally, cream ventrally.

Male genitalia (Figs. 66–68): As described for genus.

Female genitalia (Fig. 69): As described for genus.

Larva and pupa.—Not examined.

Types.—♂ (holotype); Puerto Rico: Lares, (CU).

Material examined.—PUERTO RICO: Lares: 1 ♂ (holotype), 4 ♂, 5 ♀, 2 ?sex (unspread, abdomens missing), (paratypes), Dec. 1931, F. Sein, Jr., bred from nest of *Polistes crinitus*, slides DRD 4360, USNM 28457, 33179, (CU, USNM).

Host.—Scavenger in nests of *Polistes crinitus* (Felton).

Flight period.—December.

Distribution.—Known only from the type locality, Puerto Rico.

Discussion.—Although adult morphology now suggests this species to be more allied to Lyonetiidae, the larval habit of *Taeniodictys sericella* remains as puzzling as it probably was to Forbes. Forbes reported several specimens (12 examined in the current study) reared from the nests of *Polistes crinitus* by Francisco Sein, Jr. Because there is no reason to question the accuracy of the rearing data, this may constitute the only known record of a larval scavenging habit within the family. Nearly all other species of Lyonetiidae are known to be leaf miners on a broad range of monocot and dicot families (Kyrki 1990, Dugdale et al. 1998). It should be mentioned, however, that the life histories of several genera currently included within Lyonetiidae remain unknown. Larval biologies atypical for Lyonetiidae include that reported for *Phyllobrostis eremitella* De Joannis, whose larvae live in elongate twig galls on *Daphne gnidium* L. (Mey 2006), and the larvae of *Lyonetia simplella* Snellen which may feed on fungi or mildew (Robinson et al. 2002).

Acknowledgments

We are indebted to Young Sohn and Patricia Gentili of the Department of Entomology, Smithsonian Institution, for most of the illustrations, graphics, and plate preparation essential for this publication. Drawings were also executed by Mignon Davis and Rachel Collins. John Steiner and Vic Krantz (deceased) of the Smithsonian Photographic Services assisted with the photographs. We thank E. Richard Hoebeke, Department of Entomology, Cornell University, for assisting with the loan of critical material, Jim Carpenter of the American Museum of Natural History for identifying the nest of *Chartergus* species, Robert Jeanne of the University of Wisconsin for providing reared adults and larvae of *Antipolistes anthracella,* and Elizabeth Smith, formerly of the Department of Entomology, University of Kansas, for providing a reared specimen of *Sphecioses acignatha*, as well as a copy of her dissertation and an image for the nest of *Mischocyttarus collarellus*. Although *Sphecioses acignatha* was not sampled during the ALAS III Microlepidoptera survey of the La Selva Biological Station, Costa Rica (supported by National Science Foundation grant DEB-9706976), the discovery of this new taxon from La Selva will be added to that inventory. James Whitfield, Department of Entomology, University of Illinois, sent specimens for identification of *S. acignatha* reared from nests of the neotropical bumblebees, *Bombus atratus* and *B. transversalis.* Gaden Robinson, Department of Entomology, The Natural

History Museum, London, United Kingdom, kindly provided information on the larval hosts of Lyonetiidae. DRD also acknowledges La Fundacion para el Desarrollo de las Ciencias Fisicas, Matematicas y Naturales of Venezuela and the Scholarly Studies Program of the Smithsonian Institution for their combined support of his fieldwork during 1984 at Cerro de la Neblina, Venezuela.

Specimens examined are deposited in the following institutions: Cornell University (CU), Ithaca, New York; Instituto Nacional de Biodiversidad, Santo Domingo, Costa Rica (INBIO), National Museum of Natural History (USNM), Smithsonian Institution, Washington, DC, USA, the Natural History Museum (BMNH), London, United Kingdom, and the Instituto de Zoologia Agricola Facultad de Agronomia, Universidad Central de Venezuela, Maracay-Aragua, Venezuela (UCVM).

LITERATURE CITED

Davis, D. R. 1984. Neopseustidae, Nepticulidae, Opostegidae, Tischeriidae, Incurvariidae, Cecidosidae, Adelidae, Prodoxidae, Tineidae, Psychidae, and Arrhenophanidae, pp. xx, 3–6, 16, pp. 18–25. *In* Heppner, J. B. ed. *Atlas of Neotropical Lepidoptera, Checklist:* Part 1, Micropterigoidea - Immoidea. Dr. W. Junk Publ., The Hague, Boston, Lancaster.

Davis, D. R. and G. S. Robinson. 1998. Tineoidea, pp. 91–107, 46 figs. *In* Kristensen, N. P., ed. Handbook of Zoology, Part 35, (Lepidoptera, vol. 1). Walter de Gruyter, Berlin, New York.

Dominguez Romero, M. 1996. *Sistemàtica i ecologia dels Tineids de la Penínula a Ibèrica (Lepidoptera)*. Doctoral thesis, Facultat de Ciències Biològiques, Universitat de Valéncia, pp. 1–321.

Dugdale, J. S., N. P. Kristensen, G. S. Robinson, and M. J. Scoble. 1998. 8. The Yponomeutoidea, pp. 119–130. *In* Kristensen, N. P., ed. Lepidoptera, Moths and Butterflies. *Handbuch der Zoologie,* Vol. IV, Arthropoda: Insects, Part 35. Walter de Gruyter & Co., Berlin, New York.

Forbes, W. T. 1933. Two wasp-guests from Puerto Rico (Microlepidoptera). Psyche 40(3): 89–92, plate 4.

Hinton, H. E. 1951. Myrmecophilous Lycaenidae and other Lepidoptera—A summary. Proceedings of the South London Entomological and Natural History Society (1949–1950): 111–175.

———. 1956. The larvae of the species of Tineidae of economic importance. Bulletin of entomological Research 47: 251–346.

Hölldobler, B. and E. O. Wilson. 1990. The Ants, Harvard University Press, Cambridge. pp. i–xii+1–732.

Jeanne, R. L. 1979. Construction and utilization of multiple combs in *Polistes canadensis* in relation to the biology of a predaceous moth. Behavioral Ecology and Sociobiology 4: 293–310, figs.1–7.

Kyrki, J. 1990. Tentative reclassification of holarctic Yponomeutoidea (Lepidoptera). Nota lepidopterologica 13(1): 28–42.

Makino, S. 1985. List of the parasitoids of polistine wasps. Sphecos 10: 19–25.

Mey, W. 2006. Revision of the genus *Phyllobrostis* Staudinger, 1859 (Lepidoptera, Lyonetiidae). Mitteilungen Museum Naturkunde Berlin, Deutsche entomologische Zeitschrift 53: 114–147.

Nelson, J. M. 1968. Parasites and symbionts of nests of Polistes wasps. Annals of the Entomological Society of America 61(6): 1528–1539.

Nye, I. W. B. and D. S. Fletcher. 1991. The Generic Names of Moths of the World. Vol. 6. Microlepidoptera, Natural History Publications, London. xxix + 368 pp.

Pierce, N. E. 1995. Predatory and Parasitic Lepidoptera: Carnivores living on plants. Journal of the Lepidopterists' Society 49(4): 412–453.

Petersen, G. 1963. Tineiden als Bestandteil der Nidicolenfauna Beiträge zur Entomologie 13(3/4): 411–427.

Rau, P. 1933. The jungle bees and wasps of Barro Colorado Island (with notes on other insects). P. Rau, Kirkwood, Mo. 324 pp.

———. 1941. Observations on certain Lepidopterous and Hymenopterous parasites of *Polistes* wasps. Annals of the Entomological Society of America 34: 355–366.

Robinson, G. S. and E. S. Nielsen. 1993. *Tineid Genera of Australia (Lepidoptera)*, xvi + 344 p. Monographs on Australian Lepidoptera, Vol. 2. CSIRO.

Robinson, G. S., P. R. Ackery, I. J. Kitching, G. W. Beccaloni, and L. M. Hernández. 2002. Hosts—a database of the hostplants of the world's Lepidoptera. http://www.nhm.ac.uk/entomology/hostplants/index.html

Roepke, W. 1925. Eine neue myrmekophile Tineïde aus Java: *Hypophrictoïdes dolichoderella* n. g., n. sp. Tijdschrift voor Entomologie 68: 175–194.

Smith, E. F. 2004. Nest sites of the paper wasp *Mischocyttarus collarellus* (Hymenoptera: Vespidae: Polistinae) in a lowland tropical rain forest. Journal of the Kansas Entomological Society 77(4): 457–469.

———. 2005. Ecology and social biology of the paper wasp *Mischocyttarus collarellus* in a neotropical rain forest (Hymenoptera, Vespidae). Ph.D. thesis, University of Kansas, Lawrence, Kansas.

Vesey-FitzGerald, D. 1938. Social wasps (Hymenoptera: Vespidae) from Trinidad, with a note on the genus *Trypoxylon* Latreille. Transactions of the Royal Entomological Society of London 87(Part 7): 181–191.

Whitfield, J. B., S. A. Cameron, S. R. Ramírez, K. Roesch, S. Messinger, O. M. Taylor, and D. Cole. 2001. Review of the *Apanteles* species (Hymenoptera:Braconidae) attacking Lepidoptera in *Bombus* (*Fervidobombus*) (Hymenoptera:Apidae) colonies in the New World, with description of a new species from South America. Annals of the Entomological Society of America 94(6): 1–7.

Yamane, S. 1996. Ecological factors influencing the colony cycle of *Polistes* Wasps, pp. 75–97. *In* Turillazzi, S. and M. J. West-Eberhard, eds. Natural History and Evolution of Paper-Wasps. Oxford University Press, Oxford, New York, Tokyo.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 765–772

REDISCOVERY OF *TETRAOLYTTA GERARDI* (PIC) (COLEOPTERA: MELOIDAE), AN ENIGMATIC BLISTER BEETLE FROM BRAZIL: REDESCRIPTION AND TAXONOMIC PLACEMENT

Marco A. Bologna and John D. Pinto

(MAB) Dipartimento di Biologia, Università Roma Tre, Viale Marconi 446, 00146 Roma, Italy (e-mail: bologna@uniroma3.it); (JDP) Department of Entomology, University of California, Riverside, U.S.A.; current address: P.O. Box 2266, Waldport, OR 97394, U.S.A. (e-mail: john.pinto@ucr.edu)

Abstract.—The monotypic genus *Tetraolytta* Pic, endemic to southern Brazil, has remained virtually unknown since its description. Previously assigned to the subfamily Meloinae near the genus *Lytta* Fabricius, the examination of the holotype of *T. gerardi*, its type species, as well as recently collected material, clearly shows the genus belongs to the Tetraonycinae close to *Tetraonyx* Latreille. This paper includes a redescription of *Tetraolytta gerardi* and a discussion of its position relative to the other genera of Tetraonycinae. The species is recorded developing in the nests of the bee *Monoeca haemorrhoidalis* (Smith) (Apidae).

Key Words: taxonomy, *Tetraolytta*, Tetraonycinae, Neotropics

The monotypic *Tetraolytta* Pic has remained one of the most poorly known taxa of Meloidae in the New World. Pic (1919) described the type species, *Lytta gerardi* Pic, from a single specimen, without providing details on its distribution (assumed to be from South America) and referred it to a new subgenus *Tetraolytta*. With only Pic's original description available, Denier, in a series of papers, proposed varying and confusing taxonomic treatments of *Tetraolytta*. Considering the name inappropriately formed, he originally introduced an unnecessary replacement name, *Picella* Denier. Although initially continuing to treat *Picella* as a subgenus (Denier 1933a: 37, note 1), in the same paper (p. 47) and a subsequent contribution (Denier 1933b) he elevated it to a genus close to *Lytta* Fabricius. Then, in his catalogue (Denier 1935), he used the correct name, *Tetraolytta*, but returned it as a subgenus of *Lytta*. Finally upon examining a specimen of *T. gerardi* from southern Brazil and impressed by its distinctiveness and lycid-like phenotype, Denier (1940) again elevated *Tetraolytta* to genus level. Although not discussing its taxonomic placement in that paper, it is clear that Denier continued to consider *T. gerardi* as related to *Lytta* (Meloinae: Lyttini). The systematic position of *Tetraolytta* has remained questionable. Pinto and Bologna (1999) suspected a relationship to the Tetraonycinae, but continued to treat the genus as a lyttine pending further study.

Until now, only Pic and Denier had examined specimens of *T. gerardi*. We have now had the opportunity to study recently collected material from southern Brazil, as well as its type, thereby allowing us to confirm our previous suspicions of tetraonycine affinity. Herein we redescribe and figure *Tetraolytta gerardi*, formally transfer the species to the Tetraonycinae, and discuss its placement within the subfamily. The host of *Tetraolytta*, previously unknown, also is recorded.

MATERIAL EXAMINED

The redescription of the monotypic *Tetraolytta* is based primarily on the male holotype of its type species deposited in the Pic Collection (Muséum National d'Histoire Naturelle, Paris, France). The type is well preserved except for absence of both hind tarsi. The holotype has the following labels: (a) "72" (small, square, light blue, printed). (b) "*Tethaonyx* (sic!) sp. desiré" (rectangular, white, handwritten by Pic). (c) "type" (small, rectangular, white, handwritten by Pic). (d) "TYPE" (rectangular, red, printed, not contemporary). (e) "? *Lytta Petaini* Pic" (rectangular, white, handwritten by Pic). (f) "sg. *Tetraolytta* Pic" (rectangular, white, handwritten by Pic). One of us (MAB) added the following label: (g) "*Tetraolytta gerardi* (Pic), M. Bologna det. 2003." The name *gerardi* was used upon description of the species (Pic 1919) but evidently never physically applied to the type.

Six additional specimens of this species also were studied. Collection data are as follows: Brazil (Paraná); Mananciais da Serra Reserve; Piraquara; 25°29′S, 48°59′W (1,029 m); 24-ix/29-x-2005; Armadilha de Emergencia 1, Area A; Léo Correia da Rocha Filho, collr. Beetles were collected as they emerged from the nests of the wild bee, *Monoeca haemorrhoidalis* (Smith) (Apidae). These specimens are deposited in the Bologna Collection, Università degli Studi "Roma Tre," Rome, and the Department of Entomology Research Museum, University of California, Riverside.

TAXONOMIC TREATMENT

Subfamily Tetraonycinae

Tetraonycinae, a strictly New World subfamily, now includes four genera: *Meloetyphlus* Waterhouse 1872, *Opiomeloe* Selander 1985, *Tetraolytta* Pic 1919, *Tetraonyx* Latreille 1805, all placed in a single tribe, Tetraonycini (synonym: Meloetyphlini Borgmeier 1937).

Diagnosis.—*Adult:* Maxillary galea unmodified. Pronotum with lateral margins of disk abruptly declivant to lateral surfaces. Tarsal claws without teeth, consisting of two curved blades of subequal width. Tarsi with penultimate segment generally as wide as long, that on at least foretarsus usually bilobed and wider than long. Male with sternum VII (5th visible) emarginate; sternum IX Y-shaped, relatively short; tergum IX consisting of two lateral tergites. Male genitalia with gonostyli fused only at base and to varying degree with gonocoxal piece; aedeagus with a single apically placed dorsal hook present or not; endophallic hook present and robust

First instar larva: Phoretic. Navicular. Head capsule with internal phragma at midline. Labial palpi absent. Spiracles of abdominal segment I greatly enlarged, projecting above surface, pedunculate. Larvae of only *Tetraonyx* and *Meloetyphlus* are known (MacSwain 1956, Bologna and Pinto 2001).

Comments.—Placement of Tetraonycini within Meloidae has varied. It usually has been treated as a tribe of Nemognathinae (Selander 1983, 1985), or a distinct subfamily (MacSwain 1956, Pinto and Bologna 1999). A recent phylogenetic study of the family based largely on first instar larval morphology (Bologna and Pinto 2001) supports subfamily status and hypothesizes a sister group relationship to Nemognathinae.

The short, bilobed tarsomeres distinguish adult Tetraonycinae from other subfamilies, except some species of the primitive Eleticinae. Structure of the male genitalia and claws further distinguishes them from the Nemognathinae (Selander 1965). The internal cephalic phragma, absence of labial palpi, and structure of the first abdominal spiracles separate tetraonycine first instar larvae from all other Meloidae (MacSwain 1956, Bologna and Pinto 2001).

Meloetyphlus, *Opiomeloe* and *Tetraolytta* are monotypic; *Tetraonyx* is a large genus with 102 species (Selander 1983, Selander and Martinez 1984, Selander and Selander 1992). The subfamily is primarily Neotropical with relatively few *Tetraonyx* reaching the southern Nearctic (Selander 1983, 1985; Pinto and Bologna 1999). *Tetraonyx* has never been revised and most species are unknown to current workers. The only key to species, published over 120 years ago (Haag-Rutenberg 1879), is not only outdated but was incomplete at its inception (Selander 1983).

Genus *Tetraolytta* Pic 1919

Lytta (*Tetraolytta*) Pic 1919: 3; Denier 1935: 163. Type species: *Lytta* (*Tetraolytta*) Pic, by monotypy.

Picella Denier 1933a: 37 note 1 (as subgenus), p. 47 (as genus); 1933b: 237–8, 241 (as genus). Unnecessary replacement name (obj. jun. syn. of *Tetraolytta*).

Tetraolytta: Denier 1940: 802; Pinto and Bologna 1999: 592.

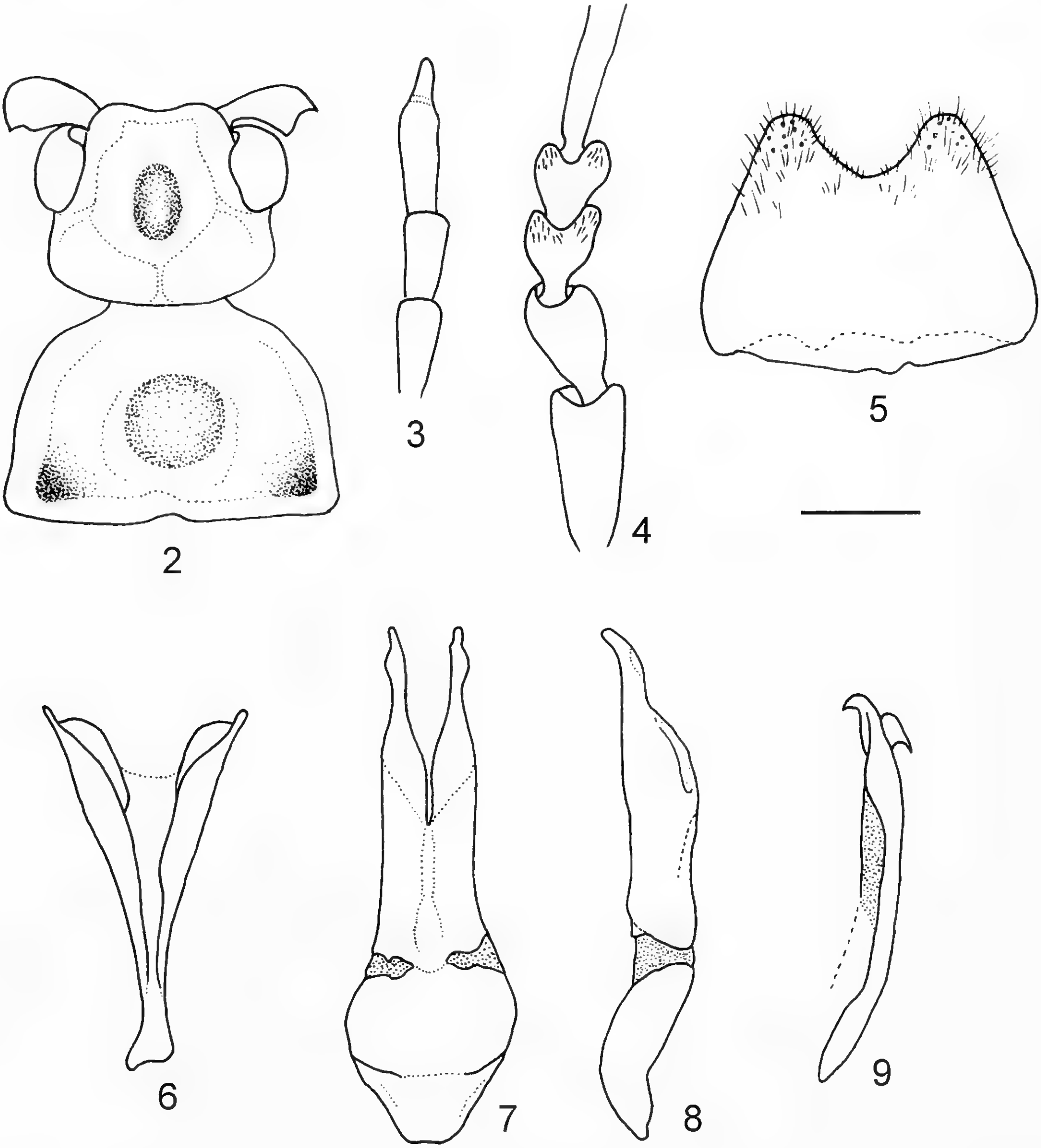
Diagnosis.—Elongate, moderately slender, superficially resembling Lycidae. Primarily black except orange laterally on pronotum and basal section of elytra. Head distinctly wider at eyes than at tempora, tempora not inflated; frons distinctly concave with a large smooth elongate bulla medially. Eyes large, immediately behind antennal sockets and above base of mandibles. Antenna not clavate, elongate, c. 0.7× elytral length in male, segments relatively broad, length of III–X not exceeding c. 2× segment width; XI distinct, elongate, twice as long as I and III, respectively in male, abruptly narrowed near midlength in both sexes; sexes varying slightly in segment proportions but otherwise antennae not dimorphic. Elytra planate somewhat widened posteriorly. Hind wings fully developed. First tarsomere of middle and hind legs elongate, length of metatarsomere I c. 1/2 length of entire tarsus. Aedeagus with one hook positioned at apex; endophallic hook well sclerotized.

Tetraolytta gerardi (Pic 1919)
(Figs. 1–9)

Lytta (*Tetraolytta*) *gerardi* Pic 1919: 3; Denier 1935: 163.

Tetraolytta gerardi: Denier 1940: 802; Pinto and Bologna 1999: 592.

Fig. 1. *Tetraolytta gerardi*, female.



Figs. 2–9. *Tetraolytta gerardi*, male holotype. 2, Head and pronotum, dorsal view (densely stippled portions near center of both structures represent elevated areas). 3, Last three antennomeres. 4, Tarsomeres I–IV of foreleg. 5, Last visible sternum. 6, Sternum IX, spiculum gastrale. 7, Gonostyli, ventral view. 8, Gonostyli, lateral view. 9, Aedeagus, lateral view. Bar = 1.0 mm (2), or 0.5 mm (3–9).

Redescription.—Based on all available material. The states of certain variable features including those characterizing the holotype are given in the Variation section below.

Male. *Length:* 15–16 mm. *Color:* Generally black with considerable orange coloration on pronotum and elytra. Black or dark brown except apical margin of labrum orange, clypeus with a subapical transverse orange to light brown band, maxilla, labium and gular area varying from dark to orange brown; pronotum orange with a broad percurrent black medial stripe, width of stripe equal to or slightly greater than greatest scutellar width, stripe tapering posteriorly or not; scutellum black; forecoxa, prosternum, meso- and metapleural areas varying from dark to orange brown; elytra orange at anterior 1/2, black posteriorly, black coloration extending further anteriorly along suture and orange coloration narrowly extending posteriorly along lateral margin to a varying degree but never more than 1/2 length of black section; hind wing dark brown except subhyaline at basal 1/5. Vestiture relatively dense and moderately elongate dorsally but not obscuring cuticle, setation color generally as that of underlying cuticle (black or orange) with some mismatching on pronotum, scutellum and base of elytra. *Head* (Fig. 2): Distinctly narrower than pronotum (0.7–0.8× as wide), 0.8× as long as wide, width at tempora 0.9× greatest width at eyes; eye large, notched in dorsal 1/2, placed immediately behind antennal sockets; clypeus and labrum somewhat reclinate to head capsule; labrum extending well beyond 1/2 length of mandible, slightly emarginate; head capsule densely punctate, punctures small, less dense on vertex and occiput than on frons, vertex and frons moderately concave, with an elongate, moderately large levigate bulla on frons between eyes; frons more distinctly concave below eyes, elevated laterally and overlapping base of antennae; occiput with narrow longitudinal furrow at middle; mandible strongly curved at apical 1/2; palpi unmodified. Antenna elongate (Fig. 3), relatively robust; length/width of segments I–XI = 1.6, 0.6, 1.6, 1.9, 1.8, 2.1, 2.2, 2.0, 2.2, 2.2, 4.4; length of III subequal to I, segments IV–X each slightly longer than III, XI c. 2× length of III and I, respectively, XI abruptly narrowed from basal 0.6 to apex. *Thorax:* Pronotum (Fig. 2) subhexagonal, broad, c. 1.3× width of head at eyes, 0.66–0.70 as long as wide, widest at base, lateral margins of disk subparallel, very slightly sinuate and broadly ridged from base to anterior 1/3, then abruptly rounded and convergent to apex; disk usually with dense and relatively small punctures, highly uneven, middle area elevated, convex, lateral areas depressed, most distinctly so in basal 2/3, with a relatively deep suboval depression on each side connected via a transverse furrow near basal margin; lateral surfaces of pronotum almost perpendicular to disk, smooth, without punctures or setation. Scutellum broadly linguiform, with a shallow sulcus along midline, apex weakly emarginate. Mesosternum posteriorly depressed and sub-triangularly elongate; mesepisterna and metasternum wide. Elytra slightly widened posteriorly, discal surface relatively planate, surface rugulose. Hind wing as in *Tetraonyx frontalis* Chevrolat, 1833 (Kaszab 1959, fig. 56) except M2 (= RP) only extending c. 1/2 as far into radial field, and A1 (= M3+4) not connected to CU (= medial bar). Legs unmodified, relatively slender; all tibiae with two apical spurs, posterior foretibial spur slightly longer, mid- and hind tibial spurs subequal in length, hind tibial spurs spatulate with inner spur parallel sided and outer spur widening slightly to apex. Middle tibia bowed, posterior surface slightly concave from base to apex. Tarsi (Fig. 4) with first and last segments relatively elongate and slender, penultimate segment shortest and bilobed, antepenultimate segment slightly longer and more weakly bilobed; relative length of fore-, mid- and hind tarsal segments as follows:17/9/7/6/15, 12/6/4/3/8, 25/8/5/14; all tarsal segments except I with light colored setation beneath, these most dense on segments II–IV of fore- and midlegs and II–III of hind legs, relatively sparse on ultimate segment; claws strongly curved, apical 2/5 almost perpendicular to base. *Abdomen:* Sternum VII (5th visible) with posterior margin broadly, shallowly emarginate; sternum VIII moderately emarginate (Fig. 5). Tergum IX consisting of a pair of well-developed, setose, lateral tergites; sternum IX (spiculum gastrale) (Fig. 6) Y-shaped, with a very short base, c. 0.7× as long as gonoforceps (Figs. 7–8). Gonostyli c. 1.7× length of gonocoxal piece, divided in apical 1/2, fused medially with gonocoxal piece, each gonostylus narrow, sinuate in outline, inflated immediately below apex (Fig. 7). Aedeagus (Fig. 9) 0.8× length of gonoforceps, with a single, relatively small dorsal hook apically, and a robust and pointed ventral endophallic hook.

Female. Non-genitalic features as in male except antennal segments III–XI more robust (Fig. 1), less elongate; length/width of segments I–XI: 2.0, 0.6, 1.3, 1.3, 1.4, 1.6, 1.7, 1.8, 1.8, 1.7, 3.0; XI only c. 1.5× length of I. Sternum VII (5th visible) not noticeably emarginate posteriorly; sternum VIII only slightly emarginate. Tergum IX as in males. Gonocoxites stout, relatively short, shorter than styli, gonostyli c. 5× as long as wide, curving slightly toward midline and widening slightly to apex.

Variation.—Minor variation between holotype and other specimens as follows: (a) gula, maxillae, labium and postocciput orange brown in type; these areas darker brown in other specimens; (b) color of prosternum, mesopleura and forecoxae orange brown in type; these areas vary from orange brown to brown in more recently collected material; (c) head punctation fine and sparse in type, whereas finely but densely punctuate in other specimens; (d) in the type the pronotal setae are yellow and sparse on the black area at middle of disk; these setae are black in the other specimens. The latter difference may be attributable to fading over time in the type.

Geographic distribution.—Southern Brazil; states of Paraná (see Material Examined) and Rio de Janeiro (Denier 1940).

Hosts.—Larvae associated with *Monoeca haemorrhoidalis* (Apidae); adult host plants unknown.

DISCUSSION

The examination of recently collected material as well as the holotype of *Tetraolytta gerardi* supports transfer of this enigmatic species to the Tetraonycinae. Earlier placement in Meloinae was prompted by phenetic similarity to South American lyttine genera, i.e., *Megalytta* Selander. However the bilobed tarsal segments and fusion of the gonostyli with the gonocoxal piece in males alone are two tetraonycine synapomorphies separating *Tetraolytta* from all Meloinae.

Among the four genera of Tetraonycinae, *Tetraolytta* is most easily separated from *Meloetyphlus* and *Opiomeloe*. The latter two are characterized by Selander (1965, 1985). Wing and eye structure is distinct in these taxa. *Meloetyphlus* lacks eyes, and has strongly abbreviated elytra and vestigial hind wings (Selander 1965). In *Opiomeloe* compound eyes are present but are relatively small and clearly separated from the base of the mandibles, and its hind wings are abbreviated, narrow, with reduced venation and unfolded (Selander 1985). *Tetraolytta* is most similar to *Tetraonyx*. Characters separating *Tetraolytta* from the vast majority of *Tetraonyx* include those that provide *Tetraolytta* its phenetic similarity to lycid beetles, specifically the more elongate, narrower body form, the longer and heavier antennae with well-separated segments, and the more planate and posteriorly expanded elytra. This contrasts with most *Tetraonyx* species which are robust beetles with considerably shorter often subclavate antennae with closely appressed segments, and convex, posteriorly tapering elytra. Other distinct differences in *Tetraolytta*, include the considerably longer and apically narrowed antennal segment XI, the smooth frontal bulla on the head, and the apically rounded lateral margins of the pronotal disk.

When discussing the possible tetraonycine affinity of *Tetraolytta gerardi*, Pinto and Bologna (1999) suggested a relationship to *Tetraonyx distincticollis* Pic 1916, a Brazilian species constituting the monotypic subgenus *Paratetraonyx* Kaszab, 1958. This purported relationship was based on comparisons from the literature. Upon examination of specimens of *T. distincticollis*, including the type (Muséum National d'Histoire Naturelle), we find little in common with *T. gerardi*. The only noteworthy similarity is the elongate first tarsomere of the middle and hind legs. In both species tarsomere I of the hind leg is subequal to half the entire tarsal length. This segment generally is considerably shorter in *Tetraonyx*. Although likely to be a derived feature, the lack of correspondence in other traits suggests convergence. Interestingly, both species have been collected together, parasitizing the same species of bee (L. Correia da Rocha Filho and J. Rozen, personal communication.).

Of greater interest are the two *Tetraonyx* species *T. superbus* Pic 1915 and *T. lycoides* Selander and Martinez, 1984, also assumed to be lycid mimics. In these species, as in *Tetraolytta gerardi*, the elytra are flared posteriorly which provides much of the lycid phenotype. Unfortunately both are known from single female specimens which we have not studied. Both species are separated from *T. gerardi* by color pattern, pronotal dimensions and size, and antennal structure. Unlike *T. gerardi*, both *Tetraonyx* have yellow markings on the legs and head. Furthermore, in *T. superbus* the elytra are costate; and in *T. lycoides* the head is divergent above the eyes and widest at the tempora, and the margins of the pronotal disk are not rounded at its apical third. Yet, *T. lycoides* at least, has certain interesting similarities to *T. gerardi*. In both species the antennae are decidedly atypical of *Tetraonyx*; they are longer, heavier, narrowing somewhat toward the apex, and in *T. lycoides*, subserrate. Also segment XI, although longer in *T. gerardi*, is abruptly narrowed distally in both species. Head and pronotal structure suggest that these similarities are convergent. General anatomy associates *T. lycoides* with Haag-Rutenberg's (1879) group A, whereas *Tetraolytta* is phenetically more similar to his group C.

Tetraolytta is inadequately separated from *Tetraonyx* at present. Only color pattern combined with the cephalic bulla, relatively narrow tempora, and anteriorly rounded pronotal disk margins will separate it from all *Tetraonyx* species known to us. Consequently, *Tetraolytta* may eventually be shown to be a derived lineage of *Tetraonyx* and that genus recognition renders the latter paraphyletic. We are not aware of any derived features of *Tetraonyx* that differentiate it from the other tetraonycine genera. Because *Tetraonyx* is such a large and poorly known genus it is impossible at present to provide a strong argument for or against generic separation of *Tetraolytta*. The same can be said for recognition of *Meloetyphlus* and *Opiomeloe*, the two other tetraonycine genera which may also be derived from *Tetraonyx* (see Selander 1985). Pending a better understanding of *Tetraonyx* diversity and a phylogenetic analysis of the subfamily we continue to tentatively recognize all four genera as distinct.

ACKNOWLEDGMENTS

We thank Claude Girard, Muséum National d'Histoire Naturelle, for examination of the Pic Collection, and Otto Merkl, Hungarian Natural History Museum, for examination of the Kaszab

Collection. We also are grateful to Jerry Rozen (American Museum of Natural History, New York) for the gift of specimens of *Tetraonyx distincticollis* as well as to Léo Correia da Rocha Filho (Universidade Federal do Paraná, Curitiba) for the recently collected specimens of *Tetraolytta gerardi* and host information. Marta Bologna and Andrea Di Giulio helped with the arrangement of figures.

LITERATURE CITED

Bologna, M. A. and J. D. Pinto. 2001. Phylogenetic studies of Meloidae (Coleoptera), with emphasis on the evolution of phoresy. Systematic Entomology 26: 33–72.

Denier, P. 1933a. Documentos para la classificación de los Meloidos Americanos. Boletin Menusel del Ministerio de Agricultura de la Nación 32: 35–52.

———. 1933b. Contibución al estudio de los Meloidos Americanos. Revista Chilena de Historia natural 37: 237–246.

———. 1935. Coleopterorum Americanorum familiae Meloidarum enumeration synonymica. Revista de la Sociedad Entomologica Argentina 6: 139–176.

———. 1940. Description de *Lytta neivai*, n. sp., du Brésil et notes sur quelques *Lytta* F. de l'Amérique du Sud (Col., Meloidae). Revista de Entomologia 11: 799–802.

Haag-Rutenberg, J. G. 1879. Beiträge zur Kenntniss der Canthariden. I. *Tetraonyx*. Stettiner Entomologische Zeitung 40: 249–275, 287–314.

Kaszab, Z. 1959. Phylogenetische Beziehungen des Flügelgeäders Meloiden (Coleoptera), nebst Beschreibung neuer Gattungen und Arten. Acta Zoologica Academiae Scientiarum Hungaricae 5: 67–114.

MacSwain, J. W. 1956. A classification of the first instar larvae of the Meloidae (Coleoptera). University of California Publications in Entomology 12: 1–182.

Pic, M. 1919. Coléoptères exotiques en partie nouveaux. L'Échange 35(391): 2–3.

Pinto, J. D. and M. A. Bologna. 1999. The New World Genera of Meloidae (Coleoptera): A key and synopsis. Journal of Natural History 33: 569–619.

Selander, R. B. 1965. The systematic position of *Meloetyphlus*, a genus of blind blister beetles (Coleoptera: Meloidae). Journal of the Kansas Entomological Society 38: 45–55.

———. 1983. An annotated catalogue of blister beetles of the tribe Tetraonycini (Coleoptera, Meloidae). Transactions of the American Entomological Society 109: 277–293.

———. 1985. A new genus of blister beetles linking *Meloetyphlus* with *Tetraonyx* (Coleoptera: Meloidae). Journal of the Kansas Entomological Society 58: 611–619.

Selander, R. B. and A. Martinez. 1984. A synopsis of the genus *Tetraonyx* in Argentina (Coleoptera: Meloidae). Proceedings of the Entomological Society of Washington 86: 913–929.

Selander, R. B. and T. C. Selander. 1992. A new species and new records of *Tetraonyx* from Argentina (Coleoptera, Meloidae). Journal of the Kansas Entomological Society 65: 357–368.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 773–778

STRINGASPIDIOTUS MACGILLIVRAY (HEMIPTERA: COCCOIDEA: DIASPIDIDAE) A NEW SYNONYM OF *PSEUDAONIDIA* COCKERELL, WITH A REDESCRIPTION OF THE TYPE SPECIES

DOUGLAS J. WILLIAMS AND DOUGLASS R. MILLER

(DJW) Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.; (DRM) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, Building 005, BARC-West, Beltsville, MD 20705, U.S.A. (e-mail: douglass.miller@ars.usda.gov)

Abstract.—The genus *Stringaspidiotus* MacGillivray, 1921 is synonymized with *Pseudaonidia* Cockerell, 1897 as a junior subjective synonym (**new synonymy**) and the type species of *Stringaspidiotus* (*Aspidiotus* (*Pseudaonidia*) *curculiginis* Green) is redescribed and illustrated.

Key Words: armored scale, *Furcaspis*, synonym, *Pseudaonidia*, description

While writing a revision of the genus *Furcaspis* Lindinger (see Williams et al. 2006), we noted that the monotypic genus *Stringaspidiotus* MacGillivray had been synonymized with *Furcaspis* by earlier authors. After examination of the type species, *S. curculiginis* (Green), we concluded that it is not a species of *Furcaspis* and should not be included in our study. However, it seems appropriate to present the results of our analysis concerning the placement of the genus and species in a separate publication. The purpose of this paper is to illustrate and redescribe the species *S. curculiginis* and to provide evidence supporting our hypothesis that *Stringaspidiotus* is a junior synonym of *Pseudaonidia* Cockerell.

The genus *Stringaspidiotus* MacGillivray (1921), at present includes the single species *S. curculiginis*, described originally as *Aspidiotus* (*Pseudaonidia*) *curculiginis* by Green (1904) from Java. MacGillivray also included *Aspidiotus articulatus* var. *celastri* Maskell described from South Africa by Maskell (1897) (later included in the genus *Selenaspidus* Cockerell by Fernald (1903)). At the same time MacGillivray synonymized *S. ferox* Lindinger with *S. celastri*. Mamet (1958) discovered that MacGillivray's concepts of *F. celastri* were not correct and redescribed *F. celastri* and *F. ferox* as separate species in *Selenapidus*, thus leaving *Stringaspidiotus* as monotypic.

Lindinger (1909) included *A.* (*Pseudaonidia*) *curculiginis* in the genus *Furcaspis* Lindinger. Although Ferris (1937) listed the type species of *Stringaspidiotus* as *Aspidiotus curculiginis*, he illustrated Green's species as *Stringaspidiotus curculiginis* and remarked that *Stringaspidiotus* was very doubtfully distinct from *Furcaspis*. When Balachowsky (1958) described the subtribe Furcadaspidina (of the tribe Aspidiotini Westwood), he included five genera: *Furcaspis* (type species *Aspidiotus biformis* Cockerell), *Neofurcaspis* Green (type species *N. andamanensis* Green), *Paraonidiella* MacGillivray (type species *Aspidiotus cladii* Maskell), *Separaspis* MacGillivray (type species *Furcaspis*

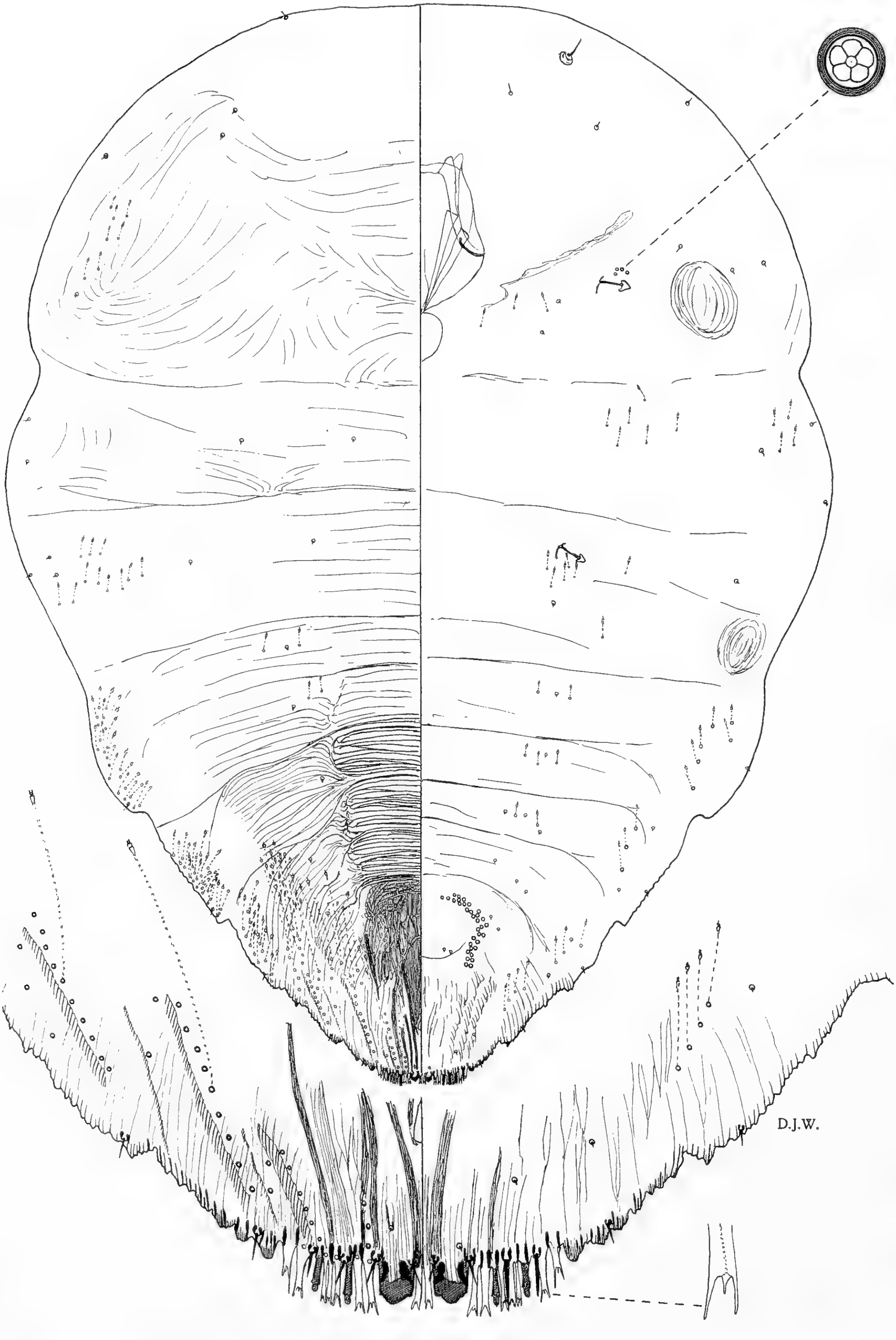


Fig. 1. Adult female *Pseudaonidia curculiginis*. Indonesia, Java, Buitenzorg (Bogor), on leaves of *Curculigo recurvata*.

proteae Brain) and *Tollaspidiotus* MacGillivray (as *Tallaspidiotus*) (type species *Aspidiotus* (*Chrysomphalus*) *mauritianus* Newstead). Borchsenius (1966) accepted the subtribe and added *Stringaspidiotus* to it, and Ben-Dov and German (2003) regarded *Stringaspidiotus* as a separate genus within the subfamily Aspidiotinae.

In a comprehensive study of the genus *Furcaspis*, Williams et al. (2006), regarded the genera *Neofurcaspis*, *Paraonidiella*, *Separaspis* and *Tollaspidiotus* as being identical to *Furcaspis* and commented that *Stringaspidiotus* should be placed in the subtribe Pseudaonidiina Balachowsky because the lobes have lateral notches (rounded in *Furcaspis*) and the antennae have only a single long seta (usually 3–6 in *Furcaspis*). Furthermore, the plates in *Furcaspis* are bifurcate, or rarely trifurcate, and lack fringing but there is always a membranous area between the tines, described by Balachowsky (1958) as an intermediate hyaline membrane. In *Stringaspidiotus*, the tines of the plates are well separated without the inner membrane, and the outermost plates are sometimes fringed laterally.

MATERIALS AND METHODS

Terms used in the description are the same as those used in Williams et al. (2006) and Miller and Davidson (2005) where they are described in detail. The enlargements in the illustration are not to scale. Abbreviations of specimen depositories are: BMNH, The Natural History Museum, Cromwell Road, London SW7 5BD, UK; UPBL, Entomological Museum, Museum of Natural History, University of the Philippines at Los Baños, Laguna, Philippines; USNM, National Entomological Collection, National Museum of Natural History, scale collection at Beltsville, Maryland, U.S.A.

RESULTS

Pseudaonidia curculiginis (Green)
(Fig. 1)

Common Name: Buli Scale

Aspidiotus (*Pseudaonidia*) *curculiginis* Green 1904: 208; Ferris 1941: 42.

Pseudaonidia curculiginis (Green): Marlatt 1908: 137.

Furcaspis curculiginis (Green): Lindinger 1909: 110.

Pseudaonidia circuliginis (Green): Robinson 1917: 33.

Stringaspidiotus curculiginis (Green): MacGillivray 1921: 451.

Aspidiotus curculiginis (Green): Ferris 1937: 52.

Type material.—(Syntypes) Indonesia, Java, Buitenzorg (Bogor), on leaves of *Curculigo recurvata*, coll. N° 33 BMNH (4 mounted adult female specimens and 5 scale covers); same data except note indicating specimens received from Green 7-VIII-1905 USNM (4 first instars, 1 second instar, and 1 adult female on 3 slides).

Field characters.—According to Green (1904): "Female puparium [scale cover] superficially resembling that of *Asp. rossi*. Elliptical, flattish; dark blackish-brown. Pellicles [exuviae] fulvous, slightly raised, with inconspicuous boss and concentric ring, surrounded by a thin whitish line. Inner surface paler brown; ventral scale persisting along the margins. Length, 2–2.50 mm.; breadth, 1.25 to 1.50 mm.

Male puparium [scale cover] similar; but smaller; pellicle [exuviae] nearer the anterior extremity. Length, 1.50 mm.; breadth, 0.80 mm."

Slide-examined characters.—Body of adult female, oval to turbinate, mature specimens moderately sclerotized with marginal indentation between prothorax and mesothorax. Anterior mediodorsal area of pygidium with an areolated pattern; dorsomedial areas of abdominal segments III–V with sclerotized striations, other anterior segments with lightly sclerotized striations; head and prothorax with circular clear areas on dorsal submargin. Lobes numbering 4 pairs. Median lobes sometimes touching or separated by a space about 2 μm wide, each lobe about 15–20 μm wide, sometimes with parallel sides or sides becoming slightly narrower distally, notched singly at each side and with thick paraphyses at base. Second lobes each usually projecting beyond median lobes, noticeably slender, 12–15 μm long, about 2 μm wide at base, expanding distally to about 5 μm wide, notched singly on each side near rounded apex. Third lobes similar to second lobes, usually shorter, 12–15 μm long. Fourth lobes each short, almost triangular, sometimes with deep lateral notch or with only faint notch, apex rounded. Paraphyses short, longest about 10 μm long, between median lobes and lateral margin of fourth lobes. Plates longer than lobes, slender, each usually with 2 long outer tines and a short medial tine; sometimes each outermost plate next to fourth lobe fringed laterally; plate formula 2-3-3 or 2-3-2. Dorsal macroducts slender, decreasing in length anteriorly, sometimes absent or reduced in number in furrows between median and second lobes and between second and third lobes; numbering 37–73 in area forward to abdominal segment V. Anterior macroducts fairly numerous, present as far forward as segment I and others resembling microducts present on margins of prothorax and metathorax. A few dorsal submedial macroducts present on abdominal segments I and II. Ventral submarginal microducts present on segments I–IV and mesothorax and submarginally on thorax and abdominal segments I–III. Perivulvar pores usually in 2 lateral groups, occasionally a lateral group divided into 2 groups; with 22–32 pores on each side. Ventral setae >representing segment VIII shorter than median lobes, those between second and third lobes and between third and fourth lobes, about as long as lobes and unusually thick. Eyes absent. Cicatrices sometimes absent or present on prothorax and abdominal segments I and III. Antennae each with single long seta, 15–20 μm long.

Other specimens examined.—INDONESIA, JAVA, Buitenzorg (Bogor), Botanical Garden, on *Magnolia* sp. (Magnoliaceae), ?-IX-1911, R.S. Woglum (USNM). PHILIPPINES, Palmera, Calabanga, on unknown plant, 19-IV-1969, F.J. Velasquez (BMNH, UPLB); Lanay Morong, Luzon, on *Pinanga barnesii* (Arecaceae), unknown date, A. Loher (USNM); Apayo, Luzon, on *Pinanga* sp., (Arecaceae), ?-V-1917, E. Fenix (USNM); Manila intercepted at San Francisco, on *Cymbidium atropurpureum* (Orchidaceae), 23-IX-1947, J. Foust (USNM); intercepted at San Francisco, on *Gramatophyllum speciosum* (Orchidaceae), 16-VII-1937, R.D. Clemens (USNM); intercepted at San Francisco, on *Cymbidium finlaysonianum* (Orchidaceae), 13-II-1951, 11-II-1948, and III-27-1940, McHatton, Thompson, and Ting (USNM). SINGAPORE, intercepted at Hawaii, on *Calathea* sp. (Marantaceae), 19-VIII-1976, M. Jodoi (USNM). THAILAND, intercepted at Miami, on palm leaf (Arecaceae), 18-III-1977, E.B. Lee (USNM). VANUATU, intercepted at England, Kew, on orchid, 1980 (BMNH). There is an additional slide from Puerto Rico, on *Cocos nucifera* (Arecaceae), 5-II-1997 in the USNM; we are uncertain if these data are correct and need corroboration with additional specimens before suggesting that the species occurs in the Caribbean area.

Discussion

In addition to the specimens examined, Robinson (1917) recorded the species from the Philippines on *Corypha* *elata* (Hypoxidaceae) and Velasquez and Rimando (1969) listed it also from the Philippines (as *Pseudaonidia curculiginis*) and gave it the name "Buli scale." Takahashi 1942 listed it from Malaya, "Fanting Squpah," on *Gardenia* sp. (Rubiaceae), and from Bangkok, Thailand without host data. Danzig and Konstantinova (1990) recorded this species from Vietnam on *Persimmon* sp. (Scrophulariaceae) (this record was listed by Ben-Dov and German (2003) from Mongolia but obviously should have been from Vietnam). Hunt (1939) indicated that the species was intercepted in San Francisco, U.S.A. on orchids from the Philippines.

Cockerell and Robinson (1915) compared *S. curculiginis* with their new species *Pseudaonidia obsita* from the Philippines, and Laing (1929) compared it with *P. baikeae* Newstead when redescribing that species from Sierra Leone.

In possessing slender second and third lobes, *P. curculiginis* is most similar to *P. duplex* (Cockerell) and *P. manilensis* Robinson but the medio-dorsal area in both these species is heavily reticulated. *Pseudaonidia manilensis* differs by having the second and third lobes without notches. *Pseudaonidia curculiginis* differs from all known species of *Pseudaonidia* in possessing heavily-sclerotized striations on abdominal segments III–V.

MacGillivray (1921) proposed the genus *Stringaspidiotus* in a key to genera of the tribe Aspidiotini He characterized the genus by having the pygidium without [conspicuous] paraphyses; pygidium without lattice pattern on dorsum; mesothorax and metathorax separated by a transverse constriction. Other character states important in diagnosing *Stringaspidiotus* include 4 pairs of lobes, second and third lobes often conspicuously narrower than median lobes, lobes with notches, 1 large seta on each antenna, and clear circular areas present on the dorsal surface of the prothorax and head. *Pseudaonidia* shares all of these character states with the exception of the lattice pattern on the dorsum of the pygidium which is well developed and conspicuous on most species in the genus. But even in this character most specimens of *S. curculiginis* have a weakly-developed lattice pattern on the anterior end of the pygidium. Therefore, we consider *Stringaspidiotus* MacGillivray, 1921 (type species *Aspidiotus* (*Pseudaonidia*) *curculiginis* Green 1904) to be a junior subjective synonym of *Pseudaonidia* Cockerell, 1897 (type species *Aspidiotus duplex* Cockerell, 1896), **new synonymy**.

ACKNOWLEDGMENTS

We are grateful to John Davidson (Department of Entomology, University of Maryland, College Park), Gary Miller and Norman Woodley (Systematic Entomology Laboratory, USDA, Beltsville, MD and Washington, DC, respectively) and Michael Williams (Department of Entomology/Plant Pathology, Auburn University, Alabama) for their useful comments and criticisms of the manuscript.

LITERATURE CITED

Balachowsky, A. S. 1958. Les cochenilles du continent Africain Noir. v. 2 Aspidiotini (2me partie), Odonaspidini et Parlatorini. Annales du Musée Royal du Congo Belge (Sciences Zoologiques) 4: 149–356.

Ben-Dov, Y. and V. German. 2003. A systematic catalogue of the Diaspididae (armoured scale insects) of the world, subfamilies Aspidiotinae, Comstockiellinae and Odonaspidinae. Intercept Ltd., Andover. 1,111 pp.

Borchsenius, N. S. 1966. A catalogue of the armoured scale insects (Diaspidoidea) of the world. Moscow and Leningrad, Nauka. 449 pp.

Cockerell, T. D. A. 1896. Preliminary diagnoses of new Coccidae. Psyche, Supplement 7: 18–21.

———. 1897. The San Jose scale and its nearest allies. United States Department of Agriculture, Division of Entomology, Technical Series 6: 1–31.

Cockerell, T. D. A. and E. Robinson. 1915. Descriptions and records of Coccidae. Bulletin of the American Museum of Natural History 34: 105–113.

Danzig, E. M. and G. M. Konstantinova. 1990. On the Coccid fauna (Homoptera, Coccinea) of Vietnam. Trudy Zoologicheskogo Instituta Akademiya Nauk AN SSSR Leningrad 209: 38–52.

Fernald, M. E. 1903. A catalogue of the Coccidae of the world. Bulletin of the Hatch Experiment Station of the Massachusetts Agricultural College 88: 1–360.

Ferris, G. F. 1937. Contributions to the knowledge of the Coccoidea (Homoptera) V. Microentomology 2: 47–102.

———. 1941. The genus *Aspidiotus* (Homoptera: Coccoidea: Diaspididae). Microentomology 6: 33–70.

Green, E. E. 1904. On some Javanese Coccidae: With descriptions of new species. Entomologist's Monthly Magazine 40: 204–210.

Hunt, H. A. 1939. Plant quarantine. Annual Report California Agricultural Experiment Station 28: 548–566.

Laing, F. 1929. Descriptions of new, and some notes on old species of Coccidae. Annals and Magazine of Natural History 4: 465–501.

Lindinger, L. 1909. Beiträge zur Kenntnis der Schildläuse und ihrer Verbreitung. Zeitzschrift für wissenschaftliche Insektenbiologie 5: 105–110.

MacGillivray, A. D. 1921. The Coccidae. Tables for the identification of the subfamilies and some of the more important genera and species together with discussions of their anatomy and life history. Urbana Ill. Scarab Company, 502 pp.

Mamet, J. R. 1958. The *Selenaspidus* complex (Homoptera, Coccoidea). Annales du Musée Royal du Congo Belge. Zoologiques, Miscellanea Zoologica, Tervuren 4: 359–429.

Marlatt, C. L. 1908. The genus *Pseudaonidia*. Proceedings of the Entomological Society of Washington 9: 131–141.

Maskell, W. M. 1897 (1896). Further coccid notes: With descriptions of new species and discussions of points of interest. Transactions and Proceedings of the New Zealand Institute 29: 293–331.

Miller, D. R. and J. A. Davidson. 2005. Armored Scale Insect Pests of Trees and Shrubs. Cornell University Press, Ithaca, New York. 442 pp.

Robinson, E. 1917. Coccidae of the Philippine Islands. Philippine Journal of Science (Ser. D) 12: 1–47.

Takahashi, R. 1942. Some injurious insects of agricultural plants and forest trees in Thailand and Indo-China. II. Coccidae. Report. Government Research Institute. Department of Agriculture. Formosa 81: 1–56.

Velasquez, F. J. and L. Rimando. 1969. A check list and host index of the armored scale insects of the Philippines (Diaspididae: Homoptera). Philippine Entomologist 1: 195–208.

Williams, D. J., D. R. Miller, and A. Rung. 2006. A systematic revision of the armored scale genus *Furcaspis* Lindinger (Diaspididae; Coccoidea; Hemiptera). Contributions of the American Entomological Institute 34(5): 1–86.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 779–790

A KEY TO NORTH AMERICAN SPECIES OF *TRIOXYS* HALIDAY (HYMENOPTERA: BRACONIDAE: APHIDIINAE), WITH A SUMMARY OF THE GEOGRAPHIC DISTRIBUTION, HOSTS, AND SPECIES DIAGNOSTIC FEATURES

J. L. Fulbright, K. S. Pike, and P. Starý

(JLF, KSP) Entomologists, Washington State University, Irrigated Agriculture Research and Extension Center, 24106 N. Bunn Road, Prosser, WA 99350, U.S.A. (e-mail: kpike@wsu.edu); (PS) Entomologist, Institute of Entomology, Academy of Sciences of the Czech Republic, Branišovská 31, 370 05 České Budějovice, Czech Republic

---

Abstract.—A key to North American species of *Trioxys* (Hymenoptera: Braconidae: Aphidiinae) is provided along with summary tables on geographic origin, distribution, hosts, and diagnostic features. Accompanying the key are illustrations of the anterior portion of the forewing (stigma, R1 and Rs veins), propodeum, petiole, and genitalia, including the seventh metasomal sternite prongs and ovipositor sheaths.

Key Words: Aphidiinae, aphid, key, parasitoid, *Acanthocaudus*, *Betuloxys*, *Binodoxys*, *Trioxys*

Trioxys Haliday 1833, and other genera in Aphidiinae (Hymenoptera: Braconidae), include larval endoparasitoids of aphid nymphs and adults. There are over 70 species in *Trioxys* worldwide (Smith 1944; Mackauer 1959, 1960, 1961, 1965, 1967; Takada 1966, 1979; Starý and Schlinger 1967; Starý 1969, 1976, 1978, 1979; Carver and Starý 1974; Starý and Remaudière 1977, 1982; Starý and Bhagat 1978; Starý and Juchnevič 1978; Marsh 1979; Starý and Marsh 1982; Gärdenfors 1990; Mescheloff and Rosen 1993; Starý and Zuparko 1995; Pike et al. 2000; Chen and Shi 2001; Tomanović and Kavallieratos 2002; Davidian 2005; Fulbright and Pike 2007).

Few keys exist for distinguishing North America aphidiines, and none are comprehensive for *Trioxys*. An early key by Gahan (1911) recognized four species of *Trioxys*, Smith (1944) recognized 11 species, and since then *Trioxys* has been broken into several distinct genera or subgenera (Mackauer 1960, Mackauer 1965, Starý and Schlinger 1967, Starý 1981, Starý and Remaudière 1982, van Achterberg 1997, Chen and Shi 2001, Davidian 2005). Keys have been developed for individual aphidiine genera in North America, including Johnson's (1987) key to *Praon* Haliday, and Pike et al.'s (1999) key to *Ephedrus* Haliday. Keys specific to certain plant-aphid associations also exist, such as a key to the small grain aphid parasitoids (Pike et al. 1997a). An updated review of aphid parasitoids of the Pacific Northwest USA (Pike et al. 2000) brought together extensive information on tritrophic associations and descriptions of new species, including species of *Trioxys*, but no keys were presented.

Trioxys can be recognized by the female's distinctive paired prongs, which are extensions of the seventh metasomal sternite, and the petiole bearing spiracular tubercles only. Four other aphidiine genera in North America, *Acanthocaudus* Smith, *Betuloxys* Mackauer, *Binodoxys* Mackauer, and *Cristicaudus* Starý and Remaudière, also possess metasomal sternite prongs. *Acanthocaudus*, *Binodoxys*, and *Cristicaudus* differ in having secondary, as well as spiracular tubercles, on the petiole. *Betuloxys* bears only spiracular tubercles, but the apical portions of the prongs are differentiated, dilated, and bear several lanceolate, perpendicular setae on the dorsal surface. *Acanthocaudus* further differs from *Trioxys*, *Betuloxys*, *Binodoxys*, and *Cristicaudus* in having a secondary projection on its prongs (Starý 1981).

Species within *Trioxys* can be distinguished by one or more of the following features: propodeal areola presence or absence, antennal flagellomere number, metasomal sternite prong shape and length, prong dorsal and ventral setae number, prong apical bristle type and number, ovipositor sheath shape, and forewing stigma and R1(=metacarpus) length. Information on host specificity is also helpful for species differentiation. The North American and world distributions, as well as host aphid associations of each species, as presently recognized, are provided in the paper.

Materials and Methods

Material examined.—*Trioxys* species examined were from authors' field collections and museum loans. Numbers of specimens examined and location are as follows : *T. ameraceris* – type USNM (National Museum of Natural History, Washington), 2 paratypes Czech (Czech Academy of Sciences, P. Starý collection); *T. artemisiarum* – type USNM, 24 paratypes [19 WSU (Washington State University-Prosser), 3 Czech and 2 USNM]; *T. auctus* – 2 UCB (University of California-Berkeley), 1 Czech; *T. betulae* – 5 Czech; *T. bonnevillensis* – 156 WSU, 20 Czech; *T. californicus* – type UCB; *T. cirsii* – 1 WSU, 1 Czech; *T. complanatus* – 21 WSU, 11 Czech; *T. curvicaudus* – 20 UCB, 5 WSU, 11 Czech; *T. exareolatus* – type USNM; *T. gahani* – type USNM, 2 WSU; *T. ibis* – 2 Czech; *T. infrequens* – type USNM; *T. latgei* – 6 Czech; *T. mexicanus* – 2 Czech; *T. monelliopsis* – 3 Czech; *T. pallidus* – 261 WSU, 35 Czech; *T. rosae* – type USNM, 6 paratypes [4 WSU, 6 Czech, 2 USNM]; *T. setaceus* – type USNM, paratypes (3 WSU, 2 Czech); *T. sunnysidensis* – type USNM, 40 paratypes [WSU 26, 8 USNM, 6 Czech]; *T. tenuicaudus* – 2 WSU, 1 Czech). Authors' collections were preserved in 70–95% ETOH, some as whole mounts on pointed or rectangular paper tabs, and some as whole and/or dissected mounts on glass slides.

Slide mounted whole specimen preparation.—Parasitoids were cleared and mounted using techniques by P. Starý, and modified by G. Graf of Washington State University as follows: (1) parasitoid immersed in 95% ETOH; (2) specimen transferred to new test tube of water and inverted several times; (3) water decanted and specimen placed in test tube of 10% KOH; (4) test tube placed in heating block for approximately 2 minutes at 98°C (heating time varied depending on sclerotization and state of specimen; dry materials required more time); (5) specimen removed from KOH, placed in test tube of water and washed and inverted several times to rinse off KOH; (6) specimen placed in 3 drops of mounting medium (200 g gum arabic, 550 g chloral hydrate, 60 ml glycerin, and 400 ml distilled water mixed and filtered through glass wool) and positioned; (7) coverslip placed over specimen; (8) code number written on slide and slide allowed to dry horizontally for 2–3 weeks on slide warmer at 50°C; (9) mount sealed around coverslip with glyptal, an alkyd-based sealant, to prevent dehydration and crystallization (Pike et al. 2003); and (10) slide fully labeled.

Parasitoid dissection.—Specimens were sometimes dissected for better feature viewing after placement in mounting medium as follows: (1) head cut from body with antennae attached or separated; (2) mesonotum separated from body with wings attached or separated; (3) propodeum separated from body, petiole sometimes left connected to propodeum in smaller specimens; (4) hind legs separated from body; (5) metasoma cut and positioned for (a) dorsal view of petiole and (b) posterior view of metasoma, including lateral view of genitalia; and (6) genitalia removed from metasoma if not protruding or visible.

Slide mounted specimen measurements.—Whole and dissected mounts were reticle measured using a compound microscope at magnifications of 50–400×.

Dry mounted specimens.—Whole mounts were placed on pin-pointed or rectangular paper tabs.

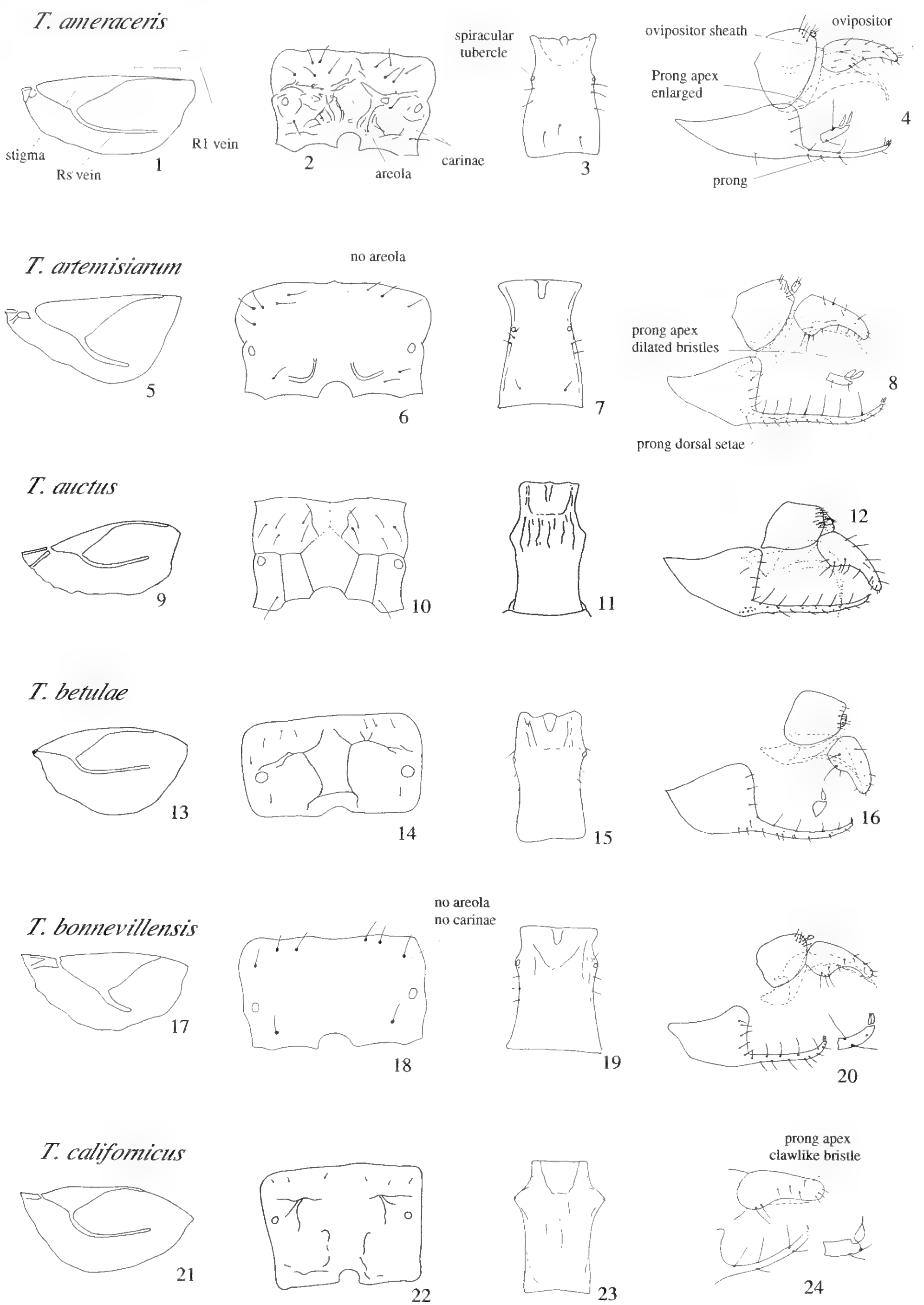
Illustrations.—Line drawings of many specimens were based on features captured with a Nikon Coolpix 990™ digital camera through an Olympus SZX12™ dissecting microscope or with a DEC13M™ digital eyepiece camera through a Zeiss Axiolab™ compound microscope. Illustrations of the wing, propodeum, petiole, genitalia and associated structures were provided for each species. For some rare species, illustrations were drawn from the type, i.e., *T. californicus* from the University of California Essig Museum of Entomology, and *T. exareolatus*, *T. gahani*, and *T. infrequens* from the National Museum of Natural History, Washington, DC. Other species were drawn from the type, paratype or other material, or redrawn after previously published drawings. Figs. 1–4, 7, 13, 17–23, 25–35, 37–52, 61–66b, 67, 77–84 were authors' original drawings; Fig. 50 was authors' conceptual illustration of the propodeum based on the original description (Smith 1944); Figs. 5, 6, and 8 were redrawn after Pike et al. 1997b; Fig. 9 after Mackauer 1959; Fig. 10 after Takada 1966; Figs. 11–12, 36 after Starý 1976; Fig. 14 after Tomanović and Kavallieratos 2002; Figs. 15–16 after Starý 1979; Fig. 24 after Starý and Zuparko 1995; Figs. 53–56 after Starý and Remaudière 1977; Figs. 57–60 after Starý and Remaudière 1982; Figs. 66c, 68 after Starý 1978; Figs. 69–72 after Pike et al. 1996; and Figs. 73–76 after Pike et al. 2000.

Terminology.—Descriptive morphology was after Sharkey and Wharton (1997).

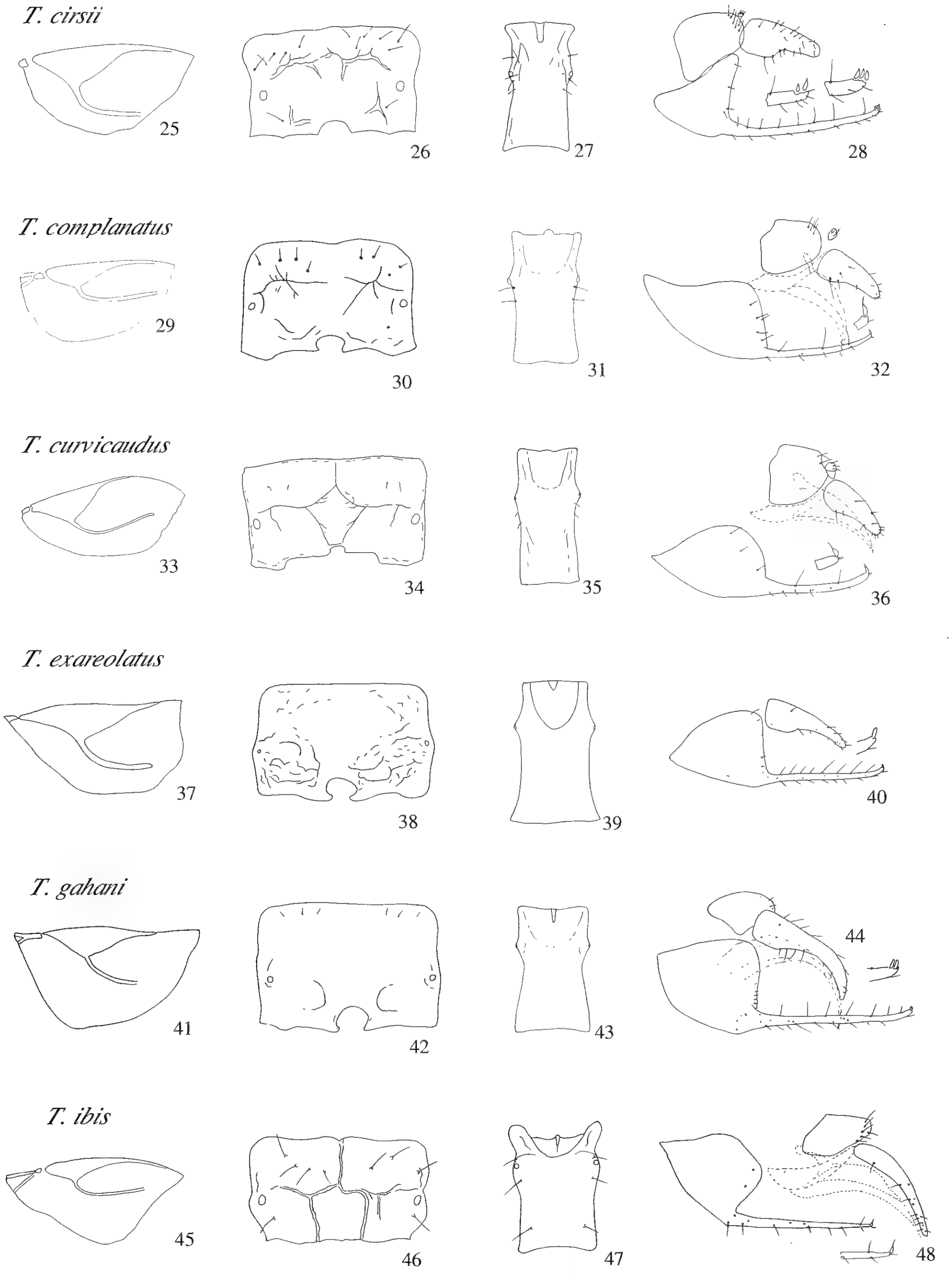
RESULTS AND DISCUSSION

A listing of aphidiine parasitoids of North America can be found in Marsh (1979). Research within the past decade (Pike et al. 1996, 1997a, 2000) has supplemented the listing of taxa and aphid host range information. Table 1 summarizes the full listing of North American species of *Trioxys*. Host range, faunal composition, and ecology of *Trioxys* parasitoids for much of North America have not been explored thoroughly. As indicated in the introduction, there is a lack of updated keys for many genera of Aphidiinae, including *Trioxys*. Table 2 outlines distinguishing characters used in the key.

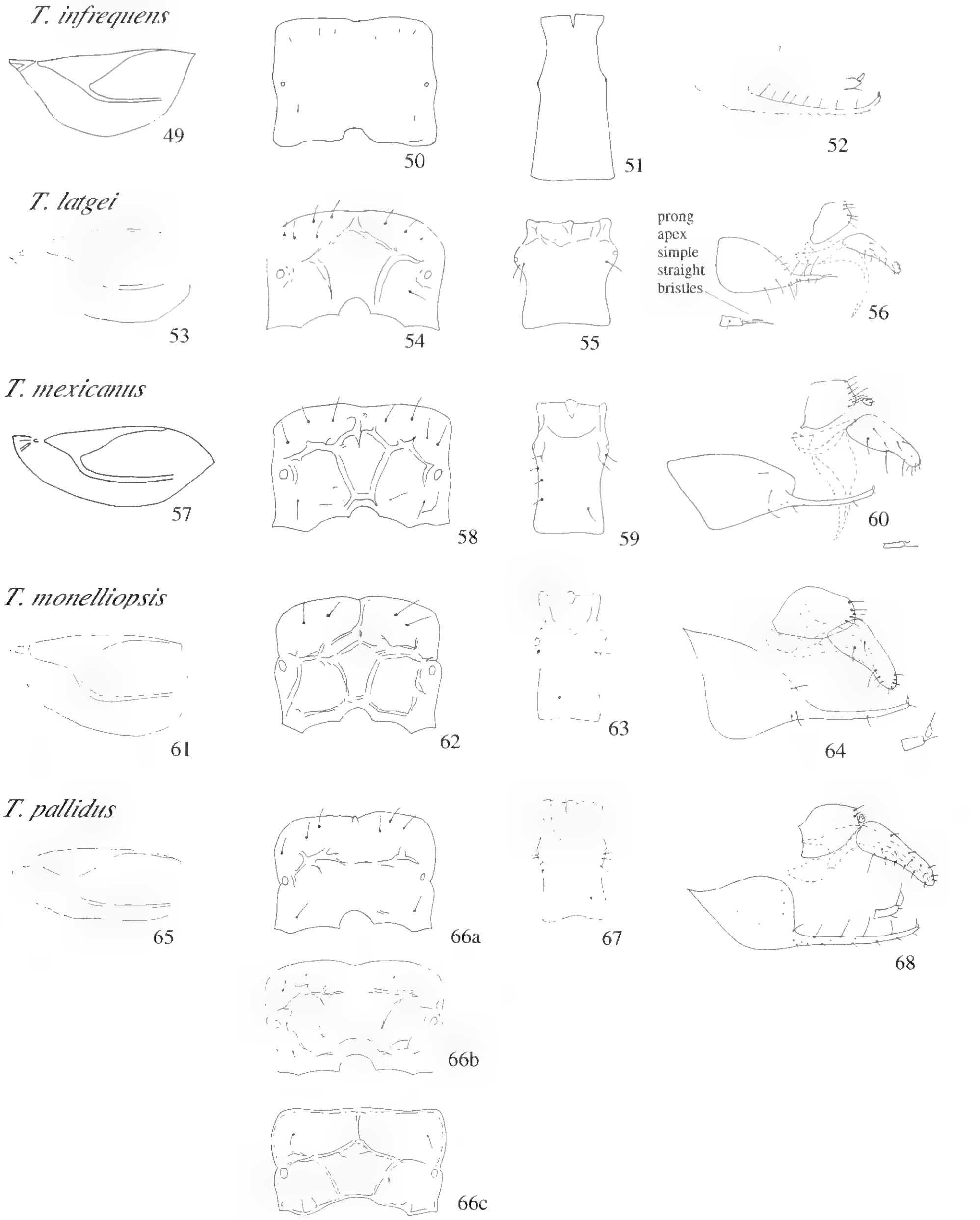
The North American *Trioxys* fauna is currently comprised of 22 species, 15 native and 7 introduced (Table 1). Members of the genus are associated with assorted groups of aphids in arboricolous, grassy riparian, sagebrush, and selected agroecosystem habitats. Eleven species of *Trioxys* utilize aphids in Myzocallidinae and Drepanosiphinae, most of which are arboricolous (i.e., aphids on alder, birch, crepe myrtle, elm, hazel, linden, maple, oak, pecan,



Figs. 1–24. *Trioxys* morphological features [columns 1, 2, 3, and 4 (left to right) = wings (part only), propodea, petioles, genitalia (includes last metasomal sternite prong and ovipositor sheath), respectively]. 1–4, *T. ameraceris*. 5–8, *T. artemisiarum*. 9–12, *T. auctus*. 13–16, *T. betulae*. 17–20, *T. bonnevillensis*. 21–24, *T. californicus*.

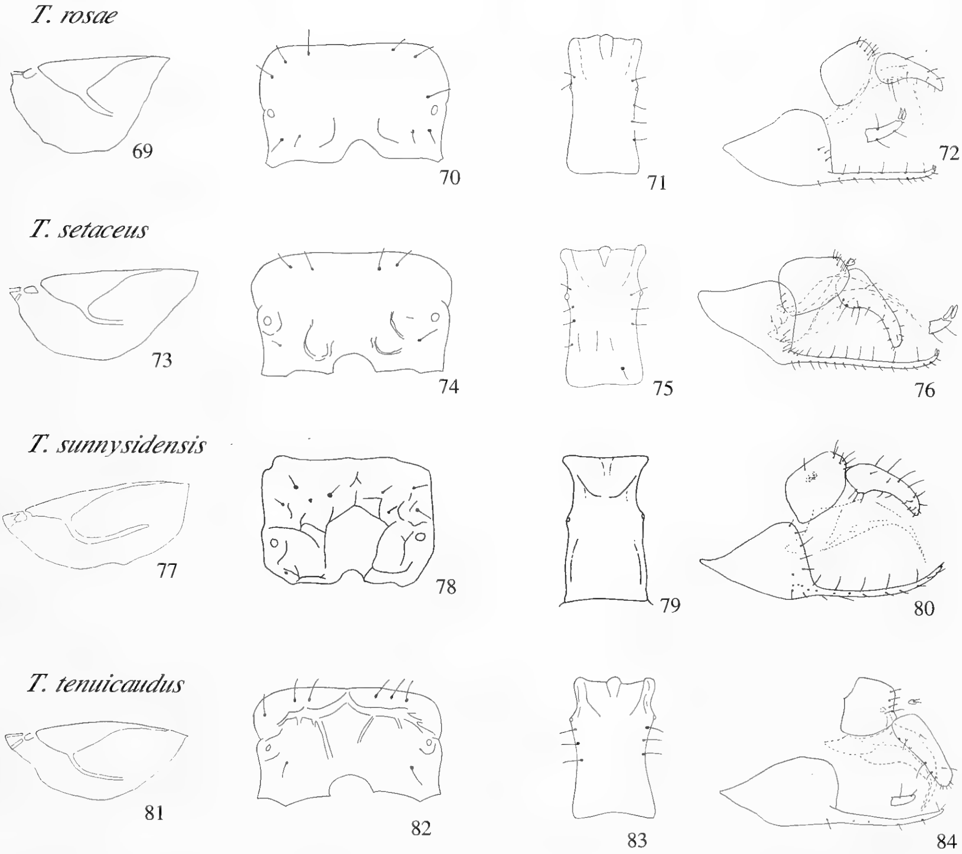


Figs. 25–48. *Trioxys* morphological features [columns 1, 2, 3, and 4 (left to right) = wings (part only), propodea, petioles, genitalia (includes last metasomal sternite prong and ovipositor sheath), respectively. 25–28, *T. cirsii*. 29–32, *T. complanatus*. 33–36, *T. curvicaudus*. 37–40, *T. exareolatus*. 41–44, *T. gahani*. 45–48, *T. ibis*.



Figs. 49–68. *Trioxys* morphological features [columns 1, 2, 3, and 4 (left to right) = wings (part only), propodea, petioles, genitalia (includes last metasomal sternite prong and ovipositor sheath), respectively. 49–52, *T. infrequens*. 53–56, *T. latgei*. 57–60, *T. mexicanus*. 61–64, *T. monelliopsis*. 65–68, *T. pallidus*.

and walnut). *Trioxys complanatus* Quilis uses a myzocallidine aphid on alfalfa, viz. the spotted alfalfa aphid, *Therioaphis trifolii* (Monell) (Table 1). Nine species of *Trioxys* attack solely aphids in Aphidiinae as follows: *T. auctus* (Haliday) on water lily aphid, *Rhopalosiphum nymphaeae* (L.) and bird cherry-oat aphid, *R. padi* (L.); *T. sunnysidensis* Fulbright and Pike on bird cherry-oat aphid; *T. artemisiarum* Pike and Starý and *T. bonnevillensis* Smith on sage aphids, *T. exar-*



Figs. 69–84. *Trioxys* morphological features [columns 1, 2, 3, and 4 (left to right) = wings (part only), propodea, petioles, genitalia (includes last metasomal sternite prong and ovipositor sheath), respectively. 69–72, *T. rosae*. 73–76, *T. setaceus*. 77–80, *T. sunnysidensis*. 81–84, *T. tenuicaudus*.

eolatus Viereck and *T. rosae* Pike and Starý on rose aphids; *T. gahani* Smith on blueberry aphid, *Ericaphis scammelli* (Mason) and *Chaetosiphon*; *T. latgei* Starý and Remaudière on juniper aphid, *Sanbornia juniperi* Pergande; and *T. setaceus* Pike and Starý on serviceberry aphid, *Acyrthosiphon macrosiphum* (Wilson) (Table 1). For two species of *Trioxys*, *T. infrequens* Smith and *T. ovalis* (Provancher), the hosts are unknown. Of the *Trioxys* species accidentally or purposely introduced into North America [*T. auctus* (Haliday), *T. betulae* Marshall, *T. cirsii* (Curtis), *T. complanatus* Quilis, *T. ibis* Mackauer, *T. pallidus* (Haliday), and *T. tenuicaudus* Starý], some have become adapted or partially adapted to native and/or long established introduced aphids.

Parasitoid determinations should be based on multiple factors whenever possible. Parasitoids which have been identified through the key should be checked against primary distinguishing features (Table 2), compared to the illustrations, and checked against the host aphid and distributional records where available.

Success in identifying parasitoids is facilitated when quality and quantity material are available. Freshly reared, cleared and mounted specimens are best. One of the challenges in making determinations with confidence is being able to see the key features. With point-

Table 1. *Trioxys* of North America: origin, hosts, North American distribution.

Species	Origin	Host Aphids Subfamily (Genus)	Reported Distribution
ameraceris Smith 1944	Nearctic	Drepanosiphinae (*Drepanaphis*)	E. Can., E. USA (Smith 1944, Marsh 1979)
artemisiarum Pike and Starý 1997	Nearctic	Aphidinae [*Aphis* (*Zyxaphis*), *Microsiphoniella*]	WA (Pike and Starý 1997b)
auctus (Haliday 1833)	Palearctic	Aphidinae (*Rhopalosiphum*)	E. Can. (QC)
betulae Marshall 1896	Palearctic	Myzocallidinae (*Calaphis*, *Clethrobius*, *Symydobius*)	E. Can. (NB, ON, QC.), NH (Marsh 1979)
bonnevillensis Smith 1944	Nearctic	Aphidinae (sage aphids[1])	ID, WA, UT, Mexico (Smith 1944, Starý and Remaudière 1982, Pike et al. 2000)
californicus Starý and Zuparko 1995	Nearctic	Myzocallidinae (*Eucallipterus*)	CA (Starý and Zuparko 1995)
cirsii (Curtis 1831)	European	Drepanosiphinae (*Drepanosiphum*)	WA (Pike et al. 2000)
complanatus Quilis 1931	Eurasian	Myzocallidinae (*Therioaphis*)	Can., USA (Marsh 1979, Pike et al. 2000)
curvicaudus Mackauer 1967	Nearctic	Myzocallidinae (*Eucallipterus*, *Tuberculatus*)	CA (Mackauer 1967, Starý 1978)
exareolatus Viereck 1916	Nearctic	Aphidinae (*Macrosiphum*)	CT (Viereck 1916, Marsh 1979)
gahani Smith 1944	Nearctic	Aphidinae (*Ericaphis*, *Chaetosiphon*)	NJ, WA (Smith 1944, Marsh 1979)
ibis Mackauer 1961	European	Myzocallidinae (*Betulaphis*)	E. Can. (NB) (Mackauer 1961, Marsh 1979)
infrequens Smith 1944	Nearctic	Unknown	W. Can., CO (Marsh 1979)
latgei Starý and Remaudière 1977	Nearctic	Aphidinae (*Sanbornia*)	ME (Starý and Remaudière 1977)
mexicanus Starý and Remaudière 1982	Nearctic	Myzocallidinae (*Myzocallis*)	Mexico (Starý and Remaudière 1982)
monelliopsis Starý and Marsh 1982	Nearctic	Myzocallidinae (*Monelliopsis*)	GA (Starý and Marsh 1982)
ovalis (Provancher 1886)	Nearctic	Unknown[2]	E. Can. (Smith 1939, 1944, Marsh 1979)
pallidus (Haliday 1833)	Palearctic	Myzocallidinae (tree aphids[3])	W. USA (Marsh 1979, Pike et al. 2000)
rosae Pike and Starý 1996	Nearctic	Aphidinae (*Macrosiphum*)	WA (Pike et al. 1996, 2000)
setaceus Pike and Starý 2000	Nearctic	Aphidinae (*Acyrthosiphon*)	MT, WA (Pike et al. 2000)
sunnysidensis Fulbright and Pike 2007	Nearctic	Aphidinae (*Rhopalosiphum*)	WA (Fulbright and Pike 2007)
tenuicaudus Starý 1978	Palearctic	Myzocallidinae (*Eucallipterus*, *Myzocallis*, *Tinocallis*, *Tuberculatus*)	WA (Starý 1978, Pike et al. 2000)

[1] *Aphis* (*Zyxaphis*), *Artemisaphis*, *Epameibaphis*, *Flabellomicrosiphum*, *Microsiphoniella*, *Obtusicauda*, *Pleotrichophorus*, *Pseudoepameibaphis*.

[2] Reared from an aphid on *Helianthus* sp. (Smith 1939).

[3] *Chromaphis*, *Eucallipterus*, *Hoplocallis*, *Monelliopsis*, *Myzocallis*, *Panaphis*, *Tinocallis*, *Tuberculatus*.

mounted specimens on pins, it is not always possible to see or see clearly all of the distinguishing characters used in the key. Clearing and slide mounting representative specimens is recommended, if not essential. Slide mounts, when properly sealed and labeled, become permanent holdings and are easily viewable.

Key to Female *Trioxys* of North America

[*Trioxys ovalis* (Provancher) de-

Table 2. *Trioxys* of North America: Antennal segment no., prong dorsal setae no., prong apical bristle type and no., and propodeal sculpture.

Species	Antennal Segment No.	Dorsal Setae No.	Apical Bristle Type	Apical Bristle No.	Propodeal Sculpture
ameraceris	11, 12 (rarely)	1–3	dilated	2	areola
artemisiarum	12	7	dilated	2	largely smooth, divergent posterior carinae
auctus	12	4–6	simple, straight	2	areola
betulae	11	2–6	claw	1	areola
bonnevillensis	11	4–5	dilated	2	smooth
californicus	13	3	clawlike	1	some carinae
cirsii	11	6–8	dilated	2 or 3	areola, may be incomplete
complanatus	11	2–4	clawlike	1	some carinae
curvicaudus	11	2–5	clawlike	1	areola
exareolatus	11?	8	dilated	1	some carinae
gahani	11	7	dilated	2	largely smooth, divergent posterior carinae
ibis	12	1	clawlike	1	areola
infrequens	11	8	dilated	1	smooth
latgei	11	3–4	simple, straight	2	areola
mexicanus	11	0	dilated	1	areola
monelliopsis	11	0	clawlike	1	areola
pallidus	11	3–4	clawlike	1	areola (part) or irregular lateral carinae
rosae	11	4–5	dilated	2	largely smooth, divergent posterior carinae
setaceus	11	6–8	dilated	2	some carinae
sunnysidensis	11 (rarely), 12	4–5	simple, straight	2	areola
tenuicaudus	11	1	simple, straight	1	areola

scribed in 1886 from Ontario, Canada not included in key; type lost, description inadequate, placement uncertain.]

1. Propodeum with an areola (Fig. 2), may be open (Figs. 26, 82) 2

– Propodeum without an areola, smooth (Fig. 18) or with some carinae (Figs. 22, 42) 13

2(1). Prong with clawlike (Figs. 24, 64) or dilated apical bristle(s) (Figs. 4, 8) 3

– Prong with straight simple bristle(s) (Fig. 56) 10

3(2). Prong with single clawlike apical bristle (Fig. 64) 4

– Prong with dilated apical bristle(s) (Figs. 4, 60) 8

4(3). Prong dorsal surface with setae (Fig. 8) 5

– Prong dorsal surface without setae (Fig. 64); (host, *Monelliopsis nigropunctata* on pecan; Georgia) (Figs. 61–64) . . . . *monelliopsis* Starý and Marsh

5(4). Ovipositor sheath long and narrow (Fig. 48); stigma length 3× width; antenna 12-segmented; host, *Betulaphis quadrituberculata* on birch; Europe, New Brunswick) (Figs. 45–48) . . . . *ibis* Mackauer

– Not with combination of features above . . 6

6(5). Prongs fused from base for more than half their length (hosts, *Calaphis*, *Clethrobius*, *Symydobius* on alder or birch; Asia, eastern Canada, Europe, Russia, (Figs. 13–16) . . . . *betulae* Marshall

– Prongs distinctly separated 7

7(6). Prong dorsal surface with 2 setae (Fig. 36) ; prongs arcuate at apex (hosts, *Eucallipterus tiliae* on linden and *Tuberculatus* on oak; California, Europe, and Russia) (Figs. 33–36) *curvicaudus* Mackauer

– Prong dorsal surface with 3–4 setae (Fig. 68); prongs relatively straight (hosts, various tree aphids, *Chromaphis*, *Eucallipterus*, *Hoplocallis*, *Monellia*, *Monelliopsis*, *Myzocallis*, *Tuberculatus*, *Tinocallis*, *Panaphis*; Asia, Australia, Europe, Russia, Tasmania [specimens with propodeal areola not observed in North America]) (Figs. 65–68) . . . *pallidus* (Haliday) (in part)

8(3). Prong dorsal surface without setae (Fig. 60); 1 dilated apical bristle (host, *Myzocallis* on oak; Mexico) (Figs. 57–60) ..... *mexicanus* Starý and Remaudière

– Prong dorsal surface with setae; 1–3 dilated apical bristles (Figs. 4, 28) 9

9(8). Prong dorsal surface with 2–3 setae (Fig. 4) (host, *Drepanaphis* on maple; eastern Canada, Florida, Missouri, Ohio, Tennessee) (Figs. 1–4) ... *ameraceris* Smith

– Prong dorsal surface with 6–8 setae (Fig. 28) (host, *Drepanosiphum* on maple; known distribution, Asia, Australia, Europe, Washington) (Figs. 25–28) *cirsii* (Curtis)

10(2). Prong short and straight, with two long apical bristles (Fig. 56); petiole short, only slightly longer than wide (Fig. 55) (host, *Sanbornia juniperi* on juniper; Maine) (Figs. 53–56) ... *latgei* Starý and Remaudière

– Not with the combination of features above 11

11(10). Prong dorsal surface with one preapical seta (Fig. 84); ovipositor sheath very shallowly emarginate on ventral side (Fig. 84) (host, various tree aphids – *Eucallipterus*, *Myzocallis*, *Tinocallis*, *Tuberculatus*; Australia, Europe, Russia, and Washington) (Figs. 81–84) *tenuicaudus* Starý

– Prong dorsal surface with 4 or more setae (Fig. 80) 12

12(11). Petiole with numerous longitudinal striations in proximal half (Fig. 11) (host, *Rhopalosiphum*; Eurasia and Ontario [introduced]) (Figs. 9–12) ... *auctus* (Haliday)

– Petiole without striations (Fig. 79) (host, *Rhopalosiphum* on wheat; Washington) (Figs. 77–80) .... *sunnysidensis* Fulbright and Pike

13(1). Antenna 13-segmented (host, *Eucallipterus tiliae*; California; species rare, described from a single specimen) (Figs. 21–24) ...... *californicus* Starý and Zuparko

– Antenna 11–12 segmented 14

14(13). Petiole dilating from poorly prominent spiracular tubercles to apex (Fig. 7); antenna 12-segmented; (hosts, various sagebrush aphids – *Aphis* (*Zyxaphis*), *Microsiphoniella*; Washington) (Figs. 5–8) .... *artemisiarum* Pike and Starý

– Petiole spiracles on prominently visible tubercles (Fig. 51) antenna usually 11-segmented; 15

15(14). Prong dorsal surface with 6–8 setae (Fig. 52) 16

– Prong dorsal surface with 2–5 setae (Fig. 20) 19

16(15). Petiole length/width at spiracles ≥ 2 (Figs. 51); propodeum smooth (host, unknown; Colorado, western Canada) (Figs. 49–52) .... *infrequens* Smith

– Petiole length/width at spiracles 1.5–1.9 (Figs. 39, 43, 75); propodeum with some carinae (Figs. 38, 42, 74) 17

17(16). Prong ventral surface with > 12 setae (Fig. 76) (host, *Acyrthosiphon macrosiphum* on western serviceberry; Montana and Washington) (Figs. 73–76) .... *setaceus* Pike and Starý

– Prong ventral surface with usually < 10 setae (Figs. 40, 44) (host,not *Acyrthosiphon macrosiphum*) 18

18(17). Prong dorsal surface bearing 4 distal setae approximately twice as long as 4 basal setae; tip of R1 vein yellowish or light ferruginous (Smith 1944); stigma length about 2× R1 vein; F1 and F2 antennal segments long, 0.19 and 0.16 mm, respectively (host, rose aphid; Connecticut, rare, described from a single specimen) (Figs. 37–40) .... *exareolatus* Viereck

– Prong dorsal surface setae not as above; F1 and F2 antennal segments short, each 0.11–0.12 mm (hosts, *Ericaphis*, *Chaetosiphon*; New Jersey and Washington) (Figs. 41–44) .... *gahani* Smith

19(15). Propodeum entirely smooth (Fig. 18), R1 vein short, < 0.25× stigma length (Fig. 17) (hosts, sage aphids – *Aphis* (*Zyxaphis*), *Artemisaphis*, *Epameibaphis*, *Flabellomicrosiphum*, *Microsiphoniella*, *Obtusicauda*, *Pleotrichophorus*, *Pseudoepameibaphis*; Idaho, Mexico, Utah, and Washington) (Figs. 17–20) .... *bonnevillensis* Smith

– Propodeum with at least some carinae (Figs. 30), R1 vein length variable 20

20(19). Propodeum smooth except for divergent carinae in posterior declivity (Fig. 70); R1 vein 0.3× stigma length (Fig. 69); (host, *Macrosiphum rosae* on rose; Washington) (Figs. 69–72) .... *rosae* Pike and Starý

– Propodeum with irregular lateral carinae (Figs. 30, 66a, 66b); R1 vein 0.4× stigma length or greater (Figs 29, 65) 21

21(20). [Species in couplet morphologically similar – check for a match with correct host] Ovipositor sheath ventral margin with 5–7 setae excluding apical setae (Fig. 68) (hosts, various tree aphids – *Chromaphis*, *Eucallipterus*, *Hoplocallis*, *Monellia*, *Monelliopsis*, *Myzocallis*, *Tuberculatus*, *Tinocallis*, *Panaphis*; California, Oregon, Washington (Figs. 65–68) .... *pallidus* (Haliday) (in part)

– Ovipositor sheath ventral margin with 3–4 setae excluding apical setae (Fig. 32) (hosts, *Therioaphis* – North America;, *Pterocallis* – Eurasia) (Figs. 29–32) .. *complanatus* Quilis

ACKNOWLEDGMENTS

We express thanks to R. Kula, Systematic Entomology Laboratory, USDA, Washington, DC for loan of several *Trioxys* types; R. L. Zuparko, Essig Museum of Entomology, University of California, Berkeley, for loan of specimens; G. Graf for parasitoid dissecting and mounting assistance; D. Allison for technical assistance; and R. Potter for manuscript formatting and technical assistance. The work was made possible with support from Washington State University, Department of Entomology, and Academy of Sciences of the Czech Republic, Entomology Institute project Z50070508.

LITERATURE CITED

Carver, M. and P. Starý. 1974. A preliminary review of the Aphidiidae (Hymenoptera: Ichneumonoidea) of Australia and New Zealand. Journal of Australian Entomological Society 13: 235–240.

Chen, J. and Q. Shi. 2001. Systematic Studies on Aphidiidae of China (Hymenoptera: Aphidiidae). Fujian Science and Technology Press, Fuhzhou. 273 pp.

Curtis, J. 1831. British entomology; being illustrations and descriptions of the genera of insects found in Great Britain and Ireland. Printed by the author, London 8: 383.

Davidian, E. M. 2005. A review of species of the subgenus *Trioxys* s. str., genus *Trioxys* Hal. (Hymenoptera: Aphidiidae) of Russia and adjacent countries. Entomogitsheskoe Obozrenie 84: 579–609.

Fulbright, J. L. and K. S. Pike. 2007. A new species of *Trioxys* (Hymenoptera: Braconidae: Aphidiinae) parasitic on the bird cherry-oat aphid, *Rhopalosiphum padi* (L.) (Hemiptera: Aphididae) in the Pacific Northwest. Proceedings of the Entomological Society of Washington 109: 541–546.

Gahan, A. B. 1911. Aphidiinae of North America. Maryland Agricultural Experiment Station Research Bulletin 152: 147–200.

Gärdenfors, U. 1990. *Trioxys apterus* sp. n. from Ecuador, a new wingless species of Aphidiinae (Hymenoptera: Braconidae). Entomologica Scandinavica 21: 67–69.

Haliday, A. H. 1833. An essay on the classification of the parasitic Hymenoptera of Britain, which correspond with the Ichneumones minuti of Linnaeus. Entomological Magazine 1: 259–276.

Johnson, J. W. 1987. A revision of the species of *Praon* Haliday in North America north of Mexico (Hymenoptera: Aphidiidae). Canadian Entomologist 119: 999–1025.

Mackauer, M. 1959. Die mittel-, west- und nordeuropäischen Arten der Gattung *Trioxys* Haliday. Beiträge zur Entomologie 9: 144–179.

———. 1960. Zur systematic der Gattung *Trioxys* Haliday. Beiträge zur Entomologie 10: 137–160.

———. 1961. Neue europäische Blattlaus-Schlupfwespen (Hymenoptera: Aphidiidae). Bollettino del Laboratorio di entomologia agraria Filippo Silvestri Portrici 19: 270–290.

———. 1965. Notes on and additions to the *Trioxys* and *Binodoxys* species (Hymenoptera: Aphidiidae) of North America. Canadian Entomologist 97(3): 225–231.

———. 1967. A new genus and several new species of aphid parasites. Entomophaga 12(2): 139–147.

Marsh, P. M. 1979. Aphidiidae, pp. 295–313. *In* Krombein, K. V., P. D. Hurd, D. R. Smith, and D. B. Burks, eds. Catalog of Hymenoptera of America North of Mexico, Vol. 1 Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington D. C. 1198 pp.

Marshall, T. A. 1896. Braconides. *In* André, E. ed. Species des Hyménoptères d'Europe et d'Algérie. Bouffaut Frères, Paris, Gray, 5. 635 pp.

Mescheloff, E. and D. Rosen. 1993. Biosystematic studies on the Aphidiidae of Israel (Hymenoptera: Ichneumonoidea). Israel Journal of Entomology 25: 31–47.

Pike, K. S., L. L. Boydston, and D. W. Allison. 2003. Aphids of western North America north of Mexico with keys to subfamilies and genera for female alatae. Washington State University Cooperative Extension MISC0523, Pullman, Washington. 282 pp.

Pike, K. S., P. Starý, R. Miller, D. Allison, L. Boydston, G. Graf, and T. Miller. 1996. New species and host records of aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) from the Pacific Northwest, U.S.A. Proceedings of the Entomological Society of Washington 98: 570–591.

Pike, K. S., P. Starý, T. Miller, D. Allison, L. Boydston, G. Graf, and R. Gillespie. 1997a. Small-grain aphid parasitoids (Hymenoptera: Aphelinidae and Aphidiidae) of Washington: Distribution, relative abundance, seasonal occurrence, and key to known North American species. Environmental Entomology 26: 1299–1311.

Pike, K. S., P. Starý, G. Graf, D. Allison, L. Boydston, R. Miller, and T. Miller. 1997b. Parasitoids (Hymenoptera: Braconidae: Aphidiinae) of aphids on big sagebrush (*Artemisia tridentata*) and prairie sage (*Artemisia ludoviciana*) in Washington State. Proceedings of the Entomological Society of Washington 99: 143–155.

Pike, K. S., P. Starý, T. Miller, R. Miller, D. Allison, G. Graf, and L. Boydston. 1999. *Ephedrus clavicornis* sp. n. (Hymenoptera, Braconidae, Aphidiinae), an aphid parasitoid of the Pacific Northwest, and key to nearctic *Ephedrus*. Journal of the Kansas Entomological Society 72: 10–16.

Pike, K. S., P. Starý, T. Miller, G. Graf, D. Allison, L. Boydston, and R. Miller. 2000. Aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) of Northwest USA. Proceedings of the Entomological Society of Washington 102: 688–740.

Provancher, L. 1886. Additions et corrections à la Faune hyménoptèrologique de la Province de Québec. C. Darveau, Québec. 475 pp.

Quilis Pérez, M. 1931. Especies nuevas de Aphidiidae españoles (Hymenoptera: Braconidae). Eos, Madrid 7: 25–84.

Sharkey, M. J. and R. A. Wharton. 1997. Morphology and terminology, pp. 19–37. *In* Wharton, R. A., P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World genera of the family Braconidae (Hymenoptera). Special Publication, No. 1, International Society of Hymenopterists, Washington, DC. 439 pp.

Smith, C. F. 1939. Hymenopterous parasites of aphids with special reference to the Aphidiinae. Ph.D. Dissertation, The Ohio State University, Columbus, Ohio. 133 pp.

———. 1944. The Aphidiinae of North America (Braconidae: Hymenoptera). Ohio State University Contributions in Zoology and Entomology No. 6, 164 pp.

Starý, P. 1969. Aphids and their parasites associated with oaks in Iraq. Proceedings of the Entomological Society of Washington 71(3): 279–297.

———. 1976. Aphid Parasites (Hymenoptera: Aphidiidae) of the Mediterranean Area. W. Junk, The Hague. 95 pp.

———. 1978. Parasitoid spectrum of the arboricolous callaphidid aphids in Europe (Hymenoptera, Aphidiidae; Homoptera, Aphidoidea, Callaphididae). Acta Entomologica Bohemoslovaca 75: 164–177.

———. 1979. Aphid Parasites (Hymenoptera: Aphidiidae) of the Central Asian Area. W. Junk, The Hague. 114 pp.

———. 1981. Biosystematical classification of *Trioxys* Haliday and related genera (Hymenoptera, Aphidiidae). Bollettino del Laboratorio di Entomologia Agraria Filippo Silvestri 38: 85–93.

Starý, P. and R. C. Bhagat. 1978. Records and descriptions of aphid parasitoids from Kashmir, India (Hymenoptera: Aphidiidae). Acta Entomologica Bohemoslovaca 75: 387–393.

Starý, P. and L. A. Juchnevič. 1978. Aphid parasites (Hymenoptera, Aphidiidae) from Kazakhstan, USSR. Bulletin Entomologique de Pologne 48: 523–532.

Starý, P. and P. M. Marsh. 1982. A new species of *Trioxys* (Hymenoptera: Aphidiidae) parasitic on a pecan aphid. Proceedings of the Entomological Society of Washington 84(4): 726–728.

Starý, P. and G. Remaudière. 1977. Some aphid parasitoids (Hymenoptera: Aphidiidae) from nearctic America. Annales de la Société Entomologique de France, N.S. 13: 669–674.

———. 1982. New genera, species and host records of aphid parasites (Hymenoptera: Aphidiidae) from Mexico. Annales de la Société Entomologique de France, N.S. 18: 107–127.

Starý, P. and E. I. Schlinger. 1967. A revision of the Far East Asian Aphidiidae (Hymenoptera). W. Junk, The Hague, Netherlands. 204 pp.

Starý, P. and R. L. Zuparko. 1995. A new species of *Trioxys* (Hymenoptera: Braconidae) from California. Pan-Pacific Entomologist 71: 173–175.

Takada, H. 1966. A preliminary revision of species of *Trioxys* Haliday occurring in Japan, with descriptions of eight new species. Insecta Matsumurana 29: 23–36.

———. 1979. Aphidiidae (Hymenoptera) from Mongolia. Folia Entomologica Hungarica 32: 189–202.

Tomanović, Ž. and N. G. Kavallieratos. 2002. *Trioxys* Haliday (Hym.: Braconidae: Aphidiinae) in Serbia and Montenegro. Acta Entomologica Serbica 7: 67–81.

van Achterberg, C. 1997. Subfamily Aphidiinae, pp. 119–131. *In* Wharton, R. A., P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World Genera of the Family Braconidae (Hymenoptera). Special Publication, No. 1, International Society of Hymenopterists, Washington, DC. 439 pp.

Viereck, H. L. 1916. The Hymenoptera, or wasp-like insects of Connecticut, Part III. Connecticut State Geological and Natural History Survey Bulletin 22: 1–824.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 791–797

PROGOMPHUS LAMBERTOI (ODONATA: ANISOPTERA: GOMPHIDAE), A NEW SPECIES FROM MEXICO

RODOLFO NOVELO-GUTIÉRREZ

Instituto de Ecología, A.C.Departamento de Entomología, Apartado Postal 63, 91070 Xalapa, Veracruz, MÉXICO (e-mail: rodolfo.novelo@inecol.edu.mx)

Abstract.—**Progomphus lambertoi, n. sp.** (holotype ♂ from La Chichihua, State of Michoacán, México) (1,127 m asl; 18° 44.812 N; 103° 13.379 W), is described and illustrated. It appears closely related to *P. borealis* McLachlan, from which it can be distinguished by its smaller stature, paler coloration, enlarged and carinated hook of the posterior hamule, and male cerci not basoventrally carinated.

Resumen.—Se describe e ilustra a ***Progomphus lambertoi*, sp. nov.** (holotipo ♂ de La Chichihua, estado de Michoacán, México) (1,127 m snm; 18° 44.812 N; 103° 13.379 W). La especie nueva es muy parecida a *P. borealis* McLachlan, de la cual se diferencia por su talla menor, coloración más pálida, el gancho del hamulus posterior alargado y carinado, y los cercos del macho sin carina ventrobasal.

Key Words: Odonata, Gomphidae, *Progomphus lambertoi*, new species, México

Recently, I described a new species of *Progomphus* from Michoacán State (Novelo-Gutiérrez 2007) belonging to the *pygmaeus* group (Belle 1991), which brought the current total number of species for Mexico to 11. Here I describe another new species, but belonging to the *obscurus* group (Needham 1941, Belle 1991), closely related to *P. borealis* McLachlan, which increases to 12 the species occurring in Mexico, and to 69 for the entire genus.

Progomphus lambertoi **Novelo-Gutiérrez, new species**

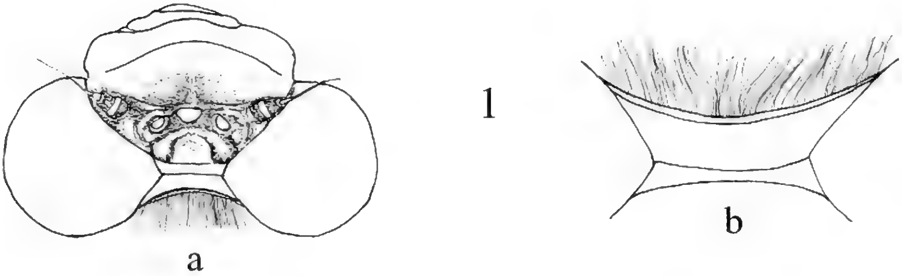
(Figs. 1–3, 4a–b, 5a–b, 6, 7a–b)

Material.—Holotype ♂: MEXICO: State of Michoacán, Municipality of Coalcomán, La Chichihua (1,127 m asl; 18° 44.812 N; 103° 13.379 W), 21-IV-2006, R. Novelo. J.A. Gómez leg. Deposited in Colección Entomológica del Instituto de Ecología, A.C., Xalapa (IEXA). Paratypes: (3 ♂) same data as holotype; (1 ♂) same data as holotype but 02-IV-2005. Other specimen: (1 teneral ♂ in ethanol), not included in paratype series, same data but: Municipality of Tepalcatepec, Pinolapa, Río Pinolapa (616 m asl; 19° 00.524 N; 103° 01.456 W), 28-III-2005; paratypes and other specimen deposited in IEXA.

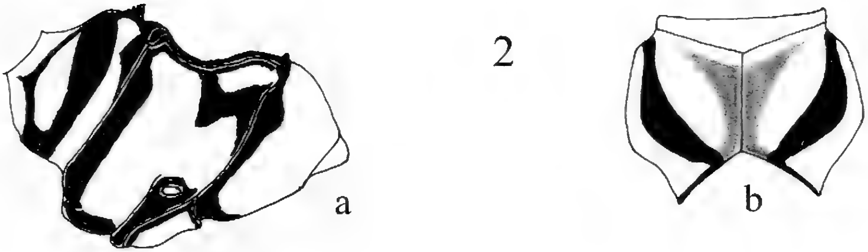
Etymology.—This species is dedicated to the memory of the late Dr. Lamberto González Cota, friend and colleague, for his encouragement in the study of the entomofauna of Michoacán State.

Male (holotype).—*Head:* Labium creamy pale, setae reddish; eye color in life gray violaceous; antenna dark brown, black basally. Labrum, base of mandible, gena and anteclypeus creamy pale; postclypeus, antefrons and anterior half of postfrons pale green, basal half of

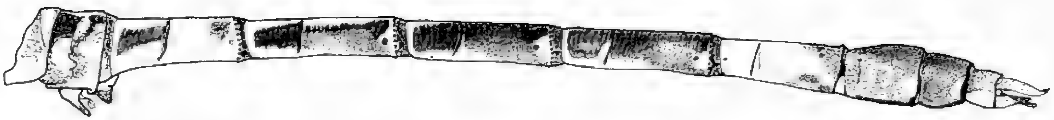
1



2



3



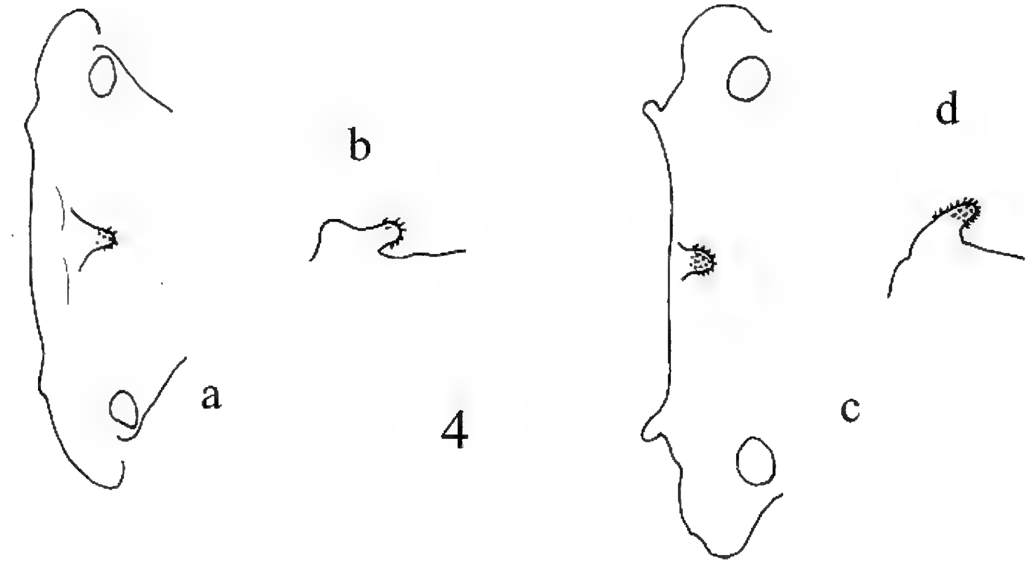
Figs. 1–3. *Progomphus lambertoi* (holotype ♂). 1a, Head, dorsal view. 1b, Detail of occiput. 2a, Color pattern of pterothorax, left lateral view. 2b, Color pattern of mesepisterna, dorsal view. 3, Color pattern of abdomen, left lateral view .

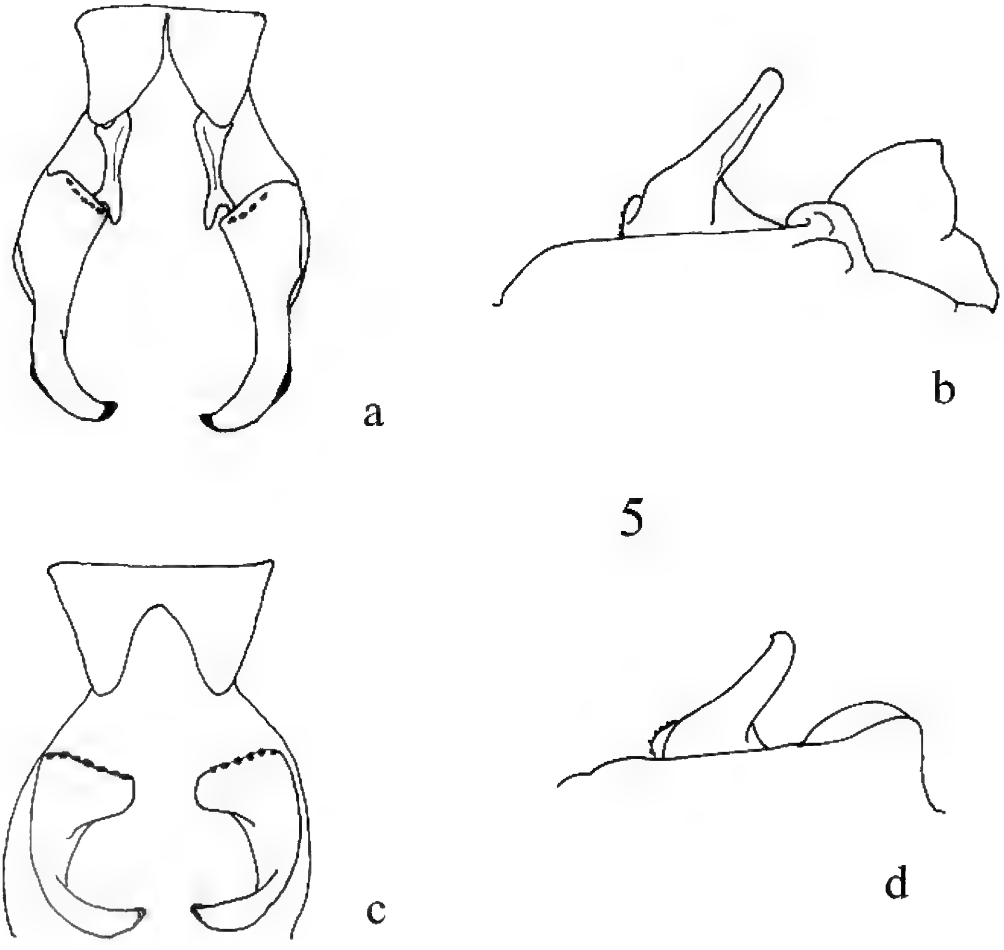
postfrons brown (Fig. 1a); vertex pale green, interocellar area brown, postocellar ridge concave at middle; a deep furrow between vertex and occiput; occiput pale green (Fig. 1b), its posterior border thick, yellowish orange, widely concave, beset with a fringe of long whithish setae; posterior area of head with a central, pale green, rectangular spot, dark brown at sides.

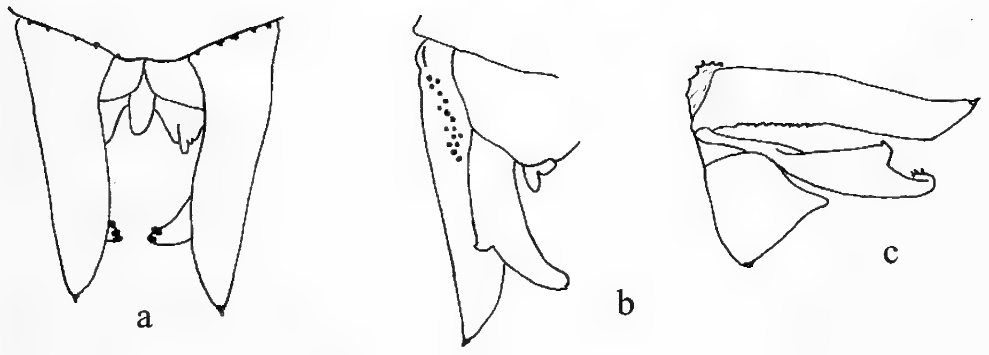
Thorax: Prothorax with anterior lobe black, anterior margin pale; midlobe pale at sides, brown at middle; posterior lobe pale with posterior border black. Pterothorax (Fig. 2) with mesepisternum pale green with brown markings as follows: a difuse, reddish brown, triangular spot on each side of middorsal carina and antealar crest, a wide antehumeral stripe tapering on both ends, upper end connecting to triangular spot described above; dorsal carina and mesothoracic collar pale, antealar crest brown; mesokatepisternum pale, with a brown, rectangular spot on posterior half; brown humeral stripe complete, connecting to antehumeral stripe by a narrow, transverse bridge at upper 0.20 its length; mesepimera and metepisterna mostly gray violaceous; interpleural (midlateral) brown stripe lacking; metakatepisternum pale green; metaspiracle black, brown around it; brown stripe complete on metapleural suture, abruptly widening at upper end, entering as a wide band over the upper third of metepisternum, leaving an isolated, dorsal, pale spot and reaching subalar carina; metepimera creamy pale; sternum pale green. Wings hyaline with a tint of brown at extreme base hardly reaching basal subcostal crossvein; anterior edge of costa yellow including basal 0.40 length of pterostigma. Venation: Fore wing (FW) with 7 paranal cells and 5 and 7 supplementary cells posterior to them (left and right wings, respectively), area posterior to Cu2 one cell wide for first 3 cells then increasing to 2 cells for a distance of 3 cells then increasing to 3 cells for a distance of 4 cells, then decreasing to 2 cells for a distance of one cell then decreasing to one cell for a distance of one cell; first and fifth antenodals thickened in all wings; antenodal crossveins (anx) on FW 13/14, on HW 10/10; postnodal crossveins (pnx) on FW 10/10, on HW 8/8; basal subcostal crossvein present in all wings; triangles 3-celled on FW, 4- and 2-celled on left and right HW respectively, subtriangles 2-celled in FW and right HW, 1-celled in left HW; pterostigma light yellow brown, surmounting 5 cells in left wings, 6 cells in right wings. Legs: coxae yellowish green laterally, light brown anteriorly; trochanters yellowish green lateroposteriorly, anterior surfaces of meso- and metatrochanters dark brown and reddish brown on basal and distal trochanters, respectively; femora with a complex color pattern of longitudinal pale bands intercalated with reddish-brown stripes; tibiae, tarsi, and basal 0.60 of claws yellowish brown, armature and apical 0.40 of claws black; hind tibia 0.70 length of hind femur; hind tarsi (excluding claws) 0.75 length of hind tibia.

Abdomen (Fig. 3): Segments 1–6 light brown, with gray violaceous markings on inferolateral areas of 1–3 and auricles, auricles with 8–9 black tubercles, also with creamy pale markings as follows: a dorsal stripe on 2–4 tapering posteriorly becoming a mere line on 5–6, entire area posterior to transverse carina on 3 except for a subapical dorsal light brown spot to each side of midline, a narrow basal ring connecting to middorsal stripe as well as to inferolateral stripe which runs along basal half on 4–6, a distolateral spot on each side on 4–6, transverse carina on 3–7 black; segment 7 mostly creamy pale, with a dorsal, triangular, light brown area on apical 0.40, as well as an irregular light brown spot on distolateral areas; segments 8–10 reddish brown dorsally, light brown laterally, with a pale spot on distolateral areas of 8–9; inferolateral margin of 10 pale. Abdominal segment 1 with a small (0.2 mm), yellow, midventral spiny tubercle located at basal 0.20 length of sternite (Figs. 4a,b), directed caudad, with most spines at extreme tip (Fig. 4b); anterior hamule small (Fig. 5a) dark brown, widely emarginated apically; posterior hamule (Figs. 5a,b) yellow with apex black, a row of 4–5 black, low, basoventral tubercles, external margin of hook carinated, carina reddish brown except for a black midcentral area. Cercus (Fig. 6) entirely creamy pale except on basoventral 0.40 which is light brown, not carinated, and with 15–16 black, low tubercles not arranged in a row (Fig. 6b); spines at tip of cercus black; tip of cercus divergent (Fig. 6a) and slightly upturned (Fig. 6c). Lobes of epiproct in ventral view curved inward (Fig. 7a), tips bifid, the ventrointernal branch largest, yellow, with 2–3 sharp, black tubercles at tip, superoexternal branch low, brown, rounded with a very small tubercle at tip (Fig. 7b); epiproct reaching basal 0.80 length of cerci (Fig. 7a). Paraprocts with an apical lobe bearing numerous, long, reddish, stiff setae.

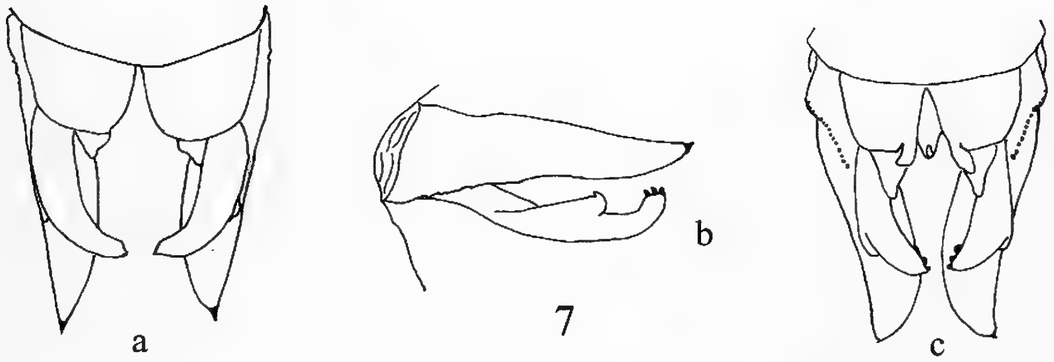
Measurements (mm): Total length (incl. cerci) 52.0, abdomen 39.0, hind


4


5



6



7

Figs. 6–7. Details of caudal appendages of male *Progomphus*. 6, *P. lambertoi:* a, dorsal view of cerci; b, ventrolateral view of right cercus showing basal black tubercles not arranged in a row, and absence of ventrobasal carina; c, left lateral view of cercus and epiproct lobe. 7, a: ventral view of epiproctal lobes; b: laterodorsal view of cercus and epiproctal lobe; c: ventral view of caudal appendages (a–b, *P. lambertoi*; c, *P. borealis*).

wing 30.0, pterostigma of fore wing 4.0, fore tibia 3.5, hind femur 5.0, cercus 1.7 (measured dorsally along internal margin).

Female.—Unknown.

Variation in paratypes.—In three individuals, there is no connection between the humeral and antehumeral brown stripes; the individual collected on 2 April 2005 has the dark coloration less defined (perhaps due to its young condition). Wing venation: one individual has 6 paranal cells in the right wing, two individuals have 4 supplementary cells behind the paranal cells, and other two have 4–5 supplementary cells. The nodal formula is highly variable, as follows: FW anx 12–14, pnx 7–10; HW anx 9–11, pnx 7–9; one individual lacks a basal subcostal crossvein in the right HW and its FW triangle has 2 cells; the number of cells in the HW triangles and subtriangles varies from 2–3 and 1–3, respectively. The area posterior to Cu2 varies only

---

←

Figs. 4–5. Details of morphology of male *Progomphus*. 4, Partial view of sternum of abdominal segment 1 showing ventral tubercle in ventral (a and c) and left lateral (b and d) views (a–b, *P. lambertoi*; c–d, *P. borealis*). 5, Accesory genitalia: a and c, ventral view of hamuli (anterior hamuli omitted in c); b and d, left lateral view of posterior hamuli (notice lateral carina on hook in b) (a–b, *P. lambertoi*; c–d, *P. borealis*).

in the distal half. The number of cells surmounted by the pterostigmata is usually 5 but ranges from 4 to 7. One individual has 4 black basoventral tubercles on each posterior hamule, and another has 6. Likewise, the number of basoventral black tubercles on the cerci varies from 13 to 18.

Measurements (mm): Total length (incl. cerci) 49.5–53; abdomen 37–39.5; hind wing 28.7–30; pterostigma 3.6–4.3; fore tibia 3.5–3.7; hind femur 4.8–5.0; cerci 1.7–1.8

Remarks.—Males of *Progomphus lambertoi* were captured at shallow rocky streams, around 11:00 h on sunny days. They were perching on small rocks where the water flow is moderate. Apparently the flying season is restricted to the first half of spring as they could not be found other times of the year despite systematic searches during two consecutive years, as well as previous non-systematic searches over a 4-year period.

Discussion.—*Progomphus lambertoi* belongs to the *obscurus* group (Belle 1991) (subgenus *Neaprogomphus* Carle [Tennessen 1992]) by the presence of a small ventral tubercle on abdominal segment 1. *Progomphus lambertoi* appears more closely related to *P. borealis* than any other species of the *obscurus* group, from which it is easily differentiated by the following characteristics (those of *P. borealis* in parentheses): smaller stature, 49.5–53.0 mm (larger, 57–62 mm); dark coloration light brown to reddish brown (brown to dark brown); vertex mostly pale (mostly dark); occiput 0.4 mm in length, posterior margin widely concave (0.8 mm in length, posterior margin sinuate); antehumeral dark stripe separated from humeral stripe by a pale stripe (pale stripe absent, usually a very wide, unique dark band); brown stripe on metapleural suture branching at upper end (unbranched); ventral tubercle on abdominal segment 1 at basal 0.20 the length of the sternite, directed caudad (Figs. 4a,b) (only on the anterior margin, directed ventrocaudad [Figs. 4c,d]); auricles with 10 or fewer black tubercles (with 25 or more); hook of posterior hamule enlarged, its basal half more or less straight, then curved inward, thus the apex of the hook is 1.0–1.1 mm beyond the internal angle of the base of the hamule (Fig. 5a) (hook not enlarged, strongly incurved all the way [Fig. 5c]); hook of posterior hamule partially carinated externally (Fig. 5b) (rounded, not carinated [Fig. 5d]); male cercus not basoventrally carinated, basoventral black tubercles 13–18, not arranged in one row (Fig. 6b) (strongly carinated, basoventral black tubercles 8–10 arranged in one row along the carina); internal margin of paraproctal lobe, in ventral view, more or less straight at basal 0.70, then abruply incurved at apical 0.30 (Fig. 7a) (slightly concave along the internal margin [Fig. 7c]); and ventrointernal branch of paraproctal lobe with 2–3 sharp, black tubercles at tip (usually with 4 such tubercles).

The new species in Belle's (1973) key will key out as follows:

25.	Third femora brown or light brown with pale markings	25a
–	Second and third femora brown	26
25a.	Posterior hamuli enlarged (1.5 mm length measured laterally), lateral margins carinated; midventral process on abdominal segment 1 at basal 0.20 the length of the sternite, directed caudad; male cercus without basoventral carina, and basoventral black tubercles not arranged in one row	*lambertoi*
–	Posterior hamuli not enlarged but strongly incurved all the way (1.1 mm length), lateral margins rounded, never carinated; midventral process on abdominal segment 1 at the anterior margin, directed ventrocaudad; male cercus strongly carinated on basoventral area with black tubercles arranged in one row	*borealis*

ACKNOWLEDGMENTS

I thank José Antonio Gómez-Anaya for his companionship and invaluable collaboration during field collectings. Special thanks are due to Dr. Ken Tennessen (Wisconsin) and two annonymous reviewers for their constructive criticism to the final manuscript. Financial support was provided by a CONACYT grant (43091-Q).

LITERATURE CITED

Belle, J. 1973. A revision of the New World genus *Progomphus* Selys, 1854 (Anisoptera: Gomphidae). Odonatologica 2(4): 191–308.

———. 1991. The ultimate instar larvae of the Central American species of *Progomphus* Selys, with a description of *P. belyshevi* spec. nov. from Mexico (Anisoptera: Gomphidae). Odonatologica 20(1): 9–27.

Needham, J. G. 1941. Life history studies on *Progomphus* and its nearest allies (Odonata: Aeschnidae). Transactions of the American Entomological Society 67: 221–245, pl. 20.

Novelo-Gutiérrez, R. 2007. *Progomphus marcelae* spec. nov. from western Mexico (Anisoptera: Gomphidae). Odonatologica 36(1): 79–84.

Tennessen, K. J. 1992. *Progomphus amarillus* spec. nov. from eastern Mexico (Anisoptera: Gomphidae). Odonatologica 21(2): 247–252.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 798–800

MADIZA NITENS (MELANDER, 1913), NEW COMBINATION (DIPTERA: MILICHIIDAE)

IRINA BRAKE

Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K. (e-mail: i.brake@nhm.ac.uk)

Abstract.—*Neophyllomyza nitens* Melander, 1913, is transferred to the genus *Madiza* Fallén, **new combination**, and redescribed.

Key Words: Diptera, Milichiidae, *Madiza nitens*, new combination

Melander (1913) described *Madiza nitens* in the genus *Neophyllomyza*, but C. W. Sabrosky, in a note next to the specimens in the USNM collection, wrote that the species belongs to *Madiza* Fallén. Sabrosky, however, never published his finding, which I now do in Sabrosky's honor and memory. *Madiza* now contains five species: *M. glabra* Fallén, 1820, *M. pachymera* Becker, 1908, *M. nitens* (Melander 1913), *M. britannica* Hennig, 1937, and *M. eximia* Papp, 1993. Papp (1993) compiled a key to the world's species. The genus is characterized by a tibial organ on the male hindleg and glands in the male abdomen.

MATERIALS AND METHODS

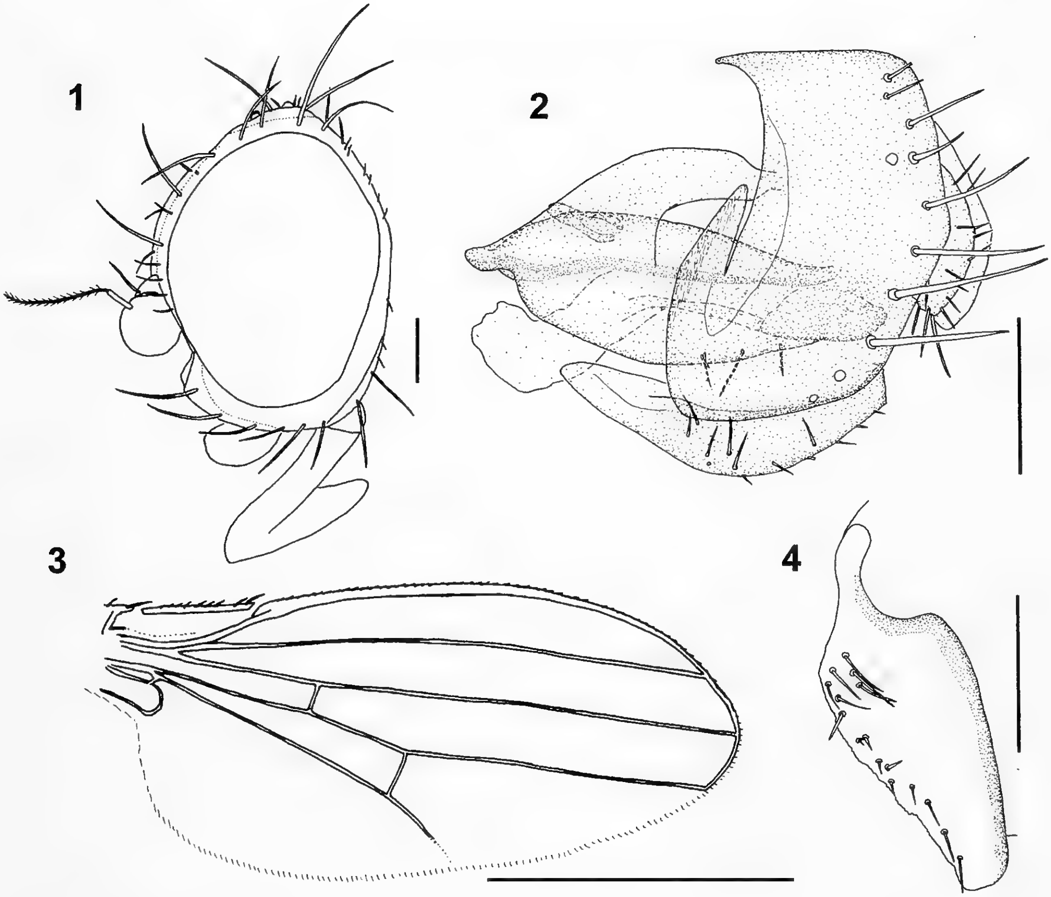
The terminology essentially follows McAlpine (1981) with a few exceptions. For the orbital and frontal setae I use the terms "posterior" and "anterior" instead of "upper" and "lower," and for the first flagellomere I use the term basoflagellomere. All specimens are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA (USNM).

Madiza nitens (Melander 1913), **new combination**
(Figs. 1–4)

Male.—*Coloration:* Body black, except for yellowish base of tibiae and all tarsi. Lunula yellowish in some specimens. Setae black except for yellow setulae ventrally on basitarsomeres of fore and hind legs.

Head (Fig. 1): Frons subshiny, orbital triangle and orbits shiny. Frons about as long as wide. Frontal triangle extending to level of anterior orbital seta. Posterior orbital seta nearly as long as anterior orbital setae. Lunula barely visible. Arista 0.8× eye height, pubescence slightly longer than pubescence on basoflagellomere. Vibrissa well developed, followed posteriorly by row of 6 genal setae. Anterior genal seta of same length as vibrissa. Gena about 0.1× eye height and about 0.5× width of basoflagellomere. Eye 1.3× as high as wide. Proboscis with labella about as long as length of gena. Palpus flat, spatulate, with several setulae, which are longer on ventrolateral edge.

Thorax: Mesonotum about as long as broad and subshiny. Scutellum coppery microtomentose. Anterior dorsocentral



Figs. 1–4. *Madiza nitens*, male. 1, Head, lateral view. 2, Wing. 3, Terminalia. 4, Surstylus in greatest extension. Scale bars: 0.1 mm, for wing 1.0 mm.

seta about 0.5× length of posterior seta. Legs: Fore coxa and femora normal, not enlarged. Wing (Fig. 3): hyaline.

Abdomen: Tergites 1–4 with coppery microtomentum on dorsal parts, T5 shiny. Anterior half of T5 modified to glandular structure with very fine hairs/microtomentum on outside and 'tubular' sclerotizations inside. Tergite 6 absent. Synsternite 7/8 symmetrical, dorsal, relatively wide, and with two spiracles. Sternite 6 absent. Glandlike structures near terminalia present but not studied due to age of material. Male terminalia as in Figs. 2 and 4. Female: Abdomen without glandular structures.

Type material.—Holotype female: USA. Idaho: Latah Co., Avon, 46°49′34 N, 116°36′50 W (USNM). Labels: "Avon Ida/26. Jul. 12" (handwritten), "AL Melander/Collection/1961" (printed), and "Neophyllomyza nitens/Typ. Mel." (handwritten).

Other material.—4♂, 6♀. CANADA: BRITISH COLUMBIA: Revelstoke, Murphys Ranch, 1.vii.1968, W. W. Wirth (2♂, 1♀). USA: WASHINGTON: Pierce Co., Mt. Rainier, White River, 19.vii. 1924, A. L. Melander, *Heracleum* (1♂, 1♀). IDAHO: Moscow Mt., 10.viii.1924, A. L. Melander (1♂). CALIFORNIA: Santa Clara Co., 7 mi W of

Palo Alto, Monte Bello Open Space Preserve, 23.viii.1987, S. Geohegan & D. Hevel (1♀); Mt. Home Can, 4400 ft, 25.vii.1955, A. L. Melander (1♀); San Mateo Co., Stanford University Campus Experimental Area, A. R. Moldenke, no. 3426 (1♀). AUSTRIA: Tirol: Ötz, 18.vi.1964, J. Abraham & J. C. Deeming (1♀).

Distribution.—Nearctic Region: Canada (British Columbia), USA (California, Idaho, Washington); Palaearctic Region: Austria.

Comments.—In Papp's key to world's species (1993), *nitens* keys to couplet 1, *eximia*, having orbits with an additional orbital seta (ors) between bases of posterior orbital seta and medial vertical seta (vti), which is not much shorter than anterior orbital seta. *Madiza nitens*, however, differs from *eximia* in the following characters: proboscis slightly longer than height of head, frons subshiny, and abdominal sclerites 1–4 dull.

ACKNOWLEDGMENTS

I thank F.C. Thompson, Systematic Entomology Laboratory, USDA, and W.N. Mathis, Department of Entomology, Smithsonian Institution, for reviewing a draft of this paper. I am grateful to the Schlinger Foundation for providing the funds for my Smithsonian fellowship.

LITERATURE CITED

McAlpine, J. F. 1981. Chapter 2, Morphology and Terminology-Adults, pp. 9–63. *In* McAlpine, J. F., B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood, eds. coord. Manual of Nearctic Diptera, Vol. 1. Agriculture Canada, Monograph 27: pp. i–vi, pp. 1–674.

Melander, A. L. 1913. A Synopsis of the dipterous groups Agromyzidae, Milichiidae, Ochthiphilinae and Geomyzinae. Journal of the New York Entomological Society 21: 219–273, 283–300, pl. 8.

Papp, L. 1993. Three new milichiid species from Hungary. Annales Historico-Naturales Musei Nationalis Hungarici 85: 133–139.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 801–806

TWO NEW SPECIES OF THE *DICTYOTUS* GROUP OF THE GENUS *EXALLONYX* (HYMENOPTERA: PROCTOTRUPIDAE) FROM CHINA, WITH A KEY TO THE WORLD SPECIES

Zaifu Xu, Jingxian Liu, and Junhua He

(ZX, JL) Department of Entomology, South China Agricultural University, Guangzhou 510642, P. R. China (e-mail: xuzaifu@scau.edu.cn); (JH) Institute of Insect Science, Zhejiang University, Hangzhou 310029, P. R. China (e-mail: jhhe@zju.edu.cn)

Abstract.—***Exallonyx rufimandibularis*, n. sp.**, and ***E. arcus*, n. sp.**, from China are described and illustrated. A key to the world species of the *Exallonyx* (*Exallonyx*) *dictyotus* group is given.

Key Words: Hymenoptera, Proctotrupidae, *Exallonyx*, new species, China

Exallonyx Kieffer, 1904, parasitoids of Staphylinidae (Coleoptera), is the largest genus of the tribe Proctotrupini, and also the largest in the family Proctotrupidae (Townes and Townes 1981, Fan and He 2003, He and Fan 2004). This genus includes two subgenera, *Eocodrus* Panzer and *Exallonyx* Kieffer. The subgenus *Exallonyx* is divided into eleven species groups (Townes and Townes 1981). The *Dictyotus* group is a small species group including fourteen species, one from Madagascar, three from China, and the rest from New Guinea (Townes and Townes 1981, He and Fan 2004, Liu et al. 2006). In this paper we described two additional species of the *dictyotus* group from China.

The descriptions follow the terminology used by Townes and Townes (1981) and He and Fan (2004). The type specimens are deposited in the Hymenoptera Collection of Zhejiang University, Hangzhou, China (ZU).

KEY TO THE WORLD SPECIES OF THE *EXALLONYX* (*EXALLONYX*) *DICTYOTUS* GROUP (MODIFIED FROM TOWNES AND TOWNES 1981)

Female

1. Wings blackish; flagellum with apical four or more segments light brown to white . . . 2
– Wings hyaline or weakly tinged with brown or fuscous (Fig. 2); flagellum entirely black 4
2. Occipital carina unusually high; epomia absent; abdominal stalk almost smooth, upper profile concave (New Guinea) . . . . *E. camelinus* Townes
– Occipital carina moderately high; epomia present; abdominal stalk with conspicuous grooves, upper profile straight 3
3. Abdominal stalk 1.65× as long as deep, grooves on side moderately fine and shallow (New Guinea) . . . *E. soror* Townes
– Abdominal stalk 1.1× as long as deep, grooves on side moderately coarse and deep (New Guinea) . . . *E. torquatus* Townes
4. Side of abdominal stalk with four transverse ridges on basal half, nearly smooth on apical half with only one distinct longitudinal groove (Figs. 4, 6) (China) . . . . *E. rufimandibularis*, n. sp.

– Side of abdominal stalk fully with distinct grooves, not smooth on apical half 5
5. Hind trochanter whitish 6
– Hind trochanter black or dark brown . . . 7
6. Second flagellar segment 3.0× as long as wide; hind femur 4.2× as long as wide (New Guinea) . . . . . . *E. dictyotus* Townes
– Second flagellar segment 3.8× as long as wide; hind femur 5.7× as long as wide (New Guinea) . . . . *E. cracenus* Townes
7. Flagellum enlarged apically; hind femur 5.5× as long as wide (New Guinea) . . . . *E. dilatus* Townes
– Flagellum not enlarged apically; hind femur 3.6 to 4.9× as long as wide 8
8. Abdominal stalk 1.9× as long as deep (New Guinea) . . . . . . *E. ejuncidus* Townes
– Abdominal stalk 1.3× as long as deep (New Guinea) . . . . . . *E. coracinus* Townes

Male

1. Upper margin of pronotum without a row of hairs; base of syntergite with five longitudinal grooves of almost equal length (Madagascar) . . . . *E. nimius* Townes
– Upper margin of pronotum with one or two rows of hairs; base of syntergite with a single long median groove or with a median groove and one to three lateral grooves about half as long as median groove 2
2. Flagellum with apical four or more segments stramineous whitish (New Guinea) . . . . *E. torquatus* Townes
– Flagellum entirely dark brown to black . . 3
3. Flagellum entirely dark brown; abdominal stalk with arcuate transverse ridges at the basal half in dorsal view (Fig. 11) (China) . . . . *E. arcus*, n. sp.
– Flagellum entirely black; abdominal stalk without arcuate transverse ridges at the basal half in dorsal view 4
4. Wing blackish 5
– Wing tinged with yellowish brown or weakly infuscate 6
5. Abdominal stalk 2.0× as long as deep, grooves on side sloping downward at front end; small punctures on upper front part of metapleurom very sparse (New Guinea) . . . . *E. clinatus* Townes
– Abdominal stalk as long as deep, grooves on side approximately horizontal; small punctures on upper front part of metapleurom sparse (New Guinea) . . . . *E. melanoptera* Townes
6. Hind trochanter black 7
– Hind trochanter whitish or reddish brown 8
7. Upper margin of pronotum with one row of hairs; epomia absent (New Guinea) . . . . *E. coracinus* Townes
– Upper margin of pronotum with two rows of hairs; epomia distinct (China) . . . . *E. nigrolabius* Liu, He, and Xu
8 Upper margin of pronotum with two rows of hairs; flagellum with conspicous tyloid. . . . . *E. hangzhouensis* He and Fan
– Upper margin of pronotum with one row of hairs; flagellum without conspicous tyloids 9
9. Hind femur 3.7× as long as wide; abdominal stalk 0.5× as long as deep; epomia distinct (China) . . . . *E. brevicarinus* Liu, He, and Xu
– Hind femur 4.4× to 5.2× as long as wide; abdominal stalk 0.9× to 1.3× as long as deep; epomia absent. 10
10 Scape fulvous or light brown; hind femur 4.4× as long as wide; abdominal stalk 0.9× as long as deep (New Guinea) . . . . *E. dictyotus* Townes
– Scape black; hind femur 5.2× as long as wide; abdominal stalk 1.3× as long as deep (New Guinea) . . . . *E. cracens* Townes

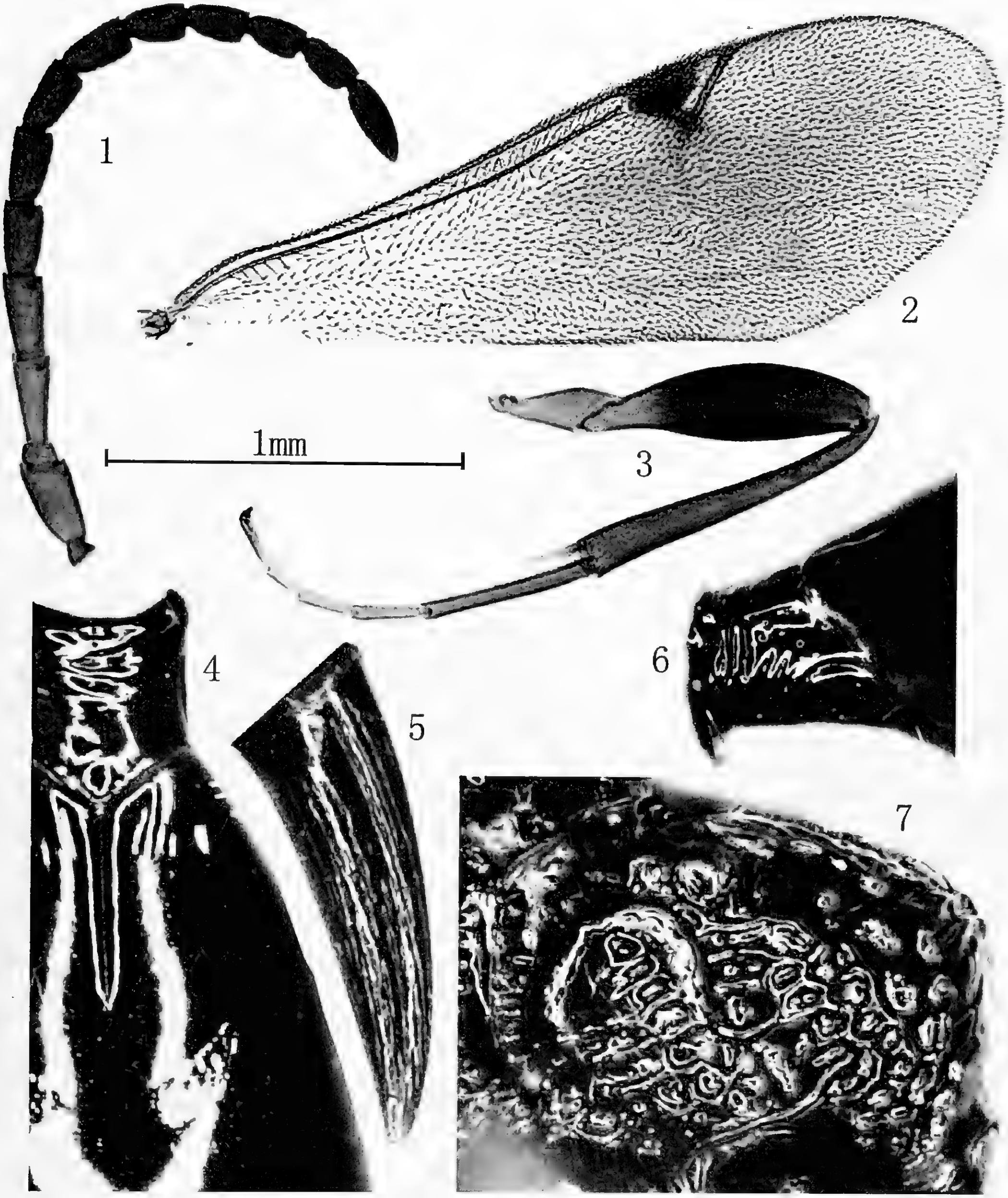
Exallonyx rufimandibularis Xu, Liu, and He, new species

(Figs. 1–7)

Female.—Front wing length 3.0 mm. *Color:* Body black. Antenna reddish brown to dark reddish brown, with gradual transition from reddish brown at base to dark reddish brown at apex. Labrum and apical half of mandible reddish brown. Palpi yellow. Tegula fulvous. Legs reddish brown except coxae black, and trochanters and tarsi fulvous. Front wing hyaline, stigma and strong veins brown, weak veins colorless.

Head: Temple 0.91× as long as eye in dorsal view. Cheek 0.41× as long as longest diameter of eye. Clypeus 2.7× as wide as long, weakly convex, apex truncate. Second flagellar segment 2.2× as long as wide. Tenth flagellar segment 1.6× as long as wide. Apical segment 1.6× as long as penultimate segment (Fig. 1). Area between antennal sockets with a strong, high carina.

Mesosoma: Pronotum with three transverse wrinkles on collar. Epomia



Figs. 1–7. *Exallonyx rufimandibularis*. 1, Antenna. 2, Front wing. 3, Hind leg. 4, Abdominal stalk, dorsal. 5, Ovipositor sheath. 6, Abdominal stalk, lateral; 7, Posterior part of mesosoma, lateral.

distinct. Side of pronotum without hairs behind epomia and upper end of carina on collar. Upper margin of pronotum with a single row of hairs. Lower corner of pronotum with a single pit. Front edge of mesopleuron with a patch of hairs on upper corner, elsewhere hairless. Speculum with sparse hairs on upper 0.5. Lower half of mesopleuron with sparse hairs, except hairless along horizontal groove; posterior lower corner with parallel wrinkles. Smooth area of metapleuron 0.3× as long as metapleuron and 0.53× as deep as metapleuron, rest of metapleuron with reticulate wrinkles. Upper margin of propodeum angular in lateral view. Upper face of propodeum rugose, with a very small smooth area at base. Median ridge of propodeum incomplete and reaching to middle of hind face. Hind face weakly winkled on basal half and smooth on apical half. Pleural face of propodeum with reticulate wrinkles. Hind femur 3.7× as long as wide (Fig. 3). Longer spur of hind tibia 0.4× as long as hind basitarsus. Stigma 1.56× as long as wide, receiving radius at near middle (Fig. 2). Costal side of radial cell 0.50× as long as width of stigma; posterodistal side of stigma weakly convex. First radial vein oblique, 0.6× as long as wide. Second radial vein straight. Posterior margin of hind wing with a shallow notch at basal 0.35.

Metasoma: Abdominal stalk (Figs. 4, 6) as long as wide in dorsal view, with three weak transverse ridges on center of basal half, elsewhere smooth. Abdominal stalk as long as deep in lateral view, with four weak transverse ridges on basal half, apical half nearly smooth with only one distinct longitudinal groove. Base of syntergite with median groove reaching 0.72 to space between thyridia, on each side with two very shallow lateral grooves; sublateral groove 0.44× as long as median groove. First thyridium 2.5× as wide as long, separated from each by 0.75× width of one thyridium. Hairs on syntergite sparse and short, separated far from lower margin of syntergite. Ovipositor sheath (Fig. 5) 0.54× as long as hind tibia, 4.4× as long as wide; with fine longitudinal striations and hairs.

Male.—Unknown.

Variation.—Propodeum of paratype with strong transverse reticulate wrinkles on apical half of upper face and basal part of hind face.

Distribution.—China (Guangdong Province and Guangxi Zhuang Autonomous Region).

Material examined.—Holotype, ♀, China: National Forest Park of Liuxihe, Conghua, Guangdong Province, 13.IV.2002, Zaifu Xu, No. 20026961, deposited in ZU. Paratype: 1♀, China: Fangcheng, Guangxi Zhuang Autonomous Region, 8.VI.2000, Hong Wu, No. 2001002320, deposited in ZU.

Etymology.—The specific name is derived from the Latin adjective *rufi-* (reddish) + *mandibularis* (mandible), referring to the reddish-brown mandibles.

Remarks.—This new species is easily distinguished from those previously known by the upper margin of the propodeum angular in lateral view, upper face of abdominal stalk with three weak transverse ridges at center of basal half, and side of abdominal stalk with four weak ridges on basal half and nearly smooth on apical half.

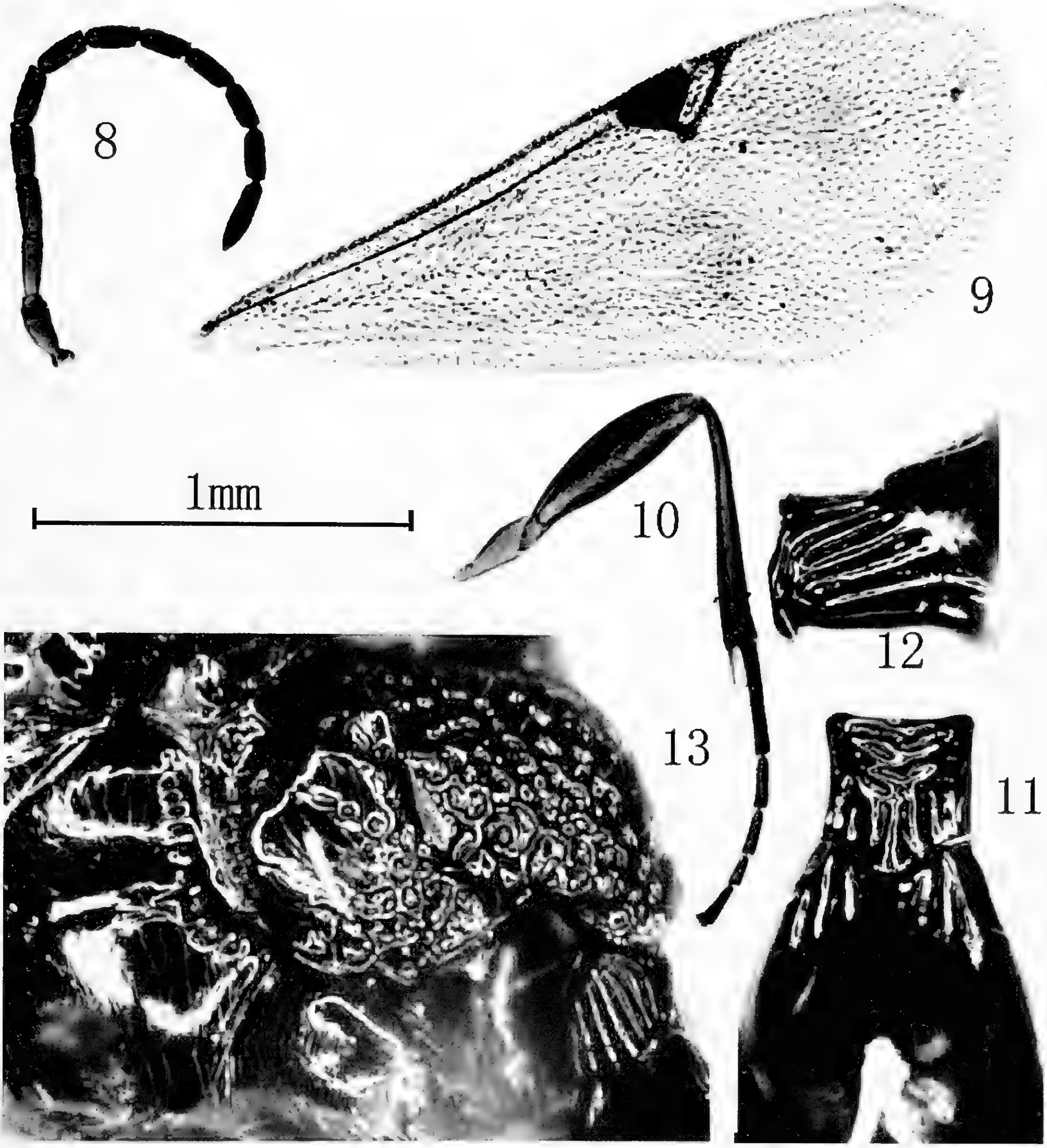
Exallonyx arcus Xu, Liu, and He, new species

(Figs. 8–13)

Male.—Front wing length 2.3 mm. *Color:* Body black. Antenna brown except scape, pedicel, and first flagellum fulvous. Labrum and apical half of mandible reddish brown. Palpi yellow. Tegula brown. Leg fulvous except front coxa light black brown, middle and hind coxae black brown. Front wing hyaline, tinged with fulvous, stigma and strong veins fulvous. Weak veins colorless.

Head: Temple 0.83× as long as eye in dorsal view. Cheek 0.31× as long as longest diameter of eye. Clypeus 3.0× as wide as long, weakly convex, apex oblique and truncate. Second flagellar segment 2.7× as long as wide. Tenth flagellar segment 3.0× as long as wide. Apical segment 1.4× as long as penultimate segment (Fig. 8). Tyloids absent. Area between antennal sockets with a weak carina.

Mesosoma: Pronotum with four to five transverse wrinkles on collar. Epomia



Figs. 8–13. *Exallonyx arcus*. 8, Antenna. 9, Front wing. 10, Hind leg. 11, Abdominal stalk, dorsal. 12, Abdominal stalk, lateral. 13, Posterior part of mesosoma, lateral.

weak. Side of pronotum without hairs behind epomia and upper end of carina on collar. Upper margin of pronotum with two rows of hairs. Lower corner with a single pit. Front edge of mesopleuron with a patch of hairs on upper corner and another above horizontal groove, hairless area 0.9× as long as tegula. Speculum with sparse hairs on upper 0.67. Lower half of mesopleuron with sparse hairs. Smooth area of metapleuron with some punctures, 0.5× as long as metapleuron and 0.75× as deep as metapleuron. Upper margin of propodeum arcuate in lateral view. Upper face of propodeum with smooth area on basal half and with fine reticulate wrinkles on apical half. Median ridge of propodeum complete. Hind face and pleural face of propodeum with reticulate wrinkles. Hind femur 4.0× as long as wide (Fig. 10). Longer spurs of hind tibia 0.5× as long as hind basitarsus. Stigma 1.8 as long as wide, receiving radius at middle (Fig. 8). Costal side of radial cell 0.52× as long as width of stigma, posterodistal side of stigma weakly convex. First radial vein weakly oblique, 1.5× as long as wide. Second radial vein straight. Posterior margin of hind wing with a shallow notch at basal 0.35.

Metasoma: Abdominal stalk (Figs. 11, 12) 1.1× as long as wide in dorsal view, with four arcuate transverse ridges on basal half and five longitudinal ridges at apical half. Abdominal stalk 0.7× as long as deep in lateral view, underside with one transverse ridge on base, side of stalk with seven longitudinal ridges behind transverse ridge. Base of syntergite with median groove reaching 0.6 to space between thyridia, on each side with three lateral grooves, sublateral groove 0.5× as long as median groove. First thyridium 1.8× as wide as long, separated from each by 0.28 width of one thyridium. Hairs on syntergite sparse and short, separated far from the lower margin of syntergite. Claspers triangular, not decurved, sharp at tip.

Female.—Unknown.

Variation.—Side of abdominal stalk of paratype with five longitudinal ridges.

Distribution.—China (Zhejiang Province).

Material examined.—Holotype, ♂, China: Mt. Tianmushan, Zhejiang Province, 11.VI.1993, Xuexin Chen, No. 935052, deposited at ZU. Paratype: 1♂, China: same locality as holotype, 3.VII.1998, Mingshui Zhao, No. 20000119, deposited at ZU.

Etymology.—The specific name derived from the Latin adjective *arcus* (arcuate), referring to the abdominal stalk with arcuate transverse ridges at the basal half in dorsal view.

Remarks.—This new species is similar to *Exallonyx torquatus*, but it is distinguished from the latter by the upper margin of the pronotum with two rows of hairs, upper face of abdominal stalk with four arcuate transverse ridges at the basal half and five longitudinal ridges at the apical half, and median groove on basal syntergite with three lateral grooves.

ACKNOWLEDGMENTS

We gratefully thank Prof. Xuexin Chen and Associate Prof. Yun Ma of the Institute of Insect Science, Zhejiang University, for their kind help during the study. This project is supported by the National Natural Sciences Foundation of China (No. 30370173, 30499341).

LITERATURE CITED

Fan, J. J. and J. J. He. 2003. Hymenoptera: Serphidae, pp. 716–723. *In* Huang, B. K. ed., Fauna of Insects in Fujian Province of China, Fujian Science and Technology Publishing House, Fuzhou vol. VII.

He, J. H. and J. J. Fan. 2004. Hymenoptera: Proctotrupidae, pp. 326–345. *In* He, J. H. ed. Hymenopteran Insect Fauna of Zhejiang. Science Press, Beijing.

Kieffer, J. J. 1904. Nouveaux proctotrypides myrmécophiles. Bulletin de la Société d'Histoire Naturelle de Metz 23: 34.

Liu, J. X., J. H. He, and Z. F. Xu. 2006. Two new species of the *dictyotus* group in genus *Exallonyx* Kieffer (Hymenoptera: Proctotrupidae) from China. Entomotaxonomia 28(2): 139–144.

Townes, H. and M. Townes. 1981. A Revision of the Serphidae (Hymenoptera). Memoirs of the American Entomological Institute 32: 1–541.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 807–812

TWO NEW SPECIES OF GELECHIIDAE (LEPIDOPTERA) FROM KOREA, WITH NOTES ON THE TAXONOMIC STATUS OF *TELPHUSA EURYZEUCTA* MEYRICK

Kyu-Tek Park and Margarita G. Ponomarenko

(K-TP) Center for Insect Systematics, Kangwon National University, Chuncheon, 200-701, Korea (e-mail: keitpark@hanmail.net); (MGP) Institute of Biology and Soil Science, Far Eastern Branch of Russian Academy of Sciences, Vladivostok, 690022, Russia (e-mail: margp@ibss.dvo.ru)

Abstract.—Two new species of the family Gelechiidae, ***Concubina trigonalis*** **Park and Ponomarenko, n. sp.** and ***Teleiodes gangwonensis*** **Park and Ponomarenko, n. sp.** are described from Korea. *Telphusa euryzeucta* Meyrick, 1922, is transferred to *Concubina: Concubina euryzeucta* (Meyrick 1922), **n. comb.** *Concubina subita* N. Omelko and M. Omelko, 2004 is considered **a new junior synonym** of *C. euryzeucta*.

Key Words: Insecta, Lepidoptera, Gelechiidae, *Concubina*, *Teleiodes*, taxonomy, Korea

---

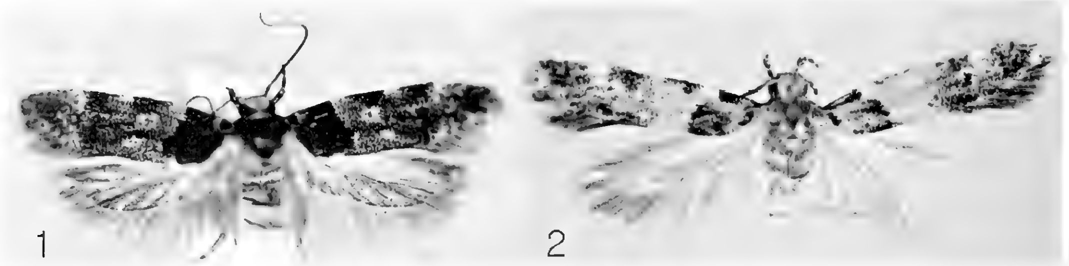
The Gelechiidae of Korea were recently reviewed by Park (2004), with 146 known species. During a recent study of the material of the Gelechiidae in the collection of the Center for Insect Systematics (CIS), Korea, we found two new species that are described herein, *Concubina trigonalis* and *Teleiodes gangwonensis*. In addition, *Telphusa euryzeucta* Meyrick, 1922, which was described from a single female from Shanghai, China, is transferred to the genus *Concubina* N. Omelko and M. Omelko, because the species agrees with *Concubina* in every diagnostic aspect. Furthermore, *C. subita* N. Omelko and M. Omelko, 2004, the type species of *Concubina*, can not be distinguished morphologically from *C. euryzeucta*; thus, we propose *C. subita* as a new junior synonym of *C. euryzeucta*.

Terminology of the male genitalia mainly follows Klots (1970) and Ponomarenko (2005). The holotypes and paratypes of the new species are deposited in the collection of the CIS, Chuncheon, Korea.

TAXONOMIC ACCOUNTS

Concubina trigonalis Park and Ponomarenko, new species
(Figs. 1, 3, 3a, 3b, 4)

Type material.—Holotype: ♂, Mt. Seolak-san, Gangwon Province., Korea, 10 August 1989, coll. K. T. Park, gen. prep. no. CIS-1790/Park. Paratypes: 1 ♂, Mt. Kyejok-san, Youngwol, Gangwon Prov., Korea, 14 July 1998, coll. S. M. Lee, gen. prep. no. CIS-5183/Ponomarenko; 1 ♂ and 2 ♀, Mt. Taewha-san, Youngwol, Gangwon Prov., Korea, 14 July 1998, coll. S. M. Lee; 1 ♀, Mt. Geumdan-san, Hanam, Gyeonggi Prov., Korea, 25 July 1996, coll. Bae, Paek, Lee and Ahn, gen. prep. no. CIS-5184/Ponomarenko; 1 ♀, same locality as the preceding specimen, 1 August 2000, coll. Lee & al.



Figs. 1–2. Adults. 1, *Concubina trigonalis*, holotype. 2, *Teleiodes gangwonensis*, holotype.

Description.—Wingspan 14.0–14.5 mm. Head pale gray, speckled with brownish-gray scales dorsally and with dark-gray scales laterocaudally. Tegula dark gray. Thorax dark gray, with somewhat erect scales distally. Antenna about 4/5 length of forewing; basal segment slender, dark gray; dorsum of flagellum with alternate dark and pale gray scale pattern, paler beyond middle. Second segment of labial palpus thickened, furrowed beneath, dark fuscous with three white bands; one at base, one at middle, and one at 3/4 on both surfaces; third segment dark fuscous with two white bands: one near base and one at middle; apex whitish, acute. Abdomen brownish gray dorsally. Hind tibia ochreous white, shinny, with pale brownish rough hairlike scales above. Forewing relatively broad, with dark-gray basal fascia within 1/4 length, basal fascia with oblique and sinuate outer margin; antemedian band creamy white on anterior half, with two brownish scale-tufts on posterior half, or extending to median fascia; median fascia dark fuscous, broad, exceeding 3/4 length of forewing, with several small scale-tufts on surface; costa with a small ochreous spot at middle and large, triangular ochreous patch at 3/4 length; area beyond medial fascia densely speckled with dark fuscous scales centrally; ochreous scales scattered along inner margin beyond tornus; apex obtuse; termen oblique; fringe gray, irrorated with dark fuscous scales. Vein R_3 separated from R_{4+5}; R_4 and R_5 stalked at middle; R_5 to costa; M_1 arising from cell separately; M_2 close to M_3 at base; distance M_3-CuA_1 about 1/2 of CuA_1-CuA_2. Hind wing gray; apex acute; termen strongly sinuate; fringe gray. Veins Sc and Rs connected with a crossvein at basal 1/3 of Sc; Rs and M_1 separated beyond cell; M_2 absent; M_3 and CuA_1 separated.

Male genitalia (Figs. 3, 3a, 3b): Eighth tergite subtriangular, rather small with round apex, anterior margin roundly concave, shorter than length of eighth sternite. Eighth sternite trapezoidal, relatively short; anterior margin convex medially (Fig. 3b). Uncus slightly narrowed towards bilobed apex. Tegumen broad, divided into two relatively wide parts anteriorly, with deep emargination on anterior margin reaching to one half length, with two triangular lobes on distal part. Gnathos absent. Cucullus absent. Ventral sclerite formed by fused sacculi and vinculum, relatively wide, with two triangular plates posteriorly; saccus absent. Aedeagus stout, tubelike, much wider basally, narrowed gradually towards apex.

Female genitalia (Fig. 4): Ovipositor long, membrane between eighth and ninth segments more than 5.5 times as long as papillae anales. Apophyses posteriores about 3 times as long as apophyses anteriores. Eighth segment annular, with longitudinal gutter near antrum along anterior margin. Antrum sclerotized laterally, narrowed near middle. Ductus bursa membranous, about twice as long as corpus bursae, with dilated anterior half; ductus seminalis arising from distal part. Corpus bursa oval, membranous, with dense spicules on inner surface; signum rhomboidal, large, with serrated margins and a transverse furrow medially.

Distribution.—Korea (central).

Etymology.—The specific name is derived from the Greek, "*trigono*," referring to the shape of the fusion of the vinculum and the sacculus.

Diagnosis.—*Concubina trigonalis* is similar to *C. euryzeucta* Meyrick, 1922, which was described in the genus *Telphusa* Chambers from China, in the structure of the male and female genitalia, but it differs from the latter species in having the uncus slightly narrowed distally and bilobed at its apex, the ventral sclerite with triangular plates posteriorly instead of plates rounded on distal margin of *euryzeucta* Meyrick in the male genitalia, and longer eighth sternite in the female genitalia.

Remarks.—The genus *Concubina* N. Omelko and M. Omelko, 2004 was described as monotypic with the type species *C. subita* N. Omelko and M. Omelko, 2004, from far eastern Russia. This is the second species of the genus. The genus is restricted to far eastern Asia, including Russia, central Korean Peninsula, and eastern, northern, and central China. The host plants of only *C. euryzeucta* Meyrick are known. Larvae feed on *Prunus persica* Batsch, *P. pseudocerasus* Lindl., *P. armenicana* L., *P. salicina* Lindl., *P. mume* Sieb. et Zucc (Li 2002).

Concubina euryzeucta (Meyrick 1922), **n. comb.**

Telphusa euryzeucta Meyrick 1922: 501; Caradja and Meyrick 1936: 157; Li 2002: 120. TL: Shanghai, China.

Concubina subita N. Omelko and M. Omelko 2004: 193, figs. 1–5. **New synonymy**.

Diagnosis.—Wingspan 12–16 mm. This species is similar to the preceding new species, *C. trigonalis*, by the forewing pattern, but it can be distinguishable by the white ground color of the forewing with a large costal spot at the middle. Also it can be distinguished by the structure of the male genitalia as noted in the diagnosis of *C. trigonalis*.

Remarks.—Originally, *euryzeucta* Meyrick, 1922, was described in the genus *Telphusa* Chambers, but it differs from the type species, *Telphusa curvistrigella* Chambers, 1872 (= *T. longifasciella* (Clemens, 1863)) by the absence of gnathos, the reduced cucullus, and the fused sacculus and vinculum. The forewing pattern and the genitalia of both sexes of *euryzeucta* Meyrick, 1922, figured by Li (2002: 122, figs. 118, 119) turned out identical to *Concubina subita* N. Omelko and M. Omelko (2004: 195, figs. 1–5), which is the type species of the genus *Concubina*, and *C. subita* is herein synonymized with *C. euryzeucta* Meyrick.

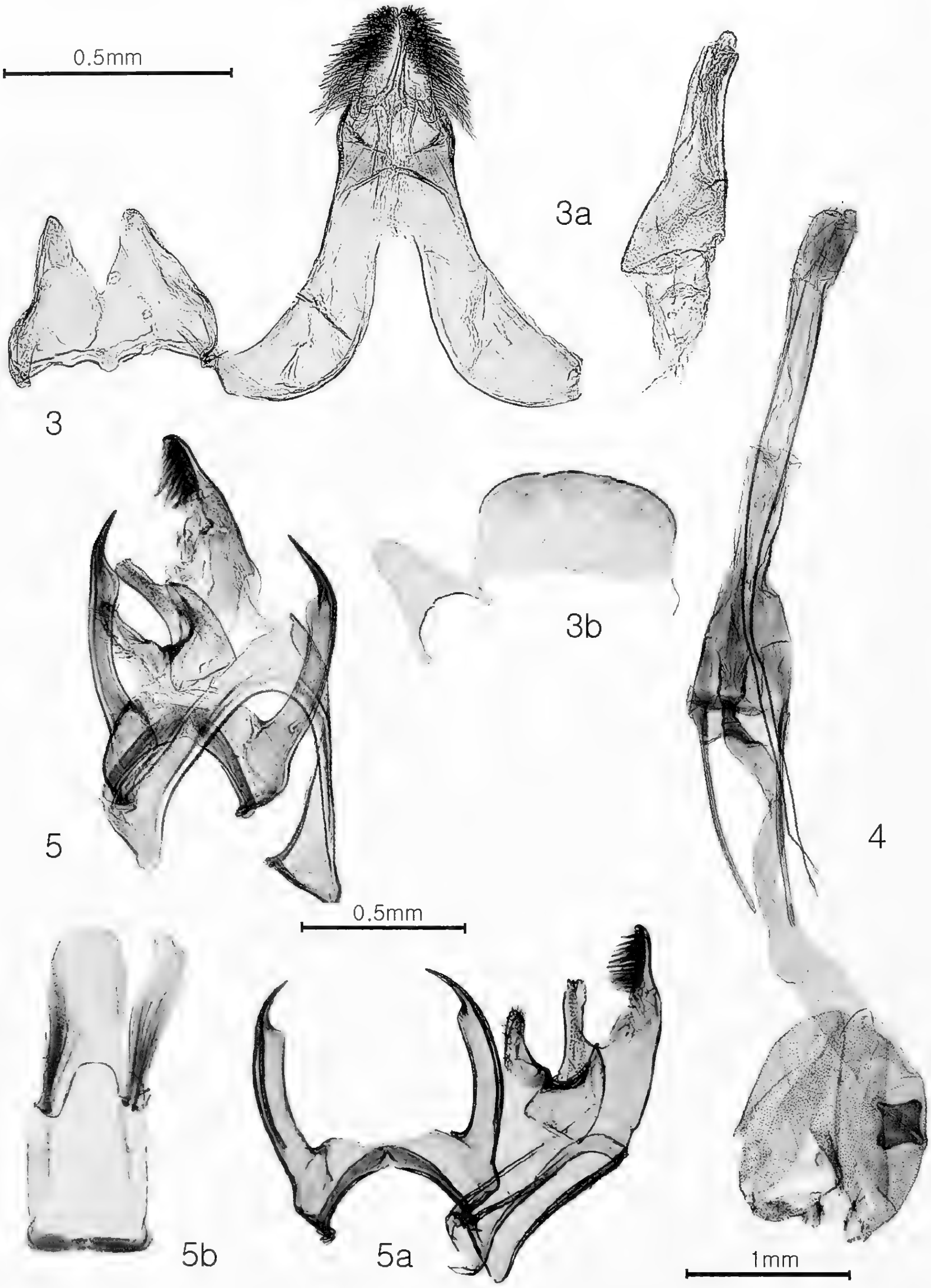
Distribution.—China (Beijing, Tianjin, Hebei, Shanxi, Shandong, Shanghai, Gansu, Qinghai, Shaanxi, Hunan, Jiangxi); Russia (Primorsk Territory).

Teleiodes gangwonensis **Park and Ponomarenko, new species**

(Figs. 2, 5, 5a, 5b)

Type mateial.—Holotype: ♂, Seomyun, Yangyang, Gangwon Prov., Korea, 17 August 1992, coll. K. T. Park and B. K. Byun, gen. prep. no. CIS-5199/Park. Paratype: 1 ♂, Chuncheon, Gangwon Prov., Korea, 11 June 1989, coll. K. T. Park, gen. prep. no. CIS-5148/Ponomarenko.

Description.—Wingspan, 10.0–10.5 mm. Head pale gray with dark gray scales laterally. Tegula and thorax grayish, speckled with dark-gray scales. Antenna with basal segment gray dorsally; flagellum with alternate dark and pale gray scale pattern dorsally. Second segment of labial palpus



Figs. 3–5. Male and female genitalia. 3, Male genitalia of *Concubina trigonalis*, gen. prep. no. 1970, holotype. 3a, Aedeagus. 3b, Eighth tergite and sternite, holotype. 4, Female genitalia, gen. prep. no. 5184. 5, Male genitalia of *Teleiodes gangwonensis*, paratype, gen. prep. no. 5148. 5a, Same of *T. gangwonensis*, holotype, lateral view, gen. prep. no. 5199. 5b, Eighth tergite and sternite of abdomen of *T. gangwonensis*, holotype.

thickened, pale gray with three dark brown bands: near base, beyond middle, and at preapex; third segment ochreous white to pale gray, with dark gray bands: at base, middle, and preapex, middle one very broad; apex acute, whitish. Forewing ground color pale gray, with dark-gray basal fascia; outer margin of basal fascia incised at 1/3, convex beyond 1/3; antemedian band broad, pale brown, with a large, triangular costal patch at 1/3; median fascia dark gray, broadly developed; an ochreous white patch beyond median fascia along costa; dark fuscous scales scattered beyond median fascia; apex acute; termen strongly oblique; Fringe dark gray. Hind wing pale gray; apex acute; termen strongly sinuate; fringe grayish orange. The female is unknown.

Male genitalia (Figs. 5, 5a, 5b): Eighth tergite cone-shaped, much longer than sternite; anterior margin deeply emarginated, reaching 1/3 of its total length. Eighth sternite trapezoidal, with a pair of dense hair pencils along anterior margin; anterior margin slightly concave medially (fig. 5b). Uncus narrowed distally, apically truncate. Gnathos absent. Tegumen long, anterior half divided into broad lateral parts; anterior margin deeply emarginated to half length. Cucullus absent. Glandiductors abruptly narrowed beyond 3/4 length, forming a long spine-like process. Glandular ductus extending from 1/4 to apex of glandiductors. Ventral sclerite formed by fused vinculum and sacculus, consisting of two parts, with heavily sclerotized band along anterior margin. Aedeagus stout, truncated beyond 2/3, with an elongate parallel apex. Vesica with several small cornuti. Juxta with a ventrolateral support for aedeagus, with long fingerlike, weakly sclerotized setaceous lateral lobes.

Distribution.—Korea (central).

Etymology.—The specific name is derived from the collecting locality of the holotype, “Gangwon.”

Diagnosis.—The new species is very similar to *Teleiodes luculella* (Hübner) in the structure of the male genitalia and the pattern of the forewing (Huemer and Karsholt 1999: 227, fig. 21), but it differs from the latter by having a longer uncus; abruptly narrowed glandiductors (referred as valva by Huemer and Karsholt 1999), which are narrow and strongly curved in *luculella* (Hübner); and an abruptly truncated distal part of the aedeagus proximal to the apex, with the distal part forming a narrow tube.

Remarks.—The genus *Teleiodes* Sattler, 1960 comprises more than 100 species distributed worldwide. Many of the species have been transferred into other genera; *Carpatolechia* Capuse, *Pseudotelphusa* Janse, *Istrianis* Meyrick, and *Streyella* Janse, but *Teleiodes* Sattler is still considered polyphyletic and needs to be revised. The newly described species belongs to the monophyletic species group together with the type species of the genus, *Teleiodes vulgella* [Denis and Schiffermuller], 1775. Larvae feed on various deciduous trees and bushes of different families: Rosaceae, Fagaceae, Betulaceae, Corylaceae, and Salicaceae (Huemer and Karsholt 1999).

ACKNOWLEDGMENTS

We thank the Korea Science and Engineering Foundation for financial support, especially for travel expenses for the second author (2005–2007) in Korea. Thanks are extended to the first author's students H.L. Han, Minyoung Kim, and Sora Kim for their help in collecting, spreading, and the preparation of some specimens. This study was funded in part, by the Korea National Arboretum, Korea.

LITERATURE CITED

Caradja, A. and E. Meyrick. 1936. Materialen zu einer Lepidopterenfauna des Taishanmassivs, Provinz Shantung. Deutsche Entomologische Zeitschrift, Iris 50: 135–159.

Huemer, P. and O. Karsholt. 1999. Gelechiidae 1. *In* Huemer, P., O. Karsholt, and L. Lyneborg, eds. Microlepidoptera Europe 3. Apollo Books, Stenstrup. 356 pp.

Klots, A. B. 1970. Lepidoptera, pp. 115–130. *In* Tuxen, S. L. ed. Taxonomist's Glossary of Genitalia in Insects. Munksgaard, Copenhagen and S-H Service Agency, Inc., Darien, Conn.

Li, H. 2002. The Gelechiidae of China (I) (Lepidoptera: Gelechioidea). Tianjin. 538 pp.

Meyrick, E. 1922. Exotic Microlepidoptera 2. Marlborough. 639 pp.

Omelko, N. V. and M. M. Omelko. 2004. New genus and species of gelechiid moths (Lepidoptera, Gelechiidae) from subfamily Teleiodinae in South Primorye. Biologicheskie issledovaniyana Gornotaezhnoi stantcii 9: 193–196.

Park, K. T. 2004. Lepidoptera (Gelechiidae and Lecithoceridae). Jeungheng-sa, Seoul. 151 pp.

Ponomarenko, M. G. 2005. Gelechiid moths (Lepidoptera, Gelechiidae) of the Palaearctic: functional morphology of the male genitalia, phylogeny and taxonomy. Chteniya pamyati N. A. Kholodkovskogo 58. Zoological Institute of Russian Academy of Sciences, St. Petersburg. 139 pp.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 813–828

PHENOLOGY, REPRODUCTIVE CYCLES, AND SPECIES COMPOSITION OF A DUNG BEETLE COMMUNITY (COLEOPTERA: SCARABAEOIDEA) FROM A HIGH MOUNTAIN PASTURE SYSTEM ON THE ORIENTAL NEOVOLCANIC AXIS (VERACRUZ, MEXICO)

Francisco J. Cabrero-Sañudo, Nuria Trotta-Moreu, and Imelda Martínez M.

Departamento de Biodiversidad y Ecología Animal, Instituto de Ecología A.C., Apartado Postal 63, Km 2,5 carret. Antigua a Coatepec 351, Congregación El Haya, 91070 Xalapa, Veracruz, Mexico (e-mail: francisco.cabrero@inecol.edu.mx; imelda.martinez@inecol.edu.mx; nuria.trotta@inecol.edu.mx)

Abstract.—This 13-month study focused on a dung beetle community in the high mountain pastures of the Oriental Neovolcanic Axis, near Tonalaco, a site located on the southeastern slope of the Cofre de Perote volcano (Veracruz, Mexico), at an altitude of 2620 meters. A total of 1997 individuals from seven dung beetle species were collected in monthly samples of cattle and horse dung. These species included one Geotrupinae, *Geotrupes (Halffterius) rufoclavatus*; five Aphodiinae species, *Blackburneus (sensu lato) charmionus, Chilothorax ornatus, Gonaphodiellus opisthius, Oxyomus setosopunctatus,* and *Planolinellus vittatus*; and, one Scarabaeinae, *Onthophagus chevrolati.* Phenology and reproductive cycles were analyzed for the three most abundant species. *Gonaphodiellus opisthius* showed two population peaks significantly associated with the rainy season and the precipitation, and they were strongly univoltine. In contrast, *P. vittatus* and *O. chevrolati* seemed associated with the dry season, although they were also collected in the rainy season. They were multivoltine. Species composition was also analyzed for other dung beetle similar studies on the Oriental Neovolcanic Axis. In general, eight dung beetle species showed especially characteristic from these localities (the last five former species plus *Cephalocyclus durangoensis, C. hogei*, and *Liothorax levatus*). Most of the dung beetles from the Oriental Neovolcanic Axis present univoltine reproductive cycles, as a consequence of their high mountain adaptation. Moreover, they are principally distributed at the Mexican Transition Zone and Mesoamerica, and could be considered as Nearctic elements.

Resumen.—El presente estudio, desarrollado durante 13 meses, tuvo como objetivo estudiar la comunidad de los escarabajos del estiércol de pastos de alta montaña de la región oriental del Eje Neovolcánico, cerca de Tonalaco, localidad situada en la ladera sudeste del volcán Cofre de Perote (Veracruz, México). Se colectó un total de 1997 individuos, pertenecientes a siete especies de escarabajos del estiércol, mediante muestreos mensuales realizados en excremento de vaca y caballo. Estas especies incluyeron un Geotrupinae, *Geotrupes (Halffterius) rufoclavatus*; cinco Aphodiinae, *Blackburneus (sensu lato) charmionus, Chilothorax ornatus, Gonaphodiellus opisthius, Oxyomus setosopunctatus* y *Planolinellus vittatus*; y, un Scarabaeidae, *Onthophagus chevrolati.* Se estudiaron la fenología y los ciclos reproductivos para las tres especies más abundantes. *G. opisthius* mostró dos picos poblacionales significativamente asociados con la estación de lluvias y con las precipitaciones, y se comportó marcadamente univoltino. Por el contrario, *P. vittatus* y *O. chevrolati* se mostraron posiblemente asociados con la estación seca, aunque también se colectaron durante la estación de lluvias; se comportaron como multivoltinos. Se analizó también la composición de especies para otros estudios de escarabajos del estiércol realizados en la región oriental del Eje Neovolcánico. En general, ocho especies de escarabajos del estiércol son especialmente características de estas localidades (las cinco primeras especies anteriormente nombradas más *Cephalocyclus durangoensis, C. hogei*, and *Liothorax levatus*). La mayoría de los escarabajos estercoleros de la región oriental del Eje Neovolcánico tienen ciclos univoltinos, como consecuencia de su adaptación a alta montaña. Además, presentan principalmente una distribución comprendida en la Zona de Transición Mexicana y Mesoamérica, y se podrían considerar como elementos Neárticos.

Key Words: dung beetles, Aphodiinae, Scarabaeinae, Geotrupinae, Oriental Neovolcanic Axis, phenology, reproductive cycles, geographic distribution

High mountain habitats are a very interesting setting for ecological studies because of the seasonal and predictable changes in environmental conditions. Communities of dung beetles usually inhabit high mountain pastures worldwide (Lumaret and Stiernet 1991), and therefore they also populate tropical and subtropical regions of the Northern Hemisphere (Kohlman 1991). These dung beetle communities are generally dominated by Aphodiinae (Coleoptera: Scarabaeoidea: Scarabaeidae) (Hanski 1991), although it is possible to find species belonging to other groups, such as Geotrupidae (Coleoptera: Scarabaeoidea) and Scarabaeinae (Coleoptera: Scarabaeoidea: Scarabaeidae). Most of these species are coprophagous feeders, although some are euriphagic and saprophagous species that could alternately or occasionally share the habitat and the food (Halffter and Edmonds 1982).

Dung beetles are ecologically important in pasturelands because of their recycling of nutrients (Fincher 1981, Rougon et al. 1988, Yokohama et al. 1991) and control of livestock parasites (Bryan 1973, Fincher 1975, McQueen 1975, McQueen and Beirne 1975, Chirico et al. 2003) and flies (Moon et al. 1980, Ridsdill-Smith et al. 1987, Ridsdill-Smith and Hayles 1990). However, dung beetles are possibly one of the most sensitive and often-damaged groups of high mountain pasture systems, as a consequence of changes in land use and chemical applications (vermicides and herbicides) (Lumaret and Martínez 2005, Martínez and Lumaret 2006). Therefore, the study of the biology and peculiarities of dung beetle communities is necessary to understand the natural processes of these systems and then to try to minimize possible impacts which could bring significant effects on the environment balance.

The Neovolcanic Axis is a mountain system situated in Central Mexico, between the 17°15′–21°14′N and 96°9′–105°16′W coordinates. It extends from northwest to southeast more than 1,000 km long and 50–150 km wide. The Neovolcanic Axis started to form during the Oligocene, although it underwent more intense development during Pliocene-Pleistocene (Halffter 1987). In this study, a community of dung beetles from a high mountain pasture (>2500 meters above sea level), situated on the southeastern slope of the Cofre de Perote volcano, at the Oriental Neovolcanic Axis, was observed and analyzed throughout a year.

Several other studies have already analyzed the phenology and reproductive biology of some Mexican dung beetles, especially Aphodiinae (Halffter et al. 1985; Martínez 1992, 2001, 2003, 2005; Martínez et al. 1996, 1998, 2000, 2001a, 2001b; Cruz and Huerta 1998; Martínez and Cruz 1999, 2002; Martínez and Alvarado 2001; Cruz et al. 2002; Martínez and Suárez 2006). This study examines the abundance of the different species, the species' reproductive cycles, and local climatic data to determine possible relationships and to describe the community.

Additionally, to determine the importance of the dung beetle communities situated on high mountain pastures of this region, other previous similar studies conducted at the Oriental Neovolcanic Axis have been also considered (Cruz et al. 2002, Martínez 2005, Martínez and Suárez 2006). Thus, reproductive cycles and geographic distribution of cited species have been analyzed jointly to explain the composition and importance of these communities and to characterize them.

MATERIALS AND METHODS

Study area.—The sampling was carried out in a grassland area where some horses and cattle usually graze, on the southeastern slope of the Cofre de Perote volcano (19°25′59″N, 97°7′51″W, 2620 meters), close to Tonalaco village, Xico municipality, Veracruz State, Mexico (Fig. 1). The sampling area was situated in a rainforest area, with induced pastures and pine-oak forests (Rzedowski 1978). The weather is temperate, with an annual mean temperature of 12.3°C, which ranges between 2.5 and 21.9°C of minimum and maximum temperatures respectively, and with a total annual precipitation of 908 mm (data generated through interpolation of average monthly climate data from world weather stations, covering a 30- to 50-year period; database from Hijmans et al. 2006; Fig. 2). Data from the closest climatic station Oxtlapa (around 5 km away; National Water Commission, State of Veracruz) was not taken into account as it was situated at an elevation of 1850 meters.

Collecting methods.—The insects were collected monthly, from February 2005 through February 2006. Ten dung pat samplings of about 250 grams each were taken once a month. These samplings were selected from cattle and horse dung with an external crust and an internal semi-moist consistency. Along with the dung, two centimetres of soil underneath were also examined for each sampling. Temperature and humidity measures and general climatic conditions at the moment of sampling were also noted down. All the dung beetles from these samplings were manually gathered, identified, and counted at the laboratory.

Species phenology.—Individuals of each species and species richness were counted from February 2005 through February 2006. Correlations between species richness and number of individuals per month were analyzed in the context of climatic variables. Climatic data taken at time of sampling as well as the world climatic database of Hijmans et al. (2006) were used to check correlations, the latter extracting monthly data (mean, minimum, and maximum temperatures and total precipitation) for the Tonalaco location according to its geographic coordinates (≈1 km error). Correlations were rectified by means of the Bonferroni correction.

Moreover, monthly data were also separated according to yearly seasons, dry (from November to the beginning of May) and rainy (from the end of May to October), and the groups were statisti-

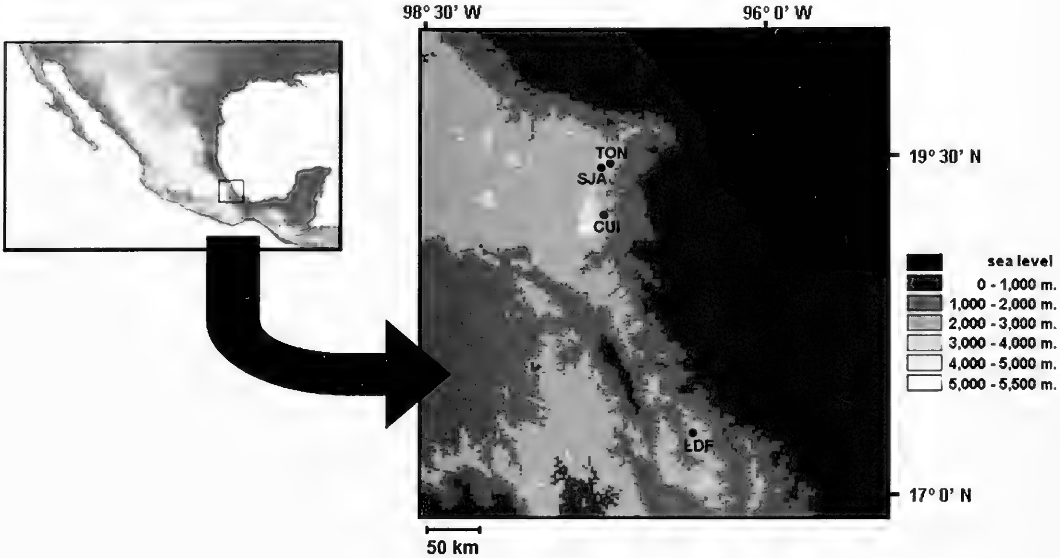


Fig. 1. Geographic location of the Tonalaco locality (Veracruz, México). The location of three other annual dung beetles studies are also shown on the map (CUI: Cuiyachapa; LDF: Llano de las Flores; SJA: San José Aguazuelas; TON: Tonalaco).

cally compared for species richness and number of individuals.

Reproductive cycles.—To determine the reproductive cycles of the species, the study considered dung beetles gathered from March 2005 through February 2006. Species were selected for examination of their reproductive cycles depending on whether a considerable number of specimens had been collected for the species and whether they appeared during several months over the sampling period. Whenever possible, at least 10 individuals of each species were chosen at random and their reproductive systems were dissected in Ringer-Ephrussi saline solution. The reproductive systems were fixed in AFTAD (96% ethanol – formaldehyde – trichloroacetic acid – dimethylsulfoxide) and subsequently preserved in 96° ethanol. Most of these samples were also dyed in toto with Feulgen-green light (Martínez 2002).

For female gonads, three maturing stages were discriminated: immature, mature/maturing before oviposition, and mature after oviposition. For males, three stages were also considered: immature, mature/maturing before copulation, and mature after copulation. Ovarian activity was determined for each female according to the length of basal oocytes, the appearance of chorion, and the wideness and laxity of the lateral oviducts. Male testicular and glandular activity was determined taking into account the length of testis follicles, volume of the accessory gland reservoirs, and presence of seminal fluid in the gland ducts and reservoirs (Martínez 2002).

This method was chosen because it has been satisfactorily carried out with other Scarabaeidae species (Martínez 1992a, 1992b, 2005; Martínez and Cruz 1992, 2002; Martínez et al. 1996, 1998; Cruz and Huerta 1998; Cruz et al. 2002).

Completeness of inventories and characterization of dung beetle communities. – Reliability of the species inventory obtained in the samples was evaluated by using non-parametric estimators of species richness, Chao2 and ACE (Chao 1987, Colwell and Coddington 1994,

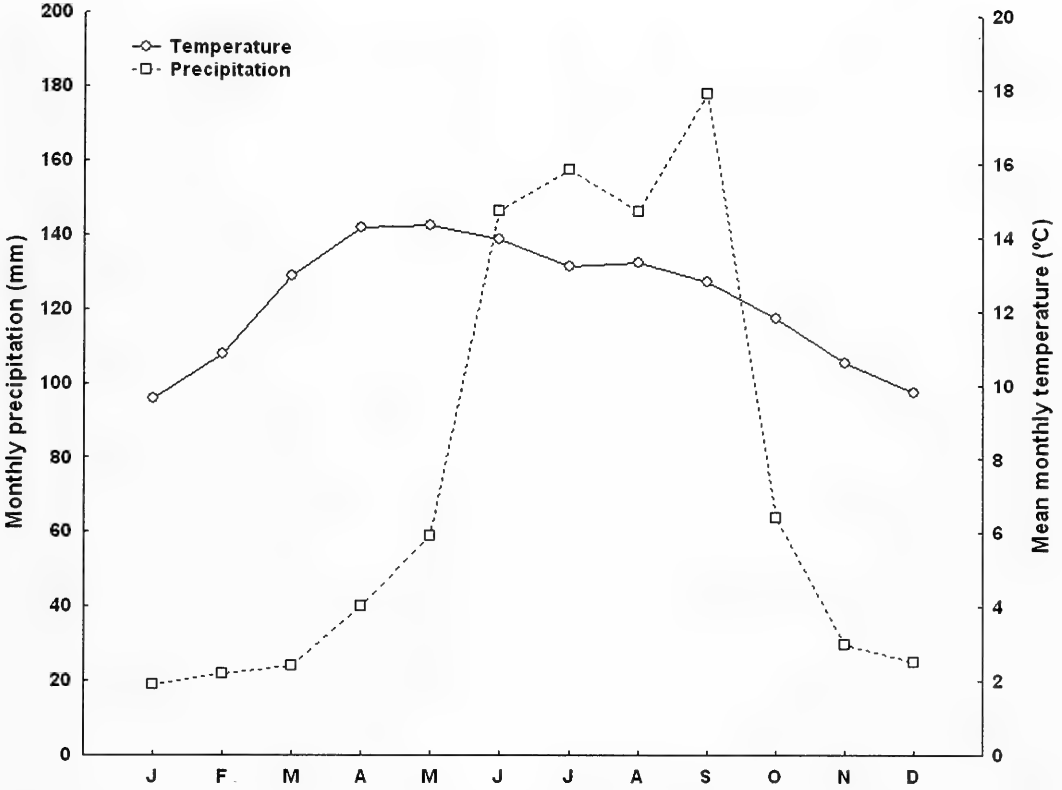


Fig. 2. Ombrothermic chart for Tonalaco (Veracruz, Mexico) station (19°25′59″N, 97°7′51″W, 2620 meters; Hijmans et al. 2006). Note that the precipitation axis is 10 times the temperature axis, instead of two times, as is usual for ombrothermic charts.

Chazdon et al. 1998). The values of estimators were obtained by means of the EstimateS program (Colwell 2005).

Three other annual dung beetle studies carried out in localities on high mountain pastures (>2500 m) in the Oriental Neovolcanic Axis (Fig. 1) were also analyzed this way in order to confirm if their sampling efforts had been suitable: (CUI) Cuiyachapa, at an altitude of 2700 m, on the eastern side of the Pico de Orizaba volcano, Veracruz (Cruz et al. 2002); (SJA) San José de Aguazuelas, at 2700 m, on the southwestern slope of the Cofre de Perote volcano, Veracruz (Martínez 2005); and (LDF) Llano de las Flores, at an altitude of 2600 m, on the eastern slope of the Sierra de Juárez, Oaxaca (Martínez and Suárez 2006). The original record sheets of these three studies were accessed and consulted in order to obtain some species abundances which were not finally included in the previous articles.

Subsequently, the species lists from these studies were completed with data taken from hand sampling by E. Montes de Oca and Q. Santiago leg., for Tonalaco (TON); F. J. Cabrero-Sañudo and N. Trotta-Moreu leg., for CUI; M. Dellacasa, I. Martínez, T. Pensado, Q. Santiago, and T. Suárez leg., for SJA; and J. Ari, M. Cruz, I. Martínez, P. Reyes, T. Suárez, and M. Zunino leg., for LDF; and from other published works by Dellacasa et al. 2002, for CUI and SJA; and by Arellano 2002, for SJA.

In order to describe the dung beetle communities of high mountain pastures situated in the Oriental Neovolcanic

Axis, some data from species were compiled.

Total richness of Aphodiinae, Scarabaeinae, and Geotrupinae species was obtained for each locality. For each species, known reproductive cycles were also consulted on literature (Cruz et al. 2002, Martínez 2005, Martínez and Suárez 2006). Geographic distribution of species was taken mainly from Delgado-Castillo and Márquez (2006), Dellacasa and Dellacasa (2005), Dellacasa and Stebnicka (2001), Dellacasa et al. (2002), Edmonds (1994), Galante et al. (2003), Howden (2003), Morón et al. (2003), Navarrete-Heredia and Deloya (2005), and Zunino and Halffter (1988). Biogeographic categories for each species were based on regions and dominions proposed by Morrone (2006).

RESULTS

Seven Scarabaeoidea species were found during the complete sampling period (February 2005 – February 2006), with a total of 1997 individuals. Samples encountered one Geotrupidae: Geotrupinae species, *Geotrupes* (*Halffterius*) *rufoclavatus* (Jekel, 1865); five Aphodiinae, *Blackburneus charmionus* (Bates, 1887), *Chilothorax ornatus* (Schmidt, A., 1911), *Gonaphodiellus opisthius* (Bates, 1887), *Oxyomus setosopunctatus* Schmidt A., 1911, and *Planolinellus vittatus* (Say, 1825); and one Scarabaeinae, *Onthophagus chevrolati* ssp. *chevrolati* Harold, 1869 (Table 1).

Species phenology and reproductive cycles.—Throughout all the sampling period in Tonalaco, the months of February, July, and November 2005, and February 2006 were those with highest species richness (4 to 6 species), whereas lowest richness (2 species) was seen in March and October 2005 and January 2006 (Table 1). For Aphodiinae, February, July, and November 2005 showed the highest richness (3 to 4 species), while the lowest richness (0 to

Table 1. Species gathered and individual abundances for the sampling near Tonalaco (Veracruz, Mexico) from February 2005 to February 2006.

	Dry Season				Rainy Season					Dry Season				
	II-7-2005	III-7-2005	IV-4-2005	V-2-2005	VI-6-2005	VII-13-2005	IX-2-2005	IX-26-2005	X-21-2005	XI-28-2005	XII-13-2005	I-24-2006	II-21-2006	TOTAL
Scarabaeidae: Aphodiinae														
Blackburneus charmionus (Bates, 1887)	8	-	-	-	-	-	-	-	-	2	-	-	2	12
Chilothorax ornatus (Schmidt, A., 1911)	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Gonaphodiellus opisthius (Bates, 1887)	-	-	5	10	861	411	20	54	123	47	21	-	-	1552
Oxyomus setosopunctatus Schmidt, A., 1911	1	-	-	-	-	5	-	-	-	-	-	-	-	6
Planolinellus vittatus (Say, 1825)	45	58	27	20	13	4	-	-	-	3	7	-	18	195
Scarabaeidae: Scarabaeinae														
Onthophagus chevrolati Harold, 1869	80	40	7	7	5	5	17	14	16	8	9	3	9	220
Geotrupidae: Geotrupinae														
Geotrupes (*Halffterius*) *rufoclavatus* Jekel, 1865	2	-	-	-	-	-	1	2	-	-	-	5	1	11

1 species) occurred in March, September, and October 2005, and January 2006. Geotrupinae richness was at a maximum in February, September, and January 2005 and February 2006, though with only one species each month and null during the rest of the year. For Scarabaeidae, a species richness of one was a constant throughout the whole year. No significant correlations were observed between species richness or species abundances and monthly mean, minimum, or maximum temperatures or precipitation, except for *G. opisthius*; nor were significant differences observed in species richness or abundances between rainy and dry seasons, except for *G. opisthius*.

The most abundant species was *G. opisthius* (Table 1). This species was active from April to December, presenting two population peaks, a higher one in June–July, and a smaller one in October. This species displayed a significant relationship to precipitation (rs = 0.56; P = 0.047) and there was a significant higher number of individuals captured on the rainy season (t = −2.33; df = 11; P = 0.040). Female individuals collected in May and June were maturing and ready for oviposition (Fig. 3). In July, all the females had laid eggs, and in August, 20% had. From August to December 2005, most (80% in August) or all the females were immature. With regard to males, in May, 60% were approaching a mature stage; the other 40% were fully mature males that had already copulated. From June to August, all the males found had copulated, as well as 10% of males in September. Immature males were observed from September (90% of males) to December.

Planolinellus vittatus showed a moderate number of individuals throughout the year (Table 1). This species was found from February to July and from November to December, showing its highest peak in February–March. This species seems to disappear when rains are at their highest point, though it has not been statistically confirmed. Maturing females and mature females before oviposition were found in March, June, July, and December 2005, and February 2006, whereas some females had already oviposited in March–July, November and December 2005, and February 2006 (Fig. 3). For males, the immature stage is present at least during two months, April (10%) and June (60%). Most of the remaining males were found maturing or mature before copulation in March to June, November, December 2005, and February 2006. Only a small proportion of males had already copulated, and these were observed in the months of March, May, December 2005, and February 2006.

The species *O. chevrolati* also presented a moderate number of individuals throughout the year (Table 1). *Onthophagus chevrolati* was active all year, presenting the two highest abundances in February–March and September–October. Its highest peak appeared to occur during the dry season, though statistically there are no abundance differences with the rainy season. All the mature females that had copulated were found from May to December, whereas most of the remaining females were maturing or mature without having oviposited (Fig. 3). Only a modest percentage of females in June (30%) were immature. All the males observed throughout the year were maturing or already mature, before or after copulation, and no immature individual at all appeared. Mature males that had not copulated were found in the months of April and June, and from August to February. Males that had copulated were the majority of individuals in March, July, January, and February, but a small percentage was observed in June and August.

Blackburneus charmionus and *C. ornatus* were active during the dry season,

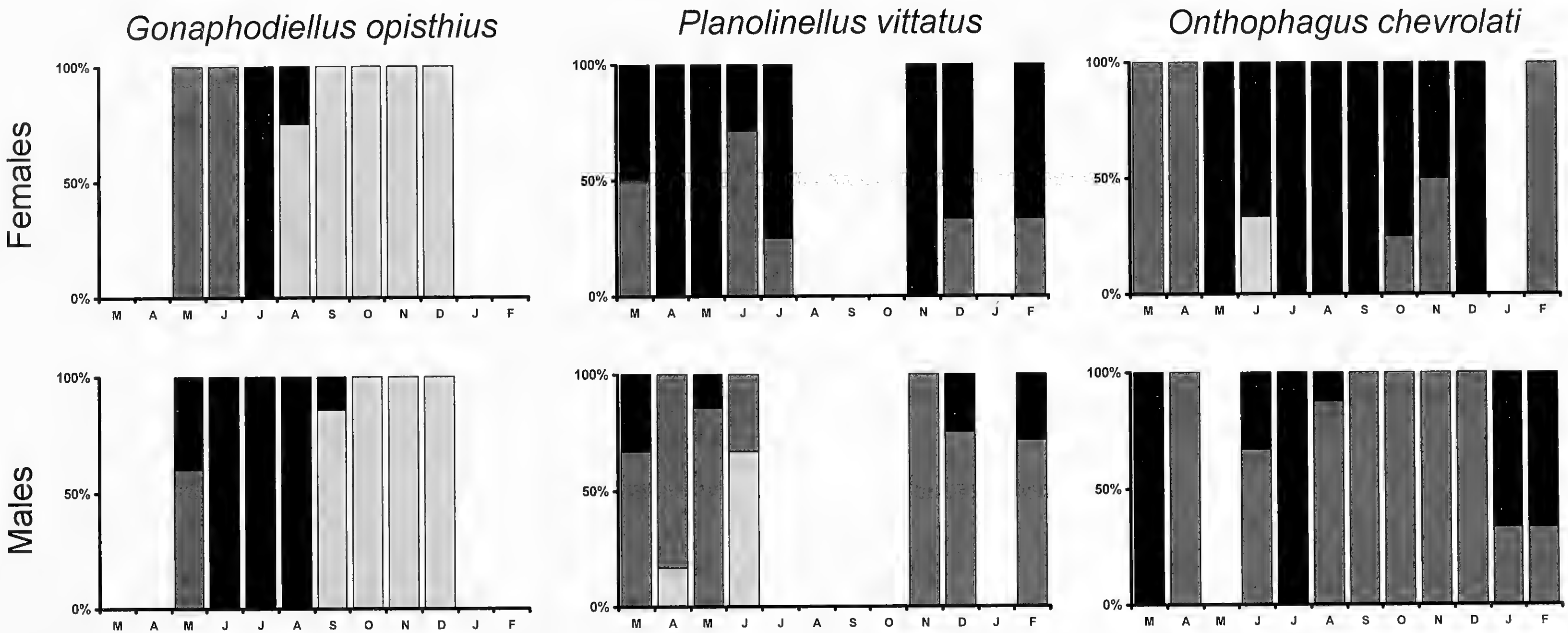


Fig. 3. Monthly percentages of reproductive stages for the three most abundant species gathered near Tonalaco, Veracruz, Mexico, from March 2005 to February 2006. For females, light grey portions of the bar represent the immature stage, dark grey portions the stage before oviposition, and black portions the stage after oviposition. For males, light grey bar portions represent the immature stage, dark grey portions the stage before copulation, and black portions the stage after copulation.

whereas *O. setosopunctatus* and *G.* (*H.*) *rufoclavatus* appeared in both seasons. Nevertheless, the first three species only showed sporadically in low numbers of individuals and in no more than three scattered months, so they were not considered for examination of their reproductive cycles. Data for *G.* (*H.*) *rufoclavatus* have been not included in this study — those data will be integrated in a future article along with data about its distribution (Trotta-Moreu et al., in press).

Completeness of inventories and characterization of dung beetle communities.—Predicted species richness values for ACE were 6 (LDF), 7 (CUI), and 8 (SJA and TON), so the sampling most likely recovered between 87.5% and 100% of total dung beetle species present at the localities. According to Chao2, predicted species richness values were 6 (LDF) and 7 (CUI, SJA, and TON), so 100% of present dung beetle species had been recovered during the samplings. It must be considered that estimators are just notifying that the samplings have a suitable invested effort, since some other species had been cited for these localities at some point.

Table 2 summarizes the species observed in each of the four high mountain localities. Of a total of 21 observed species, three are observed in all four communities: two Aphodiinae, *O. setosopunctatus*, and *P. vittatus*, and one Scarabainae, *O. chevrolati* (although three of the localities have the nominal *chevrolati* subspecies and the LDF locality has the subspecies *retusus* Harold, 1869). Two Aphodiinae species have been also captured in three of these communities: *C. hogei* and *G. opisthius*. A total of twelve species have been cited from only one of these communities.

The greatest total species richness has been observed at CUI (11 species), whereas SJA shows 10 species, LDF 9 species, and TON 8 species. The observed species richness for Aphodiinae is similar in all the localities (6–8 species). CUI is the only locality where three Scarabaeinae species have been cited; the rest only have one. For Geotrupinae, there is only a different species in each locality.

Reproductive cycles for each species taken from literature have been also added to Table 2. A great number of reproductive cycles remain yet to be analyzed. Most of the studied Aphodiinae species behave as univoltine. Only one reproductive cycle for Scarabaeinae species is known, and it is multivoltine. For Geotrupinae, no reproductive cycle of cited species has been previously examined.

Table 2 also shows the geographic distribution of species. Most of the species are restricted to Mexican Transition Zone (MTZ) and Mesoamerican distributions. Aphodiinae species show basically distributions spread on both regions. However, three species of Aphodiinae are exclusively endemic to the MTZ, and other three have a wide distribution. For Scarabaeinae two species are restricted to the MTZ, whereas another species is distributed on both the MTZ and the Mesoamerican dominion. All observed Geotrupinae species are endemic to the MTZ.

DISCUSSION

Phenology and reproductive cycles.—In the present study, all dung beetle species showed periods of presence and absence throughout the year, except for *O. chevrolati*, which is found all year.

Gonaphodiellus opisthius is a markedly univoltine species, associated with precipitations and the rainy season (Cruz et al. 2002). The two population peaks observed throughout the year represented different generations (Cruz et al. 2002): one from May to August, corresponding to individuals born the previous year, which mature, reproduce,

Table 2. Matrix of species abundances for each dung beetle community studied on high mountain pastures, including known reproductive cycles and geographic distributions. (CUI, Cuiyachapa; LDF, Llano de las Flores; SJA, San José Aguazuelas; TON, Tonalaco). Number of months of continued samplings between parenthesis. Data sources (completed with data from their record sheets): CUI, Cruz et al. 2002; SJA, Martínez 2005; LDF, Martínez and Suárez 2006; TON, present study. * Additional data (only presences): CUI, Dellacasa et al. 2002, and samplings by hand [F. J. Cabrero-Sañudo and N. Trotta-Moreu leg.]; SJA, Arellano 2002, Dellacasa et al. 2002, and samplings by hand [M. Dellacasa, I. Martínez, T. Pensado, Q. Santiago, and T. Suárez leg.]; LDF, samplings by hand [J. Ari, M. Cruz, I. Martínez, P. Reyes, T. Suárez, and M. Zunino leg.]; TON, samplings by hand [E. Montes de Oca and Q. Santiago leg.]). Unknown reproductive cycles have been marked with a question mark. Information for species geographic distributions has been taken from Delgado-Castillo and Márquez (2006), Dellacasa and Dellacasa (2005), Dellacasa and Stebnicka (2001), Dellacasa et al. (2002), Edmonds (1994), Galante et al. (2003), Howden (2003), Morón et al. (2003), Navarrete-Heredia and Deloya (2005), and Zunino and Halffter (1988), and distributions categories were based on Morrone (2006), except for wide distributed species.

	CUI (13)	LDF (12)	SJA (12)	TON (13)	Reproductive Cycle	Geographic Distribution
Scarabaeidae: Aphodiinae						
Agrilinus azteca (Harold, 1863)	*	-	-	-	?	MTZ, Mesoamerican
Blackburneus charmionus (Bates, 1887)	*	-	-	12	?	MTZ, Mesoamerican
Blackburneus guatemalensis (Bates, 1887)	-	*	*	-	?	MTZ, Mesoamerican
Blackburneus sp. *aff. diminutus* (Bates, 1887)	-	-	-		?	MTZ, Mesoamerican
Cephalocyclus durangoensis (Bates, 1887)	-	379	-	-	Univoltine	MTZ
Cephalocyclus hogei (Bates, 1887)	6964	*	228	-	Univoltine	MTZ, Mesoamerican
Chilothorax ornatus (Schmidt, A., 1911)	-	-	108	1	Univoltine	MTZ
Gonaphodiellus opisthius (Bates, 1887)	19155	436	-	1552	Univoltine	MTZ, Mesoamerican
Labarrus pseudolividus (Balthasar, 1941)	*	-	-	-	?	Afrotropical, Australian, Nearctic, Neotropical, Oriental
Liothorax innexus (Say, 1835)	-	-	*	-	?	Californian, Continental Nearctic, MTZ, Mesoamerican, Antillean
Liothorax levatus (Schmidt, A., 1907)	-	164	116	-	Univoltine	MTZ, Mesoamerican
Oxyomus setosopunctatus Schmidt, A., 1911	*	*	37	6	?	MTZ, Mesoamerican
Planolinellus vittatus (Say, 1825)	211	1238	*	195	Multivoltine	Holarctic
Trichonotuloides glyptus (Bates, 1887)	-	-	9	-	?	MTZ
Scarabaeidae: Scarabaeinae						
Onthophagus aureofuscus Bates, 1887	1	-	-	-	?	MTZ
Onthophagus chevrolati chevrolati Harold, 1869	300	-	71	220		
retusus Harold, 1869	-	312	-	-	Multivoltine	MTZ
Phanaeus amethystinus amethystinus Harold, 1863	2	-	-	-	?	MTZ, Mesoamerican

Table 2. Continued.

	CUI (13)	LDF (12)	SJA (12)	TON (13)	Reproductive Cycle	Geographic Distribution
Geotrupidae: Geotrupinae						
Geotrupes (Halffterius) rufoclavatus Jekel, 1865	-	-	-	11	?	MTZ
Geotrupes (Onthotrupes) herbeus Jekel, 1865	-	-	1	-	?	MTZ
Geotrupes (Onthotrupes) sobrinus Jekel, 1865	30	-	-	-	?	MTZ
Geotrupes (Onthotrupes) viridiobscurus Jekel, 1865	-	45	-	-	?	MTZ

and finally die; and another from September to December, corresponding to the new generation, composed of immature imagoes.

In contrast to *G. opisthius*, the phenologies of *P. vittatus* and *O. chevrolati* are possibly associated with the dry season, with higher numbers of individuals when rains are lower (as at Llano de las Flores, Oaxaca; Martínez and Suárez 2006). Mature *P. vittatus* imagoes probably take refuge during the most humid and driest conditions, and when the time is suitable for them they come up and reproduce. Once they copulate, males disappear, whereas females outlast the males briefly, during which time they lay eggs. This phenology is also similar to that observed at Las Vigas de Ramírez, Veracruz, and under laboratory conditions, where they apparently reproduce all year (I. Martínez M., unpublished observations).

Onthophagus chevrolati females lay eggs during the rainy season, whereas in the driest months, they remain mature but do not lay eggs. Males quickly mature and probably die after copulation during the rainy season, although many males survive the driest months of the year and the beginning of the rainy season after having copulated. It is possible that, just like *P. vittatus*, these individuals also mate whenever conditions are favourable.

Dung beetle communities from the Oriental Neovolcanic Axis.—This study is the fourth of this sort carried out in a high mountain dung beetle community on the Oriental Neovolcanic Axis. The San José Aguazuelas study by Martínez (2005) was conducted at roughly 6.6 km distant in a straight line from the Tonalaco study site. The Cuiyachapa study was situated around 50 km away, in a straight line to the south of these two previous localities (Cruz et al. 2002). Finally, Llano de las Flores sampling was carried out around 230 km in a straight line to the southeast of those localities (Martínez and Suárez 2006). Despite distances, the four localities share some characteristics as regards to their dung beetle communities.

First of all, the four localities hold similar dung beetle species richness values for the three subfamilies considered, independently and jointly. Only Cuiyachapa locality apparently presents a greater number of Scarabaeinae species, although two of these species are possibly random vagrants with low numbers of individuals (*O. aureofuscus* and *P. amethystinus*).

Six species are the most abundant taxa and are present in at least two of these high mountain pastures localities (*C. hogei, C. ornatus, G. opisthius, L. levatus, P. vittatus*, and *O. chevrolati*; Table 2). *Cephalocyclus durangoensis* showed also a high number of individuals at Llano de las Flores location, and *O. setosopunctatus* was also captured at one time in all localities. Thus, basically, these eight species could portray the dung beetles communities composition at the Oriental Neovolcanic Axis localities.

Phenology and reproductive cycles of most of these species have been previously studied (Cruz et al. 2002, Martínez 2005, Martínez and Suárez 2006). In general terms, most Mexican high mountain dung beetle species would show marked seasonal activity patterns in the field, and would be probably univoltine. Reproductive cycles of the four Geotrupinae species cited for the surveyed localities are unknown, although possibly they are also univoltine, as it has been suggested for *G. rufoclavatus* (Trotta et al., in press) and observed for another high mountain species from the Sierra Madre Occidental, *Geotrupes (Megatrupes) cavicollis* Bates, 1887 (Halffter et al. 1980, 1985).

Dung beetles tend to adjust their activity and reproductive periods to optimum climatic and environmental conditions, as other insects (Engelmann 1970, Raabe 1986). Thus, most species at high mountain pastures would present short reproductive cycles corresponding to suitable seasons. This behaviour has been also observed on other dung beetle species, especially from the Western Palaearctic (Kirk and Wallace 1990, Martínez 2001). Nevertheless, as it has been examined in the present study, *P. vittatus* and *O. chevrolati* are an exception, being active during all the year whenever weather conditions are appropriate, and producing several generations per year.

Two principal dung beetle activity periods may be observed through the year: one at the beginning of the rainy season (basically from the end of May to the beginning of August) and another from the end of the rainy season to the middle of the dry season (from August to February). The first period is characterized by species as *C. durangoensis, C. hogei* and *G. opisthius*. These species would need the first rains and the rise of temperatures at high mountain localities in order to breed (Cruz et al. 2002, Martínez 2005, Martínez and Suárez 2006). Species as *L. levatus, C. ornatus* and, possibly, *O. setosopunctatus* stand out at the second period. These species would probably appear when there are still some regular rains, the temperature is moderate, and the soil is still moist (Martínez 2005, Martínez and Suárez 2006). *Planolinellus vittatus* and *O. chevrolati* are present through all the year, although they show a greater affinity to the dry season.

As regards to geographical distribution, most Oriental Neovolcanic Axis Aphodiinae display greater ranges than Scarabaeinae or Geotrupinae. Most high mountain Aphodiinae extend their distribution to the MTZ and Mesoamerica, whereas most Scarabaeinae and Geotrupinae are only present at the MTZ (Geotrupinae species show some regionalization, so their ranges could be even more limited, as shown on Table 2). Most of the dung beetles present at the Oriental Neovolcanic Axis would be Nearctic elements *sensu* Halffter (1987, 2006), that is, taxa with a predominantly northern affinity, of recent penetration and development, and restricted to orographic systems of the MTZ and Centro America. Some exceptions to this are, for example, *P. vittatus* (as a matter of fact, one species which has been also observed as multivoltine), with a Holarctic distribution and possibly a Paleo-American element *sensu* Halffter (1987, 2006) – early immigrated taxa from northern latitudes –; *G. opisthius* and *Blackburneus* species, with southern affinities and possibly Montane Meso-American elements *sensu* Halffter (1987, 2006) – taxa with an early South American origin and linked to mountains –; and, *L. pseudolividus*, also with southern affinities and probably a Neotropical element *sensu* Halffter (1987, 2006) – a species with a relatively recent arrival from South America and related to tropical lowlands –, which has been able to reach higher elevations.

The Tonalaco dung beetle community is the poorest, although only slightly, in species richness compared to the other three localities where similar sampling techniques were applied. According to several analytical studies about land evolution during the 20th century in Xico territory, the municipality encompassing Tonalaco and its surrounding areas, this land has suffered a great environmental degradation in recent years (Hoffmann 1992, 1993). Thus, this mountain has been characterized by a loss of habitats (mainly changes in traditional land uses and crops, forestry and illegal deforestation, and fragmentation of larger to smaller-scale farming; Hoffmann 1992, 1993) and uncontrolled chemical applications (mainly herbicide applications to reduce weeds from pastures and aggressive techniques to remove parasites from livestock, survey to cattle-raisers from Xico municipality, Martínez et al. unpublished data).

As many mountain dung beetle species of the Mexican Transition Zone are usually widespread, it is probably that most of them are not directly threatened by complete extinction. But these habitat changes at Tonalaco are only a sample of progressively generalized agricultural tendencies for the productive lands of the Oriental Neovolcanic Axis and other mountain ranges from the Mexican Transition Zone (Hoffmann 1992), that might decimate these mountain species locally and widely in the near future. Considering that, it is important to keep in mind the irreplaceable loss of biodiversity that habitat degradation could hasten, beyond the loss of the ecological and parasite-controlling role that dung beetle species play in local pasture systems.

ACKNOWLEDGMENTS

This paper was supported by two post-doctoral grants, from the Instituto de Ecología, A.C. (Veracruz, Mexico) and the Ministerio de Educación y Ciencia (Spain), to Francisco José Cabrero-Sañudo, and a doctoral grant from the Ministerio de Asuntos Exteriores (Spain) to Nuria Trotta-Moreu. This work was also made possible with the aid of the Department of Biodiversity and Animal Ecology (Instituto de Ecología A.C.). We are grateful to María Teresa Suárez (Instituto de Ecología A.C.), who assisted the authors during field samplings and laboratory dissections, and to Magdalena Cruz, who shared with us the record sheets of the study at Cuiyachapa. We also thank Marco Dellacasa (University of Pisa, Italy) and Leonardo Delgado (Instituto de Ecología A.C.), who confirmed the species identification. We greatly appreciate Ann Covalt for helping us with the English style and two anonymous referees whose insightful suggestions improved the article.

LITERATURE CITED

Arellano, L. 2002. Evaluación de la diversidad alfa, beta y gamma de Scarabaeoidea y Silphidae (Insecta: Coleoptera) en la región Cofre de Perote, Veracruz, México. Master degree thesis, Universidad Nacional Autónoma de México, 205 pp.

Bryan, R. P. 1973. The effects of dung beetle activity on the number of parasitic gastrointestinal helminths larvae recovered from pasture samples. Australian Journal of Agricultural Research 24: 161–168.

Chao, A. 1987. Estimating the population size for capture-recapture data with unequal catchability. Biometrics 43: 783–791.

Chazdon, R. L., R. K. Colwell, J. S. Denslow, and M. R. Guariguata. 1998. Statistical methods for estimating species richness of woody regeneration in primary and secondary rain forests of north-eastern Costa Rica, pp. 285–309. *In* Dallmeir, F. and J. A. Comiskey, eds. Forest Biodiversity Background and Old World Case Studies. Parthenon Publishing, Paris.

Chirico, J., S. Wiktelius, and P. J. Waller. 2003. Dung beetle activity and development of trichostrongylid eggs into infective larve in cattle faeces. Veterinary Parasitology 118: 157–163.

Colwell, R. K. 2005. EstimateS 7.5. http://viceroy.eeb.uconn.edu/EstimateS.

Colwell, R. K. and J. A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society of London B 345: 101–118.

Cruz, M. and C. Huerta. 1998. Comportamiento y actividad reproductora de los machos de *Copris incertus* Say (Coleoptera: Scarabaeidae). Acta Zoológica Mexicana 74: 163–173.

Cruz, M., I. Martínez M., and M. Alvarado. 2002. Population and reproductive features of *Aphodius (Trichaphodius) opisthius* Bates and *Cephalocyclus hogei* Bates (Coleoptera, Aphodiidae: Aphodiinae). The Coleopterists Bulletin 56: 221–235.

Delgado-Castillo, L. and J. Márquez. 2006. Estado del conocimiento y conservación de los coleópteros Scarabaeoidea (Insecta) del estado de Hidalgo, México. Acta Zoológica Mexicana 22: 57–108.

Dellacasa, M. and G. Dellacasa. 2005. Comments on some systematic and nomenclatural questions in Aphodiinae with descriptions of new genera and on Italian taxa (Coleoptera Aphodiidae). Memorie della Società Entomologica Italiana 84: 45–101.

Dellacasa, M. and Z. Stebnicka. 2001. A new genus for *Oxyomus morosus* Harold, 1869 (Eupariini) and redefinition of *Oxyomus setosopunctatus* A. Schmidt, 1911 (Aphodiini) (Coleoptera Scarabaeidae: Aphodiinae). Acta Zoologica Mexicana 83: 29–34.

Dellacasa, M., R. D. Gordon, and G. Dellacasa. 2002. Aphodiinae described or recorded by Bates in Biología Centrali-Americana (Coleoptera Scarabaeoidea: Aphodiidae). Acta Zoológica Mexicana 86: 155–223.

Engelmann, F. 1970. The physiology of insect reproduction. Pergamon Press, Oxford.

Fincher, G. T. 1975. Effect of dung beetle activity on the number of nematode parasitoid required by grazing cattle. Journal of Parasitology 61: 759–762.

———. 1981. The potential value of dung beetles in pasture ecosystems. Journal of the Georgia Entomological Society 16: 316–333.

Galante, E., Z. Stebnicka, and J. R. Verdú. 2003. The Aphodiinae and Rhyparinae in southern states of Mexico (Chiapas, Oaxaca, Puebla and Veracruz). Acta Zoologica Cracoviensia 46: 283–312.

Halffter, G. 1987. Biogeography of the montane entomofauna of Mexico and Central America. Annual Review of Entomology 32: 95–114.

———. 2006. Biogeografía de la entomofauna de montaña de México y América Central, pp. 1–21. *In* Morrone, J. J. and J. Llorente Bousquets, eds. Componentes bióticos principales de la entomofauna mexicana, Volumen I. Las Prensas de Ciencias UNAM, México. 562 pp.

Halffter, G. and W. D. Edmonds. 1982. The nesting behaviour of dung beetles (Scarabaeinae). An ecological and evolutive approach. Instituto de Ecología, Mexico D.F, D.E., 176 pp.

Halffter, V., Y. López-Guerrero, and G. Halffter. 1980. Comportamiento sexual de *Geotrupes* (Coleoptera: Scarabaeidae: Geotrupinae). Folia Entomológica Mexicana 45: 63–65.

———. 1985. Nesting and ovarian development in *Geotrupes cavicollis* Bates (Coleoptera: Scarabeidae). Acta Zoológica Mexicana 7: 1–28.

Hanski, I. 1991. North temperate dung beetles, pp. 75–96. *In* Hanski, I. and Y. Cambefort, eds. Dung Beetle Ecology. Princeton University Press, New Jersey. 481 pp.

Hijmans, R. J., S. Cameron, J. Parra, P. Jones, A. Jarvis, and K. Richardson. 2006. WorldClim version 1.4. Museum of Vertebrate Zoology of the University of California, CIAT, and Rainforest CRC, http://www.worldclim.org/.

Hoffmann, O. 1992. Tierras y territorios en Xico, Ver. Comisión Estatal Conmemorativa del V Centenario del Encuentro de Dos Mundos. Gobierno del Estado de Veracruz, Xalapa, Veracruz. 288 pp.

———. 1993. Geografía de un municipio de la Sierra de Veracruz. Instituto de Ecología, A.C. and ORSTOM - L'Institut Français de Recherche Scientifique pour le Développement en Coopération, Xalapa, Veracruz. 132 pp.

Howden, H. F. 2003. Geotrupinae, pp. 95–106. *In* Morón, M. A. ed. Atlas de los escarabajos de México, Coleoptera Lamellicornia, Vol. II, Familias Scarabaeidae, Trogidae, Passalidae y Lucanidae. Arganda Editio, Barcelona. 227 pp.

Kirk, A. A. and M. M. H. Wallace. 1990. Seasonal variations in numbers, biomass and breeding patterns of dung beetles (Coleoptera: Scarabaeidae) in Southern France. BioControl 35: 569–581.

Kohlmann, B. 1991. Dung beetles in subtropical North America, pp. 116–132. *In* Hanski, I. and Y. Cambefort, eds. Dung Beetle Ecology. Princeton University Press, New Jersey. 481 pp.

Lumaret, J. P. and I. Martínez M. 2005. El impacto de los productos veterinarios sobre los insectos coprófagos: Consecuencias sobre la degradación del estiércol en pastizales. Acta Zoológica Mexicana 21: 137–148.

Lumaret, J. P. and N. Stiernet. 1991. Montane dung beetles, pp. 242–254. *In* Hanski, I. and Y. Cambefort, eds. Dung Beetle Ecology. Princeton University Press, Princeton. 481 pp.

Martínez M., I. 1992a. Données comparatives sur l'activité reproductrice chez *Canthon indigaceus chevrolati* Harold et *Canthon cyanellus cyanellus* LeConte (Coleoptera, Scarabaeidae). Annales de la Société entomologique de France 28: 397–408.

———. 1992b. L'activité ovarienne pendant la vie imaginable chez deux espéces de *Canthon* (Coleoptera, Scarabaeidae). Bolletino del Museo regionale di Scienze naturali, Torino 10: 367–386.

———. 2001. La biología reproductiva en Aphodiidae (Coleoptera Scarabaeoidea): Síntesis de datos conocidos. Bolletino della Società Entomologica Italiana 133: 113–130.

———. 2002. Técnicas básicas de anatomía microscópica y de morfometría para estudiar los insectos. Boletín de la Sociedad Entomológica Aragonesa 30: 187–195.

———. 2003. Spermatophore in Aphodiinae (Coleoptera Scarabaeidae). Proceedings of the Entomological Society of Washington 105: 982–989.

———. 2005. Abundancias poblacionales y ciclos reproductivos de tres especies de escarabajos estercoleros (Coleoptera: Aphodiinae: Aphodiini) del volcán Cofre de Perote, Veracruz, México. Folia Entomológica Mexicana 44: 27–36.

Martínez M., I. and Alvarado. 2001. Comportamiento de nidificación en *Aphodius (Trichaphodius) opisthius* Bates. Elytron 15: 73–78.

Martínez M., I. and M. Cruz. 1992. L'activité de l'appareil reproducteur mâle pendant la vie imaginale chez deux espéces de *Canthon* (Coleoptera: Scarabaeinae). Acta Zoológica Mexicana 49: 1–22.

———. 1999. Comparative morphological analysis of testis follicles in dung beetles (Coleoptera Scarabaeidae: Scarabaeinae, Aphodiinae, Geotrupinae). Proceedings of the Entomological Society of Washington 101: 804–815.

———. 2002. Fenología y ciclos reproductivos en *Ataenius apicalis* Hinton y *A. sculptor* Harold (Coleoptera, Aphodiidae). Bulletin de la Société entomologique de France 107: 177–186.

Martínez M., I. and J. P. Lumaret. 2006. Las prácticas agropecuarias y sus consecuencias en la entomofauna y el entorno ambiental. Folia Entomológica Mexicana 45: 57–68.

Martínez M., I. and T. Suárez. 2006. Phenology, trophic preferentes, and reproductive activity in some dung-inhabiting beetles (Coleoptera: Scarabaeoidea) in El Llano de las Flores, Oaxaca, Mexico. Proceedings of the Entomological Society of Washington 108: 774–784.

Martínez M., I., M. Cruz, and J. P. Lumaret. 2000. Efecto del diferente manejo de los pastizales y del ganado sobre los escarabajos coprófagos *Ataenius apicalis* Hinton y *Ataenius sculptor* Harold (Scarabaeidae: Aphodiinae: Eupariini). Acta Zoológica Mexicana 80: 185–196.

Martínez M., I., C. Deloya, and M. Dellacasa. 2001a. Anatomical and functional data on female and male reproductive systems of some dung beetles species of Aphodiinae and Eupariinae inhabiting México (Coleoptera: Aphodiidae). Proceedings of the Entomological Society of Washington 103: 227–248.

Martínez M., I., C. Huerta, and M. Cruz. 1996. Comportamiento reproductor en hembras de *Copris incertus* Say (Coleoptera Scarabaeidae: Scarabaeinae). Bulletin de la Société entomologique de France 101: 121–130.

Martínez M., I., J. P. Lumaret, and M. Cruz. 2001b. Suspected side effects of a herbicide on dung beetle populations (Coleoptera: Scarabaeidae). Comptes Rendus de l'Académie des Sciences. Paris. Sciences de la Vie 324: 989–994.

Martínez M., I., E. Montes de Oca, and M. Cruz. 1998. Contribución al conocimiento de la biología del escarabajo coprófago *Onthophagus incensus* Say (Coleoptera Scarabaeidae: Scarabaeinae): Datos ecológicos y reproductivos en relación a su fenología. Folia Entomológica Mexicana 103: 1–13.

McQueen, A. 1975. Dung as insect food source: Dung beetles as competitors of other coprophagous fauna and as targets for predators. Journal of Applied Ecology 12: 821–827.

McQueen, A. and B. P. Beirne. 1975. Influence of other insects on production of horn fly, *Haematobia irritans* (Diptera: Muscidae), from cattle dung in south-central British Columbia. Canadian Journal of Plant Sciences 107: 1255.1264.

Moon, R. D., E. C. Loomis, and J. R. Anderson. 1980. Influence of two species of dung beetles on larvae of face fly. Environmental Entomology 9: 607–612.

Morón, M. A. 2003. Atlas de los escarabajos de México. Coleoptera: Lamellicornia Vol. II. Familias Scarabaeidae, Trogidae, Passalidae y Lucanidae. Argania Editio, S.C.P., Barcelona. 227 pp.

Morón, M. A., G. Halffter, B. Kohlmann, W. D. Edmonds, and M. Zunino. 2003. Familia Scarabaeidae (sensu stricto), pp. 19–74. *In* Morón, M. A. ed. Atlas de los escarabajos de

México, Coleoptera Lamellicornia, Vol. II, Familias Scarabaeidae, Trogidae, Passalidae y Lucanidae. Arganda Editio, Barcelona. 227 pp.

Morrone, J. A. 2006. Biogeographic areas and transition zones of Latin America and the Caribbean Islands based on panbiogeographic and cladistic analices of the entomofauna. Annual Review of Entomology 51: 467–494.

Navarrete-Heredia, J. L. and C. Deloya. 2005. Comentarios sobre algunas especies de Aphodiinae (Coleoptera: Scarabaeidae) de Jalisco, México. Dugesiana 12: 19–21.

Raabe, M. 1986. Insect reproduction: regulation and successive steps. Advances in Insect Physiology 19: 29–154.

Ridsdill-Smith, T. J. and L. Hayles. 1990. Stages of bush fly, *Musca vetustussima* (Diptera: Muscidae), killed by scarabeinae dung beetles (Coleoptera: Scarabaeidae) in favourable cattle dung. Bulletin of Entomological Research 80: 473–478.

Ridsdill-Smith, T. J., L. Hayles, and M. J. Palmer. 1987. Mortality of eggs and larvae of the bush fly *Musca vetustissima* Walker (Diptera: Muscidae) caused by scarabeinae dung beetles (Coleoptera: Scarabaeidae) in favourable cattle dung. Bulletin of Entomological Research 78: 633–639.

Rougon, D. C. Rougon, J. Trichet, and J. Levieux. 1988. Enrichissement en matière organique d'un sol sahélien aun Niger par les insectes coprophages (Coleoptera, Scarabaeidae) implications agronomiques. Revue d'Ecologie et de Biologique du Sol 25: 413–434.

Rzedowski, J. 1978. Vegetación de México. Editorial Limusa, 432 pp.

Trotta-Moreu, N., E. Montes de Oca, and I. Martínez M. In press. Ecological and reproductive characteristics of *Halffterius rufoclavatus* Jekel, 1865 (Coleoptera: Scarabaeoidea: Geotrupidae) on the Cofre de Perote Volcano (Veracruz, México). *The Coleopterists Bulletin.*

Yokohama, K., H. Kai, T. Koga, and T. Aibe. 1991. Nitrogen mineralization and microbial populations in cow dung, dung balls and underlying soil affected by paracoprid dung beetles. Soil Biology & Biochemistry 23: 643–647.

Zunino, M. and G. Halffter. 1988. Análisis taxonómico, ecológico y biogeográfico de un grupo americano de *Onthophagus*. Monografie IX, Museo Regionale di Science Naturali di Torino, 1–212.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 829–835

BIOLOGICAL OBSERVATIONS ON *HEMISARCOPTES COCCOPHAGUS* MEYER (ACARI: ASTIGMATA: HEMISARCOPTIDAE) ASSOCIATED WITH WILLOW ARMORED SCALE, *CHIONASPIS SALICIS* (L.) (HEMIPTERA: DIASPIDIDAE) IN ERZURUM, TURKEY

Önder Çalmaşur and Hikmet Özbek

Atatürk University, Agricultural Faculty, Department of Plant Protection, 25240 Erzurum, Turkey (e-mail: calmasur@atauni.edu.tr; hozbek@atauni.edu.tr)

Abstract.—The willow armored scale insect, *Chionaspis salicis* (L.) (Homoptera: Diaspididae) is an important pest of willow (*Salix* spp.), poplar (*Populus* spp.), and elm (*Ulmus* spp.) trees, particularly in the eastern part of Turkey. *Hemisarcoptes coccophagus* Meyer (Acari: Astigmata: Hemisarcoptidae) was observed attacking egg and nymph stages of *C. salicis*. This predatory mite species overwinters in adult and nymphal stages, rarely eggs, under the shield of *C. salicis* in the field. It has three generations in the vicinity of Erzurum. From the beginning of April to the end of October, *H. coccophagus* was active, consuming an average of 35% (up to 49%) of the eggs of *C. salicis* and could be considered a candidate for the biological control of *C. salicis*.

Key Words: Willow armored scale insect, *Chionaspis salicis*, *Hemisarcoptes coccophagus*, predatory mite, biocontrol agent, Turkey

---

The willow armored scale insect, *Chionaspis salicis* (L.) (Homoptera: Diaspididae), is considered one of the severe pests on willow (*Salix* spp.), poplar (*Populus* spp.), and elm (*Ulmus* spp.) trees in Turkey and is widely distributed in the country (Bodenheimer 1949, 1952, 1953; Aysu 1950; Tuatay et al. 1967, 1972; Yıldız 1972; Çanakçıoğlu 1977; Yaşar 1995; Çalmaşur et al. 2000). It is often very injurious particularly to smaller trees. On heavily infested trees, the entire surface of the bark may be coated with the overlapping dirty-white scales and show signs of reduced vigor; the foliage becomes more or less yellow and spotted; and the twigs, shoots and occasionally the entire trees die (Çalmaşur et al. 2000). Recently, *C. salicis* reached very high populations on some willow trees in various localities of Erzurum, Turkey.

Mites of the genus *Hemisarcoptes* (Acari: Astigmata: Hemisarcoptidae) are small (≈300 µm) and soft bodied, and are widely distributed. The mobile stages (larva, protonymph, and adult) are specialized predators of armored scale insects (Gerson and Schneider 1981; Gerson et al. 1990; Houck and OConnor 1990; Hill et al. 1993; Izraylevich and Gerson 1993, 1995a). *Hemisarcoptes coccophagus* Meyer is an Old World species, so far recorded from Spain, the Middle East, and northern African countries, and appears to survive under extreme climatic conditions (Gerson et al. 1990).

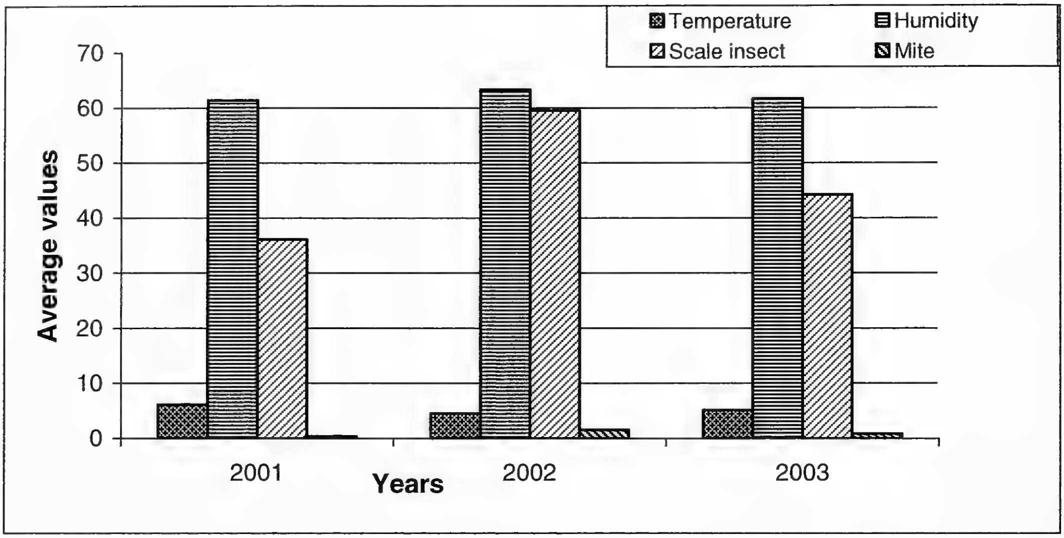


Fig. 1. Annual averages of temperature, humidity, *Chionaspis salicis*, and *Hemisarcoptes coccophagus* (2001, 2002, and 2003) in Erzurum, Turkey.

Several studies have been conducted on the biology, population structure, phoresy, sex ratio, host preferences, and population dynamics of *Hemisarcoptes coccophagus* in Israel (Izraylevich and Gerson 1993, 1995b, 1995c; Izraylevich et al. 1995). *Hemisarcoptes coccophagus* has been introducted from Israel to New Zealand to control various species of armored scale insects (Diaspididae) (Hill et al. 1993; Charles et al. 1995, 1998).

Hemisarcoptes coccophagus was known as a predator of the San Jose scale, *Diaspidiotus perniciosus* (Comstock), *Aonidiella aurantii* (Mask.), and *A. citrina* (Cog.) (Diaspididae) in Turkey (Düzgüneş et al. 1975). *Chionaspis salicis* is a new host record for *H. coccophagus* in Turkey. The objectives of this study are to contribute to the knowledge of the biology and mite-host relationships of *H. coccophagus* under Erzurum ecological conditions.

Materials and Methods

The study was conducted in willow stands containing dominant and co-dominant trees from 3 to 7 m high on the campus of Atatürk University (39°54′005″N and 41°14′184″E with an altitude of 1850–1900 m) in Erzurum during 2001–2003. The study area is insecticide free. Erzurum has cold and snowy winters, rainy springs, and dry summers, with an average temperature of 5.3°C in 1950–2003 and relative humidity of 64.2% during the same intervals (Fig. 1).

The samples of *C. salicis* infested willow twigs were collected from April to October at 10–15 day intervals. The number of adults and eggs of *H. coccophagus*, and the number of the eggs and nymphs of the scale insect were recorded from 50 adult female insects randomly selected by lifting each scale cover with a needle. Nymphs of *Hemisarcoptes* are phoretic on coccinellid beetles of the genus *Chilocorus* and occur under the beetle's elytra along the inner surface of the epipleura (Houck and OConnor 1990). Taking into account this situation, irregular searches were made in the field for the presence of *Chilocorus* beetles. For statistical analysis, SPSS 11.0 packet programs were used. Additional surveys were conducted on other willow growing districts of

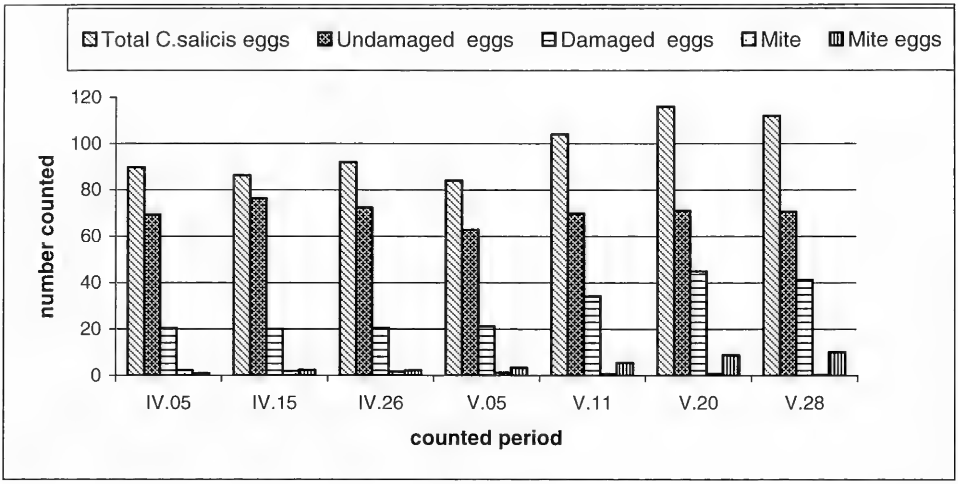
Erzurum to determine if the predatory mite species was present.

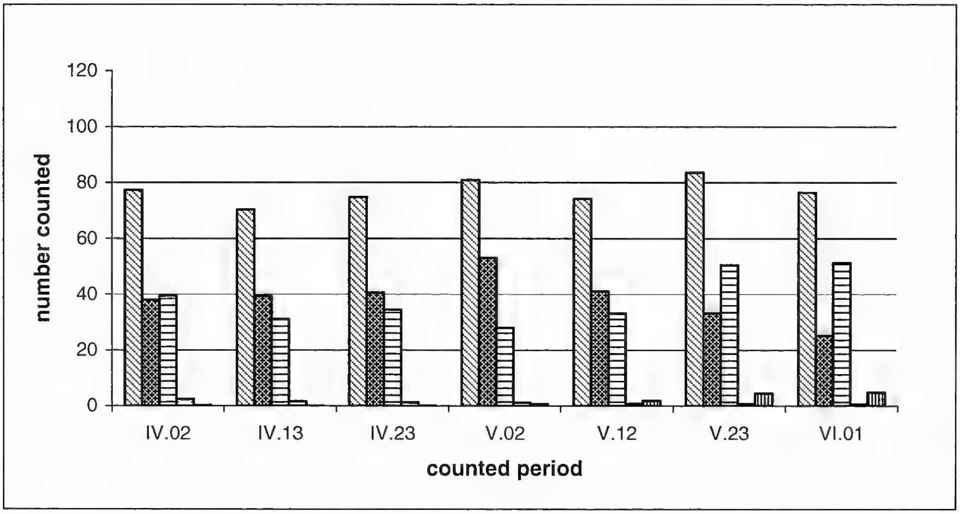
Results and Discussion

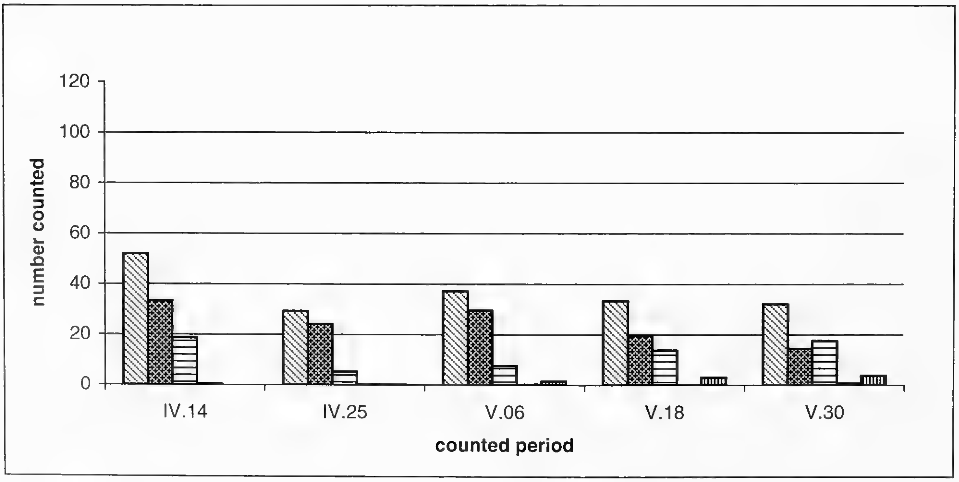
Hemisarcoptes coccophagus was observed feeding on eggs and nymphs of *Chionaspis salicis* in 2000 in Erzurum. Many mites were observed under one scale insect cover. We found from 1 to 31 mites (Mean = 1.05, SE = ±0.15, N = 21) and 0–32 (Mean = 2.57, SE = ±0.62, N = 21) eggs of mites (Fig. 7c). The mites were more abundant on between two twigs and twigs with high populated scale insects (Fig. 7a–b). On infested twigs we counted 24–65 scale insect covers in 1 cm^2-area (Mean = 47.75, SE = ±4.35, N = 12) (Fig. 7d). Under one shield 30–116 eggs of scale insect (Mean = 73.96, SE = ±5.42, N = 21) were counted.

The mite overwinters as adult and nymphal stage under the cover of *C. salicis*. Occasionally eggs were encountered during the examination of the shields during the winter. Overwintering *H. coccophagus* started feeding on eggs of scale insects on April 1, April 13, and April 14 in 2001, 2002, and 2003, respectively (Figs. 2–4). Once the predatory mite consumed all the eggs under a shield, it moved to an adjacent scale insect and entered through a proper opening between the shield and bark of the plant and repeated the process. The female mite laid eggs among the eggs of the scale insect between April 1–5, April 25–30, and April 14–20 in 2001, 2002, and 2003 respectively (Fig. 7). The eggs of the scale insect hatched May 18–28, May 16–23, and May 21–30 in 2001, 2002, and 2003 respectively. The mite average consumption capacity was established as 35% and it was 26%, 49%, and 34% in 2001, 2002, and 2003 respectively. The mite also fed on the scale insect nymphs both under the cover before the nymphs left and also while crawling on the bark. For feeding, the mite inserted its mouth parts into the body of the nymph ventrally and sucked the body fluids. The female mites laid second generation eggs under the cover of the nymphs of scale insect between June 13–17, July 7–12 and July 1–7 in 2001, 2002, and 2003, respectively and the developmental cycle was repeated. The eggs hatched in June 27–30, July 23–26, and July 15–17 in 2001, 2002, and 2003, respectively. The females of the new generation of the scale insects laid their eggs between July 27–30, August 26–30, and August 20–25 in 2001, 2002, and 2003, respectively. The mite continued feeding on the scale eggs and the average damage for the three years was about 25%. The mite laid its third generation of eggs during August 26–September 2. These eggs hatched on September 9–12, September 20–24, and October 9–11 in 2001, 2002, and 2003, respectively. Feeding continued until about the end of October. The fall counting was conducted in 2002 and 2003 (Figs. 5–6). Damaged scale eggs were in lower numbers than in the spring (mean: 14.43 SE = ±4.78, N: 6), 24% of the eggs of *C. salicis* was consumed. Consequently, under the ecological conditions of Erzurum, *H. Coccophagus* has three generations each year.

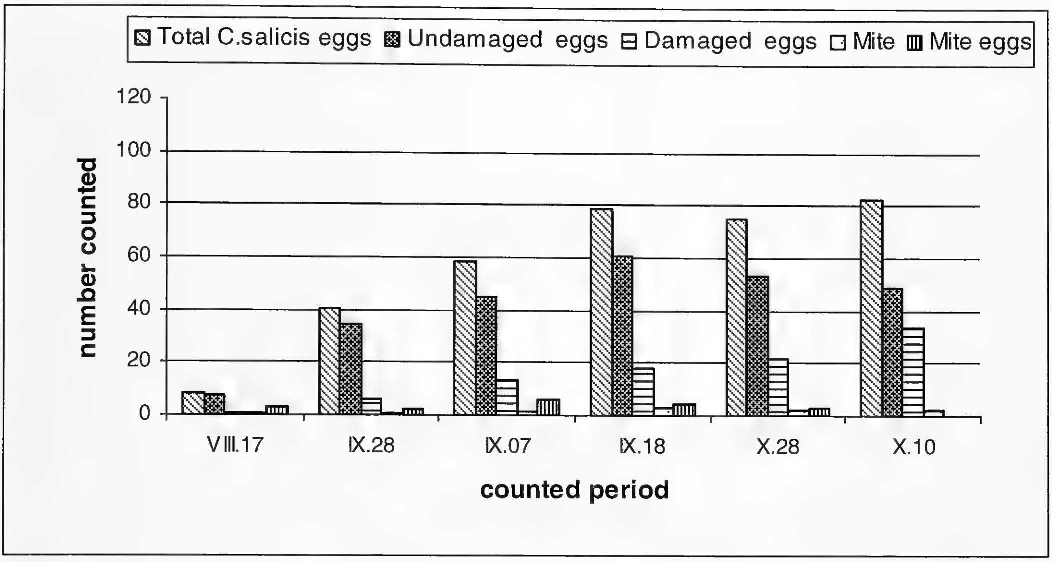
We found the ladybird beetle, *Chilocorus bipustulatus* (L.) (Coleoptera: Coccinellidae) associated with *C. salicis* and *H. coccophagus* at the study site. We observed mites attached under the elytra of the beetle around the anterolateral margins. It has been known that the heteromorphic deutonymphal stage (hypopus) of *Hemisercoptes* is adapted for phoresy and is dispersed by *Chilocorus* adults (Houck and OConnor 1991, Charles et al. 1995). However, the population of *C. bipustulatus* was very low; during the entire year we encountered only 15 beetles and each beetle had 18 mites, whereas, Houck and OConnor (1990) observed as many as 800 mites per

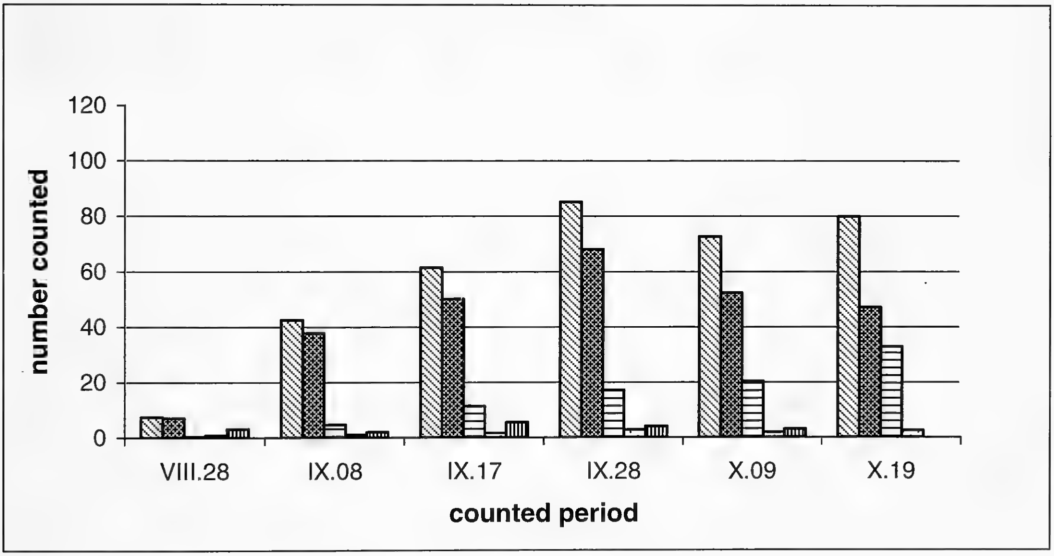






Figs. 2–4. Feeding of *Hemisarcoptes coccophagus* on *Chionaspis salicis* in the spring of 2001 (top), spring of 2002 (middle), and spring of 2003 (bottom).





Figs. 5–6. Feeding of *Hemisarcoptes coccophagus* on *Chionaspis salicis* in fall of 2002 (top), and fall of 2003 (bottom).

beetle under natural field conditions. Based on our observations, we concluded that the mites may be able to live and scatter in the absence of *Chilocorus* beetles. Charles et al. (1995) and Ji et al. (1994) reached a similar conclusion that *Hemisercoptes* species could survive and disperse slowly in the absence of ladybird beetles.

Prey and predator relationships in natural conditions revealed that *H. coccophagus* is a voracious feeder, capable of consuming large numbers of eggs of *C. salicis*. It influenced the population

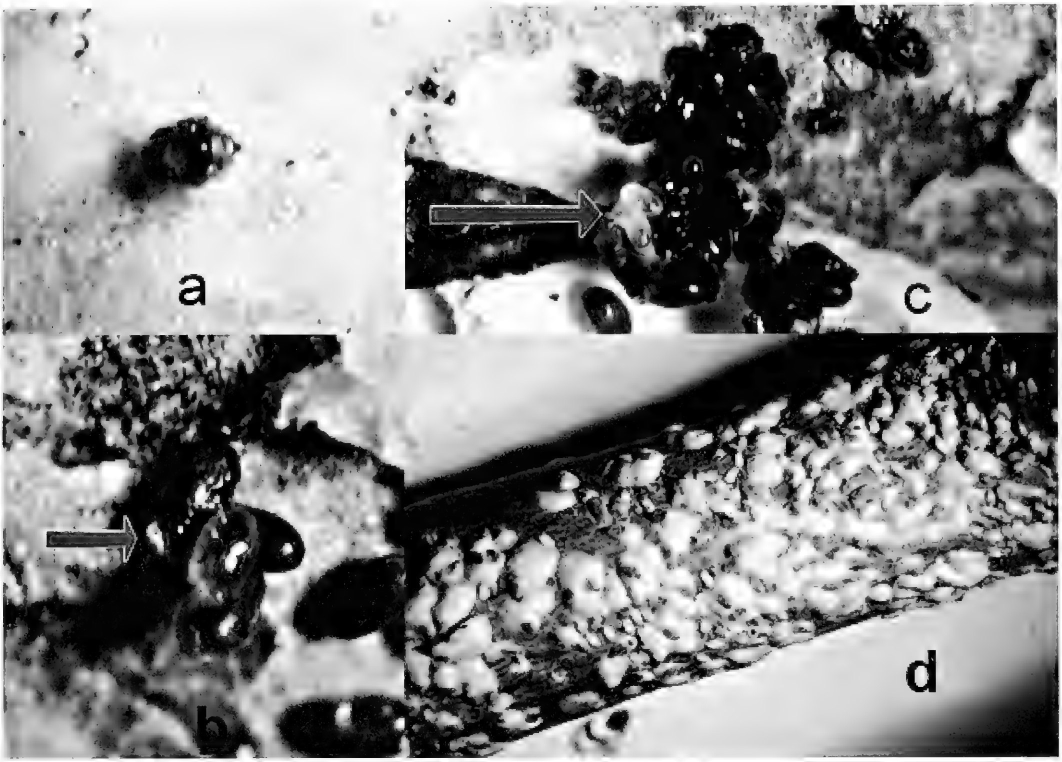


Fig. 7. a,b, Adult of *Hemisarcoptes coccophagus*. c, Eggs of *H. coccophagus* and *Chionaspis salicis*. d, Shell and nymph of *C. salicis* on willow branch.

density of this scale insect (egg destruction is up to 49%), despite the low population of *C. bipustulatus* and the harsh climatic conditions in Erzurum. Since *H. coccophagus* has been successful in the control of various diaspid species, such as *Diaspidiotus perniciosus* (Comstock), *D.* ostrea*eformis* (Curtis), *Lepidosaphes ulmi* (L.), *Hemiberlesisia lataniae (Signoret)* (Charles et al. 1995, 1998); *H. coccophagus* could be considered a candidate for biological control of *C. salicis* in Turkey. Further research is needed to develop mass production strategies and mechanisms for successful field releases of this predatory mite.

Acknowledgments

We are grateful to Dr. Nedim Uygun and Dr. Sultan Çobanoğlu for determination of *Chilocorus bipustulatus* and *Hemisercoptes coccophagus*, respectively.

Literature Cited

Aysu, R. 1950. Türkiye koşnilleri Liste 1. Mahsul Hekimi 3(3): 59–61.

Bodenheimer, F. S. 1949. Coccoidea species of Turkey, Monographic study of Diaspididae, Publication Directorship No: 670, p. 264 (in Turkish).

———. 1952. The Coccoidea of Turkey I. Istanbul University, Faculty of Sciences Publications Serial B 17(4): 315–351 (in Turkish).

———. 1953. The Coccoidea of Turkey II. Istanbul University, Faculty of Sciences Publications Serial B 18(1): 1–16 (in Turkish).

Çalmaşur, Ö., E. Yıldırım, H. Özbek, and İ. Aslan. 2000. The biology, damage and natural enemies of *Chionaspis salicis* (L.) (Homoptera, Diaspidae) in Erzurum provinces, Turkey. Proceedings of The Fourth Turkish National Congress of Entomology, 12–15 September 2000, Aydın, pp. 85–89 (in Turkish).

Çanakçıoğlu, H. 1977. Researches on Coccoidea (Homoptera) species damaging on trees and bushes in Turkey. Publications of Forestry Faculty of Istanbul University No: 227, Istanbul (in Turkish).

Charles, J. G., M. G. Hill, and D. J. Allan. 1995. Releases and recoveries of *Chilocorus* spp. (Coleoptera, Coccinellidae) and *Hemisarcoptes* spp. (Acari, Hemisarcoptidae) in Kiwifruit orchards 1987–93. New Zealand Journal of Zoology 22(3): 319–324.

Charles, J. G., D. J. Allan, C. H. Wearing, G. M. Burnip, and P. W. Shaw. 1998. Releases of *Hemisarcoptes coccophagus* Meyer (Acari, Hemisarcoptidae), a predator of armored scale insects, in South Island. New Zealand Journal of Entomology 21: 93–98.

Düzgüneş, Z., K. Akman, M. Altay, M. Tunçyürek, H. Kıroğlu, and S. Sezer. 1975. Control of San Jose Scale insect, (*Quadraspidiotus perniciosus* Comst.) in Turkey. Sciences Congress 1975: 3–28 (in Turkish).

Gerson, U. and R. Schneider. 1981. Laboratory and field studies on the mite *Hemisarcoptes coccophagus* Meyer (Astigmata: Hemisarcoptidae), a natural enemy of armored scale insect. Acarologia 22: 119–208.

Gerson, U., M. OConnor, and M. A. Houck. 1990. Acari. pp. 77–97. *In* Rosen, D. ed. The Armoured Scale Insects. Their Biology, Natural Enemies and Control. Vol. 4. B. Elsevier, Amsterdam.

Hill, M. G., D. J. Allan, R. C. Henderson, and J. G. Charles. 1993. Introduction of armored scale predators and establishment of the predatory mite *Hemisarcoptes coccophagus* (Acari, Hemisarcoptidae) on lantania scale, *Hemiberlesia lantaniae* (Homoptera, Diaspididae) in Kiwifruit shelter trees in New Zealand. Bulletin of Entomological Research 83(3): 369–376.

Houck, M. A. and B. M. OConnor. 1990. Ontogeny and life history of *Hemisarcoptes cooremani* (Acari: Hemisarcoptidae). Annals of the Entomological Society of America 83(5): 869–886.

Izraylevich, S. and U. Gerson. 1993. Population dynamics of *Hemisarcoptes coccophagus* Meyer (Astigmata, Hemisarcoptidae) Attacking 3 species of armored scale insects (Homoptera, Diaspididae). Experimental and Applied Acarology 17(12): 877–888.

———. 1995a. The hypopus of *Hemisarcoptes coccophagus:* Distribution and apolysis. Acarologia 36(4): 333–339.

———. 1995b. Sex ratio of *Hemisarcoptes coccophagus*, a mite parasitic on insects: Density-dependent processes. Oikos 74(3): 439–446.

———. 1995c. Spatial patterns of the parasitic mite *Hemisarcoptes coccophagus* (Astigmata, Hemisarcoptidae)- Host effect, density-dependence of aggregation, and implications for biological-control. Bulletin of Entomological Research 85(2): 235–240.

Izraylevich, S., O. Hasson, and U. Gerson. 1995. Frequency dependent host selection by parasitic mites a model and a case study. Oecologia 102(2): 138–145.

Ji, L., U. Gerson, and S. Izraylevich. 1994. The mite *Hemisacoptes* sp. (Astigmata: Hemisarcoptidae) parasitizing willow oyster scale (Homoptera: Diaspididae) on poplars in Northern China. Experimental and Applied Acarology 18: 623–627.

Tuatay, N., S. Gül, A. Demirtola, A. Kalkandelen, and N. Çağatay. 1967. Insect catalog of Plant Protection Museum (1961–1966). Ayyıldız Publication, Ankara (in Turkish).

Tuatay, N., A. Kalkandelen, and N. Aysen. 1972. Insect catalog of Plant Protection Museum (1961–1971). Yenigün Publication, Ankara (in Turkish).

Yaşar, B. 1995. Taxonomic studies on the fauna of Diaspididae (Homoptera:Coccoidea) in Turkey. Yüzüncüyıl University Publication, Van. 289 (in Turkish). pp.

Yıldız, N. 1972. Coccoidea pest of Populus in East, South, and Central Anatolia regions. Forest Research Bulletin 7: 189–192 (in Turkish).

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 836–840

OVARY STRUCTURE AND OOCYTE SIZE IN RELATION TO FEMALE SIZE AND AGE IN THE BROOD PARASITIC WASP *STIZOIDES RENICINCTUS* (SAY) (HYMENOPTERA: CRABRONIDAE)

KEVIN M. O'NEILL AND APRIL M. PEARCE

Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59717, U.S.A. (e-mail: koneill@montana.edu; april.pearce@myportal.montana.edu)

Abstract.—*Stizoides renicinctus* (Say) is a brood parasitic bembicine wasp that lays eggs in nests of nest-provisioning species of *Palmodes* and *Prionyx*, where its larvae feed on the host's provisions. Published comparative evidence based on a limited number of dissections in each species suggests that females of *Stizoides* and other brood parasitic Bembicinae have more have more ovarioles (8 vs. 6) and carry a greater number of relatively small mature oocytes than do nest-provisioning bembicines. To explore this further, we studied of a larger sample of *S. renicinctus*. Most females actually had 10 ovarioles, two more than any previous record reported for apoid wasps. Females also carried more mature oocytes (up to 6) and relatively smaller mature oocytes than their nest-provisioning relatives among the Bembicinae. In addition, we found a positive correlation of female *S. renicinctus* body size with the number and size of oocytes carried. And older females, as judged by their greater wing wear, tended to carry relatively fewer and smaller oocytes. Thus, there may be both size- and age-related constraints on reproduction in this species.

Key Words: Crabronidae, Bembicinae, *Stizoides renicinctus*, brood parasite, ovariole number, oocyte number, body size, age

---

Besides providing offspring with a nest and prey, solitary nest-provisioning wasps also lay relatively large eggs. Because of this and because of space limitations in their abdomens, female nest-provisioners tend to carry relatively few mature eggs at any one time, usually 0–2, even though they have six ovarioles (Iwata 1955, 1960; Itô 1978, O'Neill 1985, 2001; Ohl and Linde 2003). The smaller number of mature eggs carried may not limit the rate of offspring production, because nest provisioners often spend one or more days preparing and provisioning a single brood cell, perhaps allowing time for the next largest oocyte to mature. The situation may be different, however, for related parasitoid and brood parasitic species that have a potentially higher rate of egg-laying as they move from host to host without being constrained by the need to construct and provision a nest. The hypothesis that parasitoid and brood parasitic wasps carry a greater number of mature eggs that are smaller than those of similar-sized nest provisioners is generally supported by comparative evidence (Itô 1978, O'Neill 2001, Ohl and Linde 2003).

Among apoid wasps, all obligate brood parasites are in the subfamily

Bembicinae of the Crabronidae. Recently, Ohl and Linde (2003) reported on the number of ovarioles and mature oocytes of 68 species of apoid wasps, and reviewed earlier studies by Iwata (1955, 1960). With one exception, the mean number of mature oocytes in the 16 species of nest-provisioning Bembicinae ranged from 0 to 2, and all 16 species had three ovarioles in each of their two ovaries. In contrast, all nine species of brood parasitic Bembicinae had four ovarioles per ovary, and the 12 individuals examined in nine species carried 2–5 (mean = 4.2) mature oocytes. One of the North American species examined was *Stizoides renicinctus* (Say), a brood parasite of wasps of the genera *Palmodes* Kohl and *Prionyx* Vander Linden (Sphecidae) (Evans 1966). The single female *S. renicinctus* dissected by Ohl and Linde had five mature oocytes distributed among eight ovarioles. But, there is relatively little information available on intraspecific variation in ovariole number and oocyte size in apoid wasps. Because of this, Ohl and Linde (2003) note that the hypothesis that brood parasitic apoid wasps carry relatively smaller eggs than their nest provisioning relatives needs to be tested with larger data sets. Recently, we had the opportunity to examine a larger sample of female *S. renicinctus*, with the aim of documenting intraspecific variation in oocyte size and number, as well as its relationship to female size and age.

MATERIALS AND METHODS

We collected *S. renicinctus* at two locations in Montana: 1) 14 km south of Three Forks, Gallatin, Co. and 2) 4 km southeast of Bridger, Carbon Co. at the USDA-NRCS Bridger Plant Materials Center. All specimens of *S. renicinctus* were preserved in Kahle's solution soon after capture. We recorded each female's maximum head width (to nearest 0.05 mm) and thorax width (to nearest 0.04 mm, measured as the "distance between the outer extremities of the tegulae"; Iwata and Sakagami 1966). We then dissected females in ethanol under a stereomicroscope fitted with an ocular micrometer, and recorded the number, length (L), and width (W) of all mature oocytes (to the nearest 0.4 mm), and the total number of ovarioles and visible oocytes. An oocyte was scored as mature if it was pale yellow and generally sausage-shaped, and lacked associated nurse cells. The volume (V) of mature oocytes was estimated as: $V = (L - 2r)\pi r^2 + (4\pi r^3/3)$, where r (radius) = L/2 (O'Neill 1985). For each female, we also calculated an "egg index," the ratio of the length of the largest egg carried by a female to thorax width, which facilitates comparisons of relative egg size among females of different sizes, including females of different species (Iwata and Sakagami 1966).

RESULTS AND DISCUSSION

At Three Forks, we collected females from two diffuse sleeping clusters, each containing two female *S. renicinctus* and two *Prionyx* sp.; the two clusters were about 60–70 cm high on yellow sweetclover (*Melilotus officinalis* L.). At Bridger, we found eight sleeping clusters on *Kochia scoparia* (L.) Schrad. protruding above cultivated rows of *Dalea candida* Michx. ex Willd. Two clusters collected together from Bridger contained a total of 52 *S. renicinctus* (7 males, 45 females), along with 1 male *Prionyx canadensis* Provancher (Sphecidae), 1 male *Stenodynerus* sp., 5 female *Euodynerus* sp., and one male *Agapostemon angelica* Cockerell. Another single cluster contained 11 *S. renicinctus* (10 males, 1 female), 3 *P. canadensis* (2 males, 1 female), 1 male *Sphex lucae* Lepeletier, 1 *Ammophila* sp., and 6 male *Euodynerus* sp.. The *S. renicinctus* perched close to one another near the plant's central stem, and grasped either the main stem, leaflets just off of the main stem, or each other. At both sites, clusters were seen during late morning or early afternoon on partly cloudy or overcast days. Mixed-species sleeping clusters that include *Stizoides*, along with potential hosts, also have been reported in Rau (1938) and (Ohl 1999).

The ovaries of *S. renicinctus* had 8 (N = 12), 9 (N = 1) or 10 (N = 18) ovarioles each; females with 8 vs. 10 ovarioles did not differ in head width (Mann-Whitney test, $P = 0.64$). As far as we know, this is the first report of an apoid wasp with more than 8 ovarioles (Iwata 1955, 1960; Ohl and Linde 2003). Among aculeate wasps, ovariole numbers exceeding six have been reported only for parasitoids of the families Mutillidae (up to 10) and Chrysididae (usually 8–10), for eusocial Vespidae (up to 22), and for brood parasitic Bembicinae of the tribe Nyssonini (6–8) (Ohl and Linde 2003). Intraspecific variability in ovariole number has also been reported in *Mutilla europaea* L. (8–10), *Chrysis ignita* L. (8–10), and *Vespa* spp., as well as in the brood parasitic bee *Nomada japonica* Smith (8–11) (Iwata 1955).

Ovaries of *S. renicinctus* carried 18–38 oocytes (visible at 40× magnification) in all stages of development (mean ± SE = 27.0 ± 1.0) and 1–6 mature oocytes (mean ± SE = 3.6 ± 0.2); we never found more than one mature oocyte per ovariole. The average number of mature oocytes per ovariole (0.40) was within the range of values reported for other bembicine brood parasites (0.25–0.84), and higher than most values reported for bembicine nest provisioners, which generally range from 0.17–0.33 (Ohl and Linde 2003). The mean length of mature oocytes was 2.58 ± 0.04 mm (range: 2.1–3.1 mm), whereas their mean volume was 0.72 ± 0.03 mm^3 (range: 0.38–1.15 mm^3).

Iwata and Sakagami (1966), Itô (1978), and Ohl and Linde (2003) compared relative egg sizes among parasitoid, brood parasitic, and nest provisioning solitary wasps with different body sizes using the "egg index." Egg indices have been published for a number of solitary aculeate wasps, but 58 of the 90 published values for crabronid wasps are for species for which just a single female was dissected, and another 23 were derived from samples of 2–3 females (Ohl and Linde 2003). The mean egg index for 30 *S. renicinctus* females in our sample was 0.77 ± 0.02 (range: 0.65–0.96). The fact that the egg index was quite variable and that it varied inversely with body size (head width-egg index correlation, Spearmann correlation, $r = -0.86$, $P < 0.001$), gives further indication that larger data sets are needed to characterize relative egg size.

The mean egg index for *S. renicinctus* is similar to the mean (0.74) for the other seven species of brood parasitic Bembicinae in Ohl and Linde (2003). In contrast, the seven species of nest-provisioning crabronids on Table 1 (the only species with sample sizes greater than 10) have egg index values 9–22% higher than that of *S. renicinctus*; the 22% value being that for *Bembecinus quinequespinosus* (Say), a member of the same tribe (Stizini) as *S. renicinctus*. The range in the sizes of the largest mature oocytes carried by *S. renicinctus* is about the same as that for *B. quinquespinosus* and *Philanthus pulcher* Dalla Torre, although both are smaller than *S. renicinctus*, much smaller in the case of *P. pulcher*. Unlike mature oocytes in ovaries of *Philanthus* (O'Neill 1985), those of *S. renicinctus* appeared much less crowded and deformed by other organs and tissues in the abdomen. Brood parasitic solitary bees also have relatively smaller mature oocytes compared to similar-sized nest provisioners (Alexander and Rozen 1987).

Despite the differences documented above, *S. renicinctus* is similar to its nest-provisioning relatives in that head

Table 1. Egg indices for species of Crabronidae for which more than 10 females have been examined.

Species	N	Egg Index	Source
Bembicinae			
Bembecinus quinquespinosus (Say)	30	0.94	O'Neill 1985[1]
Bembix americana F.	30	0.84	O'Neill 1985[1]
Stizoides renicinctus (Say)	31	0.77	present study
Philanthinae			
Cerceris graphica Smith	32	0.84	Ohl and Linde 2003
Cerceris morata Cresson	13	0.95	Ohl and Linde 2003
Philanthus bicinctus (Mickel)	21	0.90	O'Neill 1985[1]
Philanthus pulcher Dalla Torre	40	0.92	O'Neill 1985[1]
Philanthus zebratus Cresson	41	0.86	O'Neill 1985[1]

[1] Egg index calculated from egg length data in O'Neill (1985) and our unpublished measurements of thorax width.

width was correlated, intraspecifically, with 1) the number of visible oocytes ($r = 0.84$, $P < 0.001$), 2) the number of mature oocytes ($r = 0.59$, $P < 0.001$), 3) the number of mature oocytes per ovariole ($r = 0.51$, $P = 0.004$) and 4) the length ($r = 0.65$, $P < 0.001$) and volume ($r = 0.66$, $P < 0.001$) of each female's largest oocyte. Thus, larger female *S. renicinctus* may be better able to exploit a series of host nests in rapid succession, and to lay larger, more yolk-rich eggs than can smaller conspecifics. Among apoid wasps, higher fecundity and smaller relative egg size has evolved secondarily, not only among the brood parasitic Bembicinae, but among the few parasitoid sphecids (e.g., *Larra* spp., *Chlorion lobatum* F.) (O'Neill 2001, Ohl and Linde 2003). In addition, some ground-nesters that make a series of simple single-celled nests over short time intervals may have evolved the ability to reduce the time between successive ovipositions by carrying greater numbers of smaller mature eggs. For example, each female of *Podalonia valida* (Cresson), which carry as many as seven mature oocytes, provisions a series of shallow single-celled nests in close proximity to one another, and does so more rapidly than relatives that dig more complex nests provisioned with multiple prey per cell (O'Neill and Evans 1999).

We also found evidence of age-related constraints on the quantity and size of eggs. The age of females, judged by the amount of wing wear, was correlated with the number, size, and condition of oocytes they carried. Thirteen females had no visible wing wear, so were likely relatively young, whereas 17 displayed varying degrees of tattering and tearing at wing edges; females in the two samples did not differ in size (Mann-Whitney test, $P = 0.16$). Compared with females with at least some wing wear, those having no wing wear carried a greater number of mature oocytes per ovariole (mean = 0.47 ± 0.05 vs. 0.34 ± 0.02; Mann-Whitney test, $P = 0.02$). The largest oocyte carried by younger females also had a greater volume than that carried by older females (mean = 0.80 ± 0.05 vs. 0.66 ± 0.03 mm^3; Mann-Whitney test, $P = 0.04$). Eleven (61%) of the females with at least some wing wear had one terminal oocyte that was apparently in the process of being resorbed (i.e., it was often as long as normal, mature terminal oocytes, but was very slender and often deformed). In contrast, just one (8%) of females with no wing wear had such an oocyte ($\chi^2 = 7.00$, $P =$

0.008). Thus, there may be both size- and age-related constraints on reproduction of *S. renicinctus* females.

ACKNOWLEDGMENTS

We thank Sue Blodgett, Michael Ohl, Ruth O'Neill, and Richard Miller for comments on the manuscript. The research was supported by the Montana Agricultural Experiment Station and USDA-NRCS.

LITERATURE CITED

Alexander, B. A. and J. G. Rozen, Jr. 1987. Ovaries, ovarioles, and oocytes in parasitic bees. The Pan-Pacific Entomologist 63: 155–164.

Evans, H. E. 1966. The Comparative Ethology and Evolution of the Sand Wasps. Harvard University Press, Cambridge, Massachusetts.

Itô, Y. 1978. Comparative Ecology. Cambridge University Press, Cambridge.

Iwata, K. 1955. The comparative anatomy of the ovary in Hymenoptera. Part I. Aculeata. Mushi 29: 17–34.

———. 1960. The comparative anatomy of the ovary in Hymenoptera. Supplement on Aculeata with descriptions of ovarian eggs of certain species. Acta Hymenopterologica 1: 205–211.

Iwata, K. and S. F. Sakagami. 1966. Gigantism and dwarfism in bee eggs in relation to the modes of life, with notes on the number of ovarioles. Japanese Journal of Ecology 16: 4–16.

Ohl, M. 1999. A revision of *Stizoides* Guérin-Méneville, 1844: Taxonomy, phylogenetic relationships, biogeography, and evolution (Hymenoptera: Apoidea: "Sphecidae"). Mitteilungen der Museum Naturkunde Berlin, Zoologische Reihe 75: 63–169.

Ohl, M. and D. Linde. 2003. Ovaries, ovarioles, and oocytes in apoid wasps, with special reference to cleptoparasitic species (Hymenoptera: Apoidea, "Sphecidae"). Journal of the Kansas Entomological Society 76: 147–159.

O'Neill, K. M. 1985. Egg size, prey size, and sexual size dimorphism in digger wasps (Hymenoptera: Sphecidae). Canadian Journal of Zoology 63: 2187–2193.

———. 2001. Solitary Wasps: Natural History and Behavior. Cornell University Press, Ithaca, New York.

O'Neill, K. M. and H. E. Evans. 1999. Observations on nests and prey of *Podalonia valida* (Hymenoptera: Sphecidae). Proceedings of the Entomological Society of Washington 101: 312–315.

Rau, P. 1938. Additional observations on the sleep of insects. Annals of the Entomological Society of America 31: 540–556.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 841–846

A KEY TO SPECIES OF *NISOTRA* BALY (COLEOPTERA: CHRYSOMELIDAE: ALTICINAE) FROM CHINA, WITH DESCRIPTION OF A NEW SPECIES AND TWO NEW RECORDS FOR CHINA

Yong Zhang and Xingke Yang

(YZ, XY) Institute of Zoology, Chinese Academy of Sciences, 36 Box, 25 Bei SihuanXiLu, Haidian, Beijing, 100080, China (e-mail: zhangy@ioz.ac.cn); (YZ) Graduate School, Chinese Academy of Sciences, Yuquanlu, Shijingshan, Beijing, 100039, China. Corresponding author: Xingke Yang (e-mail: yangxk@ioz.ac.cn)

Abstract.—Five species of the genus *Nisotra* Baly are known from China. ***Nisotra xinjiangana*, n. sp.**, is described, and *Nisotra dohertyi* Maulik and *Nisotra nigripes* Jacoby are newly recorded from China. A key to the known Chinese species is given. The habitus of the new species and the aedeagus and the spermatheca of all species are illustrated.

Key Words: Alticinae, *Nisotra*, new species, new record, China

---

The genus *Nisotra* was proposed by Baly in 1864, with the type species *Haltica gemella* Erichson. At present, more than 70 world species are known. Among them, five species occur in China. There have been studies on some Chinese species of *Nisotra* by Baly (1864, 1876), Duvivier (1885), Jacoby (1885), Motschulsky (1866), Maulik (1926), Oglobin (1930), Chen (1933), Chen and Zia (1966), Gressitt and Kimoto (1963), Scherer (1969), and Wang (1992, 1996). However, the Chinese species of this genus have not been studied thoroughly. For this paper, we studied all of the 5 known Chinese species, one of them is new to science and two of them are recorded for the first time from China. All specimens examined, including the types of the new species, are deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing, P. R. China (IZAS). The habitus of the new species and the aedeagus and the spermatheca of all species are illustrated.

Nisotra Baly, 1864

Nisotra Baly 1864: 437 (type species: *Haltica gemella* Erichson, 1834, by original designation).

Description.—Body ovate, convex, with apex narrow. *Head:* Moderately recessed as viewed from above, vertex broad and convex. Frontal tubercles inconspicuous, interantennal area flat, clypeus slightly convex, with anterior margin sinuate. Antenna slender and short, not exceeding middle of elytra. *Pronotum:* Broader than long, anterior margin concave behind, each side of anterior and posterior margins with a longitudinal groove, perpendicular to them. Scutellum triangular, with apex obtuse. *Elytra:* With fine and shallow punctures, punctures irregular or sometimes arranged in double rows, area between punctures flat; humeri convex. *Abdomen:* With punctures and pubescence, anterior coxal cavities closed behind, claws appendiculate. Last sternite of male abdomen trilobed, of female rounded.

Diagnosis.—*Nisotra* is distinguished from other flea beetles by the ovate, convex body, moderately recessed head, and the longitudinal grooves on the anterior and posterior margins of the pronotum.

Distribution.—Oriental, Australian, and Afrotropical regions.

KEY TO CHINESE SPECIES OF *NISOTRA*

1. Distinct broad and deep longitudinal groove on each side of anterior margin of pronotum 2
– Inconspicuous short and shallow longitudinal groove on each side of anterior margin of pronotum 4
2. Body ovate, dorsum convex; length 4.00–4.50 mm; elytra metallic blue (genitalia in Figs. 2A–D) . . . . *N. dohertyi* Maulik
– Body elongate (as in Fig. 5E), dorsum not convex; length less than 4.00 mm; elytra not metallic blue 3
3. Legs black (genitalia in Figs. 4A–D) . . . . *N. nigripes* Jacoby
– Legs reddish brown (genitalia in Figs. 1A–D) . . . . *N. chrysomeloides* Jacoby
4. Longitudinal groove of posterior margin of pronotum inconspicous, short and shallow, length shorter than 1/5 of pronotum (genitalia in Figs. 3A–D) . . . . *N. gemella* (Erichson)
– Longitudinal groove of posterior margin of pronotum distinct long and deep, length about 1/5 of pronotum (genitalia in Figs. 5A–E) . . . . *N. xinjiangana*, n. sp.

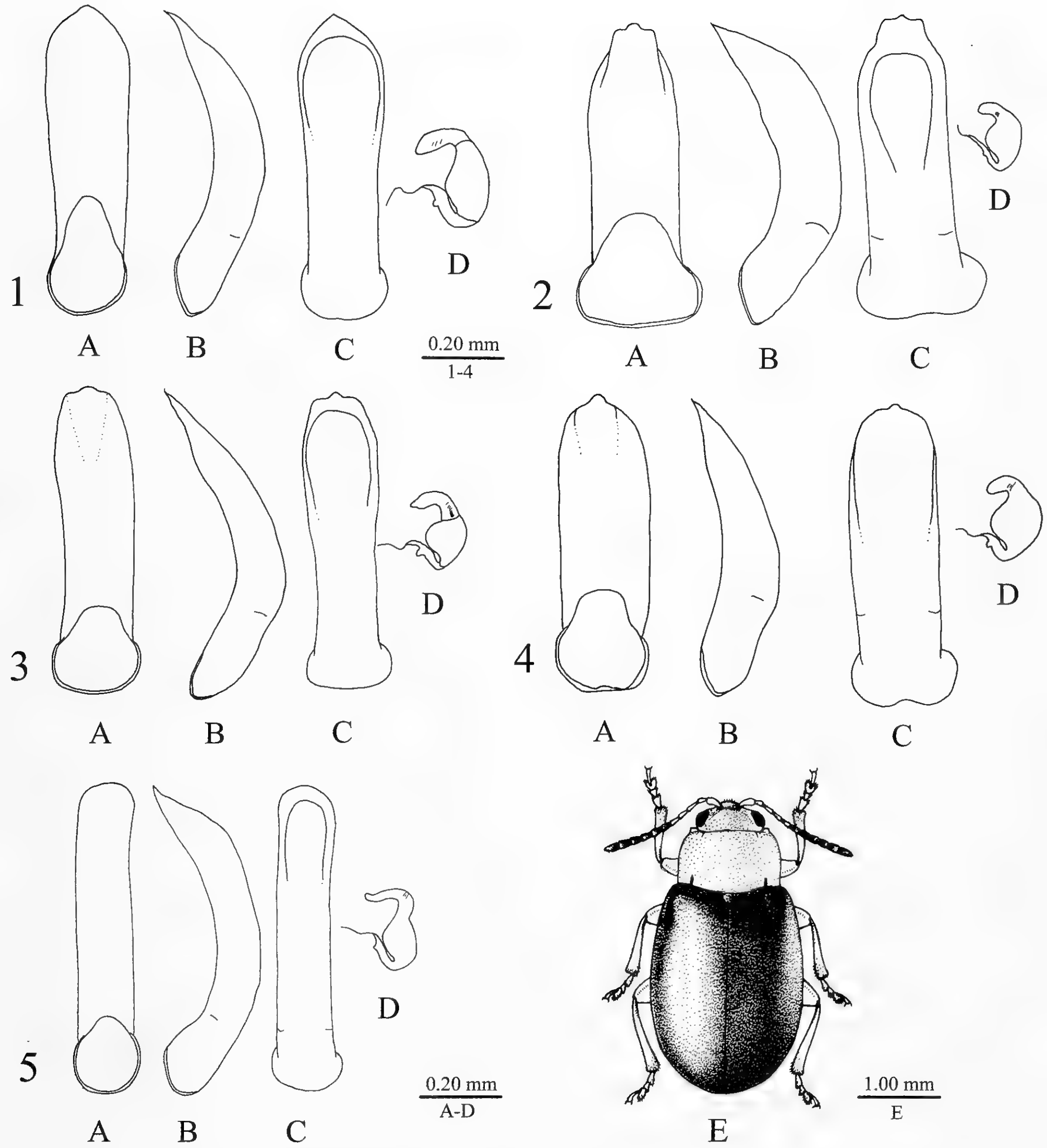
Nisotra dohertyi Maulik
(Figs. 2A–D)

Nisotra dohertyi Maulik 1926: 274.

Diagnosis.—Body ovate, dorsum more convex. Elytra metallic blue; pronotum, four basal segments of antenna, and legs reddish brown; venter of thorax and abdomen piceous; seven apical segments of antenna black.

Head: Vertex convex and broad, impunctate; frontal tubercles inconspicuous, as two oblique impressed lines; interantennal space broad and slightly convex. Antenna reaching middle of elytra; first segment clubbed, longest, second shortest, third slightly longer than second, fourth slightly shorter than third, fifth almost equal to fourth, remaining segments slightly thickened and covered with short hairs. *Pronotum:* Broader than long, anterior margin slightly concave, lateral margin arched, posterior margin arched towards elytra in middle sinuate; anterior angles thickened, with apex acute, posterior angles obtuse; each side of anterior and posterior margins with a longitudinal groove, perpendicular to the margin; surface not lustrous, with uniform and dense punctures. *Elytra:* Broader than pronotum at base, closely and confusedly punctuate. Abdominal sternites sparsely covered with pubescence. Genitalia of this species with apex somewhat truncate and also a denticle in middle, in ventral view each lateral side of apex with a longitudinal concave.

Material examined.—P. R. China. Yunnan: menglongbanna: mengsong, 1600 m, 22~27 Apr. 1958, 16♂, 22♀, coll. Xu-Wu Meng; 22~24 Apr. 1958, 15♂, 16♀, coll. Shu-Yong WANG; 22~27 Apr. 1958, 15♂, 18♀, coll. Chun-Pei HONG; 22~28 Apr. 1958, 14♂, 20♀, coll. Fu-Ji PU; 24~26 May 1958, 28♂, 33♀, coll. Le-Yi ZHENG; 25 Apr. 1958, 3♂, 5♀, coll. Zhi-Zi CHEN; Pingbian: daweishan, 1500 m, 22 June 1956, 78♂, 89♀, coll. Ke-Ren HUANG etc.; 1350 m, 22~27 June 1956, 20♂, 30♀, coll. Panfilov; Gengma, 4 May 1955, 17♂, 19♀, coll. Tian-Rong HUANG; Jinping: hetouzhai, 2000 m, 10 May 1956, 8♂, 11♀, coll. Ke-Ren HUANG etc.; 1500–1700 m, 11 May 1956, 40♂, 46♀, coll. Ke-Ren HUANG etc.; 1600 m, 14 May 1956, 4♂, 4♀, coll. Ke-Ren HUANG etc.; 1700 m, 16 May 1956, 30♂, 38♀, coll. Ke-Ren HUANG etc.; Changpotou, 1200 m, 14 May 1956,



Figs. 1–5. *Nisotra* spp. 1, *N. chrysomeloides*. 2, *N. dohertyi*. 3, *N. gemella*. 4, *N. nigripes*. 5, *N. xinjiangana*. A = ventral view of aedeagus; B = lateral view of aedeagus; C = dorsal view of aedeagus; D = spermatheca; E = habitus.

2♂, coll. Ke-Ren HUANG etc.; Mengla, 370 m, 18 Apr. 1956, 1♀, coll. Ke-Ren HUANG etc.; Near Jinping, 900 m, 27 May 1956, 1♂, coll. Panfilov; Xishuangbanna: mengzhe, 24 June 1958, 5♂, 6♀, coll. Shu-Yong WANG; 25 June 1958, 2♂, 1♀, coll. Zhi-Zi CHEN; 1750 m, 25 June 1958, 8♂, 12♀, coll. Fu-Ji PU; 1200 m, 28 June 1958, 3♂, 2♀, coll. Fu-Ji PU; Menghun, 1200–1400 m, 9~24 May 1958, 3♂, 6♀, coll. Chun-Pei HONG; 18~23 May 1958, 1♂, 2♀, coll. Xu-Wu MENG; 22~24 May 1958, 6♂, 6♀, coll. Yi-Ran ZHANG; 24 May 1958, 2♂, 3♀, coll. Xu-Wu MENG; 1200 m, 24 May 1958, 2♀, coll. Le-Yi ZHENG; Damenglong, 650 m, 7~9 Apr. 1958, 2♂, 2♀, coll. Unknown; Menga, 1050–

1080 m, 23 May 1958, coll. Shu-Yong WANG; 31 May 1958, 1♀, coll. Fu-Ji PU; Menghai, 1200–1600 m, 24 July 1958, 1♀, coll. Shu-Yong WANG; Ruili: mengxiu, 1300 m, 28 Apr. 1980, 1♂, 1♀, coll. Hong-Xing LI. All specimens are deposited in IZAS.

Distribution.—China (Yunnan). This is a new record for China. The species was described from Burma.

Nisotra nigripes Jacoby
(Figs. 4A–D)

Nisotra nigripes Jacoby 1894: 293.

Diagnosis.—Body elongate ovate. Head, pronotum and four basal segments of antenna fulvous, remaining segments black; elytra dark blue; scutellum obscure fulvous; venter of thorax and abdomen and legs black.

Head: Vertex broad, impunctate; frontal tubercles obsolete; antenna extending to middle of elytra, first segment apically clubbed, longest, second shortest, shorter than first, third longer than second, fourth slightly longer than third, remaining segments almost equal in length to fourth and covered with pubescence. *Pronotum:* Distinctly broader than long, surface very finely punctured, anterior margin straight, lateral margin arched, posterior margin moderately arched towards elytra in middle; anterior margin with a very deep and rather long perpendicular groove at each side, posterior margin with very narrow and shallow longitudinal groove. Scutellum triangular, with surface more smooth. *Elytra:* With irregular punctures, sometimes arranged in double rows, interstices with fine punctures. Genitalia of this species with apex slightly triangular and also with a denticle in middle, each side of apex with a longitudinal and shallow groove near lateral part.

Material examined.—P. R. China. Yunan: xishuangbanna: menghun, 1200–1400 m, 19 May 1958, 1♂, 2♀, coll. Chun-Pei HONG; 19 May 1958, 1♀, coll. Xu-Wu MENG; 21 May 1958, 1♀, coll. Xu-Wu MENG; 1200 m, 17 June 1958, 1♀, coll. Le-Yi ZHENG; Menga, 800 m, 29 May 1958, 1♂, coll. Shu-Yong WANG; 1050–1080 m, 31 May 1958, 2♂, 6♀, coll. Fu-Ji PU; 10 Aug. 1958, 2♀, coll. Shu-Yong WANG; Damenglong, 650 m, 11~12 July 1958, 3♂, 3♀, coll. Chun-Pei HONG; Mengzhe, 1200 m, 31 Aug. 1958, 1♀, coll. Fu-Ji PU; Yiwubanna: menglun, 650 m, 23 July 1959, 5♂, 7♀, coll. Fa-Cai ZHANG; 1♂, 2♀, coll. Zhen-Fu LI; 3♂, 6♀, coll. Fu-Ji PU; 11 Apr. 1982, 4♂, 5♀, coll. Pei-Yu YU; Kunming, 1900 m, 23 Mar. 1958, 1♀, coll. Fu-Ji PU; Jinping: mengla, 370 m, 22 Apr. 1956, 1♀, coll. Ke-Ren HUANG; 350 m, 22 May 1956, 1♀, coll. Panfilov; East of Jingdong, 1300 m, 31 May 1956, 1♀, coll. Kryzanovsky. All specimens are deposited in IZAS.

Distribution.—China (Yunnan). This is a new record for China. The species was described from Burma.

***Nisotra xinjiangana* Zhang and Yang, new species**
(Figs. 5A–E)

Description.—Body elongate ovate. Length: 4.40–4.60 mm, width: 2.20–2.40 mm. Head, dorsal and ventral surface of prothorax and legs reddish brown, basal 4 segments of antenna reddish brown, remaining segments black; mandible black, mesosternum, metasternum, and abodomen black; elytra deep blue; scutellum brown.

Head: Protruding, vertex broad and convex, surface smooth, sparse with fine punctures; frontal tubercles elongate, oblique, separated by a longitudinal furrow; eyes ovate, with surface coarse; clypeus broad between antenna, middle slightly convex, each side with few punctures, anterior margin straight; labrum with 6 setigerous pores near anterior margin, anterior margin arched. Antenna extending slightly beyond humerus of elytra, about 1/3 of elytra length, first segment apically clubbed, longest, second shortest, third longer than fourth, fifth almost equal in length with fourth, remainder somewhat equal in length, last segment longer than tenth, with apex acute, proportion of each segment as: 1.20: 0.60: 0.80: 0.70: 0.70: 0.70: 0.70: 0.70: 0.80: 0.80: 1.00, segments from fourth to end slightly thicker and more hairy. *Pronotum:* Broader than long, somewhat convex, length: 1.10–1.30 mm, width: 1.70–1.90 mm; surface with close and confused punctures, anterior margin straight, lateral margin arched, posterior margin arched towards elytra in middle; at each side near lateral margin, two longitudinal impressions perpendicular to both anterior and posterior margin, those of anterior margin inconspicuous, sometimes replaced with 1 to 2 punctures, that of posterior margin distinct and rather curved, length about 1/5 pronotum length; anterior angle thickened, with apex acute, posterior angle obtuse. Scutellum triangular, surface with wrinkles. *Elytra:* Length: 3.70–3.90 mm, width: 2.60–2.80 mm; moderately convex, broader at base than pronotum, humeri raised, scutellum rows shorter, arranged in double rows, elytral punctures confused, with fine punctures between larger ones; epipleura broad at base, gradually narrowing behind, surface with transverse wrinkles, especially distinct in posterior part. *Venter:* Prosternum narrowest between anterior coxal cavity, with apex rounded, anterior coxal cavity closed behind, mesosternum narrower than metasternum, metasternum with a longitudinal groove in middle, surface with pubescence and punctures. Claws appendiculate. Abodominal surface with pubescence and punctures, last sternite of male trilobed, that of female rounded.

Type material.—Holotype: ♂, P. R. CHINA. Xinjiang: aletaikemuqi, 800 m, 22 Aug. 1960, coll. Shu-Yong Wang. Paratypes: 16 Aug. 1960, 2♂, 1♀, coll. Shu-Yong Wang; 40♂, 62♀, the same to holotype; 23 Aug. 1960, 2♂, coll. Shu-Yong Wang; 18♂, 15♀, coll. Zhang Fa-Cai; Jinghe, 24~25 Aug. 1955, 1♂, 2♀, coll. Shi-Jun MA, Kai-ling XIA & Yong-Lin Chen; Laoshihezi, 8 June 1957, 1♀, coll. Chun-Pei Hong; Mt. Tian, 690 m, 4 Aug. 1957, 1♀, coll. Guang Wang. Type materials are deposited in IZAS.

Diagnosis.—This new species is similar to *N. gemella*, but can be distinguished as follows: *N. gemella* with longitudinal impressions of anterior margin more distinct, while the new species with the impressions more inconspicuous, sometimes replaced by 1 to 2 punctures; *N. gemella* with longitudinal impressions of posterior margin inconspicuous, length shorter than 1/5 of pronotum, while the new species with the impressions more distinct and deep, about 1/5th of the pronotal length; and genitalia of *N. gemella* with a denticle at apex and a triangular apically concave about 1/4th of genitalia, while the new species with apex rounded and not a concave apically.

Etymology.—The name of the new species is derived from the type locality.

Distribution.—China (Xinjiang).

Host plant.—*Althaea rosea* (Linn.) Cavan. (Malvaceae).

ACKNOWLEDGMENTS

Appreciation is given to Mr. Wen-Zhu Li for drawing the figure of the habitus. We also thank Dr. Si-Qin Ge and Dr. Huai-Jun Xue for their helpful advice and comments on the manuscript.

LITERATURE CITED

Baly, J. S. 1864. Desciptions of new genera and species of Phytophaga. The Annals and Magazine of Natural History, Ser. 3 14: 433–442.

———. 1876. Description of new genera and species of Halticinae. The Transactions of the Entomological Society of London, 581–602.

Chen, S. H. 1933. Study of Chinese halticine beetle with descriptions of some exotic new species. Sinensia 3(9): 211–254.

Chen, S. H. and Y. Zia. 1966. On the Chinese citrum flea-beetles. Acta Zootaxonomia Sinica 3(1): 68–75.

Duvivier, A. 1885. Phytophages (Halticides et Galerucides). Annales de la Société Entomologique de Belgique 29: 48–56.

Gressitt, J. L. and S. Kimoto. 1963. The Chrysomelidae (Coleoptera) China and Korea. Part 2. Pacific Insects Monograph 1B: 739–893.

Jacoby, M. 1885. Descriptions of new genera and species of phytophagous Coleoptera from the Indo-Malayan and Autro-Malayan subregions. Annali del Museo Civico di Storia Naturale di Genova, Ser.2 2(22): 20–76.

———. 1894. Descriptions of new genera and species of phytophagous Coleoptera obtained by W. Doherty in the Malayan Archipelago. Novitates Zoologicae 1: 267–330.

Maulik, S. 1926. The fauna of British India, including Ceylon and Burma, Chrysomelidae, (Chrysomelinae & Halticinae). London. 441 pp.

Motschulsky, V. 1866. Essai d'un Catalogae des Insectes de l'ile de Ceylon. Bulletin de la Société Impériale des Naturalistes Moscou 39(1): 393–446.

Ogloblin, D. A. 1930. De quelques espèces de Halticinae de la collection de V. Motschulsky. Eos 6: 83–112.

Scherer, G. 1969. Die Alticinae des indischen Subkontinentes (Coleoptera: Chrysomelidae). Pacific Insects Monograph, No. 22, 251 pp.

Wang, S. Y. 1992. Coleoptera: Chrysomelidae: Alticinae, pp. 675–753. *In* Chen, S. H., ed. Insects of the Hengduan Mountains Regions. Science Press, Beijing, China.

———. 1996. Coleoptera: Chrysomelidae: Alticinae, pp. 196–299. *In* Yu, P. Y., S. Y. Wang, and X. K. Yang, eds. Economic Insect Fauna of China. Science Press, Beijing, China, vol. 54.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 847–855

A NEW GENUS AND TWO NEW SPECIES OF DASYNINI (HEMIPTERA: HETEROPTERA: COREIDAE) FROM MADAGASCAR

Harry Brailovsky

Departamento de Zoología, Instituto de Biología, U. N. A. M., Apdo Postal No. 70153, México, 04510 D. F., México (e-mail: coreidae@servidor.unam.mx)

Abstract.—***Madagalaesus*, new genus**, and two **new species,** ***M. garciai*** and ***M. notios***, from Madagascar are described in the tribe Dasynini (Coreidae). Habitus illustrations and drawings of the antennae, pronotum, and male and female genitalia are provided. A key to the known species is presented.

Key Words: Insecta, Heteroptera, Coreidae, Dasynini, new genus, new species, Madagascar

The Dasynini (Hemiptera: Coreidae) constitutes a distinctive and well-defined tribe characterized by having the head comparatively long, the anterior portion porrect, surpassing the antenniferous tubercles that are widely spaced; the tylus apically rounded; the eyes hemispheric and protruding; antennal segment IV longer than I; the rostrum reaching or extending beyond the mesosternum; the femora unarmed; the hind femur in the males not distinctly incrassate; the tibiae sulcate and not expanded; and species of the genus usually light colored.

Dasynini is primarily an Old World tropical and subtropical tribe distributed in the Eastern Hemisphere. In Africa, the tribe is represented by 5 genera and 14 species: *Anadasynus* China (one species), *Dasynus* Burmeister (one species), *Galaesus* Dallas (five species), *Pseudopendulinus* Schouteden (two species), and *Therаptus* Stål (five species) (Dallas 1852, Schouteden 1938).

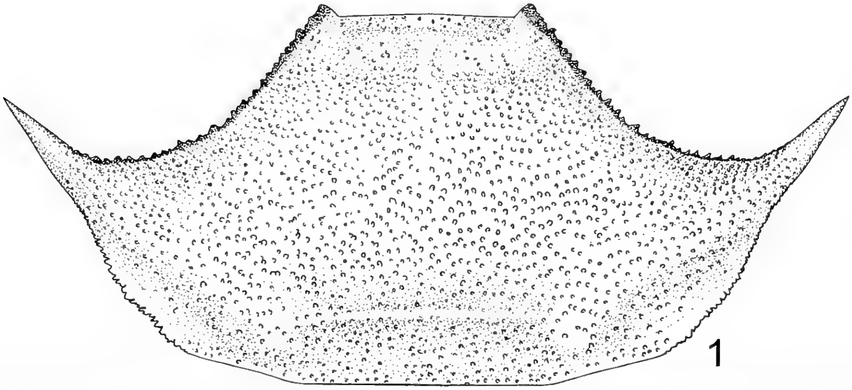
In this work, Dasynini is recorded for the first time from Madagascar, with the description of one new genus and two new species.

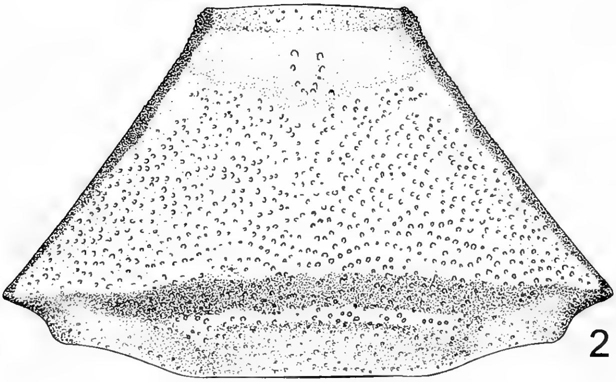
The following abbreviations are used for the institutions cited in this paper: MNHN (Muséum National d' Histoire Naturelle, Paris, France); MNHP (National Museum, Prague, Czech Republic); UNAM (Instituto de Biología, Universidad Nacional Autónoma de México, Colección Nacional de Insectos).

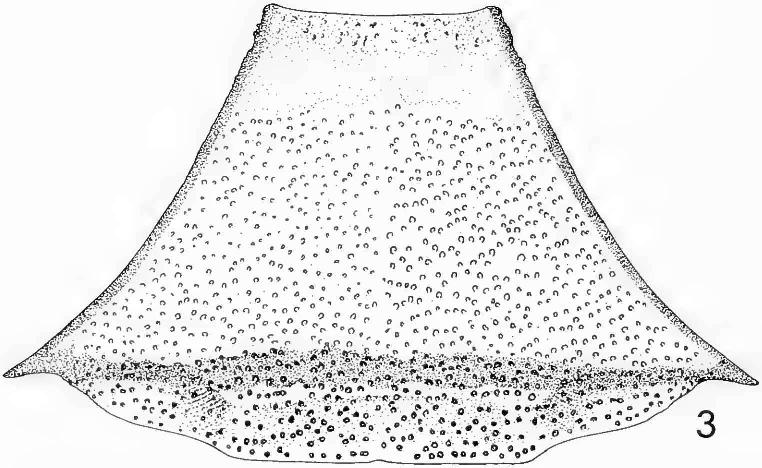
All measurements are given in millimeters.

Madagalaesus Brailovsky, new genus

Diagnosis.—*Madagalaesus* is similar to *Galaesus* Dallas, with the postocular tubercle indistinct, antenniferous tubercles unarmed, rostral segment IV the longest, collar wide, femora unarmed, and the female abdominal sternite VII with plica and fissura. *Madagalaesus*, known only from Madagascar, is recognized by having the humeral angles projected into large and acute spines; abdominal sterna III to VI yellow to pale yellowish orange, without black anterior margins; and antennal segments II and III cylindrical, with the apical third barely stout and carinate. In *Galaesus*,


1


2


3

Figs. 1–3. Pronotum of *Madagalaesus* spp. 1, *M. garciai.* 2–3, *M. notios.*

recorded from Beni, Cameroon, Belgian Congo, Gambia, Guinea, Mozambique, Sierra Leone, and South Africa, the humeral angles are obtuse and rounded; abdominal sterna III to VI yellow, or pale yellowish orange, or reddish orange and always with the anterior margin black; and antennal segments II and III uniformly carinate, with the apical third cylindrical or remarkably expanded, and obovate.

Description.—Body nearly parallel-sided. *Head:* Wider than long, shorter than length of pronotum, pentagonal, non-declivant, dorsally flat, and distinctly produced and surpassing antenniferous tubercles; tylus unarmed, apically globose, barely raised, extending anteriorly to and laterally higher than juga; juga unarmed; antenniferous tubercles unarmed, borders entire, continuous, almost circular, not prominent, widely separated; antennal segment I thicker than succeeding segments, cylindrical, curved outward, apically slightly expanded, longer than head; antennal segments II and III slender, apically slightly expanded, and flanked by carinae, and segment IV fusiform; antennal segment IV longest, III shortest, and I longer than II, or antennal segment II longest, III shortest, and IV longer than I; ocelli proximate to eyes; preocellar pit deep; ocellar tubercles barely raised; eyes globose, upper margin located almost at same level as frontal and vertex area; postocular tubercle indistinct; mandibular plate unarmed; buccula rectangular, raised, short, entire, not projecting beyond antenniferous tubercles, meeting posteriorly, and closed; rostrum reaching posterior margin of metasternum or posterior margin of abdominal sternite III; rostral segment I not extending beyond base of head or reaching anterior margin of prosternum, or reaching or passing posterior margin of metasternum; rostral segment IV longest, III shortest, and I and II subequal.

Thorax: Pronotum wider than long, trapeziform, gradually declivant; collar wide; anterior border almost straight, smooth; frontal angles barely exposed; anterolateral borders obliquely straight, nodulose; humeral angles thick at base, tapering into remarkably large and acute spine, pointing strongly upward (Fig. 1), or tapering into medium-sized to stout spine pointing outward, slightly backward, and barely upward (Figs. 2–3); posterolateral borders sinuate, outer third nodulose, inner third smooth; posterior border straight or weakly concave, smooth; calli indistinct, not raised, with deep submedial longitudinal furrow; triangular process absent; pronotal disk without longitudinal medial carinae; posterior margin with low transverse ridge, running between humeral angles. Prosternum with deep excavation; mesosternum, and metasternum entire; anterior margin of mesosternum in front of area between fore legs produced into broad, blunt keel.

Legs: Unarmed; tibiae terete, sulcate.

Scutellum: Longer than wide, triangular, flat, apically subacute.

Hemelytron: Macropterous, reaching apex of last abdominal segment; costal margin emarginated; apical margin sinuate, with apical angle obtuse, extending beyond middle third of membrane.

Abdomen: Connexival segments distinctly raised above tergum, with posterior angle sometimes produced into short, subacute spine; abdominal sterna without medial furrow; abdominal spiracles circular, small, closest to anterior border, and remote from upper border of connexivum; abdominal spiracle II not visible.

Integument: Body surface rather dull, almost glabrous; posterior lobe of pronotal disk, clavus, and corium strongly punctate; head, calli, connexival segments, prosternum, mesosternum, metasternum, abdominal sterna, male genital capsule, and female genital plates impunctate; propleuron, mesopleuron, metapleuron and acetabulae strongly punctate or with scattered punctures; scutellum transversely striate, strongly punctate or with scattered punctures; tibiae and tarsi densely clothed with large, erect, bristlelike setae; antennal segments with tiny setae, not densely adpressed.

Male genitalia: Posteroventral edge of genital capsule with lateral angles rounded, and mesial lobe stout and apically bifid (Fig. 6), or mesial lobe short and rounded (Fig. 7).

Female genitalia: Abdominal sternite VII with plica and fissura; plica short, subtriangular, reaching anterior margin of the sternite, or reduced to small hemispheric elevation; fissura covering 2/3 to almost the entire length of sternite; gonocoxae I wide, enlarged anteroposteriorly, in caudal view closed, in lateral view convex; paratergite VIII triangular, spiracle visible; paratergite IX projected as a broad squarish lobe (Figs. 8–9).

Etymology.—The name emphasizes the relationship of this genus with *Galaesus*; and the contraction Mada, meaning Madagascar. Gender masculine.

Type species.—*Madagalaesus garciai* Brailovsky, new species.

Madagalaesus garciai Brailovsky, new species

(Figs. 1, 4, 6, 8, 10)

Description.—Measurements: Male: Head length 2.20; width across eyes 2.28; interocular space 1.14; interocellar space 0.60; preocular distance 1.24; antennal segments lengths: I, 4.33; II, 3.87; III, 3.11; IV, 4.94. Pronotal length 3.34; width across humeral angles 6.61. Scutellar length 2.12; width 1.90. Total body length 18.27. Female. Head length 1.97; width across eyes 2.37; interocular space 1.32; interocellar space 0.65; preocular distance 1.24; antennal segments lengths: I, 3.42; II, 3.26; III, 2.67; IV, 3.95. Pronotal length 3.42; width across humeral angles 6.46. Scutellar length 2.12; width 1.90. Total body length 18.70.

Male: *Coloration:* Pale orange yellow with following areas black: head dorsally with single and narrow longitudinal stripe on middle line, apex of rostral segment IV, anterolateral margins of pronotum, large discoidal spot on propleuron, mesopleuron and metapleuron, two wide discoidal spots on basal third of scutellar disk, basal 2/3 of costal margin of corium, large discoidal spot between abdominal segments V–VI, two large discoidal spots on abdominal sterna III to V, and one on abdominal sterna VI–VII.; antennal segment I reddish brown with basal joint pale orange yellow; antennal segments II and III reddish brown with apical third black, and IV reddish brown with middle third black (Fig. 4); hemelytral membrane dark brown with basal angle pale orange yellow.

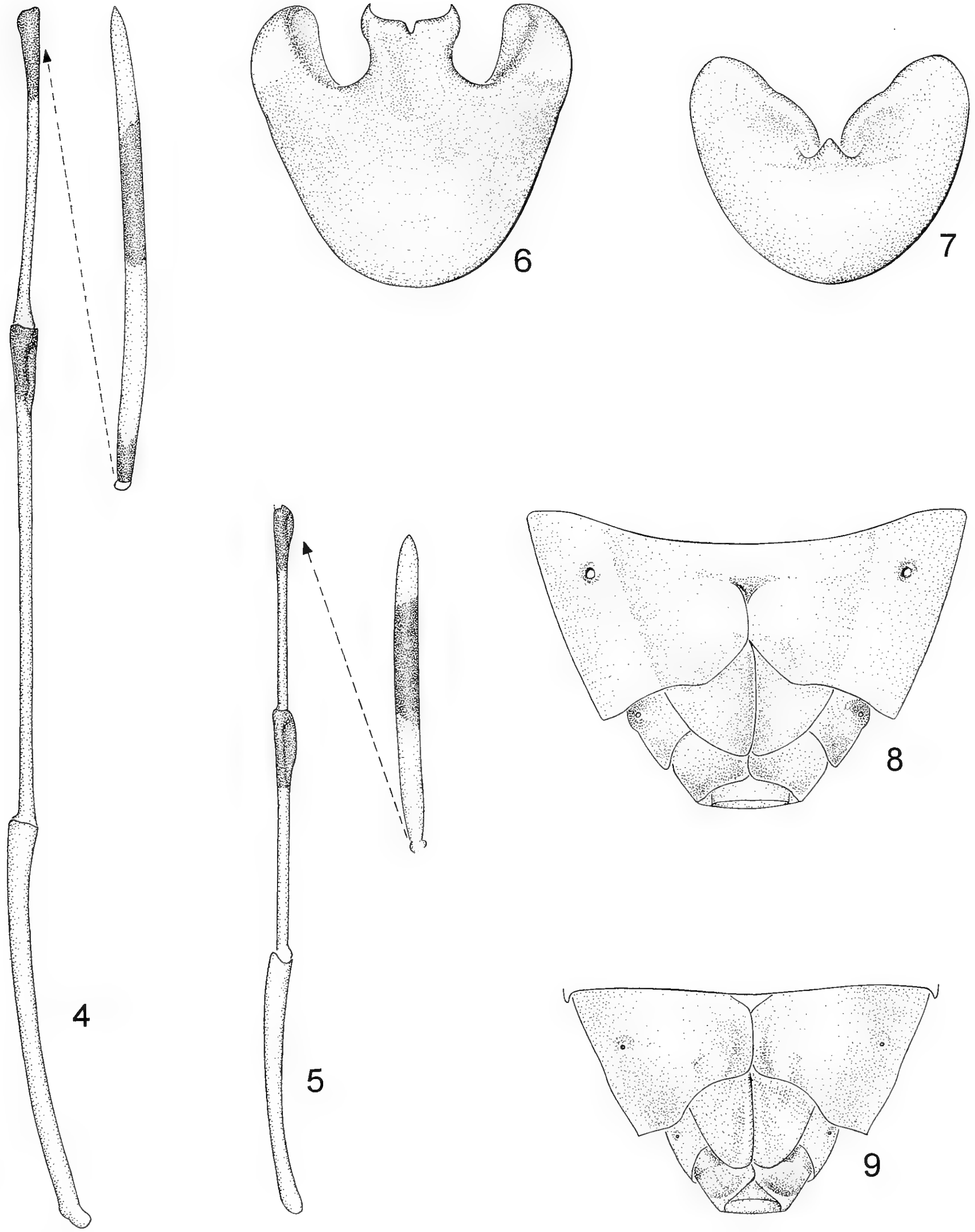
Head: Antennal segment IV longest, III shortest, and I longer than II; rostrum reaching posterior margin of metasternum; rostral segment I reaching base of head.

Thorax: Humeral angles tapering into remarkably large and acute spine, pointing upward (Fig. 1).

Abdomen: Connexival segments with posterior angles produced into short subacute spine; propleura, mesopleura, metapleura, and acetabulae strongly punctate.

Genital capsule. Posteroventral edge with lateral angles rounded, and mesial lobe stout, apically bifid (Fig. 6).

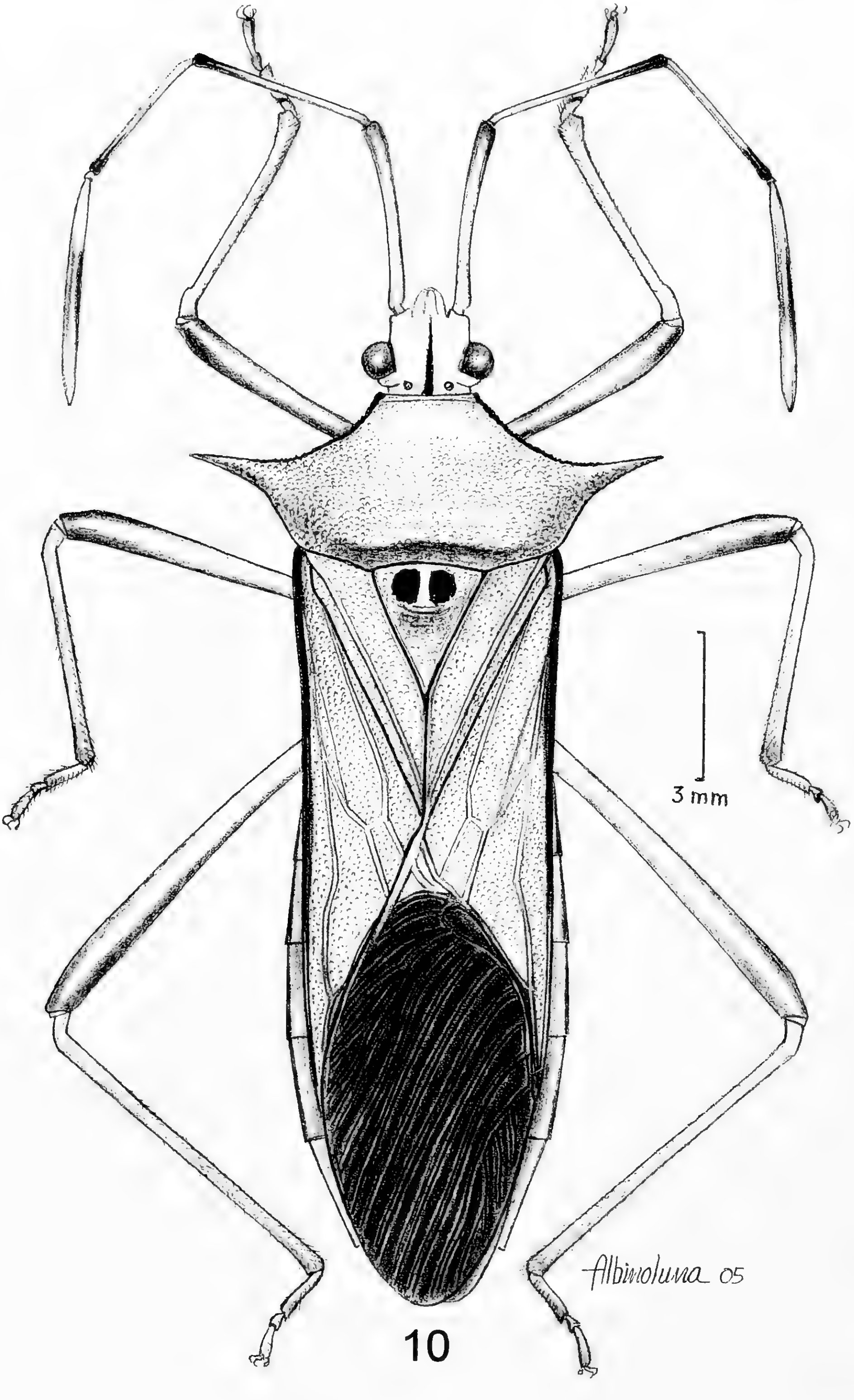
Female: Coloration similar to male holotype. Antennal segment I dark yellow, with basal joint paler; antennal segments II and III dark yellow with apical third black, and IV dark yellow with middle third pale brown; connexivum shiny reddish orange, with upper border pale yellow; dorsal abdominal segments shiny reddish orange with pale brown discoidal spot between segments V and VI; genital plates pale orange yellow.



Figs. 4–9. *Madagalaesus* spp. 4–5, Antennae. 4, *M. garciai*. 5, *M. notios*. 6–7, Male genital capsule. 6, *M. garciai*. 7, *M. notios*. 8–9, Female genital plates. 8, *M. garciai*. 9, *M. notios*.

Genital plates: Plica short, subtriangular, reaching anterior margin of sternite; fissura covered 2/3 of total sternite length (Fig. 8).

Variation.—1, Antennal segment I dark orange with basal joint paler. 2, Antennal segments II and III dark orange with apical third black. 3, Antennal



10

Fig. 10. Dorsal view of *Madagalaesus garciai*, female.

segment IV dark orange with middle third pale brown. 4, Connexivum and dorsal abdominal segments shiny reddish orange. 5, Upper border of connexivum pale yellow or shiny reddish orange. 6, Abdominal sterna III and V with one black and large discoidal spot.

Type material.—Holotype: ♂, Madagascar, Diego Suarez ? (Legon Etrangire), 1903 (MNHN). Paratypes: Madagascar: 2 ♂, 1 ♀, Hera, Ankazoabo (without date) (MNHN, UNAM); 1 ♀, Morondava, Foret Sud de Betasy, January 1956, R. Paulian (RP) (MNHN); 1 ♀, Bekily, Region Sud de L' Ile, A. Seyrig (without date) (UNAM).

Etymology.—Named after Luis Garcia Prieto, a distinguished Mexican helmintologist.

Madagalaesus notios Brailovsky, new species

(Figs. 2–3, 5, 7, 9, 11)

Description.—Measurements: Male: Head length 1.76; width across eyes 2.05; interocular space1.09; interocellar space 0.48; preocular distance 1.24; antennal segments lengths: I, 3.49; II, 4.18; III, 2.66; IV, 3.87. Pronotal length 2.81; width across humeral angles 5.01. Scutellar length 1.90; width 1.67. Total body length 15.30. Female: Head length 2.05; width across eyes 2.28; interocular space 1.29; interocellar space 0.61; preocular distance 1.39; antennal segments lengths: I, 3.64; II, 4.25; III, 2.73; IV, 4.02. Pronotal length 3.26; width across humeral angles 6.08. Scutellar length 2.20; width: 2.10. Total body length 18.60.

Male: *Dorsal coloration:* Head pale yellow with preocular and postocular space black; antennal segment I shiny reddish orange, II and III dark orange with apical third black, and IV with basal half pale orange (basal joint black) and apical half pale brown (apex dark brown)(Fig. 5); pronotum pale yellow with anterolateral margins, borders of humeral spine, and wide transverse stripe near posterior margin black; posterior margin dark yellow with reddish-brown punctures; scutellum dark yellow with reddish-brown punctures, and apically pale yellow; clavus dark yellow with reddish-brown punctures; corium dark yellow, with costal margin black (except apical third) and reddish-brown punctures; hemelytral membrane dark yellowish with basal angle pale brown; connexivum yellow with posterior angle and inner border black; dorsal abdominal segments III to VI shiny reddish orange, and VII shiny reddish orange with posterior border yellow and black stripe dorsally. *Ventral coloration:* Pale yellow with apex of rostral segment IV, and large discoidal spot at abdominal sterna IV and V black; coxae, and trochanter pale yellow; femora dark yellow with apex tinged with pale orange marks; tibiae and tarsi shiny reddish orange.

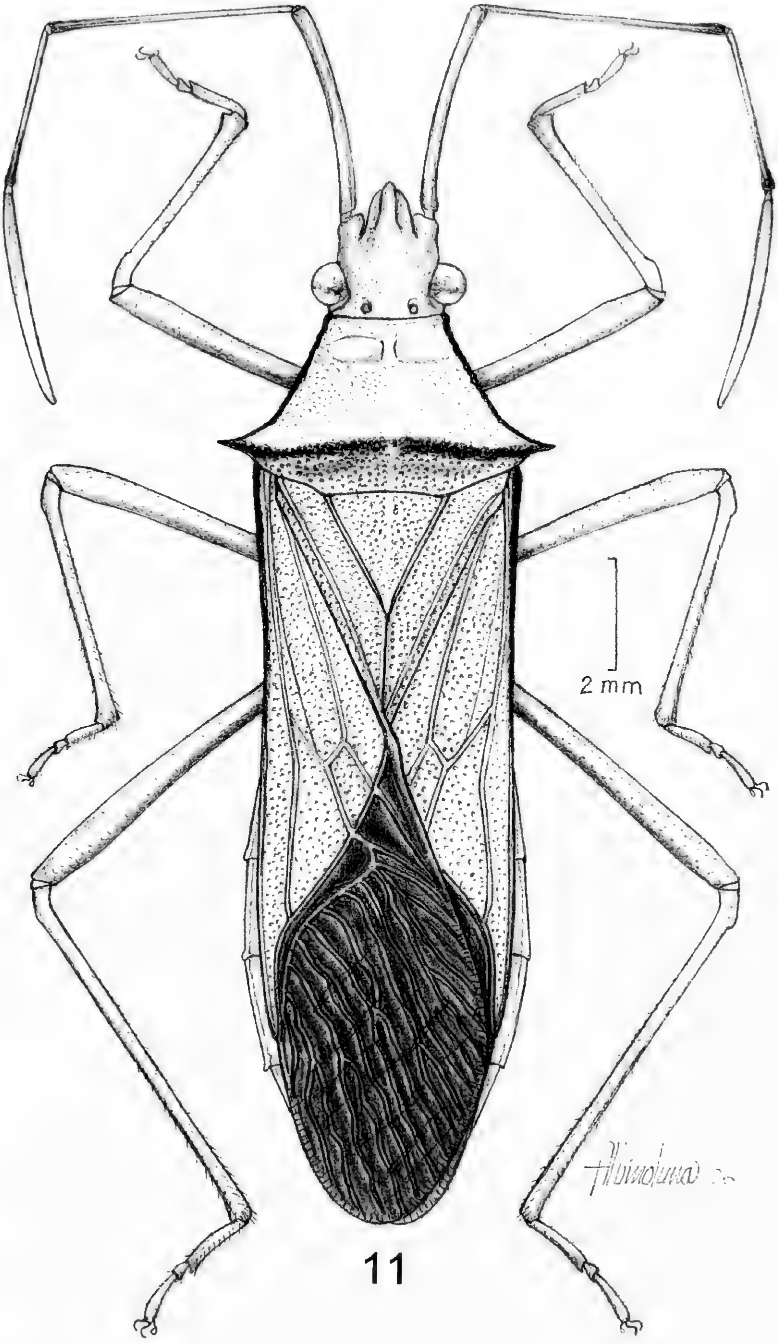
Head: Antennal segment II longest, III shortest, and IV longer than I; rostrum reaching posterior margin of abdominal sternite III; rostral segment I reaching anterior margin of prosternum.

Thorax: Humeral angles tapering into medium sized (Fig. 3) or stout spine (Fig. 2), pointing outward, and barely backward and upward.

Abdomen: Connexival segments with posterior angle produced into short subacute spine; propleura, mesopleura, metapleura, and acetabulae with scattered punctures.

Genital capsule. Posteroventral edge with lateral angles rounded, and mesial lobe short and rounded (Fig. 7).

Female: Coloration. Like male holotype. Connexival segments VIII and IX shiny reddish orange, with upper border yellow and inner margin suffused with pale brown marks; dorsal abdominal segments VIII and IX shiny reddish orange; genital plates pale yellow.



11

Fig. 11. Dorsal view of *Madagalaesus notios*, female.

Genital plates: Plica reduced to small hemispheric elevation; fissura covering almost entire length of sternite (Fig. 9).

Variation.—1, Humeral spine of pronotum shorter and robust (Fig. 2). 2, Fore and middle legs with femora, tibiae, and tarsi dark yellow. 3, Inner margin of connexivum shiny reddish orange.

Type material.—Holotype: ♂, Madagascar, Mahaganga, Prov. Mahajamba, River Ampatika Env., 10–12 December 1996, I. Jeanis (MNHP). Paratypes: Madagascar: 1 ♂, Bezanozano (coll. Noualhier 1898) (without date) (MNHN); 1 ♀, Ampandrandava, A. Seyrig (without date) (UNAM); 1 ♀, Fomboni, A. R. (without date) (MNHN); 1 ♀, Madagascar, 1919, E. Fleutiaux (whitout data)(MNHN); 1 ♂ , Bekily, Region Sud de L' Ile, A. Seyrig (whitout date) (UNAM).

Etymology.—From the Greek, *notios*, meaning southern, referring to the southern distribution of this species.

KEY TO *MADAGALAESUS* SPECIES

1. Head dorsally pale orange yellow, with narrow, longitudinal black stripe at middle line; pronotal disk without black transverse stripe near posterior margin; scutellar disk pale orange yellow, with two black discoidal spots on basal third; humeral angles tapering into remarkably large and acute spine (Fig. 1); posteroventral edge of male genital capsule apically bifid with stout mesial lobe, (Fig. 6) . . . . *M. garciai*, n. sp.

\- Head dorsally pale yellow, without a longitudinal black stripe; pronotal disk with a wide, transverse black stripe near posterior margin; scutellum dark yellow with reddish-brown punctures; humeral angles tapering into medium-sized (Fig. 3) or stout spine (Fig. 2), pointing outward and barely backward; posteroventral edge of male genital capsule with short and rounded mesial lobe (Fig. 7) . . . *M. notios*, n. sp.

ACKNOWLEDGMENTS

Sincere thanks and appreciation are given to for the loan of specimens: Dominique Pluot (MNHN) and Petr Kment (MNHP) and to Albino Luna (UNAM) and Ernesto Barrera (UNAM) for the dorsal-view illustrations and general drawings. This work was supported by the Dirección General de Asuntos del Personal Académico (Subdirección de Formación Académica) Universidad Nacional Autónoma de México (DGAPA), and Embajada de Francia (CCC-IFAL).

LITERATURE CITED

Dallas, W. S. 1852. List of the specimens of hemipterous insects in the collection of the British Museum. Part II. Taylor and Francis, Inc., London. pp. 369–592.

Schouteden, H. 1938. Catalogues Raisonnes de la Faune Entomologique du Congo Belge. Hemiptéres, Coreidae. Annales du Musée du Congo Belge, C. Zoologie, Serie III (II). Tome 1. Fascicule 4: 221–308.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 856–862

A NEW SPECIES OF *JURINELLA* (DIPTERA: TACHINIDAE) FROM THE DOMINICAN REPUBLIC WITH A KEY TO GENERA OF THE TRIBE TACHININI FROM THE CARIBBEAN

NORMAN E. WOODLEY

Systematic Entomology Laboratory, PSI, Agricultural Research Service, U. S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, DC 20013-7012, U.S.A. (e-mail: norman.woodley@ars.usda.gov)

Abstract.—***Jurinella baoruco*, n. sp.**, (Diptera: Tachinidae) is described and illustrated from the Sierra de Baoruco, Dominican Republic. A key to the genera of Tachinini from the Caribbean is presented. Two **new generic synonyms** are proposed: *Hystriciella* Townsend, 1915 and *Parajurinia* Townsend, 1928 both = *Jurinella* Brauer & Bergenstamm, 1889, resulting in *Jurinella pilosa* (Drury), **new combination** and *Jurinella obesa* (Townsend), **new combination**.

Key Words: Diptera, Tachinidae, Tachinini, *Jurinella*, Caribbean, taxonomy

Jurinella Brauer & Bergenstamm is a New World genus of Tachinini that ranges from southwestern United States to southern Brazil and northern Argentina. All of the described species are included in Guimarães (1971) who listed 53 species in *Jurinella*, and one each in the genera *Hystriciella* Townsend and *Parajurinia* Townsend, which I consider to be congeneric. During collecting in the Dominican Republic I obtained specimens of a striking new species that is described herein (my material deposited at the Department of Entomology, Smithsonian Institution, Washington, DC, cited below as USNM). Additional specimens were made available from material collected during several expeditions by colleagues from the Carnegie Museum of Natural History, Pittsburgh, PA (cited below as CMNH). Paratypes are also deposited at the Canadian National Collection, Agriculture Canada, Ottawa (cited below as CNC).

Members of the tribe Tachinini are moderate to large tachinids that have the prosternum bare, the first postsutural supra-alar bristle at least as long and stout as the first postsutural dorsocentral bristle, and the hind margin of the hind coxa setose, usually over the entire hind margin (but if sparse, present at least on the posterolateral corner). Tachinines are a very diverse tribe in Central and South America, particularly at middle and high elevations, that includes several hundred species. However, the fauna of the Caribbean islands is surprisingly depauperate, with fewer than a dozen recorded species. This undoubtedly reflects lack of collection to some extent, but in my experience in the Dominican Republic tachinines are truly scarce. Since there are a small number of Caribbean genera and most species in the region are poorly known, it seems worthwhile to present a generic key at this time to facilitate their identification. I have included the islands from which the genera are known based on literature records and material present in the USNM collection. In all likelihood, some of the genera will be found on additional islands. Taxa from essentially continental islands, especially Trinidad, are not included. *Adejeania armata* (Wiedemann) was described from a specimen supposedly from Cuba, but this is believed to be erroneously labeled (D. M. Wood, personal communication, cited in Woodley 1993) and no further *Adejeania* Townsend have been seen from the Caribbean, so the genus is excluded from the key.

KEY TO GENERA OF TACHININI FROM THE CARIBBEAN ISLANDS

1. Eyes densely pilose; abdominal tergites 3 and 4 with a dense medial patch of discal setae; large palpi present (Cuba, Dominican Republic, Jamaica) . . . . *Jurinella* Brauer & Bergenstamm

– Eyes appearing bare, any setae present very small, sparse, and inconspicuous; abdominal tergites with or more usually without medial discal setae; palpi present or absent 2

2. Lower part of parafacial with two large, bristle-like setae that are very much larger than surrounding hairs; palpus filiform, very reduced, or absent 3

– Lower part of parafacial without large, bristle-like setae; palpus large, expanded apically, club-shaped 5

3. Palpi completely absent (Cuba, Dominican Republic, Puerto Rico) . . . . *Deopalpus* Townsend

– Palpi present although they may be very small 4

4. Palpi filiform, about as long as length of antennal pedicel + first flagellomere combined (Dominican Republic) . . . . *Peleteria* Robineau-Desvoidy

– Palpi short cylindrical, much reduced, much shorter than length of first antennal flagellomere (Puerto Rico) . . . . *Neosarromyia* Townsend

5. Abdomen with a row of marginal setae on tergites 3 and 4 that is displaced anteriorly at midline enclosing a small patch of bristles between it and posterior margin of tergite; large yellow and black flies (Dominican Republic; Woodley 1993) . . . . *Paradejeania* Brauer & Bergenstamm

– Abdomen with marginal setae on tergites 3 and 4 variable in number but not displaced anteriorly at midline 6

6. Abdominal tergite 3 with a row of numerous median marginal setae; large robust flies with very shiny reddish-brown abdomen lacking tomentum (Cuba, Jamaica; Sabrosky 1969) . . . . *Juriniopsis* Townsend

– Abdominal tergite 3 usually with a single pair of median marginal setae, rarely none; moderate to large flies but less robust with abdomen variably colored but usually with at least some tomentum (widespread in Greater and Lesser Antilles) . . . . *Archytas* Jaennicke

Genus *Jurinella* Brauer & Bergenstamm

Jurinella Brauer & Bergenstamm, 1889: 132. Type species, *Jurinia caeruleonigra* Macquart, by monotypy.

Hystriciella Townsend, 1915: 95. Type species, *Hystriciella aurifrons* Townsend [holotype examined, USNM](= *Musca pilosa* Drury), by original designation. **New synonymy**.

Parajurinia Townsend, 1928: 153. Type species, *Parajurinia obesa* Townsend [syntype examined, USNM], by original designation. **New synonymy**.

Remarks.—The following new combinations result from these new generic synonyms: *Jurinella pilosa* (Drury), **new combination** and *Jurinella obesa* (Townsend), **new combination**.

***Jurinella baoruco* Woodley, new species**
(Figs. 1–4)

Diagnosis.—*Jurinella baoruco* differs from all other described *Jurinella* from the Caribbean by having a pale, shiny, reddish-brown abdomen (Fig. 1); brownish-yellow legs; and pale calypters.

Description.—*Male:* Head with ground color yellowish to brownish but nearly entirely obscured by golden yellow tomentum, ground color only visible on frontal vitta and extremely narrowly along ptilinal suture, parafrontals and ocellar tubercle apparently darker; major setae of frons and vertex, vibrissae and a few setae above

1

Fig. 1. Dorsal habitus of male of *Jurinella baoruco*.

and below them, and upper setae of postocular row black, all other setulae and larger setae golden yellow; parafacials setulose; frons at vertex 0.26–0.32 head width; without proclinate orbital setae; antenna orange yellow, sometimes parts of basal flagellomere irregularly darker, arista brown; first two aristomeres subequal in length, each about 3 times longer than its diameter; scape and pedicel with black setae; palpus dark yellow, laterally flattened, inner surface bare, with short black setae mostly confined to dorsal side, a small group of larger, yellow setae present subapically on ventral side; proboscis brownish yellow, prementum 0.76–0.88 height of eye, labella with yellowish hairs.

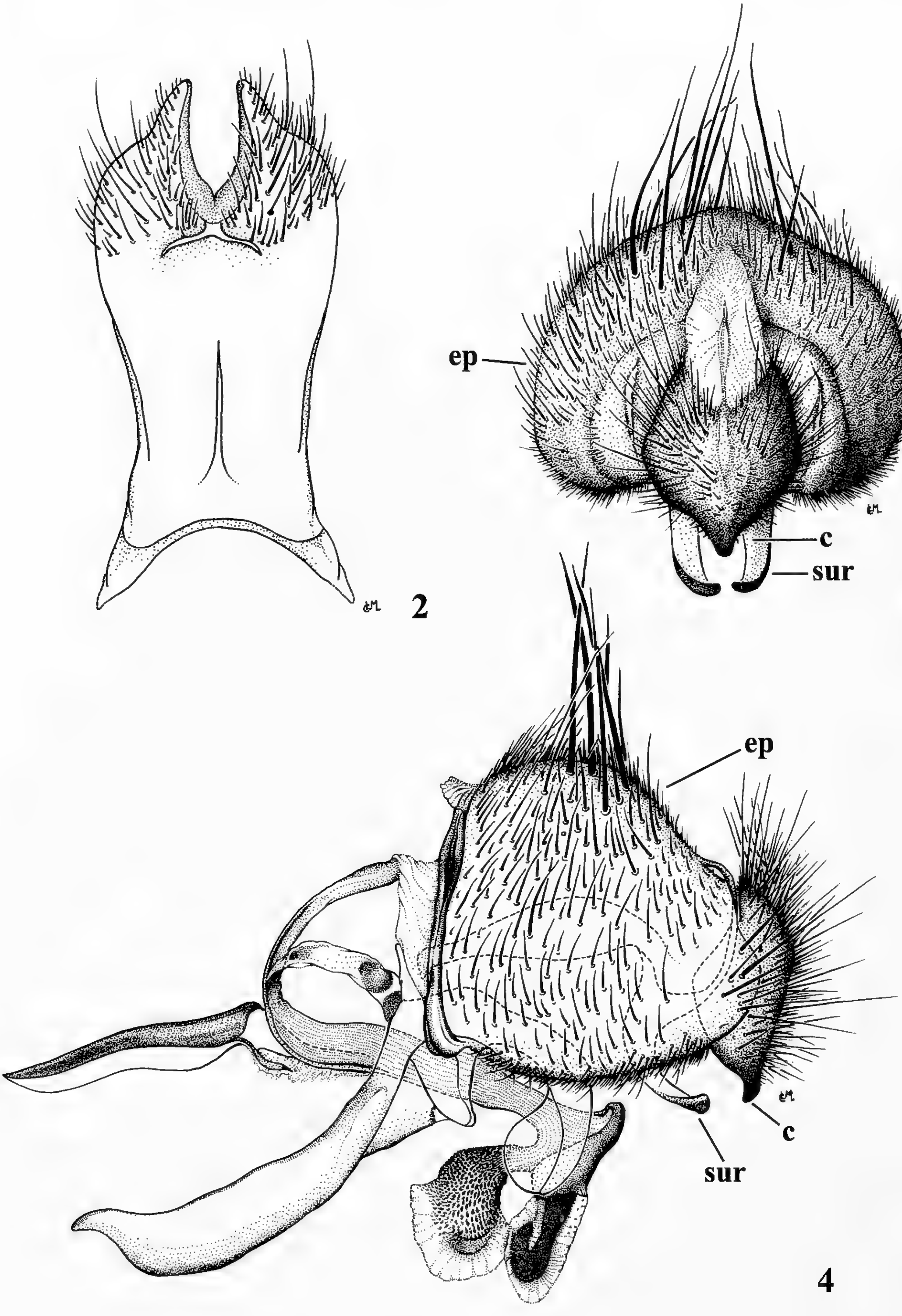
Thorax predominantly yellowish brown, scutum, lower parts of pleura, subscutellum and mediotergite darker; scutum with dense, yellowish-gray tomentum; scutum with 4 dark vittae best visible in posterior view, each ending just anterior to suture, then submedial pair extending postsuturally from suture about one-third of distance to scutellum, and sublateral pair extending about two-thirds to scutellum; also a more vague medial dark vitta presuturally; major setae of thorax black, finer setae and setulae mostly pale to golden yellowish, including all setae of meron, except black hairs intermixed on scutum; katepisternum with three setae arranged in a triangle with lower seta equidistant from anterior and posterior setae; wings with slight brownish infuscation, tegula and basicosta yellow, veins yellowish to pale brownish; all wing setae black; both calypters pale, whitish with some pale yellowish-brown infuscation, all hairs along fringe pale; halter with stem yellowish, knob whitish yellow; legs entirely dark yellowish with tibiae and tarsi slightly darker than femora; hairs and larger setae of legs primarily black but dark yellowish hairs present on coxae and femora, the latter with black hairs mostly on dorsal and anterior surfaces; pulvilli pale yellow, claws yellow with black apices.

Abdomen yellowish brown, shiny, virtually without tomentum, tergites 1+2 black medially, tergite 3 with small black medial area sometimes ending before posterior margin, some specimens with indistinct darkening on narrow medial area of tergite 4; major setae and hairs of abdomen black except anterior areas of tergite 1+2 and medioventral areas of tergites 1+2, 3, and 4 as well as sternites 1–4 with yellow hairs but major setae of sternites black; tergite 1+2 without major setae; tergite 3 with patch of setae occupying medial third, setae along posterior margin larger than others; tergite 4 with complete row of large setae along posterior margin with medial two pairs reduced in size, anterior to this a transverse band of large setae slightly wider than patch on tergite 3 and not quite extending to anterior margin; tergite 5 except for narrow area along anterior margin completely covered with larger setae.

Terminalia with fifth sternite (Fig. 2) with medial emargination narrowly U-shaped, resulting posterior lobes acute in ventral view, rounded in lateral view; epandrium (Figs. 3–4) evenly rounded in posterior view, mostly covered with small setae but with 5–7 large setae on each side dorsally; surstyli with lower portion arcuate with apices directed posteriorly (Fig. 4), apices gently curving medially in posterior view (Fig. 3); cerci entirely fused (Fig. 3), short, triangularly-produced ventrally, extreme apex reflexed anteriorly and minutely emarginate; Length 13.5–16.0 mm.

Female: Very similar to male in most respects, differing as follows: Head with frons 0.29–0.32 head width, with two proclinate orbital setae. Thorax with tarsomeres 2–4 of front leg slightly expanded laterally and flattened; claws and pulvilli of all legs smaller than in male. Length 13.7–15.1 mm.

Material examined.—Male holotype (USNM): DOMINICAN REPUBLIC: Pedernales Province, Parque Nacional Sierra de Baoruco, Las Abejas, 18° 09.011′N, 71°37.342′W, 1150 meters, 11 July 2004, N. E. Woodley. Paratypes: 26♂, 5♀, all DOMINICAN REPUBLIC: 1♀, Pedernales Province, Parque Nacional Sierra de Baoruco, Las Abejas, 7.3 km NNE of Las Mercedes, 18°09′N, 71°38′W, 1100–1150 meters, 23 August 1983, F. M. Harrington, J. D. Weintraub (USNM); 1♀, Pedernales Province, 5 km N of Los Arroyos, 18°15′N, 71°45′W, 1600 meters, 28 March 1984, F. M. Harrington, J. D. Weintraub, N. E. Woodley (USNM); 3♂, Pedernales Province, 5 km N of Los Arroyos, 18°15′N, 71°45′W, 1600 meters, 13 November 1985, N. E. Woodley (USNM); 1♂, Pedernales Province, 5 km NE of Los Arroyos, 18°15′N, 71°45′W, 1680 meters, 17–18 July 1991, C. Young, J. E. Rawlings, S. Thompson (CMNH); 16♂, Independencia Province, near summit of Sierra de Baoruco, 3.5 km S of El



Figs. 2–4. Male terminalia of *Jurinella baoruco*. 2, Fifth abdominal sternite, ventral view. 3, Male terminalia, posterior view. 4, Male terminalia, left lateral view. Abbreviations: c, cerci; ep, epandrium; sur, surstylus.

Aguacate, 18°17′N, 71°42′W, 2210 meters, 30 September 1991, montane meadow, C. Young, S. Thompson, R. Davidson, J. Rawlins (10 in CMNH, 4 in USNM, 2 in CNC); 5♂, Independencia Province, north slope Sierra de Baoruco, 3 km ESE of El Aguacate, 18°18′N, 71°42′W, 1980 meters, pine woodland, 28–29 September 1991, J. Rawlins, R. Davidson, C. Young, S. Thompson (4 in CMNH, 1 in USNM); 1♀, Independencia Province, Sierra de Baoruco, Loma del Toro, 18°17′16″N, 71°42′46″W, 2310 meters, meadow in pine woods, 7–8 November 2002, W. A. Zanol, C. W. Young, C. Staresinic, J. Rawlins (CMNH); 1♀, Independencia Province, Sierra de Baoruco, Loma del Toro, 5.3 km SW of El Aguacate, 18°17′16″N, 71°42′46″W, 2316 meters, *Pinus-Garrya* montane forest, 29–30 March 2004, C. Young, R. Davidson, J. Rawlins (CMNH); 1♂, 1♀, Independencia Province, Sierra de Baoruco, north slope, 13.5 km SE of Puerto Escondido, 18°12′24″N, 71°30′54″W, 1807 meters, broadleaf-*Pinus* dense woodland, J. Rawlins, V. Verdecia, C. Young, C. Nunez, W. Zanol (CMNH).

Etymology.—The species name, a noun in apposition, is from Sierra de Baoruco, the mountain range from which all known specimens have been collected.

Remarks.—*Jurinella baoruco* is one of the minority species in the genus that has a reddish-brown abdomen. Its general appearance resembles that of *Dumerillia rubida* Robineau-Desvoidy from Brazil. *Dumerilla* Robineau-Desvoidy is a monotypic genus that differs little from *Jurinella*, mainly in having smaller patches of discal setae on abdominal tergites 3 and 4, and males which have proclinate orbital setae. It is quite possible that *Jurinella* will be synonymized with *Dumerillia* when the generic concepts within this group of tachinine genera can be studied in detail.

Jurinella baoruco differs from other described Caribbean species of this genus by having the paler coloration noted above. Both *Jurinella pilosa* (Drury) and *J. epileuca* (Walker) have darker abdomens and legs, dark brown to black. I have seen a single specimen (CMNH) of *Jurinella* from the Sierra de Martín García, Dominican Republic, that resembles *J. baoruco*, but it differs by being notably smaller and having more uniformly pale hairs on the thoracic scutum. It likely represents an additional undescribed species.

Jurinella baoruco has to date only been collected from the Sierra de Baoruco, formed when the southern paleo-island collided with the northern paleo-island to form modern Hispaniola (Keith et al. 2003 and references therein). *Paradejeania xenisma* Woodley (1993) was also originally known from the Sierra de Baoruco, but I have recently collected specimens near La Ciénaga in the Cordillera Central, La Vega Province. It seems likely that *J. baoruco* will eventually be found to have a wider distribution since these insects are strong fliers.

The males of *J. baoruco* I collected near Los Arroyos in 1985 were frequenting flowers on roadside shrubs 2–3 meters above the ground.

ACKNOWLEDGMENTS

I am very grateful to Chen Young of the Carnegie Museum for loaning material in his care. Some of the specimens from the Carnegie were obtained during a project funded by National Science Foundation grant DEB-0206520 of the Biotic Surveys and Inventory Program. I am also grateful to Nigel Wyatt of The Natural History Museum, London, for excellent notes he sent on the type of *J. epileuca* (Walker). Thanks go to Christina Marent who drew Figs. 2–4, and Gary Ouellette who took the habitus photograph and composed the final plates. Steve Lingafelter and Allen Norrbom (Systematic Entomology Laboratory), Wayne Mathis (Smithsonian Institution), and Paul H. Arnaud, Jr. (California Academy of Sciences) kindly reviewed the manuscript.

LITERATURE CITED

Keith, A. R., J. W. Wiley, S. C. Latta, and J. A. Ottenwalder. 2003. The Birds of Hispaniola, Haiti and the Dominican Republic, an Annotated Checklist. The British Ornithologists' Union/British Ornithologists' Club, Tring, England. xvi + 293 pp.

Guimarães, J. H. 1971. 104. Tachinidae (Larvaevoridae). *In* A Catalogue of the Diptera of the Americas South of the United States. Museu de Zoologia, Universidade de São Paulo, São Paulo. pp. 104.1–104.333.

Sabrosky, C. W. 1969. A review of the genus *Juriniopsis* Townsend (Diptera: Tachinidae). The Florida Entomologist 52: 79–90.

Townsend, C. H. T. 1915. Nine new tropical American genera of Muscoidea. Insecutor Inscitiae Manstruus 3: 91–97.

———. 1928. New Muscoidea from humid tropical South America. Wiener Entomologische Zeitung 44: 143–154.

Woodley, N. E. 1993. A remarkable new species of *Paradejeania* from the Dominican Republic (Diptera: Tachinidae). Proceedings of the Entomological Society of Washington 95: 182–188.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 863–867

THE STATUS OF *TRAUBELLA* PRINCE, EADS AND BARNES, 1976 (SIPHONAPTERA: CERATOPHYLLIDAE)

ROBERT E. LEWIS

Research Associate, Section of Invertebrate Zoology, Carnegie Museum of Natural History, Pittsburgh, PA 15213-4080, U.S.A.; mailing address: 3906 Stone Brooke Circle, Ames, IA 50010-4174, U.S.A. (e-mail: relewis@iastate.edu)

Abstract.—The ceratophyllid genus *Traubella* is redescribed in order to contrast it with the closely related genus *Malaraeus* Jordan, 1933. Its literary history is reviewed and its diagnostic characters are figured.

Key Words: *Traubella*, *Malaraeus*, *Amphipsylla*, Siphonaptera, distribution, host preferences, classification

Of the 28 ceratophyllid genera with representatives in North America a few of them are so similar that taxonomic discrimination is extremely difficult, especially in the females. In some groups of plants and animals generic characters are obvious and may involve anatomical modifications such as venation, leaf configuration or flower formulae, leaving genitalic characters for differentiation at the subgeneric and species levels. This is not true with fleas where practically the only characters used in identification are genitalic. This is further complicated by the fact that females of closely related genera are so similar as to be inseparable at the species level. It is the purpose of this study to clarify the relationship between *Traubella* Prince, Eads and Barnes, 1976, and the closely related genus *Malaraeus* Jordan, 1933.

Traubella was proposed for the taxon *Amphipsylla neotomae* I. Fox, 1940, which was originally placed in the Leptopsyllidae. It is a rare species that evidently is a parasite of *Neotoma lepida* Thomas, 1893 (Rodentia: Muridae), with a very restricted range in southern California. An additional species, *T. grundmanni* Egoscue, 1989, has since been determined to belong to *Malaraeus* Jordan, 1933, according to Lewis (in press) and it is included in a study of that genus.

Genus *Traubella* Prince, Eads and Barnes, 1976

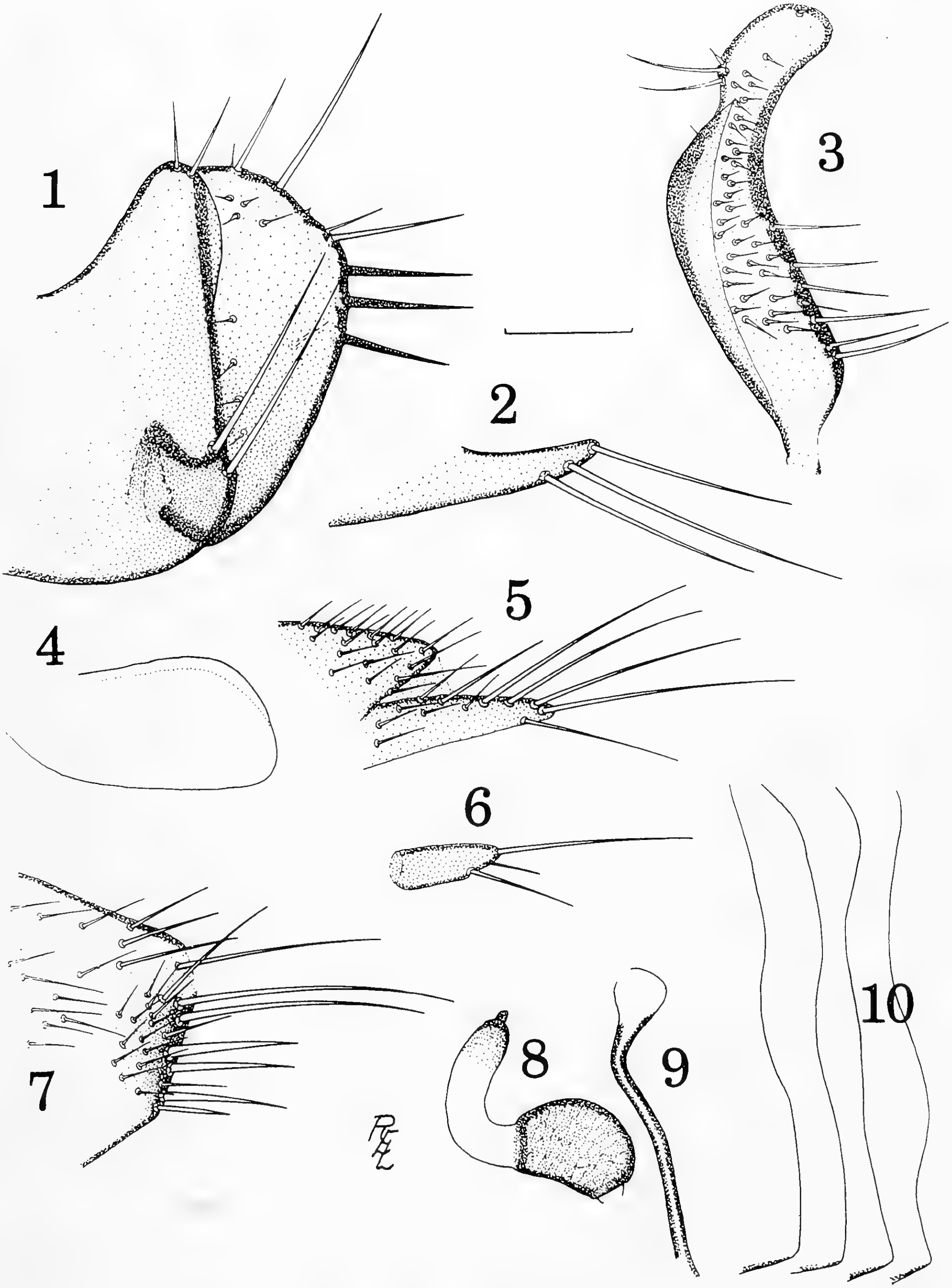
Traubella Prince, Eads, and Barnes, 1976: 162–168, figs. 1–13. Type species: *Amphipsylla neotomae* I. Fox, 1940.

Traubella: Lewis, 1990: 157. Adams and Lewis, 1995: 71.

Generic diagnosis.—*Male:* Setae on caudal margin of legs coarse, heavy and forming false combs. Longest setae of hindtarsal segment II only extending to base of tarsal segment IV, while these in *Malaraeus* species are more delicate and extend at least to base of segment V. Sternite VIII short, linear and vestigial, its apex bearing 3–5 short setae, while this sclerite is asetose, very reduced or absent in *Malaraeus*. The proximal arm of st IX truncated, its terminus blunt and directed cephalad. This structure in *Malaraeus* is not truncated, its terminus bluntly rounded, the arm flexed caudad ~90°. Cephalic arm of manubrium blunt, its apex only slightly flexed dorsad, while in *Malaraeus* this structure is sharply pointed and flexed dorsad, Movable process crescentric, semicircular, its caudal margin with 3 evenly spaced long setae. In *Malaraeus* species this structure is more rectangular, its setation varying by species, *Female:* In the female, though similar to those of *Malaraeus*, some *Megabothris* Jordan, 1933, and *Monopsyllus vison* Baker, 1904, they differ in the following characters. The ductus obturatus is absent; the spermathecal hilla is papillate and the anal stylet is ~2× as long as wide, widest in middle and with 2–3 subapical setae. Females of the 3 species of *Malaraeus* possess a ductus obturatus; the hilla of the spermatheca is apapillate, and the anal stylet is 4–5× as long as wide at base, its margins subparallel, tapering to a narrow apex, and with only 1 well developed lateral seta.

Following is a redescription of the genus, including additional characters, some shared by related genera that in combination with those listed above, are diagnostic for the genus.

Redescription.—No genal comb. Tentorium visible as a vestige in a few specimens, never conspicuous. No interantennal suture. Clavus of male antenna extending onto propleuron. Metanotum and some anterior abdominal tergites with marginal spinelets. Sternite VIII of male narrow, sometimes reduced but always present and with 3–4 setae on apex. *Head:* Frontal tubercle present but inconspicuous in both sexes. Frontal setal row of 5–7 bristles on males, 4–6 in females. Trabecula centralis small, circular, above and before the eye. Eye well developed although somewhat reduced, slightly oval, with only the periphery heavily pigmented. A vestige of the tentorium persists in some specimens but is not conspicuous. Ocular setal row of 3 bristles in both sexes. Postocular seta absent. Pedicellar setae short in males, extending to claval segments 4–6 in females. With 1 preoccipital setal row of 1–3 bristles in males, usually 0 in females. Occipital setal row of 5–6 setae in both sexes. Labial palpi and stylets extending to apex of forecoxa. *Thorax:* Setae per side in pronotal row, 5–6 in males, 4–6 in female. Spines in pronotal comb, 22–24 in males, 19–26 in females. Setae per side in main mesonotal row, 5–6 in both sexes and 4–6 pseudosetae under the mesonotal collar. Setae per side in main metanotal row usually 5, occasionally 6. Marginal metanotal spinelets 1/1 or 2/1. Metepisternal squamulum present as a low thickening on the margin above the middle, its height about 2× its depth. Metepisternal setae 7–11 in 3 irregular rows. *Legs:* Midcoxal sulcus incomplete. Notches in caudal margin of fore, mid and hindfemur 5, 6 and 8 in both sexes. No apical setae on hindtarsal segment I in either sex reaching segment III. Lateral plantar setae on tarsal segment V 5 per side, pair I slightly shifted on to the plantar surface. Tarsal ungues unmodified, sculptured ventrally. *Abdomen (unmodified segments):* No tergal "mane" on anterior abdominal segments in either sex. Marginal spinelets on anterior segments 1, 1–2, 1–2 and 1–2. Spiracular fossae circular and very small. Main setal row of anterior segments, 6–8 per side. *Modified segments:* Male. Wagner's organ absent. Apex of manubrium blunt to rounded, but not hooked dorsad. Terminal appendage of penis plate usually poorly developed (broken off in holotype). Penis rods coiled <180°. Antepygidial seta single, bordered dorsally and ventrally by short setae (not setulae). Spiculose area on inner surface of st VIII absent. Sternum VIII present but reduced and bearing 3–4 setae near apex. Ventral anal lobe about half again



Figs. 1–10. *Traubella neotomae.* 1, Clasper of holotype male. 2, Sternite VIII of male holotype. 3, Sternite IX of male holotype. 4, Crochet of male holotype. 5, Dorsal and ventral anal lobes of male holotype. 6, Anal stylet of female. 7, Dorsal and ventral anal lobes of female. 8, Spermatheca of female. 9, Bursa copulatrix of female. 10, Variation in caudal margin of st VII in females.

as long as dorsal lobe. Proximal arm of st IX relatively straight, its expanded apex directed cephalad. Distal arm of st IX not conspicuously bilobed. Movable process clavate, with 3 heavy setae on middle of caudal margin. Fixed process conical, as long as movable process. Female. Three antepygidial setae, the median the longest, the laterals about half as long as median and usually subequal, the dorsalmost the shorter. Dorsal and ventral anal lobes of equal length. Anal stylet about 2.5× as long as wide at base and usually with 2 subapical setae. Caudal margin of st VII sinuate, with dorsal and ventral lobes separated by a shallow sinus. Bulga of spermatheca oval, with a concave ventral margin. Hilla longer than bulga, its apex with a small papilla. Bursa copulatrix sinuate and sclerotized. Ductus obturatus absent.

Traubella neotomae (I. Fox 1940)

(Figs. 1–10)

Amphipsylla neotomae I. Fox, 1940: 273, fig. 3. U.S.A., California, Merced County, Dos Palos, 36.59N 120.39W. from *Neotoma lepida*, III. 1934, H. S. Gentry leg. Holotype male, USNM No. 54012.

Amphipsylla neotomae: Augustson, 1942: 39; 1943: 76; Ewing and I. Fox, 1943: 31; Hubbard, 1943: 1; Costa Lima and Hathaway, 1946: 256; Hubbard, 1947: 260; Holland, 1949: 108; Augustson and Durham, 1961: 10; Beck and Allred, 1966: 24; Prince et al., 1976: 162; Hopkins and Rothschild, 1971: 456; Smit and Wright, 1978: 25; Adams and Lewis, 1995: 25.

Malaraeus neotomae: Jellison et al., 1953: 94; Lewis, 1974: 665.

Traubella neotomae: Haddow et al., 1983: 161; Smit, 1983: 28; Lewis, 1990: 157; Adams and Lewis, 1995: 25.

Remarks.—Since this is a monotypic genus, the characters listed above also apply to the species, *Traubella neotomae* (I. Fox 1940). The other species has been reassigned to *Malaraeus* by Lewis (in press).

In addition to the male holotype and a misdesignated female "allotype" from Riverside County, California, from *Spilogale gracilis*, the following material was available to me: California, Imperial County, from *Neotoma lepida*, 2 males, 2 females; Inyo County, also from *N. lepida*, 1 female; Riverside County, from *Neotoma* nest, 1 male; and Arizona, Mohave County, from *Neotoma* sp. and *Peromyscus crinitus*, 1 male, 1 female. All specimens are in the Carnegie Natural History Museum (CMNH), Pittsburgh, PA, and the National Museum of Natural History, Smithsonian Institution, Washington, DC. (USNM)

Male 3 mm, female 4 mm.

ACKNOWLEDGMENTS

I thank the following curators and their institutions for the loan of material upon which this study was based. Both Dr. John Rawlins and the late Ms. Nancy Adams loaned material from their respective institutions, the CMNH and USNM. Also, Mr. James Kučera of Salt Lake City made available specimens of *Traubella grundmanni* for comparison with those of *T. neotomae*. My thanks to these colleagues for their cooperation.

LITERATURE CITED

Adams, N. E. and R. E. Lewis. 1995. An annotated catalogue of primary types of Siphonaptera in the National Museum of Natural History, Smithsonian Institution. Smithsonian Contributions to Zoology 660: 1–86.

Augustson, G. F. 1942. The allotype of *Amphipsylla neotomae* I. Fox, 1940. (Siphonaptera: Dolichopsyllidae). Bulletin of the Southern California Academy of Sciences 41: 39–41.

———. 1943. Preliminary records and discussion of some species of Siphonaptera from the Pacific southwest. Bulletin of the Southern California Academy of Sciences 42: 69–89.

Augustson, G. F. and F. E. Durham. 1961. Records of fleas (Siphonaptera) from northwestern Arizona. Bulletin of the Southern California Academy of Sciences 60: 100–105.

Beck, D. E. and D. M. Allred. 1966. Siphonaptera (fleas) of the Nevada test site. Brigham Young University Science Bulletin 7: 27.

Costa Lima, A da. and C. R. Hathaway. 1946. Pulgas: Bibliografia, catálogo e animais por elas sugados. Monographia do Instituto Oswaldo Cruz 4: 1–522.

Ewing, H. E. and I. Fox. 1943. The fleas of North America. Classification, identification and geographic distribution of these injurious and disease-spreading insects. United States Department of Agriculture Miscellaneous Publications 500: 1–142.

Fox, I. 1940. Siphonaptera from western United States. Journal of the Washington Academy of Sciences 30: 272–275.

Haddow, J. F., R. Traub, and M. Rothschild. 1983. Distribution of ceratophyllid fleas and notes on their hosts. Material in the collection, with notes and maps of the genera. pp. 42–163. *In* Traub, R., M. Rothschild, and J. F. Haddow, eds. The Rothschild collection of fleas. The family Ceratophyllidae: Key to the genera and relationships, with notes on their evolution, zoogeography and medical importance Cambridge University Press. U. K. Distributed by Academic Press, Inc. London.

Holland, G. P. 1949. The Siphonaptera of Canada. Canadian Department of Agriculture Technical Bulletin 70: 1–306.

Hopkins, G. H. E. and M. Rothschild. 1971. An illustrated catalogue of the Rothschild collection of fleas (Siphonaptera) in the British Museum (Natural History). Vol. V. Leptopsyllidae, Ancistropsyllidae. British Museum (Natural History), London.

Hubbard, C. A. 1943. The fleas of California (with check lists of the fleas of Oregon, Washington, British Columbia, Alaska, Idaho, Nevada, Arizona) Pacific University Bulletin 39(8): 1–2.

———. 1947. Fleas of North America. Iowa State College Press, Ames.

Jellison, W. L., B. Locker, and R. Bacon. 1953. Index to the literature of Siphonaptera of North America. Supplement #1, 1939–1950. Mimeographed manuscript. Rocky Mountain Laboratory, Hamilton, Montana.

Lewis, R. E. 1974. Notes on the geographical distribution and host preferences in the order Siphonaptera. Part 6. Ceratophyllidae. Journal of Medical Entomology 11: 658–676.

———. 1990. The Ceratophyllidae: Currently accepted valid taxa (Insecta: Siphonaptera). Theses Zoologicae 13. Koeltz Scientific Books Koenigstein, Germany.

———. In press. *Malaraeus* Jordan, 1933, a North American genus of fleas (Siphonaptera: Ceratophyllidae). Annals of the Carnegie Museum of Natural History.

Prince, F. M., R. B. Eads, and A. M. Barnes. 1976. *Traubella*, a new genus of flea (Siphonaptera: Ceratophyllidae). Journal of Medical Entomology 13: 162–168.

Smit, F. G. A. M. 1983. Key to the genera and subgenera of Ceratophyllidae, pp. 1–41. *In* Traub, R., M. Rothschild, and J. F. Haddow, eds. The Rothschild collection of fleas. The family Ceratophyllidae: Key to the genera and relationships, with notes on their evolution, zoogeography and medical importance Cambridge University Press. U. K. Distributed by Academic Press, Inc. London.

Smit, F. G. A. M. and A. M. Wright. 1978. A list of code numbers of species and subspecies of Siphonaptera. Department of Entomology. British Museum (Natural History). London (mimeographed).

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 868–871

ENDOBIA DONACIS ERDÖS (HYMENOPTERA: EURYTOMIDAE) NEWLY REPORTED FROM THE WESTERN HEMISPHERE, AND A REVIEW OF THE GENUS

M. W. GATES AND David. R. SMITH

Systematic Entomology Laboratory, PSI, Agricultural Research Service, U. S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, P. O. Box 37012, MRC 168, Washington, DC 20013-7012, U.S.A. (e-mail: michael.gates@ars.usda.gov; dave.smith@ars.usda.gov)

Abstract.—The distribution of *Endobia* Erdös (Hymenoptera: Eurytomidae), containing the nominal taxa *E. donacis* Erdös and *E. indica* Mani and Kaul, is reviewed. *Endobia donacis* is reported for the first time from the Western Hemisphere (Fairfax Co., Virginia, USA). This species is discussed and its host associations summarized. *Endobia indica* is synonymized with *E. donacis* (**n. syn.**).

Key Words: Hymenoptera, Chalcidoidea, Eurytomidae, *Endobia*, new record, new synonymy, Western Hemisphere

The genus *Endobia* Erdös is known from two species, *E. donacis* Erdös (Fig. 1; Erdös 1964) and *E. indica* (Mani and Kaul) (Mani et al. 1974), found in the Mediterranean Basin, southeastern Asia, and the Indian subcontinent (Bouček 1983). No definitive host records have been reported for this genus, only host associations as recorded in the specific treatment below.

Endobia indica, known from India, was initially described in *Isosoma* Walker, later transferred to *Tetramesa* Walker (Farooqi and Subba Rao 1986), and finally to *Endobia* from *Tetramesa* (Narendran 1994). The holotype was supposed to be deposited in the National Museum of Natural History, Smithsonian Institution (USNM). However, only two co-mounted cotypes, mislabeled as "Holotype," were found in the type collection. Examination of the Smithsonian Institution's Department of Entomology accession records in its museum catalog indicate that only a holotype is recorded as having been received. Colleagues in various institutions in India (University of Calicut [Kerala] and St. John's College [Agra]) have had no success in locating this specimen. The two paratypes deposited in the USNM bear a Bouček identification label that reads "♀ Endobia donacis Erdös, det. Z. Bouček 1986." Given that Bouček (1983) does not mention this material as part of his treatment of this genus and that it was not transferred to *Endobia* until 1994, we suspect that he discovered the specific synonymy and simply never published this information.

The type species, *E. donacis*, is known from southern France, southern India, Burma, and Thailand (Bouček 1983). This species was originally described from southern France where it has been associated with dry stems of the giant reed *Arundo donax* L. (Cyperales: Poaceae) and a eurytomid feeding on its stems, *Tetramesa romana* (Walker) (Erdös 1964). *Endobia donacis* was thought

Fig. 1. *Endobia donacis*, female habitus.

to have been introduced through the activities of man to the Mediterranean Basin from its native range in southern Asia (Bouček 1983). It remains possible that this species is native to both the Mediterranean basin and the Indian subcontinent (Delvare, personal communication). Records reported by Bouček (1983) indicate that possible hosts are bostrichid beetles, possibly *Dinoderus minutus* F. or *D. brevis* Horn. Both of these bostrichids commonly attack various bamboos and are widely distributed throughout southern Asia, the Pacific Basin, and have been introduced numerous times in the New World (Fisher 1950). Further, *D. minutus* has been intercepted in stems of *A. donax* and the reported host range of *D. brevis* indicates that *A. donax* may be an acceptable host (Fisher 1950).

Narendran's (1994) redescription of *Endobia donacis* and, presumably, his key separating it from *E. indica*, are based on a plesiotype of *E. donacis* from India, rather than material from the type locality in France or the type specimen. After examination of the paratypes of *E. indica*, our measurements indicate that the postmarginal vein is longer than the stigmal vein (28:18), the postmarginal vein is just shorter than the marginal vein (28:30), and the funicle possesses five segments. This information contradicts all of the characters used to separate the two species offered by Narendran (1994). Narendran reported that, after examining the USNM's "holotype" of *E. indica*, it possessed a postmarginal vein distinctly shorter than the marginal vein, a stigmal vein that was as long as the postmarginal vein, and six funicular segments. He indicated he examined the holotype from the USNM. If this is true, then he measured the same specimens we have studied. After examining paratype material of *E. indica* and the holotype of *E. donacis*, we consider the former a junior subjective synonym of the latter (**n. syn.**).

Diagnosis.—*Endobia* is readily separated from other Nearctic genera of Eurytomidae by first funicular ~3× length second funicular, chalice-shaped; pro- and metafemora enlarged, approximately 2.5 and 2.1× as long as broad, respectively; propodeum finely sculptured and biconvex, convexities separated medially by complete, deep median furrow. In the key to genera of Eurytomidae in the Nearctic (DiGiulio 1997), *Endobia* keys to the second half of couplet 9 with *Tetramesa*. The aforementioned diagnostics serve to separate *Endobia* from *Tetramesa* as the latter never possesses a chalice-shaped first funicular, enlarged pro- and metafemora, or distinctly biconvex propodeum.

First New World record.—The newly discovered specimens reported in this paper represent the first Western Hemisphere record of *Endobia donacis*. Only seven specimens have been collected, but they correspond well with the cotypes, although there is some color variation ranging from medium to very dark brown. Two females were first recovered in August 2005 and five additional females were taken in July–August 2006 from a Malaise trap located in the backyard of one of us (DRS) in a suburban residential neighborhood in eastern Fairfax County, Virginia. The Malaise trap has been used in the same spot every year since 1980 and is emptied weekly from the end of February through the end of October.

Habitat and hosts.—The subdivision, Holmes Run Acres, is located < 1/4 mile east of the Gallows Road (Rt. 650) and the Interstate 495 interchange. The yard and adjacent lots where *E. donacis* was collected are relatively well maintained and landscaped with gardens and various ornamental plants and shrubs. Within 7 m of the trap is a woodpile consisting of maple (*Acer* spp.; Sapindaceae), redbud (*Cercis canadensis* L.; Fabaceae), dogwood (*Cornus* spp.; Cornaceae), and pine (*Pinus* spp.; Pinaceae) in various stages of decay. Silver maples (*Acer saccharinum* L.), a holly bush (*Ilex* sp., Aquifoliaceae), cherry trees (*Prunus serotina* Ehrh., Rosaceae), dogwood (*Cornus* spp.), and forsythia (*Forsythia* sp., Oleaceae) also grow in the immediate vicinity of the trap (38°50′N, 77°12′W). Various grasses, ferns, and weeds also grow next to the trap. A planting of bamboo, growing approximately 25 m uphill from the trap location, is infested with boring insects and serves as a nesting substrate for other arthropods. The bamboo has been identified as *Pseudosasa japonica* (Siebold & Zucc. ex Steud.) Makino ex Nakai (Poaceae) and has occupied its present location since before 1965. During 2006, MWG caged approximately 150 infested stems of *P. japonica*, 75 from each of two collection events in April and August, to determine if *Endobia* was present. Unfortunately, no specimens emerged from the samples. A specimen of *P. japonica* (voucher: MWG-bamboo; SI Accession # US-3459116) has been deposited in the Smithsonian Institution Herbarium.

ACKNOWLEDGMENTS

We thank Paul Peterson (Department of Botany, National Museum of Natural History [USNM], Smithsonian Institution) for identifying the bamboo and assisting us in accessioning the plant sample. Csosz Sandor at the Hungarian Natural History Museum secured the loan of the *Endobia* holotype. Thanks also are given to Natalia Vandenberg (Systematic Entomology Laboratory [SEL], ARS, USDA, c/o USNM) for discussions of potential host beetle distributions. M. G. Pogue (SEL), T.J. Henry (SEL), and E. E. Grissell (SEL, retired) provided comments on the manuscript and made suggestions for its improvement.

LITERATURE CITED

Bouček, Z. 1983. On *Buresium*, *Masneroma* (n. gen.) and some other Eurytomidae (Hymenoptera). Entomologica Scandinavica 14: 186–194.

DiGiulio, J. 1997. Family Eurytomidae, pp. 477–495. *In* Gibson, G., J. Huber, and J. Woolley, eds. Annotated Keys to the Genera of Nearctic Chalcidoidea (Hymenoptera). NRC Research Press, Ottawa, Ontario, Canada. xi + 794 pp.

Erdös, J. 1964. Chalcidoidea nova in Gallia er Numidia inventa (Hym.). Bulletin de la Société Entomologique de France 69: 89–101.

Farooqi, S. I. and B. R. Subba Rao. 1986. Family Eurytomidae, pp. 247–258. *In* Subba Rao, B. R. and M. Hayat, eds. The Chalcidoidea (Insecta: Hymenoptera) of India and the adjacent countries. Oriental Insects 20: pp. 1–430.

Fisher, W. S. 1950. A revision of the North American species of beetles belonging to the family Bostrichidae. U.S. Department of Agriculture Miscellaneous Publication 698: 1–157.

Mani, M. S., O. P. Dubey, B. K. Kaul, and G. G. Saraswat. 1974. Descriptions of some new and new records of some known Chalcidoidea (Hymenoptera) from India. Memoirs of the School of Entomology, St. John's College, Agra No 3: 1–108.

Narendran, T. C. 1994. Torymidae and Eurytomidae of Indian subcontinent (Hymenoptera: Chalcidoidea). Zoological Monograph, Department of Zoology, University of Calicut, Kerala, India. 500 pp.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 872–879

SPECIES OF THE GENUS *ZEROS* CRESSON (DIPTERA: EPHYDRIDAE) FROM CHINA

JINJUA ZHANG, DING YANG, AND WAYNE N. MATHIS

(JZ, DY) Department of Entomology, China Agricultural University, Beijing 100094, China (e-mail: dyangcau@yahoo.com.cn); (WNM) Department of Entomology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 169, Washington, DC 20013-7012, U.S.A. (e-mail: mathisw@si.edu)

Abstract.—The genus *Zeros* Cresson is recorded from China for the first time. The two species, ***Z. maculosus*, n. sp.**, and *Z. orientalis* Miyagi, are described, and a key to distinguish them is presented.

Key Words: Diptera, Ephydridae, *Zeros*, new species, China

The shore-fly genus *Zeros* Cresson, 1943, is currently placed in the tribe Ilytheini, subfamily Ilytheinae. The genus occurs worldwide in temperate and tropical zones, and thus far 11 species have been described (Mathis and Zatwarnicki 1995). Two species are known from the Palearctic Region (Cogan 1984) and three species have been recorded from the Oriental Region (Cogan and Wirth 1977, Mathis and Zatwarnicki 1995). Herein the genus is recorded from China for the first time and is represented by two species, which are revised. In addition to their descriptions and illustrations, we are providing locality data from China and elsewhere in the Oriental Region. A key to the two species occurring in China is presented to facilitate their identification.

METHODS AND MATERIALS

The descriptive terminology, with the exceptions noted in Mathis (1986) and Mathis and Zatwarnicki (1990a), follows McAlpine (1981). Because specimens are small, less than 2.50 mm in length, study and illustration of the male terminalia requires use of a compound microscope. For most of the structures of the male terminalia, we follow the terminology that other workers in Ephydridae have used (see references in Mathis [1986] and Mathis and Zatwarnicki [1990a, 1990b]). The species' descriptions are composite and not based solely on holotypes.

Two venational indices used in the descriptions are defined below.

1. Costal vein ratio: the straight line distance between the apices of R_{2+3} and R_{4+5} (costal section III)/distance between the apices of R_1 and R_{2+3} (costal section II).
2. M vein index is the straight line distance along vein M between crossveins dm-cu and r-m/distance apicad of dm-cu.

Most specimens examined as part of this study are deposited in the Entomological Museum of the China Agricultural University (CAU), Beijing, China, and the holotype of *Z. orientalis* Miyagi is deposited in the Entomological Institute, Hokkaido University, Sapporo, Japan (HUS). We also studied specimens in the National Museum of Natural History, Smithsonian Institution, Washington, D. C. (USNM).

Tribe Ilytheini Cresson

Ilytheini Cresson 1943: 2. Type genus: *Ilythea* Haliday *in* Curtis 1837.—Cresson 1943: 1–16 [review].—Cogan and Wirth 1977: 336 [Oriental catalog].—Mathis and Zatwarnicki 1995: 186–190 [world catalog].—Hollmann-Schirrmacher 1998: 17–29 [review].

Diagnosis.—Ilytheini are distinguished from other tribes of the subfamily Ilytheinae by the following combination of characters (synapomorphies indicated by an asterisk): *Head:* Fronto-orbital setae conspicuous, well developed, mostly reclinate, proclinate, or both. *Thorax:* Acrostichal setae in 2 rows, some species with setae comparatively well developed; *posterior notopleural seta inserted much farther dorsad from notopleural suture than anterior seta; 1–2 intra-alar setae well developed; prescutellar acrostichal setae well developed. *Crossvein r-m aligned between humeral and subcostal costal breaks, distinctly basad of level of subcostal break. *Abdomen:* *Male terminalia with gonite greatly reduced. *Female sternites 4 and 5 bearing rows of setae; *female ventral receptacle with reduced operculum.

Remarks.—The tribe Ilytheini includes three genera: *Donaceus* Cresson, 1949, *Ilythea* Haliday, 1837 and *Zeros* Cresson, 1943 that can be distinguished using the following key.

KEY TO GENERA OF ILYTHEINI

1. Dorsocentral setae 3 (1+2) . . *Donaceus* Cresson
– Dorsocentral setae 2 (1+1) 2
2. Vein R_{2+3} long, subparallel to C; costal section II over twice as long as section III . . . . *Ilythea* Haliday
– Vein R_{2+3} short, running almost straight to C; costal section II subequal to section III . . . . *Zeros* Cresson

Zeros Cresson, 1943

Zeros Cresson 1943: 10 [type species: *Ilythea obscura* Cresson, by original designation].—Cogan and Wirth 1977: 336 [Oriental catalog].—Mathis and Zatwarnicki 1995: 188–190 [world catalog].—Hollmann-Schirrmacher 1998: 24 [review].

Diagnosis.—*Zeros* is distinguished from other genera of the tribe Ilytheini by the following combination of characters: dorsocentral setae 2 (1+1); postsutural intra-alar setae 1; vein R_{2+3} short, usually extended almost straight to C; length of costal section II subequal to that of section III; and 2 supra-alar setae (Hollmann-Schirrmacher 1998).

Description.—*Head:* Frons uniformly, slightly convex, with a longitudinal, medial sulcus between anterior of ocelli and ptilinal suture; mesofrons and parafrons separated by slight impression; vertex rather sharp; occiput concave. Antenna short, inserted well above center line of head and eye; arista pectinate with long, dorsal branches. Face large, moderately protuberant in lateral view; intrafoveal carina prominent, as a nose-like prominence with a rather distinct, sometimes denuded tubercle at level dividing sloping dorsal facial surfaces; facial setae mostly mesoclinate, long, and well developed, series sometimes extended ventrally in line with parafacials, dorsal seta somewhat dorsoclinate, setae ventrad becoming gradually more ventroclinate. Eye large, nearly round. Genal seta well developed, inserted anteriorly. Mouth opening large, gaping; clypeus thin, frequently not exposed.

Thorax: Short, subglobose; scutum quadrate. Acrostichal setae 4–5, moderately well developed; dorsocentral setae 2 (1+1); postsutural intra-alar setae 1; basal scutellar seta inserted near base; postpronotum lacking setae; posterior notopleural seta inserted at elevated level from anterior seta; presutural supra-alar seta reduced or lacking; postsutural supra-alar seta lacking; postsutural intra-alar seta 1, inserted posteriorly; anepisternal and katepisternal setae well developed. Wing usually hyaline to faintly infuscate with dark linear spots or bands, these sometimes partially connected, forming 2–3 irregular, transverse bands; vein R_{2+3} short, strongly divergent from vein R_{4+5}, making costal sections II and III more or less equal in length; last section of vein CuA_1 almost reaching posterior wing margin. Legs slender, not conspicuously setose.

Abdomen: Ovate to rotund; tergite 5 of male longer than 4; 5th sternite of male deeply U-shaped or divided as 2 lateral sclerites. Male terminalia generally reduced with fusion and/or loss of structures such as pre- and postsurstylus (presurstylus may be fused to ventral margin of epandrium), most of gonite (sometimes evident), a tubular, gently to strongly curved aedeagus, a reduced phallapodeme, and hypandrium narrow to wide, elongate.

Natural history.—Foote (2007) reported that the larvae of *Zeros* and *Ilythea* construct a case that probably gives protection by providing a camouflage covering against predators. The larvae feed on diatoms in wet, sandy or muddy habitats.

KEY TO SPECIES OF *ZEROS* FROM CHINA

1. Wing (Fig. 1) with many dark brown spots; vein R_{2+3} sinuous; epandrium (Fig. 2) slender dorsally, tapered toward base with several strong setae toward ventral end and around cercal cavity in posterior view; hypandrium (Fig. 5) with a triangular projection in lateral view . . *Z. maculosus*, n. sp.

– Wing (Fig. 7) with few dark brown spots; veins straight; epandrium (Fig. 8) parallel-sided with 4 strong setae at ventral end in posterior view; hypandrium (Fig. 11) lacking projection in lateral view . . . . *Z. orientalis* Miyagi

***Zeros maculosus* Zhang, Yang, and Mathis, new species**

(Figs. 1–6)

Diagnosis.—Wing with many dark brown spots; veins near spots sinuous. Epandrium tapered toward base in posterior view, with several strong setae at base; hypandrium with a projection in lateral view; aedeagus spoon-shaped in lateral view.

Description.—Male. Body length 2.05 mm, wing length 2.25 mm.

Head: Subshiny black; frons dull black, with brownish-yellow microtomentum. 2 vertical setae; 2 fronto-orbital setae, anterior fronto-orbital proclinate, posterior fronto-orbital reclinate, reclinate fronto-orbital stronger than proclinate fronto-orbital seta; 1 pair of strong ocellar setae. Face brownish yellow with silvery-white microtomentum, facial tubercle dark brown with brownish-yellow microtomentum; face with 4 strong setae on each side. Gena with 1 strong seta. Antenna brown with brownish-yellow microtomentum; pedicel with 2 dorsal setae; arista with 7 dorsal rays.

Thorax: Subshiny black; mesonotum, notopleuron, anepisternum, and katepisternum brownish-yellow microtomentose. 1 presutural supra-alar seta; 2 strong dorsocentral setae; 2 rows of small acrostichal setulae; 1 strong prescutellar seta; 2 notopleural setae; 2 strong supra-alar setae. Anepisternum covered with fine yellow setulae at upper portion, with 1 strong seta at posterior margin; katepisternum with 1 strong seta. Scutellum black with brownish-yellow microtomentum, with 2 pairs of scutellar setae. Wing (Fig. 1) with many dark brown spots; veins near spots, especially vein R_{2+3}, sinuous, apex of vein R_{2+3} meeting C at nearly right angle; crossvein dm-cu conspicuous; costal vein index 0.70; M vein index 0.71. Halter yellow. Legs yellow except mid- and hindcoxae and tarsomere 5 dark brown.

Abdomen: Subshiny black with thin brownish-yellow microtomentum. 5th sternite of male deeply U-shaped. Male genitalia (Figs. 2–5). Epandrium in posterior view tapered medioventrally, bearing several strong setae medially including around cercal cavity and toward ventral margin (Fig. 2), in lateral view (Fig. 3) curved, sinuous; hypandrium in lateral view (Fig. 5) with a subapical, lateral projection; aedeagus in lateral view (Fig. 5) irregularly spoon-shaped, asymmetrically furcate basally, forming narrowly excavate sub-basal gap with a short, pointed projection near middle at end of gap and along longer extension; phallapodeme narrowly wedge-shaped in ventral view (Fig. 4); hypandrium (Fig. 5) greatly enlarged, wide, especially basally, with a medial, triangular-shaped keel subapically.

Female: Body length: 2.00 mm; wing length: 2.30 mm. Ventral receptacle round, with convex round cap at apex, and with wide tail at base (Fig. 6).

Type material.—Holotype male: CHINA. *Fujian:* Longqishan, Yujiaping (26°44′N, 117°28′E), 26.VIII.2006, Xian Zhou. The holotype is deposited in CAU. One female paratype: CHINA. *Yunnan:* Mengyang, Yexianggu (21°04′N, 100°53′E), 5.IV.1999, Ding Yang (CAU). Other paratypes are as follows: JAPAN. *Honshu:* Ibaraki Prefecture, Tsuchiura (36°05′N, 140°12′E; marsh; Malaise trap), 12 Jul–6 Sep 1989, M. J. Sharkey (11♂, 4♀; USNM).

Distribution.—Oriental: China (Fujian, Yunnan). Palearctic: Japan (Honshu).

Etymology.—The specific epithet, *maculosus*, refers to the spotted wing.

Remarks.—This new species is somewhat similar to *Z. invenatus* (Lamb) from the Oriental and Palearctic Regions in wing markings but can be distinguished from the latter by the brownish-yellow face, the presence of crossvein dm-cu, and the yellow forecoxa. In *Z. invenatus*, the face is reddish, crossvein dm-cu is absent, and the forecoxa is nearly black (Cresson 1943).

Zeros orientalis Miyagi
(Figs. 7–12)

Zeros orientalis Miyagi 1977: 60 [Japan. Ryukyu Islands: Okinawa, Nago (26°35.5′N, 127°58.6′E); HT ♀; HUS]. —Morimoto 1989: 823 [checklist, Japan].—Mathis and Zatwarnicki 1995: 190 [world catalog].

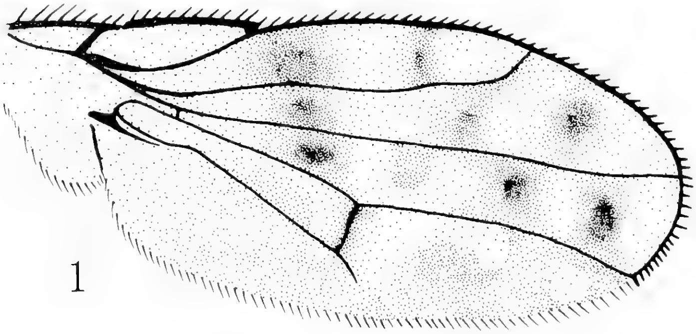
Diagnosis.—Wing with few dark brown spots; veins straight. Epandrium parallel-sided in posterior view, with 4 strong setae at anterior end; hypandrium without projection in lateral view; aedeagus C-shaped in lateral view.

Description.—Male. Body length 1.65 mm, wing length 1.70 mm.

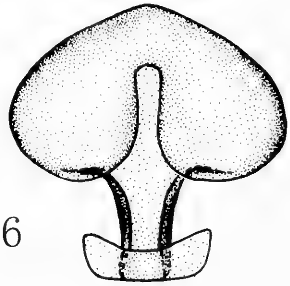
Head: Brown; frons brownish yellow with thin brownish-yellow microtomentum. 2 vertical setae; 2 fronto-orbital setae, anterior fronto-orbital seta proclinate, posterior fronto-orbital reclinate, reclinate fronto-orbital seta stronger than proclinate fronto-orbital seta; 1 pair of strong ocellar setae. Face black with grayish white microtomentum; face with 3 strong setae on each side. Gena with 1 strong seta. Antenna brownish yellow except antennal segment III yellow ventrally. Pedicel with 3 dorsal setae; arista with 7–8 dorsal rays.

Thorax: Subshiny black; mesonotum, notopleuron and anepisternum with brownish-yellow microtomentum; katepisternum with yellowish-gray microtomentum. 1 presutural supra-alar seta; 2 strong dorsocentral setae; 2 rows of small acrostichal setulae; 1 strong prescutellar seta; 2 notopleural setae; 2 strong supra-alar setae. Anepisternum with 3 strong setae at posterior margin; katepisternum with 1 strong seta. Scutellum brownish-yellow microtomentose, with 2 pairs of scutellar setae. Wing (Fig. 7) with a few, moderately short, dark brown, transverse bars rather than spots; veins straight; crossvein dm-cu conspicuous; costal vein index 0.88; M vein index 0.53. Halter yellow. Legs yellow except mid- and hindcoxae brown and tarsomere 5 brownish yellow.

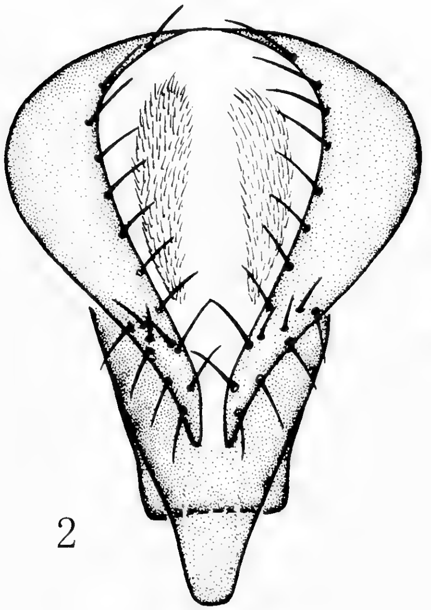
Abdomen: Brown. Male genitalia (Figs. 8–11): Epandrium in posterior



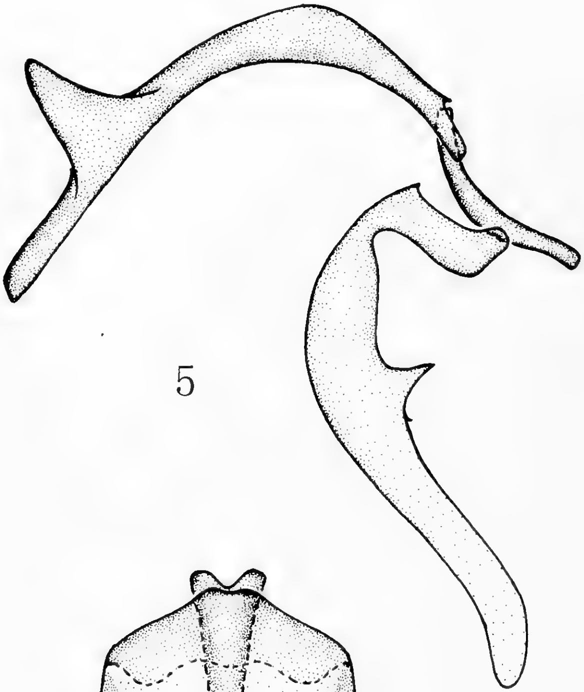
1



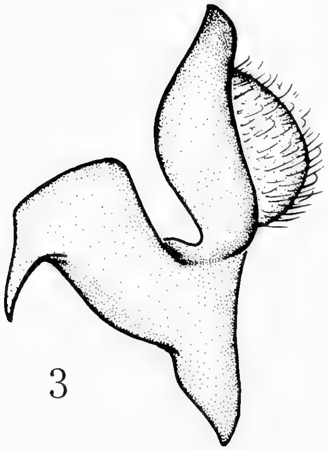
6



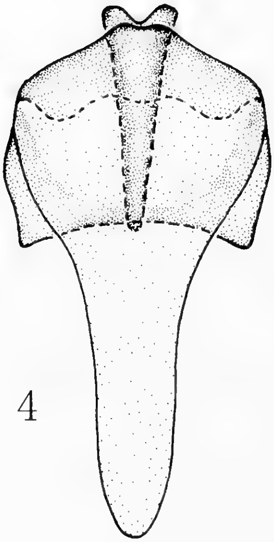
2



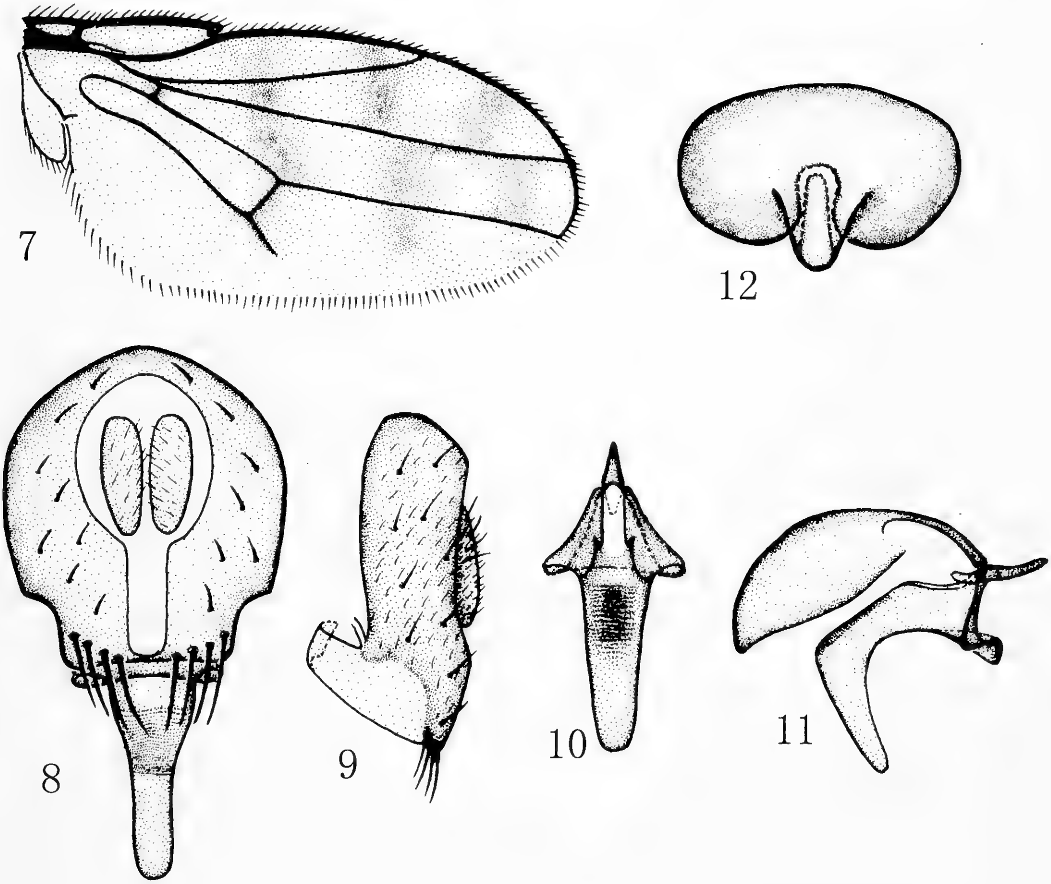
5



3



4



Figs. 7–12. *Zeros orientalis.* 7–12, Male. 7, Wing. 8, Epandrium, cercus and aedeagus, posterior view. 9, Epandrium and cercus, lateral view. 10, Aedeagus and phallapodeme, ventral view. 11, Hypandrium, aedeagus and phallapodeme, lateral view. 12, Female, ventral receptacle.

view (Fig. 8) almost parallel-sided over medial portion, thereafter sharply narrowed steplike, ventral margin nearly truncate, bearing 4 strong setae on each side, setae oriented ventrally, in lateral view (Fig. 9) nearly straight vertically; hypandrium in lateral view (Fig. 11) pouch or pocket-like without lateral projection; aedeagus in lateral view (Fig. 11) angulate U-shaped, inner emargination deeply rounded, in ventral view (Fig. 10) triangular on basal 1/3, thereafter apically digitiform, only slightly tapered; phallapodeme reduced, bar-like in lateral view (Fig. 11), in ventral view (Fig. 10) sharply pointed.

Female: Body length 1.75 mm; wing length 2.15 mm. Ventral receptacle approximately round, with slender tail at base (Fig. 12).

←

Figs. 1–6. *Zeros maculosus.* 1–5, Male. 1, Wing. 2, Epandrium, cercus and hypandrium, posterior view. 3, Epandrium and cercus, lateral view. 4, Aedeagus and phallapodeme, ventral view. 5, Hypandrium, aedeagus and phallapodeme, lateral view. 6, Female, ventral receptacle.

Specimens examined.—CHINA. *Guangxi:* Maoershan, Tongrencun (25°53′N, 110°25′E), 2 May 2004, Ding Yang (1♂; CAU); Maoershan, Tongrencun (25°53′N, 110°25′E), 2 May 2004, Yanling Xu (1♀; CAU). *Henan:* Anyang, Linzhou, Shibanyan (36°06′N, 114°21′E), 23 Jul 2006, Junhua Zhang (3♂; CAU).

INDIA. *Assam:* Chabua (27°29′N, 95°11′E), 9 Jan 1944, D. E. Hardy (1♂; USNM); Digboi (27°23′N, 95°38′E), 30 Mar 1944, D. E. Hardy (1♀; USNM); Duamara (NE Doom Dooma; 27°34′N, 95°34′E), 2 Dec 1943, D. E. Hardy (2♂, 2♀; USNM); Misamari (35 mi NW Tezpur; 26°48′N, 92°36′E), 29 Jan 1944, D. E. Hardy (1♂, 1♀; USNM); Rupsi (15 mi NW Dhubri; 26°08′N, 89°56′E), 3 Nov 1943, D. E. Hardy (2♂, 4♀; USNM); Sadiya (27°50′N, 95°40′E), 13 Feb 1944, D. E. Hardy (3♂, 4♀; USNM); Tinsukia (6 mi N; 27°30′N, 95°22′E), 26 Mar 1944, D. E. Hardy (7♂, 5♀; USNM). *Bengal:* Kolkata (Botanical Garden; 22°32′N, 88°20′E), 4 Nov 2002, A. Freidberg (1♀; USNM). *Karnataka:* Mudigere (19 km W; 13°08′N, 75°26′E), 6 Apr 1980, A. Freidberg, W. N. Mathis (3♀; USNM); Mudigere (24 km W; 13°07.8′N, 75°24′E), 7 Apr 1980, A. Freidberg, W. N. Mathis (1♂; USNM); Mudigere (27 km NW; 13°10′N, 75°25′E), 6 Apr 1980, A. Freidberg, W. N. Mathis (1♀; USNM); Mudigere (13°07.8′N, 75°37.8′E), 6–7 Apr 1980, A. Freidberg, W. N. Mathis (1♂, 1♀; USNM). *Rajasthan:* Bap Lake, near Phalodi (Rt. 15; 27°07.8′N, 72°22.2′E), 19 Nov 2002, A. Freidberg (2♀; USNM); Nagda Temple (25 km N Udaipur; Lake; 24°34.8′N, 73°41.4′E), 22 Nov 2002, A. Freidberg (3♀; USNM).

JAPAN. *Honshu:* Ibaraki Prefecture, Tsuchiura (36°05′N, 140°12′E; marsh; Malaise trap), 24 Jul–6 Sep 1989, M. J. Sharkey (1♂, 1♀; USNM).

NEPAL. *Chitwan:* Dhungari Khola (2 km E; 27°30′N, 84°20′E), 1 Nov 1985, W. N. Mathis (1♀; USNM).

Distribution.—Oriental: China (Guangxi); India (Assam, Bengal, Karnataka, Rajasthan), Japan (Ryukyu Islands), Nepal (Chitwan). Palearctic: China (Henan); Japan (Honshu, Shikoku).

Remarks.—Until now, this species was known only from Japan, and the records noted here from China, India, and Nepal are the first for their respective countries on mainland Asia.

This species is similar to *Z. defectus* (Malloch) but differs from it in structures of the male terminalia, especially the ventral margin of the epandrium (fused surstyli), which is essentially truncate, bearing 4–5 large setae, and the acutely curved aedeagus (somewhat angulate around outer curvature). Our comparison with *Z. defectus* is based on specimens from Queensland, Australia, near the type locality of the female holotype of *Z. defectus.*

ACKNOWLEDGMENTS

We are very grateful to Ms. Yanling Xu and Xian Zhou (Beijing) for collecting some of the specimens. This research is supported by the National Natural Science Foundation of China (No. 30225009). We also express thanks to Philip J. Clausen (University of Minnesota), Joe E. Keiper (Cleveland Museum of Natural History), and Allen L. Norrbom (USDA, Systematic Entomology Laboratory) for their reviews of the manuscript.

LITERATURE CITED

Cogan, B. H. 1984. Family Ephydridae, pp. 126–176. *In* Soós, Á. and L. Papp, eds. Catalogue of Palaearctic Diptera 10. Elsevier Science Publishers, Amsterdam: and Akadémiai Kiadó, Budapest. 402 pp.

Cogan, B. H. and W. W. Wirth. 1977. Family Ephydridae, pp. 321–339. *In* Delfinado, M. D. and D. E. Hardy, eds. A catalogue of the Diptera of the Oriental Region. Volume III. Suborder Cyclorrhapha (excluding Division Aschiza). University Press of Hawaii, Honolulu. 451 + vii pp.

Cresson, E. T. Jr. 1943. The species of the tribe Ilytheini (Diptera: Ephydridae: Notiphilinae). Transactions of the American Entomological Society 69: 1–16.

Foote, B. A. 2007. Biology of *Ilythea caniceps*, *I. spilota*, and *Zeros flavipes* (Diptera: Ephydridae), case-making consumers of diatoms on shorelines. Proceedings of the Entomological Society of Washington 109: 125–130.

Hollmann-Schirrmacher, V. 1998. Phylogeny of the subfamily Ilytheinae (Diptera, Ephydridae) with special reference to the genus *Philygria*. Studia Dipterologica Supplement 5: 1–144.

Mathis, W. N. 1986. Studies of Psilopinae (Diptera: Ephydridae), I: A revision of the shore fly genus Placopsidella Kertész. Smithsonian Contributions to Zoology 430: 1–30 + iv pp.

Mathis, W. N. and T. Zatwarnicki. 1990a. A revision of the western Palearctic species of Athyroglossa (Diptera: Ephydridae). Transactions of the American Entomological Society 116(1): 103–133.

———. 1990b. Taxonomic notes on Ephydridae (Diptera). Proceedings of the Biological Society of Washington 103(4): 891–906.

———. 1995. A world catalog of the shore flies (Diptera: Ephydridae). Memoirs on Entomology, International 4: 1–423.

McAlpine, J. F. 1981. Morphology and Terminology–Adults, pp. 9–63. *In* McAlpine, J. F., et al., eds. Manual of Nearctic Diptera, Ottawa, [Vol. 1 is Monograph 27 of Research Branch Agriculture Canada.]

Miyagi, I. 1977. Ephydridae (Insecta: Diptera). In, Fauna Japonica. Keigaku Publishing Company, Limited, Tokyo. 113 pp.

Morimoto, K. 1989. Diptera, pp. 699–874. *In* Hiraschim, Y. ed. A check list of Japanese insects. 2. Entomological Laboratory, Faculty of Agriculture, Kyushu University and Japan Wildlife Research Center. Isseido Printing Company, Fukuoka. 1088 pp. [In Japanese.]

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 880–885

EUGNAMPTUS PROTERUS, N. SP. (COLEOPTERA: CURCULIONOIDEA: RHYNCHITIDAE), A TOOTH-NOSED SNOUT BEETLE IN MEXICAN AMBER

George Poinar, Jr. and Alex E. Brown

(GP) Department of Zoology, Oregon State University, Corvallis, OR 97331, U.S.A. (e-mail: poinarg@science.oregonstate.edu); (AEB) 629 Euclid Avenue, Berkeley, CA 94708, U.S.A.

Abstract.—a **new species** of tooth-nosed snout beetle, ***Eugnamptus proterus*** **Poinar and Brown** (Coleoptera: Curculionoidea: Rhynchitidae) is described from Mexican amber. Distinguishing characters include 1) the next to last strial row joins the last strial row near the middle of the elytra, 2) the presence of a median longitudinal ridge on the rostrum, 3) long, slender, erect dark setae on the frons, 4) a narrow, cylindrical prothorax and extended "neck" region and 5) unusually broad claw appendages. Based on the available literature, the closest described extant species is the Japanese *E. aurifrons* Roel. A brief survey of fossil rhynchitids is presented.

Key Words: *Eugnamptus proterus*, Rhynchitidae, Curculionoidea, Mexican amber

The tooth-nosed snout beetles (Rhynchitidae), often considered a subfamily of the leaf-roller weevils (Attelabidae), are a primitive group that Zimmerman (1994) assigned to his "convenience" Division Orthoceri based on their non-geniculate, straight antennae. There are over 1,000 described species in 49 genera, and while the range is cosmopolitan, most taxa are restricted to the warmer portions of the globe (Zimmerman 1994; Kuschel 1995; Thompson 1992; Voss 1941).

The present study describes a representative of this group in Mexican amber.

Materials and Methods

The specimen was obtained from an amber mine in the Simojovel area of Chiapas, Mexico. Locations of the Chiapas mines and a synopsis of Mexican amber are presented in Poinar (1992). Amber from this region was produced by *Hymenaea mexicana* (Fabaceae) (Poinar and Brown 2002) and occurs in lignitic beds among sequences of primarily marine calcareous sandstones and silt. The amber is associated with Balumtun Sandstone of the early Miocene and the La Quinta formation of the Late Oligocene with radiometric ages from 22.5 to 26 million - years (Berggren and Van Couvering 1974). Since the amber is secondarily deposited in these marine formations, it is somewhat older than the above dates.

The piece of amber containing the fossil is 11 mm long, 5 mm wide and 4 mm deep. The body length measurement was a direct line from the tip of the elytra to the anterior border of the eyes (excluding the rostrum). Body width was taken at the widest part of the elytra, head length was measured as the portion of the head bordered by the eyes, head width at the widest point between the eyes, frons width was the head width at the midpoint of the eyes, neck length was measured from the posterior border of the eyes to the anterior collar of the pronotum, and head- eye width was the distance from the outer rim of one eye across the head to the outer rim of the opposite eye. All measurements are in mm unless otherwise specified.

The specimen is complete and well preserved. In the same piece of amber are an oribatid mite, an adult gall gnat (Diptera: Cecidomyidae) and a worker ant of the genus *Azteca* (Hymenoptera: Formicidae). Systematic placement follows that of O'Brien and Wibmer (1982) and the generic diagnoses of *Eugnamptus* Schönherr as presented by Voss (1941) and Hamilton (1989) were used.

Eugnamptus proterus **Poinar and Brown, new species**

(Figs. 1–4)

Description.—Length, 4.7; width, 1.3; color reddish brown throughout, antennal funicle paler.

Head: Elongated, somewhat dorsoventrally flattened; length (0.60) greater than width (1.30); frons wide, width, 0.38; head-eye width, 0.96; weakly narrowed behind eyes; portion between eyes with few scattered medium-sized punctures; most of rostrum with few barely detectable fine punctures; neck (length, 0.40) with small punctures arranged in longitudinal rows; approximately equal to width at base of rostrum; length rostrum, 1.20; eyes large, protruding, distance between outer borders slightly less than length of rostrum; rostrum long, narrow, broadening at apex, longer than head but shorter than head + pronotum; rostrum with median longitudinal ridge extending from between antennal insertions toward apex; antennae insertions at middle of rostrum; scape longer than first funicular joint; club subequal to funicle in length; club segments elongate, subequal in length.

Thorax: Pronotum cylindrical, longer than wide, widest at middle; with four irregular longitudinal rows of medium- to large- sized puncta; legs elongate, all terminated by paired pointed claws with unusually broad appendages at bases.

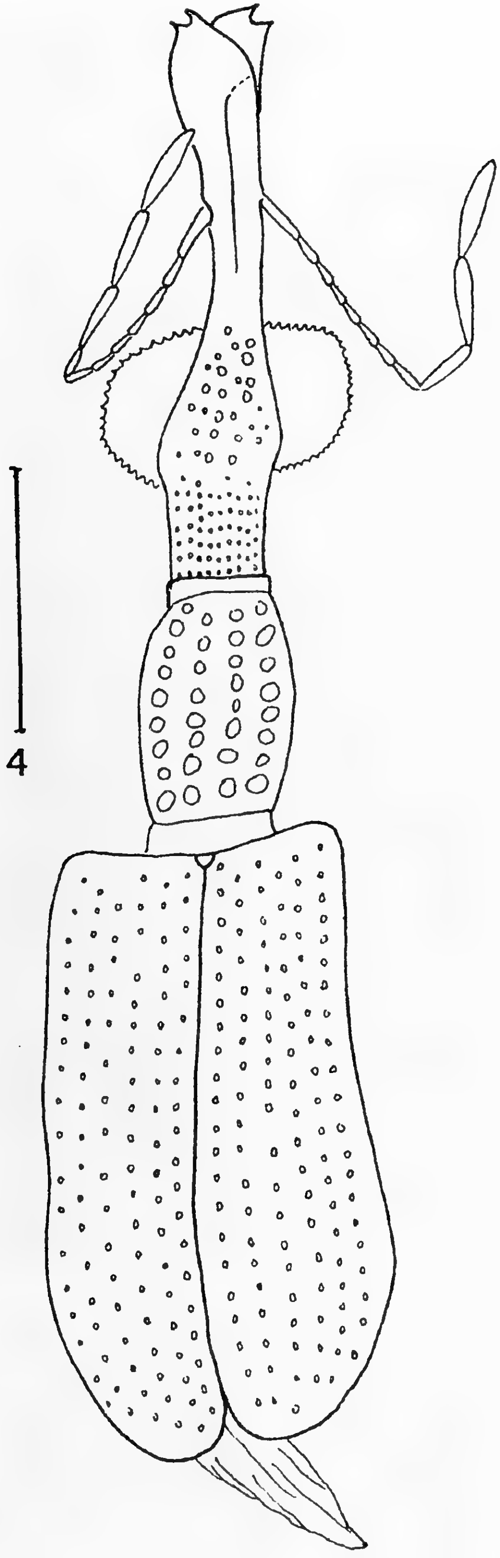
Abdomen: First ventral suture not distinctly impressed throughout; elytra long and narrow (2 ½ times longer than wide), widest near declivities, lacking noticeable spots; with rows of small puncta; next to last strial row joins last strial row near middle of elytron; rows of semi-erect to reclinate setae associated with elytral interspaces; scattered larger erect setae between rows of puncta; scutellum small, partly concealed; scutellar striole not visible; pygidium obscured by partially exposed inner wings.

Material examined.—Holotype female in amber from Chiapas, Mexico. Deposited in the Poinar amber collection maintained at Oregon State University (accession number C-7-402).

Etymology.—The specific epithet "proterus," a latinised adjective derived from the Greek próteros meaning earlier, refers to the specimen being the first definite fossil representative of the genus.

Comments.—Whether the pygidium is or is not exposed is a character used in separating members of this group (Voss 1941; Hamilton and Novinger 2004). It is not possible to determine if the tip of the pygdium is exposed since that area is covered by the tips of the inner pair of wings. However, based on the curved tips of the elytra, it is likely that at least some portion of the pygidium would have been exposed in life. The character "next to last strial row joins the last strial row near the middle of the elytron" places the fossil in the subgenus *Eugnamptobius* Voss (1941) however this taxon was given generic status by Legalov (2003). In the key to the species of this subgenus provided by Voss (1941), the fossil runs to the Japanese *E. aurifrons* Roel. Both species share several

Figs. 1–3. *Eugnamptus proterus* in Mexican amber. 1, Lateral view. Bar = 0.85 mm. 2, Frontal view showing rostral ridge. Bar = 0.37 mm. 3, Appendiculate claw. Bar = 0.07 mm.



characters, including a medial carina on the rostrum. However, the fossil is larger in total length (4.7 mm vs. 3.5 mm) and has a head width (including eyes) of almost 1.5 times the width of the prothorax (this ratio is roughly equal in *E. aurifrons*).

In the key to the La Selva species of Eugnamptina (Hamilton and Novinger 2004), the fossil keys to the couplet separating *E. pusillus* Hamilton and Novinger and *E. herediensis* Hamilton and Novinger. These two species are separated by color differences, which cannot be used in the fossil since lighter colors darken over time. However, both of these extant species have shortened elytra depressed behind the scutellum, which is not the case with the present fossil. Other extant species that resemble *E. proterus* are *E. rufifrons* Sharp and *E. obscurus* Sharp (Sharp 1889; Legalov 2003). However, in these species, the length of the abdomen is longer or at most subequal to the combined lengths of the head (including beak) and thorax, while in *E. proterus*, the combined length of the head and thorax is 1.3 times the length of the abdomen.

Distinguishing characters of the fossil include the median longitudinal carina extending from the antennal insertions almost to the apex of the rostrum, the elongate "neck" region, the cylindrical, narrow pronotum, a head width of almost 1.5 times the width of the prothorax and the unusually wide claw appendages.

DISCUSSION

All previously described fossils assigned to the family Rhynchitidae are impression fossils and many of their

---

←

Fig. 4. Dorsal view of *Eugnamptus proterus* in Mexican amber. Scutellar striole not visible. Bar = 1.0 mm.

characters are difficult to discern. Two previous fossils have been described in the genus *Eugnamptus*, namely *E. decemsatus* Scudder 1878 and *E. grandaevus* Scudder 1890, both from the Eocene Green River shales. However, the specimens (three of *E. grandaevus* and one of *E. decemsatus*) are all fragmentary and their assignment to the genus *Eugnamptus* is questionable. In a later work listing the fossil weevils from the United States, Scudder (1893) acknowledged that neither of these two fossil species were placed in *Eugnamptus* "with any great confidence."

Also in his 1893 publication, Scudder described an additional seven genera of Rhynchitidae in his newly proposed subfamily Isotheinae from the Florissant beds in North America. He characterized the subfamily as having the insertion of the antennae "before the middle of the basal half of the straight and porrect beak." The straight and porrect beak separates these genera from species in the genus *Eugnamptus*, including the present fossil. Other fossil rhynchitids include members of the genus *Masteutes* Scudder 1893 as well as species of *Auletes* Schönherr and *Rhynchites* Schneider (Scudder 1893), all of which are morphologically distinct from the present fossil. The fossil genus *Eugnamptidea* Wickham 1912 has a four-segmented club and *Rhynchites martynovi* Ter-Minasyan (1947) from Pleistocene shales in Asia is much larger and has characters similar to those of the genus *Rhynchites*.

Zherichin (1992) described four fossil attelabids from the Upper Oligocene of Rott, Siebengebirge, Germany. All of them (*Cartorhynchites struvei* Zherichin, *Coenorhinus goergesi* Zherikhin, *Involvulus rottensis* Zherichin, and *Involvulus* ? sp.) lack a distinct neck region and have compact club segments, which distinguishes them from *E. proterus*. Both fossil species *Rhynchites hageni* Heyden and Heyden (1866) and *Rhynchites orcinus* Heyden and Heyden (1866) have antennae with thickened clubs inserted at the base of the rostrum and robust bodies with a straight beak, which differs from that of the present fossil.

The biology of eugnamptines is poorly known although most appear to have arboreal habits. Adults of the North American *Eugnamptus angustatus* (Herbst) feed and mate on sassafras trees while the larvae mine both dead and living leaves of sassafras, oak, walnut, dogwood, hickory and black gum (Hamilton 1980; Bright 1993). In Central America, species of *Eugnamptus* have been recovered from the tree families, Anacardiaceae, Hernandiaceae, Leguminoseae, Meliaceae, Myristicaceae, Sabiaceae and Tiliaceae (Hamilton and Novinger 2004). The flora in Mexican amber has been little studied; however, aside from *Hymenaea mexicana* Poinar and Brown (2002) (Fabaceae), Miranda (1963) described *Tapirira durhamii* Miranda (Anacardiaceae) and an *Acacia* sp. (Fabaceae) from these deposits. It is interesting that *Tapirira guianensis* Aubl. was one of the trees from which Hamilton and Novinger (2004) obtained *Eugnamptus* for their studies.

ACKNOWLEDGMENTS

We thank G. Kuschel, M. Alonza, and A. Riedel for discussions regarding the systematic position of this fossil, Alexander G. Kirejtshuk for supplying references on fossil rhynchitids, Lucas Roots for translation services, and Roberta Poinar for corrections on earlier drafts.

LITERATURE CITED

Berggren, W. A. and J. A. H. Van Couvering. 1974. The late Neogene. Palaeogeography, Palaeoclimatology and Palaeoecology 16: 1–216.

Bright, D. E. 1993. The Insects and Arachnids of Canada, Part 21; the weevils of Canada and Alaska: Vol. 1; Coleoptera: Curculionoidea, excluding Scolytidae and Curculionidae. Centre for Land and Biological Resources Research, Ottawa. 217 pp.

Hamilton, R. W. 1980. Notes on biology of *Eugnamptus collaris* (Fabr.)(Coleoptera: Rhynchitidae), with descriptions of the larva and pupa. Coleopterist Bulletin 37: 19–22.

———. 1989. A revision of the weevil genus *Eugnamptus* Schoenherr (Coleoptera: Rhynchitidae) in America north of Mexico. Transactions of the American Entomological Society 115: 475–502.

Hamilton, R. W. and A. L. Novinger. 2004. Eugnamptine weevils of La Selva, Costa Rica (Coleoptera: Rhynchitidae). Zootaxa 610: 1–43.

Heyden, C. von. and L. von Heyden. 1866. Käfer und Polypen aus der Braunkohle des Siebengebirges. Palaeontograpica 15: 131–156.

Kuschel, G. 1995. A phylogenetic classification of Curculionoidea to families and subfamilies. Memoirs of the Entomological Society of Washington No. 14, pp. 5–33.

Legalov, A. A. 2003. Taxonomy, classification and phylogeny of the leaf-rolling weevils (Coleoptera: Rhynchitidae, Attelabidae) of the world fauna. Novosibirsk, CD-Rom. 641 MB. 733 pp.

Miranda, F. 1963. Two plants from the amber of the Simojovel, Chiapas, Mexico, area. Journal of Paleontology 36: 611–614.

O'Brien, C. W. and G. J. Wibmer. 1982. Annotated checklist of the weevils (Curculionidae *sensu lato*) of North America, Central America and the West Indies (Coleoptera: Curculionoidea). Memoirs of the American Entomological Institute 34: 1–382.

Poinar, Jr., G. O. 1992. Life in Amber. Stanford Univ. Press, Stanford, CA.

Poinar, Jr., G. O. and A. E. Brown. 2002. *Hymenaea mexicana* sp. nov. (Leguminosae: Caesalpinioideae) from Mexican amber indicates Old World connections. Botanical Journal of the Linnean Society 139: 125–132.

Scudder, S. H. 1878. The fossil insects of the Green River shales. Bulletin of the United States Geological and Geographical survey of the Territories 4: 747–776.

———. 1890. The Tertiary Insects of North America. Report of the United States Geological Survey of the Territories 13: 1–734.

———. 1893. Tertiary rhynchophorous Coleoptera of the United States. Monograph of the United States Geological Survey 21: 1–206.

Sharp, D. E. 1889. Biologia Centrali-Americana, Insecta, Coleoptera, Curculionidae:Attelabinae 4: 1–40.

Ter-Minasyan, M. E. 1947. A new fossil species of the genus *Rhynchites* Schneid. from Binagadin Kirov shales (Coleoptera, Attelabidae). Proceedings of the Academy of Sciences of the Armenian SSR 7: 227–229 (in Russian).

Thompson, R. T. 1992. Observations on the morphology and classification of weevils (Coleoptera, Curculionoidea) with a key to major groups. Journal of Natural History 26: 835–891.

Voss, E. 1941. Monographie der Rhynchitinen-Tribus Rhinocartini sowie der Gattungsgruppe Eugnamptina der Tribus Rhynchitini. IV. Teil der Monographie der Rhynchitinae-Pterocolinae. Deutsche Entomologische Zeitschrift 3–4: 113–215.

Wickham, H. F. 1912. On some fossil rhynchophorous Coleoptera from Florissant, Colorado. Bulletin of the American Museum of Natural History 31: 41–55.

Zherichin, V. V. 1992. Tertiary weevils (Insecta, Coleoptera: Curculionidae), identified from the collections of the Senckenberg Museum. Senckenbergiana lethaea 72: 169–178.

Zimmerman, E. C. 1994. Australian weevils (Coleoptera: Curculionoidea). Vol. 1. Orthoceri; Anthribidae to Attelabidae; the primitive weevils, CSIRO, Canberra, Australia. 741 pp.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 886–896

TAXONOMIC STUDY OF THE LEAFHOPPER GENUS *WARODIA* DWORAKOWSKA (HEMIPTERA: CICADELLIDAE: TYPHLOCYBINAE), WITH DESCRIPTIONS OF SIX NEW SPECIES

Yalin Zhang and Min Huang

Key Laboratory of Plant Protection Resources and Pest Management, National Ministry of Education, Entomological Museum, Northwest A&F University, Yangling, Shaanxi 712100, China. Corresponding author: Min-Huang (e-mail: huangmin@nwsuaf.edu.cn or huangmin4399@sina.com)

Abstract.—Ten species of the leafhopper genus *Warodia* Dworakowska are treated, of which six **new species**, ***W. tricornis***, ***W. annulata***, ***W. falcata***, ***W. lineata***, ***W. rigida***, and ***W. gracilicornis***, are described and illustrated. A key to all species is provided.

Résumé.—Une étude taxonomique sur le genre de cicadelle *Warodia* Dworakowska est rapportée. 10 espèces sont traitées, des quelles 6 **nouvelles espèces**, ***W. tricornis***, ***W. annulata***, ***W. falcata***, ***W. lineata***, ***W. rigida***, ***W. gracilicornis***, sont décrits et illustrés, une clef à toutes les espèces est fournie.

Key Words: Hemiptera, Cicadellidae, Typhlocybinae, Typhlocybini, *Warodia*, new species

Warodia was proposed as a new genus by Dworakowska (1970) for *Typhlocyba hoso* Matsumura, 1932, from Japan and China. Thereafter, three new species were described from China (Dworakowska 1982, Hu and Kuoh 1991, Zhang and Xiao 2000). An additional six new species from China are described and illustrated in this study, together with a key to identify males of all species of the genus. The genus belongs to the *Typhlocyba* complex of Typhlocybini according to its 2 apical cells in the hindwings and also resembles the *Farynala* group members in the shape of the paramere.

The type specimens of the new species are deposited in the collections of the Entomological Museum of the Northwest A&F University (NWAFU) in Yangling (Shaanxi) and the China Agriculture University (CAU) in Beijing.

Warodia Dworakowska

Warodia Dworakowska 1970: 215; 1982: 120; Hu and Kuoh 1991: 255–256; Zhang and Xiao 2000: 110–111. Type species: *Typhlocyba hoso* Matsumura, 1932. By orig. desig.

Redescription.—Ivory to yellowish; patches on vertex, pronotum and scutellum, streaks on vein Cua and clavus of forewing, light yellow, orange to ochre; apical quarter of forewing with a smoky pattern. Forewing with second apical cell largest, expanded towards apex, third apical cell subtriangular with short petiole. Hindwing with R and M confluent apically.

Male genitalia: Posterior part of pygofer lobe with hoodlike lower angle and variable-shaped upper angle bearing a few rigid setae along margin. Subgenital plate slender, with one basal macroseta; row of gracile setae longitudinally along midline ventrally; an interrupted row of thickened setae at one-third to half of dorsolateral margin, grouped more densely toward apex. Paramere long; inner margin with row of sensory pits ventrally, outer margin with row of thin setae adjoining group of usually thicker setae on well-developed lateral lobe. Connective large and lamellate, median ledge well developed. Aedeagal shaft bearing processes apically.

Distribution.—Palaearctic and Oriental regions.

KEY TO SPECIES (MALES)

1\. Aedeagus with unpaired median process at tip in addition to paired processes (Figs. 8, 30) 2
\– Aedeagus with only paired dorsal processes at tip 3
2\. Aedeagus with one pair of distal processes (Figs. 29–31) . . . . *W. tricornis*, n.sp.
\– Aedeagus with two pairs of distal processes (Figs. 8–9) . . . . *W. hoso*
3\. Paramere with apex rounded; process of aedeagus branched (Fig. 69) . . . . *W. gracilicornis*, n.sp.
\– Paramere with apex acuminate; process of aedeagus not branched 4
4\. Paramere with numerous rigid setae on upper part of lateral lobe 5
\– Paramere with gracile setae on lateral lobe 7
5\. Aedeagal shaft stout, shorter than process (Fig. 52) . . . . *W. lineata*, n.sp.
\– Aedeagal shaft slender, longer than process 6
6\. Pygofer lobe with acute protrusion on upper part of posterior margin; aedeagus with median pair of distal processes crossed at midlength (Figs. 34, 37) . . *W. annulata*, n.sp.
\– Pygofer lobe not as above; aedeagus with distal processes divergent (Fig. 45). . . . . *W. falcata*, n.sp.
7\. Posterior process much longer than anterior process of aedeagus (lateral view) (Fig. 61) . . . . *W. rigida*, n.sp.
\– Posterior process shorter than anterior process of aedeagus (lateral view, Figs. 12,19,22) 8
8\. Posterior process shorter than 1/2 anterior process of aedeagus (lateral view) and anterior process roundly curved basally (Fig. 12) . . . . *W. biguttata*
\– Posterior process longer than 1/2 anterior process of aedeagus (lateral view) and anterior process somewhat straight (Fig. 19,22) 9
9\. Aedeagal shaft laterally compressed, almost equal in length to processes (Fig. 22–23) . . . . *W. euryaedeaga*
\– Aedeagal shaft not compressed, much longer than processes (Fig. 18–19). . . . . *W. gregoryi*

Warodia hoso (Matsumura 1932)
(Figs. 1–9)

Typhlocyba hoso Matsumura 1932: 64.
Typhlocyba kiiensis Matsumura 1932: 64; Dworakowska 1982: 120.
Warodia hoso: Dworakowska 1970: 215, figs. 25, 42–52; Zhang 1990: 156, fig. 178.

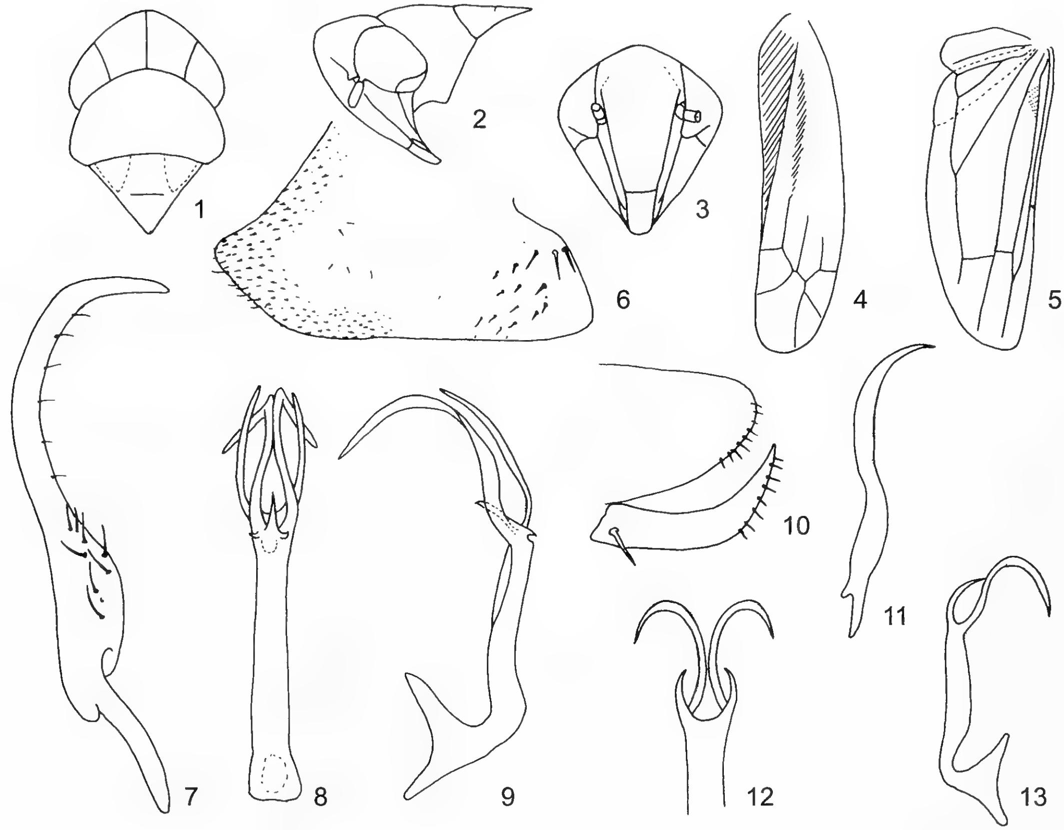
Specimens examined.—CHINA: 1 ♀, Xinjiang: Yili, alt. 700 m, August 19~20, 1979, coll. Tong Chen; 1 ♂, Guangxi: Lingchuan, Lingtian, Longkou, June 5, 1984, coll. Xiaolin Lu, at lamp; 7 ♂, Hunan Province: Chenzhou, August 4, 1985, coll. Yalin Zhang and Yonghui Chai; 7 ♂, 2 ♀, Shaanxi Province: Liuba, Miaotaizi, August 19, 1995, coll. Wenzhu Zhang and Liyun Ren; 1 ♂, 11 ♀, Hubei Province: Mt. Wudang, Taizi slope, July 22, 2001, coll. Min Huang and Guiling Zhang, at light.

Distribution.—China (Zhejiang, Hunan, Hubei, Guangxi, Shaanxi, and Xinjiang), Japan.

Warodia biguttata Hu and Kuoh, 1991
(Figs. 10–13)

Warodia biguttata Hu and Kuoh 1991:255–256, fig. 1.

Specimens examined.—CHINA: 1 ♂, Yunnan Province: Sanchahe, June 7, 1991, coll. Rungang TIAN; 1 ♂, Mt. Zixi, alt. 2,400 m, on *Alnus* and *Rubus*, Nov. 10, 1999, coll. Dworakowska.



Figs. 1–13. 1–9, *Warodia hoso* (after Dworakowska, 1970). 1, Head, pronotum and scutellum, dorsal view. 2, Same, lateral view. 3, Face. 4, Forewing. 5, Hindwing. 6, ♂ pygofer, lateral view. 7, Paramere. 8, Aedeagus, posterior view. 9, Aedeagus, lateral view. 10–13, *Warodia biguttata* (after Hu and Kuoh 1991). 10, ♂ pygofer, lateral view. 11, Paramere. 12, Apical part of aedeagus.13, Aedeagus, lateral view.

Distribution.—SW China (Guizhou, Yunnan).

Warodia gregoryi Dworakowska, 1982
(Figs. 14–20)

Warodia gregoryi Dworakowska 1982: 120, figs. 251–262.

Specimens examined.—CHINA: 1 ♂, Yunnan Province: Xinzhu, alt. 2,300 m, pine forest, Nov.15, 1999; 1 ♀, alt. 2,500 m, pine forest, Nov.15, 1999; 1 ♀, northeastern slop, alt. 2,500 m, Nov.16, 1999; 2 ♀, alt. 2,450 m, on Ericaceae, Nov.14, 1999; 1 ♀, Tengchong, alt. 1,700 m, Nov.22, 1999, on *Quercus*, coll. Dworakowska.

Distribution.—SW China (Yunnan).

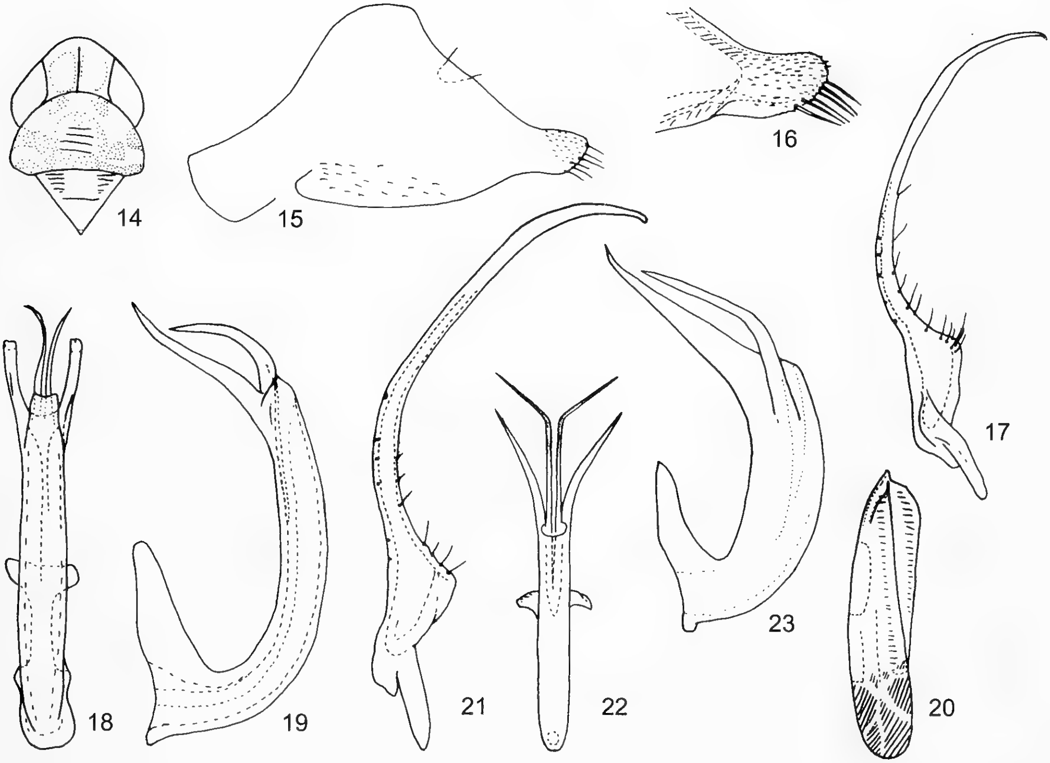
Warodia euryaedeaga Zhang and Xiao, 2000
(Figs. 21–23)

Warodia euryaedeaga Zhang and Xiao 2000:110, figs. 27–30.

Distribution.—SW China (Yunnan).

***Warodia tricornis* Zhang and Huang, new species**
(Figs. 24–31)

Notes.—This species resembles *W. biguttata*, but it can be distinguished by the absence of the patches on the vertex



Figs. 14–23. 14–20, *Warodia gregoryi* (after Dworakowska, 1982). 14, Head, pronotum and scutellum, dorsal view. 15, ♂ pygofer, lateral view. 16, Hind part of ♂ pygofer, lateral view. 17, Paramere. 18, Aedeagus, posterior view. 19, Aedeagus, lateral view. 20, Forewing. 21–23, *Warodia euryaedeaga* (after Zhang and Xiao 2000). 21, Paramere. 22, Aedeagus, posterior view. 23, Aedeagus, lateral view.

and pronotum and by its single process between the long paired processes at the tip of the aedeagus (Fig. 30).

Description.—Beige, basal triangles yellow; forewing yellowish, with apical quarter light smoky.

Male. Abdominal apodemes reaching base of 5th abdominal sternite (Fig. 24). Pygofer lobe gradually narrowed, posterior margin truncate with row of short rigid setae; a group of different-sized rigid setae scattered at basal angle (Figs. 25–26). Dorsolateral margin of subgenital plate with basal and distal groups of short setae (Fig. 27). Paramere with apex slender and slightly sinuated, and with shorter and less numerous setae on central part (Fig. 28). Aedeagal shaft straight, terminating in pair of long sinuate lateral processes and a single short dorsal process (Figs. 30–31).

Length: ♂, 3.21 mm.

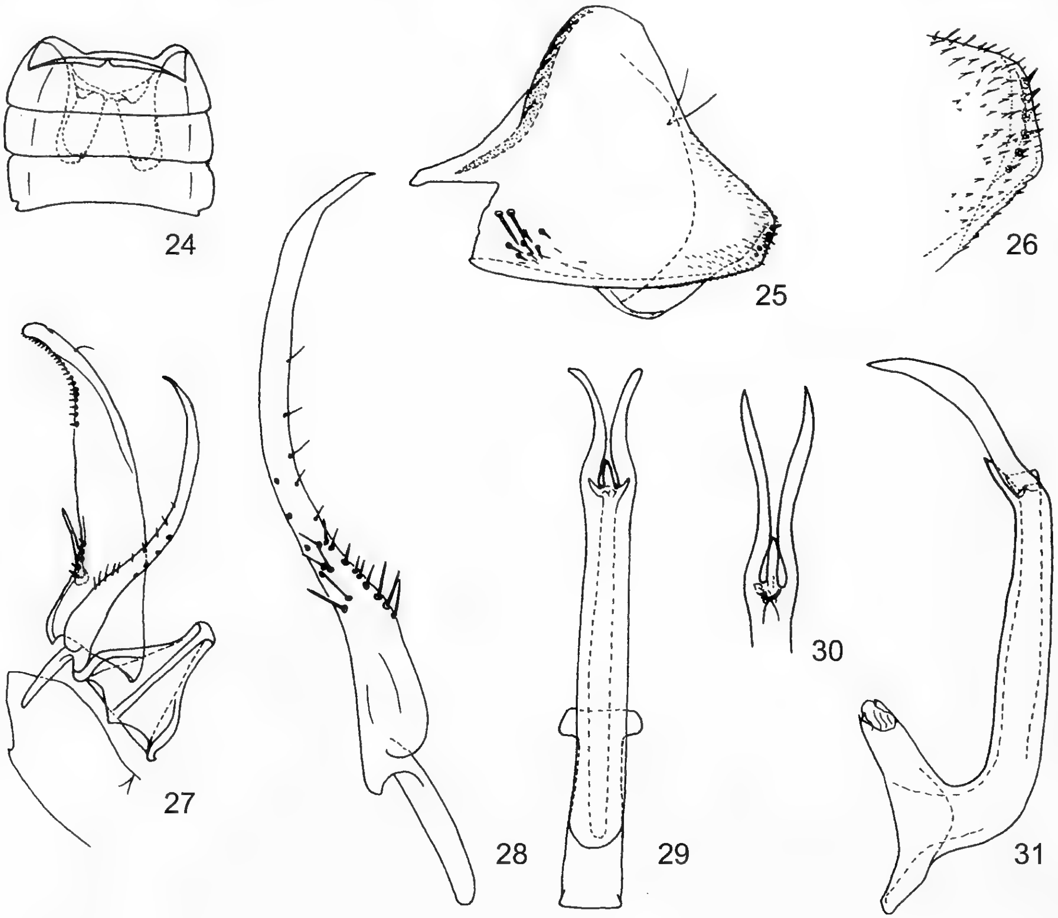
Type material.—Holotype: ♂, CHINA. Yunnan Province: Kunming, Jindian Botanic Garden, alt. 2,050 m, Jan.2, 2000, coll. I. Dworakowska (NWAFU).

Etymology.—The species is named for the three processes of the aedeagus.

Warodia annulata Zhang and Huang, new species

(Figs. 32–38)

Notes.—This species is close to *W. hoso*, but the aedeagal shaft of the former species is arched, with all processes paired and the dorsal ones crossed (Figs. 37–38).



Figs. 24–31. *Warodia tricornis*. 24, Abdominal apodemes. 25, ♂ pygofer, lateral view. 26, Hind part of ♂ pygofer, lateral view. 27, Paramere, connective, subgenital plate and sternite 9, dorsal view. 28, Paramere. 29, Aedeagus, posterior view. 30, Apical part of aedeagus, ventral view. 31, Aedeagus, lateral view.

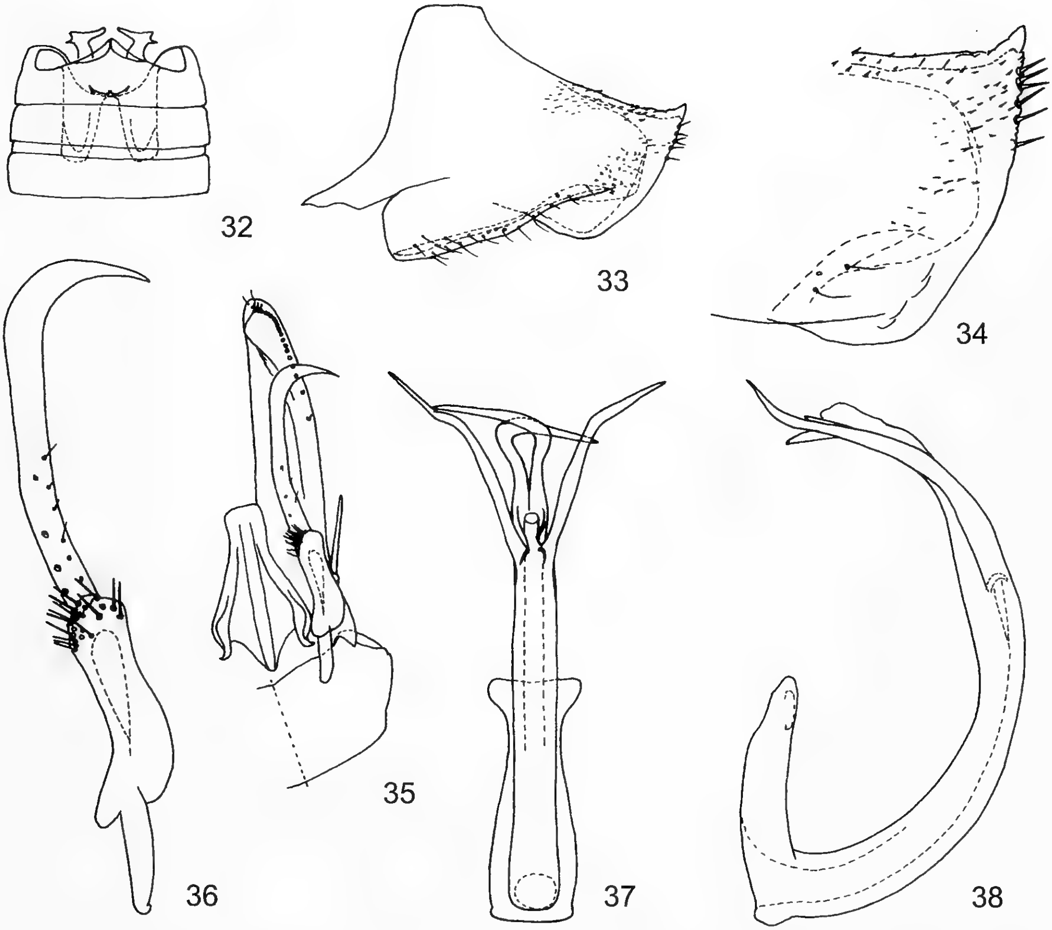
Description.—Yellowish; forewing greenish yellow, with faint streaks, apical quarter light smoky.

Male. Abdominal apodemes reaching to 1/3 of 5th abdominal sternite (Fig. 32). Pygofer lobe with acute protrusion dorsoapically, posterior margin rounded with row of rigid setae on upper part (Fig. 34). Subgenital plate bearing a group of rigid setae apically and peglike setae along upper 1/3 of outer margin (Fig. 35). Paramere with apex somewhat hooked, with thick setae on lateral lobe (Fig. 36). Aedeagus evenly recurved (Fig. 38), with two pairs of apical processes, medial pair crossed ringlike at midlength, in posterior view, lateral pair curved laterad (Fig. 37).

Length: ♂, 3.12 mm.

Type material.—Holotype: ♂, CHINA. Yunnan Province: Xinzhu, alt. 2,450 m, on Ericaceae, Nov.14, 1999, coll. I. Dworakowska (NWAFU).

Etymology.—The specific name is derived from the Latin words "*annulata*," referring to the ringlike shape formed by the crossed dorsal processes of the aedeagus in posterior view.



Figs. 32–38. *Warodia annulata*. 32, Abdominal apodemes. 33, ♂ pygofer, lateral view. 34, Hind part of ♂ pygofer, lateral view. 35, Paramere, connective, subgenital plate and sternite 9, dorsal view. 36, Paramere. 37, Aedeagus, posterior view. 38, Aedeagus, lateral view.

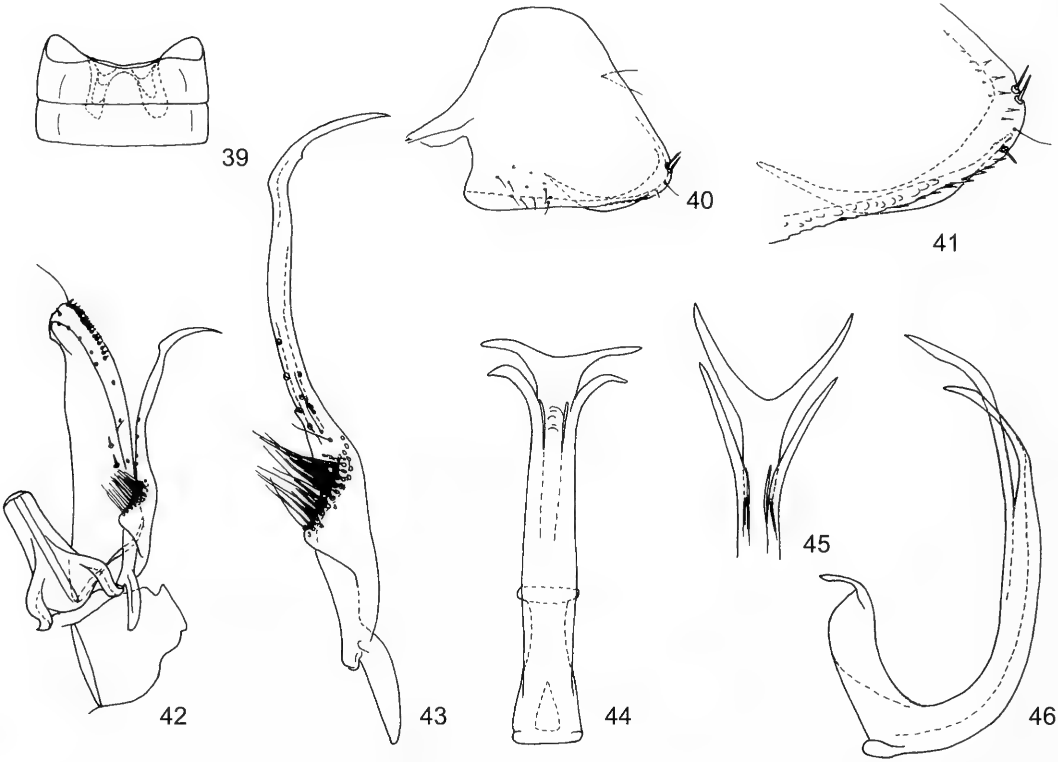
Warodia falcata Zhang and Huang, new species

(Figs. 39–46)

Notes.—This species is similar to *W. annulata*, but it can be distinguished from the latter in having the male pygofer narrowing and rounded caudally without a protrusion (Figs. 40–41) and the apical aedeagal processes shorter and straighter (Fig. 45).

Description.—Beige. Patches on lateral margin of vertex and lateral part of anterior margin of pronotum yellow, basal triangles golden yellow; longitudinal oval patch on midline of pronotum yellowish ocher. Streaks in forewing, from base to apical part, yellowish ocher to yellow.

Male. Abdominal apodemes reaching 1/3 length of 4th abdominal sternite (Fig. 39). Pygofer lobe rounded apically, with few rigid setae on upper angle (Fig. 41). Row of marginal setae on subgenital plate interrupted, with very few setae basally (Fig. 42). Paramere with apex slender and falciform, dorsomedial lobe with numerous gracile and rigid setae (Fig. 43). Aedeagus evenly recurved, with two pairs of distal pro-



Figs. 39–46. *Warodia falcata*. 39, Abdominal apodemes. 40, ♂ pygofer, lateral view. 41, Hind part of ♂ pygofer, lateral view. 42, Paramere, connective, subgenital plate and sternite 9, dorsal view. 43, Paramere. 44, Aedeagus, posterior view. 45, Apical part of aedeagus, ventral view. 46, Aedeagus, lateral view.

cesses curved laterad (Fig. 46), dorsal pair longer and fused basally (Fig. 45).

Length: ♂, 3.12 mm; ♀, 3.06 mm.

Type material.—Holotype: ♂, CHINA. Yunnan Province: Xinzhu Botanic Garden, alt. 2,300 m, on grass and shrub, Nov.16, 1999, coll. I. Dworakowska (NWAFU). Paratype, 1 ♀, same data as holotype (NWAFU).

Etymology.—The species is named for the sicle-shaped apex of the paramere.

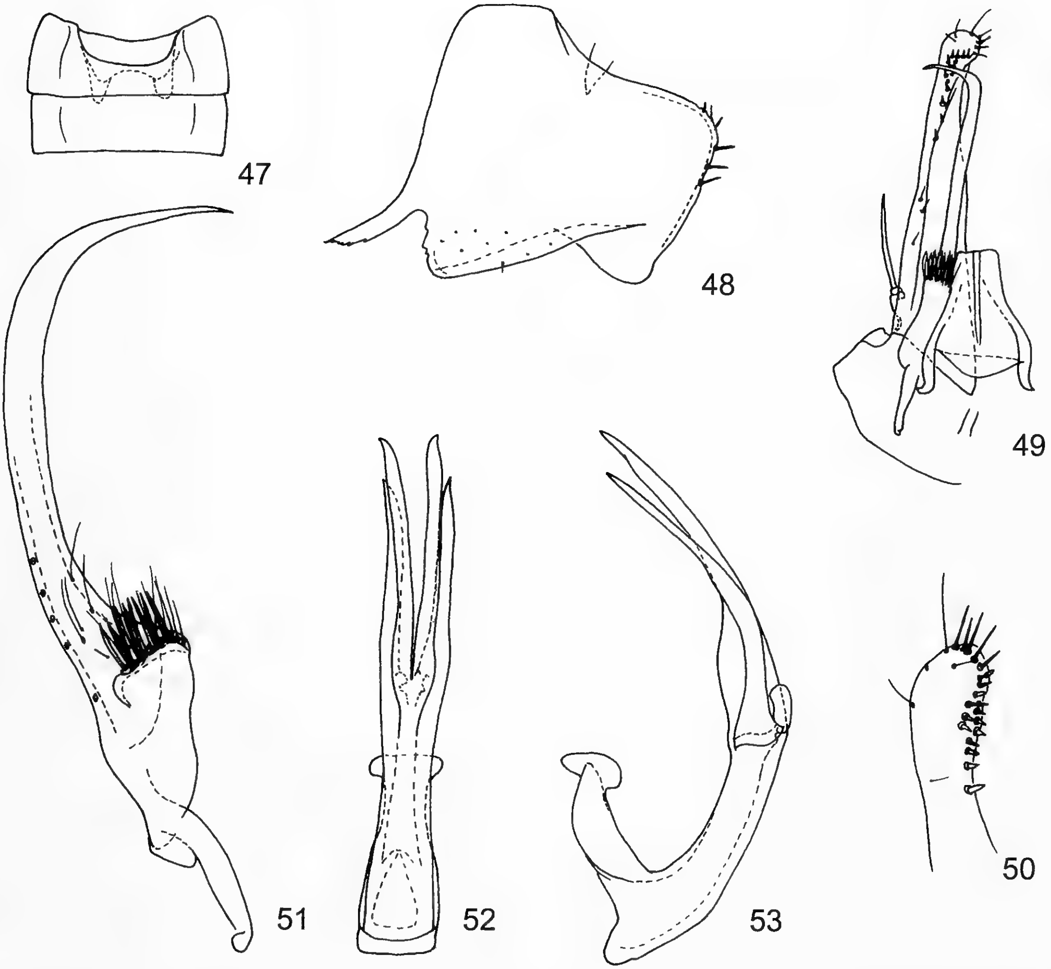
Warodia lineata Zhang and Huang, new species

(Figs. 47–53)

Notes.—This species is close to *W. falcata* externally, but it differs from the latter in having the male pygofer broadened and truncate caudally (Fig. 48) and the aedeagus with processes longer than the stout shaft (Fig. 53).

Description.—Beige. Two patches on disk of vertex yellow. Pronotum with hind part light smoky, two patches N-shaped on disc yellowish orange, each with small reddish-orange spots scattered on inner arm. Scutellum with basal triangles infuscate, tip and lateral margin blackish brown. Forewing yellowish with apical quarter smoky with reddish-orange streaks.

Male. Abdominal apodemes reaching 4th abdominal sternite (Fig. 47). Pygofer lobe truncate and broadened, with a few rigid setae on upper part of posterior margin (Fig. 48). Subgenital plates with marginal row of setae interrupted, with few setae located near midlength (Fig. 49). Paramere with apex long and



Figs. 47–53. *Warodia lineata*. 47, Abdominal apodemes. 48, ♂ pygofer, lateral view. 49, Paramere, connective, subgenital plate and sternite 9, dorsal view. 50, Apical part of subgenital plate. 51, Paramere. 52, Aedeagus, posterior view. 53, Aedeagus, lateral view.

arched, acute apically; few gracile and numerous rigid setae on upper part of lateral lobe (Fig. 51). Aedeagal shaft short and slightly curved dorsally (Fig. 53), with two pairs of strong processes at tip, each pair relatively straight and longer than shaft (Fig. 52).

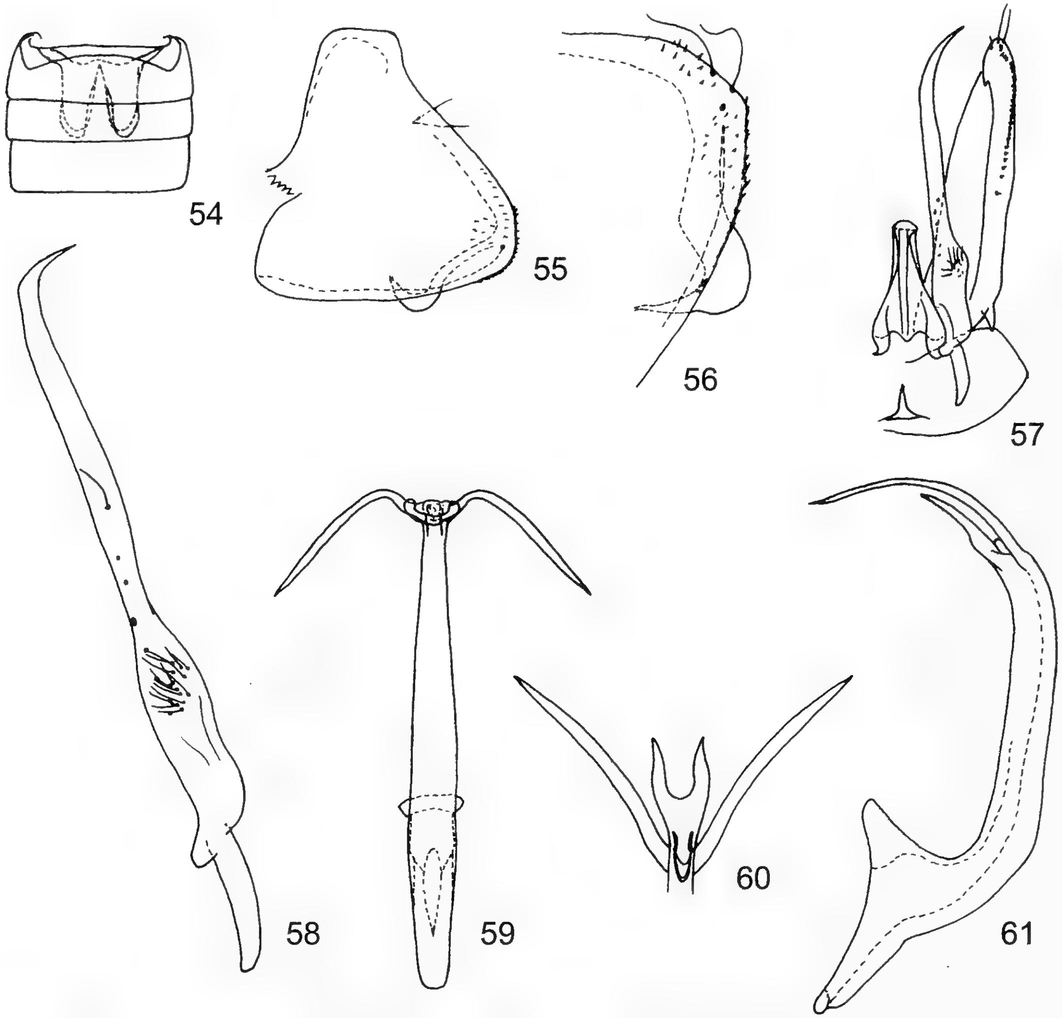
Length: ♂, 3.75 mm; ♀, 3.60 mm.

Type material.—Holotype: ♂, CHINA. Yunnan Province: Xinzhu, alt. 2,450 m, on Ericaceae, Nov.14, 1999, coll. I. Dworakowska (NWAFU). Paratype: 1 ♂, 1 ♀, north slope, alt. 2,300 m, on *Alnus*, Nov.16, 1999; 1 ♀, north slope, alt. 2,400 m, Nov.16, 1999, coll. I. Dworakowska (NWAFU); 1 ♂, 1 ♀, Kunming, Xishan, alt. 2,000 m, May 16, 1981, coll. Jikun Yang (CAU).

Etymology.—The specific name is derived from the Latin words "*lineata*," referring to the erect processes of the aedeagus.

Warodia rigida **Zhang and Huang, new species**
(Figs. 54–61)

Notes.—This species resembles *W. biguttata* in the male genitalia, but it can



Figs. 54–61. *Warodia rigida*. 54, Abdominal apodemes. 55, ♂ pygofer, lateral view. 56, Hind part of ♂ pygofer, lateral view. 57, Paramere, connective, subgenital plate and sternite 9, dorsal view. 58, Paramere. 59, Aedeagus, posterior view. 60, Apical part of aedeagus, from above. 61, Aedeagus, lateral view.

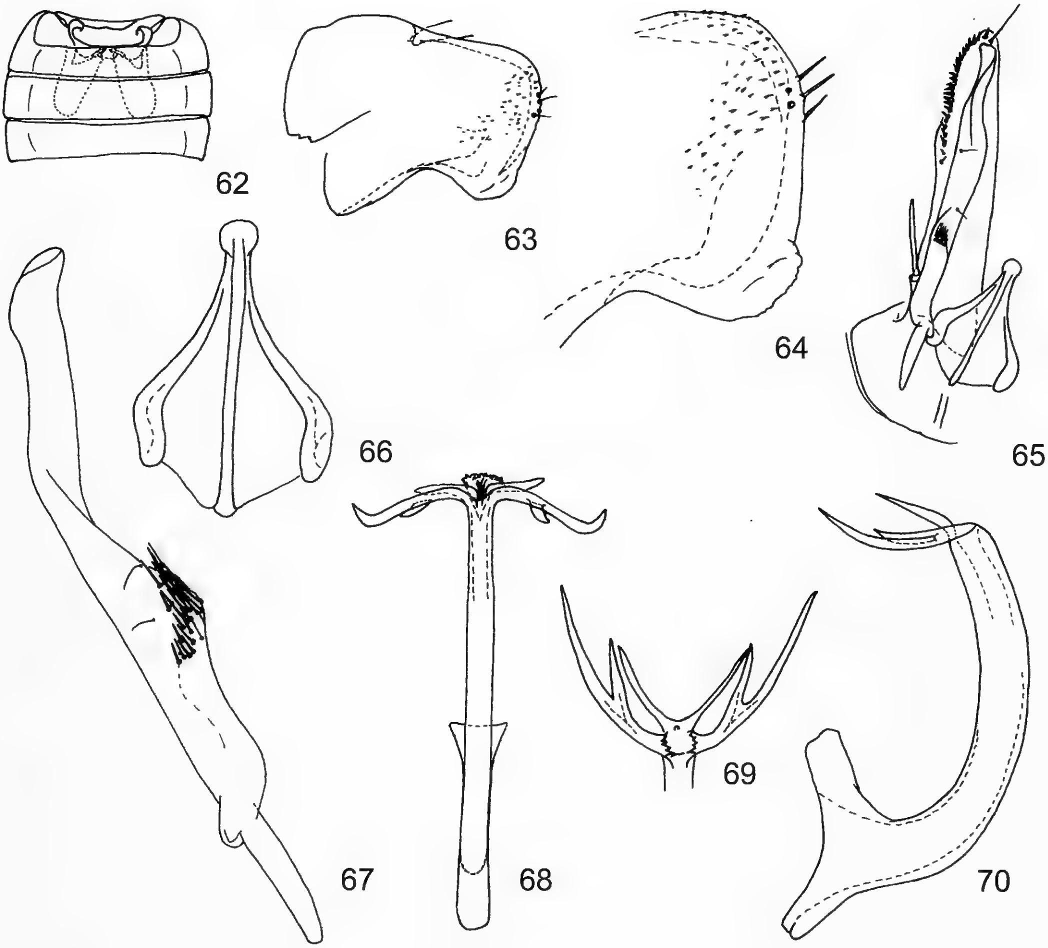
be distinguished from the latter in having the dorsoapical aedeagal processes on a longer base and the lateral processes V-shaped in dorsal view (Fig. 60).

Description.—Beige. Patches near midline of vertex, anterior part of pronotum, scutellum, streaks in Cua and clavus and rounded patch at end of claval area of forewing yellowish.

Male. Abdominal apodemes extended nearly 5th abdominal sternite (Fig. 54). Pygofer lobe narrow, apex somewhat truncate, microsetae not detectable (Fig. 56). Subgenital plate with row of lateral setae on caudal half (Fig. 57). Paramere with apex relatively straight with a hooklike apex; numerous gracile and few rigid setae on central part (Fig. 58). Aedeagus shaft relatively straight, bearing two pairs of processes on tip (Fig. 61), dorsal pair U-shaped and about half length of slender lateral pair (Fig. 60).

Length: ♂, 3.30 mm.

Type material.—Holotype: ♂, CHINA. Yunnan Province: Xinzhu, north-



Figs. 62–70. *Warodia gracilicornis*. 62, Abdominal apodemes. 63, ♂ pygofer, lateral view. 64, Hind part of ♂ pygofer, lateral view. 65, Paramere, connective, subgenital plate and sternite 9, dorsal view. 66, Connective. 67, Paramere. 68, Aedeagus, posterior view. 69, Apical part of aedeagus, dorsal view. 70, Aedeagus, lateral view.

west slope, alt. 2,400–2,500 m, Nov.16, 1999, coll. I. Dworakowska (NWAFU).

Etymology.—The species is named for its rigid dorsal aedeagal appendages.

Warodia gracilicornis Zhang and Huang, new species

(Figs. 62–70)

Notes.—This species is close to *W. rigida*, but it differs from the latter by its broadened posterior margin of the pygofer lobe (Fig. 64) and branched lateral aedeagal process (Fig. 69).

Description.—Beige. Patches near midline of vertex, streaks along anterior margin of pronotum, scutellum and streaks on forewing yellow.

Male. Abdominal apodemes reaching end of 4th abdominal sternite (Fig. 62). Pygofer lobe with posterior margin strongly truncate, with a few rigid setae on caudodorsal angle (Fig. 64). Subgenital plate with row of compact and relatively long thickened setae (Fig. 65). Paramere with short apex rounded apically; numerous short and rigid setae on lateral lobe (Fig. 67). Aedeagal shaft arched, bearing two pairs of gracile processes (Fig. 70), dorsal pair V-shaped, lateral pair with a short inner branch (Fig. 69).

Length: ♂, 3.12 mm.

Type material.—Holotype: ♂, CHINA. Yunnan Province: Xinzhu, pine forest, alt. 2,300 m, Nov.15, 1999, coll. I. Dworakowska (NWAFU).

Etymology.—The species is named for its gracile aedeagal appendages.

ACKNOWLEDGMENTS

We thank I. Dworakowska for her contribution to the knowledge of Chinese Typhlocybinae during her visit to the Entomology Museum of Northwest A&F University supported by CIDA, and M. Webb for revising the manuscript. This project is supported by "Northwest A&F University Grant for Outstanding Faculty Members," and "Northwest A&F University Youth Foundation."

LITERATURE CITED

Dworakowska, I. 1970. On some East Palaearctic and Oriental Typhlocybini (Homoptera, Cicadellidae,Typhlocybinae). Bulletin de l'Academie Polonaise des Sciences. Serie des Sciences Biologiques 18(4): 211–217.

———. 1982. Typhlocybini of Asia (Homoptera, Auchenorrhyncha, Cicadellidae). Entomologische Abhandlungen Staatlichen Museum für Tierkunde in Dresden 45(6): 99–181.

Hu, J. and C. Kuoh. 1991. Six new species of Typhlocybini (Homptera: Cicadellidae). Entomotaxonomia 13(4): 255–262.

Matsumura, S. 1932. A revision of the Palaearctic and Oriental Typhlocybid-genera with description of new species and new genera. Insecta Matsumurana 6: 55–120.

Zhang, Y. and N. Xiao. 2000. Typhlocybinae (Auchenorryncha: Cicadellidae) Collected by a light trap in Yuxi, Yunnan. Entomotaxonomia 22(2): 107–115.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 897–908

A NEW SPECIES AND SPECIES DISTRIBUTION RECORDS OF *NEOLEUCINODES* (LEPIDOPTERA: CRAMBIDAE: SPILOMELINAE) FROM COLOMBIA FEEDING ON *SOLANUM* SP.

Ana Elizabeth Díaz and M. Alma Solis

(AED) Programa de Manejo Integrado de Plagas, CORPOICA, C. I. Palmira, Colombia (e-mail: anadiaz@telesat.com.co); (MAS) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U. S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, DC 20013-7012, U.S.A. (e-mail: alma.solis@ars.usda.gov)

Abstract.—***Neoleucinodes silvaniae*, n. sp.**, from Colombia, is described. The larvae feed on the fruit of wild *Solanum lanceifolium* Jacq. Adults and larvae of the new species are figured. The new species is compared to *Neoleucinodes elegantalis* (Guenée), a major pest of tomatoes throughout South America. *Neoleucinodes prophetica* (Dyar), *N. imperialis* (Guenée), and *N. torvis* Capps are reported from Colombia for the first time.

Key Words: Colombia, *Solanum*, Solanaceae, larvae, morphology

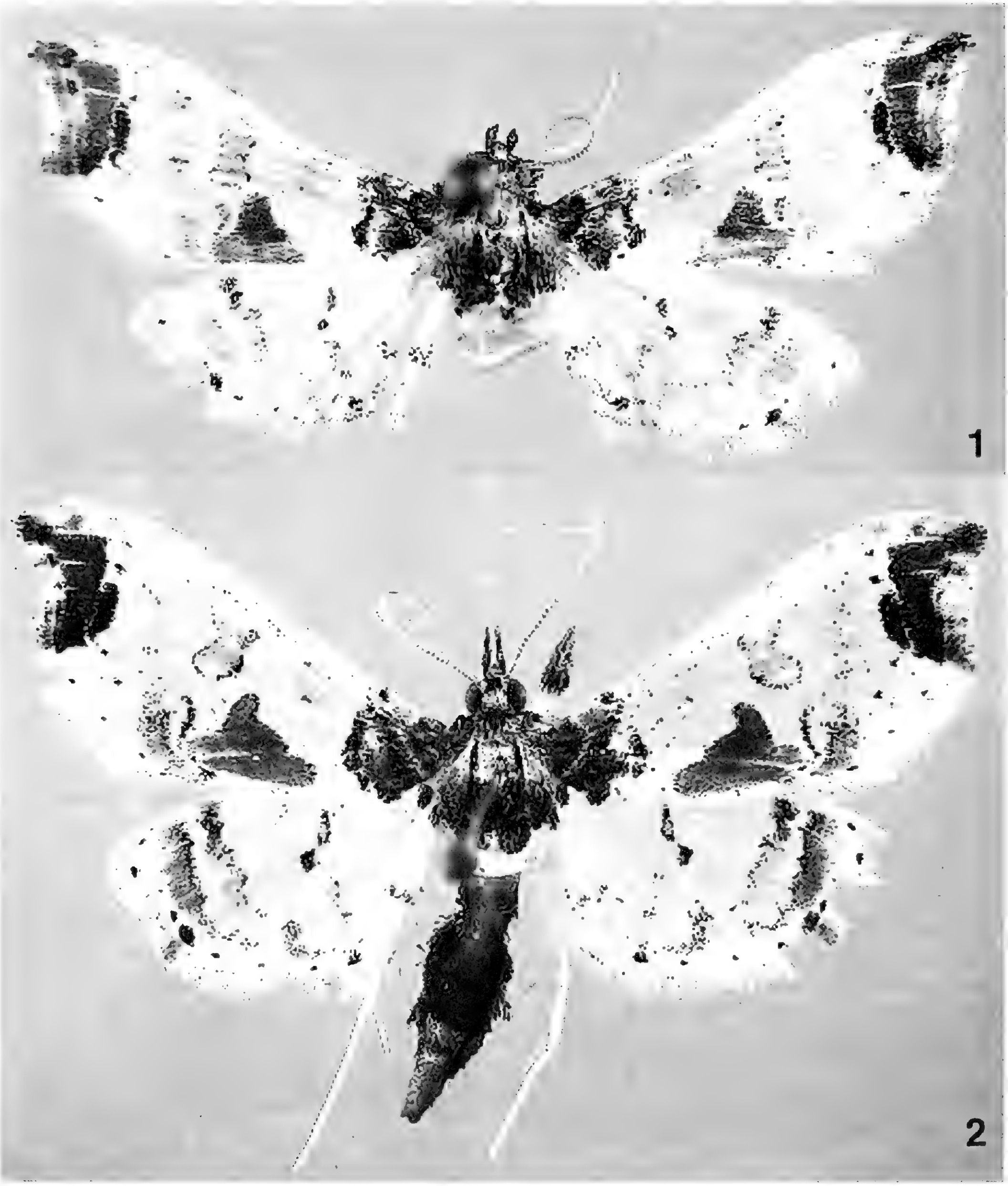
Neoleucinodes elegantalis (Guenée, 1854), the tomato fruit borer, causes economic loss throughout South America in crops of solanaceous vegetables including tomato, *Solanum lycopersicum* L., eggplant, *Solanum melongena* L., pepper, *Capsicum annuum* L., and tropical solanaceous fruits such as the tomato tree, *Solanum betaceum* Cav., and naranjilla, *Solanum quitoense* Lam. In Colombia *N. elegantalis* was the only species of this genus reported in the literature to occur in warm and cold climates (Viafára et al. 1999) primarily as a pest of solanaceous crops (Gallego 1960, A.L.A.E. 1968, Sanchez 1973, Posada et al. 1981, Gallego and Velez 1992). Capps (1948) reported *N. elegantalis* from "San Antonio," department unknown, in Colombia.

Capps (1948) described and revised *Neoleucinodes*, and described several new species and closely related genera. The first author (AED) conducted the first study on the distribution and biology of *N. elegantalis* associated with cultivated and wild solanaceous species in Colombia. In addition, this is the only comprehensive re-examination of *Neoleucinodes* species and its description since Capps (1948).

In this paper, the presence of *N. elegantalis* in Colombia was confirmed, a new species was discovered, and is named here, and three other species of the genus were discovered. The adults and larvae of the new species are described below and compared to and/or differentiated from *N. elegantalis*.

Material and Methods

Solanaceous fruits infested with larvae were collected from 50 localities and 15 departments in Colombia and taken to the laboratory in Palmira (COPROICA). Fifty percent of the larvae from each locality were boiled and placed in vials



Figs. 1–2. Male adult dorsal view. 1, *Neoleucinodes silvaniae*. 2, *N. elegantalis*.

with 30% ethanol. The other fifty percent of the infested fruits were placed in separate rearing containers where larvae matured and pupated within cocoons in paper towels. After emergence, the moths were frozen, wings were spread, and specimens were labelled. The specimens are deposited at COPROICA in Palmira.

Eighty-eight male and female genitalic preparations (50% males, 50% females) were made from different species feeding on different host plants. The abdomen of the adult was removed, cleared in 10% KOH, transferred to 15% ethanol, and brushed to remove scales. Then they were stained with chlorazol black and the excess color removed with clove oil. Before slide mounting in Canada Balsam, the clove oil was removed with Histoclear.

Observations were made using a Wild M5 dissecting microscope and a Leitz Laborlux-S compound scope. Measurements made using an external ruler (Wild Heerbrugg Switzerland – 310345) included female genitalic structures, forewing length, and labial palpal length. Specifically, the length of the bursa copulatrix (from the ostium bursae to the anterior end of the corpus bursae) and the length of A7, length from the ductus seminalis to the anterior end of the corpus bursae, from the intersegmental part of A8 to the anterior margin of the A7, and lengths of the anterior and posterior apophyses. A camera lucida was used to make sketches of the third labial palpal segment of the adults, and its length was indirectly measured from the drawing. The forewing length was measured from the base to apex, and the width was measured from the costal margin to posterior margin along the median line.

The following abbreviations are used: National Museum of Natural History, Washington, D.C. (USNM); Entomological Museum, Agronomy Faculty, National University of Colombia, Bogotá (UNAB); National Taxonomic Collection of Insect "Luis Maria Murillo" (CTNI). Morphological terminology is according to Munroe and Solis (1995) and Maes (1995) for the adults and Stehr (1987) for the larvae.

The diagnosis of the new species below includes only derived characters or synapomorphies. The adults of the new species were compared to closely related species from the Western Hemisphere of *Neoleucinodes* (*N. elegantalis* (Guenée), *N. dissolvens* (Dyar), *N. prophetica* (Dyar), *N. torvis* Capps, and *N. imperialis* (Guenée)), and to species in related genera, *Proelucinodes melanoleuca* Hampson, *P. xylopastalis* (Schaus). In addition, the adults were compared to *Euleucinodes conifrons* Capps, and *Leucinodes orbonalis* (Guenée) from Africa, the latter a pest of solanaceous crops that has been intercepted at U.S. ports. Only the host plants and larvae of *N. elegantalis* and *L. orbonalis* are known, therefore the immatures of the new species were compared only to these two species.

RESULTS

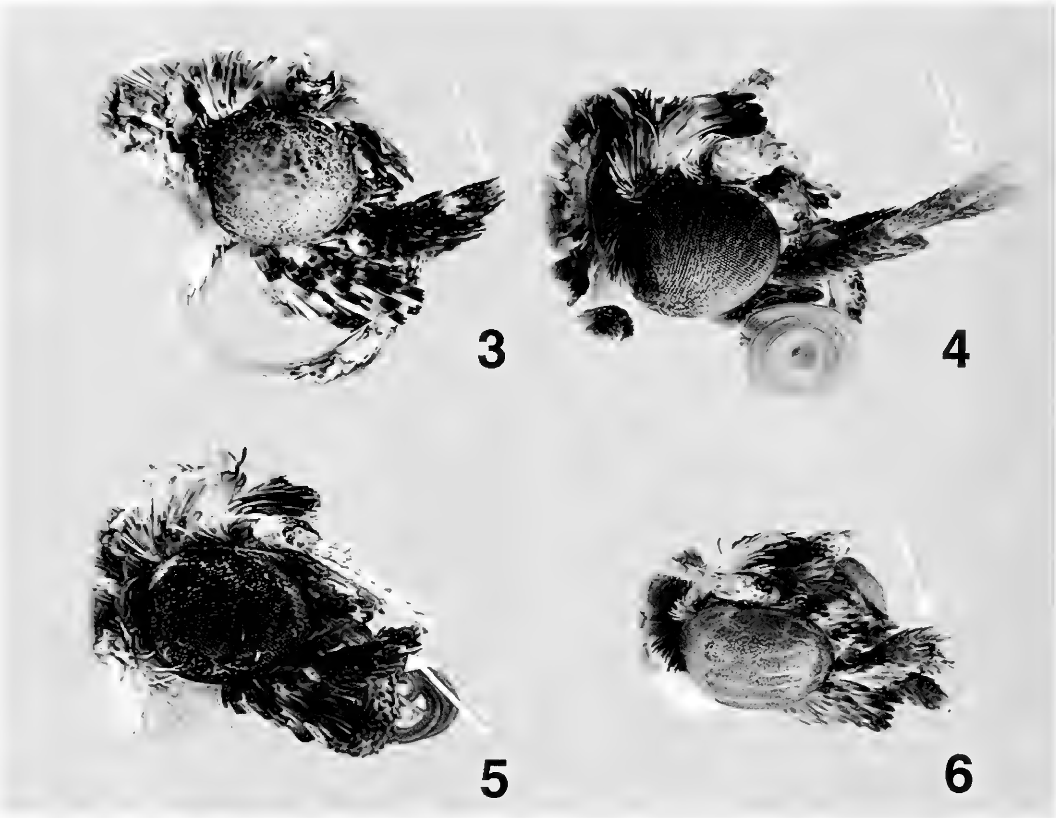
In Colombia, *Neoleucinodes* is now comprised of five species. Their distributions and known hosts within Colombia and in South America have been expanded. *Neoleucinodes elegantalis*, the only previously known species in Colombia, was collected in the three cordilleras of the Andean region and the northern Caribbean region of Colombia. It has been reared on five cultivated and seven wild solanaceous species. The new species described below, from Dept. Cundinamarca, was reared on *S. lanceifolium*; *Neoleucinodes prophetica* collected in Darién, Dept. Valle on January 5, 2006 at an altitude of 1,539 m was reared on *Solanum umbellatum* Mill; *N. imperialis* collected in Algeciras, Dept. Huila on February 15, 2006 at an altitude of 2,248 m. was reared on *Solanum subinerme* Jacq; and *N. torvis* collected from Jardín, Dept. Antioquia on February 9, 2006 at an altitude of 2,282 was reared on *Solanum rudepannum* Dunal.

Neoleucinodes silvaniae **Diaz and Solis, new species**

(Figs. 1, 7, 9, 11–12, 14, 16–19, 24–25)

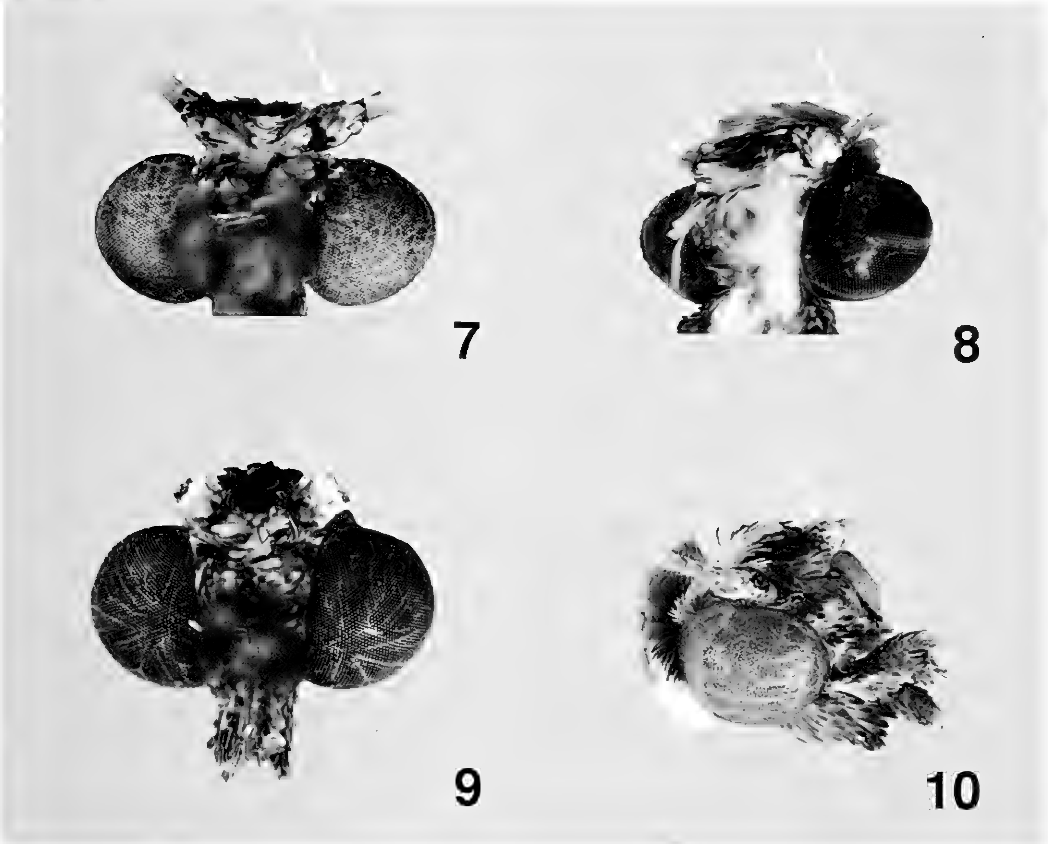
Diagnosis.—Third segment of labial palpus in *N. silvaniae* short, less than 0.4 mm, in both sexes. Female scape red dorsally, male scape white dorsally. Abdomen grey and whitish. Forewing length 2.2 cm in females and 1.7 cm in males.

Adult.—*Head:* Frons round, red; ocelli posteriorly surrounded by white scales; chaetosema with red and white scales.



Figs. 3–6. 3, Female, *Neoleucinodes silvaniae*. 4, Female, *N. elegantalis*. 5, Male, *N. silvaniae*. 6, Male, *N. elegantalis* [arrow = third labial palpal segment].

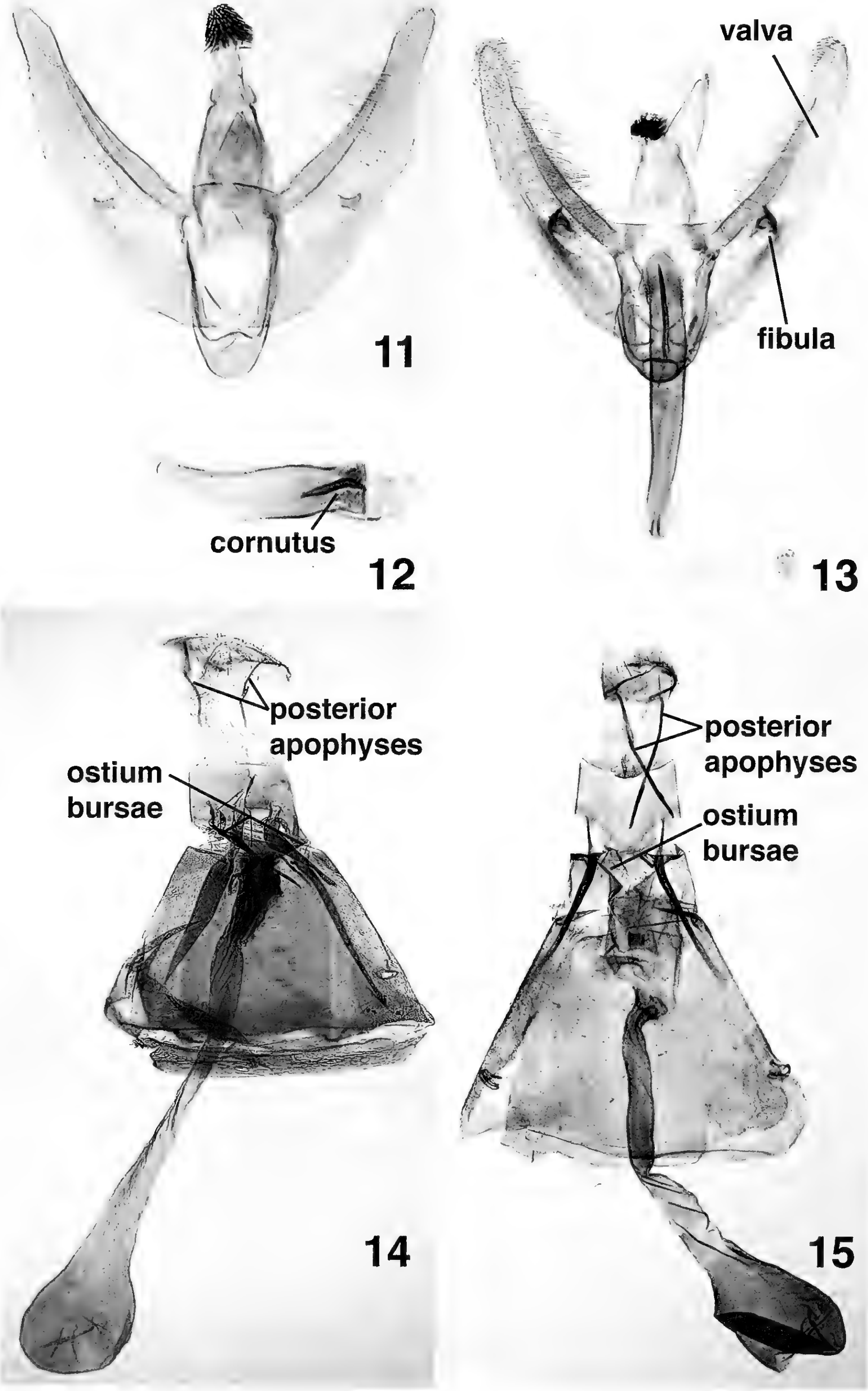
Antenna with female scape dorsally red, laterally red and white; male scape white with some red scales dorsally (Figs. 7, 9). Labial palpus red; both sexes with third segment of labial palpus short. Third labial palpal segment in female = 0.4 mm (n = 1) (Fig. 3), in male = 0.1 mm (n = 1) (Fig. 5). Maxillary palpus short in both sexes. Patagium with red and white scales. Tegula mostly black with red scales, posteriorly with brown-tipped scales, reaching posterior margin of metathorax. *Prothorax:* Red, black- tipped scales, anterolaterally with two small black spots. *Mesothorax:* Scales red, black-tipped. Mesoscutellum with two tufts of red and black-tipped scales on anterolateral corners. *Metathorax:* Dorsally white with two tufts of red and black-tipped scales protruding from each anterolateral side of metascutum. *Legs:* Front coxa with white, red, and yellow scales. Front femur white with red and black-tipped scales; front tibia with black scales on base and white scales on apex; front tarsus white and pretarsus with black empodium; mid- and hindlegs white with some red scales on tibial base; last two tarsal segments yellow in color. *Wings* (Fig. 1): Forewing with hyaline scales, white at margins; length = 9.5 mm, width = 3.25 mm (n = 4); scales red, black-tipped at base of wing. Hindwing with black discal spot and postmedian line. Golden yellow at apex in radial area and at margin (Fig. 1). *Abdomen:* First tergite white, second and third tergites with varying amount of golden-yellow, red, and black scales, with some white at medial line



Figs. 7–10. Antennal scape (arrow). 7, *Neoleucinodes silvaniae*, female. 8, *N. elegantalis*, female. 9, *N. silvaniae*, male. 10, *N. elegantalis*, male.

and distal margin, abdominal sternites white; distally curved dorsally in both females and males of live adults. *Male genitalia* (Fig. 11): Tegumen with anterior margin completely sclerotized; fibula simple with base not hollow, closer to valval base than to apex. Apex of valva truncate, sclerotized costa extending 3/4 of valva length; cornutus of aedeagus bladelike, curved slightly apically (Fig. 12). *Female genitalia* (Fig. 14): Ostium bursae membranous, bow-shaped, with large aperture; anterior and posterior apophyses short, approximate same length (0.7 and 0.6 mm, respectively (n = 1)); bursa copulatrix (ductus + bursae) three times length of A7; signum absent.

Larva (Figs. 16–19.).—6–8 mm long (last instar) (n = 1), body smooth, beige. Body with conspicuously pigmented pinacula, particularly on mesothorax (Fig. 16). Head yellow with dark reticulations. Posterior margin of cephalic capsule with black pigmentation. Stemma 2 closer to 1 than to stemma 3. Stemma black, arranged in normal arc. Seta S1 on median line connecting center of stemma 2 and 3. Prothoracic shield dark brown with strong dark marking, shield sclerotized with reniform spot and with extended dark brown reticulations posterior to XD2 seta. Dorsal anterior, dorsal posterior, and middle central areas of prothoracic shield with dark brown, poorly defined reticulations. Two pores between setae D1 and XD1, and between D1 and D2. Prothorax with prespiracular setae, L1 and L2, and two



Figs. 11–15. Genitalia. 11, Male *Neoleucinodes silvaniae*. 12, Male aedeagus *N. silvaniae*. 13. Male *N. elegantalis*. 14, Female *N. silvaniae*. 15, Female *N. elegantalis*.

subventral setae SV1 and SV2. Mesothorax and metathorax with one subventral seta, SV1. A3 to A8 with SD1 seta on pinaculum dorsal to each spiracle. Seta SD2 present and easily visible, borne on pigmented pinaculum anterior to spiracle (Fig. 19). Seta L1 close to L2 in same pinaculum below and anterior position in relation to spiracle. A9 with D2, D1, SD1 and L1, on same large, highly sclerotized pinaculum (Fig. 18); L3 present, L1 and L2 absent. Crochets on prolegs of A6 triordinal, oriented mesally; an incomplete circle, interrupted outwardly on lateral margin.

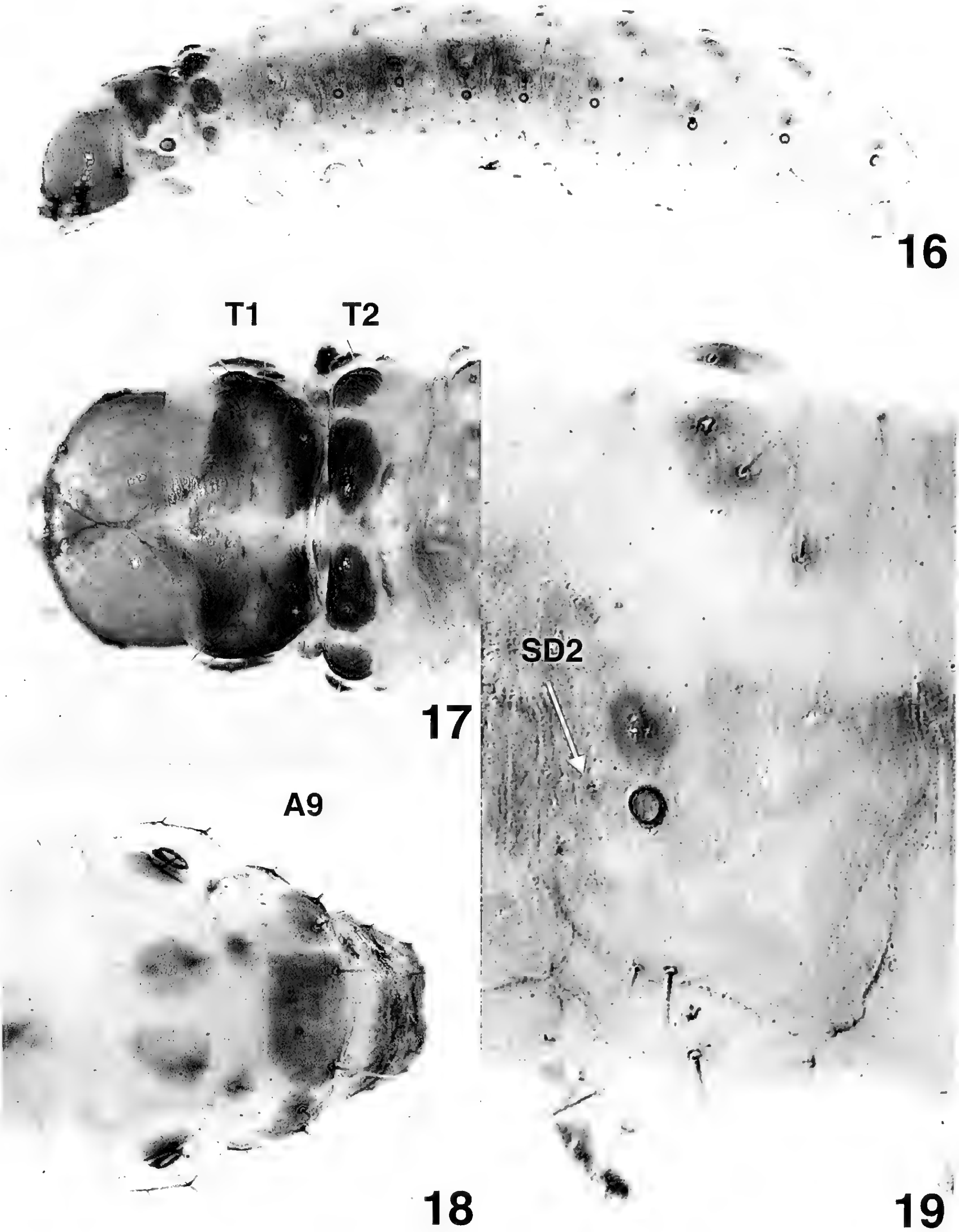
Biology.—*Neoleucinodes silvaniae* was reared on a wild solanaceus fruit, *Solanum lanceifolium* Jacq., called "uña de gato" in Spanish by the local farmers (Figs. 24–25). One fruit supports only one larva of *N. silvaniae*. The infested fruits have a scar that corresponds to the oviposition site, and the larva makes an exit hole before pupation. The larvae of *N. silvaniae* are parasitized by *Copidosoma* sp. (Hymenoptera: Encyrtidae).

Distribution.—Colombia, Department Cundinamarca.

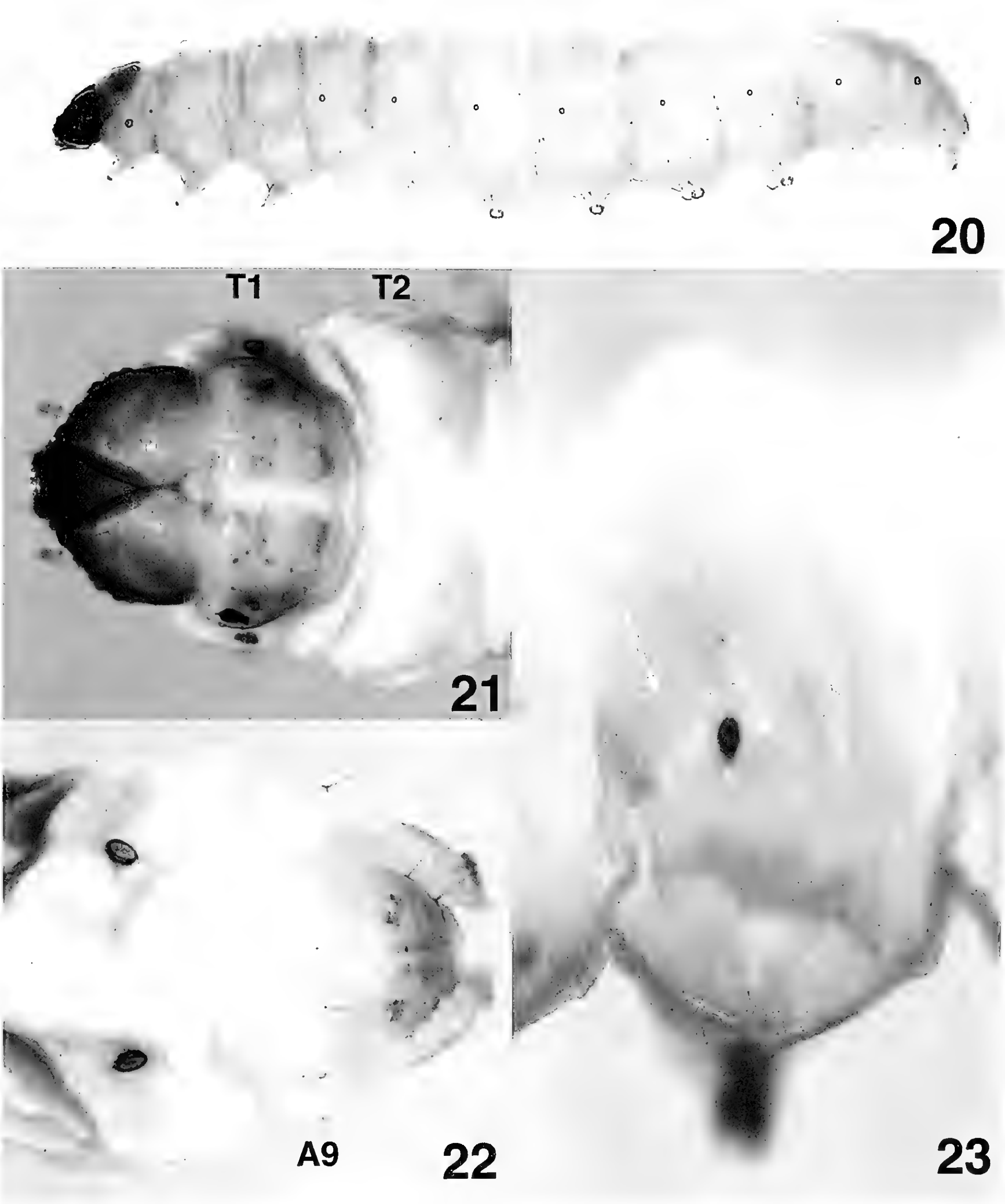
Type material.—Holotype male, Colombia, Cundinamarca, Vereda San Luis Bajo, Finca Villa Gloria. 4°42′15.2″N 74°37′6.41″W, 1,641 m alt., 24.ii.2005, Ex. *Solanum Solanum lanceifolium* Jacq. Collected by A.E. Diaz (Ana Elizabeth Diaz) [UNAB]. Paratypes: 5 ♂, 1 ♀ with same data as holotype [USNM, CTNI].

Etymology.—The species name *silvaniae* is the name of the municipality Silvania, where it was originally collected.

Species comparison.—Externally *N. silvaniae* appears identical to *N. elegantalis*, but it can be distinguished by the short third labial palpal segment in females and males of *N. silvaniae* (Figs. 3,5). The labial palpi in *N. elegantalis* are sexually dimorphic, the females have a long third labial palpal segment and in the males it is shorter (Figs. 4,6). The scape color is red in the females of *N. silvaniae*, but white in *N. elegantalis* females (Figs. 7–8). In *N. silvaniae* the ostium bursae is membranous, bow-shaped, and has a large aperture (Fig. 14). *Neoleucinodes elegantalis* also has a large aperture, but it is sclerotized and cup-shaped (Fig. 15). The anterior and posterior apophyses in *N. elegantalis* are approximately twice the length of apophyses in *N. silvaniae*. In the male genitalia (Figs. 11–13), *N. silvaniae* has a tegumen with the anterior margin completely sclerotized, but it is completely membranous in *N. elegantalis*. Although the fibula is closer to base than to apex of the valva in both species in comparison to other species in the genus, the fibula of *N. silvaniae* is simple with the base not hollow, and in *N. elegantalis* it is bulky, with a hollow base. The apex of the valva is truncate in *N. silvaniae*, and round in *N. elegantalis*. The cornutus of the aedeagus is bladelike in both species, but in *N. silvaniae* the apex is less curved that in *N. elegantalis*. The larva (Figs. 16–19) of *N. silvaniae* has conspicuously raised, sclerotized, pigmented pinacula, and the pinaculum color is different from the adjacent body color, particularly on the mesothorax where the pigmentaton is brownish. *Neoleucinodes elegantalis* pinacula are usually concolorous with the adjacent body area and only slightly raised (blisterlike), particularly on the mesothorax (Figs. 20–23). The prothoracic shield of *N. silvaniae* is dark brown, with strong, dark markings, with a sclerotized reniform spot and with extended, blackish-brown reticulations posterior to the XD2 seta. In *N. elegantalis* the prothoracic shield is pale yellow with light brown markings, without a conspicuous blackish, reniform spot posterior to seta XD2. In *N. silvaniae* seta SD2 is present and easily visible with a dissecting scope on a pigmented pinaculum in front of the spiracle on A3 to A8. In *N. elegantalis* SD2 is present on A3 to A8, but they are difficult to see with a dissecting microscope and are not associated



Figs. 16–19. *Neoleucinodes silvaniae* larva. 16, Entire lateral view. 17, Mesothorax with pinaculum color different from adjacent body color. 18, Pinaculum of A9 with D2, D1, SD1 and L1 setae. 19, Seta SD2 visible (arrow) on pigmented pinaculum anterior to spiracle on A5.



Figs. 20–23. *Neoleucinodes elegantalis* larva. 20, Entire lateral view. 21, Mesothorax with pinaculum color different from adjacent body color. 22, Pinaculum of A9 with D2, D1, SD1 and L1 setae. 23, Seta SD2 not visible (arrow) anterior to spiracle on A5.

with a pigmented pinaculum. On A9 of *N. silvaniae* D1, D2, SD1, and L1 setae are on the same large pinaculum that is strongly sclerotized, but in *N. elegantalis* D1 and D2 are separated from SD1 and L1; neither the pinaculum or adjacent area are visible, but are slightly raised (blisterlike).


24


25

DISCUSSION

The discovery of more species of *Neoleucinodes* in Colombia is not unexpected. The three species, *N. prophetica*, *N. imperialis*, and *N. torvis*, occur in neighboring countries. The only species of *Neoleucinodes* not yet discovered in Colombia, *N. dissolvens*, is known to occur in the neighboring countries of Ecuador and Brazil. One major reason for these new discoveries is probably due to the paucity of adult moths collected at lights, the most common method for collecting moths, from Colombia. Also, because species new to Colombia were found feeding on wild solanaceous plants and not on economically important plants, they were less likely to be found by rearing.

Knowledge of *Neoleuciodes* species, their distribution and biology, is important for the development of biological control programs for the tomato fruit borer. Colombian farmers use insecticide applications as the only control strategy for *N. elegantalis*, although there are natural enemies of *N. elegantalis* that could be used for biological control. In addition, insecticide applications have been shown to be inefficient due to differences for each crop in the behavior of the larvae (Da Costa Lima 1949), and in the manner of oviposition and pupation (Viafara et al. 1999).

ACKNOWLEDGMENTS

We thank Martha Poveda (UMATA Silvania, Cundinamarca, Colombia) for her help with the local collecting; Joel Giron (Agronomy Engineering, National University of Colombia, Bogotá) for his invaluable help in the field collecting and spreading, mounting, and labelling of moths; and Juan Carlos Granados (Systematic Institute of Natural Sciences, National University of Colombia, Bogotá) for the host plant identification. We thank Michael Gates, SEL, USDA, for the parasitoid identification and Mark Metz, SEL, USDA for most of the photos. The first author thanks Jon A. (Buck) Lewis, Museum Specialist, Systematic Entomology Laboratory (USDA) for his advice with the genitalic preparation and photography and David Furth (Department of Entomology, Smithsonian Institution) for help with English in the earlier drafts of this manuscript.

LITERATURE CITED

Asociación Latinoamericana de Entomología A. L. A. E. 1968. Catalogo de insectos de importancia económica en Colombia. Publicación N°1. Agricultura Tropical. Bogotá (Colombia). 155 pp.

Capps, H. W. 1948. Status of the pyraustid moths of genus *Leucinodes* in the New World, with descriptions of new genera and species. Proceedings of the United States National Museum 98(3223): 69–83.

Da Costa Lima, A. 1949. Insectos do Brasil 6.° Tomo Capitulo XXVIII. Lepidópteros 2.a parte. Escola Nacional de Agronomía Serie didáctica N°. 8. 420 pp.

Gallego, F. 1960. Gusano del tomate de árbol. Revista Facultad de Agronomía Medellín (Colombia) 20(54): 39.

Gallego, F. and R. Vélez. 1992. Lista de insectos que afectan los principales cultivos, plantas forestales, animales domésticos y al hombre en Colombia. Universidad Nacional de Colombia. SOCOLEN Medellín (Colombia). 142 pp.

Maes, K. V. N. 1995. A comparative morphological study of the adult Crambidae (Lepidoptera: Pyraloidea). Annales de la Société royale entomologique de Belgique 131: 159–168.

Posada, L., I. Polania, A. López, N. Ruiz, and D. Rodríguez. 1981. Nuevo huésped. En: Notas y Noticias Entomológicas. Bogotá (Colombia). ICA. 11 pp.

←

Figs. 24–25. Host plant of *Neoleucinodes silvaniae*. 24, Wild *Solanum lanceifolium* named by local farmers as "uña de gato," 25, Infested fruit with *N. silvaniae* larva.

Sánchez, G. G. 1973. Las plagas del lulo y su control ICA Programa Nacional Entomología. Boletín Técnico N°25. 26 pp.

Stehr, F. W., ed. 1987. Order Lepidoptera, pp. 288–596. *In* and Stehr, F. W., ed. Immature insects. Volume 1. Kendall Hunt Publishing Company, Dubuque, Iowa. 754 pp.

Viafára, H. F., F. García, and A. E. Diaz. 1999. Parasitismo natural de *Neoleucinodes elegantalis* (Guenée) (Lepidoptera:Pyralidae) en algunas zonas productoras de solanaceas del Cauca y Valle del Cauca, Colombia. Revista Colombiana de Entomología 25(3–4): 151–159.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 909–913

A NEW SPECIES OF THE GENUS *CRAESUS* (HYMENOPTERA: TENTHREDINIDAE) FROM JAPAN FEEDING ON *JUGLANS* (JUGLANDACEAE)

Ichiji Togashi

1-chome, Tsurugihonmachi, Hakusan-shi, Ishikawa Prefecture 920-2121, Japan

Abstract.—***Craesus kondoi*, n. sp.**, from Honshu, Japan, is described and illustrated. It was reared from larvae feeding on leaves of *Juglans ailanthifolia* Carr. (Juglandaceae).

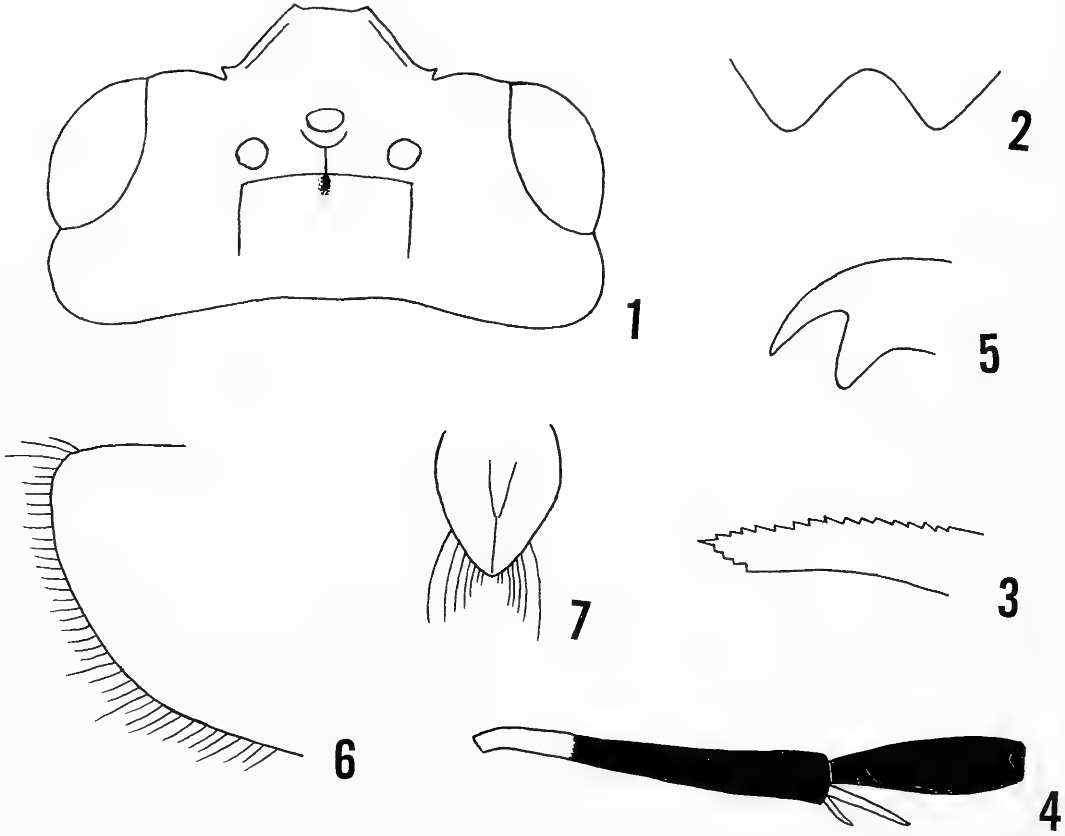
Key Words: Symphyta, Tenthredinidae, Nematinae, *Craesus*, new species, food plant, *Juglans ailanthifolia*

The genus *Craesus* Leach, 1817, is distributed in the Holarctic and Oriental regions (Benson 1963; Smith 1972). There are about 20 described world species (Taeger and Blank 2005). Among the Nematinae, *Craesus* is characterized by the expanded and laterally compressed hind basitarsus and apex of the hind tibia (Fig. 4). Larvae of most species of *Craesus* feed on the foliage of Betulaceae, Fagaceae, and Juglandaceae (Smith 1972; Togashi 1997). Six species are known from Japan, *C. betulae* Togashi, 1997, *C. japonicus* Takeuchi, 1921, *C. morimotoi* Togashi 1963, *C. platycaryae* Togashi, 1997, *C. rotundiformis* Togashi, 1997, and *C. shinoharai* Beneš, 1990 (Togashi 1997).

Recently, I examined six females and one male of a species of *Craesus* through the courtesy of Mr. T. Kondo which were reared from larvae feeding on the leaves of *Juglans ailanathifolia* Carr. According to the literature, these specimens closely resemble *C. japonica* from Japan and *C. castaneae* Rohwer from North America, but they are distinguished from these two species by the wing maculation and by the shape of the serrulae of the lancet. They also resemble *C. juglandis* Beneš, described from Korea and also from *Juglans ailanathifolia*, but are distinguished by the color of the clypeus, shape of the hind basitarsis, and length of the petiole of the anal cell of the hind wing. Therefore, I consider these specimens to represent a new species, and I describe and illustrate this species and give a revised key to the species of *Craesus* of Japan.

Key to Japanese Species of *Craesus* (Modified from Togashi 1997)

1. Female 2
– Male 8
2. Sawsheath nearly truncate in dorsal view; postocellar area rectangular 3
– Sawsheath subacute (Fig. 7) or rounded in dorsal view; postocellar area rectangular or subquadrate 4
3. Hind tibia entirely black; inner hind tibial spur nearly straight . . . . *morimotoi* Togashi
– Basal third of hind tibia milky white; inner hind tibial spur strongly curved. . . . . *shinoharai* Beneš
4. Basal half of hind tibia milky white; sawsheath rounded in dorsal view; lancet with 14 serrulae . . . . *rotundiformis* Togashi
– Basal quarter or third of hind tibia milky white (Fig. 4); sawsheath subacute in dorsal view (Fig. 7) 5
5. Sawsheath broad in dorsal view; 3rd antennal segment as long as 4th; lancet



Figs. 1–7. *Craesus kondoi.* 1, Head, dorsal view. 2, Clypeus. 3, Inner fore tibial spur. 4, Hind tibia and basitarsus. 5, Tarsal claw. 6, Sawsheath, lateral view. 7, Sawsheath, dorsal view.

with 14 serrulae (food plant, *Betula ermani* Sieb. and Zucc.) . . . . *betulae* Togashi

– Sawsheath narrow in dorsal view (Fig. 7); 3rd antennal segment shorter than 4th . . . 6

6. Third antennal segment shorter than 4th (ratio about 1.0:1.2–1.5); lancet with 16 serrulae (food plant, *Platycarya strobilacea* Sieb. and Zucc.). . . . . *platycaryae* Togashi

– Third antennal segment slightly shorter than 4th (ratio about 1.0:1.1) 7

7. Forewing hyaline with distinct dark band below stigma; basal third of hind tibia milky white; hind basitarsus about 1.4× length of following 4 segments combined; lancet with 13 serrulae, serrulae shallow (food plant, *Alnus japonica* Sieb. and Zucc.) . . . . *japonicus* Takeuchi

– Forewing hyaline, without a distinct dark band; basal quarter of hind tibia milky white (Fig. 4); hind basitarsus about 2.0× length of following 4 segments combined; lancet with 15 serrulae, serrulae deep (Fig. 9) (food plant, *Juglans ailanthifolia* Carr.) . . . . . *kondoi*, n. sp.

8. Apical margin of subgenital plate broadly rounded (Fig. 11); harpes subquadrate or triangular (Fig. 12) 9

– Apical margin of subgenital plate narrowly rounded or truncate; harpes elongate or rectangular 10

9. Harpes subquadrate; mesal margin of parapenis acute . . . . . . *japonicus* Takeuchi

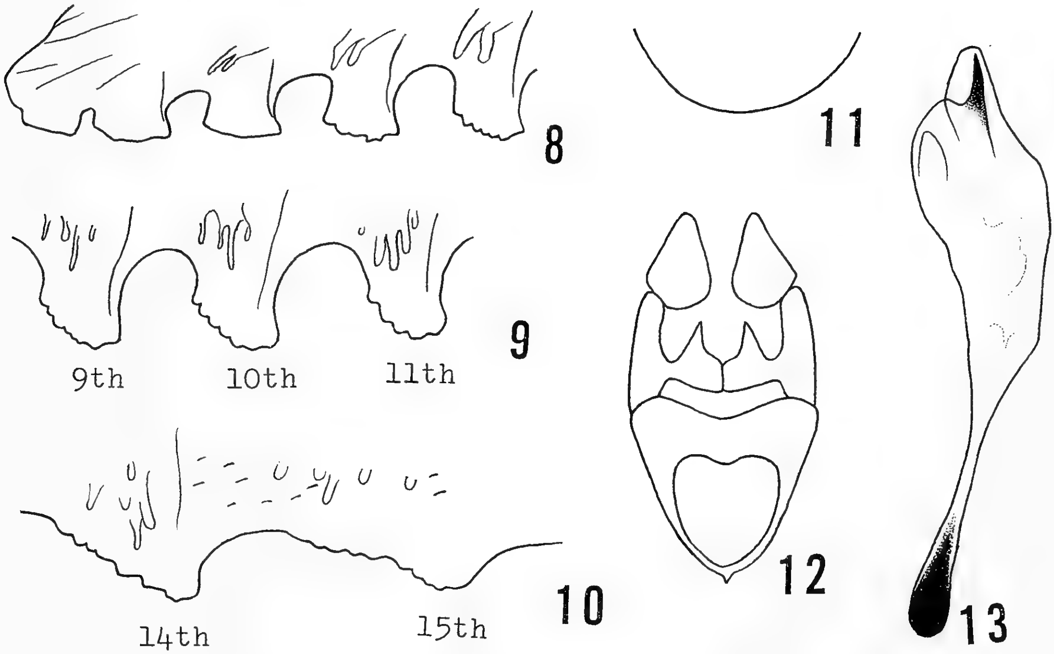
– Harpes nearly triangular, elongated; mesal margin of parapenis truncate (Fig. 12) . . . . *kondoi*, n. sp.

10. Apical margin of subgenital plate narrowly rounded; harpes elongate. . . . . *platycaryae* Togashi

– Apical margin of subgenital plate truncate; harpes subquatrate . . . . . . *betulae* Togashi

Craesus kondoi Togashi, new species
(Figs. 1–13)

Female.—Length, 8–9 mm. *Color:* Body including antenna black. Wings hyaline, stigma and veins dark brown to



Figs. 8–13. *Craesus kondoi*. 8, Apical serrulae of lancet. 9, 9th to 11th serrulae of lancet. 10, 14th and 15th serrulae of lancet. 11, Male subgenital plate. 12, Ventral view of genital capsule. 13, Penis valve, lateral view.

black. Legs black with following milky white: basal ¼ of hind tibia, apical portion of hind coxa, and hind trochaters. Apical ¾ of foretibia and basitarsis dark brown.

Head: Postocellar area rectangular, length:width about 1.0:1.4, moderately convex, anterior 1/3 of postocellar area with distinct longitudinal furrow, connected with interocellar furrow; circumocellar, interocellar, and postocellar furrows distinct; lateral furrows distinct and deep; OOL:POL:OCL = 0.8:1.0:1.1; frontal area slightly concave, with median longitudinal furrow; median fovea distinct and deep, circular in outline; lateral fovea distinct and deep, circular in outline; antenno-ocular distance 1.1× length of distance between antennal sockets; supraclypeal area slightly convex; clypeus convex, anterior margin emarginated (Fig. 2); labrum convex; malar space shorter than diameter of front ocellus. Antenna 1.1× length of costa + stigma of forewing; relative lengths of segments about 1.7:1.0:6.5:7.0:6.3:5.0:4.5:4.5:4.0; pedicel subquadrate.

Thorax: Mesoscutellum flattened; breadth of cenchrus nearly as long as distance between cenchri. Wings: 2nd cubital cell very long, about 4.0× length of 1st cubital cell; petiole of anal cell of hindwing about 1.2× length of nervulus. Legs: Apical width of hind tibia about 0.5× length of inner hind tibial spur; hind tibia about 1.7× length of hind basitarsus; hind basitarsis nearly 2.0× length of following 4 segments combined; length of hind basitarsus 2.7× longer than broad; apical tooth of claw slender (Fig. 5).

Abdomen: Sawsheath, in lateral and dorsal views, as in Figs. 6–7; cercus longer than sawsheath in dorsal view; lancet with 15 serrulae (Figs. 8–10), serrulae deep (Fig. 9).

Punctation: Head and thorax covered with fine setigerous punctures; central portion of mesoscutellar appendage distinctly and sparsely punctured, laterally distinctly and closely punctured. Abdominal tergites covered with fine setigerous punctures.

Male.—Length, 7 mm. Similar to female in color and structure except for sexual segments. Apical margin of subgential plate broadly rounded (Fig. 11); genitalia as in Fig. 12; penis valve as in Fig. 13.

Food plant.—*Juglans ailanthifolia* Carr. (Juglandaceae).

Distribution.—Japan (Honshu).

Types.—Holotype ♀, 2.X.2000, emerged from larva feeding on leaves of *Juglans ailanthifolia*; collected in Takahashi City, Okayama Prefecture, Japan, T. Kondo leg. Paratypes: 5 ♀ and 1 ♂, same data as for holotype except 4–7.X.2000. Holotype and three paratypes (including male) deposited in the National Science Museum (Natural History), Tokyo. One paratype deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., and 2 paratypes deposited in the collection of the Kurashiki Museum, Kurashiki City, Okayama Prefecture.

Etymology.—This species is named after Mr. T. Kondo, Kurashiki City, who collected the specimens.

Remarks.—This new species is closely allied to *C. japonicus* and keys to *C. japonicus* in Togashi (1997), but it is distinguished from the latter by the entirely clear forewing (with a distinct dark band below the stigma in *C. japonicus*), by the hind basitarsus nearly twice as long as the following four segments combined (only slightly longer in *C. japonicus*), by the structure of the lancet (compare Figs. 8–10 and Figs. 13, 17, 21 in Togashi 1997), and by the rather triangular harpes (rectangular in *C. japonicus*, compare Fig. 28 and Fig. 12 in Togashi 1997).

From *C. castaneae*, the new species is distinguished by the clear forewing (lightly and uniformly infuscated in *C. castaneae*), by the black clypeus and labrum (apex of clypeus and labrum whitish in *C. castaneae*), by the black midbasitarsus (whitish in *C. castaneae*), and by the white hind trochanters (black in *C. castaneae*).

From *C. juglandis*, it is distinguished by the black clypeus (rufous except for lateral part in *C. juglandis*), by the ratio of the length and width of the hind basitarsus, about 3.5:1.0 (3.0:1.0 in *C. juglandis*), by the length of the petiole of the anal cell of the hind wing, longer than the nervulus (scarcely as long in *C. juglandis*), by the 15 serrulae of the lancet (14 in *C. juglandis*), by the small size, 8–9 mm (9.8 mm in *C. juglandis*), by the circular median fovea (elongate in *C. juglandis*), by the rounded apex of the sawsheath in lateral view (acute in *C. juglandis*), and by the rounded apex of the subgenital plate (subacute in *C. juglandis*).

From *C. eglagratus* Wei and Nie, 1999, the new species is distinguished by the 15 serrulae of the lancet (14 in *C. eglabratus*) and by the shape of the anterior margin of the subgenital plate (triangular in *C. eglabratus*).

From *C. nigrodorsatus* Malaise, it is distinguished by the black anterior four tibiae (white in *C. nigrodorsatus*) and by the rounded apex of the sawsheath in lateral view (subacute in *C. nigrodorsatus*).

ACKNOWLEDGMENTS

I thank David R. Smith, Systematic Entomology Laboratory, U. S. Department of Agriculture, Washington, D.C., for reviewing this manuscript. I also thank Mr. T. Kondo, Kurashiki City, Okayama Prefecture, for lending the valuable specimens.

LITERATURE CITED

Beneš, K. 1990. Two new East Palearctic species of the genus *Croesus* (Hymenoptera, Tenthredinidae). Acta Entomologica Bohemoslovaca 87(5): 385–392.

Benson, R. B. 1963. The Nematinae (Hymenoptera, Tenthredinidae) of south-east Asia. Entomologisk Tidskrift 84: 18–27.

Taeger, A. and S. M. Blank. 2005. ECatSym-Electronci World Catalog of Symphyta (Insecta, Hymenoptera). Version 1.0 (August 1, 2005). ECatSym Online Service Müncheberg, http://www.zalf.de/home_zalf/institute/dei/php_e/index.html.

Togashi, I. 1997. Three new species of the genus *Craesus* Leach from Japan (Hymenoptera, Tenthredinidae). Japanese Journal of Systematic Entomology 5: 67–73.

Smith, D. R. 1972. Sawflies of the genus *Croesus* Leach in North America. Proceedings of the Entomological Society of Washington 74: 169–180.

Wei, M. and H. Nie. 1999. Sawflies collected from Mt. Dabieshan, Henan (Hymenoptera: Tenthredinomorpha), pp. 167–185. *In* Shen, X. and H. Pei, eds. Insects of the Mountains Funui and Dabie Regions. The Fauna and Taxonomy of Insects in Henan. Vol. 4a. China Agricultural Science and Technology Press, 415 pp.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 914–919

MELESE FARRI (LEPIDOPTERA: NOCTUIDAE: ARCTIINAE): A NEW SPECIES FROM JAMAICA

Catherine P. Murphy and Eric Garraway

Department of Life Sciences, University of the West Indies, Mona, Kingston 7, Jamaica (e-mail: catherine.murphy@unimona.edu.jm)

Abstract.—An ongoing survey of Jamaica's invertebrate fauna uncovered a species of arctiine moth, ***Melese farri* Murphy and Garraway, n. sp.** Members of the genus *Melese* Walker, occur throughout Central and South America; however, Trinidad is the only other Caribbean island from which a *Melese* species has been described. *Melese farri* in Jamaica raises questions concerning the biogeography of the genus *Melese* throughout the Caribbean.

Key Words: *Melese farri*, Arctiinae, tymbal organs, genitalia, Jamaica, South and Central America

In Jamaica, the clearing of lands to facilitate bauxite mining and road and house construction has led to the destruction of many habitats and the flora and fauna associated with them. Jamaica, with its high level of endemism (Government of Jamaica 1987), urgently needs to catalogue the invertebrate fauna before further species loss occurs. A survey of Jamaica's Lepidoptera fauna was undertaken to determine its status and generate checklists.

Twenty locations across the island were sampled between 1995 and 2000. Thirteen specimens of a previously undescribed species from the subfamily Arctiinae, tribe Arctiini, were collected from four sites, Windsor and Dromilly in the Cockpit Country, Trelawny Parish; Accompong Maroon Village in St. Elizabeth Parish and a single specimen from St. Toolis in southern Manchester Parish in central Jamaica. This species is placed in the genus *Melese* Walker based on general external morphology and the structure of the female genitalia.

Based on museum collections, the genus *Melese* appears to be a native of Central and South America with 35 species (Watson 1971), identified from this region. In the Caribbean, Trinidad is the only island with any record of this genus. *Melese incertus* (Walker) (*flavipuncta* Rothschild) is reported from Trinidad (Watson and Goodger 1986) but Trinidad is regarded as having a South American fauna because of its proximity to Venezuela. The absence of any record of *Melese* species from other Caribbean islands might be due to a lack of study in these areas; its occurrence in Jamaica however suggests that there may be members of the genus in other Caribbean islands.

A description of the new species from Jamaica, including descriptions of male and female genitalia and tymbal organs, is given.

Materials and Methods

Moths were collected at hourly intervals between dusk and dawn using

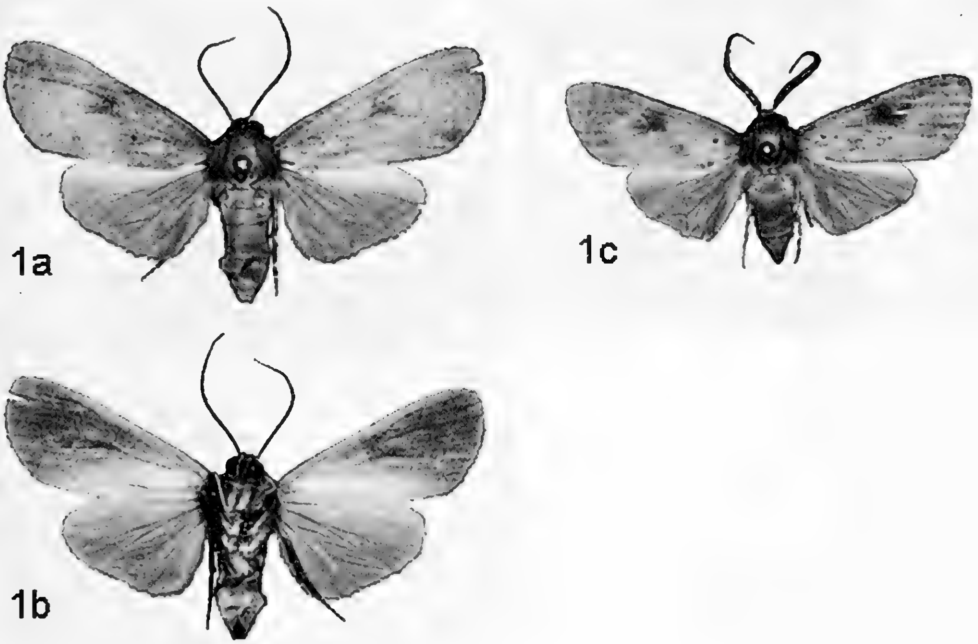


Fig. 1. *Melese farri*, adult. 1a, Female dorsal. 1b, Female ventral. 1c, Male dorsal.

a modification of Robinson's light trap with 125W mercury vapor lamps and plastic buckets. After dispatch with ethyl acetate, spread specimens of suspected arctiines were examined, their sex determined and the moths described with the aid of a stereo-microscope with zoom objective. Dorsal and ventral surfaces of both sexes were photographed. The wings of males and females were measured, from the apex to the point of attachment to the thorax, following which, they were prepared for venation studies according to the method outlined in Borror et al. (1992). Specimens were classified using general description keys (Borror et al. 1992; Heppner 1993) and this classification adjusted based on Lafontaine and Fibiger's revised classification of the Noctuoidea (2006). Identification to species demanded comparison with specimens at the Institute of Jamaica, the Carnegie Museum in Pittsburgh, Pennsylvania, and The Natural

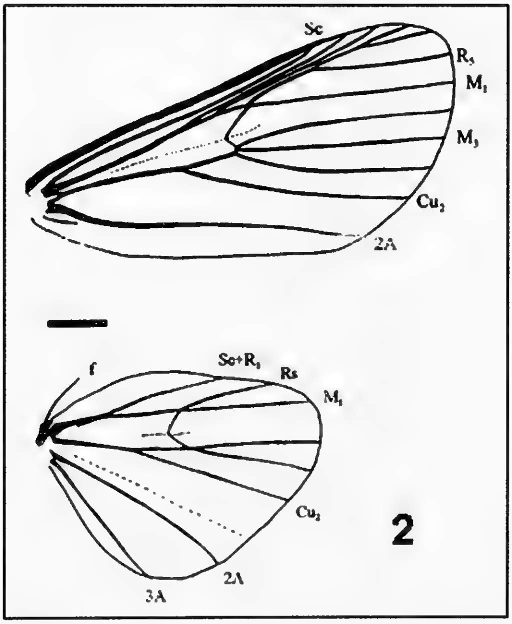
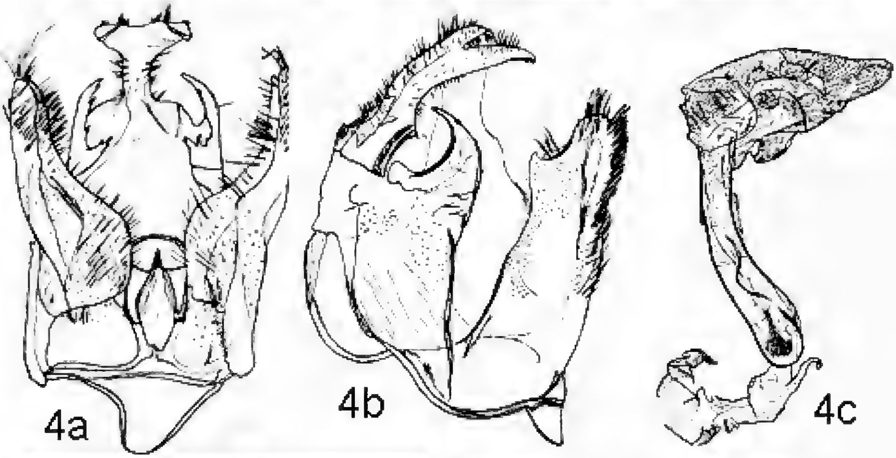
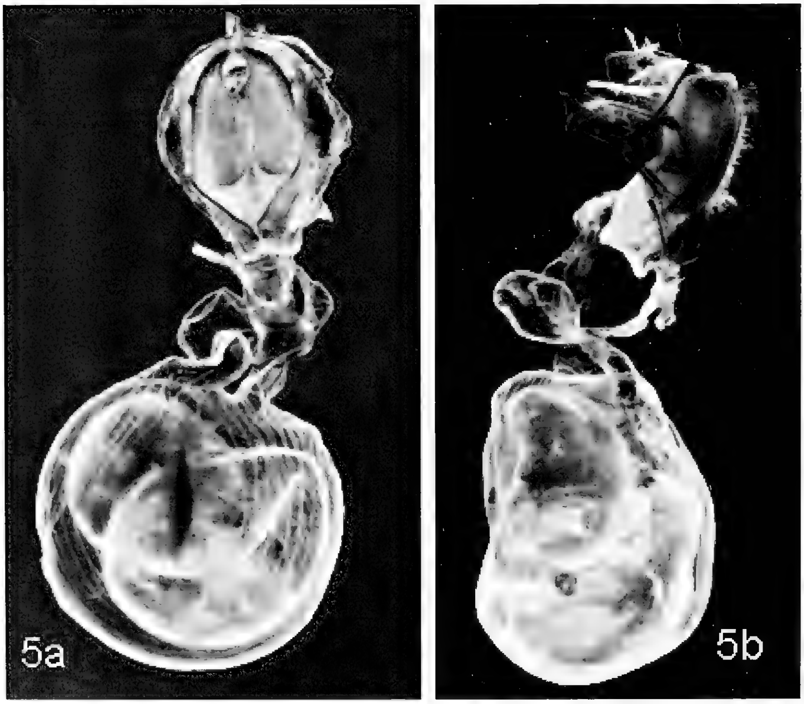


Fig. 2. *Melese farri*, right wings. Scale bar = 2.0 mm.


3a
3b


4a
4b
4c


5a
5b

History Museum in London. Arctiines from the American Museum of Natural History which were loaned to the Carnegie Museum at that time were also examined.

Genitalia studies required the removal of the posterior halves of abdomens, maceration in potassium hydroxide solution (10% for males, 5% for females) overnight, then dissection of the genitalia followed by repeated washing in distilled water and storing in 50% iso-propanol. Male genitalia were further treated by removing aedeagi and eversion of vesicae; valvae were also spread to show their inner surfaces. Male and female genitalia were described, photographed or otherwise illustrated and measured following which they were dehydrated and stored separately in vials of absolute iso-propanol.

Hindlegs of specimens were removed to facilitate tymbal organ studies. Scales on the meta-thoracic episternite were described then removed by abrasion with insect pins to reveal tymbal organs. These organs were described and photographed.

RESULTS

Melese farri Murphy and Garraway, new species

(Figs. 1–5)

Material examined.—*Holotype*: ♂, Jamaica: St. Elizabeth Parish, Accompong Maroon Village, C. P. Murphy and E. Garraway in light trap, 02-03-viii-1997. Deposited in the Entomology Museum, University of the West Indies, Mona, Kingston, Jamaica.

Paratypes: 1♂, 02-viii-97, 1♂ 03-viii-97, 1♀ 02-viii-97, 1♂, 03-04-viii-97, Jamaica: same data as holotype; 1♂, 1♀, Trelawny Parish, Windsor, Cockpit Country, 09-vii-99; 1♂, 1♀, 04-x-99, 2♂, 24-ix-2000, 3♂ 24-25-ix-2000, Windsor; 1♂, Manchester Parish, St. Toolis, 04-02-2000. Deposited with holotype.

1 ♂, Windsor; 24-ix-2000, 1 ♀, Trelawny Parish, Dromilly, Cockpit Country, 27-iv-2001. Deposited in the Insect Collection at the Institute of Jamaica, 12 East Street, Kingston, Jamaica.

Diagnosis.—The species is similar in appearance to *Melese columbiana* Rothschild from Santa Fé de Bogotá. Male specimens of *M. columbiana* have three white lines along the basal 2/3 of the costal margin with a white spot between the second cubital vein and the second anal vein. Jamaican specimens have no white spot and there is a black spot at each forewing base between the second anal vein and the inner margin of the wing. Females of *M. columbiana* possess several white spots as well as white lines on each forewing.

Description adults (Fig. 1).—*Head*: Vertex gray brown, rough scaled; frons darker. Antenna bipectinate, tapering; rami lined with cilia; scape pink on outer lateral surfaces, brown on inner surface; antennal shaft brown with scales on a few basal segments, pink color decreasing distally. Female antenna less feathery. Compound eye prominent, ringed with brown scales; proboscis developed; ocellus in shallow groove behind antennal scape; labial palpus three-segmented, upturned, reaching up to brown vertex.

Thorax: Patagium and tegula covered with various shades of dark brown scales. Forewing, mixture of brown and dark brown, with a black spot near its base and a brown discal spot of irregular shape. Hindwing bright orange pink; overlap region of fore- and hindwings

←

Figs. 3–5. *Melese farri*. 3, Tymbal organs, male (a), female (b). 4, Male genitalia, dorsal (a), lateral (b), aedeagus with everted vesica (c). 5, Female genitalia, ventral (a), lateral (b).

pale, almost golden in color. First anal vein (1A) weak in hindwing (Fig. 2), completely absent in forewing. Ventral wing surfaces like dorsal, except black spots absent.

Forewing length (male) 13.0–16.0 mm, mean 14.6 mm, n = 10.

Forewing length (female) 15.0–16.0 mm, mean 15.7 mm, n = 4.

Metepisternites lightly covered with small, circular scales which when removed, reveal tymbal organs comprising translucent blisters each bearing a striated band of 20 to 22 raised bars with rounded ends in female (Fig. 3) and 16 to 20 bars in male (Fig. 3); bands taper at both ends. Each bar bears several striae. Coxa of foreleg bright orange pink with dark brown scales on basal half of outer surface; coxae of mid- and hindlegs similarly but less brightly colored. Foreleg femur brown on outer, orange pink on inner surface; foretibia dark brown along outer edges, orange pink near base; rings of light brown scales at tibial-tarsal joints and at base of tarsal segments. Tibiae of other legs similarly colored. Coloring on female legs less intense than that of male. Foreleg bears epiphysis, mid- and hindlegs one and two pairs of tibial spurs respectively.

Abdomen: Dorsal surface with orange pink hairs on first three segments, short smooth scales on remaining segments; ventral abdomen with orange pink scales; lateral abdomen brown. Abdomen of female larger than male and more rounded.

Male genitalia (Fig. 4): Lightly sclerotized with doubly indented anterior margin. A rectangular hood projecting from caudal margin gives rise to bifurcate, setose, rodlike uncus. Arising from caudal tegumen and ventrolateral of uncus, a pair of thin plates bearing several large spines at their distal margins curve towards each other. Lightly sclerotized diaphragma forms wide tubular anellus; juxta small. Vinculum, a thin rod, expands ventrally forming a well-developed saccus.

Well-developed valvae attach to tegumen laterally. Base of each valva large; setose sacculi meet at their bases. Each valva bears a short ridge on its inner surface, a valvula and a setose cucullus, a small triangular projection from costa. Distal valva covered thickly with hairs on inner and outer surfaces. Aedeagus with distinct rounded coecum penis, ductus ejaculatorius bulges where it meets phallus giving aedeagus a bilobed appearance. Everted vesica covered with spines.

Female genitalia (Fig. 5): Papillae anales triangular, sclerotized, setose lobes, with two pairs of short apodemes and a pair of triangular dorsal pheromone glands which arise posteriorly. Ostium bursae's position marked by a notch in narrow genital plate. Ostium bursae opens into antrum of ductus bursae which continues as a curved tube and connects with corpus bursae via a short, unsclerotized neck. Corpus bursae, large, spherical with regularly spaced crenulations running longitudinally along its outer surface and covered with small regularly spaced pimples. Ventrally, corpus bursae bears a large, leaf-shaped, highly sclerotized signum; a smaller signum occurs on dorsal surface. Appendix bursae, a small spherical sac, arises from anterior corpus bursae adjacent to ductus bursae. A short tube arising from posterior appendix bursae, ductus seminalis, bears an ovoid sac, or spermatheca which in turn leads to an oblong-shaped bulla seminalis before joining vagina.

Etymology.—The species is named for the late Dr. Thomas Farr, entomologist at the Institute of Jamaica, the island's national museum. Dr. Farr, the only resident insect taxonomist on the island for four decades, died in 1996. His work encouraged us to undertake the present survey.

Discussion.—The external morphological similarities (body and wing color and size) between *M. farri* and other *Melese* species from Central and South America is immediately apparent. Placement among the Arctiinae is supported by studies of wing venation, quadrifid forewing, and trifine hindwing (Fig. 2). Comparison of the female genitalia with those of *Melese rubricata* Dognin and *Melese flavimaculata* Dognin from French Guiana and Ecuador, respectively, supports inclusion in the genus.

Melese farri appears to be somewhat restricted in its Jamaican distribution. Of the thirteen specimens collected, all except one was found in the Cockpit Country, a moist to wet limestone forest known for its large number of endemic vascular plants (Proctor 1986). The single specimen collected outside of the Cockpit Country occurred in St. Toolis which comprises a series of rocky limestone hills with a secondary dry limestone forest. The specimen from St. Toolis was collected in February in one of the dry seasons in Jamaica while those from Cockpit Country sites were collected between July and September, another dry season. Monthly collections in both the Cockpit Country and St. Toolis would identify the breeding season for this species and would clarify whether it favors wet forest conditions or cool, dry conditions. Although *M. farri* appears to favor the Cockpit Country, it might not be endemic to this region.

The genus *Melese* appears to be Neotropical and its occurrence in Trinidad is not surprising. Its absence so far from other Caribbean islands is surprising and its occurrence in Jamaica raises questions concerning its origin and biogeography throughout the Americas.

ACKNOWLEDGMENTS

Thanks to Dr. John Rawlins and the staff at the Carnegie Museum in Pittsburgh, Pennsylvania, for their advice and assistance during this study. Thanks to Mr. David T. Goodger and Mr. David Carter at The Natural History Museum in London who gave assistance with the identification of the Jamaican species.

LITERATURE CITED

Borror, D. J., C. A. Triplehorn, and N. F. Johnson. 1992. An Introduction to the study of Insects, 6th edition. Saunders College Publishing, 664 pp.

Government of Jamaica. 1987. Wildlife Resources, pp. 133–159. *In* Jamaica: Country Environmental Profile, Kingston, Jamaica: prepared by the Ministry of Agriculture, Natural Resources Conservation Division and Ralph M. Field and Assoc. Inc.

Heppner, J. B. 1993. Keys to families of Lepidoptera. Tropical Lepidoptera 4, Supplement 3: 1–28.

Lafontaine, J. D. and M. Fibiger. 2006. Revised higher classification of the Noctuoidea (Lepidoptera). Canadian Entomologist 138: 610–635.

Proctor, G. R. 1986. Cockpit country and its Vegetation, pp. 43–47. *In* Thompson, D. A., P. K. Bretting, and M. Humphreys, eds. Forests of Jamaica: Papers on the Caribbean Regional Seminar on Forests of Jamaica held in Kingston, Jamaica 1983. The Jamaican Society of Scientists and Technologists.

Watson, A. 1971. An illustrated catalog of the Neotropic Arctiinae types in the United States National Museum (Lepidoptera: Arctiidae) part 1. Smithsonian Contributions to Zoology 50: 6, 13, 16, 21, 23, 31, 35, 46, 61, 70, 77, 78, 82, 83, 86, 87, 147–149, 254–258, 345.

Watson, A. and D. T. Goodger. 1986. Catalogue of the Neoptropical tiger-moths. Occasional Papers on Systematic Entomology, British Museum (Natural History) No. 1, 71 pp., 4 pls.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 920–929

A NEW SPECIES OF NET-WINGED MIDGE OF THE GENUS *BLEPHARICERA* MACQUART (DIPTERA: BLEPHARICERIDAE) FROM THE CUMBERLAND PLATEAU OF TENNESSEE

John K. Moulton and Gregory R. Curler

Department of Entomology and Plant Pathology, 2431 Joe Johnson Drive, 205 Ellington Plant Sciences Building, The University of Tennessee, Knoxville, TN 37996-4560, U.S.A. (e-mail: jmoulton@utk.edu)

Abstract.—***Blepharicera courtneyi* Curler and Moulton, new species**, is described and illustrated from larvae, pupae, and adults taken from several localities on the Cumberland Plateau of eastern Tennessee. This new species belongs to the *Blepharicera tenuipes* group and shares a number of similarities with *Blepharicera tenuipes* (Walker) and *B. hispida* Courtney. It can be separated from these species by unique combinations of larval and adult characteristics. This is the first record for the family from the Middle Cumberland Plateau Physiographic Region, an area well known for its rugged topography and spectacular, albeit seasonal, whitewater rivers.

Key Words: Diptera, Blephariceridae, net-winged midge, taxonomy, United States

---

Blepharicera Macquart is one of the most widespread genera of net-winged midges and is the only blepharicerid genus found in both the eastern and western portions of the Nearctic Region. All eastern Nearctic species belong to the *Blepharicera tenuipes* group, a presumedly monophyletic assemblage comprised of 16 described species (Hogue 1978, 1987; Hogue and Georgian 1986; Courtney 2000). In March 2006, we collected larvae of two species of *Blepharicera* at two localities on the Cumberland Plateau of east-central Tennessee, *B. capitata* Loew from the Sequatchie River in Cumberland County and an undescribed species similar to *B. hispida* Courtney and *B. tenuipes* (Walker) from the Piney River in Rhea County. Subsequent expeditions to Piney River and additional localities on the Cumberland Plateau yielded additional material of only the latter species, which is described below.

Materials and Methods

Study Area.—Sampling areas included several fast-flowing streams on the Cumberland Plateau near Crossville, Tennessee. Piney River drains a portion of the Plateau known as Walden's Ridge. It rises near the Rhea-Bledsoe County line and is referred to in its upper reaches as Piney Creek. Its major tributary, Little Piney Creek, flows over two spectacular but largely inaccessible waterfalls near the community of Grandview. The confluence of the two streams occurs below the falls of the smaller stream in an area referred to as "Shut-in Gap," which we designate as the type locality. Mammys Creek is a major tributary of Piney Creek before the Bumbee Creek confluence. Caney Fork River rises in Cumberland County about 10 km WNW of Crossville and descends off of the Cumberland Plateau through a deep, steep gorge in a remote area known as Scott's Gulf.

Cane Creek flows northwest from its headwaters in southwestern Bledsoe County towards its confluence with the Caney Fork River. A significant waterfall on Cane Creek is located inside the boundary of Fall Creek Falls State Park.

Material.—All specimens were collected between February and May 2006 by benthic sampling, sweeping, and black light. Pupa-adult associations were made using the ontogenetic method (Hogue and Bedoya-Ortiz 1989) or by rearing pupae to emergence (Courtney 1998).

Specimen preparation.—Field-collected specimens preserved in 70 or 95% EtOH. Morphological studies were based on slide-mounted specimens. Slides of larvae were prepared using cedarwood oil to clear specimens and Canada balsam as a mounting medium. Slides of adult structures were prepared using 85% lactic acid, 10% NaOH, or cedarwood oil to clear specimens and Canada balsam as a mounting medium. Specimens were examined using a Meiji Techno RZ stereomicroscope and Nikon E800 and Nikon Optiphot compound microscopes, the former two fitted with optical micrometers. Drawings were rendered with the aid of a drawing tube on the Nikon Optiphot system. The photomicrograph of pupal microsculpture is a composite of images captured using a SPOT RT® Color digital camera and Adobe Photoshop® 7.0. Composite images were created using Helicon Focus®.

Terminology.—Terminology follows Hogue (1978) and Courtney (2000).

Descriptive format.—Diagnoses are provided for all stages. Complete descriptions of the adult female, pupa and larval instar IV and a partial description of the adult male (head and terminalia) are provided. When applicable, sample sizes are provided before each description with measurements in millimeters presented as a mean followed by a range in parentheses. Adult head width was measured at the point of greatest width of the eyes. Palpal segment ratios were computed as proportions, considering the basal palpomere as 1. Wing length and width were measured at the points of greatest length and width, respectively. Measurements were not taken for pharate adults. Unless otherwise noted, larval characters refer to instar IV. Larval cranial width was measured as the distance between the antennae. Total length of larvae was measured from the anterior-most point of the head capsule to the posterior-most point of the anal division. Abbreviations for life stages: L = larva; P = pupa; A = adult. Abbreviations for type and voucher repositories: USNM = National Museum of Natural History, Smithsonian Institution; UTK = University of Tennessee Insect Museum.

Blepharicera courtneyi Curler and Moulton, new species

(Figs. 1–8)

Diagnosis.—A medium-sized *Blepharicera. Larva:* Dorsum of cephalic division (= cephalothorax) and abdominal segments II–VI each with 4 loosely arranged transverse clusters of fustiform dorsal secondary sensilla. *Pupa:* Integument of abdominal tergites shiny, dark brown; lamellae of respiratory organ of subequal width, broadly pointed apically; anal tergite never wrinkled. *Adult male:* Dorsal eye division much smaller than ventral; cercus with inner margin straight, posterolateral margin slightly extended into rounded lobe, and outer margin cleft; apex of dorsal paramere slightly emarginate on either side of medial dorsal carina; lateral parameral lobe elongate, twice as long (measured from distance of apex to base of ejaculatory apodeme) as median width; apex of ventral paramere extended beyond apical margin of dorsal paramere. *Adult female:* 3 ovoid spermathecae with uni-

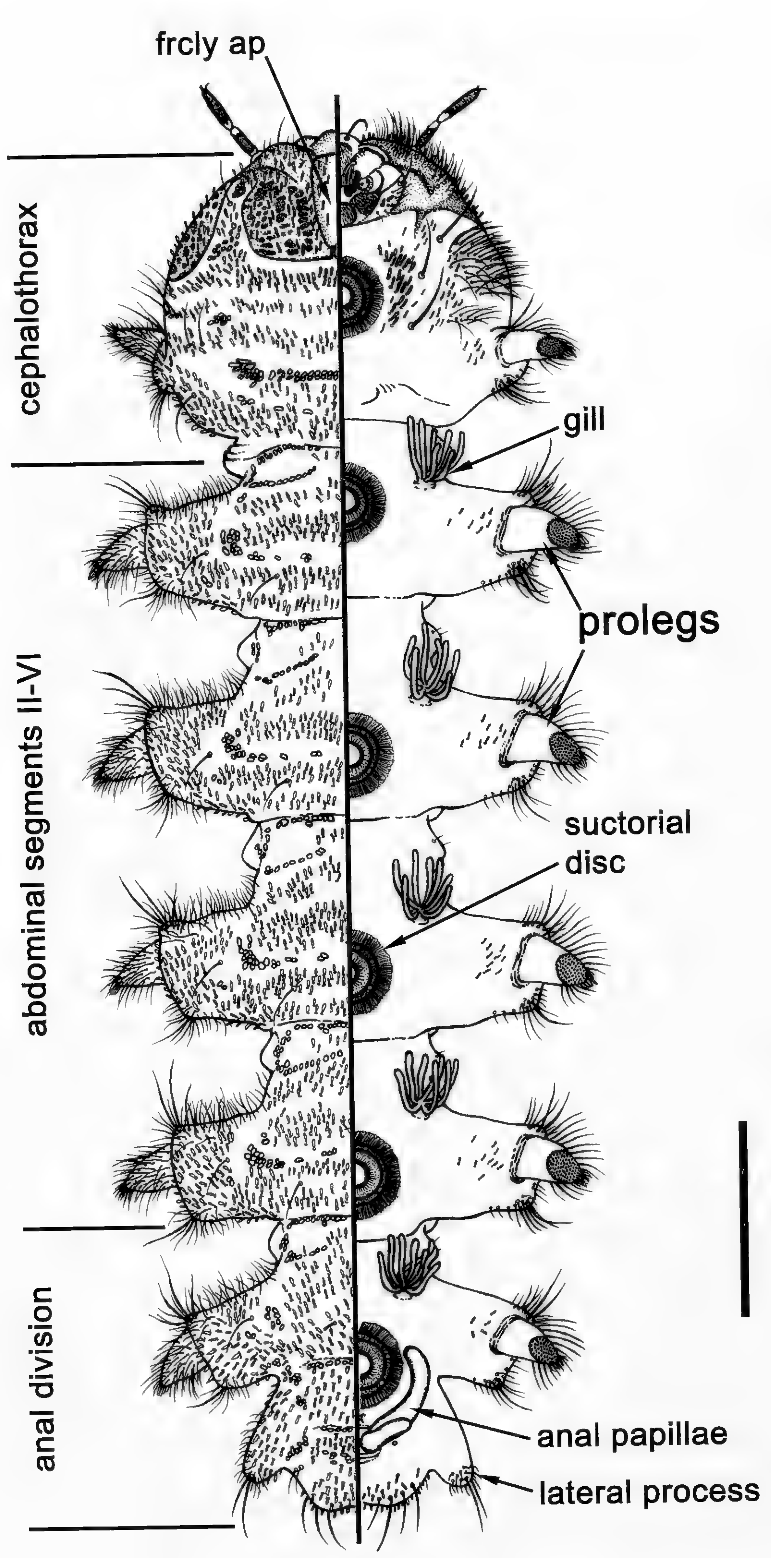


Fig. 1. *Blepharicera courtneyi* larva, dorsal (left) and ventral (right) view. Scale bar = 1 mm.

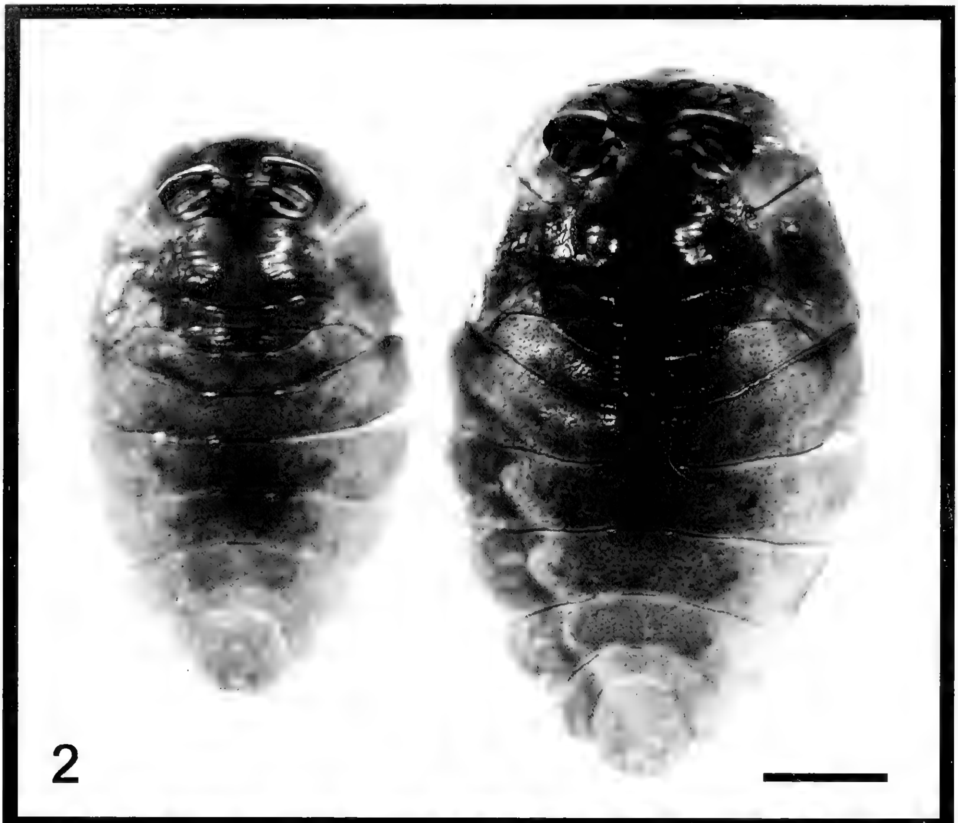
formly sclerotized and unpigmented ducts; dorsal and ventral eye divisions separated by narrow callis oculi; distal palpomere short (< 3 times length of penultimate palpomere); number of parietal sensilla 12; number of clypeal sensilla ≈ 20.

Description.—Larva (Fig. 1): Measurements, instar I (n = 5) total length 1.1 mm (0.9–1.4), cranial width 0.2 mm, antennal length 0.1 mm; instar II (n = 10) total length 2.1 mm (1.5–2.4), cranial width 0.3 mm (0.3–0.4), antennal segments: 0.02 mm, 0.1 mm; membranous region 0.02 mm; instar III (n = 10) total length 3.9 mm (3.0–4.8), cranial width 0.5 mm, antennal segments: 0.1 mm, 0.1 mm (0.1–0.2); membranous region 0.04 mm (0.02–0.05); instar IV (n = 10) total length 6.5 mm (5.4–7.9), cranial width 0.7 mm, antennal segments: 0.1 mm, 0.2 mm; membranous region 0.1 mm. Cranial sclerites light brown to brown, except interrupted by dark brown or black muscle scars; ecdysial lines with long stem line; posterior margin of frontoclypeal apotome well removed from posterior cranial margin; clypeal spines absent. Cephalic division, trunk, lateral lobes and prolegs light brown to brown. Anal division bluntly trilobed, with posterior margin slightly concave medially, never elongate; lateral process bluntly rounded apically. Chaetotaxy: Dorsal secondary sensilla fustiform, about 5–6 times length of their apical diameter; head with numerous fustiforms anteriorly and laterally, arranged in longitudinal rows between muscle scar rows dorsally; cephalic division and dorsomedial region of abdominal segments II–VI each with 4 loosely arranged transverse clusters of fustiforms; anal division covered with numerous fustiforms dorsally, not in clusters, with 4–6 prominent setiforms along apex of median lobe; lateral lobes with numerous fustiforms dorsally, few scattered fustiforms ventrally, numerous setiforms along anterior margin and apical half of posterior margin; prolegs with numerous setiforms dorsally; substernal setae elongate digitiform, pale brown, 35–40 in number.

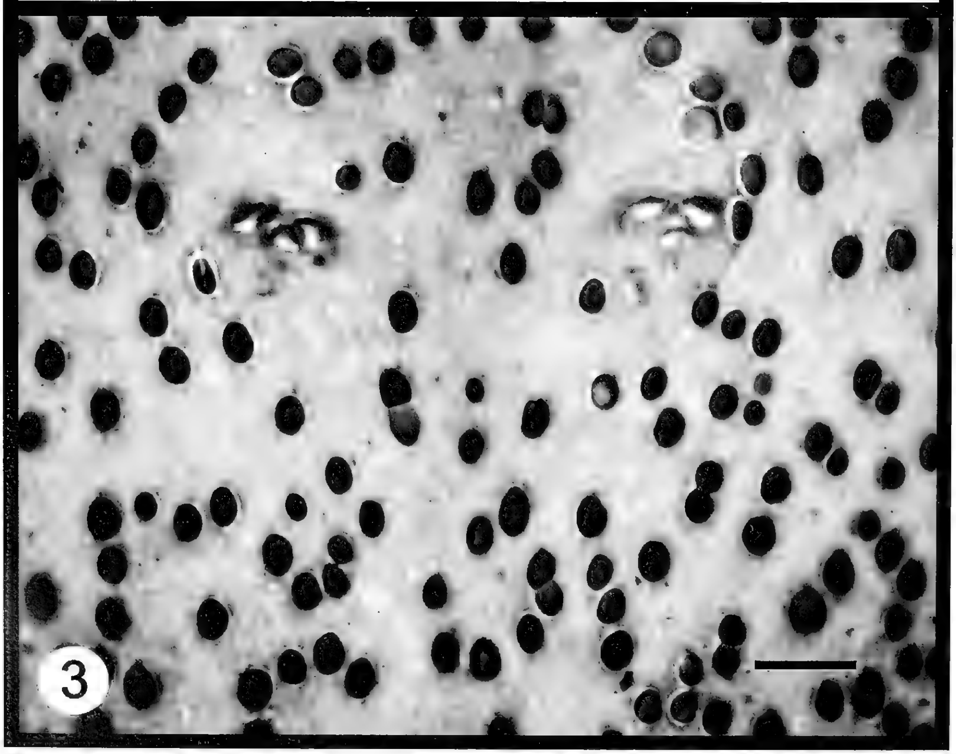
Pupa (Figs. 2–3): Measurements, male (n = 10) length 4.4 mm (4.1–4.6), width 2.7 (2.5–2.8); female (n = 10) length 5.3 (5.1–5.7), width 3.2 (3.1–3.3). Cuticle dark brown; body outline generally ovoid. Integument: Dorsal papillae present, dark, with minute spinules, irregularly distributed on abdominal segments, gaps between papillae subequal to or greater than papilla width; metatergite with numerous papillae medially, none laterally; branchial sclerite without papillae. Cuticle homogeneous, without reticulate pattern. Anal tergite not wrinkled. Respiratory lamellae dark brown to black; middle lamellae broad, width at midpoint greater than half width of outer lamellae.

Adult male: Head and terminalia only (from dissected pupae).

Head (Fig. 5): Structure: Normal type, semi-dichoptic. Clypeus length/width = 2.2. Eyes well separated dorsally, interocular distance approximately 0.1 mm; eye divided, dorsal division much smaller than and contiguous with ventral division (callis oculi absent); dorsal division with approximately 11–12 rows of ommatidia along mid-meridian; dorsal ommatidia larger in diameter than ventral ones. Length of free portion of proboscis about 0.37 times head width; mandibles absent; palpi with 5 palpomeres, distal 4 palpomere proportions 1.0–1.1–1.1–3.5. Antenna with 15 articles, flagellomeres cylindrical; length of ultimate flagellomere 1.2 times length of penultimate flagellomere; scape and pedicel with several prominent setiforms, flagellomere 1 mostly glabrous basally but setose apically, f2–f12 setose, f13 setose with setae larger basally than apically, terminated in 2 prominent setiforms; scape, pedicel and flagellomeres



2



3

brown. Chaetotaxy: Setiform groups as follows, clypeals (≈ 12), parietals (0), occipitals (≈ 24), verticals (5 or 6), postgenals (≈ 12).

Coloration: Frons and face dark brown, pruinose; clypeus brown; ocellar triangle dark brown. Thorax pruinose; mesoscutum and scutellum dark brown to brown; pleuron dark brown anteriorly, pale posteriorly. Forecoxae pale with brown patch anteriorly, other coxae pale. Abdominal tergites light brown to brown, sternites pale, pleural membrane pale.

Terminalia (Figs. 7–8)*:* Abdominal segment VIII reduced, mostly membranous; tergite consisting of basal ligulate sclerite extended to pleural region; pleurites and sternites undifferentiated. Epandrium simple, slightly emarginate posteromedially, bearing numerous setiform sensilla. Cerci well developed, parallel, bearing numerous setiform sensilla; interlobular depression U-shaped; individual cercal lobes elongate, medial margin convex near apex, posterior margin slightly emarginate with prominent hook arising near medial margin, posterolateral margin extended posterolaterally as a rounded lobe. Genital capsule small, slightly longer than wide. Gonostylus bearing numerous setiform sensilla. Aedeagal rods of phallus with median filament subequal in length to lateral filaments, with simple apices. Ejaculatory apodeme extended about 1/2 distance to anterior margin of lateral parameral lobes. Parameres: Dorsal paramere opaque, apex weakly to moderately emarginate on either side of medial dorsal carina; ventral parameres longer than aedeagal rods, broad throughout, tapered to complex apex with slight hook on inner wall; lateral parameral lobes large, broad, outer margins slightly divergent and emarginate.

Adult female: Size: Medium. Measurements (n = 10): Total length 5.9 mm (5.5–6.4), wing length 6.8 mm (6.3–7.2), width 2.1 mm (1.9–2.4).

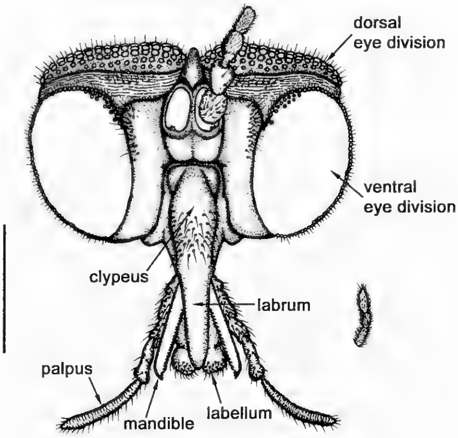
Head (Fig. 4): Structure: Normal holoptic. Clypeus length/width = 2.6. Eyes approximate dorsally, interocular distance approximately 0.04 mm (0.04–0.05); eye divided, dorsal division slightly smaller than and well differentiated from ventral division (callis oculi narrow); dorsal division with 13–14 ommatidia along mid-meridian. Length of free portion of proboscis about 0.48 times head width; mandibles present; palpus with 5 palpomeres, distal 4 palpomere proportions 1.0–1.4–1.5–3.3. Antenna with 15 articles, flagellomeres filiform; ultimate flagellomere 1.5 times length of penultimate flagellomere; scape and pedicel with several prominent setiforms, flagellomere 1 glabrous basally, setose apically, f2–f12 setose, f13 setose with 2 prominent setiforms apically; scape light brown, pedicel and base of f1 brown, remaining portion black. Chaetotaxy: Setiform groups as follows (number per side): clypeals (≈ 20), parietals (12), occipitals (≈ 14), verticals (3), postgenals (≈ 10).

Thorax and appendages: Tibial spurs 0-0-2; spurs asymmetrical, one each long (0.2 mm) and short (0.07 mm); base of hind tarsomere 1 with five or six dark, spiniform sensilla. Leg-segment lengths summarized in Table 1. Leg-segment proportions: fore—36:31:14:8:4:3:4, mid—36:30:14:8:5:3:4, hind—38:34:14:5:3:2:3. Chaetotaxy: Scutum glabrous; scutellum with cluster of 20 chaetiforms laterally and diffuse row of chaetiforms across midline.

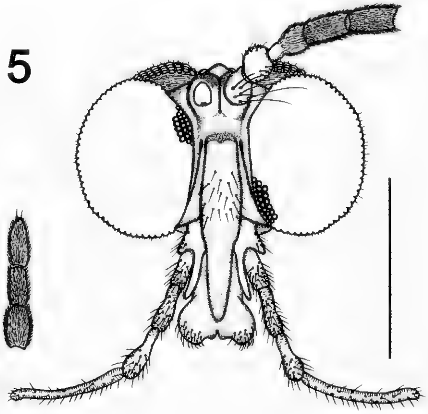
←

Figs. 2–3. Light micrographs of pupal *Blepharicera courtneyi*. 2, Habitus of male (left) and female (right), dorsal view. 3, Microsculpture, abdominal tergite V. Scale bars = 1 mm (Fig. 2), 0.05 mm (Fig. 3).

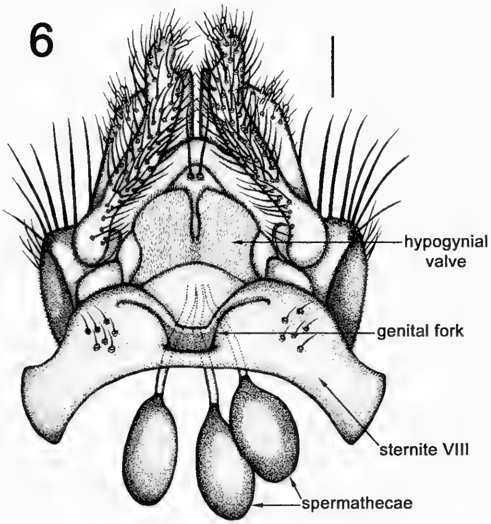
4



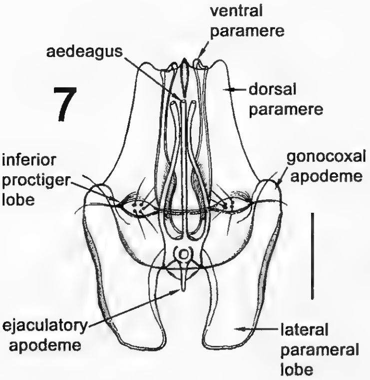
5



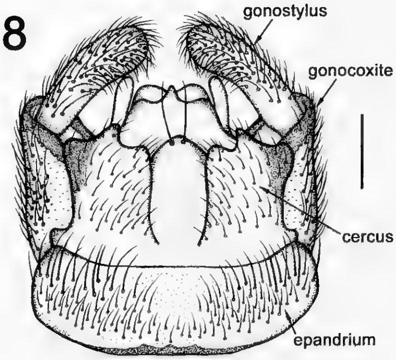
6



7



8



Figs. 4–8. Adults of *Blepharicera courtneyi*. 4, Female head and antennal apex, frontal view. 5, Male head and antennal apex, frontal view. 6, Female terminalia, ventral view. 7, Male terminalia (phallic structures), dorsal view. 8, Male terminalia, dorsal view. Scale bars = 0.5 mm (Figs. 4–5), 0.1 mm (Figs. 6–8).

Table 1. Lengths of leg segments of adult female *Blepharicera courtneyi*, n. sp. (n = 5). Measurements in millimeters; mean (range).

Leg-segment Lengths:	Foreleg	Midleg	Hindleg
femur	3.9 (3.6–4.2)	3.8 (3.5–4.1)	5.5 (5.1–6.0)
tibia	3.3 (3.0–3.6)	3.2 (2.9–3.5)	4.5 (4.5–5.3)
tarsus 1	1.5 (1.4–1.7)	1.5 (1.4–1.7)	2.1 (1.9–2.2)
2	0.9 (0.7–0.9)	0.8 (0.7–0.9)	0.8 (0.7–0.8)
3	0.5 (0.4–0.5)	0.5 (0.4–0.5)	0.4 (0.4–0.5)
4	0.3 (0.3–0.4)	0.3	0.3 (0.3–0.4)
5	0.4	0.4	0.4 (0.3–0.4)

Coloration: Frons and face dark brown to gray, pruinose; clypeus pruinose basally, light brown apically. Thorax pruinose; mesoscutum brown, scutellum light brown; pleuron brown to light brown anteriorly (episternum, anterior 1/2 of anepimeron), pale posteriorly. Coxae pale. Abdominal tergites brown with narrow, light brown band near posterior margin; sternites light brown, pleural membrane pale.

Terminalia (Fig. 6)*:* Posterior margin of sternite VIII broadly bilobate, medial depression prominent, broadly U-shaped. Sternite IX (genital fork) broadly Y-shaped, with short sclerotized extensions anteriorly and laterally. Hypogynial plate broad basally, narrowed slightly to apical valves; individual valves narrow basally, slightly expanded medially, tapered to rounded apex posteriorly; inner margins of valves parallel basally, divergent posteriorly. Accessory gland narrow, elongate, and extended beyond spermathecae basally, ovoid distally. Spermathecae 3 in number; corpora ovoid, about twice as long as wide, with short necks; ducts short, uniformly sclerotized and unpigmented. Chaetotaxy: Sternite VIII with 6–7 setiforms laterally and few minute setiforms medially; hypogynial plate and valves bearing numerous minute setiforms; epiproct with two prominent setiforms apically.

Type material.—Holotype [adult female]: UNITED STATES. TENNESSEE: *Rhea Co:* Piney River @ Shut-in Gap Rd., 35°42.873′N 84°52.831′W, 3 May 2006, coll. G.R. Curler and J.K. Moulton. Specimen pinned, genitalia in glycerin microvial [USNM]. Paratypes: Same locality as holotype, 12 March 2006 [10 instar IV L (EtOH), 2 instar IV L (slides)], coll. G.R. Curler and J.K. Moulton; 24 April 2006 [1 male P (slide), 4 A female (pinned), 2 A female (pinned, head and genitalia in glycerin microvials), 2 A female (slides), 6 male P, 6 female P (EtOH), 1 female P (slide)], coll. G.R. Curler and J.K. Moulton; TENNESSEE: *Cumberland Co:* Mammys Creek @ U.S. 70, 0.5 km W of Westel, 35°52.409′N 84°47.113′W, 28 March 2006 [10 instar IV L (EtOH)], coll. J.K. Moulton; 24 April 2006 [4 male P (slides)], coll. G.R. Curler and J.K. Moulton; 3 May 2006 [3 male P (slides), 6 male P, 6 female P (EtOH)], coll. G.R. Curler and J.K. Moulton; 30 April 2007 [3 male A (reared, EtOH)], coll. G.R. Curler. Holotype and most paratypes deposited in USNM; remaining paratypes deposited in UTK.

Other material examined.—UNITED STATES. TENNESSEE: *Rhea Co:* Piney River @ Shut-in Gap Rd., 35°42.873′N 84°52.831′W, 25 February 2006 [L], coll. G.R. Curler and J.K. Moulton; 12 March 2006 [L], coll. G.R. Curler and J.K. Moulton; 24 April 2006 [LPA], coll. G.R. Curler and J.K. Moulton; *Bledsoe Co:* Fall Creek Falls State Park @ Cane Creek

Cascades, 35°39.461′N 85°21.023′W, 28 March 2007 [L], coll. G.R. Curler and J.K. Moulton; *Cumberland Co:* Mammys Creek @ U.S. 70, 0.5 km W of Westel, 35°52.409′N 84°47.113′W, 28 March 2006 [LP], coll. J.K. Moulton; 24 April 2006 [LP], coll. G.R. Curler and J.K. Moulton; 3 May 2006 [LP] coll. G.R. Curler and J.K. Moulton; *White Co:* Caney Fork River @ Scott's Gulf Rd. 35°50′N 85°16′W, 16 March 2006 [L], coll. J.K. Moulton.

Etymology.—This species is named in honor of our colleague and noted blepharicerid systematist, Dr. Gregory W. Courtney.

Distribution.—*Blepharicera courtneyi* is known only from four sites on the Cumberland Plateau of east-central Tennessee: Piney River, Mammys Creek, Cane Creek, and Caney Fork River. Focused collecting efforts in other fast flowing streams and rivers on the Cumberland Plateau, including the Big South Fork National River and Recreation Area, during early spring should yield additional material of this species.

Bionomics.—Available records suggest this species is univoltine, with larvae first noticeable in February, and adults on the wing by early May. Fourth-instar larvae are common by mid-March and pupae are present by mid-April. Adult females were observed resting on leaf-tips of hardwoods, particularly maple-leaved viburnum, *Viburnum acerifolium* L., along a hiking trail adjacent to the Piney River at Shut-in Gap in late April and early May. Females were also taken on those same dates at a blacklight trap placed on the banks of the Piney River adjacent to a calm pool. Males have not been observed in nature.

Remarks.—All life stages after the egg most closely resemble those of *B. hispida* and *B. tenuipes*. Larvae can be distinguished by chaetotaxy: dorsum of abdominal segments with four transverse clusters of fustiform sensilla, rather than being completely covered as in *B. hispida* or with two transverse clusters as in *B. tenuipes*. Larvae of *B. courtneyi* also differ from those of *B. hispida* by having shorter dorsal secondary sensilla (5–6 rather than 8–10 times the length of their apical diameter). Pupae appear indistinguishable from those of *B. tenuipes* and differ only slightly from pupae of *B. hispida* and *B. coweetae* Hogue and Georgian (latter two with wrinkled anal tergite and somewhat dull surface luster). A scanning electron microscopy study of *B. courtneyi* pupae may reveal additional diagnostic characters. Adult males and females can be separated from *B. hispida*, *B. tenuipes*, and other eastern Nearctic *Bleparicera* species by a combination of head and genitalic characters. Males can be separated by the following suite of characters: cercus with inner margin straight (sinuate in *B. hispida*), posterolateral margin extended into rounded lobe (truncate in *B. hispida*), and outer margin concave (straight in *B. hispida*); lateral parameral lobe elongate, twice as long as median width (as long as broad in *B. hispida*); apex of ventral paramere extended to distal 1/3 or more of apex of dorsal carina (barely reaching anterior portion of dorsal carina in *B. tenuipes*). Females can be identified by the following suite of characters: dorsal and ventral eye divisions separated by narrow callis oculi (broad in *B. tenuipes*); distal palpomere short, ca. twice length of penultimate palpomere ($>$ 2.5 times length in *B. hispida* and *B. tenuipes*); spermatheca ovoid, ca. twice as long as broad (subspherical in *B. hispida*); number of parietal sensilla 12 ($>$ 30 in *B. tenuipes*); number of clypeal sensilla $\approx$ 20 (10–15 in *B. hispida*).

ACKNOWLEDGMENTS

We thank W. L. Grogan, Jr. and an anonymous reviewer for providing several helpful comments on this manuscript. This research was supported in part by the University of Tennessee Agricultural

Experiment Station, United States Army Medical Research and Materiel Command (Grant No. W81XWH-06-1-0471 awarded to JKM), and Discover Life in America (DLIA) (Moth Fly Inventory of the Great Smoky Mountains National Park awarded to GRC and JKM).

LITERATURE CITED

Courtney, G. W. 2000. Revision of the net-winged midges of the genus *Blepharicera* Macquart (Diptera: Blephariceridae) of eastern North America. Memoirs of the Entomological Society of Washington, No. 23. 99 pp.

———. 1998. A method for rearing pupae of net-winged midges (Diptera: Blephariceridae) and other torrenticolous flies. Proceedings of the Entomological Society of Washington 100: 742–745.

Hogue, C. L. 1978. The net-winged midges of eastern North America, with notes on new taxonomic characters in the family Blephariceridae (Diptera). Contributions in Science, Natural History Museum of Los Angeles County 291: 1–41.

———. 1987. Blephariceridae. *In* Griffiths, G. C. D., ed. Flies of the Nearctic Region. Stuttgart: E. Scweizerbart'sche Verlagsbuchhandlung, 2(4): 1–172.

Hogue, C. L. and I. Bedoya-Ortiz. 1989. The net-wing midge fauna (Diptera: Blephariceridae) of Antioquia Department, Colombia. Contributions in Science, Natural History Museum of Los Angeles County 413: 1–57.

Hogue, C. L. and T. Georgian. 1986. Recent discoveries in the *Blepharicera tenuipes* group, including descriptions of two new species from Appalachia (Diptera: Blephariceridae). Contributions in Science, Natural History Museum of Los Angeles County 377: 1–20.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 930–937

A NEW SUBSPECIES, REPLACEMENT NAMES, AND SPELLING FIXATIONS FOR SPECIES OF DELTOCEPHALINAE AND MACROPSINAE (HEMIPTERA: CICADELLIDAE)

S. H. McKamey and A. L. Hicks

(SHM) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, DC 20013-7012 (e-mail: stuart.mckamey@ars.usda.gov); (ALH) University of Colorado Museum, Henderson Building, Campus Box 218, Boulder, CO 80309-0218 (e-mail: andrew.hicks@colorado.edu)

Abstract.—Nomenclatural and taxonomic changes are made to align the classification of Deltocephalinae with the International Code of Zoological Nomenclature. The **new subspecies**, ***Tetartostylus parabolatus spinus***, is described, *Balclutha frontalis* Ferrari is reinstated as valid, and nine **replacement names** are given: ***Balclutha flavidella***, ***Cephalius villiersi***, ***Exitianus evansi***, ***Hecalus chilensis***, ***Macropsis ishiharai***, ***Scaphytopius delongi***, ***Scaphytopius* (*Cloanthanus*) *linnavuorii***, ***Sorhoanus lii***, and ***Thamnotettix matsumurai***. Additionally, the principle of first revisor is applied to fix the correct spellings of 13 species spelled multiple ways within their original descriptions.

Key Words: Membracoidea, leafhopper, new names, subspecies, nomenclature

Inconsistency often becomes apparent when one brings together many disparately published species into a single classification. Although no single classification is likely to please all researchers, due to inherent subjectivity, all names used in classifications must meet the requirements of the International Rules of Zoological Nomenclature (ICZN; International Commission on Zoological Nomenclature 1999). While preparing the Leafhoppers of the World Database (LOWD), we discovered many changes needed purely on nomenclatural grounds.

Necessary replacement names for preoccupied leafhopper genera already were provided recently, along with consequent new species combinations (Seven 1997; McKamey 2003, 2006; Dmitriev and Dietrich 2006). The first paper dealing with purely species-level changes uncovered while compiling LOWD dealt with the subfamily Cicadellinae (McKamey 2006). This paper, the second installment, is on the Deltocephalinae and Macropsinae.

The limits of Macropsinae are not in dispute. The limits of Deltocephalinae, however, have been variably defined (Metcalf 1967a, b; Hamilton 1975; Oman et al. 1990) to sometimes include several taxa that are otherwise treated as separate subfamilies, such as the Aphrodinae. Even in the most restricted sense, as applied here, Deltocephalinae is the largest subfamily of leafhoppers, containing about 5,400 species. They are cosmopolitan and many are known to transmit phytopathogens, such as reoviruses and rhabdoviruses (Conti 1985).

No nomenclatural problems have been discovered in Aphrodinae, Arrugadinae, Acostemminae, Drakensbergeniinae, Eupelicinae, Koebeliinae, Mukariinae, Paraboloponinae, Penthimiinae, or Selenocephalinae, which are taxa considered to be closely related to Deltocephalinae in recent phylogenetic analyses (C. Dietrich and J. Zahniser, unpublished).

References before 1986 have key letters consistent with the bibliographies by Metcalf (1964a) and Oman et al. (1990).

MACROPSINAE

Macropsis ishiharai McKamey and Hicks, new name

Macropsis ishiharai, nomen novum for *Macropsis orientalis* Ishihara 1961a: 238, preoccupied by *Macropsis* (*Macropsis*) *orientalis* (Distant 1916a: 239).

Both species are valid and without synonyms. *Macropsis orientalis* (Distant) was described from India and *M. orientalis* Ishihara was described from Thailand. The new name is dedicated to the author of the junior homonym for his contributions to Auchenorrhyncha taxonomy.

DELTOCEPHALINAE

Tetartostylus parabolatus spinus McKamey and Hicks, new subspecies

Tetartostylus parabolatus spinus, new subspecies here described by bibliographic reference: *Tetartostylus parabolatus* var. *spinosus* Linnavuori 1961a: 483 [n. var.].

Distribution: South Africa [type depository not stated in original description].

Note: Linnavuori's use of "var." was in the sense of a subspecies; he designated a name-bearing type ("...a male (type) (Loc. No. 251).") for the taxon.

Placotettix taeniatifrons "var." *meridionalis* Metcalf, unavailable

Like the former subspecies, Metcalf (1967a: 386) named *Placotettix taeniatifrons* "var." *meridionalis*, not as a new subspecies but as a *nomen novum* for *Thamnotettix aliena* Fieber (1885a). Note that a new subspecies is not required to be described for it because the preoccupied name, *T. aliena*, was placed as a junior synonym of *Placotettix taeniatifrons* (Kirschbaum 1868b: 89) by Nast (1972a: 353).

Balclutha flavidella McKamey and Hicks, new name

Balclutha flavidella, nomen novum for *Eugnathodus lineatus* Osborn 1924c: 449, preoccupied by *Gnathodus lineatus* Melichar 1903b: 208.

Eugnathodus flavidus Osborn 1926c: 351, preoccupied by *Eugnathodus flavidus* Naudé 1926a: 88.

Balclutha lineata (Melichar 1903b: 208) was a valid name until placed in synonymy under *Balclutha rosea* (Scott 1876d: 83) by Knight (1987a: 1208) but see below. A secondary junior homonym, *Balclutha lineata* (Osborn 1924c), was formed when Linnavuori (1959b: 340) referred the species from the genus *Nesosteles* to *Balclutha*, and up to now was still in use as a valid name, but has not been used by at least 10 authors. *Balclutha lineata* (Osborn 1924c) has one junior synonym: *Eugnathodus flavidus* Osborn (1926c). *Eugnathodus flavidus* Osborn is a junior primary homonym of *E. flavidus* Naudé (1926a: 88), which was valid until 1973 (most recently, Knight (1987a: 1206) placed it as a junior synonym of *Balclutha incisa* (Matsumura 1902a)).

Balclutha lineata (Osborn) fails to meet the prevailing usage requirements (ICZN Art. 23.9.1) and lacks a valid synonym. It therefore requires a *nomen novum*. *Eugnathodus flavidus* Osborn does not require a replacement name because it has a valid synonym, namely, the *nomen novum* given above for *B. lineata* (Osborn).

The new name was chosen to retain the meaning (*flavus*: Latin for yellowish) of the junior homonym.

Balclutha frontalis Ferrari, reinstated as valid

Gnathodus roseus Scott 1876d: 83. Knight 1987a: 1208 [implicit reinst. as *Balclutha rosea*] Preoccupied by *Typhlocyba rosea* Provancher (1872c), which is a junior synonym of *Balclutha punctata* (Fabricius 1775a).

Gnathodus frontalis Ferrari 1882a: 117. Knight 1987a: 1208 [implicit reinst. syn. under *Balclutha rosea* (Scott)].

Gnathodus lineatus Melichar 1903b: 208. Knight 1987a: 1208 [n. syn.].

Nesosteles hebe Kirkaldy 1906c: 343. Knight 1987a: 1208 [n. syn.].

Nesosteles dryas Kirkaldy 1907d: 65. Knight 1987a: 1209 [n. syn.].

Gnathodus pallidulus Matsumura 1908a: 11. Knight 1987a: 1209 [implicit n. syn.].

Balclutha montana Melichar 1914b: 138. To *Balclutha rosea* (Scott); Knight 1987a: 1209 [n. syn.].

Balclutha orientalis Matsumura 1914a: 169. To *Balclutha rosea* (Scott); Knight 1987a: 1209 [implicit n. syn.].

Cicadula longiforma Cogan 1916a: 196. Theron 1970b: 322 (cited by Knight 1987a: 1209).

Eugnathodus guajanae DeLong 1923 [in Wolcott 1923b: 267]. Knight 1987a: 1209 [implicit reinst. syn.].

Blaclutha flava Haupt 1927a: 37. Linnavuori 1962a: 39 [n. syn.].

Eugnathodus calcara DeLong and Davidson 1933a: 57. Knight 1987a: 1209 [implicit reinst. syn.].

Agellus philippinensis Merino 1936a: 382. Knight 1987a: 1209 [n. syn.].

Balclutha pulchella Lindberg 1948b: 141. Linnavuori 1959b: 339 [n. syn.].

Balclutha haupti Metcalf 1955a: 266 [nom. nov. for *Balclutha flava* Haupt 1927a]. To *Balclutha rosea* (Scott); Knight 1987a: 1209 [listed as syn.].

Balclutha rosea (Scott) was treated as valid by Linnavuori (1959b: 339, 1960a: 339, 1960b: 60), Metcalf (1967c: 2434), Knight (1987a: 1208) [who revised the genus], Webb and Vilbaste (1994a: 57), and Dai et al. (2004a: 750). Linnavuori (1975c: 631) and Giustina (1989a: 92), however, listed it as a synonym of *Balclutha frontalis*. The senior homonym of *Balclutha rosea* (Scott), namely *Typhlocyba rosea* Provancher (1872c: 378), is a junior synonym of *Balclutha punctata* (Fabricius 1775a: 687) (Baker 1896a; Metcalf 1967c).

Cephalius villiersi McKamey and Hicks, new name

Cephalius villiersi, nomen novum for *Cephalius chobauti* Villiers 1956a: 835, preoccupied by *Cephalius chobauti* Puton (1898a: 173).

Both species are valid without synonyms. *Cephalius chobauti* Puton was described from Algeria and *C. chobauti* Villiers from Mauritania. The new name is based on the author of the junior homonym.

Exitianus evansi McKamey and Hicks, new name

Exitianus evansi, nomen novum for *Eutettix pallida* Evans 1938b: 14, precoccupied by *Eutettix pallidus* Osborn (1926c: 348).

The senior homonym, whose valid name is now *Euscelis pallidus* Osborn (1926c: 348), is recorded from Cuba and the United States. It was a valid species of *Exitianus* until Linnavuori (1959b: 315) placed it in synonymy under *Exitianus exitiosa* (Uhler 1880a: 72).

The junior homonym, *Eutettix pallida* Evans, was referred to *Exitianus* by Evans (1966a: 228). Ross (1968a), in his revision of Old World *Exitianus*, included *Eutettix pallida* Evans in *Exitianus*, having been described from female types, and suggested that it might prove to be a junior synonym of *E. plebeius* (Kirkaldy 1906c: 331). Fletcher and Larivière (2001) indicated that *E. pallidus* "is not a true *Exitianus*." At present, however, the species is treated as valid in *Exitianus*, and therefore requires a new replacement name.

The new name is based on the author of the junior homonym.

Hecalus chilensis **McKamey and Hicks, new name**

Hecalus chilensis, nomen novum for *Hecalus australis* Linnavuori and DeLong 1977c: 183, preoccupied by *H. australis* (Evans 1941e).

Both species are valid without synonyms. *Hecalus australis* Linnavuori and DeLong was described from Chile and *H. australis* Evans was described from Australia.

The homonymy arose through a series of events: *Parabolocratus australis* Evans was moved to his new genus *Linnavuoriella* (Evans 1966a: 135). *Linnavuoriella* was synonymized under *Hecalus* by Morrison (1973a) who did not list the species. Linnavuori (1975a) treated *Linnavuoriella* as a valid genus, but he did not cite Morrison's (1973a) paper, suggesting that Linnavuori was unaware of the change. The new combination *Hecalus australis* (Evans) was first published by Day and Fletcher (1994a: 1215).

The new name is based on the species' country of origin.

Scaphytopius delongi **McKamey and Hicks, new name**

Scaphytopius delongi, nomen novum for *Hebenarus abruptus* DeLong 1944c: 44, preoccupied by *Scaphytopius* (*Convelinus*) *abruptus* Ball 1909c: 165.

Van Duzee (1910a: 230) placed the senior homonym as a junior synonym of *Scaphytopius* (*Convelinus*) *fuscifrons* (Van Duzee 1894f: 206), which occurs in the United States. Oman (1949a: 101) synonymized *Hebenarus* under *Scaphytopius*, which resulted in the homonymy, but did not list the senior homonym. The *nomen novum* for the junior homonym denotes a valid species described from Mexico.

The new name is based on the author of the junior homonym.

Scaphytopius **(*Cloanthanus*)** ***linnavuorii*** **McKamey and Hicks, new name**

Scaphytopius (*Cloanthanus*) *linnavuorii, nomen novum* for *Scaphytopius* (*Cloanthanus*) *divisus* DeLong and Linnavuori 1978b: 116, preoccupied by *Scaphytopius divisus* (DeLong 1944a: 171).

Both species are valid without synonyms. *Scaphytopius divisus* (DeLong 1944a) was described from Mexico and *Scaphytopius divisus* DeLong and Linnavuori (1978b) was described from Peru. The new name is based on one author of the junior homonym.

Sorhoanus lii **McKamey and Hicks, new name**

Sorhoanus lii, nomen novum for *Sorhoanus binotatus* Li and Dai 2003a: 10, preoccupied by *Sorhoanus binotatus* Kuoh 1985b: 87.

Both species are valid without synonyms. *Sorhoanus binotatus* Kuoh was described from China and *S. binotatus* Li and Dai was described from Taiwan. The new name is based on the author of the junior homonym.

Thamnotettix matsumurai **McKamey and Hicks, new name**

Thamnotettix matsumurai, nomen novum for *Thamnotettix infuscatus* Matsumura 1911b: 28, preoccupied by *Thamnotettix infuscatus* Gillette and Baker 1895a: 98.

The senior homonym *Thamnotettix infuscatus* Gillette and Baker is a junior synonym of *T. confinis* Zetterstedt (1828a: 527), which has a widespread distribution: United States, Canada, Europe (Scandinavia to western Mediterranean), northern Africa, Russia, eastern Baltic States (Metcalf 1967a), and Mongolia (Dlabola 1965c). *Thamnotettix infuscatus* Matsumura, a valid species without synonyms, was described from Russia.

The new name is based on the author of the junior homonym.

Fixed Correct Original Spellings

The principle of first reviser (ICZN Art. 24) is here applied to fix the spellings of 13 species that were spelled multiple ways in their original descriptions. All are valid species without synonyms.

Acinopterus igualanus Linnavuori and DeLong 1977d: 252. The spelling "*igualanum*" (in Abstract) is deemed incorrect.

Acinopterus perdicoensis Linnavuori and DeLong 1977d: 250. The spelling "*peridicoensis*" (p. 250) is deemed incorrect.

Allygus (*Syringius*) *rebellatrix* Dlabola 1995a: 317. The spelling "*rebelatrix*" (p. 318) is deemed incorrect.

Amplicephalus latus DeLong 1984d: 169. The spelling "*lastus*" (p. 171) is deemed incorrect.

Angubahita atra DeLong 1982a: 185. The spelling "*arta*" in the species heading is deemed incorrect.

Bendara lyrata DeLong 1980h: 64. The spelling "*lyarata*" [in note, p. 64] is deemed incorrect.

Deltocephalus diagnalis DeLong 1984f: 110. The spelling "*diagnalus*" in the species heading is deemed incorrect.

Haldorus nigrifrons Linnavuori and DeLong 1979a: 51. The spelling "*nigifrons*" (p. 51) is deemed incorrect.

Macrosteles purpurea Kuoh [in Kuoh and Lu 1986a: 121]. The spelling "*purpureta*" (p. 121) is deemed incorrect.

Neurotettix flangenus Shen and Dai (2002: 89) appears as such in the abstract, the introduction, at the head of the species description and in the Chinese summary (and is therefore presumed to be the intended name). It is misspelled as *N. robustus* (presumably a *lapsus calami*) in the key and in the figure caption.

Paratanus bipunctus DeLong and Cwikla 1985a: 725. The spelling "*bipunctatus*" in the abstract is deemed incorrect.

Perubahita longifalx Linnavuori and DeLong 1978b: 114. The spelling "*longifal*" (p. 114) is deemed incorrect.

Scaphoideus wideaedeagus Wang and Li 2004a: 17. The spelling "*windeaedeagus*" in English summary (p. 18) is deemed incorrect.

Acknowledgments

We thank the many researchers of Membracoidea who have encouraged the LOWD project since its beginning, and to F. C. Thompson, L. Deitz and two anonymous reviewers for suggestions on earlier drafts of this manuscript.

Literature Cited

Baker, C. F. 1896a. The North American species of *Gnathodus*. Canadian Entomologist 28: 35–42.

Ball, E. D. 1909c. Several new western jassids. Entomological News 20: 163–168.

Cogan, E. S. 1916a. Homopterous studies. Part 1. Contribution towards our knowledge of the Homoptera of South Africa. Ohio Journal of Science 16: 161–208.

Conti, M. 1985. Transmission of plant viruses by leafhoppers and planthoppers, pp. 289–307. *In* Nault, L. R. and J. G. Rodriguez, eds. The Leafhoppers and Planthoppers. Wiley and Sons, New York.

Dai, R.-H., Z. Z. Li, and X. X. Chen. 2004a. Notes on Chinese species of *Balclutha* with descriptions of three new species (Homoptera, Cicadellidae, Euscelinae). Acta Zootaxonomica Sinica 29(4): 749–755.

Day, M. F. and M. J. Fletcher. 1994a. An annotated catalogue of the Australian Cicadelloidea (Hemiptera: Auchenorrhyncha). Invertebrate Taxonomy 8: 1117–1288.

DeLong, D. M. 1944a. A new genus (*Tumeus*) and six new species of leafhoppers closely related to *Cloanthanus* (Homoptera, Cicadellidae). Bulletin of the Brooklyn Entomological Society 38: 168–174.

———. 1944c. A new genus—*Hebenarus*—and thirteen new species of leafhoppers closely related to *Cloanthanus* (Homoptera, Cicadellidae). Pan-Pacific Entomologist 20: 41–53.

———. 1980h. New genera and species of Mexican and South American deltocephaline leafhoppers (Homoptera, Cicadellidae, Deltocephalinae). Revista Peruana de Entomologia 23(1): 63–71.

———. 1982a. New Central and South American leafhoppers of the "*Bahita*" group (Homoptera: Cicadellidae: Deltocephalinae). Proceedings of the Entomological Society of Washington 84(1): 184–190.

———. 1984d. Some new species of Bolivian *Amplicephalus* (Homoptera: Cicadellidae: Deltocephalinae). Uttar Pradesh Journal of Zoology 4(2): 168–174.

———. 1984f. New species of Central American *Polyamia* and *Deltocephalus* (Homoptera: Cicadellidae: Deltocephalinae). Brenesia 22: 107–114.

DeLong, D. M. and P. S. Cwikla. 1985a [1984]. New Neotropical Deltocephalinae (Homoptera: Cicadellidae). Journal of the Kansas Entomological Society 57(4): 725–728.

DeLong, D. M. and R. H. Davidson. 1933a. Some new species of *Eugnathodus* (Homoptera, Cicadellidae). Ohio Journal of Science 33: 55–58.

DeLong, D. M. and R. Linnavuori. 1978b. Studies of Neotropical leafhoppers (Homoptera: Cicadellidae). Entomologica Scandinavica 9: 111–123.

Distant, W. L. 1916a. Rhynchota, Homoptera. Appendix. The Fauna of British India, Including Ceylon and Burma. Published under the authority of the Secretary of State for India Council 6: pp. i–vii, pp. 1–248, Taylor and Francis, Bombay, India

Dlabola, J. 1965c. Ergebnisse der Zoologischen Forschungen von Dr. Z. Kaszab in der Mongolei. 54. Homoptera—Auchenorrhyncha. Sbornik Faunistickych Praci Entomologickeho Odelini Narodniho Musea V Prace 11(100): 79–136.

———. 1995a. *Mycterodus* verwandte Taxone und sieben neue Zikadenarten (Homoptera, Auchenorrhyncha). [Taxa related to *Mycterodus* and seven new cicada species (Homoptera, Auchenorrhyncha).] Acta Entomologica Nationalis Prague 44: 301–319.

Dmitriev, D. A. and C. H. Dietrich. 2006. Nomenclatural changes and notes in the tribe Erythroneurini (Homoptera: Cicadellidae: Typhlocybinae). Zootaxa 1120: 35–39.

Evans, J. W. 1938b. Australian leafhoppers (Homoptera, Jassoidea). Part VIII. Royal Society of Tasmania Papers and Proceedings 1938: 1–18.

———. 1941e. New Australian leafhoppers. Royal Society of South Australia Transactions 65: 36–41.

———. 1966a. The leafhoppers and froghoppers of Australia and New Zealand (Homoptera: Cicadelloidea and Cercopoidea). Memoirs of the Australian Museum 12: 1–347.

Fabricius, J. C. 1775a. Ryngota. Systema Entomologiae. Sisten insectorum classes, ordines, genera, species, adiectis synonymis, locis, descriptionibus, observationibus. Korte, 816 pp., Flansburg and Leipzig, Germany.

Ferrari, P. M. 1882a. Cicadaria Agri Ligustici. Annali del Museo Civico de storia naturale di Genova 18: 75–165.

Fieber, F. X. 1885a. Description des Cicadines d'Europe des genres *Cicadula* et *Thamnotettix*. (Traduit de l'allemand sur le manuscrit original, par F. Reiber.) Avec des additions, par L. Lethierry. Revue d'Entomologie 4: 40–110.

Fletcher, M. J. and M. C. Larivière. 2001 (and last update 2007). Identification keys and checklists for the leafhoppers, planthoppers and their relatives occurring in Australia and New Zealand (Hemiptera: Auchenorrhyncha). http://www.agric.nsw.gov.au/Hort/ascu/leafhop/athysan.htm [last accessed 6/18/07]

Gillette, C. P. and C. F. Baker. 1895a. A preliminary list of the Hemiptera of Colorado. Colorado Agricultural Experiment Station Bulletin 31: 1–137.

Giustina, W. della. 1989a. Homoptères Cicadellidae. Volume 3. Complements aux ouvrages d'Henri Ribaut. Faune de France 73: 1–350.

Hamilton, K. G. A. 1975. A review of the Northern Hemisphere Aphrodina (Rhynchota: Homoptera: Cicadellidae), with special reference to the Nearctic fauna. Canadian Entomologist 107: 1009–1027.

Haupt, H. 1927a. Homoptera Palestinae I. Palestine Agricultural Experiment Station Bulletin 8: 5–43.

International Commission on Zoological Nomenclature, International Code of Zoological Nomenclature. 4th ed. 1999. International Trust for Zoological Nomenclature, London. xxix + 306 pp.

Ishihara, T. 1961a. Homoptera of Southeast Asia collected by the Osaka City University Biological Expedition to Southeast Asia 1957–1958. Nature and Life in Southeast Asia 1: 225–257.

Kirkaldy, G. W. 1906c. Leafhoppers and their natural enemies. Pt. IX, Leafhoppers. Hemiptera. Hawaiian Sugar Planters' Association, Division of Entomology Bulletin 1: 271–479.

———. 1907d. Leafhoppers supplement (Hemiptera). Hawaiian Sugar Planters' Association, Division of Entomology Bulletin 3: 1–186.

Kirschbaum, C. L. 1868b. Die Cicadinen der gegend von Wiesbaden und Frankfurt A. M. nebst einer anzahl neuer oder Schwer zu unterschneidender Arten aus anderen Gegenden Europa's Tabellarisch Beschrieben. Jahrbucher des Vereins fur Naturkunde im Herzogthum Nassau 21–22: 1–202.

Knight, W. J. 1987a. Leafhoppers of the grass-feeding genus *Balclutha* (Homoptera: Cicadellidae) in the Pacific Region. Journal of Natural History 21: 1173–1224.

Kuoh, C. L. 1985b. Homoptera: Cicadelloidea, pp. 82–89. *In* Organisms of Mt. Tuomuer area in Tianshan. Xinjiang People Press, Urumqi, China.

Kuoh, C. L. and Z. Lu. 1986a. A new leafhopper injurious to water caltrop (Homoptera: Cicadellidae). Entomotaxonomia 8(1–2): 121–123.

Li, Z. Z. and R. Dai. 2003a. Description of four new species of the Deltocephalinae from Taiwan (Homoptera: Cicadellidae.) Collection and Research 16: 7–12.

Lindberg, H. 1948b. On the insect fauna of Cyprus. Results of the expedition of 1939 by Harald Häkan and P. H. Lindberg. I. Heteroptera und Homoptera Cicadina der Insel Zypern. Commentationes Biologicae 10(7): 23–175.

Linnavuori, R. 1959b. Revision of the Neotropical Deltocephalinae and some related subfamilies (Homoptera). Suomalaisen Elain-ja Kasvitieteelisen Seuran Vanamon Elaintieteellisia Julkaisuja 20: 1–370.

———. 1960a. Insects of Micronesia. Homoptera: Cicadellidae. Honolulu, Bishop Museum 6(5): 231–344.

———. 1960b. Cicadellidae (Homoptera, Auchenorrhyncha) of Fiji. Acta Entomologica Fennica 15: 1–71.

———. 1961a. Hemiptera (Homoptera): Cicadellidae, pp. 452–486. *In* Hanstrom, Brinck, and Rudebeck, eds. South African Animal Life Volume 8.

———. 1962a. Hemiptera of Israel. III. Suomalaisen Elain-ja Kasviteiteellisen Seuran vanamon Elaintieteellsia Julkaisuja 24(3): 1–108.

———. 1975a. Revision of the Cicadellidae (Homoptera) of the Ethiopian Region. III. Deltocephalinae, Hecalini. Acta Zoologica Fennica 143: 1–37.

———. 1975c. Homoptera: Cicadellidae (Supplement). Insects of Micronesia 6(9): 611–632.

Linnavuori, R. E. and D. M. Delong. 1977c. The leafhoppers (Homoptera: Cicadellidae) known from Chile. Brenesia 12&13: 163–267.

———. 1977d. The genus *Acinopterus* (Homoptera: Cicadellidae) in Mexico and the Neotropical Region. Entomological News 88(9–10): 249–254.

———. 1978b. Neotropical leafhoppers of the *Bahita* group (Homoptera: Cicadellidae: Deltocephalinae). A contribution to the taxonomy. Brenesia 14&15: 109–169.

———. 1979a. New genera and species of the tribe Deltocephalini from South America. Entomologica Scandinavica 10: 43–53.

Matsumura, S. 1902a. Monographie der Jassinen Japans. Természetrajzi Füzetek 25: 353–404.

———. 1908a. Neue Cicadinen aus Europa und Mittelmeergebiet. Journal of the College of Science, Imperial University of Tokyo 23(6): 1–46.

———. 1911b. Erster Beitrag zur Insekten-Fauna von Sachalin. Journal of the College of Agriculture, Tohoku Imperial University, Sapporo 4: 1–145.

———. 1914a. Die Jassinen und einige neue Acocephalinen Japans. Journal of the College of Agriculture, Tohoku Imperial University, Sapporo 5: 165–240.

McKamey, S. H. 2003. Some new generic names in the Cicadellidae (Hemiptera: Deltocephalinae, Selenocephalinae). Proceedings of the Entomological Society of Washington 105(2): 447–451.

———. 2006. Further new genus-group names in the Cicadellidae (Hemiptera). Proceedings of the Entomological Society of Washington 108(3): 502–510.

Melichar, L. 1903b. Homopteren-Fauna von Ceylon. 248 pp.

———. 1914b. Homopteren von Java, gesammelt von Herrn. Ewd. Jacobson. Leydon Museum Notes 36: 91–147.

Merino, G. 1936a. Philippine Cicadellidae (Homoptera). Philippine Journal of Science 61: 307–400.

Metcalf, Z. P. 1955a. New names in the Homoptera. Journal of the Washington Academy of Sciences 45: 262–267.

———. 1964a. General Catalogue of the Homoptera. Fascicle VI. Cicadelloidea. Bibliography of the Cicadelloidea (Homoptera: Auchenorrhyncha). United States Department of Agriculture, Agriculture Research Service, Washington, D.C. 349 pp.

———. 1967a. General Catalogue of the Homoptera. Fascicle VI. Cicadelloidea. Part 10. Section I. Euscelidae. U.S. Department of Agriculture, Agriculture Research Service, Washington, D.C. 1077 pp.

———. 1967b. General Catalogue of the Homoptera. Fascicle VI. Cicadelloidea. Part 10. Section II. Euscelidae. U.S. Department of Agriculture, Agriculture Research Service, Washington, D.C. pp. 1078–2074.

———. 1967c. General Catalogue of the Homoptera. Fascicle VI. Cicadelloidea. Part 10. Section III. Euscelidae. U.S. Department of Agriculture, Agriculture Research Service, Washington, D.C. pp. 2075–2695.

Morrison, W. P. 1973a. A revision of the Hecalinae (Homoptera: Cicadellidae) of the Oriental Region. Pacific Insects 15(3–4): 379–438.

Nast, J. 1972a. Palearctic Auchenorrhyncha (Homoptera): An annotated check list. Institute of Zoology. Polish Academy of Sciences, Polish Scientific Publisher, Warsaw. 550 pp.

Naudé, T. J. 1926a. Cicadellidae of South Africa, a taxonomic and faunistic study. Union of South Africa Department of Agriculture and Forestry, Entomology Memoirs 4: 1–106.

Oman, P. W. 1949a. The Nearctic leafhoppers (Homoptera: Cicadellidae). A generic classification and check list. Memoirs of the Entomological Society of Washington No. 3, 253 pp.

Oman, P. W., W. J. Knight, and M. W. Nielson. 1990. Leafhoppers (Cicadellidae): A Bibliography, Generic Check-list and Index to the World Literature 1956–1985. CAB International Institute of Entomology, Wallingford, UK. [iv] + 368 pp.

Osborn, H. 1924c. Neotropical Homoptera of the Carnegie Museum. Part 4. Report upon the collection in the subfamily Jassinae, with descriptions of new species. Annals of the Carnegie Museum 15: 397–462.

———. 1926c. Faunistic and ecologic notes on Cuban Homoptera. Annals of the Entomological Society of America 19: 335–366.

Provancher, L. 1872c. Description de plusieurs Hémiptères nouveaux. Naturaliste Canadien 4: 376–379.

Puton, A. 1898a. Hémiptères nouveaux. Revue d'Entomologie 17: 273–274.

Ross, H. H. 1968a. The evolution and dispersal of the grassland leafhopper genus *Exitianus*, with keys to the Old World species (Cicadellidae-Hemiptera). Bulletin of the British Museum (Natural History) Entomology 22(1): 1–30.

Scott, J. 1876d. Descriptions of three new species of European Hemiptera-Homoptera. Entomologist's Monthly Magazine 13: 83–85.

Seven, S. 1997. Pasifik Adalarindan bir Cicadellid cinsinin nomenklaturu uzerine notlar (Homoptera). Centre for Entomological Studies Miscellaneous Papers 35–36: 6–7. [Publication not seen; source: Zoological Record v. 133–135 1997–1999.]

Shen, L. and W. Dai. 2002. A new species of the genus *Neurotettix* Matsumura (Homoptera: Cicadellidae: Deltocephalinae). Entomotaxonomia 24(2): 89–92.

Theron, J. G. 1970b. Redescription of ten of Cogan's species of South African Cicadelloidea (Hemiptera). Journal of the Entomological Society of Southern Africa 33(2): 303–323.

Uhler, P. R. 1880a. Remarks on a new form of Jassid. American Entomologist 3: 72–73.

Van Duzee, E. P. 1894f. Descriptions of some new North American homopterous insects. Bulletin of the Buffalo Society of Natural Sciences 5: 205–216.

———. 1910a. A revision of the American species of Platymetopius. Annals of the Entomological Society of America 3: 214–231.

Villiers, A. 1956a. Contribution a l'etude du peuplement de la Mauritanie: Description de nouveaux Hemipteres. Bulletin de l'Institut Français d'Afrique Noire (Serie A) 18: 834–842.

Wang, L. M. and Z. Z. Li. 2004a. Three new species of the genus *Scaphoideus* (Homoptera: Cicadellidae: Euscelinae) from Yunnan. Entomotaxonomia 26(1): 15–18.

Webb, M. D. and J. Vilbaste. 1994a. Review of the leafhopper genus *Balclutha* Kirkaldy in the Oriental Region (Insecta, Homoptera, Auchenorrhyncha). Entomologische Abhandlungen 56: 55–87.

Wolcott, G. N. 1923b. Insectae Portoricensis.A preliminary annotated check-list of the insects of Porto Rico, with descriptions of some new species. Puerto Rico University Journal of Agriculture 7(1): 1–313.

Zetterstedt, J. W. 1828a. Ordo III. Hemiptera. Fauna Insectorum Lapponica 1: 1–563.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 938–947

A NEW SPECIES OF *DICHRORAMPHA* (LEPIDOPTERA: TORTRICIDAE: GRAPHOLITINI) FROM JAMAICA: A POTENTIAL BIOCONTROL AGENT AGAINST *CHROMOLAENA ODORATA* (ASTERACEAE)

John W. Brown and Costas Zachariades

(JWB) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, DC 20013-7012, U.S.A. (e-mail: john.brown@ars.usda.gov); (CZ) ARC-Plant Protection Research Institute, Weeds Research Division, Private Bag X6006, Hilton 3245, South Africa (e-mail: zachariadesc@arc.agric.za)

Abstract.—***Dichrorampha odorata*** **Brown and Zachariades, new species**, is described and illustrated from Jamaica. It is most similar to *D. sapodilla* Heppner among described species, both superficially and in the male genitalia. However, the two are easily separated by the long costal fold of the male forewing of *D. odorata*, which is absent in *D. sapodilla*. The shapes of the valva and cucullus also distinguish the two. The related *D. azteca* Walsingham, revised status, which shares a distinct male forewing costal fold with *D. odorata*, is returned to *Dichrorampha*. *Dichrorampha odorata* induces galls in the shoot tips of the invasive weed *Chromolaena odorata* (L.) R. M. King & H. Robinson (Asteraceae), commonly known as triffid, Jack-in-the-bush, bitter bush, Christmas bush, and Siam weed. The new species appears to have considerable potential as a biological control agent against this weedy shrub in South Africa.

Key Words: Systematics, Tortricidae, *Dichrorampha*, new species, biological control, triffid, Jack-in-the-bush, *Chromolaena odorata*, Jamaica, South Africa

With over a dozen common names, including triffid, Jack-in-the-bush, Siam weed, bitter bush, and Christmas bush, *Chromolaena odorata* (L.) R. M. King & H. Robinson (Asteraceae) (formerly known as *Eupatorium odoratum* L.) is a perennial shrub native to South and Central America (Holm et al. 1977). In recent decades it has become a serious pest in the humid tropics of southeastern Asia, Africa, and the Pacific Islands. It has been nominated as among the top 100 "world's worst" invaders (Wilson 2006). It spreads rapidly in lands used for forestry, pasture, and plantation crops such as rubber, coffee, coconut, cocoa, and cashew, owing to its efficient short- and long-distance dispersal abilities (Muniappan 2005). In South Africa it is a problem primarily for biodiversity conservation, grazing, and forestry (Goodall and Erasmus 1996). Invasive populations of *C. odorata* in Asia and southern Africa both originated from the Caribbean, although the southern African form (biotype) of *C. odorata* is distinct from that invading southeastern Asia and western Africa (Zachariades et al. 2004). Plants identical to the South African biotype have been found only on islands in the northern Caribbean, most notably Jamaica and Cuba (Zachariades et al. 2004).

During efforts to identify biological control agents against this weed, a new species of tortricid moth was discovered in Jamaica that induces galls in the terminal shoots of the plant. The purposes of this paper are to describe and illustrate this new species and present information on its biology.

MATERIALS AND METHODS

Specimens of larvae were discovered in galls of *Chromolaena odorata* in three general areas in Jamaica by personnel from the Plant Protection Research Institute, South African Agricultural Research Council: (1) near Mandeville, (2) in the Blue Mountains, and (3) along the north coast from Port Maria to southwest of Montego Bay. The galls were imported into quarantine in South Africa and successfully cultured (see Biology below). Representative larvae and pupae were placed in boiling water for approximately 2 minutes and transferred to 90% EtOH for preservation. Dissection methodology follows that presented in J. Brown and Powell (1991, 2000). The image of the adult was captured using a Microptics© digital camera system. Preliminary illustrations of the genitalia were drawn from slide-mounted preparations using a Ken-a-Vision microprojector; final illustrations were inked using dissecting and compound microscopes. Terminology for genitalia structures and wing venation follows Horak (1984); terminology for larval chaetotaxy follows R. Brown (1987); terminology for forewing pattern follows R. Brown and Powell (1991), as modified by Baixeras (2002); and plant taxonomy follows GRIN (2006) and METAFRO (2006).

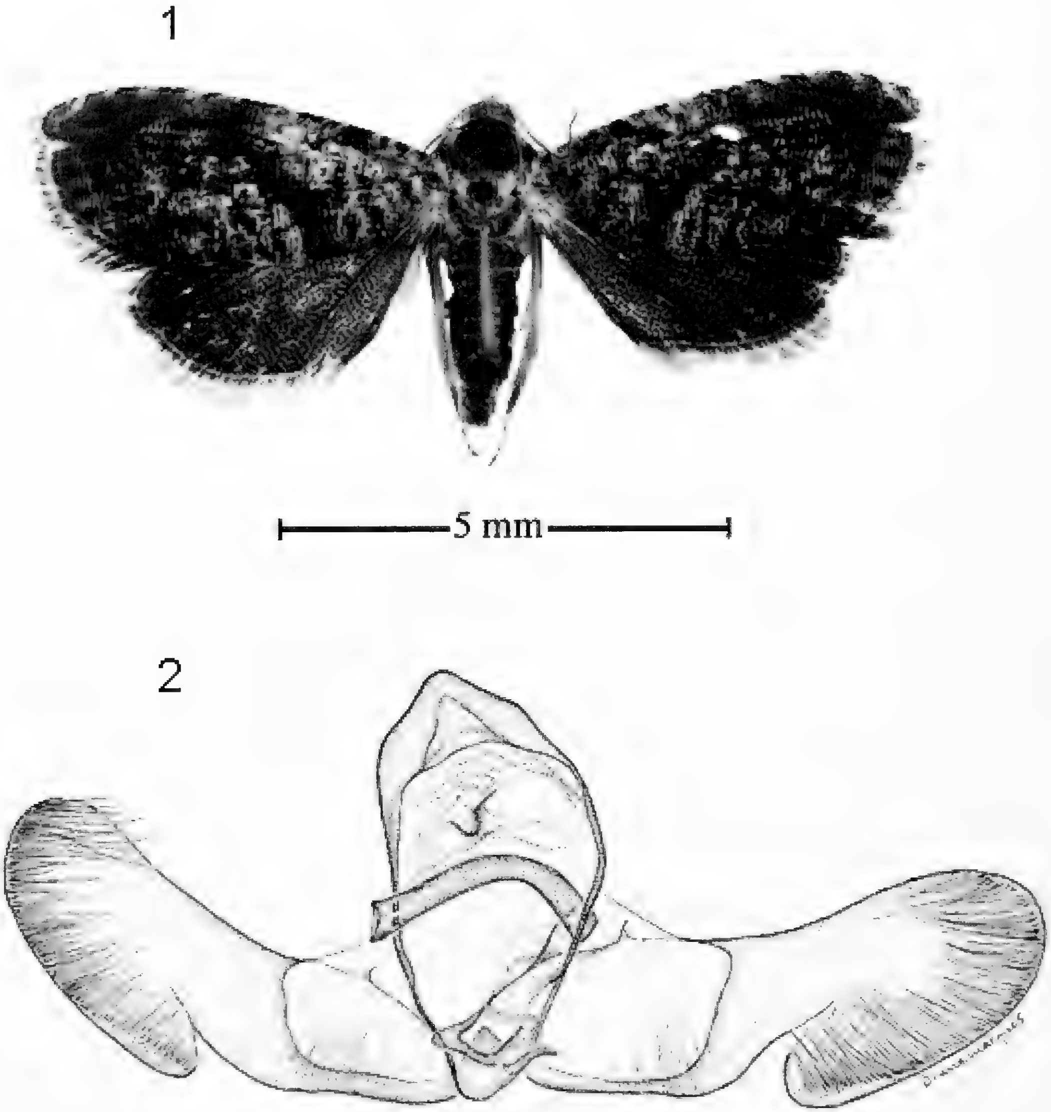
SYSTEMATICS

Dichrorampha, with 112 described species worldwide (Brown 2005), is primarily Palaearctic (ca. 80 species), with 20 described species in North America, 10 in the Neotropics, and one in South Africa. The new species is assigned to the genus on the basis of the following character states: male forewing with a well developed costal fold (present or absent in *Dichrorampha*, but absent in all other New World Grapholitini) (Heinrich 1926); a distinct row of dark dots along the termen of the forewing (Komai 1999) (Fig. 1); female genitalia with the sterigma, seventh sternite, and sclerotized posterior portion of ductus bursae fused (Komai 1999) (Fig. 3); and female genitalia with a single thornlike signum (usually with two thornlike signa in other genera of Grapholitini) (Heinrich 1926) (Fig. 3). Most species of *Dichrorampha* for which host plants are known (i.e., about 25 species) feed on Asteraceae (e.g., McDunnough 1946; Swatschek 1958; MacKay 1959; Danilevsky and Kuznetzov 1968; Bradley et al. 1979; Jensen and Palm 1981; Park 1983; Godfrey et al. 1987; Sterling 1991; Corley 1992) with a few notable exceptions: *Dichrorampha okui* Komai has been reported from acorns of *Quercus* sp. (Fagaceae) (Oh et al. 2001); *Dichrorampha petiverella* (Linnaeus) (reported as *dorsana*) from *Lathyrus* sp. and *Pisum* sp. (Fabaceae) (Disque 1908; Bradley et al. 1979); and *Dichrorampha manilkara* Heppner and *D. sapodilla* Heppner from *Manilkara* sp. (Sapotaceae) (Heppner 1981). Five of the six species reported from Europe by Swatschek (1958) feed in the roots of their asteraceous hosts, with the sixth feeding on shoots.

Dichrorampha odorata Brown and Zachariades, new species

(Figs. 1–9)

Diagnosis.—*Dichrorampha odorata* is most similar to *D. sapodilla* Heppner (TL: USA, Florida), both superficially and in the male genitalia. However, the two are easily separated by the long



Figs. 1–2 *Dichrorampha odorata*. 1, Adult male (with scale bar), 2, Male genitalia.

costal fold of the male forewing of *D. odorata*, which is absent in *D. sapodilla*. The shape of the cucullus is also distinctive between the two: in *D. sapodilla* it has distinct dorsal and basal lobes and is well separated from the basal part of the valva by a rounded excavation along the venter of the valva; in *D. odorata* the cucullus lacks the dorsal lobe and is separated from the basal part of the valva by a narrow incision along the venter (Fig. 2). Also, *D. sapodilla* has been reared only from *Manilkara zapota* (L.) P. Royen (Sapotaceae) (Heppner 1981), whereas the new species is known only from *Chromolaena odorata* (Asteraceae).

Dichrorampha odorata is superficially similar to *D. azteca* Walsingham, revised status (TL: Mexico, Guerrero), particularly in the shared possession of a well-developed costal fold in the male fore-

Fig. 3. *Dichrorampha odorata*, female genitalia.

wing. However, the male genitalia of *D. azteca* have a relatively broad, deep, U-shaped excavation immediately basad of the cucullus as in *D. sapodilla* and unlike that of *D. odorata*.

The female of *D. odorata* has a frenulum comprised of two bristles. Although somewhat unusual, this character state is found in several other Grapholitini (e.g., a few species in each of the genera *Pammene, Cydia*, and *Grapholita*). Komai (1999) proposed that it represented a synapomorphy for *Strophedra* Herrich-Schäffer and *Andrioplecta* Obraztsov, but it is considerably more widespread and variable within the tribe (Brown and Baixeras 2006).

Description.—Adult: *Head:* Vertex rough-scaled, cream and pale tan, scales extending forward nearly to middle of labial palpus; frons pale tan; outer surface of labial palpus cream in basal half with small dark spot at base, blackish gray in distal half, with scaling broadly expanded, inner surface cream; antenna pale gray; ocellus present. *Thorax:* Dorsum brown, mixed with pale scales posteriorly, without posterior crest; legs striped cream and gray-brown, male without conspicuous secondary sex scales. Forewing (Fig. 1) ground color mottled gray-brown, brown, and ochreous; termen with distinct subapical indentation between R_5 and M_1 at base of apical-most, white, terminal strigula; a pair of parallel, narrow, brown, oblique fasciae, arising between costal strigulae 7–8 and 9 (i.e., subterminal fascia) and 5–6 and 7–8 (i.e., postmedian fascia), narrowly bordered by pale orange and separated by narrow black line, originating at costa ca. 0.5 and 0.7 distance from base to apex, extending toward termen; costa with 7 pairs of pale strigulae, basal pairs indistinct, distal pairs frequently coalesced; basal half of wing with ill-defined, dark, oblique band, originating at dorsal margin ca. 0.33 distance from base to tornus, attenuating before reaching mid-costa; ocellus (patch) not developed; 3–4 small black spots forming line parallel to termen in yellow-speckled terminal region; interfacial spot ill-defined, mostly obscured with gray-brown. Fringe grayish brown. Ventral surface lustrous bronze. Hindwing uniform dark brown above, except broad area of overlap with forewing whitish. Fringe grayish brown. Ventral surface lustrous bronze. Male frenulum with one bristle, female frenulum with two. *Abdomen:* Scaling dark brown, without conspicuous secondary sex scaling in male. Male genitalia (Fig. 2; based on 2 preparations) with tegumen rather broad, rounded-triangular dorsally, with small mid-dorsal hump; gnathos a narrow, ill-defined band dorsad of aedeagus; vinculum weakly sclerotized; valva moderately broad, with large, subrectangular basal excavation, costa weakly arched from ca. base to ca. middle of cucullus, apex rounded; sacculus not developed; cucullus broad with large reflexed basal lobe, densely setose, separated from basal portion of valva along ventral edge by deep, narrow incision; "neck" of valva inconspicuous owing to narrow incision; aedeagus relatively long, ca. 0.5 length of valva, arched, slightly dilated distally, with diffuse patch of fixed cornuti. Female genitalia (Fig. 3; 2 preparations) with papillae anales slender, slightly broader in distal 0.5; apophyses posteriores ca. 0.75 times length of apophyses anteriores; sterigma symmetrical, unsclerotized except for narrow crescent-shaped patches extending from lateral edge of rounded, sclerotized ostium; ductus bursae comparatively broad, ca. 8 times longer than wide, distal two-fifths more sclerotized, slightly elongate funnel-shaped, remainder of ductus bursae membranous; ductus seminalis from ductus bursae ca. 0.6 distance from ostium to junction of ductus and corpus bursae; corpus bursae oblong, membranous, with a single, slender, thornlike signum at right lateral side of corpus.

Larva: General (last instar): Length 6.0–7.0 mm (n = 3), head somewhat circular in outline in dorsal view, amber to pale yellow with variably developed brown stemmatal patch and spot at genal angle; prothoracic shield pale yellow with faint or no traces of pattern; body pale, pinacula weakly pigmented, inconspicuous; anal shield very pale yellow, unmarked. Thoracic chaetotaxy typically tortricoid, with L-group trisetose on T1 and SV-group 2:1:1 on T1–3. Abdomen with spiracles small and circular, only slightly smaller than that of T1; spiracle on A8 slightly posterior to middle of segment; segments 1–8 with SD2 inconspicuous, SD1 dorsad of spiracle on A1–7, anteriorad of spiracle on A8; L1 and L2 on same pinaculum on A1–8; D2s on shared dorsal pinaculum on A9; D1 and SD1 on a shared pinaculum on A9; L-group trisetose on A9; V's about the same distance apart on A7–9, or slightly further apart on A9; SV Group on 1, 2, 7, 8, 9 is 2:2:2:2:1. Crochets uniordinal, 18–20 on prolegs (A3–6), 10–14 on A10. Anal fork present.

According to Swatschek (1958), the larvae of *Dichrorampha* are characterized by the following: seta SD1 on A8 immediately anterior of the spiracle and SV group bisetose on A1, 2, 7, and 8, and unisetose on A9, except occasionally trisetose on A2. The only species of *Dichrorampha* treated by MacKay (1959) (i.e., *D. bittana*) was reported to lack an anal fork; Swatschek (1958) did not mention this feature is his key or diagnoses of larval *Dichrorampha*.

Pupa: Fusiform, length ca. 5 mm, width ca. 1 mm (n = 5); typically tortricoid, without cephalic projection or conspicuous sculpturing. Dorsum of segment A1 lacking spines; dorsum of A2–8 with two rows of spines, anterior row situated at anterior edge of segment, with larger spines, row attenuate well before spiracle; posterior row situated at posterior edge of segment, with smaller spines but frequently extending further laterad; segment A8 sometimes with posterior row weak or absent. Segments A9–10 each with short row of larger thorns; A10 with 6 slender, hook-tipped setae; cremaster absent.

Holotype.—Male, Jamaica, Jackson Town, WP 042, 18.25N, 77.29W, 13 Nov 1999, C. Zachariades. Deposited in Institute of Jamaica, Kingston, Jamaica.

Paratypes.—1♂, 10♀. Jamaica: Blue Mountains, WP 032-5, 047-051, 18.03N, 76.45W to 18.01N, 76.40W, 9, 10, 14 Nov 1999 (2♀), C. Zachariades. Blue Mountains; north along coast from Port Maria to southwest of Montego Bay, 18°01.959–18°27.630N, 78°42.048–78°01.423W, 29–846 m, 16–24 Nov 2005 (1♂, 8♀), C. Zachariades & L. D. Khumalo. Deposited in the South African National Collection of Insects, Pretoria, South Africa; the National Museum of Natural History, Smithsonian Institution, Washington, DC, USA; and The Natural History Museum, London, England.

Distribution.—Known from Jamaica and Cuba.

Etymology.—The specific epithet is derived from the species name of the larval host plant.

Remarks.—The paratypes were collected over a range of localities (i.e., "waypoints J05-008, 009, 010, 011, 013, 014, 016, 017, 018, 019, 029, 021, 022, 025, 026"); hence the precise locality of each individual is unknown. The male holotype, although not the best specimen, was selected because it has more precise locality data.

Dichrorampha azteca Walsingham, **revised status**

Dichrorampha azteca Walsingham 1914: 258.

"*Dichrorampha*" [misplaced] *azteca:* Powell et al. 1995: 157.

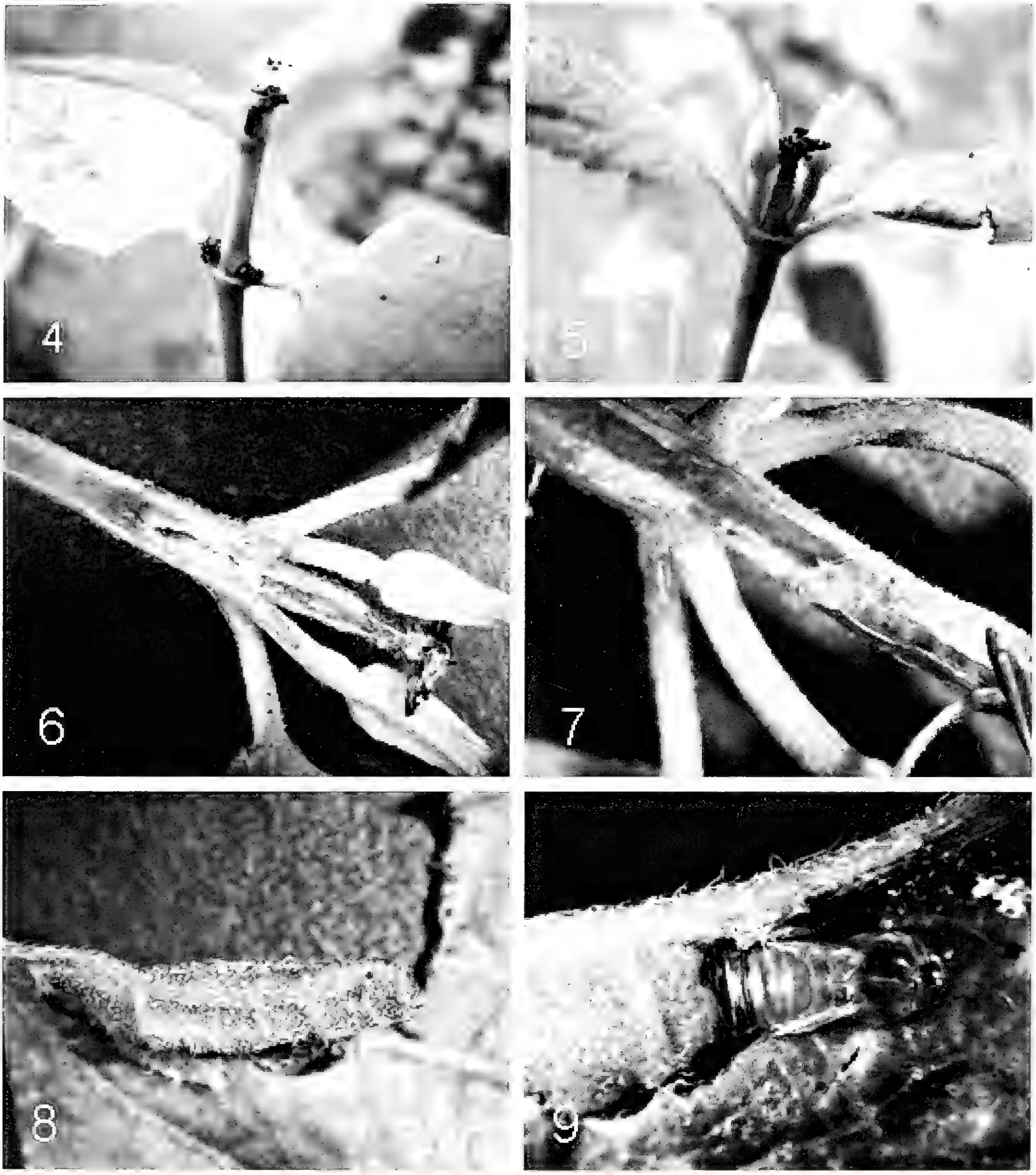
"Grapholitini Unplaced Species" *azteca:* Brown 2005: 365.

Based on features of the male genitalia and forewing pattern, *D. azteca* is undoubtedly congeneric with *D. odorata* and *D. sapodilla*. It can be separated from those species by the features discussed above in the diagnosis of *D. odorata*. Although described in *Dichrorampha, azteca* was treated as "*Dichrorampha*" [misplaced] by Powell et al. (1995), and this treatment was followed by Brown (2005), who placed it in "Grapholitini Unplaced Species." However, an examination of the syntype male (The Natural History Museum, London) revealed that it is appropriately assigned to *Dichrorampha* based on its similarity with *D. odorata* and *D. sapodilla*.

BIOLOGY AND DISCUSSION

During field surveys for biological control agents against *Chromolaena odorata*, *Dichrorampha odorata* was collected in Jamaica and Cuba, but only in small numbers. However, in November 2005 large numbers of galled shoot tips were discovered on *Chromolaena odorata* in Jamaica, and a large percentage of the galls contained larvae of *Dichrorampha odorata*. These galls were imported into quarantine in South Africa and successfully cultured.

The damage caused by *Dichrorampha odorata* is superficially similar to that caused by *Phestinia costella* (Hampson) (Lepidoptera: Pyralidae: Phycitinae), also on *C. odorata*, but less frass is produced, the eggs probably are laid in the shoot tip, and the larvae bore into the shoot tip causing the terminal 15–20 mm of the stem to swell slightly and often turn yellow. The terminal shoot tip dies, and the stem ceases its growth. The swollen stems (loosely interpreted as "galls") induced by *Dichrorampha odorata* are smaller and less obvious than those induced by *Phestinia* species, but growth of the terminal shoot is effectively stopped (Figs. 4–5). In the field, galls of *D. odorata* were found only on terminal shoots whereas those of *Phestinia* were found in axillary shoots as well. Axillary buds are attacked by *Dichrorampha odorata* in the laboratory probably owing to a shortage of oviposition sites. Larvae (Figs. 6–7) bore down the stem for a distance of 15 to 20 mm ($\bar{x} \pm 1$ SD = 18.6 ± 3.47 mm for n = 11 vacated galls or galls containing mature larvae) and are easily transferred be-



Figs. 4–9. Biology of *Dichrorampha odorata*. 4, Point of entrance of *D. odorata* larvae at shoot tip and axillary buds of *Chromolaena odorata*; 5, Damage to shoot tip of *Chromolaena odorata*; 6, Stem of *Chromolaena odorata* revealing internal damage; 7, Larva of *D. odorata* within stem of *Chromolaena odorata*; 8, Pupal shelter of *D. odorata* on leaf of *Chromolaena odorata*; 9, Pupal exuvium extruded from leaf shelter.

tween plants. When ready to pupate the larva exits the gall and cuts a semicircle in a leaf, folds it over, and attaches its edge back to the leaf with silk to create a shelter (Fig. 8). Prior to emergence the pupal case is extruded beyond the shelter (Fig. 9). Adults tend to walk rapidly (scuttle) along stems and over leaves of the plant. They have been induced to mate in standard cages (50 × 50 ×

100 cm). Thus far the species has been bred easily and quickly (generation time of 6–7 weeks) in these cages, showing a fairly high rate of increase (the highest was a six-fold increase from one generation to the next).

Larval no-choice tests have been initiated, similar to those conducted by Cruttwell (1977) on insects identified as *Mescinia* nr. *parvula* (Zeller) from Trinidad, but which likely are *Phestinia costella* (A. Solis, personal communication). These tests are considered appropriate because the larvae are highly mobile and are unlikely to bore into plants that they find unsuitable as hosts. In initial tests, mid-instar larvae were placed on marked shoot tips of 10 species of Asteraceae as well as *C. odorata*. Asteraceae were targeted because this family includes the most commonly documented hosts of *Dichrorampha*. Larvae caused galls on only two species (*Mikania capensis* DC. and *Ageratum conyzoides* L.) other than *C. odorata*, but galling was minimal, and none of the larvae on these plants pupated. None of the eight other Asteraceae species offered to larvae (i.e., *Adenostemma caffrum* DC., *Ageratina adenophora* (Sprengel) King & Robinson, *A. riparia* (Regel) King & Robinson, *Synphyotrichum novibelgii* (L.) G. L. Nesom, *Chrysanthemum* × *morifolium* Ramat., *Delairea odorata* Lem., *Distephanus angulifolius* (DC.) Robinson & B. Khan., *Microglossa mespilifolia* (DC.) Robinson) was fed upon to any degree. The insect thus seems highly host specific.

Provided that it has a host range restricted to *C. odorata, Dichrorampha odorata* has several attributes that make it a promising biocontrol agent for this weed in South Africa. It is bred easily under caged conditions, making it a good species for mass-rearing for release. It has a short life cycle and high fecundity, and therefore is likely to increase and spread quite rapidly in the field. Two leaf-feeding agents, *Pareuchaetes insulata* (Walker) (Lepidoptera: Arctiidae) and *Calycomyza eupatorivora* Spencer (Diptera: Agromyzidae), already are established in South Africa. A stem-tip attacker has long been considered an important element in any successful biological control program against *C. odorata*, both to decrease the extremely high growth rate of the stems and to decrease the number of shoot tips available for flowering (in the laboratory, *D. odorata* larvae also bored into flower buds). Although several other stem-tip attackers are known, many have proven difficult to rear under laboratory conditions. In addition, poor compatibility between the southern African *C. odorata* biotype and insects or pathogens collected from other morphological forms of *C. odorata* in South or Central America frequently has been observed or suspected (Zachariades et al. 2004). This should not be a problem with *D. odorata* because the biotype of *C. odorata* invading southern Africa is believed to have originated in Jamaica or Cuba. When released in the field in South Africa, the ultimate distribution of *D. odorata* may be confined to the coastal belt and other areas with a less severe dry season. In certain inland areas (e.g., Zululand) *C. odorata* dies back during winter, losing its leaves and sometimes its upper stems; fire is also a common occurrence in these areas. The two established leaf-feeding agents, neither of which has a prominent diapause mechanism, currently are restricted to the coastal belt. *Dichrorampha odorata* does not have an obvious diapause, but may achieve a somewhat wider distribution than *P. insulata* and *C. eupatorivora* because it does not rely on leaves for its biology to the same degree as these two species.

ACKNOWLEDGMENTS

We thank Kevin Tuck (The Natural History Museum, London) and José

Montero (Instituto Nacional de Biodiversidad, Santo Domingo, Costa Rica) for allowing us to examine specimens in their care. Diana Marques provided the drawings of the genitalia, and Karolyn Darrow provided the photograph of the adult. We thank the following for helpful reviews of the manuscript: Matthew Buffington and Thomas Henry, Systematic Entomology Laboratory, USDA, Washington, D.C.; Richard Brown, Mississippi State University, Mississippi State, MS; and Joaquin Baixeras, Universitat de Valencia, Spain. The Working for Water program and the Agricultural Research Council provided funding for research on the biocontrol of *C. odorata* in South Africa. We thank the University of the West Indies, Jamaica, for assistance, and the National Environment and Planning Agency, Jamaica, for permission to collect and export live material.

LITERATURE CITED

Baixeras, J. 2002. An overview of genus-level taxonomic problems surrounding *Argyroploce* Hübner (Lepidoptera: Tortricidae), with description of a new species. Annals of the Entomological Society of America 95: 422–431.

Bradley, J. D., W. G. Tremewan, and A. Smith. 1979. British tortricoid moths. Tortricidae: Olethreutinae. The Ray Society, London. 336 pp.

Brown, J. W. 2005. World Catalogue of Insects. Volume 5. Tortricidae (Lepidoptera). Apollo Books. 741 pp.

Brown, J. W. and J. Baixeras. 2006. *Macrocydia divergens*, a new genus and species of Grapholitini (Lepidoptera: Tortricidae: Olethreutinae) from Central America. Zootaxa 1197: 45–54.

Brown, J. W. and J. A. Powell. 1991. Systematics of the *Chrysoxena* group of genera (Lepidoptera: Tortricidae: Euliini). University of California Publication Entomology 111, 87 pp. + figs.

———. 2000. Systematics of *Anopina* Obraztsov (Lepidoptera: Tortricidae: Euliini). University of California Publications in Entomology 120, 128 pp. + figs.

Brown, R. L. 1987. Tortricidae (Tortricoidea), pp. 419–433. *In* Stehr, F. W., ed. Immature Insects, volume 1. Kendall/Hunt, Dubuque, Iowa.

Brown, R. L. and J. A. Powell. 1991. Description of a new species of *Epiblema* (Lepidoptera: Tortricidae: Olethreutinae) from coastal redwood forests in California with an analysis of the forewing pattern. Pan-Pacific Entomologist 67: 107–114.

Corley, M. F. V. 1992. The summer brood of *Dichrorampha acuminatana* (Lienig & Zeller) (Lep., Tortricidae). Entomologist's Record and Journal of Variation 104: 159–160.

Cruttwell, R. E. 1977. Insects and mites attacking *Eupatorium odoratum* L. in the Neotropics. 5. *Mescinia* sp. nr. *parvula* (Zeller). Technical Bulletin of the Commonwealth Institute of Biological Control 18: 49–58.

Danilevsky, A. S. and V. I. Kuznetzov. 1968. Tortricidae, Tribe Laspeyresiini, in Fauna USSR (N.S.) 98, Insecta-Lepidoptera 5(1): 1–635. Akademia Nauk SSSR, Leningrad.

Disque, H. 1908. Versuch einer microlepidopterologischen Botanik. Deutsch Entomologische Zeitschrift Iris (1908): 34–147.

Godfrey, G. L., E. D. Cashatt, and M. O. Glenn. 1987. Microlepidoptera from the Sandy Creek and Illinois River Region: An annotated checklist of the suborders Dacnonypha, Monotrysia, and Ditrysia (in part) (Insecta). Special Publication 7. Illinois Natural History Survey.

Goodall, J. M. and D. J. Erasmus. 1996. Review of the status and integrated control of the invasive alien weed, *Chromolaena odorata*, in South Africa. Agriculture, Ecosystems and Environment 56: 151–164.

GRIN (Germplasm Resources Information Network). 2006. United States Department of Agriculture, Agricultural Research Service. http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?411002. (Accessed 9 November 2006).

Heinrich, C. 1926. Revision of the North American moths of the subfamilies Laspeyresiinae and Olethreutinae. United States National Museum Bulletin 132: 1–216.

Heppner, J. B. 1981. Two new *Dichrorampha* (Lepidoptera: Tortricidae) from Florida. Florida Entomologist 64: 271–276.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and P. D. Herberger. 1977. The World's Worst Weeds. Distribution and Biology. University Press of Hawaii, Honolulu.

Horak, M. 1984. Assessment of taxonomically significant structures in Tortricinae (Lep., Tortricidae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 57: 3–64.

Jensen, K. and E. Palm. 1981. [*Dichrorampha alpinana* Tr., a new microlepidoptera for Denmark.] Lepidoptera Kbh 4: 7–10. [In Danish]

Komai, F. 1999. A taxonomic review of the genus *Grapholita* and allied genera (Lepidoptera: Tortricidae) in the Palaearctic region. Entomologica Scandinavica Supplement 55: 1–226.

MacKay, M. R. 1959. Larvae of the North American Olethreutidae (Lepidoptera). Canadian Entomologist Supplement 10: 1–338.

McDunnough, J. 1946. Note on certain *Dichrorampha* species (Lepid., Laspeyresiinae). Canadian Entomologist 78: 65–67.

METAFRO. 2006. Medicinal Plants Database. http://www.metafro.be/prelude/view_plant?pi=08640. (Accessed 9 November 2006).

Muniappan, R., G. V. P. Reddy, and P. Y. Lai. 2005. Distribution and biological control of *Chromolaena odorata,* pp. 223–233. *In* Inderjit, K., ed. Invasive Plants:Ecological and Agricultural Aspects. Birkhauser Verlag, Switzerland.

Muniappan, R. 2006. *Chromolaena odorata*, biological control in the tropics. http://www.ehs.cdu.edu.au/chromolaena/siamhome.html. (Accessed 20 May 2006).

Oh, K.-S., Y.-S. Bae, and J.-D. Park. Moth pests of *Quercus* (Fagaceae) cone. Korean Journal of Entomology 31: 221–224.

Park, K.-T. 1983. Tortricidae and Cochylidae, pp. 592–603, 942–988. *In* Shin, Y. S. et al., eds. Illustrated Flora and Fuana of Korea, 27. Insecta IX.

Powell, J. A., J. Razowski, and R. L. Brown. 1995. Tortricidae: Olethreutinae, pp. 151–157. *In* Heppner, J. B., ed. Atlas of Neotropical Lepidoptera, Checklist Part II: Hyblaeoidea - Pyraloidea - Tortricoidea. Association for Tropical Lepidoptera, Scientific Publishers, Gainesville, Florida.

Sterling, M. 1991. *Dichrorampha senectana* (Guenée) bred from *C. lecanthemum* (L.) ox-eye daisy. Entomologist's Record and Journal of Variation 103: 106–107.

Swatschek, B. 1958. Die larval systematik der wickler (Tortricidae and Carposinidae) aus dem zoologischen Institut der Universitat Erlangen. Akademie-Verlag, Berlin. 269 pp. [Abhandlungen zur larvalsystematik Insekten 3.]

Walsingham and Lord T. de Grey. 1914. Lepidoptera-Heteroptera, vol. 4. Tineina, Pterophorina, Orneodina, and Pyralidina and Hepialidina (part). *In*: Godman, F. D. and O. Salvin, eds. Biologia Centrali-Americana, Insecta, 482 pp. 10 color plates pp.

Wilson, C. 2006. Global invasive species database. http://www.issg.org/database/species/ecology.asp?si=47&fr=1&sts. (Accessed 7 December 2006)

Zachariades, C., I. von Senger, and N. P. Barker. 2004. Evidence for a northern Caribbean origin for the southern African biotype of *Chromolaena odorata*, pp. 25–27. *In* Day, M. D. and R. E. MacFadyen, eds. Proceedings of the 6th International Workshop on Biological Control and Management of *Chromolaena*, Cairns, Australia. ACIAR Technical Reports 55.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 948–956

DEVELOPMENT AND TAXONOMIC VALUE OF DORSAL TERTIARY FRINGE SCALES ON THE WINGS OF ADULT MOSQUITOES (DIPTERA: CULICIDAE)

JOHN F. REINERT

Center for Medical, Agricultural and Veterinary Entomology (CMAVE), U. S. Department of Agriculture, Agricultural Research Service, 1600/1700 SW 23rd Drive, Gainesville, Florida 32608-1067, U.S.A. and collaborator Walter Reed Biosystematics Unit (WRBU), National Museum of Natural History, Smithsonian Institution, Washington, DC. (e-mail: John.Reinert@ars.usda.gov)

Abstract.—The condition of dorsal tertiary fringe scales on the wings of females and males for numerous species of tribe Aedini and representative species of other culicid tribes and subfamily Anophelinae is noted. With few exceptions the presence or absence of these scales appears to be consistent for species included in well-defined generic-level taxa.

Key Words: Dorsal tertiary fringe scales, wing, Diptera, Culicidae, Anophelinae, Culicinae, Aedini, Aedeomyiini, Culicini, Culisetini, Mansoniini, Orthopodomyiini, Sabethini, Toxorhynchitini, Uranotaeniini

---

Small, narrow to broad scales inserted parallel or at a slight angle to the dorsal posterior margin of the wings of adult mosquitoes are termed dorsal tertiary fringe scales (DTFS). Only the small scales on the dorsal surface of the posterior margin of the wing are reported herein since the tertiary fringe scales on the ventral posterior margin of the wing are normally reduced in number or completely absent in species possessing DTFS. Harbach and Knight (1980) provided illustrations of DTFS (as tertiary fringe scales), i.e., *Anopheles* (*Cellia*) (Fig. 17f) and *Culiseta inornata* (Williston) (Fig. 19c,d). Their Figure 17a of *Uranotaenia lowii* Theobald illustrates the absence of DTFS. The DTFS in mosquitoes may be of a uniform color or have pale ones intermixed or in small patches within darker-scaled areas. The DTFS are normally present on the entire dorsal posterior margin of females but some taxa have these scales totally absent or absent at least on the proximal 0.5 of the wing. These scales are absent in males of numerous culicid taxa but are present in others. The presence or absence and other characteristics of DTFS were found to be of importance in distinguishing species, species groups and generic-level taxa. Unfortunately, these scales are very rarely mentioned in taxonomic descriptions of species or higher-level taxa of Culicidae.

The presence/absence of DTFS on the wing of females and males is indicated for 345 species in Table 1. The table primarily includes species of tribe Aedini but also includes representatives of other tribes and subfamily Anophelinae. Subfamilies and tribes within Culicidae follow the classification outlined by Harbach and Kitching (1998). Generic

Table 1. List of mosquito taxa with or without dorsal tertiary fringe scales.

Species	Female	Male
SUBFAMILY ANOPHELINAE		
Anopheles (*Anopheles*) *atropos* Dyar and Knab	+	–
An. (*Ano.*) *barberi* Coquillett	+	+
An. (*Ano.*) *bradleyi* King	+	–
An. (*Ano.*) *punctipennis* (Say)	+	–
An. (*Ano.*) *quadrimaculatus* Say	+	–
An. (*Cellia*) *indefinitus* (Ludlow)	+	–
An. (*Cel.*) *kochi* Dönitz	+	–
An. (*Nyssorhynchus*) *albimanus* Weidemann	+	–
SUBFAMILY CULICINAE		
Tribe Aedeomyiini		
Aedeomyia squamiger (Lynch Arribalzaga)	+	+
Tribe Aedini		
Abraedes papago (Zavortink)	+	–
Aedes cinereus Meigen	+	–
Ae. esoensis Yamada	+	–
'*Ae.* (*Aedimorphus*)' *albocephalus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *alboscutellatus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *apicoannulatus* (Edwards)	+	–
'*Ae.* (*Adm.*)' *argenteopunctatus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *caecus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *culicinus* Edwards	+	–
'*Ae.* (*Adm.*)' *cumminsii* (Theobald)	+	–
'*Ae.* (*Adm.*)' *dalzieli* (Theobald)	+	–
'*Ae.* (*Adm.*)' *dentatus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *domesticus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *eritreae* Lewis	+	–
'*Ae.* (*Adm.*)' *irritans* (Theobald)	+	–
'*Ae.* (*Adm.*)' *mediolineatus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *ochraceus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *orbitae* Edwards	+	–
'*Ae.* (*Adm.*)' *pallidostriatus* (Theobald)	+	–
'*Ae.* (*Adm.*)' *pampangensis* (Ludlow)	+	–
'*Ae.* (*Adm.*)' *pipersalatus* (Giles)	+	–
'*Ae.* (*Adm.*)' *punctifemoris* (Ludlow)	+	–
'*Ae.* (*Adm.*)' *simulans* (Newstead and Carter)	+	–
'*Ae.* (*Adm.*)' *taeniorhynchoides* (Christophers)	+	–
'*Ae.* (*Adm.*)' *tarsalis* (Newstead)	+	–
'*Ae.* (*Adm.*)' *vexans vexans* (Meigen)	+	–
'*Ae.* (*Cancraedes*)' *masculinus* Mattingly	+	–
'*Ae.* (*Can.*)' *penghuensis* Lien	+	–
Alanstonea brevitibia (Edwards)	–	–
Albuginosus capensis (Edwards)	+	+
Al. kapretwae (Edwards)	+	+
Al. marshallii (Theobald)	+	+
Al. ngong (van Someren)	+	+
Al. stokesi (Evans)	+	+
Armigeres (*Armigeres*) *breinli* (Taylor)	+	–
Ar. (*Arm.*) *subalbatus* (Coquillett)	+	–
Ar. (*Lei.*) *flavus* (Leicester)	+	–
Ar. (*Lei.*) *longipalpis* (Leicester)	+	–
Ayurakitia griffithi Thurman	+	–
Ay. peytoni (Reinert)	+	–
Aztecaedes ramirezi (Vargas and Downs)	+	–

Table 1. Continued.

Species	Female	Male
Belkinius aurotaeniatus (Edwards)	+	–
Borichinda cavernicola Rattanarithikul and Harbach	+	+
Bothaella eldridgei (Reinert)	+	–
Bo. helenae (Reinert)	+	–
Bruceharrisonius alektorovi (Stackelberg)	+	–
Br. aureostriatus (Doleschall)	+	–
Br. greenii (Theobald)	+	–
Christophersiomyia gombakensis (Mattingly)	+	+
Cr. thomsoni (Theobald)	+	+
Collessius banksi (Edwards)	+	–
Co. elsiae (Barraud)	+	–
Co. macdougalli (Edwards)	+	–
Co. macfarlanei (Edwards)	+	–
Co. pseudotaeniatus (Giles)	+	–
Dahliana echinus (Edwards)	+	+
Da. geniculata (Olivier)	+	+
Diceromyia franciscoi (Mattingly)	+	+
Di. furcifer (Edwards)	+	+
Di. iyengari (Edwards)	+	+
Di. meronephada (Dyar and Shannon)	+	+
Di. micropterus (Giles)	+	+
Di. periskelata (Giles)	+	+
Di. reginae (Edwards)	+	+
Di. scanloni (Reinert)	+	+
Di. taylori (Edwards)	+	+
Di. whartoni (Mattingly)	+	+
Dobrotworskyius alboannulatus (Macquart)	+	–
Db. rubrithorax (Macquart)	+	–
Db. tubbutiensis (Dobrotworsky)	+	–
Downsiomyia harinasutai (Knight)	+	–
Do. leonis (Colless)	+	–
Do. nipponica (LaCasse and Yamaguti)	+	–
Do. nivea (Ludlow)	+	–
Do. vanua (Colless)	+	–
Edwardsaedes bekkui (Mogi)	+	–
Ed. imprimens (Walker)	+	–
Eretmapodites chrysogaster Graham	+	–
Er. dracaenae Edwards	+	–
Er. inornatus Newstead	+	–
Er. penicillatus Edwards	+	–
Er. quinquevittatus Theobald	+	–
Finlaya fijiensis (Marks)	+	+
Fl. franclemonti (Belkin)	+	+
Fl. gahnicola (Marks)	+	+
Fl. knighti (Stone and Bohart)	+	+
Fl. kochi (Dönitz)	+	+
Fl. poicilia Theobald	+	–
Fl. wallacei (Edwards)	+	+
Fredwardsius vittatus (Bigot)	+	–
Georgecraigius (*Georgecraigius*) *atropalpus* (Coquillett)	+	+
Gc. (*Gec.*) *epactius* (Dyar and Knab)	+	–
Gc. (*Horsfallius*) *fluviatilis* (Lutz)	+	–
Geoskusea baisasi (Knight and Hull)	+	–
Ge. fimbripes (Edwards)	+	–
Ge. longiforceps (Edwards)	+	–

Table 1. Continued.

Species	Female	Male
Gilesius pulchriventer (Giles)	+	–
Gymnometopa mediovittata (Coquillett)	+	–
Haemagogus (*Conopostegus*) *leucocelaenus* (Dyar and Shannon)	+	–
Hg. (*Con.*) *leucotaeniatus* (Komp)	+	–
Hg. (*Haemagogus*) *equinus* Theobald	–	–
Hg. (*Hag.*) *lucifer* (Howard, Dyar and Knab)	–	–
Hg. (*Hag.*) *splendens* Williston	–	–
Halaedes australis (Erichson)	+	+
Heizmannia (*Heizmannia*) *complex* (Theobald)	+	+
Hz. (*Hez.*) *scintillans* Ludlow	+	+
Hz. (*Mattinglyia*) *achaetae* (Leicester)	+	+
Himalaius gilli (Barraud)	+	–
Howardina albonotata (Coquillett)	+	–
Hw. fulvithorax (Lutz)	+	–
Hw. sexlineata (Theobald)	+	–
Hw. walkeri (Theobald)	+	–
Hw. whitmorei (Dunn)	+	–
Huaedes wauensis (Huang)	+	–
Hulecoeteomyia chrysolineata (Theobald)	+	–
Hl. harveyi (Barraud)	+	–
Hl. saxicola (Edwards)	+	–
Hl. sherki (Knight)	+	–
Isoaedes cavaticus (Reinert)	+	–
Jarnellius (*Jarnellius*) *deserticola* (Zavortink)	+	+
Ja. (*Jar.*) *monticola* (Belkin and McDonald)	+	+
Ja. (*Jar.*) *sierrensis* (Ludlow)	+	+
Ja. (*Jar.*) *varipalpus* (Coquillett)	+	+
Ja. (*Lewnielsenius*) *muelleri* (Dyar)	+	–
Jihlienius chungi (Lien)	+	–
Kenknightia dissimilis (Leicester)	+	–
Ke. harbachi (Reinert)	+	–
Kompia purpureipes (Aitken)	+	–
Leptosomatomyia aurimargo (Edwards)	+	–
Levua geoskusea (Amos)	+	+
Lorrainea amesii (Ludlow)	+	+
Lo. dasyorrhus (King and Hoogstraal)	+	+
Lo. fumida (Edwards)	+	+
Macleaya (*Chaetocruiomyia*) *elchoensis* (Taylor)	+	–
Mc. (*Cha.*) *wattensis* (Taylor)	+	–
Mc. (*Macleaya*) *tremula* Theobald	+	–
Molpemyia auridorsum (Edwards)	+	–
Mo. pecuniosa (Edwards)	+	–
Mucidus (*Mucidus*) *alternans* (Westwood)	+	–
Mu. (*Muc.*) *laniger* (Wiedemann)	–	–
Mu. (*Muc.*) *scatophagoides* Theobald	+	–
Mu. (*Pardomyia*) *a. aurantius* (Theobald)	–	–
Mu. (*Pdo.*) *painei* (Knight)	–	–
Mu. (*Pdo.*) *quadripunctis* (Ludlow)	–	–
Neomelaniconion lineatopenne (Ludlow)	+	–
Ne. palpale Newstead	+	–
Ochlerotatus (*Rusticoidus*) *bicristatus* (Thurman and Winkler)	+	–
Oc. (*Rus.*) *refiki* (Medschid)	+	–
Oc. (*Rus.*) *rusticus* (Rossi)	+	–
Oc. atlanticus (Dyar and Knab)	+	–
Oc. communis (de Geer)	+	–

Table 1. Continued.

Species	Female	Male
Oc. dorsalis (Meigen)	+	–
Oc. fulvus fulvus (Wiedemann)	–	–
Oc. fulvus pallens (Ross)	–	–
Oc. infirmatus (Dyar and Knab)	+	–
Oc. scapularis (Rondani)	+	–
Oc. sollicitans (Walker)	+	–
'*Oc.* (*Finlaya*)' *biocellatus* (Taylor)	+	–
'*Oc.* (*Fin.*)' *candidoscutellum* (Marks)	+	–
'*Oc.* (*Fin.*)' *crossi* (Lien)	+	–
'*Oc.* (*Fin.*)' *embuensis* (Edwards)	+	–
'*Oc.* (*Fin.*)' *ingrami* (Edwards)	+	–
'*Oc.* (*Fin.*)' *keefei* (King and Hoogstraal)	+	–
'*Oc.* (*Fin.*)' *roai* (Belkin)	+	–
'*Oc.* (*Ochlerotatus*)' *aculeatus* (Theobald)	–	–
'*Oc.* (*Och.*)' *albifasciatus* (Macquart)	+	–
'*Oc.* (*Och.*)' *andersoni* (Edwards)	+	–
'*Oc.* (*Och.*)' *aurifer* (Coquillett)	+	–
'*Oc.* (*Och.*)' *caballus* (Theobald)	+	–
'*Oc.* (*Och.*)' *calcariae* (Marks)	+	–
'*Oc.* (*Och.*)' *calumnior* (Belkin, Heinemann and Page)	–	–
'*Oc.* (*Och.*)' *campestris* (Dyar and Knab)	+	–
'*Oc.* (*Och.*)' *c. canadensis* (Theobald)	+	–
'*Oc.* (*Och.*)' *cantans* (Meigen)	+	–
'*Oc.* (*Och.*)' *cantator* (Coquillett)	+	–
'*Oc.* (*Och.*)' *caspius* (Pallas)	+	–
'*Oc.* (*Och.*)' *cataphylla* (Dyar)	+	–
'*Oc.* (*Och.*)' *diantaeus* (Howard, Dyar and Knab)	+	+
'*Oc.* (*Och.*)' *dupreei* (Coquillett)	+	–
'*Oc.* (*Och.*)' *edgari* (Stone and Rosen)	+	–
'*Oc.* (*Och.*)' *excrucians* (Walker)	+	–
'*Oc.* (*Och.*)' *fitchii* (Felt and Young)	+	–
'*Oc.* (*Och.*)' *flavescens* (Muller)	+	–
'*Oc.* (*Och.*)' *flavifrons* (Skuse)	+	–
'*Oc.* (*Och.*)' *grossbecki* (Dyar and Knab)	+	–
'*Oc.* (*Och.*)' *hexodontus* (Dyar)	+	–
'*Oc.* (*Och.*)' *hortator* (Dyar and Knab)	+	–
'*Oc.* (*Och.*)' *impiger* (Walker)	+	–
'*Oc.* (*Och.*)' *implicatus* (Vockeroth)	+	–
'*Oc.* (*Och.*)' *increpitus* (Dyar)	+	–
'*Oc.* (*Och.*)' *intrudens* (Dyar)	+	–
'*Oc.* (*Och.*)' *mcdonaldi* (Belkin)	–	–
'*Oc.* (*Och.*)' *milleri* (Dyar)	+	–
'*Oc.* (*Och.*)' *mitchellae* (Dyar)	+	–
'*Oc.* (*Och.*)' *nevadensis* (Chapman and Barr)	+	–
'*Oc.* (*Och.*)' *nigripes* (Zetterstedt)	+	–
'*Oc.* (*Och.*)' *nigrithorax* (Macquart)	+	–
'*Oc.* (*Och.*)' *nigromaculis* (Ludlow)	+	–
'*Oc.* (*Och.*)' *niphadopsis* (Dyar and Knab)	+	–
'*Oc.* (*Och.*)' *pennai* (Antunes and Lane)	–	–
'*Oc.* (*Och.*)' *pertinax* (Grabham)	+	–
'*Oc.* (*Och.*)' *pionips* (Dyar)	+	–
'*Oc.* (*Och.*)' *pullatus* (Coquillett)	+	–
'*Oc.* (*Och.*)' *punctor* (Kirby)	+	–
'*Oc.* (*Och.*)' *ratcliffei* (Marks)	+	–
'*Oc.* (*Och.*)' *riparius* (Dyar and Knab)	+	–

Table 1. Continued.

Species	Female	Male
'*Oc.* (*Och.*)' *schizopinax* (Dyar)	+	–
'*Oc.* (*Och.*)' *serratus* (Theobald)	+	–
'*Oc.* (*Och.*)' *spencerii* (Theobald)	+	–
'*Oc.* (*Och.*)' *spilotus* (Marks)	–	–
'*Oc.* (*Och.*)' *squamiger* (Coquillett)	+	–
'*Oc.* (*Och.*)' *sticticus* (Meigen)	+	–
'*Oc.* (*Och.*)' *stimulans* (Walker)	+	–
'*Oc.* (*Och.*)' *taeniorhynchus* (Wiedemann)	+	–
'*Oc.* (*Och.*)' *thibaulti* (Dyar and Knab)	+	+
'*Oc.* (*Och.*)' *trivittatus* (Coquillett)	+	–
'*Oc.* (*Och.*)' *vigilax* (Skuse)	+	–
'*Oc.* (*Protomacleaya*)' *brelandi* (Zavortink)	+	–
'*Oc.* (*Pro.*)' *burgeri* (Zavortink)	+	–
'*Oc.* (*Pro.*)' *galindoi* (Schick)	+	–
'*Oc.* (*Pro.*)' *hendersoni* (Cockerell)	+	–
'*Oc.* (*Pro.*)' *homoeopus* (Dyar)	+	–
'*Oc.* (*Pro.*)' *kompi* (Vargas and Downs)	+	–
'*Oc.* (*Pro.*)' *terrens* (Walker)	+	–
'*Oc.* (*Pro.*)' *triseriatus* (Say)	+	+
'*Oc.* (*Pro.*)' *zoosophus* (Dyar and Knab)	+	–
Opifex (*Nothoskusea*) *chathamicus* (Dumbleton)	+	+
Op. (*Opifex*) *fuscus* Hutton	+	+
Paraedes barraudi Edwards	+	–
Pr. chrysoscuta (Theobald)	+	–
Pr. ostentatio (Leicester)	+	–
Pr. thailandensis (Reinert)	+	–
Patmarksia argyronotum (Belkin)	+	–
Pm. hollandia (King and Hoogstraal)	+	–
Pm. novalbitarsis (King and Hoogstraal)	+	–
Pm. palmarum (Edwards)	+	–
Pm. papuensis (Taylor)	+	–
Phagomyia assamensis (Theobald)	+	–
Ph. gubernatoris (Giles)	+	–
Ph. khazani (Edwards)	+	–
Ph. lophoventralis (Theobald)	+	–
Ph. prominens (Barraud)	+	–
Pseudarmigeres argenteoventralis dunni (Evans)	+	–
Pa. michaelikati (van Someren)	+	–
Pseudoskusea bancroftiana (Edwards)	+	–
Pk. postspiraculosa (Dobrotworsky)	+	+
Psorophora (*Grabhamia*) *columbiae* (Dyar and Knab)	+	–
Ps. (*Gra.*) *jamaicensis* Theobald	+	–
Ps. (*Janthinosoma*) *cyanescens* (Coquillett)	–	–
Ps. (*Jan.*) *ferox* (von Humboldt)	–	–
Ps. (*Jan.*) *horrida* (Dyar and Knab)	–	–
Ps. (*Psorophora*) *ciliata* (Fabricius)	–	–
Ps. (*Pso.*) *howardii* Coquillett	–	–
Ps. (*Pso.*) *lineata* (von Humboldt)	–	–
Rampamyia albilabris (Edwards)	+	+
Ra. notoscripta (Skuse)	+	–
Rhinoskusea longirostris (Leicester)	–	–
Rh. wardi (Reinert)	–	–
Scutomyia albolineata Theobald	+	–
Sc. arboricola (Knight and Rozeboom)	+	–
Sc. boharti (Knight and Rozeboom)	+	–

Table 1. Continued.

Species	Female	Male
Skusea pembaensis (Theobald)	+	–
Stegomyia aegypti (Linnaeus)	+	–
St. africana Theobald	+	–
St. albopicta (Skuse)	+	–
St. annandalei Theobald	+	–
St. apicoargentea Theobald	+	–
St. bromeliae Theobald	+	–
St. craggi Barraud	+	–
St. deboeri (Edwards)	+	–
St. dendrophila (Edwards)	+	–
St. desmotes Giles	+	–
St. g. gardnerii Ludlow	+	–
St. luteocephala Newstead	+	–
St. mediopunctata Theobald	+	–
St. metallica (Edwards)	+	–
St. perplexa Leicester	+	–
St. poweri Theobald	+	–
St. riversi (Bohart and Ingram)	+	–
St. scutellaris (Walker)	+	–
St. simpsoni Theobald	+	–
St. unilineata (Theobald)	+	–
St. w–albus Theobald	+	–
Tanakaius savoryi (Bohart)	+	–
Ta. togoi (Theobald)	+	+
Tewarius agastyai (Tewari and Hiriyan)	+	–
Te. reubenae (Tewari and Hiriyan)	+	–
Udaya argyrurus (Edwards)	+	–
Ud. lucaris Macdonald and Mattingly	+	–
Vansomerenis luteostriata (Robinson)	+	+
Va. pulchrithorax (Edwards)	+	+
Verrallina (*Harbachius*) *nobukonis* (Yamada)	–	–
Ve. (*Har.*) *yusafi* (Barraud)	–	–
Ve. (*Neomacleaya*) *agrestis* (Barraud)	–	–
Ve. (*Nma.*) *indica* (Theobald)	–	–
Ve. (*Nma.*) *pseudomediofasciata* (Theobald)	–	–
Ve. (*Nma.*) *yerburyi* (Edwards)	–	–
Ve. (*Verrallina*) *butleri* (Theobald)	+	–
Ve. (*Ver.*) *carmenti* (Edwards)	+	–
Ve. (*Ver.*) *dux* (Dyar and Shannon)	+	–
Ve. (*Ver.*) *lugubris* (Barraud)	+	–
Zavortinkius fulgens (Edwards)	+	–
Za. longipalpis (Grunberg)	+	–
Zeugnomyia gracilis Leicester	+	–
Ze. lawtoni Baisas	+	–
Tribe Culicini		
Culex (*Culex*) *nigripalpus* Theobald	+	–
Cx. (*Cux.*) *quinquefasciatus* Say	+	–
Cx. (*Cux.*) *restuans* Theobald	+	–
Cx. (*Melanoconion*) *pilosus* (Dyar and Knab)	+	–
Cx. (*Neoculex*) *territans* Walker	+	–
Deinocerites cancer Theobald	+	+
De. mathesoni Belkin and Hogue	+	+
De. pseudes Dyar and Knab	+	+
Tribe Culisetini		
Culiseta (*Allotheobaldia*) *longiareolata* (Macquart)	+	–

Table 1. Continued.

Species	Female	Male
Cs. (*Climacura*) *melanura* (Coquillett)	+	+
Cs. (*Culicella*) *morsitans* (Theobald)	+	–
Cs. (*Culiseta*) *alaskaensis* (Ludlow)	+	–
Cs. (*Cus.*) *incidens* (Thomson)	+	–
Cs. (*Cus.*) *inornata* (Williston)	+	–
Tribe Mansoniini		
Coquillettidia (*Coquillettidia*) *perturbans* (Walker)	+	–
Mansonia (*Mansonia*) *indubitans* Dyar and Shannon	+	–
Ma. (*Man.*) *titillans* (Walker)	+	–
Ma. (*Mansonioides*) *africana* (Theobald)	+	–
Ma. (*Mnd.*) *uniformis* (Theobald)	+	–
Tribe Orthopodomyiini		
Orthopodomyia signifera (Coquillett)	+	+
Tribe Sabethini		
Malaya genurostris Leicester	+	+
Maorigoeldia argyropus (Walker)	+	+
Sabethes (*Sabethes*) *tarsopus* Dyar and Knab	+	+
Trichoprosopon (*Trichoprosopon*) *digitatum* (Rondani)	+	–
Tripteroides (*Rachionotomyia*) *aranoides* (Theobald)	+	–
Wyeomyia (*Wyeomyia*) *mitchellii* (Theobald)	+	+
Wy. (*Wyo.*) *vanduzeei* Dyar and Knab	+	+
Tribe Toxorhynchitini		
Toxorhynchites (*Lynchiella*) *r. rutilus* (Coquillett)	–	–
Tribe Uranotaeniini		
Uranotaenia (*Pseudoficalbia*) *anhydor* Dyar	+	–
Ur. (*Uranotaenia*) *lowii* Theobald	–	–
Ur. (*Ura.*) *sapphirina* (Osten Sacken)	–	–

and subgeneric placement of species within tribe Aedini follows Reinert et al. (2004, 2006). Species of uncertain taxonomic position (*incertae sedis*) listed as such in Appendix 4 of Reinert et al. (2006) have the generic-level names enclosed in single quotation marks, e.g., '*Ochlerotatus* (*Finlaya*)' and '*Ochlerotatus* (*Ochlerotatus*)'. The abbreviations of aedine genera and subgenera are from Appendix 5 of Reinert et al. (2006), and those of non-aedine genera and subgenera are from Reinert (2001). Presence of DTFS on the proximal 0.5 of the wing is indicated by a plus sign (+) and their absence on the proximal 0.5 by a minus sign (−) in Table 1.

Dorsal tertiary fringe scales occur in both females and males of *Corethrella appendiculata* Grabham (Corethrellidae) and *Chaoborus* (*Sayomyia*) *punctipennis* (Say) (Chaoboridae), taxa that are related to Culicidae.

Based on the information in Table 1, the presence or absence of DTFS appears to be consistent for females and males of species included in well-defined subgenera and genera of Culicidae, especially in tribe Aedini, with few exceptions, e.g., *Pseudoskusea* and *Tanakaius*. Variability within *Ochlerotatus sensu lato* may be due to the inclusion of species in groups, subgenera, or genera that are not monophyletic. Additional studies are underway to resolve this issue.

Three conditions of DTFS are discernable for species listed in Table 1: both females and males with scales absent on the proximal 0.5, e.g., *Al. brevitibia, Hg.* (*Haemagogus*), *Mu.* (*Pardomyia*), *Ps.* (*Psorophora*), and subgenera *Harbachius* and

Neomacleaya of *Verrallina*; females with scales present and males with scales absent on the proximal 0.5, e.g., *Aedes, Armigeres, Collessius, Howardina,* and *Zavortinkius*; and both females and males with scales present on the proximal 0.5, e.g., *Albuginosus, Christophersiomyia, Dahliana, Halaedes,* and *Heizmannia*.

The DTFS are of a uniform color in most culicid taxa, e.g., *Ae. cinereus, Gc.* (*Gec.*) *atropalpus, Gy. mediovittata, Ja.* (*Jar.*) *varipalpus,* and *Oc. infirmatus*. In some taxa, however, pale scales or patches are intermixed with dark scales, e.g., '*Ae.* (*Adm.*)' *pipersalatus, Ad. squamiger, An.* (*Nys.*) *albimanus, Cq.* (*Coq.*) *perturbans, Fl. kochi, Mu.* (*Muc.*) *alternans,* '*Oc.* (*Och.*)' *campestris,* and *Ps.* (*Gra.*) *columbiae*.

Acknowledgments

Appreciation is expressed to Kenneth J. Linthicum and Gary G. Clark (CMAVE) for providing research facilities, and to Ralph E. Harbach (The Natural History Museum, London, U. K.) and Bruce A. Harrison (North Carolina Department of Environmental and Natural Resources, Winston-Salem, NC) for reviewing the manuscript and providing suggested improvements.

Literature Cited

Harbach, R. E. and I. J. Kitching. 1998. Phylogeny and classification of the Culicidae (Diptera). Systematic Entomology 23: 327–370.

Harbach, R. E. and K. L. Knight. 1980. Taxonomists' Glossary of Mosquito Anatomy. Plexus Publishing, Incorporated, Marlton, New Jersey. 415 pp.

Reinert, J. F. 2001. Revised list of abbreviations for genera and subgenera of Culicidae (Diptera) and notes on generic and subgeneric changes. Journal of the American Mosquito Control Association 17: 51–55.

Reinert, J. F., R. E. Harbach, and I. J. Kitching. 2004. Phylogeny and classification of Aedini (Diptera: Culicidae), based on morphological characters of all life stages. Zoological Journal of the Linnean Society 142: 289–368.

———. 2006. Phylogeny and classification of *Finlaya* and allied taxa (Diptera: Culicidae: Aedini) based on morphological data from all life stages. Zoological Journal of the Linnean Society 148: 1–101.

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, p. 957

NOTE

Wasbauerellus, a New Replacement Name for *Priocnemioides* Brailovsky, 2006 (Hemiptera: Heteroptera: Coreidae: Cloresmini)

Radoszkowski (1888: 482) established a new genus *Priocnemioides* to accommodate *Pompilus (Priocnemis) fulvicornis* Cresson 1867 of the family Pompilidae. Later, Brailovsky (2006: 375–378) used the name *Priocnemioides* for his new genus of the tribe Cloresmini, family Coreidae, including a single species *Priocnemioides modicus* Brailovsky 2006. Radoszkowski derived the name from the subgenus *Priocnemis* Cresson 1867, and Brailovsky from the genus *Priocnemicoris* Costa 1863.

***Wasbauerellus*, new name**, is proposed for *Priocnemioides* Brailovsky 2006 to remove the homonymy, and a **new combination**, *Wasbauerellus modicus* (Brailovsky) is established. The new generic name is dedicated to Marius Wasbauer, distinguished American hymenopterist; the gender is masculine.

I express thanks to Michele Touchet (Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington, D. C.) for providing important literature relevant to this study.

LITERATURE CITED

Brailovsky, H. 2006. New genus and new species of Cloresmini (Insecta: Heteroptera: Coreidae) from Papua New Guinea. The Pan-Pacific Entomologist 82: 375–380.

Costa, A. 1863. Illustrazione di alguni emitteri stranieri all' Europa. Nota Seconda. Nuovi Generi e Nouve specie di Coreidei. Rendiconto della advanze e de lavori della Reale Academia della Scienzi di Napoli 2(6): 250–261.

Cresson, E. T. 1867. Descriptions of American Pompilidae. Transactions of the American Entomological Society 1: 85–150.

Radoszkowski, O. 1888. Révision des armures copulatrices des males de la famille Pompilidae. Bulletin de la Société Imperiale des Naturalistes de Moscou, Nouvelle Sèrie 2: 482–483.

Harry Brailovsky, *Departamento de Zoologia, Instituto de Biologia, UNAM, Apdo Postal No. 70153, Mexico 04510 D. F., Mexico (e-mail: coreidae@servidor.unam.mx)*

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 958–959

NOTE

Quedius molochinus (Coleoptera: Staphylinidae) Newly Recorded in the Maritime Provinces of Canada

Majka and Smetana (2007) recently recorded *Quedius fuliginosus* (Gravenhorst, 1802) as new in North America from specimens collected in Nova Scotia. They also newly recorded *Quedius curtipennis* Bernhauer, 1908 from Nova Scotia and *Quedius mesomelinus* (Marsham, 1802) from New Brunswick. Although Majka and Smetana (2007) wrote that *Q. curtipennis* was newly reported in eastern North America, there is one previous specimen collected by D.S. Chandler in 1983 in New Hampshire (Smetana 1990). Other introduced species in the genus include *Quedius fulgidus* (Fabricius, 1793), widely distributed in the United States and in southwestern British Columbia and Manitoba (Smetana 1971); *Quedius cinctus* (Paykull, 1790), found in Massachusetts, New Jersey, New York, and Washington (Smetana 1971, 1990); and *Quedius cruentus* (Olivier, 1794) reported by Gusarov (2001) from New York.

Smetana (1965, 1971) also reported the Palearctic *Quedius molochinus* (Gravenhorst, 1806) from three specimens collected by C.H. Lindroth in 1949 in St. John's, Newfoundland. Smetana (1973, 1976, 1981) later reported the species from the Québec City area, and Smetana (1981, 1990) reported further records from Newfoundland (chiefly in the vicinity of St. John's, but also from Harricott at the head of St. Mary's Bay, approximately 75 km away), concluding that the species was well-established on the Avalon Peninsula. To date, *Q. molochinus* has only been known in North America from these two areas, largely restricted to sites around the original ports of entry. Recently specimens of *Q. molochinus* were collected in Nova Scotia (Kings County, Sheffield Mills, 25.ix.2002, Ken Neil, pitfall trap, Nova Scotia Museum collection) and Prince Edward Island (Queens County, Harrington, 7.ix.2006, C. Noronha, potato field, pitfall trap, Nova Scotia Museum collection) that now establish the presence of this species in the Maritime Provinces (New Brunswick, Nova Scotia, and Prince Edward Island). These records clearly represent separate introduction events from those in Newfoundland and Québec.

Majka and Smetana (2007) pointed out that there are a large number of introduced, Palearctic staphylinids in the region (16% of Nova Scotia's rove beetle fauna) and Klimaszewski et al. (2007) added records of six additional species to the Maritime fauna. Majka and Smetana (2007) highlighted the nautical history of the region and how it has contributed to the large number of introduced Coleoptera. Lindroth (1957) collected *Q. molochinus* at the Appledore rock quarry on the River Torridge in North Devon, England – one of eight sites investigated by him as principal sources of dry ballast destined for Atlantic Canadian ports. Both sites in the Maritime Provinces where *Q. molochinus* has been found are in agricultural areas with many synanthropic environments, not far from seaports, and have substantial suites of introduced beetles. Smetana (1971) noted that all the specimens from Newfoundland were found on land affected by cultivation. *Quedius molochinus* thus joins the large spectrum of introduced rove beetles found in the Maritime Provinces.

Sincere thanks to Ken Neil and Christine Noronha for collecting the specimens, to Aleš Smetana for verifying the determination, and to two anonymous reviewers for their constructive comments. This research has been assisted by the Board of Governors of the Nova Scotia Museum.

LITERATURE CITED

Gusarov, V. I. 2001. *Quedius cruentus* (Olivier, 1794) (Coleoptera, Staphylinidae), a Palearctic species new to North America. The Coleopterists Bulletin 55(3): 374–377.

Klimaszewski, J., Assing, V., Majka, C. G., Pelletier, G., Webster, R. P., and Langor, D. 2007. Records of adventive aleocharine beetles found in Canada (Coleoptera, Staphylinidae, Aleocharinae). The Canadian Entomologist 139: 54–79.

Lindroth, C. H. 1957. The faunal connections between Europe and North America. Almqvist & Wiksell, Stockholm, Sweden. 344 pp.

Majka, C. G. and Smetana, A. 2007. New records of introduced species of *Quedius* Stephens, 1829 (Coleoptera: Staphylinidae) from the Maritime Provinces of Canada. Proceedings of the Entomological Society of Washington 109(2): 427–434.

Smetana, A. 1965. Staphylinini und Quediini (Col., Staphylinidae) von Newfoundland, Südost-Labrador und Nova Scotia. Acta Entomologica Fennica 20. 60 pp.

———. 1971. Revision of the tribe Quediini of America north of Mexico (Coleoptera: Staphylinidae). Memoirs of the Entomological Society of Canada 79. 303 pp.

———. 1973. Revision of the tribe Quediini of America North of Mexico (Coleoptera: Staphylinidae). Supplementum 2. The Canadian Entomologist 105: 1421–1434.

———. 1976. Revision of the tribe Quediini of America North of Mexico (Coleoptera: Staphylinidae). Supplementum 3. The Canadian Entomologist 108: 169–184.

———. A. 1981. Revision of the tribe Quediini of America North of Mexico (Coleoptera: Staphylinidae). Supplementum 5. The Canadian Entomologist 113: 631–644.

———. 1990. Revision of the tribe Quediini of America North of Mexico (Coleoptera: Staphylinidae). Supplementum 6. The Coleopterists Bulletin 44: 95–104.

Christopher G. Majka, *Nova Scotia Museum, 1747 Summer Street, Halifax, Nova Scotia, Canada, B3H 3A6. (e-mail: c.majka@ns.sympatico.ca)*

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 960–962

NOTE

New Records and Notes on the Ecology of African Species of *Melyris* Fabricius (Coleoptera: Melyridae), with Discussion of Pollination Biology

The beetle genus *Melyris* Fabricius contains 113 described species, most of which are known only from sub-Saharan Africa (Pic 1929, Peacock 1980). Adults of many species in this genus are brightly colored, with green, blue, violet, or coppery iridescence. The adult beetles are often abundant on flowers and consequently many species are represented in museum collections by large series of specimens. Despite the abundance and attractive coloration of these beetles, very little has been published about them, aside from an early taxonomic study by Champion (1919) and a catalogue of species by Pic (1929). In this paper, I present new distributional records for five species, review the existing literature on the ecology of species in this genus, and describe field observations made in South Africa in September, 2006.

In preparation for more detailed studies of this group, I examined the collection of *Melyris* species in the National Museum of Natural History, Smithsonian Institution. During the course of this curatorial work, I discovered the following specimens which represent new distribution records. For accuracy, I have given the country and locality information exactly as it appears on the original specimen labels, keeping in mind that in several cases these names have changed since the specimens were collected and labeled.

Melyris abdominalis Fabricius.—Ivory Coast, 23 km E of Toumodi, 12–14.X.1971 (16 adults); Côte d'Ivoire, Ferkessédougou (6 adults). New country record. This is a common species which has been previously reported from many West African countries, including Benin, Cameroon, Ghana, Nigeria, and Senegal (Champion 1919).

Melyris alluaudi Pic.—Kenya, Nairobi, 12.I.1920 (1 adult). Previously known only from montane areas such as the slopes of Mt. Kenya, Kilimanjaro, and the Ruwenzori Mountains (Champion 1919). The Nairobi record suggests a broader distribution for this species within Kenya.

Melyris nigripes Harold.—Rhodesia, Chingola Dist. X–XII.1960 (1 adult). New country record. This species is abundant in the Congo River basin and there are also records from present-day Malawi and Zambia (Champion 1919).

Melyris quadricollis Champion.—Ethiopia, Alemaya, 1.V.1913, in roses (7 adults), 26 IV.1964, in roses (7 adults). Known previously from only two localities in Ethiopia, with no information available about floral associates (Champion 1919).

Melyris sansibarica Harold.—Kenya, Makindu near Thabu on Athi River, IX-1956 (4 adults), Golini, IX-1934 (1 adult), Simba, VI-1934 (1 adult). Known previously from only two localities, the type locality of Zanzibar and Kitui, Kenya (Champion 1919). The new records suggest a fairly broad distribution for this species within Kenya.

Very little has been published to date on the ecology of species of *Melyris*. Adults of species in this genus are found on flowers, where they feed on nectar, pollen, and floral parts and may form large feeding aggregations (Evans 1984). Plant genera whose flowers are known to be visited by these beetles include *Acacia* (Mimosaceae), *Delairea, Echinops, Heli-*

chrysum (Asteraceae), *Protea* (Proteaceae), and *Rosa* (Rosaceae) (Champion 1919, Evans 1984, Grobbelaar et al. 2000, Iziko Museums of Cape Town 2004). I report a collection of *Melyris* from flowers of *Brachylaena* (Asteraceae) for the first time below.

Many of the museum specimens that I examined were covered with dried nectar and/or pollen grains, suggesting that species of *Melyris* may function as pollinators of the flowers they visit. Pollination by melyrid beetles has been confirmed in North America (Grant and Grant 1965) and South America (Medan 1990). In South Africa, du Toit (1990) investigated the pollination efficiencies of the introduced melyrid *Astylus atromaculatus* Blanchard in plantations of commercial sunflowers (*Helianthus annuus* L.). Under the experimental conditions established by du Toit, commercial sunflowers pollinated by *A. atromaculatus* have higher seed set (76% versus 72%) than flowers pollinated by honeybees (*Apis mellifera* L., Hymenoptera: Apidae). Given that the genus *Astylus* Castelnau is closely related to *Melyris* (essentially forming its South American counterpart within the subfamily Melyrinae), it seems likely that species of *Melyris* also serve as pollinators.

On September 3 and 4, 2006, I visited the National Botanic Garden in Pretoria, South Africa, where I observed adults of *Melyris natalensis* Boheman on flowers of the tree *Brachylaena elliptica* (Thunberg) DeCandolle (Asteraceae). The melyrid beetles were the most numerous visitors to these flowers; other floral visitors included syrphid flies (Diptera: Syrphidae), halictid bees (Hymenoptera: Halictidae), and honeybees. Each terminal flower cluster had 2–8 beetles present. The beetles fed on pollen and were observed crawling from flower to flower during the course of feeding. Pollen grains were observed adhering to the beetles. When disturbed, the beetles dropped from the flowers or took flight, indicating that they have the potential to move between inflorescences or even trees.

Further field investigations of the pollination ecology of species of *Melyris* are clearly indicated. Other potential directions for study are indicated by fascinating but fragmentary reports such as that of Evans (1984), who reported that the Lebanese species *Melyris bicolor* F. is "distasteful to avian insectivores" and "aposematic" in its coloration. The possibility that some species of *Melyris* are chemically defended should not be ruled out, as similar defenses are known to occur in species of the related family Cleridae (Mawdsley 2002).

Another interesting report is that of Nash (1933), who reported that larvae of *Melyris pallidiventris* Pic were predators of the puparia of the tsetse fly *Glossina morsitans* Westwood (Diptera: Glossinidae). The melyrid larvae were found only in the laboratory, not "in the bush;" however, in the laboratory they were abundant enough to become a "nuisance" (Nash 1933). Clearly, further investigations of the larvae and larval biology of *Melyris* species are needed in areas where tsetse flies are endemic, to determine whether or not these beetles are actually significant predators of the flies in natural settings.

For assistance with the field portion of this study, I thank Ralph and Alice Mawdsley of Cleveland State University, as well as Hendrik Sithole and Freek Venter of South Africa National Parks. For permission to examine specimens in their care, I thank Natalia Vandenberg, Systematic Entomology Laboratory, USDA, and Terry Erwin, National Museum of Natural History, Smithsonian Institution. Enid Peacock, formerly of The Natural History Museum, London, identified many of the specimens of species of *Melyris* in the NMNH collection.

LITERATURE CITED

Champion, G. C. 1919. Notes on the African and Asiatic species of *Melyris*, Fab. (*sensu lato*), with an account of their sexual characters. Annals and Magazine of Natural History 9(4): 157–219.

du Toit, A. P. 1990. The importance of certain insects as pollinators of sunflower (*Helianthus annuus* L.). South Africa Journal of Plant and Soil Science 7(3): 159–162.

Evans, D. L. 1984. A sit-and-wait predator attacking assemblages of aposematic prey. Abstracts, International Congress of Entomology 17: 285.

Grant, V. and K. A. Grant. 1965. Flower pollination in the phlox family. Columbia University Press, New York. 180 pp.

Grobbelaar, E., J. Balciunas, O. C. Neser, and S. Neser. 2000. A survey in South Africa for insects with potential as biological control agents for Cape ivy (*Delairea odorata* Lemaire). Proceedings California Exotic Pest Plant Council Symposiums 6: 18–28.

Iziko Museums of Cape Town. 2004. Genus: *Melyris*. World Wide Web document at: http://www.museums.org.za/bio/insects/beetles/melyridae/melyris.htm. (Accessed August 21, 2006).

Mawdsley, J. R. 2002. Comparative ecology of the genus *Lecontella* Wolcott and Chapin, with notes on chemically defended species of the beetle family Cleridae (Coleoptera). Proceedings of the Entomological Society of Washington 104(1): 164–167.

Medan, D. 1990. Reproductive phenology, pollination biology, and gynoecium development in *Discaria americana* (Rhamnaceae). New Zealand Journal of Botany 29: 31–42.

Nash, T. A. M. 1933. The ecology of *Glossina morsitans*, Westw., and two possible methods for its destruction. -Part II. Bulletin of Entomological Research 24: 153–195 + pls. IV–V.

Peacock, E. R. 1980. *Melyris shaumariensis* n.sp. from Jordan (Coleoptera: Melyridae). Entomologica Scandinavica 11: 236–240.

Pic, M. 1929. Dasytidae: Melyrinae. Coleopterorum Catalogus 103: 1–32.

Jonathan R. Mawdsley. *Research Associate, Department of Entomology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, MRC 187, Washington, DC 20013-7012 U.S.A. (e-mail: mawdsley@heinzctr.org)*

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 963–964

BOOK REVIEW

A Field Guide to the Tiger Beetles of the United States and Canada: Identification, Natural History, and Distribution of the Cicindelidae. David L. Pearson, C. Barry Knisley, Charles J. Kazilek. 2006. 227 pp. + 24 pls. Oxford University Press, New York. ISBN 0-19-518156-5.

This field guide is, without question, the most significant book published to date on North American tiger beetles. Contained in one handy and inexpensive volume are beautiful full-color photographs of every species and subspecies of tiger beetle known to occur in the United States and Canada, complemented by authoritative species accounts, distribution maps, a key to species, and chapters on topics such as phylogeny and taxonomy, ecology and behavior, and conservation. For those readers whose only experience with tiger beetles has been an occasional encounter with the common six-spotted tiger beetle on a nature trail, this field guide will undoubtedly serve as an eye-opener to the diversity and beauty of North America Cicindelidae. For the confirmed tiger beetle enthusiast, the book is destined to become an indispensable field companion, as well as an important resource for identifying and organizing collections of specimens and photographs.

The two senior authors are eminently qualified to write this book, as they collectively have over 50 years' experience studying and publishing papers on the ecology, taxonomy, and conservation biology of North American tiger beetles. The high-resolution color digital photographs by the third author are true works of art, comparable in quality to the illustrations gracing larger and much more expensive "coffee-table" books on these insects.

For the more experienced reader, part of the interest in this book will come from seeing the choices that the authors have made in regards to many of the long-standing taxonomic and nomenclatural questions in this group, questions which have generated much spirited discussion among tiger beetle enthusiasts. To provide just a few examples, the authors opt to use the genus name *Tetracha* for the North American species of "bigheaded" tiger beetles, rather than *Megacephala*. They follow conventional U.S. usage in regarding Emilie Rivalier's generic-level groupings as subgenera of *Cicindela* rather than as separate genera. And tiger beetles are treated in this book as a separate family, rather than a subfamily under Carabidae. The authors provide ample justification for their decisions on these and other important points, although there will probably always continue to be differences of opinion on these matters among hard-core tiger beetle fans.

The coverage of species and subspecies in this guide is quite complete and there are only a few color forms that remain to be illustrated in future editions. Probably the most common and widespread of these is an unnamed variety of *C. duodecimguttata* Dejean with more extensive white markings, which is found in the north-central U.S. and central Canada. Additional illustrations could also be provided of forms in the *C. scutellaris* Say complex, in particular the intergrades between *C. scutellaris scutellaris* and *C. scutellaris lecontei* Haldeman, some of which are similar in coloration to the illustrated Colorado subspecies *C. scutellaris yampae* Rumpp. One might also have wished for an illustration of the brilliant red or red-violet color forms of *C. purpurea purpurea* Olivier or *C.*

limbalis Klug, but then many individuals of these two taxa are indeed a muddy greenish-purple, exactly like the specimens that are illustrated in this book. However, these are very minor issues which certainly do not detract from the overall attractiveness or usefulness of this field guide.

Given the popularity of tiger beetles among amateur insect collectors and professional entomologists, this field guide will undoubtedly be received enthusiastically by the entomological community. Outside of entomological circles, this book will also unquestionably serve as an essential reference for conservation biologists and natural area managers, facilitating the identification and management of rare or endangered tiger beetle species. And among the much broader community of amateur naturalists and wildlife enthusiasts, this attractive and inexpensive field guide can only serve to catalyze further interest in these beautiful beetles. The authors of this book are to be commended for producing such an outstanding, timely, and useful volume.

Jonathan R. Mawdsley, *Research Associate, Department of Entomology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, Washington, D.C. 20013-7012, U.S.A. (e-mail: mawdsley@heinzctr.org)*

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 965–968

SOCIETY MEETINGS

1106th Regular Meeting—4 January 2007

President Michael Gates called the 1106th regular meeting of the Entomological Society of Washington (ESW) to order at 7:05 p.m. in the Cathy Kerby room of the National Museum of Natural History, Washington, DC. Twenty members and 10 guests attended the meeting. Minutes of the 1105th meeting were approved with modification. There was one new applicant for membership, Dr. Kyu-Tek Park. No new members were present; one visitor was introduced.

For exhibits Wayne Mathis brought two books, *Biotaxonomy of Tephritoidea* edited by A. Freidberg and *Phylogeny, Taxonomy, and Biology of Tephritoid Flies (Diptera, Tephritoidea): Proceedings of the 3rd Tephritoid Taxonomist's Meeting* edited by B. Merz. He also noted that Al Norrbom is the contact person for the 4th Tephritoid Taxonomist's Meeting in Washington, DC in 2008. Dave Furth brought two books, *Orchid Bees of Tropical America: Biology and Field Guide* by D.W. Roubik and P.E. Hanson and *Im Bernsteinwald* by W. Wichard and W. Weitschat. He also brought two t-shirts from the Entomological Society of America annual meeting.

President Gates announced that Katja Seltmann of Florida State University would visit the National Museum of Natural History January 16–19, 2007 to promote MorphBank, an open web repository of biological images. He mentioned that Ms. Seltmann would present a seminar on the MorphBank project and would be available for individual meetings during her visit.

Betty and Chris Thompson reported on recent local collecting activity that may document effects of climate change. They have been collecting flower flies around their home in northern Virginia during the fall and early winter months for the last few years. They have not collected any flower files during the month of February but collected three species, *Eristalis tenax* (Linnaeus), *Eupeodes americanus* (Wiedemann), and *Toxomerus marginatus* (Say), visiting dandelion on January 2, 2007. Prior to this record the earliest collection of a flower fly for the local area was *Eu. americanus* on January 3, 2004. Dr. and Mrs. Thompson have also found that the fall diversity has species not found in the spring or summer. Further, three late flying species, *Palpada furcata* (Wiedemann), *Pa. vinetorum* (Fabricius), *Pseudoros clavata* Fabricius, are not known from the local area, but rather, are known from localities south of this area. Given their findings they suggest that collecting in the late fall and early winter may provide useful documentation about climate change when done under proper scientific protocols.

President Gates introduced the speaker, Past President Dr. Steven Lingafelter of the Systematic Entomology Laboratory, whose presentation was entitled "Diversity of Cerambycidae in Bolivia." Following a brief introduction of previous collecting efforts in Bolivia, Dr. Lingafelter provided an overview of the "Bolivian Bycid Biodiversity Project," a collaborative effort among researchers at the American Coleopteran Museum, the National Museum of Natural History, the Florida State Collection of Arthropods, and the Noel Kempff Museum. Cerambycids are collected from a variety of habitats and areas in Bolivia, including grasslands, deserts, fertile valleys, and lowland Amazonia. Collecting methods include beating vegetation during the day and light trapping at night. A total of 1,259 species have been recorded, with 496 species not previously known from Bolivia. An additional 300 species are new or have not yet been determined. In addition to the project overview, Dr. Lingafelter showed a short video of the late Frank Hovore collecting titan beetle, *Titanus giganteus*, and summarized the biological diversity and species richness of each cerambycid subfamily.

The meeting was adjourned at 8:06 p.m. Refreshments were provided by the Society.

Respectfully submitted,
Robert R. Kula
Recording Secretary

1107th Regular Meeting—1 February 2007

President Michael Gates called the 1107th regular meeting of the Entomological Society of Washington to order at 7:00 p.m. in the Cathy Kerby room of the National Museum of Natural History, Washington, DC. Eighteen members and eight guests attended the meeting. Minutes of the 1106th meeting were approved as read. There were no new applicants for membership. Two visitors were introduced.

For exhibits Ed Barrows brought *Guide to the Siricid Woodwasps of North America* by N. M. Schiff, S. A. Valley, J. R. LaBonte, and D. R. Smith. Ralph Eckerlin brought *Biodiversidad de Guatemala* edited by E. B. Cano. Dave Furth brought two books, a treatise on Sarcophagidae by B. C. Nandi published in *The Fauna of India and the Adjacent Countries* and Proceedings of the 6th International Symposium on the Chrysomelidae published in *Bonner Zoologische Beiträge*. He also brought an Entomological Society of Israel t-shirt. Art Evans brought several boxes of pinned and labeled beetles that were collected at Virginia BioBlitz. In response to Chris and Betty Thompson's suggestion that entomologists should collect locally during the winter, Gary Hevel reported that he collected 70 species of insects by sweeping for 15 minutes each on two days in January.

Dave Furth introduced the speaker, Mr. Randy J. Mercurio from the American Museum of Natural History, whose presentation was entitled "On the Diversity and Biogeography of Centipedes in New York State and North America." Following a brief overview of centipede classification, geographic distribution, morphology, and biology, Mr. Mercurio detailed the geographic distribution, morphological features, habitat preferences, and biology of several species. A short video showing centipede behavior and a question and answer session followed the presentation.

The meeting was adjourned at 8:01 p.m. Refreshments were provided by the Society.

Respectfully submitted,
Robert R. Kula
Recording Secretary

1108th Regular Meeting—1 March 2007

President Michael Gates called the 1108th regular meeting of the Entomological Society of Washington to order at 7:00 p.m. in the Cathy Kerby room of the National Museum of Natural History, Washington, DC. Seventeen members and six guests attended the meeting. Minutes of the 1107th meeting were approved with modification. There was one new applicant for membership, Dr. Joseph C. Schaffner. Two visitors were introduced.

For exhibits Ed Barrows brought a box of dolichopodid flies collected from Malaise traps at Dyke Marsh Wildlife Preserve in Virginia. Art Evans brought *Kaufman Field Guide to Insects of North America* by E. R. Eaton and K. Kaufman and noted that 336 species or morphospecies of beetles were collected at Virginia BioBlitz. Dave Furth brought three books: *Bibliography of Australian*

Entomology 1687–2000 by G. Daniels, *Insect Sounds and Communication: Physiology, Behaviour and Evolution* edited by S. Drosopoulos and M. F. Claridge, and *Myriapod Memoranda* volume 9 edited by C. A. W. Jeekel.

Dave Furth introduced the speaker, Dr. Jay Evans from the USDA-ARS Bee Lab in Beltsville, MD, whose presentation was entitled "Genomics of Social Insects." Dr. Evans discussed genomics research on social insects with an emphasis on the honey bee. The presentation covered four major topics: (1) the genetics of cast determination, particularly patterns of gene expression; (2) recent breakthroughs in the areas of gene regulation, bee forensics, and bee evolution through the NIH-funded effort to sequence the entire honey bee genome; (3) honey bee disease and immunity, especially larval tolerance and immune response heritability; and (4) comparative insect genomics.

The meeting was adjourned at 8:25 p.m. Refreshments were provided by the Society.

Respectfully submitted,
Robert R. Kula
Recording Secretary

1109th Regular Meeting—5 April 2007

President Michael Gates called the 1109th regular meeting of the Entomological Society of Washington to order at 7:03 p.m. in the Cathy Kerby room of the National Museum of Natural History, Washington, DC. Fourteen members and 10 guests attended the meeting. Minutes of the 1108th meeting were approved as read. There were no new applicants for membership. Five visitors were introduced.

For exhibits Ed Barrows brought *Handbook of the Canadian Rockies* by B. Gadd. Dave Furth brought a poster with drawings of aleocharine staphylinid beetles entitled "In Black and White" by S. Taliaferro. He also described the IPM Scope™, a handheld USB powered digital microscope produced by Spectrum® Technologies, Inc. The microscope operates between 40 and 140X magnification and can be used to capture still images and record movies. Bob Kula brought *Handbook to the Construction and Use of Insect Collection and Rearing Devices* by G. S. Paulson. Linda Rayor mentioned the book *The Other Insect Societies* by J. T. Costa.

Dave Furth introduced the speaker, Dr. Linda Rayor from Cornell University, Ithaca, NY, whose presentation was entitled "Living with cannibals: cooperation and conflict in an unusual social huntsman spider." Sociality in arachnids is rare, with ~70 species exhibiting social behavior. Features of social spiders include communal web, prolonged association and tolerance of conspecifics, high frequency of inbreeding, and strong female biased sex ratio. However, Australian huntsmen spiders, *Delena canerides* Walckenaer, do not construct webs, are aggressive to non-colony conspecifics, outbreed frequently, and exhibit a 1:1 sex ratio. Australian huntsman spiders live under the bark of dead trees and are relatively rare, with only 66 colonies found among 1,000+ suitable trees. The limited number of available retreats has resulted in increased reproductive competition and intraconflict. Dr. Rayor has also observed behavioral and developmental differences between *D. canerides* and other huntsmen spiders, with the former exhibiting long developmental time, no infanticide, infrequent cannibalism, frequent prey sharing, large feeding groups, and prey sharing throughout development.

The meeting was adjourned at 8:21 p.m. Refreshments were provided by the Society.

Respectfully submitted,
Robert R. Kula
Recording Secretary

1110th Regular Meeting—5 May 2007

President Michael Gates called the 1110th regular meeting of the Entomological Society of Washington to order at 7:07 p.m. in the Cathy Kerby room of the National Museum of Natural History, Washington, DC. Fourteen members and eight guests attended the meeting. Minutes of the 1109th meeting were approved as read. There were no new applicants for membership. Three visitors were introduced.

For exhibits and announcements Mike Gates brought *Introdicción a los Hymenoptera de la Región Neotropical* edited by F. Fernández and M. Sharkey. Charlie Staines brought an article entitled "*Creature Feature*" in the May/June 2007 issue of AAA World magazine that featured the Insectarium in Philadelphia. Gary Hevel announced that the annual Entomological Society of Washington banquet, featuring speaker Zack Lemman, will be held June 21 at the NMNH. Further details will be announced later. Dave Furth brought three books: (1) *Recent Sawfly Research: Synthesis and Prospects* edited by S. Blank, S. Schmidt, and A. Taeger; (2) *Proceedings of the 6th International Symposium on Fruit Flies*, Stellenbosch, South Africa, edited by B. Barnes; and (3) *World Review of Predatory Hoverflies (Diptera, Syrphidae: Syrphinae) and Their Prey* by S. Rojo, M. Marcos-García, J. Nieto, and M. Mier.

Dave Furth introduced the speaker, Dr. Tom Allen an associate at the Philadelphia Academy of Natural Sciences, Philadelphia, PA, whose presentation was entitled "Four years of collecting and camping: insect biodiversity of the southeastern USA." After some brief background information, Dr. Allen began with a US map on which collection localities for Diplura had been plotted and detailed his goal of filling in distributional gaps. He focuses primarily on Japygidae and Campodeidae, each comprised of ~80 nominal species and notes the existence of an east-west species-level endemism. Dr. Allen decided to focus on collecting in the southeastern USA given the published natural history efforts in the region (e.g., Say, Bartram, Gatesby). Further selection criteria included: (1) Dr. Allen born and raised in the south, (2) high regional diversity, (3) few Diplura records, and (4) plentiful National Forest lands. Dr. Allen mapped out some of his recent collecting activities by year, in 2003 driving from Philadelphia to Mississippi then the Great Smokies and finally on to Minnesota. In 2004 he drove ~22,000 miles throughout the southeast, excepting Arkansas and Florida; in 2005 he spent two months collecting in the Smokies. In 2006 he decided to collect non-apterygote insects only and strongly recommended the St. Francis National Forest in eastern Arkansas as being very rich and productive. He plans to focus his efforts in 2007 on North and South Carolina. He uses a variety of techniques, including but not limited to, Malaise traps, pitfall traps, bucket light traps, UV lights, sugaring, Berlese funnels, carrion baits, and direct hand/net collecting.

To date his collecting efforts have resulted in the description of a new genus and species (*Molaricampa fergusoni* Allen 2005), as well as six new species of *Litocampa* (Allen 2003, 2006). Additionally, he has recovered two undescribed species of *Campodea*. He currently has a backlog of approximately 400 specimens of Japygidae.

The meeting was adjourned at 8:10 p.m. Refreshments were provided by the Society.

Respectfully submitted,
Michael Gates
President

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 969–977

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY
of
WASHINGTON

Volume 109

OFFICERS FOR THE YEAR 2007

President	Michael W. Gates
President-Elect	Gary Hevel
Recording Secretary	Robert R. Kula
Membership Secretary	Hollis B. Williams
Treasurer	Michael G. Pogue
Program Chair	Matthew L. Buffington
Custodian	Jon A. Lewis
Editor	David R. Smith
Past President	Steven W. Lingafelter

Published by the Society
WASHINGTON, D.C.
2007

TABLE OF CONTENTS, VOLUME 109

ARTICLES

NOTES

Book Reviews

Miscellaneous

PROC. ENTOMOL. SOC. WASH.
109(4), 2007, pp. 978–979

INSTRUCTIONS FOR AUTHORS

General policy.—Articles for publication are accepted from members and nonmembers. However, non-members pay a higher publication charge and cannot apply for a waiver of page charges. Only one author of an article needs to be a member for member rates. Articles must be in English, but an abstract in French, German, Spanish, Portuguese, Russian, and some other languages is acceptable. Such an abstract should be placed immediately after the English abstract and may be a translation of that abstract.

Manuscripts of 15 printed pages or less are encouraged, but longer manuscripts are acceptable and considered. Publication charges for pages over 15 are at a higher rate and are never waived. About two and one-half double-spaced typewritten pages equal one printed page. Manuscripts are peer reviewed before acceptance. Final acceptance is the responsibility of the Editor. Articles are published in the order received, not the date of acceptance. Immediate publication ahead of schedule is available with payment of full page charges. Notes, book reviews, and obituaries are published as space is available.

Manuscript submittal.—Manuscripts may be submitted as hard copy or electronically. For electronic submittal, send as an attachment to the editor: dave.smith@ars.usda.gov. Illustrations sent electronically should be in TIFF format. When submitting printed copies, please include three copies to the Editor. It is not necessary to send original illustrations until requested after the manuscript has been accepted. After acceptance, the editor will give instructions on sending the final copy and illustrations.

Format for manuscripts submitted should fit letter-sized paper. The entire manuscript should be double spaced, allowing adequate (1–1½″) margins. Words to be italicized may be indicated in italic form or underlined. Do not use bold face; the editor will mark what is to be in bold. Manuscript contents should be in the following sequence, and items 1–6 should begin a new page:

1. Title page with title, author(s), and author(s) byline. The corresponding author and address, telephone and fax numbers, and e-mail should be in the upper left corner. Title must include order and family placement, e.g., "… (Hymenoptera: Xyelidae)." Taxa of the genus- and species-group levels may have the author's name.
2. Abstract; key words. Key words should include those that do not appear in the title.
3. Text of paper; acknowledgments at end.
4. Literature cited (see below).
5. Figure legends.
6. Appendix; footnotes (if any).
7. Copies of tables; legends for tables are placed at the top of each table.
8. Copies of plates arranged in final form by author.

Illustrations.—There is no extra charge for line drawings or half tones. Authors should plan illustrations for reduction to dimensions of the printed page and allow room for legends at the bottom. Illustrations may be submitted on disk or CD, and should be in TIFF format with a resolution of 400–600 dpi; however, a printout of each illustration/plate should be provided. Illustrations also may be submitted mounted on suitable board which will be scanned by the printer. These should be trimmed, grouped together, abutted, and numbered when mounted, i.e., the author is responsible for preparation of the final plate. Consecutive figure numbers are preferred (not 1a, 1b, . . ., 2a, 2b, . . ., etc.), numbered consecutively in the sequence in which they are referred to in the text,

and positioning of the numbers for the figures at the lower right of each is preferred. Reference in the text should be as "Fig. 1," "Figs. 2, 3," "Figs. 2–5," and for Tables, "Table 1," etc. See recent *Proceedings* for style of figure legends.

Literature cited.—Cite only papers referred to in the text; list alphabetically by author; spell out references (e.g., journal names) completely, including conjunctions and prepositions. Do not italicize journal names or titles of books. See recent *Proceedings* for style of journals, books, and book chapters.

When referring to references in text, format as follows: Henry (1990), (Henry 1990), (Henry 1987, 1990), (Smith 1990, Henry 1991), (Smith 1990; Henry 1991, 1995), (Miller 1990a, 1990b), (Gagné et al. 1999). Do not italicize "et al." Citations "in press" should be cited as "in press," not with the expected year of publication. Cite as "in press" those papers that have been accepted for publication.

Names of persons providing unpublished information should include initials and be referenced in the text as: W. Mathis (personal communication) [information obtained orally] or W. Mathis (in litt.) [information obtained in writing].

Names of organisms.—The first mention of a plant or animal should include the full scientific name including the authority, spelled in full (authorities for plant names may be abbreviated). Generic names may be abbreviated after first use but should always be spelled out at the beginning of a sentence or if two or more genera being discussed have the same first letter. Within sentences use the generic name or initial preceding a species name.

Taxonomic papers.—Taxonomic papers must conform to requirements of the *International Code of Zoological Nomenclature* (1999). Holotypes must be designated for new species described, type depositories must be clearly indicated, and new taxa must be clearly differentiated from existing taxa by means of keys or differential diagnoses. An etymology section should provide the derivation of name(s), and the gender should be stated for all new genus-group names. In short, papers must conform to good taxonomic practices.

Book reviews.—Send to Dr. Raymond J. Gagné, Book Review Editor, or Editor at the address of the Society on the inside front cover. Electronic transmission is acceptable, to: rgagne@sel.barc.usda.gov, or dsmith@sel.barc.usda.gov. See recent issues of the *Proceedings* for format.

Charges.—Authors will be assessed a charge to cover editing and publication expenses. The current charges are $40.00 per printed page for members and $60.00 per printed page for non-members and for immediate publication. Charges for reprints, if ordered, and for author's corrections in proof are extra.

Member authors who are retired or not affiliated with an institution may request to have charges partially or completely waived *and should do so when the manuscript is submitted.* A maximum of 15 pages of an article may be waived. A complete or partial waiver may delay publication. Waiver of publication charges does not include cost of reprints, if ordered, or author's corrections in proof.

Acceptance of papers in based only on scientific merit without regard to the author's financial support.

HISTORY OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

"The Entomological Society of Washington was conceived on February 29, 1884, at a small informal gathering and was born on March 12th at the first formal meeting at 1700 13th Street, N.W., in Washington" (Spilman 1984). There were only four entomological societies in the United States that produced serial journals at that time, and the *Proceedings* is second in longevity, having been published to the present without interruption (Day 1989).

The Centennial Banquet of the Society was held March 12, 1984, at the Center of Adult Education, University of Maryland, College Park. Guests included Emile Wenban-Smith, granddaughter of the late Charles Valentine Riley, and the address for the banquet was titled "In Days of Yore" presented by Curtis W. Sabrosky.

The following references pertain to the history of the Society and some of the participants:

Day, W. H. 1989. North American entomological societies and their publications in 1890 and the early *Entomological News*. Entomological News 100: 200–206.

Gurney, A. B. 1976. A short history of the Entomological Society of Washington. Proceedings of the Entomological Society of Washington 78: 225–239.

Herring, J. L. 1964. The official seal of the Entomological Society of Washington. Proceedings of the Entomological Society of Washington 66: 1.

Howard, L. O. 1895. A review of the work of the Entomological Society of Washington during the first ten years of its existence. Proceedings of the Entomological Society of Washington 3: 161–167.

Howard, L. O. 1909. The Entomological Society of Washington. Proceedings of the Entomological Society of Washington 11: 8–18.

Rohwer, S. A. 1934. Remarks on changes in the Entomological Society of Washington during the last quarter of a century. Proceedings of the Entomological Society of Washington 36: 55–59.

Spilman, T. J. 1984. Vignettes of 100 years of the Entomological Society of Washington. Proceedings of the Entomological Society of Washington 86: 1–10.

Stoetzel, M. B. 1984. Entomological Society of Washington Past-Presidents for the years 1884 through 1983, photographs and support officers. Proceedings of the Entomological Society of Washington 86: 11–35.

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

MISCELLANEOUS PUBLICATIONS

A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera): Second Edition, Revised, by E. Eric Grissell and Michael E. Schauff. 87 pp. 1997	15.00
Revision of the Oriental Species of *Aphthona* Chevrolat (Coleoptera: Chrysomelidae), by Alexander S. Konstantinov and Steven W. Lingafelter. 349 pp. 2002	40.00
Revision of the Genus *Anoplophora* (Coleoptera: Cerambycidae), by Steven W. Lingafelter and E. Richard Hoebeke. 236 pp. 2002	30.00
A Phylogenetic Revision of the Napaeina (Lepidoptera: Riodinidae: Mesosemiini), by Jason P. W. Hall. 233 pp. 2005 Softcover 18.00, Hardcover	25.00

MEMOIRS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Memoirs 1, 2, 3, and 9 are no longer available.

No.4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No.5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No.6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No.7.	Ant larvae: Review and Synthesis, by George C. and Jeanette Wheeler. 108 pp. 1976	11.00
No.8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No.10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky, edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No.11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kammiya, 370 pp. 1983	18.00
No.12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No.13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton, 98 pp. 1987	18.00
No.14.	Biology and Phylogeny of Curculionoidea, edited by R. S. Anderson and C. H. C. Lyal. 174 pp. 1995	25.00
No.15.	A Revision of the Genus *Ceratopogon* Meigen (Diptera: Ceratopogonidae), by A. Borkent and W. L. Grogan, Jr. 198 pp. 1995	25.00
No.16.	The Genera of Beridinae (Diptera: Stratiomyidae), by Norman E. Woodley. 231 pp. 1995	25.00
No.17.	Contributions on Hymenoptera and Associated Insects, Dedicated to Karl V. Krombein, edited by B. B. Norden and A. S. Menke. 216 pp. 1996	25.00
No. 18.	Contributions on Diptera, Dedicated to Willis W. Wirth, edited by Wayne N. Mathis and William L. Grogan, Jr. 297 pp. 1997	25.00
No. 19.	Monograph of the Stilt Bugs, or Berytidae (Heteroptera), of the Western Hemisphere, by Thomas J. Henry. 149 pp. 1997	18.00
No. 20.	The Genera of Elaphidiini Thomson 1864 (Coleoptera: Cerambycidae), by Steven W. Lingafelter. 118 pp. 1998	12.00
No. 21.	New World *Blepharida* Chevrolat 1836 (Coleoptera: Chrysomelidae: Alticinae), by David G. Furth. 110 pp. 1998	12.00
No. 22.	Systematics of the North American Species of *Trichogramma* Westwood (Hymenoptera: Trichogrammatidae), by John D. Pinto. 287 pp. 1999	28.00
No. 23.	Revision of the Net-Winged Midges of the Genus *Blephariceera* Macquart (Diptera: Blephariceridae) of Eastern North America, by Gregory W. Courtney. 99 pp. 2000	14.00
No. 24	Holcocerini of Costa Rica (Lepidoptera: Gelechioidea: Coleophoridae: Blastobasinae), by David Adamski. 147 pp. 2002	18.00
No. 25	A Catalog of the Cecidomyiidae (Diptera) of the World, by Raymond J. Gagné. 408 pp. 2004	50.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $60.00 per volume to non-members and $25.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra on all orders. Dealers are allowed a discount of 10 percent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Treasurer, Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, P.O. Box 37012, MRC 168, Washington, D.C. 20013-7012.

CONTENTS

(Continued from front cover)

NOTES

BOOK REVIEW

MISCELLANEOUS