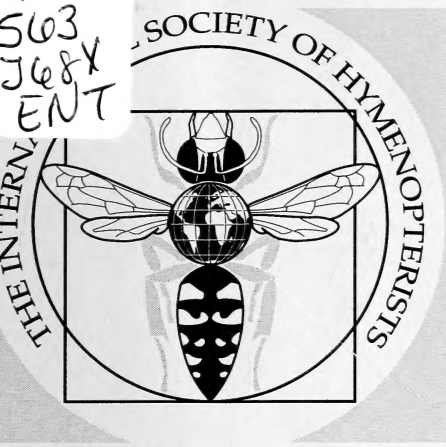


Journal of Hymenoptera Research

Volume 17, Number 2 **October 2008**

ISSN #1070-9428

CONTENTS

INTERNATIONAL SOCIETY OF HYMENOPTERISTS

Organized 1982; Incorporated 1991

All correspondence concerning Society business should be mailed to the appropriate officer at the following addresses: President, Plant Sciences Institute, Bldg. 003, Rm. 231 BARC-West, Beltsville, MD 20705, USA; Secretary, Department of Entomology, North Carolina State University, Campus Box 7613, 2301 Gardner Hall, Raleigh, NC 27695-7613, USA; Treasurer, Saint Louis University, 3507 LaClede Ave., St. Louis, MO 63103, USA; Editor, Dept. of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

Membership. Members shall be persons who have demonstrated interest in the science of entomology. Annual dues for members are US$45.00 per year (US$40.00 if paid before 1 February), payable to The International Society of Hymenopterists. Requests for membership should be sent to the Treasurer (address above). Information on membership and other details of the Society may be found on the World Wide Web at http://hymenoptera.tamn.edu/ish/.

Journal. The *Journal of Hymenoptera Research* is published twice a year by the International Society of Hymenopterists, % Department of Entomology, Smithsonian Institution, Washington, D.C. 20560-0168, U.S.A. Members in good standing receive the *Journal*. Nonmember subscriptions are $60.00 (U.S. currency) per year.

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

Please see inside back cover of this issue for information regarding preparation of manuscripts.

Statement of Ownership

Title of Publication: Journal of Hymenoptera Research.
Frequency of Issue: Twice a year.
Location of Office of Publication, Business Office of Publisher and Owner: International Society of Hymenopterists, 0 Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560-0168, U.S.A.
Editor: Gavin R. Broad, Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.
Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 1 October 2008

J. HYM. RES.
Vol. 17(2), 2008, pp. 127–133

Three Species Masquerading as One: Updating the Taxonomy of *Pseudomethoca russeola* Mickel and *P. donaeanae* (Cockerell & Fox) (Hymenoptera: Mutillidae)

KEVIN A. WILLIAMS AND JAMES P. PITTS

Utah State University, Department of Biology, Logan, Utah 84322, USA; (KAW)
email: kawilliams@biology.usu.edu

Abstract.—*Pseudomethoca donaeanae* (Cockerell & Fox) was described based on females only, while *P. russeola* Mickel was described based on males only. Manley (1999) synonymized *P. russeola* with *P. donaeanae* after associating a male that superficially resembles *P. russeola* with *P. donaeanae*. Close examination of male genitalia of specimens currently identified as *P. donaeanae*, along with additional morphological characters, suggests that three species are actually being misidentified as a single species. Our comparison of the male associated with *P. donaeanae* with the type specimen of *P. russeola* (male) suggests that these species are not synonymous. The male of *P. donaeanae* is described for the first time, and *P. russeola* **new comb.**, is resurrected from synonymy and redescribed. The third species, *P. ajattara* **sp. nov.** also superficially resembles *P. russeola* and *P. donaeanae*, but has definitive genitalia with hooked setae located ventrally along the internal margin of the parameres. The females of neither *P. russeola* or the undescribed species are known.

Pseudomethoca Ashmead is one of the largest diurnal mutillid genera in the New World, including almost 50 species in the United States. *Pseudomethoca* species occur throughout the Americas, from Canada to Argentina (Nonveiller 1990). This range is slightly misleading, however, because *Pseudomethoca* appears to be an unnatural grouping (pers. obs). Like other mutillid genera, *Pseudomethoca* species exhibit extreme sexual dimorphism. As a result, less than half of the species are known from both sexes (Krombein 1979). Additional problems stem from the relative lack of obvious characters useful for diagnosing species based on males. While many females have unique coloration schemes, males exhibit a limited suite of coloration, with most species having the integument entirely black and the setae mostly silver. In some cases, males with unique coloration are immediately recognizable, and additional morphological characters are ignored.

Pseudomethoca russeola Mickel (1924), known only from the male, is among the species having unique coloration. The head and mesosoma are black, while the metasoma is orange, and the entire insect is clothed with silvery setae. The male of *P. donaeanae* (Cockerell & Fox) was discovered by Manley (1999), when he attracted two males to a caged female. He identified these males as *P. russeola* and synonymized the two species under the name *P. donaeanae* presumably based on this "unique" coloration. A study of male genitalia and other characters in *Pseudomethoca* led to the discovery of three unique species that currently are identified as *P. russeola*, with all possessing the unique coloration. The taxonomy and sex associations of these species are addressed in this paper.

MATERIALS AND TERMINOLOGY

The following acronyms are used for institutions housing the material discussed in the current study:

ANSP Department of Entomology, Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

ASUT Frank M. Hasbrouck Insect Collection, Department of Zoology, Arizona State University, Tempe, Arizona, USA.

CASC Department of Entomology, California Academy of Sciences, San Francisco, California, USA.

CISC Essig Museum of Entomology, Department of Entomological Sciences, University of California, Berkeley, California, USA.

CSUC C.P. Gillette Arthropod Biodiversity Museum, Department of Entomology, Colorado State University, Fort Collins, Colorado, USA.

DGM Personal Collection of Donald G. Manley, Pee Dee Research Center, Florence South Carolina, USA.

EMUS Department of Biology Insect Collection, Utah State University, Logan, Utah, USA.

TAMU Department of Entomology Insect Collection, Texas A&M University, College Station, Texas, USA.

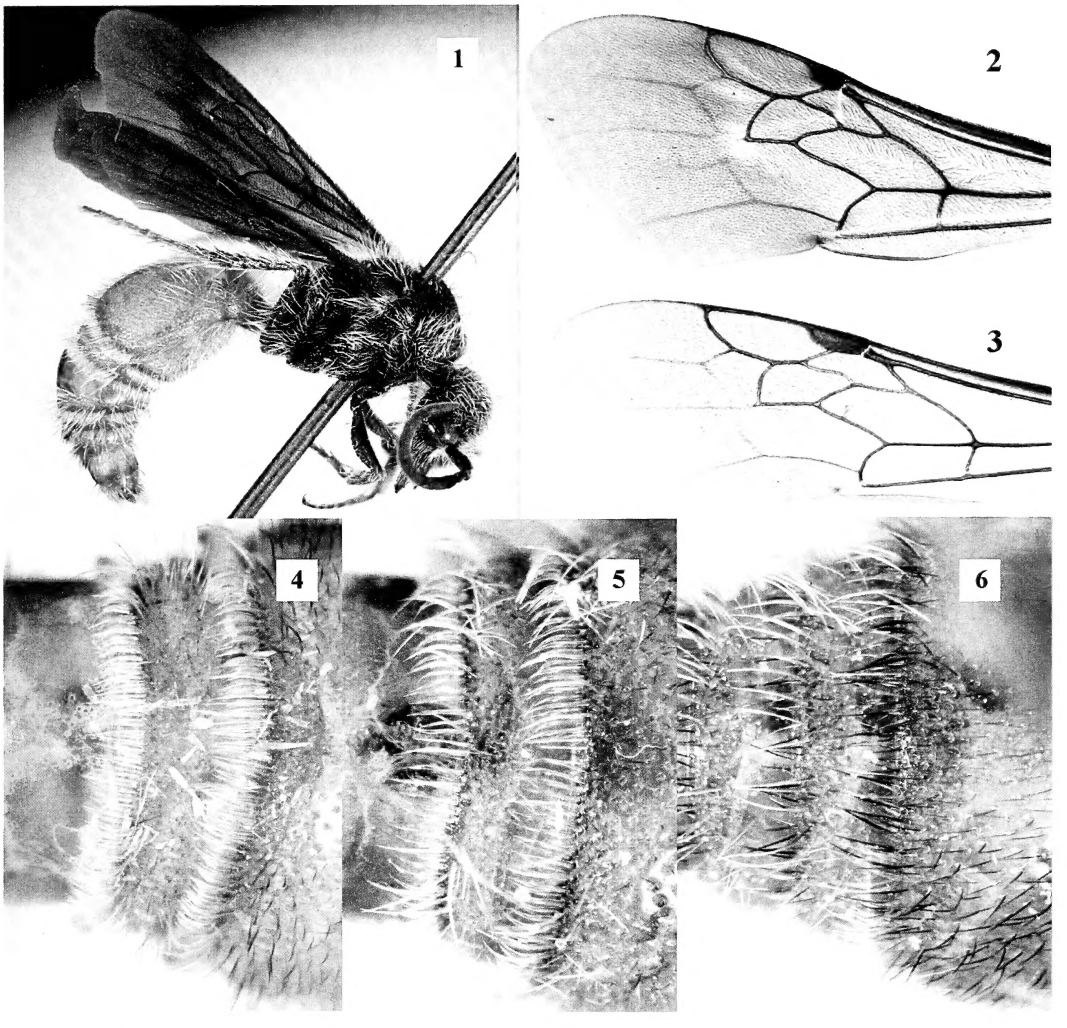
NMNH Department of Entomology, Smithsonian Institution, National Museum of Natural History, Washington, District of Colombia, USA.

The holotype of *P. russeola* was examined, but that of *P. donaeanae* was not available. We have used the acronyms T2, T3, etc., to denote the second, third, etc., metasomal tergites while S2, S3, etc., denote the second, third, etc., metasomal sternites. Lastly, punctures can sometimes be elongate and their posterior edge indistinct. We have used the term "puncture width" to indicate the transverse measurement of the width of a puncture. This is the only way to accurately and reproducibly measure an elongate puncture.

Pseudomethoca ajattara, new species
(Figs 1, 2, 5, 7, 10–13)

Diagnosis.—The male is similar to *P. donaeanae* and *P. russeola* in coloration, wherein the integument of the head and mesosoma is black, the integument of the metasoma is orange, and the setae are silvery white (Fig. 1). This species can be separated from other species with this coloration by the following combination of characters: the head is narrower than pronotum; the clypeus is expanded anteriorly with two medial approximate teeth (Fig. 7); the apical fringes of T2-4 have dense, thick, pale golden setae, while T4-5 have interspersed brown and pale golden setae; the paramere has long, elbowed setae along the internal margin (Fig. 10); and the cuspis has an apical finger-like process (Fig. 10).

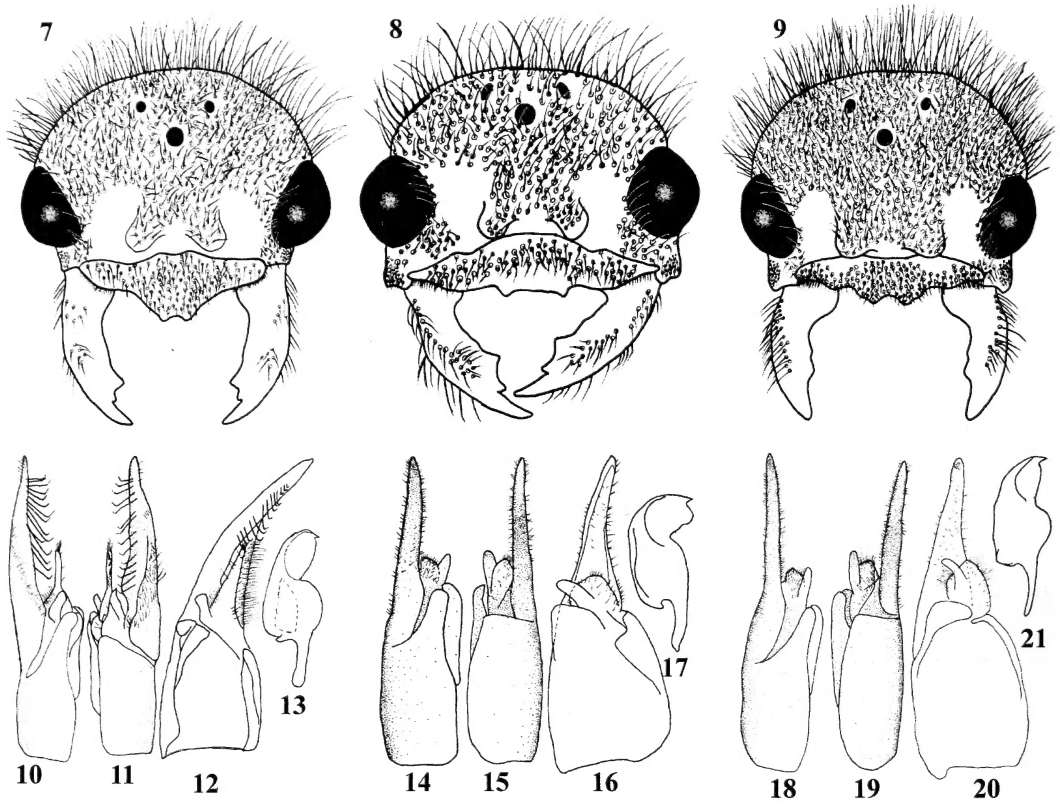
Male holotype description.—Coloration: Head and mesosoma black to dark reddish-brown, except metapleuron red; metasoma orange; legs dark reddish-brown; tibial spurs reddish-brown, lighter than legs. Wings slightly infuscated. Setae of head, mesosoma, and legs silvery white, except mesonotum with erect and appressed dark brown setae. Setae of metasoma entirely pale golden, except T5-6 and disc of T2 having interspersed brown and pale golden setae. *Head*: Narrower than pronotum, densely punctate throughout. Mandible oblique, tridentate apically, inner tooth strongly developed (Fig. 7). Clypeus densely punctate, anteriorly expanded, covering inner margin of mandibles, with two approximate median teeth (Fig. 7). Antennal scrobe lacking carina. Ocelli miniscule; ocellocular distance 10× length of lateral ocellus, interocellar distance 3× lateral ocellar length. Flagellomere I 2× pedicel length; flagellomere II 3× pedicel length. *Mesosoma*: Pronotum moderately punctate; mesonotum and scutellum densely punctate; mesopleuron moderately



Figs 1–6: Habitus, Fig. 1: *Pseudomethoca ajattara*. Metasomal terga, Figs. 2–4; Fig. 2: *P. ajattara*; Fig. 3: *P. donaeanae*; Fig. 4: *P. russeola*. Fore wing, Figs. 5–6: Fig. 5: *P. ajattara*; Fig. 6: *P. donaeanae*.

punctate with micropunctures anteriorly, metapleuron glabrous; propodeum reticulate dorsally, horizontally striate laterally. Tegula evenly convex, punctate and pubescent throughout. Marginal cell 2.75× length of stigma. *Metasoma*: Petiole broadly sessile, evenly convex. Apical fringes of T2-4 forming dense rows of short, evenly spaced, slightly curved, pale golden bristles; bristles separated by 0.5× bristle width. T1 with ovate punctures; T2 and S2 moderately punctate; T3-6 and S3-6 moderately punctate. S1 with low longitudinal carina. Pygidium densely punctate, with micropunctures and fine setae among punctations. Hypopygidium densely punctate, apical margin nearly flat. *Genitalia* (Figs 10–13): Paramere tapering apically, curved ventrally and slightly curved laterally at apex, with dense ventral brush and long curved bristles along inner margin. Cuspis with apical, finger-like process, 0.4× free length of paramere, setose basally, with apical tuft and short, thick bristles on venter of finger-like process. Basal lobe of cuspis short, glabrous. Penis valve unidentate apically, hooked baso-dorsally.

Length.—10 mm.



Figs 7–21: Clypeus, Figs. 7–10; Fig. 7: *Pseudomethoca ajattara*; Fig. 8: *P. donaeanae*; Fig. 9: *P. russeola*. Male genitalia: dorsal view, ventral view, lateral view, and penial valve, Figs 10–21: Figs 10–13: *P. ajattara*; Figs 14–17; *P. donaeanae*; Figs 18–21: *P. russeola*.

Female.—Unknown.

Host.—Unknown.

Etymology.—From Finnish mythology, Ajattara is an evil forest spirit. Treat as noun in apposition.

Distribution.—USA: southeastern Arizona.

Holotype.—USA: ARIZONA: *Cochise Co.*, Portal, 8.IX.1974, H. & M. Townes coll. (EMUS).

Remarks.—This new species is closely related to *P. nigricula* Mickel based on the genitalia, which are virtually identical (Figs 10–13; Fig. 6 in Mickel 1924). These species can be separated by setal and integumental coloration; *P. nigricula* has the integument and setae entirely black, while *P. ajattara* **sp. nov.** has the metasomal integument orange and most of the setae pale golden (Fig. 1). Additionally, *P. nigricula* has coarser punctation, especially on the pronotum and genae, where the punctures are deep and contiguous. The curved setae on the internal margin of the paramere of these two species are unique among United States species. In Mexico, however, at least three undescribed species have been examined with this genitalic feature (*pers. obs.*), which will be described at a later date.

Pseudomethoca donaeanae (Cockerell and Fox)

(Figs 3, 6, 8, 14–17)

Sphaeropthalma dona-anae Cockerell and Fox, 1897: 136. **HOLOTYPE** ♀, USA, New Mexico (ANSP).

Mutilla donae-anae Fox, 1899: 224. ♀

Pseudomethoca Donae-Anae André, 1903: 28. ♀

Pseudomethoca donaeanae Krombein, 1979: 1302. ♀

Pseudomethoca donaeanae Manley, 1999: 32. ♀ ♂

Female diagnosis.—This species can immediately be separated from all other known females of North American *Pseudomethoca* by the presence of a prominent rugose tubercle on the dorsum of the propodeum medially, although the females of *P. ajattara* and *P. russeola* are unknown.

Male diagnosis.—The male is similar to *P. russeola* and *P. ajattara* **sp. nov.** in coloration, wherein the integument of the head and mesosoma is black, the integument of the metasoma is orange, and the setae are silvery white. This species can be separated from these species by the following combination of characters: head broader than pronotum; clypeus with small, widely separated lateral teeth (Fig. 8); fringes of T2-4 with thick, slightly curved, pale silver setae and T5 with simple intermixed black and silver setae (Fig. 3); paramere covered with simple setae only (Fig. 14); and cuspis rectangular (Fig. 14).

Male description.—Coloration: Head and mesosoma black or dark reddish-brown; metasoma orange; legs reddish-brown, lighter than head and mesosoma; tibial spurs white; wings slightly infuscated. Setae of head, mesosoma, and legs silvery white, except mesonotum having appressed black setae interspersed with erect white setae. Setae of metasoma entirely silvery white, except T6-7 and disc of T2 having some black setae. *Head*: Broader than pronotum. Front and gena densely punctate, vertex moderately punctate. Mandible oblique, tridentate apically, inner tooth strongly developed (Fig. 8). Clypeus weakly punctate, flat anteriorly, with two small, sharp, lateral teeth (Fig. 8). Antennal scrobe lacking carina. Ocelli minuscule; ocellocular distance 10× length of lateral ocellus, interocellar distance 3× lateral ocellar length. Flagellomere I 1.5× pedicel length; flagellomere II 2.5× pedicel length. *Mesosoma*: Pronotum and scutellum densely punctate; mesonotum and mesopleuron moderately punctate; metapleuron glabrous; propodeum reticulate dorsally, anterior margin glabrous laterally. Tegula evenly convex, pubescent anteriorly, glabrous posteriorly. Marginal cell 1.75× length of stigma (Fig. 6). *Metasoma*: Petiole broadly sessile, evenly convex. Apical fringes of T2-5 and S2-4 forming rows of short, evenly spaced, slightly curved, silvery white bristles, those of T2-5 separated by the bristle width, those of S2-4 separated by 2× the bristle width (Fig. 3). T1 with elongate shallow punctures; T2 and S2 moderately punctate; T3-6 and S3-6 densely punctate. S1 with low longitudinal carina. Pygidium densely punctate, with micropunctures and fine setae among punctations. Hypopygidium densely punctate, apical margin slightly convex. *Genitalia* (Figs 14–17): Paramere tapering apically, moderately setose throughout, weakly curved ventrally. Cuspis short, 0.25× free length of paramere, rectangular, setose throughout. Basal lobe of cuspis extending beyond anterior margin of cuspis, dorsally curved, glabrous. Penis valve unidentate with ventral lobe apically, hooked basodorsally.

Length.—8–9 mm.

Host.—Unknown.

Distribution.—USA: southern Arizona and New Mexico, southeastern California; MEXICO: northeastern Baja California.

Material examined.—USA: **ARIZONA**: *Cochise Co.*, Portal, 1♂, 2.IX.1959, H.E. Evans coll. (DGM); *Maricopa Co.*, Granite Reef Dam, 1♂, 4.X.1964, J.W. Debolt (ASUT); *Pinal Co.*, Sacaton, 1♂, Geo. Harrison coll. (NMNH); **CALIFORNIA**: *Imperial Co.*, El Centro, 1♂ 1♀, 7.VII.1955, A. Ross coll. (EMUS); **NEW MEXICO**: *Dona Ana Co.*: Hatch, 2♂, 28–29.VII.1974, H. & M. Townes coll. (EMUS); 2 km E Radium Springs, 1♂, 2.X.1992, D.G. Manley coll. (DGM); *Hidalgo Co.*: Rodeo, 1♂, 28.VIII.1959, H.E. Evans coll. (DGM). MEXICO: **BAJA CALIFORNIA**: Mexicali, 1♂, 16.VI.1956 (CSUC); **SONORA**: 2.6 mi W La Jollita, 1♂, 21.IX.1967, G. I. Marsh coll. (CISC).

Remarks.—The sex association was discovered by Manley (1999), when he attracted two males to a caged female specimen in New Mexico. He identified the males as *P. russeola* Mickel, and synonymized the two species. Although this male keys out to

P. russeola using Mickel (1924, 1935), it has numerous morphological differences from the type of that species. Most notably, the head is broader than the pronotum (narrower in *P. russeola*), the clypeus is glabrous anteromedially (Fig. 8) (punctate throughout in *P. russeola*) (Fig. 9), and metasomal terga two to four have rows of short silver bristles (Fig. 3) (the terga of *P. russeola* have simple setae only) (Fig. 4).

Manley (1999) also suggests that the record of *P. donaeanae* from Calexico, CA may be based on a mislabelled specimen, and that it was unlikely that *P. donaeanae* actually lives that far west. A male and female from El Centro, CA and a male from Mexicali, Baja California have been examined, however, and both of these sites are within 15 miles of Calexico. Thus, we believe that the Calexico locality is legitimate. This is a relatively uncommon distribution, but many species of *Dasymutilla* Ashmead that are typically recognized from Arizona and New Mexico, have also been found in the western Sonoran Desert in California (Hurd, 1951).

Pseudomethoca russeola Mickel
(Figs 4, 9, 18–21)

Pseudomethoca russeola Mickel, 1924: 44. **NEW COMBINATION. HOLOTYPE** ♂, USA, Texas, San Diego, 4 May 1901, R.A. Cushman coll. (NMNH).

Diagnosis.—The male of this species is similar to *P. donaeanae* and *P. ajattara* **sp. nov.** in coloration, wherein the integument of the head and mesosoma is black, the integument of the metasoma is orange, and the setae are silvery white. This species can be separated from these species by the following combination of characters: head narrower than pronotum; clypeus with moderate, separated lateral teeth (Fig. 9); T2-5 with intermixed sparse, simple, black and silver setae (Fig. 4); paramere covered with simple setae only (Fig. 18); and cuspis rectangular (Fig. 18).

Additions to male description.—Antennal scrobe lacking carina. Ocelli minuscule; ocellocular distance 10× length of lateral ocellus, interocellar distance 3× lateral ocellar length. Flagellomere I 1.5× pedicel length; flagellomere II 2.5× pedicel length. Marginal cell of forewing 1.5× length of stigma. First metasomal sternum with low longitudinal carina. Pygidium densely punctate, with micropunctures and fine setae among punctations. Hypopygidium densely punctate, apical margin slightly convex. *Genitalia* (Figs 18–21): Paramere tapering apically, moderately setose throughout, weakly curved ventrally. Cuspis short, 0.25× free length of paramere, rectangular, setose throughout. Basal lobe of cuspis extending beyond anterior margin of cuspis, dorsally curved, glabrous. Penis valve unidentate apically, angulate basodorsally.

Length.—8–10 mm.

Female.—Unknown.

Host.—Unknown.

Distribution.—USA: southern Texas.

Material examined.—USA: TEXAS: *Bexar Co.*: Leon Creek, 1♂, 19.X.1952, M. Wasbauer coll.; *Hidalgo Co.*: Bentsen Rio Grande State Park, 1♂, 27.IV.1986, W.J. Pulawski coll. (CASC); 5♂, 27.V.1979, H. Evans, A. Hook & W. Rubick coll. (CSUC); 4♂, 15.V.1979, H. Evans, A. Hook & W. Rubick coll. (CSUC); 1♂, 13.VI.1978, C.C. Porter coll. (DGM); *Kleberg Co.*, Route 2045E, 30 mi. E Kingsville, 1♂, 3.XI.1990, T. Carlow coll. (TAMU).

Remarks.—This species seems to be restricted to the humid area of southern Texas, and is likely to extend far south into Mexico as well. We did not find any Mexican *P. russeola* specimens, most likely because few *Pseudomethoca* were available from that region. Unlike the other species examined in this paper, this species lacks thickened bristles on the metasomal terga, having only simple setae (Fig. 9).

ACKNOWLEDGEMENTS

We would first like to thank Donald G. Manley at the Pee Dee Research Center for allowing us to borrow voucher specimens from his previous study. We thank the curators of all the museums who provided specimens for this study. KAW was able to search for specimens in Portal, AZ using funds from the

Theodore Roosevelt Memorial Fund of the American Museum of Natural History. This research was supported by the Utah Agricultural Experiment Station, and Utah State University, Logan, Utah. Approved as journal paper no. 7921.

LITERATURE CITED

André, E. 1903. Mutillidae. *Genera Insectorum* 1: 1–77.

Cockerell, T. D. A. and W. J. Fox. 1897. Descriptions of New Hymenoptera from New Mexico. *Proceedings of the Academy of Natural Sciences, Philadelphia* 49: 135–141.

Fox, W. J. 1899. The North American Mutillidae. *Transactions of the American Entomological Society* 25: 219–292.

Hurd Jr., P. D. 1951. The California Velvet Ants of the Genus *Dasymutilla* Ashmead (Hymenoptera: Mutillidae). *Bulletin of the California Inset Survey* Vol. 1, 4: 88–114 + 1 plate.

Krombein, K. V. 1979. Chapter 76. Mutillidae. Pp. 1276–1313 in: Krombein, K. V., et al., eds. *Catalog of Hymenoptera in America North of Mexico* vol. 2. Smithsonian Institution Press, Washington, D. C, xvi + 1199–2209 pp.

Manley, D. G. 1999. A synonymy for *Pseudomethoca donaeanae* (Cockerell & Fox) (Hymenoptera: Mutillidae). *Pan-Pacific Entomologist* 75: 32–34.

Mickel, C. E. 1924. A revision of the mutillid wasps of the genera *Myrmilloides* and *Pseudomethoca* occurring in America north of Mexico. *Proceedings of the United States National Museum* 64: 1–52.

———. 1935. Descriptions and records of nearctic mutillid wasps of the genera *Myrmilloides* and *Pseudomethoca* (Hymenoptera: Mutillidae). *Annals of the Entomological Society of America* 29: 29–60.

Nonveiller, G. 1990. Catalog of the Mutillidae, Myrmosidae and Bradynobaenidae of the Neotropical region including Mexico. *Hymenopterorum Catalogus, Pars* 18: 1–350.

J. HYM. RES.
Vol. 17(2), 2008, pp. 134–137

A New Species of *Encarsia* (Hymenoptera: Aphelinidae) Parasitising *Aleuromarginatus tephrosiae* (Hemiptera: Aleyrodidae) in Iran and Oman

ANDREW POLASZEK AND SHAHAB MANZARI

(AP) Dept of Entomology, the Natural History Museum, London SW7 5BD, U.K. (SM) Insect Taxonomy Research Department, Iranian Research Institute of Plant Protection, P.O. Box 1454, Tehran 19395, Iran; email: manzari@ppdri.ac.ir

Abstract.—***Encarsia indigoferae* Polaszek & Manzari, new species**, is described and illustrated. It is known from Iran and Oman, and all known specimens were reared from the whitefly *Aleuromarginatus tephrosiae* Corbett.

The purpose of this paper is to describe a new species in the genus *Encarsia*. *E. indigoferae* is clearly a member of the *Encarsia strenua*-group, having scutellar sensilla separated by approximately the maximum diameter of one sensillum (see Fig. 4), a characteristic stigmal vein with an asetose area above it, and a seta present at the junction of the marginal and submarginal veins. It differs from other species of the *strenua*-group in having a combination of three setae on the submarginal vein and a rugose stemmaticum. The host, *Aleuromarginatus tephrosiae* Corbett, was described from Sierra Leone (Corbett 1935) and is widespread in Africa and Asia, apparently specific to various Papilionaceae (Bink-Moenen 1983). It seems probable that *E. indigoferae* is more widespread than is currently known. It is worth mentioning that within the colony of *A. tephrosiae* on *Indigofera* sp. collected in Iran, parasitised pupae of *Zaphanera cyanotis* Corbett with parasitoid emergence holes were also collected. These two whitefly species, which had heavily infested *Indigofera* sp. in the collecting areas, were found to be mostly parasitised. It is quite likely that *Z. cyanotis* is also being parasitised by *E. indigoferae* but no parasitoid was reared from the former species.

To whom correspondence should be addressed: E-mail: a.polaszek@nhm.ac.uk

Encarsia species are mostly parasitoids of whiteflies and armoured scale insects (Diaspididae), and are of considerable economic importance. The systematics and biology of the genus are treated in detail by Heraty et al. (2008).

Abbreviations.—

NHM	Natural History Museum, London, U.K.
HMIM	Hayk Mirzayans Insect Museum, Iranian Research Institute of Plant Protection, Tehran, IRAN.

Encarsia indigoferae **Polaszek & Manzari**
new species
Figs 1–4

Description.—**Female**

Colour. Head and body yellow except the following areas pigmented with brown (Fig. 1): three spots on stemmaticum (Fig. 3), adjacent to ocelli; pronotum and front of mesoscutum, notauli (especially poteriorly); most of axillae, but fading posteriorly; T2 and T3-T6 either just laterally or more extensively. Antennae and legs uniformly pale brown, or appearing paler, almost yellow. Fore wings hyaline.

Morphology. Stemmaticum with densely rugose surface sculpture (Fig. 3). Antennal formula 1,1,3,3 (Fig. 2). Pedicel equal in

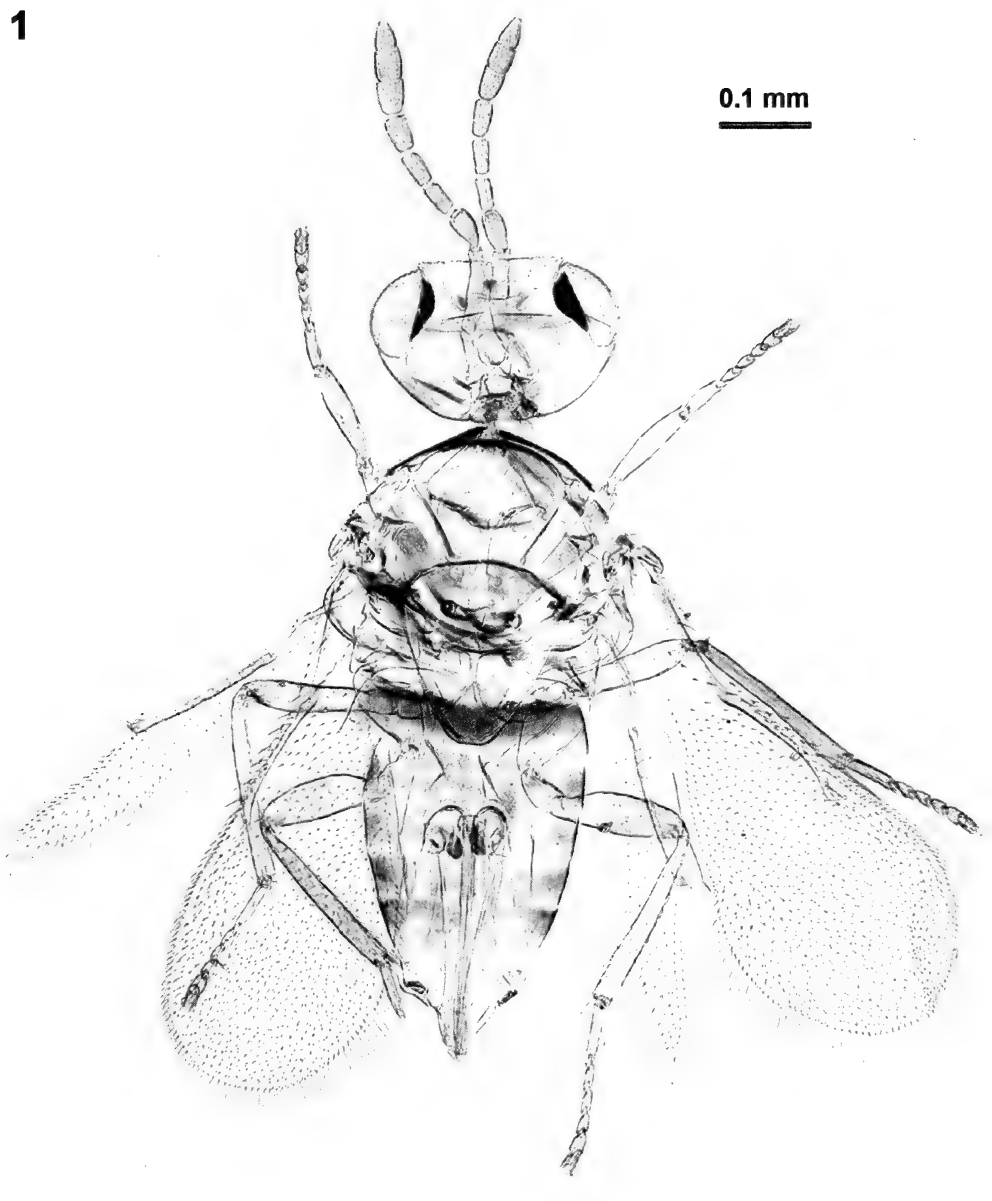


Fig. 1. *Encarsia indigoferae* holotype female, habitus.

length to F1 and F2. Flagellomeres with the following numbers of sensilla: F1: 1–2 (1), F2: 1–2 (1), F3: 2–3 (2), F4: 3–4 (3), F5: 3–4 (4), F6: 2–3 (3). Midlobe of mesoscutum (Fig. 4) with 12–15 (14) setae arranged symmetrically, side lobes with 3 setae each. Scutellar sensilla close together, separated by a distance of about the width of a sensillum. Distance between anterior pair of scutellar setae smaller than between posterior pair. Fore wing 2.3–2.5 (2.4) times as long as width of disc. Marginal fringe 0.19–0.20 times as long as width of disc (0.16 times in Oman specimens). Submarginal vein with 3 setae (4 on one side in one individual), marginal vein anteriorly with

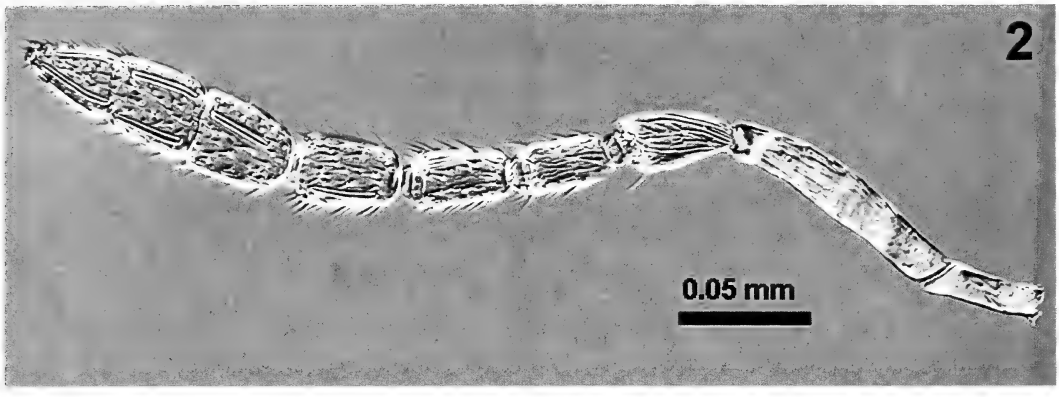


Fig. 2. *Encarsia indigoferae* female, antenna.

6–9 setae. Basal cell with 4–7, leading edge of costal cell with 2–4 distinct setae (less conspicuous in Oman specimens). Tarsal formula 5-5-5. Apical spur of midtibia subequal in length to corresponding basitarsus. Tergites laterally with the following numbers of setae: T1: 0, T2: 1, T3: 1, T4: 1, T5: 2–3, T6: 2–3, T7 with 5–8 (6) setae. Ovipositor longer than midtibia, 1.22–1.37 (1.22) and 2.4–2.9 (2.4) times as long as clava. Third valvula 0.20–0.21 (0.21) times as long as ovipositor.

Male. Morphology as for female, except for antennal and genitalia characters. F5 and F6 apparently partially fused, as in many males of *strenua*-group species. Pronotum, mesoscutum anteriorly and centrally, axillae and metasoma entirely dark.

Species group placement.—*E. strenua* group.

Distribution.—Iran, Oman.

Host.—*Aleuromarginatus tephrosiae* Corbett.

Material studied.—Holotype ♀, IRAN: Sistan-Balouchestan, Chabahar, Nobandian, 28 m. 18.xii.2006, 25° 28′ 54.8″ N, 61° 9′ 21.9″ E. (S. Manzari, M. Moghaddam & Durbin), ex *Aleuromarginatus tephrosiae* on *Indigofera* sp. (HMIM). Paratypes: 15♀, 10♂, same data as holotype (NHM, HMIM); 4♀, 1♂, IRAN: Sistan-Balouchestan, Nikshahr, Geshig, 631 m. 20.xii.2006, 26° 18′ 6.1″ N, 60° 20′ 3.7″ E. (S. Manzari), ex *A. tephrosiae* on *Indigofera* sp. (HMIM). OMAN: 3♀, 1♂, Rumais, 18.iii.1992, ex *A. tephrosiae* on weed IIE 22998 (NHM, HMIM).

Comments.—*E. indigoferae* is related to *E. dialeurodis* Hayat from Pakistan, and to the Australian *E. oakeyensis* Schmidt & Nau-

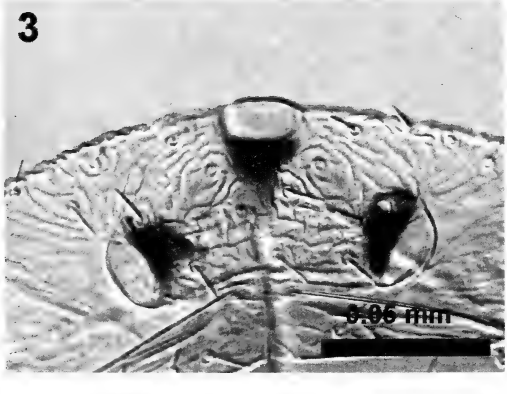


Fig. 3. *Encarsia indigoferae* female, stemmaticum.

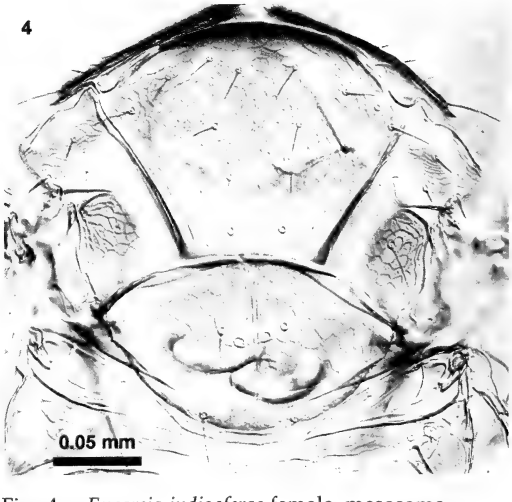


Fig. 4. *Encarsia indigoferae* female, mesosoma.

mann. It differs from both these species in having three setae on the submarginal vein. It can be further distinguished from other species in the *strenua*-group having 3 or more setae on the submarginal vein by the rugose (rather than reticulate or striate) stemmaticum (Fig. 3).

ACKNOWLEDGEMENTS

We would like to thank N. Shahbazvar for slide mounting the whitefly specimens.

LITERATURE CITED

Bink-Moenen, R. M. 1983. Revision of the African whiteflies (Aleyrodidae). *Monografieën van de Nederlandse Entomologische Vereniging* 10: 1–212.

Corbett, G. H. 1935. On new Aleurodidae. *Annals and Magazine of Natural History* 16: 240–252.

Heraty, J. M., A. Polaszek, and M. E. Schauff. 2008. Systematics and Biology of *Encarsia*. Chapter 4, Pp. 71–87 in: Gould, J., K. Hoelmer, and J. Goolsby eds. *Classical Biological Control of* Bemisia tabaci *in the United States. A review of interagency research and implementation*. Springer, 343 pp.

J. HYM. RES.
Vol. 17(2), 2008, pp. 138–156

Taxonomic Status and Location of Type Specimens for Species of *Coelinidea* Viereck and *Sarops* Nixon (Hymenoptera: Braconidae: Alysiinae) Described by Garland T. Riegel

ROBERT R. KULA

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; email: Robert.Kula@ars.usda.gov

Abstract.—The following species of *Coelinidea* Viereck and *Sarops* Nixon described by Garland T. Riegel are transferred to other genera resulting in 28 new combinations: ***Chorebus pallidus* (Riegel), n. comb.**, ***Coelinius acicula* (Riegel), n. comb.**, ***Coelinius acontia* (Riegel), n. comb.**, ***Coelinius alima*, (Riegel), n. comb.**, ***Coelinius alrutzae* (Riegel), n. comb.**, ***Coelinius arizona* (Riegel), n. comb.**, ***Coelinius arnella* (Riegel), n. comb.**, ***Coelinius bakeri* (Riegel), n. comb.**, ***Coelinius baldufi* (Riegel), n. comb.**, ***Coelinius calcara* (Riegel), n. comb.**, ***Coelinius columbia* (Riegel), n. comb.**, ***Coelinius crota* (Riegel), n. comb.**, ***Coelinius dubius* (Riegel), n. comb.**, ***Coelinius ellenaae* (Riegel), n. comb.**, ***Coelinius frisoni* (Riegel), n. comb.**, ***Coelinius garthi* (Riegel), n. comb.**, ***Coelinius hayesi* (Riegel), n. comb.**, ***Coelinius jeanae* (Riegel), n. comb.**, ***Coelinius marki* (Riegel), n. comb.**, ***Coelinius marylandicus* (Riegel), n. comb.**, ***Coelinius minnesota* (Riegel), n. comb.**, ***Coelinius montana* (Riegel), n. comb.**, ***Coelinius muesebecki* (Riegel), n. comb.**, ***Coelinius nellae* (Riegel), n. comb.**, ***Coelinius niobrara* (Riegel), n. comb.**, ***Coelinius robinae* (Riegel), n. comb.**, ***Coelinius ruthae* (Riegel), n. comb.**, and ***Coelinius sommermanae* (Riegel), n. comb.** *Coelinius ohioensis* (Riegel, 1982), and *Coelinius wheeleri* (Riegel, 1982) are **new synonys**, and the former is designated the senior synonym because the holotype is a female. The holotypes of *Coelinidea antha* Riegel, *Coelinidea arca* Riegel, *Coelinidea colora* Riegel, and *Coelinidea coma* Riegel, reportedly deposited at the Academy of Natural Sciences, Philadelphia, Pennsylvania, apparently are lost. Therefore, all four names are considered *nomina dubia* since each species is known only from the holotype, and information Riegel provided in the original descriptions and key to North American species of *Coelinidea* is not adequate to apply the names unequivocally. The locations of primary and, where applicable, secondary types are indicated for all other species of *Coelinidea* and *Sarops* described by Riegel. *Coelinius alima*, *C. marki*, *C. ohioensis*, and *C. robinae* are first recorded from Quebec, Wyoming, Wisconsin, and Kansas and Missouri, respectively.

Alysiinae is a speciose subfamily of koinobiont endoparastioids of cyclorrhaphous Diptera (Wharton 1997). The subfamily consists of Alysiini and Dacnusini with ~1,245 and ~817 described species, respectively, as of mid-November 2007 for Alysiini and mid-June 2008 for Dacnusini (Yu et al. 2005). Most species of Alysiini with known hosts are parasitoids of saprophagous flies; as far as is known, all dacnusines are parasitoids of plant-feeding flies (Wharton 1997). The Palearctic species of Dacnusini have been studied extensively, including comprehensive taxonomic revisions (Griffiths 1964, 1966a, 1966b, 1967, 1968a, 1968b, Nixon 1937, 1943, 1944, 1945, 1946, 1948, 1949, 1954). Few taxonomic treatments have been published for Nearctic dacnusines; notable works include Rohwer (1914), Riegel (1950, 1982), Wharton (1994), and Kula and Zolnerowich (2008).

Riegel (1982) revised the Nearctic species of *Chaenusa* Haliday *sensu stricto*, *Chorebidea* Viereck, *Chorebidella* Riegel, *Coelinidea* Viereck, and *Sarops* Nixon. The revision, based

largely on Riegel's doctoral dissertation from 1947, included descriptions of 44 new species, over half of the ~86 described Nearctic species of Dacnusini (Yu et al. 2005). Several taxonomic changes occurred in the 35 years between completion and publication of the revision. Griffiths (1964) provided hypotheses on character polarity for dacnusines and for the most part only recognized groups he considered monophyletic. As a result Griffiths (1964) synonymized *Chorebidea* Viereck, 1913 and *Chorebidella* Riegel, 1950 with *Chaenusa* Haliday, 1839 (i.e., *Chaenusa sensu lato*). Further, Griffiths (1964) treated *Coelinidea* Viereck, 1913 and *Polemochartus* Schulz, 1911 as subgenera of *Coelinius* Nees, 1819 (i.e., *Coelinius s.l.*) and synonymized *Sarops* Nixon, 1942 with *Synelix* Förster, 1862. Riegel (1982), in reference to Griffiths (1964), stated that he was "not convinced that certain genera should have been placed in synonymy" and recognized *Chorebidea*, *Coelinidea*, and *Sarops* as valid genera and described four, 32, and four new species in each genus, respectively. Wharton and Austin (1991) agreed with the synonymies in Griffiths (1964) and determined that *Lepton* Zetterstedt, 1838 has priority over *Coelinidea* but considered the division of *Coelinius* into subgenera "premature" because of undescribed "intermediate forms" from the Oriental Region. However, Wharton and Austin (1991) did not transfer any of the species described in Riegel (1982) to *Chaenusa s.l.* or *Coelinius s.l.* Wharton (1994) considered *Coelinius s.l.* monophyletic based on three putative apomorphies, the presence of an additional tooth between tooth one and two, a laterally compressed gaster, and the exclusive use of chloropids as hosts, and on this basis synonymized *Sarops* with *Coelinius* rather than following the synonymy of *Sarops* and *Synelix* in Griffiths (1964). Kula and Zolnerowich (2008) transferred the species of *Chorebidea* described in Riegel (1982) to *Chaenusa s.l.* and returned *Chorebidella bergi* Riegel to *Chaenusa s.l.*

I agree with Wharton (1994) and consider *Coelinius s.l.* monophyletic based on the apomorphies mentioned above. Kula (2006) recovered *Coelinius sensu* Wharton (1994) as monophyletic in one of two preliminary cladistic analyses for Dacnusini based on morphology, but bootstrap support was low. Clades corresponding to *Coelinius s.s.*, *Lepton*, and *Polemochartus* were also recovered, with the included species of *Coelinius s.s.* and *Sarops* forming a clade, but only *Polemochartus* had moderate bootstrap support. Therefore, I agree with Wharton and Austin (1991) and Wharton (1994) that *Coelinius s.l.* should not be split into genera or divided into subgenera at this point in time since only *Polemochartus* is clearly monophyletic.

The species of *Sarops* described in Riegel (1982) were transferred to *Coelinius* through the synonymy of *Coelinius* and *Sarops* in Wharton (1994), but the taxonomic placement of each species has not been verified through the examination of holotypes. The species of *Coelinidea* described in Riegel (1982) have not been transferred to *Coelinius s.l.*, and holotypes should be examined for these species to verify placement before they are transferred. Holotypes of several species described in Riegel (1982) are currently housed in repositories other than those indicated in the original descriptions, and four holotypes apparently are lost. Therefore, the primary objectives of this study are to (1) verify and update the taxonomic placement of species of *Coelinidea* and *Sarops* described in Riegel (1982) and (2) document the location and condition of holotypes for these species since most are known only from the holotype. Additionally, repositories are indicated for all paratypes of the aforementioned species, and new distribution records are provided for four species of *Coelinius s.l.*

MATERIALS AND METHODS

Specimens were examined using a Leica Wild M10 stereomicroscope with 25×

oculars. Images of holotypes were captured using a Microptics digital camera system, and image clarity was enhanced using Adobe Photoshop 9.0. A color image of each holotype was deposited in Morphbank (collection number 369162), and if a holotype is damaged, its condition is described. Morphological terminology follows Sharkey and Wharton (1997) except as noted below. All species in this study have three major mandibular teeth; the recognition and numbering of teeth follows Wharton (2002) and Wharton (1977), respectively. Tooth one is the dorsal tooth, tooth two is the middle tooth, and tooth three is the ventral tooth. In addition to the three major teeth, a smaller tooth is present between tooth two and three in *Chorebus pallidus* (Riegel), new combination and is referred to as tooth four. Another smaller tooth is present between tooth one and two in all species and is referred to as tooth five. Thus, the numbering of mandibular teeth in this article differs from Kula and Zolnerowich (2008) in that the latter article referred to a smaller additional tooth as tooth four regardless of its position. The apical rim of the clypeus, metapleural rosette, and tuft of curved setae on the metacoxa are as in Kula and Zolnerowich (2008).

The material examined sections are formatted as in Kula and Zolnerowich (2008). Exact label data are reported for holotypes; Riegel (1982) provided more extensive type locality information. The following museum codens (Evenhuis and Samuelson 2007) are used to indicate repositories where type specimens of species Riegel (1982) described in *Coelinidea* and *Sarops* are housed currently: Albert J. Cook Arthropod Research Collection, Michigan State University, East Lansing (MSUC); California Academy of Sciences, San Francisco (CAS); Canadian National Collection of Insects, Ottawa (CNC); Cornell University Insect Collection, Ithaca, New York (CUIC); Illinois Natural History Survey, Champaign (INHS); Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZ); Smithsonian Institution National Museum of Natural History, Washington, DC (USNM); Snow Entomological Museum, University of Kansas, Lawrence (SEMC); University of Minnesota Insect Collection, Saint Paul (UMSP); and University of Wyoming Insect Museum, Laramie (ESUW). The holotypes of *Coelinidea antha* Riegel, *Coelinidea arca* Riegel, *Coelinidea colora* Riegel, and *Coelinidea coma* Riegel, reportedly deposited at the Academy of Natural Sciences, Philadelphia, Pennsylvania (ANSP), apparently are lost and could not be examined. All other holotypes of species Riegel (1982) described in *Coelinidea* and *Sarops* were examined, as were all paratypes except specimens of *Coelinius acontia* (Riegel), new combination at ESUW, *Coelinius marylandicus* (Riegel), new combination at MCZ, and *Coelinius niobrara* (Riegel), new combination at ESUW.

In addition to the repositories listed above, new distribution records and synonyms were discovered through examination of specimens borrowed from the American Entomological Institute, Gainesville, Florida (AEIC) and the Bohart Museum of Entomology, University of California, Davis (UCDC). Entries with an asterisk are new distribution records.

The specific epithets of *C. acontia*, *Coelinius alima* (Riegel), new combination, *Coelinius arnella* (Riegel), new combination, *Coelinius calcara* (Riegel), new combination and *Coelinius crota* (Riegel), new combination, show evidence of being derived from Latin or Greek words. However, they cannot be traced in a standard dictionary and do not follow established rules of Latin grammar. Therefore, in accordance with ICZN Article 31.2.2, "the original spelling is...retained [for the aforementioned specific epithets], with gender ending unchanged" since "the evidence of usage is not decisive" (ICZN 1999).

RESULTS AND DISCUSSION

Chorebus pallidus (Riegel), new combination (Fig. 1)

Coelinidea pallida Riegel 1982: 80, 92 [USNM, examined].

Type material.—Holotype male: Top label (white; partially handwritten, partially typewritten) = "Washgtn [;] 30-6 DC". Second label (white; typewritten) = "Type". Third label (white; handwritten) = "Chaenon [;] pallidus [;] ♀ Ashm". Fourth label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] pallida [;] Riegel" (USNM). *Paratypes:* 1 [sex unknown] USA, WASHINGTON, DC, 30.vi, Collection Ashmead (USNM).

Discussion.—Riegel (1982) indicated that the holotype and paratype of *C. pallidus* were deposited at USNM. The holotype bears a glass vial with a cork cap between the third and fourth labels. The vial contains the posterior portion of the metasoma. The antennae are broken, as is the tarsus of one prothroacic leg. One mesothoracic leg is missing except for the coxa and trochanter; the other is broken at the coxa. One metathoracic leg is broken at the coxa. Either a meso- or metathoracic leg that has broken off of the specimen at the trochanter is glued to the point.

The mandible of *C. pallidus* has five teeth, with tooth four between tooth two and three and tooth five between tooth one and two. *Coelinius s.l.* is partially defined by the presence of a small tooth between tooth one and two; *Chorebus* is partially defined by the presence of a small tooth between tooth two and three. Thus, the mandible is intermediate between *Chorebus* and *Coelinius s.l.* However, *C. pallidus* has a complete metapleural rosette, a narrow, smooth sternaulus, and a tuft of curved setae on the metacoxa, features Griffiths (1968b) used to define the *Chorebus affinis*-group but not found among species of *Coelinius s.l.* Additionally, the apical rim of the clypeus is present in *C. pallidus*, and t2 is smooth. The apical rim is present in all species of *Chorebus*, and t2 is smooth in most species. The apical rim is present in species of *Coelinius s.l.* that fit *Coelinius s.s.* (Griffiths 1964, Riegel 1982) and *Sarops sensu* Riegel (1982) and Maetô (1983), but t2 is striate. Therefore, *C. pallidus* is transferred to *Chorebus* because it fits the genus aside from the additional tooth between tooth one and two and otherwise fits the *affinis*-group.

Coelinius acicula (Riegel), new combination (Fig. 2)

Coelinidea acicula Riegel 1982: 82, 109 [SEMC, examined].

Type material.—Holotype male: Top label (white; typewritten) = "Northgate Colo [;] 8-20-31 [;] L. D. Anderson". Bottom label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] acicula [;] Riegel" (SEMC).

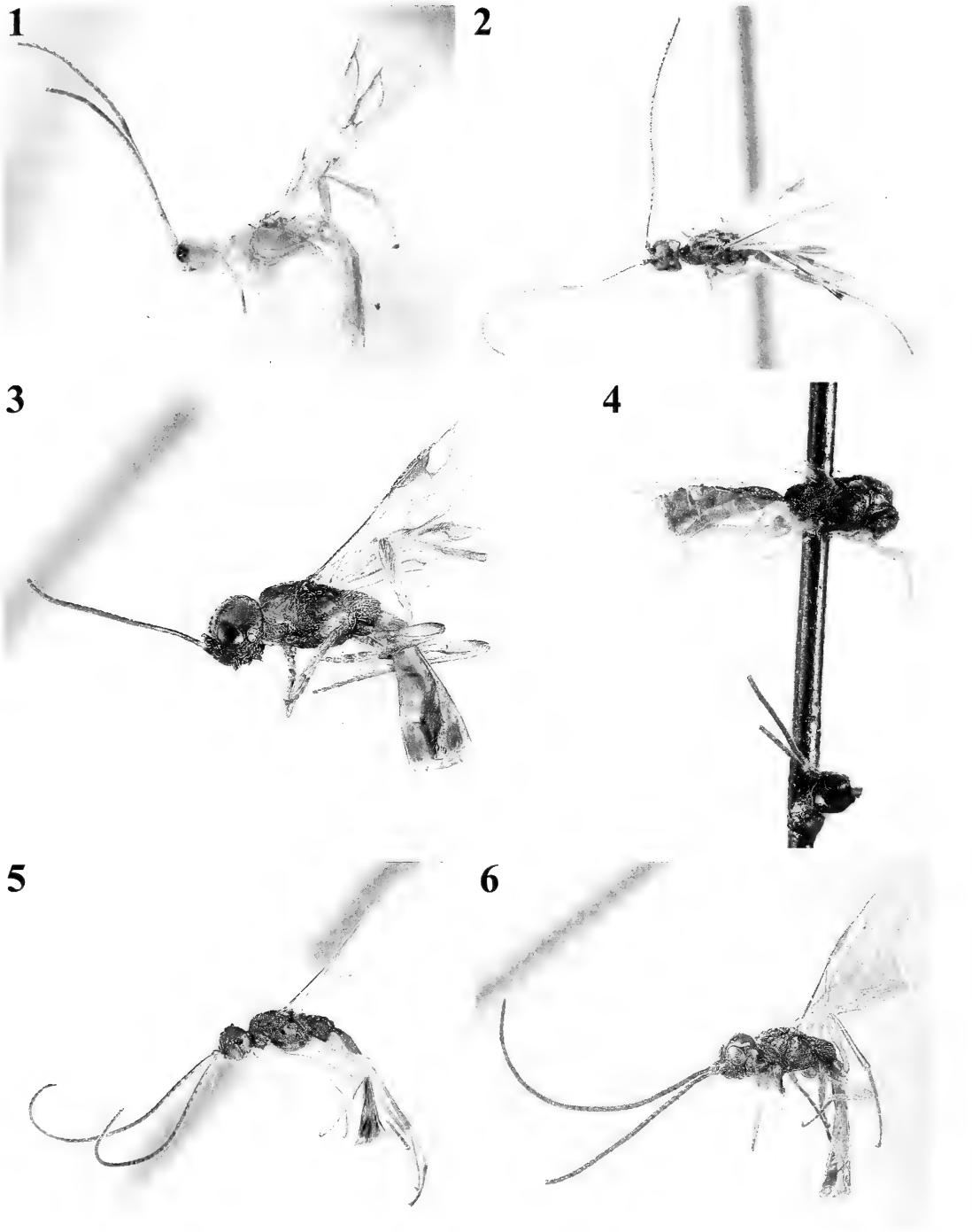
Discussion.—Coelinius acicula is known only from the holotype, which Riegel (1982) indicated was deposited at the "University of Kansas...(KU)." The holotype bears a glass vial with a cork cap between the top and bottom labels. The vial contains the posterior portion of the metasoma. One antenna is broken.

Coelinius acontia (Riegel), new combination (Fig. 3)

Coelinidea acontia Riegel 1982: 81, 102 [INHS, examined].

Type material.—Holotype female: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 213,095". Second label (white; handwritten) = "Albany Co., Wyo" [;] July 11, 1944 [;] R. E. Pfadt". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Coelinidea [;] acontia [;] Riegel" (INHS). *Paratypes:* 1 ♀ same data as holotype (ESUW); USA, WYOMING: 1 ♂ Goshen Co., 21.vii.1944, R. E. Pfadt, INHS Insect Collection 213,096 (INHS); 1 ♂ Platte Co., 13.vii.1944, R. E. Pfadt (ESUW).

Discussion.—Riegel (1982) indicated that the holotype and all paratypes of *C. acontia*



Figs 1–6. Holotypes of species of *Coelinidea* and *Sarops* described in Riegel (1982) with current taxonomic affiliations. 1, *Chorebus pallidus*. 2, *Coelinius acicula*. 3, *Coelinius acontia*. 4, *Coelinius alberta*. 5, *Coelinius alima*. 6, *Coelinius alrutzae*.

were deposited at the "University of Wyoming...(WYO)." Scott Shaw (in litt.) confirmed that ESUW has two paratypes, but INHS currently has the holotype and a paratype. The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma. The antennae are broken, as is the tarsus of one pro- and mesothoracic leg. One metatarsus is broken; the other is missing.

Coelinius alberta (Riegel)
(Fig. 4)

Sarops alberta Riegel 1982: 56, 57 [CNC, examined].

Coelinius alberta: Wharton 1994: 631 [synonymy of *Coelinius* and *Sarops*].

Type material.—Holotype female: Top label (white; partially handwritten, partially typewritten) = "Banff, Alta. [;] 16 vi.1922 [;] C. B. D. Garrett". Second label (yellow; handwritten) = "wing [;] on slide". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Sarops [;] alberta [;] Riegel". Fourth label (red; partially handwritten, partially typewritten) = "HOLOTYPE [;] 21202 [;] CNC No." (CNC).

Discussion.—Coelinius alberta is known only from the holotype, which Riegel (1982) indicated was deposited at the "Canadian Department of Agriculture, G. S. Walley (GSW)." The holotype bears a glass vial with a cork cap between the top and second labels. The vial contains some debris but otherwise appears to be empty. The head has been broken off of the specimen and is glued to the pin. The antennae are broken, as are the tarsi except for one mesotarsus. One forewing is mounted on a slide.

Coelinius alima (Riegel), new combination
(Fig. 5)

Coelinidea alima Riegel 1982: 85, 143 [INHS, examined].

Type material.—Holotype female: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 201,193". Second label (white; typewritten) = "Fox Lake, Ill." [;] June 3, 1943 [;] Ross&Sanderson". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Coelinidea [;] alima [;] Riegel" (INHS). *Paratypes:* 1 ♂ same data as holotype except INHS Insect Collection 201,194 (INHS).

Other material examined.—*CANADA: QUEBEC: 1 ♀ 2 ♂ Témiscamingue, Laniel, 8.vii.1944, A. R. Brooks (CNC).

Discussion.—Riegel (1982) indicated that the holotype and paratype of *C. alima* were deposited at INHS. A glass vial with a cork cap was associated with the holotype at some point in time. The cap is still associated, but apparently the vial has been lost. The specimens from CNC expand the range of this species to southeastern Quebec.

Coelinius alrutzae (Riegel), new combination
(Fig. 6)

Coelinidea alrutzae Riegel 1982: 83, 119 [INHS, examined].

Type material.—Holotype male: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 201,195". Second label (white; partially handwritten, partially typewritten) = "Algonquin, Ill. [;] June 15 '08 [;] Nason 192". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] alrutzae [;] Riegel" (INHS).

Discussion.—Coelinius alrutzae is known only from the holotype, which Riegel (1982) indicated was deposited at the "University of Illinois...(UILL)." The University of Illinois insect collection was transferred to INHS in 1979 (P. Tinerella in litt.), and thus, Riegel apparently deposited the holotype in INHS. The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma. One antenna is broken. One prothroacic leg is missing except for the coxa; the other has a broken tarsus.

Coelinius arizona (Riegel), new combination
(Fig. 7)

Coelinidea arizona Riegel 1982: 81, 107 [USNM, examined].

Type material.—Holotype male: Top label (white; partially handwritten, partially typewritten) = "Huachuca Mts. [;] Ariz., 4-14 1938 [;] R. H. Crandall". Second label (white; handwritten) = "171". Third label (white; partially handwritten, partially typewritten) = "Coelinidea [;] sp. [;] det [;] Mues". Fourth label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] arizona [;] Riegel" (USNM).

Discussion.—Coelinius arizona is known only from the holotype, which Riegel (1982) indicated was deposited at the "University of Arizona...(ARIZ)." The holotype was transferred to USNM in 1999 (D. Furth in litt.). The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma. The antennae are broken. One prothoracic leg is imbedded in glue; the other has a broken tarsus. One mesothoracic leg has a broken tarsus; the other is missing except for the coxa, trochanter, and trochantellus, as is the case with one metathoracic leg. One forewing is missing; the other wings are torn and missing distally.

Coelinius arnella (Riegel), new combination
(Fig. 8)

Coelinidea arnella Riegel 1982: 82, 114 [INHS, examined].

Type material.—Holotype male: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 201,099". Second label (white; partially handwritten, partially typewritten) = "Mont. Exp. Sta. [;] Sidney, Mont. [;] June 14, 1913". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] arnella [;] Riegel". Fourth label (white; handwritten) = "[MON]". Fifth label (white; typewritten) = "INHS [;] TYPE [;] #2030" (INHS).

Discussion.—Coelinius arnella is known only from the holotype. Riegel (1982) indicated that the holotype was deposited at "Montana State College...(MONT)," but INHS currently has the holotype. The holotype bears a glass vial with a cork cap below the fifth label. The vial contains the posterior portion of the metasoma. The antennae are broken, and the forewings are torn.

Coelinius bakeri (Riegel), new combination
(Fig. 9)

Coelinidea bakeri Riegel 1982: 83, 123 [USNM, examined].

Type material.—Holotype male: Top label (white; partially handwritten, partially typewritten) = "Colo [;] 1563". Second label (white; typewritten) = "Collection [;] CFBaker". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] bakeri [;] Riegel" (USNM).

Other material examined.—USA, COLORADO: 3 ♀ Larimer Co., Estes Park, 5.viii.1947, L. D. Beamer (SEMC).

Discussion.—Coelinius bakeri was previously known only from the holotype, which Riegel (1982) indicated was deposited at USNM. The holotype bears a glass vial with a cork cap between the second and third labels. The vial contains the posterior portion of the metasoma. The antennae are broken. Riegel (1982) indicated that the holotype was collected in Fort Collins, Larimer County, Colorado.

Coelinius baldufi (Riegel), new combination
(Fig. 10)

Coelinidea baldufi Riegel 1982: 79, 86 [SEMC, examined].

Type material.—Holotype male: Top label (white; typewritten) = "Little Beaver Cr. [;] Colo 7 - 11 - 37 [;] C. L. Johnston". Second label (white; typewritten) = "Wing on [;] Sl. No.". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] baldufi [;] Riegel" (SEMC).

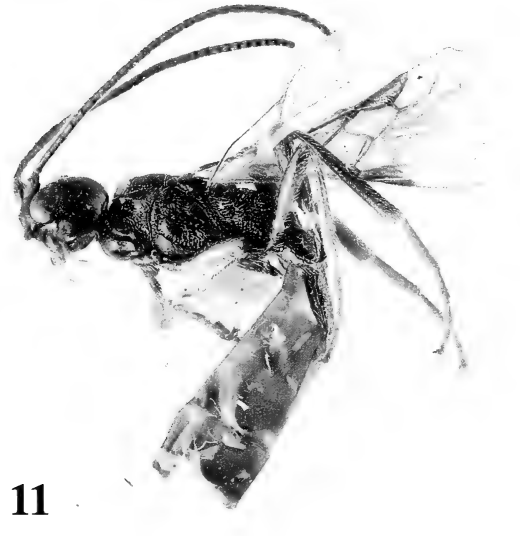
Discussion.—Coelinius baldufi is known only from the holotype, which Riegel (1982) indicated was deposited at "KU." The holotype bears a glass vial with a cork cap between the top and second labels. The vial contains the posterior portion of the metasoma. One forewing is mounted on a slide.

7

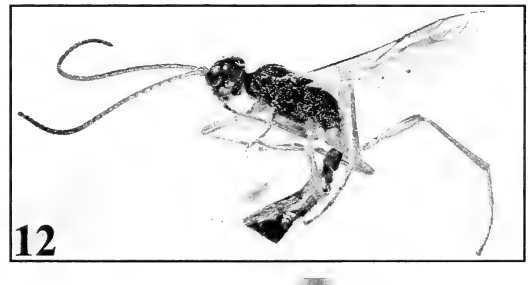
8

9

10



11



12

13

Figs 7–13. Holotypes of species of *Coelinidea* described in Riegel (1982) with current taxonomic affiliations. 7, *Coelinius arizona*. 8, *Coelinius arnella*. 9, *Coelinius bakeri*. 10, *Coelinius baldufi*. 11, *Coelinius calcara*. 12, *Coelinius columbia*. 13, *Coelinius crota*.

Coelinius calcara (Riegel), new combination
(Fig. 11)

Coelinidea calcara Riegel 1982: 81, 106 [CAS, examined].

Type material.—Holotype female: Top label (white; typewritten) = "Sparks Nev. [;] June 28 1927". Second label (white; typewritten) = "EPVanDunzee [;] Collector". Third label (brown; partially handwritten, partially typewritten) = HOLOTYPE ♀ [;] Coelinidea [;] calcara [;] Riegel". Fourth label (white; partially handwritten, partially typewritten) = "California Academy [;] of Sciences [;] Type 16687 [;] No." (CAS). *Paratypes:* 1 ♂ same data as holotype; USA, CALIFORNIA: 1 ♀ Inyo Co., Lone Pine, 10.vii.1929, R. L. Usinger; 1 ♀ San Diego Co., Pine Valley, 24.iv.1920, E. P. VanDuzee; 1 ♂ same data as previous except W. M. Giffard; 1 ♂ same data as previous except E. P. VanDuzee, *Coelinidea calcara* Riegel, 16687 (CAS).

Discussion.—Riegel (1982) indicated that the holotype and all paratypes of *C. calcara* were deposited at the "California Academy of Sciences...(CALAS)." The holotype bears a glass vial with a cork cap between the second and third labels. The vial contains the posterior portion of the metasoma. One antenna is broken.

Coelinius columbia (Riegel), new combination
(Fig. 12)

Coelinidea columbia Riegel 1982: 85, 144 [CUIC, examined].

Type material.—Holotype female: Top label (white; typewritten) = "Columbia, Mo. [;] May 26–June 8, '06. [;] C.R. Crosby Coll.". Second label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Coelinidea [;] columbia [;] Riegel". Third label (red; partially handwritten, partially typewritten) = "HOLOTYPE [;] Cornell U. [;] No. 6491" (CUIC). *Paratypes:* USA, NEW YORK: 1 ♀ Tompkins Co., McLean, 2.vii.-3.vii.1904, PARATYPE, Cornell U., No. 6491 (CUIC).

Discussion.—Riegel (1982) indicated that the holotype and paratype of *C. columbia* were deposited at "Cornell University...(CN)." The holotype bears a glass vial with a cork cap between the top and second labels. The vial contains the posterior portion of the metasoma. One antenna is broken.

Coelinius crota (Riegel), new combination
(Fig. 13)

Coelinidea crota Riegel 1982: 79, 90 [INHS, examined].

Type material.—Holotype male: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 201,196". Second label (white; typewritten) = "Apple Riv. Can. S.P. [;] Ill., Aug. 23, 1939 [;] Ross & Riegel". Third label (brown; partially handwritten, partially typewritten) = HOLOTYPE ♂ [;] Coelinidea [;] crota [;] Riegel" (INHS).

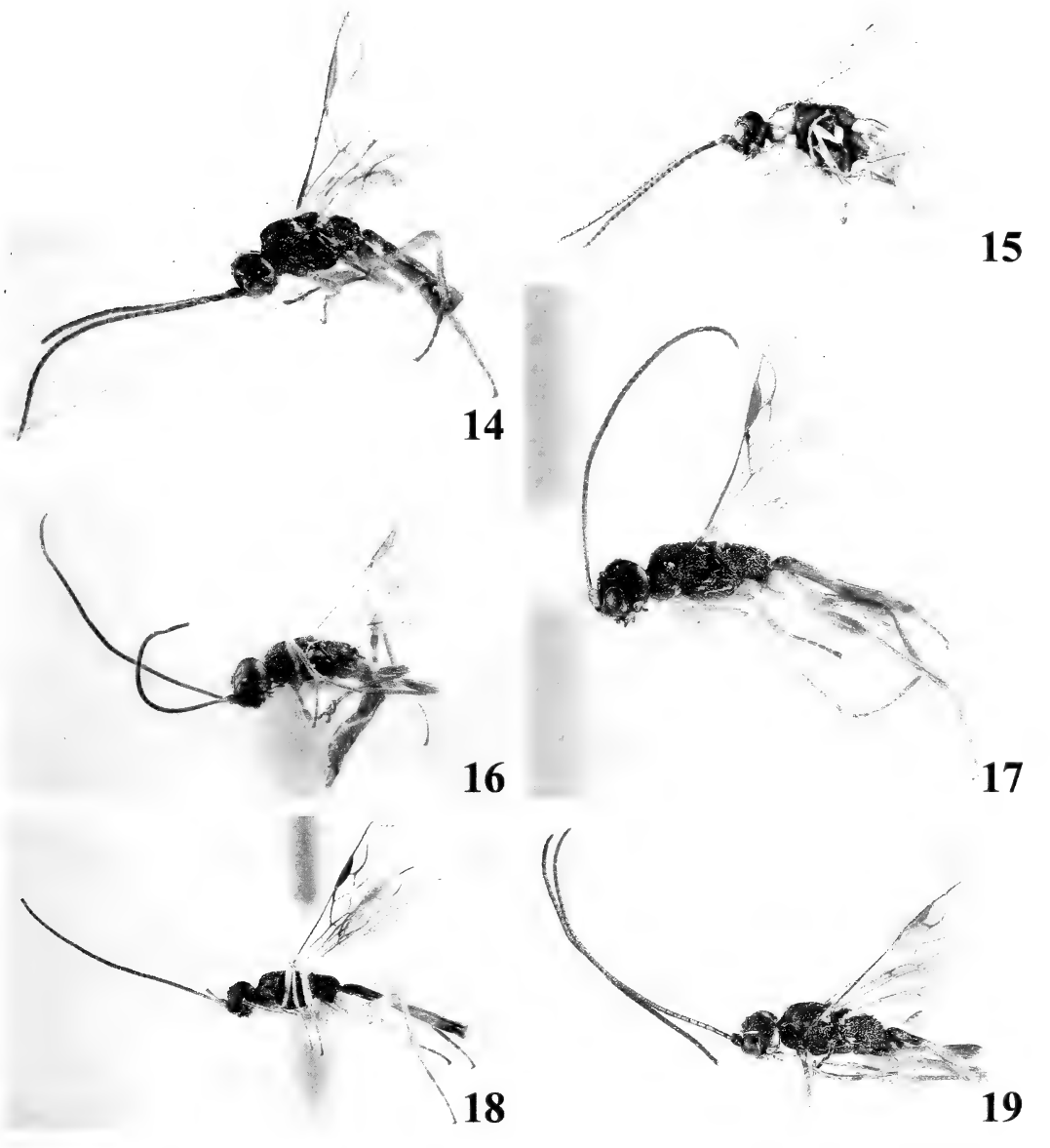
Discussion.—Coelinius crota is known only from the holotype, which Riegel (1982) indicated was deposited at INHS. The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma.

Coelinius dreisbachi (Riegel)
(Fig. 14)

Sarops dreisbachi Riegel 1982: 57, 60 [MSUC, examined].
Coelinius dreisbachi: Wharton 1994: 631 [synonymy of *Coelinius* and *Sarops*].

Type material.—Holotype male: Top label (white; partially handwritten, partially typewritten) = "Midland Co., Mich. [;] 5-21-42 [;] R. R. Dreisbach". Second label (yellow; handwritten) = "wing [;] on slide". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Sarops [;] dreisbachi [;] Riegel" (MSUC).

Discussion.—Coelinius dreisbachi is known only from the holotype. Riegel (1982) indicated that "R. R. Dreisbach (DREI)" either loaned or donated the holotype but did not specify where the holotype was deposited. The holotype is currently housed in MSUC, presumably donated after Dreisbach's death, and bears a glass vial with a cork cap between the top and second label. The vial contains the posterior portion of the



Figs 14–19. Holotypes of species of *Coelinidea* and *Sarops* described in Riegel (1982) with current taxonomic affiliations. 14, *Coelinius dreisbachi*. 15, *Coelinius dubius*. 16, *Coelinius ellenaae*. 17, *Coelinius frisoni*. 18, *Coelinius garthi*. 19, *Coelinius hayesi*.

metasoma. One antenna is broken. One forewing is mounted on a slide, and a forewing and hind wing are torn.

Coelinius dubius (Riegel), new combination
(Fig. 15)

Coelinidea dubia Riegel 1982: 84, 129 [INHS, examined].

Type material.—Holotype male: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 201,197". Second label (white; typewritten) = "3326". Third label (white; typewritten) = "Ashmead [;] Det. '99". Fourth label (brown; partially handwritten, partially typewritten) = HOLOTYPE ♂ [;] Coelinidea [;] dubia [;] Riegel" (INHS).

Discussion.—Coelinius dubius is known only from the holotype, which Riegel

(1982) indicated was deposited at INHS. The holotype bears a glass vial with a cork cap below the fourth label. The vial contains the posterior portion of the metasoma. The antennae are broken.

Coelinius ellenaae (Riegel), new combination
(Fig. 16)

Coelinidea ellenaae Riegel 1982: 81, 105 [SEMC, examined].

Type material.—Holotype male: Top label (white; typewritten) = "Little Beaver Cr." [;] Colo 7 - 11 - 37 [;] C. L. Johnston". Bottom label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] ellenaae [;] Riegel" (SEMC).

Discussion.—Coelinius ellenaae is known only from the holotype, which Riegel (1982) indicated was deposited at "KU." The holotype bears a glass vial with a cork cap between the top and bottom labels. The vial contains the posterior portion of the metasoma. One antenna is broken.

Coelinius frisoni (Riegel), new combination
(Fig. 17)

Coelinidea frisoni Riegel 1982: 83, 117 [INHS, examined].

Type material.—Holotype female: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 201,198". Second label (white; typewritten) = "Empire, Colo. [;] July 23, 1938 [;] H.H. & J.A. Ross". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Coelinidea [;] frisoni [;] Riegel" (INHS).

Discussion.—Coelinius frisoni is known only from the holotype, which Riegel (1982) indicated was deposited at INHS. The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma. One antenna is broken.

Coelinius garthi (Riegel), new combination
(Fig. 18)

Coelinidea garthi Riegel 1982: 84, 130 [INHS, examined].

Type material.—Holotype male: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 201,199". Second label (white; typewritten) = "New Milford, Ill [;] July 2, 1936 [;] Ross & Parks". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] garthi [;] Riegel". Fourth label (white; handwritten) "Freak [;] wing" (INHS).

Discussion.—Coelinius garthi is known only from the holotype, which Riegel (1982) indicated was deposited at INHS. The holotype bears a glass vial with a cork cap below the fourth label. The vial contains the posterior portion of the metasoma. The antennae are broken.

Coelinius hayesi (Riegel), new combination
(Fig. 19)

Coelinidea hayesi Riegel 1982: 83, 121 [USNM, examined].

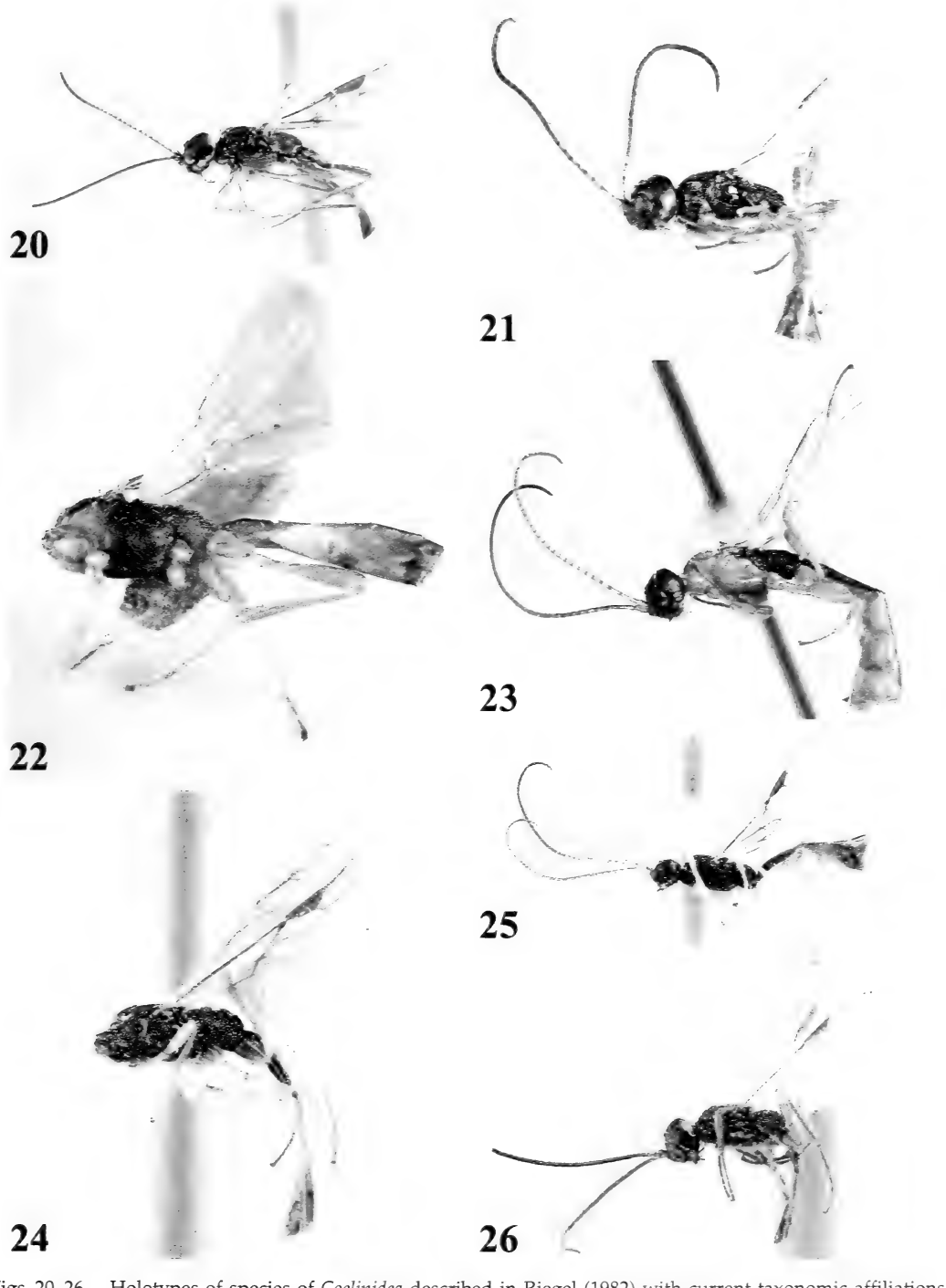
Type material.—Holotype male: Top label (white; partially handwritten, partially typewritten) = "Colo [;] 1233". Second label (white; handwritten) = "31". Third label (white; typewritten) = "Collection [;] Ashmead". Fourth label (white; handwritten) = "Coelinius [;] longulus [;] Ashm.". Fifth label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] hayesi [;] Riegel" (USNM).

Discussion.—Coelinius hayesi is known only from the holotype, which Riegel (1982) indicated was deposited at USNM. The holotype bears a glass vial with a cork cap between the fourth and fifth labels. The vial contains the posterior portion of the metasoma. One antenna is broken at the pedicel; the flagellum of that antenna is stuck to the other antenna.

Coelinius jeanae (Riegel), new combination
(Fig. 20)

Coelinidea jeanae Riegel 1982: 79, 87 [INHS, examined].

Type material.—Holotype male: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 201,200". Second label (white; partially handwritten, partially typewritten) = "Green Mt. Falls, [;] Colo. Jn. 21, 1938 [;] J.A. Ross". Third label (brown; partially handwritten, par-



Figs 20–26. Holotypes of species of *Coelinidea* described in Riegel (1982) with current taxonomic affiliations. 20, *Coelinius jeanae*. 21, *Coelinius marki*. 22, *Coelinius marylandicus*. 23, *Coelinius minnesota*. 24, *Coelinius montana*. 25, *Coelinius muesebecki*. 26, *Coelinius nellae*.

tially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] jeanae [;] Riegel" (INHS). *Paratypes:* 1 ♂ same data as holotype except 17.vii.1938, H. H. & J. A. Ross (INHS); 1 ♂ USA, COLORADO: Great Sand Dunes near Botger C.R., 23.vi.1944 (USNM).

Discussion.—Riegel (1982) indicated that the holotype and a paratype of *C. jeanae* were deposited at INHS and that a paratype was deposited at USNM. The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma. The antennae are broken, as is the tarsus of one prothroacic leg.

Coelinius marki (Riegel), new combination
(Fig. 21)

Coelinidea marki Riegel 1982: 80, 97 [INHS, examined].

Type material.—*Holotype female:* Top label (white; typewritten) = "INHS [;] Insect Collection [;] 221,941". Second label (white; partially handwritten, partially typewritten) = "Green Mt. Falls, [;] Colo., Jly. 17, 1938 [;] J. A. Ross & [;] H. H. Ross". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Coelinidea [;] marki [;] Riegel" (INHS).

Other material examined.—USA, *WYOMING: 1 ♀ 1 [sex unknown] Big Horn Co., Cowley, 8.viii.1935, in wheat stem (ESUW).

Discussion.—*Coelinius marki* was previously known only from the holotype, which Riegel (1982) indicated was deposited at INHS. The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma. The specimens from ESUW expand the range of this species to northwestern Wyoming.

Coelinius marylandicus (Riegel), new combination
(Fig. 22)

Coelinidea marylandica Riegel 1982: 83, 125 [USNM, examined].

Type material.—*Holotype female:* Top label (white; typewritten) = "Md.". Second label (white; typewritten) = "Collection [;] Ashmead". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Coelinidea [;] marylandica [;] Riegel" (USNM). *Paratypes:* 1 ♀ same data as holotype; 1 ♀ same data as holotype except *Coelinius marylandicus* Ashm, *Coelinidea* n. sp. Mues.; USA, TENNESSEE: 1 ♂ Middle Tennessee, Cedar Glade Area, 9.xi, Adelphia Meyer, sweep net; 1 ♀ same data as previous except 524, *Coelinidea* n. sp. det. Mues. (USNM); USA, VIRGINIA: 1 ♀ Falls Church, 20.v, Nathan Banks (MCZ).

Discussion.—Riegel (1982) indicated that the holotype and four paratypes of *C. marylandicus* were deposited at USNM and a paratype was deposited at MCZ. The paratypes at USNM were examined, and Stefan Cover (in litt.) confirmed that the other paratype is at MCZ. The holotype bears a glass vial with a cork cap between the second and third labels. The vial contains the posterior portion of the metasoma. The head is missing, as are the mesothoracic legs except for the coxae. One prothoracic leg is missing except for the coxa; the other has a broken tarsus. One forewing is torn.

Coelinius minnesota (Riegel), new combination
(Fig. 23)

Coelinidea minnesota Riegel 1982: 84, 131 [UMSP, examined].

Type material.—*Holotype female:* Top label (white; typewritten) = "Minneapolis, Minn. [;] Excelsior Blvd. [;] Aug. 13, 1927 [;] A. T. Hertig". Bottom label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Coelinidea [;] minnesota [;] Riegel" (UMSP). *Paratypes:* 1 ♂ same data as holotype (UMSP).

Discussion.—Riegel (1982) indicated that the holotype and paratype of *C. minnesota* were deposited at the "University of Minnesota...(MINN)." The holotype bears a glass vial with a cork cap between the top and bottom labels. The vial contains the posterior portion of the metasoma.

Coelinius montana (Riegel), new combination
(Fig. 24)

Coelinidea montana Riegel 1982: 82, 111 [SEMC, examined].

Type material.—Holotype male: Top label (white; typewritten) = "Bennett Montana [;] 8-12-31 [;] J Nottingham". Bottom label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] montana [;] Riegel" (SEMC).

Discussion.—Coelinius montana is known only from the holotype, which Riegel (1982) indicated was deposited at "KU." The holotype bears a glass vial with a cork cap between the top and bottom labels. The vial contains the posterior portion of the metasoma. The head is missing.

Coelinius muesebecki (Riegel), new combination
(Fig. 25)

Coelinidea muesebecki Riegel 1982: 84, 141 [INHS, examined].

Type material.—Holotype female: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 221,942". Second label (white; handwritten) = "Ripley, Ill. [;] Sept. 1, 1939 [;] Ross & Riegel". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Coelinidea [;] muesebecki [;] Riegel" (INHS).

Discussion.—Coelinius muesebecki is known only from the holotype, which Riegel (1982) indicated was deposited at INHS. The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma.

Coelinius nellae (Riegel), new combination
(Fig. 26)

Coelinidea nellae Riegel 1982: 83, 116 [SEMC, examined].

Type material.—Holotype male: Top label (white; partially handwritten, partially typewritten) = "Summit Co., Ohio [;] 6-9 1937 [;] Louis J. Lipovsky". Bottom label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] nellae [;] Riegel" (SEMC).

Discussion.—Coelinius nellae is known only from the holotype, which Riegel (1982) indicated was deposited at "KU." The holotype bears a glass vial with a partially broken cork cap between the top and bottom labels. The vial contains the posterior portion of the metasoma. One antenna is broken.

Coelinius niobrara (Riegel), new combination
(Fig. 27)

Coelinidea niobrara Riegel 1982: 83, 122 [INHS, examined].

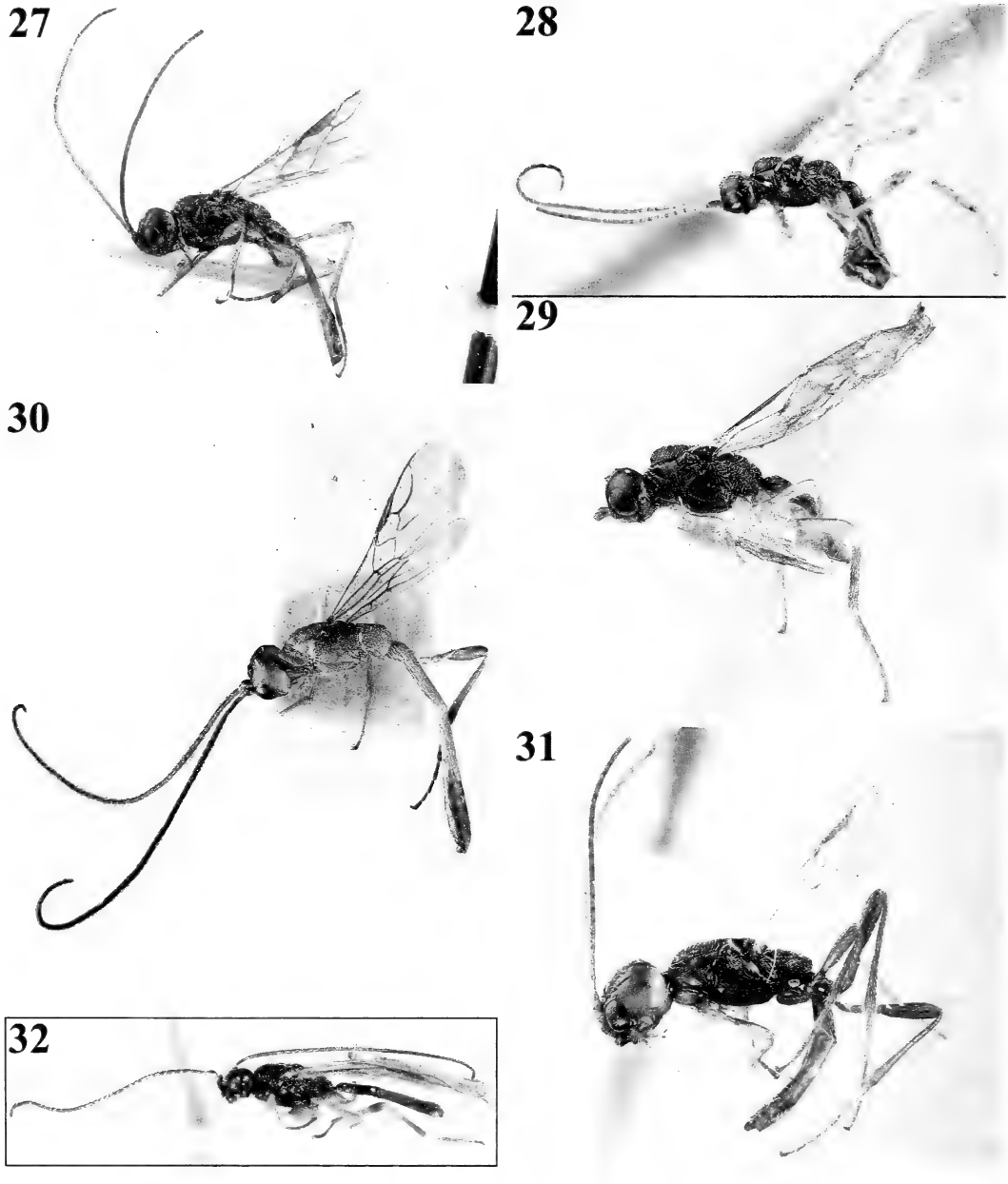
Type material.—Holotype male: Top label (white; typewritten) = "INHS [;] Insect Collection [;] 213,097". Second label (white; partially handwritten, partially typewritten) = "Niobrara Co. Wyo. Stop [;] July 1, 1943 [;] Collected by R.E. Pfadt". Third label (white; handwritten) = "LWYO". Fourth label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] niobrara [;] Riegel" (INHS). *Paratypes:* 1 ♂ same data as holotype except INHS Insect Collection 213,098 (INHS); 2 ♂ same data as holotype (ESUW).

Discussion.—Riegel (1982) indicated that the holotype and all paratypes of *C. niobrara* were deposited at "WYO." Scott Shaw (in litt.) confirmed that ESUW has two paratypes, but the INHS has the holotype and a paratype. The holotype bears a glass vial with a cork cap below the third label. The vial contains the posterior portion of the metasoma. One antenna is broken, as is the tarsus of one metathoracic leg.

Coelinius ohioensis (Riegel)
(Figs 28, 29)

Sarops ohioensis Riegel 1982: 56, 58 [SEMC, examined].
Coelinius ohioensis: Wharton 1994: 631 [synonymy of *Coelinius* and *Sarops*].
Sarops wheeleri Riegel 1982: 56, 59 [INHS, examined].
Coelinius wheeleri: Wharton 1994: 631 [synonymy of *Coelinius* and *Sarops*]. New synonym.

Type material.—Holotype female, Sarops ohioensis: Top label (white; partially handwritten, partially typewritten) = "Summit Co., Ohio [;] 9-1 1937 [;] Louis J. Lipovsky". Second label (yellow; handwritten) = "Wings [;] on slide". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♀ [;] Sarops [;] ohioensis [;] Riegel" (SEMC). *Holotype male, Sarops wheeleri:* Top label (white; typewritten) = "INHS [;] Insect



Figs 27–32. Holotypes of species of *Coelinidea* and *Sarops* described in Riegel (1982) with current taxonomic affiliations. 27, *Coelinius niobrara*. 28, *Coelinius ohioensis*. 29, *Coelinius wheeleri*. 30, *Coelinius robinae*. 31, *Coelinius ruthae*. 32, *Coelinius sommermanae*.

Collection [;] 212,943''. Second label (white; partially handwritten, partially typewritten) = ''Contoocook [;] N.H. ix-4-'21 [;] E.W. Hall''. Third label (brown; partially handwritten, partially typewritten) = ''HOLOTYPE ♂ [;] Sarops [;] wheeleri [;] Riegel''. Fourth label (yellow; handwritten) = ''wings [;] on slide'' (INHS).

Other material examined.—All USA, *WISCONSIN; 3 ♀ Fond du Lac Co., T13N R19E S23, 4.ix.1975, gypsy moth Malaise trap; 1 ♀ same data as previous except 4.ix.-9.ix.1975; 1 ♀ 1 ♂ same data as previous except 9.ix.-2.x.1975; 1 ♀ 1 ♂ Jackson Co., T21N R4W S27, 15.ix.-22.ix.1975, gypsy moth Malaise trap; 1 ♀ Oneida

Co., T35N R11E S17, 12.viii.-25.viii.1975, gypsy moth Malaise trap (AEIC).

Discussion.—The holotypes of *C. ohioensis* (Riegel, 1982) (Fig. 28) and *C. wheeleri* (Riegel, 1982) (Fig. 29) fit within a morphospecies series of seven females and two males from Wisconsin and are simply conspecific female and male specimens, respectively. The species are not referenced in the literature beyond Riegel (1982). Therefore, *C. ohioensis* is designated the senior synonym because the holotype is a female; in dacnusines females usually have a greater number of diagnostic features compared to males.

Coelinius ohioensis and *C. wheeleri* were described from the holotypes only, which Riegel (1982) indicated were deposited at "KU" and INHS, respectively. The holotype of *C. ohioensis* bears a glass vial with a cork cap between the top and second labels. The holotype of *C. wheeleri* bears a glass vial with a cork cap below the fourth label. The vials contain the posterior portion of the metasoma of each species. One antenna of the *C. ohioensis* holotype is broken, and one forewing is mounted on a slide. The antennae of the *C. wheeleri* holotype are broken, as is the tarsus of one meso- and metathoracic leg. The other mesotarsus is missing. One forewing is mounted on a slide. The specimens from AEIC expand the range of this species to northern and central Wisconsin.

Coelinius robinae (Riegel), new combination
(Fig. 30)

Coelinidea robinae Riegel 1982: 83, 118 [USNM, examined].

Type material.—Holotype male: Top label (white; partially handwritten, partially typewritten) = "Harry L. Johnson [;] 8-14-1940 [;] So. Meriden Conn.". Second label (white; partially handwritten, partially typewritten) = Coelinidea [;] sp. [;] det [;] Mues". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] robinae [;] Riegel" (USNM).

Other material examined.—USA, *KANSAS: 1 ♂ Douglas Co., 23.v.1941, D. E. Hardy; 1 ♀ 5 ♂ same data as previous except 20.vi.1945, R. H. Beamer; 2 ♀ 7 ♂ same data as previous except 21.vi.1945; 2 ♀ same data as previous except 25.vi.1945 (SEMC); 1 ♀ 1 ♂ Riley Co., Konza Prairie Biological Station, watershed N2B, 39°05.27'N 96°35.09'W, 25.v.-27.v.2001, Zolnerowich, Kula, Brown, Malaise trap; 2 ♀ 1 ♂ same data as previous except 1.vi.-8.vi.2001; 1 ♀ same data as previous except 8.vi.-12.vi.2001; 3 ♂ same data as previous except watershed 4F, 39°04.37'N 96°34.26'W, 1.vi.-8.vi.2001; 5 ♂ same data as previous except 8.vi.-12.vi.2001; 8 ♂ same data as previous except 15.vi.-19.vi.2001; 1 ♀ same data as previous except 19.vi.-22.vi.2001; 5 ♂ same data as previous except 22.vi.-26.vi.2001; 1 ♂ same data as previous except watershed 4B, 39°04.65'N 96°35.75'W, 12.vi.-15.vi.2001; 1 ♂ same data as previous except 22.vi.-26.vi.2001 (KSUC); *MISSOURI: 2 ♂ Boone Co., Columbia, 7.vi.1970, Malaise trap (UCDC).

Discussion.—Coelinius robinae was previously known only from the holotype, which Riegel (1982) indicated was deposited at the "Connecticut Agricultural Experiment Station...(CONN)." All types in the Connecticut Agricultural Experiment Station collection were transferred to USNM in 1962 (G. Ridge in litt.), and thus, Riegel apparently deposited the holotype in USNM. The metasoma is intact unlike holotypes of other species described in Riegel (1982). Thus, a glass vial is not associated with the specimen. The mesothoracic legs are missing, as is one metathoracic leg, one forewing, and one hind wing. One prothoracic leg is broken at the trochanter; the rest of the leg, except for the trochantellus, is glued to the card. The specimens from UCDC and KSUC expand the range of this species to central Missouri and northeastern Kansas, respectively.

Coelinius ruthae (Riegel), new combination
(Fig. 31)

Coelinidea ruthae Riegel 1982: 79, 85 [SEMC, examined].

Type material.—Holotype male: Top label (white; typewritten) = "Pagosa Springs [;] Colo.

7-5-37 [;] C. L. Johnston". Second label (white; typewritten) = "Wing on [;] Sl. No.". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] ruthae [;] Riegel" (SEMC).

Discussion.—Coelinius ruthae is known only from the holotype, which Riegel (1982) indicated was deposited at "KU." The holotype bears a glass vial with a cork cap between the top and second labels. The vial contains the posterior portion of the metasoma. The antennae are broken, as is the tarsus of one mesothoracic leg. One forewing is mounted on a slide.

Coelinius sommermanae (Riegel), new combination (Fig. 32)

Coelinidea sommermanae Riegel 1982: 80, 93 [CUIC, examined].

Type material.—Holotype male: Top label (white; typewritten) = "Downie Creek [;] Selkirk Mts. [;] 14 Aug.'05 Br Col [;] J. Ch. Bradley". Second label (white with red border; handwritten) = "Coelinius [;] Nees". Third label (brown; partially handwritten, partially typewritten) = "HOLOTYPE ♂ [;] Coelinidea [;] sommermanae [;] Riegel". Fourth label (red; partially handwritten, partially typewritten) = "HOLOTYPE [;] Cornell U. [;] No. 6490" (CUIC).

Discussion.—Coelinius sommermanae is known only from the holotype, which Riegel (1982) indicated was deposited at "CN." The holotype bears a glass vial with a cork cap between the second and third labels. The vial contains the posterior portion of the metasoma. The antennae are broken.

NAMES CONSIDERED *NOMINA DUBIA*

The holotypes of four species of *Coelinidea* described in Riegel (1982) apparently are lost: *C. antha*, *C. arca*, *C. colora*, and *C. coma*. Riegel (1982) indicated that the holotype of each species was deposited at the "Philadelphia Academy of Natural Sciences...(PHIL)." The holotypes do not appear in the ANSP primary type database. Further, I searched throughout the entire ANSP collection in 2006 but did not find any specimens that could potentially be the holotypes. Museum visits and/or correspondence with curators and collection managers confirmed that the holotypes are not in any of the repositories referenced in Riegel (1982). The holotypes of *C. antha*, *C. colora*, and *C. coma* will be difficult to locate in the absence of an explicit holotype label because the locality label on each of the three specimens is apparently "Col," (Riegel 1982), an abbreviation for Colorado that is the only locality information for many specimens in ANSP. Recognition of *C. arca* in the absence of an explicit holotype label may be possible, as locality data according to Riegel (1982) are "Cochise Co., Arizona, July 26, 1919, Pinery Canyon, 6000 feet, Chiricahua Mts., Witmer Stone." All four species are known only from the holotypes; the original descriptions and key to North American species of *Coelinidea* in Riegel (1982) do not provide enough detail to apply the names unequivocally. Therefore, the names *C. antha*, *C. arca*, *C. colora*, and *C. coma* are considered *nomina dubia*.

ACKNOWLEDGMENTS

The following individuals kindly provided specimens examined in this study: Philip Clausen (UMSP), Zachary Falin (SEMC), Colin Favret (INHS), Henri Goulet (CNC), Steven Heydon (UCDC), E. Richard Hoebeke (CUIC), Gary Parsons (MSUC), Scott Shaw (ESUW), David Wahl (AEIC), and Robert Zuparko (CAS). I appreciate Stefan Cover (MCZ) and Scott Shaw's confirmation of paratypes in MCZ and ESUW, respectively. I give special thanks to Zhiwei Liu (Eastern Illinois University [EIU]), Michael Goodrich (EIU), and Jason Weintraub (ANSP) for their efforts in locating misplaced holotypes. I am indebted to Jens Prena (Systematic Entomology Laboratory [SEL] at the USNM) for his advice on Latin grammar. Marie Metz captured and processed all original images. I am grateful to Paul Marsh (Kansas State University), John Brown (SEL), and Thomas Henry (SEL) for their comments on the manuscript.

LITERATURE CITED

Evenhuis, N. L. and G. A. Samuelson. 2007. *The Insect and Spider Collections of the World Website* Bishop Museum, Honolulu, Hawaii, http://hbs.bishopmuseum.org/codens/codens-r-us.html [accessed 17 November 2007].

Förster, A. 1862. Synopsis der Familien und Gattungen der Braconen. *Verhandlungen des Naturhistorischen Vereines preussischen Rheinlande und Westphalens* 19: 225–288.

Griffiths, G. C. D. 1964. The Alysiinae (Hym. Braconidae) parasites of the Agromyzidae (Diptera). I. General questions of taxonomy, biology and evolution. *Beiträge zur Entomologie* 14: 823–914.

———. 1966a. The Alysiinae (Hym. Braconidae) parasites of the Agromyzidae (Diptera). II. The parasites of *Agromyza* Fallén. *Beiträge zur Entomologie* 16: 551–605.

———. 1966b. The Alysiinae (Hym. Braconidae) parasites of the Agromyzidae (Diptera). III. The parasites of *Paraphytomyza* Enderlein, *Phytagromyza* Hendel and *Phytomyza* Fallén. *Beiträge zur Entomologie* 16: 775–951.

———. 1967. The Alysiinae (Hym. Braconidae) parasites of the Agromyzidae (Diptera). IV. The parasites of *Hexomyza* Enderlein, *Melanagromyza* Hendel, *Ophiomyia* Braschnikov and *Napomyza* Westwood. *Beiträge zur Entomologie* 17: 653–698.

———. 1968a. The Alysiinae (Hym. Braconidae) parasites of the Agromyzidae (Diptera). V. The parasites of *Liriomyza* Mik and certain small genera of Phytomyzinae. *Beiträge zur Entomologie* 18: 5–62.

———. 1968b. The Alysiinae (Hym. Braconidae) parasites of the Agromyzidae (Diptera). VI. The parasites of *Cerodontha* Rondani s.l. *Beiträge zur Entomologie* 18: 63–152.

Haliday, A. H. 1839. *Hymenoptera Britannica: Alysia.* Hippolytus Baillière, London. 28 pp.

ICZN. 1999. *International Code of Zoological Nomenclature. Fourth Edition.* The International Trust for Zoological Nomenclature, London. XIX + 306 pp.

Kula, R. R. 2006. *Systematics of Dacnusini (Hymenoptera: Braconidae: Alysiinae), Parasitoids of Cyclorrhaphous Diptera.* Ph.D. Dissertation Kansas State University, Manhatttan, Kansas. 243 pp.

——— and G. Zolnerowich. 2008. Revision of New World *Chaenusa* Haliday *sensu lato* (Hymenoptera: Braconidae: Alysiinae), with new species, synonymies, hosts, and distribution records. *Proceedings of the Entomological Society of Washington* 110: 1–60.

Maetô, K. 1983. Discovery of two genera, *Sarops* Nixon and *Protodacnusa* Griffiths, from Japan (Hymenoptera, Braconidae). *Kontyû* 51: 247–253.

Nees von Esenbeck, C. G. 1819. Appendix ad J. L. C. Gravenhorst conspectum generum et familiarum ichneumonidum. Genera et familias Ichneumonidum adscitorum exhibens. *Nova Acta Physico-Medica Academiae Ceasareae Leopoldinae-Carolinae* 9: 299–310.

Nixon, G. E. J. 1937. The British species of *Dacnusa* (Hym., Fam. Braconidae). *Transactions of the Society for British Entomology* 4: 1–85.

———. 1942. A new species of *Dacnusa* and a new dacnusine genus (Hym., Braconidae). *The Entomologist's Monthly Magazine* 78: 131–135.

———. 1943. A revision of the European Dacnusini (Hym., Braconidae, Dacnusinae). *The Entomologist's Monthly Magazine* 79: 20–34, 159–168.

———. 1944. A revision of the European Dacnusini (Hym., Braconidae, Dacnusinae). *The Entomologist's Monthly Magazine* 80: 88–108, 140–151, 193–200, 249–255.

———. 1945. A revision of the European Dacnusini (Hym., Braconidae, Dacnusinae). *The Entomologist's Monthly Magazine* 81: 189–204, 217–229.

———. 1946. A revision of the European Dacnusini (Hym., Braconidae, Dacnusinae). *The Entomologist's Monthly Magazine* 82: 279–300.

———. 1948. A revision of the European Dacnusini (Hym., Braconidae, Dacnusinae). *The Entomologist's Monthly Magazine* 84: 207–224.

———. 1949. A revision of the European Dacnusini (Hym., Braconidae, Dacnusinae). *The Entomologist's Monthly Magazine* 85: 289–298.

———. 1954. A revision of the European Dacnusini (Hym., Braconidae, Dacnusinae). *The Entomologist's Monthly Magazine* 90: 257–290.

Riegel, G. T. 1947. *The American Species of Dacnusinae, Excluding Certain Dacnusini (Hymenoptera: Braconidae).* Ph.D. Dissertation, University of Illinois, Urbana-Champaign, Illinois. 236 pp.

———. 1950. A new genus and species of Dacnusini (Hym.: Braconidae). *Entomological News* 61: 125–129.

———. 1982. The American species of Dacnusinae, excluding certain Dacnusini (Hymenoptera: Braconidae). *Novitates Arthropropodae* 1: 1–185.

Rohwer, S. A. 1914. The Nearctic species of the hymenopterous genus *Symphya* Foerster. *Entomological News* 25: 168–172.

Schulz, W. A. 1911. Zweihundert alte Hymenopteren. *Zoologische Annalen* 4: 1–220.

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).* The International Society of Hymenopterists, Washington, DC. 439 pp.

Viereck, H. L. 1913. Descriptions of ten new genera and twenty-three new species of ichneumon-flies. *Proceedings of the United States National Museum* 44: 555–568.

Wharton, R. A. 1977. New World *Aphaereta* species (Hymenoptera: Braconidae: Alysiinae), with a discussion of terminology used in the tribe Alysiini. *Annals of the Entomological Society of America* 70: 782–803.

———. 1994. New genera, species, and records of New World Alysiinae (Hymenoptera: Braconidae). *Proceedings of the Entomological Society of Washington* 96: 630–664.

———. 1997. Subfamily Alysiinae. Pp. 84–117 in: Wharton, R. A., P. M. Marsh, and M. J. Sharkey, eds. *Manual of the New World Genera of the Family Braconidae (Hymenoptera)*. The International Society of Hymenopterists, Washington, DC. 439 pp.

———. 2002. Revision of the Australian Alysiini (Hymenoptera: Braconidae). *Invertebrate Systematics* 16: 7–105.

——— and A. D. Austin. 1991. Revision of Australian Dacnusini (Hymenoptera: Braconidae: Alysiinae), parasitoids of cyclorrhaphous Diptera. *Journal of the Australian Entomological Society* 30: 193–206.

Yu, D. S., C. van Achterberg, and K. Horstmann. 2005. *World Ichneumonoidea 2004. Taxonomy, Biology, Morphology and Distribution*. DVD/CD. Taxapad, Vancouver.

Zetterstedt, J. W. 1838. *Insecta Lapponica Sectio secunda Hymenoptera*. Voss, Lipsiae. 1140 pp.

J. HYM. RES.
Vol. 17(2), 2008, pp. 157–174

The Neotropical Chrysidid Genus *Adelphe* Mocsáry Revisited (Hymenoptera: Chrysididae: Amiseginae)

LYNN S. KIMSEY

Bohart Museum of Entomology, Department of Entomology University of California, Davis, CA 95616, USA

Abstract.—The chrysidid genus *Adelphe* is reviewed. The species *Nesogyne taino* Krombein is moved into *Adelphe* (**new combination**) and *Nesogyne* Krombein is synonymized herein as a junior synonym of *Adelphe*. Thirteen **new species** are described, namely ***acuta*** (Dominican Republic), ***azurea*** (Costa Rica, Panama), ***gibba*** (Ecuador), ***glabra*** (French Guiana), ***guayanensis*** (French Guiana, Guyana), ***hyalophora*** (Puerto Rico), ***intermedia*** (Costa Rica, Panama), ***leuropos*** (Ecuador, Peru), ***lobata*** (Ecuador, Brazil), ***lyra*** (Venezuela), ***paracubana*** (Puerto Rico, Dominican Republic), ***polita*** (Bolivia) and ***unidens*** (Costa Rica). All of these species are based on males, or males and females, with the exception of *lyra*, which is known only from females. In addition, a key to the species is provided.

The genus *Adelphe* is among the more primitive members of the chrysidid subfamily Amiseginae (Kimsey and Bohart 1991). The subfamily was reviewed by Kimsey and Bohart (1991) who also provided keys to genera. This is the most speciose genus of Amiseginae, with 40 species including those described below. *Adelphe* was most recently revised by Kimsey (1986), with later additions of species by Kimsey (1993). There are undoubtedly additional undescribed species, particularly in South America. The genus is primarily Neotropical, with only one species, *anisomorphae* Krombein, 1957, occurring in North America. This is the only amisegine genus found in the Greater and Lesser Antilles.

Adelphe species are characterized by a mixture of derived and primitive features. The most distinctive derived features are the peculiar, flattened male mandible and the well-developed transverse pronotal carina. Configuration of the male mandible is a trait only otherwise seen in the South African genus *Anachrysis* and South American *Anadelphe*. The transverse pronotal carina extends across the anterior margin of the pronotal disk and wraps laterally, ending at the pronotal lobe. This feature is not found in any other chrysidid genera. Primitive features include the extensively sculptured propodeum and mesopleuron, the presence of a scrobal sulcus and omaulus, presence of ocular setulae, and fully developed wings in both sexes, with one exception. Only the species *Nesogyne taino* Krombein, which is moved into *Adelphe* herein (**new combination**), is known to have brachypterous females. However, females are unknown for some species. With the exception of the reduced wings, *Nesogyne* shares all of the diagnostic features of *Adelphe*. Thus *Nesogyne* is made a junior synonym of *Adelphe* herein (**new synonymy**). Brachyptery also occurs in two species of *Amisega*, the North American *bella* (Krombein) and the Chilean *chilensis* Kimsey. Among the American amisegine genera only *Adelphe* has a laterally angulate or dentate propodeum. Other diagnostic characters include the well-developed occipital carina and the presence of an elevated metanotal disk.

Sexual dimorphism occurs in *Adelphe* as it does in most other amisegine genera.

Males have broad, foliaceous mandibles and an elongate, slender flagellum. Female mandibles are slender, edentate and are otherwise unmodified, and the flagellum is short and broad; the basal articles may be strikingly pale in females of a few species, such as *paradoxa* (Kieffer). Fortunately, in some species the sexes share enough features in modifications of the propodeum, eyes and mesopleuron that they can be associated.

The biology of *Adelphe* is poorly known. Members of the genus are thought to be phasmid egg parasites, but to date only one host, *Anisomorpha ferruginea* (Beauv.) (Phasmatidae), is known, and that is for the North American species, *anisomorphae* (Krombein 1957). Males are more commonly collected than females. This is probably because males spend more time flying and perching on vegetation above the ground. Females may spend the majority of their time on the ground and in leaf litter looking for host eggs. The most effective methods for collecting these wasps are yellow bowls, flight intercept traps (FIT) and Malaise traps.

To facilitate identification and the recognition of new species, a key to species based on males is given below. Because females are known for only about one-quarter of the species they are not included in the key.

MATERIALS AND METHODS

This study was made possible by loans of specimens from the following institutions and individuals: Canadian National Insect Collection, Agriculture Canada, Ottawa, Ontario (CNC) (J. Huber, L. Masner); Natural History Museum of Los Angeles, Los Angeles (LACM) (W. Xie), Museo de Insectos, Universidad de Costa Rica, San Jose (MUCR) (P. Hanson) and the Bohart Museum of Entomology, University of California, Davis (BME) (S. L. Heydon). Types are deposited in the museums indicated in the type series by the museum acronym given in parentheses.

A number of morphological features are used in the key and descriptions below that require further description. These are shown in Fig. 1. The scapal basin is the area immediately above the antennal sockets, which is often concave and cross-ridged. Many measurements are made using the greatest side to side diameter of the midocellus (MOD) (Fig. 1A). The flagellomeres are numbered using Roman numerals starting with the flagellomere closest to the pedicel. Flagellomere proportions are measured using the greatest breadth and length of each article (Fig. 1A). The postocular distance is measured in dorsal view and is the area between the posterior eye margin and the outer margin of the occipital carina on the side of the head (Fig. 1B). The scrobal sulcus is measured from the anterior margin of the sulcus to the scrobe, or prior to the scrobe if the sulcus abruptly narrows, in which case the length is measured to the point of constriction (Fig. 1D). The greatest width of the sulcus is used in the measurement. Finally, the metanotum has an elevated medial disk, which has different dimensions in different species (Fig. 1E). The greatest width is measured relative to the length along the midline. A rough estimate of punctation is given using the puncture diameter (PD) on the structure in question to measure the average distance between punctures. These features need to be measured and not determined by "eye".

KEY TO MALE *ADELPHE*

1 Mandible with one apical tooth (Figs 4, 7, 13) 2
– Mandible with two apical teeth (as in Fig. 3) 5

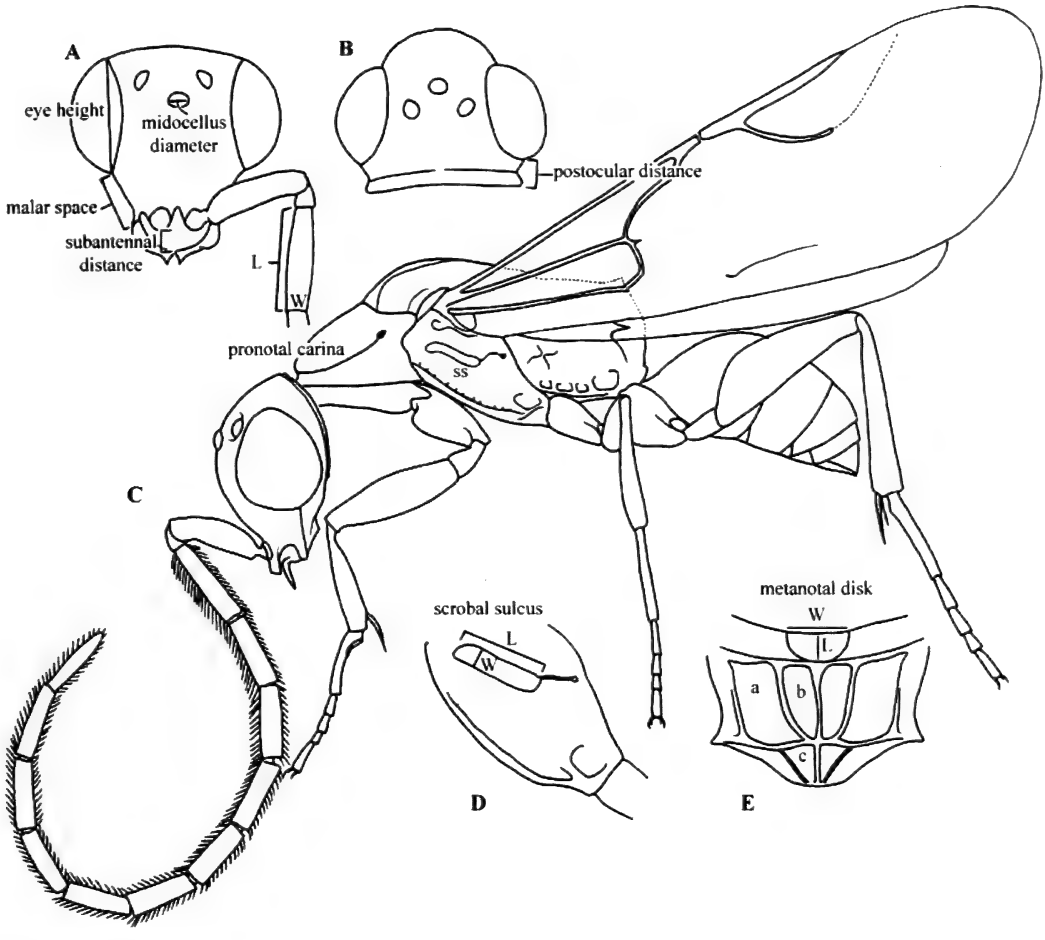


Fig. 1. *Adelphe* structural features, L = length, W = width. A. Front view of face. B. Dorsal view of head. C. Side view of body, ss = scrobal sulcus. D. Lateral view of mesopleuron. E. Dorsal view of propodeum, a. dorsolateral enclosure, b. dorsomedial enclosure, c. posteromedial enclosure.

2 Scapal basin smooth without cross-ridging (Fig. 7); scrobal sulcus more than 8× as long as broad; eye height 1.9–2.0× as long as malar space length in side view; Puerto Rico . . . . . *hyalophora* Kimsey, **new species**

– Scapal basin extensively cross-ridged (as in Figs 4, 13); scrobal sulcus less than 8× as long as broad; eye height less than 1.8× as long as malar space length in side view 3

3 Face long, narrow, margins below eyes nearly parallel-sided medially (Fig. 4); head in dorsal view breadth 1.3× length (Fig. 25); Ecuador . . . . . *gibba* Kimsey, **new species**

– Face broad, margins below eyes strongly converging below (as in Fig. 13); head in dorsal view breadth 1.5× or more length 4

4 Subantennal distance 1 MOD long; flagellomere I 2.9–3.0× as long as broad; eye height more than 1.5× malar space length in side view; Brazil, Ecuador . *paradoxa* (Kieffer)

– Subantennal distance more than 1 MOD long; flagellomere I 2.5× as long as broad; eye height 1.5× malar space length in side view; Costa Rica *unidens* Kimsey, **new species**

5 Scapal basin cross-ridged or vertically rugose (as in Figs 6, 8, 10) 6

– Scapal basin smooth, without cross-ridging (as in Figs 3, 5, 9, 11, 12) 17

6 Scrobal sulcus absent; body with extensive decumbent silvery pubescence; Dominican Republic . . . . . *argentea* Kimsey

– Scrobal sulcus well-developed; body without decumbent silvery setae 7
7 Scrobal sulcus more than 6.0× as long as broad 8
– Scrobal sulcus less than 5.5× as long as broad 9
8 Head posteriorly with deep pit on either side of midline between occipital and hypostomal carinae; propodeum without lateral tooth or angle; thorax red; pronotum without lateral carina; Puerto Rico ..... *masneri* Kimsey
– Head posteriorly without pit on either side of midline between occipital and hypostomal carinae; propodeum with lateral tooth or angle; thorax black; pronotum with lateral carina; Brazil ..... *cylindrica* Kimsey
9 Flagellomere I 3.0× or less as long as broad; flagellomere II twice as long as broad or less 10
– Flagellomere I 3.4× or more as long as broad; flagellomere II more than twice as long as broad 11
10 Malar space 4 MOD long in front view; eye height less than twice as long as malar space length in lateral view; Mexico ..... *mexicana* Mocsáry
– Malar space less than 3 MOD long in front view; eye height twice as long as malar space length in lateral view; Canada, USA ..... *anisomorphae* Krombein
11 Flagellomere I more than 4× as long as broad; scrobal sulcus 3.5× as long as broad; Mexico ..... *laevis* Kimsey
– Flagellomere I less than 4× as long as broad; scrobal sulcus 4–5× as long as broad ... 12
12 Pronotal carina obsolescent laterally; Panama ..... *confusa* Kimsey
– Pronotal carina well-developed laterally 13
13 Scrobal sulcus 5× as long as broad; flagellomere I 4× as long as broad; flagellomere II 3× as long as broad; Costa Rica ..... *limonae* Kimsey
– Scrobal sulcus 4.5× as long as broad or shorter; flagellomere I 3.5× as long as broad or shorter; flagellomere II less than 3× as long as broad 14
14 Eye height less than twice malar space length in side view 15
– Eye height twice malar space length in side view 16
15 Subantennal distance less than 1.5 MOD long; Panama ..... *robusta* Kimsey
– Subantennal distance more than 1.5MOD long; Costa Rica ..... *intermedia* Kimsey
16 Subantennal distance 1 MOD long; malar space 2.5 MOD long in front view; French Guiana, Guyana ..... *guayanensis* Kimsey, **new species**
– Subantennal distance 2 MOD long; malar space 3 MOD long in front view Ecuador ..... *lobata* Kimsey, **new species**
17 Scrobal sulcus 3.0–4.5× as long as broad 18
– Scrobal sulcus 5× as long as broad or longer 28
18 Flagellomere I less than 3.6× as long as broad 19
– Flagellomere I 4× or more as long as broad 23
19 Malar space 4 MOD long in front view; eye height 1.0–1.5× malar space length in side view 20
– Malar space 3 MOD long in front view; eye height 1.9–2.5× malar space length in side view 21
20 Flagellomere I 3.5× as long as broad; flagellomere II more than 2.5× as long as broad; Dominican Republic ..... *dominicana* Kimsey
– Flagellomere I 2.0–2.2× as long as broad; flagellomere II less than twice as long as broad; Ecuador, Colombia. ..... *longifacies* Kimsey
21 Eye with minute ocular setulae or setulae lacking; scrobal sulcus 3.5× or less as long as broad; French Guiana ..... *glabra* Kimsey, **new species**
– Eye with ocular setulae 0.3–0.7 MOD long; scrobal sulcus 3.8–4.0× as long as broad ... 22
22 Postocular distance short, about 1 MOD wide in dorsal view; eye height more than twice malar space length in side view; Ecuador, Peru *leuropos* Kimsey, **new species**
– Postocular distance long, 2 MOD wide in dorsal view; eye height less than twice malar space length in side view; Costa Rica ..... *hansoni* Kimsey

23 Scrobal sulcus 3.0–3.5× as long as broad 24
– Scrobal sulcus 4.0–4.5× as long as broad 26
24 Eye height 1.0–1.5× as long as malar space length in side view; malar space 3.5–3.8 MOD long in front view; postocular distance more than 1.5 MOD wide in dorsal view Venezuela ..... *meridae* Kimsey
– Eye height 2–3× malar space length in side view; malar space 2.5–3.0 MOD long in front view; postocular distance 1.0–1.5 MOD wide in dorsal view 25
25 Subantennal distance 1 MOD long; malar space 2.5 MOD long in front view; eye height twice malar space length in side view; Brazil. ..... *metallica* (Kieffer)
– Subantennal distance 1.5 MOD long; malar space 3 MOD long in front view; eye height 2.6× malar space length in side view; Brazil ..... *flavipes* (Ducke)
26 Eye height twice malar space length in side view; subantennal distance 1 MOD long; malar space 3 MOD long in front view; Costa Rica ..... *nitida* Kimsey
– Eye height less than twice malar space length in side view; subantennal distance more than 1.4 MOD long; malar space less than 3 MOD long 27
27 Flagellomere II 2.5× as long as broad; subantennal distance1.7 MOD long; propodeal medial enclosures smooth; Costa Rica ..... *paralaevis* Kimsey, **new species**
– Flagellomere II more than 3× as long as broad; subantennal distance1.5 MOD long; propodeal medial enclosures coarsely rugoseor cross-ridged; Costa Rica *azurea* Kimsey, **new species**
28 Scrobal sulcus 10× as long as broad 29
– Scrobal sulcus 5–8× as long as broad 30
29 Subantennal distance more than 1.5 MOD long; eye height more than 2.6× malar space length in lateral view; West Indies ..... *nesos* Kimsey
– Subantennal distance less than 1.5 MOD long; eye height twice malar space length in lateral view; Dominican Republic ..... *minuta* Kimsey
30 Flagellomere I 3× or less as long as broad; flagellomere II less than twice as long as broad; Brazil ..... *calvata* Kimsey
– Flagellomere I 3–5× as long as broad; flagellomere II more than twice as long as broad .. 31
31 Flagellomere I 3.0–3.5× as long as broad; flagellomere II 2.8–4.0× as long as broad ... 32
– Flagellomere I 4–5× as long as broad; flagellomere II 2.0–2.5× as long as broad ... 36
32 Scrobal sulcus less than 6× as long as broad 33
– Scrobal sulcus 7–8× as long as broad 34
33 Flagellomere IX more than 4.5× as long as broad; subantennal distance less than 1.5 MOD long; Brazil ..... *brasiliensis* Kimsey
– Flagellomere IX 4× as long as broad; subantennal distance 1.5 MOD long or longer; Bolivia ..... *polita* Kimsey, **new species**
34 Subantennal distance 2.5 MOD long; postocular distance more than 2 MOD wide; scrobal sulcus 8× as long as broad; Jamaica ..... *ziva* Kimsey
– Subantennal distance 1 MOD long or less; postocular distance less than 2 MOD wide; scrobal sulcus 7× as long as broad 35
35 Eye height less than twice malar space length in side view; postocular distance less than 1 MOD wide; Jamaica ..... *insula* Kimsey
– Eye height twice malar space length in side view; postocular distance more than 1 MOD wide; Puerto Rico ..... *paracubana* Kimsey, **new species**
36 Subantennal distance less than 1 MOD long; postocular distance 1 MOD wide or less; Brazil ..... *antennalis* Kimsey
– Subantennal distance 1 MOD long or longer; postocular distance 1.3–1.6 MOD wide ... 37
37 Flagellomere II less than 3× as long as broad; eye height twice malar space length or more 38
– Flagellomere II more than 3× as long as broad; eye height less than twice malar space length 39

38	Scrobal sulcus 6× as long as broad; malar space less than 2.5 MOD long in front view; Puerto Rico ..... *puertoricana* Kimsey
–	Scrobal sulcus 7× as long as broad; malar space more than 3 MOD long in front view; Jamaica ..... *jamaicensis* Kimsey
39	Flagellomere II 4× as long as broad; Dominican Republic .. *acuta* Kimsey, **new species**
–	Flagellomere II less than 3.5× as long as broad; Cuba ..... *cubana* Kimsey

Adelphe acuta Kimsey, **new species**
Figs 2, 14, 23, 35

Male.—Body length 2–3 mm. *Head* (Fig. 2): face highly polished, sparsely punctate, punctures small, 4–6 PD apart; scapal basin smooth, polished; mandible with two apical teeth; subantennal space 1 MOD long; malar space 3 MOD long; eye height 1.5× malar space length; postocular distance 1.2–1.4 MOD wide, 0.8 MOD wide between occipital carina and posterior eye margin, occipital carina 0.2 MOD (Fig. 23); flagellomere I length 4.3× breadth; flagellomere II 4.0× as long as broad; occipital carina narrow, weakly punctate not septate. *Thorax*: pronotal carina well-developed laterally; mesopleuron highly polished, punctures small, 2–5 PD apart, posteriorly impunctate, scrobal sulcus 9× as long as broad (Fig. 35); metanotal disk 1.7× as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorsolateral enclosure cross-ridged, posterolateral enclosure rugose, lateral tooth long, acute (Fig. 35). *Pubescence*: body with sparse erect pale setae; ocular setulae dense, 0.3 MOD long; flagellar setae 0.7 MOD long. *Color*: head and thorax black, thoracic dorsum with metallic tints; metasoma dark brown; legs yellowish brown; scape and pedicel brown, slightly paler than flagellum, flagellum dark brown.

Female.—Body length 3.0–3.5 mm; same as ♂, except flagellomere I length 2.3× breadth; flagellomere II length 0.8× breadth (Fig. 14); scapal basin highly polished, frons, vertex, pronotum and mesopleuron with large nearly contiguous punctures; head and thoracic dorsum with bronze tints, with erect black setae; flagellomere II slightly broader than long; antenna reddish brown, scape slightly paler than rest of antenna; femora reddish brown, rest of legs paler, yellowish brown.

Type material.—Holotype ♂: DOMINICAN REPUBLIC: La Vega, Cienaga, Parque Nacional A. Bermudez, 19 July–2 Aug.1995, S & J Peck, flight intercept trap (CNC); Paratypes: 2 ♂♂, same data as holotype.

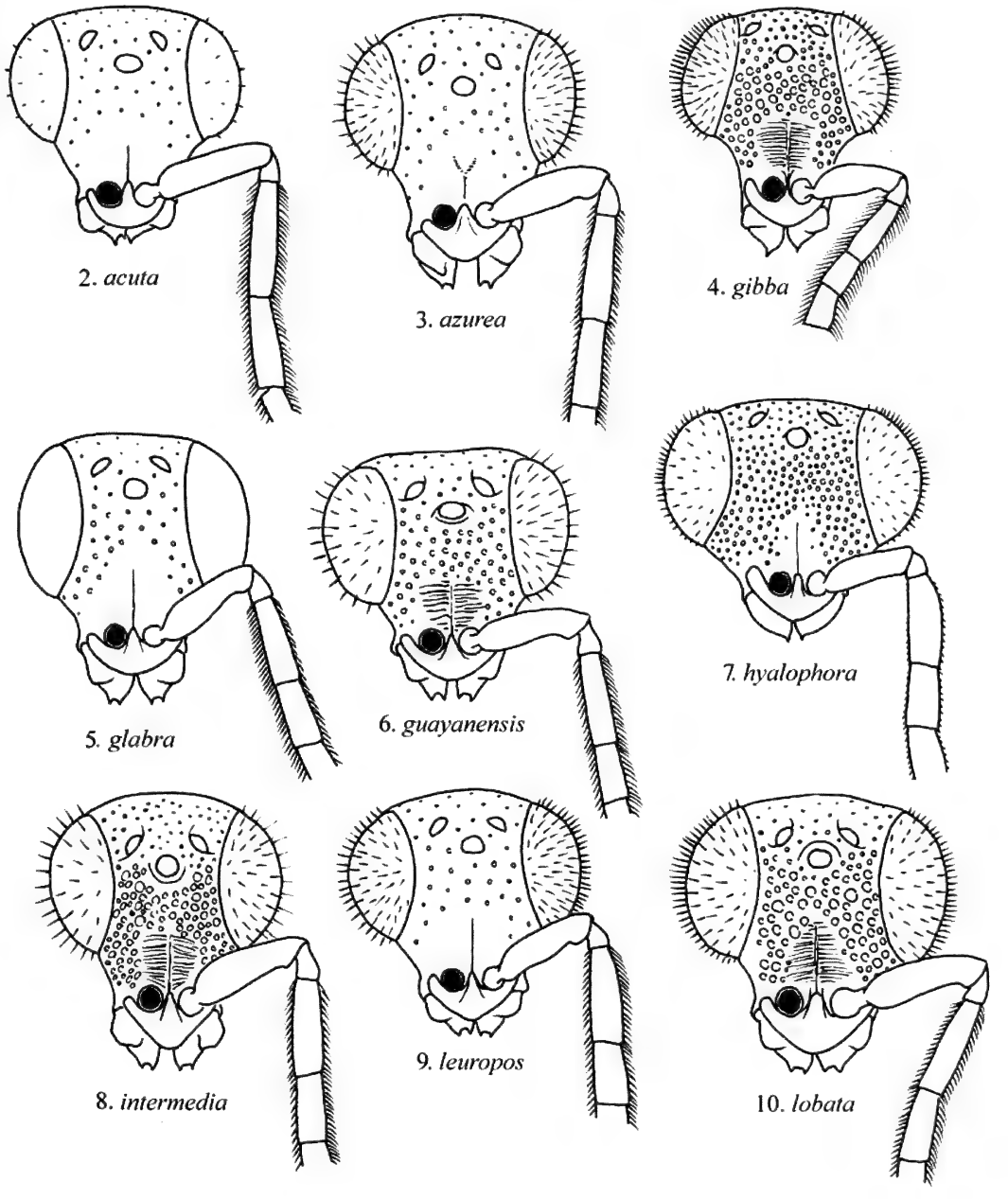
Additional specimens: 1 ♀: same data as holotype; 1 ♀: Parque Nacional del Este, 18°21N 68°49W, 16–17 Nov. 2005, L. Masner, yellow pan trap (CNC, BME).

Etymology.—The name, *acuta*, refers to the long, sharp propodeal tooth.

Discussion.—*Adelphe acuta* appears to be most closely related to the group of species, including *antennalis*, *puertoricana*, *jamaicensis* and *cubana*, which have a smooth scapal basin, two mandibular teeth, flagellomere I 4× or more as long as broad, relatively narrow scrobal sulcus, and malar space 2–3 MOD long. It shares the acute, almost tooth-like propodeal tooth with *antennalis*. However, *acuta* can be distinguished from these species by the shorter flagellomere I (4× as long as broad), flagellomere II more than 3× as long as broad and the eye height less than twice as long as the malar space.

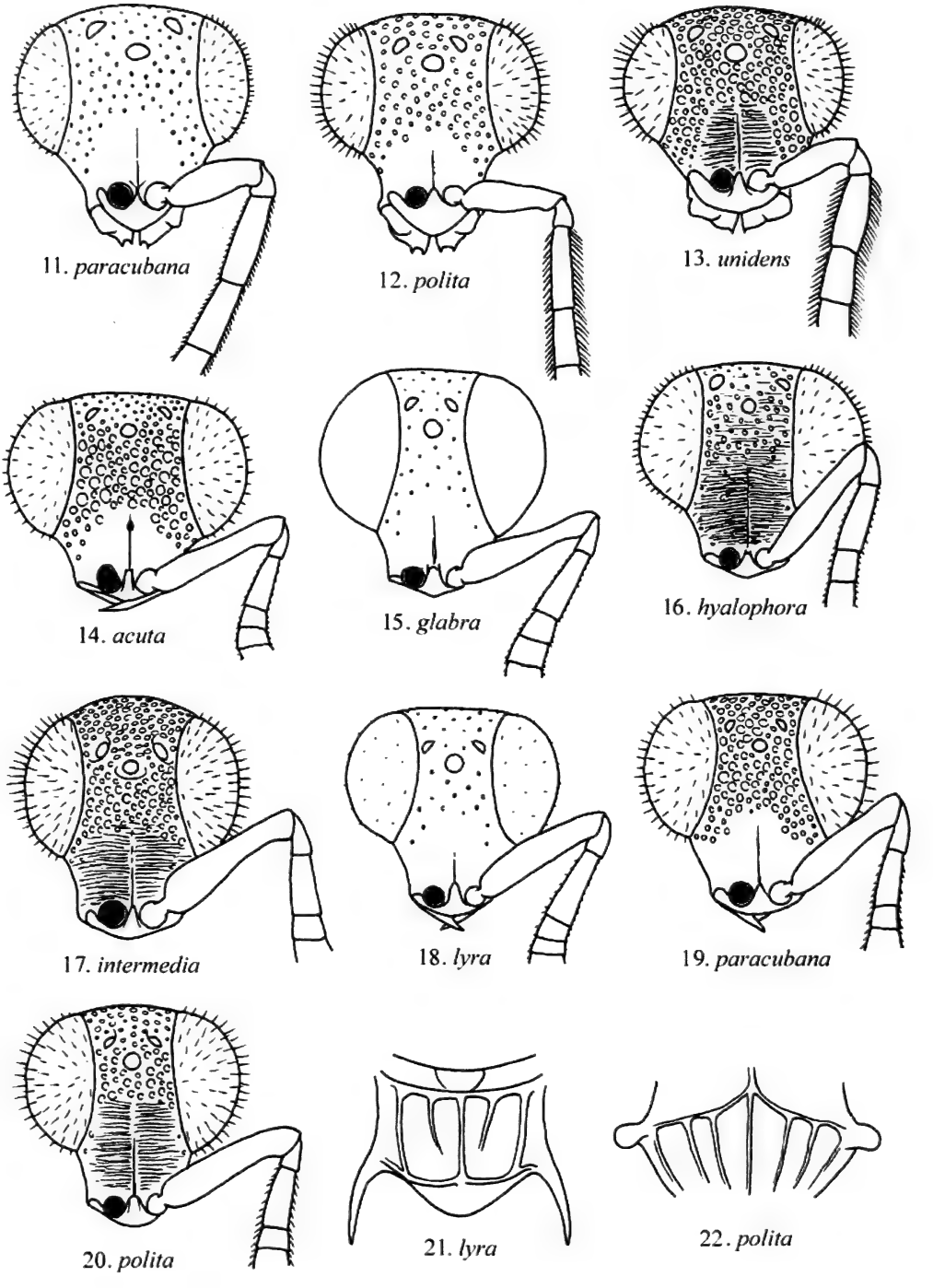
Adelphe azurea Kimsey, **new species**
Figs 3, 24, 37

Male.—Body length 3.5–4.5 mm. *Head* (Fig. 3): face smooth, with sparse punctures, 2–4 PD apart; scapal basin smooth, without cross-ridges; mandible with two apical teeth; subantennal space 1.3 MOD long; malar space 3.0 MOD long; eye

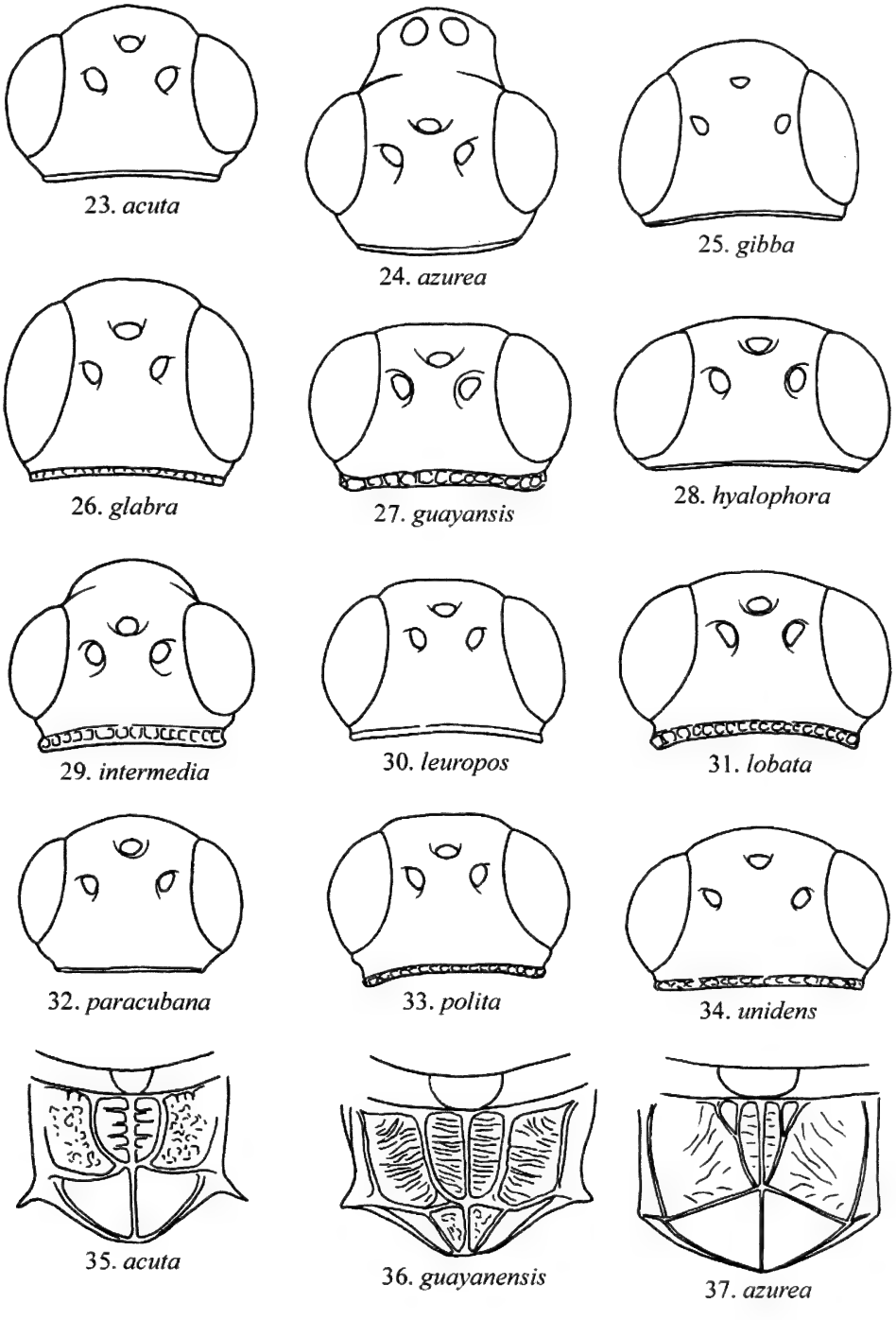


Figs 2–10. Front view of male face.

height 1.6× malar space length; face appearing prognathous in dorsal view (Fig. 24); postocular distance 1.6 MOD wide between occipital carina and posterior eye margin, occipital carina, faintly punctate, not septate; 0.2 MOD wide (Fig. 24); flagellomere I 4× as long as broad; flagellomere II 3.0–3.2× as long as broad. *Thorax*: pronotal carina obsolescent laterally; mesopleuron polished, largely impunctate, scrobal sulcus 4.0–4.2× as long as broad; metanotal disk twice as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorso-



Figs 11–13. Front view of male face. Figs 14–20. Front view of female face. Fig. 21. Dorsal view of female propodeum. Fig. 22. Posterior view of male propodeum.



Figs 23–34. Dorsal view of male head. Figs 35–37. Dorsal view of male propodeum.

lateral enclosure cross-ridged, posterolateral enclosure rugose, lateral angle low, obtuse. *Pubescence*: body with dense erect dark brown setae; ocular setulae dense, 0.6 MOD long; flagellar setae 0.7 MOD long. *Color*: head and thorax black, dorsum with metallic blue highlights; metasoma reddish brown; legs yellowish brown; scape and pedicel red, flagellum dark brown.

Female.—Unknown.

Type material.—Holotype ♂: COSTA RICA: Cartago, La Cangreja, July 1991, Hanson & Godoy (BME); Paratypes: 9 ♂♂ (BME, MUCR): 3 ♂♂, same data as holotype; 2 ♂♂, same data as holotype except Mar.–May 1992; 1 ♂, San José, Zurquí de Moravia, Mar.–April 1993, P. Hanson; 1 ♂, Zurquí de Moravia, July 1991, P Hanson; Cartago, Cerro de la Muerte, Villa Mills, July–Sept. 1990, P. Hanson; 1 ♂, PANAMA: Chiriquí, La Fortuna, 25 May–9 June 1995, Ashe & Brooks, flight intercept trap.

Etymology.—The name refers to the blue tints on the head and thorax.

Discussion.—This is one of seven species recorded from Costa Rica. It shares the majority of features with *paralaevis*, including the smooth scapal basin, flagellomere I 3.5–3.7× as long as broad, and scrobal sulcus 4–5× as long as broad. The two species differ in size, with *azurea* much larger, with a longer flagellomere II (2.5× versus 3.0× in *paralaevis*), longer subantennal distance (1.7 MOD versus 1.5 MOD), and the smooth medial propodeal enclosures (rugose or cross-ridged in *paralaevis*). Male *azurea* are also colored with strong blue tints on the head and thorax.

Adelphe gibba Kimsey, **new species**
Figs 4, 25

Male.—Body length 3 mm. *Head* (Fig. 4): face with large, nearly contiguous punctures; scapal basin coarsely cross-ridged; mandible with one apical tooth; subantennal space 1.2 MOD long; malar space 4.0 MOD long; eye height 1.6× malar space length; postocular distance 0.5 MOD wide between outer margin of occipital carina and posterior eye margin, occipital carina 0.1 MOD wide (Fig. 25); flagellomere I 2.5–2.7× as long as broad; flagellomere II 2.0× as long as broad. *Thorax*: cylindrical, pronotum laterally impressed, strongly convex dorsally; pronotal carina well-developed laterally; mesopleuron with large, nearly contiguous punctures, scrobal sulcus 5.5–6.0× as long as broad; metanotal disk twice as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorsolateral enclosure cross-ridged, posterolateral enclosure rugose, lateral tooth strongly protruding, apex broadly rounded. *Pubescence*: body with dense erect dark brown setae; ocular setulae dense, 0.8 MOD long; flagellar setae 0.8 long. *Color*: head and thoracic dorsum black, with faint bluish tints, particularly on head; metasoma and legs dark brown; antenna dark brown, scape slightly paler.

Female.—Body length 3.0–3.5 mm; same as ♂, except flagellomere I length twice breadth; flagellomere II length equal to breadth; scape and pedicel yellow, flagellomeres I–II pale yellow to whitish, flagellomeres III–XI dark brown; metasoma dark brown; legs pale yellowish brown.

Type material.—Holotype ♂: ECUADOR: Sucumbios, Sacha Lodge, 0°05S 76.05W, 290 m, 13–23 June 1994, P. Hibbs, Malaise trap (LACM). Paratypes 42 ♂♂, 13 ♀♀ (LACM, BME, CNC); 3 ♂♂, 5 ♀♀, same locality and collector as holotype: 1 ♂, 12–22 Feb.1994; 1 ♀, 22 Feb.–4 Mar. 1994;4–14 Mar.1994; 1 ♂, 2 ♀, 14–24 Mar. 1994; 1 ♂, 4–14 April 1994; 1 ♀, 13–23 April 1994; 2 ♂♂, 1 ♀, 23 April–4 May 1994; 3 ♂♂, 1 ♀, 14–24 May 1994; 2 ♂, 3–13 April 1994; 1 ♂, 13–20 April 1994; 3 ♂♂, 1 ♀, 13–23 April 1994; 3 ♂♂, 23 June–3 July 1994; 1 ♂, 24 June–3 July 1994; 8 ♂♂, 3–13 July 1994; 2 ♂♂,2 ♀♀, 13–25 July 1994; 5 ♂♂, 25 July–3 Aug. 1994; 3 ♂♂, 1 ♀, 3–16 Aug. 1994; 2 ♂♂, 1♀, 27 Aug.–10 Sept. 1994; 1 ♂, 12–21 Oct. 1994; 1 ♀; 1 ♂, 31 Oct.–10 Nov. 1994, Napo, Yasuni Research Station, 0°40.05S 78°24W, June–July 1999, C. Carlton, FIT.

Etymology.—The name derives from the strongly bulging frons in this species.

Discussion.—*Adelphe gibba* is one of two species, including *cylindrica*, with a compressed, somewhat cylindrical body. The pronotum is strongly convex dorsally, appearing somewhat impressed sublaterally. The head is unusually narrow across the lower face, with the sides below the eyes nearly parallel in front view. In side view the frons is strongly convex, a feature not seen in any other described species. This is one of four species, including *paradoxa*, *hyalophora* and *unidens*, where the male mandible has a single apical tooth. *A. minuta* was originally described as having a single mandibular tooth but subsequent examination with better optics has revealed the presence of a second tiny tooth. Additional diagnostic male features of *gibba* include the cross-ridged scapal basin, scrobal sulcus 5–6× as long as broad, large coarse punctuation on the face and mesopleuron, eye height 1.6× as long as malar space length. Females have whitish basal flagellomeres.

There are only two species of *Adelphe* described from Ecuador, *gibba* and *longifacies*. However, there are quite likely to be more. Additional collecting, particularly with Malaise traps and yellow bowls, will undoubtedly reveal new species.

Adelphe glabra Kimsey, **new species**
Figs 5, 15, 26

Male.—Body length 3 mm. *Head* (Fig. 5): face highly polished, sparsely punctate, punctures shallow, 1–2 PD apart; scapal basin smooth, polished; mandible with two apical teeth; subantennal space 1.3 MOD long; malar space 3.0 MOD long; eye height 2.5× malar space length; postocular distance 1 MOD wide, occipital carina 0.4 MOD wide (Fig. 26); flagellomere I 3.0–3.5× as long as broad; flagellomere II 2.2–2.4× as long as broad; occipital carina narrow, weakly punctate not septate. *Thorax*: pronotal carina well-developed laterally; mesopleuron highly polished, punctures small, 2–3PD apart, posterior part nearly impunctate, scrobal sulcus 3.5× as long as broad; metanotal disk 3× as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorsolateral enclosure cross-ridged, posterolateral enclosure rugose, lateral tooth short, apically acute. *Pubescence*: body with sparse erect black setae; ocular setulae minute, less than 0.1 MOD long or absent; flagellar setae 0.5 long. *Color*: head and thorax black, thoracic dorsum with metallic tints; metasoma dark brown; legs yellow; antenna brown, with slightly lighter colored scape.

Female.—Body length 3.0–3.5 mm; same as ♂, except flagellomere I length 1.6× breadth; flagellomere II 0.6× (Fig. 15); scapal basin highly polished, frons, vertex, pronotum and mesopleuron nearly impunctate; head and thorax black, with erect black setae; metasoma brown; antenna brown with, scape, pedicel and flagellomere I paler, yellowish brown; legs brownish yellow.

Type material.—Holotype ♂: FRENCH GUIANA: Saul, 7 km s Les Eaux Claires, 170 m, 30 May–4 June 1997, J. Ashe & R. Brooks, FIT (CNC). Paratypes: 6 ♂♂, 2 ♀♀; 4 ♂♂ (CNC, BME); 1 ♀, same data as holotype; 1 ♂, 240 m, 18 km sse Roura, 4°46.61N 52°13.41W, 22 May–10 June 1997, J. Ashe & R. Brooks, FIT; 1 ♂, 8.4 km sse Roura, 4°40.59N 52°17.47W, 22–24 May 1997, J. Ashe & R. Brooks, MT; 1 ♀, Saul, 7 km n and 3 km e Les Eaux Claires, Mt. Fumee, 490 m, 1–8 June 1997, J. Ashe & R. Brooks, FIT.

Etymology.—The name, *glabra*, refers to the nearly hairless eyes (Latin, f.).

Discussion.—The most distinctive feature of this species is the essentially hairless eyes in both sexes. The only other species where this is seen is the Brazilian species, *calvata*. It can be distinguished from *calvata* by the wider scrobal sulcus (3.5× versus 7× in *calvata*), and broader postocular distance (1 MOD wide versus 0.6 MOD in *calvata*). In other features, including flagel-

lomere I less than 3.5× as long as broad, scapal basin smooth, scrobal sulcus 3–5× as long as broad and mandible with two apical teeth, *glabra* is closest to *leuropos* and *hansoni*.

Adelphe guayanensis Kimsey, **new species**
Figs 6, 27, 36

Male.—Body length 4.0–4.5 mm. *Head* (Fig. 6): face coarsely punctate, punctures 0.5–1.0 PD apart; scapal basin cross-ridged; mandible with two apical teeth; subantennal space 1.0–1.3 MOD long; malar space 2.5 MOD long; eye height 2.6× malar space length; postocular distance 1.1 MOD wide, 0.3 MOD wide between occipital carina and posterior eye margin, occipital carina broad, 0.5 MOD wide, traversed by septa (Fig. 27); flagellomere I 3.5× as long as broad; flagellomere II 2.3× as long as broad. *Thorax*: pronotal carina well-developed laterally; mesopleuron smooth, with punctures small, 0.5–1.0 PD apart anteriorly, becoming nearly impunctate posteriorly, scrobal sulcus 4.5× as long as broad; metanotal disk twice as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorsolateral enclosure cross-ridged, posterolateral enclosure rugose, lateral tooth large, broadly rounded apically (Fig. 36). *Pubescence*: body with erect dark brown setae; ocular setulae dense, 0.5 MOD long; flagellar setae 0.5 long. *Color*: head and thorax black, dorsum with bronze tints; antenna brown; legs pale yellowish brown; metasoma dark brown.

Female.—Unknown.

Type material.—Holotype ♂: GUYANA, Region 8, Iwokrama Forest Res., 4°40.19N 58°41.04W, May–June 2001, R. W. Brooks & Z. Hain, flight intercept trap (CNC). Paratypes: 4 ♂♂; 2 ♂♂ (CNC, BME): same data as holotype; FRENCH GUYANA: 1 ♂: Les Eaux Claires, 7 km s, Saul, 30 May–4 June 1997, Ashe & Brooks, flight intercept trap; 1 ♂: Les Eaux Claires, 7 km s Mt. Fumes, 4–8 June 1997, Ashe & Brooks, flight intercept trap;

Etymology.—The name refers to the collection localities in the Guayanas.

Discussion.—This is one of twelve species of *Adelphe* with a cross-ridged scapal basin and 2-toothed mandible in the male. It most closely resembles *lobata*, as both have a relatively short flagellomere I (3.5× as long as broad or shorter), scrobal sulcus 4.5–5.0× as long as broad and malar space 2–3 MOD long. *A. lobata* has a large protruding, apically rounded propodeal angle, whereas it is low and obtuse in *guayanensis*. *A. guayanensis* can be distinguished from *lobata* by the shorter subantennal distance (1 MOD versus 2 MOD long), flagellomere II 2.3× as long as broad (versus 2.8× as long as broad), malar space 2 MOD long (longer in *lobata*), and flagellomere XI 4.5× as long as broad versus 4.0×.

Adelphe hyalophora Kimsey, **new species**
Figs 7, 16, 28

Male.—Body length 3 mm. *Head* (Fig. 7): face with nearly contiguous, medium punctures; scapal basin coarsely cross-ridged; mandible with one apical tooth; subantennal space 1.2 MOD long; malar space 4.0 MOD long; eye height 1.9× malar space length; postocular distance 1 MOD wide, 0.6 MOD wide between occipital carina and posterior eye margin, occipital carina narrow, 0.1 MOD wide, weakly punctate, not septate (Fig. 28); flagellomere I 3.0× as long as broad; flagellomere II twice as long as broad. *Thorax*: pronotal lateral carina well-developed; mesopleuron polished, punctures small, shallow, 1–4 PD apart, scrobal sulcus narrow, parallel-sided, 8.5× as long as broad; metanotal disk 1.8× as broad as long; propodeal dorsomedial and dorsolateral enclosures transversely rugose, posterolateral enclosure irregularly rugose, lateral tooth obtuse. *Pubescence*: body with erect whitish setae; ocular setulae sparse, 0.5 MOD long; flagellar setae short, less than 0.2 MOD long. *Color*: head and thorax

black; antenna dark brown, scape somewhat paler brown.

Female.—Body length 2–3 mm. same as ♂, except flagellomere I length 2.8× breadth; flagellomere II length 1.2× breadth (Fig. 16); scape, pedicel yellowish brown, flagellomeres dark brown; legs yellow.

Etymology.—This species is found in low elevation forest in Puerto Rico. The name is Latin for forest (*hyalos*) lover (*phora*).

Type material.—Holotype ♂: USA: Puerto Rico, Bosque Estatal de Guánica, 17°961N 66°847W, 15 ft., 19–25 Sept. 1998 (LACM). Paratypes: 4 ♂♂, 2 ♀♀ (BME, LACM), same data as holotype.

Discussion.—This is the fourth species of *Adelphe* described from Puerto Rico, including *hyalophora, masneri, paracubana* and *puertoricana*. All four are among the smallest bodied *Adelphe*, ranging in length from 2–3 mm. *A. hyalophora* can be distinguished from *paracubana* and *puertoricana* by the lack of transverse ridging in the scapal basin. Both *hyalophora* and *masneri* have a smooth, highly polished and sparsely punctate face. *A. hyalophora* can be distinguished from all of these species by the presence of only one apical tooth on the male mandible.

Adelphe intermedia Kimsey, **new species**
Figs 8, 17, 29

Male.—Body length 3.5–5.0 mm. *Head* (Fig. 8): face coarsely punctate, punctures contiguous; scapal basin cross-ridged; mandible with two apical teeth; subantennal space 1.5–1.7 MOD long; malar space 3.0 MOD long; eye height 1.5× malar space length; postocular distance 1.4 MOD, occipital carina broad, 0.57 MOD wide, traversed by septa (Fig. 29); flagellomere I 3.5× as long as broad; flagellomere II 2.5× as long as broad. *Thorax*: pronotal carina well-developed laterally; mesopleuron smooth, punctures small, 0.5–1.5 PD apart, scrobal sulcus 4.0–4.3× as long as broad; metanotal disk twice as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorsolateral enclosure cross-ridged, posterolateral enclosure rugose, lateral tooth low, obtuse. *Pubescence*: body with extensive erect dark brown to black setae; ocular setulae dense, 0.7 MOD long; flagellar setae 0.5 long. *Color*: head and thorax black, dorsum with metallic yellowish green highlights; antenna dark brown.

Female.—Body length 3.0–3.5 mm; same as ♂, except flagellomere I length twice breadth; flagellomere II length 0.6× breadth (Fig. 17); scapal basin densely cross-ridged; frons, vertex, pronotum and mesopleuron anteriorly, with dense, small punctures, punctures 0.5 PD apart; head and thorax black, dorsum with faint metallic yellow tints, with erect black setae; antenna brown, scape, pedicel and flagellomere I slightly paler than rest; legs and metasoma brown.

Type material.—Holotype ♂, COSTA RICA: San José, Tunel, 9.5 km e, Parque Nacional Braulio Carillo, July–Nov. 1990, P. Hanson (BME). Paratypes: 12 ♂♂ (BME, MUCR): 1 ♂, same data as holotype except March–April 1990; 3 ♂♂, San José, Zurqi de Moravia, Aug. 1990, P. Hanson; 1 ♂, Heredia, 10°17N, 84°10W, 30/v/1973, J. Helava; 1 ♂, Cartago, La Cengreja, July 1991, Hanson & Godoy; 1 ♂, Guanacaste, Est. Mengo, sw Volcán Cacao; PANAMA: 1 ♂, El Llano-Cartí Rd., July 1982, B Gill, FIT; 1 ♂, El Llano-Carti Rd., June 1982, B. Gill, flight intercept trap; 2 ♂♂, Chiriquí, La Fortuna dam, 14 June–16 July1982, B Gill, FIT.

Additional specimens: 2 ♀♀, PANAMA: Chiriquí, La Fortuna dam, 14 June–16 July1982, B Gill, FIT; 1 ♀: El Llano-Cartí Rd., July 1982, B Gill, FIT.

Etymology.—The name refers to the intermediate nature of the structural features between this species and the other Costa Rican and Panamanian species, *robusta, confusa* and *limonae* that have a cross-ridged scapal basin.

Discussion.—Diagnostic features of male *intermedia* include the cross-ridged scapal

basin, apically bidentate mandible, broad scrobal sulcus (4× as long as broad), and short eye height relative to the length of the malar space (about 1.5× malar space length). The related species, *robusta, confusa* and *limonae,* from the same region of Central America can be distinguished from *intermedia* by the longer malar space and narrower scrobal sulcus. Other distinctive features of *intermedia* include the relatively long subantennal distance (1.6 MOD) and ocular setulae longer than the flagellar setae.

Adelphe leuropos Kimsey, **new species**
Figs 9, 30

Male.—Body length 3 mm. *Head* (Fig. 9): face highly polished, sparsely punctate, punctures shallow, 1–2 PD apart; scapal basin smooth, polished; mandible with two apical teeth; subantennal space 1.5 MOD long; malar space 3 MOD long; eye height 2.3× malar space length; postocular distance 0.9–1.0 MOD wide, occipital carina 0.3 MOD (Fig. 30); flagellomere I 3.0× as long as broad; flagellomere II 2.0× as long as broad; occipital carina narrow, weakly punctate not septate. *Thorax*: pronotal carina well-developed laterally; mesopleuron highly polished, punctures small, 2–3PD apart, posteriorly nearly impunctate, scrobal sulcus 4× as long as broad; metanotal disk twice as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorsolateral enclosure cross-ridged, posterolateral enclosure rugose, lateral tooth short, apically acute. *Pubescence*: body with sparse erect black setae; ocular setulae 0.6 MOD long; flagellar setae 0.6 MOD long. *Color*: head and thorax black, thoracic dorsum black with metallic tints; metasoma dark brown, legs yellow; antenna brown, with paler scape.

Female.—Unknown.

Type material.—Holotype ♂: ECUADOR: Morona, Santiago Mizal, 50 km se Macas, 4–7 Jan. 1993, 300 m, M. & J. Wasbauer (BME). Paratypes: 5 ♂♂ (LACM, BME, CNC); 2 ♂♂, Napo Prov., Hatun Sacha Biol. Sta. 40 m, 13 June 1994, F. Génier, FIT, lowland rainforest; 3 ♂♂, PERU: Loreto Prov., 220 m, Teniente Lopez, 2°36S 76°07W, July 1993, R. Leschen, FIT.

Etymology.—The name, *leuropos,* refers to the "smooth face" (Greek, feminine).

Discussion.—*A. leuropos* is another of the species with two mandibular teeth, a smooth scapal basin, short broad scrobal sulcus, short flagellomere I (3× as long as broad) and short flagellomere II (about twice as long as broad). Based on all of these features *leuropos* most closely resembles the Central American species *hansoni.* It can be distinguished from *hansoni* by the longer eye height (twice the malar the space length versus shorter in *hansoni*) and narrower postocular distance (1 MOD versus 2 MOD wide). Among the Ecuadorian species, *lobata, gibba, longifacies* and *leuropos,* only *longifacies* and *leuropos* have a smooth scapal basin.

Adelphe lobata Kimsey, **new species**
Figs 10, 31

Male.—Body length 2.5–3.5 mm. *Head* (Fig. 10): face coarsely punctate, punctures contiguous; scapal basin cross-ridged; mandible with two apical teeth; subantennal space 2.0 MOD long; malar space 3.0 MOD long; eye height 2.3× malar space length; postocular distance 1.4 MOD wide, occipital carina area broad, 0.5 MOD wide, traversed by septa (Fig. 31); flagellomere I 3.5× as long as broad; flagellomere II 2.6–2.8× as long as broad. *Thorax*: pronotal carina well-developed laterally; mesopleuron polished, punctures large, 0.5–1.0 PD apart anteriorly becoming smaller and more widely separated medially, nearly impunctate posteriorly, scrobal sulcus 4× as long as broad; metanotal disk twice as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorsolateral enclosure cross-ridged, posterolateral enclosure finely rugose, lat-

eral tooth large, broadly rounded apically (similar to Fig. 22). *Pubescence*: body with erect dark brown setae; ocular setulae dense, 0.6 MOD long; flagellar setae 0.6 long. *Color*: head and thoracic dorsum black, with strong metallic blue tints; antenna dark brown; legs yellow.

Female.—Unknown

Type material.—Holotype ♂: ECUADOR: Napo, Huahua Sumaco, km 45 on Hollin-Loreto Rd., 22 Dec. 1989, Wasbauer & Real, Malaise trap (BME). Paratypes 9 ♂♂ (BME, CNC); 1 ♂, same data as holotype; 1 ♂, Pichincha, Santo Domingo, Tinalandia, 16 km e, 4 June–25 Jul. 1986, S. & J. Peck, FIT; 3 ♂♂, Napo, Puerto Napo, 21 km e, Jatun Sacha Biol. Sta., 9–13 July 1994, F. Génier, FIT; BRAZIL: 2 ♂♂, Rondonia, Ariquemes, 62 km e Fazenda Rancho Grande, 10°18S, 62°53W, 8–20 Apr. 1997, Rehn & Alexander; 2 ♂♂, Amazonas, Estivao do Equador, Rio Javari, Sept. 1979, M. Alvaranga, Malaise trap.

Etymology.—The species name, *lobata*, refers to the large, blunt propodeal tooth.

Discussion.—Diagnostic features of male *lobata* include the apically bidentate mandible, cross-ridged scapal basin, subantennal distance 2 MOD long, malar space 3 MOD long, flagellomere I 3.5× as long as broad, flagellomere II 2.8× as long as broad and the scrobal sulcus 4× as long as broad. Characteristics that will separate *lobata* from *guayanensis*, the species it most closely resembles, are discussed under *guayanensis*.

Adelphe lyra Kimsey, **new species**
Figs 18, 21

Male.—Unknown.

Female.—Body length 3.5–5.0 mm. *Head* (Fig. 18): face smooth, nearly impunctate, punctures small, 4–6 PD apart; scapal basin smooth; subantennal space MOD long; malar space 3.6 MOD long; flagellomere I 2.6× as long as broad; flagellomere II 0.7× as long as broad. *Thorax*: pronotal carina well-developed laterally; mesopleuron polished, punctures 3–6 PD apart, scrobal sulcus 4.5× as long as broad; metanotal disk twice as broad as long; propodeal dorsomedial, dorsolateral and posterolateral enclosures smooth, polished, lateral tooth elongate, acute, 5× as long as broad at the base (Fig. 21). *Pubescence*: body with erect brown setae; ocular setulae minute, less than 0.1 MOD long; flagellar setae 0.3 MOD long. *Color*: head and thorax black; metasoma and legs reddish brown; scape, pedicel and flagellomeres I–II yellowish brown, flagellomeres III–X brown.

Type material.—Holotype ♀: VENEZUELA: Aragua, Rancho Grande, 3–10 Aug. 1987, C. Bordon & S. Peck (CNC). Paratypes: 2 ♀♀ (BME, CNC): 1 ♀, 2 Jun. 1987, C. Bordon; 1 ♀, H. Pifier National Park, 14 May 1998, S. Ashe, flight intercept trap.

Etymology.—*Adelphe lyra* is named for the unusually long propodeal teeth

Discussion.—There is only one other species recorded from Venezuela, *meridae*, which is only known from males. It is possible that *lyra* is the female of *meridae*. However, in the majority of species where both sexes are known, males and females share similar modifications of the propodeal angle and scrobal sulcus. These features differ considerably between the two species. Venezuela has not been adequately sampled, so it would not be surprising if there are multiple species of *Adelphe*. However, the unusually long propodeal teeth in *lyra* differ from all other *Adelphe* females. In addition, *lyra* is distinguished by the lack of whitish antennomeres, the minute ocular setulae and smooth, polished propodeal enclosures.

Adelphe paracubana Kimsey, **new species**
Figs 11, 19, 32

Male.—Body length 2.0–2.5 mm. *Head* (Fig. 11): face with small, scattered punctures, punctures 1–3 PD apart; scapal basin smooth, polished; mandible with two apical teeth; subantennal space 1.0 MOD

long; malar space 2.5 MOD long; eye height twice malar space length; postocular distance 1.6 MOD wide between occipital carina and posterior eye margin, occipital carina area 0.1 MOD wide, carina septate (Fig. 32); flagellomere I 3.5× as long as broad; flagellomere II 2.5× as long as broad. *Thorax*: pronotal carina complete laterally; mesopleuron highly polished, with small, sparse punctures, 1–4 PD apart or more, scrobal sulcus narrow, parallel-sided, 7× as long as broad; metanotal disk 3× as broad as long; propodeal dorsomedial and dorsolateral enclosures smooth, with faint rugae, posterolateral enclosure smooth, lateral tooth obtuse, with translucent apex. *Pubescence*: body with erect pale setae; ocular setulae sparse, 0.4 MOD long; flagellar setae 0.4 MOD long. *Color*: head and thorax black; metasoma dark brown; scape yellow; pedicel and flagellum brown.

Female.—Body length 3.0 mm; same as ♂, except flagellomere I length 2.8× breadth; flagellomere II length 0.6× breadth (Fig. 19); scapal basin densely cross-ridged; frons, vertex, pronotum with dense, contiguous punctures dorsally; mesopleuron sparsely punctate anteriorly, impunctate posteriorly; head and thorax black, dorsum with faint yellowish tints, with erect black setae; antenna and legs brown.

Etymology.—The name derives from the superficial resemblance of this species to *cubana*.

Type material.—Holotype ♂: USA: Puerto Rico, Bosque Estatal de Guánica, 17°961N 66°847W, 15 ft., 19–25 Sept. 1998 (LACM). Paratypes, 18 ♂♂ (LACM, BME): 5 ♂♂, same data as holotype; 1 ♂, Guánica, 17°84N 66°86W, Sept. 1998, MT, R. Snelling; 5 ♂♂, DOMINICAN REPUBLIC: La Vega Prov., 10 mi ne Jarabacoa, Hotel Montana forest, 16 June–4 July 1995, S. & J. Peck, FIT, #95-30; 2 ♂♂, La Vega Prov., PN A. Bermudez, Cienaga, 19 July–2 Aug. 1995, 1010 m, tropical evergreen forest, FIT, S & J. Peck, 95-30; 1 ♂, La Vega Prov., 12 km ne Jarabacoa, 550 m, 1–17 Sept. 1988, flight intercept trap, M.A. Ivie, T.K. Philips, J. Jonson; 2 ♂♂, La Vega Prov., PN A. Bermudez, near La Ciénaga, 1000 m, FIT, 12–22 Jan. 1989, L. Masner; Parque Nacional del Este, 18°21N 68°49W, 16–17 Nov. 2005, L. Masner, YPT; VIRGIN IS.: 1 ♂, St. John Est. Caneel Bay, Caneel Hill, 240 ft., 17 Dec.–2 Jan. 1992, VIBFP colrs., flight intercept trap #6.

Additional specimens: 16 ♀♀: DOMINICAN REPUBLIC: La Vega Prov., 10 mi ne Jarabacoa, Hotel Montana forest, 18 July–4 Aug. 1995, 550 ft, S. & J. Peck, FIT, 95–30; Duarte, 15 km ne San Francisco de Macoris, 800 m, Loma Quita Espuela, MT, May–July 1991; Duarte, 20 km ne San Francisco de Macoris, 800 m, Loma Quita Espuela, MT, 19–26 Mar. 1991; Prov. La Vega, 12 km ne Jarabacoa, 550 m, 1–17 Sept. 1988, flight intercept trap, Ivie, Philips & Johnson; Pedernales, 4 km w Oviedo, 10 m, NP Jaragua, 28 Nov.–4 Dec. 1991, FIT, L. Masner & S. B. Peck; Punta Cana Reserva, 18°30.40N 68°22.38W, 11–14 Nov. 2005, forest, L. Masner, YPT.

Discussion.—The ten Caribbean species, (*cubana, dominicana, insula, jamaicensis, acuta, nesos, minuta, paracubana,* and *puertoricana*) all have a smooth, unsculptured scapal basin and bidentate male mandibles. *A. paracubana* most closely resembles *insula*. It can be distinguished from *insula* by the larger eye (twice the length of the malar space), broader postocular distance (more than 1 MOD wide), somewhat shorter malar space (2.5 MOD versus 2.9 MOD long) and generally smaller body length (2 mm, versus 3.5–4.0 in *insula*).

Female specimens listed under "Additional specimens" are not treated as paratypes for this species because although they were collected at the same time and place as the males they do not share enough characteristics to be certain that they are conspecific. There are multiple species known from males from the Dominican Republic and Puerto Rico.

Adelphe polita Kimsey, **new species**
Figs 12, 20, 33

Male.—Body length 3 mm. *Head* (Fig. 12): face polished, sparsely punctate, punctures

shallow, 1–2 PD apart; scapal basin smooth, with some wrinkles laterally; mandible with two apical teeth; subantennal space 1.6 MOD long; malar space 2.6 MOD long; eye height 2.7× malar space length; postocular distance 1.4 MOD wide, occipital carina area 0.4 MOD weakly punctate not septate (Fig. 33); flagellomere I 3.8× as long as broad; flagellomere II 2.3× as long as broad *Thorax*: pronotal carina well-developed laterally; mesopleuron highly polished, punctures small, 2–3 PD apart, posteriorly nearly impunctate, scrobal sulcus 5.4× as long as broad; metanotal disk 2.5× as broad as long; propodeal dorsomedial enclosure with coarse transverse cross-ridges, dorsolateral enclosure cross-ridged, posterolateral enclosure rugose, lateral tooth short, apically acute. *Pubescence*: body with sparse erect dark brown setae; ocular setulae 0.6 MOD long; flagellar setae 0.6 MOD long. *Color*: head and thorax black, dorsum with metallic tints; metasoma dark brown, legs yellow; antenna brown, with slightly lighter colored scape.

Female.—Body length 3.0–3.5 mm; same as ♂, except flagellomere I length twice breadth; flagellomere II length 0.6 breadth (Fig. 20); scapal basin densely cross-ridged; frons, vertex, pronotum and mesopleuron with dense punctures, 0.5 PD apart, becoming impunctate posteriorly; head and thorax black, dorsum with faint metallic yellow tints, with erect black setae; antenna dark brown, metasoma reddish brown; legs yellowish brown; wing membrane brown-tinted.

Type material.—Holotype ♂: BOLIVIA: Santa Cruz, 5 km sse Buena Vista, 440 m, 17°29.95S 63°39.129W, 15–24 Dec. 2003, S. & J. Peck, FIT (CNC). Paratypes: 19 ♂♂, 7 ♀♀ (BME, CNC); 17 ♂♂, 5 ♀♀, same data as holotype; 1 ♂, 2 ♀♀, Cochabamba, Est. Biol. Valle Sajta, 300 m, 17°06.52S 64°47.87W, 7–9 Feb. 1999, R.S. Hanley & F. Génier, FIT; 1 ♂, 17°08.52S 65°.46.57W, 6–8 Feb. 1999, F., FIT, cloud forest.

Etymology.—The name, *polita*, refers to the polished appearance of the face and mesopleuron (Latin, feminine).

Discussion.—This is the only species so far described or recorded from Bolivia. The most distinctive features of *polita* are the broad, ovoid scrobal sulcus in both sexes, and male with flagellomere I 4× as long as broad, face smooth and polished and a bidentate mandible. The entire male body is smooth and largely impunctate. Male *polita* most closely resemble the Brazilian species *brasiliensis* and Jamaican species *insula*. It can be distinguished from these species by the longer flagellomere I, longer subantennal distance and the eye height less than twice the malar space length.

Adelphe unidens Kimsey, **new species**
Figs 13, 34

Male.—Body length 3.0 mm. *Head* (Fig. 13): face with nearly contiguous, medium punctures; scapal basin coarsely cross-ridged; mandible with one apical tooth; subantennal space 1.2 MOD long; malar space 3.0 MOD long; eye height 1.5× malar space length; postocular distance 0.8 MOD wide, occipital carina area 0.4 MOD wide, punctate, not septate (Fig. 34); flagellomere I 2.5× as long as broad; flagellomere II 1.2× as long as broad. *Thorax*: pronotal lateral carina well-developed; mesopleuron coarsely punctate anteriorly, punctures large, 0.5 PD apart, becoming impunctate posteriorly, scrobal sulcus parallel-sided, 6.0× as long as broad; metanotal disk 1.7× as broad as long; propodeal dorsomedial and dorsolateral enclosures transversely rugose, posterolateral enclosure irregularly rugose, lateral tooth obtuse. *Pubescence*: body with black setae; ocular setulae 0.7 MOD long; flagellar setae 0.1 MOD long. *Color*: head and thorax black; legs dark brown, with pale coxal-femoral and femoral-tibial joints; antenna black.

Female.—Unknown.

Etymology.—The name, *unidens*, refers to the single mandibular tooth.

Type material.—Holotype ♂: COSTA RICA: San Jose, P. N. Braulio Carrillo, 8 km ne Tunel, 1100 m, 15/v/1989, P.

Hanson (BME). Paratype: 1 ♂, Limón, 4 km ne Bribri, 50 m, ix–xi/1989, P. Hanson (MUCR).

Discussion.—Among the four species (*unidens, paradoxa, hyalophora* and *gibba*) that have a cross-ridged scapal basin and single, apical mandibular tooth in the male, *unidens* very closely resembles the Brazilian *paradoxa*. *Adelphe unidens* is the only Central American representative of the group. It can be distinguished from *paradoxa* by the longer subantennal distance (more than 1 MOD versus 1 MOD long), shorter flagellomere I (less than 2.8× as long as broad) and shorter eye height relative to the length of the malar space (only 1.5× malar space length versus longer) and flagellomere IX (4× as long as broad versus 3×).

ACKNOWLEDGEMENTS

This study was made possible by all of the collections staff who loaned me specimens. I particularly wish to thank Lubomir Masner, whose tireless collecting and education of others has revealed many new species of amisegines.

LITERATURE CITED

Kimsey, L. S. 1986. New species of the American genus *Adelphe* Mocsáry (Hymenoptera, Chrysididae). *Insecta Mundi* 1: 197–206.

———. 1993. New neotropical amisegine wasps (Hymenoptera: Chrysididae). *Pan-Pacific Entomologist* 69: 205–212.

——— and R. M. Bohart. 1991 (1990). *The chrysidid wasps of the world*. Oxford University Press, Oxford. ix + 652 pp.

Krombein, K. V. 1957. A generic review of the Amiseginae, a group of phasmatid egg parasites, and notes on the Adelphinae. *Transactions of the American Entomological Society* 82: 147–215.

J. HYM. RES.
Vol. 17(2), 2008, pp. 175–194

The Genus *Mymaromella* (Hymenoptera: Mymarommatidae) in North America, with a Key to Described Extant Species

JOHN T. HUBER*, GARY A. P. GIBSON, LEAH S. BAUER, HOUPING LIU, AND MICHAEL GATES

(JH) Canadian Forestry Service, Natural Resources Canada, c/o K.W. Neatby building, 960 Carling Avenue, Ottawa, ON, K1A 0C6, Canada; email: huberjh@agr.gc.ca
(GAPG) Agriculture and Agri-Food Canada, Biodiversity and Integrated Pest Management, K.W. Neatby building, 960 Carling Avenue, Ottawa, Ontario, Canada, K1A 0C6, Canada; email: gibsong@agr.gc.ca
(LSB) USDA Forest Service, Northern Research Station, 1407 S. Harrison Rd., East Lansing, MI, 48823, USA; email: lbauer@fs.fed.us
(HL) Department of Entomology, Michigan State University, East Lansing, Michigan, 48824, USA; email: liuho@msu.edu
(MG) Systematic Entomology Laboratory, USDA, c/o National Museum of Natural History, Washington, DC, 20013-7012, USA; email: michael.gates@ars.usda.gov

Abstract.—A key is given to the five described extant species of *Mymaromella*. Two new species, *Mymaromella pala* Huber & Gibson, sp. n. and *M. palella* Huber & Gibson, sp. n. (Mymarommatoidea: Mymarommatidae), are described as the first species of the family from North America. Psocoptera (Insecta) are proposed as the probable hosts of Mymarommatidae, based on circumstantial evidence obtained from their morphology, phenology, biogeography, habitats, and paleontology.

Gibson et al. (2007) revised the higher classification of Mymarommatoidea (Hymenoptera), recognizing two families, the extinct family Gallorommatidae and the Mymarommatidae. Mymarommatidae contains 18 described species in five genera, of which two genera and seven species are known only from fossils (Gibson et al. 2007). One of the three extant genera, *Mymaromella* Girault, contains one extinct and three extant species. The extant species include the type species of the genus from Australia, *M. mira* (Girault), plus *M. chaoi* (Lin) from China and *M. cyclopterus* (Fidalgo & De Santis) from Argentina. The extinct species *M. duerrenfeldi* (Schlüter & Kohring), from Sicilian amber, is about 5 million years old.

No extant species of Mymarommatidae have been formally described from the Nearctic region though their presence has been known for many years (Clouâtre et al. 1989, Gibson 1993, Gibson et al. 2007). The three specimens that Clouâtre et al. (1989) identified in their paper as an unidentified species of *Palaeomymar* Meunier represent one of our new species of *Mymaromella*. Since their initial collection, several more specimens of this species and a second new species of *Mymaromella* have been collected from various localities in Canada and USA. Recent, intensive surveys in Michigan for natural enemies of the emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae) yielded about 30 specimens of one of the new species. These specimens emerged in the laboratory from cut sections of ash trees (*Fraxinus* spp.: Oleaceae). Here we describe the two *Mymaromella* species from North America and provide a key to the five described extant species of *Mymaromella*. Undescribed species tenta-

* Corresponding author

tively identified by Gibson et al. (2007: 120, species 16–23) are not described here because of insufficient material.

Gibson (1993) reported a single specimen of one of our new species as reared from a backet fungus. Other than this record and the specimens reared from ash logs, nothing is known of the biology or hosts of Mymarommatidae. Because of their minute body size, Yoshimoto (1984) suggested mymarommatids probably are parasitoids of insect eggs.

METHODS

This study is based on specimens from the institutions listed below. Acronyms preceding the institution designate deposition of specimens; the name of the curator of the collection is given in parentheses:

ANIC Australian National Insect Collection, Canberra, Australia (J. LaSalle).

CNC Canadian National Collection of Insects, Ottawa, Canada (G. Gibson, J. Huber).

FAFU Biological Control Research Institute, Fujian Agricultural and Forestry University, Fuzhou, Fujian, China (N.-Q. Lin).

MLPA Museo de la Plata, La Plata, Argentina (M. Loiácono).

MSUC Entomology Collection, Michigan State University, East Lansing (G. Parsons).

UCRC University of California, Riverside, CA, USA (S. Triapitsyn).

USNM National Museum of Natural History, Washington, DC, USA (M. Gates).

Numerous specimens of *M. pala* n. sp. were obtained during research on the natural enemies of the emerald ash borer in southeastern, lower Michigan, USA (Bauer et al. 2003, 2007). The specimens were reared from heavily infested green (*Fraxinus pennsylvanica* Marsh) and white (*F. americana* L.) ash trees. At each of 14 sites, 2 or 3 heavily infested ash trees were randomly selected, felled with a chainsaw, and cut into 60 cm logs from March through May 2004; each log was identified by site, tree, and height above the ground. The logs were stored in a walk-in cold room at 4°C. From April through November, logs were removed from cold storage and placed inside individual cardboard tubes (20–30 cm in diameter by 70 cm in length) (Saginaw Paper Tube, Saginaw, MI) for emergence of insects in the laboratory at 20–25°C, 40–60% RH, and 24 hr lighting. The emergence tubes were capped on one end with a plastic lid to exclude light and the other end was sealed with a plastic lid modified by the addition of a translucent plastic screw-top collection cup from which emergent insects were collected daily for up to 8 weeks. The mymarommatid specimens, already dead in the collection cups as well as at the bottom of the emergence tubes, were removed and placed in 70% ethanol for subsequent preparation at the CNC. Some specimens were slide mounted in Canada balsam and the rest were card-mounted. A few specimens had been used previously for scanning electron micrographs (Gibson et al. 2007).

Material examined includes figure number(s) for the specimens that were used to illustrate the respective species in the plates of illustrations. Measurements used in the species treatments are in micrometers. Morphological terms are described in Gibson (1997). Abbreviations used are FIT = flight intercept trap, fl_x = funicle segment (female) or flagellomere (male), FWL = fore wing length, FWW = fore wing width, MT = Malaise trap, POD = posterior ocellus diameter, POL = poserior ocellar line.

MYMAROMELLA GIRAULT

Mymaromella Girault, 1931: 4; Gibson et al., 2007:100 (redescription).

Diagnosis.—Propleura abutting but not fused; foretibial calcar relatively long,

curved and apically bifurcate; occipital plate with paramedian setae (apomorphy 4); clava of female with the two or three s4-type sensilla usually situated more or less medially (apomorphy 13) but sometimes in dorsal third; metanotum fused posterolaterally to propodeum (apomorphy 16); metapleural pit about midway between ventral margin of pleuron and propodeal spiracle (apomorphy 18).

The above features and apomorphy numbers are abstracted from the key and character state summary in Gibson et al. (2007: 94, 120). The genus is variable and difficult to define but the curved, apically bifurcate calcar separates *Mymaromella* species from those of *Palaeomymar* and *Mymaromma*. In females, the 1-segmented clava separates *Mymaromella* species from those of *Zealaromma*.

KEY TO FEMALES OF EXTANT SPECIES OF *MYMAROMELLA*

1	Ocelli absent (Figs 13, 14); fore wing convex, spoon-like	***M. palella* Huber & Gibson**
–	Ocelli present (Figs 1, 2); fore wing flat	2
2(1)	Fore wing without a single, long, thin seta on hind margin just basal to row of short spine-like setae (Figs 17, 19, 20, 21), the posterior fringe thus beginning with a short, spine-like seta	3
–	Fore wing with a single long, thin seta basally on hind margin, the posterior fringe thus beginning with a long, slender seta (Figs 18, 22, 23)	5
3(2)	Fore wing wider and more distinctly truncate apically (Fig. 19)	***M. cyclopterus* Fidalgo & De Santis**
–	Fore wing narrower and more rounded apically (Figs 17, 18, 20)	4
4(3)	Fore wing surface with acanthae shorter and thinner (Fig. 20)	***M. pala* Huber & Gibson**
–	Fore wing surface with acanthae longer and thicker (Figs 17, 18)	***M. chaoi* Lin (part)**
5(2)	Eye with more than 35 ommatidia	***M. mira* Girault**
	Eye with fewer than 20 ommatidia (specimens from Hebei, China, with unusually long ovipositor)	***M. ?chaoi* Lin (part)**

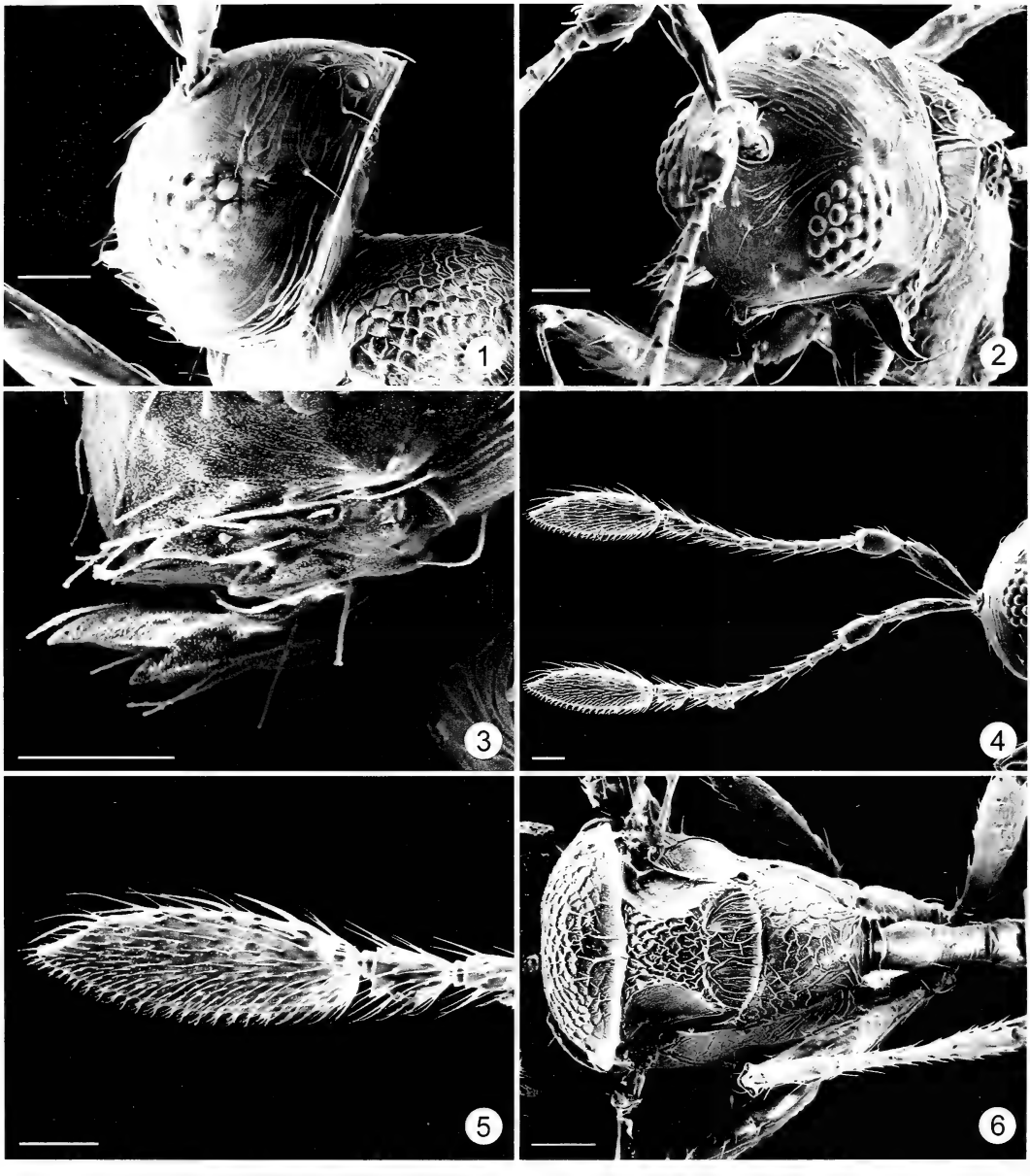
Mymaromella pala Huber & Gibson, sp. n.
(Figs 1–10, 20, 26, 30)

Mymaromella sp. 14: Gibson et al., 2007 (figs 41, 44, 48, 91, 92, 117, 130, 139, 167, 177, 178).

Etymology.—The specific epithet *pala* is Latin for "shovel", referring to the shovel-shaped outline of the fore wing.

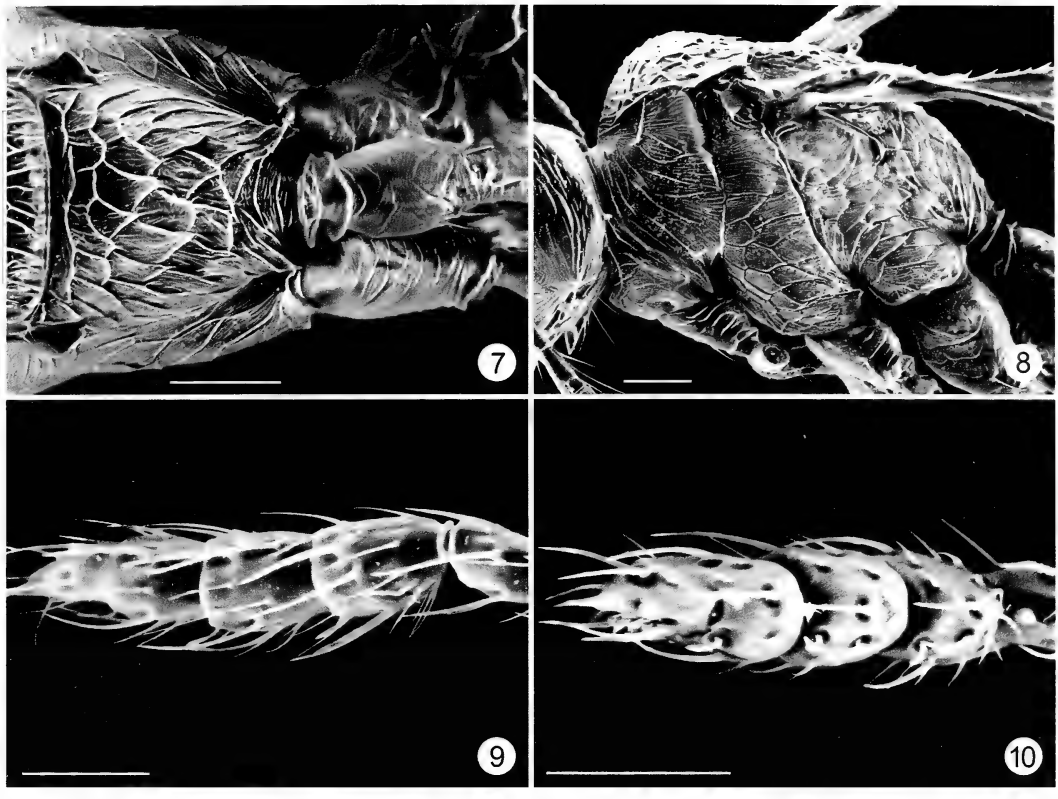
Material examined.—**Holotype** female (CNC), in good condition, mounted dorsally under three cover slips on slide with two labels: 1. "USA: MI, Wayne Co., Flat Rock, Oakwoods Metro Park, em. 14.ix.2004 ex log of Fraxinus pennsylvanicus or americana". 2. "Mymaromella pala Huber and Gibson Holotype ♀ dorsal". 3. "CNCI JDR-specm 2005-387 (green label)".

Paratypes. 37♀ and 1♂ on cards or points, 7♀ and 2♂ on slides. **CANADA. Ontario:** Haliburton Forest and Wildlife Reserve, 45°15'N 78°35'W, 7.viii.2001, C. Vance, canopy MT, maple (Fig. 6) (3♀, CNC), same data, ground MT, pine forest (1♀, CNC); Oxford Mills, 3–10.viii.1973, G. Gibson (1♀, CNC); Shirley's Bay, Innes Point [ca. 15 km W. Ottawa], 29.vii–5.viii, 5–12.viii, 5–11.ix (Figs 1, 4, 5), 24.ix–1.x.1985, M. Sanborne, MT (4♀, CNC).**USA. California:** *Plumas Co.*, 8 mi. NW. Chester, Warner Creek, 5000', 3.ix.1993, E.E. Lindquist, ex. cottonwood litter (2♀, CNC). **Maryland:** *Calvert Co.*, 7 mi. S. Prince Frederick, 24.viii–14.ix.1987, hardwood forest, MT, CNC Hym. team (1♀, CNC). *Prince George Co.*, Laurel, Patuxent Wildlife Research Center, 25.vii–8.viii.1980, M. Schauff, Malaise in old field (1♂, USNM).



Figs 1–6. *Mymaromella pala*. 1, head, dorsolateral; 2, head; 3, mandibles; 4, female antennae; 5, female clava; 6, mesosoma and petiole, dorsal. Scale lines = 20 μm.

Michigan: *Livingston Co.*, Brighton Island Lake State Park, 2.vi.2004 (1♀, CNC). *Oakland Co.*, Milford, Kensington Metro Park, em. 30.viii and 10.xi.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (4♀, UCRC, USNM) and 25.v.2004 (Figs 9, 10) (1♂, CNC); White Lake, Indian Springs Metro Park, 22.v and 17.vi.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (2♀, MSUC). *Washtenaw Co.*, Ann Arbor, Delhi Metro Park, em. 22.v and 4.vii.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (4♀, MSUC, USNM); Willis, Sylvia Taylor's woodlot, em. 26.vi.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (1♀, CNC). *Wayne Co.*, Belleville, Lower Huron Metro Park, em. 24.v.2004, ex mixed rearing logs, L. Bauer (4♀, CNC, FAFU) and 18.viii.2004,

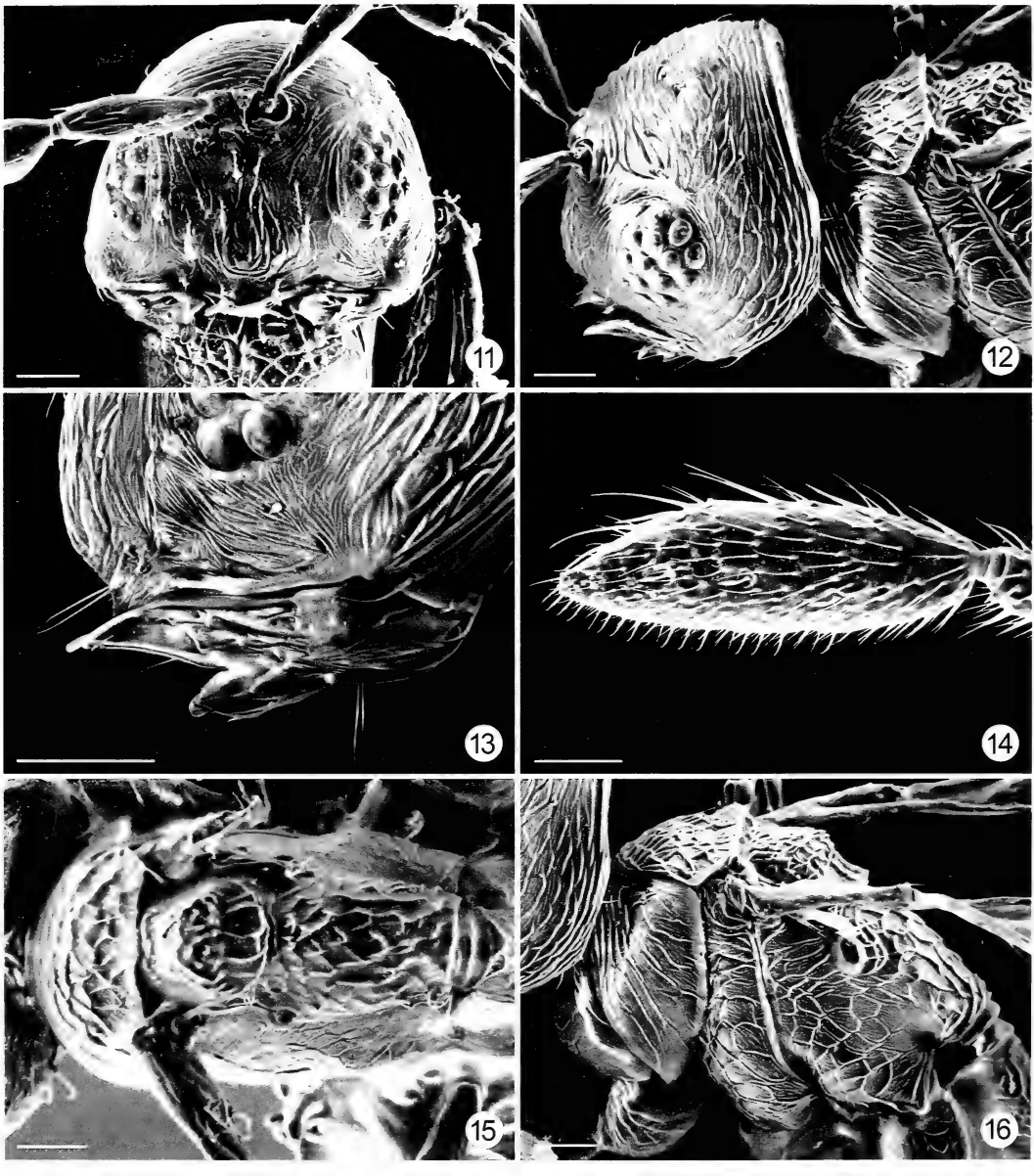


Figs 7–10. *Mymaromella pala*. 7, propodeum and petiole, dorsal; 8, mesosoma, lateral; 9, male clava, lateral; 10, male clava, anterolateral. Scale lines = 20 µm.

ex. *Fraxinus pennsylvanica* or *F. americana* logs (Fig. 30) (1♀, CNC); Flat Rock, Oakwoods Metro Park, em.10.vi (Fig. 3), 11.vi, 18.viii and 14.ix.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (3♀, 1♂, CNC); various counties in Detroit area, em. 2.vi (Fig. 2), 8–9.vi and 19.vi.2004, ex white or green ash logs (4♀, CNC). **New York:** *Jefferson Co.*, Alexandria Bay environs, 7.v.1978, L. Masner and L. Huggert, reared in lab. from dry bracket fungus on ?*Acer* sp. v–vi.1978 (1♀, CNC). **North Carolina:** *Dorchester Co.*, Francis Beidler Forest, 10 km NE. Harleyville, 5–15.v.1987, bald cypress swamp, MT (1♀, CNC). *McDowell Co.*, 37°00′N 81°30′W, 9.vii–17.ix.1987, FIT, oak-rhododendron CNC Hym. team (2♀, CNC). **South Carolina:** *Anderson Co.*, Pendleton, Tanglewood Spring, 34°38.7′N 82°47.1′W, 225 m, 16–29.vii.1987, J. Morse, MT (Figs 7, 8) (3♀, CNC). **Virginia:** *Montgomery Co.*, 8 km NW. Blacksburg, 19–30.vi.1987, 1000 m, rural area, MT, CNC Hym. team (1♀, CNC).

Diagnosis.—Mymaromella pala differs from *M. palella* Huber & Gibson, the only other *Mymaromella* species in North America, by the presence of ocelli, and a flat fore wing with longer and more numerous marginal setae (Fig. 20). *M. palella* has a concave fore wing with shorter, thicker and fewer marginal setae, Fig. 21, fewer eye facets (cf. Figs 2, 11) and a comparatively wider gena.

Mymaromella pala differs from *M. cyclopterus* (Fidalgo & Ogloblin) by its slenderer fore wing with less prominent acanthae on the wing surface, and from *M. mira* Girault and some *M. chaoi* Lin by the absence of a long, basal seta on the posterior margin of the fore wing. From other *M. chaoi* sensu Lin (1994) that have a long seta on the



Figs 11–16. *Mymaromella palella*. 11, head, anterior; 12, head + anterior part of mesosoma, dorsolateral; 13, mandible; 14, female clava; 15, mesosomal, dorsal; 16, mesosoma, lateral (= fig. 96 in Gibson et al. 2007). Scale lines = 20 µm.

posterior margin of the fore wing it is differentiated by shorter and thinner acanthae on the wing surface (cf. Figs 18, 20).

Description.—**Female**. Body length 297–356 µm (mean = 328, n = 9; air dried specimens from Michigan). Body honey yellow, except clava and sometimes apical two funicular segments slightly darker, greyish, and apical half of gaster brown. Petiolar segments and legs pale yellow. Eyes and ocelli grey with a pink tinge. Hind leg and, less distinctly, middle and fore legs with apparent apex of each tarsomere narrowly brown (slide mounts show that it is the basal insertion of a

segment into the previous segment that is brown). Mesopleuron occasionally with minute brown spot below base of fore wing.

Head. Width 102–108 (n = 5). Face with 1 seta ventromedially next to each eye, 2 or 3 submedian setae in a row ventral to each torulus, 2 median setae in a line ventral to and between toruli and 4 short submedian setae in a row just above mouth opening; sculpture finely obliquely striate and oblique between eyes except medially where it forms a faint, circular, engraved-reticulate pattern (Gibson et al. 2007, fig. 48). Ocelli present, forming an equilateral triangle (Figs 1, 2); POL = 11, POD = 6. Frons with 1 seta next to anterior ocellus and 2 setae lateral to posterior ocelli; sculpture transverse-striate. Eye with about 20–26 ommatidia. Back of head (Gibson et al. 2007, fig. 41) with 2 submedian setae well above foramen magnum and 3 setae in a vertical row lateral to foramen; sculpture above foramen magnum reticulate, isodiametric medially but becoming more elongate laterally; sculpture lateral to foramen magnum engraved and obliquely striate; gena width equal to eye width. Mouthparts as shown in Gibson et al. 2007 (fig. 41, posterior view; fig. 44, ventral view); mandible with two distinct teeth (Fig. 3).

Antenna. Fl_6 the longest funicular segment (Figs 4, 26), fl_7 the widest, with its ventral margin convex (Gibson et al. 2007, fig. 178 nec 177), clava in lateral view as in Fig. 5. L(W) measurements (n = 6, except n = 4 for scape): scape 59–63 (12–15); pedicel 32–34 (14–16); fl_1 10–13 (6–7), fl_2 13–15 (6–7), fl_3 15–17 (6–7), fl_4 15–18 (7), fl_5 18–23 (7–8), fl_6 27–29 (7–9), fl_7 23–26 (11–12), clava 78–85 (20–27).

Mesosoma. Total length 128–138 (n = 7). Mesoscutum length 36–41, width 82–84 (n = 4); scutellum length 43–48. Sculpture dorsally (Fig. 6) mostly isodiametric reticulate on mesoscutum except posteriorly, on anterior scutellum and, more coarsely, on propodeum (Fig. 7; Gibson et al. 2007, fig. 91); axilla smooth; posterior margin of mesoscutum and posterior scutellum with elongate reticulate sculpture (Fig. 6); mesosoma laterally (Fig. 8) with shallower, almost engraved reticulation. Propleura, pronotum, and mesopleuron faintly, striate/reticulate (Fig. 8).

Fore wing. Flat, with broadly rounded apex (Fig. 20; Gibson et al. 2007, figs 117, 130, 167); dorsal surface with relatively short acanthae arranged in poorly defined rows at least in basal part of blade; posterior margin with about 8 short, spine-like setae. FWL 317–365, FWW 120–148, FWL/W 2.27–2.87, longest marginal setae 121–151, venation length 59–68 (n = 8).

Legs. Metacoxa reticulate, remainder of legs apparently smooth. Metatibia length 104–110 (n = 5).

Metasoma. Petiolar segment 1 length 72–78, segment 2 length 69–72 (n = 7), both petiolar segments with irregular transverse striations and segment 1 with two setae at or just before mid-length (Gibson et al. 2007, fig. 92). Gaster apparently smooth. Ovipositor (including valves) length 49–53 (n = 5), 0.36–0.40 (n = 6) times metatibia length.

Male. Similar to female except as follows. Antenna (Fig. 30; Gibson et al. 2007, fig. 177 nec fig. 178) with 4-segmented clava, but apical two segments only indistinctly separated (Figs 9, 10). L/W measurements (n = 1) scape about 57 (12), pedicel 33 (17), fl_1 11 (7), fl_2 15 (8), fl_3 16 (7), fl_4 17 (7), fl_5 21 (8), fl_6 27 (8), fl_7 26 (12), fl_8 25 (16), fl_9 22 (16), fl_{10} 17 (15), fl_{11} 20 (12). POD 9, slightly larger than for female, and POL 9, slightly shorter than for female.

Biology.—Unknown. Specimens were reared from a bracket fungus and from ash logs (see type material, above). Based on its morphology (flat, well-developed fore wing evidently capable of flight) and micro-habitat (ash logs), *M. pala* is postulated to parasitize arboreal hosts on tree trunks.

Mymaromella palella Huber & Gibson, sp. n.

(Figs 11–16, 21, 27)

Palaeomymar sp.: Clouâtre et al., 1989: 825 (collection localities, habitat description).

Mymaromella sp. 15: Gibson et al., 2007 (figs 43, 96) (generic transfer).

Etymology.—The specific epithet *palella* is Latin for "little shovel", referring to the shovel-like nature of the fore wing, both in outline and in depth.

Material examined.—**Holotype** female (CNC), in good condition, mounted dorsally under two coverslips on slide with three labels: 1. "Canada: QC, Mirabel, 15.viii.1984, A. Clouâtre, forest litter, CNC det. lot 88-638". 2. "CNCI JDR-specm 2005-207 (green label)". 3. "Mymaromella palella Huber & Gibson HOLOTYPE female dorsal".

Paratypes. 5♀. **CANADA. New Brunswick:** Kouchibouguac Nat. Park, Kolloch Creek trail, 10.viii.1979, E. Lindquist, ex. maple, white pine litter, Berlese extraction (Figs 12, 13, 16) (1♀, CNC). **Ontario:** Alfred Bog, 2.vii.1984, M. Sanborne, MT (Fig. 11) (1♀, CNC); 42 mi. N. Hurkett, 2 mi. S. of outlet at Black Sturgeon Lake, 17.viii.1972, E.E. Lindquist, ex. mixed cedar-alder litter (1♀, CNC). **Quebec:** Mirabel, 25.vi.1984, A. Clouâtre, forest litter (Fig. 15) (1♀, CNC); Argenteuil Co., 7 km NE. Grenville, 45 30'41"N 74 34'34"W, 115 m, ex. Berlese extraction of soil from maple-hickory forest, A. Clouâtre (Fig. 14) (1♀, CNC).

Diagnosis.—*Mymaromella palella* differs from *M. pala* and all other described *Mymaromella* by the absence of ocelli (Fig. 12). It is also differentiated from *M. pala* by its convex fore wing with thicker and fewer long marginal setae (cf. Figs 20, 21), fewer eye facets (cf. Figs 11, 12) and comparatively wider gena. The body of *M. palella* is longer than that of *M. pala*, but this may partly be an artifact due to different methods of preparation (critical point drying vs air drying).

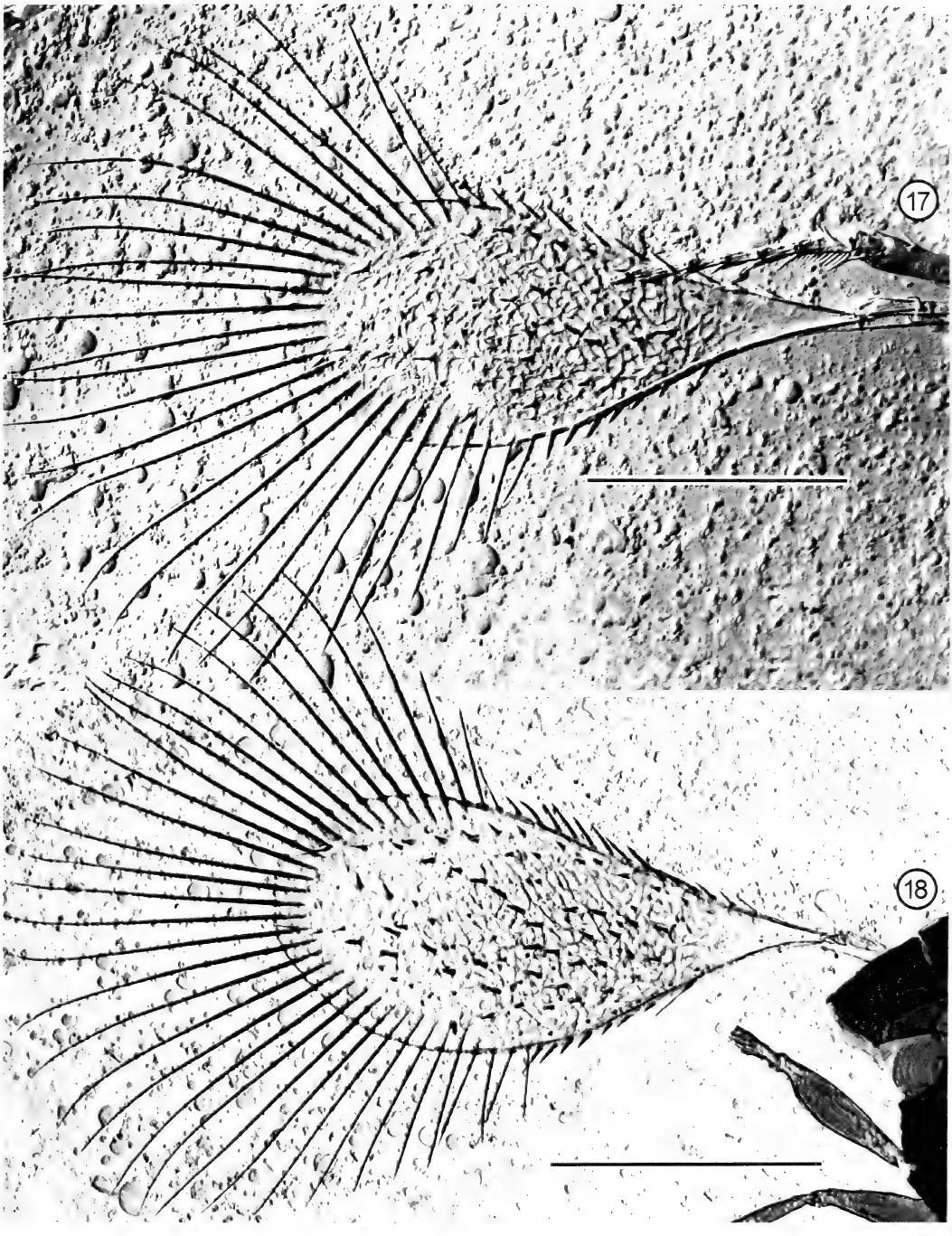
Description.—**Female**. Body length 425–455 μm (mean = 444, n = 5, critical point dried paratypes). Body honey yellow except gaster entirely or, sometimes, only apical third brown. Petiolar segments and legs yellow. Eyes grey with a pink tinge. Apparent apex of each tarsomere narrowly brown.

Head. Width 110–114 (n = 2). Face with 3 setae ventrolaterally next to each eye, 2 submedian setae in a horizontal row below toruli, and 4 short submedian setae in a row just above mouth opening (Fig. 11); sculpture finely obliquely striate between eyes except medially where it forms a circular, engraved-reticulate pattern. Ocelli absent (Figs 11, 12). Frons with a transverse row or two of 2–6 setae above eyes and toruli; sculpture transverse-striate. Eye with about 13 ommatidia (Figs 11, 12). Back of head with 2 submedian setae well above foramen magnum and 4 setae in a vertical row lateral to foramen; sculpture above and lateral to foramen magnum apparently elongate-reticulate to almost striate; gena width greater than eye width. Mouthparts (ventral view) as in Gibson et al. (2007, fig. 43); mandible with 2 distinct teeth (Fig. 15).

Antenna. Fl_6 the longest funicular segment (Fig. 27), fl_7 the widest, with its ventral margin convex, clava in lateral view as in Fig. 16. L(W) measurements (n = 2): scape 53–56 (15–16); pedicel 33–35 (17–19); fl_1 16–18 (8–9), fl_2 16–22 (8–9), fl_3 21–22 (8–9), fl_4 23–24 (9), fl_5 25–28 (8–9), fl_6 38–39 (10), fl_7 29–31 (10–13), clava 87–97 (22).

Mesosoma. Total length 488 (n = 1). Mesoscutum length 29, width about 45 (n = 1); dorsally with sculpture mostly isodiametric reticulate, except axilla smooth; scutellum relatively narrow, with sculpture finer anteriorly than posteriorly (Fig. 17), and laterally with shallower reticulation (Gibson et al. 2007, fig. 96).

Fore wing. Distinctly convex, spoon-shaped (Fig. 21, wing flattened by cover slip and hence slightly distorted), with about 18 long marginal setae at wing apex and distal quarter of blade beyond venation, but with short, spine-like setae along



Figs 17, 18.—*Mymaromella chaoi*, fore wings. 17, holotype; 18, paratype. Scale lines = 50 µm.

basal three-quarters of anterior and posterior margins beyond venation. Dorsal surface of wing with acanthae relatively long, thick and arranged in fairly distinct, oblique rows, at least in basal part of blade. FWL 314–335, FWW 130–134, FWL/W 2.42–2.65, longest marginal setae 79–84, venation length 52–59 (n = 2).

Legs. Metatibia length 143 (n = 1).

Metasoma. Petiolar segment 1 length 72, segment 2 length 40 (n = 1). Gaster smooth. Ovipositor (including valves) length 70–81 (n = 2), 0.49 (n = 1) times metatibia length.

Male. Unknown.

Biology.—Unknown. Based on its morphology (fore wing somewhat reduced and presumably partially protective in function) and microhabitat, *M. palella* is postulated to parasitize hosts in soil or litter. Clouâtre et al. (1989) obtained their specimens from Berlese extraction and the specimens collected by Linquist came from forest litter extractions. *Mymaromella palella* is the only described species of *Mymaromella* that is adapted to crawling through soil or litter as evidenced by the lack of ocelli, relatively few ommatidia in the eye, shortened, spoon-shaped (in depth as well as in outline) fore wing evidently able to envelop the dorsal half or so of the metasoma, and fore wing fringe with relatively few, somewhat thicker and shorter setae than typical. One of the specimens collected by Clouâtre et al. (1989) had only partially expanded wings, indicating that it had freshly emerged from a host.

Mymaromella chaoi Lin
(Figs 17, 18, 24)

Palaeomymar chaoi Lin, 1994: 123.
Mymaromella chaoi Gibson et al., 2007: 100 (generic transfer).

Material examined.—Holotype female (FAFU) on slide under one square cover slip, with three labels in Chinese and English (English part quoted here): 1. "Jinshan, Fuzhou, N26° E119°, 30 Oct. 1987, Naiquan Lin Yellowpan trap." 2. "Palaeomymar chaoi Lin (♀) Holotype". 3. "Holotype (red label)."

Paratypes (Fig 24) (14♀ in FAFU). Because the paper is in Chinese an English translation of localities is provided here. All paratypes, only 10 of which were seen, are from Fujian province as follows: same locality as holotype but 13.ix, 20.ix, 17.x (Fig. 18), 20.x, and 24.x.1987 (7♀); Anle, Ninghua, 16.x.1987 (1♀); Wenquan, Xianyou, 7.x.1987 (1♀); Youxi County, 10.viii.1987 (1♀). All were collected in yellow pan traps. Unfortunately, the specimens are mounted in cloudy balsam.

Six females of *M. chaoi* not listed in the original description (the label dates do not correspond with description dates), and which are therefore not part of the type series, were also examined. Four are from the holotype locality but collected 2.viii.1985, 29.xi.1987, 30.x.1987, and 3.i.1988. One is from Henan, Jiaozuo, 31.vii.2006; it has an ovipositor/hind tibia ratio of 0.42. Two, from Guangxi, Nanning, 30.x.2002 and from Hainan, Danzhou, 6.v.2002, each have an ovipositor/hind tibial ratio of 0.56. All three specimens are considered to be conspecific with *M. chaoi* because their ovipositor/hind tibia ratio falls within the range of the type series. They are the first specimens of *M. chaoi* collected outside Fujian province.

Descriptive notes.—**Female**. Measurements were taken from type specimens (holotype included) collected at the type locality only.

Body length. 378 µm (holotype).

Antenna. Fig. 24. L(W) (n = 10): scape 46–66 (12–18); pedicel 29–36 (15–20); fl_1 10–14 (6–8), fl_2 10–17 (6–8), fl_3 12–19 (6–8), fl_4 12–17 (6–8), fl_5 15–21 (7–9), fl_6 20–30 (7–10), fl_7 20–28 (11–15), clava 62–96 (24–33).

Fore wing. Figs 17, 18. FWL (n = 7) 270–360, FWW 92–134, FWL(W) 2.71–2.95. Based on wing length, *M. chaoi* is the smallest species among the described *Mymaromella* and has the narrowest wings among the species with flat wings.

Metasoma. Ovipositor very short, arising in the apical third of the gaster, 0.39–0.69 times hind tibial length (n = 8).

Variation.—The holotype and five paratypes of *M. chaoi* do not have a long basal fringe seta on the posterior margin of the wing whereas five other paratypes do have it. In specimens lacking the seta it is not

because it is broken off because either the long seta is present on both fore wings of the same specimen or it is absent from both fore wings. At present we cannot determine if this is individual variation or whether two sibling species are present. The species is keyed out twice in order to emphasise the presence or absence of this seta in specimens from the same locality.

Three specimens, not included in the type series, were examined from Hebei, Yangjiaping, viii.2005 (FAFU). They are labelled as *M. chaoi* but have relatively longer ovipositors: ovipositor/hind tibial ratio of 0.93–0.95 and the ovipositor clearly occupies a relatively longer proportion (0.61–0.77) of the gaster than in *M. chaoi*. They are probably not *M. chaoi*. The ovipositor/hind tibia length of the type series of *M. chaoi* varies by about 1.8 times (0.39–0.69). If the Hebei specimens are indeed *M. chaoi* then the ovipositor/hind tibia length would vary up to 2.4 times. Perhaps this is possible within a species but it seems unlikely.

At present, it is perhaps best to consider that *M. chaoi*, as more narrowly defined, includes specimens with a relatively short ovipositor only and either with or without a long basal seta. Much more material is needed to assess variation in these characters more confidently.

Mymaromella cyclopterus Fidalgo & De Santis
(Figs 19, 25, 31)

Palaeomymar cyclopterus Fidalgo and De Santis, 1982: 3.

Mymaromella cyclopterus Gibson et al., 2007: 100 (fig. 166, generic transfer).

Material examined.—The holotype female (Figs 19, 25, 31) and only known specimen of *M. cyclopterus*, is on a slide under one large coverslip, labelled: 1. "Galeomymar cyclopterus & A.O. Loreto, Misiones, 29.iv.1933. A.O. Typus!" 2. Palaeomymar cyclopterus Det. De Santis et Fidalgo Holotypo Museo de la Plata" 3. "3912/1".

Descriptive notes.—**Female. Body length** 409 µm (holotype).

Head. Ocelli are definitely present (Fig. 31), in contrast to what was stated in Fidalgo and De Santis (1982). The number of ommatidia cannot be counted because the eyes are mostly black (Figs 25, 31).

Antenna. Fig. 25. L(W) measurements (holotype) are: scape 56 (15); pedicel 35 (17); fl_1 15 (7), fl_2 19 (7), fl_3 21 (6), fl_4 21 (6), fl_5 24 (8), fl_6 23 (8), fl_7 27 (11), clava 96 (24). FWL 414, FWW 194, FWL(W) 2.13.

Fore wing. Fig. 19. Without a long seta on posterior margin basal to short, spine-like setae of the marginal fringe.

Mymaromella mira Girault
(Figs 22, 23, 28, 29)

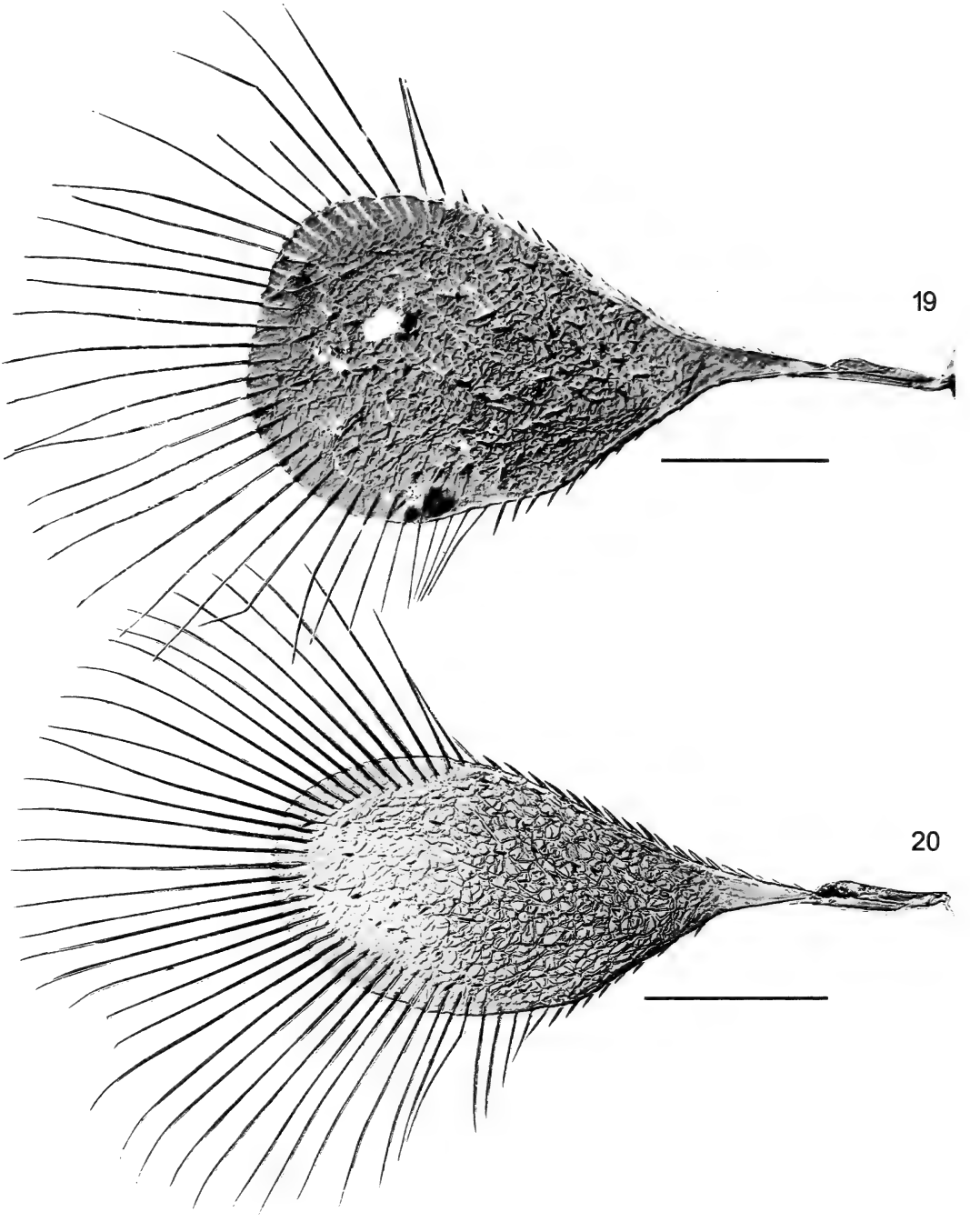
Mymaromella mira Girault, 1931: 4; Dahms, 1984: 823; Gordh et al., 1979: 283 (reprint of original description); Gibson et al., 2007: 101 and figs 13, 35, 65, 66, 93, 94, 97, 98, 162, 168 (revised status from *Palaeomymar*).

Material examined.—The holotype specimen no longer exists, but Fig. 23 is a photograph of it (Gibson et al. 2007).

Twenty-one specimens, including 5♀ and 1♂ on slides, as follows: AUSTRALIA. **ACT:** Blundells Creek, 35.22S 148.50E, ii.1987, D.H. Colless, Malaise trap (Figs. 22, 28) (2♀, ANIC); Canberra, Black Mountain, CSIRO, 1–15.ii.1999, G. Gibson, YPT (Fig. 29) (4♀, 13♂, CNC); Piccadilly Circus, 1240 m, 35.22S 148.48E, xii.1984, J. Lawrence, T. Weir, H.-L. Johnson, light intercept/window/trough trap, figured specimen in the Insects of Australia, 2nd edition (1♀, ANIC). **Victoria:** [?Ot]Otway Forest, Ormond, no date given, W.S. Anderson (1♀, USNM).

Descriptive notes.—**Female. Body length** 376 µm (n = 1, critical point dried specimen), 500–543 (n = 3, slide mounted specimens from Blundells Creek and Black Mountain). Mesosoma brown, head, appendages and petiolar segments honey yellow, gaster usually brown but in one specimen yellow.

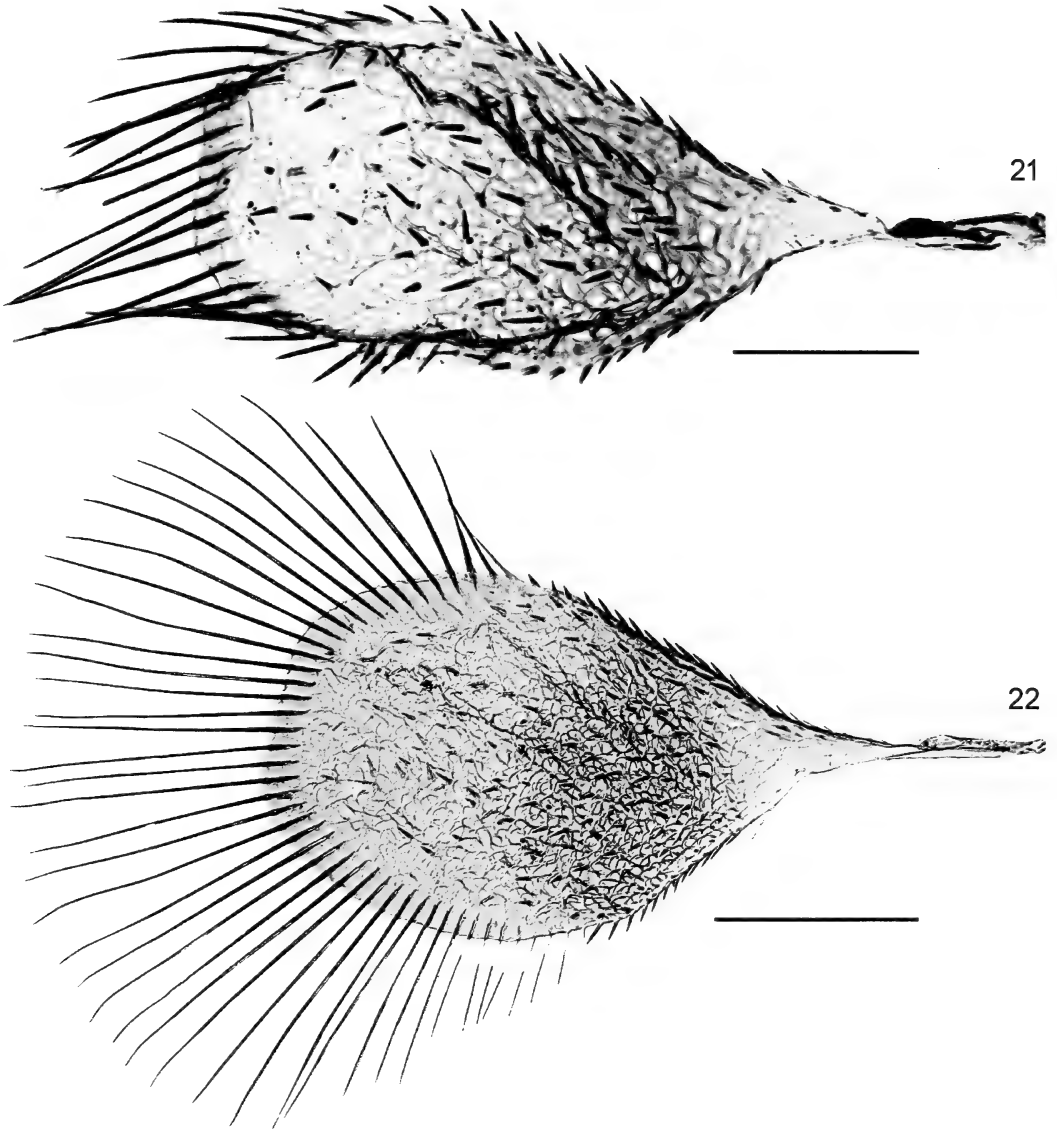
Head. Eye with at least 30 ommatidia (in Black Mountain specimens). Head width 133–142 (n = 2). Sculpture reticulate-striate



Figs 19, 20.—*Mymaromella* spp., fore wings. 19, *M. cyclopterus*, holotype; 20, *M. pala*, holotype. Scale lines = 50 µm.

(Gibson et al. 2007, figs 13, 35). Ocelli present.

Antenna. Female antenna (Fig. 28). L(W) measurements (n = 3 or, for width, 2): scape 66–68 (18); pedicel 36–38 (16–22); fl_1 18–23 (9–11), fl_2 20–24 (8–10), fl_3 24–26 (8–10), fl_4 21–23 (9–10), fl_5 26–30 (9–10), fl_6 40–44 (9–10), fl_7 33–35 (13–16), clava 106–



Figs 21, 22.—*Mymaromella* spp., fore wings. 21, *M. palella*; holotype; 22, *M. mira*. Scale lines = 50 µm.

111 (30–32), with slightly pointed apex (Fig. 29; Gibson et al. 2007, fig. 65).

Mesosoma. Mesosoma with reticulate sculpture, more distinct dorsally than laterally (Gibson et al. 2007, figs 93, 97, 98).

Fore wing. Flat, with broadly rounded apex and with hair-like basal seta (Figs 22, 23; Gibson et al. 2007, fig. 168 — seta not visible in the published image but definitely present in original photograph). Fore wing broad: FWL 508–555, FWW 222–243, FWL/W 2.15–2.29, longest marginal setae 184–190, venation length 85–86 (n = 3).

Metasoma. Petiolar segment 1 length 72–82, segment 2 length 45–47 (n = 2), both petiolar segments with irregular transverse striations and segment 1 with 2 setae at or just before mid-length (Gibson et al. 2007, figs 93, 94). Ovipositor length (including valves) 86–97 (n = 2).

Fig. 23. *Mymaromella mira*, holotype photograph.

Male. Colour as in female except gaster honey yellow. Body length 376–445 (n = 8, critical point dried specimens).

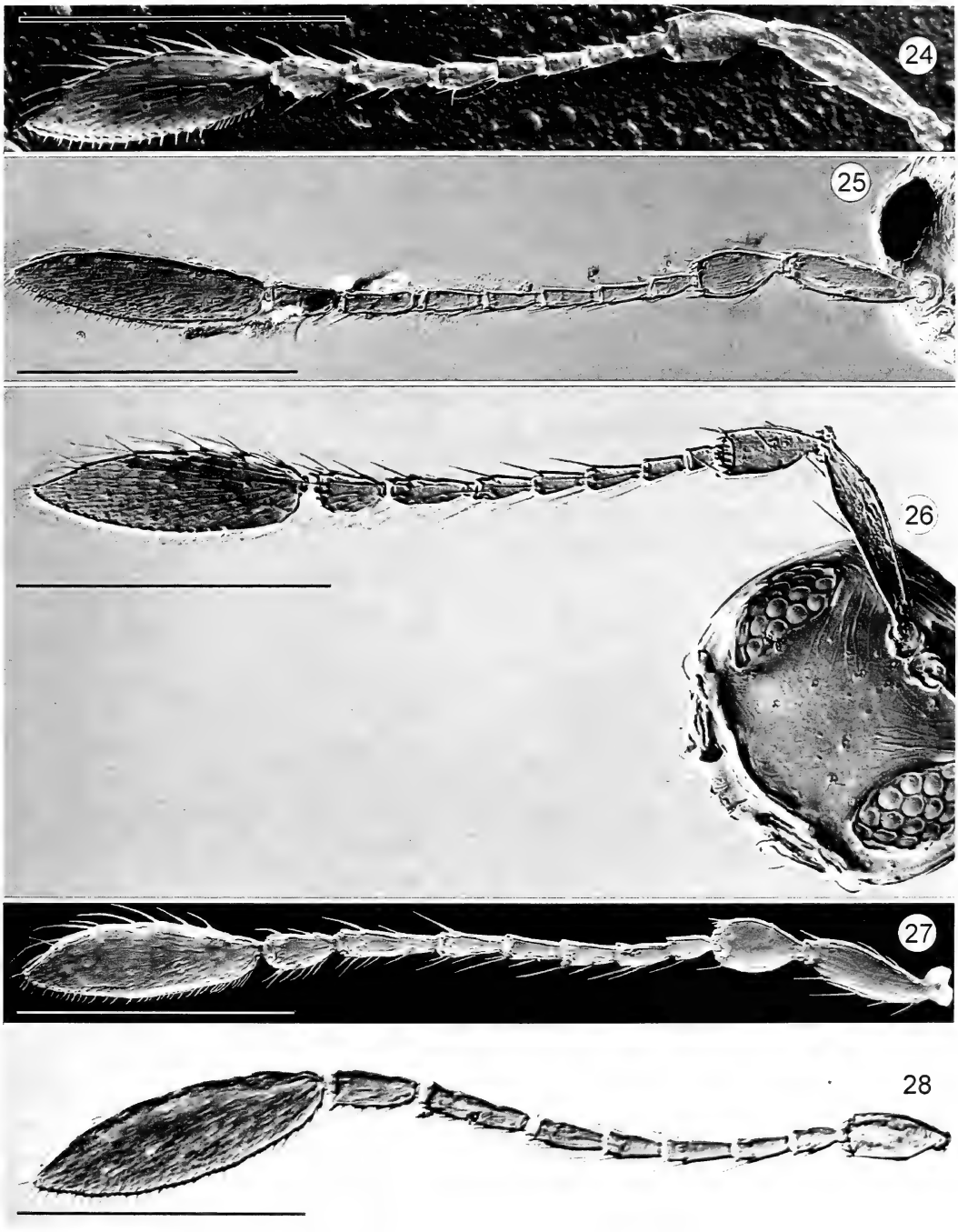
Head. Eye with about 50 ommatidia.

Antenna. Fig. 29 and Gibson et al. (2007) fig. 66. Measurements L (W) (n = 1): scape — not accurately measurable, pedicel 34 (15), fl_1 14 (8), fl_2 17 (9), fl_3 19 (9), fl_4 20 (9), fl_5 29 (9), fl_6 28 (11), fl_7 28 (13), fl_8 28 (16), fl_9 22 (17), fl_{10} 22 (15), fl_{11} 24 (14).

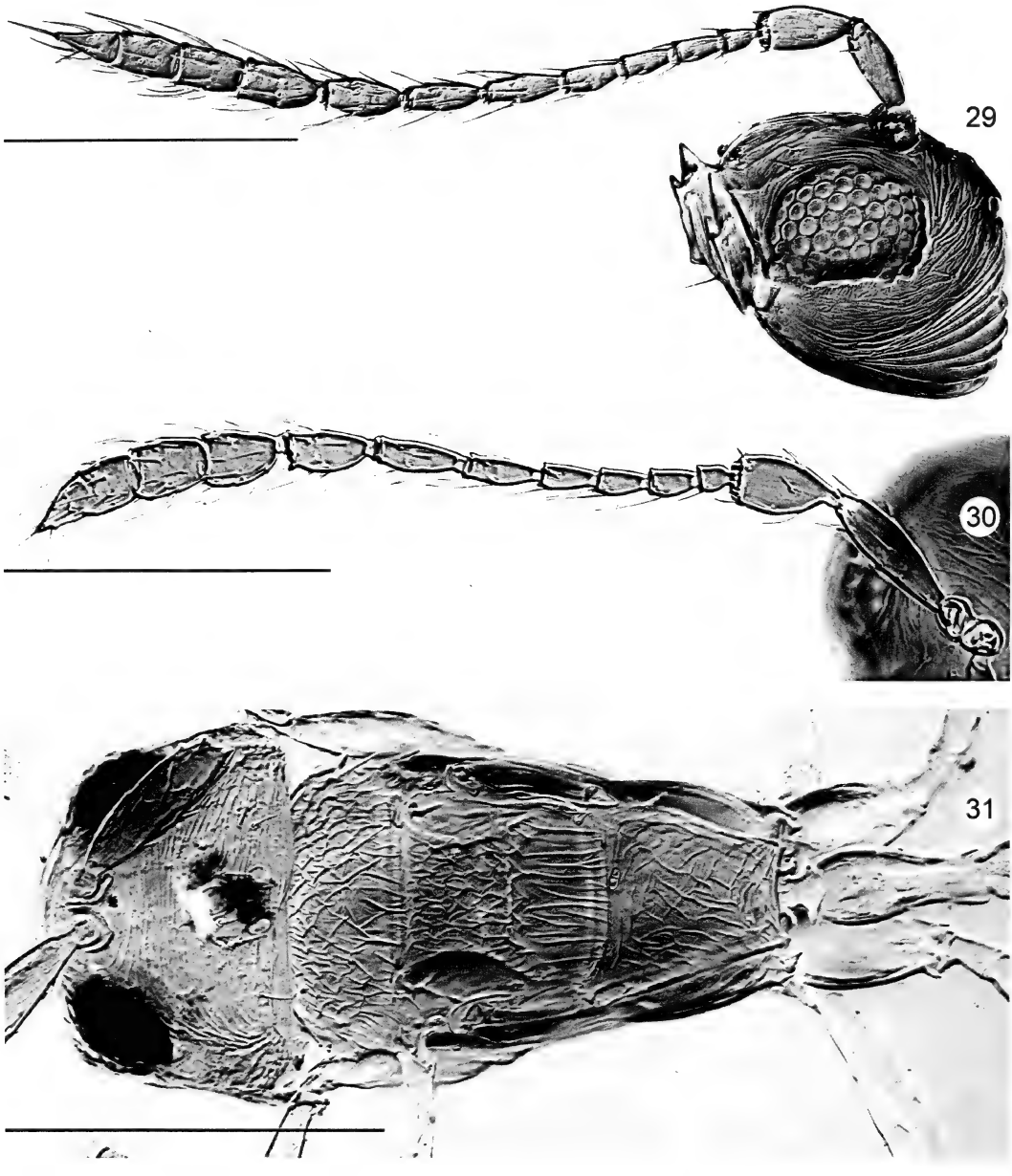
Fore wing. Fig. 23. L/W 2.63 (n = 1).

Metasoma. Genitalia (Gibson et al. 2007, fig. 162).

Variation.—Girault's (1931) description mentions six features that can be compared accurately with the slide-mounted speci-



Figs 24–28. *Mymaromella* spp., female antennae. 24, *M. chaoi*, paratype; 25, *M. cyclopterus*, holotype; 26, *M. pala* (+ head, anterior), holotype; 27, *M. palella*, holotype; 28, *M. mira*. Scale lines = 50 μm.



Figs 29–31. *Mymaromella* spp. 29, *M. mira*, male antenna + head, lateral; 30, *M. pala*, male antenna; 31, *M. cyclopterus*, head, mesosoma and first segment of gastral petiole, holotype. Scale lines = 50 μm.

mens we examined. All but one feature almost exactly matches the specimens from ACT. The one feature that does not match is that fl_6 is not nearly twice as long as fl_7 but is only 1.2–1.3 times as long on the three females we measured. We do not know how Girault measured the funicular lengths but differences in method of measurement may partially account for the discrepancy. We consider that there is a close enough match between our specimens and the original description and type photograph to be certain that the females are *M. mira*. By association, we also place the males from Black Mountain in this species although the fore wing is narrower,

with the dark band not so wide or conspicuous.

HOSTS AND BIOLOGY

The hosts and biology of Mymarommatidae are unknown. However, the information on distribution and habitat obtained from the literature and from specimens in collections provides us with circumstantial evidence for the likely host group. The evidence presented below is based on mymarommatid morphology, collection data, biogeography, habitats, and palaeontology, all of which correlate well with one order of potential hosts — the Psocoptera.

Morphology. Because Mymarommatoidea belong to the parasitic Hymenoptera, probably as the sister group of Chalcidoidea (Gibson et al. 2007), it can reasonably be assumed they are parasitoids of other insects. Their small size, rivalling that of small Mymaridae and Trichogrammatidae, and their very short ovipositors, at most about 110 μm long, suggest they parasitize the egg stage, as do members of the latter two families. We also assume that Mymarommatidae are solitary, internal parasitoids that feed on the egg contents before the host cells have begun to differentiate, thus avoiding the problem of overcoming a host immune system, which does not appear before the host larva develops. Minute wasps generally would have a harder time parasitizing the mobile stage of an insect larva or adult compared to an immobile stage (egg or pupa) because a mobile host could defend itself from attack and it would also have an immune system that would have to be countered. A disadvantage of parasitizing eggs is that the body size of an internal parasitoid is limited to that of its host egg.

What kind of eggs could be parasitized? We suggest small, thin-walled eggs from which an adult wasp could emerge in one of two ways, assuming that the parasitoid is solitary and completely fills the egg once development is complete. Mymarommatidae are unique among Hymenoptera because they have the front and back of the head joined by pleated membrane that extends between the base of each mandible across the top of the head. Either an adult mymarommatid could burst open the host egg simply by flattening the pleated membrane, thus enlarging its head (see Gibson et al. 2007, figs 13–15), through hydrostatic pressure or muscle action. Or the expanded head may not itself burst the host egg but instead provides a buttress for the exodont mandibles (another feature of Mymarommatidae — Fig. 2, 26, 29, and Gibson et al. 2007, figs 23, 25, 28, 41, 44, 49, 50) to tear a hole in the chorion through which the wasp emerges. Psocoptera have a thin egg chorion, about 1 μm thick (Seeger 1979). Because of this it may be fairly elastic and easily distorted, hence difficult for an internal parasitoid to bite through without buttressing from an expanded head. Exodont mandibles may also be more efficient than endodont mandibles in pushing an emergence hole through the soil or bark debris, silk threads or fecal material that many Psocoptera use to cover and protect their eggs (Hinton 1981), but may make it more difficult for an internal parasitoid to bite through the chorion. Consequently, a mechanism to expand the head and firmly appress the exodont mandibles to the chorion may be required.

Abundance and phenology. Mymarommatidae are usually collected singly or in small numbers. This is partly an artifact of their small size and the consequent difficulty of seeing them. Occasionally, considerable numbers (50 or more) may be collected in a short time by a particular Malaise or yellow pan trap. This suggests a mass emergence, possibly from hosts that lay clusters of eggs.

Specimens of both *Mymaromella* and *Mymaromma* Girault have been collected in the field during every month from May to September in mid latitudes of the Northern Hemisphere (Canada, USA, various European countries, Japan, Korea) and

have emerged in November from logs maintained in the lab in Michigan). In the Southern Hemisphere (Australia, New Zealand) specimens have been collected every month from October to June. In the tropics (Brazil, Côte d'Ivoire, Gabon, Hawaiian Is., Taiwan, Thailand) specimens have been collected from November to July. Presumably, a given species of mymarommatid has several generations per year and adults may be found throughout the warm season in higher latitudes and most of the year in the humid tropics.

Psocoptera lay eggs either singly or in batches, occasionally with up to 80–90 per batch, and are univoltine or multivoltine (New 1987). A given species may have several generations over many months, thus providing a fairly constant source of eggs to be parasitized. If all the eggs in a cluster were parasitized it would account for a mass emergence of a particular species of Mymarommatidae, especially if many egg clusters were so parasitized. Most Psocoptera overwinter as eggs so their eggs would serve as overwintering sites for diapausing mymarommatids.

Biogeography. Specimens of Mymarommatidae have been collected from all continents except Antarctica, and from remote oceanic islands such as Hawaii (Beardsley et al. 2000) and some subantarctic islands of New Zealand including Campbell Island, which has one species of Mymarommatidae (Valentine 1971).

Psocoptera occur worldwide including many oceanic islands such as Campbell Island, which has three species (Gressitt 1964, Gressitt and Wise 1971) mainly in moss (Gressitt 1964) among the 380 reported arthropod species. The species of Mymarommatidae on Campbell Island must be restricted to one or several of the potential arthropod hosts, possibly Psocoptera. Psocoptera are also relatively easily dispersed, sometimes (by implication) over long distances (New 1987) and evidently occur wherever mymarommatids have been collected.

Habitats. Data from the literature and from specimens assembled at the CNC for Gibson et al. (2007) indicate that most Mymarommatidae may be collected in a wide diversity of forested habitats from sea level (Bermuda) to 1050 m (Japan). Based on label data, the habitats and countries from which specimens were seen are: Peucedano-pinetum (Poland), garrigue (France), climax flood forest (Czech Republic), small meadow in old deciduous forest (Japan), secondary forest (Taiwan), mango patch (Australia), sclerophyll forest (Australia), riverine forest (Thailand), cerrado (Brazil), dense forest (New Caledonia), yellow sticky traps hung on roadside trees (Hawaii — Beardsley et al. 2000), ex ash logs from Metropolitan parks (Michigan, USA), maple and white pine litter, mixed cedar and alder litter, Berlese extract of soil from maple-hickory forest (Canada), deciduous forest litter (Canada — Clouâtre et al. 1989), *Nothofagus* forest, litter of *Stilbocarpa* in *Olearia* forest (New Zealand), and ex bracket fungus (New York, USA). The only records we have seen from outside forested habitats are: litter of *Anisotome latifolia* at upper margin of supralittoral zone, litter and peat under *Stilbocarpa polaris*, and ex *Poa tannantiana* (New Zealand: Snares, Campbell, Auckland, and Antipodes Is., from label data and from Valentine 1971), *Caprobrotus*, Munro Beach cottages (Bermuda), and an old field (USA, Maryland).

Psocoptera occur in soil and ground litter, low vegetation, on bark of tree trunks and branches, on foliage (New 1987), and in bracket fungi (Matthewman and Pielou 1971).

Palaeontology. Mymarommatoidea are known from at least 100 mya as shown by Cretaceous amber fossils from Lebanon, Canada, and Russia (Gibson et al. 2007).

Fossils of Psocoptera are known from the Jurassic and various extant families are known from 100 mya Cretaceous amber from Lebanon and India (Kukalová-Peck 1991) so they were present as potential

hosts when mymarommatids occurred in the fossil record.

Discussion.—Psocoptera are proposed as the most likely insect hosts for Mymarommatidae because their eggs are small and thin-walled, may be laid in clusters, may be present throughout the period that adult mymarommatids have been collected, and in higher latitudes are the over wintering stage. Psocoptera also occur wherever Mymarommatidae have been collected worldwide and may be abundant in a range of different habitats, including the same ones as mymarommatids. However, these lines of circumstantial evidence could fit several other groups of possible hosts that have the same distribution, habitats, fossil record and egg size as Psocoptera. Such alternative possible hosts include some Coleoptera (such as Curculionidae or Staphylinidae) and Diptera (such as various Nematocera). Other arthropod groups, notably Acari and Collembola emerged in considerable numbers from over wintered ash logs but we consider them unlikely hosts because parasitic Hymenoptera have rarely been reared from Acari and never, so far, from Collembola. Lists of species reared from bracket fungus (Matthewman and Pielou 1971) and logs of ash trees (often loaded with lichens) over wintered under laboratory conditions (this study) are fairly short. Matthewman and Pielou (1971) list 6 families and 14 species of Psocoptera among 59 families and 133 species of insects from bracket fungus in Quebec. Our ash rearings in Michigan resulted in about 30 genera of predaceous and parasitic Hymenoptera, about five genera of Diptera, about five genera of Coleoptera, and eight genera of Psocoptera including *Atropsocus atratus* (Aaron), *Blaste subquieta* (Chapman), *Blastopsocus lithinus* (Chapman) and *B. semistriatus* (Walsh), *Echmepteryx hageni* (Packard), *Loensia moesta* (Hagen), *Liposcelis* sp., *Psocus leidyi* Aaron, and *Trichadenotecnum alexanderae* Sommerman. Hymenoptera are unlikely as hosts of Mymarommatidae because they themselves are parasitic and most lay their eggs within a host and would be inaccessible for parasitism. Psocoptera therefore seem to be the most likely host group, particularly as a diversity of genera and species were reared from ash logs.

CONCLUSIONS

More species of *Mymaromella* than the five keyed above are known to us. They are numbered in Gibson et al. (2007) but we leave them undescribed until more material is collected and the respective regional faunas are studied more thoroughly. The biology of *Mymaromella* and indeed the entire family Mymarommatidae remains unknown, though we hypothesize Psocoptera as hosts based on the circumstantial evidence presented above. Whereas some other insect groups, such as certain Diptera or Coleoptera, could also be potential hosts of mymarommatids, the taxa reared from bracket fungi and ash logs seem to make these groups less likely candidates. Our hypothesis can be tested by rearing Psocoptera eggs. We suggest that the best chance of obtaining a definite rearing of any species of Mymarommatidae would be from Psocoptera eggs collected from bracket fungi, from litter and mosses collected in the subantarctic islands of New Zealand or from trunks of various ash species in north eastern North America.

ACKNOWLEDGEMENTS

We thank M. Loiacono for the loan of *M. cyclopterus* holotype, N.-Q. Lin for the loan of *M. chaoi* types, E. Mockford for identifications of the Psocoptera reared from ash logs, and K. Wu for translating the type locality information. J. Read is gratefully acknowledged for preparing the scanning electron micrographs and compiling the plates of illustrations.

LITERATURE CITED

Bauer, L. S., Liu, H-P., Haack, R. A., Petrice, T. R., and Miller, D. L. 2003. Natural enemies of emerald ash borer in southeastern Michigan. Pp. 33–34, in: *The Proceedings of the 2003 Emerald Ash Borer Research and Technology Development Meeting*. USDA Forest Service FHTET 2004-02.

———, Liu, H-P., Gould, J., and Reardon, R. 2007. Progress on biological control of the emerald ash borer in North America. *Biocontrol News and Information* 28: 51N–54N.

Beardsley, J. W., Huber, J. T., and Perreira, W. D. 2000. Mymarommatoidea, a superfamily of Hymenoptera new for the Hawaiian Islands. *Proceedings of the Hawaiian Entomological Society* 34: 61–63.

Clouâtre, A., Coderre, D., and Gagnon, D. 1989. Habitat of a new Mymarommatidae found in southern Quebec, Canada (Hymenoptera: Terebrantes). *The Canadian Entomologist* 12: 825–826.

Dahms, E. C. 1984. A checklist of the types of Australian Hymenoptera described by Alexandre Arsene Girault: III. Chalcidoidea species F-M with advisory notes. *Memoirs of the Queensland Museum* 21: 579–842.

Fidalgo, A. P. and L. de Santis. 1982. Una nueva especie Argentina de mimarido de la subfamilia Mymaromminae (Insecta, Hymenoptera). *Revista del Museo de La Plata (Nueva Serie), Zoología* 127: 1–6.

Gibson, G. A. P. 1993. Superfamilies Mymarommatoidea and Chalcidoidea. Pp. 570–655 in: Goulet, H., and J. Huber eds. *Hymenoptera of the world: an identification guide to families.* Agriculture Canada Research Branch Monograph No. 1894E, Ottawa. 668 pp.

———. 1997, Morphology and terminology. Pp. 16–44 in: Gibson, G. A. P., J. T. Huber, and J. B. Woolley eds. *Annotated keys to the genera of Nearctic Chalcidoidea.* NRC Research Press, Ottawa. 794 pp.

———, Read, J., and Huber, J. T. 2007. Diversity, classification and higher relationships of Mymarommatoidea (Hymenoptera). *Journal of Hymenoptera Research* 16: 51–146.

Girault, A. A. 1931. A new habit in an old insect, *Homo pudicus* and new Eurytomidae. Privately printed. 4 pp.

Gordh, G., Menke, A. S., Dahms, E. C., and Hall, J. C. 1979. The privately printed papers of A. A. Girault. *American Entomological Institute* 28: 1–400.

Gressitt, J. L. 1964. Insects of Campbell Island. *Pacific Insects Monograph* 7: 1–663.

——— and Wise, K. A. J. 1971. Entomology of the Aucklands and other islands south of New Zealand: Introduction. *Pacific Islands Monograph* 27: 1–45.

Hinton, H. E. 1981. *Biology of insect eggs in three volumes.* Vol. II. xviii + 475–778. Pergamon Press, Oxford, UK. 1125 pp.

Kukalová-Peck, J. 1991. Fossil history and the evolution of hexapod structures. Pp. 141–179 in: *The insects of Australia. Second Edition. Vol. I.* Melbourne University Press, Carleton, Vic. 542 pp.

Matthewman, W. G. and Pielou, D. P. 1971. Arthopods inhabiting the sporophores of *Fomes fomentarius* (Polyporaceae) in Gatineau Park, Quebec. *The Canadian Entomologist* 103: 775–847.

Lin, N-Q. 1994. First discovery of Mymarommatidae (Hymenoptera) from China, with description of a new species. *Entomotaxonomia* 16: 120–125.

New, T. R. 1987. Biology of the Psocoptera. *Oriental Insects* 21: 1–109.

Seeger, W. 1979. Specialmerkmale an Eihüllen und Embryonen von Psocoptera im Vegleich zu anderen Paraneoptera (Insecta); Psocoptera als monophyletische Gruppe. *Stuttgarter Beiträge zur Naturkunde, Serie A (Biologie)* 329: 1–57.

Valentine, E. W. 1971. Entomology of the Aucklands and other islands South of New Zealand: Hymenoptera: Mymaridae. *Pacific Insects Monograph* 27: 327–333.

Yoshimoto, C. M. 1984. *The insects and arachnids of Canada, Part 12. The families and subfamilies of Canadian chalcidoid wasps.* Publication 1760, Canadian Government Publishing Centre, Supply and Services Canada, Ottawa. 149 pp.

J. HYM. RES.
Vol. 17(2), 2008, pp. 195–200

Evaluation of Specimen Preservatives for DNA Analyses of Bees

MARK FRAMPTON*, SAM DROEGE, TRAVIS CONRAD, SEAN PRAGER, AND MIRIAM H. RICHARDS

(MF, SP, MHR) Department of Biological Sciences, Brock University, St. Catharines, Ontario, Canada; (SD, TC) USGS Patuxent Wildlife Research Center, Beltsville, Maryland, USA

Abstract.—Large-scale insect collecting efforts that are facilitated by the use of pan traps result in large numbers of specimens being collected. Storage of these specimens can be problematic if space and equipment are limited. In this study, we investigated the effects of various preservatives (alcohol solutions and DMSO) on the amount and quality of DNA extracted from bees (specifically Halictidae, Apidae, and Andrenidae). In addition, we examined the amount and quality of DNA obtained from bee specimens killed and stored at −80°C and from specimens stored for up to 24 years in ethanol. DNA quality was measured in terms of how well it could be PCR-amplified using a set of mitochondrial primers that are commonly used in insect molecular systematics. Overall the best methods of preservation were ultra-cold freezing and dimethyl sulfoxide, but these are both expensive and in the case of ultra-cold freezing, somewhat impractical for field entomologists. Additionally, dimethyl sulfoxide was shown to have adverse effects on morphological characters that are typically used for identification to the level of species. We therefore recommend that the best alternative is 95% ethanol, as it preserves bee specimens well for both morphological and molecular studies.

Recent advances in insect molecular systematics, made possible by the polymerase chain reaction (PCR) and other molecular techniques have made it important to properly preserve rare specimens for maintaining museum collections, or for molecular analysis. Since DNA can be damaged by enzymatic breakdown, oxidation and hydrolysis (Lindahl 1993, Quicke et al. 1999), specimens need to be preserved from the time of collection to the time of analysis in order to minimize DNA degradation. Several factors have been reported that affect DNA degradation in stored insect specimens, including preservative type and concentration, time in preservative, temperature, pH, and the age of the specimen (Dillon et al. 1996). It is generally accepted that the highest quality of DNA is extracted from live specimens (Tayutivutikul et al. 2003), live specimens frozen at −80°C (Dillon et al. 1996), or live specimens quick frozen in liquid nitrogen (Quicke et al. 1999). However, these methods are not always practical for field biologists, and several alternatives have been reported for preserving arthropod, mammalian or plant specimens for the purpose of genetic analysis. These include storage in preservatives such as methanol, ethanol, and isopropanol (Post et al. 1993), propylene glycol (Rubink et al. 2003), acetone (Fukatsu 1999), Carnoy's solution (Post et al. 1993), and dimethyl sulfoxide (Kilpatrick 2002). An important motivation for the current study is an increasing research emphasis on large-scale collections of bees, especially using pan traps that generate specimens used for molecular systematics and population genetic studies. We therefore needed to assess the relative merits of various preservatives since specimens may have to be preserved for considerable periods of time before being analysed.

While few studies of the efficacy of the various preservation methods have fo-

* Author for correspondence

cused on collections of bees, other insect groups have been well represented, but many of these studies focused only on DNA preservation, or morphology. King and Porter (2004) determined that 95% ethanol or 95% isopropanol were ideal for preserving ants for card-point mounting and through a literature review concluded that DNA was best preserved in 95% ethanol. Quicke et al. (1998), studying wasps of the superfamilies Ichneumonoidea and Chalcidoidea, had an 80% success rate at PCR amplification of 28S rDNA from specimens preserved in 70% ethanol at room temperature. Austin and Dillon (1997) also suggested that chemical drying methods could be used to generate sufficient quantities of quality DNA from ichneumonoid and chalcidoid wasps. In this report we present our findings on the relative efficacies of several storage methods of bees including ultra cold freezing, various alcohols, and pure dimethyl sulfoxide (DMSO) in terms of the quality of DNA preserved for downstream applications such as PCR, as well as the ability to preserve delicate morphological features that are required for taxonomic identification. We analyzed 121 individuals representing three families, Halictidae, Apidae, and Andrenidae, as part of several larger studies of bee diversity. To determine the quality of the DNA that was extracted using each of our preservation methods, three amplicons within the mitochondrially encoded gene, *cytochrome oxidase subunit I* (COI), a gene widely used in insect systematics, were compared. While the majority of the specimens collected for this study were part of a pre-planned experiment, we supplemented the data using older, preserved specimens that had been previously collected in the course of other projects.

MATERIALS AND METHODS

Most of the bee specimens used in this study were collected in southern Ontario, Canada and Maryland, USA, using pan traps containing a mixture of water and blue Dawn® dish detergent. Pan traps were placed approximately 10 m apart along transects and were subject to both sun and shade conditions for between 6 and 24 hours. Bees were identified and then transferred to methanol (50 or 95% in water), ethanol (50, 70 or 95% in water), an ethanol-methanol solution (70:30, 95:5), or pure DMSO. Bees were stored at room temperature for between one and twelve months after which they were pinned and stored at room temperature until DNA was extracted.

In addition to these specimens, we also analyzed specimens that were live caught in nets. These included eight *Xylocopa virginica* that were killed by freezing at −80°C, four *Lasioglossum marginatum* caught in Greece and stored in ethanol since 1994, and 24 *Halictus poeyi* caught in Florida and stored in 70% ethanol since 1982. These latter bees, as well as those stored in DMSO, remained in preservative, or frozen, until DNA was extracted. Prior to DNA extraction, bees were dried overnight at room temperature to remove any remaining preservative. Bees preserved in DMSO were washed with 95% ethanol, and then allowed to dry overnight at room temperature.

DNA was extracted using either the Qiagen DNeasy Tissue Kit (insect protocol) or the Sigma-Aldrich GenElute Mammalian Genomic DNA Purification Kit, following the manufacturers' instructions. The quality of the extracted DNA was assessed by agarose gel electrophoresis of 5 uL of sample on 1.2% agarose gels in TAE buffer containing 10 mg/ml ethidium bromide. Total DNA extracted from each specimen was quantified using a Beckman DU-530 spectrophotometer. DNA extractions were based on whole specimens, with the exception of *X. virginica*, a very large bee species, for which a single leg was used. The effect of body size on the amount of DNA extracted from bees of different species was statistically controlled by

measuring the average head width of a set of pinned specimens (in halictid and xylocopine bees, head width is highly correlated with body mass).

Polymerase chain reaction (PCR) was carried out to determine the quality of the preserved DNA. COI amplicons were amplified using the primers Ron (C1-J-1751), Nancy (C1-N-2191), Jerry (C1-J-2183), and Pat (L2-N-3014) (Simon et al. 1994). The first PCR reaction was performed with the Ron-Pat primer pair generating an amplicon of 1264 bp. Upon successful amplification of the 1264 bp amplicon, specimens were removed from any further attempts at amplification. For those specimens that did not successfully amplify using the Ron-Pat primers, a second PCR reaction was performed on 1:100 dilutions of the Ron-Pat PCR product and used either the Ron-Nancy or Jerry-Pat primers.

The quality and quantity of PCR amplification products were analyzed by agarose gel electrophoresis as described above. Successful amplifications were scored using a system based on the brightness of the bands present on the gel. A score of '0' was given for no amplification, a score of '1' was given for weak amplification not containing enough DNA to be sequenced, and a score of '2' was given for a bright band that would contain a sufficient quantity of DNA for sequencing (note that our lab has successfully used this scoring system for DNA sequencing for more than 5 years). Images were photographed on the Bio-Rad Gel Doc 1000 using Multi-Analyst (Bio-Rad) software.

RESULTS

Qualitative Observations

Specimens that were preserved in alcohol-based solutions were dehydrated, brittle, and easily damaged when handled. Bees preserved in DMSO were less brittle than those stored in alcohol, but many of the morphological characters that are typically used for identification were distorted; for instance, wings were shrivelled (Fig. 1). Several halictids that were stored in DMSO, notably the augochlorine bees, changed colour from bright green to reddish gold, although their natural green colour was restored after washing them in ethanol. These morphological changes proved problematic for those specimens that had not been identified prior to preservation.

DNA Quality

All preservation methods tested produced DNA of varying quality and concentration (Fig. 2). Pure DMSO was most successful at maintaining genomic quality (the brightest genomic band is Lane 8 in Fig. 2), whereas ethanol and methanol-preserved bees produced weak genomic DNA bands. All three methanol treatments, as well as the 50% ethanol and ethanol-methanol blends, showed signs of DNA degradation indicated by extensive smearing.

Several factors could affect both the amount and quality of the DNA from our specimens including species, collection method, preservative, and specimen size (Table 1). An ANCOVA analysis showed that specimen size was the strongest contributor to the DNA quantity ($F=30.03$, $df=1$, $p<0.0001$) and preservative type had only a slight effect ($F=2.10$, $df=7$, $p=0.0568$). Other potential influences (type of DNA extraction kit and time in preservative) had non-significant effects on the amount and quality of DNA obtained from specimens.

For systematics projects, the amount of DNA obtained from specimens is less important than how well the DNA can be PCR-amplified. DNA concentration and preservative type had strong effects on PCR amplification scores; the highest amplification scores were for specimens that were caught live and immediately frozen in a $-80°C$ freezer, despite the low amount of total DNA that was recovered. The best

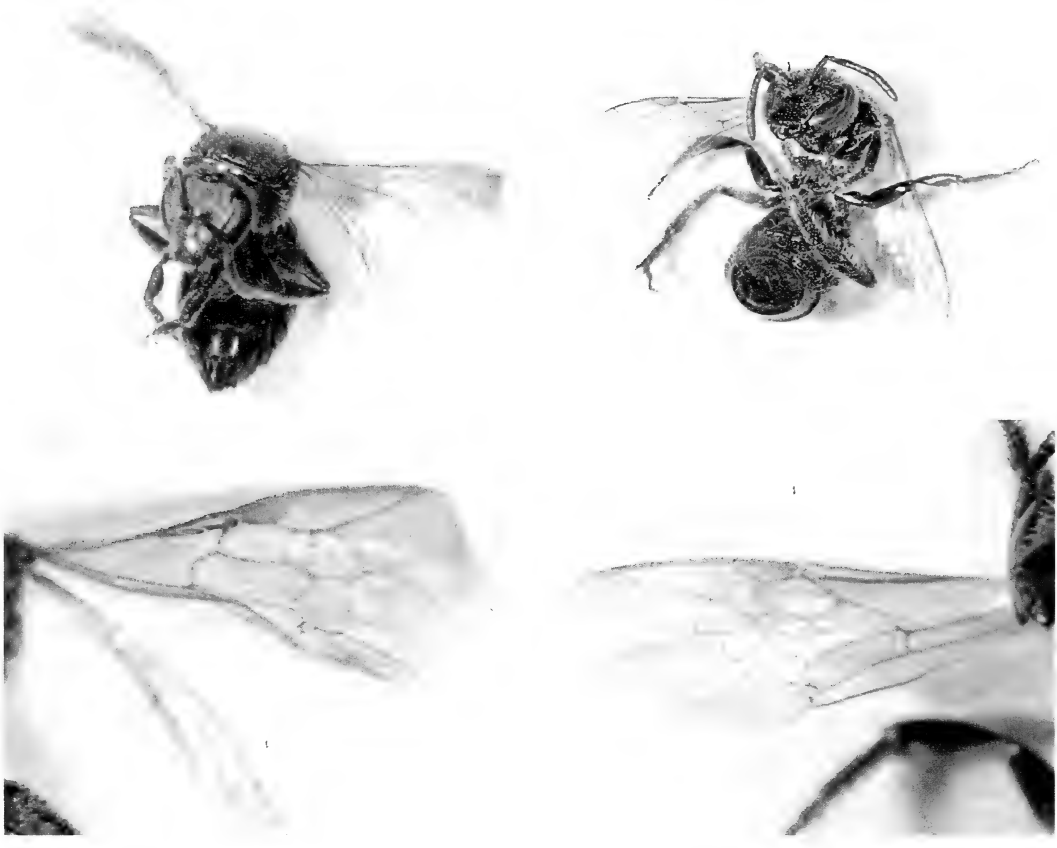


Fig. 1. Pictures of *Augochlorella striata* that were preserved in 100% DMSO (left column) and 100% ethanol (right column). The top row indicates the colour changes that are apparent in the DMSO preserved bees. The bottom row shows how DMSO dehydrates the wings causing them to become misshapen.

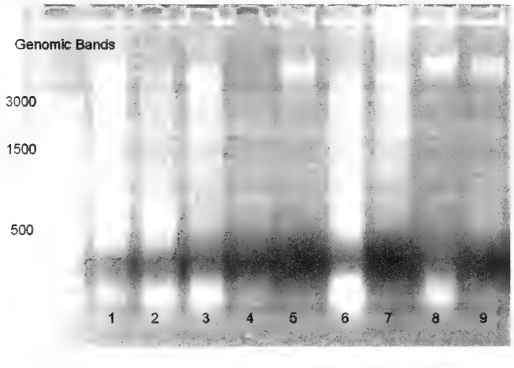


Fig. 2. Representative samples of extracted DNA from various preserved specimens separated on 1.2% agarose stained with ethidium bromide. Lanes contain the following: (1) 95% methanol, (2) 50% methanol, (3) 50% ethanol, (4) 70% ethanol, (5) 95% ethanol, (6) 70:30 ethanol-methanol, (7) 95:5 ethanol-methanol, (8) 100% DMSO, and (9) −80°C. 2.5 µg of a 100 bp size marker (Fermentas) is loaded in each of the outside lanes.

amplification scores from a liquid preservative came from those bees preserved in DMSO, followed by those preserved in 95% ethanol (lower DNA concentrations produced higher amplification scores).

As a final note, we also attempted to extract and amplify DNA from 28 specimens that had been stored in ethanol (probably 70% ethanol) for 10–24 years. These comprised four *Lasioglossum marginatum* specimens that were collected in Greece in 1994, as well as 24 *Halictus poeyi* that were collected in Florida in 1982. For three of the four *L. marginatum*, we were able to amplify only the smallest of the COI amplicons (using primers Ron and Nancy), with amplification scores of 1. Attempts at recovering DNA from the much older (and

Table 1. Mean DNA concentration, proportion of specimens scoring '2', and amplification score ranks for each of the preservative types tested.

Collection method	Preservative	No. specimens	Average DNA concentration (μg/mL) (SD)	No. specimens with amplification scores of 2
Pan traps	50% Methanol	10	138.9 (141.1)	0
	95% Ethanol	10	69.4 (26.6)	1
	50% Ethanol	10	93.8 (52.7)	3
	70% Ethanol	23	50.8 (18.9)	10
	95% Ethanol	10	56.3 (25.0)	8
	Ethanol:methanol blend 70:30	8	104.1 (60.5)	3
	Ethanol:methanol blend 95:5	10	89.6 (59.0)	3
	DMSO	8	104.3 (44.3)	6
Live caught	−80°C	8	17.0 (10.9)	8

more poorly preserved) *H. poeyi* specimens were completely unsuccessful.

DISCUSSION

The ideal preservative for field collections of bees and other insect specimens should be easy to use, cost efficient, and easily transportable. Typically, primary alcohols have been used to meet these requirements, but recent studies have examined the use of propylene glycol (Rubink et al. 2003, Vink et al. 2005), acetone (Fukatsu 1999), and other commercial products (Vink et al. 2005). Preserving the quality of both genomic and mitochondrial DNA is of great importance for conducting molecular studies. We found that ultra cold freezing was the best method for killing and preserving specimens, but this is often impractical either because specimens cannot be captured alive or because ultra cold freezing facilities are not available. The use of ultra cold freezing has been suggested by Reiss et al. (1995) and Dillon et al. (1996). In the later study, ultra cold storage of parasitic wasps did not affect the amount of DNA that could be recovered or successfully amplified.

Among the liquid preservatives DMSO serves as an ideal candidate for denaturing DNA damaging enzymes and for preserving the quality of genomic and mitochondrial DNA. The drawback to using DMSO as a preservative is that it distorts morphological characters required for identification of specimens although this problem can be overcome by identifying specimens prior to storage in DMSO. Furthermore, DMSO is considerably more expensive than ethanol. Despite the finding that primary alcohols caused advanced signs of genomic degradation, the best alternative appears to be 95% ethanol. It is relatively inexpensive, easy to transport, and does not distort morphological characters to the same degree as DMSO.

Preservative type and concentration, as well as storage time, affect the quality as well as the quantity of DNA that can be extracted from a given specimen. Additionally, some methods of preservation have adverse effects on morphological characters that need to be preserved for specimen identification. In this paper we propose that 95% ethanol is the best chemical preservative for maximizing the quantity and quality of DNA, as well as for maintaining morphological integrity when ultra-cold freezing is not immediately available.

ACKNOWLEDGEMENTS

Special thanks to T. Chessar and H. Ginsberg for reviewing the early stages of this manuscript, and S. Rehan for bee measurements. Funding was provided by Brock University, NSERC, USGS.

LITERATURE CITED

Austin, A. and N. Dillon. 1997. Extraction and PCR of DNA from parasitoid wasps that have been chemically dried. *Australian Journal of Entomology* 36: 241–244.

Dillon, N., A. Austin, and E. Bartowsky. 1996. Comparison of preservation techniques for DNA extraction from hymenopterous insects. *Insect Molecular Biology* 5: 21–24.

Fukatsu, T. 1999. Acetone preservation: A practical technique for molecular analysis. *Molecular Ecology* 8: 1935–1945.

Kilpatrick, C. W. 2002. Noncryogenic preservation of mammalian tissues for DNA extraction: An assessment of storage methods. *Biochemical Genetics* 40: 53–62.

King, J. R. and S. D. Porter. 2004. Recommendations on the use of alcohols for preservation of ant specimens (Hymenoptera, Formicidae). *Insectes Sociaux* 51: 197–202.

Lindahl, T. 1993. Instability and decay of the primary structure of DNA. *Nature* 362: 709–715.

Post, R. J., P. K. Flook, and A. L. Millest. 1993. Methods for the preservation of insects for DNA studies. *Biochemical Systematics and Ecology* 21: 85–92.

Quicke, D. L. J., C. Lopez-Vaamonde, and R. Belshaw. 1999. Preservation of hymenopteran specimens for subsequent molecular and morphological study. *Zoologica Scripta* 28: 261–267.

Rubink, W. L., K. D. Murray, K. A. Baum, and M. A. Pinto. 2003. Long term preservation of DNA from honey bees (*Apis mellifera*) collected in aerial pitfall traps. *The Texas Journal of Science* 55: 159–169.

Simon, C., F. Frati, A. Beckenbach, B. Crespi, H. Liu, and P. Flook. 1994. Evolution, weighting, and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. *Annals of the Entomological Society of America* 87: 651–701.

Tayutivutikul, J., W. Pongprasert, L. A. Royce, and K. Ruangrit. 2003. Comparison of preservation techniques for silkworm (*Bombyx mori* L.) DNA based on polymerase chain reaction (PCR) products. *Chiang Mai University Journal* 2: 107–114.

Vink, C. J., S. M. Thomas, P. Paquin, C. Y. Hayashi, and M. Hedin. 2005. The effects of preservatives and temperatures on arachnid DNA. *Invertebrate Systematics* 19: 99–104.

J. HYM. RES.
Vol. 17(2), 2008, pp. 201–209

Sex Determination and Genome Size in *Catolaccus grandis* (Burks, 1954) (Hymenoptera: Pteromalidae)

N. M. Barcenas, N. J. Thompson, V. Gomez-Tovar, J. A. Morales-Ramos and J. S. Johnston

(NMB) Heritage University, 3240 Fort Rd, Toppenish, WA 98948, USA
(NJT) Department of Biology, Texas A&M University 3258, College Station, TX 77883, USA
(VGT) SENASICA-SAGARPA Insurgentes Sur 498, 06100 México, D.F.
(JAMR) USDA-ARS National Biological Control Laboratory, Biological Control of Pests Research Unit 59 Lee Road Stoneville, MS 38776, USA
(JSJ) Department of Entomology, Texas A&M University 2475, College Station, TX 77883, USA

Abstract.—Complementary sex determination (CSD) is a common form of the haplodiploid sex determination system found in all wasps, ants, and bees (Hymenoptera). Exceptions exist to CSD, but too few have been documented to make phylogenetic conclusions. Males that are homozygous at CSD loci are diploid and often sterile. Any effect that increases homozygosity (inbreeding and small population size) should increase the proportion of diploid males. We use flow cytometry to determine the genome size of males and females of the parasitic wasp *Catolaccus grandis* (Burks) (Hymenoptera: Pteromalidae) (1 C = 455.4 ± 3.4 mb). We then score haploid and diploid males (and females) from populations that were 25% and 50% inbred. None of the 314 males scored were diploid. We conclude that the CSD system is very unlikely to exist in this species and discuss the implications for sex determination systems in the Pteromalidae and other chalcidoids.

Evolving independently at least eight and possibly as many as 15 times in mites and insects (White 1973, Mable and Otto 1998) in phylogenic lineages that represent nearly 20% of all animal species (Bell 1982, Bull 1983), haplodiploidy is the sole reproductive mode in Hymenoptera, including the pteromalid wasp *Catolaccus grandis* (Burks, 1954) (Hymenoptera: Pteromalidae) studied here. The most common system of haplodiploidy is arrhenotokous reproduction, where females develop from fertilized eggs and males from unfertilized eggs. The most studied form of arrhenotoky is the complementary sex determination (CSD) mechanism, whereby a sex locus with multiple alleles determines the sexual development of the offspring (Whiting 1943, Beye et al. 2003). In the CSD system, zygotes heterozygous at the CSD locus develop into biparental diploid females; males are produced as uniparental haploids that have one CSD allele. Uniparental males are typically produced as unfertilized eggs, but in some cases are produced as zygotes in which one parental genome is excluded post fertilization (Keller et al. 2001, Beukeboom et al. 2007).

The CSD form of arrhenotoky fails when the female is fertilized by a male whose single allele at the CSD locus is identical to one of the two CSD alleles that she carries. When this happens, half of her diploid fertilized progeny (all of whom should develop as female) are homozygous for a CSD allele and develop into biparental diploid males. Diploid males were first observed in a single locus CSD (sl-CSD) system by Whiting in *Bracon hebetor* Say, 1836 (Whiting 1943) but have been observed in very many species since (Trent et al. 2006). Diploid males are often sterile, yet lacking the division of chromosomes required to produce haploid sperm, may

produce diploid sperm and consequently, sterile triploid females (Whiting 1943, Stouthamer et al. 1992, Cowan and Stahlhut 2004). Whether in natural populations or in laboratory reared colonies, diploid males and triploid sterile females represent a reproductive cost, affecting fertility and sex ratio (Stouthamer et al. 1992, Wu et al. 2005, see exception in Cowan and Stahlhut 2004). Production of diploid males and triploid females is most apparent when the number of CSD alleles is reduced by population bottlenecks and founder events, or when homozygosity increases as a result of consanguinity. The latter is important, since inbreeding by sib-mating occurs often in hymenopteran species that are solitary or are social parasites (Schrempf et al. 2006).

The parasitoid pteromalid wasp, *C. grandis*, is economically important for use in bio-control of the boll weevil, *Anthonomous grandis* (Boheman, 1843) (Coleoptera: Curculionidae), and has been released experimentally for crop management in many areas of the southern U.S.A., including the Rio Grande Valley, Texas, San Angelo, Texas, and Aliceville, Alabama (Morales-Ramos et al. 1994, 1995a, 1998, Summy et al. 1995, 1997). An ectoparasitoid, *C. grandis* lays its eggs on boll weevil larvae (most often the third instar or pupa), greatly suppressing the numbers of the boll weevil and thereby reducing the damage caused to cotton (Summy et al. 1995). As an idiobiont, the female stops host development with a paralytic venom (Morales-Ramos et al. 1995b) and the emerging larva consumes its paralyzed host. These characteristics may give an advantage as an efficient biocontrol agent (Morales-Ramos et al. 1995b). However, production efficiency in insect mass rearing of *C. grandis* and related species can be problematic if sl-CSD is present, because that would necessitate a large number of sex alleles to minimize diploid male production. Special measures would need to be taken in colony management to avoid founder events, population bottlenecks, and inbreeding leading to a loss of the sex alleles.

Economically important hymenopterans are among the best studied, and their sex determination is among the best documented. The sl-CSD system is well demonstrated in the red imported fire ant (*Solenopsis invicta* Buren, 1972) and the honey bee *Apis mellifera* L., 1758 (Hymenoptera: Apidae); 11 to 19 alleles were determined for the complementary sex determiner (csd) locus in honey bees (Beye et al. 2003), with a smaller number of alleles (8 to 13) in the population of red imported fire ants, that went through a bottleneck when introduced into southern United States (Ross et al. 1993). The occurrence of CSD in the Hymenoptera has been demonstrated in symphytan, ichneumonid, and braconid species, but to date not in chalcidoids (Stouthamer et al. 1992). In several of these groups apparent exceptions exist, specifically in instances where inbreeding has not exposed sl-CSD (Wu et al. 2005).

The relative phylogenetic position of pteromalids within the tree of life is largely unknown, although studies are underway to remedy this situation (Castro and Dowton 2005, J. Heraty personal communication). Understanding the kind of sex determination system and the ancestral or derived state of the CSD system should be part of this phylogenetic effort. We assume that CSD is the ancestral mode of reproduction. There is little published research to prove this, however, especially in the more ancestral taxa (Cook and Crozier 1995). Here we test the hypothesis that a form of the CSD system exists in *C. grandis*. This represents the second test of CSD in Pteromalidae. We employ a new approach in studying CSD by determining genome size first, and then directly scoring males of consanguineous matings, using flow cytometry to score ploidy level. If a CSD system exists in this species, diploid male production, to the extent they survive, will be directly proportional to the level of consanguinity.

METHODS

Live Material

Catolaccus grandis from wild-caught individuals were used to initiate a reared population. The lab colony used here was founded with: 6 genomes from El Salvador, Central America (host plant of boll weevil: wild and cultivated cotton), 56 genomes from Tabasco, México (host plant of boll weevil: *Hampea nutricia* Fryxell (Malvaceae)), and 15 genomes from Oaxaca, México (host plant of boll weevil: *Cienfuegosia rosei* Fryxell (Malvaceae)). All *C. grandis* in this study were from controlled matings among reared individuals.

Crosses

A. Sib-mating offspring.—Virgin *C. grandis* females were mated with a single male. Their offspring were confined in individual Petri dishes and allowed to mate (sibling matings). Each female was isolated in a Petri dish 3–4 days after emergence for independent offspring evaluation. Host boll weevil larvae were presented to the *C. grandis* females encapsulated in Parafilm® using the method described by Cate (1987). Twelve Parafilm® encapsulated boll weevil larvae per female per day over five days were provided as hosts. Females that produced only male offspring were discarded (presumably they were not fertilized and had no opportunity to produce diploid males). Male offspring of fertilized females were prepared for flow cytometry.

B. Backcross offspring.—Virgin sibling couples were isolated in Petri dishes, allowed to mate, and were removed after offspring emergence. Families with only male offspring or without father survival were discarded. Daughters were paired with their fathers to induce mating and allowed to reproduce. Again, offspring with only males were not included in the analysis.

Flow Cytometry

Individual *C. grandis* males were prepared for flow cytometric analysis of genome size and ploidy level following Johnston et al. (2004). The head and thorax of a *C. grandis* was placed in a 1.5 ml Kontes Dounce tissue grinder into 1 ml of cold Galbraith buffer (per litre: 4.26 g $MgCl_2$, 8.84 g sodium citrate, 4.2 g 3-[N-morpholino] propane sulfonic acid, 1 mL Triton X-100, 20 µg/mL boiled Ribonuclease A, pH 7.2; Galbraith et al. 1983). Chicken red blood cells (CRBCs) were added to act as standards (1 C = 1212 Mb; Bennett et al. 2003). To release and isolate nuclei, the head and thorax plus the CRBCs in buffer solution were stroked 15 times with an A pestle and filtered through a 20-µm nylon filter. Propidium iodide, an intercalating dye that binds stoichiometrically to DNA and fluoresces in direct proportion to the amount of DNA present, was added to a final concentration of 50 ppm, and the mixture co-stained in the dark at 4°C for 20–40 minutes. The mean fluorescence of co-stained nuclei in replicate samples of each sex was quantified using a Coulter Epics Elite (Coulter Electronics, Hialeah, FL) with a laser tuned at 514 nm and 300 mW. Individual nuclei separate and pass across the exciting light source in the flow cell of the cytometry, where the nuclei are counted and the fluorescent light emitted from each nuclei is collected and quantified after passing a long pass filter to eliminate any reflected laser light. To avoid counting debris or nuclei with associated cytoplasmic tags, counting was activated by PI fluorescence, and only clean, singlet nuclei with low light scatter were included in the analysis. Genome size was estimated for each male and female *C. grandis* by first calculating the ratio of the fluorescent intensity of *C. grandis* nuclei to that of the CRBCs standard. The genome size was then determined by multiplying this ratio by the amount of DNA in the CRBCs.

Analysis

The genome size of *C. grandis* is given as the average (+/− standard error) of the

estimated genomes. A minimal estimate of the likelihood of scoring a diploid male is based on a binomial distribution, where the expectation of a diploid male is equal to the probability of homozygosity, assuming sufficient numbers of alleles at independent CSD loci that inbreeding is the only source of homozygosity.

RESULTS AND DISCUSSION

The genome size of *C. grandis* was estimated using a chicken red blood cell (CRBC) (1 C = 1212 Mb) standard and measured 1 C = 455.4 ± 3.4 Mb (Fig. 1 A, B). As expected, the haploid genome of males was half that of the diploid genome of females. The *C. grandis* genome is 1.37 times larger than that of the only other pteromalid genome scored to date, *N. vitripennis* (Walker) (1 C = 332.5) and 3 times larger than the genome of the only scored braconid wasp, *Habrobracon juglandis* (Ashmead, 1889) (1 C = 156.5) (Rasch et al.1975).

Catolaccus grandis were easily scored for ploidy level. Females revealed only a diploid peak (Figure 1A). Haploid males showed 2 fluorescent peaks with equal numbers of haploid and diploid (endoreduplicated) nuclei (Fig. 1 B). This endoreduplicated peak is observed because of the diploid tissue found in the muscle (Johnston et al. 2004). Diploid males (if present) would have shown only one strong diploid peak, as observed in the females. All 124 males from the F-2 gave a strong haploid peak as seen in Figure 2; no diploid males were scored. These results indicate that a CSD system, if it exists, is based on a number of loci in a multilocus complementary sex determination system (ml-CSD). A second set of inbred backcross offspring was produced, collected, and scored in order to estimate more precisely the number of genes involved in a potential ml-CSD system. Backcross offspring were selected because the expected 50% homozygosity in the backcross to the haploid male parent reduces the sample size needed to detect diploid males (Table 1). All males produced from the backcrosses (190 in total) were haploid.

If the CSD system exists for *C. grandis*, inbreeding should increase homozygosity and result in significant diploid male production. Given haplodiploid sex determination, sib mated and backcross zygotes had a probability of homozygosity at a single locus of 0.25 and 0.50 respectively. The failure to observe diploid males among the 314 scored males indicates that a CSD system, if it occurs at all in *C. grandis*, involves >5 independent loci. The probability that diploid males will be produced in significant numbers due to sib mating in nature, or due to small effective size in mass rearing colonies is low.

A possible source of error in these analyses is cannibalism or other forms of reduced survival of diploid males. Selective cannibalism based on semiochemicals is known to occur in honey bees, where the workers will consume any diploid males (Woyke 1963). A parasitoid of the codling moth, *Liotryphon caudatus* (Ratzeburg, 1848) (Hymenoptera: Ichneumonidae) with known cannibalism produces a significant diploid male population (T. R. Unruh, personal communication). This suggests, that in some haplodiploid species, cannibalism does not necessarily lead to selective killing of diploid males. In culture, *C. grandis* females lay eggs either on the boll weevil larvae or on the interior surface of the Parafilm® capsule where the host is presented as Parafilm® encapsulated larvae. In the rearing conditions here, the female is expected to lay 1, 2, or 3 eggs per host. An emerged *C. grandis* larva will move around and eat any other eggs or larvae that it encounters (Morales-Ramos and Cate 1992), and rarely are two parasitoid pupae found in the same host.

Two sources of data suggest that diploid male mortality cannot explain the absence of diploid males in our study. Fully 44.4% of hosts receive a single egg, and the

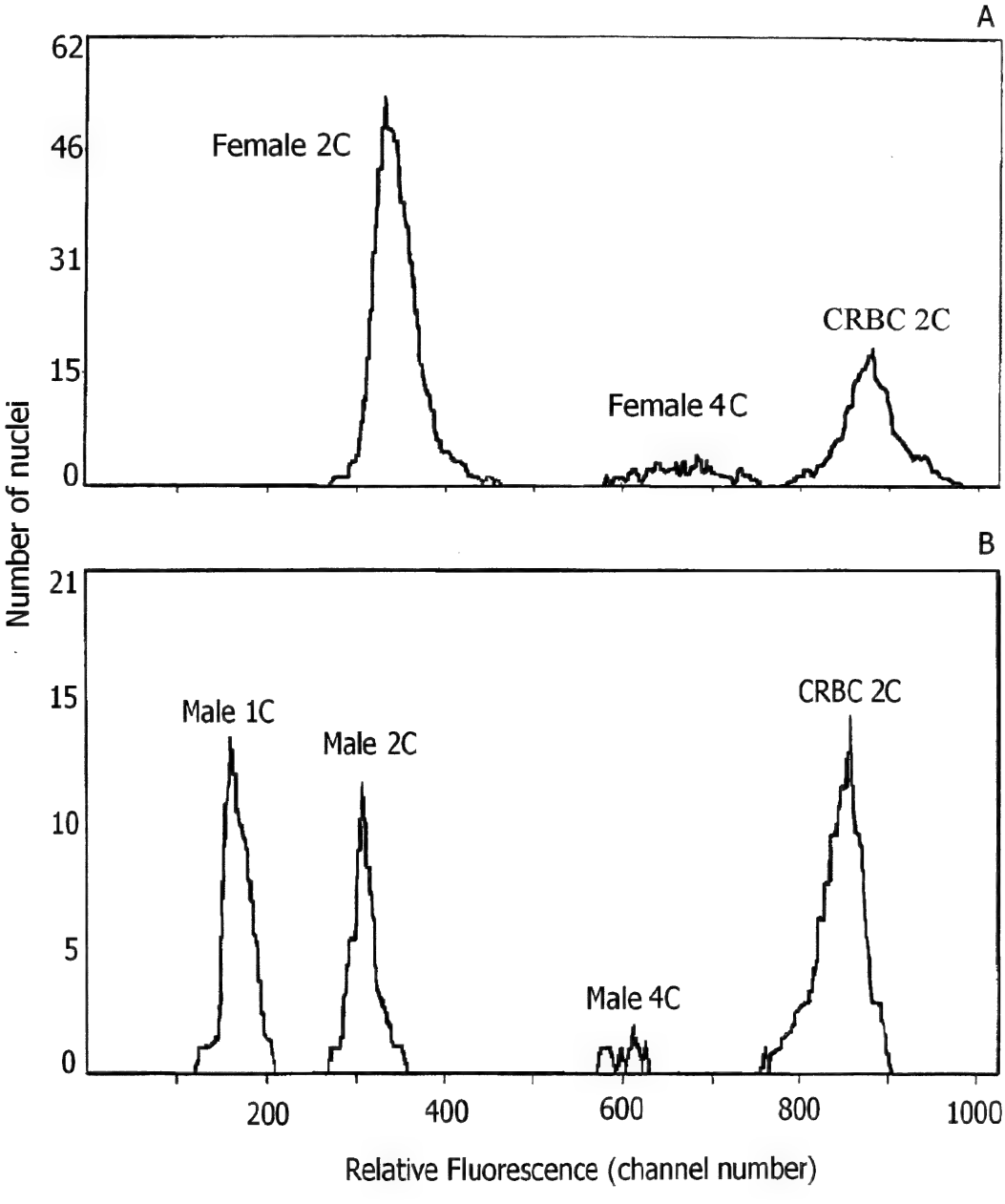


Fig. 1. Relative DNA staining in nuclei from the head of A) female *Catolaccus grandis* plus chicken red blood cells (CRBCs) and B) haploid male *C. grandis* plus CRBCs. Neural tissue produces the first 1 C peak in haploid males. DNA in the nuclei of muscle is largely endoreduplicated in haploid males (Johnston *et al.*, 2004) resulting in the diagnostic 1 C, 2 C and small 4 C peaks shown here. Relative DNA amount is calculated as the product of the ratio of the mean fluorescence of the leftmost peak (1 C in haploid males, 2 C in females)/mean fluorescence of CRBC standard multiplied by the estimated genome size of the CRBC standard (1140 Mb; Bennett et al. 2003).

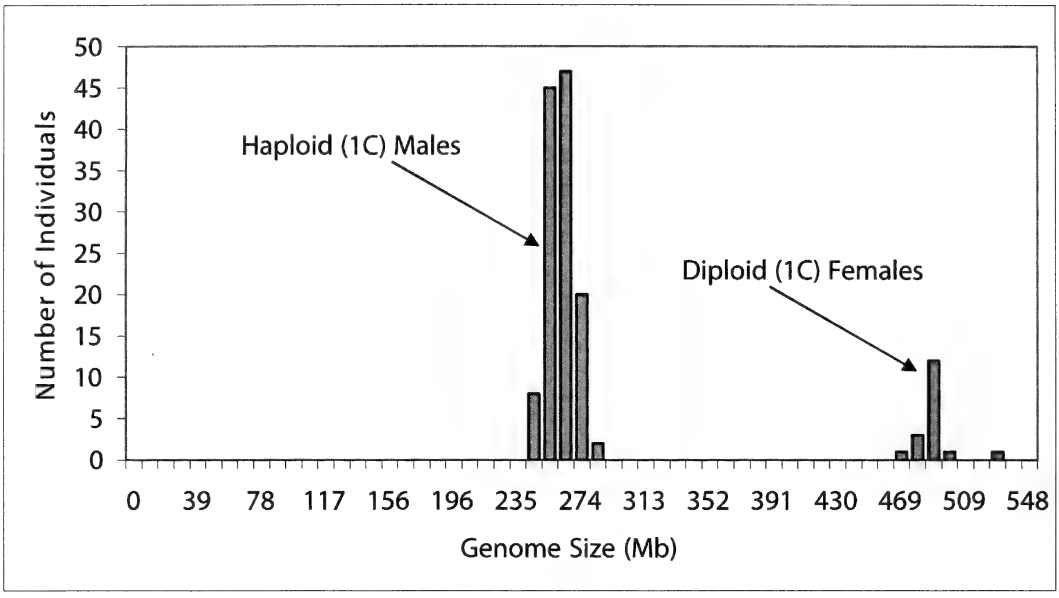


Fig. 2. Relative genome sizes of individuals of haploid males and diploid females.

remainder (55.6%) receive two or more eggs (Fig. 3). Even under the assumption that diploid males from single egg hosts are the only ones that survive cannibalism, a significant number of diploid males in a CSD system would be expected. Additional evidence that diploid males should have survived cannibalism is supported by the observation that there was no deviation of the sex ratio from what was expected. Under lab conditions, the sex ratio observed for the sib-matings was approximately 2.8:1. The previously published sex ratio in natural populations is 3:1 or 4:1 (Morales-Ramos and Cate 1992). A reduction in sex ratio (more surviving males) (1.2:1) was observed in the backcrosses, but this could be related to the age of the father. Gomez et al. (1997) exposed a virgin female every day during the life span of *C. grandis* males and observed a reduction over time in the ability of males to inseminate females.

Table 1. Sample size needed to detect a diploid male in F2 and backcross offspring (BC), given a sex determining system with one to five genes involved (ml-CSD) and a 4:1 female: male sex ratio in fertilized females under random mating based on binomial distribution.

	F2		BC	
Number of loci	P=95%	P=99%	P=95%	P=99%
1	10	13	4	6
2	18	27	6	9
3	66	101	10	15
4	258	396	18	27
5	1025	1575	35	76

Inbreeding, because it increases the chance of homozygosity and thus increases the appearance of diploid males, reduces the fitness of species with sl-CSD. In species with proven CSD, the effect of population bottlenecks and founder events that decrease the number of alleles and increase inbreeding may be reduced by modification of the CSD system, including inbreeding avoidance behaviors, and the development of a non-CSD system (Cook and Crozier 1995, Dobson and Tanouye 1998). One modification of CSD is to involve multiple loci, although the sex determination mechanism remains the same: females are heterozygous at one or more loci, while full fertility is expected only in haploid males where each CSD allele is present as a single copy (Paxton et

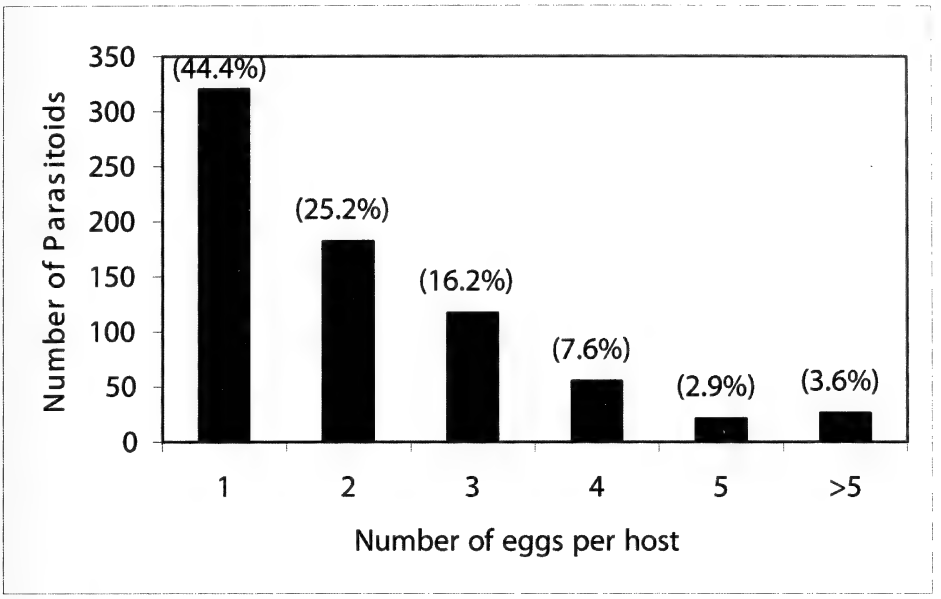


Fig. 3. The number and percentage (in parenthesis) of 721 hosts parasitized by 1, 2, 3, 4 and 5 or more eggs.

al. 2000). In ml-CSD, the chance of a homozygous diploid male is greatly reduced, even in inbreeding populations. Inbreeding effects have not been well tested experimentally for many Hymenoptera, however, and it can be argued that ml-CSD has not been persuasively demonstrated (Beukeboom et al. 2007), leaving the as best-known mechanism for inbreeding avoidance in the presence of CSD, the premating dispersal observed in *Bracon hebetor* (Ode et al. 1995). Because we experimentally controlled matings, mechanisms to avoid inbreeding were not an issue, and even an ml-CSD system is unlikely.

Single locus CSD has been demonstrated for at least 60 species of hymenopterans (Beukeboom et al. 2007), including most social species that have been studied (see exception in Schrempf et al. 2006). However, the CSD system is not the only mechanism for arrhenotokous reproduction. The absence of sl-CSD system has been conclusively demonstrated in *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Chalcidoidea) and the parasitoid *Heterospilus prosopidis* Viereck, 1910 (Hymenoptera: Braconidae) (Wu et al. 2005). It is also absent in the more distantly related ant *Cardiocondyla obscurior* Wheeler, 1929 (Formicidae), which shows no evidence of diploid males but does show inbreeding depression (Schrempf et al. 2006). Proposed alternative sex determination mechanisms in arrhenotokous insects include genomic imprinting, fertilization sex determination, genic balance sex determination, and maternal effect sex determination, which were all tested in populations of *N. vitripennis* (Dobson and Tanouye 1998, Beukeboom et al. 2007). The genomic imprinting model fits well for *N. vitripennis* (Trent et al. 2006) and may also be present in related Chalcidoidea.

Flow cytometry allowed us to quickly score for diploid male production, and we showed that the CSD model is unlikely to be the sex determination mechanism for the pteromalid, *C. grandis*. These results, along with fairly compelling evidence to reject CSD in one Trichogrammatidae (Chalcidoidea) species (Stouthamer and Kazmer 1994), raise the question of whether the CSD model arose independently or in a common ancestor of these species.

LITERATURE CITED

Bell, G. 1982. *The Masterpiece of Nature: The Evolution and Genetics of Sexuality*. University of California Press, Los Angeles.

Bennett, M. D., I. J. Leitch, H. J. Price, and J. S. Johnston. 2003. Comparisons with *Caenorhabditis* (~100 Mb) and *Drosophila* (~175 Mb) using flow cytometry show genome size in *Arabidopsis* to be ~157 Mb and thus ~25% larger than the *Arabidopsis* initiative estimate of ~125 Mb. *Annals of Botany* 91: 547–557.

Beukeboom, L. W., A. Kamping, and L. van de Zande. 2007. Sex determination in the haplodiploid wasp *Nasonia vitripennis* (Hymenoptera: Chalcidoidea): A critical consideration of models and evidence. *Seminars in Cell and Developmental Biology* 18: 371–378.

Beye, M., M. Hasselman, M. K. Fondrk, R. E. Page Jr, and S. W. Omholt. 2003. The Gene *csd* is the primary signal for sexual development in the honeybee and encodes an SR-type protein. *Cell* 114: 419–429.

Bull, J. J. 1983. *Evolution of Sex Determining Mechanisms*. Benjamin/Cummings Publishing Company, Menlo Park, CA.

Cate, J. R. 1987. A method of rearing parasitoids of boll weevil without the host plant. *Southwestern Entomology* 12: 211–215.

Castro, L. R. and Dowton, M. 2005. The position of the Hymenoptera within the Holometabola as inferred from the mitochondrial genome of *Perga condei* (Hymenoptera: Symphyta: Pergidae). *Molecular Phylogeneics and Evolution* 34: 469–479.

Cook, J. M. and R. H. Crozier. 1995. Sex determination and population biology in Hymenoptera. *Trends in Ecology and Evolution* 10: 281–286.

Cowan, D. P. and J. K. Stahlhut. 2004. Functionally reproductive diploid and haploid males in an inbreeding hymenopteran with complementary sex determination. *Proceedings of the National Academy of Sciences of the United States of America* 101: 10374–10379.

Dobson, S. L. and M. A. Tanouye. 1998. Evidence for a genomic imprinting sex determination mechanism in *Nasonia vitripennis* (Hymenoptera; Chalcidoidea). *Genetics* 149: 2333–242.

Galbraith, D. W., K. R. Harkins, J. M. Maddox, N. M. Ayres, D. P. Sharma, and E. Firoosabady. 1983. Rapid flow cytometric analysis of the cell cycle in intact plant tissues. *Science* 220: 1049–1051.

Gómez, T. V., N. M. Bárcenas, and E. G. King. 1997. Longevidad y capacidad de inseminación de machos de Catolaccus grandis (Burks) (Hymenoptera: Pteromalidae), parasitoide del picudo del algodón Anthonomus grandis Boheman (Coleoptera: Curculionidae). *Memorias del XX Congreso Nacional de Control Biológico. Guadalajara, Jal.* 13–14 de noviembre de 1997: 102–104.

Johnston, J. S., L. D. Ross, D. P. Hughes, L. Beani, and J. Kathirithamby. 2004. Tiny genomes and endoreduplication in Strepsiptera. *Insect Molecular Biology* 13: 581–5.

Keller, L., C. Liautard, M. Reuter, W. D. Brown, L. Sundstrom, and M. Chapuisat. 2001. Sex ratio and *Wolbachia* infection in the ant *Formica exsecta*. *Heredity* 87: 227–233.

Mable, B. K. and S. P. Otto. 1998. The evolution of life cycles with haploid and diploid phases. *BioEssays* 20: 453–462.

Morales-Ramos, J. A. and J. R. Cate. 1992. Functional response of *Catolaccus grandis* (Burks) (Hymenoptera: Pteromalidae) in field cages. *Biological Control* 2: 193–202.

———, M. G. Rojas, J. Roberson, R. G. Jones, E. G. King, K. R. Summy, and J. R. Brazzel. 1994. Suppression of the boll weevil first generation by augmentative releases of *Catolaccus grandis* in Aliceville, Alabama. Pp. 958–961 in: *1994 Proceedings of the Beltwide Cotton Conferences Vol. 2*. National Cotton Council of America, Memphis, TN.

———, K. R. Summy, and E. G. King. 1995a. Estimating parasitism by *Catolaccus grandis* (Hymenoptera: Pteromalidae) after inundative releases against the boll weevil (Coleoptera: Curculionidae). *Environmental Entomology* 24: 1718–1725.

———, M. G. Rojas, and E. G. King. 1995b. Venom of *Catolaccus grandis* (Hymenoptera: Pteromalidae) and its role in parasitoid development and host regulation. *Annals of the Entomological Society of America* 88: 800–808.

———, M. G. Rojas, R. J. Coleman, and E. G. King. 1998. Potential use of in vitro-reared *Catolaccus grandis* (Hymenoptera: Pteromalidae) for biological control of the boll weevil (Coleoptera: Curculionidae). *Journal of Economic Entomology* 91: 101–109.

Ode, P. J., M. F. Antolin, and M. R. Strand. 1995. Broodmate avoidance in the parasitic wasp *Bracon hebetor*. *Animal Behavior* 49: 1239–1248.

Paxton, R. J., P. A. Thoren, N. Gyllenstrand, and J. Tengo. 2000. Microsatellite DNA analysis reveals low diploid male production in a communal bee with inbreeding. *Biology Journal of the Linnaean Society* 69: 945–959.

Rasch, E. M., J. D. Cassidy, and R. C. King. 1975. Estimates of genome size in haplodiploid species of parasitoid wasps. *Journal of Histochemistry and Cytochemistry* 23: 317.

Ross, K. G., E. L. Vargo, L. Keller, and J. C. Trager. 1993. Effect of a founder event on variation in the genetic sex-determining system of the fire ant *Solenopsis invicta*. *Genetics* 135: 843–854.

Schrempf, A., S. Aron, and J. Heinze. 2006. Sex determination and inbreeding depression in an ant with regular sib-mating. *Heredity* 97: 75–80.

Stouthamer, R. and D. J. Kazmer. 1994. Cytogenetics of microbe-associated parthenogenesis and its consequences for gene flow in *Trichogramma* wasps. *Heredity* 73: 317–327.

———, R. F. Luck, and J. H. Werren. 1992. Genetics of sex determination and the improvement of biological control using parasitoids. *Environmental Entomology* 21: 427–435.

Summy, K. R., J. A. Morales, and E. G. King. 1995. Suppression of boll weevil (Coleoptera: Curculionidae) infestations on south Texas cotton by augmentative releases of the parasite *Catolaccus grandis* (Hymenoptera: Pteromalidae). *Biological Control* 5: 523–529.

———, J. A. Morales-Ramos, and E. G. King. 1997. Suppression of boll weevil infestations (Coleoptera: Curculionidae) occurring on fallow-season cotton in Southern Texas by augmentative releases of *Catolaccus grandis* (Hymenoptera: Pteromalidae). *Biological Control* 9: 209–215.

Trent, C., C. Crosby, and J. Eavey. 2006. Additional evidence for the genomic imprinting model of sex determination in the haplodiploid wasp *Nasonia vitripennis*: isolation of biparental diploid males after X-ray mutagenesis. *Heredity* 96: 368–376.

White, M. J. D. 1973. *Animal Cytology and Evolution.* 3rd ed. Cambridge University Press, Cambridge, U.K.

Whiting, P. W. 1943. Multiple alleles in complementary sex determination of *Habrobracon*. *Genetics* 28: 365–382.

Woyke, J. 1963. What happens to the diploid drone larvae in a honeybee colony. *Journal of Apiculture Research* 19: 89–95.

Wu, Z., K. R. Hopper, P. J. Ode, R. W. Fuester, M. Tuda, and G. E. Heimpel. 2005. Single-locus complementary sex determination absent in *Heterospilus prosopidis* (Hymenoptera: Braconidae). *Heredity* 95: 228–234.

J. HYM. RES.
Vol. 17(2), 2008, pp. 210–215

On Two Asian Species of the Genus *Mellinus* Fabricius, 1790 (Hymenoptera: Crabronidae)

SURESH K. GUPTA, SEVERIANO F. GAYUBO, AND WOJCIECH J. PULAWSKI

(SKG) Northern Regional Station, Zoological Survey of India, 218, Kaulagarh Road, Dehradun, 248 195, India; email: skgupta48@yahoo.co.in
(SFG) Área de Zoología, Facultad de Biología, Universidad de Salamanca E-37071, Salamanca, Spain; email: gayubo@usal.es
(WJP) Department of Entomology, California Academy of Sciences, 55 Music Concourse Drive, San Francisco, California 94118, USA; email: wpulawski@calacademy.org

Abstract.—*Mellinus obscurus* Handlirsch, 1888, currently recognized as a subspecies of *arvensis* (Linnaeus, 1758), is restored to full species status based on the unusual structure of its antennal socket. *Mellinus orientalis* is described from India and Nepal; its main diagnostic characters are a finely sculptured propodeal enclosure and a carina separating the propodeal posterior surface from the side.

The following are the abbreviations used in the text below:

CAS:	California Academy of Sciences, San Francisco, California, USA
USAL:	Área de Zoología, Facultad de Biologia, Universidad de Salamanca, Spain
ZSI:	Northern Regional Station, Zoological Survey of India, Dehradun, India.

Mellinus obscurus Handlirsch, species status restored

Mellinus obscurus Handlirsch, 1888:289, E. Holotype: E, Korea: no specific locality (KRAKÓW). – Dalla Torre, 1897:561 (in catalog of world Sphecidae); Maidl and Klima, 1939:39 and 43 (in catalog of world Astatinae and Bembicinae); Yasumatsu, 1943:2 (China: Hebei Province, Inner Mongolia, description of Γ); Tsuneki, 1965:26 (in key to Bembicinae of Japan and Korea): Haneda, 1968:46 (Japan); Tano, 1968:33 (Japan); Tsuneki, 1969a:18 (Japan: Sapporo area: nesting habits, prey,), 1969b:26 (Japan: specimens in Osaka Museum); Tsuneki, 1969c:64 (Japan: Mount Hyonosen); Nambu, 1973:152 (Japan: Saitama Prefecture); Suda, 1973:123 (Japan: Yamanashi Prefecture); Siri and R. Bohart, 1974:170 (in key to world *Mellinus*), 174 (in review of world *Mellinus*); Nambu, 1975:72 (Japan: Saitama Prefecture); R. Bohart and Menke, 1976:449 (listed); Kazenas, 1980:84 (first record from Russia: Primorskiy Kray and Kuril Islands); Tsuneki, 1982:18 (known from Korea; as *obscrus*), 1982b:36 (first record from Taiwan: Chiay Prefecture: Mount Ali); Miyatake, 1996:103 (specimens in Hiroshi Aoki collection). – **As *Mellinus arvensis obscurus***: Nemkov *in* Nemkov, Kazenas, Budrys, et Antropov, 1995:455 (new status, in key to Sphecidae of Russian Far East); Nemkov, 2005:157 (Russia: Sakhalin Island), 2006:169 (Russia: Primorskiy Kray: Kedrovaya Pad' Nature Reserve); nec Boesi, Polidori, Gayubo, Tormos, Asís, and Andrietti, 2007:184 (= *Mellinus orientalis*); Nemkov, 2007:74 (Russia: Kuril Islands: Iturup and Kunashir Islands), 2008:20 (in key to *Mellinus* of Russia).

Mellinus tristis Pérez, 1905:156, E. Holotype or syntypes: E, Japan: no specific locality but presumably Tokyo area (MNHN). Synonymized with *Mellinus obscurus* by Tsuneki,

1965:26. – Pérez, 1905:26 (listed); Maidl and Klima, 1939:42 (in catalog of world Astatinae and Bembicinae); Tsuneki, 1946:85 (prey records). – **As *Mellinus obscurus tristis***: Yasumatsu, 1943:3 (comparison with *Mellinus obscurus*); Maruyama, 1948:7 (nesting habits); Tsuneki and Shimoyama, 1963:48 (Japan: Towada Prefecture).

We have not seen the type *of Mellinus obscurus*, but there is little doubt about the interpretation of this species, as it is the only member of the genus that occurs in the Asian Far East. It was described as a full species, but differentiated from *arvensis* only by chromatic characters (Handlirsch, 1888; Siri and Bohart, 1974; Nemkov et al., 1995, 2008). In *arvensis* the mesopleuron, scutellum, gastral terga II, III and V (female) or VI (male) are marked with yellow, and the hindtibia is yellowish brown, whereas these body parts, except tergum III (and occasionally other terga), are black in *obscurus*. In addition, *arvensis* occurs in Europe, Turkey, Kazakhstan, and east to the Irkutsk area and Altai Mts. in Siberia, while *obscurus* is known from the Russian Far East, Korea, Japan, China (Hebei Province and Inner Mongolia), and Taiwan. Because the differences between *arvensis* and *obscurus* were in color only, and because they appeared to be vicariant species, Nemkov et al. (1995) downgraded *obscurus* to a subspecies of *arvensis*. *Mellinus obscurus*, however, strikingly differs from all its congeners in having the antennal socket with an overhanging frontal lobe (compare Figs 1a, b and 2a). In our opinion, this difference alone suffices to treat *obscurus* as a full species.

We have examined 7 ♀, 6 ♂ from Japan and 1 ♀ and 1 ♂ from Kuril Islands, Russia.

Mellinus orientalis Gupta, Gayubo, and Pulawski, sp. nov.

Mellinus sp.: Gupta, 1997:102 (first record of *Mellinus* from Oriental Region).

As *Mellinus arvensis obscurus*: Boesi, Polidori, Gayubo, Tormos, Asís, and Andrietti, 2007:184 (Nepal; nesting habits, adult morphology, description of larva).

Name derivation.—*Orientalis*, a Latin masculine and feminine adjective meaning *Oriental*; with reference to this species distribution.

Taxonomic history.—Gupta (1997) first recorded *Mellinus* from the Oriental Region, but he determined his specimens to genus only. Boesi et al. (2007) examined 17 females from Nepal, comparing them to the European *Mellinus arvensis* and the Japanese *M. arvensis obscurus*. They discussed several sculptural, setal, and chromatic characters, but not the antennal socket nor the pygidial plate, and concluded that the Nepalese specimens were conspecific with *arvensis obscurus*. We consider all these specimens to represent a distinct new species, *Mellinus orientalis*.

Diagnosis.—As in the Palearctic *arvensis* (Linnaeus), *crabroneus* (Thunberg), *obscurus* Handlirsch, and also the Mesoamerican *costaricae* (Bohart) recently transferred to *Mellinus* from *Trachogorytes* by Pulawski (2007), *orientalis* has a well-defined carina that separates the propodeal posterior (oblique) surface from the side. It differs from these four species by five characters: 1. its propodeal enclosure is finely rugose on a narrow median zone (rather than conspicuously rugose on a large portion of the enclosure, compare Figs. 1c and 2b), 2. the gaster is all black or tergum III has a pair of lateral pale spots (at least tergum II has pale spots in the other four species), 3. the female pygidial plate is punctate over more than half its length and ridged only apically (rather than punctate basally and ridged over more than half of its length, compare Figs. 1e and 2d), 4. male flagellomeres VI–IX each has a narrow, almost linear placoid (rather than a broadly elliptical placoid; male unknown in *costaricae*), and 5. gonocoxite narrowed apically (rather than conspicuously broad (compare Fig. 1f and 2e). Also, the erect setae on tergum I are shorter in *orientalis* than in *arvensis* and *obscurus* (compare Figs. 1d and 2c).

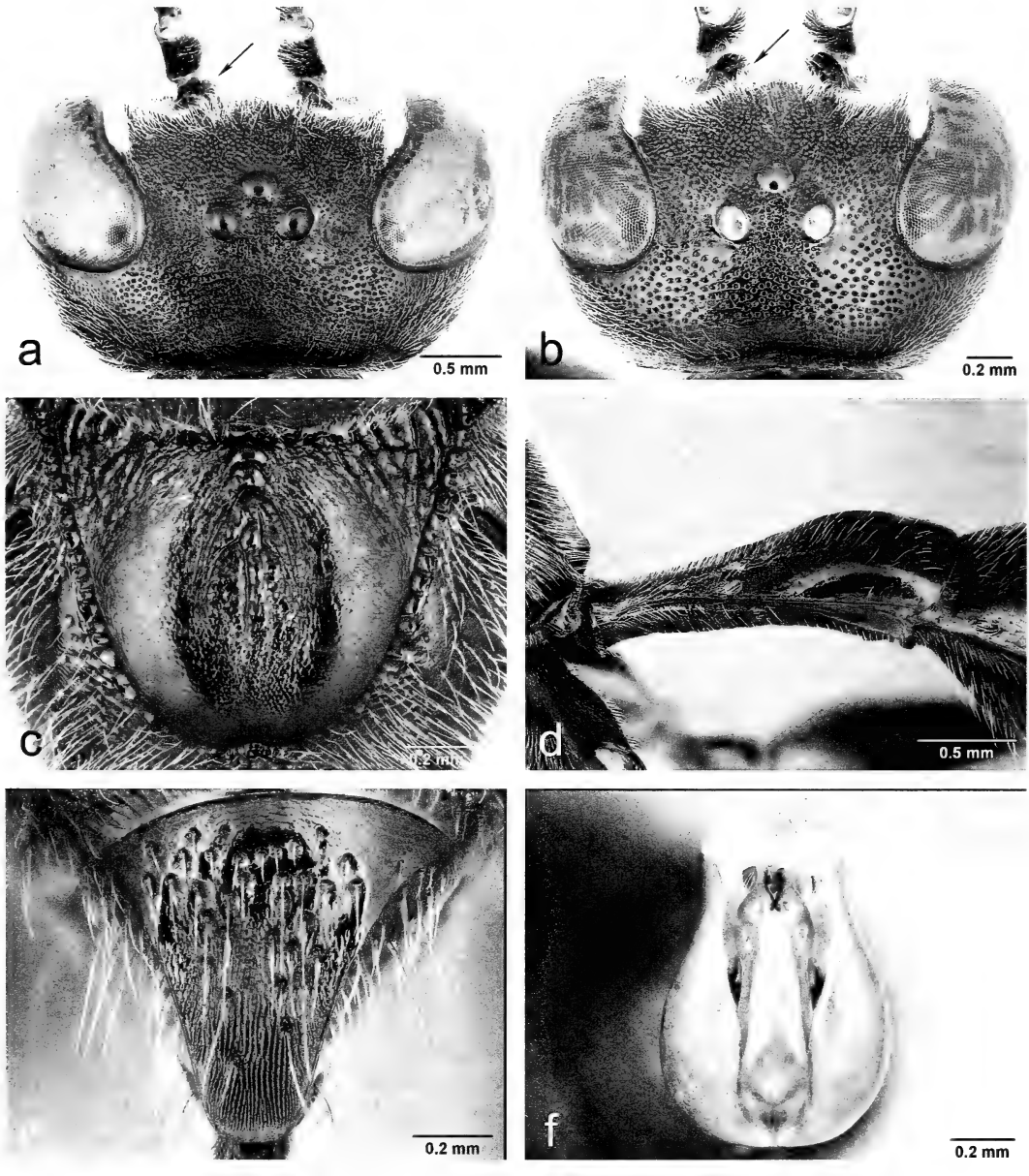


Fig. 1. *Mellinus obscurus* Handlirsch: a – female head in dorsal view showing antennal sockets; b – male head in dorsal view showing antennal sockets; c – propodeal enclosure of female; d – female tergum I in lateral view; e – pygidial plate of female; f – male genitalia in dorsal view.

Description.—Clypeal free margin with three well-defined teeth. Tentorial pit closer to antennal socket than to inner eye orbit (0.7:1.0) in female, equidistant in male. Frontal and scutal punctation slightly finer than in *arvensis*. Mesopleuron punctate. Propodeal enclosure microscopically areolate and with finely rugose median area (Fig. 2b) that is slightly narrower than midocellar width (the rugose area is no longer than midocellar width in some specimens, and extends to about enclosure midlength in others); propodeal side punctate, unsculptured anteriorly, separated from posterior (oblique) surface by longitudinal carina

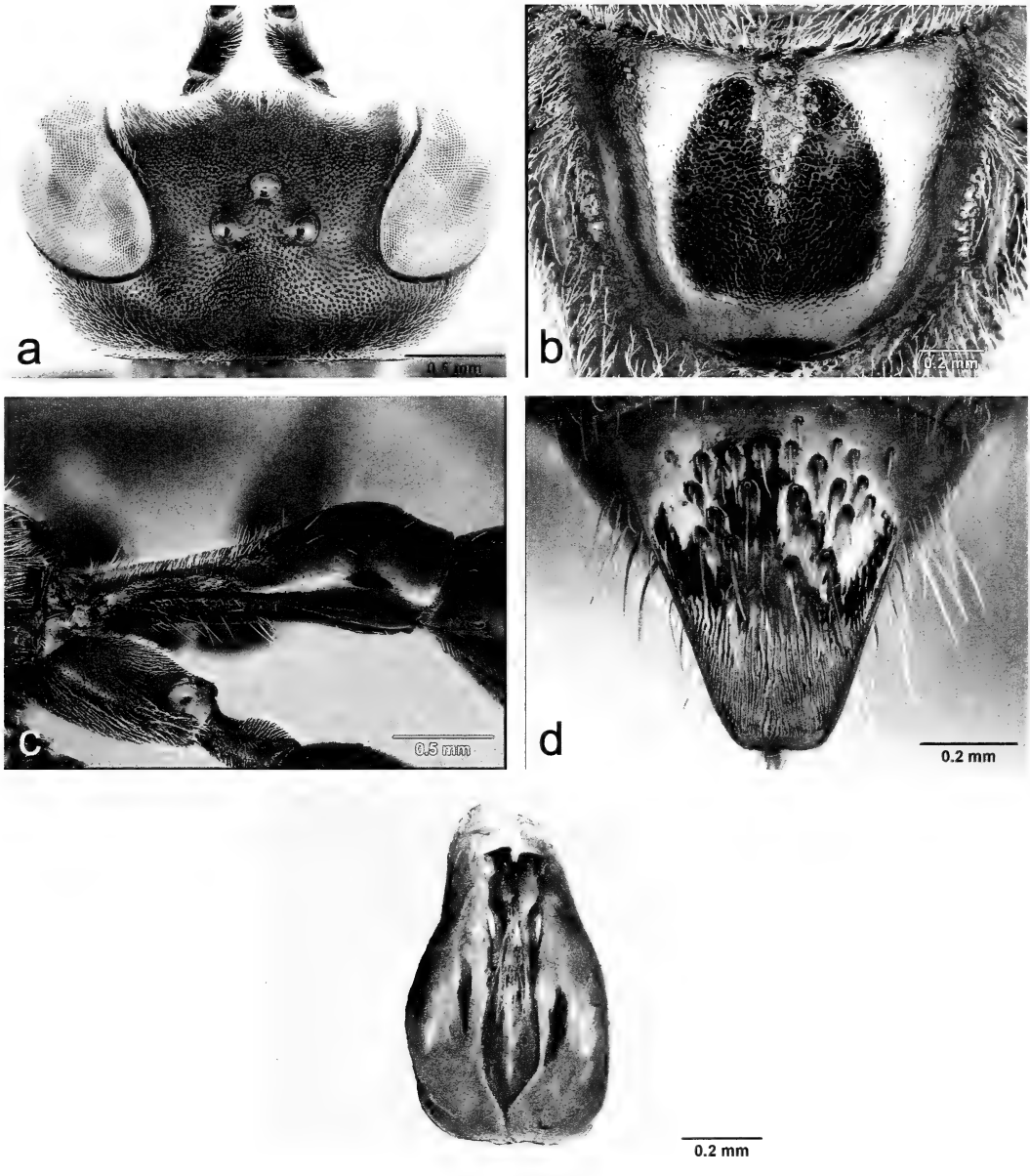


Fig. 2. *Mellinus orientalis* Gupta, Gayubo, and Pulawski: a – female head in dorsal view showing antennal sockets; b – propodeal enclosure of female; c – female tergum I in lateral view; d – pygidial plate of female; e – male genitalia in dorsal view.

that starts about two midocellar widths behind propodeal spiracle; posterior surface punctured. Tergum I narrow, its maximum width 2.0 × basal width (measured just behind gastro-propodeal articulation) in female, 1.7 × in male.

Setae erect on dorsum of peduncle of tergum I, markedly shorter than those on sternum I (setal length about 0.5 × midocellar width, Fig. 2c).

Head, thorax, propodeum, and gaster black except the following are pale yellow: narrow paraorbital stripe (extending to about orbit midheight), scapal venter, ventral half of clypeus in Nepalese specimens (clypeus all black in Indian male and

with two admedian and two small lateral spots in Indian female), and pair of spots on pronotal collar in some Nepalese specimens. Legs black except inner foretibial surface pale yellow in Nepalese specimens, partly yellowish brown in Indian female, and dark brown in Indian male; and apical tarsomeres yellowish brown to brown. Tergum III with pair of lateral pale spots in most Nepalese specimens (all black in two).

♀. – Pygidial plate punctate over more than half its length, ridged on remaining apical portion (Fig. 2d). Length: 9.5–12.0 mm.

♂. – Flagellomeres VI–IX each with narrow, almost linear placoid. Genitalia: Fig. 2e. Length 7.5 mm.

Geographic distribution.—Northern India, Nepal.

Records. —HOLOTYPE: ♀, **INDIA**: **Uttarakhand**: Dwali in Almora District, 2734 m, 31 Aug 1990, P.C. Tak & party (ZSI: NRS/ZSI/A9837). PARATYPES: **INDIA**: **Himachal Pradesh**: Dalhousie, 2132 m, 17 Aug 1972, Gulati (1 ♂, ZSI: NRS/ZSI/A9838); Narkanda [ca 2700 m], 21 June 1972, Mayank (1 ♂, CAS). **Uttarakhand**: between Dwali and Phurkia in Almora District, 2,734–3,260 m , 1 Sept 1990, P.C. Tak & party (1 ♀, CAS). **NEPAL**: **Eastern Region**: Solu Khumbu District: Sagarmatha National Park at 27°45′–28°07′N 86°28′–87°07′E, Roberto Boesi, 30 May 2003 (1 ♀, USAL); 26 June 2003 (2 ♀, CAS; 3 ♀, USAL), 30 June 2003 (1 ♀, USAL), 6 July 2003 (7 ♀, USAL); 10 July 2003 (1 ♀, CAS; 2 ♀, USAL).

ACKNOWLEGMENTS

We thank Arnold S. Menke and Robert L. Zuparko for their critical reading of the manuscript and many excellent suggestions. April Nobile generated illustrations using Auto-Montage.

LITERATURE CITED

Bohart, R. M. and A. S. Menke. 1976. *Sphecid Wasps of the World. A generic revision.* University of California Press, BerkeleyLos AngelesLondon, 1 color plate, IX + 695 pp.

Boesi, R., C. Polidori, S. F. Gayubo, J. Tormos, J. Asís, and F. Andrietti. 2007. Nesting biology, morphological remarks, and description of the mature larva of *Mellinus arvensis obscurus* (Hymenoptera: Crabronidae) in Nepal. *Florida Entomologist* 90: 184–190.

Dalla Torre, C. G. 1897. *Catalogus Hymenopterorum hucusque descriptorum systematicus et synonymicus*, Volumen VIII: Fossores (Sphegidae). Guilelmi Engelmann, Lipsiae [= Leipzig]. 749 pp.

Gupta, S. K. 1997. Hymenoptera. Pp. 97–104 in: Zoological Survey of India. Fauna of Conservation Areas 9: *Fauna of Nanda Devi Biosphere Reserve.*

Handlirsch, A. 1888. (1887) Monographie der mit *Nysson* und *Bembex* verwandten Grabwespen. II. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Abtheilung I* 96: 219–311, pls I–II.

Kazenas, V. L. 1980. Materialy k faune royushchikh os (Hymenoptera, Sphecidae) Dal'nego Vostoka SSSR [= Contributions to the digger wasp fauna (Hymenoptera, Sphecidae) of the Soviet Far East]. pp. 80–94 in: Lehr, P. A. ed. *Taxonomiya nasekomykh Dal'nego Vostoka.* Akademiya Nauk SSSR, Dal'nevostochnyi Nauchnyi Tsentr, Vladivostok. 122 pp. (in Russian).

Haneda, Y. 1968. Contribution from my cabinets to the knowledge of the Japanese Hymenoptera. *The Life Study (Fukui)* 12, 42–48 (in Japanese).

Maidl, F. and A. Klima. 1939. Pars 8: Sphecidae I. (Astatinae – Nyssoninae). In: Hedicke, H. ed. *Hymenopterorum Catalogus.* Dr. W. Junk, Verlag für Naturwissenschaften, 's-Gravenhage. 150 pp.

Maryuama, K. 1948. Habits of a Diptera-hunter, *Mellinus obscurus tristis* Pérez (Hymenoptera). *Mushi* 19: 7–11.

Miyatake, Y. 1996. A list of the insect collection by Mr. Hiroshi Aoki. *Special Publications from the Osaka Museum of Natural History* 28: 1–132 (in Japanese). [Sphecidae on pp. 101–103].

Nambu, T. 1973. Saitama-ken dôbutsushi kiso chôsa. Rikusei kontyû rui chôsa hôkoku. Makushi moku – Hymenoptera [= Studies on the Saitama Prefecture fauna. A report on the terrestrial entomofauna. Order Hymenoptera]. *Saitama-ken Dôbutsushi Kari-no Moku Roku [=Preliminary Reports on the Saitama Prefecture Fauna]* 3: 147–154 (in Japanese).

———. 1975. Kontyû-ko makushi moku Saitama-no hati [= Wasps of Saitama (Insecta, Hymenoptera)]. *Saitama-ken Dôbutsushi Kari-no Moku Roku [= Preliminary Reports on the Saitama Prefecture Fauna]* 4: 49–82 (in Japanese).

Nemkov, P. G. 2005. Fauna royushchikh os (Hymenoptera, Sphecidae, Crabronidae) ostrova Sakhalin – Digger wasp fauna (Hymenoptera, Sphecidae, Crabronidae) of Sakhalin Island., in: *Flora and Fauna of Sakhalin Island (Materials of International Sakhalin Project).* Part 2. Dalnauka, Vladivostok, (in Russian). pp. 141–167.

———. 2006. K faune royushchikh os (Hymenoptera: Sphecidae, Crabronidae) zapovednika «Kedrovaya Pad'» – Contribution to the fauna of digger

wasps (Hymenoptera: Sphecidae, Crabronidae) of Kedrovaya Pad Nature Reserve. Pp. 166–170 in: Makarchenko, A. ed. *Rastitel'nyi i zhivotnyi mir zapovednika «Kedrovaya Pad'» – Flora and Fauna of Kedrovaya Pad Nature Reserve.* Dalnauka, Vladivostok. 268 pp. (in Russian).

———. 2007. Rauna royushchikh os (Hymenoptera: Sphecidae, Crabronidae) Kurilskikh ostrovov – The digger wasp fauna (Hymenoptera: Sphecidae, Crabronidae) of Kuril Islands. *Euroasian Entomological Journal* 6: 67–76 (in Russian).

———. 2008. A key to the digger wasps of the genus *Mellinus* (Hymenoptera, Crabronidae, Mellininae) of the Russia. *Far Eastern Entomologist* 185: 19–20.

———, V. L. Kazenas, E. R. Budrys, and A. V. Antropov. 1995. Nadsem. Sphecoidea. 67. Sem. Sphecidae – Royushchiye osy. Pp. 368–480 in: Lehr, P. A. ed. *Opredelitel' nasekomykh Dal'nego Vostoka Rossii v shesti tomakh. Tom IV. Setchatokrylyie, skorpionnitsy, pereponchatokrylyie. Chast' 1.* Nauka, Sankt-Peterburg. 604 + 2 unnumbered pp. (in Russian).

Pérez, J. 1905. Hyménoptères recueillis dans le Japon central, par M. Harmand, ministre plénipotentiaire de France à Tokio. *Bulletin du Muséum d'Histoire Naturelle* 1905: 23–39, 79–87, 148–158.

Pulawski, W. J. 2007. The status of *Liris magnificus* Kohl, 1884, and *Trachogorytes costaricae* R. Bohart, 2000 (Hymenoptera: Crabronidae: Crabroninae, Bembicinae). *Journal of Hymenoptera Research* 16: 293–296.

Siri, M. L. and R. M. Bohart. 1974. A review of the genus *Mellinus* (Hymenoptera: Sphecidae). *The Pan-Pacific Entomologist* 50: 169–176.

Suda, H. 1973. Sphecidae of Yamanashi Pref., Japan. *The Life Study (Fukui)* 17: 121–124 (in Japanese).

Tano, T. 1968. Contribution from my cabinets to the knowledge of the Japanese Hymenoptera. *The Life Study (Fukui)* 12: 32–36 (in Japanese).

Tsuneki, K. 1946. Prey records of *Mellinus tristis* Pérez. *Matsumushi* 1: 85.

———. 1965. A guide to the study of the Japanese Hymenoptera (22) (10). Nyssoninae of Japan and Korea (1). *The Life Study (Fukui)* 9: 24–33.

———. 1969a. Gleanings on the bionomics of the East-Asiatic non-social wasps (Hymenoptera). IV. Some species of Bembicini, Stizini, Gorytini, Mellinini and Alyssonini. *Etizenia* 41: 1–19.

———. 1969b. Chrysidoidea and Sphecoidea in the collection of the Osaka Museum of Natural History. *The Life Study (Fukui)* 13: 23–28 (in Japanese).

———. 1969c. Addition to the Sphecidae-Fauna of Mt. Hyonosen. *The Life Study (Fukui)* 13: 64 (in Japanese).

———. 1982a. Sphecidae from North Korea (II) with the list of the species of the family known from the Korean Peninsula (Hymenoptera). *Special Publications of the Japan Hymenopterists Association* 20: 1–22.

———. 1982b. Studies on the new material of Sphecidae, Chrysididae and Mutillidae from Formosa and the Southern Ryukyus (Hymenoptera). *Special Publications of the Japan Hymenopterists Association* 23: 15–45.

——— and K. Shimoyama. 1963. Sphecidae and Chrysididae collected in the District of Towada, Japan. *The Life Study (Fukui)* 7: 48–50 (in Japanese).

Yasumatsu, K. 1943. Notes on some East-Asiatic Sphecoidea in the collection of the Musée Heude. *Notes d'Entomologie Chinoise* 10: 1–32.

J. HYM. RES.
Vol. 17(2), 2008, pp. 216–218

Clement E. Dasch, 1925–2007

ANDREW BENNETT, DAVID WAHL, AND IAN GAULD

(AB) Canadian National Collection of Insects, Ottawa, Ontario
(DW) American Entomological Institute, 3005 SW 56th Ave., Gainesville, FL 32608-5047, USA; email: aei@aei.cfcoxmail.com
(IG) The Natural History Museum, London, UK

Dr. Clement E. Dasch, 82, of New Concord, Ohio, died Nov. 29, 2007. He was a leading authority of Nearctic Ichneumonidae for over 40 years. Dr. Dasch was born Nov. 28, 1925 in Steubenville, OH and was a veteran of World War II, having served as a mortarman with the U.S. Army in France and Germany. He was a recipient of the Purple Heart.

He obtained his bachelor and doctorate degrees from Cornell and was a professor of biology at Muskingum College, New Concord for 37 years, retiring in 1990. He was a long-time member of the Entomological Society of America and the International Society of Hymenopterists, as well as a Director of the American Entomological Institute. He is survived by his wife Betty, four sons, nine grandchildren and his brother Lawrence.

In terms of contributions to Hymenoptera, Clement Dasch published 10 works on Ichneumonidae from 1958 to 1992. Seven of these were revisionary memoirs of more than 300 pages each. A summary of his major studies is presented in Table 1.

Dr. Dasch's work greatly complemented Henry Townes's higher level studies, and the meticulous and comprehensive nature of his Nearctic revisions contribute to making the Nearctic probably the best known region of the world for Ichneumonidae. What is most notable in Table 1 is the proportion of new species that he described, clearly illustrating the dearth of alpha-level knowledge of the family prior to his work. Perhaps most remarkable was his 1988 revision of the 313 Nearctic species of *Glypta*, of which 269 were new. As this genus is one of the most important for biological control of lepidopterous forest pests, Dr. Dasch thus leaves a legacy not only in taxonomy, but in applied entomology as well. It must be mentioned that this work would not have been possible without the partnership of his wife Betty, who worked tirelessly with him to produce these studies.

In addition to the revisionary work, Clement and Betty Dasch were exceptional collectors, amassing over 300,000 parasitic Hymenoptera from 1948–1998. The bulk of the collection (including 236,000 Ichneu-

Table 1. Statistics of Clement Dasch's major ichneumonid studies.

Ichneumonid taxon revised by region	Year	specimens examined	species treated	species described	% new species
Neotropical Diplazontinae	1964	n/a	52	42	81%
Nearctic Diplazontinae	1964	16762	101	58	57%
Nearctic Mesochorinae	1971	10057	127	95	75%
Neotropical Mesochorinae	1974	2416	277	263	95%
Nearctic Anomaloninae	1979	25304	179	111	62%
Nearctic Cremastinae	1984	16002	322	257	80%
Nearctic Glyptini	1988	21671	317	271	86%
Nearctic Orthocentrinae *s.l.*	1992	29500	120	88	73%
Total		**121712**	**1495**	**1185**	

Fig. 1. Clement Dasch visiting the Provancher Collection, Université Laval, Québec in 1981.

monidae) was given to the American Entomological Institute in Gainesville, Florida and is housed in the Clement and Betty Dasch room at the facility. One of the amazing aspects of Dasch's research was that he was not a full-time research taxonomist, but a professional teacher. His outstanding contribution towards ichneumonid taxonomy was undertaken as an extra; a passion that consumed most of his

and his wife's time. They collected prodigiously, then mounted and labelled and sorted far more specimens than most museum collections processed. Amongst the sciences, taxonomy is perhaps unique in depending on the efforts of a few individuals who have a level of dedication that is truly phenomenal. Notable examples are C.P. Alexander in Tipulidae, Walter Rothschild and Karl Jordan in Sphingidae, and of course Henry and Marjorie Townes in Ichneumonidae. Dasch is on a level with these all-time greats: an individual who has made many subfamilies of ichneumonids accessible to North American biologists during an era when taxonomy was a Cinderella subject and funding for systematics was in global decline. If we are ever going to really know the fauna of planet Earth, society needs to be able to cultivate more individuals like Clement Dasch. His death leaves a gap that is unlikely to be filled in the foreseeable future.

CLEMENT E. DASCH PUBLICATIONS

Butler, G. D. Jr. and C. E. Dasch. 1958. The Diplazontinae of Arizona (Hymenoptera: Ichneumonidae). *Arizona Agricultural Experimental Station Technical Bulletin* 135: 1–10.

Dasch, C. E. 1964. The Neotropic Diplazontinae. *Contributions of the American Entomological Institute* 1: 1–77.

———. 1964. Ichneumon-flies of America north of Mexico: 5. Subfamily Diplazontinae. *Memoirs of the American Entomological Institute* 3: 1–304.

———. 1971. Ichneumon-flies of America north of Mexico: 6. Subfamily Mesochorinae. *Memoirs of the American Entomological Institute* 16: 1–376.

———. 1971. Hibernating Ichneumonidae of Ohio (Hymenoptera). *Ohio Journal of Science* 71: 270–283.

———. 1974. Neotropic Mesochorinae (Hymenoptera: Ichneumonidae). *Memoirs of the American Entomological Institute* 22: 1–509.

———. 1979. Ichneumon-flies of America north of Mexico: 8. Subfamily Cremastinae. *Memoirs of the American Entomological Institute* 29: 1–702.

———. 1984. Ichneumon-flies of America north of Mexico: 9. Subfamilies Theriinae and Anomaloninae. *Memoirs of the American Entomological Institute* 36: 1–610.

———. 1988. Ichneumon-flies of America north of Mexico: 10. Subfamily Banchinae, tribe Glyptini. *Memoirs of the American Entomological Institute* 43: 1–644.

———. 1992. Ichneumon-flies of America north of Mexico: 12. Subfamilies Microleptinae, Helictinae, Cylloceriinae and Oxytorinae. *Memoirs of the American Entomological Institute* 52: 1–470.

INSTRUCTIONS FOR AUTHORS

General Policy. *The Journal of Hymenoptera Research* invites papers of high scientific quality reporting comprehensive research on all aspects of Hymenoptera, including biology, behavior, ecology, systematics, taxonomy, genetics, and morphology. Taxonomic papers describing single species are acceptable if the species has economic importance or provides new data on the biology or evolution of the genus or higher taxon. Manuscript length generally should not exceed 50 typed pages; however, no upper limit on length has been set for papers of exceptional quality and importance, including taxonomic monographs at generic or higher level. All papers will be reviewed by at least two referees. The referees will be chosen by the appropriate subject editor. However, it would be helpful if authors would submit the names of two persons who are competent to review the manuscript. The language of publication is English. Summaries in other languages are acceptable.

The deadline for receipt of manuscripts is 1 September (for the April issue) and 1 March (for the October issue).

Format and Preparation. Authors are strongly encouraged to submit manuscripts electronically to the editor at the email address below, and in the format specified below. On the upper left of the title page give name, address, telephone and fax numbers, and email address of the author to whom all correspondence is to be sent. The paper should have a concise and informative title, followed by the names and addresses of all authors. The sequence of material should be: title, author(s), abstract, text, acknowledgments, literature cited, appendix, figure legends, figure copies (each numbered and identified), tables (each numbered and with heading). Each of the following should start a new page: (1) title page, (2) abstract, (3) text, (4) literature cited, (5) figure legends, (6) footnotes.

Upon **final acceptance** of a manuscript, the author should provide the editor with an emailed IBM formatted electronic version. CD-ROMs or 3.5 inch floppy disks are acceptable. Because symbols and tables are not always correctly translated it is best to also send a printed copy of the manuscript. Preferred word processing programs are Microsoft Word and WordPerfect. If possible, all words that must be italicized should be done so, not underscored. Tables may be formatted in a spread sheet program such as MS Works or MS Excel. Text should be double-spaced typing, with 25 mm left and right margins. Tables should be put in a separate file. CDs and Diskettes should be accompanied by the name of the software program used (e.g., WordPerfect, Microsoft Word). Authors should keep backup copies of all material sent to the Editor. The Society cannot be responsible for diskettes or text mislaid or destroyed in transit or during editing.

Illustrations should be planned for reduction to the dimension of the printed page (14 × 20.5 cm, column width 6.7 mm) and allow room for legends at the top and bottom. Do not make plates larger than 14 × 18 in. (35.5 × 46 cm). Individual figures should be mounted on a suitable drawing board or similar heavy stock. Photographs should be trimmed, grouped together and abutted when mounted. Figure numbers should be on the plate. Include title, author(s) and address(es), and illustration numbers on back of each plate. Original figures need not be sent until requested by the editor, usually after the manuscript has been accepted. Reference to figures/tables in the text should be in the style "(Fig.1)" "(Table 1)". Measurements should be in the metric system.

Electronic plates may be submitted on disc, via email or uploaded to an ftp site (instructions will be given). They must be fully composited, labeled, and sized to fit the proportions of the journal page. Line art should be scanned at 1200 dpi (minimum input resolution is 600 dpi). Color or grayscale (halftone) images should have a dpi of 300-350. Color files should be in CMYK and not RGB. Graphics should be submitted as TIFF, Adobe Illustrator or EPS files. No PowerPoint or Word/WordPerfect files with images embedded in them are acceptable.

All papers must conform to the *International Code of Zoological Nomenclature*. The first mention of a plant or animal name should include the full scientific name including the authority. Genus names should not be abbreviated at the beginning of a sentence. In taxonomic papers type specimens must be clearly designated, type depositories must be clearly indicated, and new taxa must be clearly differentiated from existing taxa by means of keys or differential diagnoses. Authors are required to deposit all type material in recognized institutions (not private collections). Voucher specimens should be designated for specimens used in behavioral or autecological studies, and they should be deposited similarly. DNA sequences must be deposited in GenBank/EMBL/DNA Databank of Japan.

Acceptance of taxonomic papers will not require use of cladistic methods; however, authors using them will be expected to specify the phylogenetic program used, including discussion of program options used. A data matrix should be provided for morphological characters. Cladograms must be hung with characters and these should include descriptors (not numbers alone) when feasible. The number of parsimonious cladograms generated should be stated and reasons given for the one adopted. Lengths and consistency indices should be provided. Adequate discussions should be given for characters, plesiomorphic conditions, and distributions of characters among outgroups when problematical.

References in the text should be (Smith 1999), without a comma, or Smith (1999). Two articles by a single author should be (Smith 1999a, 1999b) or Smith (1999a, 1999b). For multiple authors, use the word "and," not the symbol "&" (Smith and Jones 1999). For papers in press, use "in press," not the expected publication date. The Literature Cited section should include all papers referred to in the paper. Journal names should be spelled out completely and in italics.

Charges. Publication charges are $10.00 per printed page. At least one author of the paper must be a member of the International Society of Hymenopterists. Reprints are charged to the author and must be ordered when returning the proofs; there are no free reprints. Author's corrections and changes in proof are also charged to the author. Color plates will be billed at full cost to the author.

All manuscripts and correspondence should be addressed to:

Dr Gavin Broad
Dept. of Entomology
The Natural History Museum
Cromwell Road
London SW7 5BD, UK
Phone: +44(0)207 9425938; Fax: +44(0)207 9425229; Email: editor@hymenopterists.org