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(Continued on inside of back cover)

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A NEW SPECIES OF COLLEMBOLA FROM UTAH (COLLEMBOLA: KATIANNIDAE)[1]

Richard J. Snider[2]

ABSTRACT: A new species of Collembola, *Sminthurinus* (*Polykatianna*) *utahensis* is described from Logan County, Utah. The species was taken from maple (*Acer* sp.) litter using the Tullgren extraction method.

Recently, through the kind cooperation of Howard V. Weems, Jr., Curator of the Florida State Collection of Arthropods, I have been able to examine a large collection of Collembola from Utah. Specimens, described here as a new species, were taken in the field by George F. Knowlton, Utah State University. The classification of higher catagories used in this report follows Betsch (1980); generic level follows Richards (1968) and Christiansen and Bellinger (1981).

Sminthurinus (Polykatianna) utahensis n. sp.

COLOR DESCRIPTION

Antenna light purple, becoming darker distally. Head with lower frons dusted with light purple. Black maculae occur between antennal bases and interocular area, otherwise head is white. Prothoracic region white, dark purple pigment occurs over major portion of body both dorsally and laterally. Pattern forms a large white spot laterally, that opens downwards. Appendages white. (Figs. 1 & 2).

MORPHOLOGICAL DESCRIPTION

HEAD: eyes 8 + 8 on black patches, ocelli C and D at least 1/2 diameter of others (Fig. 3); mean antennal ratio 1:2:2.5:6.25; ANT I with 4 dorsal anterior and 1 ventral setae (Fig. 4); ANT II not remarkable (Fig. 5); ANT III with subapical sense rods lying in shallow depressions, lateral sensory papilla simple (Fig. 6); ANT IV divided into 9 subsegments (Fig. 7), with median apical bulb (Fig. 8); frons with 1 + 1 fovea and 1 + 1 oval organs below antennal bases (Fig. 9). FORELEG: coxa with 1 seta; trochanter with 3 anterior and 1 posterior setae, femur with 1 short, distal posterior seat (arrow); tibiotarsus with 10 clavate tenent hairs (Fig. 10); pretarsus with anterior and posterior setulae; unguis lanceolate, with 2 weak inner teeth; unguiculus with distinct inner corner tooth and short subapical needle (Fig. 13). MESOLEG: coxa with 3 setae; trochanter with 3 anterior and 2 posterior setae, D_2 modified into a trochanteral organ (arrow); femur with 1 short, distal posterior seta (arrow); tibiotarsus with 1 "epine accolee" on posterior surface (arrow) and 10 clavate tenent hairs (Fig. 11); pretarsus with anterior and posterior setulae; unguis lanceolate, with 2 weak inner teeth; unguiculus with distinct inner corner tooth and short subapical needle (Fig. 14).

METALEG: coxa with 3 setae; trochanter with 3 anterior and 2 posterior setae, D_2 modified

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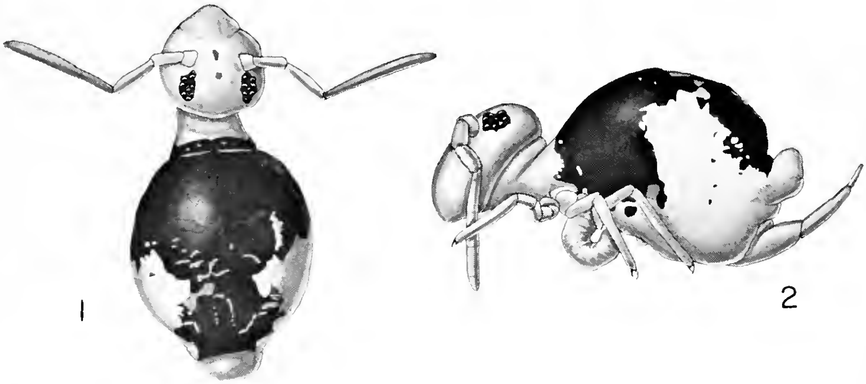
[1] Received April 30, 1987. Accepted July 22, 1987.

[2] Department of Zoology, Michigan State University Lansing, MI 48824.

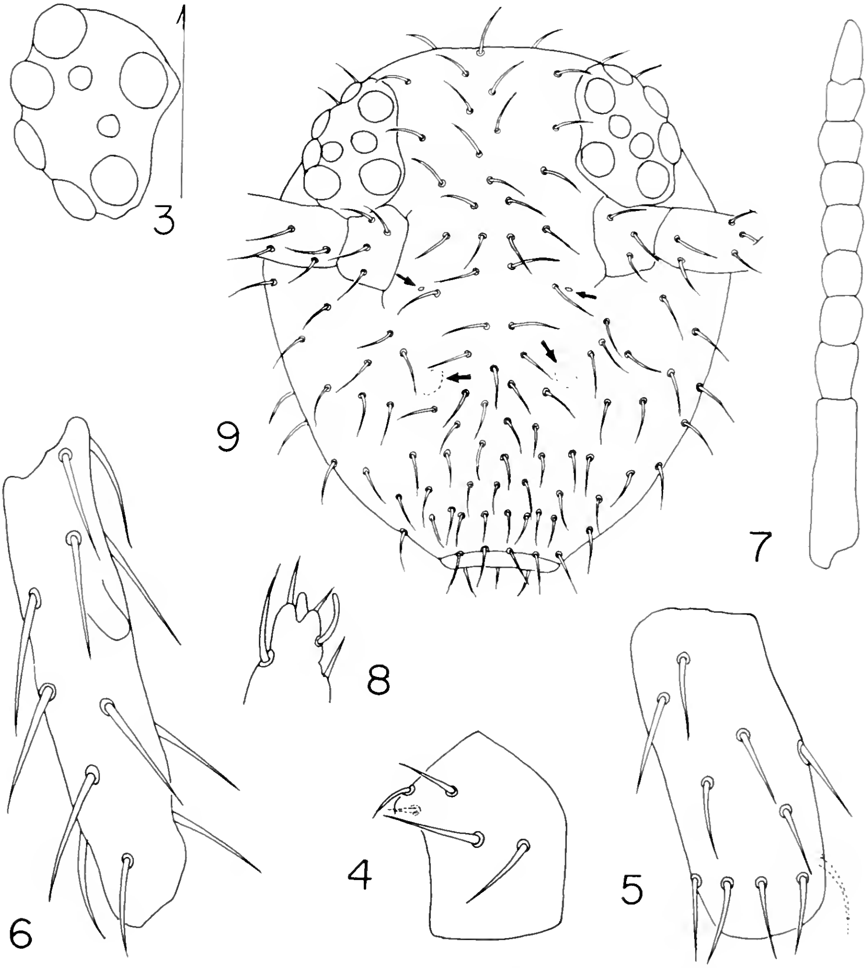
into trochanteral organ (arrow); femur with 2 posterior setulae; tibiotarsus lacks "epine accolee" on posterior surface with 10 clavate tenent hairs (Fig. 12); pretarsus with anterior and posterior setulae; unguis lanceolate, with 2 weak inner teeth, unguiculus with distinct inner corner tooth and short subapical needle (Fig. 15). GREAT ABDOMEN: collophore with 2 + 2 distal anterior setae (Fig. 16), sacs warty; retinaculum with 3 teeth and 1 basal horn, corpus with 2 setae (Fig. 17); manubrium with 7 + 7 ventral setae (Fig. 18); dens with 1 ventral subapical seta (Fig. 19) and dorsally with L_1, -L_2-L_3-L_5, ID_1 -ID_7 present (Fig. 20); mucro with outer edge smooth, inner serrate (Fig. 21). LESSER ABDOMEN: simple supraanal seta, anal papilla absent, subanal appandage palmate (Fig. 22); bothriotrix D with low truncated cone, seta short and stiff (Fig. 23); anal setae of ♀ not basally expanded (Fig. 24). Body setae short, slightly curving, sparsely distributed over abdomen. Length up to 0.60 mm.

DIAGNOSIS

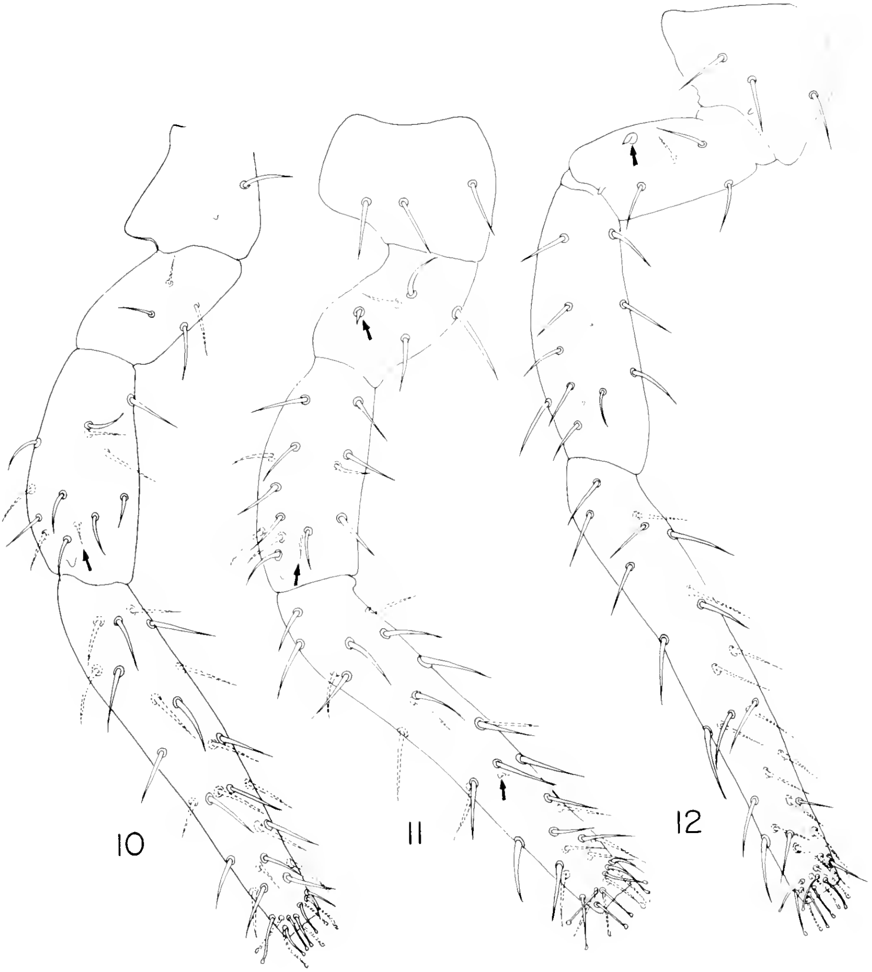
Sminthurinus (*Polykatianna*) *utahensis* keys out closest to *Sminthurinus* (*Sminthurinus*) *conchyliatus* Snider in Christiansen & Bellinger (1981). However, the two species are easily separated by subgeneric morphological characteristics. *S. utahensis* has antennal segment IV subsegmented, median supraanal seta simple and papilla of antennal segment III simple. Of the known members of the subgenus *Polykatianna*, *S. utahensis* comes closest to *S.* (*Polykatianna*) *polygonius* Snider. Not



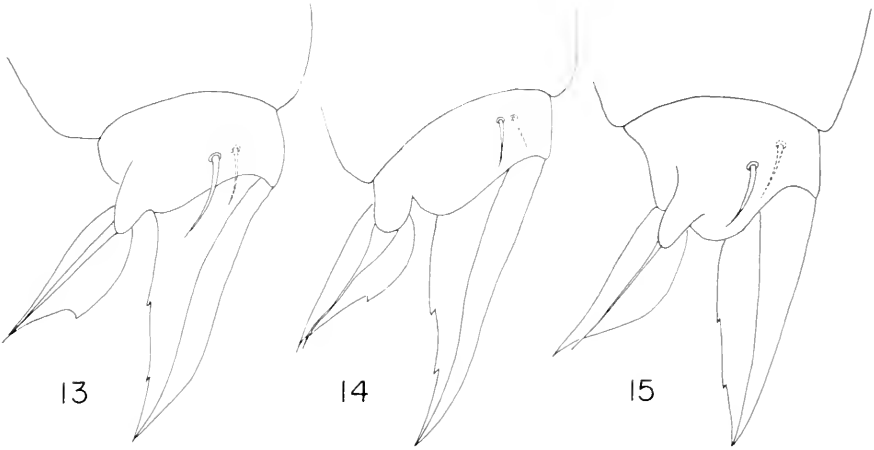
Figs. 1. *S.* (*Polykatianna*) *utahensis* n. sp., dorsal habitus. 2. lateral habitus.



Figs. 3. left eyepatch. 4. ANT I. 5. ANT II. 6. ANT III showing lateral sensory papilla. 7. ANT IV. 8. ANT IV, apical segment. 9. frontal view of head, arrows indicate oval organs and fovea.



Figs. 10. foreleg. 11. mesoleg. 12. metaleg.



Figs. 13. foreclaw. 14. mesoclaw. 15. metaclaw.

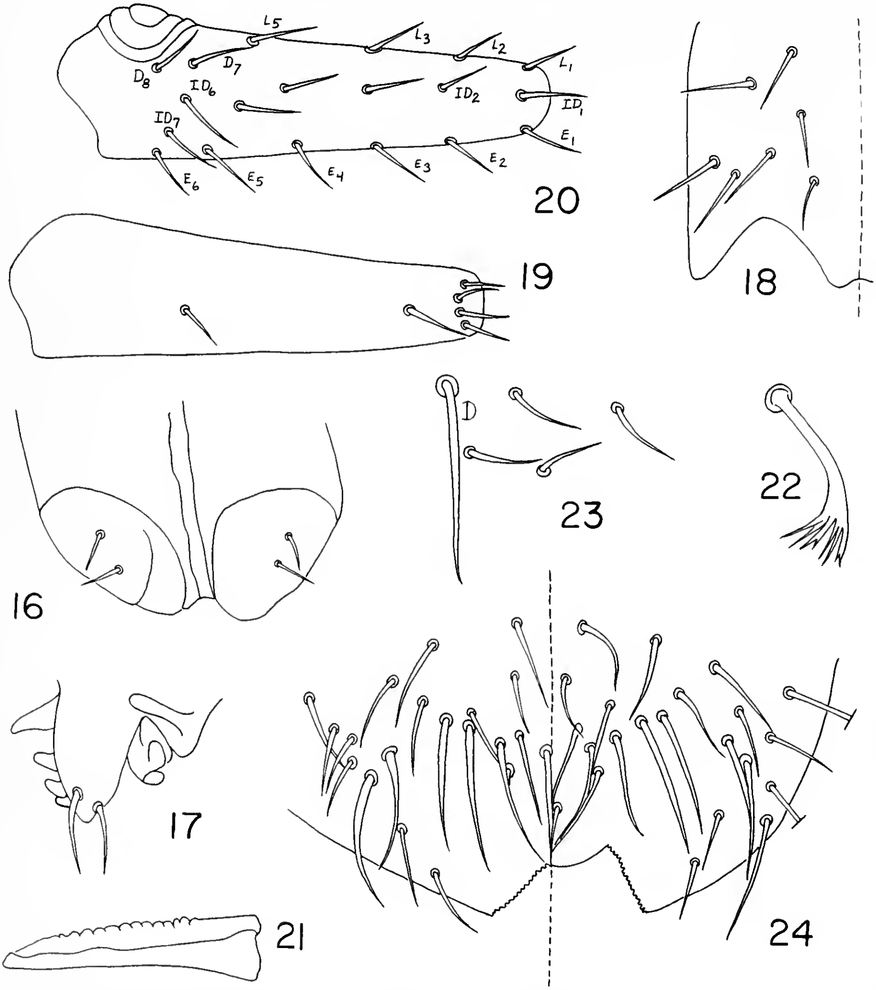
only do they differ in color pattern, but *S. polygonius* lacks an apical bulb on antennal segment IV and has 3 ventral subapical setae on the dens. In Stach (1956) *S. utahensis* keys out to *Sminthurinus bimaculatus* (Axelson). It differs from that species by having 10 clavate tenent hairs, rather than 4-5; with only the outer margin of the mucro serrate instead of both inner and outer margins serrate; and the papilla of antennal segment III of *S. bimaculatus* is divided into 4 parts, while *S. utahensis* has a simple papilla.

TYPES

Holotype (female) and Allotype (male) preserved in ethanol, 50 paratypes in ethanol, and five paratypes mounted on slides in polyvinyl alcohol. Holotype, allotype and 40 paratypes deposited in the Florida State Collection of Arthropods at Gainesville, Florida; 10 paratypes and 5 mounted slides deposited in the Entomology Museum, Department of Entomology, Michigan State University in East Lansing, Michigan. All specimens were collected in Utah, Cache County, Logan Canyon, Spring Hollow, June 14, 1984, maple litter (*Acer* sp.) by George F. Knowlton.

ACKNOWLEDGMENTS

Thanks are extended to Howard V. Weems, Jr. curator of the Florida State Collection of Arthropods for the loan of specimens.



Figs. 16. collophore, 17. retinaculum, left view. 18. manubrium. 19. dens, ventral aspect. 20. dens, dorsal aspect. 21. mucro, lateral view. 22. subanal appendage. 23. bothriotrix D. 24. anal setae of ♀, dorsal aspect.

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DESCRIPTION OF THE FEMALE OF *PADUNIELLA NEARCTICA* (TRICHOPTERA: PSYCHOMYIIDAE)[1,2]

David E. Bowles[3], Robert T. Allen[4]

ABSTRACT: The female of *Paduniella nearctica* is described and the genitalia illustrated. This constitutes the first Nearctic record of a female of this species. Collection sites for the species are presented.

Paduniella nearctica Flint is the only representative of the subfamily Paduniellinae (Psychomyiidae) known from the Nearctic region (Flint 1967). However, females of this species were unknown until recently. To date, approximately 200 males have been collected from several localities in northwest Arkansas with collection dates ranging from May through September. On 7 June 1986, six adult females were collected with a UV-light placed on a white drop-cloth at ground level. Previous attempts to collect *P. nearctica* females were from a bridge approximately 4 m above the water surface. The bridge collecting site had not produced any females, suggesting that they may be weak or inactive fliers. No additional females have been collected, and the larvae and pupae remain unknown.

Records for females of the genus *Paduniella* are scarce (Fischer 1962), and descriptions have often been inadequate. Banks (1930) described the female of *P. borneensis* in written form but did not include any drawings. Moreover, his written description did not mention genitalia. Malicky (1983) depicted the female genitalia of *P. vandeli* Decamps with line drawings but did not include a written description. The present paper describes the female of *P. nearctica* Flint and lists collection sites for the species in Arkansas.

The morphology of the Psychomyiidae female genitalia was described in detail by Nielsen (1980). Nielsen's descriptions were based exclusively on the Psychomyiinae and did not include examinations of the Xiphocentroninae or Paduniellinae. Our investigation of *P. nearctica* female genitalia suggests a close relationship between the Paduniellinae and Psychomyiinae (e.g., Nielsen 1980; Schmid 1980, figs. 208-209, 213).

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[2] Published with the approval of the director of the Arkansas Agriculture Experimental Station, Fayetteville, AR, 72701.

[3] Graduate research assistant. Department of Entomology, University of Arkansas, Fayetteville, AR, 72701.

[4] Professor. Department of Entomology, University of Arkansas, Fayetteville, AR, 72701.

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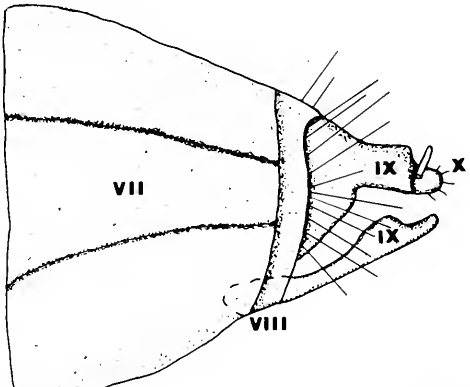

Fig. 1

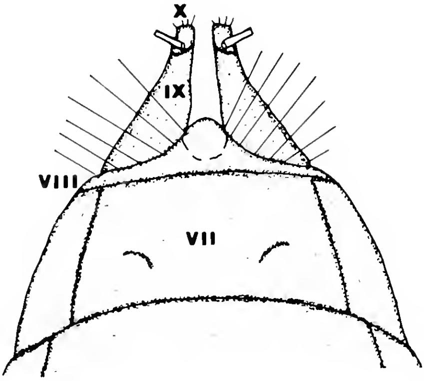

Fig. 2

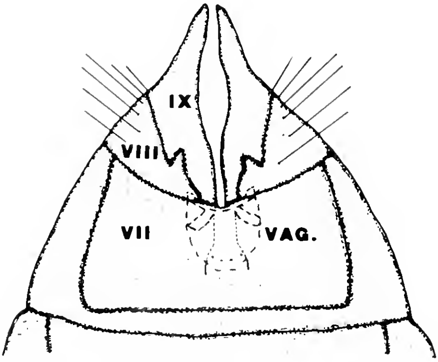

Fig. 3

Figs. 1-3. Lateral, dorsal and ventral views of *Paduniella nearctica* female genitalia showing abdominal segments 7-10, and the vagina.

However, no homologies are attempted in this paper. Enumeration of the genital segments depicted in this study follows that of Nielsen (1980).

Bernard (1940), in a generalized description of the genus *Paduniella,* stated that males have six segmented maxillary palpi and four segmented labial palpi while the females bear five segmented maxillary palpi and three segmented labial palpi. The females of *P. nearctica* differ from their eastern hemisphere counterparts in that the maxillary and labial palpi bear the same number of segments as those of the male. However, segmentation of the female palpi is difficult to observe because of their light color, and the female palpi are shorter than those of the male. It is not known if this is true of all species of the genus.

Description

Adult female (figs. 1-3): Forewing length 5.0 mm. Color straw to light brown. Antennae annulate with dark brown. Female genitalia: Eighth tergite narrow and produced posteriorly on dorsum. Ninth tergite and sternite deeply cleft on meson. Eighth tergite overlapping ninth sternite ventrally, with a row of long setae bordering posterior margin. Tenth tergite short with cerci implanted in small membranous areas. Vagina moderately sclerotized and saccular, extending one-half the distance of the anterior margin of segment seven. Vagina without a distinct boundary at common oviduct.

Collection sites for *P. nearctica:* Arkansas, Johnson Co., 5 mi. W. Oark; 1 mi. E. Yale; 2 mi. E Hagarville. Arkansas, Washington Co., 15 mi. S. Prairie Grove; Devils Den St. Park. The *P. nearctica* collected during this study are deposited in the University of Arkansas Entomology Museum.

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THE GENERIC PLACEMENT OF *PROSOPIS? ALLODAPE? MUSTELA* VACHAL, 1895 (HYMENOPTERA: APOIDEA)[1]

Roy R. Snelling[2]

ABSTRACT: *Prosopis? Allodape? mustela* Vachal is a Burmese species of *Hylaeus* known with certainty only from the type female. It is redescribed and figured from the type; the subgeneric placement is uncertain, but seems nearest to the Australian subgenus *Prosopisteron.*

Vachal (1895) described a new species of bee as '*Prosopis*? *Allodape*? *mustela*." The single female specimen was from Carin Cheba, collected in December, 1888, by Leonardo Fea. Bingham (1897) placed this species in *Prosopis* and may have seen the type and cited it from "Karen Hills, Burma; Tenasserim". The species has remained unknown since then, although Meade-Waldo (1923) listed it in *Hylaeus.*

The type specimen is in the collections of the Museo Civico di Storia Naturale, Genova, Italy. It was loaned to Dr. C.D. Michener in 1986 in connection with his studies of the allodapine bees. Dr. Michener, in turn, sent the type to me because it is a species of *Hylaeus*, not an allodapine. The type remains the only known specimen. I have redescribed it here in the hope that the species might be recognized in the future. Vachal's original description is inadequate.

Hylaeus (?Prosopisteron) mustela (Vachal)

Figs. 1, 2

Prosopis ? *Allodape* ? *mustela* Vachal, 1895:446; ♀.
Prosopis mustela: Bingham, 1897:411; ♀.
Hylaeus mustela: Meade-Waldo, 1923:24.

Female Holotype. Measurements (mm): head width 1.19; head length 1.09; total length 4.5.

Head (Fig. 1) width 1.09 times head length; inner eye margins moderately convergent below, upper interocular distance 1.5 times lower interocular distance; head thick in profile (Fig. 2). Clypeal width about 1.2 times clypeal length, punctures fine (0.02-0.03 mm diam.), separated by 1.0-2.5 diameters, surface moderately shiny and distinctly tessellate. Supraclypeal area more sharply tessellate, duller, with scattered punctures. Frontal shield width about 1.35 times greatest length. Frons a little duller than clypeus, punctures averaging finer (0.02-0.21 mm diam), separated by 0.5-1.0 diameters, becoming scattered and slightly larger on vertocciput. Facial foveae long, curved toward ocelli at upper end, and ending about one-third of distance between eye and lateral ocellus. Interocellar distance 1.5, ocellocular distance 2.3, and ocelloccipital distance 1.5 times diameter of anterior ocellus. Mandible bidentate.

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[1] Received April 16, 1987. Accepted July 31, 1987.

[2] Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, California 90007, U.S.A.

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Pronotal collor compressed in middle, lateral lobes rounded, without transverse carina or ridge. Mesoscutum slightly shiny, distinctly tessellate, punctures 0.01 mm diam., very irregularly spaced, 2-6 diameters apart. Scutellum flat, sculpture apparently about as on mesoscutum. Metanotum not visible (covered by adhesive). Mesepisternum similar to mesoscutum, most punctures about 0.01 mm diam., 1-4 diameters apart. Metepisternum dull, punctures about 0.01 mm diam., contiguous to subcontiguous. Side of propodeum dull, appearing granulose; lateral and oblique carinae absent; stigmatal area shallowly reticulate-punctate, becoming punctate on declivity, punctures about 0.02 mm diam., sparse. Basal area strongly sloping, without definite basal triangle.

Wings transparent light brownish, veins and stigma light brown; sparsely hairy; stigma not parallel-sided; SM1 a little more than twice as long as SM2 on M.

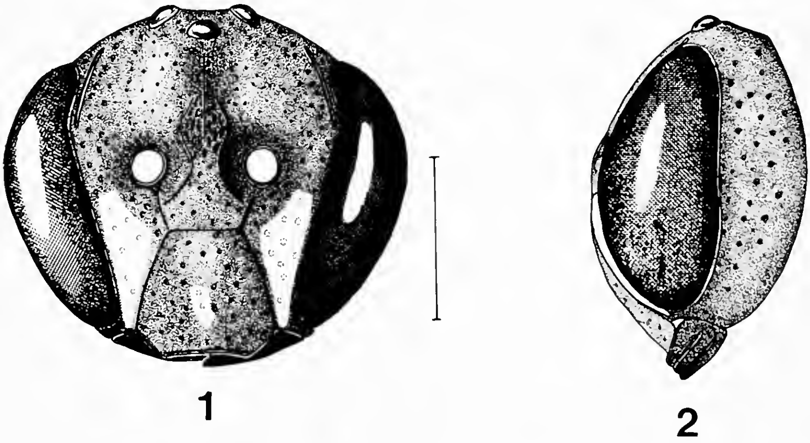
Metasomal tergum 1, in profile, evenly sloping, without definite anterior and dorsal faces, tessellate and moderately shiny, with scattered, obscure, minute punctures less than 0.01 mm diam.; tergum 2 similar but punctures less evident, depressed apical margin shinier than disc., basal gradulus weak.

Vestiture very sparse and short, mostly simple except appressed plumose hairs on side of propodeum; antennal area without plumose hairs; mesoscutum without erect hairs; metasomal terga 1 and 2 without apicolateral pubescent fasciae.

Black, the following yellow: elongate spot on clypeal midline; paraocular area, angled above toward eye margin, ending abruptly at level of antennal socket; interrupted band on pronotal collar; large spot on pronotal lobe; spot on tegula; outer face of protibia; basal two-fifths of metatibia.

DISCUSSION

The type is glued on its right side to a card and is in poor condition: the head is glued on; both flagella are missing; the right front leg and both middle and hind legs are missing; most of the posterior part of the mesosoma is



Hylaeus mustelus, holotype female. Fig. 1, frontal view of head. Fig. 2, lateral view of head. Scale line = 0.50 mm.

covered with adhesive; the wing tips are folded back.

The type is from "Carin Cheba, 900-1100 m, L. Fea, V-XII-88." This locality, at 24° 59'N 96° 52'E, is in a mountainous area about 105 km NW of Bhamo, Kachin State, Burma.

The specific name is Latin (weasel) and feminine in gender in its original combination; it presumably should be treated as a noun in apposition, hence is unchanged.

The few Hylaeinae described from tropical Asia are very poorly studied; most species have not been recognized since their original descriptions. Consequently, it is impossible to comment on the relationships of this species. In the key to Australian subgenera of *Hylaeus* by Michener (1965), *H. mustela* seems nearest to *Prosopisteron* Cockerell, 1906. This large subgenus, with many Australian species is also represented in the Chatham Islands, New Zealand, New Guinea, and the Tuamotu Islands. As Michener noted, *Prosopisteron* probably is not a natural group since it includes species with greatly differing hidden metamosal sterna in the males. *Hylaeus mustela* differs from most, if not all, species of *Prosopisteron* in the strongly sloping basal area of the propodeum, though this may not be significant when more species are examined. This species shows no obvious affinities with any of the Sri Lankin or south Indian species that I dealt with in 1980.

ACKNOWLEDGMENTS

I am very much indebted to Charles D. Michener, University of Kansas, and Roberto Poggi, Museo Civico di Storia Naturale, Genoa, for allowing me to examine the type of *H. mustela*. My thanks go also to the anonymous reviewer who spared me an embarrassing error.

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A NEW SPECIES OF *CENTRIS* (*MELANOCENTRIS*) FROM CERRO DE LA NEBLINA, VENEZUELA (HYMENOPTERA: ANTHOPHORIDAE)[1]

Roy R. Snelling[2]

ABSTRACT: *Centris* (*Melanocentris*) *gavisa* is described from female specimens collected at Cerro de la Neblina, Amazonas, Venezuela. It is a member of the *C. plumipes* group recognized by the fulvous mesosomal pilosity and the lack of scutellar tuberacles.

The following new species is described in order that the name might be available for use by S.S. Renner in a paper on floral visitation by bees on Cerro de la Neblina.

This species of *Centris* (*Melanocentris*) is a member of the group of *C. plumipes* F. Smith, 1854. This is a small group characterized by the conspicuously maculate clypeus of the female, with the lower one-half (approximately) smooth and shiny, the mesosoma, at least, part metallic bluish or greenish, the pale female scopa, the dull, subcontiguously to contiguously punctate metasomal terga, and the subacute apex of the female pygidial plate. *Centris plumipes* ranges from Costa Rica to the Amazonian region of Peru and Brazil (Snelling, 1984). The only other species in the group, *C. lilacina* Cockerell, 1919, is known from Peru and Bolivia.

Centris (Melanocentris) gavisa, new species

Figures 1-4

Diagnosis. A member of the *C. plumipes* group of *Melanocentris;* distinguished from both *C. plumipes* and *C. lilacina* by the pale mesosomal pilosity and the very weakly developed scutellar tubercles.

Description. Measurements (paratypes in parentheses) (mm): head width 5.38 (5.49-5.54); head length 4.41 (4.46-4.56); wing length 14.5 (14.1-14.6); total length 21.3 (18.5-21.0).

Head (Fig. 4) 1.22-1.31 times as broad as long; inner eye margins slightly divergent below, upper interocular distance 0.86-0.91 times lower interocular distance; occipital margin, in frontal view, slightly convex. Interocellar distance 1.40-1.46 and ocellocular distance 1.15-1.29 times diameter of anterior ocellus.

Mandible (Fig. 1) slender, but somewhat broadened and abruptly bent before apex; quadridentate, middle preapical tooth nearer subapical tooth than innermost. Maxillary palpus 4-segmented, last segment pointed and about one-half as long as third.

Labrum broader than long, apex narrowly rounded; base shiny and impunctate, disc shiny between contiguous, moderate-sized, piligerous punctures. Clypeus a little broader than

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[2] Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, California 90007

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long, midline slightly raised, polished and impunctate; disc duller, slightly tessellate between moderate, subcontiguous to close punctures. Frons slightly shiny between subcontiguous fine punctures; vertocciput similar but with scattered moderate punctures and usual impunctate areas adjacent to ocelli, these areas slightly tessellate rather than smooth and polished.

Antennal scape about twice as long as broad; first flagellar segment much longer than broad, about 1.20-1.32 times length of scape and about 1.33-1.50 times combined lengths of following two segments.

Mesosoma robust as usual in *Centris.* Mesoscutum slightly shiny between subcontiguous, moderate punctures over most of disc that become sparse in posterior middle; scutellum similar, but punctures merely close along middle, and with submedian impunctate, very slightly convex areas rather than definite tubercles such as are present in *C. plumipes* and *C. lilacina.* Mesepisternum slightly shiny, punctures dense to subcontiguous and not sharply defined.

Basitibial plate of metatibia (Fig. 2) elongate and lower margin narrowly rounded; secondary plate with posterior margin beyond that of primary plate.

Summit of metasomal tergum I punctate across middle, punctures fine and close to sparse, interspaces moderately shiny; discs of terga 2-3 dull, with contiguous, shallow, minute punctures; terga 4-5 also dull, with dense, fine, distinct punctures; pygidial plate (Fig. 3) narrow beyond secondary plate, apex subacute; secondary plate broadly triangular, margins sharply defined.

Pilosity: Whitish, highly plumose hairs on face around antennal sockets, middle of vertex, occipital margin, and gena; entire mesosoma covered by dense, pale fulvous pilosity that becomes lighter below; tergum I with pale fulvous hairs on side of dorsal face; terga 4 and 5 with short yellow hairs on discs, but apical fimbria of 5 dark bown. Scopal hairs yellowish. Clypeus mostly bare, but with numerous long, brownish setae of variable length at sides; similar setae scattered on frons and predominating across vertex; hairs of legs mostly very dark brown or blackish; discs of terga 2 and 3 with dense, short, simple blackish hairs.

Integument: Blackish, with blue-green reflections on frons, mesoscutum, mesepisternum, and metasomal terga, except: labrum (except margins), clypeus (except median stripe), and paraocular areas yellowish white; metasomal terga 2 and 3 with transverse reddish bands; terga 4 and 5 variable, from largely dark to largely reddish with small median areas dark. Tegula blackish. Wings dark brown.

Type material. Holotype and three paratype females: "camp VII" Cerro de la Neblina, 00°52'N, 65°58'W, 2100m elev., Amazons, Venezuela, collected by S.S. Renner in 1985 as follows: 31 Jan., on *Saxofridericia compressa;* 4 Feb., on *Diacidia rufa;* 8 Feb., on *Disterigma humboldtii;* 9 Feb., on *S. compressa;* the holotype was collected on 8 Feb. Holotype and one paratype in USNM; two paratypes in LACM.

Etymology. From Latin, causing joy, because of the attractive appearance of this bee.

DISCUSSION

As noted in the diagnosis, this species is easily separated from the other two members of the *C. plumipes* group by the lack of definite tubercles on the scutellum. Both *C. plumipes* and *C. lilacina* possess prominent nude tubercles on either side of the scutellum that are elevated well above the general level of the scutellum, and are directed obliquely away from the

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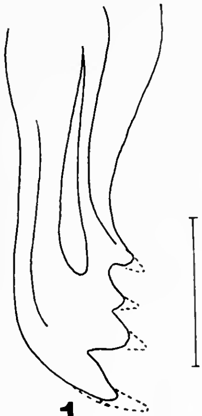
Figures 1-3, *Centris (Melanocentris) garisa,* female: 1, mandible (dotted lines show probable shape of unworn teeth); 2, basitibial plate; 3, pygidial plate; 4, front of head. Scale line = 1.0mm.



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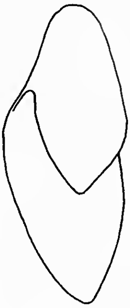

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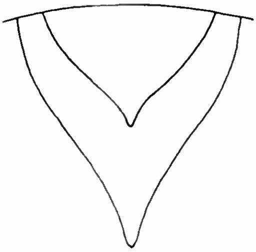

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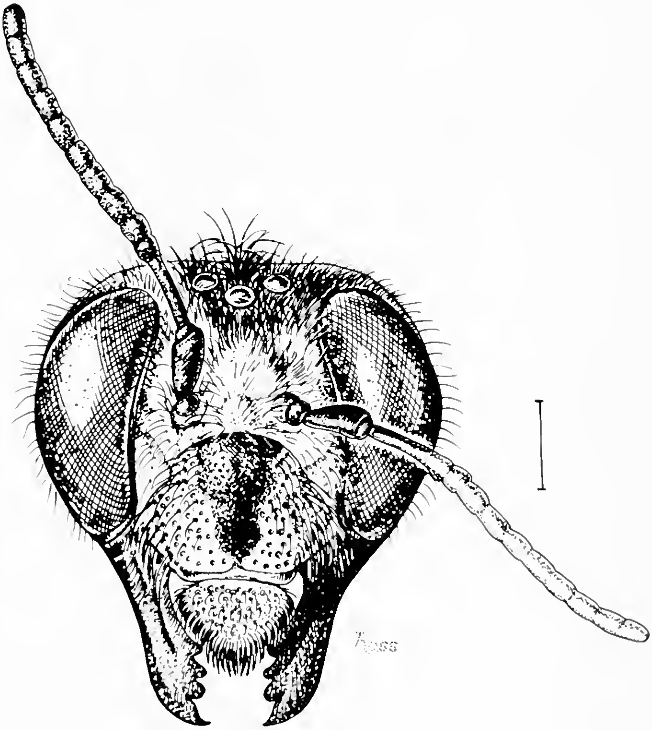

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midline. In *C. gavisa* the area where the tubercles would be is impunctate and merely very slightly convex above the general level of the segment.

The pale fulvous pilosity of the mesosoma of *C. gavisa* is also characteristic for this species. In *C. plumipes* and *C. lilacina* the hairs of the dorsum and much of the mesepisternum are dark but with pale branches. The metasoma of *C. plumipes* is dark, with segments 3-5 somewhat coppery, and that of *C. lilacina* is predominantly red, with limited blue or blue-green median blotches sometimes present on terga 3-5.

Although no males of *C. gavisa* are presently available, they will probably be similar to the females in color, especially of the mesosomal pilosity, and will probably be without scutellar tubercles. Males of both the other species resemble their respective females in color and possess scutellar tubercles, although the tubercles are not as prominent as in the females.

ACKNOWLEDGMENTS

I wish to thank Suzanne S. Renner for making these specimens, as well as other centridines collected at Cerro de la Neblina, available for study. Figure 4 is by Tina Ross, whose illustrative talents are much appreciated. Thanks, too, are extended to the anonymous reviewer for helpful comments.

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NORTH DAKOTA *ELEODES* (COLEOPTRA: TENEBRIONIDAE)[1]

Paul K. Lago[2]

ABSTRACT: Seven species of *Eleodes* (Coleoptera: Tenebrionidae) are recorded for North Dakota: *E. extricatus, E. hispilabris, E. nigrinus, E. obsoletus, E. opacus, E. suturalis* and *E. tricostatus*. Information on geographical and seasonal distribution is presented, along with a key to the species.

Eleodes is the largest genus of Tenebrionidae in North America. Its species are decidedly western in distribution, being most diverse in southwestern desert areas of the United States and in arid parts of Mexico. Larvae, called false wireworms, cause considerable damage to wheat and other crops throughout the Great Plains. Although none have been previously reported from North Dakota[3], members of this genus form a conspicuous and economically important part of the ground-inhabiting beetle fauna of the state. The purpose of this paper is to present a list of the species occurring in North Dakota, annotated with information on seasonal and geographical distribution, and a key with which specimens may be identified.

North Dakota is divided into three principal physiographic areas: Missouri Plateau, Drift Prairie and Red River Valley (Fig. 1). Distribution of *Eleodes* spp. is concentrated in the Missouri Plateau, which approximately covers that portion of the state having a semiarid climate (Omodt, *et al.* 1968). Diversity and population densities peak in the unglaciated portion of the Plateau, and, in particular, in the Badlands, where six of the seven species herein recorded occur. Most records from the Drift Prairie are from sandy areas and this is also true for records from the Red River Valley. Both

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[3] Papp (1961) listed *E. tricostatus* and *E. suturalis* from "Dak." These records were apparently extracted from Blaisdell's (1909) work on the genus in which he presented records for these species from localities actually in South Dakota. Blaisdell (1909) also reported *E. extricatus* and *E. nigrinus* from Dakota, but gave no specific localities. The latter was probably extracted from Horn (1870) who recorded "Dacota" as part of the distribution of *E. nigrinus*. The additional distribution data presented by Tanner (1961) also contained no references to North Dakota. Wade (1921) mentioned North Dakota in his work on injurious Tenebrionidae, but did not refer to any particular species. In their paper on the biology of *E. suturalis*, Wade and St. George (1923) indicated that "the Dakotas" are within the area where false wireworms damage wheat crops, but presented distribution records for *E. suturalis* only from South Dakota and other states to the south and west.

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[1] Received May 16, 1987. Accepted August 11, 1987.

[2] Dept. of Biology, University of Mississippi, University, MS 38677.

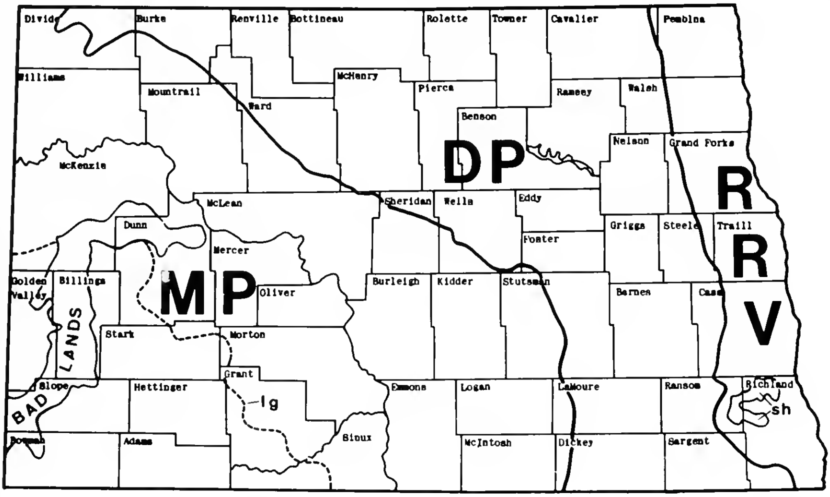

Fig. 1. Major physiographic features of North Dakota. DP - Drift Prairie; MP - Missouri Plateau; RRV - Red River Valley; lg - limit of glaciation; sh - sand hills region of Sheyenne River Delta.

of these areas are dominated by heavier soils (Omodt, *et al.* 1968) that generally do not support large populations of *Eleodes.*

The following records are based primarily on specimens contained in the insect collections at North Dakota State University and the University of North Dakota, and in my collection. Additional records were provided by E.U. Balsbaugh, Jr. (NDSU) from a study being conducted by M.J. Weiss, and by J.T. Doyen (University of California, Berkeley). These are indicated by the initials EUB and JTD, respectively, in the text.

Distribution Records

Eleodes extricatus (Say).

Forty-eight records from the following localities: *Benson Co.,* Pleasant Lake (JTD).. *Billings Co.,* T. Roosevelt Nat. Mem. Park; 6 mi. S. Medora (JTD). *Bowman Co.,* no locality. *Dunn Co.,* Killdeer Mts. *Golden Valley Co.,* Beach; Sentinel Butte. *Grant Co.,* Heart Butte Dam. *Mercer Co.,* T144N-R85W-Sec. 9. *McKenzie Co.,* T146N-R98W-Sec. 16. *Morton Co.,* 3.5 mi. S. St. Anthony. *Ransom Co.,* no locality. *Slope Co.,* Burning Coal Vein; 9 mi. NW Amidon (JTD); Chalky Buttes; T136N-R102W-Sec. 24.
Collection dates: 30 April - 21 September.
Specimens examined: 546.

This species is locally abundant in southwestern North Dakota, and is essentially restricted to that part of the state south and west of the Missouri River.

Eleodes hispilabris (Say).

Eighty-two records from the following localities: *Adams Co.,* Hettinger. *Barnes Co.,* no locality. *Billings Co.,* T. Roosevelt Nat. Mem. Park; 1 mi. N Bear Creek. *Burleigh Co.,* no locality. *Cass Co.,* Fargo; numerous specimens with no specific locality. *Dickey Co.,* 1 mi. W and 4 mi. S. Oakes. *Divide Co.,* no locality. *Dunn Co.,* T146N-R97W-Sec. 25; T144N-R94W-Sec. 7; 3 mi. NW Killdeer (JTD); Killdeer Mts. *Golden Valley Co.,* Sentinel Butte. *Grand Forks Co.,* Grand Forks; Inkster; T151N-R52W-Sec. 16. *Grant Co.,* Heart Butte Dam. *Hettinger Co.,* New England. *McHenry Co.,* no locality. *McKenzie Co.,* T. Roosevelt Nat. Mem. Park; Cannonball Crk.; T146N-R98W-Sec. 16. *McLean Co.,* Missouri Riv. S of Garrison. Morton *Co.,* Mandan; 9.5 mi. E Flasher. *Nelson Co.,* no locality. *Ramsey Co.,* Webster. *Sargent Co.,* no locality. *Slope Co.,* Burning Coal Vein; Chalky Buttes; 3 mi. NE Marmarth (JTD); T136N-R102W-Sec. 10 (JTD); numerous specimens with no specific locality. *Stark Co.,* no locality. Ward Co., North Central Exp. Sta (EUB) *Williams Co.,* Williston; Williston Exp. Sta. (EUB).
Collection dates: 24 April - 18 October.
Specimens examined: 146.

Eleodes hispilabris is the largest of the common North Dakota species. It is somewhat more widely distributed than *E. extricata* in the state; and, like that species, is primarily confined to the west. Only 17 specimens were seen from localities east of the Missouri River. These beetles are never abundant; 56 of the above records are based on single specimens.

Eleodes nigrinus (LeConte.

Record: Badlands, N.D. (no county given). 13 May 1940.
Specimens examined: 1

Considering the great amount of collecting that has occurred in the North Dakota Badlands, it seems unusual that more specimens of this species have not been found, if, in fact, it occurs in the state. The general habitus of this species is such that it is not easily confused with others in the area, so I doubt that specimens are being overlooked. Actually the larger size of *E. nigrinus* (compared to the abundant *E. extricata, E. obsoleta* and *E. opaca*) would seem to make it more of a target for general collectors.

Eleodes obsoletus (Say).

Forty-eight records from the following localities: *Adams Co.,* Hettinger. *Billings Co.,* T. Roosevelt Nat. Mem. Park. *Bowman Co.,* Bowman-Haley Dam. *Dunn Co.,* Killdeer Mts; 3 mi. NW Killdeer (JTD); T146N-R97W-Sec. 25.*Golden Valley Co.,* no locality. *Grant Co.,*

Heart Butte Dam; 3.5 mi. S Elgin; 20 mi. NE Carson; 18 mi. NE Carson. *Hettinger Co.*, T134N-R97W-Sec. 9. *McKenzie Co.*, T146N-R98W-Sec. 16. *McLean Co.*, Missouri Riv. S of Garrison. *Mercer Co.*, Beulah; T144N-R85W-Sec. 9. *Ransom Co.*, (?) no locality. *Slope Co.*, Amidon; Burning Coal Vein; Chalky Buttes; T136-N-R102W-Sec. 24; T134N-R101W-Sec. 15; Mineral Springs. *Stutsman Co.*, Chase Lake.
Collection dates: 18 April - 26 September.
Specimens examined: 379.

Eleodes obsoletus is essentially restricted to the area south and west of the Missouri River, although there is a population in the vicinity of Chase Lake in Stutsman County, a locality also within the Missouri Plateau. The only record outside the Plateau is for one specimen from Ransom County. This specimen bears the same label as the specimen of *E. extricatus* from the same county. No specific locality and no collector is given. The date, 8 June 1962, is the same on both. During extensive collecting in Ransom County, I was unable to find specimens of either species. I am, therefore, inclined to regard both specimens as mislabeled.

Like *E. extricatus, E. obsoletus* is locally abundant. In particular, large numbers were collected on hillsides near Heart Butte Dam in Grant County and Burning Coal Vein in Slope County.

Eleodes opacus (Say)

Ninety records from the following localities: *Adams Co.*, no locality. *Billings Co.*, T. Roosevelt Nat. Mem. Park. *Bowman Co.*, Bowman-Haley Dam. *Burleigh Co.*, Bismarck. *Cass Co.*, no locality. *Divide Co.*, 3 mil W Noonan. *Dunn Co.*, T144N-R94W-Sec. 7; T146N-R97W-Sec. 25; 10 mi. N Killdeer. *Enmons Co.*, no locality. *Golden Valley Co.*, Beach. *Grant Co.* Heart Butte Dam. *Hettinger Co.*, T134N-R37W-Sec. 9. *McKenzie Co.*, T146N-R98W-Sec 16; 2 mi. S Keene. *McLean Co.*, Missouri Riv. S of Garrison. *Morton Co.*, Mandan; Heart Butte. *Ransom Co.*, McLeod. *Richland Co.*, Walcott Dunes; 14 mi. SW Walcott (JTD); 11 mi. W Walcott (JTD); T134N-R52W-Sec. 30 and 31. *Slope Co.*, Burining Coal Vein; Chalky Buttes; Mineral Springs; 3 mi. NE Marmarth (JTD); T136N-R104W-Sec. 2. *Stutsman Co.*, Chase Lake. *Williams Co.*, Williston; Williston Exp. Sta. (EUB).
Collection dates: 1 June - 11 October.
Specimens examined: 314.

Although most abundant on the Missouri Plateau, *E. opacus* is fairly common in the sandhills region of the Sheyenne River Delta in Ransom and Richland counties (Red River Valley). There are no records from the Drift Prairie. This is the latest emerging of the five common species, appearing about the first of June, over four weeks later than the others. Specimens are seldom encountered in abundance. The largest series I have examined are from pit trap collections in McKenzie and Dunn counties (24 and 15 specimens respectively).

Eleodes suturalis (Say).

Records: *Cass Co.,* Fargo, 25 May 1940. *Richland Co.,* Walcott Dunes, 31 July 1974, 23 July 1976. Specimens examined: 3

Eleodes suturalis appears to be restricted to the lower Red River Valley, but too few specimens have been collected to make any generalizations. This species is distributed state wide in South Dakota (Kirk and Balsbaugh, 1975), and quite possibly occurs irregularly throughout southern North Dakota, but it is certainly not common.

Eleodes tricostatus (Say).

Ninety-three records from the following localities: *Billings Co.,* T. Roosevelt Nat. Mem. Park. *Burleigh Co.,* Bismarck. *Cass Co.,* Fargo. *Dickey Co.,* 1 mi. W and 4 mi. S Oakes. *Dunn Co.,* T144N-R94W-Sec. 7; Killdeer Mts.; 10 mi. N Killdeer; 3 mi. NW Killdeer (JTD); T146N-R97W-Sec. 25. *Eddy Co.,* no locality. *Golden Valley Co.,* Beach; Sentinel Butte. *Grand Forks Co.,* Arvilla; University (Grand Forks). *Grant Co.,* Heart Butte Dam; 18 mi. NE Carson. *Hettinger Co.,* T134N-R97W-Sec. 9. *Logan Co.,* no locality. *McHenry* Co., Towner. *McKenzie Co.,* T146N-R98W-Sec. 16; Cannonball Crk., 27 mi. W Grassy Butte; T148N-R98W-Sec. 18. *McLean Co.,* no locality. *Mercer Co.,* 10 mi. E Hazen; Stanton area. *Morton Co.,* Mandan; 3.5 mi. S St. Anthony. *Pembina Co.,* T161N-R56W-Sec. 22. *Ransom Co.,* McLeod; T135N-R53W-Sec. 15; 1 mi. SE McLeod (JTD). *Richland Co.,* Walcott Dunes; 11 mi. W Walcott (JTD); Mirror Pool. *Slope Co.,* Burning Coal Vein; T136N-R104W-Sec. 2. *Stutsman Co.,* Chase Lake. *Walsh Co.,* S Branch, Park Riv. NE of Adams. *Ward Co.,* North Central Exp Sta. (EUB). *Wells Co.,* no locality. *Williams Co.,* Williston Exp. Sta. (EUB).
Collection dates: 21 April - 21 September
Specimens examined: 255

Recorded from six counties in the Red River Valley and five in the Drift Prairie, as well as from throughout the Missouri Plateau, this is the most widely distributed species of *Eleodes* in North Dakota. It is rarely encountered in large numbers in the state, 79 of the above records are represented by three or fewer specimens. It is most abundant in the sandhills of the Sheyenne River Delta.

Key To Species

1. Elytra rounded laterally (in cross section) 2
1' Elytra carinate laterally, or, in doubtful specimens (*E. tricostata*), with elytra costate, the odd costae better developed than the even 5
2. Elytra evidently (macroscopically) sulcate; elytral epipleura with or without tubercules 3
2' Elytra punctate, but without distinctly impressed stria, appearing smooth macroscopically; elytral epipleura generally smooth, not tuberculate 4

3. Profemora with ventral subapical tooth on anterior margin; elytral epipleura not tuberculate; anterior pronotal angles dentiform; length greater than 15.. *E. hispilabris* (Say)

3' Profemora not toothed; elytral epipleura tuberculate; anterior pronotal angles not dentiform; length generally less than 15 mm in North Dakota specimens .... *E. obsoletus* (Say)

4. Pronotum, in dorsal view, distinctly narrowed, usually constricted, basally; length 17 mm. or greater (only one North Dakota record) .... *E. nigrinus Lec.*

4' Pronotum, in dorsal view, subparallel or gradually narrowed behind, never constricted; length less than 15 mm (common in western North Dakota) ...... *E. extricatus* (Say)

5. Lateral margins of pronotum broadly explanate; elytra appear flattened and often have reddish stripe along suture; length greater than 20 mm .... *E. suturalis* (Say)

5' Lateral margins of pronotum not explanate; elytra without red sutural stripes; length less than 20 mm 6

6. Elytra evidently costate, the costae tuberculate; length generally greater than 12 mm .... *E. tricostatus* (Say)

6' Elytra nearly smooth, not tuberculate-costate; length generally less than 12 mm .... *E. opacus* (Say)

ACKNOWLEDGMENTS

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AN ADDITIONAL USE FOR ANT LARVAE (HYMENOPTERA: FORMICIDAE)[1]

George C. Wheeler, Jeanette Wheeler[2]

ABSTRACT: The only food of the queen of *Mystrium mysticum* Roger is the hemolymph of larvae.

Of what use are ant larvae? The obvious answer is to build up and maintain the labor force of the colony and, sometimes, for the production of reproductives. Another use, seldom mentioned, is that in times of famine they may be eaten as a reserve supply. In the 1970s and 1980s we have seen numerous references to a third which we discussed at some length in 1979 (p. 334-336) and epitomized in 1986 (p. 696) with a borrowed sentence: "Adult ants are dependent on soluble proteins and amino acids from the larvae, which digest protein for the whole colony."

Now comes a fourth function, which is a bit startling when one considers the "tender loving care" ants are supposed to give their young: queens cut holes in the integument of the larvae and feed upon the exuding hemolymph. We refer to Masuko (1986), who has summarized his findings as follows: "The queens of larger colonies of the primitive ant *Amblyopone silvestrii* are exclusively dependent on the hemolymph of their own larvae as a nutrient even when prey feeding is possible. On the other hand, the foundresses suppress larval hemolymph feeding (LHF) when prey is available, allowing them to rear the first workers more swiftly. The nondestructive form of cannibalism can be regarded as a nutritive adaptation related to: (1) the lack of social food transfer in this species, and (2) its specialized predation on large sporadic prey (centipedes)." (p. 249.) Later he added: "These facts suggest that, even under natural conditions, the potentially destructive effects of LHF on the larval population is not profound" (p. 251).

It is a strange coincidence that while Masuko was studying larval hemolymph feeding in *Amblyopone silvestrii* Wheeler in Japan, Gerhard Wegener was observing a similar phenomenon in Basel, Switzerland in *Mystrium mysticum* Roger collected in Madagascar. *Amblyopone* and *Mystrium* are closely related, both belonging to the ponerine tribe Amblyoponini.

We corresponded with Wegener about *Mystrium* larvae throughout 1985 and tried to persuade him to publish his results, but he declined. He

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[2] 3358 NE 58th Avenue, Silver Springs, Florida 32688

has, however, urged and approved publication of this report of his pertinent observations:

Handling larvae to get hemolymph is the only occupation of the queen in an established colony (besides egg laying, of course). The queen holds the larva between her mandibles and kneads it. This causes the larva to writhe and wriggle. Apparently this results in cuts in the integument by the queen's many acute mandibular teeth. "This could explain the numerous 'black spots of healing' all over the body." Small clear drops ("like beads of perspiration") appeared all over the body. This "perspiration" is apparently the queen's liquid supply.

The main aim of this treatment, however, is to produce a second kind of secretion: "a large drop of milky, granular, viscous consistency (like that of a cut open insect pupa) in the intersegmental membrane at the front edge of AII." This is on the dorsal surface in the groove between the first and second abdominal somites. This secretion is not followed by a scar. It "must be the queen's food-supply."

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ARTHROPODS IN LIVE OAK GALLS IN TEXAS[1]

Jeanette Wheeler[2], John T. Longino[3]

ABSTRACT: The relationship between colonies of the ant *Leptothorax obturator* and stem galls on live oaks made by the cynipid *Disholcaspis cinerosa* is discussed. Seven other ant species in the genera *Camponotus, Colobopsis, Crematogaster, Leptothorax, Macromischa, Strumigenys* and *Zacryptocerus* were found in the galls. Sixteen species of arthropods in the orders Araneida, Coleoptera, (other) Hymenoptera, Lepidoptera, Neuroptera and Diplopoda were also present.

In 1903 (p. 251) W.M. Wheeler described *Leptothorax obturator* Wheeler workers, queens and males "from many specimens collected at different times from abandoned *Holcaspis cinerosus* [=*Disholcaspis cinerosa* (Bassett)] galls on live-oaks (*Q. virginia*). The young fertilized queen, on entering the gall to establish her colony, gnaws minute fragments from the ligneous wall, mixes these with some secretion (saliva?) and completely plugs up the round opening through which the *Holcaspis* escaped and she herself has entered. Later when the first batch of tiny workers appear, they perforate the center of the plug with a small opening like a pin-prick, and just large enough for egress and ingress." He also reported it "is also occasionally found nesting in twigs of the wafer-ash (*Ptelea trifoliata*) which have been hollowed out by the tiny carpenter bees (*Ceratina nanula* Ckll. and *C. arizonensis* Ckll.). The relatively large entrance made by the bees at the end of the twig is plugged up by the ants with agglutinated vegetable particles and then perforated with a minute opening in the center." The type locality is Austin, Travis County, Texas.

In 1910 Wheeler figured (Fig. 113, p. 208) the perforated plug in a gall (see also Longino and Wheeler 1987). He also listed six species which he found in galls, in order of increasing frequency: *Leptothorax schaumi* Roger (as *L. fortinodis* Mayr), *L. obturator, Colobopsis etiolata* Wheeler, *Crematogaster laeviuscula* Mayr (as *C. clara* Mayr), *Camponotus decipiens* Emery and *Camponotus sayi* Emery (as *C. rasilis* Wheeler). He described the method used by *Colobopsis etiolata* soldiers in a mature colony to plug the hole with its head. None of these ants build the occluding plug and the pin-prick-sized opening characteristic of *L. obturator,* although one *Colobopsis etiolata* queen with eggs was found in a "sealed gall."

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[2] 3358 NE 58th Avenue, Silver Springs, Florida 32688.

[3] Department of Biological Sciences, University of California, Santa Barbara, California 93106.

No further mention was made in the literature of *L. obturator* until Moody and Franke (1982:41 and map 23) recorded this species from oak galls in Real and Uvalde Counties. Wheeler and Wheeler (1985:61) added Bexar County and Longino and Wheeler (1987) added Kerr County, all in Texas.

In Bexar County, Texas, from 29 March 1981 to 15 December 1984 JW collected 999 stem galls made by *D. cinerosa* (Cynipidae) on *Quercus virginiana* (live oak) in one 5-acre plot. Galls were collected from 45 cm to 3 m above ground. Solid unused galls, i.e., galls in which no cynipid larva had developed, accounted for 592 (59%) of the total. Spiny millipedes (*Polyxenus* sp.) lived in 155 (15%); the gall-maker (*Disholcaspis cinerosa*) as larve, pupae or nearly-ready-to-fly imagines were in 50 (5%); spiders in 54 (5%); beetles in 17 (2%). Neuroptera, unidentified small wasps, mites, coleopterous and lepidopterous larvae each accounted for less than 1% (total 3%). (See Table 1.)

Table 1. Some arthropod inhabitants of *Dishcolcaspis cinerosa* galls on *Quercus virginia.*

Order	Family	Genus and Species
Araneida	Salticidae	*Metaphiddipus protervus* (Walskenaer)
	Clubionidae	*Trachelas tranquillus* (Henz)
Coleoptera	Cleridae	*Cymatodera* sp. (larva)
	Bruchidae	*Mimosetes amicus* (Horn)
		M. protractus (Horn)
		Algarobius bottimeri Kingsolver
	Cerambycidae	*Euderces pini* (Oliv.)
	Anobiidae	*Tricorynus castaneus* (Hamilton)
		Tricorynus sp.
Hymenoptera	Cynipidae	*Disholcaspis cinerosa* (Bassett)
	Bethylidae	*Goniozus punctaticeps* (Kieffer)
		Cephalonomia hyalinipennis Ashmead
	Chalcidoidea: larvae and pupae (families not determined)	
Lepidoptera	Gelechiidae	*Coleotechnites* sp.
Neuroptera	Chrysopidae	*Chrysopa rufibarbis* Burm.
		Chrysopa sp.
Diplopoda	Polyxenidae	*Polyxenus* sp.

The spiny milliped *Polyxenus* sp. (Order Diplopoda) numbered from 2 or 3 to more than a dozen in a gall. When they were present there were no other arthropods in that gall. They apparently hollowed the gall until there was only a thin shell left. Spiders seemed to use the galls as safe hiding places for egg-laying nests. According to J.M. Kingsolver (personal correspondence) bruchid beetles [*Mimosestes amicus* (Horn), *M. protractus* (Horn) and *Algarobius bottimeri* Kingsolver] "are apparently overwintering as inquilines in the galls. *M. amicus* feeds in seeds of *Prosopis* and several shrubs or trees, *M. protractus* feeds in seeds of *Prosopis* as does *A. bottineri.* Larvae are the feeders in seeds, but the adults feed on pollen and nectar in whatever flower is open at the time." Bruchids hold over, until *Prosopis* pods form, in trash, birds' nests, and galls.

A neuropteron (*Chrysopa* "sp. prob. *rufilabris* Burm.") larva was found feeding on a *D. cinerosa* larva; one *C. rufilabris* was reared out of a cocoon from a gall.

JTL made general collections of arboreal ants, including inhabitants of oak galls, at three sites in Texas: Travis County, near Beecave, 3 November 1982 and Webberville, 2 October 1983; Kerr County, Kerr Wildlife Management Area, 1 September and 8 November 1983.

In our combined collections *Leptothorax obturator* occupied 46% of galls containing ants (see Table 2). They showed the typical plug built by the queen and the pin-prick-sized hole opened by the workers. The colony continued to develop in the gall and as it developed the workers did considerable excavation inside the gall. In Bexar County, queens, eggs, larvae and pupae were collected from March to October. On June 16 one gall contained 4 winged females and one male; another contained a single winged female. On the same date an incipient colony in a plugged gall contained a queen and young brood. This suggests that it is possible for *Leptothorax obturator* colonies to spend their entire life cycle in galls. JW found no ants in dead twigs but not for lack of searching.

Table 2. Number and percent of galls inhabited by ants of various species.

	Texas Counties			
SPECIES	Bexar	Kerr	Travis	% of galls
Leptothorax obturator	50	12	4	46
Camponotus caryae discolor	25	4	4	23
Crematogaster laeviuscula	20	0	1	15
Colobopsis etiolata	5	5	2	8
Zacryptocerus texanus	8	0	0	6
Macromischa subditiva	1	0	0	*
Leptothorax sp.	0	0	0	*
Strumigenys louisianae	0	0	1**	*

* = less than 1%
** = 3 workers in same gall with *C. caryae discolor*

Leptothorax obturator was found nesting away from oak galls at the Webberville site. No oak galls were found, but three colonies of *L. obturator* were found in the dead twigs of *Bumelia lanuginosa* (ironwood). In general, *L. obturator* appears to be a specialized inhabitant of

Disholcaspis cinerosa galls on live oaks but can nest elsewhere.

Crematogaster laeviuscula, Zacryptocerus texanus (Santschi), *Camponotus caryae discolor* (Buckley) and *Colobopsis etiolata* were frequently observed nesting in dead branches of oaks. When these species were observed nesting in galls, each was often an incipient colony and contained a single queen, brood and a few very small workers. A colony that started in a gall might later add branch nests in adjacent galls or locate a suitable dead branch and move to the new nest site. Thus, galls could be very important sites for establishing colonies in these species.

The unidentified *Leptothorax* was found only once. *Strumigenys louisianae* Roger would be classified as an accidental inhabitant, for it was found only once: 3 workers in a gall with several *Camponotus caryae discolor* workers.

Torossian (1971a, 1971b, 1972) reported on a 9-year study of 1500 cynipid galls collected in Bouconne forest, 22 km west of Toulouse, France. The gall-formers were *Cynips quercus tozae* and *C. kollari* on 3 species of oaks (*Quercus pedunculata, Q. pubescens* and *Q. sessiliflora*). He found that *Leptothorax nylanderi* (Foerster) and *L. rabaudi* Bondroit together occupied 36.97% of galls inhabited by ants, *Colobopsis truncata* (Spinola) 20.24%, and *Dolichoderus guadripunctatus* (Linnaeus) 26.35%. These 3 genera together accounted for 91.55% of ants found in galls. He considered two species, *Crematogaster scutellaris* (Olivier) and *Camponotus fallax* (Nylander), totaling 7.6%, "'hôtes habituels' des galles." The third group, which combined accounted for 0.5%, he classified as accidental inhabitants: *Lasius alienus* (Foerster), *Aphaenogaster subterranea* (Latreille), *Myrmecina graminicola* (Latreille) and *Ponera coarctata* (Latreille).

In 1983 Espadaler and Nieves published a report on ants inhabiting 66 cynipid galls produced by 4 species of gall-makers on 5 species of *Quercus* in Spain. They grouped 7 species of *Leptothorax* and placed them first in their list of ants (in order of decreasing frequency) in the galls, followed by: *Crematogaster scutellaris, Colobopsis truncata, Camponotus fallax, Dolichoderus quadripunctatus* and "otras especies" last.

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RECORDS OF NYMPHAL *STENONEMA* (EPHEMEROPTERA: HEPTAGENIIDAE) FROM WEST VIRGINIA[1]

Janice E. Fisher[2], Donald C. Tarter[3]

ABSTRACT: Over 3,000 nymphs of the genus *Stenonema* were collected from 395 sites in West Virginia. A total of 12 species revealed two state records: *S. exiguum* and *S. sinclairi. Stenonema vicarium* was the most abundant species; *S. sinclairi* was the rarest. *Stenonema mediopunctatum mediopunctatum, S terminatum, S. pulchellum, S. femoratum,* and *S. vicarium* were distributed statewide. Species restricted to the Appalachian Mountains were *S. meririvulanum, S. ithaca, S. modestum,* and *S. pudicum. Stenonema mexicanium integrum* and *S. exiguum* occurred only in the larger rivers. Range extensions are noted for three species: *S. sinclairi, S. exiguum,* and *S. pulchellum.*

Prior to this investigation, Faulkner and Tarter (1977) reported seven *Stenonema* species from West Virginia: *S. bipunctatum* (McDunnough) (= *S. terminatum), S. femoratum* (Say), *S. intergrum (McDunnough), S. ithaca* (Clemens and Leonard), *S. pudicum* (Hagen), *S. pulchellum* (Walsh), and *S. vicarium* (Walker). Bednarik and McCafferty (1979) recorded *S. modestum* (Banks) and *S. mediopunctatum mediopunctatum* (McDunnough) from West Virginia. Carle and Lewis (1978) reported *S. meririvulanum* from Pocahontas County, West Virginia.

From 395 sites in West Virginia (Figure 1), approximately 3,000 nymphs of the genus *Stenonema* were collected and identified using the nymphal key of Bednarik and McCafferty (1979). Nymphs were collected with a dredge net, seine, Surber sampler, Hester-Dendy multiplate sampler, and by handpicking rocks. Twelve species, including two state records (*), were recorded from these collections. Nymphs are stored in the West Virginia Benthological Survey at Marshall University, and detailed records are found in Fisher (1985).

Range extensions are noted for three species. *Stenonema pulchellum,* previously considered to occur only in the Ohio River basin (Bednarik and McCafferty, 1979), was collected in Monongahela River and Potomac River drainage basins in the extreme eastern portion of the stae. *Stenonema mediopunctatum mediopunctatum* was recorded as an Appalachian Mountain species by Bednarick and McCafferty (1979); however, nymphs from this study were found in several western counties. *Stenonema*

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[1] Received March 30, 1987. Accepted July 13, 1987.

[2] West Virginia Department of Natural Resources, Water Resources Division, Charleston, WV 25311.

[3] Department of Biological Sciences, Marshall University, Huntington, WV 25701.

exiguum, previously reported from Minnesota to Michigan southward to Texas and northern Florida (Bednarick and McCafferty, 1979), was collected from the major rivers in the Ohio, Kanawha, Monongahela, and Potomac drainage basins. Prior to this investigation, *S. sinclairi* had been reported only from small, cold streams in a former strip-mined area in southeastern Tennessee (Lewis, 1979). In West Virginia, *S. sinclairi* was collected from the Shennandoah River in Jefferson County.

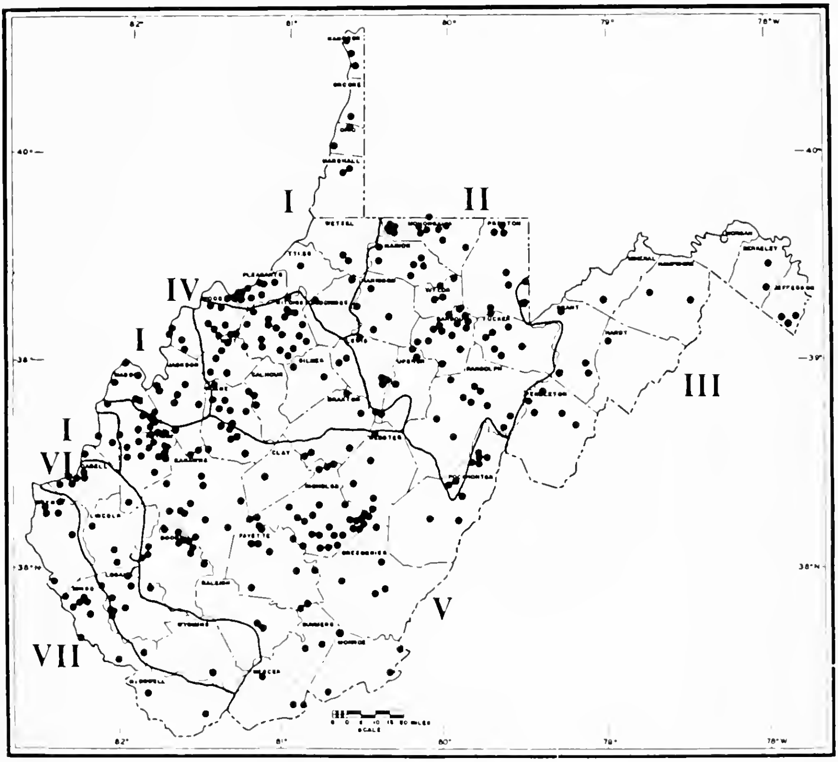

Figure 1. Drainage Basins in West Virginia (Janssen, 1973). I. Ohio River. II. Monongahela River. III. Potomac River. IV. Little Kanawha River. V. Kanawha River. VI. Guyandot River. VII. Big Sandy River. Black dots represent collecting sites.

Species Collected

***Stenonema exiguum* Traver: Drainages II, III, V, VI
S. femoratum (Say): Drainages I-VII
S. mexicanium integrum (McDunnough): Drainages I, IV, VI
S. ithaca (Clemens and Leonard): Drainages I-VII
S. mediopunctatum mediopunctatum (McDunnough): Drainages II-VII
S. meririvulanum Carle and Lewis: Drainages II, V-VII
S. modestum (Banks): Drainages II-VI
S. pudicum (Hagen): Drainages II, V
S. pulchellum (Walsh): Drainages II-V
**S. sinclairi* Lewis: Drainage III
S. terminatum
S. terminatum (Walsh): Drainages I-III, V-VII
S. vicarium (Walker): Drainages I-VII

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IDENTIFYING JUVENILES OF SIMILAR SPIDER SPECIES (ARANEAE)[1]

Mark W. LaSalle[2]

ABSTRACT: A technique using tarsal claw characteristics was developed and used to separate juveniles of similar spider species. Differences in shape, number and arrangement of teeth on claws were useful in distinguishing the early instars of two species pairs as well as damaged specimens of a number of additional species. The ability to separate juveniles allows for a more complete study of each population.

The identification of similar juvenile spiders has been problematic in studies of spider assemblages, often resulting in a category labeled juveniles (all species combined). This approach precludes any detailed consideration of populations within a given community. Toft (1983) recognized this problem in studies of European spider assemblages pointing out that while there is an adequate descriptive base for identification of adult European spiders, there remains a poor knowledge of juvenile specimens. Using color patterns of the abdomen and cephalothorax, Toft (1983) was able to separate the stages of three species of *Meta* (Araneidae) and suggested that careful studies of other problematic groups could lead to their separation as well.

Problems which arise in separating congeneric species involve similarities in shape, size, and color as well as common familiar and generic characteristics such as eye patterns and setation. Similar problems may also arise in separating confamilial species, particularly within the diverse family Linyphiidae where closely related genera are separated largely on the basis of adult characters. Typically, the characters of the early instars are most similar, while those of later instars progress toward those of the adult forms.

In an effort to avoid these problems, a technique using tarsal claw tooth number and shape was developed and used to sort juveniles of a congeneric and a confamilial species pair collected during a study of the spider assemblages of two brackish marsh habitats (LaSalle and de la Cruz, 1985). The clubionid spiders *Clubiona maritima* L. Koch and *Clubiona saltitans* Emerton (Clubionidae) are easily separated as adults based on size and relative proportions. Juvenile stages of similar size, however, have a similar shape, color and eye pattern. The linyphiid spiders *Floricomus* sp. and *Eperigone serrata* Ivie and Barrows (Linyphiidae) are distinct in shape and color as adults. However, early stages of both species are pale with

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[1] Received March 4, 1987. Accepted July 13, 1987.

[2] Address: 1615 Wallace St., New Iberia, LA 70560.

similar eye patterns. After examination of several characters (eye pattern, leg setation, coloration, etc.) of adult and juvenile specimens of the species in question, I determined tarsal-claw characters to be species specific and therefore useful in separating species.

Observations of tarsal-claw characters require the removal and mounting on slides of the leg-tarsus (with claws) for viewing in a compound microscope. Temporary mounts are easily prepared using glycerine as a mounting medium. Moderate pressure is generally required to spread and flatten the claws for adequate viewing. Specimens used in this study were chosen from adult-juvenile associations, either from females collected with egg sacs (*C. maritima*) or individual field collections having a range of juveniles of a single species. Additional field-collected early-stage specimens of *C. maritima* were examined to compare with egg-sac collections. In the case of *Clubiona* spp., 2nd-stage spiderlings emerge from the egg sac as evidenced by the presence of cast 1st-stage exuviae within the empty egg sac.

Clubionid spiders have two, subequal tarsal claws. In the case of both species of *Clubiona* a combination of number (Table 1) of claw teeth on either the prolateral (larger) or retrolateral claw was necessary to distinguish between early-stage juveniles. Observations were made on all four legs of adult and penultimate male and female as well as 2nd-stage specimens. The number of claw teeth varied less on leg I and II of 2nd-stage juveniles of both species (Table 1). For convenience, the number of teeth on leg I was subsequently used to make identifications. Differences in the number of claw teeth between species were consistent for all stages except males (Table 1).

Adult males of both species had more and longer teeth than other stages. Additional within-species variation involved differences between 2nd-stage spiders and other stages. There was no difference, however, between penultimate male and female spiders for either species. All but a few (2-3%) juveniles of both species were distinguishable using these characters. Questionable specimens were either assigned to a species on the basis of association with known species in the sample or by making a "best guess" decision.

Linyphiid spiders have three tarsal claws, two subequal pro- and retrolateral claws and a small median claw. In the case of *Floricomus* sp. and *E. serrata,* the shape of the first tooth of the median claw (pointed versus blade-shaped) on leg I was determined to be sufficient to distinguish early-stage juveniles (Fig. 1). Differences were also noted in the shape and size of the teeth on the two large claws; however, these were not always readily apparent unless the claws were adequately flattened on the slide. The number of teeth on the large claws also increased from early to late

Table 1. Modal values (range) of claw teeth on prolateral and retrolateral tarsal claws of all legs of 2nd-stage and leg I of penultimate (P) and adult *Clubiona maritima* and *Clubiona saltitans.*

		C. maritima claw			*C. saltitans* claw		
Stage	Leg	Prolateral	Retrolateral	N	Prolateral	Retrolateral	N
2nd	I	10 (9-11)[ab]	7(5-8)[ab]	20	8 (7-9)	6 (5-7)[b]	11
	II	10 (9-11)[a]	7(6-8)[a]		8 (7-8)	5.5*(5-7)	
	III	9 (8-11)[a]	7(6-8)[a]		7 (5-9)	5 (3-6)	
	IV	10 (9-13)[a]	6 (4-9)[a]		10 (8-11)	4 (2-8)	
P♀	I	10 (10-12)[a]	5.5*(4-6)	5	9 (8-9)	5 (5-6)	5
♀	I	11 (10-13)[a]	6 (5-6)	5	9 (8-9)	5 (5-6)	5
P♂	I	11 (10-12)[a]	6 (5-7)	5	8 (8-10)	5 (5-6)	5
♂	I	13.5*(13-16)[b]	9 (9-10)[b]	4	11 (10-12)[b]	8 (8-9)[b]	5

a - mean values were significantly different between species (Mann-Whitney, $P < 0.05$)

b - mean values were significantly different from all other conspecific stages (Kruskal-Wallis, $P < 0.05$)

* - modal value calculated as the average of two equally frequent values

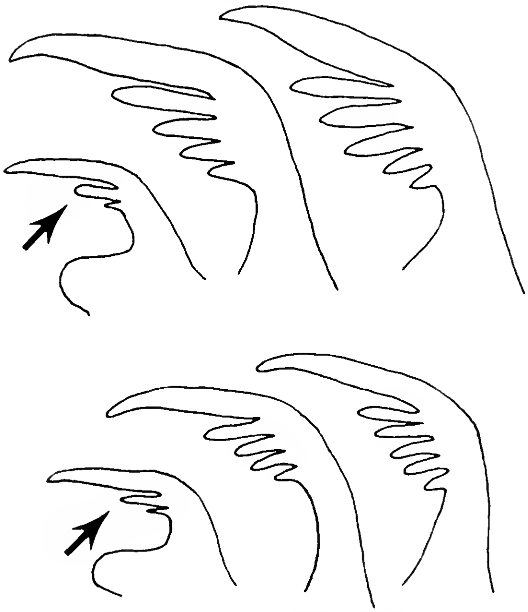

Figure 1. Tarsal claws of juvenile *Eperigone serrata* (top) and *Floricomus* sp. (bottom). Arrows point to teeth on median claws used to identify species.

stages. Oil immersion was often necessary to view the claws of small specimens. As with *Clubiona,* the identities of only a few (1-2%) juvenile specimens were questionable and were treated as previously described.

In addition to identifying similar species, I was also able to identify damaged specimens using this technique. Species from a number of families were readily identifiable using species-specific claw characters. Although the technique is somewhat time consuming, the benefit of obtaining specific identification of each specimen far outweighs the additional effort. Once the investigator becomes familiar with the characters and has mastered the preparation, each specimen in question can be identified in 3-4 minutes.

The use of claw characters as a means of identifying juvenile spiders apparently has application within a given spider assemblage. However, since characters may vary between geographically separate populations, species-specific characters should be determined for each study. As shown here, some characters may be readily apparent while others may require more careful study. Toft (1983) also pointed to the need for careful examination within a given habitat either through breeding of known species or through extensive collections and associations from confined areas.

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LATRODECTUS HESPERUS (ARANEAE: THERIDIIDAE) IN MAINE[1,2]

Daniel T. Jennings[3], Ivan N. McDaniel[4]

ABSTRACT: A female and egg sac of the western black widow, *Latrodectus hesperus*, were introduced into Maine among household goods transported from Phoenix, Arizona. A total of 292 spiderlings emerged from the egg sac. Survival of offspring could have formed the nucleus of a breeding population.

Spiders are dispersed over great distances by aerial ballooning and by human transport (Gertsch 1979). Kaston (1983) referred to spiders transported by man from one area to another as anthropochores, and those species commonly associated with man as synanthropes. He further indicated that there is a close relation between the synanthropic and anthropochorous conditions, i.e., spiders closely associated with man's domiciles are most apt to be transported by commerce. Several species of anthropochorous synanthropes are of medical importance and include species of *Latrodectus* and *Loxosceles* (Kaston 1983). Here we describe long-range transport and introduction of a potentially dangerous spider into Maine.

On 22 October 1986, David W. Lister collected a female black widow spider inside a house on Cedar Street, Bangor, Penobscot County, Maine. The following day he examined household goods stored in the attic and found much spider webbing and an egg sac. The egg sac was in the hollow center of an automobile jack stand which previously had been placed outdoors in Arizona. Mr. Lister recently moved (19-29 September 1986) to Maine from his former residence in Phoenix, Maricopa County, Arizona.

After collection, the spider and egg sac were confined together in a small canning jar on 24 October and kept alive at room temperature. The spider spun a characteristic tangle web inside the jar and readily "accepted" the egg sac, i.e., she positioned the egg sac in her web, remained nearby, and changed the egg sac's location from lower to upper regions of the web. Six days later, on 30 October, young spiderlings had emerged from the egg sac.

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[3] USDA, Forest Service, Northeastern Forest Experiment Station, University of Maine, Orono, ME 04469.

[4] Department of Entomology, University of Maine, Orono, ME 04469.

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Spiderlings and adult female spider were killed and preserved in 75% ethanol on 3 November 1986.

The female spider and spiderlings were identified by the senior author as *Latrodectus hesperus* Chamberlin and Ivie. This species is known as the western widow spider (MacKay 1982), or the western black widow (Gertsch 1979), and is found in the western United States and eastward into west Texas (Kaston 1970; Allred and Kaston 1983) and western Canadian provinces (Chamberlin and Ivie 1935; Kaston 1970).

The female *L. hesperus* collected in Bangor, Maine, measured about 11 mm in body length. Kaston (1970) reported that females of *hesperus* were the largest among the three species of black widows found in the United States (*L. mactans,* (Fabricius), *L. variolus* Walckenaer, and *L. hesperus);* he noted that *hesperus* females ranged from 8 to 15.5 mm, with most from 10.5 to 13 mm. [In addition to three species of black widows, the red widow (*Latrodectus bishopi* Kaston) and the brown widow (*Latrodectus geometricus* C.L. Koch) also are found in the United States (Kaston 1970)].

The female's epigynum was dissected and internal structures examined. The connecting ducts (bursae copulatrices) had three outside coils and the heavily sclerotized spermathecae were dumbbell shaped. Although both *L. hesperus* and *L. variolus* have three outside coils while *L. mactans* has four (Kaston 1970), *hesperus* generally can be distinguished from *variolus* by the absence of dorsal abdominal markings. *L. variolus* has a row of middorsal red spots and diagonal white stripes on the abdomen (Kaston 1970).

The collected egg sac was pear-shaped, about 12 mm in height and 10 mm in diameter, and creamy white in color. Kaston (1970) described the egg sacs of *L. hesperus* as pear-shaped, 13 or 14 mm in height, 10 or 12 mm in diameter, and creamy yellow to light tan. The exact date of oviposition and egg-sac spinning are unknown for the Maine-collected sac; Kaston (1970) indicated the average time from oviposition to emergence was 30.3 ± 2.8 days for *L. hesperus* reared in the laboratory.

A total of 292 spiderlings emerged from the egg sac. [For *L. hesperus,* Kaston (1970) reported that the number of eggs per sac commonly ranged from 160 to 225, with an observed maximum of 598. This species also spins more than one egg sac (maximum 21)]. Mean carapace width of the first postemergence instars was 0.48 ± 0.01 mm (S.D.), $n = 50$. The spiderlings characteristically were marked with two rows of black spots extending along the dorsum of the abdomen. These and other markings (Kaston 1970) confirmed species identification of the *L. hesperus* spiderlings.

For *L. mactans hesperus* (= *L. hesperus*) in Utah, Chamberlin and Ivie (1935) noted that although young hatched late in the season may overwinter in the immature condition, most overwintering individuals were adults.

MacKay (1982) indicated that *L. hesperus* overwinters as spiderlings in California.

The female *L. hesperus,* egg sac, and young spiderlings are deposited in the arachnid collections of the U.S. National Museum of Natural History, Washington, D.C.

The neurotoxic symptoms of black widow spider bites are well known. Gertsch (1979) described the bite of *L. hesperus* as producing intense pain followed by other symptoms including nausea and vomiting, faintness, dizziness, tremors, loss of muscle tone, and shock. Respiration may be strongly affected, followed by cyanosis and prostration, and, in some instances, death. Most victims were bitten by female widow spiders, though Allred (1974) reported a bite by a subadult male of *L. hesperus.* The species introduced into Maine, *L. hesperus,* has been described as the most dangerous spider in Arizona (Randall 1982).

Despite numerous alleged spider-bite cases in Maine (some 25 cases since 1976 requiring medical attention), none has been directly associated with specimens of black widows, or with specimens of the brown recluse (*Loxosceles reclusa* Gertsch & Mulaik) (McDaniel and Jennings 1983). There is only one previous report of *Latrodectus* spiders being collected in Maine; Kaston (1954) examined a specimen collected on 25 October 1953 at Gorham, Cumberland County, Maine. He noted that the specimen differed from *L. mactans* by the absence of a red spot above the anal tubercle, and that the spider was entirely black except for two very small spots in the middorsal line on the anterior half of the abdomen — a color pattern similar to that of *L. variolus.* Although Thorp and Woodson (1945) included one report of a black widow bite in Maine (1726 to 1943), Kaston (1954, p. 193) refuted their claim, noting that the "record was an error, presumably based upon a misidentification." If Maine has an indigenous species of *Latrodectus,* it probably is the northern black widow, *L. variolus*. Levi (1959) recorded *L. curacaviensis* (Muller), now considered *L. variolus* (see Kaston 1970), from various locations in southern Vermont and New Hampshire.

This collection of *L. hesperus* female, egg sac, and emergent spiderlings represents the second example of a medically important spider accidentally introduced into Maine. Earlier, we described the collection of another anthropochorous synanthrope, *Loxosceles reclusa,* brought into Maine from Oklahoma (McDaniel and Jennings 1983). In neither case have breeding populations of these potentially dangerous spiders become established. However, the introduction of impregnated female spiders or their egg sacs (as described here) poses a potential threat of successful establishment, especially when the spiders or egg sacs are confined indoors. We suspect that, without discovery, capture, confinement, and eventual destruction, the female and young spiderlings could have survived the Maine winter indoors in an insulated but unheated attic (estimated temperature 10°C). Depending upon available food, survivorship, and mating potential, offspring that reached maturity could have formed the nucleus of a breeding population in Maine.

ACKNOWLEDGMENTS

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A COLLAPSIBLE, FULL-SIZED BERLESE-FUNNEL SYSTEM[1]

Roy A. Norton[2], John B. Kethley[3]

ABSTRACT: A portable Berlese-funnel system which is lightweight and collapsible, yet provides the extraction capabilities of standard full-sized metal funnels, is described. Pattern and construction information is given for pyramidal funnels made from rip-stop nylon, with a 14″ (35.6 cm) square loading space. A stand which holds three funnels is made from household shelving brackets, and polyethylene bags (Whirl-paks®) are used to hold the preservative.

Currently used designs of full-sized metal Berlese-funnels (e.g., Martin 1977, Steyskal *et al.* 1986) are not very portable; they are bulky, and a set of 8-10 funnels, along with accessories and supporting racks, can be quite heavy. This paper describes a different approach to their construction, using fabric funnels and a simple, lightweight supporting stand. The funnels collapse to 1/2″ (1.3 cm) thickness or less for packing and the stand breaks down into small sections, so that a single set of funnels can be added to a suitcase for *ad hoc* collecting, or several sets can fit in a modest-sized crate for a major expedition. Set-up and take-down are relatively fast, so the funnels are efficient for overnight stops, and if only one or two samples are to be processed, they can be hung from any convenient existing support (e.g., closet poles, shower-curtain supports), without setting up the stand. The following descriptions of materials and methods are for pyramidal funnels with a 14″ (35.6 cm) square loading space, along with a stand designed to hold three funnels. Most materials we describe (or their equivalents) are available in hardware or department stores; rip-stop nylon is carried by many, but not all, fabric shops, and the aluminum ground wire can be found in most electronics specialty stores.

Statistical comparisons of extraction efficiency, relative to standard metal Berlese-funnel systems, have not been done. Several times, however, large raw samples of substrate have been evenly divided between the two styles of funnel, run side-by-side, with no noticeable difference in numbers or types of arthropods collected.

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[1] Received April 23, 1987. Accepted July 13, 1987.

[2] SUNY College of Environmental Science and Forestry, Syracuse, NY 13210, and Research Associate, Field Museum of Natural History, Chicago 60605.

[3] Division of Insects, Field Museum of Natural History, Roosevelt Rd. at Lake Shore Drive, Chicago, Illinois 60605.

MATERIALS

Principal materials needed for each funnel:

- rip-stop nylon (tent material); about 10 ft^2 (0.93 m^2) per funnel if patterns are laid out side-by side, less if they are alternated (i.e., every other one inverted to avoid waste)
- aluminum ground wire (8-guage); about 11′ (3.4 m)
- strong nylon cord; about 5′ (1.5 m)
- hardware cloth (1/4″ [6.4 mm] galvanized wire mesh); 15″ (38.1 cm) square
- household lamp ("lightbulb") socket, wall plug, and 18-guage electrical cord (or socket-plug and extension cord)
- cardboard for reflector (see below)
- heavy-duty aluminum foil

For each stand (3-funnel capacity):

- aluminum shelf brackets (18′ [5.5 m] total length); we use 11/16″ (1.8 cm) width, household style brackets, but any will do
- strong nylon cord (about 5′ [1.5 m])
- 1″ (2.5 cm) angle brackets (2)
- 1¼″ (3.2 cm) stove bolts (machine screws), with lock-washers and nuts (9)
- household extension cord

CONSTRUCTION

1. Cut the four sides from rip-stop nylon using a paper pattern (Fig. 1); four thicknesses of material, pinned to a layout board, can be cut at the same time using a rotary cutter. The pattern includes a 1/2″ (91.3 cm) seam allowance on all sides, except for the lower tab (t). Since the material ravels easily, a commercial anti-fraying compound can be applied to each edge after cutting, or a candle flame can be carefully moved along the edge to seal it.

2. Add two reinforcement strips (rs) where fabric will contact the metal frames. Seam-binding material (applied with fabric-glue) works well, or a strong tape (i.e., duct tape) can be used.

3. Sew the four sides together, right-side in, leaving the bottom tabs free. For strength and good appearance, the seam allowance can then be folded and attached with a second pass through the sewing machine ("flat-felled" seam), or left loose if the edges have been well sealed.

4. Bend aluminum ground wire into two 14″ (35.6 cm) squares, leaving an extra 1″ (2.5 cm) for overlap and joining on one side. Although joining the two ends can be done in a variety of ways, this is not a large stress bearing joint, so that wrapping the overlap with whipping cord or heavy canvas thread, followed by a thick coat of varnish, is sufficient. The hardware-cloth square, which serves as the sample support shelf, is fastened to one of these frames by bending the excess length and width over the aluminum wire, being careful that no sharp ends are directed toward the outside, where they could cut the fabric funnel.

5. Sew the open frame into the top of the funnel, centered on the reinforcing strips. This can be done with care on a sewing machine, using a simple fold-over seam. The hardware cloth unit is then positioned on the lower reinforcement strips, and sewn in by hand, using a heavy canvas thread or similar strong, thin cord; a curved needle helps here.

6. Attach four loops to the top of the funnel for tying the hanger cords. This can be done in a variety of ways, but we have sewn on loops of fabric seam-binding passed through small plastic curtain-rings (Fig. 2, cr), although the latter are not really necessary. One could also attach a well-reinforced grommet ("eyelet") just below the upper aluminum frame, through which the funnel-support cords could pass.

7. The lower opening of the funnel must be supported in order to hold its shape. Figure 3 shows a dual-purpose support bent from aluminum ground wire; the "wings" serve for the attachment of the wire closures on the collecting bag (see below). A simple version (Fig. 4) is used if some other means of attachment is provided for the collecting bag, such as a pair of small rubber "0-rings" sewn onto two alternating sides of the funnel, perhaps 1/2″ (1.3 cm) above the opening. In either case, the four free tabs of the funnel are passed through the wire support, folded back against the funnel sides and attached with fabric-glue (Fig. 5).

8. Wire a standard lamp socket with about 2′ (0.6 m) of household 18-gauge electrical cord ("zip-cord") and a two-prong plug. Adding a 2″ (5.1 cm) section of rubber tubing (Fig. 6, rt) where the electrical cord joins the socket provides extra strength and insulation, as well as an attachment location for a small hook, bent from aluminum ground wire (hk). The hook should be bent so that it allows the socket to hang vertically when the bulb is in place. A simple alternative design uses a short household extension cord with a socket-plug (plug to lightbulb-socket adapter). For added safety, grounded versions of all electrical components can be used, but the system would be heavier, and might require a different supporting stand.

9. Bend a hanger (Fig. 7) from another piece of ground wire. This serves as an attachment for the nylon cords supporting the funnel (each about 11″ [27.9 cm] long), as well as the light assembly.

10. Construct a reflector from four pieces of strong, stiff cardboard (such as heavy herbarium mounting sheets), or similar stiff, but thin material, cut in a truncated triangle (Fig. 8). A reflective surface is made by cementing heavy-duty aluminum foil to the inner face. Aluminum roof flashing is an alternative reflector material. The four pieces are joined flexibly with strong tape (i.e., duct-tape), leaving the last edges unconnected.

11. Cut the aluminum shelf brackets into eight 21" (53.3 cm) lengths for legs and two 22" lengths (56.4 cm) for the spanner. Each leg and the spanner is thus composed of two pieces. Two leg pieces (upper halves) are movably joined back-to-back with a stove-bolt, lock-washer and nut (Fig. 9); the bolt is first passed through an angle-bracket (br); repeat, to make a second assemblage. These assemblages are kept fastened together during storage and use. Drill holes in remaining leg and spanner pieces so that the halves may be joined during assembly by a bolt, with an overlap of about 1.5" (3.8 cm). Two lower halves of support legs are attached by a 20" (50.8 cm) length of nylon cord which prevents spreading when the stand is assembled (Fig. 10).

ASSEMBLY AND USE

The stand is assembled by overlapping leg pieces in opposite directions, face-to-face, so that they nest tightly, and fastening with a bolt, washer and nut (preferably a wing-nut for ease of assembly). The same technique is used to connect the two longer sections to form the spanner (Fig. 10, sp). Use bolts, lock washers and wing-nuts to attach the spanner (Fig. 9, sp) to the free ends of the angle brackets. Thus constructed, the stand depends greatly on the angle brackets, and since the spanner is the only longitudinal piece, it is somewhat wobbly in the longitudinal direction. However, when used with reasonable care the stand is sturdy enough to hold three loaded funnels. It can be made stronger by adding metal angle-supports between the spanner and upper leg sections. A simple household extension cord provides current, with the female end taped near the center of the spanner.

After hanging the funnels, the hardware-cloth shelf is lined with a suitable material, determined by the particle-size of the sample and the organisms of interest. Cheesecloth, purchased in bandage-squares large enough to cover the shelf with several inches left over on each side, allows larger arthropods (beetles, centipedes, spiders, etc.) to force the threads apart, while keeping most of the debris from falling into the collecting bag. Once the sample is in place, the excess material is folded over the top of it, thereby discouraging vertical escape, and providing "handles" for removing the sample after extraction. If only small arthropods (mites, collembolans, etc.) are sought, fiberglass window-screen, cut to fit the shelf may be used.

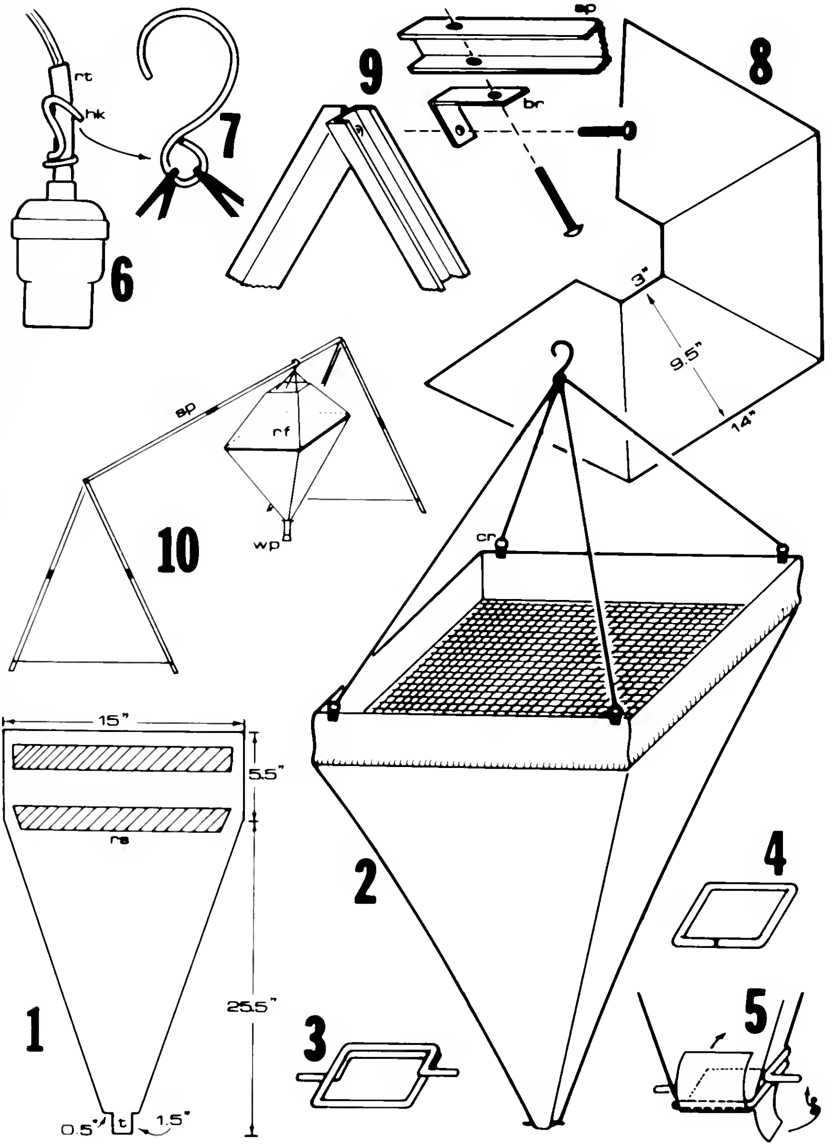
The wattage of light bulb utilized in the extractors is a function of sample moisture and length of time available for extraction. If extraction time can be several days, low wattage bulbs (15-40), commonly thought to be less dangerous for small, soft-bodied arthropods, can be used. When overnight extraction is desired, 60 watt bulbs are usually necessary, and the depth of substrate on the shelf should be restricted to about 1/2″ (1.3 cm), or even less if it is rather compact. The pyramidal reflector (Fig. 10, rf) is then gently positioned on top of the funnel, and the two free sides joined with a small piece of tape.

Organisms are extracted into a 6 oz (177 ml) Whirl-pak® polyethylene bag (Fig. 10, wp), about 1/4-filled with preservative (70% ethanol), which is attached to the funnel bottom (to either the metal "wings" or "0-rings") with its closure wires. These bags can be obtained through most biological supply houses. After extraction, air is removed from the bag by carefully drawing it over a finger or table-top, prior to sealing. The result is a flat, low-volume sample, but it must be protected from being crushed during storage and transport; small sturdy cardboard boxes or plastic sandwich boxes work well. For extra protection, three of the sealed 6 oz bags can be placed in one 18 oz (532 ml) bag, which is sealed with enough included air to provide cushioning.

DISCUSSION

Various designs for fabric funnels have been field-tested over the last decade by personnel of the Field Museum of Natural History. One alternative is to construct the top section of the funnel (above the support shelf) from a porous material, such as muslin. The upper sides are made much higher than those described above and are provided with a drawstring at the upper edge, so that when the sample is in place and the drawstring is pulled, there is little opportunity for external contamination (e.g., moths or beetles attracted to the light). In this design, a square reflector made from sheet-aluminum (e.g. roof flashing) is used, with a central hole for passage of the lamp socket, rather than the pyramidal reflector described above; the square reflector also serves to support the muslin top after it is drawn together.

Larger capacity funnels can be made in a rectangular (e.g., 14″ x 24″ [35.6 x 60.0 cm]), rather than square format, to better fit along a wall. The muslin-top design works best in this case. Heat is provided by two 100 watt bulbs mounted horizontally on either side of an extension cord, using socket-plugs; the reflector is cut in a rectangle proportional to the funnel. Since the loaded-weight of large funnels is substantial, a more sturdy support than that described above is needed; tubular tentframes, cut to size,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Figs. 1. Individual side panel, with reinforcement strips. 2. Completed funnel. 3. Wire support for funnel opening, provided with side wings for hanging collecting bag. 4. Wire support used when collecting bag is hung from separate "0-rings". 5. Folding of tabs (at bottom of side panels) around wire support.) 6. Light-assemblage. 7. Hanger. 8. Assembled reflector, laid flat. 9. Exploded diagram of joint between legs and spanner; horizontal bolt is fastened with lockwasher and nut, vertical bolt with lockwasher and wingnut (for ease of assembly). 10. Assembled stand with one funnel unit in place.

Abbreviations: br (angle bracket); cr (curtain ring); hk (aluminum wire hook); rf (reflector, folded in place); rs (reinforcing strip); rt (rubber tubing); sp (spanner); t (free tab); wp (Whirl-pak® collecting bag).

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have worked well. In general, if the size of samples is variable, a number of medium-sized (14" [35.6 cm] square) funnels provide a more flexible system than a few large units.

One factor which affects extraction time, and probably efficiency, is the uniformity of the substrate, and we strongly recommend the use of a sifter when collecting such materials as leaf litter and rotten wood. Important benefits include: the concentration of material and animals by eliminating bulky, larger pieces; the ease of pouring onto the funnel shelf; and more rapid and uniform drying of the low bulk-density siftings, thereby avoiding moisture pockets which can serve as refugia. Such sifters are normally constructed from steel hoops, hardware cloth, and canvas, denim, or similar material (e.g., Martin 1977), but if weight and size are important, smaller versions can be made from rip-stop nylon.

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THE STRUCTURE OF WAGNER'S ORGAN IN *OROPSYLLA (DIAMANUS) MONTANA MONTANA* (SIPHONAPTERA: CERATOPHYLLIDAE): PRELIMINARY INVESTIGATIONS[1,2]

Tom Cheetham[3], Robert Lewis[4]

ABSTRACT: The structure of Wagner's Organ in *Oropsylla* (*Diamanus*) *montana montana* was examined via light and scanning electron microscopy.

First explicitly noted by Wagner (1932a,b; 1933), many male fleas in the family Ceratophyllidae possess paired, sac-like structures lined with minute, inward directed spines, lying laterad of the base of the eighth sternum. Wagner referred to these structures as "X-glands". They are present in all but 11 of the 43 currently recognized genera in the family (Smit, 1983). Wagner and others have suggested that they have a secretory function (Wagner, 1932a,b, 1933; Günther, 1961; Traub & Rothschild, 1983), perhaps in the production of pheromones. Male Ceratophyllidae also possess well developed spiculose intersegmental membranes between the eighth and ninth segments. Wagner (1932b) has proposed that these act to provide expanded surface area to facilitate evaporation of the proposed products of the "gland". A study was begun to ascertain something more about the structure and function of these bodies, with the intention of investigating any associated secretory tissues.

MATERIALS AND METHODS

Adult male specimens of *Oropsylla* (*Diamanus*) *montana montana* (Baker, 1895), a parasite of *Spermophilus* species, were obtained from a colony maintained by the Center for Disease Control in Fort Collins, Colorado. Individuals were dissected in 2.5% glutaraldehyde and 2% paraformaldehyde in 0.1M cacodylate buffer. pH 7.3, and the tissues left in the fixative for 1-2 hours. After a buffer wash and postfixation in osmium tetroxide for 1 hour, the tissues were dehydrated in a graded ethanol series and embedded in Medcast (TM) resin. Thick sections were cut with glass

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[3] Present address: USDA-ARS, 2021 S. Peach Ave., Fresno, CA 93727.

[4] Department of Entomology, Iowa State University, Ames, IA 50011.

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knives, stained with toluidine blue (1% in 1% borax, aqueous), and viewed with a Zeiss photomicroscope. For observation with the scanning electron microscope, the embedded tissues were etched following the procedure of Erlandsen *et al.* (1973), sputter-coated with gold-palladium and viewed with a JEOL JSM-35 scanning microscope operated at 25KV.

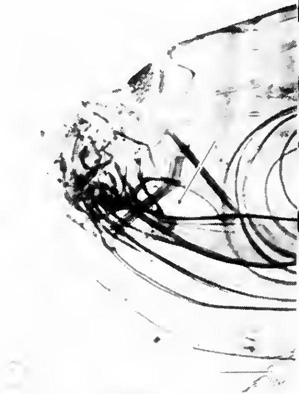
RESULTS AND DISCUSSION

The arrow in Figure 1 shows the location of Wagner's Organ as it is seen in cleared specimens as they are normally mounted for study, although the location and shape vary both within and among species. In Figure 2 the organ itself with its inner spines is visible as seen in whole mounts. Figure 3 depicts a transverse section through the male abdomen, showing the relative position of the rectum (r), the aedeagus (ae), and the paired Wagner's Organs (arrows). The lumen of the organ itself is lined throughout with a thin cuticular intima, which is produced into spines of varying lengths (Fig. 4). These spines are hollow, as would be expected of this kind of cuticular growth, and many are of a length which seems out of proportion to the space within which they lie. In the dorsal region of the lumen inclusions which are spherical in section can be seen, which may be traces of a secretion associated with this organ (Fig. 5: arrow).

Most surprising is the seeming lack of glandular tissue associated with these bodies. Wagner (1932b; Fig. 2) has illustrated and discussed small cells located near the internal surface of the organ in *Ceratophyllus hirundinis,* the outer surface of which stained densely with carmine in dissected specimens. He tentatively identified these as gland cells, and the stained substance as their product. He found no connection between these cells and the lumen of the "X-gland" and suggested that the cells might lie within its walls.

During this study sections were taken well into the body of the animals, and in none of the half-dozen which were sectioned was there any clear evidence of cells or tissue of a glandular nature surrounding, or even near, the bodies. No ducts leading into the lumen of the organ were noticed in the surrounding area, the presence of which might suggest connection to a gland elsewhere in the abdomen. There is, however, as has been noted by Wagner and others in various species (Wagner, 1932b; Dampf, 1942; Traub, 1950), an opening leading from the organ to the surface of the intersegmental membrane between sterna eight and nine. Wagner's Organ itself no doubt arises as an ectodermal invagination of these membranes and opens out onto them through the "duct" thus formed.

The specimens which were sectioned were all adults when they were selected for shipment. It is possible that the production of secretions by cells



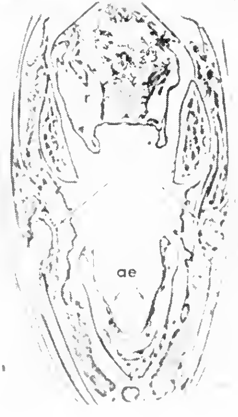


Fig. 1. Male terminalia of *Oropsylla (Diamanus) montana montana.* Location of Wagner's Organ is indicated by the arrow. Scale line = 100 microns.

Fig. 2. Light micrograph of Wagner's Organ (oil immersion). Scale line = 25 microns.

Fig. 3. Transverse section of the male abdomen, ae: aedeagus.r: rectum. arrows: Wagner's Organs. Scale line = 50 microns.

Fig. 4. Light micrograph of Wagner's Organ and surrounding tissue. Note the length of the spines. Scale line = 10 microns.

Fig. 5. As Fig. 4. Contents of the lumen are indicated by the arrow. Scale line = 10 microns.

Fig. 6. Scanning electron micrograph of resin embedded tissues. Some of the resin has been etched away to reveal the structures. The content of the lumen of the organ is undissolved resin rather than natural content. The hollow core of the spines is just visible in this micrograph (arrow). Scale line = 10 microns.

associated with this organ is dependent upon the age of the animal, and that any secretory cells present had degenerated by the time the specimens were fixed. Careful selection of males in mating condition is required to determine whether this is the case. In any event, the mode of secretion remains a puzzle, given the seeming lack of ducts leading into the organ. Subcellular cuticular ducts do occur in certain insects, for instance in the gland cells surrounding the spermathecae of some Asilidae (Reichardt, 1929; Cheetham, unpublished observations), and some such arrangement may exist here. Further work is necessary on reproductively active specimens and should include transmission electron microscopy and histochemistry.

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GROUP AND INDIVIDUAL REARING OF FIELD CRICKETS (ORTHOPTERA: GRYLLIDAE)[1,2]

Susan A. Wineriter, Thomas J. Walker[3]

ABSTRACT: Groups of ca. 50 field cricket hatchlings, *Gryllus* spp., produce 20-40 adults when reared in gallon jars provisioned with water, Purina Cricket Chow®, and a sand substrate. *Gryllus rubens* hatchlings can be reared singly in 1-oz cups on a pintobean diet developed for cabbage loopers. This is the first account of a method suited to rearing large numbers of crickets singly; survivorship is high. Other cricket researchers report a variety of methods and diets that are useful in group rearing species of *Gryllus* and related genera.

Field crickets (Gryllinae, especially *Gryllus* spp.) have many advantages for use in field and laboratory studies of insect ecology and behavior. They are widely distributed, easily collected, large in size, easily sexed, can endure much handling, and have surfaces that permit easy marking for individual or group recognition. Moreover, they can be reared in groups of ca. 50 or singly at modest cost in money, labor, and space. The group-rearing method reported here has been used and improved during studies of southeastern *Gryllus* starting in 1970 (e.g., Walker 1974, 1980, 1987; Wineriter and Walker 1984; Walker and Sivinski 1986). The single rearing method was developed in order to eliminate social effects in experiments on the genetic and environmental determinants of wing dimorphism in *Gryllus rubens* (Walker 1987).

Group rearing methods developed by other researchers and used with *Gryllus* spp. and related crickets are summarized in Appendices A (personal communications) and B (published accounts).

Group Rearing

General. One-gallon (ca. 4 liters), wide-mouth glass jars serve as rearing containers. The jars are economical because they are mass-produced for food processors; their proportions make it difficult for crickets to leap out when the lids are off.

Approximately 900 ml of heat-sterilized, dry, fine sand is placed in the bottom of a jar and made to slope at 20-30 degrees (Fig. 1A). The sand at the lower elevation is then moistened with 50-60 ml of water establishing a gradient of moisture from damp sand on the lower elevation to dry sand on

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[2] Florida Agricultural Experiment Station Journal Series No. 8063.

[3] Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.

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the higher elevation. The wetter area provides suitable sites for oviposition and maintains a favorable humidity within the jar. The drier area provides a favorable site for a food dish.

Next, a water vial (Fig. 1B) is pushed slightly into the moistened sand. The wet tip must not contact the sand or the water will be drawn out. Also, a polystyrene disposable weighing boat, 40x40 mm, or one-half of a plastic petri dish, 60x15 mm, of food (diet discussed below) is placed in the drier area (to slow molding). Size of the food container and amount of food depends on the number and size of crickets being reared. The weighing boat is adequate for smaller crickets while the petri dish is better for larger crickets. The container should hold enough food to last a little more than one week.

Finally, crickets are added — either a mated female is placed in the jar to lay eggs, then removed at or before first hatch (approximately 3 weeks), or 50 hatchlings from another oviposition container are placed in the jar. When the juveniles become larger, a perch is added to provide more space (Fig. 1A). The jar is capped with a plastic lid that has a 9 cm diameter hole for air circulation (Fig. 1A). A 10 cm diameter piece of wire cloth epoxyed to the lower surface of the lid prevents escapes of crickets and entry of flies, ants, and spiders. If a higher humidity within the jar is required, a circular cardboard or plastic disc with a hole less than 9 cm in diameter can be placed inside the lid. Reducing the area of the hole less than 50% is not recommended as this may cause the food to mold quickly. The jars are maintained in a rearing room or outdoors under a plywood roof. Under our usual laboratory conditions, 25°C and 16L:8D, most field crickets mature in approximately 4 months.

The jars of crickets are tended weekly. The food dish is changed and new food added. (If left longer, food will mold.) A wash bottle is used to remoisten the sand while maintaining the moisture gradient. The water vial requires filling no more than monthly if at all. The food dish and the water vial and its stopper are reused after washing with water and soaking 24 h in a 5-10% bleach solution for disinfection.

For most species, most of the time, we expect 20-40 adult crickets from a jar started with 50 hatchlings. Starting more than 50 hatchlings per jar usually does not change the outcome. Note, furthermore, that extra hatchlings do not have to be removed from a jar, i.e., oviposition jar, unless knowing the number started is important. Mortality is higher in crowded jars, but 20-40 full-sized adults can still be expected.

Diet. Finding a nutritionally adequate diet for grylline crickets is generally no problem. Foods used by other researchers for laboratory rearing of *Acheta* and *Gryllus* include Purina Cat Chow® and lettuce (Harrison 1979, Roff 1986), Purina Cat and Rabbit Chows® (Roff 1986), chicken mash (Stout *et al.* 1976), and lettuce and dog biscuits (Weber *et al.* 1981). For many years, we used Purina Dog Chow®, finely ground for small nymphs and whole for larger nymphs and adults, and successfully reared at least eight species of *Gryllus* for one to eight generations. However, on three occasions we had greatly reduced survivorship in *G. rubens* beyond the second laboratory generation. Upon the third occasion, we inquired about alternative foods and learned that Purina sold another product wholesale to commercial rearers of bait crickets — viz., Cricket Chow®. We switched to Cricket Chow and survival of lab-reared *rubens* returned to its earlier levels for several generations, then began to decline again.

Because of this recurring problem with rearing *rubens,* we decided to test effects of three diets on the survivorship and rate of development of two genetic lines: F_1 hatchlings of field-collected *rubens* and F_{11} hatchlings of short-wing selected *rubens* (Walker 1987). The diets were newly purchased Purina Dog Chow, freezer-stored Purina Cricket Chow (purchased 2 years previously), and refrigerator-stored Cricket Chow (purchased 2 years previously). Five groups of 50 crickets each were started for each treatment in the F_1 line or 250 crickets per treatment. Due to a shortage of F_{11} crickets, three groups of 50, one group of 40, and one group of 32 crickets or 222 per treatment were started. Results are summarized in Table 1.

Table 1. Mean percent survivorship of two strains of crickets fed three diets.*

Diet	F_1 N	*G. rubens* Mean %	F_{11} N	*G. rubens* Mean %
Dog Chow	250	20.8^a	222	4.5^a
Refrigerated Cricket Chow	250	56.8^b	222	6.8^a
Freezer-stored Cricket Chow	250	58.0^b	222	18.9^b

*Means in the same column that have the same letter are not significantly different ($P > 0.05$) using Fisher's Protected LSD test.

An ANOVA indicated significant differences between survivorship of the two strains ($Pr > F = .0001$) as well as significant differences between diets within strains ($Pr > F = .0001$). Therefore each strain was analyzed independently using Fisher's Protected LSD to test for significant differences between diets.

F_1 lab-reared crickets had a higher survivorship on all diets than F_{11} lab-reared crickets. Significant differences between diets were not the same between strains. F_1 crickets survived well on refrigerator- and freezer-stored Cricket Chow but not on Dog Chow; F_{11} crickets did poorly on freezer-stored Cricket Chow and still worse on refrigerator-stored Cricket

Chow or Dog Chow.

F_1 crickets were also compared in terms of rate of development. Crickets reared on Dog Chow were slower to mature and more variable in maturation time than those on the other two diets (Fig. 2). While 74-79% of the crickets reared on refrigerator- and freezer-stored Cricket Chow matured during weeks 13-15, only 13% of the crickets reared on Dog Chow had matured through week 15 and the greatest percent maturing during a 3-week period was 51% (wks 16-18). For F_{11} crickets reared on freezer-stored Cricket Chow, the pattern of development was similar to F_1 crickets reared on that diet (too few F_{11} crickets survived on the other diets to be considered here).

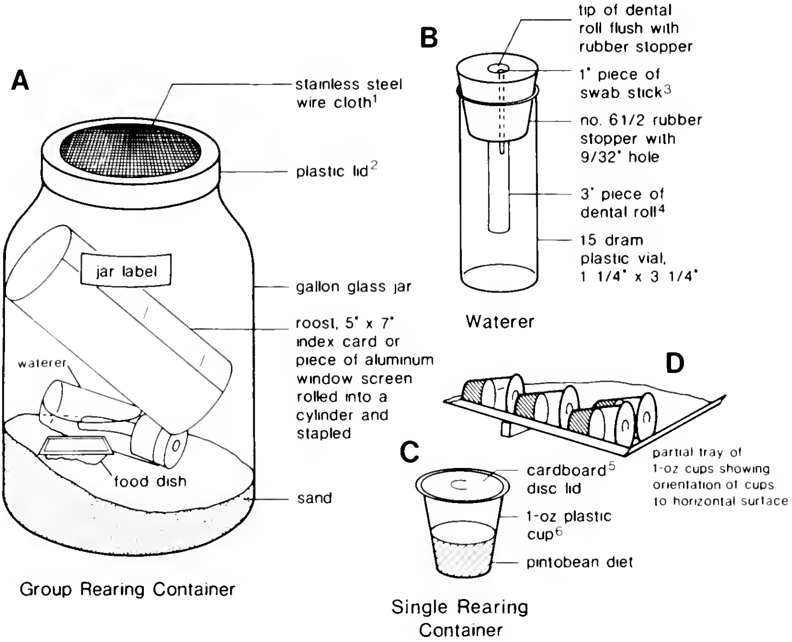

Fig. 1. A. Group rearing container. B. Waterer. C. Single rearing container. D. Holding tray. (1" = 2.54 cm) Notes (referenced by superscript numbers): (1) Stainless steel wire cloth, 60 mesh/inch, .0075" dia wire, .0092" width of opening, 30.5% open area. McNichols Co., 5501 Gray St., Tampa, FL 33609. [Wire window screen can be substituted, but it will admit ants and small spiders.] (2) 4¾ O.D. plastic lid, Dynalab Corp., P.O. Box 112, Rochester, NY 14692. (3) Piece of swab stick prevents vacuum from forming and causing the exposed tip of dental roll to become dry. (4) No. 2 (⅜" dia), 6-inch dental roll. Johnson and Johnson, New Brunswick, NJ 08903. Hand-rolled cotton or cloth might work. (5) Cardboard disc lid, 1.476"dia, no wax, no staples, pull tab. Standard Cap and Seal Co., P.O. Box 1766, Norton, GA 30091. (6) #410 clear plastic cup. Fill-Rite Inc., 49-55 Liberty St., Newark, NJ 07102.

These experimental results confirm what our previous data had suggested: that today's Purina Dog Chow is a poor diet for rearing *Gryllus rubens* especially in later laboratory generations, and that Purina Cricket Chow is a good diet. Moreover, the F_{11} lab-reared crickets were more sensitive to the effects of long-term storage of Cricket Chow than the F_1 crickets. Freezer-stored Chow apparently maintained its nutritional quality better than refrigerator-stored Chow.

Single Rearing

Rearing large numbers of crickets, one per gallon jar, would be inefficient and require a great deal of space. Therefore a method used to singly rear cabbage loopers (*Trichoplusia ni*) at the Insect Attractants, Behavior, and Basic Biology Research Laboratory, ARS-USDA, Gainesville, Florida (Guy, *et al.* 1985), was tested on *Gryllus rubens.* It worked well and required little space or labor.

Each newly hatched cricket that is to be reared is transferred, using a short-handled plastic teaspoon, to a one-ounce (15 ml) plastic cup (Fig. 1C) one-third to half-full of pintobean diet, a semi-soft solid diet (Guy *et al.* 1985). The cup is then closed with a tightly fitting cardboard lid and placed on its side in a tray. The tray is elevated on one end so that the end of the cup containing the diet is elevated (Fig. 1D). This allows wastes to roll to the other end and keeps the diet fresher. A 23 x 31 cm tray accommodates 28 cups.

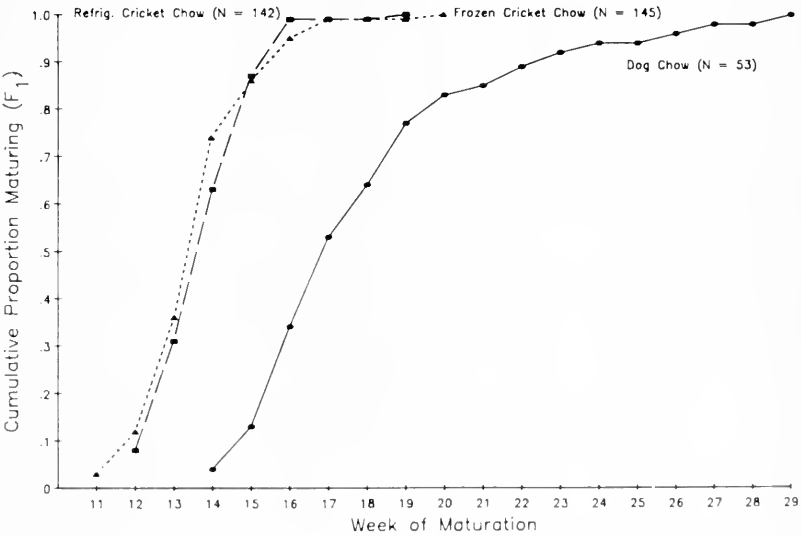

Fig. 2. Cumulative proportion of F_1 *G. rubens* maturing weekly on three diets.

Crickets live in these containers, held at 25±1°C and 70% R.H., for approximately three weeks with very little mortality. During this time, as moisture from the diet gradually escapes through the lid, the diet becomes drier. After three weeks, the diet is either too dry for the crickets to eat and/or the humidity of the container is too low and mortality increases. Therefore, crickets are transferred to new containers every three weeks. Transfers continue until the crickets reach maturity. At 25±1°C, 70% RH, 16L:8D, crickets require 4-6 transfers to reach maturity.

We do not know if this diet will sustain generations of crickets, but our singly reared crickets produced many progeny when allowed to mate and oviposit in one-gallon jars. Singly reared crickets were healthy and similar in size to field collected and first generation group-reared crickets. Of 27 cohorts of crickets (1 cohort = 25-78 hatchlings), representing 2 genetic strains, 2 inter-strain crosses, and 7 time periods, survival was never less than 50% and was ≥ 70%, 75% of the time.

DISCUSSION

Our problems with Dog Chow illustrate dangers in using commercial pet foods for rearing crickets. Unannounced changes in the formulas of pet foods may mean that successive batches of the "same" food may not be nutritionally equivalent. In addition, a formula that works well initially may prove inadequate after a few laboratory generations.

One solution to possible dietary problems in group-reared crickets is to develop a simple, user-controlled, nutritionally adequate diet. Because the pintobean diet met these criteria for singly reared crickets, we tried feeding pieces of fresh diet transferred directly from 1-oz. cups. This failed because very young crickets became trapped in beads of moisture that formed on the diet and died. (This rarely occurred in 1-oz. cups). We then tried drying the diet and grinding the pellets in a food mill. In preliminary tests, dried pintobean diet gave encouraging results, but longer and more extensive tests are needed. A cricket diet prepared and tested by Gardiner (1981) is also a candidate.

The group rearing methods described here are for modest numbers of crickets — the most that can be reared in a gallon jar is about 60. For economically rearing larger numbers, larger containers, such as garbage cans or large aquaria, should be used (see Appendix A).

In preparing this paper we circulated a draft to other researchers who rear crickets and invited them to submit notes and helpful hints on cricket rearing. Their responses were generous and touched on many aspects that we had not considered. Their comments are summarized in Appendix A and include information on rearing species in the following genera: *Acheta, Dianemobius, Gryllodes, Gryllus, Scapsipedus,* and *Teleogryllus.*

When we reviewed the literature, we found no comprehensive account of group or single rearing of field crickets; however, we did find three articles in which noteworthy techniques and diets are described. These articles are summarized in Appendix B and include information on rearing species in these genera: *Acheta, Gryllotalpa, Gryllodes, Gryllus, Mogoplistes, Nemobius, Plebeiogryllus,* and *Teleogryllus.*

Appendix A. Comments from other cricket-rearers.

1. T. Weber and F. Huber, Max-Planck-Institut für Verhaltensphysiologie, Seewiesen, W. Germany, rear eight species of crickets: *Gryllus campestris, G. bimaculatus, G.* sp. (from Argentina), *Acheta domesticus, Teleogryllus commodus, T. oceanicus, Scapsipedus marginatus,* and *Gryllodes supplicans.*

G. campestris is reared in a greenhouse under ambient conditions (natural photoperiod and near natural temperature; relative humidity about 60%) except in winter when the light cycle is artificially prolonged to 12 hours, the temperature is elevated to 24°C and moisture is added to maintain 60% R.H.

Outdoors, *G. campestris* produces one generation per year and overwinters in the penultimate instar. Under the greenhouse conditions, diapause is reduced to two months. However, females maturing under these conditions seem to lay fewer eggs and produce weaker offspring. Furthermore, the hemolymph is more fluid, and the animals do not survive as long under electrophysiological preparations as freshly caught ones. Therefore, nymphs are collected every fall and bred for one generation only.

Young *G. campestris* nymphs are housed in plastic aquaria — 25 x 50 x 30 cm (l x w x h) — with a screen cover. Because older nymphs are aggressive and may be injured by fighting, the last instars are isolated in 800 ml glass jars until maturity. For breeding, 5-6 males and females are placed in an aquarium.

Other species of crickets are kept in climate-controlled rooms, at 24 or 26°C, 12L:12D, and 60% RH. Molting success is better at higher humidity, but mites are worse.

About 30-50 adult crickets are kept in one plastic aquarium. More nymphs, depending on their size, are maintained in one aquarium. The floor of the aquarium is covered with 1 cm of sterlized sand (heated to 100°C for 1 hour). Three to four egg cartons, sterilized in the same way, are added as hiding places. Food is supplied in 8 cm dia shallow dishes. Every two days the back wall of the aquarium is sprayed with water. Molting crickets prefer this area. Additional water is supplied by a bird-cage waterer.

Eggs are laid in dishes filled with 4 parts peat and 1 part sand (sterilized as above), kept slightly moist by spraying with water. Dishes with eggs are covered with a transparent plastic cover and put in an incubator at 30°C until the first nymphs appear. Then they are returned to aquaria provided with special lighting — two parallel "fluorescent" lamps with a 12L:12D cycle (1 Osram daylight lamp L 65 watt/19 de Luxe and 1 Osram L Flora 65 Watt/77 R; the latter, normally used for growing plants, provides some UV light). This light program was instituted because *G. bimaculatus* looked pale after two generations. With this special lighting their pigmentation remains more natural.

When nymphs are in the first and second instars and difficult to collect, the aquaria are cleaned and the contents changed every four weeks. Otherwise, aquaria are cleaned every three weeks to prevent infestations of mites.

All crickets are fed a laboratory prepared diet as reported by Weber *et al.* (1981). Additional ingredients may be added such as dry fish-powder and pupae of flies or ants. Food is replenished every 2-3 days. Lettuce, washed 3 times by soaking in water for 30 minutes, is provided daily; the outer leaves are removed to prevent contamination by pesticides. Excess lettuce is given to provide humid places for the crickets. Pieces of carrots and apples are also provided daily.

2. D.B. Weissman, California Academy of Sciences, San Francisco, California, has raised all species of western U.S. *Gryllus* in small numbers. Females oviposit into 20 mm deep petri dishes filled with sterile sand that is watered every few days and "topped off" as the female digs around. After 1- 2 weeks, the top layer of sand and associated droppings are removed and the dish is covered and kept at room temperature (21-26°C). The humidity is high and the eggs do well. Eggs hatch in 17-21 days and nymphs are then transferred to a 20 mm deep covered petri dish where the humidity can be kept high for the first few molts. They are fed rolled oats, Purina Cat Chow®, and pesticide-free Romaine lettuce (a source of protein as well as water). Damp filter paper provides moisture and a molting surface.

3. G. Tschuch, Martin-Luther-Universitat, Domplatz, E. Germany, rears *Gryllus bimaculatus* on dry sand at 28°C, 12L:12D with dishes of moist sand, 30 mm x 60 mm (h x dia) provided for egg-laying. Crickets are fed a diet of equal parts of soya flour, wheaten flour, bruised wheat, rolled oats, and powdered milk. Lettuce (stored in a deep freezer) is provided weekly. Without lettuce, sexual maturity of the imago is delayed. A bird waterer provides additional water.

4. H.W. Honegger. Technische Universität München, Garching, W. Germany, rears *Gryllus campestris.* Adults are aggressive and are housed separately in jars, 10 cm x 8 cm (h x dia), on a layer of dried peat. For breeding, females are transferred into jars with males. After mating, females are put singly overnight in jars two-thirds full of wet sand. Copulation is repeated with different males every second day for 10-14 days. Each female is allowed to lay eggs nightly for 14 days. The egg jars are then transferred to plastic aquaria, 45 x 24 x 26 cm. Nymphs move from an egg jar to the aquarium via a strip of paper. The stirp is bent over the rim of the jar — one end is jammed into the sand of the jar, the other end touches the aquarium floor.

At 26°C and 60-70% RH eggs start to hatch in about 21 days. When the population reaches 100-200 individuals, the egg-jars are removed and placed in a new aquarium. Crickets are fed a mixture of oatmeal, dried fish food (Tetramin) and dried bird food; the latter contains small ground-up insects and ant pupae. They are also fed organically grown lettuce 5 times per week, the only source of water provided. Old leaves are not removed unless they rot or become moldy. About 2-3 weeks after the first eggs hatch, a layer of dried peat is put into the aquarium.

Crickets take five months to develop from egg to adult at 26°C. As the juveniles grow, they are transferred into larger containers with smooth walls to prevent escape. A second generation can be reared over the winter, although it is difficult to get the adults to breed then.

Honegger notes the following pecularities of rearing *G. campestris.* The penultimate instar becomes quiescent for about a month, showing no signs of further development although fed. At least 20 pairs of crickets have to be mixed to prevent inbreeding. If only a few adults are used there are F_1 infertile individuals. Full siblings do not produce offspring even though mating seems to be successful (attachment of a spermatophore at the female's genital opening). Even under good rearing conditions, females reared in the lab differ slightly from those in the field; they have, for example, narrower heads.

5. S. Masaki, Hirosaki University, Hirosaki, Japan, notes that rearing nemobiine crickets economizes on space. About 70 can be reared in a 2 liter jar. A vial filled with water and plugged with cotton provides water as well as an oviposition site. Crickets are fed "Insect Feed," which consists of pellets of a mixture of powdered dry fish and corn meal. His laboratory has maintained a culture of *Dianemobius fascipes* from the Island of Ishigaki for more than 14 years.

6. R. Hoy and D.D. Yager, Cornell University, New York, rear *Teleogryllus oceanicus, T. commodus, Scapsipedus marginatus* and four species of *Gryllus.* A high priority is producing 50-100 virgin females of *T. oceanicus* every 2-3 weeks. Crickets are reared in 33 gal garbage cans at 27-29°C, 50-60% RH and 14L:10D. No "ground-like" substrate is used. Shelter and roosting places are provided by filling cans at least half-full with loosely crumpled paper towels (sometimes less depending on size of crickets). When eggs are needed, a deep dish filled with

moist peat moss or dark potting soil is introduced. The size of the next generation is controlled by limiting access to the egg dish or by limiting the number of hatching days.

Fine netting over the ventilation holes in the garbage can lids controls larger vermin. Occasional blooms of mites (*Tyrophagus* spp.) and booklice are controlled by extra cleaning and alcohol swabbing of the cans.

Crickets are fed Purina Cat Chow®. Water is provided by a vial filled with water and plugged with cotton. There has been some difficulty in rearing *G. rubens.* Two stocks died out gradually. They did well for 8-15 generations, then their fertility declined.

T. oceanicus is sometimes reared individually in petri dishes with no special food, substrate or water. Eggs require 18-20 days to hatch, nymphs require 7-10 weeks to reach maturity, and adults live for about 8 weeks.

7. V.R. Vickery, Macdonald College, McGill University, Ste. Anne de Bellevue, Quebec, uses aquaria for rearing large numbers of crickets. Mated females are kept in jars provided with sand-filled petri dishes. For species that require winter diapause, these space-efficient dishes are stored at +4°C for six or more weeks, and at times, up to 10 months before allowing hatching at room temperature.

8. K.H. Hoffmann, Universitat Ulm, Ulm, Federal Republic of Germany, has maintained a stock of *Gryllus bimaculatus* for two years. Crickets are kept according to stage in large plastic-tanks. IR-breeding lamps provide constant light. Temperature is maintained at 32°C. No mold occurs. Animals are fed minced Altromin 2023 standard diet (for rabbits and rats) and water. Egg-dividers provide hideouts for the crickets.

Temperature and % of protein in the diet affect the growth of *G. bimaculatus* (Merkel 1977). Nymphs allowed to bask in "sunshine" at self-determined intervals have reduced development times (Behrens *et al.* 1983 and Remmert 1985).

Appendix B. Notes from pertinent articles.

1. Clifford, C.W., R.M. Roe, and J.P. Woodring. 1977. Rearing methods for obtaining house crickets, *Acheta domesticus,* of known age, sex, and instar. Ann. Entomol. Soc. Am. 70:69-74.

Clifford *et al.* present in detail a method of group rearing *Acheta domesticus* of known ages. They report 82% total survival from hatchling to adult with 100% survival after the second instar. Moreover their procedures seem time-efficient.

Of particular note is their use of 1-gallon compressed cardboard containers with screen-top lids for rearing 10-12 last instar crickets. The rim is fitted with a 2-3 cm piece of heavy aluminum foil to prevent crickets from crawling out. The lid center is replaced with window screening for ventilation. The cardboard surface provides floor (192 cm^2) and wall space (574 cm^2) for crickets to rest on eliminating the need for a perch. A petri dish with masking tape on the outside wall for easy climbing is used to hold the food. Water is supplied by a plastic vial with two holes cut along the rim, filled and inverted into a petri dish, similarly rimmed with masking tape. This setup will sustain crickets for at least eight days. They report cardboard containers can withstand frequent washings and will last several months.

2. Mathad, S.B., and K. Dakshayani. 1972. Laboratory rearing of the cricket *Plebeiogryllus guttiventris.* Ann. Entomol. Soc. Am. 65:282-283.

Mathad and Dakshayani are the first to report rearing this species in the lab. They experimented with various diets and temperatures and reported that guinea pig diet and 35°C gave high survival and short duration of the nymphal stage.

3. Gardiner, B.O.C. 1981. Rearing crickets. Bull. Amat. Entomol. Soc. 40:132-143.

Gardiner presents a table of 5 diet formulations used by researchers for crickets and rearing notes on these species: *Acheta configuratus, Gryllotalpa gryllotalpa, Gryllodes sigillatus, Gryllus campestris, G. bimaculatus, Mogoplistes squamiger, Nemobius sylvestris, Plebeiogryllus guttiventris,* and *Teleogryllus* sp.

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NEW RECORD OF THE ALDERFLY *SIALIS VAGANS* FOR WEST VIRGINIA (MEGALOPTERA: SIALIDAE)[1]

Donald C. Tarter[2]

ABSTRACT: *Sialis vagans* is reported for the first time from West Virginia. Additionally, state distribution records of the genus *Sialis* are reviewed from the literature.

Sialis vagans Ross is reported for the first time from West Virginia. On 2 June 1987, three males and two females were captured on shoreline vegetation around a 6.3-acre lake at the Handley Public Hunting and Fishing Area 13 miles northwest of Marlington in Pocahontas County off State Secondary Route 17.

The genus *Sialis* Latreille contains 23 Nearctic species (Ross, 1937; Townsend, 1939; Flint, 1964). Ross (1937) described the holotype male of *S. vagans* from Eel River near Columbia City, Indiana. *Sialis vagans* has been recorded from New Brunswick, Nova Scotia, Ontario, Quebec and 20 states (AR, CT, GA, IL, IN, KS, ME, MA, MI, MN, MS, NH, NJ, NY, NC, OH, PA, VT, VA, WI) (Ross, 1937; Flint, 1964; Stark and Lago, 1980; Tennessen, 1968; Liechti and Huggins, 1977; and Tarter *et al.* 1978). In the United States, east of the Rocky Mountains, adult alderflies emerged between March 4 (AR) and July 19 (NY) (Tarter *et al.,* 1978).

Prior to this new state record, six species of alderflies have been recorded for West Virginia: (1) *S. velata* Ross (Jefferson County) (Ross, 1937), (2) *S. joppa* Ross (Pendleton County) (Tarter and Woodrum, 1937a), (3) *S. aegualis* Banks (Wayne County) (Tarter and Woodrum, 1973b), (4) *S. itasca* Ross (Wayne County) (Tarter *et al.,* 1976), (5) *S. concava* Banks (Pocahontas County) (Tarter *et al.,* 1977), and (6) *S. iola* Ross (Greenbrier County) (Canterbury, 1978).

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[2] Department of Biological Sciences, Marshall University, Huntington, WV 25701.

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HETEROPTERA OVERWINTERING IN MAGNOLIA LEAF LITTER IN PENNSYLVANIA[1]

A.G. Wheeler, Jr., James F. Stimmel[2]

ABSTRACT: Magnolia leaf litter, particularly that of the large-leaved cucumber tree. *Magnolia macrophylla,* offers protection for numerous overwintering arthropods, including adult Heteroptera. In a period spanning the winters of 1984-87, we examined 6 samples of 300-400 longitudinally folded leaves at a nursery in southcentral Pennsylvania. Twenty-five heteropteran species, representing 9 families and 190 individuals (including 13 dead specimens), were collected. Families yielding the largest number of species were the Lygaeidae (7) and Pentatomidae (6); species represented by the largest number of specimens were the tarnished plant bug, *Lygus lineolaris* (Palisot) (43 live individuals), and the nabid *Nabis roseipennis* Reuter (41). All species and number of individuals observed are given in a table, and species previously recorded to overwinter in leaf litter are noted.

Overwintering stages of many common North American Heteroptera have been determined. For species hibernating in the adult stage, individuals may merely be reported to choose "protected places." But records of more specific sites—in grass clumps, beneath bark, under logs or rocks, or in fallen leaves—are numerous in the literature, though sometimes based on single observations. Such information has accumulated from general studies on arthropod hibernation (e.g. Holmquist, 1926; Dowdy, 1955); winter collecting of Heteroptera in particular regions, e.g. western Indiana (Blatchley, 1895), Los Angeles, California (Blatchley, 1934), and northern Arkansas (Isaza-Restrepo, 1958); observations of microhabitats, e.g., mullein rosettes (McAtee, 1924), dry trees (Dennys, 1927), and Spanish moss (Rainwater, 1941); and studies on particular species, e.g., the tarnished plant bug, *Lygus lineolaris* (Palisot) (Painter, 1929). In addition, Jones and Sullivan (1981) reported on habitat preferences, spring emergence, and winter mortality of 47 species of Heteroptera in South Carolina, and Schowalter (1986) studied overwintering site selection and aggregation in the western boxelder bug, *Boisea rubrolineata* (Barber).

Holmquist (1926) remarked that fallen leaves offer excellent protection for arthropod hibernation. A Pennsylvania nursery in which several large-leaved magnolias are grown provided an opportunity to study the heteropteran fauna using fallen, often longitudinally folded leaves as overwintering sites. Here we record species taken on 6 sample dates during 3 winters and give notes on their abundance and behavior.

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[2] Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, PA 17110.

METHODS AND STUDY SITE

Collections were made in a nursery at Manchester (York Co.) in south-central Pennsylvania on 20 Dec. 1984, 7 and 27 Mar. 1985, 5 Mar. and 19 Nov. 1986, and 12 Mar. 1987. On each sample date we examined 300-400 fallen magnolia leaves, mostly those of a large-leaved cucumber tree, *Magnolia macrophylla* Michx., a species endemic from Kentucky to Florida and west to Arkansas and Louisiana. This tall shrub or broad-headed tree has the largest leaves (Fig. 1) of any native tree hardy in North America: 9 dm or nearly 1 m (3 ft) long (Britton, 1908; Everett, 1981). A few fallen leaves were also examined from a row of magnolias that included umbrella tree, *M. tripetala* L. (Fig. 2), in addition to *M. macrophylla*. The largest leaves of umbrella tree are about 7 dm (2 ft) long (Britton, 1908).

Sampling consisted of opening dead leaves folded in half along the midrib (Fig. 1) or having at least a portion overlapping. Repeat sampling of the same leaves was minimized by working in slightly different areas beneath the large *M. macrophylla* used for the majority of the survey. Heteroptera that could be identified with certainty in the field were recorded and released; others were collected and determined in the laboratory.

Figs. 1-2. Magnolia leaf litter in Pennsylvania. 1. Open and folded dead leaves of *Magnolia macrophylla;* 2. fallen leaves of *M. tripetala.*

Numbers of each species (alive or dead) were recorded, except on the first collection date when the number of individuals was only approximated. Voucher specimens have been deposited in the insect collection of the Pennsylvania Department of Agriculture.

RESULTS AND DISCUSSION

Twenty-five species in nine heteropteran families were found overwintering in magnolia leaf litter (Table 1). The majority of the approximately 190 individuals observed (13 were dead) were present in longitudinally folded leaves rather than between layers of leaves.

All species in our samples were adults except for the reduviid *Zelus* sp., which was collected as fifth-instar nymphs. All individuals were observed in recently fallen (previous summer's) leaves except for *Acrosternum hilare* (Say); 2 adults of this pentatomid were taken in a folded, partially decomposed leaf of a previous season. The only other species not collected singly in folded leaves were *Lygus lineolaris* (occasionally 2/leaf were observed) and the lygaeid *Drymus unus* (Say), which once was found coupled end to end in a copulatory position. Sweet (1964) determined in the laboratory that this cold-adapted lygaeid may oviposit at temperatures as low as 5°C. Species collected singly in folded leaves often were observed with individuals of other arthropod groups (particularly spiders and beetles).

Families represented by the largest number of species were the Lygaeidae (7) and Pentatomidae (6), though only 18 individuals of the latter were observed (Table 1). Only one member of the largest heteropteran family, the Miridae, was found. A high percentage of mirids inhabiting temperate regions are univoltine and overwinter as diapausing eggs (e.g., Knight, 1941; Kullenberg, 1944; Cobben, 1968).

Most species collected in the study were represented only by a few specimens. Nine were taken only on one sample date, and only one individual of 8 species was collected. No species was observed on all 6 dates, but *L. lineolaris* and the nabids *Hoplistoscelis sordidus* (Reuter) and *Nabis roseipennis* Reuter were taken on all but one date. Two of these species, *L. lineolaris* (43 live individuals) and *N. roseipennis* (41), yielded the largest number of specimens (Table 1).

Several of the species encountered have been recorded to hibernate in leaf litter. Among them are the berytids *Jalysus spinosus* (Say) (Froeschner, 1942) and *Neides muticus* (Say) (Holmquist, 1926); the lygaeid *Myodocha serripes* Olivier (Blatchley, 1895); *Lygus lineolaris* (Crosby and Leonard, 1914; Holmquist, 1926; Blake, 1927; Painter, 1929); the nabid *Hoplistoscelis sordidus* (Harris, 1928); the pentatomids *Acrosternum hilare*

(Whitmarsh, 1917; Underhill, 1934), *Banasa dimidiata* (Say) (Stoner, 1916), *Euschistus tristigmus* (Say) (Jones and Sullivan, 1981), *E. variolarius* (Palisot) (Holmquist, 1926; Froeschner, 1941), and *Holcostethus limbolarius* (Stal) (Stoner, 1920); and the rhopalid *Arhyssus lateralis* (Say) (Blatchley, 1926). Several other species taken in our study have been collected during winter beneath the woolly leaves of common mullein, *Verbascum thapsus* (L.) (e.g. Blatchley, 1895, 1926; McAtee, 1924; Froeschner, 1944).

In New England, Sweet (1964) found that *Drymus unus* overwinters in the egg stage and suggested that this lygaeid's late oviposition habits and cold hardiness explain records of supposed hibernating adults. He noted that all such records were for late November or December. But the presence in our study of an adult on 20 Dec. 1984, 2 on 5 Mar. 1986, and 1 on 12 Mar. 1987 indicates that some adults overwinter in southcentral Pennsylvania. Two of the 6 individuals we observed were dead (Table 1), possibly suggesting a high winter mortality.

When disturbed, individuals of most species were not completely dormant and moved slowly within folded leaves. On warm days in winter some Heteroptera undoubtedly move within the leaf litter or emerge from hibernation quarters; on 27 March 1985 when the ambient temperature was about 20°C, several tarnished plant bugs were observed in flight. In Illinois, Blake (1927) noted that numbers of this species occurring in the leaf stratum during winter fluctuated widely from week to week. Some individuals of the various Heteroptera observed in magnolia leaf litter may move deeper into the layer of leaves or into the soil with the onset of colder temperatures. Dead individuals of 7 species (including *D. unus* discussed above) were observed, suggesting a winter-induced mortality. For example, 3 of 4 *Arhyssus lateralis* collected on 7 Mar. 1985 were dead; on 12 Mar. 1987 all 3 *Nabis roseipennis* observed were dead, as were 2 of 3 *Acrosternum hilare* (Table 1).

Total number of insects captured on various sample dates varied significantly, undoubtedly the result of many factors. Fluctuating temperatures may have affected the number of insects found while sampling. As the leaf litter warms on mild winter days, some insects are known to come out of their dormant condition and leave their protective sites (Holmquist, 1926), making fewer specimens available for collection. In our study, populations of spiders in the leaf litter were relatively high, and even on the coldest sampling days the spiders were relatively active. Indeed, studies have shown that spiders are affected less by cold than most insects (Dowdy, 1955). Perhaps spider predation plays a role in diminishing overwintering populations of insects. Other predators, such as certain carabids and staphylinids, were found during our study and could also have affected the

Table 1. Numbers of Heteroptera overwintering in magnolia leaf litter; numbers in parentheses indicate dead individuals.

	Collection Dates and No. of Individuals					
Taxa	20-XII-84	7-III-85	27-III-85	5-III-86	19-XI-86	12-III-87
Berytidae						
Jalysus spinosus (Say)	0	0	0	1	2	0
J. wickhami Van Duzee	6	2	1	0	0	0
Neides muticus (Say)	0	1	1	0	0	0
Coreidae						
Leptoglossus fulvicornis (Westwood)	0	0	0	0	1	0
Lygaeidae						
Drymus unus (Say)	1	(1)	0	2	0	1 (1)
Geocoris uliginosus (Say)	1	0	0	1	0	0
Heraeus plebejus Stal	0	(1)	0	1	0	0
Kleidocerys resedae (Panzer)	0	2	0	0	0	0
Myodocha serripes Olivier	3	0	0	1	0	0
Pseudopachybrachius basalis (Dallas)	1	0	0	0	0	0
Scolopostethus thomsoni Reuter	0	0	1	0	0	0
Miridae						
Lygus lineolaris (Palisot)	15	15 (1)	2	10	1	0
Nabidae						
Hoplistoscelis sordidus (Reuter)	8	1	9	4	0	0
Nabis americoferus Carayon	0	0	0	1	1	0
N. roseipennis Reuter	25	9	0	3	4	(3)
Pentatomidae						
Acrosternum hilare (Say)	0	3	1	2	5	1 (2)
Banasa dimidiata (Say)	0	0	1	1	0	0
Euschistus tristigmus (Say)	1	0	0	0	0	0
E. variolarius (Palisot)	0	0	0	0	1	0
Holocostethus limbolarius (Stal)	0	1	0	0	0	0
Thyanta accerra McAtee	1	0	0	0	0	0
Phymatidae						
Phymata pennsylvanica Handlirsch	1	0	0	0	0	0
Reduviidae						
Zelus sp. prob. *luridus* Stal	0	0	1	2	3	4
Rhopalidae						
Arhyssus lateralis (Say)	3	1 (3)	0	1	0	0
Harmostes reflexulus (Say)	0	1 (1)	0	0	2	0

number of insects overwintering. Patch (1907) observed that in overwintering haunts *Lygus lineolaris* fell prey to ground beetles and rove beetles. Finally, many of the insects that we observed may simply have succumbed to the cold; for *L. lineolaris,* Painter (1929) observed that only 40-60% survived even in the most favorable hibernation sites.

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The Eagle Hill Wildlife Research Station (EHWRS), located on the edge of the ocean, 35 miles east of Bar Harbor, Maine, is offering a special field course on insects June 26-July 2. Course is on a research participation basis. For information, write or call EHWRS, Dyer Bay Rd., Steuben, ME 04680, (207-546-2821).

SYSTEMATIC NOTES AND GENERIC PLACEMENT OF *UTACAPNIA NEDIA* (PLECOPTERA: CAPNIIDAE)[1]

C. Riley Nelson, Richard W. Baumann[2].

ABSTRACT: The collection of additional specimens of *Utacapnia nedia* is reported. The female is described for the first time and additional morphological information based on fresh adult material is presented for the male along with illustrations of both sexes. The species is transferred to the genus *Utacapnia* and justification is given along with notes regarding tentative phylogenetic relationships of the species to others in the genus. A discrepancy in the original type locality is noted and additional distributional data presented.

Nebeker and Gaufin (1966) described *Capnia nedia* based on a single, teneral male removed from its nymphal exuvium. Excellent figures of the specimen were produced from which an accurate species identification could be made. Despite good illustrations and examination of the holotype, questions still existed regarding the validity and identity of this species. The epiproct of capniids curves over the dorsum of the terminal abdominal segments with the apex directed anteriorly. In mature male capniid nymphs the epiproct is visible through the nymphal skin with the apex projecting posteriorly. Since the only specimen of *C. nedia* had been removed from its nymphal exuvium and had a short, triangular epiproct bearing two openings, an interpretation of the adult orientation of the epiproct was confusing. Additionally, the tip of the epiproct appeared to be missing and the configuration of the epiproct and dorsum of the abdomen were not congruent with any of the morphologically defined species groups of North American *Capnia.* Fortuitously, specimens of this species were collected despite misleading type locality information. Adult epiproctal orientation was examined and found to be most similar to that of the genus *Utacapnia.* Specimens reported in this paper are deposited in the insect collection at Brigham Young University and the Smithsonian Institution.

Utacapnia nedia (Nebeker and Gaufin) new status.

Capnia nedia Nebeker and Gaufin 1966: 36. Nebeker and Gaufin, 1967: 418. Nebeker and Gaufin, 1968: 3. Baumann, Gaufin, and Surdick, 1977: 73.

Male holotype: IDAHO. Boise Co., Boise, Sand Creek, 8 April 1961, Max Ollieu, (USNM). A discrepancy in this reported type locality exists. Boise, Idaho is in Ada County, not Boise County. Examination of several maps including Boise and Ada counties failed to

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[1] Received May 26, 1987. Accepted September 14, 1987.

[2] Department of Zoology, Brigham Young University, Provo, UT 84602.

find any creeks named Sand Creek. Several Boise residents were questioned as to knowledge of any Sand Creek in that area and all responses were negative. However, searching creeks in these counties resulted in the collection of this species from several locations.

Description of female: body length 7.2 - 8.0 mm; macropterous, length of forewing 7.4 - 8.2 mm; body color black with light intersegmental membranes; subgenital plate darkened, heavily sclerotized, posterior margin modified into an angular projection overhanging posterior margin of sternum eight; anterior margin of sternum eight with medial membranous area, posterior margin of sternum eight formed as narrow band of sclerotization (Fig. 5).

Redescription of male: body length 5.6 - 7.2 mm; micropterous, length of forewing 0.4 - 1.0 mm; abdominal terga lacking knobs or projections (Figs. 1-2); epiproct length 0.4 - 0.6 mm, with openings at tip of epiproct and at apex of anterior declivity (Fig. 3) (for definition see Nelson and Baumann, 1987b); anterior declivity bearing pair of short projections near apex.

Diagnosis. The male of *U. nedia* may be readily separated from the genus *Capnia* by having two openings in the epiproct, one at the apex of the lower limb and one at the base of the anterior declivity. *Capnia* males have a single opening either at the apex of the epiproct or represented by a slit on the upper surface of the epiproct. The female can be separated from those of *Capnia* and *Capnura* by the presence of a heavy, darkly sclerotized subgenital plate, with the apex of the hind margin overhanging the posterior margin of sternum eight. The males of *Utacapnia* (including *U. nedia*) are separated from *Capnura* (Nelson and Baumann, 1987a) by the lack of dorsal knobs on the abdominal terga. Males of *U. nedia* are distinguished from all other species of *Utacapnia* in having an epiproct consisting of a single limb (homologous to the lower limb of other *Utacapnia* males). The female of *Utacapnia nedia* differs from others in the genus in having the projecting hind margin of the subgenital plate entire, not bifid as in *U. lemoniana* or irregular as in *U. logana.*

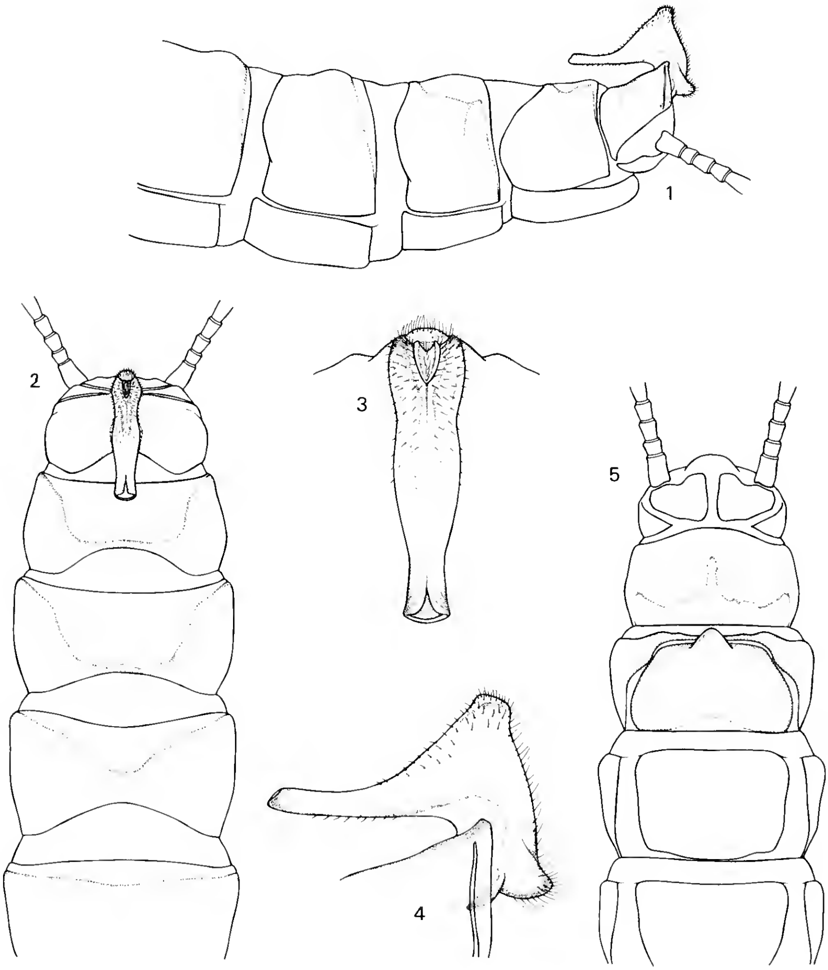
Distribution. IDAHO, Ada Co., Cottonwood Creek, 11 February 1985, A. Allen, 2 males; Cottonwood Creek, Mountain Cove Road, 1 mile inside Boise City limits, 2 March 1985, K. and A. Allen, 3 males; Washington Co., Manns Creek Reservoir, 1/4 mile N of mouth, 3 March 1985, E.M. Coombs, 1 female; Monroe Creek bridge, Highway 95, 4 mi N of Weiser, 3 March 1985, E.M. Coombs, 8 males and 3 females; OREGON, Malheur Co., 1 mile W of Bully Creek Reservoir, 9 March 1985, E.M. Coombs, 1 male. Total number of specimens examined, 18.

Taxonomic notes. This species appears to be a highly derived form of the genus *Utacapnia.* The members of this genus were reviewed by Nebeker and Gaufin (1965). Males of this species may be separated from the others in the key of Nebeker and Gaufin (1965) by inserting the following modified section in the place of couplet 5 on page 482:

5a. Upper supra-anal process (upper limb of epiproct) absent (Figs. 3 - 4, this paper) .... *nedia* Nebeker and Gaufin

— Upper supra-anal process (upper limb of epiproct) present. 5b

5b. Upper supra-anal process slender with fan-shaped enlargement at tip; lower process nearly twice as long as upper. 6
— Upper supra-anal process massive and deeply forked, forming two definite prongs; lower process one third longer than upper . . . . *lemoniana* (Nebeker and Gaufin)



Figures 1-5: *Utacapnia nedia* (Nebeker and Gaufin); 1. male terminalia, lateral view; 2. male terminalia, dorsal view; 3. epiproct, dorsal view; 4. epiproct, lateral view; 5. female terminalia, ventral view.

Females may be identified using this modified key section replacing couplet 3 on page 483 in Nebeker and Gaufin (1965):

3a. Posteror margin of subgenital plate irregular, usually bearing four points or lobes .... *logana* (Nebeker and Gaufin)
— Posterior margin of subgenital plate regular, bearing one or two medial lobes 3b
3b. Posterior margin of subgenital plate bearing single medial, darkly colored lobe (Fig. 5) .... *nedia* (Nebeker and Gaufin)
— Posterior margin of subgenital plate divided into two lobes, coloration of lobes variable...4

Utacapnia has been generally defined (Baumann, Gaufin and Surdick, 1977; Nebeker and Gaufin, 1965; Harper and Stewart, 1984) as capniids with males having an epiproct composed of two widely separated limbs paralleling each other with the upper limb more or less forked. Females in the genus have the subgenital plate with a striking color pattern and the posterior margin notched apically. The inclusion of *nedia* in the genus necessitates a change of these concepts. We view *Utacapnia* as capniids, the males of which have an epiproct with a broad base which bears a lower limb with a terminal membranous opening and often has the upper limb divided at the apex. Females have the medial portion of the subgenital plate heavily sclerotized and darkened with the posterior margin of the plate produced rearward over the hind margin of sternum eight. Couplet 50 in Harper and Stewart (1984) may be changed to read:

50. Epiproct of male usually divided into 2 slender processes often with upper process forked at tip (Fig. 13.159 of Harper and Stewart, 1984), or if epiproct composed of a single process (*nedia*) then apex of anterior declivity with short flanges and opening distinctly separated from that of epiproct tip; color of intersegmental membranes contrasting greatly with ground color of abdominal sclerites in fresh specimens; female sternum 8 with striking color pattern, its hind margin bearing 1-4 lobes .... *Utacapnia*
— Epiproct of male usually simple, no flanges or separate opening on anterior declivity (Fig. 13.160 of Harper and Stewart, 1984); if not simple, processes are short, or tip of upper process not forked; female sternum 8 not as above 51

Fresh specimens of the genus, both males and females, are dark black with intersegmental areas contrastingly light. Coloration varies from brown to black in *Capnia* and *Mesocapnia; Capnura* adults are generally dark brown to black. The males of *Utacapnia nedia* have an epiproct composed of a single limb which is homologous to the lower limb of other *Utacapnia.* This limb terminates in a membranous opening in both *nedia* and other members of the genus. The upper limb of nedia is reduced to an indistinct opening and two extremely short lateral flanges where the base of the upper limb joins the base of the epiproct. The forked feature of the upper limb is entirely absent in this species unless the short lateral flanges are homologous to the fork. No opening is apparent in the upper limb of *Utacapnia logana* or *U. lemoniana.* The basal structure of the epiproct in *nedia* is heavy and broad as in *Utacapnia,* not slender as in *Capnia.* In brief, the morphology of the epiproct of *U. nedia* can be summarized as that of other *Utacapnia* with a shorter lower limb and a reduced upper limb.

Phylogeny and Zoogeography. It is beyond the scope of this paper to produce an overall phylogeny summarizing relationships of species in the genus *Utacapnia.* A few comments regarding the possible affinities of the anomalous *U. nedia,* however, are in order. This species bears shortened wings in the males which is considered apomorphic when compared with *Capnura* as an outgroup. This apomorphic state is also supported by comparisons to *Capnia* and *Mesocapnia.* The absence of the upper limb in *nedia* is interpreted as being an apomorphic reduction from the long, forked state that exists in the remaining members of the genus. The pointed unforked apex of the subgenital plate in the female is similar to that seen in some females of *U. logana* although the apex is more irregularly produced in the latter. The regular, unforked apex of the subgenital plate of *U. nedia* appears to be autapomorphic.

ACKNOWLEDGMENTS

The authors thank A. Allen, C.W. Baker, W.H. Clark, and E.M. Coombs for collecting winter stoneflies near Boise, Idaho; J.A. Stanger for the illustrations; and the Department of Zoology, Brigham Young University for financial support.

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A NEW SPECIES OF *CAPNIA* (PLECOPTERA: CAPNIIDAE) FROM THE ROCKY MOUNTAINS OF COLORADO[1]

C. Riley Nelson[2], Boris C. Kondratieff[3]

ABSTRACT: *Capnia arapahoe* is described from specimens collected from the Front Range of the Rocky Mountains in Colorado. Figures are included for important taxonomic features. Phylogenetic relationships of this species to others in the genus are discussed. Ecological notes and other associated Plecoptera are also given.

The genus *Capnia* in the Nearctic region consists of about 50 species in western and boreal North America. The senior author's studies on the North American fauna have indicated many undescribed species, including 15 new species from California (Nelson and Baumann, 1987). During an investigation of the winter stoneflies of Colorado, another undescribed species was discovered.

Capnia arapahoe, new species

Figs. 1-4.

Description. Male, body length 4.9mm; macropterous, length of forewing 5.0mm, length of hindwing 4.2mm; abdominal terga one through six unmodified, tergum seven with medial tuberculate knob, tergum eight divided medially by membranous area one-third width of segment, tergum nine with medial patch of membrane. Epiproct fusiform (Figs. 2-3), 0.64mm long and 0.10mm at greatest width, tip of epiproct with pair of short horns separated distally from main tube; epiproct recurved slightly (Figs. 1, 4), without distinct declivities; tip of epiproct slightly upturned, epiproct in relaxed specimen nearly reaching posterior margin of tergum eight; medial groove extending from apex approximately one-half length of epiproct.

Material. Male holotype, Colorado, Larimer Co., Elkhorn Creek at junction of Highway 14, 22 miles west of Fort Collins, 2012 m (6600'), 3 April 1987, B.C. Kondratieff and P. Zwick; deposited in United States National Museum. Male paratype, Colorado, Larimer Co., Young Gulch, above Ansel Watrous Campground, 1768 m (5800'), 22 March 1986, B.C. Kondratieff, deposited in the Brigham Young University Insect Collection at the M.L. Bean Museum.

The paratype is proportionately larger than the holotype, body length 5.6mm, forewing length 5.4mm, hindwing length (deformed) 4.2mm, epiproct length 0.70mm, and epiproct width 0.12mm, but agrees with the holotype in other details.

The female and immature stages are unknown.

Etymology. This species is named in honor of the Arapahoe Indians. The Cache la Poudre Valley at the eastern end of the Rocky Mountains was a favorite haunt of these natives of Colorado. The name is used as a noun in apposition.

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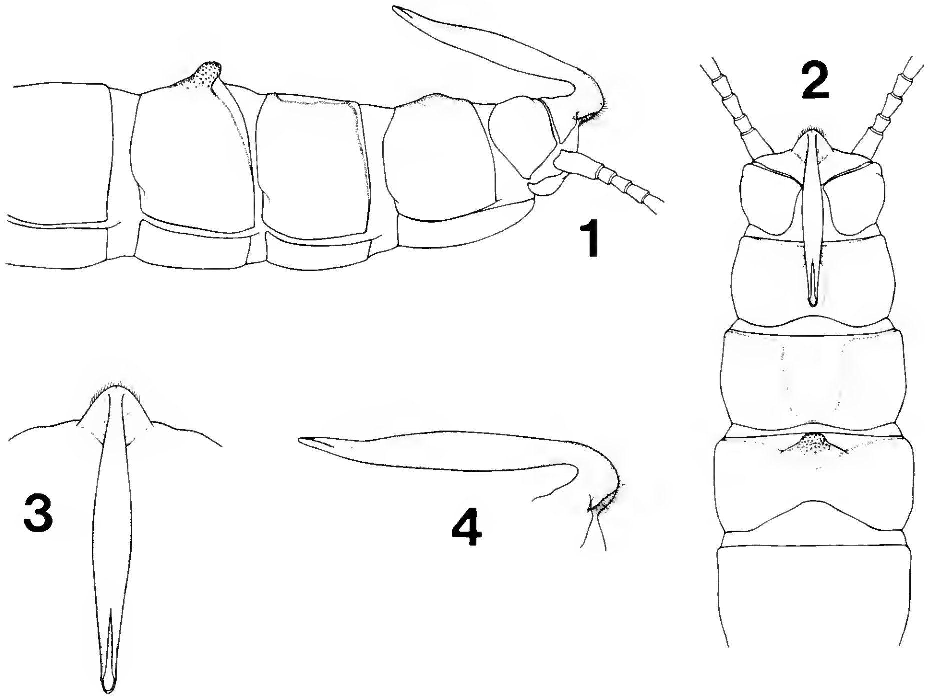
[1] Received October 10, 1987. Accepted November 12, 1987.

[2] M.L. Bean Museum, Brigham Young University, Provo, UT 84602.

[3] Department of Entomology, Colorado State University, Fort Collins, CO 80523.



Figures 1-4. *Capnia arapahoe* new species. 1, male terminalia, lateral view. 2, male terminalia, dorsal view. 3, epiproct, dorsal view. 4, epiproct, lateral view.

Diagnosis. *Capnia arapahoe* is placed in the Decepta group (Nelson and Baumann, 1987) based on the presence of a well-differentiated tergal knob on abdominal segment seven and on the presence of horns on the tip of the epiproct. It differs from other members of the group in lacking a mesal bulbous expansion of the epiproct, and in the slim profile of the epiproct in both dorsal and lateral aspects. Members of the Decepta group include: *C. coyote* Nelson and Baumann, *C. decepta* (Banks), *C. pileata* Jewett, *C. sequoia* Nelson and Baumann, *C. teresa* Claassen, *C. tumida* Claassen, and *C. utahensis* Gaufin and Jewett. This species may be confused with *C. confusa* Claassen based on the general shape of the epiproct, but can be distinguished from *C. confusa* by the presence of a tuberculate knob on tergum seven and an epiproct which recurves slightly and bears horns.

Remarks. Both streams where this species has been collected are small tributaries of the Cache la Poudre River and are typical of the Front Range of the Rocky Mountains of Colorado. The upper reaches are typified by steep slopes and canyons with ponderosa pine dominating the sparse riparian vegetation, whereas the lower reaches near the confluence with the river are more open in topography with cottonwood, willow, and box elder trees occurring along the stream margins. The substrate consists of pebble, cobble, and areas of bedrock. In summer and fall, sections of both streams become intermittent.

Other species of winter stoneflies collected in association with *C. arapahoe* include *C. confusa* Claassen, *C. decepta* (Banks), *C. gracilaria* Claassen, *Capnura wanica* (Frison), *Zapada cinctipes* (Banks), and *Prostoia besametsa* (Ricker).

Numerous visits to the Young Gulch locality have failed to yield any additional specimens. The discovery of the female may provide additional insight into the phylogeny of the Decepta group.

Phylogenetic and zoogeographic relationships. The relationships among the species in the Decepta group were analyzed using the IBM PC version of the PAUP program (Swofford, 1985) with the Barberi group serving as the outgroup. The resulting tree placed *C. arapahoe* as the sister group to the remaining species in the group. The nearest relatives of *C. arapahoe* were *C. utahensis* and *C. sequoia.* This is interesting because the present ranges of these species are about 400 miles (640 km) from the localities where *C. arapahoe* has been collected while *C. decepta,* a more distantly related species, occurs in the same streams at the same time.

ACKNOWLEDGMENTS

We thank Jean A. Stanger for the illustrations and Richard W. Baumann for providing helpful suggestions and support. Additional thanks are due the M.L. Bean Museum for financial support during the course of this study, and Wendy Meyer for suggesting such an appropriate specific name. The comments of two anonymous reviewers were appreciated.

LITERATURE CITED

Nelson, C.R. and R. W. Baumann. 1987. New winter stoneflies of the genus *Capnia* (Plecoptera: Capniidae) with notes and an annotated checklist of the Capniidae of California. Entomography 5: 485-521.

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FACULTY POSITIONS AVAILABLE

The Rocky Mt. Biological Laboratory (RMBL), Gothic, Colorado, is now accepting applications for faculty positions for future summer courses of eight weeks duration in field biology. Room, board, travel reimbursement, and a stipend are provided. Contact the director, RMBL, Box 519, Crested Butte, CO 81224.

FIRST RECORD OF PARASITES REARED FROM *SPARGANOTHIS SULFUREANA* (LEPIDOPTERA: TORTRICIDAE)[1]

Joseph J. Julian[2]

ABSTRACT: Five dipterous and hymenopterous parasites were reared for the first time from field collected larvae, pupae, or eggs of *Sparganothis sulfureana.*

The larvae of *Sparganothis sulfureana* (Clemens) has been recorded feeding on a wide variety of plants. Martin (1948) and Prentice (1965) report that the insect may be associated with various coniferous and deciduous trees. In addition, celery, corn, strawberry, tall buttercup, great burdock, blue and white vervain, horseweed, alfalfa, blueberry, sweet fern, loosestrife, cranberry and apple are listed as host plants. (Hardenburg 1903, Beckwith 1938, Tomlinson 1947, 1961, Marucci 1953, Chapman and Lienk 1971). The insect is considered economically important on apple. (Chapman and Lienk 1971). The range of *S. sulfureana* includes southern Canada and most of the United States east of the 100th Meridian. (Forbes 1923, Chapman and Lienk 1971).

MATERIALS AND METHODS

During the summers of 1982 and 1983, eggs, larvae and pupae of *S. sulfureana* were hand-picked or collected with an aspirator from leafy spurge plants (*Euphorbia esula* L.) at Lisbon, North Dakota, taken to the laboratory and transferred to rearing cages. Leafy spurge was used as the host plant for the caged insects. One 150 cm x 60 cm x 60 cm cage of acrylic, clear plexiglas, type GM, was divided into three individual compartments. Each compartment was 50 cm x 60 cm x 60 cm and completely enclosed. A 20 cm square hole was cut into each individual compartment for access and a 22.5 cm ventilation fan was placed at the end of the cage for air flow. Nylon screening was used to allow the air to flow through each of the three compartments.

Temperature in the laboratory was maintained at 21°C, the relative humidity was approximately 30%, and the length of photo-period was eight hours. Plastic specimen containers 5 cm wide and 3.5 cm high were also used to study the life stages of *S. sulfureana.* Thirty-five egg masses

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[1] Received July 27, 1987. Accepted September 4, 1987.

[2] Entomologist, Colorado State University, Cooperative Extension, Douglas County Extension Office, 355 South Wilcox, Suite 111, Castle Rock, Colorado 80104.

collected from leaves of leafy spurge plants in the field were placed in rearing containers. In addition, 116 larvae were transferred into rearing containers. Pre-pupae were isolated and one each was placed in 25 specimen containers to check for emerging parasites.

Parasitic insects that emerged from laboratory samples were sent to the United States Department of Agriculture, Beneficial Insect Laboratory in Beltsville, Maryland, or to specialists at other institutions, for confirmation of identifications. *Sparganothis sulfureana* larvae were reared to adults and sent to J.A. Powell, Department of Entomology, University of California (Berkeley) for identification.

RESULTS

Eight parasites of the orders Diptera and Hymenoptera, were reared from field collected *S. sulfureana* larvae, pupae or eggs. These, as well as parasitic species reported in the literature, are discussed below, and listed in Table 1.

Diptera

Two tachinid species, *Erynnia tortricis* (Coquillett) and *Lixophaga sp.* were recorded as larval parasites of *S. sulfureana. Erynnia tortricis* has been recorded as an internal parasite of several lepidopterous larvae, including members of the genus *Sparganothis.* (Arnaud 1978; Stone *et al.* 1965; Cole 1969). Species of *Lixophaga* are mainly parasites of Lepidoptera but have also been reared from coleopteran and hymenopteran hosts (Arnaud 1978).

Hymenoptera

Elachertus coxalis (Howard), a eulophid wasp, has previously been recorded as a parasite of various pyralid and tortricid moths, but never from *S. sulfureana* (Krombein *et al.* 1979). Three ichneumonid wasps, *Itoplectis conquisitor* (Say), *Glypta* sp., and *Chorinaeus funebris carinatus* (Cresson), were reared from *S. sulfureana.* The species *I. conquisitor* is a general parasite of lepidopteran pupae and is found throughout the U.S. (Fattig 1950; Heinrich 1977; Townes 1959; Krombein *et al.* 1979). This is the first record of *I. conquisitor* attacking *S. sulfureana.* Members of the genus *Glypta* are parasites of lepidopteran larvae such as *S. sulfureana,* which feed in places of concealment. The species of *C.f. carinatus* is known to parasitize many lepidopteran larvae mainly in the eastern and north central U.S. (Fattig 1950; Heinrich 1977; Townes 1959; Krombein *et al.* 1979) and *S. sulfureana* represents an additional host. The braconid wasp genus

Cotesia also is reported for the first time from *S. sulfureana. Cotesia* spp. are internal parasites of lepidopteran larvae (Krombein *et al.* 1979; Muesbeck *et al.* 1951).

Table 1. Parasites of *Sparganothis sulfureana.*

	Host stage attacked	Number of parasites reared
DIPTERA - (records of species not observed in this study taken from Stone, 1965).		
Tachinidae		
Erynnia tortricis (Coquillett)*	Larval	8
Lixophaga sp.**	Larval	2
Nemorilla pyste (Walker)		
HYMENOPTERA - (records of species not observed in this study taken from Krombein, 1979).		
Braconidae		
Agathis calcarata (Cresson)		
Bracon gelechiae Ashmead		
Bracon mellitor Say		
*Cotesia sp.***	Larval	1
Macrocentrus ancylivorus Rohwer		
Meterous trachynotus Viereck		
Microgaster epagoges Gahan		
Oncophanes americanus (Weed)		
Ichneumonidae		
Chorinaeus funebris carinatus (Cresson)**	Larval	2
*Glypta sp.**	Larval	1
Itoplectis conquisitor (Say)**	Pupal	3
Scambus (*Scambus*) *tecumseh* Viereck		
Temelucha epagoges (Cushman)		
Temelucha forbesi (Weed)		
Trichogrammatidae		
*Trichograma sp.**	Egg	2 egg masses
Eulophidae		
Elachertus coxalis (Howard)**	Larval	1
Chalcididae		
Spilochalcis flavopieta (Cresson)		
Bethylidae		
Goniozus platynotae Ashmead		

*Parasites reared from *Sparganothis sulfureana* found on leafy spurge
**First record of parasites reared from *Sparganothis sulfureana*

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BELVOSIA BICINCTA (DIPTERA: TACHINIDAE) PARASITIZING LARVAE OF THE WHITE-LINED SPHINX MOTH IN EASTERN NEW MEXICO[1]

N.M. Jorgensen[2]

ABSTRACT: A new host record is given for the tachinid fly, *Belvosia bicincta*, parasitizing larvae of the whitelined sphinx moth (*Hyles lineata*).

Belvosia bicincta Robineau-Desvoidy, a large tachinid, is not abundant in eastern New Mexico but has been collected occasionally from a number of flowers. Arnaud (1978) indicated that Lepidoptera of the families Noctuidae and Sphingidae are hosts of this species, but the only records are from Costa Rica (noctuid) and Jamaica (sphingid). No records are given by him or others of *B. bicincta* parasitizing *Hyles lineata* (F.) (the whitelined sphinx moth). The information in this report, therefore, represents a new record from the United States.

During the third week of May 1981, an unusually large population of whitelined sphinx moth larvae was observed thirty miles northeast of Roswell, New Mexico along U.S. highway 70. Hundreds of larvae were observed on the roadway and feeding on roadside plants. Most were feeding on *Guara villosa* Torr. (Woolly Gaura) which was in flower and abundant along that portion of the highway. The majority of the larvae were either penultimate or ultimate larval instars. Some larvae and adults of the whitelined sphinx have been observed each year, but a population of this magnitude was not observed in the ten years previous to this study or the six years following even though frequent observations were made.

Several larvae were collected to determine levels of parasitism. Quart-sized Mason jars were used as rearing chambers. Each jar was provisioned with about three centimeters of moist sand, fresh leaves of *G. villosa*, and five large larvae of *H. lineata*. Plant food for the larvae was replenished as needed. Pupation and adult emergence, which required 2-4 weeks, occurred in the moist sand. Adult moths and parasitic flies were removed upon emergence.

A total of 115 larvae of the whitelined sphinx moth was collected and placed in rearing jars. Fifty eight (50.4%) of these developed and emerged as adults, while 27 (23.5%) died before pupation with no evidence of parasitism. An additional 30 pupated but did not emerge as adults and from

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[2] Department of Life Sciences, Natural History Museum, Eastern New Mexico University, Portales, N.M. 88130.

these 30 adult flies of *Belvosia bicincta* emerged, yielding a parasitism level of 26%. There was no evidence of multiple parasitism as only one fly emerged from each parasitized pupa.

Adult flies were identified to species by comparison to specimens identified by Dr. D.M. Wood, Central Experimental Farm, Ottawa, Ontario, Canada.

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DRAGONFLIES Miller, P.L., 1987. Cambridge Univ. Press. 84 pp. $24.95.

Number seven in a series of British Naturalists' Handbooks. This small book deals with the natural history and identification of dragonflies and damselflies.

THE BUTTERFLIES OF INDIANA Shull, E.M., 1987. Indiana Univ. Press. 262 pp. $25.00.

A beautiful book with 50 fine plates, in color, showing 535 specimens of all 149 species found in Indiana. The text is in four parts: I. Brief discussions on the biology of butterflies, methods of collection and preservation, classification and identification, and conservation of habitat and endangered species. II and III are species accounts of all butterflies and skippers in Indiana, and IV is a checklist for the state.

In view of the controversies (?) swirling around the recent surfeit of beautiful books on butterflies (Shapiro, A.M., Book Review (of three such volumes) Ent. News 1986(5): 241-244), it is interesting to note that this current author chooses to follow the taxonomy of Miller and Brown (1981) in their Catalog/Checklist of the Butterflies of America North of Mexico.

MOSQUITOES OF NEW YORK Part II. Genera of Culicidae other than *Aedes* occurring in New York. Means, R.G., 1987. The State Education Dep't./The University of the State of New York. 180 pp. $11.00 paper. Order from N.Y. State Museum Publications, Albany, NY 12230.

Keys for the identification of adult females, males, and fourth instar larvae are presented for the genera: *Anopheles, Psorophora, Culex, Culiseta, Coquillettidia, Orthopodomyia, Wyeomyia, Uranotaenia,* and *Toxorhynchites.* Thirty-two species are reviewed, summarized, keyed, and illustrated. Species treatment includes synonymy, descriptions of adults and immature stages, bionomics, distribution, disease relationships, and pertinent literature. Reduction of mosquito populations through cultural, biological, and chemical means is discussed. Two hundred and three figures are included.

NEW DISTRIBUTION RECORD OF THE FORMOSAN SUBTERRANEAN TERMITE, *COPTOTERMES FORMOSANUS* (ISOPTERA: RHINOTERMITIDAE), IN AUBURN, ALABAMA[1]

Ruth C. Sponsler, Kevin S. Jordan, Arthur G. Appel[2]

ABSTRACT: The Formosan subterranean termite, *Coptotermes formosanus*, is reported from Auburn, AL. Termites were found inhabiting old railroad cross-ties that were placed on the ground as flower bed borders. All previous reported occurrences of *C. formosanus* in the continental United States have been very close to ports or major inland waterways. The approximate proportion of workers to soldiers was 6:1. The presence of swarmers indicated the colony was mature.

The Formosan subterranean termite, *Coptotermes formosanus* Shiraki is an important pest in tropical and subtropical areas such as Taiwan, and the Philippines (Oshima, 1919), Guam (Hromada, 1970), and Hawaii (Ehrhorn, 1946; Higa, 1981). In the continental United States, this species has previously been recorded only in the Southeast in areas near ports or near large inland waterways. *C. formosanus* has been discovered in Houston and Galveston, TX; Baton Rouge, Lake Charles and New Orleans, LA; Biloxi and Meridian, MS; Mobile, AL; Hallandale, Orlando and Gulfbreeze, FL; Charleston, SC; and Memphis, TN (Su and Scheffrahn, 1986). Aging railroad ties have been reported to be attacked by *C. formosanus* (Spink, 1967). Herein, we report the presence of alates, nymphs, and workers of *C. formosanus* in a previously undocumented location, Auburn, AL (32°36'N, 85°29'W), which is 26 km from the nearest inland waterway.

Alates of *C. formosanus* were observed swarming near lights on the Auburn University campus at approximately 2100 h CDT on 4 June 1987 (N.R. Holler, pers. comm.). Rain had fallen one day previously. On 20 July 1987 we unearthed railroad ties which had been buried ca. 10 cm deep in soil for about 3 years ca. 75 m away from the swarming site. Worker and soldier *C. formosanus* were observed in the ties and in the soil immediately below them to a depth of approximately 3 cm below the ties.

A laboratory colony of workers and soldiers of *C. formosanus* has been kept in Funchess Hall at Auburn University since July 1986, which is 11 months before observation of alates. Alates, workers and soldiers of *C.*

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[2] Department of Entomology and Alabama Agricultural Experiment Station, Auburn University, AL 36849-5413.

formosanus could not have been produced by this laboratory colony, since it contained no alates or reproductives.

Higa (1981) obtained alate reproductives after 11 years in colonies initiated with paired reproductives, but stated that he thought alate reproductives could appear within 5 or 6 years in field colonies. The existence of alate reproductives, therefore, indicates a mature *C. formosanus* colony, at least 5 or 6 years old (Higa, 1981). Since the ties had been in this location for only three years, the termites probably invaded the ties before they were buried. The ties had been obtained from a lumberyard in Lafayette, AL. The lumberyard, in turn, had probably obtained the ties from a wholesaler in the Montgomery, AL area; the wholesaler had gone out of business. The presence of alates is considered to represent an established infestation of *C. formosanus* (Su and Scheffrahn, 1986). Thus, our observations indicate a successful establishment of *C. formosanus* in Auburn, AL.

Four *C. formosanus* infested ties were taken to the laboratory, sectioned, and were destructively sampled. Sampling was intended to be representative, rather than exhaustive, so, numbers reported indicate observed ratios of termite stages, rather than absolute numbers of termites present in the railroad ties. Of a sample of 3593 termites, 497 (13.83%) were soldiers, 3094 (86.11%) were workers, and 2 (0.06%) were prealates. Soldiers comprised 9.7 to 10.1% of young *C. formosanus* colonies (Higa, 1981).

C. formosanus may have been introduced to the southeastern United States with infested material in ships returning from the Pacific theater at the end of World War II (Jones and LaFage, 1980). Subsequent infestations, such as the one in Auburn, AL, probably originated through human transport of infested wood products. The recent increase in the number of localities where *C. formosanus* is reported probably reflects heightened interest in this species rather than any increase in dispersion (Su and Scheffrahn, 1986). There are no federal quarantines of *C. formosanus,* partly due to lack of effective detection and eradication measures, and so the responsibility for preventing the spread of *C. formosanus* lies with transporters and users of wood products.

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NEW ROBBER FLIES (DIPTERA: ASILIDAE) FROM MAYAGUANA ISLAND, BAHAMAS, AND CUBA[1]

A.G. Scarbrough[2]

ABSTRACT: Two new species of robber flies, *Ommatius setiferous* from Mayaguana Island in the Bahamas and *O. lineolatus* from Cuba, are described. Illustrations of the male terminalia of each species are included. This report increases the number of *Ommatius* species in the Bahamas to four and in Cuba to five.

After completing a revision of West Indian *Ommatius* Wiedemann (Scarbrough 1984a, b, 1985a, b; Curran 1953), a new species from Mayaguana Island in the Bahamas and one from Cuba were sent to me for study. Both species are quite distinct and are described here to facilitate other studies in progress. Presently 7 species, not including the 2 described herein, are known from the Bahamas Islands and Cuba; all 7 are known only from the type localities (Scarbrough 1985b; Curran 1953). This report increases the number of species in the Bahamas to 4 and in Cuba to 5.

Ommatius setiferous, new species
Figure 1 a-g

Diagnosis. This large species is unlike any species thus far reported from the Bahama Islands and Cuba. It runs to couplet 6 in Scarbrough's key (1985b) but differs radically from *O. membranous* Scarbrough and *O. cubanus* Scarbrough in the larger size, color of the legs, and vestiture of the scutellum, forecoxa, and hindfemur. The swollen hindfemur is similar to *O. hanebrinki* Scarbrough and Rutkauskas (1983) and *O. hispidus* Scarbrough (1985b) but neither have a large tubercle on the hindfemur nor a wing with a strongly produced costal margin.

Male: Body black, length $\overline{X}$=14.5, R=13.0-15.6. Face, frons and occiput white to slightly yellowish pollinose, frons with small brown spot medially. Vestiture of face, palpus, frons, scape and pedicel, whitish; 7 to 12 black postocular bristles present, dorsal 1 or 2 strongly proclinate, none unusually long. Face/head width ratio $\overline{X}$=1/6.1, R=1/5.2-1/6.7. Flagellum width/length ratio $\overline{X}$=1/1.3, R=1/1.2-1/1.3; stylus shiny black with numerous black hairs below.

Scutum largely brown pollinose, lighter brown to slightly brownish-gray in grooves, above wings, and posteriorly; all black scutal bristles as follows: 4 lateral and 3 or 4 dorsocentral bristles on each side plus 3 or 4 black hairs near supra-alar bristle; abundant white hairs

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[2] Department of Biological Sciences, Towson State University, Towson, Maryland 21204.

between rows of dorsocentral bristles posteriorly, on humeral callus, and above wing. Scutellum grayish pollinose apically, light brown basally with abundant, thin, white hairs dorsally; bristles absent. Pleuron largely grayish pollinose, an- and katepisternum partially brownish to yellowish; hairs generally sparse and white, laterotergite with yellowish bristles. Halter yellow to orangish-red.

Wing with costal margin strongly produced; subcostal cell largely and 1st radial cell bordering veins narrowly brown, microtrichae dense on anterior apical 1/2 or slightly more, sparse elsewhere. R-m crossvein very short, at or slightly before middle of discal cell. First medial cell wide, base of cell and constriction beyond middle subequal to width of cell at basal 1/3. Furcation of vein R4+5 at base of 1st medial cell.

Coxae with whitish vestiture except 3 or 4 thick, black forecoxal bristles. Femora largely black with mostly whitish to yellowish vestiture; hairs abundant, long and thin on basal 1/2 ventrally; narrow base of fore- and midfemora, basal 1/5 to 1/4 of hindfemur and apical 1/4 to 1/3 of each femur, organish-red. Forefemur with 2 or 3 short, whitish bristles on basal 1/3 to 1/2, 1 anterodorsally and 1 or 2 anteroventrally. Midfemur with 6 anterior bristles, 1 or 2 of these black, and 1 posterior, pre-apical bristle. Hindfemur (Fig. 1a, b) swollen, width/length ratio 1/3.7, with 4 to 5 anterior and 7 to 9 anteroventral bristles; basal 1/3 with dense cluster of 15 to 18 black bristles arising from prominant ventroposterior tubercle; apical 1/2 of posterior surface of hindfemur with several scattered whitish bristles. Tibiae with apices brown to dark brown, most bristles black; hindtibia (Fig. 1b) with 1 long, thick apical bristle and 1 peglike pre-apical bristle, both black. Each tarsus with basal 2 segments largely orangish-red, apices and segments 3 to 5 blackish; foretarsus with 3 or 4 yellowish to organish bristles.

Abdomen slightly constricted at junction of segments 2 and 3; ground color blackish to brownish-red. Terga mostly brown pollinose with brown hairs; wide lateral margin and narrow apex of each tergum and all sterna slightly brown or yellow to yellowish-gray pollinose with whitish hairs.

Terminalia (Fig. 1c-g) orangish-red with slight sooty black tint. Ventral lamella with apical 1/2 narrow. Basal 1/2 of epandrium wide with black hairs, apical 1/2 abruptly narrowed and slender, apex rounded, hairs yellow. Hypandrium with abundant yellow pile and numerous yellow hairs medially. Gonocoxite with large toothlike process. Gonostylus flat, elongately triangular. Exposed aedeagus somewhat flat and wide, width about 2/3 its length, dorsal surface horizontal and slightly convex.

Female: Unknown.

Holotype ♂. BAHAMA ISLANDS: Mayaguana I., Abraham Bay, IV.24.1983, Arnold S. Menke. Paratypes 2 ♂, same data and collector as holotype. In U.S. National Museum.

Etymology. The species name refers to the cluster of black bristles fround on the ventral tubercle of the hindfemur.

Ommatius lineolatus, new species
Figure 2a-d

Diagnosis. *Ommatius lineolatus* is the smallest species (6.9 mm) reported from the Bahamas and Cuba. This species is unusual in that it has only 5 to 6 hairs on the antennal stylus. *Ommatius abana* Curran, a related Bahamian species, has 4 hairs on the stylus. *Ommatius lineolatus* differs from *O. abana* in its smaller size, the femora and anterior 2 tibiae are yellow with brown apices, the hindtibia is largely brown, the body is brown with mostly whitish to yellowish pollen, and the vestiture of the palpus is brown. *Ommatius abana* is slightly larger (9.0 mm), the femora and anterior 2 tibiae are largely red with black apices, and the body is black with white pollen and white hairs.

Male: Length 6.9 mm, body brown. Face yellowish-grey to yellow pollinose; mystax white and dense, hairs sparse on dorsal 1/2 of face with 4 long thin brown bristles; width of face/head ratio 1/6.7. Palpus yellowish-brown with brownish vestiture. Proboscis brown, base and apex narrowly yellowish to yellowish-brown. Frons light brownish-yellow to yellow pollinose with brown vestiture. Antenna with brown vestiture; pedicel with one long subapical

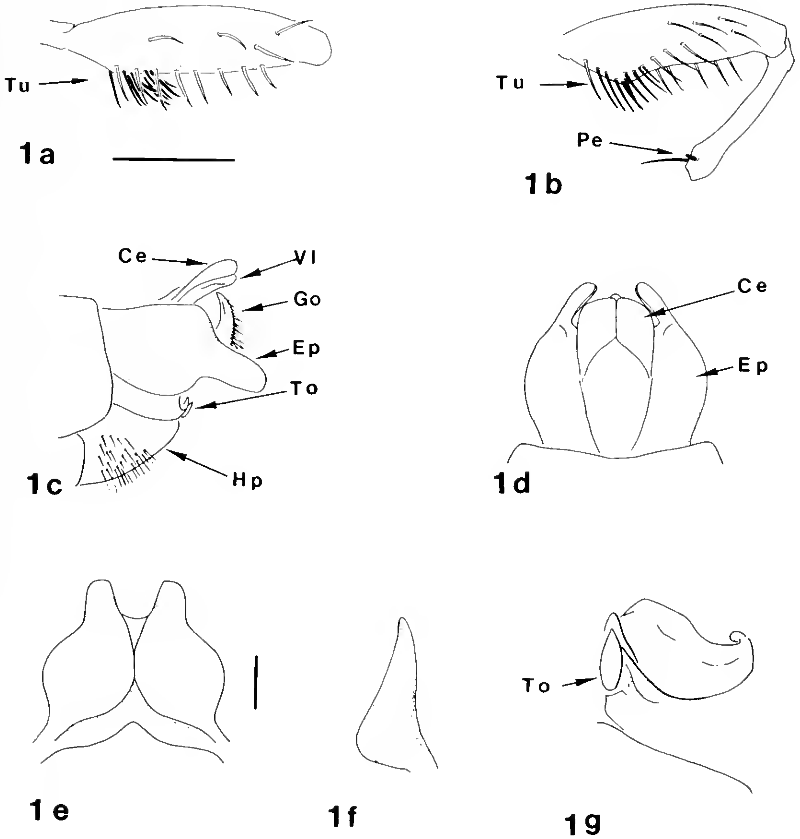

Fig. 1. *Ommatius setiferous*, n. sp.; 1a. Hindfemur with ventral setaceous tubercle and bristle pattern, anterior view; 1b. Hindfemur and hindtibia with ventral setaceous tubercle and bristle pattern, posterior view; 1c. Male terminalia, lateral view; 1d. Male terminalia, dorsal view; 1e. Ventral lamella; 1f. Left gonostylus; 1g. Right gonocoxite. Abbr.: Ce=cercus, Vl=ventral lamella, Ep=epandrium, Hp=hypandrium, To=toothlike process of gonocoxite, Go=gonostylus, Tu=ventral tubercle of hindfemur, Pe=peg-like bristle of hindtibia.

ventral bristle, bristle about 1.7 times length of flagellum; stylus with 5 ventral hairs; width/length ratio of flagellum 1/1.7. Occiput largely grayish to whitish pollinose with white hairs, slightly yellowish immediately behind vertex; 3 postocular bristles on each side, 2 brown and 1 whitish, all short and slightly proclinate.

Scutum mostly brown pollinose, lateral and posterior margins grayish to weakly yellow pollinose; 4 lateral and 2 or 3 brown dorsocentral bristles on each side, hairs generally sparse and whitish. Scutellum yellowish-gray to yellow pollinose, margin with 2 bristles and 2 short brown hairs. Pleuron largely gray to whitish pollinose with whitish vestiture, anepisternum yellowish pollinose. Epimeral bristle absent. Halter yellow.

Wing without costal dilation, microtrichae dense on anterior 1/2 or slightly more, sparse or absent otherwise. R-m crossvein beyond middle of discal cell; first medial cell narrow, base about 1/3 width of cell at basal 1/3; furation of posterior branch of radial vein well beyond base of 1st medial cell.

Coxae grayish pollinose with whitish vestiture. Trochanter brown; all femora, tibiae and basal segments of fore- and midtarsi mostly yellow with yellow hairs, brown as follows: apical 1/4 or less of all femora and anterior 2 tibiae, hindfemur with narrow band at or just before middle, hindtibia and anterior 2 tarsi largely, and hindtarsus entirely. Midfemur with 4 or 5 anterior bristles or bristly hairs and 1 posterior pre-apical bristle present, all brown. Hindfemur slender, width/length ratio 1/5.6, bristles and bristly hairs whitish to weakly yellow except for 1 anterior pre-apical bristle; 2 anterior bristles and 6 or 7 bristles present in each ventral row. Tibiae with 1 to 3 brown bristles, remaining bristles yellow. Hindtarsus with 1 and fore- and midtarsi with 3 or 4 yellowish bristles, remaining bristles brown.

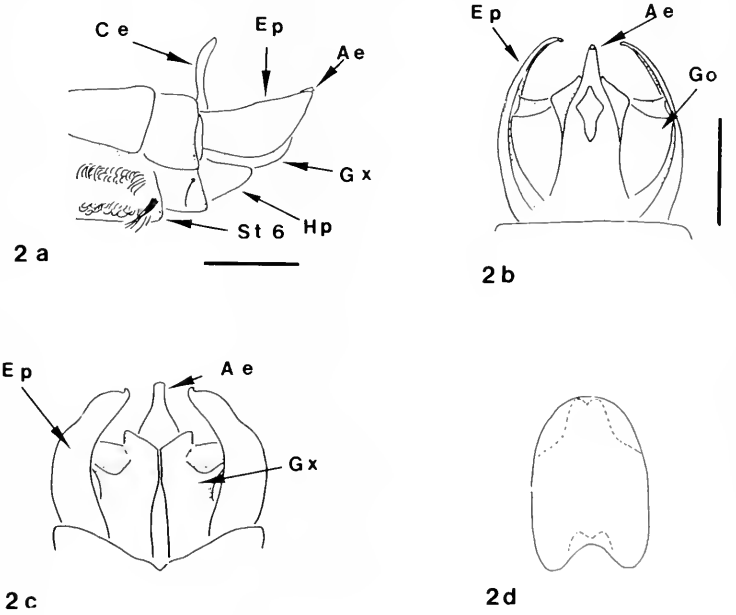

Fig. 2. *Ommatius lineolatus*, n. sp., male terminalia; 2a. Lateral view; 2b. Dorsal view; 2c. Ventral view; 2d. Ventral lamella. Abbr. See Figure 1. Ae=aedeagus, St=sternum.

Abdomen brown to brownish-yellow; sterna 1-5 with narrow longitudinal stripe devoid of pollen. Pollen mostly yellow to yellowish-gray, that on most terga brownish with brown hairs, remaining hairs mostly whitish to weak yellow; sternum 6 (Fig. 2a) with 3 brown, medio-apical bristles and 2 elongate, dense clusters of weak, pencil-like hairs; hairs largely yellowish with apices pendulate, apical end of each cluster with 7 or 8 brown hairs. Sternum 7 with all brown hairs and 2 midlateral pre-apical brown bristles.

Terminalia (2a-d) largely brown with mostly brown hairs. Apical 1/3 of epandrium broadly convex below, yellowish-brown to yellow with yellowish hairs. Gonostylus and gonocoxite yellow, both appressed to aedeagus laterally and below. Aedeagus long, apical 1/3 slightly arched upward, tip extending to apex of epandrium.

Female: Differs from male as follows; length 7.1 mm, face/head width ratio 1/6.2; flagellum width/length ratio 1/1.5. Mystax not unusually dense, proboscis wholly blackish, hairs of face and frons whitish to pale yellow. Stylus with 5 to 6 hairs; 3 brown postocular bristles present. Margin of scutellum with 1 weak brown hair and 3 whitish or pale yellow weak bristles or hairs. Midfemur with only 2 anterior bristles, all anterovertral bristles weak, pale yellowish to whitish. Hindtibia mostly dark brown, narrow base yellow. Sternum 6 of abdomen without cluster of dense pendulant hairs, sterna 6-7 with several brown bristly hairs apically. Length of sternum 8 about 1.3 times width, apical margin with moderately deep median notch. Tergum 8 narrow, apical corner not extending below cercus. Cercus triangular, apex rounded. Spermathecal glands obovatus.

Holotype ♂ and allotype ♀, CUBA: Herradura, 2-20/32. Bruner y Otero, col. In U.S. National Museum.

Etymology. The species name refers to the short, pendulate pencil-like hairs on sternum 6 of the male.

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NEW RECORD FOR *PHYLLOPHAGA* (COLEOPTERA: SCARABAEIDAE) IN NORTH DAKOTA[1,2]

Murdick J. McLeod[3], John T. Schulz[4]

ABSTRACT: The range of *Phyllophaga crassissima* is extended northward and to include North Dakota.

Lago *et al.* (1979) conducted an extensive survey of phytophagous Scarabaeidae of North Dakota in which they recorded nine species of *Phyllophaga* from the state: *P. anxia* (LeConte), *P. drakei* (Kirby), *P. fusca* (Froelich), *P. implicita* (Horn), *P. lanceolata* (Say), *P. longitarsa* (Say), *P. nitida* (LeConte), *P. rugosa* (Melsheimer), and *P. tristis* (Fabricius).

On 6 June 1984, 2 male *P. crassissima* (Blanchard) were collected by personnel of the North Dakota Department of Agriculture in a blacklight trap at Hankinson, Richland County, North Dakota. This represents the first record of *P. crassissima* for North Dakota.

Miner (1952) reported that *P. crassissima* was common throughout the prairie states of the midwest and southwest, with the principal range bounded by lines connecting Nebraska, Indiana, and Texas.

Kirk and Balsbaugh (1975) recorded *P. crassissima* from several counties in southern South Dakota. Records also exist for southern Minnesota. However, the North Dakota record represents a northern range extension of approximately 192 km. Voucher specimens have been deposited in the North Dakota State University insect collection.

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[3] Department of Entomology, North Dakota State University, Fargo, North Dakota 58105. Current address: Department of Entomology, Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.

[4] Department of Entomology, North Dakota State University, Fargo, North Dakota 58105.

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SOCIETY MEETING OF NOVEMBER 18, 1987

The European corn borer, *Ostrinia nubilalis,* became established in the United States during the second decade of this century and is now present in all but a few western states. Control of the corn borer is a major concern of Dr. Charles E. Mason, former president of the Society and currently Associate Professor of Entomology at the University of Delaware. Dr. Mason spoke at the November Society Meeting on 'Interactions of the European Corn Borer with some of its Parasites." Fourteen members and four guests attended the meeting held at the Academy of Natural Sciences of Philadelphia.

The primary focus of Dr. Mason's talk was *Lydella thompsoni.* This tachinid fly parasitizes the larvae of the corn borer. After its introduction to this country from southern Europe by the USDA, it quickly spread and was a significant factor in biological control of the corn borer. Surveys of corn borer larvae in Maryland in the late 1940's showed state averages of up to 28% of them parasitized by *L. thompsoni.* Curiously, populations of *L. thompsoni* later declined and the species apparently became extinct in the U.S. The last specimen was collected from Nebraska in 1965. In the mid-1970's new stocks of *L. thompsoni* imported from Yugoslavia were released by the University of Delaware and the USDA in southern Delaware. The parasite has become reestablished and is spreading at about 35 miles per year. This year it was reported from North Carolina, Ohio, New York, and all the states in between. Rates of parasitism are lower than with the previous strain (4 to 13% in Delaware); however, its natural movement into other states is encouraging. In addition to monitoring the spread of this parasite, Dr. Mason has been studying alternate hosts which must be present to sustain the first annual generation which emerges before the larvae of the first generation of corn borers are available. One of these alternate hosts is the stalk borer, *Papaipema nebris,* another pest which feeds on early growing corn and weeds. The parasitism in this host was over 35% by *Lydella thompsoni.*

In notes of local entomological interest, Mildred Morgan, the Society's office secretary, reported that she had participated in a New Jersey Audubon Society trip to Cape May Point, New Jersey to tag Monarch butterflies. While there were relatively few Monarchs present at that time in late September, many more were present in the second week of October when Dr. Kenneth Frank was there. Both noted that the Buckeye, *Junonia coenia,* and the Cloudless Sulphur, *Phoebis sennae,* were abundant. Dr. Frank also displayed many issues of *Butterfly News,* a British newspaper sponsored by the butterfly farm industry. Dr. Mason reported that *Varroa jacobsoni,* a major mite pest of honey bees, has been discovered in several states this year including Pennsylvania.

Harold B. White
Corresponding Secretary

USE OF OCCUPIED *GLOSSOSOMA VERDONA* (TRICHOPTERA: GLOSSOSOMATIDAE) CASES BY EARLY INSTARS OF *BAETIS* SPP. (EPHEMEROPTERA: BAETIDAE) IN A ROCKY MOUNTAIN STREAM[1]

N. LeRoy Poff, James V. Ward[2]

ABSTRACT: Collections of individual, occupied *Glossosoma verdona* larval cases from the upper surfaces of rocks in the Colorado River revealed that *Baetis* spp. nymphs occurred in the interstices between the mineral particles comprising the cases, or on the outer surface of the cases, at significantly higher densities than they did on the adjacent rock surfaces. Also, early instar nymphs of *Baetis* tended to occur at a higher proportion in and on the cases than did later instars. Such positive spatial associations may be common among the species of these two widely-distributed and frequently sympatric aquatic families.

The spatial microdistribution of aquatic insects in streams has been extensively investigated with respect to a variety of biotic and abiotic factors (e.g., Resh and Rosenberg 1984). Frequently, interspecific interactions result in negative spatial associations because of predation (Peckarsky 1982), exploitative competition (McAuliffe 1984) or interference competition (Hart 1985). Positive associations have been found, however, both for phoretic species (Steffan 1967; Dosdall *et al.* 1986) and for species that reside in the cases (Vinikour and Anderson 1981) or retreats (Diamond 1986) of various trichopteran larvae. From the point of view of the smaller species involved, the former of these associations (phoresy) may be considered as obligatory, the latter as facultative. Observations of positive associations for species of either the Glossosomatidae or the Baetidae are few. Vinikour and Anderson (1981) reported the variable occurrence of dipteran larvae within the pupal cases of *G. intermedium* (Klapalek), while Müller-Liebenau and Heard (1979) described an apparently obligatory ectosymbiosis between a tropical baetid mayfly and its unionid clam host. However, no previous record of a positive association between species of these two aquatic insect families has been documented.

During a study of factors determining microdistributional patterns of glossosomatid caddisflies in the upper Colorado River, the observation was made that *Baetis* spp. nymphs often occurred in association with occupied cases of *Glossosoma verdona* Ross. When such a case was placed in formalin, one to several nymphs could be seen to abandon the case immediately by swimming from the interstices between the mineral

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[2] Department of Biology, Colorado State University, Ft. Collins, CO 80523.

particles. A simple protocol was then devised to determine what proportion of *G. verdona* cases was occupied by *Baetis* nymphs and to evaluate whether mayfly densities on caddisfly cases differed from mayfly densities on adjacent rock surfaces.

At this location, *G. verdona* eggs hatch in late summer and pass through five instars during the fall (and possibly winter) months. Pupation and emergence occur in early spring. Three of the five instars (II, III and IV) were present at the time of this study. The cases constructed by the largest of these larvae can range up to about 6 mm in length, 5 mm in width and 4 mm in height and are composed of small mineral particles usually less than 2 mm in diameter. *Baetis* species present at this site, in order of decreasing abundance, are *B. tricaudatus* Dodds, *B. bicaudatus* Dodds, *B. insignificans* McDunnough, and *B. hageni* Eaton. Species of this genus are typically multivoltine and early instars cannot be reliably identified to species.

MATERIALS AND METHODS

On 5 October 1986, six stones were individually removed from a low velocity (<25 cm sec^{-1}) zone of a single riffle in the Colorado River about seven km below Granby Reservoir in Grand County, CO (2400 m a.s.l.). Individual *G. verdona* larvae in their cases were collected from each rock and stored separately in 5% formalin. The upper surface of each rock was then brushed into a pan with a toothbrush to dislodge and retain *Baetis* nymphs associated with the rock surface. (Nymphs typically do not drift from a rock when it is lifted gently from the water: NLP, pers. obs) Rock area was determined by placing variously-sized pieces of hardware cloth over the brushed surface. A total of 49 *G. verdona* larvae was collected from the six rocks. An additional 39 larvae were individually taken from several other rocks in the riffle for further comparison.

In the laboratory, individual *G. verdona* and their cases were placed in watch glasses and the number of *Baetis* spp. nymphs present counted. Maximum head capsule widths (HCW) of all mayfly nymphs and caddisfly larvae were measured with a stage micrometer. In addition, length, width, height and weight of the caddisfly cases were determined. The surface area of each case was estimated by assuming the exposed upper surface to approximate a hemi-ellipsoid. The density of *Baetis* on *G. verdona* cases for each rock was calculated as the number of nymphs on cases divided by the total case surface area. Density of *Baetis* on each of the rock surfaces was calculated as the number of nymphs not on caddisfly cases divided by the total area of the upper rock surface.

RESULTS

Of the total 83 *G. verdona* cases collected, 44 (53%) contained from one to six *Baetis* nymphs. On the six individually collected rocks, a significantly higher mean density of *Baetis* nymphs was found in association with *G. vedona* cases than on the adjacent rock surfaces (paired t-test, $t=3.60$, $p=0.015$). The mean density of *Baetis* spp. on cases was regularly one to two orders of magnitude greater than on rocks (Table 1). Even if case surface area were increased by a factor of 10 to allow for the additional area in the interstitial spaces, *Baetis* nymphs would still be significantly more dense on cases than on the rock surfaces ($p=0.04$).

Mayfly sizes ranged from 0.1 - 0.6 mm HCW, though the difference in mean size between nymphs on cases vs. rocks was not significant ($p=0.19$). However, 97% of all mayflies collected from cases were <0.3 mm HCW, whereas only 83% of those collected from rock surfaces were <0.3 mm HCW. This difference probably reflects the physical size limitations imposed on *Baetis* nymphs by the small interstitial spaces between the mineral particles comprising the *G. verdona* cases. Other statistically significant patterns of *Baetis* use of *G. verdona* cases were not found. For example, *Baetis* density on rocks was independent of *G. verdona* case density. When all 83 *G. verdona* larvae were combined into one sample, the number of *Baetis* per *G. verdona* case was not significantly predicted by *G. verdona* size (HCW), case area or case weight. Similarly, *Baetis* size on cases was unrelated to case area.

Table 1. Comparison of densities of *Baetis* spp. nymphs associated with rock surfaces vs. with *G. verdona* cases for six rocks collected from the Colorado River on 5 October 1986. Means ($\bar{x}$) and standard errors (s.e.) are given both for rock and case densities and for the differences between them. The t-statistic for the paired t-test is also provided and shows that *Baetis* densities are significantly higher on cases vs. rocks ($p=0.015$).

Rock	Rock Surface Area (cm^2)	Case Surface Area (cm^2)	# *Baetis* per cm^2 Rock	# *Baetis* per cm^2 Case	Case Density - Rock Density
1	145	0.9	0.04	3.30	3.26
2	185	1.6	0.02	0.48	0.46
3	201	0.8	0.06	3.61	3.55
4	210	1.8	0.07	7.98	7.91
5	219	1.6	0.20	2.60	2.40
6	227	5.0	0.08	4.23	4.15
$\bar{x}$			0.08	3.70	3.62
s.e.			0.03	1.00	1.00
t					3.60

DISCUSSION

The observation of *Baetis* spp. utilizing *G. verdona* cases as habitat is particularly interesting given that *Glossosoma* larvae have elsewhere been shown capable of competing exploitatively with *Baetis* nymphs when both graze algae on artificial substrate surfaces (McAuliffe 1984). However, the significance of *G. verdona* cases as habitat for early instars of *Baetis* cannot at this time be adequately evaluated. The cases do possess features that appear to make them attractive to *Baetis* nymphs. For example, they probably provide some refuge from potential predators because of their small interstitial spaces. If this is so, then individual *Baetis* nymphs utilizing the case habitat may have a higher probability of surviving, at least to a size where case habitat is no longer available to them. The mineral cases also trap detritus and algal cells and serve as a substrate for periphyton (NLP, pers. obs.). The *Baetis* nymphs can use these food resources, presumably without expending much energy to forage. Depending on the availability of food resources on the cases, the possibility exists that early instar *Baetis* residing on *G. verdona* cases could avoid exploitative competition with the larger caddisfly larvae.

It is unclear what, if any, benefit the *G. verdona* larvae derive from this arrangement. Possibly, the *Baetis* nymphs serve to prevent detrital accumulations from clogging the interstitial spaces of the case, thereby enhancing water circulation and gaseous exchange. In this instance, the association would be more mutualistic than commensalistic. However, the association seems to be only facultative and opportunistic, given the absence of *Baetis* from many cases and the apparent size limitations placed on *Baetis*' utilization of the case habitat. Moreover, larval glossosomatids in the upper Colorado River do not always overlap temporally with early instar baetids (NLP, pers. obs.).

Species of these two insect families are widespread across North America and often occur sympatrically. The possibility therefore exists that this positive association is also widespread. However, depending on the oxygen requirements of the various species of *Baetis* nymphs in the interstitial spaces of glossosomatid cases, such an association may be restricted geographically or seasonally to streams characterized by high dissolved oxygen content, or to microhabitats in streams where dissolved oxygen is high.

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DISTRIBUTIONS FOR TWO HOLARCTIC WEEVILS WHICH ARE NEW HOUSEHOLD PESTS (COLEOPTERA: CURCULIONIDAE)[1,2]

Edward U. Balsbaugh, Jr.[3]

ABSTRACT: *Barypeithes pellucidus* and *Brachysomus echinatus* are two Holarctic species of weevils which separately or together have been collected in homes in two states, viz. Minnesota and Montana, and are considered as pests primarily because of their presence. Distributions in North America for both species are given, including a postglacial fossil record for *Barypeithes pellucidus*, a weevil previously considered to have been introduced from Europe.

Two species of small weevils have been collected in homes where they have annoyed the occupants simply by their presence. They are *Barypeithes pellucidus* (Boheman) and *Brachysomus echinatus* (Bonsdorff). Both species were collected together several times in lakeshore summer cabins at Upper Cormorant Lake, Becker County, northwestern Minnesota. The former species has also been recently collected in a home in Missoula, Montana, where its occurrence was also annoying the occupants.

Barypeithes pellucidus (Boheman) (Brachyderinae: Brachyderini).

In Minnesota, *Barypeithes pellucidus* was first collected by J. Carter, June 26, 1983, in his lake cottage where he found them scattered on the floor and at the windows. He again found them in his home July 4, 1983. The author collected a series of these weevils on June 28, 1984, by sweeping unidentified mixed vegetation on the lawn in front of the Carter cottage.

This year, three specimens collected by Marie Root in a home in Missoula, Montana, June 9, 1987, were received by the North Dakota State University extension entomologists for identification. They too proved to be *B. pellucidus,* which is the first known occurrence of them in Montana.

Barypeithes pellucidus is a Holarctic species whose European distribution is reported to include Great Britain, the Netherlands, France, and Transylvania (von Dalla Torre *et al.,* 1937) and Central Europe, southern

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[3] Entomology Department, North Dakota State University, Fargo, North Dakota 58105.

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North Europe, eastward to Bukowina, Poland, and in the East being found only in cities, gardens and parks' (Freude *et al.*, 1981).

In America, *B. pellucidus* is transcontinental. Distribution data recorded by Donald P. Schwert from pinned specimens in the United States National Museum and Canadian National Collection include the following:

British Columbia: Squamish, Sidney, and Victoria: **District of Columbia:** Washington; **Idaho:** Clearwater Co.,; **Indiana:** Tippecanoe Co.,; **Maine:** Bar Harbor and Rockport; **Maryland:** Sparks; **Michigan:** Allegan Co.; **Newfoundland:** St. Johns and Topsail; **New Jersey:** Dundee Lake and Orange Mountains; **New York:** Brooklyn, Huntington (Long Island), Geneva, Oswego, Piermont, Rochester, and Taughannock Falls State Park; **Nova Scotia:** Kentville, Waverley and Yarmouth; **Ohio:** Wooster; **Ontario:** Carleton Place, Kerr Lake, Marmora, Ottawa, Port Rowan, and Toronto; **Oregon:** Salem; **Pennsylvania:** Chestnut Hill, Gettysburg, Philadelphia, and Pittsburgh; **Prince Edward Island:** Cavendish; **Quebec:** Knowlton; **Rhode Island:** Newport; **Washington:** Pierce County; and **Wisconsin:** Dane County. Besides the above, Kissinger (1964) also listed **California** and **Massachusetts** and O'Brien and Wibmer (1982) included **Connecticut, Illinois, New Hampshire, Vermont,** and **Virginia.**

In addition, Schwert *et al.*, (1985) collected and identified fossils representing articulated elytra of *Barypeithes pellucidus* which they recovered from intact lake sediments deposited 9000 to 11,000 years ago in southwestern Ontario.

Lindroth (1957) and O'Brien and Wibmer (1982) have stated that both *Barypeithes pellucidus* and *Brachysomus echinatus* were introduced from Europe to North America. Blatchley and Leng (1916) also implied that *Barypeithese pellucidus* is a species introduced from Europe where it is reported to attack strawberries. Thus far, no economic significance associated with crops is attributed to this species in North America.[4] The fossils of *Barypeithes pellucidus* from Ontario, however, definitely prove its prehistoric existence in North America.

Brachysomus echinatus (Bonsdorff) (Brachyderinae: Brachyderini).

Brachysomus echinatus (Bonsdorff) (= *Thricolepoides clavisetis* O'Brien, 1979 (O'Brien and Wibmer, 1984)) also is Holarctic. It is parthenogenetic (Freude *et al.*, 1981), and specimens of it were collected in a different cabin at Upper Cormorant Lake, Becker, County, Minnesota, June 12, 1978, by Lori Statler (Becker). Subsequently they appeared in other cabins at this lake, often in association with *Barypeithes pellucidus*. *Brachysomus echinatus* is widely distributed in Europe, viz. central and

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[4] Galford (1987) recently reported that *B. pellucidus* was observed feeding on 18 species of plants in Ohio, of which northern red oak, aster, American elm, hawthorn, and black cherry were preferred.

northern Europe, northern and central France, Switzerland, Caucasia and Transcaucasia, USSR (von Dalla Torre *et al.,* 1937; Freude *et al.,* 1981) but in North America has also been recorded from Quebec and Newfoundland (Lindroth, 1957) and Massachusetts (O'Brien and Wibmer, 1982).

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THE BIOLOGICAL CYCLE AND POLYMORPHISM OF *BEROSUS AFFINIS* (COLEOPTERA: HYDROPHILIDAE) IN MOROCCO[1]

Nezha Aouad[2]

ABSTRACT: *Berosus affinis* is univoltine in temporary ponds and bivoltine in fresh or brackish permanent waters. The pigmentation of the pronotum varies with the seasons: the black spot of type "f" is characteristic of the summer generation observed in permanent waters only; the type "e" spot is seen in winter in all specimens of all temporary and permanent aquatic habitats. These findings raise questions about the validity of previously described geographical races.

From 1982 to 1984, I studied the Hydrophiloidea of stagnant waters from the Moroccan Atlantic coast (Aouad, 1984). Among the 27 species collected, *Berosus affinis* Brulle seemed particularly interesting because of its ecological characteristics as well as its polymorphism. I determined its biological cycle with the purpose of finding the origin of polymorphism.

Biological Cycle

Berosus affinis has a biological cycle that depends on whether it has a permanent or a temporary environment. In a temporary habitat, the evolution of the adult population shows only one maximum, when the habitat is refilled with rainwater (Fig. 1 A). The larvae appear in spring; the pupal stage and the burying of the adults coincide with the drought period of the habitat (Fig. 1 B). *Berosus affinis,* at its imaginal stage, burrows in soil to escape summer drought; at this place, it digs a chamber in which it remains quiescent until its habitat is flooded again at the return of the rainy season.

In a permanent environment, from the viewpoint of the number of imagos, *B. affinis* presents two maxima: one in winter with an equal sex-ratio and the other in summer with a slight majority of females (60%) (Fig. 2 A).

After the winter maximum, as soon as the number of adults diminshes, that of the larvae increases until April-May. At the approach of the estival period, pupation takes place in humid soil above water level and lasts nearly a month. In August-September, the summer maximum of imagos occurs. (Fig. 2 B).

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[1] Received June 19, 1987. Accepted October 23, 1987.

[2] Université Mohamed V, faculte des Sciences de Rabat, Morocco.

Morphological Characteristics and Polymorphism

In 1982, I noted that *Berosus affinis* has, on its pronotum, a dark spot, the form of which varied according to individuals and following the periods of the seasonal cycle. Further, Chiesa (1959) mentioned five varieties of *B. affinis* described by different authors according to the spot on the pronotum (Fig. 3 A-E). The naming of certain of these "varieties" (*hispanicus* Kuster, *algericus* Kuwert) and the interpretation given by Chiesa led me to think that the question of possible "geographical races" needed to be investigated. With the idea of probing previous observations and in order to determine the factors that influence this pigmentation, I followed the evolution of this spot throughout the annual cycle.

The results obtained allowed me to find five other "varieties" (Fig. 3 F-J) in Morocco, different from those described by Chiesa. Also I was able to eliminate some factors that can influence this coloration, such as sexual dimorphism, water temperature, salinity, and the height and age of the individuals. Moreover, during the study of the spot's evolution, I noticed that this is almost the same in all individuals from temporary fresh water ponds and presents variations for those from permanent swamps with fresh or briny water. However, among all the forms encountered, only two appear regularly and frequently: in ponds, only the form "e" is found and in permanent waters, depending on the periods of the year, we detected mostly the form "e", the form "f" or both. If we refer to the biological cycle of *B. affinis,* the winter maximum corresponds to the winter generation, with the individuals having one dark spot in the middle of the pronotum (form "e"), while the summer maximum corresponds to the summer generation, with individuals with two spots in the middle of the pronotum (form "f"). The two other forms of coloration referred to by Chiesa or described by me appear as intermediate stages; they are simple variants of the two most constant and frequent forms. In addition, factors like salinity, nature of substrate, temperature, sunshine and period of filling with water, taken separately, do not seem to have any influence on the coloration but form a combination of conditions that cause variations of the pigmentation around two fundamental varieties, form "e" and form "f".

CONCLUSION

It would seem, then, that *Berosus affinis* in Morocco belongs to a geographical subspecies of which it is not actually possible to specify the limits of the variations of pigmentation. In the present state of our knowledge, we consider *B. affinis* (winter generation) living in the Rabat region, either in ponds or in permanent waters, belonging primarily to form

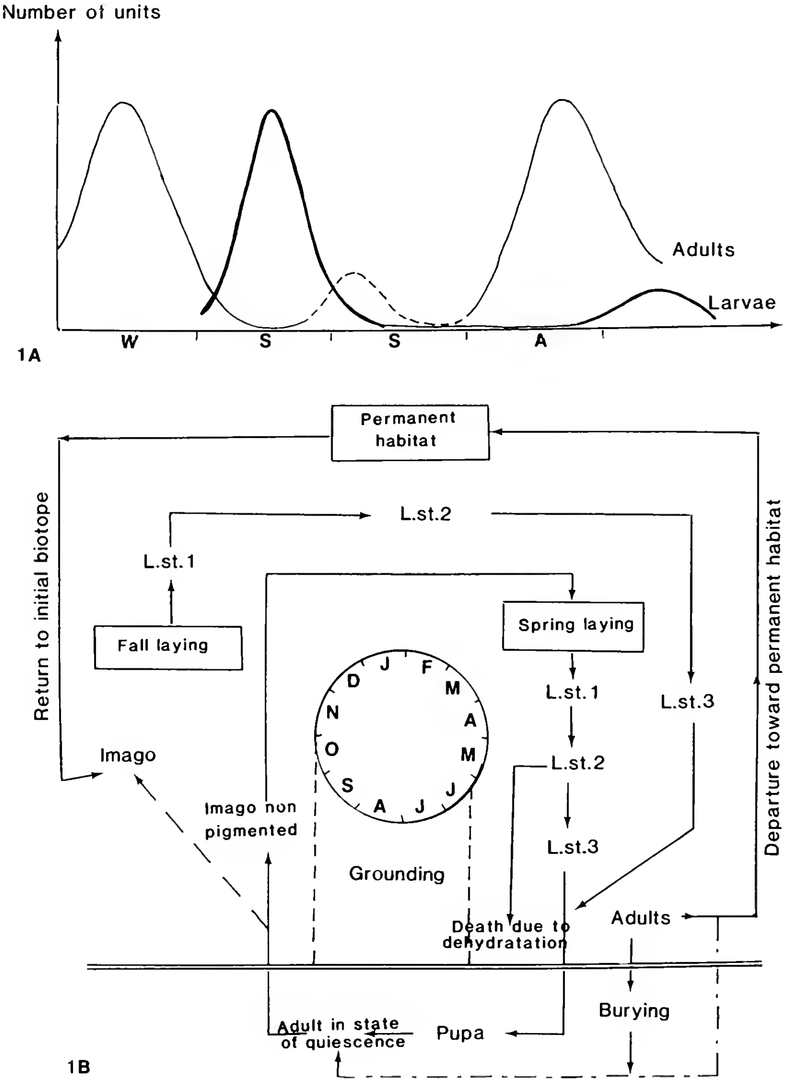

Fig. 1 (A) - Evolution of the number of specimens (adults & larvae) in a temporary pond. W = winter, S = spring, S = summer, A = autumn.

(B) - Development cycle of *Berosus affinis* in a temporary pond.

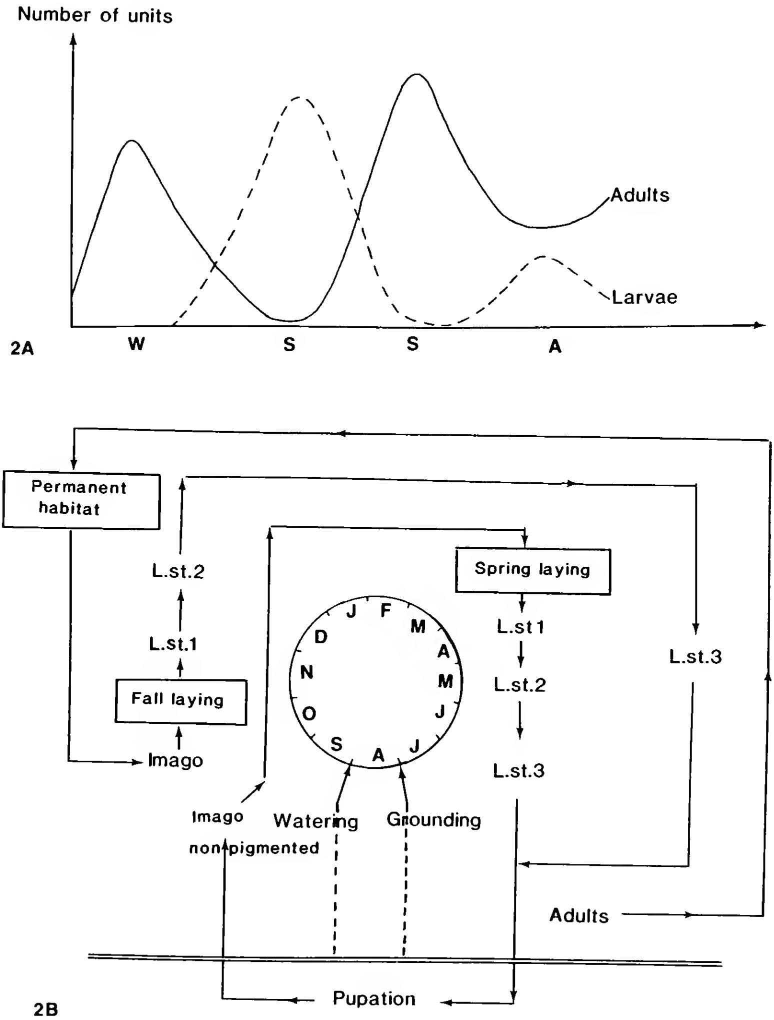

Fig. 2 (A) - Evolution of the number of specimens (adult & larvae) in a permanent stream. W = winter, S = spring, S = summer, A = autumn.

(B) - Development cycle of *Berosus affinis* in a permanent stream.

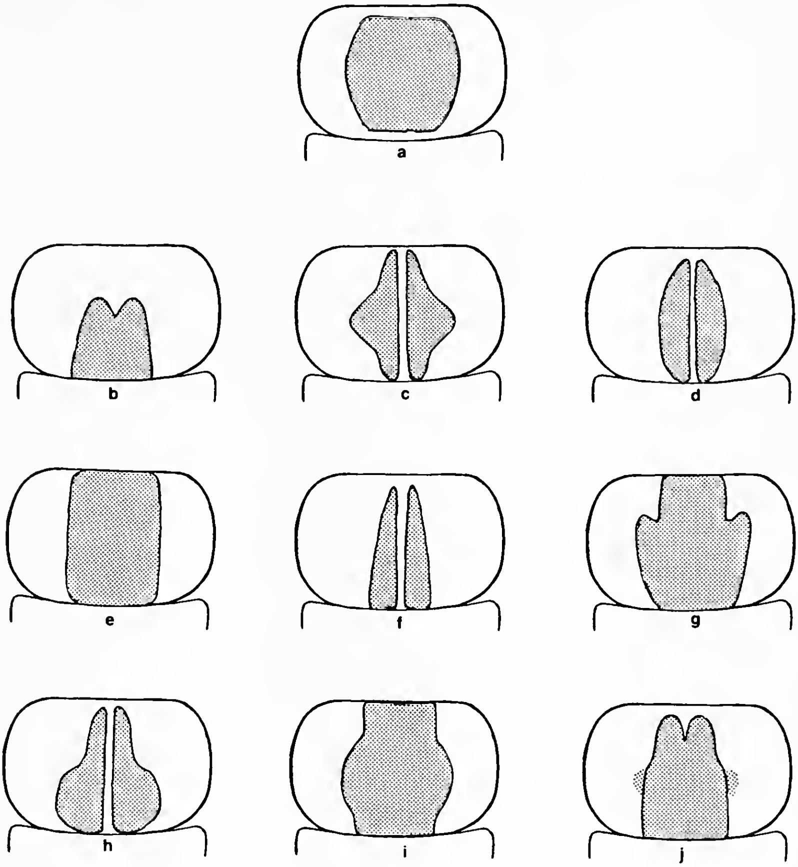

Fig. 3 (a) - *Berosus affinis* Brullé, typical shape. b) *B. affinis suturalis* Kuster. c) *B. affinis hispanicus* Küster. d) *B. affinis lineicollis* Costa. e) *B. affinis algericus* Kuwert. (f-j) Five other forms of *Berosus affinis.*

"e": denominated *B. affinis algericus* by Kuwert. However, the *B. affinis* (summer generation) corresponds to form "f", described by Küster under the name *B. affinis hispanicus.* Thus, these two subspecies could be in reality only seasonal forms of a single species with a large distribution in the Mediterranean region. Moreover, some examples collected in the Camargue region of France in November 1984 include individuals with form "e" and form "f" combined, exactly as they were at the same date in Rabat region when individuals from the two generations are mixed. When we have collected enough western specimens from different regions and variable seasons, we hope to be able, in the future, to specify and clarify the exact status of *Berosus affinis* from the western basin.

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AN ANNOTATED LIST OF THE TREEHOPPERS (HOMOPTERA: MEMBRACIDAE) OF QUÉBEC[1]

M.-C. Larivière[2], A. Larochelle[3]

ABSTRACT: Treehoppers were collected in the Province of Quebéc during the summers of 1979 to 1985. Information on geographical distribution, associated plants and seasonal occurrence has been gathered for 67 species occurring in Québec. The collection methods used were beating and sweeping. Material (more than 10,000 specimens) from entomological collections dealing with the fauna of the Province has also been identified. Geographical distribution, associated plants and seasonal range have been compiled into an annotated list of the Québec species. Prior to this study, the seasonal range and associated plants of Québec Membracidae were unknown. Seven species are recorded in Québec for the first time: *Stictocephala tauriniformis, Cyrtolobus discoidalis, Palonica tremulata, P. viridia, Telamona dubiosa, T. spreta,* and *Thelia uhleri.*

RESUME: La récolte de Membracides au Québec au cours des étés 1979 à 1985 a permis de recueillir des données sur la répartition géographique, les plantes associées et la période d'activité saisonnière de ces insectes, ainsi que l'élaboration d'une liste annotée des 67 espèces se trouvant sur ce territoire. On a utilise le battage et le fauchage comme methodes d'échantillonnage. Au cours de cette etude, on a aussi procede a la determination de plus de 10 000 exemplaires provenant de collections entomologiques se rapportant à la faune du Québec. Jusqu'à maintenant, la période d'activité saisonnière et les plantes associées des Membracidae du Québec nous étaient inconnues. Cette liste confirme la présence de sept nouvelles espèces pour la Province: *Stictocephala tauriniformis, Cyrtolobus discoidalis, Palonica tremulata, P. viridia, Telamona dubiosa, T. spreta* et *Thelia uhleri.*

Sixty-seven species of Membracidae (Homoptera) are known to occur in the Province of Québec. Most of these are concentrated in the southernmost part of this area. This family has received little attention in Québec. Since 1950, only three substantial publications (Moore 1950a, 1950b, Beirne 1959) have dealt with Québec membracids. In 1950, Moore cited 68 species in his list for the Province, mostly from the Montréal area, but 7 of these could not be confirmed by the present work. The present paper lists 67 species and is based upon 8 years of field collecting and recording of associated plants of membracids in more than 200 localities throughout Québec. Beating and sweeping were the primary methods of collection. The insects collected by the authors have been deposited in the Lyman Entomological Museum and Research Laboratory (Macdonald College of McGill University). This work also includes data from the examination of

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[2] Department of Entomology, Macdonald College of McGill University, Sainte-Anne-de-Bellevue, Québec H9X 1CO.

[3] Lyman Entomological Museum and Research Laboratory, Macdonald College of McGill University, Sainte-Anne-de-Bellevue, Québec H9X 1CO.

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more than 10,000 specimens from insect collections dealing with the Québec fauna: Canadian National Collection (Biosystematic Research Centre, Ottawa, Ontario), Complexe Scientifique du Québec (Sainte-Foy Québec), Collection Léon-Provancher (Université Laval, Sainte-Foy, Québec), Collection Ouellet-Robert (Université de Montréal, Montréal, Québec), Lyman Entomological Museum and Research Laboratory (Macdonald College of McGill University, Sainte-Anne-de-Bellevue, Québec).

The distribution, associated plants and seasonal range are listed for each species. Membracidae have been collected from 114 species of associated plants in the course of this study. A list of the host plants giving both their scientific and common names is given at the end of this paper. Prior to this study, the seasonal range and associated plants of Québec Membracidae were unknown. Seven species are recorded for Québec for the first time: *Stictocephala tauriniformis* Caldwell, *Cyrtolobus discoidalis* (Emmons), *Palonica tremulata* (Ball), *P. viridia* (Ball, *Telamona dubiosa* Van Duzee, *T. spreta* Goding, and *Thelia uhleri* Stål.

The species *Entylia sinuata* (Fabricius), *Stictocephala brevis* (Walker), *S. brevitylus* (Van Duzee), *Cyrtolobus cinereus* (Emmons), *C. gratiosus* Woodruff, *Xantholobus tumidus* Walker, *Archasia galeata* Stål, *Telamona agrandata* Ball, and *T. decorata* Ball were cited by Moore (1950b) but are excluded from the present list. These are doubtful records; specimens recorded by Moore were not found in the Lyman Entomological Museum and Research Laboratory collection, though all of his specimens are supposed to be there.

The systematic arrangement of this family follows Kopp and Yonke (1973a, b, c, 1974, and 1979).

Subfamily Centrotinae Amyot and Serville

Genus *Microcentrus* Stål

***Microcentrus caryae* (Fitch).** — 4 localities; southernmost part of Québec. Primary associated plant: *Carya cordiformis.* A few specimens also collected on *Carya ovata, Quercus macrocarpa,* and *Vitis riparia.* 6.VIII.-10.IX.

Subfamily Membracinae Dohrn

Genus *Campylenchia* Stål

Campylenchia latipes (Say). — 152 localities; north to Chibougamau (Territoire-du-Nouveau-Quebéc). In fields and along roadsides, on weeds, especially *Cirsium arvense, Cirsium sp., Melilotus alba, Solidago* *canadensis,* and *Solidago* sp. Also found on *Aster novae-angliae, A. puniceus, Betula papyrifera, Chenopodium album, Fraxinus* sp., *Galium* sp., *Medicago sativa, Polygonum persicaria, Rubus idaeus, Tsuga canadensis, Ulmus* sp., and umbellifers. 10.VII.-15.IX.

Genus *Enchenopa* Amyot and Serville

Enchenopa binotata (Say). — 43 localities; north to Dégelis (Témiscouata Co.). Primary associated plants: *Amphicarpa bracteata, Carya cordiformis, Celastrus scandens, Viburnum cassinoides,* and *V. Lentago.* This membracid has also been found in lesser numbers on *Diervilla Lonicera, Juglans cinerea, Populus balsamifera, P. tremuloides, Prunus serotina, Quercus macrocarpa, Robinia Pseudo-Acacia, Salix alba,* and *Ulmus* sp. 4.VII.-28.VIII.

Subfamily Smiliinae Stål
Tribe Acutalini Fowler
Genus *Acutalis* Fairmaire

Acutalis tartarea (Say). — 64 localities; north to New-Richmond (Bonaventure Co.) and Mont-Laurier (Labelle Co.). In fields, along roadsides, at forest edge and in marshy areas; on weeds, and shrubs, especially *Eupatorium maculatum, Solidago canadensis,* and *Solidago* sp. This membracid has also been found on *Aster novae-angliae, A. umbellatus, Cornus obliqua, Eupatorium perfoliatum, Impatiens capensis, Picea glauca, Populus tremuloides, Rumex acetosella, Solidago graminifolia,* and *Salix* spp. 4.VI-3.X.

Genus *Micrutalis* Fowler

Micrutalis dorsalis (Fitch). — 9 localities; southernmost part of Québec. Found on *Clematis virginiana.* A few specimens also were collected on *Cornus* sp., *C. stolonifera,* and *Pinus strobus.* 21.VII-13.VIII.

Tribe Ceresini Goding
Genus *Hadrophallus* Kopp and Yonke

Hadrophallus borealis (Fairmaire). — 14 localities; north to Saint-Cyrille (Drummond Co.). Associated plant: *Ulmus americana.* 20.VII.-28.VIII.

Hadrophallus constans (Walker). — 14 localities; north to La Tuque (Champlain Co.). Found mainly on *Carya cordiformis, Quercus rubra,* and *Tilia americana. Tanacetum vulgare* is probably an accidental host. 17.VII.-19.IX.

Genus *Stictocephala* Stål

Stictocephala albescens **(Van Duzee).** — 5 localities; north to Berthierville (Berthier Co.). Collected from *Ostrya virginiana* and *Solidago canadensis.* 10.VIII.-3.IX.

Stictocephala basalis **(Walker).** — 201 localities; north to Chibougamau (Territoire-du-Nouveau-Québec). In fields, along roadsides, at forest edge, and in marshy areas; on weeds, shrubs, and trees, for example: *Betula lenta, Cirsium* sp., *Comptonia peregrina, Cornus stolonifera, Impatiens capensis, Juglans cinerea, Juncus* sp., *Larix laricina, Melilotus alba, Ostrya virginiana, Parthenocissus quinquefolia, Picea mariana, Picea* sp., *Pinus sylvestris, Populus balsamifera, P. tremuloides, Quercus macrocarpa, Q. rubra, Rhus typhina, Ribes* sp., *Rubus idaeus, Salix exigua, Solidago canadensis, Solidago* sp., *Tilia americana, Ulmus americana, Vicia Cracca, Vitis riparia,* and graminaceous plants. 16.VII.-18.IX.

Stictocephala bisonia **Kopp and Yonke.** — 77 localities; north to Ile Nepawa (Abitibi Co.) and Clermont (Charlevoix-Est Co.). In fields along roadsides and at forest edge; on weeds, shrubs and trees, for example: *Cornus obliqua, Corylus cornuta, Diervilla Lonicera, Eupatorium maculatum, Fraxinus* sp., *Picea glauca, Populus deltoides, Salix* sp., *Solidago* sp., and graminaceous plants. 1.VII.-8.X.

Stictocephala brevicornis **(Fitch).** — 17 localities; north to Cap-Rouge (Québec Co.). Specimens were taken from *Ostrya virginiana, Populus tremuloides, Prunus pennsylvanica,* and *Rubus alleghaniensis.* 16.VII.-11.IX.

Stictocephala diceros **(Say).** — 98 localities; north to La Tuque (Champlain Co.). In fields, along roadsides, on a variety of plants, for example weeds, shrubs, and trees such as: *Alnus* sp., *Amelanchier* sp., *Asclepias syriaca, Betula populifolia, Clematis virginiana, Cornus stolonifera, Corylus cornuta, Crataegus* sp., *Eupatorium maculatum, Fagus grandifolia, Fraxinus* sp., *Galium* sp., *Juglans cinerea, Parthenocissus qinquefolia, Picea glauca, Pinus Banksiana, P. sylvestis, Populus tremuloides, Prunus pennsylvanica, Quercus macrocarpa, Q. rubra, Robinia* sp., *Rubus odoratus, Salix* sp., *Sambucus canadensis, Solidago canadensis, Solidago* sp., *Ulmus americana, Urtica procera, Vaccinium* sp., *Vitis riparia,* graminaceous plants, and umbellifers. 12.VII.-17.IX.

Stictocephala lutea **(Walker).** — 9 localities; southernmost part of Québec. Collected only from *Acer saccharum.* 19.V.-24.VII.

Stictocephala palmeri **(Van Duzee).** — 8 localities; southernmost part of Québec. Primary associated plants: *Quercus rubra* and *Tilia americana. Populus balsamifera* is probably an accidental host. 28.VII.-6.X.

Stictocephala taurina **(Fitch).** — 55 localities; north to Saint-Vital-de-

Clermont (Abitibi Co.) and Gaspé (Gaspé-Est Co.). In fields, along roadsides and at forest edge, on a wide variety of plants such as weeds, shrubs and trees: *Aster umbellatus, Betula papyrifera, Carya ovata, Celtis occidentalis, Cirsium* sp., *Corylus cornuta, Crataegus* sp., *Diervilla Lonicera, Laportea canadensis, Pinus strobus, Populus tremuloides, Quercus macrocarpa, Robinia* sp., *Rubus idaeus, Salix* sp., *Solidago* sp., *Solidago canadensis, Thuja occidentalis, Tsuga canadensis, Ulmus* sp., *Viburnum Lentago.* 14.VII.-15.IX.

Stictocephala tauriniformis Caldwell. — FIRST RECORD FOR THE PROVINCE. 2 localities from the southernmost part of the Province: Shawville (Pontiac Co.) and Plaisance (Papineau Co.) (Specimens deposited in the Lyman Entomological Museum). Found by the authors on *Crataegus* sp. and *Tilia americana.* 27.VII.-2.VIII.

Genus *Tortistilus* Caldwell

Tortistilus inermis (Fabricius). — 27 localities; north to Cap-Rouge (Québec Co.). Weeds; in fields and along roadsides. 9.VI.-12.IX.

Tribe Polyglyptini Goding

Genus *Entylia* Germar

Entylia carinata (Forster). — 75 localities; north to New-Richmond (Bonaventure Co.) and Saint-Jean-sur-Lac (Labelle Co.). In fields, along roadsides, at forest edge and in marshy areas. On a wide variety of plants, weeds, shrubs, and trees, especially on: *Cirsium arvense, Cirsium* sp., *Eupatorium maculatum, Salix* sp., *Solidago canadensis,* and *Solidago* sp. This membracid has also been found in lesser numbers on *Acer rubrum, A. saccharum, Alnus* sp., *Anthriscus sylvestris, Artemisia Absinthium, Aster novae-angliae, Betula populifolia, Carpinus caroliniana, Chenopodium album, Juglans cinerea, Oenothera* sp., *Pinus Strobus, Populus tremuloides, Prunus pennsylvanica, Quercus rubra, Ranunculus abortivus, Rubus* sp., *Rumex crispus, Ulmus,* and *Viburnum cassinoides.* 26.IV.-14.IX.

Genus *Publilia* Stal

Publilia concava (Say). — 71 localities; north to Gaspé (Gaspé-Est Co.). In fields, along roadsides, at forest edge and in marshy areas; particularly on *Solidago canadensis* and *Solidago* sp. Also found on *Acer spicatum, Anemone canadensis, Anthriscus sylvestris, Aster umbellatus, Cornus alternifolia, C. stolonifera, Equisetum* sp., *Picea* sp., *Quercus rubra,* *Rhamnus frangula, Rubus alleghaniensis, R. idaeus, Rubus* sp., *Rumex acetosella, Tilia americana,* and *Urtica* sp. 12.IV.-30.IX.

Tribe Smiliini
Genus *Atymna* Stål

Atymna helena **(Woodruff).** — 6 localities; southernmost part of the Province. *Quercus macrocarpa* and *Q. alba.* 21.VI.-27.VII.

Atymna querci **(Fitch).** — 10 localities; southernmost part of the Province. Found on oak trees, *Quercus alba* and *Q. macrocarpa.* One specimen also was collected on *Ostrya virginiana.* 12.VI.-11.VIII.

Genus *Cyrtolobus* Goding

Cyrtolobus cinctus **Van Duzee.** — A single locality: Montréal (Ile-de-Montréal). Associated plants are unknown for the Province. 11.IX.

Cyrtolobus discoidalis **(Emmons).** — FIRST RECORD FOR THE PROVINCE. 12 localities; southernmost part of Québec (Specimens deposited in the Lyman Entomological Museum). Found by the authors mostly on *Quercus rubra,* but also on *Amelanchier* sp., *Diervilla Lonicera, Pinus Strobus, Populus tremuloides, Prunus pennsylvanica, Quercus macrocarpa,* and *Tsuga canadensis.* 15.VI.-30.VII.

Cyrtolobus fenestratus **(Fitch).** — 11 localities; southernmost part of the Province. Found mainly on *Quercus rubra.* A few specimens collected on *Quercus alba, Q. macrocarpa,* and *Ostrya virginiana.* 15.VI.-21.VIII.

Cyrtolobus fuliginosus **(Emmons).** — 5 localities; southernmost part of the Province. Associated plant: *Quercus rubra.* One specimen also found on *Ulmus americana.* 15.VI.-30.VII.

Cyrtolobus fuscipennis **(Van Duzee).** — 5 localities; southernmost part of the Province. Found mostly on *Quercus rubra.* A few specimens also collected on *Fraxinus americana,* and *Quercus alba.* 5.VI.-5.VIII.

Cyrtolobus gramatanus **Woodruff.**— 9 localities; southernmost part of the Province. Primary associated plant: *Quercus macrocarpa.* A few specimens also collected on *Juglans cinerea, Quercus alba, Q. bicolor, Q. rubra,* and *Viburnum Rafinesquianum.* 27.VI.-29.VII.

Cyrtolobus griseus **Van Duzee.** — 13 localities; southernmost part of the Province. Associated plants: *Quercus alba, Q. macrocarpa, Q. rubra.* A few specimens also found on *Acer spicatum, Betula lutea, Carpinus caroliniana, Rubus* sp., *Spiraea* sp., *Viburnum cassinoides,* and *Zanthoxylum americanum.* 12.VI-21.VIII.

Cyrtolobus maculifrontis **(Emmons).** — 9 localities; southernmost part of Québec. Primary associated plant: *Quercus macrocarpa.* A few specimens also collected from *Amelanchier* sp., *Cornus stolonifera, Corylus cornuta, Quercus bicolor,* and *Q. rubra. 16.VI.-27.VII.*

Cyrtolobus pallidifrontis (Emmons). — 6 localities; southernmost part of the Province. Mostly found on *Quercus alba,* but also on *Quercus bicolor, Q. macrocarpa,* and *Q. rubra.* 12.VI.-21.VIII.

Cyrtolobus puritanus Woodruff. — 2 localities from the Montréal area: Montréal (Ile-de-Montréal) and Saint-Hilaire (Rouville Co.). Associated plants are unknown for the Province. 4.-14.VII.

Cyrtolobus rufulus Woodruff. — 7 localities; southern most part of Québec. Found mainly on *Quercus macrocarpa.* Two specimens also were found on *Amelanchier* sp. and *Quercus alba.* 12.VI.-21.VIII.

Cyrtolobus vau (Say). — 6 localities; north to Lévis (Lévis Co.). Associated plants are unknown for the Province. VI.

Genus *Ophiderma* Fairmaire

Ophiderma definita Woodruff. — 13 localities; southernmost part of the Province. Primary associated plant: *Quercus rubra.* A few specimens also were collected on *Amelanchier* sp. and *Quercus alba.* 10.VI.-3.IX.

Ophiderma evelyna Woodruff. — One locality: Montréal (Ile-de-Montréal). Associated plants are unknown for the Province. 10.VII.1937.

Ophiderma flava Goding — 21 localities; north to Ile d'Orléans (Montmorency No. 2 Co.). Collected mostly from *Quercus rubra.* A few specimens also collected on *Abies balsamea, Acer pennsylvanicum, A. rubrum, Amelanchier* sp., *Carpinus caroliniana, Ostrya virginiana, Quercus alba, Tsuga canadensis,* and *Ulmus* sp. 2.VI.-21.VIII.

Ophiderma flavicephala Goding. — 2 localities from the southernmost part of Quebec: Montreal (Ile-de-Montréal) and Hudson-Heights (Vaudreuil Co.). Associated plants are unknown for the Province. 9-12.VI.

Ophiderma pubescens (Emmons). — 19 localities; north to Québec (Québec Co.). Primary associated plant appears to be *Quercus rubra.* A few specimens also were collected on *Acer Negundo, A rubrum, A. saccharum, Amelanchier* sp., *Carpinus caroliniana, Corylus cornuta, Ostrya virginiana, Populus tremuloides, Prunus pennsylvanica, P. serotina, Quercus alba, Rubus idaeus,* and *Salix* sp. 15.VI.-5.VIII.

Ophiderma salamandra Fairmaire. — 14 localities; north to Lévis (Lévis Co.). Primary associated plant: *Quercus rubra.* A few specimens also were collected on *Acer rubrum, A saccharum, Amelanchier* sp., *Ostrya virginiana, Picea* sp., *Pinus resinosa, Prunus pennsylvanica,* and *Quercus alba.* 14.VI.-21.VIII.

Genus *Smilia* Germar

Smilia camelus **(Fabricius).** — 19 localities; north to Trois-Rivières (Saint-Maurice Co.). Primary associated plant: *Quercus rubra.* A few specimens also collected on *Acer saccharum, Carpinus caroliniana, Potentilla argentea,* and *Salix* sp. 31.V.-30.VII.

Genus *Xantholobus* Van Duzee

Xantholobus intermedius **(Emmons).** — 1 locality from the Montréal area: Ile-de-Montréal. Associated plants are unknown for the Province. 19.VI.-17.VII.

Xantholobus muticus **(Fabricius).** — 8 localities: southernmost part of the Province. Found mostly on *Quercus macrocarpa.* Less frequently on *Cornus stolonifera* and *Crataegus* sp. 5.VI.-6.VII.

Tribe Telamonini Goding

Genus *Archasia* Stål

Archasia belfragei Stål — 10 localities; north to Québec (Québec Co.). Taken on oak trees, *Quercus alba* and *Quercus* sp. 20.VI.-2.VIII.

Genus *Carynota* Fitch

Carynota marmorata **(Say).** — 30 localities; north to Falardeau (Chicoutimi Co.) and Grande-Cascapédia (Bonaventure Co.). Found primarily on *Alnus* sp. but a few specimens also were collected on *Picea* sp. and *Salix* sp. 9.VII.-29.VIII.

Carynota mera **(Say).** — 11 localities; southernmost part of the Province. Found on a variety of plants including *Carya cordiformis, C. ovata, Juglans cinerea,* and *Quercus macrocarpa.* 14.VII.-19.IX.

Carynota stupida **(Walker).** — 30 localities; north to Val-Paradis (Territoire-du-Nouveau-Québec). Associated plants: *Betula lutea, B. papyrifera, B. populifolia,* and *B.* sp. A few specimens also caught on *Salix* sp. and *Spiraea* sp. 7.VI.-1.IX.

Genus *Glossonotus* Butler

Glossonotus acuminatus **(Fabricius).** — 9 localities; north to Sainte-Foy (Québec Co.). Primary associated plant: *Quercus rubra.* Two specimens collected from *Ostrya virginiana* and *Quercus alba.* 27.VII.-5.VIII.

Glossonotus crataegi **(Fitch).** — 6 localities; north to Lévis (Lévis Co.). A single specimen caught on *Ostrya virginiana,* the regular associated plant being *Crataegus* sp. 22.VII.-15.IX.

Glossonotus nimbatulus **Ball.** — 6 localities; southernmost part of the Province. Associated plants are unknown for the Province. 25.VI.-13.IX.

Glossonotus turriculatus **(Emmons).** — 4 localities; southernmost part of the Province. Found on *Quercus alba* and *Q. macrocarpa.* 10.VII.-26.VIII.

Glossonotus univittatus **(Harris).** — 18 localities; north to Saint-Maurice (Champlain Co.). Primary associated plants are *Quercus macrocarpa,* and *Q. rubra.* A few specimens also were collected on *Acer rubrum, Betula papyrifera, Celastrus scandens, Corylus cornuta, Crataegus* sp., and *Populus tremuloides.* 17.VI.-31.VIII.

Genus *Heliria* Stål

Heliria scalaris **(Fairmaire).** — 25 localities; north to Amqui (Matapédia Co.). Collected mainly from *Crataegus* sp. A few specimens also collected on *Betula papyrifera, Malus pumila* and *Salix* sp. 27.V.-30.VIII.

Genus *Palonica* Ball

Palonica pyramidata **(Uhler).** — 83 localities; north to Chibougamau (Territoire-du-Nouveau-Québec). Found on a wide variety of associated plants: *Salix amygdaloides, S.* sp. A few specimens also collected on *Abies balsamea, Alnus* sp., *Artemisia Absinthium, Betula populifolia, Clematis virginiana, Cornus stolonifera, Larix laricina, Picea* sp., *Pinus Banksiana, Populus balsamifera, P. tremuloides, Prunus pennsylvanica, Trifolium pratense,* and *Ulmus* sp. 3.VII.-7.IX.

Palonica tremulata **(Ball).** — FIRST RECORD FOR THE PROVINCE. 28 localities; north to Villemontel (Abitibi Co.) and Marsoui (Gaspé-Ouest Co.) (Specimens deposited in the Lyman Entomological Museum). Found by the authors on *Populus tremuloides.* A few specimens also were collected on *Alnus* sp., *Betula papyrifera, Fraxinus americana, Populus balsamifera, Quercus macrocarpa, Salix* sp., and *Vitis riparia.* 3.VII.-23.IX.

Palonica viridia **(Ball).** — FIRST RECORD FOR THE PROVINCE. One locality: Vaudreuil (Vaudreuil Co.) (Specimens deposited in the Lyman Entomological Museum). Found by the authors on *Populus deltoides.* 9.VII.1984.

Genus *Telamona* Fitch

Telamona ampelopsidis (Harris). — 25 localities; north to Lévis (Lévis Co.). Primary associated plant: *Parthenocissus quinquefolia.* A few specimens were found on *Betula papyrifera, Carya cordiformis, Corylus cornuta,* and *Thuja occidentalis.* 8.VI.-1.IX.

Telamona concava Fitch. — 4 localities; north to Lévis (Lévis Co.). Collected from *Quercus alba, Q. rubra,* and other species of oaks. Associated plants were previously unknown for this species. 21.VI.-21.VIII.

Telamona dubiosa Van Duzee. — FIRST RECORD FOR THE PROVINCE. One locality: Pointe-Claire (Ile-de-Montréal) (Specimens deposited in the Lyman Entomological Museum). On "tree". Specific associated plants are unknown for the Province. 2.VII.1919.

Telamona monticola (Fabricius). — 28 localities; north to Sainte-Foy (Québec Co.). Main associated plant: *Quercus rubra.* A few specimens also were collected on *Acer Negundo, Alnus* sp., *Betula lutea, B. papyrifera, B. populifolia, Fagus grandifolia, Pinus resinosa, Populus deltoides, P. tremuloides, Quercus alba, Q. macrocarpa, Q.* sp., and *Salix* sp. 10.VI.-1.IX.

Telamona reclivata Fitch. — 2 localities from the southernmost part of Québec: La Trappe (Deux-Montagnes Co.) and Montebello (Papineau Co.). Associated plants: *Carpinus caroliniana* and *Quercus rubra.* 1.VII.-27.VIII.

Telamona spreta Goding. — FIRST RECORD FOR THE PROVINCE. 14 localities; north to Lévis (Lévis Co.) (Specimens deposited in the Lyman Entomological Museum). Primary associated plant: *Quercus macrocarpa.* A few specimens also were collected by the authors on *Quercus alba, Q. bicolor, Q. rubra,* and *Populus tremuloides.* 20.VI.-6.X.

Telamona tiliae Ball. — 31 localities; north to Lac Saint-Jean (Lac Saint-Jean Co.). Found mainly on *Tilia americana.* A few specimens collected on *Ostrya virginiana, Quercus alba, Q. bicolor, Q. macrocarpa,* and *Q. rubra.* 1.VII.-14.X.

Telamona tristis Fitch. — 24 localities; north to Grande-Cascapédia (Bonaventure Co.). Associated plants: *Corylus cornuta,* less frequently found on *Betula lutea, Carpinus caroliniana, Ostrya virginiana,* and *Quercus alba.* 23.VI.-13.VIII.

Telamona unicolor Fitch. — 10 localities; southernmost part of the Province. Collected from *Carya cordiformis, Populus deltoides, Ulmus* sp., and *Viburnum Lentago.* 20.VI.-28.VIII.

Telamona westcotti Goding. — 7 localities; southernmost part of Québec.

Found on *Carya ovata, Quercus macrocarpa, Q. rubra,* and *Ulmus* sp. 27.VII.-6.VIII.

Genus *Thelia* Amyot and Serville

Thelia bimaculata (Fabricius). — 2 localities from the southernmost part of the Province: Ile Sainte-Hélène and Montréal (Ile-de-Montréal). Associated tree: *Robinia Pseudo-Acacia.* 12.VIII.-4.IX.

Thelia uhleri **Stål.** — FIRST RECORD FOR THE PROVINCE. 2 localities from the southernmost part of Québec: Ile de Carillon (Argenteuil Co.) and Baie Noire (Papineau Co.) (Specimens deposited in the Lyman Entomological Museum). Collected by the authors on *Prunus serotina* and *Tilia americana.* 10.-28.VII.

Scientific and common names of associated plants

Scientific names	Common names
Abies balsamea (L.)	Balsam Fir
Acer Negundo L.	Box Elder
Acer pennsylvanicum L.	Striped Maple
Acer rubrum L.	Red Maple
Acer saccharinum L.	Silver Maple
Acer saccharum Marsh.	Sugar Maple
Acer spicatum Lam.	Mountain Maple
Alnus sp.	Alder
Amelanchier sp.	Shadbush
Amphicarpa bracteata (L.)	Hog Peanut
Anemone canadensis L.	Canadian Anemone
Anthriscus sylvestris (L.)	Wild Parsley
Artemisia Absinthium L.	Absinth
Asclepias syriaca L.	Common Milkweed
Aster novae-angliae L.	New England Aster
Aster puniceus L.	Red-stalked Aster
Aster umbellatus Mill.	Umbellate Aster
Betula sp.	Birch
Betula lutea Michx.	Yellow Birch
Betula papyrifera Marsh.	Canoe Birch
Betula populifolia Marsh.	Grey Birch
Carpinus caroliniana Walt.	Hornbeam
Carya cordiformis (Wang.) K. Koch	Bitternut
Carya ovata (Mill.) K. Koch	Shag-bark Hickory
Celastrus scandens L.	Climbing Bittersweet
Celtis occidentalis L.	Hackberry
Chenopodium album L.	White Goosefoot
Cirsium sp.	Thistle

Scientific and common names of associated plants (Continued)

Scientific names	Common names
Cirsium arvense (L.) Scop.	Canada Thistle
Clematis virginiana L.	Virginia Virgin's Bower
Comptonia peregrina (L.) Coulter	Sweet Fern
Cornus sp.	Dogwood
Cornus alternifolia L.f.	Alternate-leaved Dogwood
Cornus obliqua Raf.	Oblique Dogwood
Cornus stolonifera Michx.	Red-osier Dogwood
Corylus cornuta Marsh.	Beaked Hazelnut
Crataegus sp.	Hawthorn
Diervilla Lonicera Mill.	Bush Honeysuckle
Equisetum sp.	Horsetail
Eupatorium maculatum L.	Joe-pye-weed
Eupatorium perfoliatum L.	Thoroughwort
Fagus grandifolia Ehrh.	American Beech
Fraxinus sp.	Ash
Fraxinus americana L.	White Ash
Galium sp.	Bedstraw
Impatiens capensis Meerb.	Cape Touch-me-not
Juglans cinerea L.	Butternut
Juncus sp.	Rush
Laportea canadensis (L.) Wedd.	Wood Nettle
Larix laricina (Du Roi) Koch	Tamarack
Malus pumila Mill.	Common Apple tree
Medicago sativa L.	Alfalfa
Melilotus alba Desr.	White Sweet Clover
Myrica Gale L.	Sweet Gale
Oenothera sp.	Evening Primrose
Ostrya virginiana (Mill.) K. Koch	Ironwood
Parthenocissus quinquefolia (L.) Planch.	Virginia Creeper
Picea glauca (Moench) Voss	White Spruce
Pinus Banksiana Lamb.	Jack Pine
Pinus resinosa Art.	Red Pine
Pinus Strobus L.	White Pine
Pinus sylvestris L.	Scotch Pine
Polygonum sp.	Knotweed
Polygonum persicaria L.	Lady's -thumb
Populus balsamifera L.	Balsam Poplar
Populus deltoides Marsh.	Cottonwood
Populus tremuloides Michx.	American Aspen
Potentilla argentea L.	Silvery Cinquefoil
Prunus pennsylvanica L.f.	Wild Red Cherry
Prunus serotina Ehrh.	Rum Cherry
Prunus virginiana L.	Choke Cherry
Quercus alba L.	White Oak
Quercus bicolor Willd.	Swamp White Oak
Quercus macrocarpa Michx.	Burr Oak
Quercus rubra L.	Red Oak

Scientific and common names of associated plants (Continued)

Scientific names	Common names
Ranunculus abortivus L.	Smooth-leaved Crowfoot
Rhamnus frangula L.	Black Buckthorn
Rhus typhina L.	Staghorn Sumac
Ribes sp.	Gooseberry
Robinia Pseudo-Acacia L.	Black-locust
Rubus sp.	Blackberry
Rubus alleghaniensis Port.	Alleghany Blackberry
Rubus idaeus L.	Wild Raspberry
Rubus odoratus L.	Flowering Raspberry
Rudbeckia hirta L.	Black-eyed Susan
Rumex acetosella L.	Field Sorrel
Rumex crispus L.	Curled Dock
Salix sp.	Willow
Salix alba L.	White Willow
Salix amygdaloides And.	Peach-leaved Willow
Salix exigua Nutt.	Sandbar Willow
Sambucus canadensis L.	Canadian Elder
Solidago sp.	Goldenrod
Solidago canadensis L.	Canada Goldenrod
Solidago graminifolia (L.) Salisb.	Narrow-leaved Goldenrod
Spiraea sp.	Meadow-sweet
Tanacetum vulgare L.	Common Tansy
Thuja occidentalis L.	White Cedar
Tilia americana L.	American Linden
Trifolium pratense L.	Red Clover
Tsuga canadensis (L.) Carr	Hemlock
Ulmus sp.	Elm
Ulmus americana L.	American Elm
Urtica sp.	Nettle
Urtica procera Muhl.	Stinging Nettle
Vaccinium sp.	Blueberry
Viburnum cassinoides L.	Appalachian Tea
Viburnum Lentago L.	Sweet Viburnum
Viburnum Rafinesquianum Schult.	Rafinesque's Arrow-wood
Vicia Cracca L.	Cow Vetch
Vitis riparia Michx.	Wild Grape
Zanthoxylum americanum Müll.	Prickly Ash

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ASPECTS OF FLIGHT BEHAVIOR IN *CALINEURIA CALIFORNICA* (PLECOPTERA: PERLIDAE) FROM A ROCKY MOUNTAIN LAKE OUTLET SYSTEM[1]

Barry C. Poulton, Kenneth W. Stewart[2]

ABSTRACT: Flight frequency of male and female *Calineuria californica* was measured on three 2-day periods during their June-July, 1987, emergence. Light energy, % relative humidity, and temperature were measured to identify relationships with flight periodicity, sites of water contact, and longevity. Peaks in male flight were related to evapotranspiration potential (PET), and female oviposition peaks were related to light intensity. Sexes exhibited significantly different choices in water contact, with males landing mostly at pools and females at riffles. Both sexes lived longer under shaded experimental conditions when water was available. Male and female *Calineuria californica* fly with different periodicities due to different environmental cues.

Calineuria californica (Banks) is widespread in western North America (Stark *et al.* 1986), where it is often abundant and contributes substantially to the community dynamics in many stream systems. Siegfried & Knight (1976a) reported aspects of its life history and growth, and confirmed a 2-3 year life cycle (Sheldon 1969, Heiman & Knight 1975). Delayed hatching occurs in some systems (Siegfried & Knight 1978). These studies and Baumann *et al.* (1977) report *C. californica* emergence in June and July.

Little is known of adult flight behavior for *C. californica* or any other species of summer emerging Plecoptera. Some observations are reported by Hynes (1972) and Macan (1974). Roos (1957), Elliott (1967), Shumacher (1970), and Madsen *et al.* (1973) have studied flight direction of Plecoptera and Ephemeroptera in accordance with Muller's (1954) hypothesis of drift recolonization and dispersal by upstream flight, but flight periodicity and behavior in relation to abiotic variables has been poorly studied in these orders. This study had 3 major objectives: 1) to identify relationships between *C. californica* flight and the abiotic variables temperature, relative humidity, and light, 2) to describe any unique flight behavior(s) in both sexes in relation to the abiotic variables, and 3) to experimentally measure longevity in relation to the abiotic variables.

METHODS

The study site was a 30 m section of Owl Creek, located 1.5 km below mesotrophic Placid Lake (460 ha, elev. = 1255 m) in the Clearwater River

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[1] Received November 2, 1987. Accepted February 12, 1988.

[2] Dept. of Biological Sciences, North Texas State University, Denton, Texas 76203.

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drainage, Missoula Co., Montana. Oswood (1976a) and Sheldon & Oswood (1977) found *C. californica* to be the dominant stonefly in Owl Creek. The site was 5-12 m wide, and its east-west position and open riparian canopy of tall conifers allowed maximum sunlight exposure. The 30 m segment was divided into equal 15 m riffle and pool sections by wooden stakes and plastic flagging to facilitate flight observations and enumeration.

All measurements were taken on 3 pairs of sampling dates during the emergence period (June 25-26, July 2-3, July 9-10, 1987). Adults were captured with a sweep net attached to an extendable 3.6 m tubular aluminum handle during one 15 min period within each 1/2 h from 16:00-22:00 and 06:00-12:00 the next morning. Numbers of *C. californica* flying were recorded and catagorized under sex and water contact (riffle, pool, or transient flight with no contact). Size difference frequently confirmed by net captures, enabled sexing of flying individuals. Percent relative humidity (R.H.) and air temperature (°C) were measured with a wet bulb-dry bulb Sling Psychrometer (J.L. Stortz Div., Perkasie, PA.), and light intensity was measured with a model 268WA620 light meter (Kahl Scientific, San Diego, CA.), and converted from Ft. Candles to Lux. All measurements were taken every 30 min during the study periods.

Net-captured stoneflies were placed in 10 cm X 7.5 cm X 5 cm wire screen cages. The top side was covered with rigid aluminum and secured with rubber bands to keep debris or rain from entering. These were kept in a cooler at 3-5°C and 80-90 % R.H. for no more than 12 h until used for longevity experiments. Mature nymphs were captured with a D-frame kick net, and reared to adults in cylindrical screen wire cages placed in the stream. Reared virgin adults were held in cages under the same conditions as field-collected adults. Exuviae were removed from 7 exposed boulders having an above-water surface area of approximately 4.3-5.1 m^2 to monitor emergence during the 3-week sampling period.

Two locations at the University of Montana Biological Station were used for longevity experiments: (1) 2 m from shore of Yellow Bay, Flathead Lake (elevated 1 m above the water surface and positioned in full sunlight), and (2) along Royce Creek (elevated 20 cm above the stream under a fully shaded canopy). Groups of caged individuals (no more than 4/cage of virgins or field-collected with or without water access, males or females) were kept in each of these locations. For the water access variable, 5 X 0.5 cm petri dishes were placed in all cages, with or without water (replaced daily or as necessary in the water available treatment). Light intensity, R.H. and temperature were recorded every 30 min during the same day-periods as on-site measurements at Owl Creek. Vitality was checked 2-3 times daily, and dead adults were removed and placed in 80% ethanol. Preserved females were later dissected with forceps under a binocular dissecting microscope to determine presence of remaining eggs.

Data analysis was completed with the North Texas State University computer system (National Advanced Systems 8043 Dual Processor) and the statistical analysis system (SAS). Tests included: 1) simple and multiple regressions with and without data transformations for flight frequency data, 2) analysis of variance (ANOVA) for longevity data including a Student Newman-Keuls (SNK) multiple range test, and 3) a paired T-Test for riffle vs. pool water contact in males and females. Since the validity of multiple regression depends on the absence of colinearity between independent variables, an attempt was made to combine these into one useable variable by computation of Evapotranspiration Potential (PET), since colinearity was expected between R.H., temperature, and light. This parameter (PET) gives the potential rate of air to cause evaporation from a transpiring surface such as a plant, or in this application, a stonefly adult, in mm of water per day from a particular known surface area. We calculated this parameter utilizing the Penman (1956) equation, which is treated in detail in the works of Penman (1955), Oliver (1973), and Eagleman (1976). Conversions from Lux of light to calories of energy were acquired from Weast (1986); these conversions are not exact, but give a relative unit of measure of light energy for purposes of this study. Approximate stonefly surface area was calculated using ocular micrometer measurements of the 3 body regions in both males and females.

RESULTS AND DISCUSSION

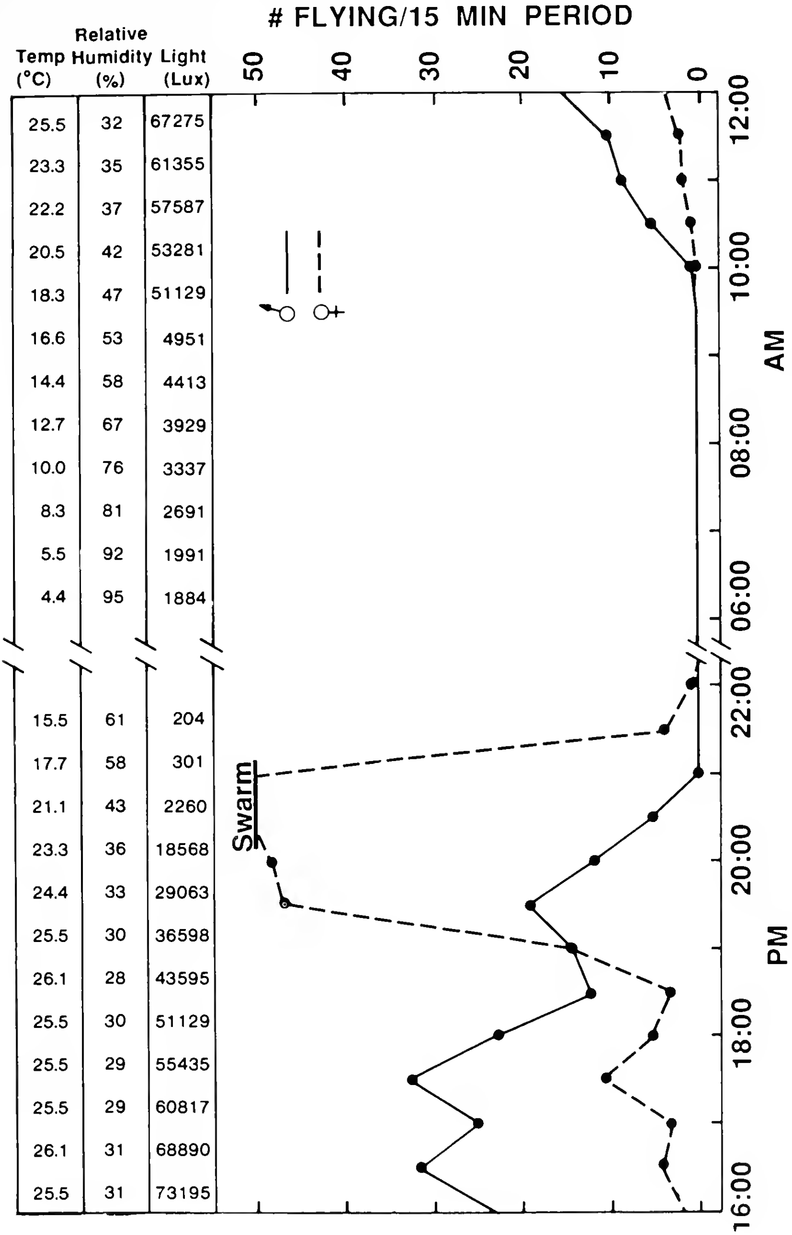
Emergence of *C. californica* was in progress and continued throughout the 3 week study period; number of exuviae removed from rock surfaces totaled 107, 63, 37, and mature nymphs collected for rearing totaled 31, 20, and 5 for the 3 pair of sampling dates, respectively. Assuming both sexes had similar preferences for emergence sites at Owl Creek, collected exuvia and reared nymphs reflected a population of 55% females and 45% males, suggesting a possible protandrous emergence in the early, unmonitored portion of the emergence period. No other large perlids were flying in large numbers; 3 *Hysperoperla pacifica* (Banks) were captured, and could easily be distinguished from *C. californica* based on size and body coloration. The 3 paired study dates were selected to insure a good range of weather conditions and abiotic variables, from warm and clear on June 25 (PM), 26 (AM), July 3 (AM), and July 9 (PM), to cloudy, cooler weather with rain nearby on July 2 (PM) and 10 (AM). Combining data from morning (AM) and evening (PM) flight did not increase the significance of any statistical relationship with abiotic variables, and therefore AM and PM data are reported separately in Table 1. Natural log transformations increased the data fit and statistical significance of all relationships, and are also reported in Table 1.

During longevity experiments, location 1 with full sunlight had mean temperatures 5% higher, relative humidities 8% lower, and light ca. 300% higher than shaded location 2. Using the Penman (1956) equation, these data convert to a mean PET 93% higher at location 1 during the hours between 06.00-22:00. Approximate mean stonefly surface area was calculated as 4.48 cm^2 for males and 6.95 cm^2 for females.

Male flight per 15 min. period peaked from 16:30-17:30 on June 25 and July 9 (Fig. 1). About 90% of male flight observed was when R.H. was below 40%, temperature was above 20°C, and light was above 10,765 Lux. The highest R^2 of models tested statistically was generated by a multiple regression with log-transformed flight frequency and the 3 abiotic variables for both AM and PM samples. However, due to significant colinearity between R.H., temperature, and light, the most valid statistical relationship was between flight frequency and PET. Evapotranspiration potential accounted for a significant portion of the variation in log-transformed AM flight frequency (R^2 =0.67) and log-transformed PM flight frequency (R^2 =0.73, Table 1), and reached a peak at 13.04 mm water/day at 16:30 for males. The largest portion of the variation in flight frequency attributed to any single regression variable was that of temperature in AM samples and % R.H. in PM samples (Table 1). These data suggest that stoneflies, like

Table 1. Summary of significant model statistics for *Calineuria californica* flight frequency in relation to abiotic variables and evapotranspiration potential (PET). All other models tested were not significant.

Dependent Variable	Independent Variable(s)	Test	Adjusted R^2	Prob. {F ($\propto$ =0.05)
♂ flight (AM)	temperature	regression	0.51	0.029
♂ flight (AM)	R.H.	regression	0.46	0.042
log ♂ flight (AM)	temp., R.H., light	regression	0.77	0.431
log ♂ flight (AM)	PET	regression	0.67	0.004
♂ flight (PM)	temperature	regression	0.59	0.0001
♂ flight (PM)	R.H.	regression	0.67	0.0001
♂ flight (PM)	light	regression	0.66	0.0001
♂ flight (PM)	temp., R.H., light	multiple reg.	0.75	0.0001
♂ flight (PM)	PET	regression	0.67	0.0001
log ♂ flight (PM)	temp., R.H., light	multiple reg.	0.86	0.0001
log ♂ flight (PM)	PET	regression	0.73	0.0001
♀ flight (PM)	light	regression	0.15	0.0196
♀ flight (PM)	temp., R.H., light	multiple reg.	0.42	0.0007
♀ flight (PM)	PET	regression	0.11	0.0298
log ♀ flight (PM)	temp., R.H., light	multiple reg.	0.56	0.0001
log ♀ flight (PM)	PET	regression	0.12	0.021



Temp (°C)	Relative Humidity (%)	Light (Lux)
25.5	32	67275
23.3	35	61355
22.2	37	57587
20.5	42	53281
18.3	47	51129
16.6	53	4951
14.4	58	4413
12.7	67	3929
10.0	76	3337
8.3	81	2691
5.5	92	1991
4.4	95	1884
15.5	61	204
17.7	58	301
21.1	43	2260
23.3	36	18568
24.4	33	29063
25.5	30	36598
26.1	28	43595
25.5	30	51129
25.5	29	55435
25.5	29	60817
26.1	31	68890
25.5	31	73195

Fig. 1. Flight frequency vs. Time in adult *Calineuria californica* during two, 6 hr periods on June 25-26, 1987 at Owl Creek, Montana. The other sampling periods demonstrated similar flight patterns.

other insects, may require a certain temperature in morning hours to attain heat energy for flight muscles to function, and since 82% of males observed flying made contact with water, late afternoon hours with low % R.H., high temperature, and high PET may stimulate a "drinking" response (dehydrating conditions prevail). During cloudy sampling dates [July 2 (PM), July 10 (AM)], male flight frequency was less, presumably due to higher % R.H. and much lower PET values. Longevity experiments reinforced this presumption, since significantly greater longevity occurred in males that were constantly provided with water (ANOVA, N=58, R^2 =0.88, F=56.15, P=0.0001). This is consistent with the work of Finni (1975) who suggested adult preference for areas of constant temperature and relatively high humidity, such as under rocks or tree bark. Male *C. californica* at Owl Creek were presumably expending flight energy to increase their longevity through drinking water.

Female flight frequency per 15 min sample peaked between 19:30-21:00 (Fig. 1) during all sets of sampling dates, with swarms of 50+ individuals observed at ca. 20:45. Lower numbers flew during cloudy and cooler weather on July 2 (PM) and this was apparently not due to a reduction in number of adults present, because a 20:45 peak on July 9 with high numbers nearly equalling that of June 25 was observed. About 90% of female flight was observed above 35% R.H., above 18°C, and below 37,675 Lux. The highest R^2 of models tested statistically was generated by a multiple regression with log transformed flight frequency and the 3 abiotic variables for both AM and PM samples. Female flight does not appear to be related to dehydration as is the case with males; % R.H. did not contribute significantly to any model tested, PET did not have a significant relationship with AM flight frequency, and low R^2 were generated with log-transformed PM flight data (R^2 =0.12, Table 1). PET values reached a peak of 19.03 mm water/day at 16:30, but very few females were observed flying near this time period. Larger amounts of fat, and therefore greater water storage in females may make "drinking" behavior less frequent, or females may combine this behavior with their water contact during oviposition to conserve energy. The largest portion of the variation in flight frequency attributed to any single abiotic variable was with temperature in AM samples and light in PM samples. Again, temperature appears necessary for generating flight energy during AM hours, and light is a significant stimulant to female flight in evening hours (Table 1). No oviposition swarm occurred during cloudy conditions on July 2 (PM), even though temperatures were warm enough for flight. About 89% of enumerated females made water contact, and net collected females frequently had attached egg masses on their abdomens. During flight from the canopy, wing beat ceased as far as 10 m above the stream. Females glided to the surface, spent 5-10 s in contact with water to oviposit, then presumed flight to return to the canopy. This gliding, "dive-bombing" method of oviposition is similar to that reported for *Clioperla clio* (Minshall & Minshall 1966).

Observations of female swarms on June 25 (PM) and July 9 (PM) confirmed light and temperature as plausible cues for stimulating flight. After oviposition and water contact ceased, the swarm gradually moved higher in elevation until 21:15 when the lowest females flying were at tree-top level. This corresponds with the level where direct sunlight still illuminated the tree tops of the riparian canopy, and when temperatures exhibited their most rapid decrease. Convective heat loss and the rise of moist air masses from the stream bed may also have contributed to the rise in the female swarm at dusk.

Female longevity data were similar to males, with significantly greater longevity for those given water and/or maintained in a cooler, shaded, moderately humid environment (Table 2). Since spent females were not expected to live long enough for the difference in abiotic factors to affect them, they were treated as separate groups in the analysis of variance,

Table 2. Summary of longevity statistics for *Calineuria californica.* Analysis of Variance (ANOVA) yielded an $R^2 = 0.88$, prob. $< F = 0.0001$ for males and $R^2 = 0.82$, prob. $> F = 0.0001$ for females, showing a significant difference in mean longevity for both sexes.

♂ H_2	location	Collection	N	X longevity (hr)	SNK grouping (means with the same letter are not significantly different)				
yes	shade	reared virgins	4	243	A				
yes	sun	reared virgins	6	138		B			
no	shade	reared virgins	3	112		B	C		
yes	shade	field collected	8	99			C		
yes	sun	field collected	8	64				D	
no	shade	field collected	15	48				D	E
no	sun	reared virgins	4	48				D	E
no	sun	field collected	10	23					E
♀									
yes	shade	reared virgins	4	213	A				
yes	sun	reared virgins	5	153		B			
no	shade	reared virgins	3	100			C		
yes	shade	field collected	16	92			C		
yes	sun	field collected	15	69			C	D	
no	sun	reard virgins	4	60			C	D	E
no	shade	field collected	10	47				D	E
no	shade	field collected	10	35				D	E
yes	shade	field - spent	2	30				D	E
yes	sun	field - spent	11	19					E
no	shade	field - spent	2	18					E
no	sun	field - spent	7	14					E

which showed significant differences in mean hours kept alive (N=67, R^2=0.82, F=33.77, P=0.0001). Longevity summary statistics for both sexes, including Student Newman-Keuls multiple range test, are given in Table 2 and are consistent with the work of Finni (1975) who found that *Allocapnia granulata* (Claassen) given water had significantly greater longevity than those without water. Reared virgin males given water had the greatest longevity (N=4, $\bar{X}$=213 h), and as expected, field collected spent females had the shortest longevity (N=7, $\bar{X}$=14 h).

Difference in male and female flight periodicity was indicated by the 2-3 hr difference in PM flight peaks (Fig. 1). The sexes also exhibited different water-contact sites, with significantly more males landing in the pool segment of the 30 m study site (N=320, $\bar{X}$=63.5%, paired T=6.01, P=0.0001) and 90.8% of females ovipositing in the riffle segment (N=374, paired T=-4.54, P=0.0001). Similarily, Macan (1974) postulated that flying insects are attracted to reflective surfaces such as riffles, and ovipositing females during swarms may have the ability to detect the greater range of wavelengths and incident angles of reflected light from a riffle area. This reflected light is greater during clear weather, which may partially explain female oviposition swarms of smaller numbers during cloudy periods such as that observed on July 2 (PM).

CONCLUSION

It is apparent that flight frequencies in male and female *Calineuria californica* from Owl Creek, Montana, were due to different cues, and occur at different time periods for different reasons due to differences in moisture, light, and temperature. Males appeared to fly in response to dehydration conditions such as low R.H., high temperature and greater sunlight energy, leading to greater PET values. Females responded significantly to light, and had a peak flight period 2-3 hr later than males. Relationships between male flight and % R.H. were stronger than that of females in our study. During morning periods, the effect of temperature thresholds prevailed in keeping stoneflies from flying until sufficient energy was generated to sustain flight later in the day. Longevity data reinforced our presumptions that water was important for extended survival of both sexes, and spent females may be ready to die regardless of experimental conditions. More behavioral experiments with stonefly flight are needed over longer periods of time with other species to better define flight patterns and behavior in Plecoptera.

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DIABROTICA CRISTATA, A CHRYSOMELID (COLEOPTERA) OF RELICT MIDWESTERN PRAIRIES DISCOVERED IN EASTERN SERPENTINE BARRENS[1]

A.G. Wheeler, Jr.[2]

ABSTRACT: *Diabrotica cristata*, a galerucine chrysomelid characteristic of relict prairie ecosystems in the Great Plains but seldom collected on the eastern seaboard, is reported from four serpentine barrens in southeastern Pennsylvania and one in adjacent Maryland. Large populations were present in two of the barrens, with adults collected from inflorescences of two grasses and from 17 species of forbs in 7 families. The larval host was not determined but is suggested to be little bluestem, *Schizachyrium scoparium*, a perennial grass dominant on serpentine soils, or the less abundant big bluestem, *Andropogon gerardii*, a known host of *D. cristata* in midwestern prairies.

Diabrotica cristata (Harris) belongs to the chrysomelid subfamily Galerucinae and tribe Luperini. It is a member of the *virgifera* group of the large New World genus *Diabrotica*, which in the United States includes the northern corn rootworm, *D. barberi* Smith and Lawrence; western corn rootworm, *D. virgifera virgifera* LeConte; and Mexican corn rootworm, *D. v. zeae* Krysan and Smith (Branson and Krysan, 1981; Krysan and Smith, 1987).

Smith (1966) noted the association of *D. cristata* with wild grasses in the United States east of the Rocky Mountains and south onto the Mexican Plateau. But until recently biological information on this rather inconspicuous inhabitant of relict prairie ecosystems was scant, and the use of grasses as larval hosts remained unconfirmed. Problems in developing corn lines resistant to rootworms, however, focused attention on the noneconomic *D. cristata*. It was hoped that an increased knowledge of its habits might elucidate the evolution of host relationships among pestiferous species of the *virgifera* group and lead to better methods of managing their populations.

Wiesenborn and Krysan (1980) observed adults of *D. cristata* on flowers of various forbs, where they apparently feed on pollen. In their survey of relict prairies in eastern South Dakota and southwestern Minnesota, they found that big bluestem, *Andropogon gerardii* Vitman, usually was a good indicator plant for *D. cristata*, but that its presence did not always provide for a beetle population. Krysan (1982) hypothesized a tropical origin of the egg dormancy mechanism in this group of *Diabrotica*, which enabled the species to invade temperate North America and to specialize on perennial grasses, a predictable food resource but one of

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restricted availability. For *D. cristata,* complexity of prairie sod and small larval populations precluded the verification of grasses as host plants; thus, grasses had been only inferred as hosts until Yaro and Krysan (1986) found larvae feeding on roots of *A. gerardii* in South Dakota. In the laboratory, this species has been reared on roots of corn (Krysan and Smith, 1987).

Although *D. cristata* was originally described from Northampton, Massachusetts (see Smith and Lawrence, 1967), and is known from New Hampshire south to Georgia and Alabama (Krysan and Smith, 1987), specimens from eastern United States are generally scarce in collections (J.L. Krysan, pers. comm.). Krysan and Smith (1987) remarked that populations of nonpest species of the *virgifera* group are "highly localized within their overall ranges." Large numbers of *D. cristata* apparently have not been recorded along the eastern seaboard, and habitat preferences outside relict midwestern prairies are unknown.

The presence of *D. cristata* in eastern serpentine barrens, including large populations at two localities, is here reported. Serpentine barrens are unique habitats that harbor a characteristic flora associated with nutrient-poor, rocky soils and are only beginning to be appreciated for their interesting insect fauna. The number of adults collected in inflorescences of various forbs and grasses on several sample dates is also given.

METHODS AND STUDY SITES

Following the discovery of *D. cristata* in a Pennsylvania serpentine barren, several eastern barrens were surveyed during late July to early September 1987 to determine the beetle's relative abundance and plant species used for adult feeding. Inflorescences of forbs and grasses were tapped into a small beating net and plant species harboring adults were recorded. On 8 Aug. the numbers of *D. cristata* taken in inflorescences of various plants during approximately 75 minutes of collecting at each of 3 serpentine barrens (Goat Hill, Nottingham Park, and Soldiers Delight) were recorded. Similar surveys of some of the same and additional barrens were made on 12 and 19 Aug. and 2 Sept. 1987. Voucher specimens of *D. cristata* have been deposited in the insect collections of Cornell University and Pennsylvania Department of Agriculture.

In addition, inflorescences of plants growing just outside (1-2 km) the well-defined limits of the Goat Hill and Nottingham Park barrens were surveyed for *D. cristata.* During studies of other insects, similar methods were used from late July to early September to try to detect populations in nonserpentine habitats in eastern Pennsylvania.

The serpentine barrens surveyed are outcrops of serpentinite, an ultramafic, often yellowish-green rock containing at least 50% hydrous magnesium silicate. In eastern North America these barrens belong to a broken chain of isolated areas stretching from western Newfoundland and the Gaspé Peninsula to east-central Alabama; the best developed formations lie in the hilly, eroded easternmost portion of the Piedmont Upland in southeastern Pennsylvania and northern Maryland (Pennell, 1930; Miller, 1977; Reed, 1986).

Serpentine soils, although varying in chemical and physical properties from site to site, tend to be low in calcium (and often other nutrients), high in iron and magnesium, and sometimes also high in chromium, cobalt, and nickel. Soils usually are shallow, excessively dry, rocky and, owing mainly to toxic concentrations of heavy metals, low calcium levels, and to other adverse chemical and physical features, are unfavorable for agriculture. Vegetation developing on nutrient-poor serpentine soils is sparse, often stunted, and nearly always contrasts sharply from that of surrounding areas (Proctor and Woodell, 1975; Miller, 1977; Mansberg and Wentworth, 1984). Serpentine plant communities are thus characterized by endemism, disjunct ranges, ecotypic differentiation, and morphological variants (Proctor and Woodell, 1975; Mansberg and Wentworth, 1984). Recent work by Knox (1984) suggested that recruitment of forest communities is episodic rather than continuous and reflects regular disturbance of stands by fire or drought, which maintains the open habitat supporting a characteristic flora.

The following are brief descriptions of the serpentine areas surveyed. Additional information on plant communities of these and other eastern serpentine barrens is available in Harshberger (1903, 1904), Pennell (1910, 1930), Wherry (1963), Miller (1977), and Reed (1986).

Goat Hill Serpentine Barrens: southeastern Chester Co., Pennsylvania, along the Octoraro Creek southwest of Nottingham near the Maryland State line; one of the largest of the eastern serpentines, encompassing 700 acres (283 ha) of pitch pine (*Pinus rigida* Mill.) - scrub oak (*Quercus ilicifolia* Wang. and *Q. prinoides* Willd.) forest; thickets of greenbrier (*Smilax* spp.); localized blackjack and post oak (*Q. marilandica* Muenchh. and *Q. stellata* Wang.); parklike openings dominated by little bluestem or prairie beardgrass (*Schizachyrium scoparium* (Michx.) Nash) and other bunch grasses; and xeric rock and gravel outcrops characterized by the presence of serpentine aster (*Aster depauperatus* (Port.) Fern.) (Asterceae), fame flower (*Talinum teretifolium* Pursh (Portulacaceae), and sandwort (*Arenaria stricta* Michx.) (Caryophyllaceae) (Pennell, 1910).

Nottingham Park Barrens: 645 acres (261 ha) west of Nottingham; like Goat Hill, belonging to the state line barrens and having diverse plant communities dominated by pine-smilax thickets, bare exposures with various "indicator" plants, and grassy openings, some with nearly pure stands of little bluestem.

New Texas (Lyles) Barrens: another of the state line group, 255 acres (103 ha) lying south of Wakefield in southern Lancaster Co. near Conowingo Creek; characterized by Virginia pine (*Pinus virginiana* Mill.), mixed oaks, eastern red-cedar (*Juniperus virginiana* L.), and large open areas of little bluestem and other grasses.

Rock Springs Barrens: 176 acres (71 ha) south of New Texas at Jenkins Corner just north of the Maryland line; the site of Miller's (1977) ecological study, consisting of Virginia pine-oak forest, open areas of little bluestem and other grasses, and other plant communities typical of eastern serpentines.

Pink Hill (Middletown) Barrens, Tyler Arboretum: about 20 acres (8 ha) (Godfrey, 1980) near Lima, Delaware Co., and a member of the Philadelphia District barrens (Reed, 1986); a relatively undisturbed area (Brooks, 1987) dominated by carpets of *Cerastium arvense* L. (Caryophyllaceae) and *Phlox subulata* L. (Polemoniaceae), stands of *Schizachyrium scoparium,* and scattered colonies of *Pycnanthemum tenuifolium* Schrad (Lamiaceae).

Unionville Barrens: a member of the Chester (Pennell, 1910) or West Chester District (Reed, 1986) and, like Pink Hill, separated from the state line group of barrens; 170 acres (69 ha) of pine-oak forest, dry upland thickets, open grassland, and other serpentine communities (Pennell, 1910) lying 1 1/2 miles northeast of Unionville (Wherry, 1963).

Soldiers Delight: an extensive serpentine outcrop of nearly 2,000 acres (800 ha) southwest of Reisterstown, Baltimore Co., Maryland, with diverse plant communities, including stands of Virginia pine, mixed oaks, openings of little bluestem and other grasses, and serpentine indicator plants (Godfrey, 1980; Knox, 1984; Reed, 1986; Brooks, 1987).

RESULTS

During studies of Miridae and other Heteroptera in the Goat Hill barrens on 20 July 1987, I collected a *Diabrotica* sp. with which I was unfamiliar. After adults were determined as *D. cristata,* a chrysomelid seldom collected in the mid-Atlantic region, I returned to obtain additional specimens and make observations. On 23 July, 21 adults were collected from inflorescences of yarrow, *Achillea millefolium* L. (Asteraceae); numerous other adults were observed. Large numbers of beetles were taken on plant inflorescences in the Goat Hill (118 specimens) and Nottingham Park barrens (126) on 8 Aug. (Table 1), including a mating pair on Queen Anne's-lace, *Daucus carota* L. (Apiaceae). Cornfields are common in the farmland surrounding these barrens, and on many inflorescences adults of the northern corn rootworm, *D. barberi,* were also present. Much smaller numbers of *D. cristata* were found on 8 Aug. at Soldiers Delight, where adults were observed only on inflorescences of plants growing near a stream: the composites *Eupatorium fistulosum* Barratt (1 adult), *Liatris spicata* (L.) Willd. (1), *Solidago juncea* Ait. (1), and *Vernonia noveboracensis* (L.) Michx. (3).

On 12 Aug., *D. cristata* was collected in serpentine barrens at Unionville and New Texas. At Unionville small numbers of beetles were observed on the composites *Cirsium muticum* Michx. (3 adults) and *Eupatorium fistulosum* Barratt (3); 6 adults were observed on another composite, *Solidago juncea,* at New Texas. No adults of *D. cristata* were collected during extensive sampling at the Pink Hill barrens on 12 Aug. Four adults were observed on *E. fistulosum* inflorescences at New Texas during additional surveys on 19 Aug., and only 1 adult, on *S. juncea,* was collected at Rock Springs. Plants from which *D. cristata* was collected in return trips to the Nottingham Park barrens on 19 Aug. and 2 Sept. are listed in Table 1. No additional adults were taken at New Texas on 2 Sept.

Large numbers of *D. cristata* also were observed on inflorescences of the composites *C. muticum, Eupatorium perfoliatum* L., *Heliopsis helianthoides* (L.) Sweet, and *Rudbeckia laciniata* L. within 2 kilometers of the Nottingham Park barrens on 12 Aug. Otherwise, this chrysomelid was scarce or absent on plants adjacent to serpentine barrens. No adults were collected in nonserpentine habitats in Pennsylvania.

DISCUSSION

Diabrotica cristata was present at five of the six serpentine barrens surveyed, with large populations found at Goat Hill and Nottingham Park and much smaller numbers at New Texas, Soldiers Delight, and Unionville; only Pink Hill proved negative for the beetle. Similarly, Wiesenborn and Krysan (1980) reported an irregular distribution for *D. cristata* in the northern Great Plains: abundant in some relict prairies but present in small numbers or absent in other prairies of similar vegetation. At Goat Hill and Nottingham Park the beetles were particularly numerous in inflorescences of dwarf sumac (*Rhus copallina*), joe-pye weed (*Eupatorium fistulosum*) and yarrow (*Achillea millefolium*). These plants (and certain others listed in Table 1) may represent preferred sources of pollen, but those yielding adults could merely have been common species that were in bloom and were encountered during the 75-minute surveys. Adults were taken in inflorescences of some of the same plant genera from which *D. cristata* was collected in the northern Great Plains: *Andropogon, Asclepias, Cirsium, Liatris, Rhus, Rudbeckia,* and *Solidago* (Kirk and Balsbaugh, 1975; Wiesenborn and Krysan, 1980). *Diabrotica cristata* and *D. barberi* are unique among species of the *virgifera* group in using a diverse group of forbs for adult feeding rather than specializing on cucurbits (Yaro *et al.,* 1987), although both will feed compulsively on cucurbitacins in laboratory assays (see Krysan and Smith, 1987).

Grasses serving as larval hosts of *D. cristata* in mid-Atlantic serpentines were not determined, but *Andropogon gerardii,* the only grass known to be a host in midwestern prairies (Yaro and Krysan, 1986), occurs at Nottingham Park (T.L. Smith, unpubl. data) and Soldiers Delight (Godfrey,

Table 1. Numbers of *Diabrotica cristata* adults collected from plant inflorescences in two serpentine barrens during summer 1987; see Methods and Study Sites for details of survey techniques and descriptions of habitats.

	Goat Hill	Nottingham Park		
Taxa	8 Aug.	8 Aug.	19 Aug.	2 Sept.
Anacardiaceae				
Rhus copallina L.	7	60	-[a]	-
Apiaceae				
Daucus carota L.	1	10	-	-
Asclepiadaceae				
Asclepias verticillata L.	1	-	-	-
Asteraceae				
Achillea millefolium L.	8	35	-	-
Ambrosia artemisiifolia L.	-	-	-	-
Cirsium muticum Michx.	-	9	5	3
Eupatorium aromaticum L.	-	1	-	-
E. fistulosum Barratt	92	-	8	-
E. perfoliatum L.	-	-	7	-
E. rugosum Houtt	-	3	-	-
Heliopsis helianthoides (L.) Sweet	3	-	-	1
Solidago juncea Ait.	4	-	1	-
S. nemoralis Ait.	-	-	-	7
Vernonia noveboracensis (L.) Michx.	-	1	-	-
Lamiaceae				
Pycnanthemum tenuifolium Schrad.	1	6	-	-
Poaceae				
Andropogon gerardii Vitman	-	-	3	-
Setaria faberi Herrm.	-	1	-	-
Phytolaccaceae				
Phytolacca americana L.	1	-	-	-
Rosaceae				
Spiraea latifolia (Ait.) Borkh.	-	-	2	-
Totals	118	126	27	11

a: Plant in pre- or post-bloom stage and therefore not sampled, or blooming but not encountered during c. 75 min. of survey.

1980). *Schizachyrium scoparium* (formerly in *Andropogon),* however, is a dominant plant of eastern serpentine barrens (Pennell, 1910; Stone, 1945; Braun, 1950) and a likely larval host plant of *D. cristata.* Godfrey (1980) noted that *S. scoparium* apparently is tolerant of heavy metals occurring in serpentine soils, has modest demands for nutrients, and benefits from the exclusion of competing plant species.

Diabrotica cristata has been recorded from widespread localities along the eastern seaboard (Krysan and Smith, 1987). Although several correspond well to the distribution of ultramafic rocks mapped by Reed (1986) and Brooks (1987), *D. cristata* obviously is not restricted to such outcrops. But east of the main Prairie Province (see Smith, 1957), which has isolated communities extending as far east as northwestern Pennsylvania (Transeau, 1935), some of the largest populations appear to occur in serpentine barrens. These relatively undisturbed islands in the eastern deciduous forest or in surrounding farmland have distinctly midwestern grassland communities that develop in parklike openings. Three of the "big four" of tall grass prairies — *A. gerardii, S. scoparium,* and Indian grass, *Sorghastrum nutans* (L.) Nash (Gould, 1975) — occur in many eastern serpentine barrens. Other grasses of midwestern plains and prairies that are present include *Aristida dichotoma* Michx., *Bouteloua curtipendula* (Michx.) Torr., and *Sporobolus heterolepis* (A. Gray) A. Gray (Pennell, 1910; Godfrey, 1980; Brooks, 1987; T.L. Smith, unpubl. data). In my survey of the eastern serpentine barrens, adults of *D. cristata* were confined to serpentine outcrops or were observed only in inflorescences of forbs growing at the periphery of these well-defined habitats.

Several authors, namely Proctor and Woodell (1975), Kruckeberg (1984), and Brooks (1987), have emphasized the dearth of ecological information available on insects and other animals associated with serpentine soils. Kruckeberg pointed out that the unique substrate should "be expected to harbor unusual faunistic features."

Five species of skippers (Lepidoptera: Hesperiidae) known to develop on *Schizachyrium scoparium* in barren habitats appear also to be intimately associated with this grass; these species either occur frequently in or are restricted to such areas in a portion of their range (Opler and Krizek, 1984). For *Hesperia metea* Scudder and *Atrytonopsis hianna* (Scudder), hesperiids for which substantial ecological and distributional data were lacking, Shapiro (1965) reported a close relationship with *S. scoparium;* neither skipper occurs in situations where little bluestem is not dominant or where it is only a short-term member of the vegetation. In southeastern Pennsylvania these hesperiids and their host reach maximum abundance on "dry, open hillsides," but they may be found in other areas of the state where little bluestem is a dominant component of the vegetation (Shapiro, 1965).

On the eastern seaboard the chrysomelid *D. cristata* becomes numerous in several serpentine barrens and could be expected to occur in nonserpentine habitats dominated by *S. scoparium,* for example, the New Jersey Pine Barrens (Shapiro, 1965). In the mid-Atlantic region it might be present in small numbers where little bluestem colonizes temporarily as an early successional species. *Diabrotica cristata* might also occur on the poor, rocky soils of New England where, according to Shapiro (1965), more permanent stands of this grass tend to develop. Specifically, this chrysomelid should be looked for near its type locality, Northampton, Massachusetts, where colonies of little bluestem occupy ridges of the nearby Mount Tom Range (B. Sorrie, pers. comm.).

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A NEW SUBSPECIES OF *CICINDELA POLITULA* FROM NEW MEXICO AND A RANGE EXTENSION FOR *CICINDELA POLITULA BARBARAANNAE* (COLEOPTERA: CICINDELIDAE)[1]

Ed V. Gage[2]

ABSTRACT: Extensive collecting throughout New Mexico has extended the range of *Cicindela politula* with the discovery of a new subspecies. This subspecies is described from 36 specimens. During this comprehensive study the known range for *C. p. barbaraannae* was extended into two additional mountain ranges in western Texas.

Cicindela politula LeConte and its known subspecies were reviewed by Sumlin (1985) and the new subspecies, *C.p. petrophila* was described from the Guadalupe Mountains of Texas and New Mexico. During surveys conducted in 1984 and 1986 for the United States Department of the Interior throughout western Texas and New Mexico to determine the exact range of this subspecies, I discovered a population which proved to be another distinct subspecies of *C. politula.*

Cicindela politula viridimonticola n. spp.

(Fig. 1)

Head: Vertex predominantly bright green (75% of the population), occasionally blue-green (19%) or cupreous (6%); and usually with fine purple or violet wrinkles between the eyes. Frons usually green (94%), occasionally blue (6%) with purple or violet stripes anterior to the eyes and extending to the clypeus. Many individuals exhibit a narrow metallic gold band vertically dividing the frons. Vertex and frons glabrous except for supraorbital sensory setae. Genae and clypeus glabrous. Clypeus green and/or violet, occasionally with purple or blue-green reflections. Labrum with a single row of subapical setae (4-7 setae, average 5.75). Labrum of female with prominent single tooth, males without this tooth. Genae violet or occasionally blue-green. Antennal scape green with cupreous or violet reflections and bearing a single subapical seta.

Thorax: Pronotum glabrous medially and laterally, finely wrinkled, predominantly green (69%), occasionally blue-green (25%), or rarely cupreous (6%); pronotal sulci predominantly purple (76%), blue (12%), or green (12%); proepisternum sparsely setose along ventral margin, usually bicolored; most frequent combinations include green and blue-green or yellow; green and purple, cupreous, or black; mesepisternum predominantly purple (56%), although blue-green (25%), blue (13%), and green (6%) occasionally occur; metepisternum green with an occasional blue or cupreous reflection; Procoxa, mesocoxa, lateral edges of metacoxa, proepimeron, mesepimeron, and metepisternum with seate; prosternum, mesepisternum, mesosternum and central metasternum glabrous.

Abdomen: Lateral edges of venter usually with a sparse covering of decumbent setae. Posterior two abdominal segments and lateral margins of visible segments red-testaceous. Remainder of ventral segments red-brown.

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[2] Research Associate, Florida State Collection of Arthropods, P.O. Box 63447, Pipe Creek, Texas 78063.

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Elytra: Male, nearly parallel-sided although slightly wider from basal third to apical third and evenly rounded to apex. Female slightly wider from basal third to apical third and evenly rounded to apex. Both male and female equipped with small sutural spines, microserrate apical margins and shallow to obscure punctae. Maculation consists of a complete marginal line with no breaks from the humerus to the apical suture in 20 (55.5%) of the individuals collected. The marginal line is broken once above the apical lunule on 10 (27.8%) specimens. This separation is sometimes so narrow it cannot be seen without some magnification. These two maculation types are referred to as a complete or fully developed marginal line. Together they represent 83.3% of the sample. On the 6 remaining individuals (16.7% of the sample), the marginal line is separated into three or four segments. Maculation white; elytral color of live specimens a brilliant grass-green in 91.6% of the individuals. Cupreous-green and greenish-purple elytra each make up 2.7 and 5.5% respectively. After being cleaned in ether, a few specimens darkened from bright green to greenish-purple or blue.

Type locality: New Mexico: Eddy County, 129.16 kilometers south of Artesia, above 2192.8 meters elevation.

Holotype: Male. Eddy Co. New Mexico, 13 August 1983, Ed V. Gage, collector. Deposited in the Florida State Collection of Arthropods, Division of Plant Industry, Gainesville, Florida.

Allotype: Female. Same data as holotype. Specimen remains in the author's collection.

Paratypes: 7 males, 7 females, same data as holotype; 9 males, 11 females (including Figure 1), same data as holotype except 6 August 1983. Paratype distribution: one paratype to the National Museum of Natural History, Washington, D.C.; one paratype each to W.D. Sumlin, III, D.L. Pearson, and W. Johnson; the remaining paratypes are in the author's collection.

Etymology: Derived from the Greek for "green, mountain dweller" which characterizes this subspecies.

Common name: Green, mountain tiger beetle.

Diagnosis: The new subspecies differs from all other known subspecies by its striking color difference. This is the only predominantly pure green subspecies of *C. politula* with a continuous marginal line or with a slight break located above the apical lunule. Nominate *C. politula* is completely black with a small apical lunule while the subspecies *C.p. laetipennis* is predominantly purple or purple-blue with the marginal line broken into several sections. Subspecies *C.p. petrophila* is predominantly blue-green, green, or blue, with a few cupreous-green or cupreous individuals. The largest percentage of known *C.p. petrophila* specimens are without maculation. Subspecies *C.p. barbaraannae* is bright red-brown with a complete, unbroken marginal line.

Remarks: Subspecies *C.p. viridimonticola* is very rare at the type locality. To collect the type series and to study the behavior and habitat of this subspecies, I spent approximately a week in the field over a three year period. Extensive observations were made in the field to determine the exact size of the population, which is estimated to occupy about 0.5 acre of native habitat.

Due to the limited amount of habitat in which this subspecies occurs

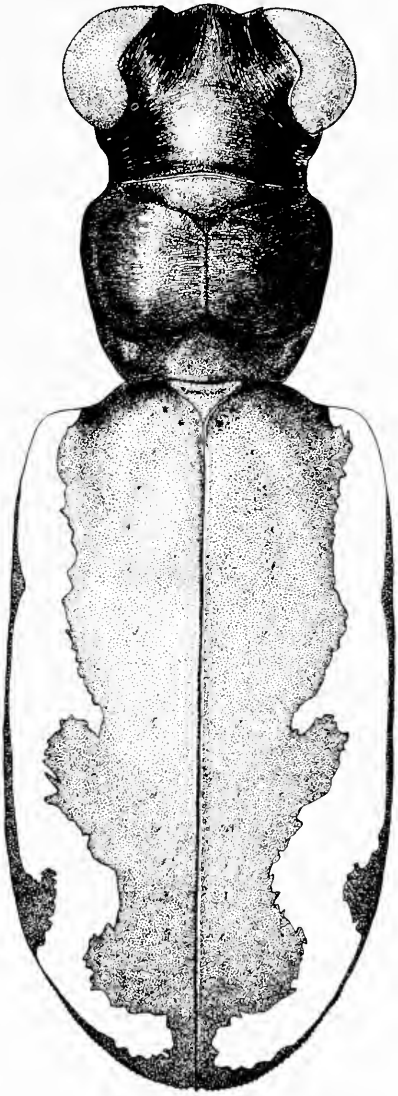

Fig. 1. *Cicindela politula viridimonticola*, n. ssp.

and its small population size, it must be considered a population highly susceptible to extinction and over-collecting is without a doubt a major danger. In order to facilitate the survival of the only known population of *C.p. viridimonticola,* its location is given in very general terms.

Further biological studies are presently being conducted to determine the precise habitat parameters of each of the subspecies of *C. politula* and to describe the larvae.

A key to separate this subspecies from other *C. politula* subspecies which are listed in Boyd (1982) has been developed as follows:

Key to Subspecies of ***Cicindela politula*** LeConte

1a. Color of elytra black .... *politula* LeConte
1b. Color of elytra not black 2
2a. Color of elytra red or brownish-red with fully developed marginal white line; known from several localities throughout West Texas and southern New Mexico.................................... *barbaraannae* Sumlin
2b. Color and maculation not as above 3
3a. Color of elytra bright green or bluish-green with a continuous marginal white line or with one break above the apical lunule in the majority of the individuals; few individuals with partial maculation. Known only from southeastern New Mexico ... *viridimonticola* n. ssp.
3b. Color of elytra purplish with partial or no maculation; or blue, blue-green, cupreous, cupreous-green, green or greenish-black and predominantly without maculation ... 4
4a. Color of elytra predominatly purple or purplish-blue; occasionally blue-green; predominantly partially maculated with an occasional non-maculated individual. Known only from southern Coahuila, Mexico.................................... *laetipennis* W. Horn.
4b. Color of elytra predominantly blue or blue-green; occasionally cupreous green, cupreous, greenish-black or green; maculation predominantly absent although occasional specimens may have partial or complete marginal line. Known only from the Guadalupe Mountains in western Texas and southeastern New Mexico.................................... *petrophila* Sumlin

Range Extension of *Cicindela politula barbaraannae*

During the course of my study on *C. politula viridimonticola,* I increased the known range of *C.p. barbaraannae* Sumlin. Subspecies *barbaraannae* was previously known only from the type locality (18.6 miles east of El Paso, Texas) in the Hueco mountains. Two additional populations were discovered which best fit the description of subspecies *barbaraannae* and a close examination of the specimens confirm this conclusion. One population occurs in the Sierra Diablo mountains, 80 miles to the east of the type locality. The habitat in this area is very different from the Hueco mountains. The Sierra Diablo mountains receive more precipitation than the Hueco mountains as evidenced by the vegetation.

There are no trees at the type locality, while in the Diablos there are dense stands of pinon pine (*Pinus cembroides*), pinchot juniper (*Juniperus pinchotii*), and several species of oak (*Quercus* spp.).

The Apache mountains represent the known eastern boundary for subspecies *barbaraannae* (120 miles east of the type locality). These mountains are very similar to the Huecos; both mountain ranges being more arid than the Diablos.

Both the Diablo and Apache Mountains have extensive limestone outcrops (like the ledges at the type locality) on which the populations occur.

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TWO MIDDLE AMERICAN LEAF BEETLES (COLEOPTERA: CHRYSOMELIDAE) NEWLY RECORDED FROM THE UNITED STATES[1,2]

Edward G. Riley[3], Edward U. Balsbaugh, Jr.[4]

ABSTRACT: Two Middle American chrysomelid beetles are recorded for the first time from the United States. *Lexiphanes teapensis,* previously known only from Mexico, is reported from one locality in New Mexico and four localities in south Texas. *Octotoma championi,* previously known from Costa Rica, Guatemala and Mexico, is reported from two localities in the Lower Rio Grande Valley of Texas where it feeds on *Lantana camara.*

Lexiphanes teapensis (Jacoby)

The genus *Lexiphanes* Gistel (Cryptocephalinae: Monachini) occurs only in the Western Hemisphere. Blackwelder (1946) listed 23 species from Central America and 93 from South America in the genus. Until now, only five species were known from America north of Mexico (Balsbaugh, 1966), viz. *L. saponatus* (F.) in eastern North America west to about the 100th meridian, *L. affinis* (Haldeman) and *L. seminulum* (Suffrian) in southeastern United States, and two Middle American species, *L. guerini* (Perbosc) and *L. mexicanus* (Jacoby), whose ranges reach into the southwestern United States.

A third Middle American species, *L. teapensis* (Jacoby), has recently been collected in the United States from five different localities. The earliest record is represented by a single specimen in the North Dakota State Insect Reference Collection [NDSU] at North Dakota State University in Fargo. It is labeled: "Guadalupe Canyon, Hidalgo Co, Nimex (sic) [a typographical error for N. Mex. (Andrews, personal communication)] VIII-19-1967 by Fred G. Andrews."

The second record is based on a series of 41 specimens collected by the first author in "Texas, Kennedy Co., 1 mi. S. of Armstrong on hwy 77: X-8-1984." All of the latter were taken by sweeping roadside vegetation, without specific plant associations. The specimens are in both the NDSU collection and the private collection of the first author [EGRC].

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[2] Approved for publication by the Director of the Louisiana Agricultural Experiment Station as manuscript number 87-17-1524.

[3] Research Associate, Department of Entomology, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge, Louisiana 70803.

[4] Professor, Department of Entomology, North Dakota State University, Fargo, North Dakota 58105.

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On October 3, 1986, E. Riley and J. Negrón collected three series of four specimens each [EGRC] at additional sites in south Texas: "Jim Wells Co., 15 mi W. Kingsville;" "Hidalgo Col., 10 mi N. San Manuel;" and "Willacy Co., 7 mi W. Port Mansfield." Again, no specific plant associations were noted.

Lexiphanes teapensis was described from about 100 specimens, all from Teapa in the Mexican state of Tabasco (Jacoby, 1889). We identified our specimens by comparing them with others that had earlier been compared with determined material in both the United States National Museum in Washington, D.C., and the Museum of Comparative Zoology at Harvard University. These included ten additional specimens in the NDSU collection from the Mexican state of "Veracruz: Palma Sola 23 Aug. 73 P. Reyes, C. Huerta, S. Gomez, Pastizal con restos selva subcauducifolia" [Grass with forest floor litter].

The new records from Texas extend the known distribution of *L. teapensis* more than 750 km north of Palma Sola, and the New Mexico record extends the range an additional 1,230 km to the northwest of the Texas localities.

In the original description of *L. teapensis,* Jacoby (1889) stated that it was very closely allied to several other species described by Suffrian, but it differed from them by the following characters: "In most specimens of *M. teapensis* the head is fulvous, but in some it is bluish black, the labrum, however, always remaining fulvous, . . .the thorax has no trace of punctation, even when seen under a very strong lens, and the middle portion of the disc is occupied by a larger or smaller black patch which sometimes extends nearly to the lateral margins, there is no row of deep punctures to be seen at the posterior margin (this being very distinct in several closely-allied species); the elytra are generally black, sometimes bluish, with prominent shoulders, and they are strongly and regularly punctate-striate, . . .the underside and legs are black, but the anterior femora (as well as the base of the two other pairs) are frequently, and the tarsi entirely, fulvous."

The beetles from Texas are consistent with Jacoby's description for most characters. However, certain of these characters vary more than what Jacoby observed for his series from Teapa. In all of the 66 specimens examined, the heads of the males are fulvous, whereas those of the females are black, including the labrum. This is true for specimens from both Texas and Veracruz. A second obvious feature of the head is that the eyes of the male are more nearly contiguous than are those of the females. It is true, the disc of the pronotum is impunctate, but the base near the meson in some specimens is indistinctly punctate; however, the punctures are small and not in a transverse linear arrangement as with *L. guerini.* Four of the specimens from Texas have the pronotal disc immaculate, or nearly so. In the remainder, the pronotum is orange-testaceous with a single, broad, black, discal spot, except for the single specimen from Guadalupe Canyon, Hidalgo Co., New Mexico, which has the pronotal spot longitudinally divided along the meson. Three of the beetles from Palma Sola, Veracruz, have the pronotum immaculate or nearly so; nine have the disc black. The pronotum of one specimen from "Km 341 along Highway 149, Veracruz" is entirely black.

The elytra also have variable patterns. Eighty-five percent of the beetles from Texas have entirely black elytra; 13 percent have a small orange-testaceous spot on each elytron, and two percent have an irregular transverse orange-testaceous fascia on each elytron. The respective percentages for these same color patterns in specimens from Veracruz were 50, 8, and 42 (n=12).

Octotoma championi Baly

The genus *Octotoma* (Hispinae: Uroplatini) is presently comprised of nine described species (Uhmann, 1957), all of which are Neotropical except *O. plicatula* (F.) which is found in the eastern United States. Four species occur in South America, one exclusively in Cuba, and three in Mexico, two of which also occur in Central America. One of the Mexican species, *O. marginicollis* Horn, was originally described from Arizona (Horn, 1883). A second Middle American species, *O. championi* Baly, has recently been collected in the Lower Rio Grande Valley of Texas near Brownsville. The three collection records and observations given below represent the first report of this, the third species of *Octotoma* recorded from the United States.

The earliest Texas record for *O. championi* is one specimen collected by Robert Turnbow, Jr. and presently contained in his private collection. It is labeled: "Tex. Cameron Co. Sabal Palm Grove Sanct. nr. Southmost 5 Sept. 1981 R. Turnbow." *Octotoma championi* has since been collected twice in Cameron County, Texas, by the first author.

On October 6-7, 1984, six specimens [EGRC] were collected 6 mi. NW of Brownsville on Highway 281 from the leaves of an undetermined species of *Lantana* (Verbenaceae). The leaves showed scars very similar to those made by the adult feeding of *O. plicatula* on trumpet creeper.

On March 28-29, 1986, twenty-two specimens [EGRC & NDSU] were collected from the upper leaf surfaces of *Lantana* plants thought to belong to the same species as that mentioned above. The plants were growing among understory vegetation on the Rio Grande levee flanking the east side of the Sabal Palm Grove Audubon Sanctuary near Southmost and at another spot on the west side of the sanctuary. The beetles had evidently fed on these plants since there were numerous feeding scars on the upper leaf surfaces.

On October 4, 1986, one of the clusters of *Lantana* plants from which adults were collected during the spring was relocated. No adults were found, but leaf-mines of the trail-type, probably the work of *Octotoma* larvae, were present in several of the leaves. The mines appeared to be complete with a darkened pupal cell on or near the mid-rib of each infested leaf. The infested leaves were retained in a plastic rearing box, but adults of *Octotoma* failed to emerge; a few hymenopteran parasites (Chalcididae) were obtained. *Lantana* plants were collected and pressed from this site and later identified as *L. camara* L.

The specimens from Texas for the most part agree with the original description by Baly (1886), except he stated that the antennal club was black. The antennae of the Texas material are yellowish brown to brown with the club segments dark brownish, not black. The Texas material matches four specimens from Mexico and two from Nicaragua in the first author's collection. Comparison with these specimens and the original description are the basis for the present identification.

Octotoma championi is similar in general habitus to *O. plicatula*. It differs in being longer on the average, 5.0 mm, range 4.3-5.5 mm (n=15) compared with 4.3 mm, range 4.1-4.7 mm (n=15), for *O. plicatula;* the irregular elevated carinae of the elytra are everywhere sharper and more strongly elevated; the sinuation of the lateral elytral margin before the explanate posterior angle is more distinct; and the hind angle itself is more angular and more coarsely serrate. The elytral sutural area just behind the scutellum and again between the large, median prominence on the apex of each elytron, has a metallic-blue or greenish luster. This metallic luster is absent or nearly so on a few specimens. To date, *O. plicatula* has not been collected in the Lower Rio Grande Valley of Texas.

Octotoma championi was described from a single specimen from Capetillo, Guatemala, a locality about 5 km southwest of Antigua, state of Sacatepequez (Selander and Vaurie, 1962). In addition to Guatemala, it is also listed from Mexico and Costa Rica (Uhmann, 1957). Prior to the discovery of the Texas specimens, the northern-most collection record known to us was Mexico, Tamaulipas, Rio Corona, 30 km NE Ciudad Victoria. This locale is approximately 288 km south-southeast of Brownsville, Texas, and about 220 km further south in latitude.

Lantana camara L. was reported by Uhmann (1937) as the host plant of *O. championi* in Costa Rica. This plant has become a weed in several tropical areas around the world. The beetle has been evaluated for its potential as a biological control agent for *L. camara* and successfully introduced into Australia for this purpose (Diatloff, 1977).

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AN UNUSUAL NEW GENUS AND SPECIES OF HECALINE LEAFHOPPER FROM VENEZUELA (HOMOPTERA: CICADELLIDAE)[1,2]

Paul H. Freytag[3], Ning Ma[4]

ABSTRACT: A new genus and species, *Acrolithus brevis*, are described from the Páramo de Guaramacal in Venezuela. The female is brachypterous, which is quite unusual among the known members of South American Hecalini.

A new species of Hecalini has been collected which cannot be placed in any of the genera known in South America (Linnavuori 1957, 1959). It is described and placed in a new genus, *Acrolithus*, which appears to be more closely related to *Egenus* Oman than to any of the other known genera.

Acrolithus, gen. n.

Body flattened, male relatively short, female elongate. Head produced, anterior margin carinate. Ocelli near lateral margin about twice width from eyes (Figs. 1 & 2). Face convex and greatly swollen (Fig. 3). Head wider and longer than pronotum. Male forewing nearly normal length leaving only the tip of the abdomen exposed, venation normal, with two anteapical cells, four apical cells and two claval veins with a crossvein between them (Fig. 4). Female forewing brachypterous leaving several abdominal segments exposed, venation reduced and not well differentiated. Color generally grayish brown. Type species *Acrolithus brevis*, n. sp.

This genus, based on the type species, appears to be closely related to *Egenus* Oman in that they both have swollen faces (Figs. 3, 7). However, the male genitalia are quite different from any known hecaline species. The female is brachypterus, which is only known at present in the genus *Hecullus* Oman, and represents a new group within the Hecalini.

Acrolithus brevis, n. sp.

(Figures 1-4, 9-13)

Length: Male 3.95-4.15 mm.: Female 5.7-5.95 mm.

Color: Male grayish brown, median line of head and pronotum usually with a darker stripe. Ventral side darker, median part of face, coxa, femora, and abdomen black. Lateral margins of thorax, abdomen and tarsi dark brown. Female dark yellowish brown, with ventral side darker brown.

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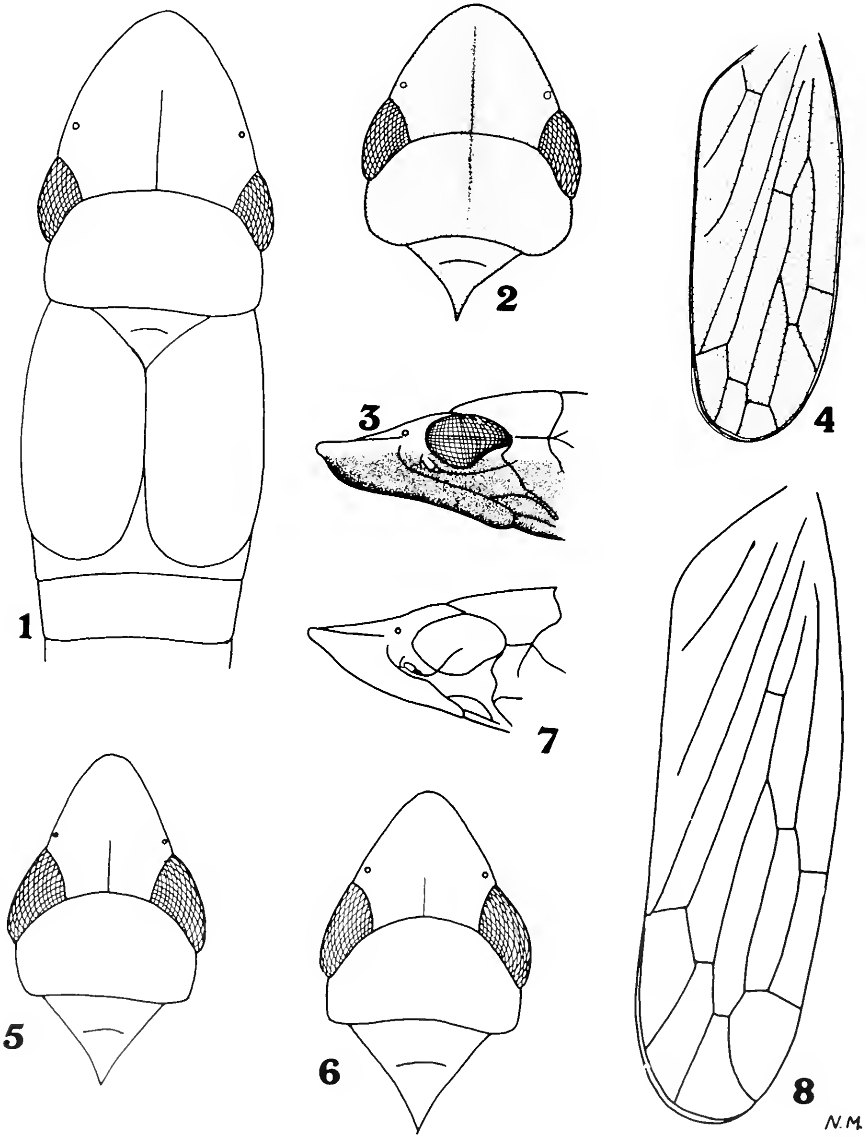
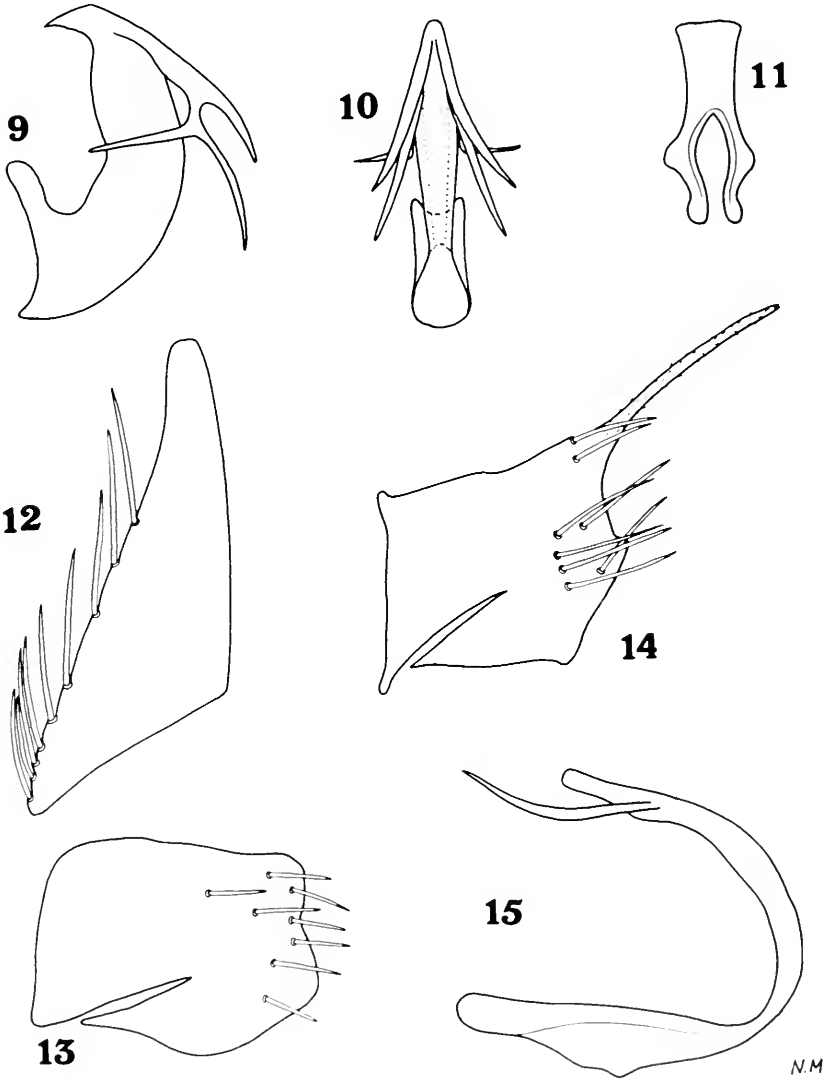
[3] Department of Entomology, University of Kentucky, Lexington, Kentucky 40546.

[4] Department of Entomology, The Ohio State University, Columbus, Ohio 43210.



Figures 1-8. *Acrolithus brevis* n. sp. 1. Dorsal aspect of female, 2. Dorsal aspect of head, pronotum and scutellum of male. 3. Lateral aspect of head and prothorax of male. 4. Forewing of male. Figures 5-8. *Egenus gracillimus* Linnavuori & DeLong. 5. Dorsal aspect of head, pronotum and scutellum of male. 6. Dorsal aspect of head, pronotum and scutellum of female. 7. Lateral aspect of head and pronotum of female. 8. Forewing of female.



Figures 9-15. *Acrolithus brevis* n. sp. 9. Lateral aspect of aedeagus. 10. Posterior aspect of aedeagus. 11. Dorsal aspect of connective. 12. Ventral aspect of genital plate. 13. Lateral aspect of pygofer. Figures 14-15. *Egenus gracillimus* Linnavouri & DeLong. 14. Lateral aspect of pygofer. 15. Lateral aspect of aedeagus.

Head produced, much longer in middle than next to eyes, wider than pronotum. Face swollen and convex. Pronotum with lateral margins carinate. Spinulation of fore tibia 3 + 3, hind femur 2+2+1. Forewing normal in male, with two anteacpical cells and two claval veins; brachypterous in female.

Male genitalia: Pygofer truncate at apex with several macrosetae. Plate triangular, about ten macrosetae along outer lateral edge. Aedeagus stout, laterally flattened with two anteapical ventrally produced processes which are branched so that each process has three spines (Figs. 9-10). Connective stout, Y-shaped. Style small, hooked at apex.

Female genitalia: Ovipositor short, extending only slightly beyond pygofer. Seventh sternum with posterior margin evenly convex.

Holotype male: Páramo de Guaramacai, near Boconó, Turjillo, Venezuela, 2900 m., May 22, 1985. Paul S. Cwikla. Paratypes: 1 female, same data as holotype; 1 male, 1 female, same locality, 2850 m., June 12, 1986, Paul H. Freytag and Marco A. Gaiani. The holotype and the first paratype in the Ohio State University Collection, and the other two paratypes in the University of Kentucky Collection. One other male is on hand from the Páramo de Cristilina, Turjillo, Venezuela, 2800 m., June 14, 1986, R.J. Barney, in the University of Kentucky Collection. A female immature collected with the pair in 1986 is also in the University of Kentucky Collection.

The pygofer is of a normal type (Fig. 13), not with a long process as in *Egenus* (Fig. 14). Also, the aedeagus is short and stout (Fig. 9), while most other genera have an aedeagus long and strap-like as in *Egenus* (Fig. 15). This species occurs at very high altitudes, above 2800 meters, while other south American species appear to occur at much lower elevations.

ACKNOWLEDGMENTS

We wish to thank Paul S. Cwikla and Robert J. Barney for making their specimens available for study, and to Paul for his suggestions and comments on this paper.

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DISTRIBUTION OF ARMY ANTS (HYMENOPTERA: FORMICIDAE) IN ILLINOIS[1]

Mark B. DuBois[2]

ABSTRACT: *Neivamyrmex carolinensis* is reported for the first time from Illinois. This is a significant range extension since no collections of this species have previously been made from this or surrounding states. Localities are listed and a key is presented for identification of worker army ants encountered in Illinois.

Neivamyrmex carolinensis (Emery) is reported from Illinois for the first time. Previously, *N. nigrescens* (Cresson) was the only species of army ant known to occur within the boundaries of the state. Distributions of both species are discussed in detail below. A third species, *Neivamyrmex opacithorax* (Emery), probably occurs here as it has been recorded from eastern Missouri and Iowa (Watkins, 1985). Army ants are most frequently discovered as a raiding column of workers during twilight hours or at night. On rare occasions, these columns are encountered above ground during daylight hours on heavily overcast days (pers. obs.).

An attempt has been made to summarize our limited knowledge of the distribution of army ants in Illinois. All collections listed are represented by workers unless otherwise noted; voucher specimens of both species are housed in the Illinois Natural History Survey collections [INHS]. It is hoped this note will stimulate further studies upon army ants in Illinois.

Neivamyrmex carolinensis is the only army ant whose colonies consistently contain multiple queens (Rettenmeyer and Watkins, 1978, and pers. obs.). Rettenmeyer and Watkins (1978) suggest that multiple queens may aid in the survival of these subterranean colonies, because of the harsh environment this species inhabits.

Neivamyrmex carolinensis

ILLINOIS: Pope Co., Dixon Springs State Park, 1 km NE of Dixon Springs, T13S R5E Sec 16, elev 150 m, 27-VI-1987, M.B. DuBois.

A raiding column was discovered (after dark) just beneath the soil surface (under a small stone) in proximity to an ultraviolet light which was being used to attract flying insects. Area was devoid of significant amounts of standing vegetation (mosses and grasses predominated) and was adjacent to deciduous forest.

This species has not previously been reported from Illinois nor

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[1] Received November 23, 1987. Accepted December 23, 1987.

[2] Current Address: 208 Oakwood Circle, Washington, Illinois 61571-2535.

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surrounding states. Closest previous collections came from Kansas, Ohio, and Mississippi (Watkins, 1976, and pers. comm.). The Ohio record is based upon a literature record only (Watkins, 1985 and pers. comm.). Infrequent collections of this species in Illinois is not surprising in light of its small size (total worker body length always under 4 mm).

Neivamyrmex nigrescens

ILLINOIS: Adams Co., Quincy, 3-IX-1936, Musselman (workers and males) [USNM - J. Watkins, pers. comm.]; Pulaski Co., N. Cairo, 28-X-1957, S.E. Ceglinski (males) [INHS]; Union Co., Anna, 5-IX-1932, L.C. Murphee [INHS].

This species has not been collected in Illinois since 1957, however, southern Illinois is well within its established range (Watkins, 1985).

Key To Workers

Army ants can be recognized through the combination of characters listed below. To confirm the identity of specimens as army ants, consult either Smith (1947) or Creighton (1950).

Workers travel in distinct files while foraging or moving their nest. These files are usually observed at dusk or at night (rarely on overcast days) and never in direct sunlight. Nests are usually very messy earthworks with most individuals located in a large central cavity. Both petiole and postpetiole are always present in workers. Their compound eyes are extremely reduced and ocellus-like; true ocelli are always absent.

Once identified as army ants, a given species can be determined using Watkins (1976, 1985). The key below is presented to aid collectors encountering army ants in Illinois; it should never be used for other regions as numerous species (which do not occur in this area) have not been included.

1a. Antennal scape always significantly exceeding eye level (figure 1-A); posterior corners of head pointed (figure 1-B); basal surface of mandible rounded into masticatory surface (figure 3) .... *N. nigrescens*

1b. Antennal scape never significantly exceeding eye level (figure 2-A); posterior corners of head more rounded (figure 2-B); basal surface of mandible forming a distinct corner or tooth at juncture with masticatory surface (figure 4) 2

2a. Node of petiole subquadrate (figure 5); total body length of major workers always less than 4 mm .... *N. carolinensis*

2b. Node of petiole elongate (figure 6); total body length of major workers always exceeding 4mm (not presently known to occur within the boundaires of Illinois) .... *N. opacithorax*

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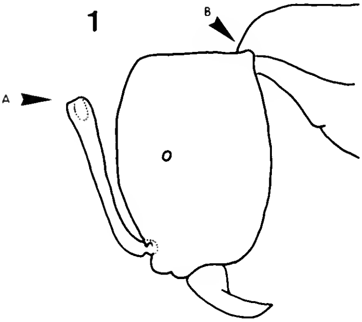

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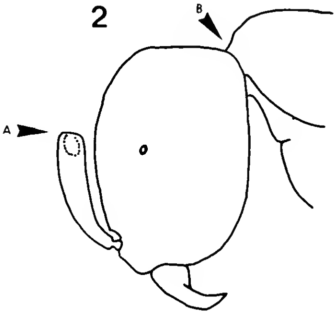

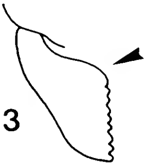

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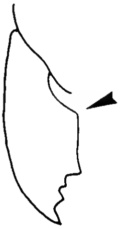

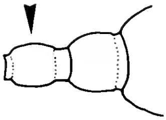

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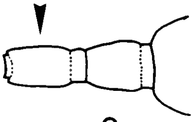

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Figure 1. *Neivamyrmex nigrescens,* head, lateral view. A - Position of antennal scape in relation to compound eye level. B - Posterior head corner. Figure 2. *Neivamyrmex carolinensis,* head, lateral view. A - Position of antennal scape in relation to compound eye level. B - Posterior head corner. Figure 3. *Neivamyrmex nigrescens,* right mandible, frontal view. Arrow points to juncture of basal and masticatory surfaces. Figure 4. *Neivamyrmex carolinensis,* right mandible, frontal view. Arrow points to juncture of basal and masticatory surfaces. Figure 5. *Neivamyrmex carolinensis,* petiole, postpetiole, and anterior portion of gaster, dorsal view. Nodes depicted with dashed lines. Figure 6. *Neivamyrmex opacithorax,* petiole, postpetiole, and anterior portion of gaster, dorsal view. Nodes depicted with dashed lines. Scale on all figures varying.

ACKNOWLEDGMENTS

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ECOLOGICAL METHODS, WITH PARTICULAR REFERENCE TO THE STUDY OF INSECT POPULATIONS. Second edition, revised. 1987. T.R.E. Southwood. Chapman and Hall. 524 pp. ppbk.

A new, revised, paperback edition of this valuable and standard text.

ECOLOGICAL APPROACH TO PEST MANAGEMENT. 1988. D.J. Horn. Guilford Press. 285 pp. ppbk. $35.00.

This book addresses principles of insect ecology and their relation to insect pest management.

ADVANCES IN INSECT PHYSIOLOGY. Vol. 20. 1988. P.D. Evans and V.B. Wigglesworth, eds., Academic Press. 222 pp. $29.00

Five contributions include: Turnover of photopransductive membrane in compound eyes and ocelli, Honey bee learning, Formation of a neurohaemal organ during insect embryogenesis, Thermoregulation and heat exchange, and Molecular targets of pyrethroid insecticides.

FIRST RECORD OF A MANTISPINE LARVA (NEUROPTERA: MANTISPIDAE) ASSOCIATED WITH AN ADULT CADDISFLY (TRICHOPTERA: LEPTOCERIDAE)[1,2]

Kevin M. Hoffman[3], Steven W. Hamilton[4]

ABSTRACT: A first instar of *Mantispa pulchella* was discovered clinging to the abdomen of an adult *Oecetis inconspicua*. This is the first record of a larva of the Mantispinae naturally infesting an insect. Because this association is most likely an act of phoresy and not a true parasite-host relationship, it is possible that such phoretic behavior may play a minor role in larval mantispine dispersal.

All known larvae of the mantispid subfamily Mantisipinae develop exclusively by feeding on spider eggs (Redborg and MacLeod 1985, Brushwein 1986). First instars employ two general strategies in order to gain access to spider eggs: larvae may either seek out and penetrate an egg sac, or they may board spiders and enter the egg sac as the eggs are being laid. Larvae which board spiders can maintain themselves for several months by feeding on host hemolymph and can be considered true ectoparasites at this stage (Redborg and MacLeod 1984). First instars of *Mantispa viridis* Walker have been shown to be obligate egg sac penetrators (Redbord and MacLeod 1985, Brushwein 1986), larvae of *Climaciella brunnea* (Say) to be obligate spider boarders (Redborg and MacLeod 1983), and larvae of *Mantispa uhleri* Banks to use both strategies (Redborg and MacLeod 1985). Recent studies indicate first instars of *Mantispa pulchella* (Banks) are also obligate spider boarders (Hoffman and Brushwein 1988).

While sorting through an ultraviolet light trap sample, a single first instar of *M. pulchella* was discovered clinging to the abdomen of an adult female caddisfly, *Oecetis inconspicua* (Walker). This is the first record of a mantispine larva being found associated with an insect. The sample was collected on 20 July 1983 in Crawford County, Georgia, approximately 5 miles SSE of Roberta at Spring Creek, a small blackwater stream bordered with typical low riparian coastal plain vegetation. The light trap used was a Ellisco® trap with a 15-watt ultraviolet bulb, operated by R.W. Holzenthal

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[3] Department of Entomology, Clemson University, Clemson, SC 29634-0365.

[4] Department of Biology, Austin Peay State University, Clarksville, TN 37044.

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and the junior author. The first instar of *M. pulchella* and the adult female *O. inconspicua* were deposited in the Clemson University Arthropod Collection (CUAC), Department of Entomology, Clemson University, Clemson, South Carolina.

Batra (1972) confined first instars of the mantispine *C. brunnea* with various insects and spiders, and reported that larvae boarded workers of a bumblebee and a wasp, as well as a spider. Redborg and MacLeod (1983) have since shown *C. brunnea* to be an obligate spider boarder, attributing the earlier report of boarding Hymenoptera to the inability of larvae to determine the suitability of the host until after contact is made. We propose that the occurrence of the first instar of *M. pulchella* on the abdomen of *O. inconspicua* was the result of a similar exploratory boarding.

During the day, adult caddisflies often rest in concealed crevices or on foliage near aquatic habitats (Ross 1944). All of the known spider hosts of *M. pulchella* actively hunt rather than construct webs for prey capture, almost all are arboreal hunters, and most of them spend the day in silk retreats in crevices or on foliage (Hoffman and Brushwein 1988). Therefore, adult caddisflies often occur in the microhabitats that first instars of *M. pulchella* are most likely to occupy, so that occassional boardings would not be unexpected. In addition, adults of *O. inconspicua* as well as other members of the Leptoceridae are often hosts for parasitic mites (Resh and Haag 1974). This is in contrast to the general lack of parasites found on members of other caddisfly families, and Resh and Haag (1974) have suggested that either a behavioral or morphological feature may be unique to the Leptoceridae that renders them more susceptible to parasitic infestations.

The extent to which mantispine larvae on spiders exploit their hosts as dispersal agents is unknown, but the potential would seem to be considerable in light of the long period of time that larvae can survive on spiders. However, the use of insects as dispersal agents would be limited to short periods of time unless larvae could maintain themselves on the hemolymph of the host insect. At present, there is no evidence that the *M. pulchella* larva fed on caddisfly hemolymph. The abdomens of *M. pulchella* larvae on spiders are commonly distended, presumably due to hemolymph intake, and the dorsal banding pattern becomes correspondingly more diffuse the more the abdomen is distended (Hoffman and Brushwein 1988). The abdomen of the larva found on the caddisfly was not distended and the dorsal banding pattern was distinct, thereby indicating that the larva had not fed extensively, if at all. Therefore, the use of non-aranaeoid hosts for dispersal by mantispine larvae, while intriguing, must at this time be considered an occasional and probably accidental extension of their normal boarding behavior.

ACKNOWLEDGMENTS

We are grateful to Joe D. Culin and John C. Morse of Clemson University for reviewing the manuscript.

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Biology, natural history, and behavior of ground-nesting, solitary wasps of the genus *Philanthus* in the family Sphecidae.

ASA FITCH AND THE EMERGENCE OF AMERICAN ENTOMOLOGY, with an Entomological Bibliography and a Catalog of Names and Type Specimens. 1988. J.K. Barnes. N.York State Museum, Bull. 461. 120 pp. ppbk. $12.50.

Biography, contributions, publications, collections, types, and taxonomic work of this early economic entomolgist.

COLLECTION METHOD FOR NEW YORK WEEVIL, *ITHYCERUS NOVEBORACENSIS*, ADULTS (COLEOPTERA: ITHYCERIDAE)

Eric A. Stavney, Kenneth F. Raffa[2]

ABSTRACT: A passive collection method for capturing New York weevils, *Ithycerus noveboracensis,* is described.

Larvae and adults of the New York weevil, *Ithycerus noveboracensis* (Forster) (Coleoptera: Ithyceridae), feed on roots and foliage, respectively of Betulaceae, Juglandaceae, Fagaceae, and Rosaceae (Sanborne 1986). Populations of these weevils can occasionally reach injurious levels in fruit orchards (Lugger 1899, Washburn 1902). The only available collection method for either feeding stage consists of active searching. This approach has the disadvantages of being highly labor-intensive, non-quantitative, and inefficient because a simultaneous survey is not possible on several sites or large trees.

We have collected *I. noveboracensis* adults in a passive trap during routine monitoring of the pine root collar weevil, *Hylobius radicis* Buchanan. The traps consist of aluminum screening wrapped around the trunks of red pine, *Pinus resinosa* Ait. (Maki 1969), approximately 100 cm above the ground. The screening was stapled to the tree, and the upper part of the screen was shaped into a cone and inserted into a glass bottle (Fig. 1). Insects crawling up the bole of the tree are funneled into the collection bottle where they become trapped. The traps were checked at least once every three weeks. Adult weevils were captured and sexed by inspection of the genitalia, and females were examined for eggs. The collection sites were 15-40 year old red pine plantations.

Adult *I. noveboracensis* were collected from four different sites in Wisconsin during June and July, 1987 (Table 1). At each site where New York weevils were found, *Quercus alba* L. seedlings or mature trees were within 20-30 meters of the pines on which weevils were caught. At most sites, *Quercus rubra* L., *Quercus macrocarpa* Michx., and *Quercus velutina* Lam. were also present, but were also at least 30 meters away. *Betula papyrifera* Marsh. and *Populus tremuloides* Michx. were typically mixed in with the oak. No weevil feeding was observed on the branches of the oaks or other trees.

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[2] Department of Entomology, University of Wisconsin, Madison, WI 53706.

Figure 1. Aluminum screen trap with glass jar used to collect *I. Novaboracensis* adults.

Occurrence of *I. noveboracensis* on pine is incidental, as we observed no feeding on this host in the laboratory or on pine twigs held in the collection jars (except when *Hylobius* weevils were present). Conversely, substantial feeding on *Q. alba* and *Q. velutina* twigs held in a laboratory glass arena was observed.

Our passive collection method is very effective and may be useful for biological studies of this or related species. Most of the weevils were dead when found in the traps. However, if live weevils are needed, our laboratory results suggest that including white oak twigs in the collection jars might improve survival.

Table 1. *I. noveboracensis* captured in screen traps on red pines in Wisconsin in 1987.

Date	Males	Females	Location
15 Jun 87	2	0	Town of Evergreen, Washburn Co.
22 Jun 87	0	1	Town of Evergreen, Washburn Co.
23 Jun 87	1	0	Town of Jackson, Burnett Co.
23 Jun 87	1	0	Town of Evergreen, Washburn Co.
3 Jul 87	0	1	Town of Dayton, Waupaca Co.
6 Jul 87	2	3	Town of Evergreen, Washburn Co.
6 Jul 87	0	2	Town of Jackson, Burnett Co.
21 Jul 87	0	1	Town of Gordon, Douglas Co.
Total	6	8	

ACKNOWLEDGMENTS

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A PHOTOGRAPHIC TECHNIQUE FOR PRODUCING HIGH-QUALITY INSECT TAGS FOR MARK/RELEASE/RECAPTURE STUDIES[1]

William L. Rubink[2]

ABSTRACT: A method for producing small (1.0-1.5 mm diam) plastic tags for marking insects is described. The tags, made from high contrast photographic film, are light-weight and provide a means for individually marking several thousand insects without reliance on complex color-coding or other schemes. The tags may be produced with a minimum of equipment, and provide a readily available solution to mark/release/recapture studies of insects. They may prove especially convenient to researchers in remote locations, and have been used intensively on mark/release/recapture studies of native screwworm, *Cochliomyia hominivorax*, populations in Central America.

Techniques for marking insects in mark/release/recapture studies have been developed (Dobson 1962, Gangwere et al 1964, Gary 1971, Southwood 1984), but those appropriate to individually marking large numbers of insects require elaborate color-coding schemes or commercially available "bee tags". These systems still do not allow for easily distinguishable marking of more than several hundred individual insects. The tags described here may be used to individually mark thousands of insects without sole reliance on color codes, and can be made smaller and lighter than commercially available tags. The technique may prove of special interest to researchers in remote areas where commercial labels are not easily obtainable, or where smaller, lighter, long-lasting tags are needed.

The method consists of photographically reducing a series of 2-digit alphanumeric codes, printed in a continuous, non repeating series, onto photographic film. One side of the developed film is then coated with a layer of opaque, plastic paint, and individual markers are punched from the painted film with a suitably-sized hole punch. These markers are then glued to the insect. They are easily read under field conditions and provide a means of marking insects as small as 0.5 to 1.0 cm in length.

I used the following equipment for fabricating 1.5 and 2.0 mm diam. labels for intensive mark/recapture studies of the screwworm, *Cochliomyia hominivorax* (Coquerel), in Costa Rica[3]:

1. Canon® camera, 50 mm macro lens, makeshift copy stand (two 200W tungsten light bulbs), Canon® bellows and slide copier.

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[2] U.S.D.A., A.R.S. Screwworm Research, American Embassy, APO Miami, FL 34020.

[3] The mention of proprietary products or tradenames does not imply their endorsement or recommendation.

2. Kodalith® (Eastman Kodak Co.) high contrast film, developing tank and chemicals.
3. Colorworks® (Illinois Bronze Paint Co., Lake Zurich, IL 60047) 100% epoxy enamel spray paint.
4. Letter quality copy of the desired number codes, generated by a short BASIC program (Fig. 1) on a Brother® EM-200 electronic, daisy-wheel, typewriter.
5. Manual hole punches of the type used in leather work, 1.5mm and 2mm diam.

Any SLR 35mm camera would be sufficient. A macro lens allows suitable size reduction from a typewritten page; however, larger copy would permit usage of a standard (non-macro) lens. Enlarging lenses ("plus diopters") could also be used. The slide copier allows black/white reversal which provides the possibility of producing dark letters on a light background. This also doubles the possible number of visually distinct labels. The Kodalith film provides optimum contrast and readability; other "lith" type films would serve equally well. Other lower contrast films might also be suitable, although I did not try any. Lith-type films are made of a thicker plastic base than higher speed films. Consequently, use of the thinner based films may provide a means for further lowering the weight of the resulting label.

Clearly printed copy material is important for crisp images after reproduction. The use of a computer and a letter quality ("daisy wheel") printer for production of the two-digit codes to be photographed expedites the process and produces crisp copy material. The symbols chosen depend to a great extent on those available on a given typewriter or printer, and must be selected carefully to avoid any possibility of misinterpretation in the field. Such characters as 'I' and '1', 'S' and '5', etc must not both be used. The horizontal and vertical spacing between codes also needs to be adjusted to the size of the desired label, although the spacing used was suitable for both 1.5 mm and 2 mm labels.

I exposed the film at ASA 4 under tungsten lighting for 1/2 sec to achieve the proper exposure. Exposure time will vary with other setups. I used a standard grey card, or Kodak® "Neutral Test Card" and the internal light-metering system of the camera for exposure measurements. Standard developing techniques were used, requiring only a developing tank and the necessary developing chemicals. Film was allowed to dry overnight before applying a very light coat of spray paint to the emulsion side. The paint required 48 hrs to dry completely at 20-25°C. Round, hardened steel, tubular hole punches and a hammer were then used to punch out the circular labels using a 3 mm thick aluminum plate for backing. This procedure produces a slightly concave surface which facilitates adhesion to the insect.

```
10  DIM A(45)
20  REM** INPUT ASCII PRINTER CODES FROM DATA STATEMENT
30  FOR I=1 TO 45: READ A(I): NEXT
40  REM** PRINT ALL POSSIBLE COMBINATIONS OF TWO LETTERS — 2
    SPACES SEPARATION.
50  LPRINT
60  FOR J=1 TO 45
70  FOR I=1 TO 45
75  REM** PRINTER CONTROL CODES FOR UNDERLINING, BOLD PRINT,
    ETC
76  REM** (SEE PRINTER MANUAL FOR APPROPRIATE CODES)
80  LPRINT (CHR$(27)+CHR$(42)+"2"+CHR$(27)+CHR$(73);
85  REM** THIS PRINTS THE CHARACTER COMBINATIONS
90  LPRINT CHR$(A(I))+CHR$(A(J));
95  REM** SPACE BETWEEN QUOTES SETS SPACE BETWEEN COMBINA-
    TIONS IN A LINE
100 LPRINT "  ";
110 REM** CHECK FOR END OF LINE (SET LINE LENGTH WITH > = VALUE)
120 IF LPOS(0) > = 63 THEN GOSUB 170
130 NEXT I,J
150 END
160 REM** SUBROUTINE TO SKIP DOWN TWO LINES (EACH "LPRINT"
    = 1 LINE:
170 LPRINT : LPRINT : RETURN
175 REM** DECIMAL ASCII CODES FOLLOW:
176 REM** (SEE PRINTER MANUAL FOR DECIMAL ASCII CODES LIST)
180 DATA 35,37,42,43,4,49,50,51,52,53,54
190 DATA 55,56,57,60,61,62,63,64,65,66,67,68
200 DATA 69,70,71,72,73,74,75,76,77,78,79,80
210 DATA 83,84,85,86,87,88,89,97,169,175
```

Figure 1. A BASIC program for producing a non-repeating series of 2-digit alphanumeric codes. Values in the DATA statement need be changed to accommodate the fonts available in a given printer. This particular program produces 45^2, or 2025 distinct combinations. More or fewer combinations may be chosen by varying the number of data values, and the corresponding value in the DIMENSION statement.

A typical 35 mm film frame is shown in Fig. 2.

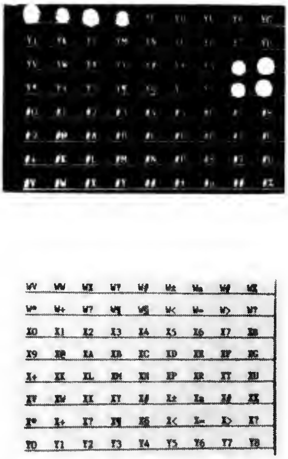

Figure 2. Typical frames of prepared 35mm film which show the spacing and general appearance of the labeling material. Several 1.5 and 2.0 mm labels have been removed from each for comparison. (actual size)

Resulting tags have been used experimentally in the study of screwworm population dynamics in the dry tropical forest of Costa Rica, where they were undamaged for periods as long as 20 days under both dry and wet weather conditions.

Tags were cemented to the dorsum of the fly thorax with the concave (painted) surface in contact with the insect (Fig. 3). Insect pins (No. 1) were found to be ideally suited for both applying cement and manipulating the small labels; one of two pins (head end) is used to place a small droplet of glue on the insect while the head of the other, moistened slightly, is used to easily pick up and position the tag on the insect. The adhesive employed was that supplied for use with the German "Opalithplattchen" bee tags (Chr. Graze Co., Endersbach, W. Germany). I found that shellac dissolved in absolute ethanol is an alternate adhesive, albeit less satisfactory due to its slow drying characteristics. It may also be less durable.

The tags weigh considerably less than the commercially produced "Opalithplattchen". The latter weigh approximately 0.0015 grams each, while the tags described herein weigh 0.0005 gms (1.5 mm diam) and 0.0008 gms (2.0mm diam). This lesser weight, combined with the smaller size, ease of production, and ability to individually mark thousands of insects with a 2 digit numbering scheme provides an ideal tag for marking many arthropods in mark/release/recapture studies.

Figure 3. 2.0mm insect label on a screwworm (*Cochliomyia hominivorax*) adult male recaptured 6 days after initial capture and marking.

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SOCIETY MEETING OF FEBRUARY 17, 1988

To a connoisseur of entomological field trips, success is dependent upon proper preparation. According to Dr. Erwin "Duke" Elsner, Extension Research Entomologist at Rutgers University, a field trip is not a field trip unless one has an old beat-up car that can withstand being mired in mud or rolling over in a ditch. Malignant rust around the wheel wells, dents in the fenders, and a loose tail pipe are sure signs of the perfect vehicle that will last for 230,000 miles and can be affectionately called "Mule". Equally important is one's choice of collecting companions. No "stick-in-the-mud" or "wet blankets" please! An adventurous spirit is required to scale cliffs, traverse quaking bogs, or bushwhack through blackberry thickets in pursuit of six-legged beasts. Directions to such exotic habitats are important. The memorability of a field trip is greatly enhanced by the "quality" of map used. Getting lost is absolutely essential. Especially sought are hand-drawn, scaleless, wrinkled maps on which the restricted habitat is marked, like Black Beard's treasure, with an "X" by the previous treasure hunter whose memory has failed in the 20 years since his last visit. Preferably private and public lands are not distinguished and the most difficult path to the prime collecting spot is detailed. But a map is not enough. No field trip can be taken without appropriate gear. Every eventuality should be anticipated - nets, light traps, waders, cameras, repellants, etc. The only limitations are the imagination and Mule's capacity. Such are the "Pleasures of the Field Trip" described by Dr. Elsner. The humor was not lost on the 13 members and 7 guests whose laughter and smiles revealed familiarity with similar experiences from their own field trips. Clearly a successful field trip does not require specimens. It is the pursuit that counts and is recounted.

The continuing saga of the Cynthia Moth, *Samia cynthia,* in Philadelphia was a subject of discussion in notes of local entomological interest before Dr. Elsner's talk. (See Ent. News 98(3): 150 (1987)). The members and guests at the meeting held at the Academy of Natural Sciences of Philadelphia were heartened to learn from Dr. Kenneth Frank that extensive searches have turned up populations both in northern and southern parts of the city. It is ironic that we should wish to exterminate the Gypsy Moth but be concerned with the extinction of the Cynthia Moth, another introduced species. Dr. Frank reported that coccoons of the Cecropia Moth, *Hyalophora cecropia,* were particularly common on wild cherry along railroad right of ways in the city.

Harold B. White
Corresponding Secretary

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A REVIEW OF THE NESTING BEHAVIOR AND OBSERVATIONS ON *TACHYPHEX POMPILIFORMIS* IN NORTH AMERICA (HYMENOPTERA: SPHECIDAE)[1]

Frank E. Kurczewski[2], Mark F. O'Brien[3]

ABSTRACT: Observations on the nesting behavior of Nearctic populations of *Tachysphex pompiliformis* are summarized. A previous study of *T. tenuipunctus (=T. pompiliformis)* is scrutinized in order to ascertain the species of *Tachysphex* observed. Observations on the nesting behavior of females of *T. pompiliformis* from the Upper Peninsula of Michigan and upstate New York are given. The wasps nested in sandy or gravelly soil, excavated burrows with the mandibles and forelegs, left entrances open during hunting and provisioning, transported prey on the ground, using the wings as an aid, and filled burrows with sand, using the forelegs and end of abdomen. The single-celled nests were short, shallow, and oriented obliquely. Cell provisions consisted of a single *Melanoplus* sp. (Acrididae) placed head inward and ventral side up. The wasp's egg was affixed to the prey's forecoxal corium and extended transversely across the sterna between the fore- and midcoxae. Behavioral similarities and differences between *T. pompiliformis* and related species are discussed.

Tachysphex pompiliformis (Panzer) has gone unrecognized in North America until recently, despite the fact that it is one of the most commonly collected species in the genus (Pulawski 1988). This species is widely distributed, occurring throughout the cooler parts of the Nearctic and Palearctic faunal zones (Pulawski 1971, 1988), e.g., mountain ranges in the western United States. Its behavior has been studied for nearly a century in Europe (summary in Pulawski 1971), but accounts of its nesting vary widely between studies. In the Nearctic region, only a moderate amount of biological information is available for *T. pompiliformis,* and some of these earlier observations may pertain to other species.

Previous Observations in North America

Peckham and Peckham (1905) were the first to study this species in North America (under the name *T. quebecensis*). They observed a female in July near Milwaukee, Wisconsin that exited from her nest, left the entrance open and flew away. An hour later she came "leaping along," holding a small grasshopper with the third pair of legs. She placed the prey

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[1] Received December 11, 1987. Accepted March 15, 1988.

[2] Environmental and Forest Biology, State University of New York College of Environmental Science and Forestry, Syracuse, NY 13210.

[3] Museum of Zoology, The University of Michigan, Ann Arbor, MI 48109-1079.

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in the entrance, turned around inside the nest, pulled in the grasshopper and then exited. In 30 min she added two more prey to the nest and closed it from within. They gave no information on the structure of the wasp's nest or its dimensions, but indicated that the wasp's egg had been placed in front of the first pair of legs of the grasshopper.

Newton (1956) reported on *T. pompiliformis* (as *T. tenuipunctus*) and what he thought were 10 unnamed species of *Tachysphex* nesting in an aggregation near Shoshone, Idaho. Seven of the unnamed species have since been identified by Pulawski (1988) as *T. montanus* (Cresson), *T. eldoradensis* Rohwer, *T. hopi* Pulawski, *T. williamsi* R. Bohart, *T. occidentalis* Pulawski, *T. yolo* Pulawski, and *T. tarsatus* (Say) and, although some of Newton's (1956) observations probably pertain to *T. pompiliformis,* they may refer as well to any of these species. Newton noted that the wasps he studied ranged in body length from 10-16 mm, with a mean of 13 mm. However, *T. pompiliformis* females are only 7-11 mm in body length with a mean of about 9 mm (Pulawski 1988). Figures in Newton's paper show a female of a *Tachysphex* sp. excavating a burrow and the same or another wasp transporting prey on the ground. Both photographs show a wasp with a black head and thorax and red abdomen. Based on size range and coloration, *T. montanus, T. pompiliformis,* or, possibly, *T. amplus* may have been the species Newton observed. Like *T. pompiliformis, T. montanus* is an inhabitant of montane regions in the western United States. Females are 11-14 mm in body length and many of them have an all red abdomen (Pulawski 1988). There are females of *T. montanus,* as well as those of *T. pompiliformis,* pinned with prey from Newton's study in the U.S. National Museum. *T. amplus* has been collected in similar habitats in Idaho. The females are 11-13 mm in body length, and the gaster is all red (Pulawski 1988). All of the *Tachysphex* species named above appear to have similar nesting behavior (Kurczewski 1987, Pulawski 1988).

The wasps Newton observed left their nest entrances open after excavation, straddled the prey venter-up, held it by its antennae, transported it on the ground, often aided by buzzing the wings, and then pulled it into the nest. After immobilizing the prey, wasps were seen to malaxate the sternal area of the grasshopper and imbibe fluids that became disgorged from the mouth. After oviposition the wasp filled her burrow and then excavated a second burrow "within a few inches" of the first one. The population of wasps he observed exhibited an unusually brief time of 3 to 8 minutes to excavate the nest.

The nests entered the soil diagonally and were "1-1/2 to 2 inches deep." During early June each cell was provisioned with two "small" acridids, but later in the summer the wasps stored only one "larger" acridid per cell. The females preyed nearly exclusively on nymphal *Oedaleonotus enigma* (Scudder), but twice captured nymphs of *Aulocara elliotti* (Thomas), and once, nymphal *Melanoplus* sp. (all Acrididae). The wasp's egg was 2 mm long, affixed to the forecoxal corium, extended transversely across the sterna, and hatched in 2-3 days.

Alcock (1973) studied three nests of *T. pompiliformis* (as *T. parvulus)* in late July at Seattle, Washington. All three nests had been dug into the slope of a path in dense vegetation. They were 1-celled, 5.5-10.0 cm ($\bar{x}$=7.2) long, and 2.5-3.5 cm ($\bar{x}$=3.0) deep. Two fully provisioned cells each held two acridids, 11 mm long, and a third, unfinished cell contained a single large grasshopper 21 mm long. All prey were positioned venter-up, and the wasp's egg had been affixed to the venter of the prothorax of the second prey brought into the first two nests.

Steiner (1981) noted that the prey of *T. pompiliformis* (as *Tachysphex* sp.) was paralyzed by a series of four successive stings. He described the sites of sting insertion, three near the leg bases and one in the throat region. Krombein (1967) listed two genera of immature Acrididae as prey of this species (as *T. quebecensis*) and Pulawski (1988) listed two genera of nymphal acridids as *T. pompiliformis* prey.

Our Observations

Our study of nesting behavior in this species comprised sporadic observations made on eight wasps at five localities in the Upper Peninsula of Michigan and upstate New York. One wasp (Ethology note no. P86-15) nested on 27 June 1986 at 1735 h (EDT) in moss-covered sand at the edge of a trail leading through an old field at the Huron Mountain Club, Marquette Co., MI; three (MFO 9-11) in a 1 m2 area of sand surrounded by grasses and mixed coniferous-hardwood woodlands at 1200-1215 h (EDT) on 10 June 1978 near Parishville, St. Lawrence Co., NY; one (TX-92) at the edge of a field adjacent to a gravel bank on 13 June 1967 in Groton, Tompkins Co., NY; two (TX-90a,b) on 8, 18 June 1968 in a sandy field at the edge of a stand of *Pinus strobus* near Chittenango, Madison Co., NY; and one (TX-91) on 12 June 1971 along a car path leading through a sandy field inside Selkirk Shores State Park, Oswego Co., NY. Observations were made on sunny days at ambient temperatures of 18° - 28°C.

Burrow excavation was observed once. The wasp used her mandibles and forelegs in unison to remove sand from the burrow. She held her antennae outstretched but lowered toward the sand and held her wings flat on the dorsum. Periodically, she backed from her excavation to remove sand that had accumulated inside of the burrow entrance. As she dug deeper, it took her longer to back out with a load of sand. Eventually, the wasp appeared headfirst inside of the entrance, walked onto the tumulus, ran around the opening three times and went off hunting. The time expended for burrow excavation was 16 min. No leveling of the tumulus was noted. Two other tumuli were 17 x 25 and 25 x 30 mm wide and long, respectively.

Females hunted for prey on the ground and low vegetation, often within 10 m of their nests. They alternated between running and making short, rapid flights between clumps of prostrate vegetation. Prey capture was not observed. Malaxation was seen twice. It involved the wasp squeezing the area of the prey's forecoxal corium with the mandibles, and possibly, lapping up a fluid in the process. During prey transport the wasp straddled the grasshopper venter-up, grasped its antennae with the mandibles and its body with the hindlegs, and proceeded rapidly forward on the ground, using the wings to aid momentum. The head of the paralyzed acridid was placed inside the entrance while the female entered the burrow, turned around within, appeared headfirst in the entrance, and backed inside, holding the prey's antennae with the mandibles. Wasps then appeared headfirst, 2.5 - 5.0 min. after entry and began filling the burrow with sand. The female came onto the surface and flung sand backward with the forelegs, backed inside the burrow while raking sand, and packed the fill into the tunnel with the vibrating end of the abdomen. Two such closures took 6 and 8 min.

The burrows entered the sand obliquely at 45° angles or less to the surface and ended in single cells. Entrances were 6-7 mm ($\bar{x}$=6.7, n=4) and burrows, 4.5-6.0 mm ($\bar{x}$=5.5, n=4) in diameter. Burrows were 24-50 mm ($\bar{x}$=40.4, n=8) long, including cell length, and 15-22 mm ($\bar{x}$=20.8, n=8) deep, including cell depth. Cell sizes ranged from 6-9 mm ($\bar{x}$=8.1, n=8) wide and 12-18 mm ($\bar{x}$=15.7, n=8) long. Each cell contained a single, relatively large (12.5-17.5 mm long) prey placed head inward and ventral side up. The wasp's egg was attached to a forecoxal corium of the prey and extended transversely between the bases of the fore- and midcoxae. The prey were identified as four nymphal *Melanoplus* sp. (MFO 9-11, P86-15); one adult male *M. viridipes eurycerus* Hebard (TX-92); one *M.* sp., possibly *bivittatus* (Say) (TX-91); and two *M.* sp., probably *sanguinipes* (F.) (TX-90a,b) (all Acrididae). Four females of *T. pompiliformis* in the U.S. National Museum are pinned with nymphal acridids as follows: *Melanoplus* sp., 13.5 and 14.0 mm long; *Oedaleonotus enigma,* 12.5 mm long (2) (Table 1).

DISCUSSION

No fewer than 19 European workers have studied the nesting behavior of *T. pompiliformis*, often as its synonym, *T. pectinipes* (L.). Morphologically and ecologically, *T. pompiliformis* is a variable species. The number of generations per year varies from one in northern Europe (Pulawski 1971) to two in Italy (Bonelli 1966). The most confusing aspects of its nesting, based upon these studies, involve whether or not the wasp appropriates pre-existing cavities for nesting sites, the exact method of prey transport, number of cells per nest, and number of prey per cell. Both Maneval (1932) and Crevecoeur (1951) have noted that females frequently renovate a subterranean cavity for a nest, yet many other workers have reported that the nest is excavated from the ground surface. Bonelli (1966) and Pulawski (1971) each reported that the prey is straddled dorsum-up, yet other workers noted transport of prey in a venter-up position. Most workers have recorded single-celled nests of *T. pompiliformis,* yet Adlerz (1904) noted three-celled nests of this species in Sweden. Many workers, notably Bonelli (1966), have recorded one, two, or three paralyzed acridids per cell; however, Maneval (1932) listed one large and 6 to 10 small prey per cell. Large grasshoppers were carried on the ground and small ones, in flight. Hardouin (1938) questioned the validity of Chevalier's (1924) observation of seven prey in one cell of *T. pompiliformis* and, therefore, would have probably also been skeptical of Maneval's (1932) report of 6-10 prey per cell for this species. The discrepancy in reports on the nesting behavior of *T. pompiliformis* in Europe is difficult to clarify because many of the observations are ambiguous or sketchy, at best, and some appear to involve doubtful identification of the wasp species.

The behavioral reports on the Nearctic populations of *T. pompiliformis*

Table 1. Genera and species of prey Acrididae of *Tachysphex pompiliformis* in North America.

Genera and species of prey*	Source of information
Aulocara elliotti (Thomas)	Newton 1956, Pulawski 1988
Camnula pellucida (Scudder)	Kurczewski 1964, Krombein 1967
Melanoplus viridipes eurycerus Hebard, Adult	FEK TX-92
Melanoplus sp., possibly *bivittatus* (Say)	FEK TX-91
Melanoplus sp., probably *sanguinipes* (F.)	FEK TX-90 a, b
Melanoplus spp.	Newton 1956, Kurczewski 1964, Krombein 1967, Pulawski 1988, MFO 9-11, P86-15
Oedaleonotus enigma (Scudder)	Newton 1956

*Nymphs unless indicated otherwise.

which have been published under the names *T. quebecensis* (Peckham and Peckham 1905), *T. tenuipunctus* (Newton 1956) and *T. parvulus* (Alcock 1973) are easier to interpret. Despite the fact that these studies were made at widely separated locations, there is some agreement on the details of nesting behavior. Newton's (1956) observations, although excellent, can be questioned because of the doubtful identity of the species of wasp. Our behavioral descriptions for this species conform in many essential elements to these earlier reports.

All wasps nested in early summer (June, July) in sandy or gravelly soil containing moderate amounts of vegetation. Females excavated their burrows, beginning from the ground surface. Entrances were left open while hunting and provisioning, and females ran around the opening several times (probably a form of orientation) prior to hunting. Prey transport was on the ground, or possibly in short flights (Peckham and Peckham 1905), the wasp grasping the prey's antennae with the mandibles and its body with the hindlegs. Females used the wings to aid forward progress. Alcock (1973) photographed a female on a plant stem, holding her prey dorsum-up. Newton (1956) photographed a wasp transporting her prey on the ground in a ventral side up position, but this female is clearly not *T. pompiliformis.* One of us (MFO) noted that the prey was transported venter-up, but we could not ascertain the exact method of grasping the acridid. Wasps released the grasshoppers inside their entrances and pulled in the prey from within the nests.

All nests were short, shallow, unicellular, and entered the soil diagonally to the surface. From one to three acridids were placed in a cell and they were positioned head inward and ventral side up. The wasp's egg was affixed to a forecoxal corium and extended transversely across the pro- and mesosterna between the bases of the first two pairs of legs.

Tachysphex pompiliformis is related morphologically to *T. montanus, T. aethiops* (Cresson), *T. acutus* (Patton), and *T. punctifrons* (Fox) (Pulawski 1988). The first three species inhabit pan-boreal zones of North America, extending southward mostly in mountainous regions (Pulawski 1988). *Tachysphex acutus* and *T. punctifrons* are collected uncommonly in the United States and southern Canada east of the Rocky Mountains (Pulawski 1988). Although the five species are unified by morphological similarities, they can be separated from each other behaviorally (Kurczewski 1987). *Tachysphex aethiops, T. punctifrons,* and *T. pompiliformis* (in Europe) dig multicellular nests and have been reported to begin nests from pre-existing soil cavities (Adlerz 1904, Maneval 1932, Crèvecoeur 1951, Evans 1970, 1973, Alcock 1973, Kurczewski 1987, O'Brien 1987). *Tachysphex acutus* excavates rudimentary bicellular nests from the surface in soil with much vegetation (Kurczewski in press). The nest of *T.*

montanus has not been described, but if Newton's (1956) observations pertain to this species, then it is single-celled. *Tachysphex punctifrons* and *T. pompiliformis* in Europe and, possibly, North America transport prey on the ground, straddling the grasshopper dorsal side up (Kurczewski 1987, Pulawski 1971, Alcock 1973), whereas *T. acutus,* and possibly, *T. montanus* carry their prey on the ground in a ventral side up position (Kurczewski in press, Newton 1956). *Tachysphex montanus* and *T. pompiliformis* capture the same species of Acrididae in Idaho, preying on medium-sized and relatively large nymphs of Oedipodinae and Cyrtacanthacridinae (Newton 1956, Krombein 1967, Pulawski 1988). *Tachysphex acutus* and *T. punctifrons* capture relatively large, nymphal or adult (*T. punctifrons*) *Melanoplus* spp. (Cyrtacanthacridinae) (Kurczewski in press, 1987), whereas *T. aethiops* preys only upon nymphal Oedipodinae (Evans 1970, 1973, O'Brien 1987).

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SOCIETY MEETING-MARCH 16, 1988

If Charles Darwin were alive today, he would instantly appreciate the modern problem of insecticide resistance. It is a dramatic example of natural selection in action. The more effective an insecticide is the greater the selective advantage there is for resistant individuals in the target species. While resistance to DDT in house flies and mosquitoes is well known, over 450 examples of insecticide resistance have been documented. Dr. David Marsden of the E.I. duPont Company, who spoke on "Insecticide Resistance Management", cited the striking example of the Diamond-back moth. This moth with a short life cycle is a year round pest of cruciferous crops in Thailand. Over the years this species has developed resistance to every insecticide used to control it. Clearly it is important to develop strategies of management to minimize, delay, or avoid resistance so that insecticides can be used for a longer time in lesser amounts and still achieve control of insect damage to crops.

Dr. Marsden presented his talk to twelve members and two guests in Townsend Hall at the University of Delaware. He described the many factors such as life history, behavior, and biochemistry that contribute to insecticide resistance. In order to design effective management as much as possible must be known about the target species. Dr. Marsden is participating in a collaborative project with the DuPont Company and four other insecticide producers, "The Pyrethroid Efficacy Group." They have jointly undertaken a large scale effort to monitor and minimize insecticide resistance of *Heliothis virescens* (Lepidoptera: Noctuidae), a major pest on cotton in the cotton growing regions of the southern United States. This program uses both laboratory and field monitoring to assess resistance levels so the appropriate methods of insect control can be used to provide acceptable efficacy and reduce potential buildup of resistant populations. These multiple measures of resistance are being used with sophisticated strategies of insecticide application to preserve the long term use of current chemicals used for *Heliothis* control in cotton. The results so far indicate that the efforts to minimize resistance have been successful.

Harold B. White,
Corresponding Secretary

4/13/88

A NEW SPECIES OF THE LEAFMINING SAWFLY GENUS *METALLUS* (HYMENOPTERA: TENTHREDINIDAE) FROM EASTERN NORTH AMERICA[1]

David R. Smith[2]

ABSTRACT: *Metallus ochreus*, new species, is described from Virginia and Maryland. It has been found only in late September and early October. Color, antennal, sheath, and ovipositor characters separate it from the other three North American species of *Metallus*.

A fourth species of *Metallus* Forbes is here added to the North American fauna. It is the first new member of the Fenusini for this continent that has come to my attention since my revision (Smith, 1971). The host is not known, but two of the other North American species and most Palearctic species are leafminers of *Rubus* spp., with one Palearctic species, *M. gei* (Brischke), a leafminer of *Geum* spp. (Benson, 1952). Three specimens of the species described here were collected in Malaise traps in two localities in Virginia in late September and early October. The traps were in operation from March to October for seven years at the Fairfax County site and for three years at the Louisa Co. site. Such a late flight period is very unusual for sawflies, most of which are spring fliers. The flight time and its small size are probably reasons it has escaped discovery. *Rubus* spp. were present near each collection site, and specimens of *Metallus rohweri* MacGillivray were also collected at each site in August to mid-September, but none as late as the new species.

Metallus ochreus **Smith, new species**

Female. — Length, 3.5-4.0 mm. Antennal scape and pedicel white, flagellum black. Head black, labrum and palpi white. Thorax black with posterior margin of pronotum and tegula orange to white and mesonotum and metanotum orange. Abdomen orange with apical segment lightly infuscated; sheath orange. Legs orange to white. Wings hyaline to very lightly uniformly infuscated; veins and stigma black.

Antennal length about 1.8X head width; 1st segment slightly longer than broad, 2nd segment about as long as broad, 3rd segment subequal to very slightly shorter than 4th segment, segments 3-9 gradually decreasing in length; segments rounded; segments 3-5 nearly 3X longer than broad. Clypeus truncate; malar space linear; lower interocular distance to eye

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[1] Received March 9, 1988. Accepted March 26, 1988.

[2] Systematic Entomology Laboratory, PSI, Agricultural Research Service, U. S. Department of Agriculture, c/o National Museum of Natural History, NHB 168, Washington, D.C. 20560.

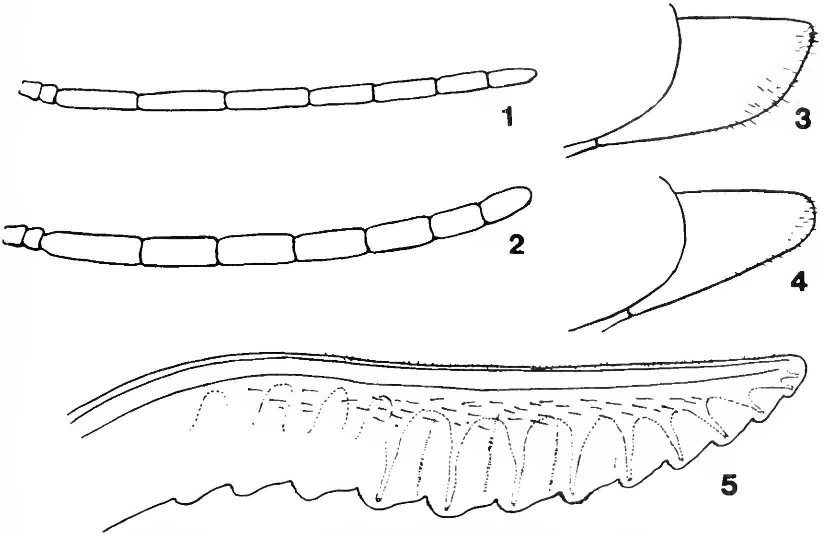

Fig. 1, Female antenna of *M. ochreus.* Fig. 2. Female antenna of *M. rohweri.* Fig. 3. Sheath of *M. ochreus.* Fig. 4. Sheath of *M. capitalis.* Fig. 5. Lancet of *M. ochreus.*

length as 1.5:1.4. Distances between eye and lateral ocellus, between hindocelli, and between hindocellus to posterior margin of head as 1.3:1.0:0.8. Head and body shining impunctate. Tarsal claw with single outer tooth and large, acute basal lobe. Forewing with vein 2A+3A straight. Hindwing with radial cell closed. Sheath bladelike, in lateral view straight above, rounded below and at apex (Fig. 3). Lancet with about 12 serrulae; serrulae broadly rounded, each with 2-4 fine, anterior subbasal teeth (Fig. 5).

Male. — Unknown.

Holotype. — Virginia, Fairfax Co., near Annandale, X-5-86, Malaise trap, David R. Smith.

Paratypes. — MARYLAND: Beltsville, 3-X-1966, L.H.M. Blommers (1 ♀). VIRGINIA: Same data as for holotype except date, IX-26-87 (1 ♀); Louisa Co., 4 mi. S. Cuckoo, 25-IX-20-X-87, Malaise trap, J. Kloke & D.R. Smith (1 ♀). Holotype and paratypes of Virginia specimens in the National Museum of Natural History, Washington, D.C.; paratype from Maryland in Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands.

DISCUSSION

The white scape, pedicel, labrum, and palpi and orange mesonotum and abdomen are the most obvious diagnostic characters for *M. ochreus.* All other species of *Metallus,* worldwide, are black with at most some brownish areas on the thorax and/or abdomen. The lancet of *M. ochreus* is similar to *M. rohweri* (Smith, 1971: Fig. 89), but *M. ochreus* has more slender antennae (compare Figs. 1, 2). The antennae of *M. rohweri* females are about 1.5X the head width and segments 4 and 5 are no more than 2X longer than broad. The antennae of *M. ochreus* are similar to those of *M.*

capitalis (Norton), but the sheath of *M. capitalis* is more slender (compare Figs. 3, 4) and the lancet of *M. capitalis* has more narrowly rounded serrulae each with a subbasal tooth on each side near the base (Smith, 1971: Fig. 88). The lancet of *M. bensoni* Smith has long, slender, pointed serrulae (Smith, 1971: Fig. 87).

The specific name refers to the extensive pale orange coloration of this species.

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SOCIETY MEETING-APRIL 20, 1988

It takes foresight and determination to deliberately plant stinging nettles in your family garden. But, if you want to share your property with the Red Admiral whose food plant is the stinging nettle, such an act is quite sensible. Jane Ruffin, a volunteer in the Entomology Department at The Academy of Natural Sciences of Philadelphia, has performed this and other similar acts in her suburban Philadelphia garden. She spoke on, "Gardening for Butterflies", at the final membership meeting of the 1987-88 season. As described by Mrs. Ruffin, there are challenges to attracting butterflies to your garden. In her case the soil was a hard infertile clay that would not support many of the plants she wanted. The solution was to import wood chips and topsoil, and apply the appropriate fertilizers. Success can also produce problems such as the complete defoliation of a nasturtium bed by caterpillars of the Cabbage White or the groundhog that took up residence in a wild flower patch. After several years experience with a variety of plants, Mrs. Ruffin recommends, 'If you have to select one plant for your garden, *Buddleia davidii* is guaranteed to attract butterflies." Last year she recorded 31 species of butterfly in her garden.

In addition to her interest in gardening for butterflies, Mrs. Ruffin is an accomplished photographer. Her presentation was illustrated with slides of the plants and butterflies she described. Also illustrated were the Butterfly Houses of her native England. These attractions have become very popular in Great Britain and are only recently receiving attention here. For example, The Day Butterfly Center at Calloway Gardens in Pine Mountain, Georgia is scheduled to open this fall. Mrs. Ruffin's topic and presentation was as attractive to local entomologists as her garden is to butterflies. Sixteen members and nine guests attended the meeting and lingered in a lively discussion long after the talk was over.

In the discussion period before the talk Bill Day introduced a historical note appropriate for the evening. A short article in an 1900 issue of *Ent. News* described with skepticism a newspaper article which claimed that exorbitant prices were being paid by British collectors, for specimens of a "rare" butterfly from California. Dr. Charles Mason noted that the U.S. will issue a honey bee stamp this year. Also Dr. Day added that Canada will produce a set of 4 insect stamps this year to commemorate the International Congress of Entomology, meeting in Vancouver in July. On issues of conservation Hal White reported that several local AES members and others were attempting to prevent timbering along Blackbird Creek in Delaware. This locality is the only known habitat in the state for a number of rare aquatic insects.

Frank Stempin, a local high school student with an interest in crickets, was presented with a one year subscription to *Entomological News* and a one year membership in the Society.

Harold B. White,
Corresponding Secretary

5/18/88

PARASITISM OF THE AQUATIC MOTH *PETROPHILA CONFUSALIS* (LEPIDOPTERA: PYRALIDAE) BY THE AQUATIC WASP *TANYCHELA PILOSA* (HYMENOPTERA: ICHNEUMONIDAE)[1]

Vincent H. Resh[2], Wanda Jamieson[3]

ABSTRACT: Pupae of the pyralid moth *Petrophila* (= *Paragyractis*) *confusalis* (Walker) are parasitized by the ichneumonid wasp *Tanychela pilosa* Dasch in Owl Creek, below Placid Lake, Missoula Co., Montana. The incidence of parasitism is localized, ranging from 55% of pupae at a site 0.5 km below Placid Lake to 24% and 0%, 3 and 5 km, respectively, below the lake. Parasitized pupal cocoons contain an air bubble, which presumably is related to the wasp's respiration.

Of the 13 orders of insects that are generally considered to have representatives in aquatic habitats (Merritt and Cummins 1984), the Hymenoptera are probably the group that are most rarely encountered. It would be safe to say that the majority of aquatic entomologists and benthic biologists spend entire careers studying stream and lake benthos without ever collecting a single aquatic hymenopteran. Many of the entomologists who have observed aquatic hymenopterans have done so in European streams where the agriotypid wasp *Agriotypus armatus* Curtis parasitizes larvae of the goerid caddisfly *Silo pallipes* (Fabricius). The presence of this parasitoid is distinct: a long respiratory ribbon protrudes from the parasitized caddisfly case (Grenier 1970, Photo 3; Elliott 1982, Plate 1).

Recent studies in a Montana stream [Owl Creek, below Placid Lake, Missoula Co., MT; see McAuliffe and Williams (1983) for site description] revealed the presence of an ichneumonid parasitoid in the pupal cocoons of the aquatic pyralid moth *Petrophila* (= *Paragyractis*) *confusalis* (Walker); this parasitoid has been identified as *Tanychela pilosa* Dasch. Previously, Hagen (1956, 1984), Lange (1956), Tuskes (1977), and Krombein *et al.* (1979) have reported that an undescribed species of ichneumonid wasp parasitized aquatic pyralids in California. *Tanychela pilosa* (one of two described species in the genus, the other occurs in Brazil) "was reared in California from a species of the pyralid genus *Argyractis*" (=*Petrophila*) and has also been collected in Mexico (Dasch 1979: 331). The female of

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[1] Received February 19, 1988. Accepted March 15, 1988.

[2] Department of Entomological Sciences, University of California, Berkeley, California 94720.

[3] Flathead Lake Biological Station, University of Montana, East Shore, Polson, Montana 59860.

this species is illustrated in Dasch (1979).

When non-parasitized, the pupa of *P. confusalis* is within a silken cocoon that is beneath an elliptical, external pupal case (McAuliffe and Williams 1983). When the pupa of *P. confusalis* is parasitized, a dark brown, leathery wasp pupal cocoon lies inside the empty moth pupal cocoon (Fig. 1). In both circumstances, shed moth larval sclerites are compacted in one end of the moth pupal cocoon. Full-grown larvae, pupae, and adults of *T. pilosa* are 7-8 mm long.

Because the empty wasp cocoon remains within the moth pupal case after the wasp has emerged, the incidence of parasitism in the moth pupal population can be ascertained. The percentage of parasitized *P. confusalis* pupae was examined at three sites along Owl Creek on July 29 and August 9, 1987; these sites were 0.5, 3, and 5 km, respectively, below the outlet of Placid Lake. Specimens were collected randomly and the results are presented in Table 1. Estimates of parasitism at two of the sites are higher than the 9-10% of *S. pallipes* pupae that were parasitized by *A. armatus* in a southwest England stream (Elliott 1982).

In parasitized moth cocoons, we found that an air bubble occupying 10-20% (by volume) of the wasp cocoon was consistently present. Grenier (1970) reported that the final instar of the wasp *A. armatus* also fills the caddisfly pupal cocoon with gas; the respiratory ribbon of the wasp pupa allows a gaseous exchange between the cocoon and the water. The pupae of *T. pilosa* lacks an obvious external respiratory ribbon and we do not know the mechanism by which the cocoon becomes gas-filled.

The agriotypid wasp *A. armatus,* like *T. pilosa,* is in the Ichneumonoidea.

Table 1. Parasitism of *P. confusalis* by the ichneumonid wasp *T. pilosa* at three sites in Owl Creek, Missoula County, Montana.

	Distance Below Placid Lake Outflow		
	0.5 km	3 km	5 km
Date of collection	July 29, 1987	August 9, 1987	August 9, 1987
Number of *P. confusalis* pupal cases examined	138	99	143
Number of *P. confusalis* pupae or emerged moth adults	62	75	143
Number of parasitized pupae or emerged wasp adults	76	24	0
% of *P. confusalis* cocoons parasitized by *T. pilosa*	55%	24%	0%

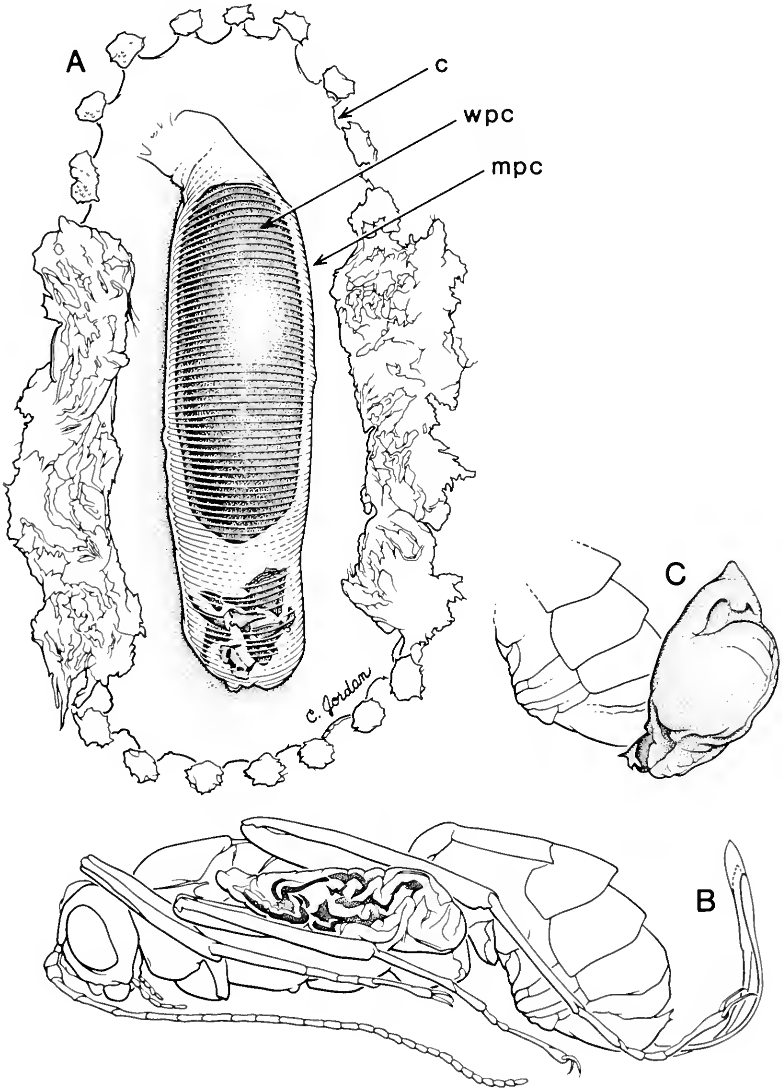

Fig. 1. A. External pupal case (c), pupal cocoon of the aquatic moth *P. confusalis* (mpc), and pupal cocoon of the aquatic wasp *T. pilosa* (wpc); B. female pupa of *T. pilosa* with pupal cocoon and meconium (i.e. fecal pellet at base of abdomen) removed; C. abdomen of *T. pilosa* pupae with meconium.

In Elliott's (1982) description of the life cycle of *A. armatus* and its host *S. pallipes,* he reported that *A. armatus* females lay eggs in the pupal cases of its host in late spring; the wasp larvae feed on the living hosts and grow rapidly to the pupal stage that summer; both the parasitoid and its host have a one-year life cycle. *P. confusalis* is univoltine in Owl Creek (McAuliffe and Williams 1983). Circumstantial evidence suggests the phenology of parasitization of *P. confusalis* pupae by *T. pilosa* is similar to the above pattern.

ACKNOWLEDGMENTS

We thank J. Imbert, R. Paige, P. Benzing, and M. Siemens for assistance in collecting specimens, J. Stanford and the staff of the Flathead Lake Biological Station for their assistance and use of facilities, C. Jordan for preparing Figure 1, K. Hagen for identification of *T. pilosa,* and K. Hagen and L. Caltagirone for their comments on the manuscript.

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ON THE IDENTIFICATION OF *DORYCTES ERYTHROMELAS* (HYMENOPTERA: BRACONIDAE)[1,2]

Donald L.J. Quicke[3], Robert A. Wharton[4]

ABSTRACT: Males from a central Texas population of the braconid parasitoid *Doryctes erythromelas* were found to differ from previous characterizations of this species. The possibility that a cryptic species exists is discussed, and variation in males and females from central Texas is described.

During investigations of internal morphology of members of the family Braconidae, we collected numerous males and females of a species of *Doryctes* Haliday from around wood-piles in Lick Creek Park, College Station, Texas during September 1987. We determined these as *Doryctes erythromelas* (Brullé), but observed that males did not precisely fit the characterization of this species provided by Marsh (1969). A series of males and females was sent to Dr. Paul Marsh, and he confirmed that all the material was indeed *D. erythromelas. Doryctes erythromelas* is widely distributed in North America (Marsh 1969), and has been frequently reared from beetle-infested logs (Hopkins 1892, Chittenden 1893, Blackman and Stage 1924, Beal and Massey 1945, Shenefelt and Marsh, 1976). Since the only available specific key to males fails to permit correct identification of males from central Texas, we provide here a partial redescription to rectify the situation.

Males from College Station, Texas, always have the ninth abdominal sternum acutely pointed anteriorly (Fig. 1) rather than "broadly rounded or truncate" (Marsh 1969). This was confirmed by the dissection of 35 males. We were unable to find any specimens with the base broadly rounded, though slight variation in the number and position of setae was observed. Although the overall shape is relatively stable, one specimen had the basal portion distinctly narrower and slightly longer than in the others. Males of *D. erythromelas* with an acutely pointed ninth sternum run to couplet 4 of Marsh's (1969) key. Couplet 4 offers the following choice of characters: "Forewings mottled, although weakly so" or "Forewings not mottled, hyaline or evenly and lightly infuscated". The fore wings of *D. erythromelas* are uniformly dark brown except for two small transparent areas near

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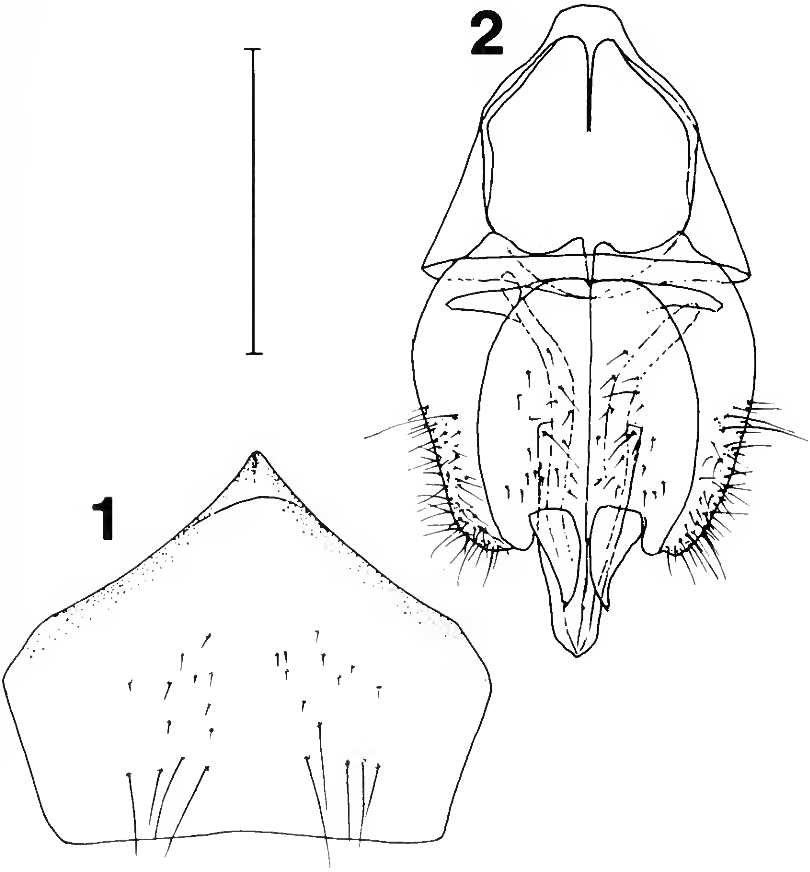
[2] Approved as TA No. 23440 by the Texas Agricultural Experiment Station.

[3] Department of Zoology, University of Sheffield, Sheffield S10 2TN, United Kingdom.

[4] Department of Entomology, Texas A&M University, College Station. Texas 77843-2475.

poorly formed veins, and thus fit neither alternative.

In addition to the shape of the 9th abdominal sternum, the College Station specimens of *D. erythromelas* differ from the figures and descriptions of that species provided by Marsh (1965, 1969) in two other ways. Firstly, the basal ring of the male genitalia (gonobase) does not agree well with that illustrated in Figure 66 of Marsh (1965) in that it is distinctly produced mid-anteriorly forming an apically obtuse gonocondyle (Fig. 2) rather than being formed into a simple point. Secondly, the second segment



Figs. 1,2. *Doryctes erythromelas* male from College Station Texas. 1, 9th abdominal sternum; 2, genitalia, dorsal aspect. Scale bar = 0.3mm.

of the mediella of the hind wing is considerably longer than the basella (mean = 1.53x; S.D. = 0.14; range = 1.21-1.72; n = 21) whereas Marsh (1969) describes the second segment of the mediella as being "usually equal to basella, occasionally slightly longer".

Females collected from the same locality were variable in two characteristics used in keys and descriptions (Marsh 1969) to distinguish the species of *Doryctes*. The penultimate segment of the maxillary palp varied from 1.1-1.5 (n = 10) times the length of the first flagellomere. Most specimens fell within a range of 1.1-1.3. The hind coxa of most specimens in this population were also rugulose dorsally, but this feature was noticeably size-dependent, with smaller individuals often having the coxa entirely smooth or nearly so. As is apparently characteristic of the genus, the hind coxa is produced anterior-ventrally to form a sharp tubercle in this species. The material examined also differs from many of the other Nearctic *Doryctes* in having the setosity of the median mesonotal lobe considerably reduced.

At this time, we do not think that the available evidence warrants segregation of the central Texas material with the anteriorly acute ninth sternum as a separate species. In the absence of character states to permit separation of females of the central Texas form from typical ones, identification of a cryptic species based on male characters would pose a difficult taxonomic problem as only one of the six junior synonyms of *D. erythromelas* is based on a male specimen. Nevertheless, the possibility that *erythromelas* includes two or more cryptic species cannot be disregarded. We therefore urge future workers to include details of the above characters and/or voucher specimens when publishing on this species in order to minimize the likelihood of confusing any possible cryptic species.

Material from this study is deposited as voucher number 274 in the Texas A&M University Insect Collection. Additional material is in the senior author's collection.

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PHEROMONE BIOCHEMISTRY. G.D. Prestwich & G.J. Blomquist, eds. 1987. Academic Press. 565 pp. $85.

A compilation of 15 chapters by authors in the fields of pheromone chemistry, glandular & antennal morphology neurobiology, and biochemistry. Book is divided into two major sections: 1) pheromone production and its regulation in female insects, and 2) reception, perception, and degradation of pheromones by male insects.

THE MAYFLIES OF FLORIDA (Revised Edition). L. Berner & M.L. Pescador. 1988. Univ. Presses of Florida 416 pp. $35.

A complete revision and updating of the original 1950 edition. Includes identifications, new keys to nymphs and adults, distribution, ecology, life histories and all other currently available data on Florida mayflies.

INSECT-EATING PLANTS & HOW TO GROW THEM. A. Slack. 1988 (ppbk ed.) Univ. of Washington Press. 172 pp. $19.95 ppbk.

Of possible peripheral interest to entomologists,, this book is primarily of interest to horticulturalists, nurserymen, and botanical gardeners. Descriptions and biology are brief. The main emphasis is on cultivation of these interesting plants.

INTERINDIVIDUAL BEHAVIORAL VARIABIILITY IN SOCIAL INSECTS. R.L. Jeanne, ed. 1988. Westview Press. 456 pp. $39.85 ppbk.

A compilation of 14 chapters representing empirical studies on some aspect of the phenomenon of individual variability in the behavior of social insects. These illustrate the range of ways individual members of a colony can differ from one another and interpret this variability in terms of the external environment, social context, or individual experience.

CATALOGUE OF PALAEARCTIC DIPTERA. Vol. 5. Athericidae - Asilidae. A. Soos, & L. Papp, eds. 1988. Elsevier Science Publishers. 446 pp.

Another volume in the continuing Catalogue which ultimately will include the taxonomic, nomenclatural, and distribution data of some 25,000 species in some 132 Diptera families.

FIRST RECORDS OF *PLATYCHALCIS* IN NORTH AMERICA AND NEW HOST RECORDS OF *CERATOSMICRA* SPP. AND *BRACHYMERIA OVATA* (HYMENOPTERA: CHALCIDIDAE)[1]

Jeffrey A. Halstead[2]

ABSTRACT: *Platychalcis phalara* is recorded for the first time in Panama, El Salvador, Mexico, and the United States. The male is described, and color and morphological variation of *Platychalcis phalara* are discussed. New host and rearing records are presented for four *Ceratosmicra* species, including a primary parasite record for *Ceratosmicra debilis* from *Stenoptilodes antirrhina* (Lepidoptera: Pterophoridae). *Ceratosmicra* were previously reported as obligatory secondary parasites of braconid and ichneumonid wasps. Previous host records are reviewed. A new host record of *Brachymeria ovata* from *Danaus plexippus* (Lepidoptera: Danaidae) is presented.

Upon studying North American Chalcididae, I recently found two specimens of the undescribed male of *Platychalcis phalara* Burks and several females which greatly expand the range of this species and show color and morphological variation. In this paper, I describe the male of *P. phalara* and discuss the color and morphological variations. Further, new host and rearing records were discovered for four *Ceratosmicra* Ashmead species and *Brachymeria ovata* (Say). A record for *Ceratosmicra debilis* (Say) demonstrates it is a primary parasite. *Ceratosmicra* were previously reported as obligatory secondary parasites (Burks 1979). This information is presented to update the host and distributional data in Burks (1979) and DeSantis (1979).

Platychalcis phalara Burks

Described by Burks (1939) from three females collected in Costa Rica and Honduras. In the genus *Platychalcis,* males are undescribed and hosts are unknown (DeSantis 1979).

Male description. — 3 mm. Black with frons, clypeus, labrum, mandibles, antennae, pronotum, tegulae, scutellum (except for base and apex), propodeum, fore and middle legs, apex of hindcoxae, apex and base of hindfemora and hindtibiae, and tarsi yellow-brown.

Head finely coriaceous with silver setae, 2X as wide as high (frontal view), 1.7X as high as wide (lateral view), wider than thorax (dorsal view); eyes large, bulging laterally, glabrous; ocelli round, lateral ocelli 0.5X their diameter from compound eye, 2X their diameter from

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[2] 2110 N. Hayes, Fresno, CA 93722.

each other, anterior ocellus 1X ocellar diameter from lateral ocelli; occiput acciculate and setose; frons concave, polished, smooth; antennae inserted just above ventral margin of compound eye, densely setose; scape 2X as wide at apex than base, reaching above anterior ocellus; flagellar segments 1 and 2, 3-8, and club 1.5X, 0.75X, and 0.5X as wide as long, respectively.

Thorax flat dorsally, with sparse setigerous umbilicate punctures, integument polished, smooth (except for acciculate base of mesoscutum); mesopleural acetabulum transversely carinate, polished; mesopleural densely punctured; propodeum with a V-shaped carina originating from small tooth at base, a few vague carina laterally, integument coriaceous; hindcoxae as long as hindfemora, outer-dorsal side polished and glabrous, outer-ventral side setose and polished; hindfemora 2X as long as wide, setose, polished, 15 small teeth along ventral margin; wings smokey throughout, densely setose.

Abdomen 0.4X length of thorax, polished, sparsely setose laterally; petiole 6X as long as wide, length 0.9X abdomen, cylindrical, smooth, matte; tergite 1 0.4X length of abdomen, length equal to tergites 2-5 together; tergite 2 2.5X tergites 3-5.

Voucher male marked with red label "Voucher, Male Description, *Platychalcis phalara* Burks" and deposited in American Museum of Natural History, New York. Collection data: "MEXICO, Chiapas, Palenque, 10 Sept 1974, W. Hanson, G. Bohart, UTAH STATE UNIVERSITY."

New distributional records for *P. phalara* include: United States, Mexico, El Salvador, and Panama, representing a considerable northward and southward range extension.

Collection data is: UNITED STATES, Arizona, (1♀), Cochise Co., S.W. Res. Sta., 5 mi W. Portal, Chiricahua Mtns., 5400', VIII-16-17-1978, Malaise trap, M.S. Wasbauer (CDFA). Florida, (2♀), Alachua Co., Gainesville, Doyle Conner Bldg., XI1-5-1976, X-25-29-1976, pan trap (Moericke trap), E.E. Grissell (FDA). MEXICO, Chiapas, (5♀, 2♂), Palenque, IX-10-1974, W. Hanson and G. Bohart (USU). Tabasco, (1♀), Cardenas, IX-8-1974, W. Hanson and G. Bohart (USU). Nayarit, (1♀), Laguna del Oro, VIII-25-1974, W. Hansen and G. Bohart (USU). Jalisco, (1♀), 18 mi N. Barro de Navidad, VIII-23-1974, Hanson and Schwartz (USU). EL SALVADOR, Quezaltepeque, (1♀), 500 m, VI-19-1963, D.Q. Cavagnaro and M.E. Irwin (CAS). PANAMA, PTO. Armulelles, (1♀), I-25-1983, Malaise trap, L. Stephens (FDA). Ancon, CZ, (3♀), on cotton, VI-1-21, A. Molino (USNM). Museum acronyms above are defined under acknowledgments.

Comments.-Males are like females except for the shape of the abdomen (ovipositor absent, ninth sternite present), the flagellum yellow versus black, the petiole 6X as long as wide versus 4X, and they are 3 mm in length versus 4 mm.

Some female specimens vary in color and body length from Burks's (1939) description. Body length varies from 3 to 5 mm. Two Florida specimens have the pronotum black (except yellow dorsolateral margin) versus the entire dorsum of the pronotum yellow, and the posterolateral yellow spot on the scutellum covering 1/16 the area versus 1/4 the area. Three Panama specimens have the scutellum (except for base medially and posterior margin which are brown) yellow versus black with a posterolateral yellow spot; they also have a yellow oblong spot mediad of the parapsidal line versus the mesoscutum completely black. The Mexican specimens have the flagellum, hindfemur markings, and gaster black versus brown.

Ceratosmicra spp. Ashmead

Host records for North American *Ceratosmicra* denote them as secondary parasites of braconid or ichneumonid wasps that parasitize Lepidoptera and/or Coleoptera (Burks 1940, 1968, 1979; Stephen 1973). Peck (1963) listed an unidentified lepidopteran host for *C. debilis*; this record was omitted from Burks (1979). Hosts are known for three (*C. campoplegicis* Burks, *C. meteori* Burks, and *C. immaculata* (Cresson)) of the six North American species (Burks 1979). DeSantis (1979) listed hosts for four other *Ceratosmicra,* indicating that two may be primary parasites. Two are recorded from braconid wasps, *Ceratosmicra quadrilineata* (Cameron) from an unidentified pterophorid moth, and *C. debilis* from *Oxyptilus* Zeller (Lepidoptera: Pterophoridae).

Ceratosmicra debilis (Say).-Two rearings indicate this wasp is also a primary parasite of *Stenoptilodes* (=*Platyptilia*) *antirrhina* (Lange) (Lepidoptera: Pterophoridae). The first record is for one male and four females: "Riverside, Riverside Co., California, reared by E.I. Schlinger, 1 August 1958, primary parasite reared from *Platyptilla antirrhina*, host plant *Antirrhinum majus*" (UCR). *Antirrhinum majus* is the common snapdragon (Scrophulariaceae). Examination of the lepidopteran pupae attached to each specimen does not show evidence of a braconid or ichneumonid primary parasite. Dr. E.I. Schlinger (pers. comm., 1983) previously dissected the *S. antirrhina* pupae and observed the same. He noted that several specimens of an unidentified ichneumonid wasp were reared from other *P. antirrhina* pupae.

The second record is a male: "Sacramento, Sacramento Co., California, reared from *Platyptilia antirrhina*, ex. snapdragon, F.G. Andrews" (CDFA). This record also indicates *C. debilis* is a primary parasite.

Ceratosmicra paya Burks.-Host records include *Oidaematophorus paleaceus* Zeller (Lepidoptera: Pterophoridae) (Schwitzgebel and Wilbur 1942, Peck 1963). The *C. paya* female from the Schwitzgebel and Wilbur study is in the USNM. No host remains are attached to the specimen. No braconid or ichneumonid wasps were reported in that study.

A male: "Smokey Valley, Tulare Co., California, from *Oidaematophorus phalcelia* McD., collected 11 June 1944, emerged 2 July 1944"

(LCM), represents a new rearing record. The stage from which this wasp emerged was not noted nor were host remains attached. Another record is a female: "La Crescenta, Los Angeles Co., California, 25 July 1958,, R.J. Lyon, emerged from Lepidoptera pupa from snapdragon" (USNM). Since no other data were noted, the parasite status (primary or secondary) cannot be established.

Ceratosmicra campoplegicis Burks.-Host records include an unidentified Campoplegini (Ichneumonidae) from *Catabena esula* Druce (Lepidoptera: Noctuidae) (Burks 1968, 1979), *Apanteles koebelei* Riley (Braconidae) from *Euphydryas chalcedona* Doubleday and Hew. (Lepidoptera: Nymphalidae) (Burks 1968, 1979), and *Perilitus coccinellae* (Shrank) (Braconidae) from the abdomen of an adult *Hippodemia convergens* Guerin-Meneville (Coleoptera: Coccinellidae) (Stephen 1973).

Two females: "Tehama Co., California, from *Schizura concinna*" (Smith) (Lepidoptera: Notodontidae), "2 July 1979, S. Wulfert" (CDFA), represent a new rearing record. No host remains or additional data are attached. Two braconids and six ichneumonids are primary parasites of *S. concinna* (Carlson 1979), but none are listed as hosts of *C. campoplegicis.*

Ceratosmicra meteori Burks.-Recorded as a secondary parasite of *Apanteles delicatus* Howard, *A. hyphantriae* Riley, *A. melanoscelus* (Ratz.) (Braconidae), *Casinaria limneitidis* (Howard) and *Meteorus hypantriae* Riley (both Ichneumonidae) (Burks 1979).

Five females: "Tehama Co., California, reared from *Schizura concinna*, 2 July 1979, S. Wulfert" (CDFA), and a female: "1 mi S. Pullman, Whitman Co., Washington, ex. *S. concinna,* 29 August 1971, R. Lagier" (USNM), are new rearing records.

The USNM specimen has the caterpillar remains attached. The caterpillar is 5 mm long, has half of the external integument eaten away, and is entirely covered with a thin layer of silk. Inside the larva is a silk covered cocoon, probably that of an ichneumonid. Six ichneumonids are primary parasites of *S. concinnia* (Carlson 1979), but none are listed as hosts of *C. meteori.*

Some of these *Ceratosmicra* records need confirmation because secondary hosts are sometimes not detected and thus only the primary host is recorded on label data. Even if a secondary host is detected, identification is difficult unless other specimens are reared and a comparison of their cocoons, pupal exuvia, etc. is made.

Overall, this information expands the potential hosts for *Ceratosmicra,* demonstrates that *C. debilis* is a primary parasite, and suggests that some species may function as primary parasites, facultative secondary parasites, or obligatory secondary parasites.

Brachymeria ovata (Say)

A female *Brachymeria ovata* which was reared from an unrecorded host-*Danaus plexippus* (Linnaeus) (Monarch Butterfly) (Lepidoptera: Danaidae) was discovered in the SJSU collection. The wasp's emergence hole is two millimeters in diameter and located at the apex of the right wingbud of the chrysalis. Collection data is "Cupertino, California, October 1933, Collector C.D. Duncan, 2031-1."

More recently, I collected two *D. plexippus* chrysalids from Humphrey's Station, Fresno Co., California, 20 June 1982, with one showing parasitization by *B. ovata.* The female chalcidid had partially emerged from its pupa, but was dead within the Monarch's chrysalis. When collected, the chrysalis was a pale green color though by February 1983, it had become dark olive green except for the abdomen which was light green. The chrysalis was dissected and found to be hollow except for the dead *B. ovata* and a small amount of dried body contents along one side. This observation is in agreement with Burks (1960) who stated that many lepidopterous pupae from which adult *B. ovata* have emerged still contain half or more of the uneaten host body tissues.

B. ovata is known to be a pupal parasite of over one hundred species of Lepidoptera, encompassing 18 families (Burks 1960, 1979) though is not recorded as a parasite of *D. plexippus* in Peck (1963) or Ackery and Vane-Wright (1984). This is believed to be the first published record of *B. ovata* from the Monarch Butterfly.

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SELWYN S. ROBACK

Dr. Selwyn S. Roback, 63, a curator of entomology at the Academy of Natural Sciences and an adjunct faculty member at the University of Pennsylvania, died July 1, 1988, following a stroke.

Sam Roback was a former President of The American Entomological Society, 1963-64, was a long time former editor of the Society's TRANSACTIONS, and, right up until his passing, was editor of the Society's MEMOIRS series. He also served the Society for many years as Chairman of its Library Committee.

Dr. Roback was known internationally for his studies in the Chironomidae. He curated the Academy's collections of aquatic insects, including over 133,000 specimens of chironomids, most of which he had personally collected. Sam was the author of nearly 100 scientific papers and the recipient of numerous grants from the National Science Foundation and the Environmental Protection Agency. He was a pioneer in river survey work needed for water quality studies.

Sam received his undergraduate degree from Cornell University and his Masters and Doctoral degrees from the University of Illinois. He was an elected member of the Royal Entomological Society of London and was honored as Thiensmann Memorial Lecturer at the Ninth Chironomid Congress in Bergen, Norway.

Dr. Roback is survived by his wife, the former Helen Handy; a son, Craig; a daughter, Barbara; and his mother, Bessie Tamer Roback.

CONTRIBUTION TO THE STUDY OF THE BIOLOGY OF *STIZUS CONTINUUS* (HYMENOPTERA: SPHECIDAE)[1]

J.D. Asis[2], J. Tormos[3], R. Jimenez[2]

ABSTRACT: Some aspects of the biology of *Stizus continuus* (Hymenoptera: Sphecidae: Nysoninae) are described. Data on the nest structure, captured prey and behavior of the adults are presented.

Few studies have been conducted on the biology of species in the genus *Stizus* Latreille, 1808, one of the largest in the Nyssoninae. These can be summarized in the works of Feron (1908), Williams (1914), Deleurance (1941), and Tsuneki (1965, 1976). Ferton, Williams and Deleurance refer to captured prey as well as some aspects of the hunting behavior and nest structure of *Stizus fasciatus* (Fabricius. 1781), *Stizus brevipennis* Walsh, 1860 and *Stizus ruficornis* (Forster, 1771). Tsuneki includes a detailed study on the nesting and hunting behavior as well as larval development of *Stizus pulcherrimus* (Smith, 1858). Evans (1966) provides a general review of the ethology of the species and Stubblefield (1984) gives a worldwide list of prey records for *Stizus.*

Considering the little information available on the biology of species in this genus (Stubblefield, 1984), we recently undertook a study of *Stizus continuus* (Klug, 1835). This species is commonly found in sandy areas such as "Dehesa del Saler", an enclave situated in the province of Valencia, Spain, where we located two colonies.

This paper contains the results of field observations, together with some aspects of their behavior observed in captivity. Both field and captivity observations were made from July to September 1985.

MATERIAL AND METHODS

Field observations were conducted at the site of the two colonies in "La Mallada Larga" of "Dehesa del Saler". The dominant vegetation in this area is *Arthrocnemum fruticosum* (Chenopodiaceae), which occurs in great abundance. This species inhabits the coastal salt marshes and dune depressions or "mallaes", which swamp temporarily but also suffer long

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[1] Received March 11, 1987. Accepted May 7, 1988.

[2] Departament de Biologia Animal, Biologia Cellular, Genetica i Parasitologia. Facultat de Ciencies Biologiques. Universitat de Valencia. Dr. Moliner, 50. 46100 Burjassot (Valencia). SPAIN.

[3] Departamento de Biologia Animal y Parasitologia. Facultad de Biologia. Universidad de Salamanca. 37071 Salamanca. SPAIN.

periods of drought, resulting in the formation of saline crusts on the soil during the summer. The resulting texture is damp sand. Other plant species occuring with *Arthrocnemum fruticosum* are, in order of abundance, *Juncus maritimus* (Juncaceae) and *Phragmites australis* (Gramineae). The nests of *Stizus continuus* were grouped in two areas, about 200 m apart.

Captivity studies began on 2 July 1985, when we captured and introduced into an observation cage 2 male and 2 female specimens of *Stizus continuus*. The last of these, a female, died on 30 July 1985. We then captured five more specimens from the same colony (3 males, 2 females) on 5 August 1985. The last of these specimens died on 4 September. The observation cage was placed in the open air where it could receive plenty of sunshine. Inside we placed a small container with honey or sugar diluted with water.

The observation cage used was similar to the one devised by Simon Thomas & Veenendaal (1978) for their studies on the behavior of *Philanthus triangulum* (Fabricius, 1775) (Hymenoptera: Sphecidae). We made some slight changes in the cage so it would serve our purpose better, namely, the lateral perspex sides were replaced with a wire netting to allow better ventilation. We felt that although these insects inhabit very sunny areas, the temperatures that would be reached in an enclosed space exposed to the sun would be so high as to prevent normal activity of the insects.

The observation cage was filled with sand collected from the place where the colony was located. This sand was periodically moistened to avoid excessive dryness which could hinder the normal digging of nests due to the constant crumbling of the burrows. Several potential prey were captured and placed in the observation cage prepared for the wasps.

RESULTS

Data observed in the field.

Imagos started to emerge in June, and as in all Nyssoninae, males usually emerged several days before females. Males made short "sun dances" - sinuous flights 5-10 cm above the ground - during the sunny periods of the day, but most of the time they alighted on the soil and pounced on any other insect that flew sufficiently near. Apparently, they defend the emerging holes and the adjacent areas against other males.

The males in their territory introduced themselves into the emerging holes, and frequently walked, touching the ground with their antennae. This behavior seemed to be directed towards finding the females that were emerging from their cocoons. When that happened, males dug in the sand, often with several males aggregating at the same spot. When the females appeared the males tried to copulate with them, and on several occasions we could see males forming a ball with a female in the center. The behavior of the males seemed to be connected with a strong competition between them to copulate with the females.

The excavation of the nest by the females was similar to that observed in captivity. Once the nest was built, the female went off in search of prey to provision it. Transport of prey was of the mesopedal type, as described below. Upon reaching the nest, the female opened the outer closure with the forelegs, which remained free, and entered with the prey.

The prey captured by the females studied were as follows:

Catantopidae:

Pezzotetix giornae (Rossi, 1794): 3 male nymphs, 7 female nymphs.
Heteracris littoralis (Rambur, 1896): 3 male imagos.
Tropidopola cylindrica cylindrica (Marschall, 1836): 5 male nymphs, 8 female nymphs; 2 male imagos.
Catantopidae 5 undetermined nymphs.

Pyrgomorphidae:

Pyrgomorpha conica (Oliv., 1791): 2 male nymphs, 3 female imagos.

Tettigoniidae:

Homorocoryphus nitidulus (Scopoli, 1786): 5 female imagos.

Prey were deposited in cells with the head towards the end of the cell and the venter upwards.

Various nests were excavated in the colony under study, in some of which provisioning had not been completed. These nests (Plate I, Fig. 5-7) presented a varying number of cells (3-8) ($\overline{x} = 5.5$, $n = 8$), being in general rather shallow and rectilinear. Their length ranged from 35-69 cm ($\overline{x} = 50.1$, $n = 11$), and their depth varied between 8-18 cm ($\overline{x} = 12.7$). In several nests observed, the female had built one or two accessory nests, near the entrance to the burrow. The number of prey deposited in a cell varied from 4 to 8. The egg (3 x 1mm) was attached to the wing bud of the first prey taken to the nest, with the caudal end fixed to it and the cephalic end free, facing the coxa of the second pair of legs (Plate II, Fig. 1, 2).

It appears that mass provisioning is the rule, that is, prey are brought to the nest by the female before the egg hatches and the larva emerges. However, on three occasions, females were observed taking prey to the nests when the larvae had already hatched and were feeding on the first prey.

The cocoon is long and oval, with a length of 19-25 mm ($\overline{x} = 22$, $n =$

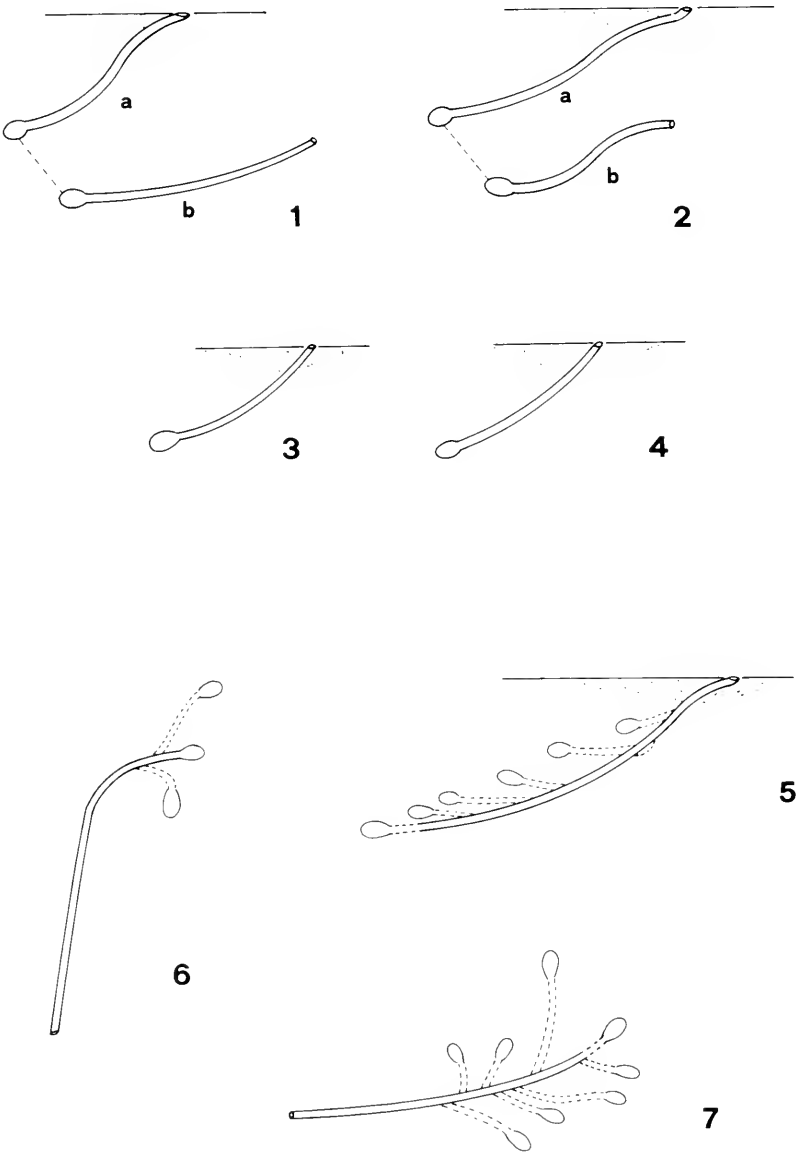
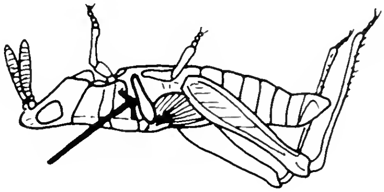


Plate I. Nests of *Stizus continuus* (Klug). Fig. 1-4: Nests made in captivity (a. lateral view; b. dorsal view). Fig. 5-7: Nests dug in the field (5. lateral view, 6 and 7. dorsal views).

10), and a maximum width of 8-10 mm ($\bar{x} = 8.6$). Towards the posterior end it narrows terminating in a small nipple-like protuberance. It is made from grains of sand of similar size (1.7- 2.1 mm), with some larger grains (up to 4 mm). There are several pores (3-6) ($\bar{x} = 4$) at the equatorial zone.

Observations made in captivity.

The insects introduced into the cage showed signs of restlessness at first, and made frequent flights, banging repeatedly against the glass. After



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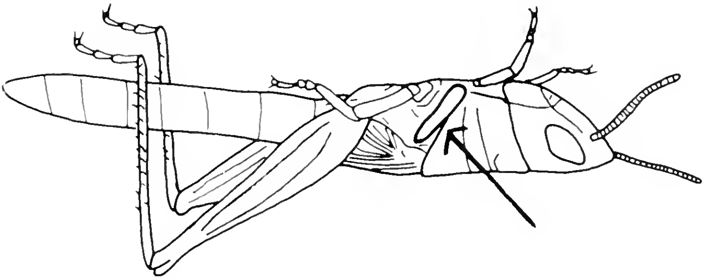

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Plate II. Immature grasshoppers bearing an egg of *Stizus continuus* (Klug). Fig. 1. *Pyrgomorpha conica* (Oliv.). Fig. 2. *Tropiodopola cylindrica cylindrica* (Marschall).

several hours they adapted to the available space and spent most of the time alighted on the wire netting, especially the males.

On the other hand, the females spent a lot of time alighted on the sand. They made frequent motions by moving the foretarsi along the mouthparts first, then along the head and the lateral and ventral parts of the thorax. They often arranged and cleaned their wings with their hind legs. These cleaning motions were also observed when a female was digging a burrow. Only twice did we observe a female spend the night on the soil. As a rule, both males and females spent the night alighted on the wire netting.

Females began digging burrows many times, but often stopped when they had dug a small tunnel measuring 1.5-3 cm. long. Females dug their nests with the forelegs, removing the sand from the burrow with simultaneous movements of the two legs; they also used their mandibles to cut small roots or to remove big sand grains. Nests dug by females in captivity (Plate I, Fig. 1-4) consisted of S-shaped or curved burrows 11-18 cm long ($\overline{x} = 15.4$, $n = 5$). At the end of the burrow there was an oval cell about 2-2.5 cm long ($\overline{x} = 2.1$), and 1-1.5 cm high ($\overline{x} = 1.4$), where prey were deposited. The cell was situated about 8 cm from the surface ($\overline{x} = 7.8$).

To paralyze prey, a female pounces on it and stings it several times in the ventral surface of the thorax, leaving the prey anaesthetized and almost completely paralyzed; the prey moving only its antennae and palpi while being removed. The mode of carrying the prey is the same as described by Tsuneki (1976) for *Stizus pulcherrimus,* that is, the prey is held venter up and head forward by the wasp's middle pair of legs (mesopedal type). The prey captured, paralyzed and deposited in the nests of the females studied in captivity were imagos of *Acrotylus insubricus insubricus* (Scopoli, 1786) (Acrididae).

DISCUSSION

Behavior studied in the field seems similar to that observed in other species of the genus. The behavior of the males, also described by Tsuneki (1976) of *Stizus pulcherrimus*, is quite similar to that described by O'Neill and Evans (1983) for *Bembecinus quinquespinosus* (Say, 1823): males are able to locate and dig up the virgin females, enter and explore the emerging holes, and form "mating balls" around the recently emerged females. This can be explained by the existence of great competition among them to copulate with the females. The territorial behavior they exhibit may produce, as indicated by Lin (1963) for *Sphecius speciosus* Drury, 1773), a spreading of the males which ensures that the majority of the females are fertilized within a short time of their emergence, as well as a reduction of the interference of other males during copulation.

Several important differences were observed between the behavior shown by individuals in the wild and those in captivity. While some patterns remain unchanged (excavation of nest, capture and transport of prey), others do not appear in captivity: in no case were the females seen to take more than one item of prey to the cell, nor did they lay eggs, nor build more than one cell per nest. These three patterns could be related to the way in which the interruption of the cycle at the moment of laying will impede the continuation of the process, no new prey being brought (given that laying is performed upon the first prey brought to the nest) nor any new cells being dug in the nest. Without doubt, in abnormal situations such as captivity, given the presence of stimuli (and/or the absence of others) different to those present in the natural state, the behavior is modified, with the possibility of multiple factors impeding completion of the nesting process, detaining it at a determined moment.

It would appear that in the genus *Stizus,* mass provisioning is the rule, although both Tsuneki (1965) for *Stizus pulcherrimus*, and ourselves for *Stizus continuus* have found some exceptions. As indicated previously, upon excavation of three nests being provisioned by the females, we were able to extract small larvae which were feeding on one of the prey; a similar case was described by Tsuneki (1965). As, in both cases, the weather had been good during the previous days, there is no apparent reason for a delay in provisioning. Tsuneki (1965) considered that the Mongolian population of *Stizus pulcherrimus* exhibited a progressive provisioning, albeit of a primitive type. At any rate, following the criterium of Genise (1982), in order to consider it as such, a continuous contact between the larva and the female would have to exist, a contact which has not been proven to exist and which would seem difficult to conceive, given that the larva, at birth, is situated on the prey located nearest the bottom. We believe that, as a rule, mass provisioning could be the norm, although perhaps the rhythm of prey delivery, probably regulated by internal factors, is not very rapid. In some cases, situations may arise in which the larva may emerge before the female has completed provisioning the nest. In this way, and using the classification proposed by Genise (1982), such behavior would represent a "slow mass provisioning". These data probably confirm the hypothesis of Evans (1955), who proposed that within the genus *Stizus* there may be species which exhibit delayed provisioning, as seems to be the case in this instance.

ACKNOWLEDGMENTS

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THE INPUT OF TERRESTRIAL INSECTS AND SPIDERS TO THE NUTRIENT CYCLE OF A "WOODLAND POND"[1]

Thomas E. Bowman[2]

ABSTRACT: Terrestrial insects (and spiders) falling upon the 34.56 m^2 surface of a swimming pool were collected during 13 1-hour periods. The numbers of insects/m^2/hour averaged 2.44 (range 0.67-5.24). Dry weight (mg/m^2/hour) averaged 1.3 (range 0.67-3.86). Diptera were by far the most abundant group, followed by ants and Hemiptera-Homoptera. The results are compared with those of previous studies, and it is concluded that the energy input of terrestrial insects may be significant and is sometimes of major importance.

A typical pond receives energy not only from production within the pond (autochthonous) but also from sources outside the pond (allochthonous). The latter include particulate organic matter from the atmosphere and inflow, and dissolved organic matter in rain and inflow. The particulate organic matter includes derivatives from vegetation such as leaves, flowers, fruits, and terrestrial insects that fly or fall into the pond. My "woodland pond" is actually an inground swimming pool in my back yard in a residential section of Montgomery County, Maryland, in the suburbs of Washington, D.C. The pool is kidney-shaped, has a maximum depth of 5 ft., and a surface area of 34.56 m^2 (372 ft^2) (Fig. 1). A concrete patio surrounds the pool, which is bounded on the east side by a house, on the north side by a stand of bamboo, and on the south side by a small lawn and a flowering crab apple (*Pyrus* sp.). On the west side is a heavily wooded slope extending uphill about 12 m (40 ft). The trees nearest to the pool are a pin oak (*Quercus palustris*), a hackberry (*Celtis occidentalis*), a Chinese chestnut (*Castanea mollissima*), a mulberry (*Morus* sp.), and a silver maple (*Acer saccharinum*). Farther up the slope are several dwarf apple trees (*Pyrus malus*), a redbud (*Cercis canadensis*), a catalpa (*Catalpa bignonioides*), a Carpathian walnut (*Juglans regia*), a black locust (*Robinia pseudoacacia*), a chestnut oak (*Quercus montana*), and several staghorn sumacs (*Rhus typhina*). The undergrowth is dominated by ferns, periwinkle (*Vinca minor*), multiflora rose (*Rosa multiflora*), and rose of sharon (*Hibiscus syriacus*). The overall effect is that of a wild woodland rather than of the usual suburban backyard; hence I believe comparing my swimming pool to a woodland pond as a "trap" for terrestrial insects is a reasonable rather than an artificial exercise.

Among the accessories that came with the pool when it was installed

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[1] Received February 16, 1988. Accepted April 25, 1988.

[2] Department of Invertebrate Zoology, Museum of Natural History, Smithsonian Institution, Washington, DC 20560.

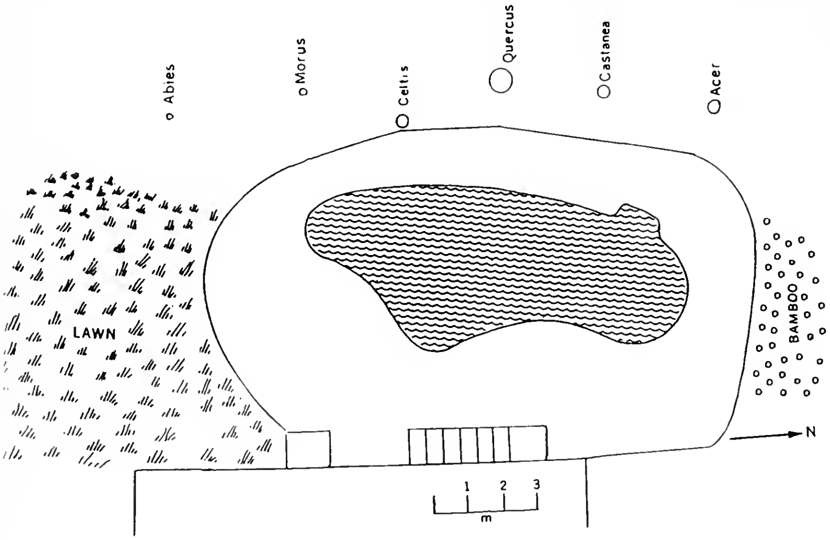

Figure 1. The swimming pool (wavy pattern) and its environs.

was a long-handled net to help keep the pool clean by removing debris from the pool surface. After a period of using the net, the composition of the debris was apparent. It consisted mainly of two components: (1) leaves, flowers, and seeds from nearby trees, (2) terrestrial insects and a few spiders. The quantity of insects was surprising to me, but I assumed that such an obvious source of organic material and energy to the aquatic community must surely be well documented and quantified in the literature on pond energetics. Indeed, I have been advised by an anonymous ecologist that "The fact that terrestrial insect contributions to the energy cycle in lentic waters are sometimes significant is well documented in the literature."

Despite my assumption and statements such as the above, I have been able to find only a few evaluations of this insect component in the limnological literature, and even fewer measurements based on quantitative sampling from a pond surface (see "Discussion" section). The opportunity to make a small contribution to this deficit in our knowledge prompted the present study.

The scope of this study is intentionally limited. My objective is to call attention to an energy source that has been largely overlooked, and to give some measurements of its magnitude in a particular habitat. My samples give only a slight indication of the variation with time of day and season of the year, and such variation needs to be assessed. I hope that my preliminary results will induce more detailed studies on terrestrial insects as an energy source to aquatic habitats.

METHODS AND MATERIALS

Collections were made of all the insects and spiders that fell into the pool during periods of 1 hr (44 min in 1 collection). The arthropods were collected either with a fine-meshed net or dipped out with a small dish or pan. Immediately before the collection period all insects were carefully removed from the pool surface. Collections were made by reaching in from the sides of the pool or by wading in the pool. In the latter case care was taken not to stir up dead insects from the bottom of the pool. At the end of the collection period the specimens were preserved in 70% ethanol. Thirteen collections were made during the spring and summer in 1982 and 1983.

The sampling methods, while simple and unsophisticated, were highly effective, since individual insects as small as 0.6 mm in length (tiny Hymenoptera) were easily seen and collected. I estimate that from 95-99% of the insects falling into the pool were collected.

Insects were enumerated to order, except that Homoptera and Hemiptera were combined as they were by Sage (1982), and ants were separated from other Hymenoptera.

Each specimen was measured in a dissecting microscope equipped with a camera lucida, and dry weights were calculated using regression statistics given by Sage (1982) for converting body lengths into weights according to the formula $\ln Y = a + bX - b^1X^2$, where Y = weight, X = body length, and a,b, and b^1 are regression coefficients determined by Sage. Calories were calculated using Golley's (1961) conversion factor for the locust *Schistocerca*, 1 g dry weight = 5363 gcal.

RESULTS

The results are summarized in Figs. 2 and 3 and Tables 1-3. The hour's collections averaged 84, with a range of 23-181 insects. The number of insects collected/m^2 averaged 2.44, with a range of 0.67-5.24. In dry weight this averaged 1.39 mg/m^2, with a range of 0.27-3.86. There was no obvious relation between the numbers or mass of insects and the time of day or season, but the temporal scope of the collecting was rather limited because of the preference of the collector for carrying out field work under pleasant conditions.

Diptera were by far the most abundant group in the samples, ranking first in 9 of the 13 samples and averaging almost 44% of all the insects collected. Of the 13 samples, Diptera ranked first in abundance in 9, second in 3, and third in 1. In total dry weight the Diptera ranked first in 10 samples and third in 3 samples.

Ants were second in abundance. They ranked first numerically in 3 samples, second in 7 samples, and third in 3 samples. In dry weight they ranked first in 2 samples, second in 5, third in 3, fourth in 1, and fifth in 2 samples.

Besides the flies and ants, the Hemiptera-Homoptera was the only group that occurred in all 13 samples. Numerically they ranked first in 1 sample, third in 9 samples, and fourth in 3 samples. In dry weight they ranked third in 2 samples, fourth in 7 samples, sixth in 3 samples, and seventh in one sample. A noteworthy member of this group was the hackberry psyllid, a locally abundant species as shown by the presence of numerous galls on virtually every leaf of the hackberry tree.

Collembola occurred in 8 of the 13 samples, numerically ranking fourth 3 times, fifth twice, sixth twice, and seventh once. In dry weight they ranked second in 1 sample, fourth in 1, fifth in 3, sixth, seventh, and eighth each in 1 sample.

None of the other groups contributed important amounts in numbers or weights. Spiders occurred in 8 samples, but were small and few in number.

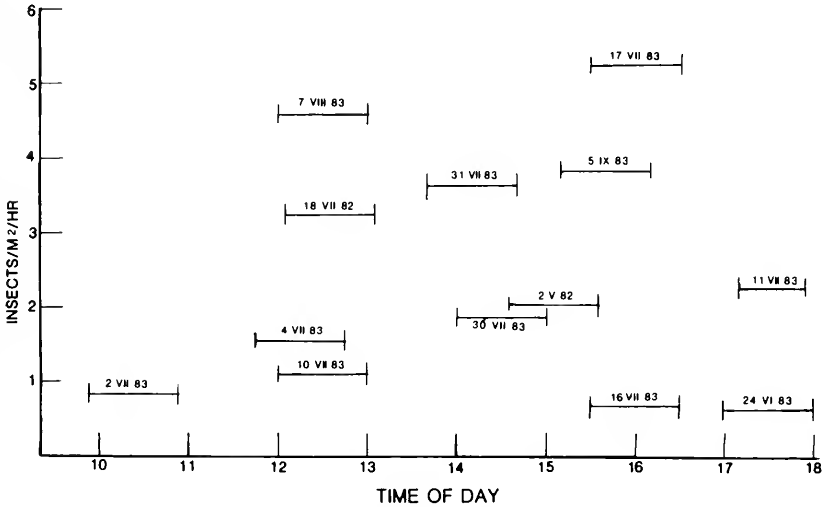

Figure 2. Numbers of insects and spiders collected from pool surface, with dates and times of collection.

DISCUSSION

The input of terrestrial insects to a stream in southern England was measured by Mason and Macdonald (1982). Their collections were made with 20 buckets, 30 cm in diameter, suspended from posts at a height of 1 m along the edge of the stream. The buckets contained water to a depth of 5 cm, plus formalin. Sampling was carried out for 14 2-week periods for a total of 28 weeks. Their results are given for the entire 28 weeks; I have calculated the numbers/hr by dividing by 1960, assuming 10 hrs of collecting per day. The numbers of insects collected per hr ranged from 0.64-25.45, compared to 0.67-5.24 for my swimming pool, and the dry weights (mg/m^2) ranged from 3.79-48.53, compared to 0.27-3.86 for the pool. Thus Mason and Macdonald's results are somewhat higher than mine, but comparable to them.

In their analysis of the energy flow in a small (about 1 ha.) north-central Texas pond, Childress *et al.* (1981) found the input of terrestrial insects to be 1.28X10^6 kcal/yr. Dividing by 365 (days in a year), 10 (hours in a day), and 10,000 (m^2 in a ha.) gives 0.035 kcal/m^2/hr or 35.07 gcal/m^2/hr, somewhat higher than my figure for the pool, 1.44-20.70 (mean 7.43)

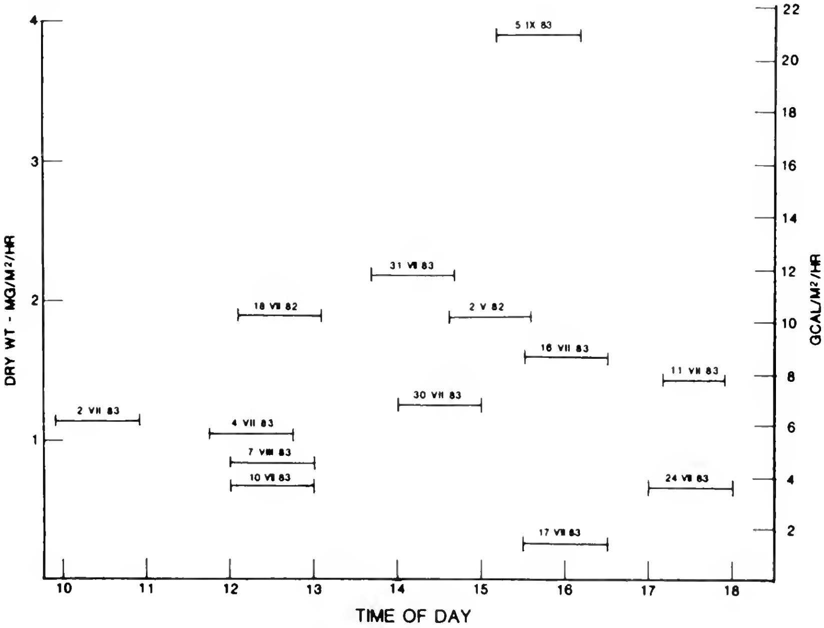

Figure 3. Dry weights and caloric values of insects and spiders collected from pool surface, with dates and times of collection.

gcal/m^2/hr. Childress *et al.* did not state how they arrived at their figure. Odum (1971), citing unpublished data from Welch (1967) for a Georgia pond managed for sport fishing, gave an input of 3 kcal/m^2/yr for terrestrial insects. This is the equivalent of 0.82 gcal/m^2/hr, which is lower than but close to the input to the pool. Odum did not reveal how Welch's input was determined. The caloric values for Mason and Macdonald's (1982) insect collections ranged from 20.33-260.27 gcal/m^2/hr.

How significant is the contribution of terrestrial insects to the food web of ponds and streams? Mason and Macdonald (1982) concluded that "The input of terrestrial invertebrates may then be equivalent to, or possibly greater than, the within-stream production of benthic invertebrates". In the Texas pond of Childress *et al.* (1981), terrestrial insects contributed 83.66% of the caloric energy to tertiary consumers (fish). But in a Canadian pond, where airborne particulate matter was collected in anchored plastic pools, 120 cm in diameter, containing rainwater, it contributed only 0.22% of the yearly organic carbon budget, 35 kg C/yr (Carpenter *et al.*, 1983). Probably a large part of this airborne matter consisted of insects, but the authors did not separate them from other particulate matter.

These studies and the present "woodland pond" measurements demonstrate that the contribution of terrestrial insects to the energy cycle of lentic

Table 1. Insects and spiders collected from surface of Bowman swimming pool (surface area 34.56 m^2) during 13 1-hr periods in 1982 and 1983.

			Dry wt	
Date	Time	No./m^2/hr	mg/m^2/hr	gcal/m^2/hr
1982				
2 May	1435-1535	2.05	1.49	7.99
18 July	1205-1305	3.24	1.49	8.00
1983				
2 July	0954-1054	0.81	1.15	6.17
4 July	1145-1245	1.53	1.03	5.52
10 July	1200-1300	1.10	0.68	3.65
11 July	1710-1754	2.55	1.45	7.78
16 July	1530-1630	0.69	1.61	8.63
17 July	1530-1630	5.24	0.27	1.45
24 July	1700-1800	0.67	0.67	3.59
30 July	1400-1500	1.88	1.26	6.76
31 July	1340-1440	3.62	2.20	11.80
7 Aug	1200-1300	4.60	0.85	4.56
5 Sept	1510-1610	3.70	3.86	20.70
		Mean 2.44	1.39	7.43

Table 2. Percentages of different insect taxa in 13 1-hr samples from surface of Bowman swimming pool.

	Total Number	Diptera	Formicidae	Other Hymenoptera	Hemiptera-Homoptera	Coleoptera	Collembola	Orthoptera	Thysanura	Isoptera	Lepidoptera	Dermaptera	Protura	larvae	unidentified	Arachnida
1982																
2 May	71	16.33	19.72	2.82	39.44	4.23	–	–	–	1.41	–	–	–	–	–	–
18 July	112	83.04	8.04	0.89	5.35	–	–	–	–	–	–	–	–	–	–	2.68
1983																
2 July	28	21.42	50.00	–	14.29	–	3.57	–	–	–	–	3.57	–	7.14	–	–
4 July	53	39.62	24.53	3.77	13.21	–	9.43	1.89	–	–	–	–	–	5.66	1.89	–
10 July	38	47.36	18.42	5.26	10.53	5.26	–	–	–	–	–	–	–	–	10.53	2.63
11 July		88	38.64	22.73	1.14	10.61	3.03	6.06	–	–	–	–	–	–	–	–
16 July	24	56.00	24.00	–	8.00	–	–	8.00	–	–	–	–	–	–	–	–
17 July	181	70.17	13.26	6.08	6.63	–	1.66	1.10	0.55	–	–	–	–	–	–	0.55
24 July	23	26.09	43.48	21.74	4.35	4.35	–	–	–	–	–	–	–	–	–	–
30 July	65	44.62	16.92	18.46	6.15	4.62	3.08	–	1.54	–	–	–	–	1.54	–	–
31 July	125	55.20	12.80	9.60	11.20	3.20	5.60	–	1.60	–	0.60	–	–	–	–	0.80
7 Aug	159	25.30	43.98	13.86	6.63	1.20	2.41	–	3.01	–	–	–	0.63	–	0.63	3.01
5 Sep	128	43.94	17.42	28.03	5.30	0.76	0.76	0.76	–	–	–	–	–	–	–	0.76
Average		43.67	24.25	8.59	10.90	1.97	2.51	0.90	0.52	0.11	0.05	0.28	0.05	1.10	1.00	0.89

Table 3. Dry weights (percentages) of different insect taxa in 13 1-hr samples.

Date	Diptera	Formicidae	Other Hymenoptera	Hemiptera-Homoptera	Coleoptera	Collembola	Orthoptera	Thysanura	Isoptera	Lepidoptera	Dermaptera	Protura	larvae	unidentified	Arachnida
1982															
2 May	13.4	13.7	8.5	0.4	62.4	–	–	–	1.5	–	–	–	–	–	–
18 July	81.0	7.5	0.9	6.1	–	–	–	–	–	–	–	–	–	–	4.5
1983															
2 July	16.9	39.3	–	13.3	–	5.0	–	–	–	–	22.7	–	2.8	–	–
4 July	31.8	17.3	2.1	15.8	–	19.0	7.4	–	–	–	–	–	1.8	4.9	–
10 July	48.2	17.5	1.9	9.6	12.2	–	–	–	–	–	–	–	–	7.0	3.6
11 July	47.8	9.7	1.6	11.5	14.3	11.6	–	–	–	–	–	–	–	–	3.4
16 July	32.2	14.5	–	26.1	–	–	27.1	–	–	–	–	–	–	–	–
17 July	79.1	8.5	8.4	2.2	–	0.4	0.2	0.1	–	–	–	–	–	–	1.0
24 July	39.7	28.4	10.5	3.1	18.3	–	–	–	–	–	–	–	–	–	–
30 July	34.0	11.8	10.5	5.0	23.3	5.8	–	2.9	–	–	–	–	0.6	–	–
31 July	40.8	7.2	10.5	9.8	20.5	7.0	–	3.0	–	0.4	–	–	–	–	0.9
7 Aug	10.8	12.3	6.5	5.8	34.8	5.7	–	9.0	–	–	–	2.2	–	–	9.5
5 Sep	35.7	21.8	35.5	2.7	1.6	0.6	1.5	–	–	–	–	–	–	–	0.5

waters may be significant and is sometimes of major importance. Mating flights of ants and termites may result in immense swarms, many of which may fall into lakes and ponds or even into marine waters. In September 1983 I observed windrows of male and female carpenter ants (*Camponotus* sp.) washed up on shore at Dewey Beach, Delaware. These windrows extended south for at least 6 miles, to the Indian River inlet, and probably farther. Using a conservative estimate of 100 ants/inch of beach, about 38 million ants perished along this 6 mile stretch of beach.

Feeding on fallen terrestrial insects by fishes, especially trout, is well known. Insects on the surfaces of ponds and streams are also eaten by a number of aquatic Hemiptera in the families Gerridae, Veliidae, Notonectidae, and Belostomatidae (Cooper, 1984). Around the Galapagos Islands the marine water strider *Halobates robustus* feeds almost exclusively on terrestrial insects that have fallen onto the sea surface. (Foster and Treherne, 1980).

Use of a swimming pool has several advantages over a natural pond. The surface area is accurately known; there are no predators to remove the insects and decrease the numbers counted; there is no emergent vegetation to conceal the fallen insects; the surface area is large enough to give quantitatively significant numbers of insects and small enough to permit easy sampling.

It has been suggested that insects flying over the pool are stunned by aerial chlorine fumes that cause them to fall into the pool. However, chlorine added to the pool is in the form of a stabilized organic compound that releases chlorine very gradually; hence the possibility that the air above the pool becomes toxic to flying insects is remote.

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EXALLONYX OBSOLETUS (HYMENOPTERA: SERPHIDAE), A LARVAL PARASITE OF THE ROVE BEETLE *QUEDIUS LAEVIGATUS* (COLEOPTERA: STAPHYLINIDAE)[1]

E. Richard Hoebeke[2], Peter W. Kovarik[3]

ABSTRACT: *Exallonyx obsoletus* is a solitary internal parasite of larvae of *Quedius laevigatus;* this represents a new host record for *E. obsoletus.* A brief synopsis of the distribution and biology of the parasite (*E. obsoletus*) and the host (*Q. laevigatus*) is provided, and staphylinid host records of world species of *Exallonyx* are reviewed.

This note further documents parasitism of staphylinid larvae by *Exallonyx* in a previously unreported host, *Quedius laevigatus* (Gyllenhal).

While collecting beetles under bark of a felled tuliptree, *Liriodendron tulipifera* L., in a wooded ravine of Hampton Hills Metropolitan Park, nr. Akron, Ohio (Summit Co.), on 25 April 1987, one of us (PWK) obtained approximately 30 staphylinid larvae of which 2 had parasite pupae protruding from the host remains. An additional parasite emerged from a third quiescent larva in the laboratory several days after the larvae were collected. Two male parasites of *Exallonyx obsoletus* Say were reared in the laboratory, while a remaining parasite succumbed in the pupal stage. A staphylinid adult, identified as *Quedius laevigatus,* was also reared from a larva that was identical to those parasitized. Voucher specimens of the parasite and beetle host are in the collections of Cornell University (Ithaca, NY) and Henry K. Townes (Gainesville, FL).

The Host.-*Quedius laevigatus* is a widely distributed species in both the Palearctic and Nearctic regions (Smetana, 1971), occurring under bark of damaged or dead trees, particularly conifers and other softwoods. Smetana (1965, 1971) recorded specimens from *Pinus ponderosa* Laws., *P. murrayana* (Grev. & Balf.) Engelm., *P. strobus* L. and *P. contorta* Dougl.; *Picea glauca* (Moench.) Voss; *Abies lasiocarpa* (Hook.) Nutt.; *Populus trichocarpa* Torr. & Gray; and *Betula* sp. In Europe and North America, it is a known predator of bark beetle larvae (Scolytidae) (Clemens, 1919: De Leon, 1934; Smetana, 1958).

The Parasite.-*Exallonyx obsoletus* occurs in deciduous woods of eastern North America, with adults found from late spring to mid-fall (Townes & Townes, 1981). It has been recorded as parasitizing larvae of

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[1] Received March 5, 1988. Accepted April 11, 1988.

[2] Department of Entomology, Cornell University, Ithaca, New York 14853.

[3] Department of Entomology, Ohio State University, Columbus, Ohio 43210.

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Staphylinus (Muesebeck, 1979; cited as *Codrus longiceps*) and larvae of *Platydracus violaceus* (Hoebeke, 1978). Townes & Townes (1981) also examined other reared specimens, including a female wasp from an unidentified staphylinid larva taken in the cambium of a dead *Ulmus americanus* in Michigan; and 1 male and 2 females from a larva of *Staphylinus* or *Creophilus* in Virginia. Details of the biology of this species are presumably similar to that described in Townes & Townes (1981:6) and Hoebeke (1978:508-509). Immediately upon emergence of the fully mature parasite larva, usually through intersegmental membranes, pupation occurs. The caudal end of the mature larva or pupa remains embedded in the host carcass, positioned venter-to-venter with the host and the head inclined forward or backward (Fig. 1). *Exallonyx obsoletus* is a solitary internal parasite of larvae of *Quedius laevigatus.* This serphid was previously reported by Hoebeke (1978) as a gregarious internal parasite of larvae of *Platydracus violaceus,* whose larvae are much larger than those of *Q. laevigatus.*

There are several literature references to the parasitism of *Quedius* larvae by serphids, but most of these are attributed to unidentified *Quedius* species. However, *Phaneroserphus calcar* Haliday and *Exallonyx ligatus* (Nees), both common species in Europe, have been recorded by Weidemann (1962) as parasites of the larvae of *Q. simplicifrons* Fairmaire. Larvae of

Fig. 1. Developing pupa of *Exallonyx obsoletus* embedded in carcass of host larva, *Quedius* laevigatus.

Q. vexans Eppelsheim have been cited as hosts of *Exallonyx trifoveata* Kieffer (Smetana, 1957, cited as *E. ligatus,* misdet.; see Townes & Townes, 1981) and *E. brevicornis* Haliday (Weidemann, 1962; Pschorn-Walcher, 1971). The *E. obsoletus/Q. laevigatus* association documented herein represents a new parasite/host record.

For the vast majority of the species of *Exallonyx* Kieffer, with more than 160 described species, little or nothing is known about their biology or host relationships (Townes & Townes, 1981). The few published records clearly demonstrate that hosts of *Exallonyx* are beetle larvae, chiefly of the family Staphylinidae. In addition to the *Quedius* species mentioned above other staphylinid hosts include species, det. and indet., in the following subfamilies [the reader is referred to Townes & Townes (1981) and Frank (1982) for literature references to these host records]:

Omaliinae: *Lesteva hanseni* Lohse.

Xantholininae: *Xantholinus* sp. indet.

Staphylininae: *Creophilus maxillosus* (L.), *Ocypus olens* (Muller), *Philonthus politus* (L.), *Philonthus turbidus* Erichson, *Philonthus* sp. indet., *Platydracus violaceus* (Gravenhorst), *Staphylinus* sp. indet.

Tachyporinae: *Tachyporus* sp. indet., indet. Tachyporini.

Aleocharinae: *Aleochara bilineata* Gyllenhal.

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ALPHITOBIUS DIAPERINUS (COLEOPTERA: TENEBRIONIDAE) LARVA AND ADULT MOUTHPARTS[1,2,3]

Richard A.B. Leschen, C. Dayton Steelman[4]

ABSTRACT: *Alphitobius diaperinus* adult and larval mouthparts are studied and described. Based on mandibular structure, adults are considered general feeders whereas larvae possess planar molar surfaces that are an adaptation for feeding on "cemented" food substances.

Alphitobius diaperinus (Panzer), commonly known as the lesser mealworm, darkling beetle or litter beetle by the poultry industry, is often sufficiently abundant in poultry houses to cause economic damage. Initially this species was known as a stored product pest, but it is now considered a structural pest of poultry house insulation (Vaughan *et al.*, 1984; Despins *et al.*, 1987). Damage occurs when prepupae burrow into insulation to pupate and additional damage is caused by emerging adults and by adults that follow the prepupae into the burrows. (Vaughan *et al.*, 1984).

The original range of *A. diaperinus* was eastern Africa where it occurs naturally in nests of birds and in bat guano (Vaughan *et al.*, 1984). McFarlane (1971) indicated that *A. diaperinus* feeds on detrital fragments found on the cave floors and in guano litter. When associated with poultry, *A. diaperinus* may feed on damp, mouldy grain, poultry carcasses and feces (Lewis, 1958; Back and Cotton, 1962; Lancaster and Simco, 1967). Pfieffer and Axtell (1980) consider *A. diaperinus* the best-adapted scavenger of poultry houses.

In this paper we describe *A. diaperinus* adult and larval mouthparts and, based on these descriptions, hypothesize as to their feeding habits.

METHODS AND MATERIALS

The heads of laboratory-reared *A. diaperinus* were removed and treated in hot 10% KOH, placed in glycerin and then dissected. Mouthparts were removed and rinsed in 70% alcohol, air dried and prepared for scanning electron microscopy (SEM). Additional structures were slide

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[4] Graduate Assistant and Professor, Department of Entomology, University of Arkansas, Fayetteville, AR. 72701.

mounted in CMC (1-Cyclohexyl-3-(2-morpholinoethyl) carbodiimide metho-p-toluenesulfonate) media. Terminology for mouthparts follows Watt (1974) and Doyen and Tschinkel (1982).

DESCRIPTIONS

Adult mouthparts. Mandibles symmetrical, each with a pair of apical incisor teeth, the dorsal tooth continuous with an incising surface extending to the middle of the mandible proper (Fig. 1E). A basal flat hyaline retinaculum is attached ventrally with a frayed mesal surface. Surrounding the retinaculum is a broad channel formed by the ventral apical tooth and outside continuity. Basally, a small ental planar mola with a vertical mesal face and an ectal area of small hairs is located above the condyle. The epipharynx, labium and maxilla are typical for Tenebrionidae.

Larva mouthparts. Mandibles asymmetrical, each with a pair of incisor teeth, the ventral tooth subapical (Fig. 1A). Left mandible with a mesal dorsal process that fits over the corresponding medial process of the right mandible. Left mandible also with a basal planar mola. Right mandible with a well-developed medial planar concave mola that fits onto the corresponding left mola (Fig. 1A,D). Epipharynx and labium typical for Tenebrionidae. Hypopharyngeal sclerite anteriorly concave (Fig. 1B). Lacinea lacking an uncus and bearing bristles (Fig. 1B).

DISCUSSION

Mandibles of adults are typical for Tenebrionini (Doyen and Tschinkel, 1982). The incisors are used for removal of food, and the dorsal incisor surface is used for scraping (Fig. 1-E). The frayed retinaculum may be used to move the food towards the molae for compaction. The mandible itself is unspecialized and is indicative of a general feeding habit.

Mandibles of larvae are massive and adapted for both shearing and compacting. Under poultry house conditions the apical incisors appear capable of removing "cemented" (large pieces of food in a matrix of smaller pieces bonded together by a natural cement, similar to concrete) food particles of poultry pellets (feed), fecal material and poultry house insulation material. The bolus is channeled posteriorly to the fossa produced by the combined ventral areas of the mandibles and by the bristled lacineae, while the assymetrical molae compact the bolus. The function of the hypopharygeal sclerome is enigmatic, but it may facilitate movement of the bolus into the mouth.

Doyen and Tschinkel (1982) considered the planar mola to be plesiomorphic in contrast to an apomorphic, specialized, striate mola. Their philosophy is based on the widespread occurrence of the plesiomorph in Heteromera and primitive tenebrionid taxa. Watt (1974) considered the striate mola to be apomorphic in larvae but plesiomorphic for adults.

Striate molar surfaces are often associated with pollen, fungus and fungus spore and wood feeding (Doyen and Tschinkel, 1982; Lawrence, 1988). No function has been proposed for the planar molar condition except for *Platydema ellipticum* (Fab.) (Diaperinae), which has a similar larval morphology to *Alphitobius* but feeds exclusively on hard bracket fungi (Lawrence, 1988).

Thus, the mouthparts of larval *Alphitobius* are adapted to feeding on material that has been organically cemented together and merely needs to be raked and compacted without trituration. Since trituration is minimized, no striate surfaces are required on the molae. Materials that are less dense

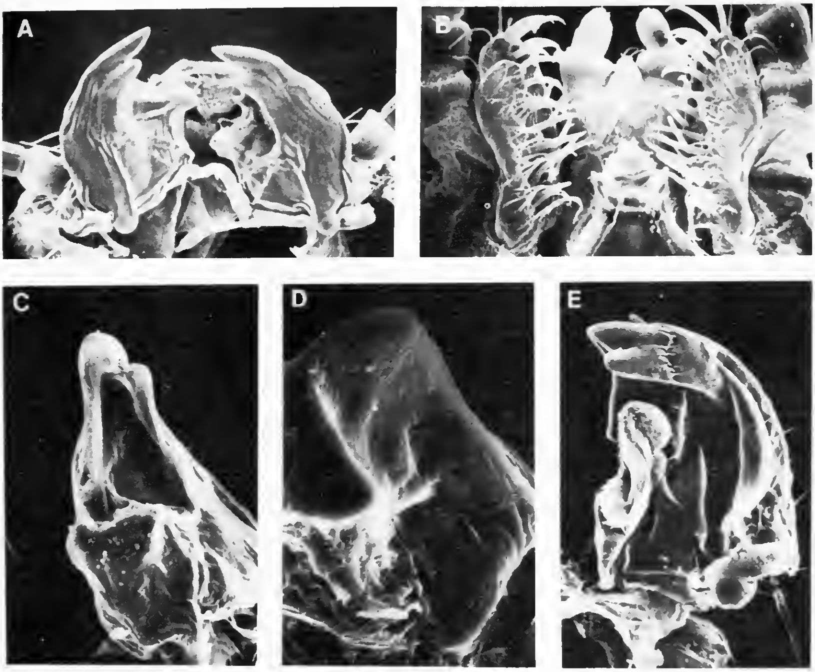

Figure 1. SEM photomicrographs of *Alphitobius diaperinus* (Panzer) mouthparts. A. Ventral aspect of larval assymetrical mandibles. B. Dorsal aspect of larval maxilla, labium and hypopharyngeal sclerome. C. Inner aspect of left mandible of larva. D. Larval right mandibulur mola showing concave planar surface. E. Adult left mandible (retinaculum shriveled due to chemical treatment).

and loosely packed may also be consumed. Vaughan et al. (1984) showed that *A. diaperinus* responds differently to insulation types. They found that polyestyrene was preferred by late instar larvae for pupation sites over polyurethane and fiberglass. Control measures should employ mechanical barriers that do not mimic textures of its natural food items.

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THE NATURAL HISTORY AND IMMATURES OF *SCAPHISOMA IMPUNCTATUM* (COLEOPTERA: SCAPHIDIIDAE)[1,2]

Richard A.B. Leschen[3]

ABSTRACT: The egg of *Scaphisoma impunctatum* Reitter is spherical and enveloped in a mucous-like wrap. The three larval instars can be distinguished from each other by head width and by morphology of the labral crenulations and antennal segments. Larvae of *Caryoscapha americanum* Löbl and *Scaphisoma* spp. can be distinguished by the morphology of the mandible, color patterns of the head, and the arrangement of the stemmata. Larval and pupal chaetotaxy are identical for described species. Preliminary data on immature forms supports subgeneric rank of *Caryoscapha* in *Scaphisoma. Scaphisoma impunctatum* larvae burrow into the stalks of *Tremellodendron pallidum* and pupate at the base of the fungus.

Scaphisoma and *Caryoscapha* are sister genera (Löbl, 1987). Ganglbauer (1899) originally erected *Caryoscapha* as a subgenus of *Scaphisoma* but it was subsequently raised to generic rank (Löbl, 1987).

Both larvae and adults of *Scaphisoma* and *Caryoscapha* feed on Basidiomycetes. *Scaphisoma* is common on Polyporaceae and less so on Hydnaceae, Clavariaceae and Agaricales (Newton, 1984). *Caryoscapha americanum* Löbl, (1987) was described from specimens found on Agaricales and a polypore. Ashe (1984) reviewed data concerning scaphidiid natural history which was included with his descriptions of the larva and pupa of *Scaphisoma terminatum* Melsheimer and the larva of *Scaphium castanipes* Kirby. Examination of Ashe's material revealed that the *S. terminatum* were in fact *C. americanum,* which was described subsequent to Ashe's study.

The immatures of the European species of *Scaphisoma agaricinum* L. were studied by Perris (1877) and Kasule (1966, 1968). Ashe's (1984) detailed descriptions and Newton's (1988) recent characterization of immature forms of Scaphidiidae provide a framework for additional studies.

The objectives of this paper are to describe or compare the immature stages of *Scaphisoma impunctatum* Reitter with *C. americanum* and discuss their taxonomic status. A detailed discussion of the natural history of *S. impunctatum* is presented.

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[1] Received May 29, 1988. Accepted June 19, 1988.

[2] Published with the approval of the Director, Agricultural Experiment Station, University of Arkansas, Fayetteville, AR 72701.

[3] Graduate Assistant, Department of Entomology, University of Arkansas, Fayetteville, AR 72701. Present address: Snow Entomological Museum, Snow Hall, University of Kansas, Lawrence KS 66045.

ENT. NEWS 99(5): 225-232, November & December, 1988

METHODS

Larvae and adults were collected from Basidiomycete hosts during 1986 and 1987. Larvae, with their respective hosts, were brought into the laboratory and reared at room temperature. A rearing chamber consisted of a large circular glass bowl covered with plate glass. The chamber contained moistened berlesate/sawdust substrate.

Field-collected specimens were preserved in 70% alcohol and lab-reared specimens were preserved in Khale's solution. Identifications of pinned adults were confirmed by Dr. Ivan Löbl, Museum d'Histoire naturelle, Geneve (MHNG). *Scaphisoma impunctatum* has been tentatively identified as such, based on a single female type; however based on male characters it appears to belong to the same species group as *S. rufulum* LeConte and *S. obesulum* Casey (Löbl, pers. com.).

Eggs of *S. impunctatum* were slide mounted in CMCP-10 mounting media and examined. Larvae were treated in cold 10% KOH for up to 3 days or until clear, then washed in 70% alcohol and dissected. Body parts and whole specimens were mounted on slides in CMCP-10 or CMCP-9AF mounting media. Mandibles were air-dried and prepared for scanning electron microscopy (SEM). Pupae were soaked in alum cochineal for 10 minutes, rinsed in 70% alcohol and examined with a compound microscope.

For larvae, lengths (L) are expressed as a range, and head capsule widths (HW) are expressed as means (x) and ranges (r). Pupae and egg lengths are also expressed as a mean. Measurements were calculated using a whipple grid mounted inside an ocular of a wild M-5 dissecting microscope.

Scaphisoma impunctatum Reitter

Egg. L = 0.40 (N = 7). White, smooth, spherical; enveloped within a mucous-like wrap (Fig. 8, 11).

Larva. First instar (N = 15): L = 1.10 - 1.40 mm; HW = 0.31 mm (r = 0.29 - 0.32 mm). Head yellow; anterior margin of labrum deeply crenulate, (Fig. 1); antenna compact (Fig. 3). Second instar (N = 19): L = 1.16 - 3.50 mm; HW = 0.40 mm (r = 0.37 - 0.42 mm). Head yellow; truncate labrum with anterior margin crenulate (Fig. 2); antenna elongate (Fig. 4). Third instar (N = 98): L = 1.83 - 4.00 mm; HW = 0.50 mm (r = 0.49 - 0.57). Head (Fig. 7): yellow, pigmented with dark macula surrounding stemmata, stemmata groups divergent, labrum same as second instar; antenna elongate (Fig. 5), mandible with 2 long acute apical lobes and a subapical psuedomola with a field of long spines (Fig. 9). All other characters the same as for *C. americanum* (Ashe, 1984).

Pupa. L = 2.45 (N = 2). White, eyes not developed. All other characters the same as for *C. americanum* (Ashe, 1984).

Material examined. *Caryoscapha americanum. Arkansas.* Logan Co., Cove Lake, Ex *Hericium erinaceus,* R. Leschen, 1 Nov. 1986 (3 larvae, 9 reared adults). *Illinois.* Jackson Co., Ferne Clyffe State Park, Ex *H. ramosum,* J.S. Ashe, 23 Oct. 1982 (12 larvae, 3 pupae, 6 reared adults). *Oklahoma.* Latimer Co., 5 mi. SW of Red Oak, Ex *H. ramosum,* R. Leschen, 3 Nov. 1987 (9 associated adults, 59 larvae, 13 pupae, 93 reared adults).

Scaphisoma impunctatum. Arkansas. Logan Co.: Cove Lake, Ex *Tremellodendron pallidum,* R. Leschen; 3 June 1986 (6 larvae, 1 pupa, 4 reared adults); 24 June 1987 (45 associated adults, 70 larvae, 1 pupa, 66 reared adults); Mt. Magazine, *T. pallidum,* R. Leschen (9 associated adults, 8 larvae); Garland Co., Camp Clearfork, Ex *T. pallidum,* R. Leschen, 12 June 1987 (8 associated adults, 5 larvae); Washington Co., L. Wedington, Ex *T. pallidum,* R. Leschen, 12 June 1987 (17 associated adults, 40 larvae, 21 reared adults).

Scaphisoma sp. *Arkansas.* Logan Co., Mt. Magazine, 5 June 1987, *Phanerochaete chrysorhizon,* R. Leschen (1 larva).

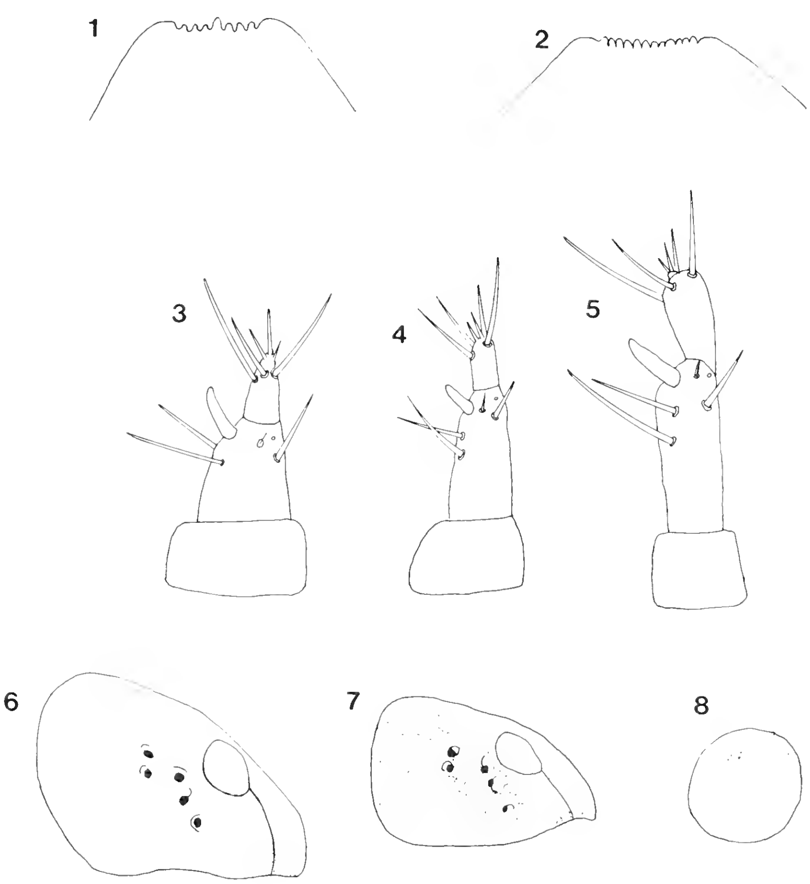
Voucher specimens were deposited as follows: 1. MHNG, 10 larvae and 10 adults of *C. americanum* and 6 adults of *S. impunctatum.* 2. Field Museum of Natural History, Chicago, (FMNH) 10 larvae, 5 pupae and 10 adults of *C. americanum* and 10 larvae and 10 adults of *S. impunctatum.* 3. Remainder in the R.A.B. Leschen Collection and the University of Arkansas Insect Collection.

Remarks. The egg description agrees with Newton (1988), with the exception of the mucous-like wrap which is unrecorded for Scaphidiidae. This mucous-like wrap is easily dissolved in 70% alcohol. A similar egg wrap occurs for the staphylinid *Trichopsenius* (Trichopseniinae) (Crowson, 1981). A micropyle was not observed, only the stemmata of the first instar larva (Fig. 8). No egg-bursters were observed on the first instar larva, however some lateral setae on the thoracic terga appear rigid and may assist in hatching.

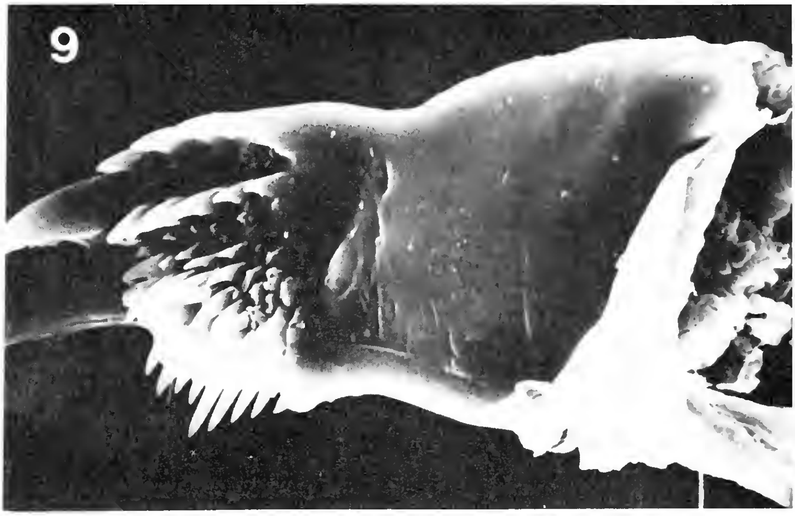
Instars can be distinguished not only by proportions, but by: 1) First instar with deeply crenulate anterior labral margin and a compact stubby antenna. 2) Third instar with pigmented head capsule and a dark macula surrounding the ocelli. 3) Second instar without the above combined characters.

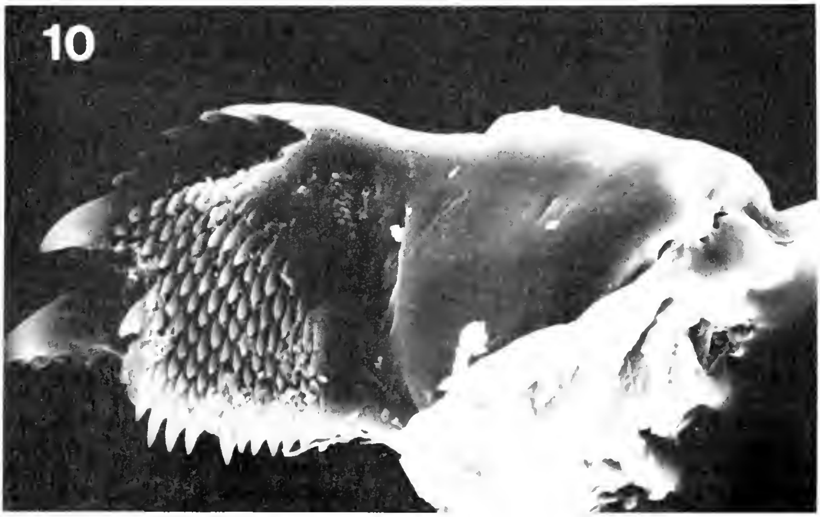
Larvae and pupae of *S. impunctatum* are almost identical to those of *C. americanum.* Larvae of *S. impunctatum* can easily be distinguished from *C. americanum* by the presence of pigment on the head capsule and a mandible with long acute incisor lobes and a subapical pseudomola with long spines. The pharate adults of *C. americanum* have triangular palpi, which are absent in *S. impunctatum.*

Rearing notes. Pupae were observed 11 days after collection date. Adults emerged 17-41 days after collection date.



Figs. 1-8. *Scaphisoma impunctatum* 1-5: 1. First instar, anterior margin of labrum. 2. Second instar, anterior margin of labrum. 3. First instar, dorsal aspect of right antenna. 4. Second instar, dorsal aspect of right antenna. 5. Third instar, dorsal aspect of right antenna. 6. *Caryoscapha americanum* third instar, lateral aspect of head capsule. 7. *S. impunctatum* third instar, lateral aspect of head capsule. 8. Egg of *S. impunctatum*.



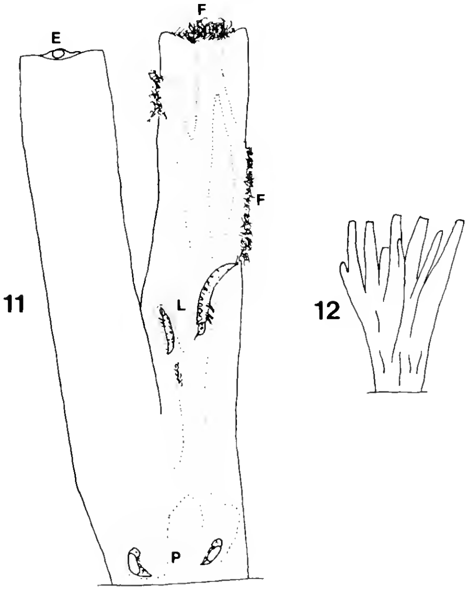


Figs. 9, 10. 9. Scanning electron micrograph (SEM) of *Scaphisoma impunctatum* left mandible, ventro-mesal view. 10. SEM of *Caryoscapha americanum* left mandible, ventro-mesal view.

Based on the material examined, head capsule pigmentation is present in *Scaphisoma* (Fig. 7) and absent in *Caryoscapha* (Fig. 6). Mandibular morphology appears to be the most informative character for species determination, however, the mandible of *C. americanum* (Fig. 10) resembles *S. agaricinum* as illustrated by Kasule (1966, 1968). Stemmatal arrangement may also be an informative character for species separation.

All other larval characters including chaetotaxy and position of cephalic and tergal glands are identical for both *Caryoscapha* and *Scaphisoma*. These data agree with Ganglbauer (1899) who originally erected *Caryoscapha* as a *Scaphisoma* subgenus. However, based on adult characters, Löbl's (1987) opinion is to consider *Caryoscapha* a distinct genus.

Tremellodendron pallidum (Schw.) Burt. (Tremellales) is a reproductive host for *S. impunctatum* (Figs. 11, 12). Its flesh is relatively tough, unlike the coral fungi (Clavariaceae) which it superficially resembles. Like *Hericium* (Hydnaceae), the reproductive host of *C. americanum*, *T. pallidum* has a distinct season but in contrast is not lignicolous and is found gregariously during late May through June. In the laboratory



Figs. 11, 12. *Tremellodendron pallidum:* 11. Diagrammatic representation of *Scaphisoma impunctatum* development from egg to pupa. 12. Habitus sketch. E = egg. F = frass. L = larva. P = pupa.

fruiting bodies retain their structural integrity for up to a period of one month.

Structural densities of the fungus hosts appear to correspond to the structure of the larval mandible. Those larvae which feed on the softer *Hericium, C. americanum,* have short apical lobes and a subapical mola consisting of numerous short spines (Fig. 10). In contrast, *S. impunctatum,* which feeds on the tough *T. pallidum,* has long apical lobes and a subapical mola consisting of well-developed long spines (Fig. 9).

Scaphisoma impunctatum females deposit eggs singly on fresh tips of *T. pallidum,* or when not so fresh, anywhere on the sporocarp. When sporocarps are fresh, larvae tunnel into the stalk and pile frass at locations where the tunnel is exposed to the outside (Fig. 11). As the number of larvae and visiting adults increase over time larvae can be seen feeding on the outside surfaces of the sporocarp. Eventually third instar prepupae burrow at the base of *T. pallidum* and pupate, often gregariously. In the laboratory some pupae were observed in the rearing substrate. Duration of each instar is unknown.

Scaphisoma impunctatum larvae feed in a similar manner to that described for *C. americanum* (Ashe, 1984). However, *C. americanum* did not pupate in the flesh of *Hericium* and Ashe suggested that this was related to the decay and degradation of the host. Larvae and pupae tentatively identified as *S. convexum* were also discovered feeding and pupating within their host *Schizopora paradoxa* (Fr.) Donk. (Polyporales). Perris (1877) noted that the European species *S. agaricinum* pupae were attached to the gills of its lignicolous host. Probably under natural conditions larvae pupate in the soil and in or near the fungus host.

Other scaphidiids reared from *T. pallidum* were: *Toxidium gammaroides* LeConte (1 adult) and *Cyparium flavipes* LeConte (1 larva, 12 adults). Newton (1984) reported *Cyparium terminale* Matthews on a *Clavaria* (Clavariaceae) host, tunneling into the branches. He also has found additional specimens of undetermined *Scaphisoma* on Clavariaceae.

ACKNOWLEDGMENTS

For determinations and comments on adult Scaphidiidae, I thank Dr. Ivan Löbl (MHNG), for unpublished information regarding Scaphidiidae, I thank Alfred F. Newton, Jr. (FMNH), and for the loan of his study specimens I thank Dr. James S. Ashe. I dedicate this paper to the memory of Dr. Milton S. Topping, Southwest Missouri State University.

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A NEW SPECIES OF *SWELTSA* FROM WEST VIRGINIA (PLECOPTERA: CHLOROPERLIDAE)[1]

Ralph F. Kirchner[2,3], Boris C. Kondratieff[4]

ABSTRACT: *Sweltsa pocahontas*, n. sp. is described from Braxton and Pocahontas County, West Virginia. This species resembles *S. urticae* (Ricker) in the structural details of the male epiproct and both species are illustrated. A holotype male and five paratype males are designated.

The Nearctic *Sweltsa* includes 21 species, of which five are eastern in distribution (Surdick 1985). Collecting by the authors has revealed an undescribed species from the Allegheny Mountain section of West Virginia.

Sweltsa pocahontas, new species

Figs. 1-3.

Male.- Body length 8.5-9.0 mm. Length of forewing 8.0 mm. General body color straw yellow in life (yellow-white in alcohol). Pronotum with black margin and center stripe. Middorsal region of abdominal terga 1-8 each with black mark. Terga 9 with transverse ridge. Epiproct erectile in cup-like basal anchor, elongate and nearly parallel sided dorsally (Fig. 2); tip hooked, recurved anteriorly, joining basal portion at acute angle, (Figs. 1 and 3).

Types.- Holotype Male, WEST VIRGINIA: Pocahontas County, Monongahela National Forest, Right Fork of Tea Creek, 0.4 miles N of WV 150, between Tea Creek Mountain and Gauley Mountain, elev. 1277 m, 16 VI 1983, R.F. Kirchner and B.C. Kondratieff. Paratypes: 3 males, same data as holotype; 2 males, Braxton County, small tributary to Falls Run, at Falls Mill, US 19, 11 V 1984, R.F. Kirchner.

The holotype and one paratype will be deposited in the collection of the United States Museum of Natural History, the remaining paratypes in the Kirchner Collection and Colorado State University Insect Collection.

Etymology: This species is named for the county in West Virginia where the holotype was collected.

---

[1] Received June 20, 1988. Accepted August 4, 1988.

[2] Department of the Army, Huntington District Corps of Engineers, Water Quality Section, 502 8th Street, Huntington, West Virginia 25701.

[3] The views of the author do not purport to reflect the position of the Department of the Army or the Department of Defense.

[4] Colorado State University, Department of Entomology, Fort Collins, Colorado 80523.

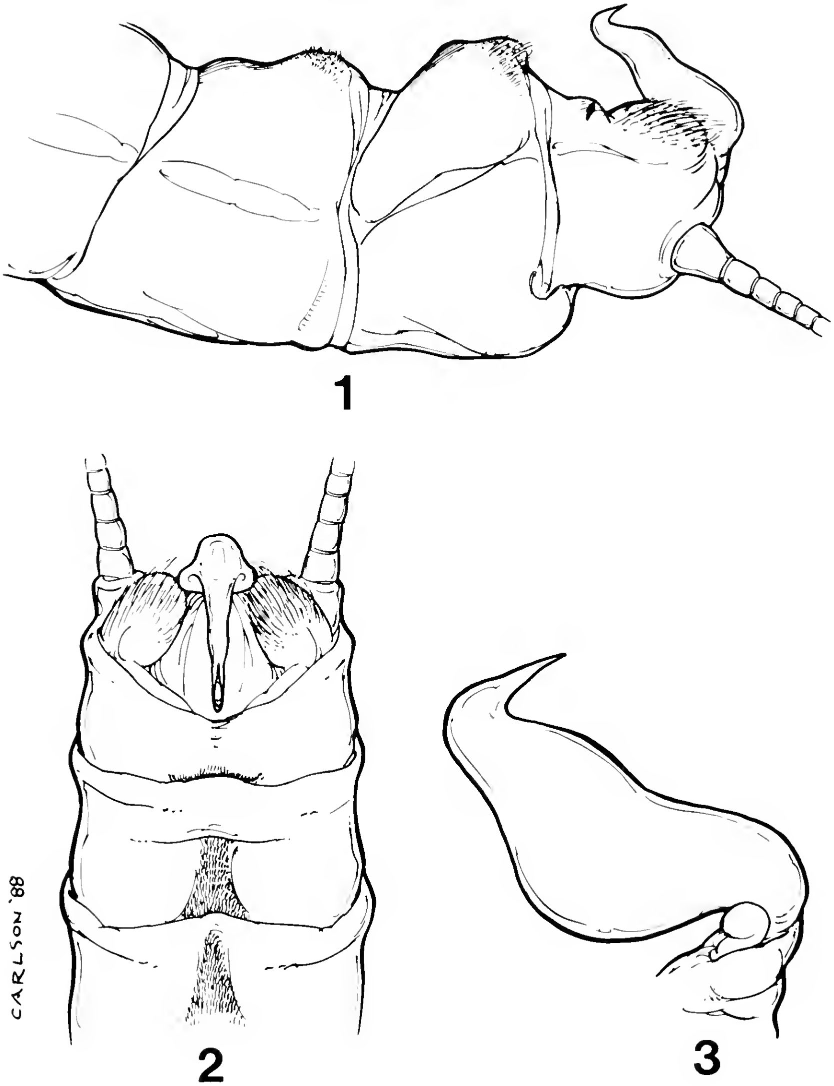
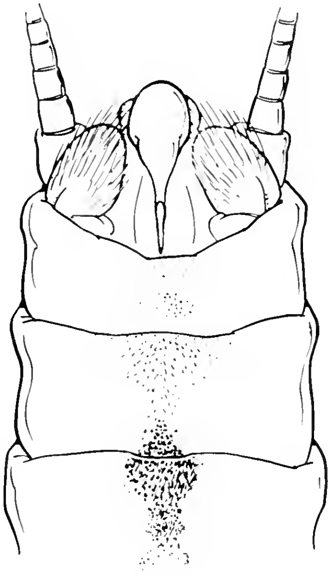


Figure 1. *Sweltsa pocahontas,* n. sp. Male terminalia, lateral. Figure 2. Male terminalia, dorsal. Figure 3. epiproct, lateral.



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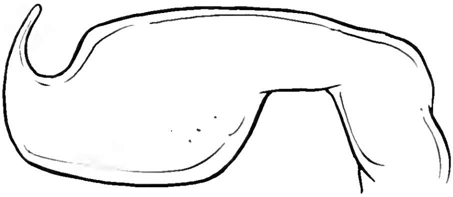

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Figure 4. *Sweltsa urticae* (Grayson Co., Virginia) Male terminalia, dorsal. Figure 5. Epiproct, lateral.

Diagnosis.- The shape of the male epiproct easily distinguishes this species from its eastern Nearctic relatives: *S. lateralis* (Banks), *S. mediana* (Banks), *S. naica* (Provancher), *S. onkos* (Ricker), and *S. urticae* (Ricker). In lateral view, the epiproct is most similar to *S. urticae* (Fig. 5), but lacks the expanded basal section of the epiproct. Additionally, the tip of the epiproct is elongate in *S. pocahontas* and forms an acute angle in lateral view (Fig. 3) rather than U-shape as in *S. urticae* (Fig. 5). Females and nymphs collected in association with *S. pocahontas* could not be reliably distinguished from females and nymphs of *S. lateralis.*

Remarks: Both streams are crenon (spring runs) habitats that become intermittent. The dominant riparian vegetation varies from cove hardwoods to northern hardwoods intermixed with red spruce.

Other species of chloroperlids associated with *Sweltsa pocahontas* included *S. lateralis, S. onkos, Alloperla usa* Ricker, and *Haploperla brevis* (Banks).

ACKNOWLEDGMENTS

We thank Drs. Richard W. Baumann, Brigham Young University and Howard E. Evans, Colorado State University for prepublication reviews. Dave Carlson provided the illustrations.

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RECORDS OF BLISTER BEETLES OF THE GENUS *CYANEOLYTTA* (COLEOPTERA: MELOIDAE) FROM ZAMBIA[1]

John K. Bouseman[2]

ABSTRACT: *Cyaneolytta granulipennis, C. iridescens* and *C. signifrons* are recorded for the first time from Zambia. A second record is provided for *C. depressicornis* in Zambia.

In a recent comprehensive summary of the literature pertaining to the Afro-Indian blister beetle genus *Cyaneolytta* Péringuey, Selander (1986) provided a useful framework upon which to organize new information about these little-known beetles. While in residence at the Kabwe Regional Experiment Station of the Zambia Ministry of Agriculture and Water Development at Kabwe (formerly Broken Hill, Northern Rhodesia) during November-December, 1984, I made a special effort to collect meloid beetles when encountered at Kabwe and environs. Results that pertain to *Cyaneolytta* are reported here. References to collection at light refer to incandescent light.

Cyaneolytta signifrons (Fahraeus)

A male collected on 15 November and a female on 1 December, both at Kabwe, provide the first records of this elegant species for Zambia. I took the specimens at light.

Cyaneolytta depressicornis (Castelnau)

On 20 November at Kabwe, I took a single male at light. This record is the second for Zambia; the species had been recorded previously from Luangwa.

Cyaneolytta granulipennis (Castelnau)

At Muswishi (ca. 28 km SE Kabwe) on 10 December, I observed this very large species feeding in numbers on unidentified weedy grasses that were emerging in a tilled field planted to maize (*Zea mays* L.). Although the sky was heavily overcast and rain fell intermittently during the period of observation, the beetles were quite active with much rapid running about;

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[1] Received January 23, 1987. Accepted March 5, 1988.

[2] Associate Entomologist, Section of Economic Entomology, Illinois Natural History Survey and Illinois Agricultural Experiment Station, University of Illinois, Urbana-Champaign, Illinois.

courtship and mating were noted. Six males and two females were taken at the site. I had previously taken a female at light at Kabwe on 16 November. These collections are the first definite records of *C. granulipennis* for Zambia. The species had been recorded previously from the ambiguous locality of Victoria Falls (Zambia-Zimbabwe).

Cyaneolytta iridescens (Haag-Rutenberg)

I collected four specimens at light at Kabwe: a male and a female on 16 November, a female on 17 November, and a male on 26 November. At Muswishi on 10 December, I collected a male and a female of *C. iridescens* in the company of *C. granulipennis* under the conditions recorded above for the latter species. Because I did not distinguish between these species at the time of collection, I cannot specifically state that *C. iridescens* is a grass-feeder. The above records are the first for this species in Zambia.

In conclusion, it seems worth noting here that on an earlier trip to Zambia (April 1984) during which I also was in residence at the Kabwe Regional Research Station and collected at the same or nearby localities, I encountered no blister beetles of the genus *Cyaneolytta.* This negative evidence compared with the positive evidence reported here suggests that the Zambian representatives of *Cyaneolytta* commence their adult activity with the beginning of the rainy season in November and conclude it by the onset in April of the seven-month dry season.

All insect specimens noted above are deposited in the collection of the Section of Faunistic Surveys and Insect Identification, Illinois Natural History Survey.

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TRANSMISSION OF THE ROSE ROSETTE DISEASE AGENT TO *ROSA MULTIFLORA* BY *PHYLLOCOPTES FRUCTIPHILUS* (ACARI: ERIOPHYIDAE)[1,2]

James W. Amrine Jr.[3], Dale F. Hindal[3], Terry A. Stasny[3],
Robert L. Williams[4], Charles C. Coffman[4]

ABSTRACT: Tests proved that rose rosette disease (RRD) results from a pathogenic agent and is not a mite-induced response of multiflora rose. Graft transmission of the RRD agent to rooted cuttings of *Rosa multiflora* required 45 to 80 days and was only 46% successful. Graft transmission to large vigorously growing transplants was more rapid (30-60 days) and 100% successful. Graft transmission showed the agent resides in roots of multiflora rose. Laboratory transmission of RRD by the eriophyid mite, *Phyllocoptes fructiphilus* (Acari: Eriophyidae) to transplants in 1986 was 92.3% and symptoms appeared in 17-24 days. Transmission of RRD by mites to rooted cuttings was unsuccessful. In 1987, the rate of field transmission with *P. fructiphilus* was 12.5% and lab transmission was 20% with symptoms appearing in 30-279 days and 29-47 days respectively. Reduced laboratory transmission in 1987 was thought to be drought-induced. Attempts to transmit RRD with *Tetranychus urticae* (Acari: Tetranychidae) were unsuccessful.

Rose rosette disease (RRD) affects numerous rose species, especially *Rosa multiflora* Thunb., and has been reported in the midwestern states (Allington *et al.* 1968, Crowe 1982 and 1983, Doudrick and Millikan 1983, Gergerich and Kim 1983, Gergerich *et al.* 1983, Hindal and Amrine 1987 and 1989). The nature of the causative agent remains unknown but studies suggest it may be a virus (Gergerich and Kim 1983) or a mycoplasma-like organism (Doudrick 1984).

The causal agent of RRD has been graft-transmitted (Thomas and Scott 1953, Allington *et al.* 1968, Doudrick 1984). Allington *et al.* (1968) demonstrated transmission by the eriophyid mite, *Phyllocoptes fructiphilus* Keifer (Fig. 1), to *Rosa eglanteria* L. (16.7%) and to *R. multiflora* Thunb. (34.3%) using mites collected from several species of roses showing symptoms of RRD. Allington *et al.* (1968) demonstrated that RRD was not a mite-induced plant reaction while Slykhuis (1980) suggested

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[3] Associate Professor of Entomology, Professor of Plant Pathology and Research Technician, respectively, Division of Plant and Soil Sciences, P.O. Box 6108, West Virginia University, Morgantown, WV 26506-6018.

[4] Plant Pathologist and Director, respectively, Plant Protection Programs, West Virginia Department of Agriculture, Charleston, WV 25305.

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that RRD may be the result of a toxicogenic reaction to mite feeding. Doudrick *et al.* (1986) failed to obtain transmission by the mite when placed on rooted cuttings of a healthy thornless clone of *R. multiflora.*

We present results of experiments of RRD transmission by grafting and mite feeding that prove 1) RRD is an infective agent of multiflora rose and 2) that *P. fructiphilus* can transmit the RRD agent to multiflora rose. We also demonstrate retention of the agent by *P. fructiphilus* and discuss variables that may influence transmission trials.

MATERIALS AND METHODS

Plant material used in transmission tests

Rooted cuttings and pruned, transplanted field grown healthy multiflora roses (transplants) were used in these tests. Stems from the thorny variety of multiflora rose were cut into three-node sections, their bases coated with Rootone (R) and placed in a greenhouse mist bed for 4-6 weeks. When rooted, these cuttings were placed in a peat-vermiculite (1:1) mix in four inch pots. The transplants were obtained by pruning healthy field grown multiflora rose plants (from the vicinity of Morgantown, West Virginia) until the stems were about 30 cm long; the plants were then dug and transplanted into 30 cm pots containing the above

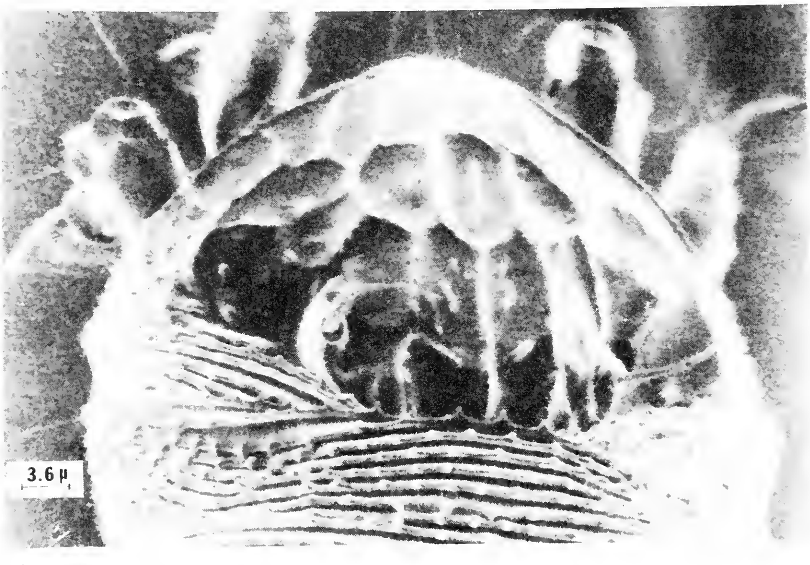

Figure 1. SEM micrograph of dorsal shield of *Phyllocoptes fructiphilus* K.

mix. All cuttings and transplants were maintained in a greenhouse containment room. Plants were sprayed with dicofol (Kelthane), propargite (Omite), oxydemetonmethyl (Metasystox R), and cyhexatin (Plictran) as needed to control spider mites (*Tetranychus urticae* Koch) and fertilized monthly with Peter's Professional, General Purpose 20-20-20 fertilizer at 1.3 ml/l monthly.

Graft and mite transmission

Rose rosette diesease infected tissues were obtained from multiflora rose shoots showing symptoms of RRD collected in S.E. Missouri, W. Kentucky and southern Indiana (Hindal and Amrine, 1987, 1989). Four graft transmission experiments were conducted with these tissues. Rooted cuttings were used in experiments 1 and 2 and transplants with succulent regrowth were used in experiments 3 and 4 (Table 1). In experiments 1, 2, and 3, pieces of infected stem tissue (3 to 5 mm long), and free of eriophyid mites were bud grafted (one per stem) onto at least three stems of each test plant. In experiment 4, eight pieces of tissue from a 5 mm diameter root of an infected plant showing symptoms of RRD were bud grafted into each of four plants. Tissues from Missouri and Kentucky were used in experiments one through three, whereas tissues from Southern Indiana were used in experiment 4.

In transmission tests using the mite, *P. fructiphilus* (Fig. 1), cuttings, transplants and field plants were used as bioassay plants. For mite transmission experiments 5 and 6, mites were field collected from *R. multiflora* showing symptoms of RRD from Scott County, Indiana on 12 Aug. 1986. These were stored at 1°C for nine days. For mite transmission experiments 7 and 8, mites were collected on 26 Sept. 1986 from affected plants at Madison Indiana and stored at 4°C for three days (Table 2). For field experiments 10 through 21, mites were collected on dates indicated in Table 3 at Clifty Falls State Park the day before experiments were conducted. For laboratory experiments 22 through 25 in 1987 (Table 4) mites were obtained from Clifty Falls State Park and for experiment 26, from Caesar Creek State Park, Warren County, Ohio.

In all mite transmission experiments, leaves of shoots showing symptoms of RRD were trimmed just above stipules and the petioles examined microscopically for mite populations. Only those petioles with 10 or more living mites were used. Infested petioles containing ca. 10 mm of stem were cut from the stems and placed in the apical leaf axils of the test plants. This procedure placed the mites into direct contact with their preferred developmental site (i.e., the petiole and axillary bud) on the test plant. The natural tendency of each leaf petiole to press against its stem acted as a double clamp, holding the petioles together.

Only one trial, experiment 5, was conducted with rooted cuttings. These cuttings were 3 months old and contained two or three small branches, but were not rapidly growing. The other laboratory mite transmission tests were conducted with transplants containing 15 to 30 cm of regrowth. Experiment 9 was conducted with "progeny mites" that had developed on the plants from experiment 8. These progeny mites on petioles were removed ten days after initiation of experiment 8 and placed, three petioles each, onto ten transplants (Table 2). In all mite transmission experiments, growing shoots were removed and examined for the presence of *P. fructiphilus* seven days after the mite-infested petioles were placed on bioassay plants for laboratory experiments, and after 30 days in field experiments. The presence of mites (especially of eggs and immatures) indicated that mites were successfully established on test plants. All plants in the laboratory transmission tests were treated with dicofol (Kelthane) and aldicarb (Temik) no later than 14 days after inoculation to eliminate both eriophyids and spider mites. In two of the field transmission experiments, one mite (experiment 11) and four mites (experiment 14) were placed onto each of 20 small leaf pieces which were then placed into growing tips of test plants to observe whether individual mites or a few mites could transmit RRD. In two of the 1987 laboratory experiments (22 and 24), *P. fructiphilus* were maintained on infected tissue for two weeks at 4°C to check for retention of the agent. (At this temperature, *P. fructiphilus* is inactive and feeding does not occur (Amrine, unpublished)).

After the transmission trials were initiated, the time, appearance, and number of plants showing RRD symptoms were observed. Test plants were determined to be infected when characteristic red or purplish pigment appeared in spots or blotches on the leaves (spot mosaic) or, later, when the veins became strongly pigmented with red (vein mosaic) (Fig. 2). These symptoms in combination with the later appearance of bright red shoots developing from the dormant buds at leaf axils, indicated that the RRD agent had been successfully transmitted (Amrine and Hindal, 1988).

During 1985 and 1986, 36 healthy multiflora rose plants in the field near Morgantown, WV, were artificially infested with *P. fructiphilus* collected from non-symptomatic plants in Cabell County, WV. These eriophyids were morphologically identical to mites collected on multiflora rose plants with RRD symptoms in Missouri, Kentucky, Indiana and Ohio.

Ten transplants were placed in a cage around a diseased plant infested with *T. urticae* (experiment 27). Canes from the symptomatic plant were placed so that they were in contact with each test plant to insure passage of spider mites. The plants were kept together for 30 days then treated with dicofol and aldicarb to eliminate the mites; during this time.

very large numbers of *T. urticae* developed and migrated among all of the plants.

RESULTS

Graft transmission in rooted cuttings. Grafting experiments in rooted cuttings showed slow development of RRD and low transmission rates. In experiment 1, a total of five of 12 plants (41.7%) showed symptoms of RRD within six months. In experiment 2, symptoms appeared as follows: four of 37 (10.8%) in 41 days, six of 37 (16.2%) by 51 days, and 17 of 37 (46%) by 80 days. Table 1 summarizes the results of the experiments.

Graft transmission in large transplants. In experiment 3, 100% of the large plants showed symptoms of RRD within 60 days of grafting. In experiment 4, all four plants grafted with infected root tissue showed symptoms in 75 days.

Mite Transmission. In experiment 5, no mites were recovered from the rooted cuttings and no symptoms developed. In experiment 6, the

Figure 2. The two leaves at the left show "spot mosaic", the first symptoms of rose rosette disease; the leaf at right shows typical vein mosaic (deep red to maroon), a characteristic advanced symptom of rose rosette disease.

plants were examined after seven days and developing mites (eggs + nymphs) were found on three of eight plants, indicating the successful establishment of mites on 37.5% of the trial plants. Four plants (50%) showed symptoms of RRD in 24 days. A fifth plant (62.5%) developed symptoms in 30 days while a sixth plant developed typical symptoms after 160 days. This indicated an overall infection rate of 75%. In experiment 7, four of eight plants contained developing mites after 10 days, thus mite establishment was successful on 50% of the plants. Six plants (75%) showed symptoms in 17 days, and all 8 (100% transmission) showed symptoms in 30 days. In experiment 8, all shoot tips examined after 10 days contained developing mites (100% successful transfer) and all 10 plants developed symptoms in 17 days (100% transmission). In experiment 9, all plants had successful mite establishment and only one plant developed symptoms in 17 days (10% transmission). No additional plants became infected after 160 days. After elimination of mites with pesticides, RRD symptoms continued to develop, producing mosaic, red lateral shoots, and witches' brooms, and eventual death of plants.

Field transmission, 1987. In experiments 10-18, 13 of 104 plants became infected in 30-279 days for 12.5% transmission. Seven of the infected plants did not show symptoms until 26 April 1988. One plant in the single mite transmission experiment and three plants in the four mite transmission experiment showed symptoms on 26 April 1988, 279 days after initiation of the test. Neither of the transmission experiments (19 and 20) conducted in the field on 23 Sep. 1987 were successful, probably because temperatures were too low for mites to be active and to feed.

Laboratory transmission, 1987. In experiments 22-26, ten of 50 plants showed symptoms of RRD in 29-70 days for 20% transmission; for experiments 22 and 24, mites had been held at 4°C for 14 days, indicating retention of the pathogen by the mites.

In establishment of *P. fructiphilus* on healthy multiflora rose, none of the 36 large field plants showed symptoms of RRD or any symptoms of mite infestation. None of the plants fed on by *T. urticae* became symptomatic.

DISCUSSION

The slow and incomplete development of RRD symptoms in RRD-grafted rooted cuttings (a total of 22 of 49 plants or 44.9% developed symptoms in 70 to 80 days) was quite striking as compared to the RRD-grafted large transplants (100% in 60 days). The physiological or pathological basis for this difference is unknown. In contrast to the production of numerous new shoots in the transplants, the rooted cuttings were not rapidly growing, and this difference may have affected the results: the causative agent of RRD may require rapidly growing tissue for efficient establishment. The high graft-transmission rate in transplants may have been enhanced by the stress condition of the plants (canes and roots were pruned and the plants were using stored reserves to produce new growth), rather than to differences in size or growth condition. It appears that transmission is incomplete in rooted cuttings and large transplants are better hosts for the identification of RRD.

The development of RRD symptoms from grafting of mite-free, symptomatic tissue supports our hypothesis that RRD is caused by a pathogenic agent and does not reflect a reaction to feeding of the eriophyid mites. The successful transmission of RRD by grafting of root tissue from RRD affected plants to stems of healthy plants (experiment four) also supports this hypothesis, since no eriophyid mite has been recovered from root tissue (Keifer, 1975). This last graft trial also indicates that the agent for RRD resides in the roots of *R. multiflora.*

During the past two years we have kept more than 200 transplants in a separate room as reserves for experiments and for future maintenance of the RRD agent. During this time, none of the plants developed symptoms of RRD, indicating that RRD was not present in field plants in West Virginia. Thus, positive results in our experiments could not have resulted from contamination or inapparent infection of dug field plants.

Definitive conclusions about the transmission of a disease agent by eriophyid mites requires that the mites must be successfully established on the test plants. *Phyllocoptes fructiphilus* requires succulent, growing tissues near apexes of shoots for successful feeding and development (Amrine and Kharboutli, unpublished). In experiment 5, the rooted cuttings were not growing rapidly and apparently were unsatisfactory for mite establishment. Failure to find any mites on the plants after seven days and the failure of RRD symptoms to develop suggests that the mites were unable to feed on the cuttings.

In experiments 6 through 8, establishment of *P. fructiphilus* on the new shoots was 92.3% successful, and RRD symptoms appeared on 18 plants by 17 days. These trials displayed the full potential of *P. fructiphilus* as a vector of the RRD agent to multiflora rose.

In experiment 9, only one plant showed symptoms of RRD in 17 days and no additional plants developed symptoms after more than 160 days. Apparently, *P. fructiphilus* loses much of its capacity to transmit the RRD agent after 10 days. Since it could not be determined whether "progeny" mites were indeed all progeny or were populated by some of the original mites, we can not determine the mechanism of this 10% transmission. The RRD agent may have just begun to multiply in stems and leaves of the newly infected plants, or a few original mites may have still been present on the transferred petioles.

The appearance of RRD symptoms within 17 days in experiments 7, 8 and 9 was the most rapid appearance of symptoms of RRD reported to date in the literature. Allington *et al.* (1968) reported the development of symptoms in 30-103 days. It appears in our investigations that *P. fructiphilus* (under optimum conditions) is more effective and efficient in introducing the RRD pathogen to susceptible tissue compared to graft transmission. The selection of healthy, large plants, dug and pruned two to four weeks before the experiments and growing vigorously at the time of the trials, was critical to the success of our experiments, both for grafting and mite transmission. The preference of *P. fructiphilus* for feeding on rapidly growing tissue near shoot apexes (where cells are very small and the 10-20 micron stylets may be able to extend past the epidermis) may give the RRD agent direct access to the xylem, phloem, or other specific host tissue which may harbor or support the RRD agent. The slower developing grafts may require longer periods of time to develop contact with these tissues. Size, growth condition, vector site preference and stress of host plants may affect the results of transmission tests of other suspected, or known, eriophyid transmitted disease agents and should be considered when conducting such tests.

Success of field and laboratory transmission trials with *P. fructiphilus* in 1987 were much less than the 92.3% successful laboratory trials conducted in 1986. Southern Indiana endured a moderate to severe drought in 1987; precipitation from April through September (14.4 ″) was only 62% of normal (23.2″) (Scheeringa, 1987). The drought affected both healthy and diseased plants of *R. multiflora* and resulted in greatly reduced new growth, and much of the foliage turned yellow and dropped off. The drought may have affected the transmission trials by modifying the mites' development or their ability to transmit the pathogen, or by reducing the availability of the pathogen in plant tissues to the mites. The drought also may have delayed expression of RRD symptoms in field plants which was evident in the appearance of some infections in April 1988. These results indicate the variability of mite transmission from season to season and the need for continuing thorough studies of all aspects of eriophyid transmission of RRD.

Transmission experiments employing one mite (Experiment 11) and four mites (Experiment 14) were successful, but symptoms did not appear until 26 April 1988. These two experiments indicate that adult *P. fructiphilus* can transmit RRD, and that single or a few adults can transmit the disease. Likewise, it proves that the mites are able to leave small pieces of drying leaves and cross onto healthy plant tissue. These two experiments also indicate that the field plants were slow in developing symptoms, perhaps because of the drought, or perhaps because a very small amount of inoculum was transferred (i.e., the larger the number of infected mites feeding, the more inoculum delivered, and the more rapid the development of symptoms). More likely, the drought retarded appearance of symptoms, since plants in four petiole experiments (one each in experiments 10, 13, 16 and 18) also did not develop symptoms until 26 April 1988.

In all of the mite transmission experiments, recovery of mites from test plants after seven days was variable. In many cases mites were found on tips but symptoms did not develop, and in other cases (experiments 6, 7, 14), symptoms developed but mites were not recovered. We believe that these discrepancies may result from two possibilities. For one, only a fraction of the mites may carry the RRD agent or be able to transmit it. And two, the mites may feed and transmit the agent, but for some reason not always establish a colony. The failure of the 36 large *P. fructiphilus* infested multiflora plants near Morgantown to develop any symptoms also indicates that RRD is not a mite-induced host response. Furthermore, during 1985 to 1987, several hundred multiflora rose plants were found infested with *P., fructiphilus* in eastern KY, OH, MD, NC, SC, and WV, but none showed symptoms of RRD. As of May 1988, no multiflora rose in West Virginia have been found to show symptoms of RRD.

Tetranychus urticae is not able to transmit RRD (Experiment 27). This pest has been a severe problem in our greenhouse; however, no unexplained transmission of RRD has appeared that may have resulted from transmission by *T. urticae.*

The relationship of the pathogen to the vector is of major importance to transmission of RRD by *P. fructiphilus.* Is the RRD agent merely a contaminant on the mouthparts or in the digestive tract, or does it actually penetrate the gut epidermis and eventually infect salivary glands? Infection of salivary glands has been demonstrated for *Aceria tulipae* K., which transmits Wheat Streak Mosaic Virus to wheat (Paliwal, 1980). Retention of the RRD agent in *P. fructiphilus* held on infected tissue for 14 days at 4° (experiments 22 and 24) suggests that the agent may be semipersistent or persistent, but more work needs to be done to elucidate this problem. It is unknown why mites held at 4°C for 7 days failed to transmit RRD (experiment 23) while retention for 14 days succeeded. We believe that because of the low rate of transmission (20%) that it is not statistically unusual to obtain no results in one test of 10 plants.

This study corroborates the conclusions by Allington *et al* (1968) that RRD is an infectious agent of multiflora (and other) roses and that it is transmitted by the eriophyid mite, *P. fructiphilus.* We believe that Doudrick *et al.* (1986) were unable to prove transmission of RRD by *P. fructi-*

iphilus because of the succulent tissue feeding requirement of the mites and also the incomplete transmission of RRD to rooted cuttings versus larger transplants. This study also shows that transmission of RRD by *P. fructiphilus* can be erratic and affected by drought or plant stress or both.

Mites collected on 20 October and 9 November were able to transmit RRD in 39 and 33 days respectively in the laboratory (experiments 25 and 26). However, petiole trials conducted in the field on 23 September (experiments 19-21) failed to show transmission. Experiment 20 employed 3 petioles with mites per plant, yet proved negative in transmission. We therefore believe that either the mites were unable to feed in the field after 23 September due to low temperatures, thus transmission could not occur, or that plants in the field could not be infected after August, perhaps due to changes in physiology as autumn and winter approaches.

Related to this discussion were collections of *P. fructiphilus* on *R. multiflora* in Fayette Co., WV, on 6 December 1985, when very large populations of mites were found, including large numbers of eggs and immatures. Also, many of the plants had developed succulent new growth at this late date because of the unusually warm fall weather. In contrast, most of the multiflora rose in Indiana and WV in fall 1987 had lost foliage and become hardened off by October. The considerable variation in growth condition of *R. multiflora* from one year to another is also reflected in potential transmission. We believe that when field moisture is adequate, temperatures are warm, and *R. multiflora* produces copious new growth, that mite populations and hence the potential for transmission of RRD are correspondingly high.

Studies in our laboratories will continue to examine the nature of *P. fructiphilus* transmission of RRD. Emphasis will be made on EM examination of *P. fructiphilus* tissues from both RRD affected and healthy plants, comparison of immature and adult mites in transmitting RRD, "feeding" times required to achieve acquisition and innoculation of the agent, retention of the agent by mites, and effect of stress on host plants to mite biology and mite transmission of RRD.

Table 1. Graft transmission of Rose Rosette Disease to *Rosa multiflora* rooted cuttings and transplants.

			Grafts		Development of Symptoms		
Experiment No.	Inoculum[1]	Bioassay type	No. of Plants	Date	Shortest Incubation Period (days)	No. Plants with Symptoms	% Infection
1	stem	cutting[2]	12	24 Dec 85	80	5	41.7
2	stem	cutting[3]	37	30 Jul 86	41	17	46.0
3	stem	transplants[4]	30	Dec 85	30	30	100.0
4	root	transplants[4]	4	20 Feb 86	53	4	100.0

[1] From plants showing symptoms of RRD.
[2] From rooted 3 node sections of healthy multiflora rose, growth rate slow.
[3] From rooted 3 node sections of healthy multiflora rose, growth rate moderate.
[4] From large, pruned field plants, dug and transplanted, growth rate rapid.

Table 2. Laboratory Transmission of Rose Rosette Disease by *P. fructiphilus* to cuttings and transplants of *Rosa multiflora*, 1986.

		Mite Transfer		Development of Symptoms		
Experiment[1] No.	Bioassay type[2]	No. of Plants	Date	Shortest Incubation Period (days)	No. Plants with Symptoms	Plants with Mites
5	cuttings[3]	10	21 Aug 86	—	0	0
6	transplants[3]	8	21 Aug 86	24	6	3
7	transplants	8	29 Sept 86	17	8	4
8	transplants	10	29 Sept 86	17	10	10
9	transplants[4]	10	9 Oct 86	17	1	10

[1] Mites were transferred from an infected multiflora rose showing symptoms of RRD. Each petiole contained 10 or more mites. Infected petioles for Experiments 5 and 6 originated near Scottsville, IN. Infected petioles for experiments 7 and 8 were obtained from Clifty Falls State Park, Madison, IN. Mites (10 or more per petiole) for experiment 9 were collected from plants in Experiment 8, ten days after original transfer.

[2] Cuttings were 3 months old, with two or three branches and growth was slow. Transplants were healthy, large, pruned field plants, dug and transplanted 14 to 30 days before the experiment, and growth was rapid; with new stems 10 to 30 cm long.

[3] Treated with dicofol on 11 Aug. 1986 to control spider mites.

[4] Treated with dicofol on 7 Sept. 1986 to control spider mites.

Table 3. Field Transmission of Rose Rosette Disease by *P. fructiphilus* to Multiflora Rose in Southern Indiana, 1987.

		Transfer of Mites			Development of Symptoms[2]						
Experiment	Inoculum Type	Location	Date	No. of Plants	16 Aug 87 S	16 Aug 87 M	22 Sep 87 S	22 Sep 87 M	19 Oct 87 S	19 Oct 87 M	26 Apr 88 S
10.	petioles[1]	Snyder Prop.	21 Jul 87	20	1	15	3	-	4	-	5
11.	1-mite	Snyder Prop.	21 Jul 87	20	0	1	3	-	4	-	1
12.	control	Snyder Prop.	21 Jul 87	20	0	1	0	-	0	-	0
13.	petioles	Rexville	23 Jul 87	20	0	2	1	-	1	-	2
14.	4-mites	Rexville	23 Jul 87	19	0	2	0	-	0	-	3
15.	control	Rexville	23 Jul 87	20	0	0	0	-	0	-	0
16.	petioles	Versailles	18 Aug 87	20	-	-	0	14	0	-	1
17.	control	Versailles	18 Aug 87	10	-	-	0	0	0	-	0
18.	petioles	N. of Rt. 50	18 Aug 87	5[3]	-	-	1	3	1	-	1
19.	petioles	Versailles	23 Sep 23	20[3]	-	-	-	-	0	6	0
20.	3-petioles	Snyder Prop.	23 Sep 87	20	-	-	-	-	0	9	0
21.	control	Snyder Prop.	23 Sep 87	10	-	-	-	-	0	0	0

[1] Mites from infected plants (Clifty Falls, St. Pk.) were placed into growing tips of test field multiflora rose as follows: "petioles" were removed from infected plants and contained 10 or more mites; "one-mite" was single, adult mites from an infected rose placed onto a small piece of leaf; "four-mite" was four adult mites from an infected rose placed onto a small piece of leaf.

[2] On dates listed, plants were examined for number developing symptoms (S) and number with mites present (M).

[3] Test plants were cut in August to test for effect of stress on transmission.

Table 4. Laboratory Transmission of Rose Rosette Disease by *P. fructiphilus* to transplants of *R. multiflora*, 1987.

Mites				Development of Symptoms				
Experiment	Date of Collection[1]	Exposure to 4°C (days)	Source	No. of Plants	Date of Inoculation[2]	Length of Incubation (days)	No. Plants with Symptoms	No. Plants with Mites[3]
22	19 Aug	14	Clifty Falls, IN	10	2 Sept	47	2	10
23	22 Sept	7	Clifty Falls, IN	10	29 Sept	—	0	7
24	22 Sept	10	Clifty Falls, IN	10	6 Oct	29	2	9
25	20 Oct	3	Clifty Falls, IN	10	23 Oct	39	3	5
26	9 Nov	1	Caesar Creek, OH	10	10 Nov	23	3	6

[1] Mites on symptomatic shoots were kept in plastic bags in a dark refrigerator at 4°C until transmission tests were conducted.

[2] Three petioles, each containing at least 10 mites, were transferred to indicator plants.

[3] Three tips examined on each indicator plant.

ACKNOWLEDGMENTS

We wish to thank the Commissioner of Agriculture, Mr. Gus Douglass, for making funds available for conducting this research. Also, Jon Apple, Entomologist, and the Indiana Department of Natural Resources greatly assisted our field work and gave permission to conduct the field trials in southern Indiana. Many other collaborators in WV, MD and OH provided specimens and conducted surveys for rose rosette disease and *P. fructiphilus.*

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NEW RECORD AND RANGE EXTENSION FOR *CERACLEA RESURGENS* (TRICHOPTERA: LEPTOCERIDAE) FROM COLORADO, WITH NOTES ON ECOLOGICAL CONDITIONS[1]

Scott J. Herrmann[2]

ABSTRACT: The western form of the caddisfly *Ceraclea resurgens* (Trichoptera: Leptoceridae) is recorded for the first time from Colorado. This record represents a major southward extension of the known range of this species. Physical, chemical, and biological conditions are described for a unique lotic microhabitat utilized by *C. resurgens* to generate a large localized population. *Glyptotendipes lobiferus* (Diptera: Chironomidae), previously reported from the Great Plains of Colorado, is associated with *C. resurgens* and is reported from the Grand Lake site in the southern Rocky Mountains.

Fourteen males and 20 females of *Ceraclea resurgens* (Walker) were hand picked from the concrete walls inside the west portal gate house of the Adams tunnel aqueduct (Figs. 1 and 2) in Grand County, Colorado (altitude 2550 mamsl; T3N, R57W, S9) on 1 August 1984. One male was also collected at an ultraviolet light from the Yampa River at Sunbeam, Moffat County, Colorado (altitude 1789 mamsl; T7N, R96N, S21) on 25 July 1984. Both collection sites are located west of the continental divide (Fig. 3). Dr. John C. Morse subsequently verified the identification of these caddisfly specimens as the "western form" of *C. resurgens* as illustrated in his 1975 publication. Morse (1987, pers. comm.) reported previously examining specimens of the "western form" from Minnesota, Manitoba, Saskatchewan, British Columbia, Northwest Territories, and Oregon, but none from locations as far south as Colorado. Three other species of *Ceraclea* were previously reported from Colorado by Herrmann *et al.* (1986).

Of the two new record sites, the Adams tunnel gate house location is unusual in several ways. In 1947 the Adams tunnel began carrying transmountain diversion water from west of the continental divide at Grand Lake (altitude 2550 mamsl) to east of the divide at Marys Lake (altitude 2451 mamsl) as part of the U.S. Bureau of Reclamation's Colorado - Big Thompson Project. Before 1947 Grand Lake, the largest and deepest natural lake in Colorado and at the headwaters of the Colorado River drainage system in the southern Rocky Mountains, had a continuous natural outlet at the west end (Nelson, 1971; Pennak, 1955). Today the Adams tunnel intake structure is the "outlet" for Grand Lake.

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[2] Department of Life Sciences, University of Southern Colorado, Pueblo, CO 81001-4901

The intake structure is fan-shaped with an outer curved perimeter of 54.0 m, a radius of 46.6 m, and a vertical opening of 1.2 m. The perimeter opening of the intake structure is covered by 16 fish screens which must be cleaned of algal growth every second or third year. Water flows from the intake structure via paired juxtaposed covered conduits 3.0 m wide, 3.4 m high, and 56.0 m long to a ground level concrete gate house (7.3 m wide and 11.0 m long) containing two radial gate valves which regulate the volume of water being sent through the Adams tunnel (3.0 m diameter; 21.1 km length) to Marys Lake. A continuous vertical air space of 610 to 910 cm exists from the gate house to near the perimeter of the intake structure. This air space permits fecundated females of *C. resurgens* to fly over and oviposit into the water flowing through the covered conduits and most of the intake structure to the gate house. Resh (1976a, 1976b) reported *C. resurgens* to release eggs over the water surface of streams and creeks with flight activity restricted to June. At the Adams tunnel and Yampa River sites conditions are favorable for oviposition over flowing water. Collections of adults from inside the gate house were attempted in mid and late June, but with negative results. Adult emergence and flight activity of Colorado forms of this species appears delayed until late July and early August.

Fig. 1 Adams tunnel gate house site with photographer facing south toward Grand Lake. Intake structure and conduits to gate house are buried under paved roadway and parking area at the right side of the picture. Photo by G.F. Price.

Ceraclea resurgens larvae were reported by Resh *et al.*(1976) to be obligate consumers of freshwater sponge. Lehmkuhl (1970) described how larvae of *C. resurgens* had ingested tissue of the sponge *Ephydatia muelleri* (Lieberkuhn) in the Red Deer River near Hudson Bay, Saskatchewan. Four species of freshwater sponge were reported for Colorado by Williams (1980); *E. muelleri* inhabits mountain lakes both east and west of the continental divide and displays a high tolerance to a wide range of water quality conditions. Personnel of the U.S. Bureau of Reclamation report that no one has been permitted into the intake structure and covered conduits to inspect or clean their surfaces since the Adams tunnel started carrying water in 1947. It is assumed larvae of *C. resurgens* are consuming tissue of a species of freshwater sponge, unknown at this time, while co-inhabiting the intake structure and/or conduits leading to the gate house. Sufficiently large growths of freshwater sponge must exist in the intake structures and/or conduits to support the feeding habits of larvae since the total of 34 adults hand picked from the inside gate house walls represented only about 5% of the total number observed on the ceilings, conduit walls, and inaccessible aqueduct structures.

A chemical and biological profile of the water entering the Adams tunnel is useful in characterizing the ecological conditions under which *C. resurgens* and associated sponge are thriving. Monthly mean and stan-

Fig. 2. Adams tunnel gate house structure at West Portal with photographer facing north. Photo by S.J. Herrmann.

dard deviation values for major anions, cations, and other physicochemical parameters are summarized in Table 1 for water passing through the intake structure, gate house, and Adams tunnel during the 11 year period 1977 - 1987. Mean monthly temperature was lowest in January (1.8°C) and highest in August (15.6°C). Concentrations of dissolved calcium, magnesium, sodium, potassium, sulfate, bicarbonate, and chloride were at a minimum during the summer months of July and August and at a maximum during late winter and early spring. Dissolved silica levels were highest in May and lowest in August. The micronutrient content of Grand Lake water entering the Adams tunnel is cited in Table 2. Concentrations of various forms of nitrogen and phosphorus are sufficiently high to describe Grand Lake as being mesotrophic (U.S. Environmental Protection Agency, 1977a). Nelson (1971) reported that essentially all primary productivity occurred in the upper 6 m of Grand Lake.

In addition to *C. resurgens* being collected from the inside of the Adams tunnel gate house, the chironomid *Glyptotendipes lobiferus* (Say) was numerous with 17 males and 2 females being captured on 1 August 1984 from the interior of the same structure. According to Sublette (1988, pers. comm.), the only other Colorado record for *C. lobiferus* is from Peetz

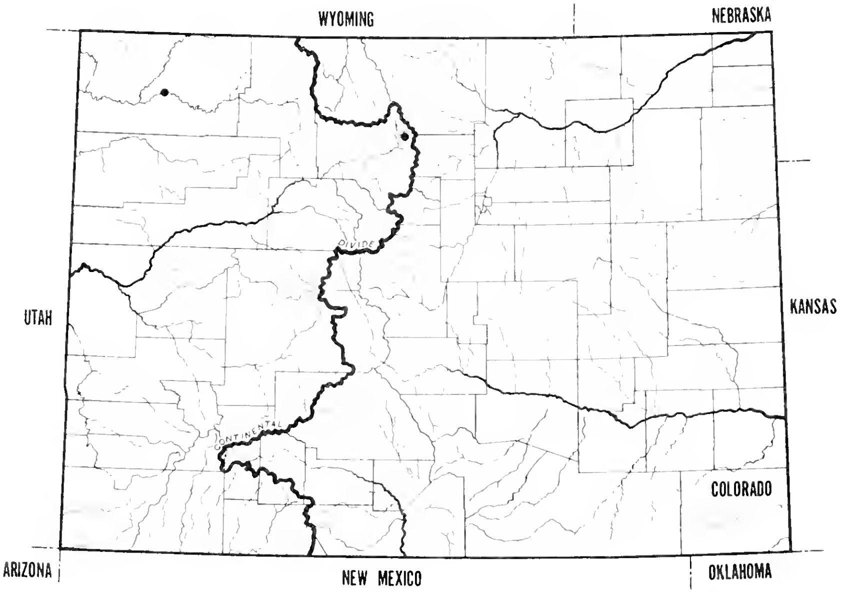

Fig. 3. Collecting sites constituting new record of *Ceraclea resurgens* in Colorado. Solid circles mark the two locations.

Table 1. Concentrations and values of major anions, cations, and limnological parameters for water conducted through the Adams tunnel from 1977 to 1987. Data were calculated from U.S. Geological Survey (1977-1987) and are cited as the mean ± 1 standard deviation with n = 11 for most months

Month	Temperature Degree C	Specific Conductance µs/cm	Alkalinity mg/L as $CaCO_3$	Dissolved Sulfate mg/L	Dissolved Chloride mg/L	Dissolved Calcium mg/L	Dissolved Magnesium mg/L	Dissolved Sodium mg/L	Dissolved Potassium mg/L	Hardness mg/L as $CaCO_3$	Dissolved Silica mg/L as SIO_2
January	1.8 ± 0.5	57 ± 6	24 ± 4	4.8 ± 0.3	0.6 ± 0.3	6.5 ± 0.6	1.3 ± 0.1	2.2 ± 0.3	0.8 ± 0.1	22 ± 2	4.3 ± 0.9
February	2.2 ± 0.6	57± 4	23 ± 4	4.5± 1.6	0.5 ± 0.2	6.8 ± 0.4	1.3 ± 0.1	2.3± 0.3	0.8 ± 0.1	22 ± 2	4.3 ± 1.0
March	2.4 ± 1.3	60 ± 5	24 ± 3	4.4 ± 1.3	0.5 ± 0.2	7.3 ± 0.7	1.3 ± 0.1	2.3 ± 0.2	0.8 ± 0.1	24 ± 2	4.4 ± 1.0
April	4.3 ± 4.3	54 ± 8	22 ± 5	4.2 ± 1.5	0.4 ± 0.1	6.5 ± 0.6	1.3 ± 0.1	2.3 ± 0.8	0.8 ± 0.1	21 ± 2	4.7 ± 1.1
May	5.3 ± 2.0	47 ± 8	18 ± 6	4.7 ± 1.7	0.5 ± 0.2	5.2 ± 1.3	1.1 ± 0.2	2.3 ± 0.6	0.8 ± 0.2	17 ± 5	7.7 ± 5.0
June	9.9 ± 3.4	33 ± 9	13 ± 4	5.2 ± 1.7	0.4 ± 0.1	4.1 ± 1.1	0.7 ± 0.2	1.8 ± 0.6	0.6 ± 0.2	13 ± 3	4.6 ± 2.1
July	14.0± 2.9	30 ± 10	11 ± 5	3.7 ± 1.5	0.3 ± 0.1	3.2 ± 1.4	0.6 ± 0.3	1.6 ± 0.9	0.4 ± 0.2	10 ± 4	4.0 ± 2.0
August	15.6 ± 1.6	35 ± 10	14 ± 6	3.5 ± 1.7	0.3 ± 0.2	4.2 ± 1.5	0.8 ± 0.3	1.5 ± 0.4	0.5 ± 0.2	14 ± 5	3.5 ± 0.5
September	12.7 ± 1.4	41 ± 8	16 ± 4	3.9 ± 2.1	0.5 ± 0.2	4.8 ± 0.9	1.0 ± 0.2	1.8 ± 0.5	0.7 ± 0.2	16 ± 3	3.8 ± 0.4
October	8.9 ± 1.2	39 ± 7	17 ± 4	4.9 ± 1.4	0.4 ± 0.1	4.8 ± 1.1	0.9 ± 0.2	1.7 ± 0.3	0.6 ± 0.1	14 ± 6	3.8 ± 0.4
November	4.5 ± 1.6	46 ± 7	18 ± 3	5.0 ± 1.8	0.5 ± 0.1	5.5 ± 0.6	1.0 ± 0.1	1.9 ± 0.3	0.7 ± 0.1	18 ± 2	4.1 ± 0.5
December	3.5 ± 0.5	50 ± 6	20 ± 3	4.0 ± 1.6	0.4 ± 0.2	6.1 ± 0.8	1.1 ± 0.2	2.0 ± 0.3	0.7 ± 0.1	20 ± 3	4.3 ± 0.6

Table 2. Micronutrient, physico-chemical, and biological data of Grand Lake water entering the Adams tunnel for transmountain diversion.*

Parameter	Range
Dissolved oxygen (mg/L)	4.8 - 8.5
pH (SU)	6.3 - 7.9
Total phosphate (mg/L)	0.001 - 0.236
Ortho phosphate (mg/L)	0.001 - 0.040
Nitrite and nitrate nitrogen (mg/L)	<0.020 - 0.180
Ammonia nitrogen - total (mg/L)	0.010 - 0.020
Total Kjeldahl nitrogen (mg/L)	0.100 - 0.400
Turbidity (JTU)	0.4 - 1.4
Chlorophyll a (μg/L)	4.0 - 5.5
Transparency - Secchi (cm)	243.8 - 426.7
Primary productivity (mg $C/m^2/hr$)	12 - 43

*Compiled from U.S. Environmental Protection Agency (1970, 1977a, 1977b) and Nelson (1971).

(altitude 1351 mamsl) on the Great Plains about 40 km north of Sterling, Colorado in Logan County. This midge species is normally associated with aquatic macrophytes and not necessarily with freshwater sponges. However, Resh (1976b) reported species of *Glyptotendipes* to feed on the symbiotic green algae within freshwater sponge. All insect material cited in this publication is deposited in the Life Sciences Museum of the University of Southern Colorado.

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I thank Jay H. Linam and James E. Sublette for their critical reviews of the manuscript; Max A. Haegele and Gene F. Price, U.S. Bureau of Reclamation, for their assistance with photographs and structural design of the Adams tunnel complex; and John C. Morse for verification of the identification of *Ceraclea resurgens.*

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100th ANNIVERSARY PAPERS WANTED

The first issue of ENTOMOLOGICAL NEWS was published in January 1890. Thus, with our next issue, Volume 100, Number 1, ENT NEWS will enter its 100th or Centennial year of publication. The American Entomological Society is proud of this record of continuous service and contributions to the science of entomology and to its literature.

The 100th Anniversary number of ENTOMOLOGICAL NEWS will be issued in January - February, 1990 as Volume 101, Number 1. A special issue is being planned. Several papers appropriate to the occasion have already been prepared and others are openly solicited. Any author who may have any material, probably of an historical nature, that may be appropriate to this occasion, and is willing to prepare a paper on the same, is encouraged to submit prospective title, abstract and or brief resume to the editor. Deadline for submission of final papers is September 1, 1989.

TRITOSMINTHURUS SCHUHI, A NEW GENUS AND SPECIES FROM CAPE PROVINCE, SOUTH AFRICA (COLLEMBOLA: BOURLETIELLIDAE)[1]

Richard J. Snider[2]

ABSTRACT: A new genus and species of Bourletiellidae is described from Cape Province, South Africa. It is separated from other members of the family by having a dorsal abdominal hump; lacking a "rastral organ" on the metatibiotarsus; apical bulb on antennal segment IV, ♂ clasping organ; with third antennal segment weakly annulated or subsegmented; unguis with subapical filament and 2-3 heavy, appressed tenent hairs on each leg.

A number of years ago a colleague, Randall T. Schuh, presented a vial of Collembola to me that he had collected while on expedition to South Africa. At the time the literature was in a state of flux and I filed the specimens until revisionary work had been published. Recently, while working on new North American sminthurids, I came across Dr. Schuh's specimens. Using Betsch (1980) to identify and compare various genera, the sample was found to contain a new genus and species in the family Bourletiellidae. My purpose is to report this unique new taxon among those already described.

Tritosminthurus gen. n.

Type species: ***Tritosminthurus schuhi*** sp. n.

Belonging to the Bourletiellidae *sensu* Betsch, 1980. Antennal segment IV subdivided, apical exertile bulb absent; antennal segment III basally swollen, giving the appearance of a subsegment, sensillae exposed; maxilla subequal to mandible; pretarsus with anterior setula; unguis small, robust without tunica; unguiculus nonlamellate, with broad apical filament; tenent hairs very thick, infundibulate; tibiotarsi with heavy, conical, smooth, setae on internal surfaces, "rastral organ" absent; retinaculum tridentate; collophore sacs warty; mucronal seta absent, mucro spoon-shaped, edges smooth; ♂ "clasping organ" absent; bothriotrichal pattern linear; body setae long, curving and smooth; great abdomen with posterior mid-dorsal hump.

Tritosminthurus schuhi sp. n (Figs. 1-41)

Color description. The following description is based upon specimens preserved in 95% ethanol. Background creamy white with slight pinkish highlights. Color distributed in polygons. Head with light dusting of blue pigment becoming heavier toward occiput; especially heavy on dorsum. A series of white polygons forming an outline

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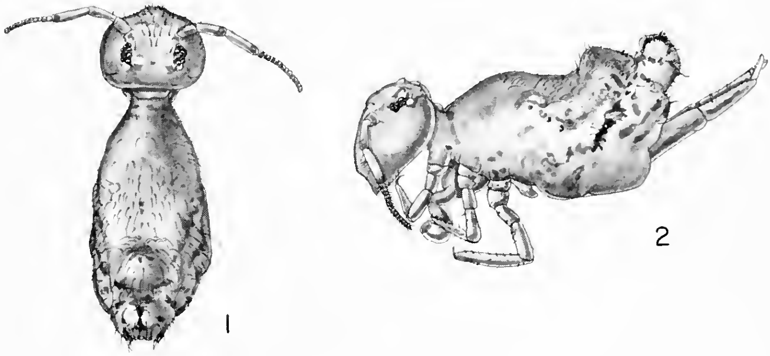
[1] Received April 25, 1988. Accepted June 10, 1988.

[2] Department of Zoology, Michigan State University East Lansing, Michigan 48824 U.S.A.

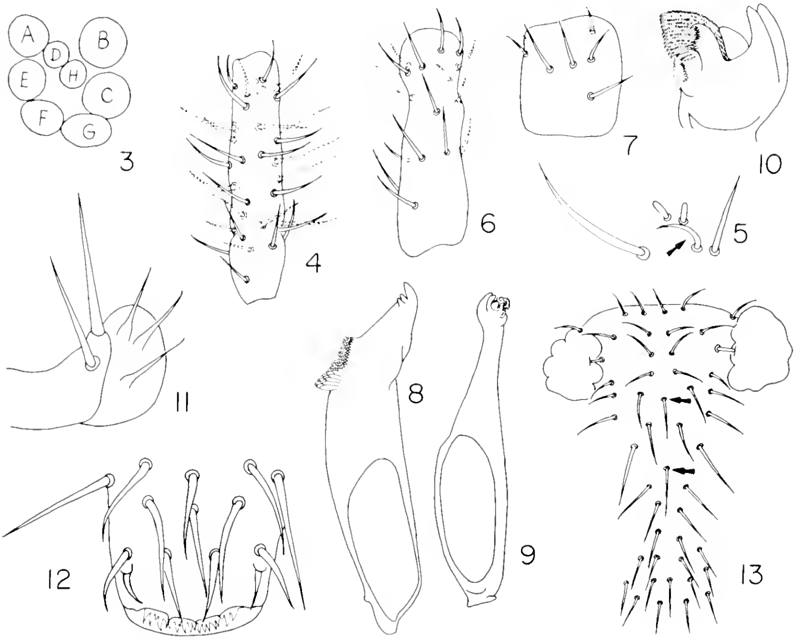
of a square between eyepatches and antennal bases, area contained within its limits lighter than surrounding field; with small triangular black macula between eyepatches. Black eyepatches with single white dot in their centers. Frontal genal grooves with white linear polygons, genae light blue. Antenna blue, becoming darker distally. Body with faint blue mid-dorsal line; dorsum with light purple patch. Blue pigment concentrated on posterior of abdomen, with heaviest blue lines and black polygons formed laterally and on parafurcular lobes. Anal papilla with dorsal black macula, bothriothrix D surrounded with black pigment. Furcula colorless. Legs with light blue dusting and black maculae at base of tibiotarsus. Bothriothrix A, B, and C surrounded with black pigment. (Figs. 1 and 2).



Figs. 1 & 2. *Tritosminthurus schuhi* gen. n., sp. n., 1. Habitus, dorsal aspect., 2. Habitus, lateral aspect.

Morphological description. HEAD: eyes 8+8; ocelli D and H 1/2 diameter of adjacent (Fig. 3). Antennal segment ratio 1:2:2:5; ANT IV with 12 subsegments, no subapical papilla or apical bulb, subsegments with or without fine setulae in the following distribution: I, II, and XII with none, III-VI with 1, VII-XI with 2; ANT III basally swollen, appearing as a subsegment, subapical sensillae exposed (Fig. 4), accessory seta hooked (Fig. 5); ANT II with 2 ventral setulae (Fig. 6); ANT I with 4 dorsal and 3 ventral setae (Fig. 7). Mandible (Fig. 8) and maxilla (Fig. 9) of equal length, capitulum of maxilla with 3 teeth (Fig. 10). Outer maxillary lobe typically sminthurid type (Fig. 11). Labral setae 2/4/3/5, teeth spinelike (Fig. 12). Postantennal seta and oval organs absent. Interocular cephalic setae curved, seta-like; 2 unpaired frontal setae (Fig. 13). FORELEG: coxa with 1 seta, no oval organ (Fig. 14); trochanter with 3 anterior and 1 posterior setae, with 1+1 oval organs (Fig. 15); femur with 7 anterior and 7 posterior setae, oval organ posterior (Fig. 16); anterior surface of tibiotarsus with 7AI, 7AL and AE$_2$, AE$_4$, AE$_6$ missing, accessory seta missing, E$_1$, and E$_7$ missing (Fig. 17); posterior surface of tibiotarsus with PE$_5$ missing, PL$_0$ truncate, PL$_7$ missing, accessory seta truncate, PL$_0$ truncate, with 5 oval organs (Fig. 18); pretarsus with anterior setula; unguis basally broad, curving, untoothed; unguiculus with subapical filament reaching beyond apex of unguis (Fig. 19). MESOLEG: coxa with 3 anterior setae and 1 oval organ (Fig. 20); trochanter with 5 anterior and 1 posterior setae, 1+1 oval organs (Fig. 21); femur with 12 anterior and 4 posterior setae, oval organ posterior (Fig. 22); anterior surface of tibiotarsus with 7AI, 7AL, and missing AE$_2$, AE$_4$, AE$_6$, accessory seta missing, E$_7$ missing (Fig. 23); posterior surface with PE$_0$ truncate, PL$_0$ truncate, PL$_3$ missing, accessory seta truncate, PI$_5$ missing, L$_3$, L$_5$ missing, L$_4$ present, 5 oval organs present (Fig. 24); pretarsus with anterior setula; unguis basally broad, curving, untoothed; unguiculus with subapical filament reaching beyond apex of unguis (Fig. 25). METALEG: coxa with 4 anterior setae and 1 oval organ (Fig. 26); trochanter with 5 anterior and 1 posterior setae, anterior and posterior oval organs present (Fig. 27); femur with 14 anterior and 3 posterior setae, posterior oval organ present (Fig. 28); anterior surface of tibiotarsus with 6AI, 8AL, missing AE$_2$, AE$_4$, AE$_6$, accessory seta missing, E$_1$, E$_7$ missing (Fig. 29); posterior surface with PE$_0$ truncate and PE$_5$ missing, all other PI setae present, PL$_0$ truncate, PL$_1$ present, all other PL setae missing, 8PI setae, L$_4$ present, accessory seta missing (Fig. 30); pretarsus with anterior setula; unguis broad basally, curving, toothless; unguiculus with subapical filament reaching beyond apex of unguis (Fig. 31). BODY: collophore with 1+1 subapical setae, sacs warty (Fig. 32). Corpus of retinaculum with 4 setulae, ramus with 3 teeth (Fig. 33). Manubrium 8+8 dorsal setae, ventral seta lacking (Fig. 34). Dens with 10 E setae, missing ID$_2$, ID$_4$, ID$_6$, ID$_8$, and ID$_{11}$ (Fig. 35); 3Ve$_1$, 3Ve$_2$, 2Ve$_3$, 1Ve$_4$ and 1Ve$_7$, 7L and with accessory L (aL) setae present (Fig. 36). Mucro with inner and outer lamallae smooth, rachis apically rounded (Fig. 37). Dorsal circumanal setae smooth, long, and tapering (Fig. 38); ventrally with a few rough setae (Figs. 39 and 40), ♀ subanal appendage spatulate and fringed(Fig. 41). Body setae long, curving and smooth; P seta of bothriothrix D complex smooth. Great abdomen with posterior hump. Length up to 2.25mm.

TYPES: Holotype (♀) and 100+ cotypes in 95% ethanol, 31 dissection slides, all de-



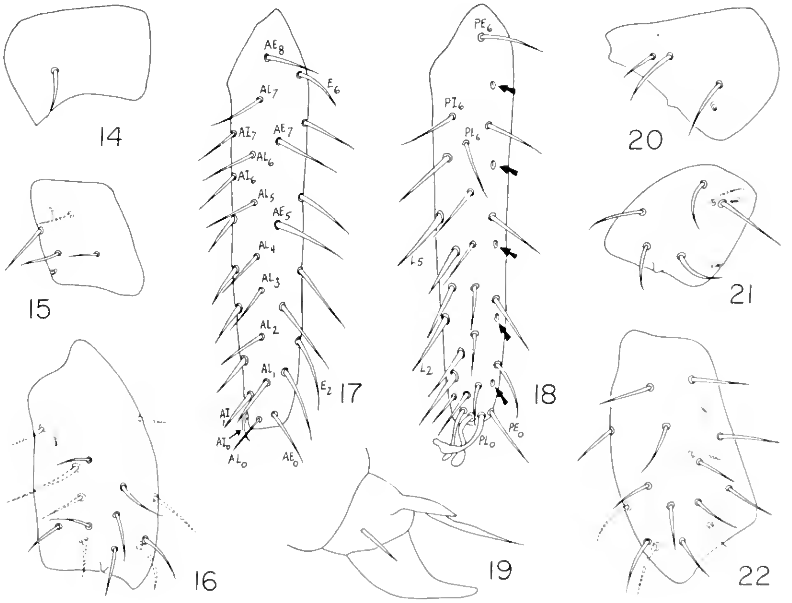
Figs. 3-13. *Tritosminthurus schuhi* gen. n., sp. n., 3. eyepatch, 4. ANT III, 5. accessory seta of ANT III, 6. ANT II, 7. ANT I, 8. mandible, 9. maxilla, 10. maxillary capitulum, 11. outer maxillary lobe, 12. labrum, 13. head, frontal aspect.

posited in the Entomology Museum, Michigan State University. Collection data as follows: South Africa, Cape Province, Cape Point Nature Reserve January 30, 1968, R.T. Schuh, J. and S. Slater, and M. Sweet, collectors.

It is my pleasure to name this new species for Dr. Randall T. Schuh, Department of Entomology, American Museum of Natural History.

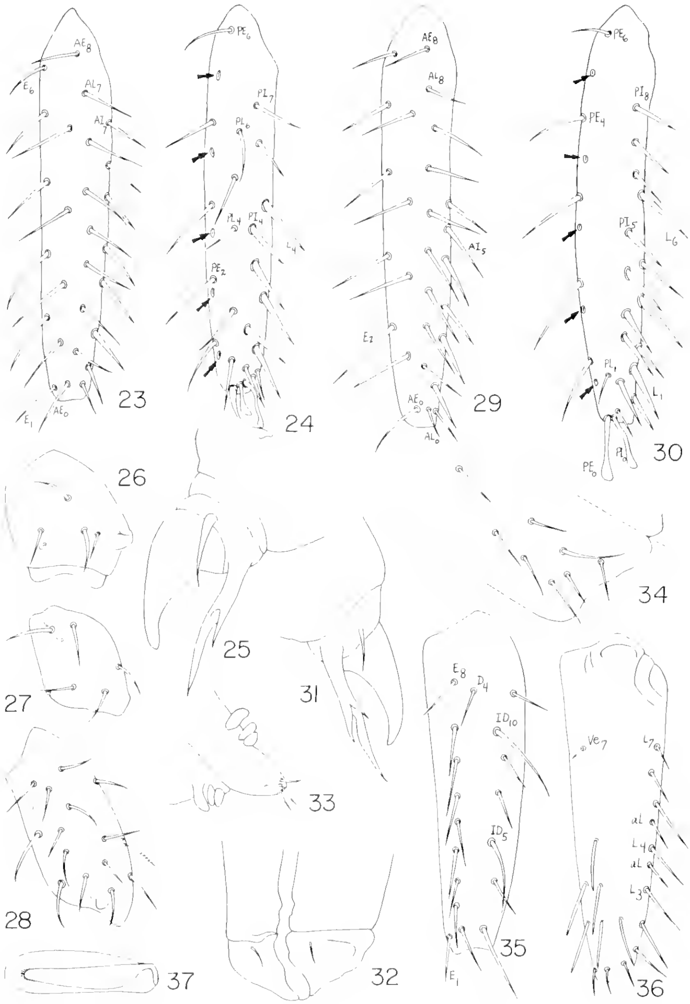
DIAGNOSIS

Initially *T. schuhi* fits into the Bourletiellidae *sensu* Betsch (1980) on the basis of a tridentate retinaculum; two pair of bothriotricha on abdominal segment V; anterior pretarsal seta; and 2-4 thick, appressed tenent hairs. Betsch follows Richard's (1968) analysis of key characteristics for Bourletiellini in setting up his family Bourletiellidae. Following those criteria, *T. schuhi* shares these generic morphological features with other family members: antennal segment IV annulated; interocular vesicles absent; trochanteral spine lacking, seta D3 present; unguis never tuni-



Figs. 14-22. *Tritosminthurus schuhi* gen. n., sp. n., 14. forecoxa, 15. foretrochanter, 16. forefemur, 17. foretibiotarsus, anterior surface, 18. foretibiotarsus, posterior surface, 19. foreclaw, 20. mesocoxa, 21. mesotrochanter, 22. mesofemur.

cate; posterior surface of pretarsus lacking a setula; mucro spatulate or paddle-shaped, mucronal seta absent; and bothriotrichal pattern ABC linear.

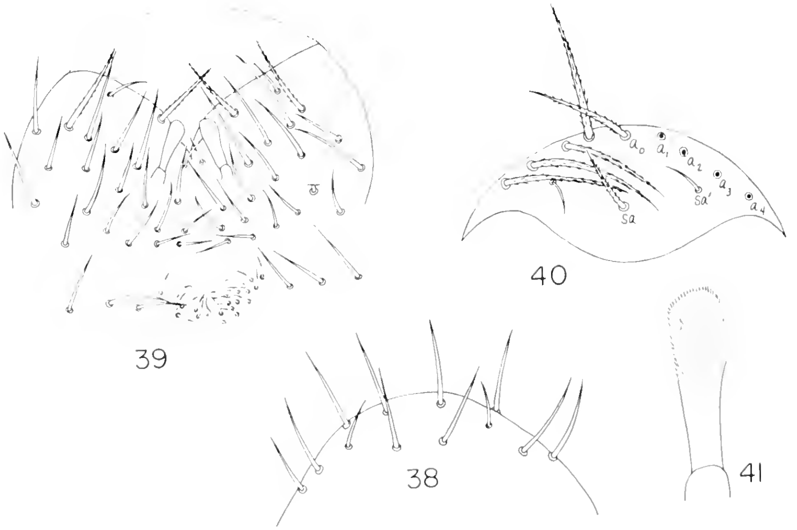


Figs. 23-37. *Tritosminthurus schuhi* gen. n., sp. n., 23. mesotibiotarsus, anterior surface, 24. mesotibiotarsus, ventral surface, 25. mesoclaw, 26. metacoxa, 27. metatrochanter, 28. metafemur, 29. metatobiotarsus, anterior surface, 30. metatibiotarsus, ventral surface, 31. metaclaw, 32. collophore, 33. retinaculum, 34. manubrium, dorsal surface, 35. dens, dorsal surface, 36. dens, ventral surface, 37. mucro.

When first examined and defined, *T. schuhi* was placed in the genus *Stenognathriopes* Betsch & Lasebikan (1979). However, a liberal definition of "rastral organ" as defined by Börner (1906) was used. Dr. Peter F. Bellinger (*in litt.*) pointed out that Betsch & Lasebikan gave a generic definition that has, "tibiotarsal spines dentate". This interpretation is, by opinion, closer to what is generally acceptable as constituting a "rastral organ", that is heavy, with conical setae having denticles. While heavy seate are present on the tibiotarsi, they neither are aligned as a "rastral organ" or are dentate. This condition eliminates both *Stenognathriopes* and *Rastriopes* as designated genera.

Most internal tibiotarsal spines are conical and the fourth antennal segment is subsegmented. These two morphological characteristics place *T. schuhi* close to the genera *Deuterosminthurus* and *Bourletiella*. It differs from those genera by not having an apical retractable bulb; with antennal segment III weakly subsegmented basally; and posterio-median hump on abdomen. Further, members of the genus *Deuterosminthurus* sp. do not have unguicular subapical filaments.

It appears that *T. schuhi* is closely related to both *Bourletiella* and *Deuterosminthurus*. It also shares some characteristics with *Rastriopes* and *Stenognathriopes*, especially in lacking an apical bulb on the antenna,



Figs. 38-41. *Tritosminthurus schuhi* gen. n., sp. n., 38. anal papilla, dorsal valve, 39. anal papilla, ventral valves, 40. anal papilla, posterior ventral valve, 41. subanal appendage.

configuration of the claws and enlarged, infundibulate tenent hairs. Still I prefer to place *Tritosminthurus schuhi* between *Rastriopes* and *Deuterosminthurus* in the phylogenetic scheme presented by Richards (1968), rather than the *Rastriopes* and *Stenognathriopes* branch proposed by Betsch (1980). Table I summarizes the morphological characteristics of what appear to be closely related genera.

Table 1. Morphological features shared by *Tritosminthurus* n.g. with related genera in the family Bourletiellidae *sensu* Betsch (1980).

CHARACTERISTIC	GENERA								
subannulated antenna	S	P	*	N	PS	B	D	H	T
apical retractile bulb	S	P	*	N	*	B	D	H	*
"rastral organ" present	S	P	R	N	*	*	*	*	*
unguiculus with subapical filament	S	P	*	*	*	B	*	*	T
stiff, thick dorsal setae	S	*	R	*	*	*	*	*	*
one pretarsal setula	*	P	R	N	PS	B	D	H	T
elongate maxilla	S	*	*	*	*	*	*	*	*
retinaculum with three teeth	S	*	*	*	PS	*	*	*	*
retinaculum with two teeth	*	P	R	*	*	B	D	H	T

S - *Stenognathriopes;* P - *Prorastriopes;* R - *Rastriopes;* N - *Nasosminthurus;* PS - *Pseudobourletiella;* B - *Bourletiella;* D - *Deuterosminthurus;* H - *Heterosminthurus;* T - *Tritosminthurus.*

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SPATIAL DISTRIBUTION OF FRIT FLY, *OSCINELLA FRIT* (DIPTERA: CHLOROPIDAE), IMMATURES IN TURFGRASS[1]

Mike P. Tolley[2], H.D. Niemczyk[3]

ABSTRACT: The spatial distribution of frit fly, *Oscinella frit*, immatures was studied by rearing adults from golf course turfgrass samples taken every 2 wks and placed in a greenhouse for 4 wks. The spatial distribution conformed to an aggregated type as indicated by K of the negative binomial, Taylor's power law, and regression of mean crowding on mean density. The common K (K_C), 1.23, exhibited agreement with a 0 y intercept and there was independence of 1/K from the sample means.

A primary requisite to understanding an organism in its ecosystem is knowledge of spatial distribution (Sevacherian and Stern, 1972). Information on spatial patterns aids in life table studies, population surveys, and recognition of subtypes (Harcourt, 1965). Moreover, understanding spatial patterns is vital in constructing sequential sampling plans (Waters, 1955), selecting variance stabilizing transformations (Southwood, 1978), and determining sample size (Karandinos, 1976).

The frit fly (FF), *Oscinella frit* (L.), a pest commonly abundant in turfgrass (Schread and Radko, 1958; Niemczyk, 1981), causes damage by larvae feeding on the central shoot. Jonasson (1982) determined that FF eggs exhibited an aggregated spatial pattern on oats; distribution of larvae was less contagious than that of eggs.

Research on FF larvae in turfgrass is labor-intensive. This is because larvae live in the base of grasses and the time required to dissect them and ascertain whether a larva is present is great. In the present study, an attempt was made to describe the spatial distribution of FF by rearing adults from turfgrass samples placed in a greenhouse. This information may be of value in future FF sampling regimes, life table studies, sequential sampling plans, and data analysis.

---

[1] Received March 19, 1988. Accepted June 20, 1988.

[2] Dow Chemical U.S.A., 450 University Club Tower, 1034 S. Brentwood Blvd., St. Louis, Missouri 63117.

[3] Department of Entomology, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, Ohio 44691.

MATERIALS AND METHODS

Sampling methods

Estimates of the densities of FF immatures were obtained by rearing adults from turf samples placed in a greenhouse. On each sampling date, 66 turf samples (ca. 300 cm^2 per sample) were collected at random with a 17.5 cm wide spade from fairway 3 at the College of Wooster Golf Course, Wooster, Ohio, every 2 wk from mid-April to mid-October, 1985. Sample locations were determined using a scaled map with locations specified by a table of random numbers. Replacement sod was used to fill sample holes left in the fairway. Fairway 3 was comprised of ca. 60% perennial ryegrass, *Lolium perenne* L., 20% Kentucky bluegrass, *Poa pratensis* L., and 20% annual bluegrass, *Poa annua reptans* L. Physical properties were: thatch = 2.5 cm, soil pH = 6.7, organic matter = 2.8%, cation exchange capacity = 10.2, sand = 30.4%, silt = 47.6%, and clay = 22.0%. The last known insecticide applied was isofenphos in 1981.

Samples were planted into a punctured, plastic-lined planter bed filled with Metro-mix 350 growing medium. The planter bed and samples were initially irrigated to moisten throughout. Thereafter, a tubing drip-irrigation system was used weekly to sustain grass growth. The punctured plastic liner allowed for water drainage. An emergence trap was placed over each sample to capture emerging FF adults. Emergence traps were maintained for 4 wk as this approximated the time of FF egg-to-adult development at greenhouse temperatures. Each trap consisted of a cone of sheer drapery cloth attached to the mouth of a 0.26 liter (0.5 pint) Ball mason jar supported 45 cm above each sample by a 6 mm diameter wooden dowel. Tapetrap was applied to the inside of each jar to capture adults as they flew up the cloth cone into the jar. Adults were removed from the Tapetrap and identified.

Statistical methods

A FORTRAN program (Davies, 1971) was used to fit negative binomial distributions to density data. The negative binomial program also calculated K, a parameter representing the degree of aggregation, and tested for overdispersion. The common K (K_c) was approximated by the method of Southwood (1978). The following dispersion indices were calculated: K of the negative binomial, slope and intercept of Iwao's mean crowding mean relationship (Iwao, 1968; Iwao and Kuno, 1971), and the slope of Taylor's power law (Taylor, 1961).

The negative binomial distributions were tested for goodness-of-fit by the χ^2 test. The aggregation index b of Taylor's power law and slope and intercept of Iwao's mean crowding mean relationship were tested for departure from 1 (for slopes) and 0 (for intercepts) by Student's t test.

RESULTS

The negative binomial indicated FF were aggregated since it fitted those data for 67% of the 12 sampling days. Estimates of the dispersion index K of the negative binomial ranged between 0.79 and 3.03. Southwood (1966) notes a K value < 8 indicates an aggregated pattern; thus, K reflects the clumped nature of FF immatures. The common K (K_c) was determined to be 1.23. The validity of K_c was determined by the nonsignificant correlation coefficients between 1/K values and sample means ($r = 0.45$; df = 6; $\underline{P} > 0.05$). The t test indicated that the intercept was not significantly different from 0 ($t = 0.65$; df = 6; $\underline{P}$ 70.05) (Southwood, 1978). The existence of a common K is important as it aids in the development of sequential sampling plans, selecting variance stabilizing transformations, and direct comparison of means between two or more distributions (Bliss and Owen, 1958).

Table 1 shows the results of Taylor's power law fitted to the log of means and variances of adults reared and Iwao's regression of mean crowding (m) on the mean. The aggregated pattern of FF was evident, because the slope (b; index of aggregation) of Taylor's power law was significantly different from 1, ($t = 6.42$; df = 10; $P < 0.05$).

The y intercept of the regression of mean crowding on the mean indicates dispersion due to behavior such as oviposition of egg masses, mutual attraction, or repulsion of individuals. The slope of the m-$\bar{x}$ regression reflects aggregation due to habitat heterogeneity in relation to population density (Iwao, 1968). The intercept from the m-$\bar{x}$ regression had a low value and was not significantly different from 0 ($t = 0.59$; df = 10; $P > 0.05$); thus, the number of immatures in the sample unit (ca.

Table 1. Regression equations of Taylor's power law relating the log of variances to the log of mean counts of the FF and the association between mean crowding (m) and the mean.

Index	Equations (n = 12)
Taylor's power law	$\text{Log}(s^2) = \text{Log } 0.302 + 1.546(\text{Log } \bar{x})$
	$r = 0.98^*$
m-x regression	$m = -0.690 + 1.958(\bar{x})$
	$r = 0.96^*$

*,significantly different from 0; $P < 0.05$; t test.

300 cm^2) exhibited a low degree of aggregation. Low aggregation may be the result of larval migration from shoots to tillers and other plants (Jones, 1969). The slope was significantly greater than 1 ($t = 5.69$; $df = 10$; $P < 0.05$), and, thus, indicated the highly aggregated distribution of samples containing FF due to habitat heterogeneity (Iwao, 1968). Such aggregation could result from a patchy distribution of turfgrass hosts with withered leaves which are preferred by females as multiple oviposition sites (Vickerman, 1978). Jonasson (1982) noted an aggregated pattern of eggs on oats due to distribution of hosts with morphological characteristics conducive for oviposition. In addition, he noted larvae exhibit less aggregation than eggs due to migration from main shoots to tillers.

CONCLUSIONS

FF immatures appear to be distributed in an aggregated pattern which may be due to the distribution of hosts with withered leaves onto which females oviposit and larva migration from old shoots to new tillers and plants. This aggregation conformed to a negative binomial distribution with a common K (K_c).

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BOOK RECEIVED AND BRIEFLY NOTED

THE ENTOMOLOGY OF INDIGENOUS AND NATURALIZED SYSTEMS IN AGRICULTURE, 1988. M.K. Harris and C.E. Rogers, eds. 230 pp. ppk.

The purpose of this book is to highlight some agriculturally important plants and their associated arthropod complexes with a biological, as well as an agricultural, perspective. Chapters include presentations on the entomology of ten plants or plant groups as indigenous and cultivated sunflowers, crucifers and cruciferous crops, muscadine grapes, strawberries, rabbiteye blueberries, Johnson grass & sorghum, rice, wheat, and pecans.

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