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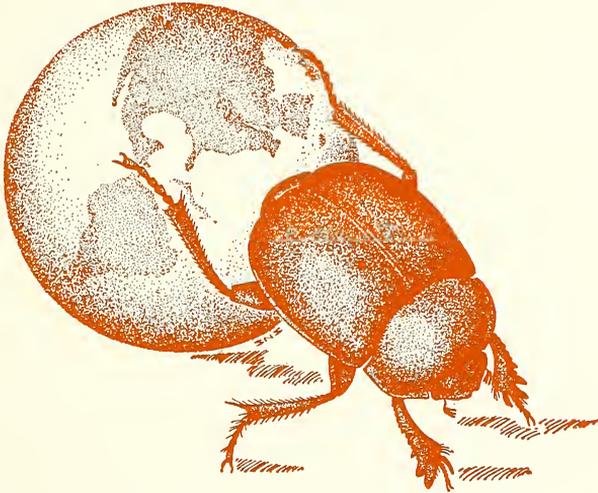
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**THE SOUTH AMERICAN WEEVIL GENUS ~~RHYEPHENES~~
(COLEOPTERA: CURCULIONIDAE; CRYPTORHYNCHINAE)**

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Abstract.—The genus *Rhyephenes* Schoenherr, endemic to the Central Chilean and Subantarctic biogeographic provinces of southern South America, is easily recognized by its black body with shape resembling a spider. This genus includes seven species: *Rhyephenes clathratus* R. Philippi, *R. gayi* (Guérin), *R. goureaui* (Gay & Solier), *R. humeralis* (Guérin), *R. lateralis* (Guérin), *R. maillei* (Gay & Solier), and *R. squamiger* F. Philippi (reinstated herein from synonymy with *R. gayi*). A key, redescriptions, habitus photographs, and illustrations of the species are provided, and their geographical distribution is mapped. A cladistic analysis using 21 characters from external morphology and male and female genitalia produced four cladograms (CI = 0.55, RI = 0.51, length 43 steps), which after successive weighting were reduced to one cladogram (CI = 0.82, RI = 0.85, length 111 steps). In the cladogram, the following phylogenetic sequence results: (*R. squamiger*, (*R. lateralis*, ((*R. clathratus*, *R. goureaui*), (*R. gayi*, (*R. humeralis*, *R. maillei*))))). Biogeographic patterns exhibited by these species indicate a sequence from central Chile to southern Chile and Argentina.

The weevil genus *Rhyephenes* (Curculionidae: Cryptorhynchinae) was described by Schoenherr (1837). This taxon of uncertain placement is one of the most characteristic weevil genera from central Chile, with two species extending also to southern Chile and Argentina. They are popularly known in Spanish as “arañitas” (little spiders), because of their typical habitus (see Figs. 1–14). Sixteen species-group names proposed by several authors (Guérin, 1830; Erichson, 1834; Gyllenhal, 1837; Gay & Solier, 1839; Blanchard, 1853; R. Philippi, 1859; F. Philippi, 1899; Fiedler, 1942) were assigned to *Rhyephenes*. This nomenclatural proliferation is mainly due to the intraspecific variability of the species of *Rhyephenes*, which led authors to describe as valid species mere geographical variants. Recent synonymies by Kuschel (1993) and Morrone (1994) reduced the number of species to six. I suspected, however, that the synonymy of *R. squamiger* F. Philippi and *R. gayi* (Guérin) by Kuschel (1993) was incorrect. A cladistic analysis of its species can help elucidate which are the valid species of *Rhyephenes*.

MATERIAL AND METHODS

The specimens examined in this study are from the following collections: AMNH, American Museum of Natural History, New York, USA (Lee Herman); BMNH, The Natural History Museum, London, Great Britain (Christopher Lyal); CWOB, Charles W. O'Brien private collection, Tallahassee, USA (Charles O'Brien); IADIZA, Instituto de Investigaciones de las Zonas Áridas, Mendoza, Argentina (Sergio Roig-Juñent); IPCN, Instituto Patagónico de Ciencias Naturales, San Martín de los Andes, Argentina (Mario Gentili); MACN, Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Buenos Aires, Argentina (Axel Bachmann); MHNS, Museo Na-

Table 1. Data matrix and list of characters used in the cladistic analysis of *Rhyephenes*.
0 = plesiomorphic; 1, 2, 3 = apomorphic.

outgroup	00000	00000	00000	00000	0
<i>R. clathratus</i>	11001	11001	21100	00010	0
<i>R. gayi</i>	10010	11000	21111	11100	1
<i>R. goureaui</i>	00001	11001	01101	01110	1
<i>R. humeralis</i>	21110	11111	21101	12101	1
<i>R. lateralis</i>	22000	10001	31000	01001	1
<i>R. maillei</i>	21010	11111	01000	11100	1
<i>R. squamiger</i>	00010	00101	10000	00100	0

1. Tubercles on male rostrum: (0) absent; (1) present, at sides; (2) present, on dorsum and sides.
2. Punctures on female rostrum: (0) broad, abundant; (1) fine, less abundant; (2) fine, sparse.
3. Prothorax: (0) slightly globose; (1) strongly globose, protuberant.
4. Relative width of the prothorax: (0) as wide as elytra; (1) wider than elytra.
5. Prothoracic anterior impression: (0) absent; (1) present.
6. Prothoracic punctures: (0) small, shallow; (1) large, deep.
7. Elytral basal area: (0) slightly impressed; (1) strongly impressed.
8. Elytral tubercles: (0) rounded; (1) subconical.
9. Elytral tubercles on intervals: (0) small, similar to those on striae; (1) large, more developed than those on striae.
10. Elytral tubercles on intervals and striae: (0) clearly separated; (1) partially fused.
11. Elytral humeral stripes of white scales: (0) absent; (1) two short stripes; (2) three short stripes; (3) three stripes, two short and one longer.
12. Body vestiture: (0) clothed with scales; (1) lacking scales.
13. Aedeagus in lateral view: (0) slender; (1) robust.
14. Ostiolar sclerites of aedeagus: (0) rounded; (1) acute.
15. Parameres: (0) long, narrow; (1) short, broad.
16. Female sternum 8 plate: (0) as long as wide; (1) longer than wide.
17. Relative length of female sternum 8 plate: (0) $< 0.40 \times$ length of manubrium; (1) $0.41-0.61 \times$ length of manubrium; (2) $> 0.61 \times$ length of manubrium.
18. Setae on sides of female sternum 8 plate: (0) absent; (1) present.
19. Arms of female sternum 8 plate: (0) narrow; (1) broad.
20. Spermathecal nodulus: (0) developed; (1) not developed.
21. Spermathecal ramus: (0) developed; (1) not developed.

cional de Historia Natural, Santiago, Chile (Mario Elgueta); and MLP, Museo de La Plata, La Plata, Argentina (Juan Schnack).

Drawings were made with a camera lucida attached to a stereoscopic microscope. Full data of type specimens are cited enclosing information from each label with square brackets with each line separated by a slash.

Characters were derived from the external morphology, and male and female genitalia. The classification of the subfamily Cryptorhynchinae is in some disarray (Lyal, 1993) and there are no keys available to the South American genera (O'Brien, 1984). Furthermore, the distinctness of *Rhyephenes* makes it presently not possible to identify its sister group, so an unrooted ingroup analysis was performed, and the root of the cladogram was determined a posteriori using an hypothetical outgroup, following

the procedure described by Nixon and Carpenter (1993). In order to construct this outgroup, several South American genera were examined and the revision of the New Zealand Cryptorhynchinae (Lyal, 1993) was consulted. Table 1 contains the data matrix and the list of characters analyzed (all multistate characters were treated as additive). Analysis was carried out with Hennig86 1.5 (Farris, 1988), applying the implicit enumeration option and the successive weighting procedure. CI and RI were calculated excluding autapomorphies. CLADOS 1.1 (Nixon, 1992) was employed for examination of character distributions and for rooting the cladogram after the unrooted analysis.

RHYEPHENES SCHOENHERR, 1837

Rhyephenes Schoenherr, 1837:312 (type species *R. incas* Gyllenhal [= *R. humeralis* (Guérin)], by original designation); Gay and Solier, 1839:24 (key); F. Philippi, 1899:3 (revision); Fiedler, 1942:274 (key).

Physothorus Gay and Solier, 1839:22 (type species *P. maillei* Gay and Solier, by original designation); Solier, 1839:L (= *Rhyephenes*).

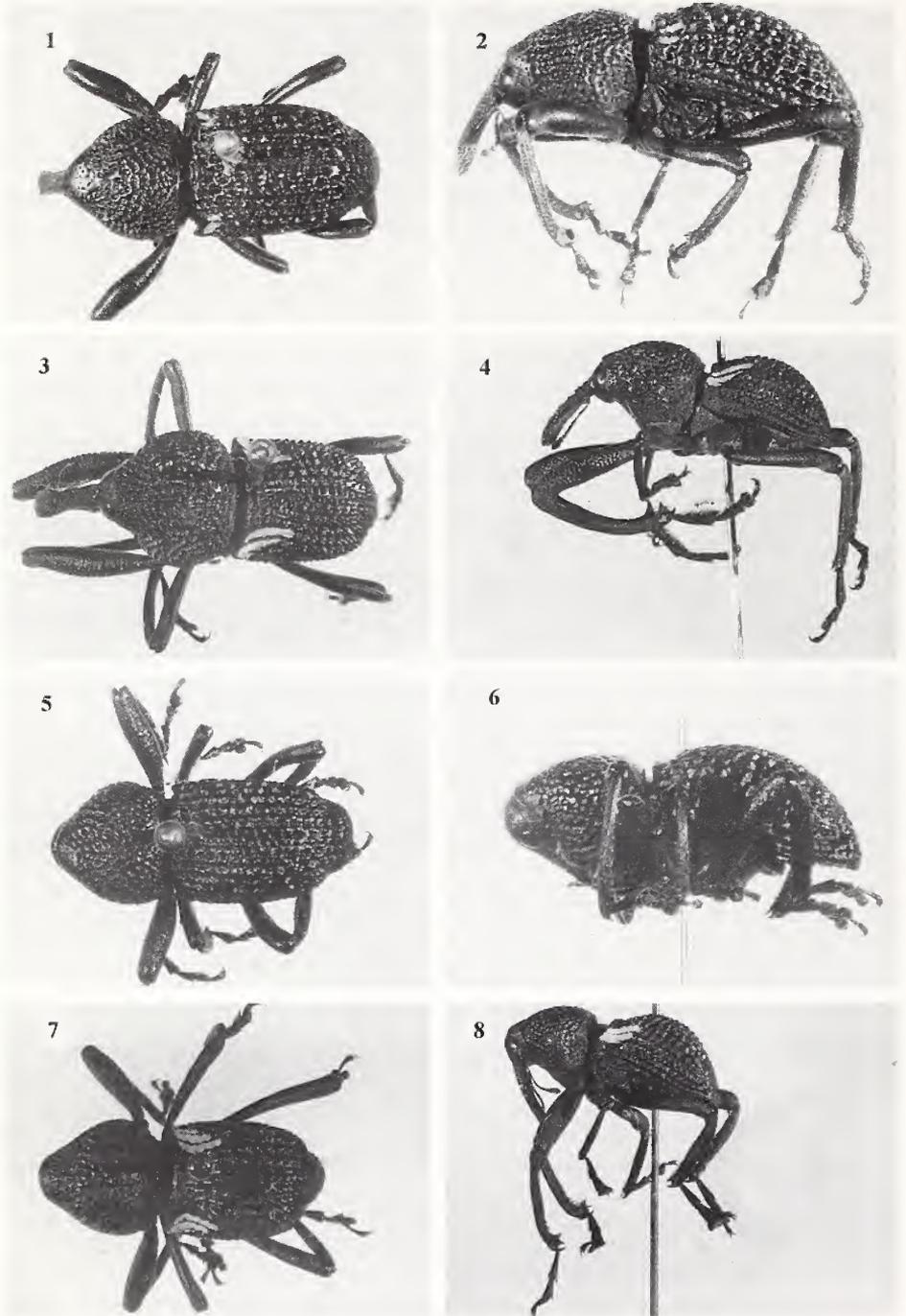
Rhyephenes is easily recognized by its black color and habitus, which resembles a spider (Figs. 1–14).

Biology: Adult *Rhyephenes* are usually seen on woody plants, females oviposit under bark of the host plants, and larvae are endophytic, excavating galleries and feeding on live wood (Angulo, 1970; Elgueta, 1993). Table 2 includes a list of the known plants where species of *Rhyephenes* have been collected, from personal observations in the field, specimen labels, and relevant literature (Fiedler, 1942; Havrylenko & Winterhalter, 1949; Solervicens & Elgueta, 1989; Barriga et al., 1993; Elgueta, 1993; Morrone & Roig-Juñent, 1995). These plants cannot be certainly assumed to be host plants.

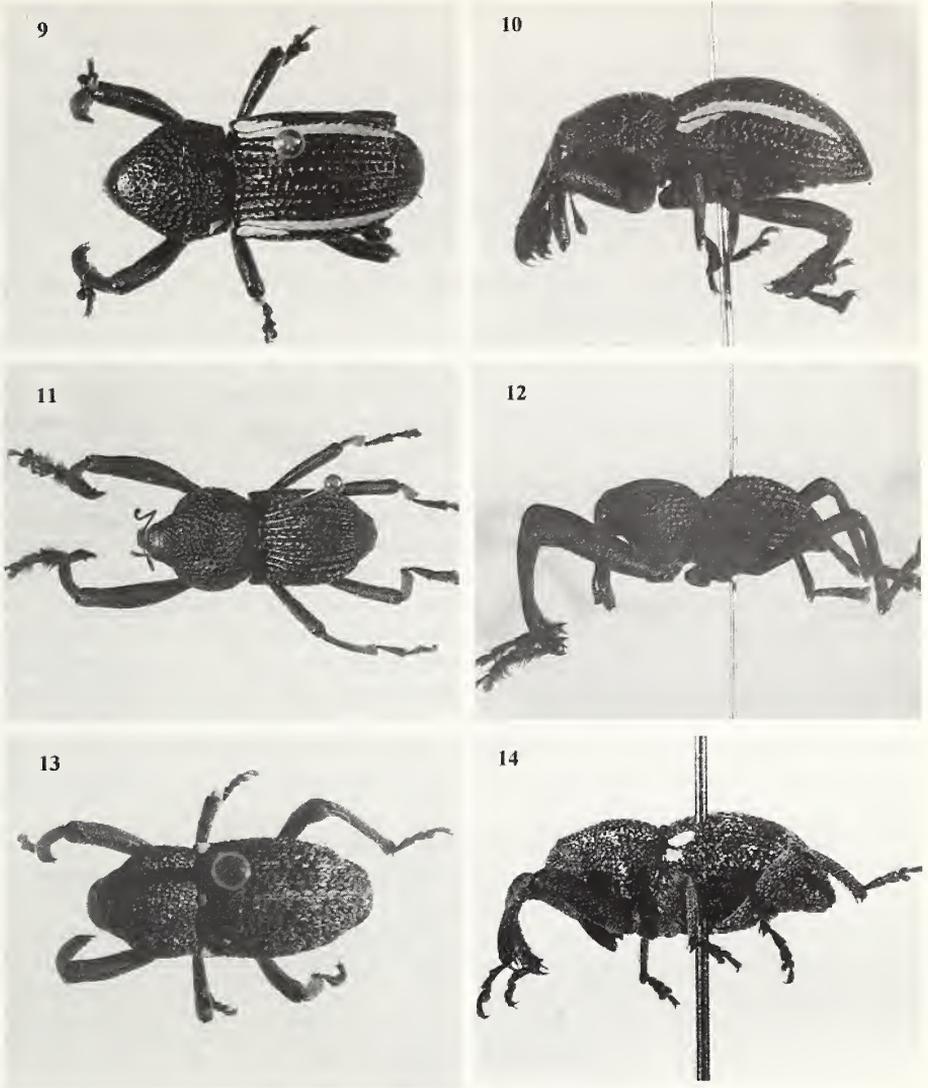
Distribution: The species of *Rhyephenes* occur in the Central Chilean and Subantarctic provinces of the Andean subregion of southern South America (Figs. 50–53).

KEY TO SPECIES OF *RHYEPHENES*

1. Elytra with 2–3 humeral stripes of white scales (Figs. 1, 3, 7, 9, 13) 2
 Elytra lacking humeral stripes of white scales (Figs. 5, 11) 6
2. Prothorax strongly globose, protuberant (Fig. 7); elytra with tubercles on intervals more developed than those on striae *R. humeralis* (Figs. 7–8)
 Prothorax slightly globose; elytra with tubercles on intervals similar to those on striae 3
3. Elytra with basal area slightly impressed; aedeagus slender in lateral view (Figs. 24, 28) 4
 Elytra with basal area strongly impressed; aedeagus robust in lateral view (Figs. 16, 18) 5
4. Body clothed with scales (Fig. 13); male rostrum lacking tubercles; female rostrum with broad, abundant punctures; prothorax wider than elytra, and with small, shallow punctures; elytra with subconical tubercles and two short humeral stripes (Fig. 13)
 *R. squamiger* (Figs. 13–14)
 Body lacking scales (Fig. 9); male rostrum with tubercles; female rostrum with fine, sparse punctures; prothorax as wide as elytra, and with large, deep punctures; elytra



Figs. 1-8. *Rhyephenes* spp., habitus. 1, 3, 5, 7, dorsal view; 2, 4, 6, 8, lateral view. 1, 2, *R. clathratus*; 3, 4, *R. gayi*; 5, 6, *R. goureaui*; 7, 8, *R. humeralis*.



Figs. 9–14. *Rhyephenes* spp., habitus. 9, 11, 13, dorsal view; 10, 12, 14, lateral view. 9, 10, *R. lateralis*; 11, 12, *R. maillei*; 13, 14, *R. squamiger*.

- with rounded tubercles and two short and one longer humeral stripes (Fig. 9)
 *R. lateralis* (Figs. 9–10)
- 5. Prothorax as wide as elytra and with anterior impression; elytra with tubercles partially fused; female rostrum with fine, less abundant punctures *R. clathratus* (Figs. 1–2)
- Prothorax wider than elytra and lacking anterior impression; elytra with tubercles clearly separated; female rostrum with broad, abundant punctures *R. gayi* (Figs. 3–4)
- 6. Prothorax wider than elytra and lacking anterior impression; elytra with basal area

strongly impressed, and subconical tubercles; aedeagus slender in lateral view; male rostrum with tubercles *R. maillei* (Figs. 11-12)
 Prothorax as wide as elytra and with anterior impression; elytra with basal area slightly impressed, and rounded tubercles; aedeagus robust in lateral view; male rostrum lacking tubercles *R. goureaui* (Figs. 5-6)

Rhyephenes clathratus R. Philippi, 1859
 (Figs. 1, 2, 15, 16, 29, 36, 43, 50)

Rhyephenes clathratus R. Philippi, 1859:666; Fairmaire, 1860:251 (= *R. goureaui*); F. Philippi, 1899:84 (reinstated).

Rhyephenes clathratus was considered a synonym of *R. goureaui* by Fairmaire (1860). According to this analysis, they are sister taxa; the latter is distinguished by the elytra lacking the humeral stripes of white scales and by characters of the female genitalia.

Redescription: Habitus (Figs. 1, 2). Body clothed with scales. Prothorax slightly globose, as wide as elytra; disc with anterior impression, and large and deep punctures. Elytra with basal area strongly impressed; with rounded tubercles; tubercles on intervals small, similar to those on striae, and partially fused to them; humeri with three short stripes of white scales. *Male.* Rostrum with tubercles at sides. Aedeagus (Figs. 15, 16) robust in lateral view; ostiolar sclerites rounded; parameres long, narrow. *Female.* Rostrum with fine punctures. Sternum 8 (Fig. 29) with plate as long as wide, and sides lacking setae; arms broad. Hemisternite (Fig. 36). Spermatheca (Fig. 43) with nodulus and ramus developed. *Length* 7.8-13.7 mm.

Type material: Lectotype male (here designated: [LECTOTYPE/*Rhyephenes clathratus*/R. Philippi] [*Rhyephenes clathratus*/R. Phil./det. G. Kuschel/1990] (MHNS).

Other material examined: CHILE. Without more precise data: 23 (1 AMNH, 3 BMNH, 19 MHNS). Cautín: Cautín, L. E. Peña, 1 (CWOB). Curicó: La Montaña, 8-IX-1970, A. Eglitis, 3 (MHNS). Limarí: Las Trancas, 12-I-1978, D. Jackson, 1 (MHNS). Malleco: Malleco, XII-1986, G. Pérez de Arce, 1 (MHNS). Talca: Constitución, pino insigne, 25-IX-1970, E. Holsten, 2 (MHNS); Los Cipreses, 1,000 m, 14-I-1968, L. E. Peña, 2 (MHNS).

Rhyephenes gayi (Guérin, 1830)
 (Figs. 3, 4, 17, 18, 30, 37, 44, 50)

Tylodes gayi Guérin, 1830:125.

Rhyephenes cacicus Gyllenhal, 1837:315.

Rhyephenes gayi; Schoenherr, 1844:402 (= *R. cacicus*); Lacordaire, 1866:108 (reinstated).

This species occurs abundantly in central Chile. It is identified by the acute ostiolar sclerite of the aedeagus.

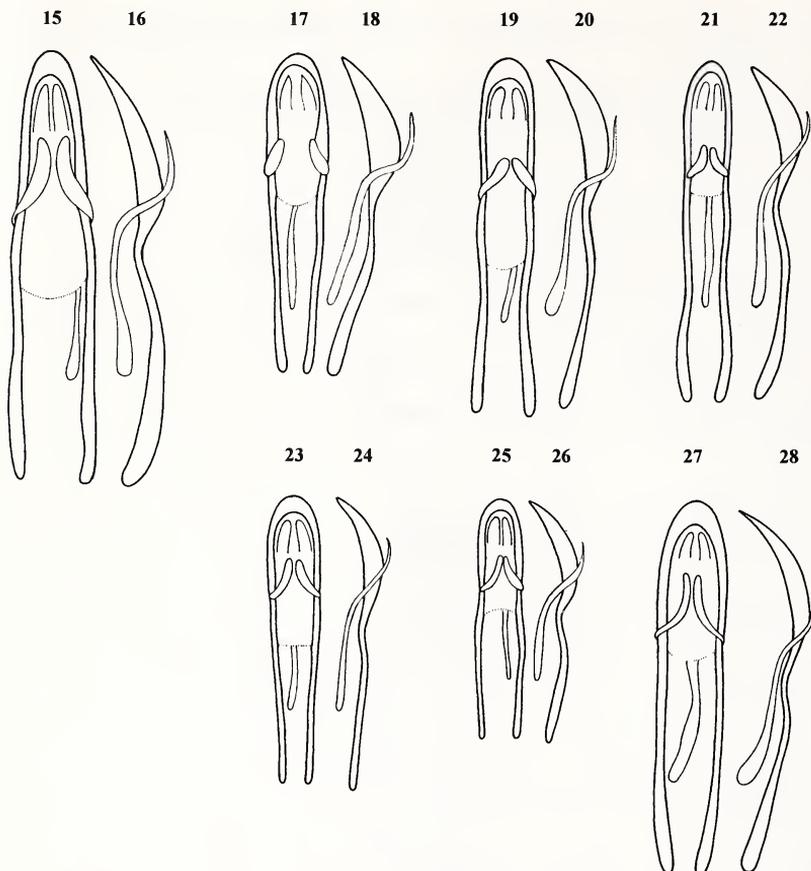
Redescription: Habitus (Figs. 3, 4). Body clothed with scales. Prothorax slightly globose, wider than elytra; disc lacking anterior impression, and large and deep punctures. Elytra with basal area strongly impressed; with rounded tubercles; tuber-

Table 2. Known plant associations of the species of *Rhyephenes* (plant families and species arranged alphabetically).

–Asteraceae	
<i>Ambrosia</i> sp.	<i>R. gayi</i>
<i>Bahia ambrosioides</i>	<i>R. squamiger</i>
<i>Baccharis concava</i>	<i>R. squamiger</i>
<i>Baccharis rhomboidalis</i>	<i>R. squamiger</i>
<i>Baccharis</i> sp.	<i>R. gayi</i> and <i>R. humeralis</i>
–Berberidaceae	
<i>Berberis rotundifolia</i>	<i>R. humeralis</i>
–Boraginaceae	
<i>Heliotropium stenophyllum</i>	<i>R. squamiger</i>
–Bromeliaceae	
<i>Puya chilensis</i>	<i>R. squamiger</i>
–Celastraceae	
<i>Maytenus boaria</i>	<i>R. maillei</i>
–Fabaceae	
<i>Adesmia microphylla</i>	<i>R. gayi</i>
<i>Anarthrophyllum</i> sp.	<i>R. gayi</i>
<i>Lupinus</i> sp.	<i>R. humeralis</i>
<i>Senna cummingii</i>	<i>R. gayi</i>
<i>Senna multiglandulosa</i>	<i>R. squamiger</i>
<i>Senna</i> sp.	<i>R. gayi</i>
–Juglandaceae	
<i>Juglans regia</i>	<i>R. humeralis</i>
–Lauraceae	
<i>Persea americana</i>	<i>R. squamiger</i>
–Nothofagaceae	
<i>Nothofagus antarctica</i>	<i>R. maillei</i>
<i>N. dombeyi</i>	<i>R. humeralis</i> and <i>R. maillei</i>
<i>N. nitida</i>	<i>R. maillei</i>
<i>N. pumilio</i>	<i>R. maillei</i>
<i>Nothofagus</i> sp.	<i>R. humeralis</i> and <i>R. maillei</i>
–Pinaceae	
<i>Pinus radiata</i>	<i>R. clathratus</i> , <i>R. humeralis</i> , and <i>R. maillei</i>
–Rosaceae	
<i>Prunus persica</i>	<i>R. humeralis</i>
<i>Quillaja saponaria</i>	<i>R. maillei</i>

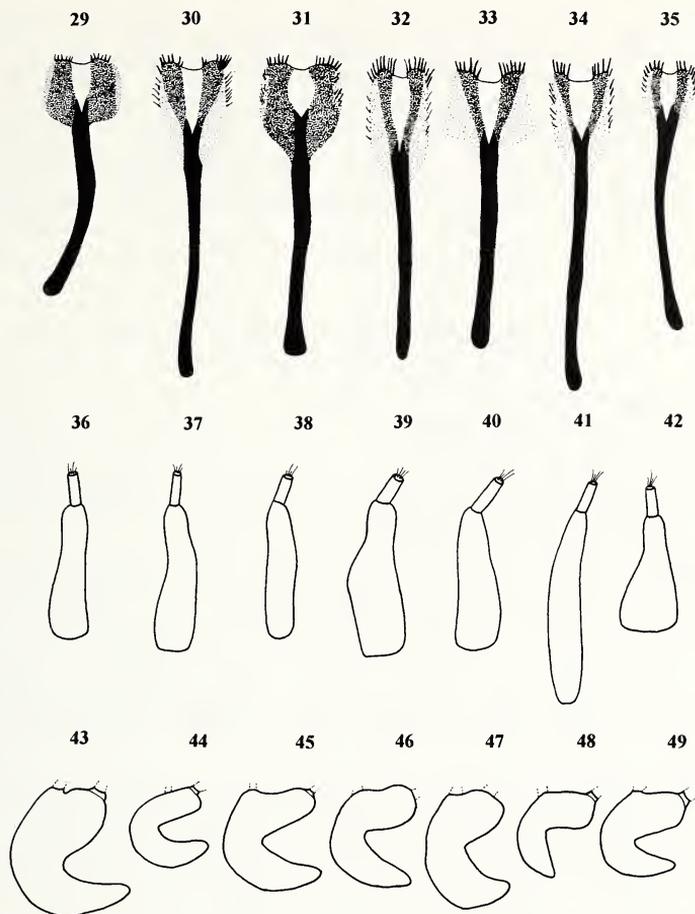
cles on intervals small, similar to those on striae, and clearly separated from them; humeri with three short stripes of white scales. *Male*. Rostrum with tubercles at sides. Aedeagus (Figs. 17, 18) robust in lateral view; ostiolar sclerites acute; parameres short, broad. *Female*. Rostrum with broad, abundant punctures. Sternum 8 (Fig. 30) with plate longer than wide, and sides with setae; arms narrow. Hemisternite (Fig. 37). Spermatheca (Fig. 44) with nodulus developed and ramus not developed. Length 7.5–15.5 mm.

Material examined: CHILE. Without more precise data: 102 (9 AMNH, 4 BMNH, 89 MHNS). Bío-Bío: Fundo María Ester, 15 km W Victoria, 14-I-1989, M. Ramírez,



Figs. 15-28. *Rhyephenes* spp., aedeagus. 15, 17, 19, 21, 23, 25, 27, dorsal view; 16, 18, 20, 22, 24, 26, 28, lateral view. 15, 16, *R. clathratus*; 17, 18, *R. gayi*; 19, 20, *R. goureaui*; 21, 22, *R. humeralis*; 23, 24, *R. lateralis*; 25, 26, *R. maillei*; 27, 28, *R. squamiger*.

2 (MACN). Cachapoal: Termas de Cauquenes, 11-I-1953, 2 (MHNS). Cauquenes: Fundo El Roble, Colhueco, E Chillán, XII-1965, 24 (AMNH); Pelluhue, 31-VII-1985, F Silva, 5 (MHNS), 18/20-IX-1985, F Silva, 1 (MHNS). Cautín: Cherquenco, 1954, 1 (MHNS). Chacabuco: Caleu, ex *Salix vitiminalis*, 10-III-1990, M. Elgueta, 1 (MHNS). Chiloé: Aucar, 6/15-I-1952, L. E. Peña, 2 (MHNS), 15-I-1952, L. E. Peña, 20 (MHNS). Choapa: Cerro La Silla del Gobernador, 31-X-1988. E. Maury, 1 (MLP); km 272 Panam. Norte, ex *Senna cummingii* var. *coquimbensis*, 14-V-1985, M. Elgueta, 4 (MHNS), 23-I-1986, M. Elgueta, 1 (MHNS), ex *Adesmia microphylla*, 11-III-1986, M. Elgueta, 1 (MHNS); Quilimari, 13-IX-1972, 1 (MHNS). Colchagua: Valle del Nilahue, 1-II-1915, 2 (MHNS). Concepción: Concepción, 26/28-XII-1926, F. & M. Edwards, 1 (BMNH), 20-III-1952, 1 (MHNS). Cordillera: El Alfalfal, 23-II-1967, V. Pérez, 4 (MHNS), 25-I-1968; J. Moroni, 3 (MHNS). Curicó: El Coigal, XI-1955, L. E. Peña, 5 (CWOB). Elqui: La Marquesa, 350 m, A. Aguilera coll.,



Figs. 29–49. *Rhyephenes* spp., female genitalia. 29–35, sternum 8, ventral view; 36–42, hemisternite, ventral view; 43–49, spermatheca. 29, 36, 43, *R. clathratus*; 30, 37, 44, *R. gayi*; 31, 38, 45, *R. goureaui*; 32, 39, 46, *R. humeralis*; 33, 40, 47, *R. lateralis*; 34, 41, 48, *R. maillei*; 35, 42, 49, *R. squamiger*.

VIII-1973, 4 (MHNS); Pta. Lengua de Vaca, 31-VII-1971, L. E. Peña, 1 (MHNS). Los Andes: Estero Leiva, X-1953, 5 (MHNS); Río Blanco, 30-XII-1917, 2 (MHNS). Malleco: Angol, 8-IX-1949, Cerda, 6 (MHNS), 18-III-1953, 1 (MHNS); Curacautín, 13-III-1952, 2 (MHNS). Melipilla: Cuesta de Barriga, 7-I-1952, 1 (MHNS); El Canelo, 30-XI-1970, G. Barria, 1 (MHNS). Petorca: Quebrada del Chivato, 30-X-1988, E. Maury, 1 (MLP); Quebrada del Talanquén, 9-XII-1984, H. Niemeyer, 3 (MHNS); Quebrada El Tigre, 8-X-1988, E. Maury, 5 (MLP). Quillota: Palmas de Ocoá, 27-X-1988, E. Maury, 1 (MLP); Quebrada Escobares, 22-II-1964, J. Solervicens, 3 (MHNS); Quillota, M. Fritz, 1 (MACN). San Felipe de Aconcagua: La Ollita, Cantillana, 2000 m, 18-XII-1969, L. E. Peña, 1 (MHNS). Santiago: Farellones, 2500

m, 4-XII-1969, J. Valencia, 1 (CWOB), 26-III-1971, J. Valencia, 2 (MHNS); Oasis, II-1966, R. Pérez, 17 (MHNS); Piche Alhue, 1800 m, 18-XII-1969, L. E. Peña, 3 (MHNS); San Cristóbal, 14-XII-1966, R. Pérez, 1 (MHNS); San José de Maipo, 17-II-1970, L. Alfaro, 1 (MHNS). Talagante: Talagante, 7-IX-1970, M. Elgueta, 4 (MHNS). Talca: Vilches Alto, Cord. de Talca, I-1990, Arce, 5 (MHNS). Valdivia: La Unión, Cocule, 6-III-1952, 2 (MHNS). Valparaíso: Marga Marga, 26-IV-1983, A. Mann, 2 (MHNS), 3 (BMNH); Quillota, sobre níspero, 1 (MHNS); Quintero, "bajo *Ambrosia*", 29-VIII-1981, 1 (MHNS); Valparaíso, XII-1925, A. Faz, 3 (BMNH).

Rhyephenes goureaui (Gay and Solier, 1839)

(Figs. 5, 6, 19, 20, 31, 38, 45, 51)

Physothorus goureaui Gay and Solier, 1839:26.

Rhyephenes goureaui; Solier, 1839:L.

This species could be confused with *R. maillei*, the other species lacking humeral stripes in the elytra; the latter has the prothorax wider than the elytra, and the elytral tubercles on intervals more developed than those on striae.

Redescription: Habitus (Figs. 5, 6). Body clothed with scales. Prothorax slightly globose, as wide as elytra; disc with anterior impression, and large and deep punctures. Elytra with basal area strongly impressed; with rounded tubercles; tubercles on intervals small, similar to those on striae, and partially fused to them; humeri lacking stripes of white scales. *Male*. Rostrum lacking tubercles. Aedeagus (Figs. 19, 20) robust in lateral view; ostiolar sclerites rounded; parameres short, broad. *Female*. Rostrum with broad, abundant punctures. Sternum 8 (Fig. 31) with plate as long as wide, and sides with setae; arms broad. Hemisternite (Fig. 38). Spermatheca (Fig. 45) with nodulus developed and ramus not developed. *Length* 8.0–15.2 mm.

Material examined: ARGENTINA. Chubut: El Maitén, 28-XII-1958, A. Kovacs, 14 (AMNH). Neuquén: Catán-Lil, 25-II-1963, 1 (IADIZA); Lago Aluminé, 25-II-1964, 4 (IADIZA), 14-I-1993, G. Debandi, 1 (IADIZA); La Victoria, X-1963, 1 (IADIZA); without more precise data, 1 (MLP). CHILE. Without more precise data: 48 (1 AMNH, 2 MACN, 43 MHNS, 2 MLP). Arauco: P. N. Contulmo, 2-XI-1904, 1 (CWOB). Bío-Bío: Abanico, 19-I-1979, M. Elgueta, 1 (MHNS); San Carlos de Purén, 22-I-1973, 1 (MHNS). Cautín: Cherquenco, 1954, L. E. Peña, 3 (MHNS). Chiloé: Ancud, 10-IV-1914, 1 (AMNH), 19-XII-1926, F. & M. Edwards, 1 (BMNH); Pivehué, 16-II-1992, S. Roig-Juñent, 1 (IADIZA). Curicó: Potrero Grande, 23-X-1976, G. Arriagada, 1 (MHNS). Llanquihue: Puerto Montt, 3 (MLP). Malleco: Cordillera Lonquimay, Sierra Nevada, 2-II-1962, J. Valencia, 1 (CWOB); P. N. Nahuel Buta, 1260 m, 23-XII-1985, S. Roig-Juñent, 5 (IADIZA). Ñuble: Cabrería, 31-I-1977, F. Rodríguez, 1 (MHNS). Valdivia: Huellélhue, 24-I-1973, M. Elgueta, 1 (MHNS).

Rhyephenes humeralis (Guérin, 1830)

(Figs. 7, 8, 21, 22, 32, 39, 46, 52)

Tylodes humeralis Guérin, 1830:124.

Cryptorhynchus arachnodes Erichson, 1834:264.

Rhyephenes incas Gyllenhal, 1837:314.

Rhyephenes arachnodes; Gyllenhal, 1837:314 (= *R. incas*); Gemminger & Harold, 1871:2563 (= *R. humeralis*); Berg, 1899:154 (Luzón, erroneous type locality).

Physothorus boyeri Gay and Solier, 1839:27.

Rhyephenes boyeri; Solier, 1839:L (= *R. incas*); Lacordaire, 1866:108 (reinstated); Kuschel, 1955:287 (= *R. humeralis*).

Rhyephenes humeralis; Schoenherr, 1844:402 (= *R. incas*); Gemminger & Harold, 1871:2563 (reinstated).

Rhyephenes inca Lacordaire, 1866:108 (error noted by Berg, 1899:154).

Rhyephenes aequalis F. Philippi, 1899:90; Kuschel, 1993:64 (= *R. humeralis*).

This widespread species is variable in length. Its diagnostic strongly globose and protuberant prothorax can be less notable in some of the smaller specimens.

Redescription: Habitus (Figs. 7, 8). Body clothed with scales. Prothorax strongly globose, protuberant, wider than elytra; disc lacking anterior impression, and large and deep punctures. Elytra with basal area strongly impressed; with subconical tubercles; tubercles on intervals large, more developed than to those on striae, and partially fused to them; humeri with three short stripes of white scales. *Male*. Rostrum with tubercles on dorsum and sides. Aedeagus (Figs. 21, 22) robust in lateral view; ostiolar sclerites rounded; parameres short, broad. *Female*. Rostrum with fine punctures. Sternum 8 (Fig. 32) with plate longer than wide, and sides with setae; arms narrow. Hemisternite (Fig. 39). Spermatheca (Fig. 46) with nodulus and ramus not developed. Length 5.5–6.7 mm.

Type material: Lectotype male (here designated): [LECTOTYPE/*Rhyephenes/aequalis*/F. Philippi] [= *Rhyephenes/humeralis*/(Guérin)/ det. G. Kuschel/1990] (MHNS).

Other material examined: ARGENTINA. Without more precise data: 10 (9 BMNH, 1 MACN). Mendoza: without more precise data, C. Bruch, 1 (MLP). Neuquén: without more precise data, 1 (MLP). Río Negro: Bariloche, 16/18-XI-1926, F. & M. Edwards, 4 (BMNH). CHILE. Aisén: Puerto Cisnes, II-1961, L. E. Peña, 6 (BMNH). Arauco: Arauco, 16-XII-1985, S. Roig-Juñent, 2 (IADIZA), Baier, 5 (MACN); Temuco, I-1975, S. Roig-Juñent, 2 (IADIZA), 2 (MLP). Bío-Bío: Pemuhue, at night, 1-II-1968, L. & C. W. O'Brien, 6 (CWOB), 20-I-1993, G. Debandi, 1 (IADIZA). Cachapoal: Molloa, XI-1967, 1 (CWOB); Rengo, II-1991, 4 (MLP). Cardenal Caro: Rosario, 23-II-1967, J. Numhauser, 2 (BMNH). Cautín: without more precise data, L. E. Peña, 5 (CWOB). Chacabuco: Caleu, ex *Salix vitiminalis*, 10-III-1990, M. Elgueta, 1 (MHNS). Chiloé: 25 km S Castro, V-1968, L. & C. W. O'Brien, 1 (CWOB); 9 km E Chepu, 4-II-1968, L. & C. W. O'Brien, 2 (CWOB). Choapa: 1 km S Huentelauquén, C. W. & L. O'Brien, 1 (CWOB); Los Vilos, 18-IX-1969, A. Tobar, 13 (CWOB); Palo Colorado, N Quilimarí, 27-X-1991, M. Elgueta, 2 (MHNS). Coihaique: Coihaique, 8-III-1972, A. Tobar, 2 (CWOB). Concepción: Concepción, 25-VIII-1968, J. Apablaza & C. W. O'Brien, 2 (CWOB), 21-III-1970, E. Holsten, 1 (MHNS), E. Reed, 1 (BMNH); 40 km E Concepción, 25-VIII-1968, J. Apablaza & C. W. O'Brien, 1 (CWOB). Cordillera: San José de Maipo, I-1969, R. Dulovitch, 1 (MLP). Curicó: El Coigo, cordillera Curicó, X-1964, 7 (AMNH), X-1974, 8 (AMNH); El Coiquel, XI-1955, L. E. Peña, 8 (CWOB); Quebrada Mala, 32 Km E Molina, 2-XI-1991, M. Elgueta, 1 (MHNS). Linares: 3 km SE Agua de

La Gloria, 4-XI-1967, 5 (CWOB); 13 km SE Agua de la Gloria, 4-XI-1967, L. & C. W. O'Brien, 4 (CWOB), 24-VIII-1968, L. & C. W. O'Brien, 1 (CWOB); La Pasarela, 28 km de Linares, I-1984, S. Roig-Juñent, 2 (IADIZA); La Vega, 6 km S Parral, 8-XI-1991, M. Elgueta, 1 (MHNS); Panamavida, 20-X-1968, D. Correa, 2 (CWOB); Romehual, cordillera Parral, 5/10-XI-1960, L. E. Peña, 1 (IPCN). Los Andes: Los Andes, 22-V-1979, Gordon, 2 (CWOB); Río Blanco, 25-I-1974, L. E. Peña, 2 (MHNS). Malleco: Angol, 3-IX-1927, E. Reed, 1 (AMNH), 22-IV-1946, 2 (AMNH), 12-X-1946, S. Pérez, 2 (AMNH), 20-VII-1947, W. Mason, 2 (CWOB); 6 km W Angol, at night, 2-XI-1967, 5 (CWOB); cordillera Lonquimay, 4-I-1962, 1 (CWOB); P. N. Nahuel Buta, 38 km W Angol, 4,300', 12-II-1968, L. & C. W. O'Brien, 1 (CWOB); Pichinahuel, Cordillera Nahuel Buta, 1/10-I-1959, L. E. Peña, 1 (BMNH). Ñuble: Fundo Las Cruces, Cordillera Parral, V-1958, L. E. Peña, 6 (BMNH), 12/14-XII-1960, L. E. Peña, 1 (BMNH); Las Trancas, 8 km W Termas de Chillán, 1300 m, 15-XI-1981, R. T. Schuh & N. I. Platnick, 1 (AMNH); 15 km SE Recinto, at night, 1-XI-1967, L. & C. W. O'Brien, 3 (CWOB). Petorca: Cachagua, 19-IX-1971, M. Elgueta, 1 (MHNS); 7 km NE Papudo, 8-VIII-1968, L. & C. W. O'Brien, 2 (CWOB); 13 km S Quinquimo, 12-XI-1967, L. & C. W. O'Brien, 1 (CWOB); 10 km SE Zapallar, 11-II-1967, L. & C. W. O'Brien, 15 (CWOB), 23-IX-1967, C. W. O'Brien, 1 (CWOB). Quillota: Limache, Cerro de la Cruz, 1975, S. Roig-Juñent, 1 (IADIZA); Cerro Macaya, 18-XI-1962, A. Tobar, 1 (CWOB); 19 km E Manzanar, 3-XI-1967, L. & C. W. O'Brien, 1 (CWOB). San Antonio: antes de Los Queñes, 15-I-1984, S. Roig-Juñent, 2 (IADIZA). San Felipe de Aconcagua: 15 km SE Llay-Llay, 18-IX-1967, L. & C. W. O'Brien, 3 (CWOB). Santiago: 15 km E Arrayán, at night, C. W. O'Brien, 2 (CWOB); Cerro Robles, 100', at night, 24-XII-1968, L. & C. W. O'Brien, 6 (CWOB), 6300', 24-XII-1967, L. & C. W. O'Brien, 1 (CWOB); Curacaví, 14-X-1967, L. & C. W. O'Brien, 1 (CWOB), 23-XI-1967, C. W. O'Brien, 1 (CWOB); El Canelo, 5-X-1963, J. Valencia, 2 (CWOB), 19-X-1963, J. Valencia, 4 (CWOB), 2-XI-1963, J. Valencia, 1 (CWOB), 23-III-1968, D. Correa, 2 (CWOB); El Manzano, 23-XII-1967, D. Correa, 4 (CWOB), 6-III-1968, D. Correa, 1 (CWOB), 4-X-1970, 1 (MHNS); 2 km E El Manzano, 1-II-1969, D. Correa, 1 (CWOB); El Salto, 20-XII-1967, D. Correa, 1 (CWOB); Farellones, 8,600', under dung, 25-XII-1968, L. & C. W. O'Brien, 7 (CWOB), 2500 m, 4-XII-1969, J. Valencia, 2 (CWOB); La Reina, 10/15-XI-1967, J. Barros, 1 (CWOB), 6-XII-1967, C. Reyes, 1 (CWOB); Las Condes, 6-III-1938, 4 (BMNH); Las Cruces, 3-III-1974, E. Arriagada, 10 (CWOB); 5 km S Melipilla, at night, 16-IX-1967, L. & C. W. O'Brien, 7 (CWOB); 11 km S Melipilla, 300', at night, 16-IX-1967, J. Apablaza & C. W. O'Brien, 5 (CWOB); 8 km W Padre Hurtado, 3-IX-1967, L. & C. W. O'Brien, 2 (CWOB); 15 km W Padre Hurtado, at night, 6-IX-1969, L. & C. W. O'Brien, 4 (CWOB); P. N. La Campana, 14-III-1985, C. Vivan, 1 (MHNS); Rocas Sto. Domingo, on lupine, 23-XI-1968, L. & C. W. O'Brien, 103 (CWOB); 4 km W Rungue, 6-IX-1968, L. & C. W. O'Brien, 1 (CWOB). Talagante: Naltagua, 10-II-1981, J. E. Barriga, 7 (MLP). Talca: Altos de Vilches, 30-X-1969, J. Rozen & L. E. Peña, 2 (AMNH), 27-XII-1969, J. Valencia, 2 (CWOB), 10-X-1970, A. Tobar, 4 (CWOB), 13-X-1970, A. Tobar, 1 (CWOB), 1280 m, 10/11-XI-1971, J. Valencia, 3 (CWOB), 1200 m, 5/7-X-1972, Coscarón, Peña & Wygodzinsky, 7 (AMNH); Constitución, 22-V-1969, E. Holsten, 3 (AMNH), 13-V-1970, E. Holsten, 2 (MHNS); 7 km W

Molina, I-1968, C. W. O'Brien, 10 (CWOB), 20-I-1968, D. Correa, 1 (CWOB), 1-II-1968, D. Correa, 30 (CWOB), 25-II-1968, on *Salix* trunk, D. Correa, 6 (CWOB), 26-XII-1968, D. Correa, 6 (CWOB); Valle Empedrado, 6-X-1970, E. Holsten, 1 (AMNH); Vilches Alto, 14-XII-1973, 2 (MHNS), 21-XII-1973, 1 (MHNS). Valdivia: Valdivia, D. Sharp, 2 (BMNH). Valparaíso: Algarrobo, on *Baccharis*, 24-XI-1968, L. & C. W. O'Brien, 1 (CWOB), IX-1969, 1 (MHNS); 15 km NW Casablanca, 1000', at night, 9-IX-1967, L. & C. W. O'Brien, 1 (CWOB); El Bato, E Illapel, 25-X-1991, M. Elgueta, 4 (MHNS); El Bato, a farm east of Illapel, 19-X-1966, 1 (AMNH); La Canela, 29-X-1991, M. Elgueta, 1 (MHNS); Valparaíso, 1903, Crawford expedition, 1 (BMNH), Walker, 1 (BMNH), E. Reed, 2 (AMNH), 3 (BMNH); 19 km SE Villa Alemana, 1,000', at night, IX-1967, L. & C. W. O'Brien, 3 (CWOB); Viña del Mar, 17-III-1938, 1 (BMNH); 13 km S Viña del Mar, 650', 3-IX-1967, J. Barros, 1 (CWOB). Without more precise data: Araucanía, R. M. Middleton, 13 (BMNH); A. Tobar, 6 (CWOB); Reed, 3 (BMNH); C. Darwin, 1 (BMNH); 116 (2 AMNH, 19 BMNH, 21 MACN, 70 MHNS, 4 MLP).

Rhyephenes lateralis (Guérin, 1830)

(Figs. 9, 10, 23, 24, 33, 40, 47, 52)

Tylodes lateralis Guérin, 1830:126.

Rhyephenes lateralis; Schoenherr, 1844:404.

This rather scarce species is easily recognized by the two short and one longer elytral humeral stripes.

Redescription: Habitus (Figs. 9, 10). Body clothed with scales. Prothorax slightly globose, as wide as elytra, wider than elytra; disc lacking anterior impression, and large and deep punctures. Elytra with basal area slightly impressed; with rounded tubercles; tubercles on intervals small, similar to those on striae, and partially fused to them; humeri with three stripes of white scales, two short and one longer. *Male*. Rostrum with tubercles on dorsum and sides. Aedeagus (Figs. 23, 24) slender in lateral view; ostiolar sclerites rounded; parameres long, narrow. *Female*. Rostrum with fine, sparse punctures. Sternum 8 (Fig. 33) with plate as long as wide, and sides lacking setae; arms narrow. Hemisternite (Fig. 40). Spermatheca (Fig. 47) with nodulus and ramus not developed. *Length* 9.1–13.2 mm.

Material examined: CHILE. Without more precise data: 3 (MHNS). Ñuble: Cobquecura, 13-I-1967, P. Ramírez, 1 (CWOB); Quirihue, I-1979, C. Vidal, 3 (MHNS). Talca: Alto Vilches, 14-III-1971, L. E. Peña, 2 (MHNS), 2-XI-1973, 1 (MHNS), 21-XII-1973, 2 (MHNS); Constitución: 27-II-1948, 2 (MHNS), 25-IX-1970, E. Holsten, 5 (AMNH). Valdivia: Panguipulli, 14-II-1966, 1 (MHNS).

Rhyephenes maillei (Gay and Solier, 1839)

(Figs. 11, 12, 25, 26, 34, 41, 48, 53)

Physothorus maillei Gay and Solier, 1839:24.

Physothorus laevirostris Gay and Solier, 1839:25 (probably synonym of *P. maillei*).

Rhyephenes maillei; Solier, 1839:L; Angulo, 1970:313 (larva).

Rhyephenes laevirostris; Solier, 1839:L; Lacordaire, 1866:108 (not synonym of *R. maillei*); Berg, 1899:153 (= *R. maillei*); F. Philippi, 1899:82 (= *R. maillei*); Hustache, 1936:235 (reinstated); Morrone, 1994:95 (= *R. maillei*).

Rhyephenes immaculatus Blanchard, 1853:251, pl. 14, Fig. 16 (= *R. laevirostris*); Berg, 1899:153 (= *R. maillei*); Hustache, 1936:235 (= *R. laevirostris*); Morrone, 1994:95 (= *R. maillei*).

Rhyephenes sulcatus F. Philippi, 1899:86; Morrone, 1994:95 (= *R. maillei*).

Rhyephenes philippii Fiedler, 1942:279; Kuschel, 1950:18 (= *R. sulcatus*); Morrone, 1994:95 (= *R. maillei*).

This widespread species is variable in length. The names *R. laevirostris*, *R. immaculatus*, *R. sulcatus*, and *R. philippii* have been applied to variants of this species.

Redescription: Habitus (Figs. 11, 12). Body clothed with scales. Prothorax slightly globose, wider than elytra; disc lacking anterior impression, and large and deep punctures. Elytra with basal area strongly impressed; with subconical tubercles; tubercles on intervals large, more developed than to those on striae; humeri lacking stripes of white scales. *Male*. Rostrum with tubercles on dorsum and sides. Aedeagus (Figs. 25, 26) slender in lateral view; ostiolar sclerites rounded; parameres long, narrow. *Female*. Rostrum with fine punctures. Sternum 8 (Fig. 34) with plate longer than wide, and sides with setae; arms narrow. Hemisternite (Fig. 41). Spermatheca (Fig. 48) with nodulus developed and ramus not developed. Length 6.3–15.4 mm.

Type material: Lectotype male (here designated): [LECTOTYPE/*Rhyephenes/sulcatus*/F. Philippi] [*Rhyephenes/maillei*/variant Gay & Solier/det. G. Kuschel/1990] (MHNS).

Other material examined: ARGENTINA. Chubut: El Hoyo, 5-V-1959, A. Kovacs, 4 (BMNH), 18-X-1960, A. Kovacs, 1 (BMNH); Lago Verde, 560 m, 4-II-1983, M. & P. Gentili, 1 (IPCN); Río Correntoso, 1 (MACN); without more precise data, 2 (MLP). Mendoza: without more precise data, 1 (AMNH). Neuquén: Aluminé, 25-II-1964, 1 (IADIZA), II-1977, O. de Ferraris, 3 (IPCN), 8-I-1991, G. Debandi, 2 (IADIZA); Chapelco, 7-III-1964, 2 (IADIZA), 1,700 m, 15-III-1964, M. Gentili, 3 (IPCN), 1750 m, XII-1965, M. Gentili, 1 (IPCN), 1400 m, 30-III-1982, M. Gentili, 1 (IPCN); Copahue, 1,925 m, 18-XII-1963, M. Gentili, 1 (IPCN), 2000 m, 3-II-1987, M. Gentili, 1 (IPCN); Huiliches, 13-XII-1991, G. Debandi, 1 (IADIZA); Kilca, 4-I-1972, 1 (IPCN); Lago Hermoso, XII-1949, M. Barrera, 3 (MACN); Lago Lácar, 23 km W San Martín de los Andes, 25-I-1972, L. Herman, 1 (CWOB); Lago Lácar, Nonthue, 640 m, 17-XI-1992, M. Gentili, 2 (IPCN); Lago Queñi, 875 m, M. Gentili, 1 (IPCN); Lago Tromen, 1,000 m, 15-XII-1962, M. Gentili, 1 (IPCN); Pucará, 1949, S. Schajovskoi, 2 (MACN), 23-XI-1957, M. Gentili, 1 (IPCN), 21-XII-1965, L. Grosso, 3 (MLP), 6-II-1972, L. Herman, 1 (CWOB); Río Aluminé, 16-XII-1965, M. Gentili, 1 (IPCN); road between Pucará and Lago Venado, 24/25-I-1972, L. Herman, 2 (CWOB); San Martín de los Andes, 4-III-1942, M. Birabén, 1 (MLP), 17-III-1964, 1 (IADIZA), 9-XII-1976, O. de Ferraris, 1 (IPCN), 1000 m, 2-XI-1986, M. & P. Gentili, 1 (IPCN), 640 m, M. Gentili, 5 (IPCN), 10-XI-1991, G. Debandi, 2 (IADIZA); valle del Río Limay, II-1947, J. Navas, 3 (MLP); without more precise data, 28 (24 MACN, 4 MLP). Río Negro: Bariloche, 25/28-X-1926, F. & M. Edwards, 2 (BMNH), II-1938, Birabén & Scott, 1 (MLP), I-1942, Rossi, 3 (MACN), 26-XI-1963, A. Kovacs, 1 (AMNH), Richter, 5 (MLP); El Bolsón, 20-IX-1956, A. Kovacs, 2 (BMNH), 12-VII-1958, A. Kovacs, 1 (BMNH), 25-XII-1958, A. Kovacs, 16 (BMNH), 18-XII-1959, A. Kovacs, 1 (BMNH), 22-XII-1959, A. Kovacs, 1 (BMNH), 29-XI-1959, A. Kovacs, 1 (BMNH), 5-X-1960, A. Kovacs, 6 (BMNH), 18-I-1961,

1 (BMNH), 10-VIII-1961, A. Kovacs, 1 (BMNH), 20-X-1961, 2 (BMNH), 1-XII-1961, A. Kovacs, 4 (BMNH), 9-XII-1962, A. Kovacs, 1 (BMNH), 22-XII-1962, A. Kovacs, 1 (BMNH), 16-I-1963, A. Kovacs, 1 (BMNH), 19-I-1965, A. Kovacs, 11 (AMNH); isla Victoria, 15-XI-1969, 1 (MACN), 2-XII-1969, 1 (MACN); isla Victoria, IV-1958, 2 (IADIZA); Ñorquinco, 10-II-1964, A. Kovacs, 1 (AMNH); P. N. Los Alerces, S. Roig-Juñent, 1 (IADIZA); Pto. Radal, isla Victoria, 1 (MACN). Santa Cruz: Lago Argentino, 1959, P. W. James, 3 (BMNH), 16/27-II-1974, C. Bordón, 1 (CWOB); valle del Lago Blanco, 1903, 2 (BMNH); Valle Túnel, 3 (MLP). Tierra del Fuego: Without more precise data, 1900, C. Bruch, 6 (MACN). Without more precise data: Patagonia, 69 (MLP); 1935, 5 (BMNH), I-1972, L. Herman, 1 (CWOB). CHILE. Without more precise data: 50 (5 AMNH, 12 BMNH, 5 MACN, 26 MHNS, 2 MLP). Aisén: Lago J. A. Ríos, Taitao, 8-XII-1956, C. Riffart, 1 (MHNS); Pto. Aisén, 12-III-1943, R. Maldonado, 39 (MLP), 21-I-1968, L. & C. W. O'Brien, 1 (CWOB); Taitao, Base no. 5, 5-XII-1956, C. Bittart, 2 (MHNS); without more precise data, II-1934, 1 (MHNS). Arauco: Arauco, 24-III-1969, G. Billings, 7 (MHNS); Cañete, 24-III-1969, R. Billings, 6 (MHNS), pino insigne, 12-V-1969, D. Edelman, 1 (AMNH); Caramávida, 31-XII-1957, L. E. Peña, 1 (MHNS), 18-X-1969, G. Barría, 1 (MHNS), 16-XII-1985, S. Roig-Juñent, 2 (IADIZA); Curanilahue, 1-IV-1970, D. Edelman, 1 (AMNH); isla Mocha, XI-1982, Bullock, 3 (MHNS); P. N. Contulmo, 19-X-1969, G. Barría, 1 (MHNS), 15-XII-1985, S. Roig-Juñent, 5 (IADIZA); without more precise data, Baier, 1 (MACN). Bío-Bío: Mulchén, 16-II-1969, F. Rojas, 1 (MHNS). Capitán Pratt: Dos Lagunas, night, 13-I-1968, C. W. & L. O'Brien, 1 (CWOB), under wood, 14-I-1968, C. W. & L. O'Brien, 5 (CWOB). Cautín: río Cautín, L. E. Peña, 2 (CWOB); 50 km S Temuco, 11-XII-1984, S. Roig-Juñent, 1 (IADIZA); Villarica, 3-II-1968, B. Heineman, 1 (AMNH). Chiloé: Aucar, 18-I-1952, L. E. Peña, 7 (MHNS), 6-V-1952, L. E. Peña, 2 (MHNS); 9 km N Castro, 7-II-1968, L. & C. W. O'Brien, 1 (CWOB); 14 km E Chepu, 4-II-1968, L. & C. W. O'Brien, 3 (CWOB); Dalcahue, 18-I-1962, R. Usinger, 1 (CWOB); 20 km N Pichue, on [*Nothofagus*] *nitida*, 16-XI-1992, S. Roig-Juñent, 1 (IADIZA); 6 km N Quellón, 6-II-1968, L. & C. W. O'Brien, 1 (CWOB); 21 km N Quellón, 6-II-1968, L. & C. W. O'Brien, 1 (CWOB); without more precise data, C. Darwin, 1 (BMNH). Coihaique: Coihaique, I-1934, 9 (MHNS); 17 km SE Coihaique, 20-I-1968, L. & C. W. O'Brien, 4 (CWOB); 56 km SE Coihaique, 20-I-1968, L. & C. W. O'Brien, 1 (CWOB); 64 km SE Coihaique, 20-I-1968, L. & C. W. O'Brien, 12 (CWOB); 7 km W Coihaique, at night, 21-I-1968, L. & C. W. O'Brien, 1 (CWOB); 33 km W Coihaique, 23-I-1968, L. & C. W. O'Brien, 4 (CWOB). Coichagua: 10 km S San Fernando, 12-XI-1967, J. Undurraga, 1 (CWOB). Concepción: Concepción, 21-III-1969, E. Holstem, 1 (AMNH). Llanquihue: El Manso, 22-I-1959, A. Kovacs, 13 (BMNH), 1-IV-1960, A. Kovacs, 52 (BMNH); Frutillar Bajo, II-1965, G. Silva, 2 (MHNS); Pto. Varas, M. Richter, 2 (MACN). Magallanes: Cabo Negro, 28-XII-1975, Pérez, 6 (MHNS); cordillera Lonquimay, Sierra Nevada, 2-I-1962, J. Valencia, 1 (CWOB), 4-I-1962, 1 (CWOB); Dawson island, 1916, 1 (BMNH); El Canelo, 15-III-1969, L. E. Peña, 3 (MHNS); Estancia Canelo, 17-I-1968, L. & C. W. O'Brien, 12 (CWOB); 26 km E Estancia Canelo, on and under *Nothofagus*, 17-I-1968, L. & C. W. O'Brien, 37 (CWOB); isla Navarino, 1935, J. Bird, 1 (AMNH); Laguna Amarga, 10-I-1968, C. W. & L. O'Brien, 1 (CWOB); Magallanes, 2-IV-1953, T. Cekalovic, 1 (MHNS); Punta Arenas, Walker, 2 (BMNH); 3 km W Punta Arenas, at night, 16-I-1968, L. &

C. W. O'Brien, 1 (CWOB). Malleco: Icalma, II-1989, 1 (MHNS); Pailahueque, X-1962, M. Fritz, 3 (MACN); P. N. Nahuel Buta, 1200 m, 23-XII-1985, S. Roig-Juñent, 3 (IADIZA), 20-I-1993, G. Debandi, 2 (IADIZA), 21-I-1993, G. Debandi, 1 (IADIZA); P. N. Tolhuaca, 13-I-1993, G. Debandi, 2 (IADIZA); Pichinahuel, Nahuelbuta, 1200 m, 14-II-1956, L. E. Peña, 1 (CWOB). Osorno: Antillanca, 3,700', *Nothofagus pumilio*, 10-II-1968, C. W. O'Brien, 1 (CWOB); 18 km NW Antillanca, 1,800', at night, 9-II-1968, L. & C. W. O'Brien, 3 (CWOB); Bahía Mansa, 26-IX-1968, C. Calderón, 3 (MHNS); Osorno, I-1975, S. Roig-Juñent, 9 (IADIZA), XII-1984, S. Roig-Juñent, 1 (MACN); 51 km E Osorno, Lago Puyehue, 800', 9-II-1968, L. & C. W. O'Brien, 8 (CWOB); P. N. Puyehue, II-1992, S. Roig-Juñent, 1 (IADIZA); P. N. Puyehue, Agua Caliente, XII-1984, S. Roig-Juñent, 1 (IADIZA); Pucatrihue, coastal town, 3/21-III-1967, 2 (AMNH); Purránque, IX-1985, J. E. Barriga, 1 (MHNS). Santiago: Lago Arrayán, 20-XII-1968, C. Barrientos, 1 (CWOB). Talagante: Maipo, 7-XI-1968, J. Marshall, 1 (CWOB). Talca: Alto de Vilches, 10-X-1970, A. Tobar, 1 (CWOB). Tierra del Fuego: forest S of Bahía Inútil (Useless Bay), XII-1904, R. Crawshay, 1 (BMNH); río McKlelland, XI/XII-1904, R. Crawshay, 1 (BMNH). Ultima Esperanza: Cancha Carreras, 24-I-1988, J. J. Morrone, 1 (MLP); Cerro Guido, *Nothofagus*, 10-I-1968, C. W. & L. O'Brien, 4 (CWOB); Cerro León, 19-I-1969, V. Pérez, 1 (MHNS); P. N. Torres del Paine, 25-I-1988, J. J. Morrone, 1 (MLP). Valdivia: Lanco, I-1980, 4 (MLP); La Unión, 10-III-1952, 1 (MHNS); Panguipuli, 14-II-1966, G. Ortega, 20 (CWOB), II-1984, L. E. Peña, 1 (CWOB); Pirehueico, 1-XII-1985, S. Roig-Juñent, 1 (IADIZA); Valdivia, 30-XII-1968, D. Correa, 1 (CWOB), 31-XII-1968, night, D. Correa, 9 (CWOB), 3-I-1969, D. Correa, 56 (CWOB), 29-XII-1986, E. Krammer, 2 (MHNS); 13 km SE Valdivia, 3-II-1968, L. & C. W. O'Brien, 1 (CWOB); 18 km N Valdivia, 4-I-1969, D. Correa, 11 (CWOB).

Rhyephenes squamiger F. Philippi, 1899, **reinstated name**

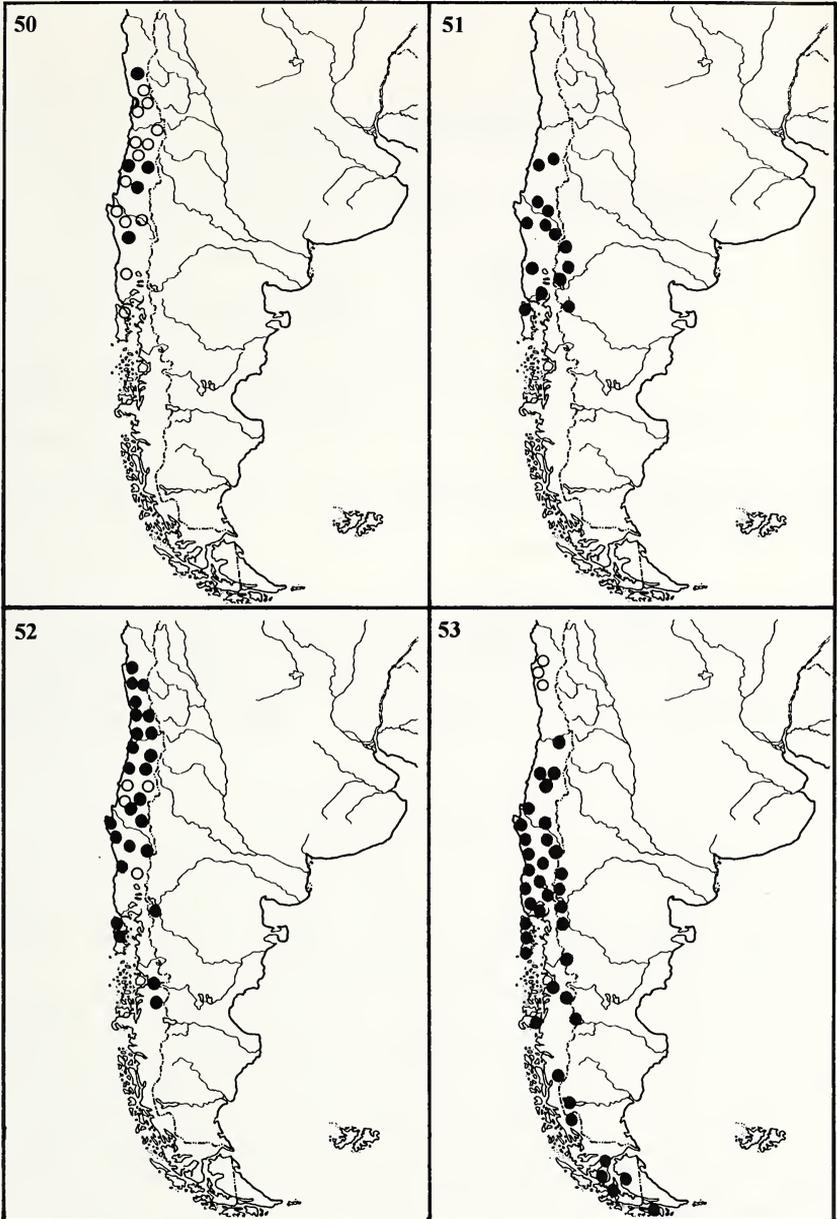
(Figs. 13, 14, 27, 28, 35, 42, 49, 53)

Rhyephenes squamiger F. Philippi, 1899:88; Kuschel, 1993:63 (= *R. gayi*).

This scarce species, easily recognized by its body clothed with scales, has a relictual distribution in central Chile. Kuschel (1993) incorrectly considers this species as a geographical race of *R. gayi*; however, the cladistic analysis indicates that they are two different (and unrelated) species.

Redescription: Habitus (Figs. 13, 14). Body lacking scales. Prothorax slightly globose, wider than elytra; disc lacking anterior impression, and small and shallow punctures. Elytra with basal area slightly impressed; with subconical tubercles; tubercles on intervals small, similar to those on striae, and partially fused to them; humeri with two short stripes of white scales. *Male.* Rostrum lacking tubercles. Aedeagus (Figs. 27, 28) slender in lateral view; ostiolar sclerites rounded; parameres long, narrow. *Female.* Rostrum with broad, abundant punctures. Sternum 8 (Fig. 35) with plate as long as wide, and sides with setae; arms narrow. Hemisternite (Fig. 42). Spermatheca (Fig. 49) with nodulus and ramus developed. *Length* 9.1–10.9 mm. **Type material:** Lectotype male (here designated): [883/a] [*squamiger*] [= *Rhyephenes/gayii* (Guérin)]/det. G. Kuschel/1990] [LECTOTYPE/*Rhyephenes/squamiger*/F. Philippi] (MHNS).

Other material examined: CHILE. Choapa: Los Vilos, "ex *Senna cummingi*",



Figs. 50–53. *Rhyephenes* spp., geographical distribution. 50, *R. clathratus* (black circles) and *R. gayi* (open circles); 51, *R. goureaui*; 52, *R. humeratis* (black circles) and *R. lateralis* (open circles); 53, *R. maillei* (black circles) and *R. squamiger* (open circles).

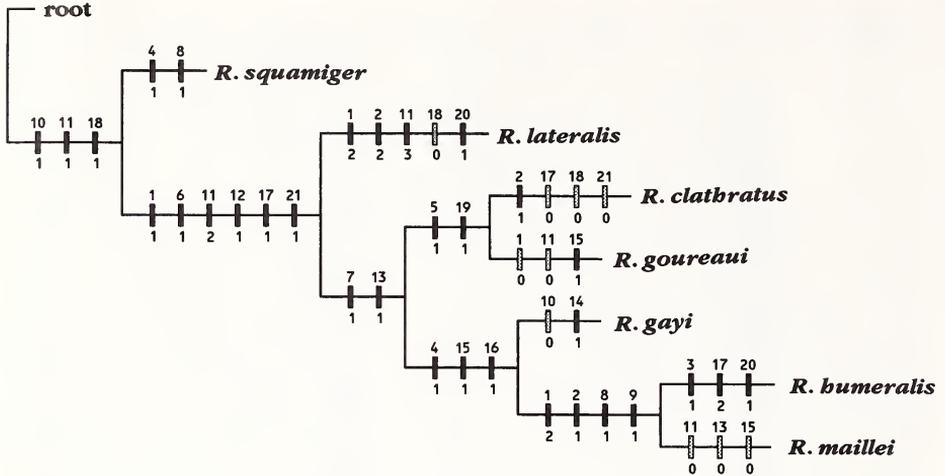


Fig. 54. Cladogram of the species of *Rhyephenes*. Black squares = synapomorphies; dotted squares = homoplasies.

II-1989, Barriga, 1 (MHNS); Nague, Los Vilos, 17-IX-1971, L. E. Peña, 1 (MHNS); km 27 Panamericana Norte, ex *Bahia ambrosioides*, 24-IX-1985, 1 (MHNS). Limarí: Fray Jorge, at night, 3-X-1967, L. & C. W. O'Brien, 1 (CWOB), 20-VI-1968, L. & C. W. O'Brien, 1 (CWOB), 21-VI-1968, L. & C. W. O'Brien, 2 (CWOB), 7-X-1975, C. Vidal, 1 (MHNS).

CLADISTICS AND BIOGEOGRAPHY

The analysis of the data matrix (Table 1) produced four cladograms (CI = 0.55, RI = 0.51, length 43 steps) under equal weights, which after successive weighting resulted in one cladogram (CI = 0.82, RI = 0.85, length 111 steps). In the cladogram (Fig. 54), the following phylogenetic sequence results: (*R. squamiger*, (*R. lateralis*, ((*R. clathratus*, *R. goureaui*), (*R. gayi*, (*R. humeralis*, *R. maillei*))))).

When the cladogram is compared with the distributional maps of the species of *Rhyephenes* (Figs. 50-53), basal species (*R. squamiger* and *R. lateralis*) appear to be endemic to central Chile, whereas the most apomorphic species are widespread in central and southern Chile (*R. gayi*) or extend also to southern Argentina (*R. humeralis* and *R. maillei*). Whether this pattern reflects a series of vicariant or dispersal events cannot be deduced directly from the cladogram sequence. Future comparisons with other plant and animal taxa distributed in the same areas will help to solve this problem.

ACKNOWLEDGMENTS

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CHECKLIST OF THE SPECIES IN THE SUBFAMILY STENOGASTRINAE (HYMENOPTERA: VESPIDAE)

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Abstract.—A checklist of the species in the subfamily Stenogastrinae is presented, including synonyms, nomenclatural changes, and distributional summaries. Forty-five species in seven genera are treated as valid, with an additional three subspecies. Excluding emendations, misspellings and *nomina nuda*, a further 16 names are treated as available synonyms, but eight of these names are listed only as questionable synonyms. A new combination is *Parischnogaster aurifrons* (Smith). Thirty new locality records are given.

The taxonomy of the hover wasps, Stenogastrinae, has not been well studied, compared to the other two social wasp subfamilies (Vespininae and Polistinae). Well corroborated taxonomic works would of course contribute greatly to the study of the biology of these wasps, which exhibit considerable divergence in social organization and nesting behavior (reviewed in Turillazzi, 1991). A checklist, which provides basic taxonomic information, such as the currently available species names, synonymy and type depositories, is helpful in perusing revisionary taxonomic works and catalogs.

The checklist presented here gives such information for the Stenogastrinae. It covers all the nomenclatural changes and provides also a summary of distributional data. The last attempt to list all of the Stenogastrinae was by von Schulthess (1927). Although useful, von Schulthess did overlook a few available names when compiling his list, and 26 taxa have since been described. This includes six genera. Five of these genera were described by the late J. van der Vecht (1969, 1972, 1977), who also described most of the species level taxa (1972, 1975, 1977). Van der Vecht was preparing taxonomic revisions of all the Stenogastrinae, but died before he published the revisions of *Eustenogaster*, *Liostenogaster* and *Parischnogaster*. The revisions van der Vecht began are now being carried on by C. K. Starr and S. Turillazzi, and a few descriptions have appeared (Turillazzi, 1988; Turillazzi and Carfi, 1996). In the meantime, over the course of his work van der Vecht distributed specimens labelled with no fewer than 24 manuscript names to various collections. One consequence of this was predictable: two of these names have been published as *nomina nuda* (Hansell, 1987; Carpenter, 1988; see below). Van der Vecht's unpublished notes also indicated a few synonymies that have still not appeared. These are listed below only as questionable synonyms, because we ourselves have not yet studied all of the relevant types. But two of these synonymies, if correct, entail the replacement of names currently in use (namely *Parischnogaster alternata* and *P. timida*). We are not taking the step of replacing these names, but are listing the putative senior

synonyms, in order to draw the attention of other scientists to the potential synonymy, and so encourage study of the possibility. Moreover, potential synonyms have been overlooked in regional works (Das and Gupta, 1984, 1989; Reyes, 1988), which are thus incomplete.

Another peculiarity of this piecemeal publication of the taxonomy for the subfamily is that most of the species were transferred from the two genera recognized by von Schulthess (1927) to the modern genera in publications devoted to other subjects. This includes the cladistic analysis by Carpenter (1982, 1988), and the book on the ethology of Hymenoptera written by Iwata. The combinations appeared in Iwata's book apparently because the wasps observed by Iwata were identified by van der Vecht. Although Iwata used these modern combinations in his original book written in Japanese (1971), the English translation published in 1976 is cited in the checklist because of the easier availability of the latter book, and because no nomenclatural changes were made for the species Iwata treated between 1971 and 1976 (except Krombein, 1976).

The arrangement of the checklist is alphabetical. The status given each taxon generally follows the most recent author to treat that taxon. Each name is followed by the original citation, followed by synonymies and generic changes, which are listed chronologically. The unpublished synonyms in van der Vecht's notes are listed with question marks preceding. Misspellings are indicated by exclamation points in brackets. Each publication is cited in abbreviated form. Where two dates are listed, the first is the true date of publication, so far as can be determined, with the date following in parentheses being the date printed on the publication. The original locality is quoted, and the type depository is then listed in parentheses, as the city containing the collection. Distributional data are summarized by country in the final paragraph for an taxon treated as valid. An asterisk denotes a new locality record.

Phylogenetic relationships among the genera are: *Liostenogaster* + ((*Eustenogaster* + *Stenogaster*) + (*Anischnogaster* + (*Metischnogaster* + *Parischnogaster*))) (Carpenter, 1988). Carpenter (1988) synonymized one of van der Vecht's (1977) genera, sinking *Holischnogaster* into *Parischnogaster*. The sole species included in *Holischnogaster*, *gracilipes*, is evidently the sister-group to *Parischnogaster*, but possesses no described autapomorphies.

SUBFAMILY STENOGASTRINAE BEQUAERT, 1918
(ISCHNOGASTERINAE ASHMEAD, 1902)

Genus *Anischnogaster* van der Vecht

Anischnogaster van der Vecht, 1972, Zool. Meded. 47:240, 241, genus.

Type species: *Ischnogaster iridipennis* Smith, 1859, by original designation.

dubia van der Vecht

Anischnogaster dubia van der Vecht, 1972, Zool. Meded. 47:242 (key), 247, figs. 24-36, female, male—"N.W. New Guinea . . . Araucaria Camp, 800 m" (holotype female Leiden); also from other localities in Irian Jaya.

Distribution: Indonesia: Irian Jaya.

iridipennis (Smith)

Ischnogaster iridipennis Smith, 1859, J. Proc. Linn. Soc., Zool. 3:166, male—"Aru" (lectotype Oxford).—Meade-Waldo, 1914, Ann. Mag. Nat. Hist. (8)14:405 (syn.: *Ischnogaster malayaensis* Cameron).—van der Vecht, 1972, Zool. Meded. 47:242 (designation of lectotype).

Ischnogaster malayaensis Cameron, 1906, Tijdschr. Ent. 49:231, female—"Etna Bay" (Amsterdam).—Meade-Waldo, 1914, Ann. Mag. Nat. Hist. (8)14:405 (syn. of *Ischnogaster iridipennis* Smith).

Ischnogaster coriaceus du Buysson, 1907, Notes Leyden Mus. 29:79, male—"Nouvelle Guinée" (Leiden).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):255 (in subgenus *Parischnogaster*).—van der Vecht, 1972, Zool. Meded. 47:243 (syn. of *Anischnogaster iridipennis* (Smith)).

Stenogaster iridipennis; von Schulthess, 1927, Suppl. Ent. 16:86, 87 (? or *Parischnogaster*).

Parischnogaster ? *coriaceus*; von Schulthess, 1927, Suppl. Ent. 16:87.

Parischnogaster ? *malayaensis*; von Schulthess, 1927, Suppl. Ent. 16:87.

Anischnogaster iridipennis; van der Vecht, 1972, Zool. Meded. 47:241, 242, figs. 1–13, 57, 58 (syms.: *Ischnogaster malayaensis* Cameron, *Ischnogaster coriaceus* du Buysson).

Distribution: Indonesia: Aru, Misool, Waigeo, Irian Jaya; Papua New Guinea.

laticeps van der Vecht

Anischnogaster laticeps van der Vecht, 1972, Zool. Meded. 47:242 (key), 249, figs. 37–46, 59, female, male—"North West New Guinea, Araucaria Camp, 800 m" (holotype female Leiden); also from other localities in New Guinea.

Distribution: Indonesia: Irian Jaya; Papua New Guinea.

loriai lorai (du Buysson)

Ischnogaster lorai du Buysson, 1909, Ann. Mus. Civ. Stor. Nat. Genova 44:313, male—"Nouvelle Guinée S. E. Moroka, 1,300 m" (Genova).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):254 (in subgenus *Ischnogaster*).

Parischnogaster ? *loriai*; von Schulthess, 1927, Suppl. Ent. 16:87.

Anischnogaster lorai lorai; van der Vecht, 1972, Zool. Meded. 47:242, 251, 253, figs. 47–56, pl. 1.

Distribution: Indonesia: Irian Jaya; Papua New Guinea.

loriai maculata van der Vecht

Anischnogaster loriai maculata van der Vecht, 1972, Zool. Meded. 47:253, female, male—"N. E. New Guinea . . . Mt. Kaindi, Nami Ck., 1700 m" (holotype male Honolulu); also from other localities in Irian Jaya.

Distribution: Indonesia: Irian Jaya.

spilaspis (Cameron)

Ischnogaster spilaspis Cameron, 1913, Bijdr. Dierk. 19:78, male—"Waigeu" (Amsterdam).

Anischnogaster spilaspis; van der Vecht, 1972, Zool. Meded. 47:242 (key), 246, figs. 14–23 (“The original description . . . no doubt . . . based on a male” “a female from ‘Waigeo, 31 Dec.’, labelled “*Ischnogaster spilaspis* Cam. type by Cameron is in Mus. Amsterdam”, but “It appears uncertain whether the true type [male] is still in existence”).

Distribution: Indonesia: Waigeo, Irian Jaya.

Genus *Eustenogaster* van der Vecht

Eustenogaster van der Vecht, 1969, in Yoshikawa *et al.*, Nature and Life in S. E. Asia 6:165, genus.

Type species: *Ischnogaster micans* de Saussure, 1852, by original designation.

Paravespa Bell, 1936, J. Bombay Nat. Hist. Soc. 38: Fig. 1, 803, 806, genus (2 species).

Type species: *Paravespa eva* Bell, 1936 [= *Stenogaster eximioides* Dover and Rao, 1922], by subsequent designation of van der Vecht and Carpenter, 1990, Zool. Verh., Leiden 260:44. Junior homonym of *Paravespa* Radoszkowski, 1886 (Vespidae: Eumeninae).

agilis (Smith)

Ischnogaster agilis Smith, 1860, J. Proc. Linn. Soc., Zool. 5, Suppl.: 89, male—“Makassar” (Oxford).

Stenogaster agilis; von Schulthess, 1927, Suppl. Ent. 16:85.

Eustenogaster agilis; Carpenter, 1988, J. New York Ent. Soc. 96:174.

Distribution: Indonesia: Sulawesi.

calyptodoma (Sakagami and Yoshikawa)

Stenogaster calyptodoma Sakagami and Yoshikawa, 1968, Annot. Zool. Japon. 41(2):77, figs. 1–2, 4, 6, female—“Kampong Astana near Kuching, Sarawak, Malaysian Borneo” (Hokkaido University, Sapporo).

Eustenogaster calyptodoma; Yoshikawa *et al.*, 1969, in Nature and Life in S. E. Asia 6:157.

Distribution: Malaysia: Peninsular Malaysia, Sarawak; Indonesia: Sumatra.

eximia eximia (Bingham)

Ischnogaster eximius Bingham, 1890, J. Bombay Nat. Hist. Soc. 5:244, male—“Ceylon” (London).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):256 (in subgenus *Ischnogaster*).

Ischnogaster eximia; von Dalla Torre, 1904, Genera Insect. 19:83 (cat.).

Stenogaster eximia; Dover and Rao, 1922, J. Asiat. Soc. Bengal (N. S.) 18: 241.—Dover, 1925 (1924), J. Asiat. Soc. Bengal (N. S.) 20:301 (syn.: *Stenogaster eximioides* Dover and Rao); 1931, J. Fed. Malay St. Mus. 16:256 (syn.: *Ischnogaster ornatifrons* Cameron).

Stenogaster eximius; von Schulthess, 1927, Suppl. Ent. 16:85.

Eustenogaster eximia; Iwata, 1976, Evol. Instruct. 275 (ethology).—Krombein, 1976, Loria 13(6):303.

Eustenogaster eximia eximia; Das and Gupta, 1984 (1983), Or. Ins. 17:401 (cat.).
Distribution: Sri Lanka; Thailand; Malaysia: Peninsular Malaysia.

eximia eximioides (Dover and Rao)

Stenogaster eximioides Dover and Rao, 1922, J. Proc. Asiat. Soc. Bengal (N. S.) 18:242, male—"Nadgani, Nilgiri Hills. 2,500 ft." (lectotype Calcutta).—Dover, 1925 (1924), J. Asiat. Soc. Bengal (N. S.) 20:301 (syn. of *Stenogaster eximia* (Bingham)).—Das and Gupta, 1989, Or. Ins. Monogr. 11:28 (designation of lectotype).

Paravespa eva Bell, 1936, J. Bombay Nat. Hist. Soc. 38:803, fig. 1, female, male—"N. Kanara District, Bombay" (London).—Das and Gupta, 1984 (1983), Or. Ins. 17:402 (syn. of *Eustenogaster eximia eximioides*).

Eustenogaster eximioides; Iwata, 1976, Evol. Instinct: 275 (ethology).

Eustenogaster eximia eximioides; Das and Gupta, 1984 (1983), Or. Ins. 17:402 (syn.: *Paravespa eva* Bell; cat.).

"*Ischnogaster eximia eximioides*"; van der Vecht and Carpenter, 1990, Zool. Verh., Leiden 260:44 (designation as type species of *Paravespa* Bell).

Distribution: India: Kerala, Tamil Nadu.

fraterna (Bingham)

Ischnogaster fraterna Bingham, 1897, Fauna Brit. India, Hym. 1:377 (key), 378, female, male—"Tenasserim" (London).

Stenogaster fraterna; Dover and Rao, 1922, J. Proc. Asiat. Soc. Bengal (N. S.) 18:240.—Dover, 1925 (1924), J. Asiat. Soc. Bengal (N. S.) 20:301 (syns.: *Ischnogaster scitula* Bingham, *Stenogaster scitula* var. *assamensis* Dover and Rao).

Eustenogaster fraterna; Iwata, 1976, Evol. Instinct: 275 (ethology).

Distribution: India: Assam, Sikkim; Myanmar; Malaysia: Peninsular Malaysia.

fulvipennis (Cameron)

Ischnogaster fulvipennis Cameron, 1902, J. Straits Branch R. Asiat. Soc. 37:106, female, male—"Mt. Penrissen, Sarawak" (London).—Dover, 1929, Bull. Raffles Mus. 2:45 (syn. of *Stenogaster micans* (de Saussure)).

? *Ischnogaster fuscipes* Cameron, 1903, J. Straits Branch R. Asiat. Soc. 39:171, sex not stated—"Klackang" (London).

Stenogaster fulvipennis; von Schulthess, 1927, Suppl. Ent. 16:86.

Eustenogaster fulvipennis; Carpenter, 1988, J. New York Ent. Soc. 96:175.

Distribution: Malaysia: Sarawak.

hauxwellii (Bingham)

Ischnogaster rufomaculata Bingham, 1894, J. Bombay Nat. Hist. Soc. 8:385, female—"Tenasserim (Salween Valley, Tavoy)" (London); 1897, Fauna Brit. India, Hym. 1:377, 379 (*rufomaculata*).—Das and Gupta, 1984 (1983), Or. Ins. 17:402 (syn. of *Eustenogaster hauxwellii* (Bingham), acting as first reviser).

Ischnogaster hauxwellii Bingham, 1894, J. Bombay Nat. Hist. Soc. 8(3):386, pl. 1 fig. 4, female, male—"Tenasserim (Ataran and Ye Valleys)" (London).

Ischnogaster hauxwelli [!]; von Dalla Torre, 1904, Gen. Ins. 19:84 (syn. of *Ischnogaster micans* de Saussure).

? *Stenogaster bicarinata* Dover and Rao, 1922, J. Proc. Asiat. Soc. Bengal (N. S.) 18:242, male—"Ten miles south of Kuching, Sarawak, Borneo" (Calcutta).

Stenogaster rufomaculata; Dover and Rao, 1922, J. Proc. Asiat. Soc. Bengal (N. S.) 18:241.

Stenogaster micans var. *hauxwelli* [!]; von Schulthess, 1927, Suppl. Ent. 16:85.

Stenogaster rufomaculatus; von Schulthess, 1927, Suppl. Ent. 16:86 (cat.).

Stenogaster nigromaculata [!]; Dover, 1931, J. Fed. Malay. St. Mus. 16:256.

Eustenogaster hauxwellii; Iwata, 1976, Evol. Instinct: 274.—Das and Gupta, 1984 (1983), Or. Ins. 17:402 (syn.: *Ischnogaster rufomaculata* Bingham, acting as first reviser; cat.; distr.).

Distribution: India: Sikkim; Myanmar; Thailand; Malaysia: Sarawak; Singapore; Indonesia: Java, Sumatra*, Bangka*, Kalimantan*; Philippines: Mindanao.

luzonensis (Rohwer)

Stenogaster micans var. *luzonensis* Rohwer, 1919, Bull. Hawaii. Sugar Pltrs. Assoc. Exp. Stat. (Ent. Ser.) 14(1):3a, 16, male, female—"Mt. Makiling, Luzon, P. I." (holotype female Washington).

Stenogaster micans var. *luzonicus* [!]; von Schulthess, 1927, Suppl. Ent. 16:85.

Eustenogaster luzonensis; Carpenter, 1988, J. New York Ent. Soc. 96:175.

Distribution: Philippines: Luzon.

micans (de Saussure)

Ischnogaster micans de Saussure, 1852, Ann. Soc. Ent. France (2)10:24, female—"Java" (Leiden).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):254 (in subgenus *Ischnogaster*).

? *Ischnogaster ornatifrons* Cameron, 1902, J. Straits Branch R. Asiat. Soc. 37: 105, female—"Santubong, Kuching, Sarawak" (London).—Meade-Waldo, 1914, Ann. Mag. Nat. Hist. (8)14:463 (in subgenus *Parischnogaster*).

Stenogaster micans; von Schulthess, 1927, Suppl. Ent. 16:81, 85.—Dover, 1929, Bull. Raffles Mus. 2:45 (syn.: *Ischnogaster fulvipennis* Cameron).

Stenogaster ornatifrons; von Schulthess, 1927, Suppl. Ent. 16:86.

Eustenogaster micans; van der Vecht, 1969, in Yoshikawa *et al.*, Nature and Life in S. E. Asia 6:165.

Holischnogaster micans; Lee, 1982, Hornets Agric. Regions China: 133 [probable error or misidentification].

Distribution: Myanmar; Thailand; Malaysia: Peninsular Malaysia*, Sarawak; Singapore; Indonesia: Java, Sumatra*, Bangka*.

palavanica Reyes

Eustenogaster palavanica Reyes, 1988, Philipp. Ent. 7(4):387, 392 (key), figs. 25–29, female, male—"Irawan River, 2000 ft, Mt. Beaufort, Palawan" (holotype male Honolulu); also from other localities in Palawan.

Distribution: Philippines: Palawan.

scitula (Bingham)

Ischnogaster scitula Bingham, 1897, Fauna Brit. India, Hym. 1:377 (key), 379, female—"Rangit Valley, Sikhim; Margherita, Assam" (London).—Dover, 1925 (1924), J. Asiat. Soc. Bengal (N. S.) 20:301 (syn. of *Stenogaster fraterna* (Bingham)).

Stenogaster scitula; Dover and Rao, 1922, J. Proc. Asiat. Soc. Bengal (N. S.) 18:240.

Stenogaster scitula var. *assamensis* Dover and Rao, 1922, J. Proc. Asiat. Soc. Bengal (N. S.) 18:240, male—"Margherita, Assam" (Calcutta).—Dover, 1925 (1924), J. Asiat. Soc. Bengal (N. S.) 20:301 (syn. of *Stenogaster scitula* (Bingham)).

Stenogaster seitula [!]; Lee, 1982, Hornets Agric. Regions China: 130.

Eustenogaster scitula; Das and Gupta, 1984 (1983), Or. Ins. 17:402 (syn.: *Stenogaster scitula* var. *assamensis* Dover and Rao).

Distribution: India: Assam, Meghalaya, Sikkim; Myanmar; Malaysia.

Genus *Liostenogaster* van der Vecht

Liostenogaster van der Vecht, 1969, in Yoshikawa *et al.*, Nature and Life in S. E. Asia 6: 165, genus.

Type species: *Ischnogaster nitidipennis* de Saussure, 1853, by original designation.

flaviplagiata (Cameron)

Ischnogaster flaviplagiatus Cameron, 1902, J. Straits Branch R. Asiat. Soc. 37: 104, female—"Kuching, Sarawak" (London).

Parischnogaster flavoplagiatus [!]; von Schulthess, 1927, Suppl. Ent. 16:87.

Stenogaster flavoplagiata [!]; Dover, 1931, J. Fed. Malay. St. Mus. 16:256 (syn. of *Stenogaster nitidipennis* (de Saussure)).

Liostenogaster flaviplagiata; Turillazzi and Carfi, 1996, Trop. Zool. 9(1):19.

Distribution: Thailand; Malaysia: Sarawak; Indonesia: Sumatra.

flavolineata (Cameron)

Ischnogaster flavolineata Cameron, 1902, J. Straits Branch R. Asiat. Soc. 37:108, female—"Lingga, Sarawak" (London).—Meade-Waldo, 1914, Ann. Mag. Nat. Hist. (8)14:463 (in subgenus *Parischnogaster*).

Ischnogaster butteli von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):255, 257, Figs. F, J–L, male, female (in subgenus *Parischnogaster*)—"Malacca, Taiping Hills, . . . Maxwell's Hill, Taiping" (Berlin).—Meade-Waldo, 1914, Ann. Mag. Nat. Hist. (8)14:463 (in subgenus *Parischnogaster*; "This species is distinct from *I. flavolineata* Cam.").—Dover, 1931, J. Fed. Malay. St. Mus. 16:256 (syn. of *Stenogaster flavolineata* (Cameron)).

Parischnogaster butteli; von Schulthess, 1927, Suppl. Ent. 16:86.

Parischnogaster flavolineatus; von Schulthess, 1927, Suppl. Ent. 16:87 (distr.).

Stenogaster flavolineata; Dover, 1929, Bull. Raffles Mus. 2:45.

Liostenogaster flavolineata; Carpenter, 1988, J. New York Ent. Soc. 96:174.

Distribution: Malaysia: Peninsular Malaysia, Sarawak; Singapore*; Indonesia: Sumatra.

lunata Carpenter

Liostenogaster lunata Carpenter, 1982, Syst. Ent. 7:34. *Nomen nudum*.

nitidipennis (de Saussure)

Ischnogaster nitidipennis de Saussure, 1853, Ét. Fam. Vesp. 2:10, male—"Selon l'étiquette, Cayenne!?? mais il est évident à mes yeux que cet insecte ne peut venir que de Java, de la Nouvelle-Guinée, ou de la Polynésie" (Paris).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):255 (in subgenus *Parischnogaster*).

Parischnogaster nitidipennis; von Schulthess, 1927, Suppl. Ent. 16:88.

Stenogaster nitidipennis; Dover, 1929, Bull. Raffles Mus. 2:46; 1931, J. Fed. Malay. St. Mus. 16:256 (syn.: *Stenogaster flavoplagiata* [!]) (Cameron)).

Liostenogaster nitidipennis; Iwata, 1976, Evol. Instinct: 275 (ethology).

Distribution: Myanmar; Thailand; Malaysia: Peninsular Malaysia, Sabah*; Singapore; Indonesia: Java, Kalimantan, Sumatra*; Philippines: Luzon, Palawan.

pardii Turillazzi and Carfi

Liostenogaster pardii Turillazzi and Carfi, 1996, Trop. Zool. 9(1):19, 20, figs. 1-22, male, female, nest—"Malaysian Peninsula. Genting Sempah, Genting Tea Estate (elev. 610 m), Pahang State" (holotype male Firenze); also from Selangor and Sarawak.

Distribution: Malaysia: Peninsular Malaysia, Sarawak.

picta (Smith)

Ischnogaster pictus Smith, 1860, J. Proc. Linn. Soc., Zool. 5, Suppl.: 89, female—"Makassar" (Oxford).

Ischnogaster picta; von Dalla Torre, 1894, Cat. Hym. 9:113 (cat.).

Stenogaster pictus; von Schulthess, 1927, Suppl. Ent. 16:86.

Liostenogaster picta; Turillazzi and Carfi, 1996, Trop. Zool. 9(1):19.

Distribution: Indonesia: Sulawesi.

varipicta (Rohwer)

Stenogaster varipictus Rohwer, 1919, Bull. Hawaii. Sugar Pltrs. Assoc. Exp. Stat. (Ent. Ser.) 14(1):3a, 15, female—"Los Baños, Luzon, P. I." (Washington).

Parischnogaster ? *varipictus*; von Schulthess, 1927, Suppl. Ent. 16:88.

Liostenogaster varipicta; Carpenter, 1981 (1982), Syst. Ent. 7:34.

Liostenogaster variapicta [!]; Reyes, 1988, Philipp. Ent. 7(4):396.

Distribution: Thailand*; Malaysia: Peninsular Malaysia, Sabah*; Singapore; Indonesia: Sumatra*, Kalimantan; Philippines: Palawan, Visayas, Mindanao, Luzon.

vechti Turillazzi

Liostenogaster arcuata Hansell, 1987, Oxford Surv. Evol. Biol. 4:167. *Nomen nudum*.

Liostenogaster vechti Turillazzi, 1988, *Tropic. Zool.* 1:193, 194, figs. 1–20, female, male—"Bukit Fraser (Fraser Hill), Jeriau Waterfall (910 m a.s.l.), Pahang State" (holotype male Firenze); also from other localities in Malaysia.

Distribution: Malaysia: Peninsular Malaysia; Indonesia: Sumatra.

Genus *Metischnogaster* van der Vecht

Metischnogaster van der Vecht, 1977, *Tijdschr. Ent.* 120:59, 60, genus.

Type species: *Ischnogaster cilipennis* Smith, 1857, by original designation.

cilipennis (Smith)

Ischnogaster cilipennis Smith, 1857, *Cat. Hym. Brit. Mus.*, Hym. 5:92, male—"Malacca (Mount Ophir)" (lectotype London).—du Buysson, 1909, *Ann. Mus. Civ. Stor. Nat. Genova* 44:312 (syn.: *Ischnogaster drewseni* (de Saussure)).—von Schulthess, 1914, *Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere)* 37(3):255 (in subgenus *Parischnogaster*).—van der Vecht, 1977, *Tijdschr. Ent.* 120:64 (designation of lectotype).

Parischnogaster cilipennis; von Schulthess, 1927, *Suppl. Ent.* 16:87 (syn.: *Ischnogaster drewseni* de Saussure).

Stenogaster cilipennis; Dover, 1931, *J. Fed. Malay St. Mus.* 16:256 (distr.).

Metischnogaster cilipennis; van der Vecht, 1977, *Tijdschr. Ent.* 120:63, 64.

Distribution: Malaysia: Peninsular Malaysia, Sarawak; Indonesia: Sumatra, Kalimantan.

drewseni (de Saussure)

Ischnogaster drewseni de Saussure, 1857, *Ann. Soc. Ent. France* (3)5:315, male—"Poulo-Pinang, île de l'Archipel Indien" (Genève).—du Buysson, 1909, *Ann. Mus. Civ. Stor. Nat. Genova* 44:312 (syn. of *Ischnogaster cilipennis* Smith).—von Schulthess, 1927, *Suppl. Ent.* 16:87 (syn. of *Parischnogaster cilipennis* (Smith)).

Ischnogaster drewsenii [!]; von Dalla Torre, 1894, *Cat. Hym.* 9:113 (cat.).

Stenogaster drewseni; Pagden, 1962, *Malay. Nat. J.* 16:95 (ethology).

Metischnogaster drewseni; van der Vecht, 1977, *Tijdschr. Ent.* 120:64 (key), 69.

Distribution: Malaysia: Peninsular Malaysia, Sarawak; Singapore; Indonesia: Sumatra, Belitung, Java, Kalimantan; Philippines: Palawan.

Genus *Parischnogaster* von Schulthess

Parischnogaster von Schulthess, 1914, *Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere)* 37:255, subgenus of *Ischnogaster* Guérin.

Type species: *Ischnogaster mellyi* de Saussure, 1852, by original designation.

Holischnogaster van der Vecht, 1977, *Tijdschr. Ent.* 120:60, 70, genus.

Type species: *Holischnogaster gracilipes* van der Vecht, 1977, by original designation and monotypy.

alternata Sakagami

? *Stenogaster sarawakensis* Dover and Rao, 1922, *J. Proc. Asiat. Soc. Bengal (N. S.)* 18:240, female—"10 miles south of Kuching, Sarawak, Borneo" (Calcutta).

Parischnogaster alternata Sakagami, 1969, in Yoshikawa *et al.*, Nature and Life in S. E. Asia 6:155, female, male—"Fraser's Hill, Malaya" (holotype male Hokkaido University, Sapporo); also from another locality in Peninsular Malaysia.

Parischnogaster alternate [!]; Kojima, 1990, Japan. J. Ent. 58(3):517.

Distribution: Thailand*; Malaysia: Peninsular Malaysia, Sabah, Sarawak; Singapore*; Indonesia*: Sumatra.

aurifrons (Smith), NEW COMBINATION

Ischnogaster aurifrons Smith, 1862, J. Proc. Linn. Soc., Zool. 6:58, female—"Celebes (Tondano)" (Oxford).

Stenogaster aurifrons; von Schulthess, 1927, Suppl. Ent. 16:85, 86 (? or *Parischnogaster*).

Distribution: Indonesia: Sulawesi.

depressigaster (Rohwer)

Stenogaster depressigaster Rohwer, 1919, Bull. Hawaii. Sugar Pltrs. Assoc. Exp. Stat. (Ent. Ser.) 14(1):3a, 16, male—"Los Baños, Luzon, P. I." (Washington).

Parischnogaster ? *äpressigaster* [!]; von Schulthess, 1927, Suppl. Ent. 16:87.

Parischnogaster depressigaster; Iwata, 1967, Nature Life S. E. Asia 5:260 (ethology).

Distribution: Philippines: Luzon.

gracilipes (van der Vecht)

Holischnogaster gracilipes van der Vecht, 1977, Tijdschr. Ent. 120:73, figs. 38-49, female, male—"Borneo: Sabah . . . Mt. Kinabalu, 5,000 ft" (Venezia); also from other localities in Borneo and Sumatra.

Parischnogaster gracilipes; Carpenter, 1988, J. New York Ent. Soc. 96:175.

Distribution: Malaysia: Sabah, Sarawak; Indonesia: Sumatra.

jacobsoni (du Buysson)

Ischnogaster jacobsoni du Buysson, 1913, Bull. Mus. Hist. Nat. Paris 7:436, male—"Java, Noesa Kambangan" (Paris).

Parischnogaster jacobsoni; von Schulthess, 1927, Suppl. Ent. 16:81, 87.

Distribution: Malaysia: Peninsular Malaysia, Sabah; Indonesia: Sumatra, Java, Bangka*, Kalimantan*.

mellyi (de Saussure)

Ischnogaster mellyi de Saussure, 1852, Ann. Soc. Ent. France (2)10:25, pl. 2, fig. 1, male—"Java" (male Genève).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):256 (in subgenus *Parischnogaster*).

Ischnogaster nigrifrons Smith, 1857, J. Proc. Linn. Soc., Zool.: 113, female—"Borneo (Sarawak)" (Oxford).—Das and Gupta, 1984 (1983), Or. Ins. 17:401 (syn. of *Parischnogaster mellyi* (de Saussure)).

Stenogaster nigrifrons; Dover and Rao, 1922, J. Proc. Asiat. Soc. Bengal (N. S.)

18:241.—Dover, 1929, Bull. Raffles Mus. 2:45; 1931, J. Fed. Malay St. Mus. 16:255 (syns.: *Ischnogaster nigricans* Cameron, *Ischnogaster serrei* du Buysson).

Parischnogaster mellyi; von Schulthess, 1927, Suppl. Ent. 16:82, 87.—Das and Gupta, 1984 (1983), Or. Ins. 17:401 (syn.: *Ischnogaster nigrifrons* Smith).

Parischnogaster nigrifrons; von Schulthess, 1927, Suppl. Ent. 16:83, 87.

Stenogaster mellyi; Pagden, 1962, Malay. Nat. J. 16:95.

Distribution: India: Assam, Meghalaya, Sikkim; Myanmar; Vietnam; Thailand; Malaysia: Peninsular Malaysia, Sabah; Singapore; Indonesia: Sumatra, Java, Kalimantan, Bangka*; Philippines: Mindanao.

nigricans nigricans (Cameron)

Ischnogaster nigricans Cameron, 1902, J. Straits Branch R. Asiat. Soc. 37:105, female—"Kuching, Sarawak" (London).—Meade-Waldo, 1914, Ann. Mag. Nat. Hist. (8)14:463 (in subgenus *Parischnogaster*).—Dover, 1931, J. Fed. Malay St. Mus. 16:255 (syn. of *Stenogaster nigrifrons* (Smith)).

Parischnogaster nigricans; von Schulthess, 1927, Suppl. Ent. 16:87.

Distribution: Malaysia: Peninsular Malaysia, Sarawak; Singapore*; Indonesia: Sumatra*, Bangka*, Krakatau*, Java*, Kangean*; Philippines: Luzon.

nigricans serrei (du Buysson)

Ischnogaster serrei du Buysson, 1905, Bull. Soc. Ent. France: 281, female, male—"Batavia" (Paris).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):255 (in subgenus *Parischnogaster*).—Dover, 1931, J. Fed. Malay St. Mus. 16:255 (syn. of *Stenogaster nigrifrons* (Smith)).

Parischnogaster serrei; von Schulthess, 1927, Suppl. Ent. 16:88 (cat.).

Stenogaster serripes [!]; von Schulthess, 1935, Rev. Suisse Zool. 42:299.

Distribution: Indonesia: Java

striatula (du Buysson)

Ischnogaster striatulus du Buysson, 1905, Bull. Soc. Ent. France: 282, female—"Sumatra" (Paris).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):255 (in subgenus *Parischnogaster*).

? *Ischnogaster clypealis* Cameron, 1906, J. Straits Branch R. Asiat. Soc. 46:122, female—"Bidi . . . Kuching" (London).

Ischnogaster foveatus du Buysson, 1907, Notes Leyden Mus. 29:80, male—"Salawatti" (Leiden).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):255 (in subgenus *Parischnogaster*).

? *Ischnogaster levifoveatus* Meade-Waldo, 1914, Ann. Mag. Nat. Hist. (8)14:462, male (in subgenus *Parischnogaster*)—"BORNEO: Sarawak, Mt. Matang" (London).

? *Parischnogaster costulatus* von Schulthess, 1927, Suppl. Ent. 16:82, female—"Sumatra, Lubuk Sulasih, 1,000 m" (Wien).

Parischnogaster striatulus; von Schulthess, 1927, Suppl. Ent. 16:82 (syn.: *foveatus* du Buysson).

Parischnogaster striatulo [!]; von Schulthess, 1927, Suppl. Ent. 16:82.

Parischnogaster striolatus [!]; von Schulthess, 1927, Suppl. Ent. 16:83.

Parischnogaster foveatus; von Schulthess, 1927, Suppl. Ent. 16:87, 88 (syn.: *Parischnogaster striatulus* (du Buysson)).

Parischnogaster ? *levifoveatus*; von Schulthess, 1927, Suppl. Ent. 16:87.

Distribution: Thailand; Malaysia: Peninsular Malaysia*, Sarawak; Indonesia: Sumatra, Kalimantan, Salawati, Java*.

timida (Williams)

? *Ischnogaster strandi* du Buysson, 1910, Bull. Soc. Ent. France: 39, male, female—"Philippines: Samar" (Berlin).

Parischnogaster strandi; von Schulthess, 1927, Suppl. Ent. 16:88.

Stenogaster timidus Williams, 1928, Bull. Hawaii. Sugar Pltrs. Assoc. Exp. Stat. (Ent. Ser.) 19:170, pl. XXXIII Fig. 228, female—"Molawin Falls, Mt. Makiling, Los Baños" (Honolulu).

Parischnogaster timida; Carpenter, 1988, J. New York Ent. Soc. 96:175.

Distribution: Philippines: Samar, Luzon.

unicuspata Reyes

Parischnogaster unicuspata Reyes, 1988, Philipp. Ent. 7(4):387, 400 (key), figs. 1, 69-75, 82, 85, 91-92, 109, female, male—"Palawan National Agricultural College, Aborlan, Palawan" (holotype male Los Banos); also from other localities in Palawan and Malaysia.

Distribution: Thailand*; Malaysia: Peninsular Malaysia, Sarawak; Singapore*; Indonesia*: Sumatra, Bangka; Philippines: Palawan.

Genus *Stenogaster* Guérin-Méneville

Stenogaster Guérin-Méneville, 1831, in Duperrey, Voyage Coquille, Zool., Ins., Atlas: pl. 9 fig. 9, genus.

Type species: *Stenogaster fulvipennis* Guérin-Méneville, 1831, by monotypy.

Ischnogaster Guérin-Méneville, 1838, in Duperrey, Voyage Coquille, Zool., Ins., Texte 2(1):268. Unnecessary replacement name for *Stenogaster* Guérin-Méneville, 1831, thought to be preoccupied by *Stenogaster* Solier, 1835 (Coleoptera).

adusta van der Vecht

Stenogaster adusta van der Vecht, 1975, J. Aust. Ent. Soc. 14:283, 287 (key), 291, figs. 21-33, female, male—"Misool . . . Fakal" (holotype female Leiden).

Distribution: Indonesia: Misool, Irian Jaya.

canaliculata (Cameron)

Ischnogaster canaliculatus Cameron, 1911, Nova Guinea 9(2), Zool.: 190, female—"Bivak Island" (lectotype Amsterdam).—Meade-Waldo, 1914, Ann. Mag. Nat. Hist (8)14:405 (syn. of *Ischnogaster fulvipennis* [!]) Guérin-Méneville).—van der Vecht, 1975, J. Aust. Ent. Soc. 14:299, 301 (designation of lectotype).

Stenogaster ? *canaliculatus*; von Schulthess, 1927, Suppl. Ent. 16:85.

Stenogaster canaliculata; van der Vecht, 1975, J. Aust. Ent. Soc. 14:298 (key), 299.

Distribution: Indonesia: Irian Jaya.

concinna van der Vecht

Stenogaster concinna van der Vecht, 1975, J. Aust. Ent. Soc. 14:283, 285, 286 (key), 295, figs. 1a–b, 53–80, male, female—“S.W. New Guinea . . . Wataikwa River” (holotype male London); also from other localities in New Guinea.

Distribution: Indonesia: Irian Jaya; Papua New Guinea.

decorata van der Vecht

Stenogaster decorata van der Vecht, 1975, J. Aust. Ent. Soc. 14:283, 287 (key), 293, figs. 34–51, female, male—“Misool . . . Fakal” (holotype female Leiden).

Distribution: Indonesia: Misool, Yapen.

flavifrons van der Vecht

Stenogaster flavifrons van der Vecht, 1975, J. Aust. Ent. Soc. 14:283, 298 (key), 303, figs. 94–103, female, male—“N.W. New Guinea . . . Japen, Mt. Baduri, 300 m” (London).

Distribution: Indonesia: Yapen.

fulgipennis (Guérin-Méneville)

Stenogaster fulgipennis Guérin-Méneville, 1831, in Duperrey, Voyage Coquille, Zool., Ins., Atlas: pl. 9 fig. 9, sex and locality not stated (holotype male from “Dory, N. Guinea,” Genova).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37(3):254 (in subgenus *Ischnogaster*).—Dover and Rao, 1922, J. Asiat. Soc. Beng. (N. S.) 18:236, footnote (correct generic name).—Bequaert, 1926, Ent. Mitt. 15:192 (generic name).—Guiglia, 1948, Ann. Mus. Civ. Stor. Nat. Giacomo Doria 63:178 (location of type).

Ischnogaster fulgipennis; Guérin-Méneville, 1938, in Duperrey, Voyage Coquille, Zool., Ins., Texte 2(1):269, “female” from “Dory, dans la Nouvelle-Guinée” [the description is evidently based on a male].—de Saussure, 1852, Ann. Soc. Ent. France (2)10:23 “fem. ou ouvrière” [redescription of Guérin-Méneville’s type]; 1853, Ét. Fam. Vesp. 2:7 (“female”).—von Schulthess, 1914, Zool. Jahrb. (Abt. Syst. Geogr. Biol. Tiere) 37:254 (type of subgenus *Ischnogaster*).

Stenogaster fulgidipennis; von Dalla Torre, 1894, Cat. Hym. 9:113, invalid emendation.

Ischnogaster fulvipennis [!]; Meade-Waldo, 1914, Ann. Mag. Nat. Hist (8)14:405 (syn.: *Ischnogaster canaliculatus* Cameron).

Distribution: Indonesia: Irian Jaya.

glabra van der Vecht

Stenogaster glabra van der Vecht, 1975, J. Aust. Ent. Soc. 14:283, 299 (key), 303, figs. 104–110, male—“N.W. Guinea . . . Cyclops Mts., 1,100 m” (London).

Distribution: Indonesia: Irian Jaya.

licina van der Vecht

Stenogaster licina van der Vecht, 1975, J. Aust. Ent. Soc. 14:283, 287 (key), 295, fig. 52, female—"N.W. Guinea . . . Road Ajamaru-Teminabuan, km 1-8" (Leiden).

Distribution: Indonesia: Irian Jaya.

macilenta van der Vecht

Stenogaster macilenta van der Vecht, 1975, J. Aust. Ent. Soc. 14:283, 298 (key), 306, figs. 1c-e, 117-131, female, male—"N.W. New Guinea . . . Lower Mist Camp, 1550 m" (holotype female Leiden); also from other localities in Irian Jaya.

Distribution: Indonesia: Irian Jaya.

pilosa van der Vecht

Stenogaster pilosa van der Vecht, 1975, J. Aust. Ent. Soc. 14:283, 299 (key), 305, figs. 111-116, male—"N.W. New Guinea . . . Cyclops Mts, Mt. Lina, 1,100-1,400 m" (London).

Distribution: Indonesia: Irian Jaya.

unicolor (Smith)

Ichnogaster unicolor Smith, 1864, J. Proc. Linn. Soc., Zool. 7:41, male—"Mysol; Waigiou" (lectotype Oxford).

Stenogaster unicolor; von Schulthess, 1927, Suppl. Ent. 16:86.

Distribution: Indonesia: Waigeo, Misool.

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**TYPES OF NEOTROPICAL SPECIES OF SCATOPSIDAE
(DIPTERA: PSYCHODOMORPHA). I. EDWARDS'
CHILEAN AND SOUTHERN ARGENTINEAN SPECIES**

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Abstract.—The types of Edwards' species of Chilean and southern Argentinean Scatopsidae are redescribed and illustrated: *Ectaetia cornuta* Edwards, *Scatopse setifera* Edwards, *Scatopse tubifera* Edwards, *Scatopse constricta* Edwards, and *Anapausis fuscinervis* (Edwards). Notes on each type are added, and the generic position of each species is discussed. *Ectaetia cornuta* and *Anapausis fuscinervis* maintain their present generic placements. New combinations are proposed for *Pararhexosa tubifera* (Edwards), n.comb. and *Neorhegmoclemina constricta* (Edwards), n.comb. The holotype of *Scatopse tubifera*, described as a male, is actually a female. A new genus—*Holoclema*, n.gen.—is erected to include *Scatopse setifera* (Edwards). *Holoclema* is considered to be the sister group of the remaining Rhegmoclematini. The Neotropical species *Rhexosa panamensis* (Cook) and *Rhexosa auricularis* (Duda) are transferred to the formerly monotypic genus *Abrhexosa* Freeman, originally described for a single Oriental species. Additional distribution data for some species is supplied. *S. maritima* and *S. costaricana* are considered *incertae sedis* in Scatopsinae until their types can be examined.

Key words: Scatopsidae, Neotropical region, types, *Holoclema*, phylogeny.

The Scatopsidae have 42 described species assigned for the Neotropical region. About 120 other, undescribed species are known for the region. Of the described species, three are cosmopolitan, namely *Scatopse notata* (Linnaeus), *Coboldia fuscipes* (Meigen), and *Holoplagia guamensis* (Johannsen). Another four are considered unrecognizable and their types are probably lost (Cook, 1967)—*Scatopse fulvitaris* Macquart of Lynch Arribálzaga, *Scatopse hyalinata* Phillippi, *Scatopse pallidipes* Lynch Arribálzaga, and *Scatopse transatlantica* Phillippi.

The remaining 35 Neotropical species of Scatopsidae are placed in the Ectaetinae, Psectrosciariinae and Scatopsinae. Two belong to *Ectaetia*, six to *Psectrosciara*, one to *Anapausis*, one to *Diamphidicus*, one to *Rhegmoclema*, one to *Aldrovandiella*, three to *Rhegmoclemina*, six to *Neorhegmoclemina*, one to *Colobostema*, one to *Holoplagia*, and four to *Swammerdamella*. Four other Neotropical species included by Cook (1967) in *Rhexosa* do not belong to the genus: Cook (1976) erected *Akorhexoza* to include the Neotropical species *Scatopse dampfi* Duda and *Akorhexoza cactivora* Cook. The structure of the male terminalia indicates that *Rhexosa panamensis* Cook should be placed in Freeman's (1985) genus *Abrhexosa*, also probably the best place for *Scatopse auricularis* Duda. Both these species are herein transferred to this genus. *Rhexosa lobata* Cook, 1956 is best allotted to a new genus, with a number of other undescribed Neo-

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tropical species, defined by a considerably modified tergite 9, divided into a pair of longitudinal strips by a mesal incision, and by a mesal perforation on the aedeagus.

Cook's (1967) catalogue of the Neotropical Scatopsidae kept five species in the genus *Scatopse*: *S. notata* (Linnaeus), *Scatopse fuscipes* Meigen, *Scatopse costaricana* Duda, *Scatopse maritima* Duda, and *Scatopse tubifera* Edwards. *Scatopse notata* does comprise a monophyletic group with *S. lapponica*, *S. alpestris*, *S. chinensis*, and *S. globulicaudata*, the small taxon to which *Scatopse* is now restricted. This taxon is typically Holarctic and the presence of the synantropic species *S. notata* in other regions is most probably due to human transportation. *Scatopse fuscipes* Meigen was correctly transferred by Cook (1974) to *Coboldia*, a Swammerdamellini genus. The descriptions of the other three Neotropical species included by Cook (1967) in *Scatopse* strongly suggest that they do not belong to *Scatopse* sensu Cook (1974). However, the original descriptions are insufficient to allow a generic replacement and only the re-examination of the types can solve the problem.

The types of *S. tubifera* were re-examined and are redescribed in this paper. *Scatopse maritima* and *S. costaricana* are best considered *incertae sedis* in the Scatopsinae before the types can be re-examined. This first paper in a series redescribing the Neotropical scatopsids deals with Edwards' (1930) types of Chilean Scatopsidae. The suprageneric, phylogenetic classification of the Scatopsidae of Amorim (1994) is followed. The "group+" artifact is employed to refer to unnamed monophyletic groups in the sequenced classification of the family (Amorim, 1982a). Many of the phylogenetic inferences used here are based on the analysis of the family in Amorim (1982b, MS).

Ectaeiinae

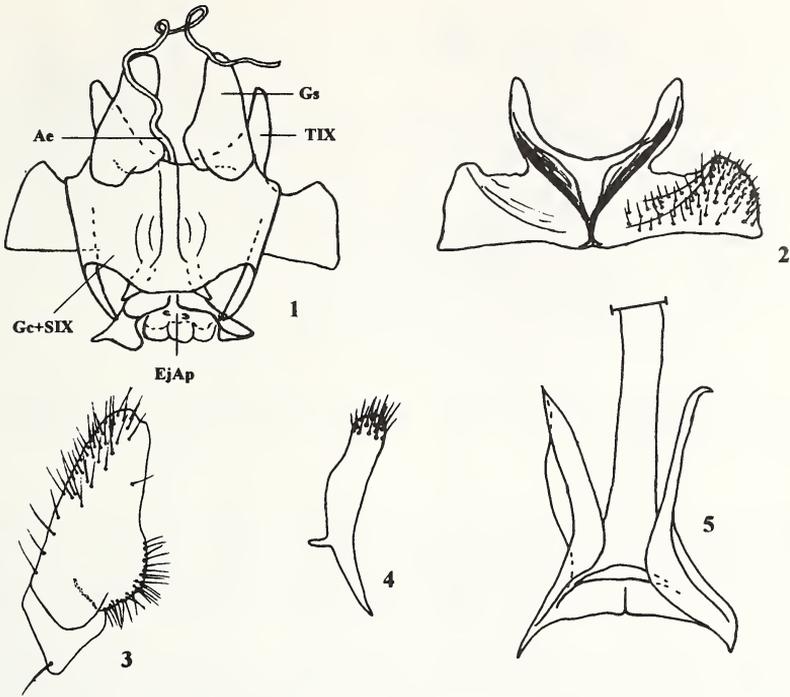
Ectaeitia cornuta Edwards

Figs. 1-5

Ectaeitia cornuta Edwards, 1930: 98, pl. X, figs. 11, 12 (wing, male terminalia). Type-locality: CHILE, Llanquihue, Casa Pangué. Types, male lectotype, one male paralectotype and five female paralectotypes in BMNH; Cook, 1967: 5 (catalogue).

The type series of *Ectaeitia cornuta* included seven specimens: a male and a female specimen on the same pin and five other specimens on separate pins. The pin with two specimens presents six levels, here described beginning from the top: (1) a strip with the specimens glued to it; (2) "Casa Pangué/4-10.xii.1926", printed; (3) a plastic strip with the male terminalia dissected in balsam; (4) a rounded red label with "Type" printed; (5) "*Ectaeitia/cornuta* Edw." handwritten and "F. W. Edwards/det. 1930" printed; (6) "S. CHILE/Llanquihue Prov./F. & M. Edwards/B.M. 1927-63" printed. The only male paratype has labels 2 and 6. The four female paratypes have the label "Castro/20-22.xi.1920", and label 6.

We add here some details to the original description, with drawings of the male terminalia (Figs. 1-5). Flagellum with 10 flagellomeres. Meral setae restricted to the dorsal margin of the sclerite. No strong scutellars. Katepisternum apparently bare. Apex of hind tibia slightly flattened, hind femur with a mesal area less well sclerotized. Wing membrane devoid of macrotrichia. The posterior wing veins translucent; C is considerably short, with R_5 curved.



Figs. 1–5. *Ectaetia cornuta* Edwards. Male holotype. 1. Terminalia, ventral view; 2. Tergite IX, dorsal view; 3. Gonostyle, ventral view; 4. Paramere, ventral view; 5. Aedeagus, ventral view.

Psectrosciarinae

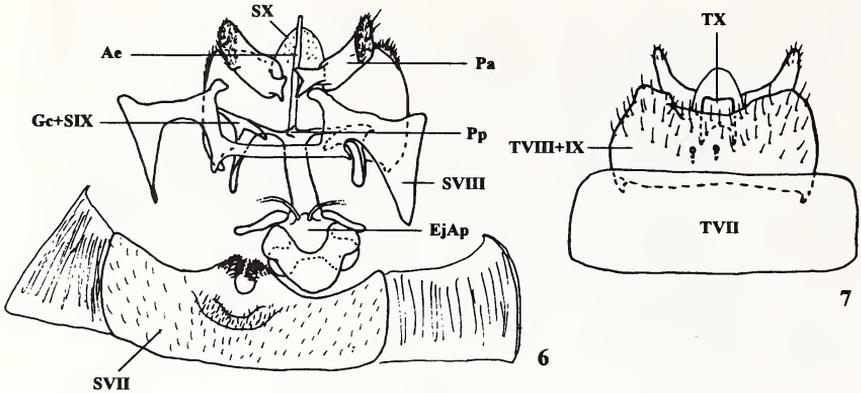
Anapausis fuscinervis (Edwards)

Figs. 6–7

Psectrosciara fuscinervis Edwards, 1930:97, pl. X, Figs. 11, 12 (male terminalia, wing).

Type-locality: CHILE, Llanquihue, Casa Pangué; Cook, 1965:16, Figs. 42, 43, 45 (male terminalia, wing); Cook, 1967:5 (catalogue); Amorim, 1982b (mouth parts).

A single male specimen is the only type of this species. The pin with the male holotype has seven labels. Beginning at the top: the specimen glued to a plastic strip; the second with the wing glued to a plastic strip; the third is a printed label written “Casa Pangué/4–10.xii.1926”; the fourth has the terminalia dissected in balsam on a plastic strip; the fifth is a red, round label with “Type” printed; the sixth is a label with “*Psectrosciara fuscinervis* Edw.” handwritten and “F. W. Edwards/1930” printed; the last label has “S. CHILE/Llanquihue Prov./F. & M. Edwards/B.M. 1927–63” printed. In some details, neither Edwards’ (1930) nor Cook’s (1965) drawings are sufficient to allow a correct understanding of the homology of the male terminalia sclerites, although they are sufficient to allow the correct identification of the species. The male terminalia are redrawn here in ventral and dorsal aspect (Figs. 6–7). Some descriptive information may be added: the meron is well separated from episternum III, this latter sclerite well



Figs. 6-7. *Anapausis fuscinervis* (Edwards). Male holotype. 6. Terminalia, ventral view; 7. Terminalia, dorsal view.

developed; tarsi brown; antenna with 8 flagellomeres; wing membrane with abundant macrotrichia present on cells posterior to M_2 , but absent anteriorly to M_2 .

Other localities are known for this species: one male, "Puerto Puyuhuapi, Sud Chile, 14-11-39, G. H. Schwabe" (Cook, 1965); a female, Chile, El Naranjo, Tilana, Coquimbo, x.1967, L. E. Peña col. (Natural History Museum, London) (Amorim, 1982b); one male and one female, Chiloe, Isla Chiloe, Ahoni Alto, September 1988, Luis E. Peña col. (Carnegie Museum of Natural History, Pittsburgh); Castro, Isla Chiloe, xii.1926, R & E Shannon col. (National Museum of Natural History, Washington, D.C.).

Scatopsinae

Rhegmoclematini

Neorhegmoclemina constricta (Edwards), **new combination**

Figs. 8-12

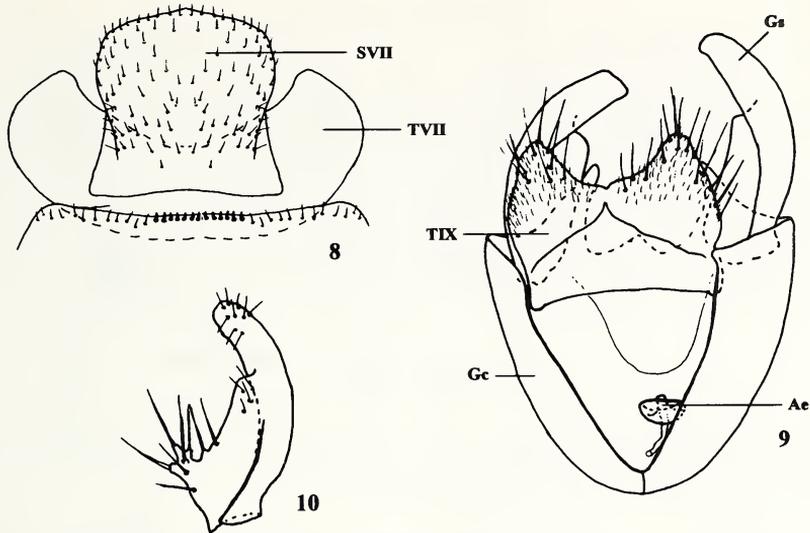
Scatopse constricta Edwards, 1930:96, pl. IX, Figs. 5, 7 (male terminalia, wing).

Type-locality: Chile, Llanquihue, Peulla.

Rhegmoclemina (*Neorhegmoclemina*) *constricta*; Cook, 1967:3 (catalogue); Amorim, 1982b (palpus, thorax, wing, male terminalia).

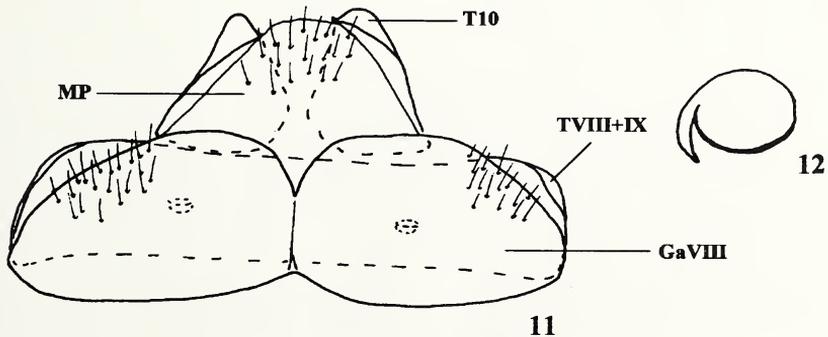
Edwards (1930) described *N. constricta* based on ten specimens from the same locality. The male holotype pin has seven layers of labels: (1) the highest one is a plastic strip with some broken parts of the body; (2) a label with handwritten "in log with/ termites"; (3) a label "Peulla/12-13.xii.1926", printed; (4) a plastic strip with the terminalia dissected in balsam; (5) a round, red label with "Type" printed; (6) "*Scatopse/constricta* Edw." handwritten on a label with "F. W. Edwards/det. 1930" printed; (7) a label with "S. CHILE/Llanquihue Prov./F. & M. Edwards/B.M. 1927-63" printed. The type series also includes one female with labels 1-4 and 7, one male with labels 1-3 and 7, and seven males with labels 1, 3 and 7.

Cook (1955) only stated that it was probable that *Scatopse constricta* Edwards belongs to *Rhegmoclemina*, without formally including it in the genus. In the catalogue of the



Figs. 8–10. *Neorhegmoclemina constricta* (Edwards), n.comb. Male holotype. 8. Segment VII, ventral view; 9. Terminalia, dorsal view; 10. Gonostyle, ventral view.

family for the Neotropical region (Cook, 1967) the species was formally transferred to *R. (Neorhegmoclemina)*. Amorim (1994) raised *Neorhegmoclemina* and *Austroclemina* to genera and the species is here formally transferred to *Neorhegmoclemina*. Amorim (1982b) studied four additional males belonging to this species, from Chile (Chepu, Chiloe, 42°S, 20.x.1958, Royal Society Chilean Expedition [Natural History Museum]), and two other undescribed species of *Neorhegmoclemina* from Chile (one in the Museu de Zoologia, São Paulo, the other in the Canada National Collection). The male terminalia of the holotype is redrawn here (Fig. 8–10) to avoid any doubt on the identification of the species. The terminalia of the female paratype is figured for the first time (Figs. 11–12).



Figs. 11–12. *Neorhegmoclemina constricta* (Edwards), n. comb. Female paratype. 11. Terminalia, ventral view; 12. Spermatheca.

Holoclema, new genus

Type-species, *Scatopse setifera* Edwards, 1930.

The following combination of features is diagnostic for this genus: antenna with 10 flagellomeres; palpus small; R_5 long, parallel but not close to C; M_1 complete; CuA_2 rather sinuous, with some macrotrichia; membrane posterior to CuA_2 with macrotrichia; a fold between the medial fork and CuA_1 ; tergite 1 without reticulation; gonocoxites with macrotrichia, well developed laterally; parameres absent; aedeagus quite wide; gradually reducing in width; a pair of spiracles dorsally on the male terminalia; no cerci.

Species included: *Holoclema setifera* (Edwards, 1930).

Holoclema setifera (Edwards), **new combination**

Figs. 13–20

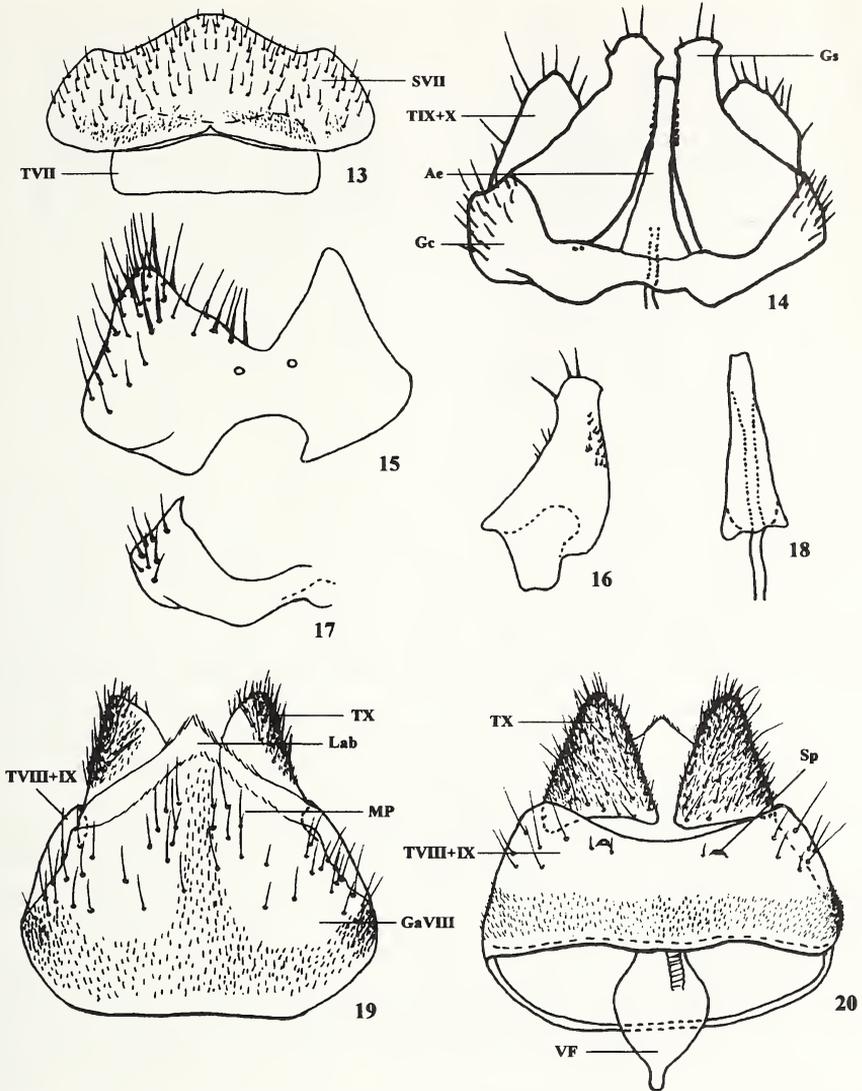
Scatopse setifera Edwards, 1930:95, pl. IX, Figs. 3–4 (wing, male terminalia). Type-locality: ARGENTINA, Rio Negro, Lago Correntoso.

Rhegmoclema setifera; Cook, 1967:3 (catalogue).

The holotype of this species has six levels of labels on the pin: (1) the specimen double-mounted on a plastic strip; (2) a label printed "L. Correntoso/18–25.xi.1926"; (3) a plastic strip with the male terminalia dissected in balsam; (4) a round, red label printed "Type"; (5) a label with "*Scatopsesetifera* Edw." handwritten and "F. W. Edwards/det. 1930" printed; (6) "ARGENTINA/Terr. Rio Negro/F & M. Edwards/B.M. 1927–63" printed on a label. Edwards (1930:95) refers to 12 paratypes. All they come from the type locality and show labels 1, 2, 5 and 6. The type series includes 5 males, 5 females, a wing remaining from a lost specimen, plus an empidid specimen, what would be unexpected for Edwards' type series. Segment 7 of the holotype is drawn here for the first time (Fig. 13) and the male terminalia are redrawn (Figs. 14–18). Terminalia of the dissected female paratype are also illustrated (Figs. 19–20).

Discussion: The question of the phylogenetic position of *Holoclema setifera* is quite difficult. Edwards (1930) rejected most of Enderlein's (1912) genera and this species was maintained in the genus *Scatopse*, as most of his Scatopsinae species. In the Neotropical catalogue of the Scatopsidae, Cook (1967) placed the species in the genus *Rhegmoclema*, but the reexamination of the type shows that this is certainly not satisfactory.

The inclusion of *Holoclema* in the Scatopsinae seems unquestionable: an independent ejaculatory apodeme—an outstanding autapomorphic feature of the subfamily—is present (Edwards, 1930, pl. IX, fig. 4). The decision on the tribal placement, however, deserves careful discussion. The presence of 10 flagellomeres and the presence of macrotrichia on the posterior wing veins definitely excludes it from the Scatopsini⁺ (which includes Scatopsini, Colobostematini and Swammerdamellini). Edwards (1930) associated the species with *S. nigripennis*, now included in *Colobostema*, possibly based on the following features: "slight and uniform smoky tinge" color of the wing membrane, "posterior veins somewhat darkened", rather longer pubescence, and eyes in contact above the antennae only for a small distance. In fact, these are similarities shared with some Colobostematini, but *Holoclema* is plesiomorphic for a number of synapomorphies of the Scatopsini⁺, of the Colobostematini⁺ and of the Colobostematini themselves,



Figs. 13–20. *Holoclema setifera* (Edwards), n.comb. Male holotype. 13. Segment VII, ventral view; 14. Terminalia, ventral view; 15. Tergites VIII + IX, ventral view; 16. Gonostyle, ventral view; 17. Right gonocoxite, ventral view; 18. Aedeagus, ventral view. Female paratype; 19. Terminalia, ventral view; 20. Terminalia, dorsal view.

suggesting that a hypothesis of close relationship with *Colobostema* is not parsimonious, and these similarities should be considered homoplastic.

Other features are relevant in the taxonomic discussion: (1) 10 flagellomeres; (2) flagellum long; (3) body pubescence long; (4) M_1 complete; (5) fork of M long; (6) C

considerably long; (7) R_5 separated from C; (8) R_5 parallel to C; (9) macrotrichia on CuA_2 and on membrane posterior to CuA_2 ; (10) long scutellar setae present; (11) tergite 1 without reticulation; (12) pretergite 2 hardly differentiated.

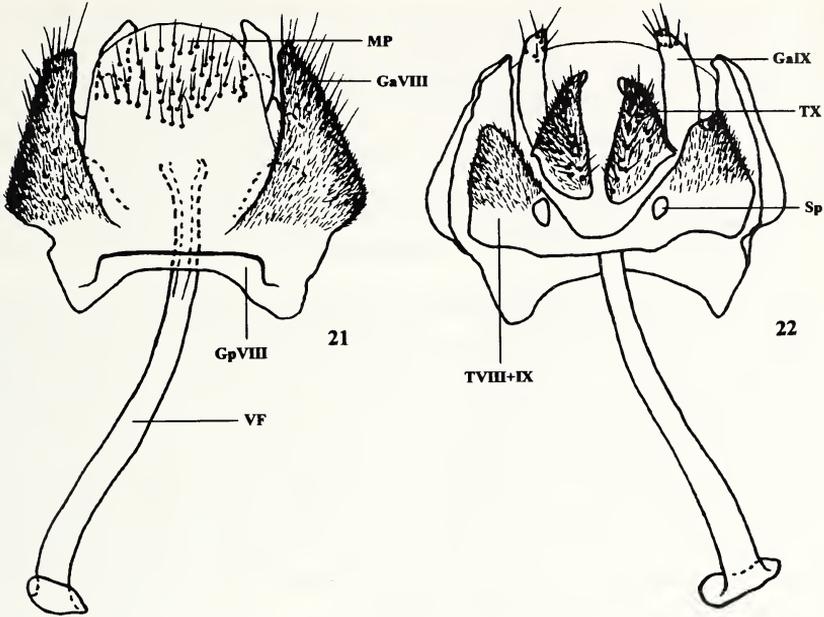
That there is no reticulation on tergite 1 would be sufficient reason to consider not including the species in *Rhegmoclema*. Also, some Afrotropical and Oriental species of *Rhegmoclema* have a complete M_1 , but no Neotropical species. Moreover, there is scarcely similarity in the male terminalia of *Holoclema* and *Rhegmoclema*.

Its inclusion in *Neorhegmoclemina* also seems inappropriate. The absence of macrotrichia on the wing membrane is a synapomorphy of this genus and there are abundant macrotrichia on the proximal-posterior cell in *H. setifera* Edwards. Also, *Parascatopsina* has a short R_5 , a feature definitely absent in Edwards' species (actually, only *Diamphidicus* and *Parmaferia* in the Rhegmoclematini show such long R_5). Other wing features would show some similarity with *Rhegmoclemina* or *Austroclemina*, but only on the basis of plesiomorphies. In addition, *Rhegmoclemina* and *Austroclemina* possess an apomorphic, 8-articulated flagellum, not found in *Holoclema*.

A more detailed study of the male terminalia gives some other clues about its position: it is plesiomorphic for the bowl-shaped, fused gonocoxites, apomorphic in all Rhegmoclematini but *Diamphidicus*. Tergite 7 is rather well developed, plesiomorphic in *H. setifera*, differently from the condition presented by the *Parascatopsina* species. Also important is that the gonocoxites in this species have setae laterally. Gonocoxal setae are absent in all Scatopsinae but *Diamphidicus*. The inclusion of *Scatopse setifera* Edwards in *Diamphidicus*, however, would also be unsuitable. A long vein R_5 and a slender connection between the gonocoxites mesally are features shared by both genera, but they are plesiomorphies; another very typical synapomorphy of *Diamphidicus*—the short M fork—is absent in *H. setifera*. Finally, a synapomorphy of the set of genera presently included in the Rhegmoclematini, the bottle-shaped aedeagus (with a large base and a distal bottle-neck), shared even by *Diamphidicus*, is absent in *Holoclema*.

The representation in a cladogram of the set of features discussed above would result in a 3-stemmed polytomy at the base of the Scatopsinae, with *Holoclema*, Rhegmoclematini and Scatopsini⁺ as terminal taxa. Three other features may give some light to this problem. On the one hand, CuA_2 is rather sigmoid in shape and there are no cerci, features apomorphic in all Rhegmoclematini. On the other hand, the male terminalia dorsally shows a pair of spiracles. The presence of spiracle pair VIII on the male terminalia is a plesiomorphic condition absent in all other known Scatopsinae (known to occur only in the Aspistinae and Psectrosciarinae within the Scatopsidae). This suggests a sister-group relationship between *Scatopse setifera* Edwards and all remaining Scatopsinae.

The female terminalia gives some additional features that corroborate some of the previous inferences. The absence of a pair of gonapophysis VIII laterally to a mesal projection of sternite VIII—an apomorphic feature shared by the Rhegmoclematina and the *Parascatopsina*—is absent in *Holoclema*. This apomorphic condition of the female terminalia, however, is absent in Edwards' species. The pair of lobes dorso-posteriorly on the terminalia, derived from tergite X (referred to by Cook as the cerci), is not fused to tergite VIII + IX, and again excludes the species from the Rhegmoclematina or from *Diamphidicus* (see Cook, 1971), which apomorphically possess this feature. The large, plesiomorphic tergite VIII + IX, on the other hand, excludes it from the *Parascatopsina*.



Figs. 21–22. *Pararhexosa tubifera* (Edwards), n.comb. Female holotype. 21. Terminalia, ventral view; 22. Terminalia, dorsal view.

These plesiomorphies of the female terminalia presented by *H. setifera* again suggest a basal placement somewhere at the base of the Scatopsinae.

The position assumed here is that a new genus must be erected for *Scatopse setifera* Edwards and that it should be provisionally placed in the Rhegmoclematini. This would mean that the sigmoid CuA_2 and the lost of cerci are truly synapomorphies uniting *Holoclema* and the remainder of the tribe. Its position in the Rhegmoclematini, hence, would be as the sister group to the remaining genera of the tribe. The spiracles, consequently, would have been lost twice in the Scatopsinae—in the Diamphidicina⁺ and in the Scatopsini⁺. Maybe more extensive studies of this species and the discovery of new species in the genus may help to better establish its placement in the system of the family.

Swammerdamellini

Pararhexosa tubifera (Edwards), new combination

Figs. 21–22

Scatopse tubifera Edwards, 1930:95, pl. IX, Figs. 6, 8 (wing, male terminalia). Type-locality: Chile, Llanquihue, Casa Pangué; Cook, 1967:2 (catalogue).

The holotype of this species has six levels of labels: (1) a plastic strip with the specimen double mounted; (2) a label with “Casa Pangué/4–10.xii.1926” printed; (3) a plastic strip with the terminalia mounted; (4) a red, round label with “Type” printed;

(5) "*Scatopse tubifera* Edw." handwritten and "F. W. Edwards/det. 1930" printed; (6) S. CHILE/Llanquihue/F. & M. Edwards/B.M. 1927-63".

Contrary from what is in the description, the holotype of this species is a female, not a male. Edwards' (1930, pl. IX, Fig. 8) drawing of the terminalia is a dorsal view, redrawn here to include the anterior part (Figs. 21-22). The maxillary palpus is long, reniform and there are setae on the front ventrally to the eye-bridge; the ocelli are adjacent to the eye-bridge. The tarsi are brown. The spiracular sclerite is small; there are 5 subspiracular setae, 2-30 anepisternals on the dorsal half of the sclerite, apparently no katepisternals and no merals, 3-5 mesepimerals. Abdominal sternites 2-6 are normally sclerotized.

The placement of this species also deserves some discussion. There is no doubt about its inclusion in the Scatopsinae. The large, reniform maxillary palpus would hardly allow any other placement than in the Swammerdamellini. The fact that abdominal sternites 2-6 are normally sclerotized shows that it certainly does not fit in the higher genera of the tribe, as *Rhexosa*, *Abhexosa*, *Quateiella* and *Hawomersleya*. The small spiracular sclerite, however, indicates still a more basal position, since all these genera, as well as *Coboldia*, *Swammerdamella*, and *Akorhexoza* do possess elongated, large spiracular sclerites. The monophyly of the genus *Pararhexosa* Freeman is still not well demonstrated. However, the species placed in this genus (some of which would fit in the generic diagnosis of *Rhexosa*) show a number of plesiomorphies that show the derived condition in all remaining genera of the Swammerdamellini.

ACKNOWLEDGMENTS

We must acknowledge the facilities given by Dr. Brian Pitkin at the British Museum for the examination of the types. This work was partially supported by FAPESP 94/2371-3 and CNPq 302531/88-2/ZO research grants. We also acknowledge a careful correction of the English version by an anonymous referee.

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**NEW TRIBAL PLACEMENT OF THE GENUS
COSCINOCEPHALUS PRELL, 1936, WITH DESCRIPTION OF THE
LARVA, PUPA AND ADULT OF A NEW SPECIES FROM
MEXICO (COLEOPTERA: SCARABAEOIDEA; DYNASTINAE)**

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Abstract.—A discussion is presented suggesting the transfer of *Coscinocephalus* from the Cyclocephalini to the Pentodontini. *Coscinocephalus tepehuanus* is described as new, based on immature and adult forms, from Durango state, Mexico. A key to the third-stage larvae of nine genera of American Pentodontini is presented. Finally, a brief commentary is given about life history information.

Resúmen.—Se presenta una discusión para justificar la transferencia del género *Coscinocephalus* de la tribu Cyclocephalini a la tribu Pentodontini. Se describe *Coscinocephalus tepehuanus* n. sp. con base en 6 adultos, así como su larva de tercer estadio y la pupa, recolectados en un bosque de pinos y encinos del estado de Durango, México. Se incluyen: una clave para separar las dos especies conocidas del género, una clave para las larvas de tercer estadio de 9 géneros de Pentodontini americanos y un comentario breve sobre los hábitos de estas especies.

Some genera of American Dynastinae have restricted geographical ranges and/or ecological tolerances, such as *Aphonides* Rivers, *Pentodina* Endrödi, *Coscinocephalus* Prell, *Barutus* Ratcliffe, *Tehuacania* Endrödi, *Gillaspytes* Howden, *Hiekeianus* Endrödi, *Neoryctes* Arrow, *Surutoides* Endrödi, *Indieraligus* Dechambre, and *Endroedianibe* Chalumeau. Some of these genera are also monotypic, with insular habitats or extreme vicariant relatives and are usually very rare in collections. It is possible that most of these genera represent relictual elements that may provide useful data for phyletic studies of the subfamily.

Recent collecting trips (both in the field and in collections) have given us new information on the controversial genus *Coscinocephalus*. Thus, the purposes of this paper are: (1) to justify the tribal transfer of *Coscinocephalus* from Cyclocephalini to Pentodontini; (2) to describe a new species from Mexico; (3) to describe the third-stage larva and pupa of the new species; (4) to update the known distribution of the genus; (5) to discuss the habits of the species; and (6) to provide a key to the known third-stage larvae of American Pentodontini. Technical terms used are those of Ritcher (1966), Morón (1987) and Costa *et al.* (1988).

Anoplocephalus cribrifrons was described by Schaeffer (1906) but the genus was preoccupied by *Anoplocephalus* Henrick 1895 (Platyhelminthes: Cestoda). Prell (1936) provided the replacement name *Coscinocephalus*. Schaeffer indicated the difficulty of placing the genus in a tribe using the then present classification. He stated

that "this genus is intermediate between Lacordaire's 'Cyclocephalides' and 'Oryctides'."

"Pentodontidae" was originally proposed by Burmeister (1847), but it was seemingly not widely used in classifications even though Bates (1888) adhered to it in the *Biologia*. It is easy to understand Schaeffer's indecision (especially if he was unfamiliar with Burmeister's work) when he had only the old *descriptions* of the "Cyclocephalides" or "Oryctides" by which to place the new genus, and neither one seemed to properly accommodate *Anoplocephalus*.

It was not until Casey (1915), nine years after the description of *Anoplocephalus*, that Pentodontini made its way into the primary North American literature. The tribe again fell into obscurity when it was not used in Leng's (1920) catalog of North American Coleoptera, Arrow's (1937) Coleopterorum Catalogus, Blackwelder's (1944) checklist of the Coleoptera of Latin America, or Arnett's (1968) beetles of the United States. Endrödi (1969, 1985) reinstated the use of Pentodontini and provided the first modern definition of it. The definition, however, leaves a lot to be desired because monophyly was not addressed; some concerns remain that the Pentodontini (as currently comprised) may be paraphyletic.

Adult pentodontines are distinguished by the presence of tubercles, carinae, or a fovea on the head and/or pronotum; mandibles on the lateral margin with or without teeth; propygidium with or without a stridulatory structure; protibiae usually tridentate, and apex of the metatibiae usually truncate and margined with short, spine-like setae. Dimorphism between the males and females is slight.

The larvae are characterized by 1–3 dorsal sensory spots on the last antennal segment; the molar area of the left mandible is dentate or, if lacking teeth, then the stridulatory teeth of the maxilla have acute projections directed distally; and the raster has one or more rows of palidia or, if lacking the palidia, then the chaetoparia of the epipharynx has few setae.

Some adults in the Pentodontini are similar to others in the Oryctini. The two tribes (as currently structured) may generally be separated by the presence of a truncate or nearly smooth apical rim on the apex of the posterior tibia in the pentodontines and by a toothed (including apical tooth) or strongly crenulate rim in the oryctines. As opposed to the Cyclocephalini, all pentodontines have at least some head or pronotal armature in the form of carinae, tubercles, or even horns.

It appears that Casey (1915) was the first to definitively place the then *Anoplocephalus* in the Cyclocephalini. Endrödi (1969, 1985) maintained its position in the Cyclocephalini based on the absence of head and pronotal armature and the presence of slender legs. In this regard, however, it should be noted that both species of *Coscinocephalus* possess as much of a developed boss, or tubercle, on the frons as in species of *Orizabus*, *Pentodina*, or *Euetheola* in the Pentodontini. The slender, long legs seem to be a variable character within tribes. In this case, we believe it is correlated with the arboreal habits of *Coscinocephalus* species. By contrast, most members of the Pentodontini have soil burrowing habits and have stouter (though not truly fossorial) legs.

We believe that *Coscinocephalus* is more appropriately placed in the Pentodontini for the following reasons: (1) the head is "armed"; (2) the mandibles, labrum, and maxilla are all relatively simple or small, and the labium is strongly constricted apically as in *Orizabus* (but unlike the general state found in the Cyclocephalini).

See Table 1 for further comparisons; (3) the clypeus is strongly bilobed and reflexed as in *Orizabus* but unlike any other Cyclocephalini; (4) the form of the parameres is more elongated, slender, and setose as in other Pentodontini but especially as in *Orizabus*; (5) the characters of the mouthparts in the larvae of *Coscinocephalus*, while showing no clear affinity (Table 2), are not like those of Cyclocephalini.

Our study of both adult and larval features leads us to conclude that *Coscinocephalus* is not a cyclocephaline. In most respects the adults seem to be more closely related to *Orizabus* in the Pentodontini while the larvae share some affinities with larvae of *Xyloryctes* in the Oryctini. Even though we have some reservations about the monophyly of each of these tribes, we here place *Coscinocephalus* in the tribe Pentodontini.

We have thus come full circle to Schaeffer's (1906) original feeling that "this genus is intermediate between Lacordaire's 'Cyclocephalides' and 'Oryctides'." The Pentodontini, a concept unknown or unrecognized by Schaeffer, is the intermediate between the Cyclocephalini and the Oryctini, and it is here that we place *Coscinocephalus*.

***Coscinocephalus tepehuanus* Morón and Ratcliffe, new species**
(Figs. 1-8)

Type series: Holotype labeled "México: Durango, Res. Biosfera 'La Michilía,' alt. 2,400 m, R. Terrón col., pino-encino, ex larva, 24-X-87, adulto 10-IV-88, suelo cerca raíces *Quercus durifolia*." Allotype labeled "México: Durango, Súchil, Piedra Herada. Res. Biosfero 'La Michilía,' alt. 2,400 m, 16-VIII-79, bosque *Quercus-Pinus*, sobre suelo, M.A. Morón col." Four paratypes with the following data: as holotype except without date of adult eclosion (1 male), as allotype except 10-VII-86 and "caminando en suelo, después de lluvia, 17 hrs. R.A. Terrón Sierra col." (2 females); "Mexico: Durango, Súchil, Res. Biosfera 'La Michilía,' Rcho. de la Peña, 26-VII-78, R. Halffter col., luz, bosque *Pinus-Quercus*, alt. 2,400 m" (1 male).

The pupal and third instar exuviae are also present for the holotype and one male paratype.

Holotype and allotype deposited in the Miguel A. Morón collection (at the Instituto de Ecología, Xalapa); two paratypes (male and female) deposited at the Instituto de Biología, UNAM collection (Mexico City); remaining male and female paratypes in the B.C. Ratcliffe collection (Lincoln).

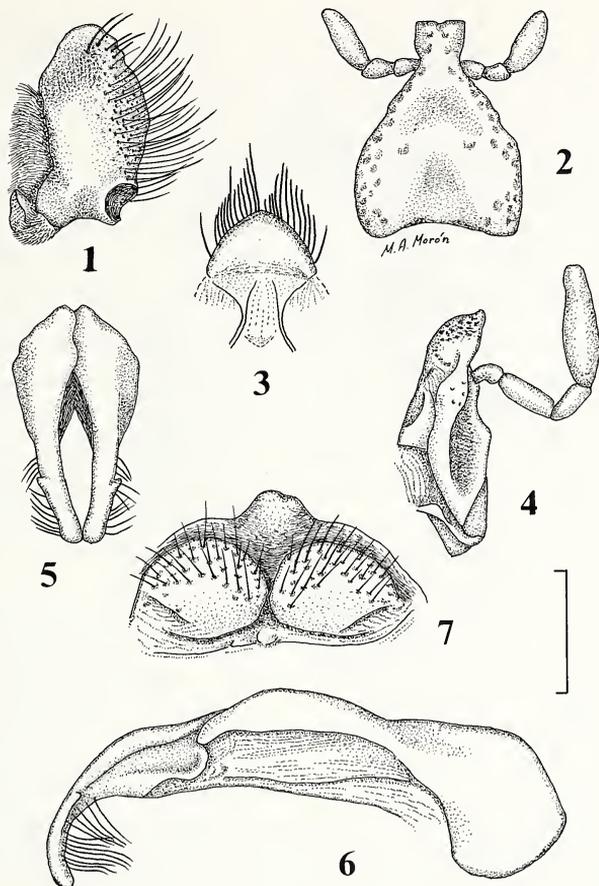
Holotype: Male. Length 21.5 mm from apex of clypeus to apex of elytra; width across humeri 11.2 mm. Color uniformly light reddish brown, moderately shining. **Head:** Clypeus with sides sinuate, converging to broad, bilobed apex; sides and apex strongly reflexed; surface densely rugopunctate. Vertex with large, oblong to transverse punctures. Low, rounded boss on frons between eyes. Interocular width equals 3.8 transverse eye diameters. Eye canthus with ventrolateral row of long, stout setae projecting laterally. Antenna with 10 segments, club subequal in length to segments 2-7. Mandibles (Fig. 1) small, not visible from above, lacking teeth, lateral edge with row of large setae, molar area small. Labium (Fig. 2) strongly contracted to small, narrow, feebly emarginate apex; lateral edges with stout setae (as long or longer than palps); ventral surface in basal half strongly and broadly depressed. Labrum (Fig. 3) small, subtriangular. Maxilla (Fig. 4) with small, subtriangular, se-

Table 1. General structure of adult mouthparts in 7 species of Dynastinae.

SPECIES	Labrum	Mandible	Maxilla	Labium
<i>Cyclocephala maffafa</i>	Wide; with condyla	Apex elbowed, without teeth; molar area wide	With 5 acute teeth	Anterior border wide, curved
<i>Ancognatha manca</i>	Wide; with condyla	Apex curved, without teeth; molar area wide	With 1 acute tooth	Anterior border wide, sinuated
<i>Paraspidolea fuliginea</i>	Wide; with condyla	Apex curved, without teeth; molar area wide	With 2 short teeth; long brush of setae	Anterior border wide, sinuated
<i>Coscinocephalus tepehuanus</i>	Narrow; without condyla	Apex rounded, without teeth; molar area small	Without teeth or brush of setae	Anterior border narrow, truncated
<i>Orizabus brevicollis</i>	Narrow; without condyla	Apex rounded, without teeth; molar area small	With 5 acute teeth	Anterior border narrow, truncated
<i>Ligyryus bituberculatus</i>	Wide; with condyla	Apex with 2 acute teeth; molar area wide	With 6 acute teeth	Anterior border wide, truncated
<i>Xyloryctes ensifer</i>	Narrow; without condyla	Apex rounded, without teeth; molar area small	With 2 acute teeth	Anterior border narrow, rounded

Table 2. Characters in third-stage larvae of six species of Dynastinae (modified from Ritcher 1966; Morón 1976; Morón and Deloya 1991).

SPECIES	Postisissorial tooth (S ₁) of left mandible	Maxillary stridulatory teeth	Shape of holes in respiratory plate	Haptoemeral process	Size of abdominal spiracles I-VIII
<i>Cyclocephala immaculata</i>	absent	truncate	oval	notched	VII-VIII large
<i>Ancognatha manca</i>	present	truncate	ameboidal	entire	similar
<i>Coscinocephalus tepahuanus</i>	absent	rounded	ameboidal	entire	similar
<i>Orizabus brevicollis</i>	absent	sharply pointed	oval	entire	decreasing I-VIII
<i>Ligyris gibbosus</i>	present	truncate	irregular?	entire	I and VIII small
<i>Xyloryctes thestalus</i>	absent	truncate and sharply pointed	oval, irregular	entire	VIII small



Figs. 1–7. *Coscinocephalus tepehuanus* n.sp. holotype ♂ 1) Right mandible, dorsal view. 2) Labium, ventral view. 3) Labrum, dorsal view. 4) Right maxilla, dorsal view. 5) Parameres, caudal view. 6) Genital capsule, lateral view. Fig. 7) Genital plates (allotype) of *C. tepehuanus*, ventral view. Scale line = 1 mm. Most of mouthpart setae have been removed for clarity.

tose galea fused to small, unarmed lacinia; stipes with groove laterally for reception of retracted maxillary palp; palpus with 4 segments, 1st segment short, 2nd segment about 4 times length of first, 3rd segment 3 times length of first, 4th segment a little shorter than 2nd and 3rd segments combined and with longitudinally depressed sensory area on dorso-lateral surface extending from near base to just past middle of segment (over half length of segment). *Pronotum*: Surface punctate, extremely finely shagreened between punctures; punctures moderate in density and size on posterior half, larger and denser in anterior half and along sides where some become rugopunctate. Sides evenly rounded, widest at middle. Sides and base with marginal bead. Scutellum minutely shagreened, lacking punctures. *Elytra*: Surface with 6 rows of punctate, furrowed striae between suture and humeral umbone and 4 distinct rows

of punctate striae on sides; punctures of striae moderate in size, subequal in size to those in posterior angle of pronotum, weakly ocellate. Intervals weakly convex, minutely shagreened, with irregularly spaced, sparse micropunctures. *Pygidium*: Prepygidium densely punctate. Pygidium regularly convex, surface with sparse, moderately sized punctures on disc, extreme base and angles weakly rugopunctate. *Venter*: Thoracic sternites with moderately dense, long, fulvous setae. Abdominal sternites each with transverse row of setae at about middle. Prosternal peg long with blunt apex covered by long setae. *Legs*: Foretibiae tridentate, teeth subequally spaced. Foreclaws slender, simple. Posterior tibiae with 8 small denticles at apex. All femora with 4 rows of setae (1 dorsal, 1 ventral, 1 on each margin). All tibiae each with 2 rows of setae on dorsal surface. Tarsi subequal in length to respective tibiae. *Parameres* (Figs. 5-6): Slender, symmetrical, with small lateral tooth just past middle of shaft. Venter with long setae in apical half on ventral aspect.

Allotype: Length 24.0 mm from apex of clypeus to apex of elytra; width across humeri 11.3 mm. As holotype except in the following respects: Color dark reddish brown. *Head*: Surface sculpturing a little more coarse. Boss on top of head stronger, a little higher. Apical segment of maxillary palpus with sensory depression less than half length of segment. *Pygidium*: Surface only weakly convex. *Legs*: Tarsi shorter than respective tibiae. *Genital plates* (Fig. 7): Ventral plates rounded, rugopunctate, covered with many long, stout setae.

Variation: Males (2 paratypes) (Fig. 8): Length 22.5-23.0 mm; width across humeri 11.5-12.0 mm. Color varies from light to dark reddish brown. Boss on frons a little stronger in both specimens than in holotype, elytral striae more furrowed. Females (2 paratypes): Length 24.0 mm; width across humeri 12.0 mm in both specimens. Both female paratypes are similar to the allotype.

Remarks: *Coscinocephalus tepehuanus* is most readily separated from *C. cribrifrons* by the characters listed in the key. The differences observed between these two species are indicative of recent separation and isolation of one species in the mountains of southeastern Arizona, Sonora, and Chihuahua from the much more southerly species in southeastern Durango. This scenario correlates well with the Pleistocene climatic events that permitted elevational lowering of vegetation. One result of this was that taxa living in the pine/oak associations of the Sierra Madre Occidental in Mexico were able to expand northward to the discontinuous mountains of southern Arizona. Subsequent warming and aridity reestablished the higher elevational gradient supporting pine/oak forests, which effectively created mountain islands harboring, at higher elevations, pine/oak forest (with its associated fauna) in a surrounding sea of lower elevation desert. See Jameson (1990) and Ratcliffe and Deloya (1992) for further information and references on climatic change.

We suggest that the ancestors of both species of *Coscinocephalus* dispersed and subsequently became isolated from one another in this way. Morphological divergence is not yet substantial between the two species due to the relatively recent isolation event. Nevertheless, differences in body structure are already evident, and geographical (hence, reproductive) isolation is now complete.

The limited number of specimens of *Coscinocephalus* collected in Chihuahua and Sonora are conspecific with the Arizona populations even though there is an absence of any mountains high enough to support pine/oak forests between those in southern Arizona and the north end of the Sierra Madre (about 31°N) in Mexico. Deep can-

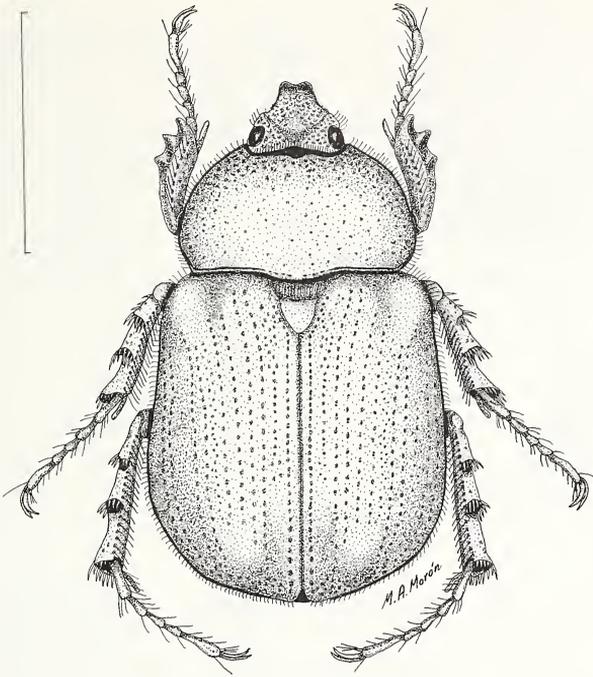
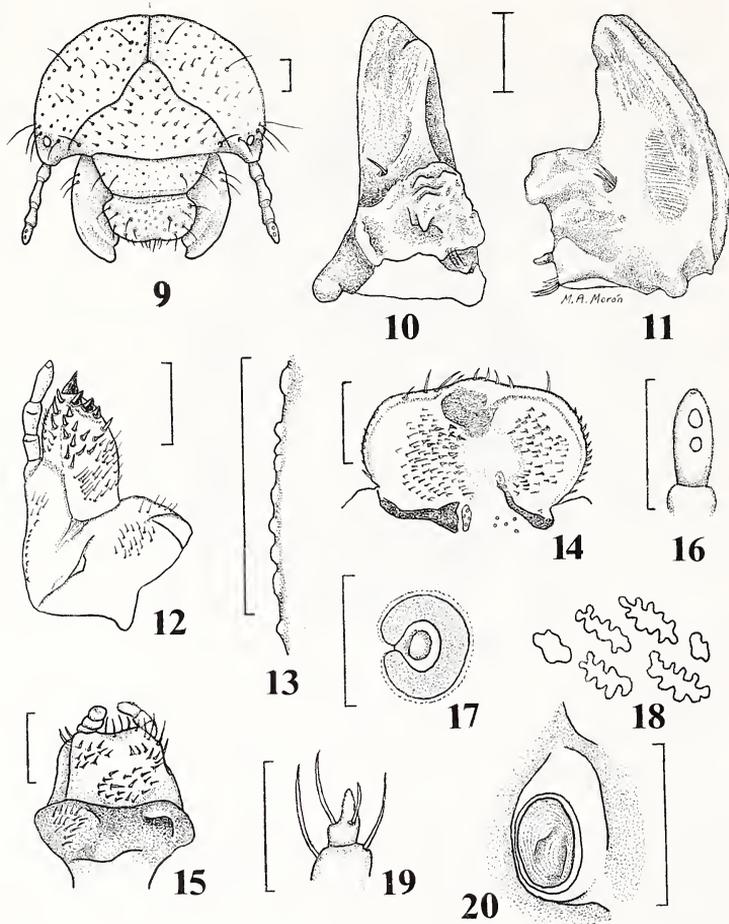


Fig. 8. Habitus of *Coscinocephalus tepehuanus* n. sp. paratype ♂. Scale line = 10 mm.

yons formed by the higher tributaries of Rio del Fuerte and Rio Mezquital (22°–27°N) probably restrict the distribution of *C. tepehuanus* to the southern Sierra de Tepehuanes, Sierra de Durango, or only to the Sierra de Michis (Fig. 21). We predict that *C. tepehuanus* should be found in other areas of southern Durango because suitable habitat exists (dry pine/oak forest). A lack of collecting accounts for the absence of additional specimens of this new species.

Etymology: Derived from *tepehuan*, meaning “the owner of the mountains” (Simeón, 1988). Tepehuans are an ancient, native people of the Nahuatl language group who still live in some parts of the mountains of Durango.

Third-stage larva: *Head:* Maximum width of head capsule 7 mm. Surface of cranium deeply and sparsely punctate, reddish brown. Frons (Fig. 9) with short, fine, sparse setae; each anterior angle of frons with 1 seta; remaining cranial surface with 1 epicranial seta, 1 dorso-epicranial seta, 1 paraocellar seta and 2 supraocellar setae, and some short, fine, sparse setae on each side. Clypeus with 4 lateral setae. Labrum ovate, slightly asymmetrical, with 2 central setae and 2 lateral setae on each side. Ocelli present, not pigmented. Epipharynx (Fig. 14) with haptomeral process entire, very prominent and sclerotized, without posterior setae; chaetoparia with few sensilla; right chaetoparia with 50–60 spinelike setae; left chaetoparia with 40–45 spinelike setae; right acanthoparia with 6 short, spinelike setae; left acanthoparia with 11 short, curvate setae; right gymnoparia wide, without plegmatia; left gymnoparia



Figs. 9-19. *Coscinocephalus tephuanus* n.sp. third-stage larva. 9) Frontal view of cranium. 10) Right mandible, mesad view. 11) Left mandible, ventral view. 12) Left maxilla, dorsal view. 13) Stridulatory area of maxilla. 14) Epipharynx. 15) Labium-hypopharynx. 16) Last antennal segment. 17) III left abdominal spiracle. 18) Form of holes in respiratory plate. 19) Claw of left posterior leg. Fig. 20. *C. tephuanus* pupa, II left abdominal spiracle. Scale lines = 1 mm.

narrowed; acroparia with 4-5 setae; pedium wide; sense cone with 4 sensilla; laeotorma curved toward center of pedium; mesal portion of dextiotormae expanded and fused with the sclerotized plate. Scissorial area of right mandible (Fig. 10) with 2 teeth before scissorial notch and with rounded projection on inner margin; molar area with 3 irregular lobes. Scissorial area of left mandible (Fig. 11) with entire cutting blade before scissorial notch; inner margin with 2 rounded, small projections; molar area with well developed distal lobe (M1); acia acute; brustia well developed; ventral stridulatory area extended, with 35-38 transverse ridges; mesad of stridulatory area is a puncture with 3 stout setae. Galea with well developed, conical, sharply

pointed uncus (Fig. 12); lacinia with 3 terminal unci fused at bases, the inner slightly shorter than others. Maxillary stridulatory area with 8–9 truncate-rounded, small teeth and with a rounded anterior process (Fig. 13). Hypopharyngeal sclerome asymmetrical, strongly produced on right side into rounded process (Fig. 15). Dorsal surface of last antennal segment with 2 oval, small, sensory spots (Fig. 16). *Thorax*: Thoracic spiracles 0.72 mm long and 0.91 mm wide; respiratory plate reddish brown, shaped as a closed “C”; lobes of respiratory plate nearly approximate; spiracular bulla prominent, rounded. Pronotum with well marked, reddish-orange, irregular formed, lateral scleromes with 2 slender fine setae. Dorsa of meso- and metathorax without setae. All legs with similar tarsal claws, claws pointed, each with 1 internal and 1 external basal setae (Fig. 19). *Abdomen*: Abdominal spiracles 0.70 mm long and 0.89 mm wide. Respiratory plate reddish brown, regularly shaped as a closed “C”; lobes of respiratory plate closely approximate (Fig. 17), with a maximum of 38–43 irregular shaped, amoeboid “holes” along any diameter (Fig. 18); spiracular bulla prominent, rounded. Chaetotaxy on dorsum of each segment as follows: I LS1(4); II LS2(2–10), SS4-5(10–16); III–V LS2-3(2–12), SS4-5(20–24); VI LS1(10), SS4-5(20–24); VII–VIII LS1(2); IX–X LS1(6). Venter of segments I–X each with 4LS. Raster without septula and palidia. Lower anal lip with 70–86 medium sized, spinelike setae. Upper anal lip with 26–40 short, spinelike setae and 10–12 long, slender setae.

Pupa: Body shape elongate, oval, stout, exarate. Color reddish orange. *Head*: Head bent sharply beneath thorax, mouthparts directed ventrally; antennae, mandibles, palpi, and compound eyes recognizable. Anterior border of clypeus slightly tumid. *Thorax*: Pronotum nearly transverse. Pterotecae closely appressed, curved ventrally around body, extending posteriorly between abdominal segments II–III. Protibiae with 3 rounded projections on exterior margin. Tarsomeres delineated. *Abdomen*: 9 visible segments. Spiracles of segment I ovate, slightly prominent, hidden by elytra and by oblique pleural fold; spiracles on segments II–IV ovate, annulate, sclerotized, prominent as rounded tubercles (Fig. 20); spiracles on segments V–VIII occluded, rosetiform, not prominent, sclerotized or pigmented. Tergal area of segments I–VI with 5 pair of deep, moderately sclerotized dioneiform organs (*sensu* Costa *et al.* 1988). Last segment with 2 symmetrical, ventrolateral folds; without urogomphi; last sternite and genital ampulla hidden by folds.

KEY TO THE SPECIES OF *COSCINOCEPHALUS* (ADULTS)

1. Color light to dark reddish brown. Elytral striae on disc with weakly ocellate punctures, punctures subequal in size to those in posterior angle of pronotum. Clypeus with lateral edge sinuate between apex and eye canthus. Southeastern Durango, México
 *C. tepehuanus* Morón & Ratcliffe, n.sp.
- 1'. Color dark brown or black. Elytral striae on disc with distinctly ocellate punctures, punctures larger than those in posterior angle of pronotum. Clypeus with lateral edge not sinuate between apex and eye canthus. Southern Arizona, USA; Sonoran and Chihuahuan Sierra Madre Occidental, México (Fig. 21) *C. cribrifrons* (Schaeffer)

Life history: *Coscinocephalus cribrifrons* is uncommonly encountered although it may be locally abundant. Part of the reason for its seeming rarity is the fact that adults have a brief period of frenetic activity only at dusk, and they are not strongly attracted to lights. On certain nights after the onset of the late summer rains, males

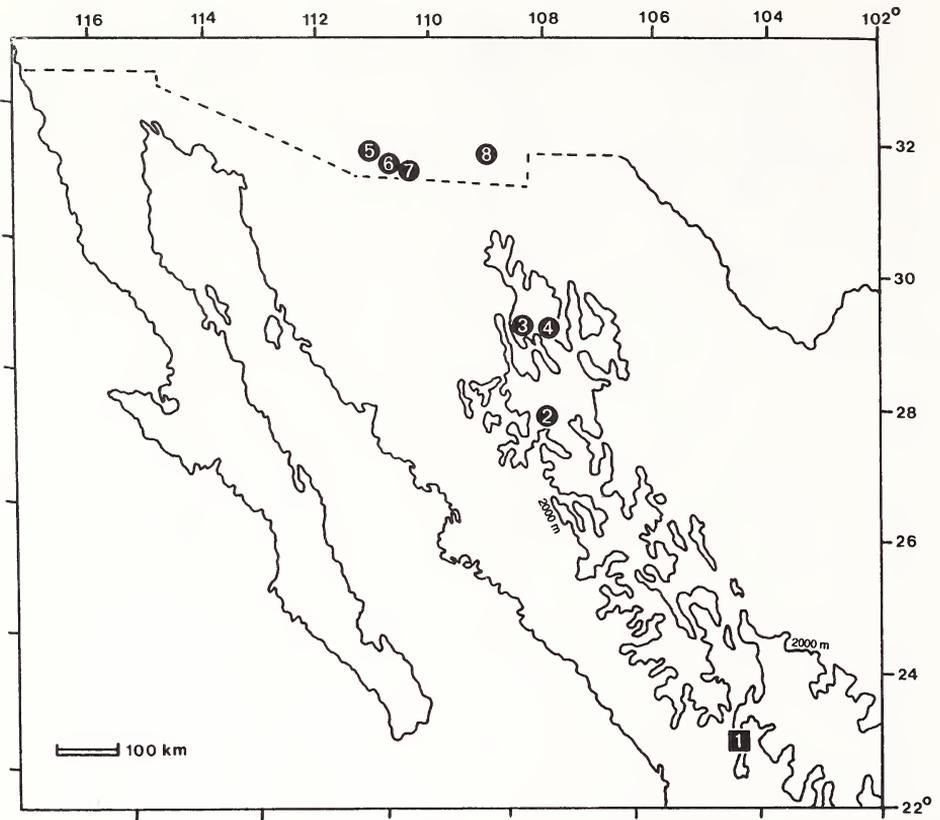


Fig. 21. Known distribution of *Coscinocephalus* species. *C. tepheuanus*: (1) La Michilía, Durango. *C. cribrifrons*: MEXICO: Chihuahua: (2) Creel; (3) Madera; (4) Yepomera; USA: Arizona: (5) Santa Rita mountains; (6) Patagonia mountains; (7) Huachuca mountains; (8) Chiricahua mountains. Base map of northwest Mexico adapted from García & Falcón (1974).

form what are probably mating aggregations. They swarm to a certain tree (Ratcliffe has observed them on pine trees) where they rapidly run up and down the trunk with an audible scratching noise as their tarsi move over the bark. Warner (personal communication to Ratcliffe, November 1994) observed the males gradually ascending to the top of the tree where, presumably, a female or females were releasing pheromones. *Coscinocephalus tepheuanus* probably has similar habits.

We know very little of their life history. The slightly elongated legs seem to us to be an adaptation for their arboreal activities related to mating. We know little of the larvae. Two larvae of *C. tepheuanus* were found in the soil near the roots of a dead oak tree. It is interesting to note that the larvae of *Xyloryctes jamaicensis* (Drury) have been found beneath leaf litter in the soil feeding on roots or microrhizae (Ratcliffe 1991) as have the larvae for *X. thestalus* Bates (Morón 1976). The larvae of *Coscinocephalus* species may be feeding on the roots of live oak trees.

The mouthparts of the adults suggest a soft diet such as sap or perhaps pollen. There are no teeth on the mandibles and maxillae for cutting or chewing, and the labrum is reduced. If we eliminate the sap of pines (*Pinus* spp.) as having too many unpalatable secondary compounds, the next most likely sources of food in these habitats are Fagaceae and Erycaceae: oaks (*Quercus* spp.), madrones (*Arbutus* spp.), and "manizallas" (*Arctostaphylos* spp.).

KEY TO THE AMERICAN GENERA OF PENTODONTINI BASED ON
KNOWN THIRD-STAGE LARVAE
(Modified from Ritcher 1966; Morón 1976; Morón & Deloya 1991;
Lumaret 1991; Morelli 1992)

1. Raster with palidia and septula 2
- 1'. Raster without palidia and septula 3
2. Palidia monostichous, nearly parallel, each palidium consisting of 7–10 strongly compressed pali whose tips are slightly hooked. Last segment of antenna with 2 dorsal sensory spots. Ocelli present. Surface of cranium chestnut brown. Maximum width of head capsule 4.37 mm *Eutheola*
- 2'. Palidia polystichous, each palidium consisting of a patch of 5–7 irregular, longitudinal rows of sharp, cylindrical, spine-like setae. Palidia and septula extending across lower anal lip. Last segment of antenna with 2–4 dorsal sensory spots. Ocelli present. Surface of cranium reddish. Maximum width of head capsule 6.5 mm *Ligyris* (*Ligyroides*)
3. Inner margin of left mandible (between scissorial and molar areas) with a small tooth 4
- 3'. Inner margin of left mandible smooth between scissorial and molar areas 8
4. Last antennal segment with 2 dorsal sensory spots 5
- 4'. Last antennal segment with 5–8 dorsal sensory spots 7
5. Spiracles of abdominal segments I–VIII similar in size 6
- 5'. Spiracles of abdominal segments I and VIII slightly smaller than those of abdominal segments II–VII, which are similar in size. Surface of cranium light brown, slightly roughened, reticulate, without distinctive pits. Maximum width of head capsule 4.8 mm *Ligyris* (*s.str.*)
6. Color of cranium yellowish-brown, surface with numerous small pores. Each side with 1 prominent, exterior frontal seta. Ocelli vague. Maximum width of head capsule 3 mm *Oxygrylius*
- 6'. Color of cranium reddish brown, surface deeply and sparsely punctate. Each side without exterior frontal setae. Ocelli present, well defined. Maximum width of head capsule 7 mm *Coscinocephalus*
7. Epicranium with a transverse, roughened carina extending to supraocellar areas. Last antennal segment with 5–6 dorsal sensory spots. Ocelli absent. Surface of cranium dark brown. Maximum width of head capsule 4.7 mm *Neoryctes*
- 7'. Epicranium smooth. Last antennal segment with 8 dorsal sensory spots. Ocelli small. Surface of cranium reddish brown. Maximum width of head capsule 7.2 mm *Diloboderus*
8. Last antennal segment with 1–2 dorsal sensory spots. Spiracles of abdominal segments I–IV similar in size; those of abdominal segments V–VIII progressively smaller posteriorly. Frons with dense covering of setae 9
- 8'. Last antennal segment with 4–5 dorsal sensory spots. Spiracles of abdominal segments I–VIII similar in size. Frons with sparse, short setae only in anterior half. Surface of cranium chestnut brown. Maximum width of head capsule 6.8 mm *Philoscaptus*

- 9. Maximum width of head capsule 6–6.5 mm. Distance between lobes of respiratory plate of spiracles much less than dorsoventral diameter of bulla *Orizabus*
- 9'. Maximum width of head capsule 3.8–5.2 mm. Distance between lobes of respiratory plate of spiracles slightly to much less than dorsoventral diameter of bulla . . . *Aphonus*

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**MORPHOLOGICAL CASTE DIFFERENCES IN NEOTROPICAL
SWARM-FOUNDING POLISTINAE WASPS.
V—*PROTOPOLYBIA EXIGUA EXIGUA*
(HYMENOPTERA: VESPIDAE)**

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Abstract.—A slight dimorphism between queens and workers and intermediates was found in a colony of *Protopolybia exigua exigua* collected in Pedregulho, southeastern Brazil. Mean sizes of all nine measured body parts of queens ($n = 30$) were statistically larger than those of workers and intermediates. Canonical discriminant analysis also showed some differentiation among them, with Mahalanobis' intercaste distance (D^2) 4.95 between queens and workers, 5.63 between queens and intermediates and 1.84 between intermediates and workers.

Key words: Vespidae; Polistinae; *Protopolybia exigua exigua*; caste differences; multivariate analysis.

Among many fascinating aspects underlying colonial organization in social insects, caste related problems are surely outstanding. On such matters the most impressive aspect involves the diversity of caste patterns that, in turn, suggests the plasticity of evolutionary strategies leading to them. Neotropical swarm-founding Polistinae, in which polygyny is a rule, have remained less explored, mainly due to the difficulty of studying them continuously under both experimental and natural conditions. On the other hand, to some extent reliable sociological and biological information about these wasps can be obtained by analyzing a sample of wasps taken from a particular nest. This is especially true for caste differentiation and related phenomena.

Caste differentiation in Polistinae is not pronounced (Richards, 1978). However, the Epiponini tribe has been morphometrically analyzed and, as pointed out by Richards (1971, 1978; Richards and Richards, 1951), at least three caste differentiation stages are found: 1-Conspicuous size and allometric differences present, with queens larger than workers in the absence of intermediates (sense Richards and Richards, 1951) (*Agelaia* spp: *A. areata*, Jeanne and Fagen, 1974; *A. pallipes* and *A. multipicta*, Simões et al., in prep.; *A. vicina*, Noll et al., in prep.; *Protonectarina sylveirae*, Shima et al., 1996b); 2-Conspicuous dimorphism present, with queens smaller than workers and no intermediates present (*Apoica flavissima*, Shima et al., 1994; *Polybia dimidiata*, Maule-Rodrigues and Santos, 1974; Shima et al., 1996a); 3-Morphological differences slight or indistinct, and intermediates present (*Pseudopolybia vespiceps*, Shima et al., in prep.). Evidently this group remains biometrically very little explored. Most of the relevant papers (e.g. Richards and Richards, 1951; Richards, 1971, 1978) aimed primarily at caste distinction for taxonomical purposes, and so only characteristics supposedly more reliable for such aims were emphasized.

The employment of a standardized methodology, as in multivariate analysis, has supported the establishment of patterns for the comparison of caste differentiation among the epiponine. Morphometric analysis on a *Protopolybia exigua exigua* colony are reported here showing that queens are slightly larger than workers and intermediates.

MATERIAL AND METHODS

The whole population, consisting of workers, intermediates and queens, was taken from a young colony of *Protopolybia exigua exigua* (de Saussure) collected in Pedregulho (Southeastern Brazil) on Feb. 2, 1995. In order to detect morphological differences between castes the whole population was measured under a binocular microscope. The measured body parts were: head width (HW), minimum interorbital distance (IDm), gena width (GW), width of mesoscutum (MSW), alitrunk length (AL), length of gastral tergum I (T_1L), basal height of T_1 (T_1BH), basal width of tergum II (T_2BW), and partial length of the forewing (distance between the anterior edge of the first submarginal cell and the final margin of the marginal cell) (WL). The numerical data were statistically analyzed in relation to the ovarian and spermathecal states. The statistical analysis including the canonical discriminant analysis (CDA: Rao, 1973) were performed with the SAS Program Package for PC computers, and Kruskal-Wallis One Way analysis of variance on ranks was used in order to detect caste differences for each character. If differences were detected, Dunn's method for multiple comparison was performed using the program Sigma Stat for Windows version 1.0.

RESULTS

Nests and related aspects: *P. exigua exigua* occurs from NW South America (Colombia, Bolivia) to Southern Brazil (Richards, 1978) and, according to him: "the nests consist of a comb suspend from a leaf or branch by one or more peduncles and surrounded by an envelope in the side or bottom of which is an exit-hole; the envelope is attached to the sides of the combs. When there are additional combs they are built on the envelope of the previous one with a new envelope and exit hole. Generally, only one comb is found but one additional one is not rare."

The one-combed analysed nest (Fig. 1) had 307 cells in which 46 contained only eggs indicating the precocious state of the nest. It was attached by one principal peduncle and two auxiliaries ones. Concerning population size it was counted at 28 workers, 37 intermediates and 30 queens.

Ovarian development and insemination: In the analyzed sample three kinds of ovary development were recognized (Fig. 2): type A, developed ovarioles bearing from two to several mature oocytes, type B, ovarioles with some oocytes at the beginning of development and/or some in final phase of vitellogenesis and, type C, filamentous ovarioles bearing from no visible to slightly developed oocytes. Since only in the A type females the spermatheca contained sperm, females with ovaries A, B and C can be characterized as queens, intermediates and workers, respectively. As a probable consequence of the colony's early stage, differences in the ovary condition between queens and intermediates were not clear and, in some cases, only insemination distinguished queens and intermediates.



Fig. 1. Nest of *Protopolybia exigua exigua*. (Scale bar = 1.0cm).

Caste differences in relation to morphometry: Among the mean relationships of the 9 analysed characters (Table 1), all of them show the comparisons between queen-worker and queen-intermediate significantly different. In contrast, intermediate-worker comparisons were not significantly different ($p < 0.05$).

The result of the canonical discriminant analysis based on 9 morphological char-

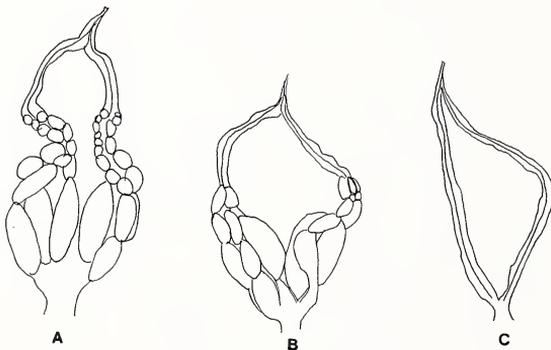


Fig. 2. Kinds of ovary development found among the females of *Protopolybia exigua exigua*. A, developed ovaries found in inseminated females; B, developed ovaries found in uninseminated females (intermediates) and C, undeveloped ovaries found in uninseminated females (workers). (Scale bar = 1.0mm).

Table 1. Means, CAN₁ and CAN₂ values and observed values of Dunn's test for 9 characters used for discriminating castes of *Protopolybia exigua exigua*.

Characters	Means (mm)			Dunn's Method (Difference on Ranks)				CAN ₁		CAN ₂	
	Queens (n = 52)	Workers (n = 34)	Interme- ditaries (n = 40)	Q/W	Q/I	I/W	Raw	Stand- arized	Raw	Stand- arized	
Head											
HW	3.54 ± 0.04	3.49 ± 0.06	3.49 ± 0.03	23.7*	30.8*	7.00	0.68	0.03	-10.71	0.55	
IDm	2.20 ± 0.05	2.13 ± 0.08	2.15 ± 0.05	18.6*	26.0*	7.44	-3.35	-0.23	8.63	0.58	
GW	0.60 ± 0.04	0.56 ± 0.05	0.57 ± 0.03	19.9*	22.8*	2.91	1.02	0.04	-2.37	-0.10	
Mesosoma											
MSW	2.57 ± 0.07	2.50 ± 0.07	2.48 ± 0.06	24.1*	30.3*	6.22	4.45	0.33	-2.59	-0.19	
AL	2.76 ± 0.06	2.65 ± 0.11	2.63 ± 0.06	30.8*	35.5*	4.63	0.02	0.002	-1.26	-0.12	
Metasoma											
T ₁ L	2.59 ± 0.06	2.46 ± 0.10	2.44 ± 0.11	34.9*	40.7*	5.81	5.71	0.65	-3.13	-0.36	
T ₁ BH	0.55 ± 0.03	0.48 ± 0.05	0.48 ± 0.03	37.0*	38.2*	1.24	16.67	0.80	5.63	0.27	
T ₂ BW	1.65 ± 0.05	1.58 ± 0.09	1.55 ± 0.06	25.1*	36.1*	11.0	-0.14	-0.01	-7.31	-0.59	
Wing											
WL	4.56 ± 0.07	4.41 ± 0.13	4.45 ± 0.10	29.3*	38.0*	8.68	0.50	0.06	10.36	1.22	

* statistically significant

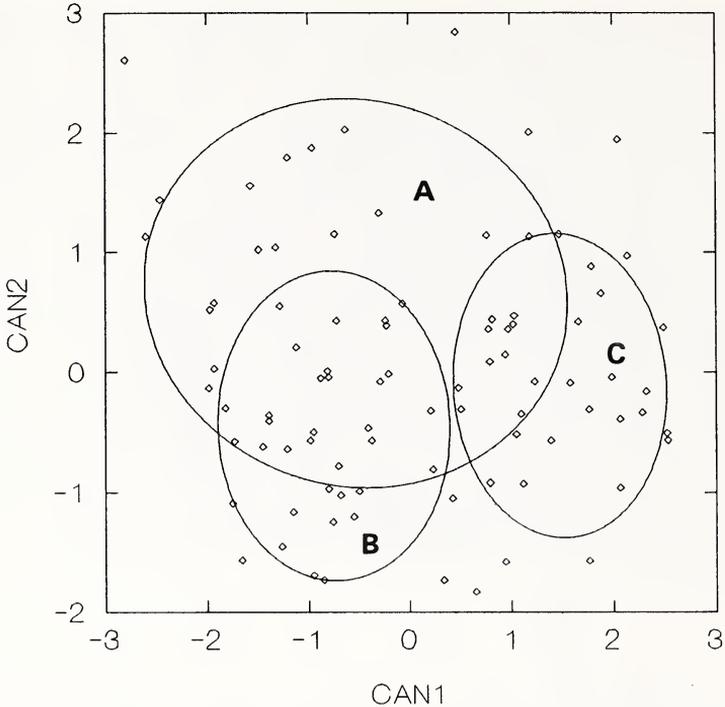


Fig. 3. Discrimination among intermediates (A), workers (B) and queens (C) of *Protopolybia exigua exigua* based on the canonical discriminant analysis using 9 metric characters. Each ellipse encompasses 67% of the variation found in each group.

acters suggests slight dimorphism between queens and, workers and intermediates. Queens showed higher values of the first canonical variable (CAN_1) than workers and intermediates (-0.36 to 3.44 vs. -2.8 to 2.12 and -3.0 to 1.0 , respectively) (Fig. 3). On the other hand, intermediates showed higher values of the second canonical variable (-1.80 to 3.00), than queens (-1.80 to 2.20) and workers (-4.20 to 1.00). According to Figure 3 queens are different but slightly from workers and intermediates.

To calculate CAN_1 and CAN_2 the following equations were used:

$$\begin{aligned}
 CAN_1 = & 0.68(HW - 3.50) - 3.35(IDm - 2.16) + 1.02(GW - 0.58) \\
 & + 4.45(MSW - 2.51) + 0.02(AL - 2.68) + 5.71(T_1L - 2.49) \\
 & + 16.67(T_1BH - 0.50) - 0.14(T_2BW - 1.59) + 0.50(WL - 4.48)
 \end{aligned}$$

$$\begin{aligned}
 CAN_2 = & -10.71(HW - 3.50) + 8.63(IDm - 2.16) - 2.37(GW - 0.58) \\
 & - 2.59(MSW - 2.51) - 1.26(AL - 2.68) - 3.13(T_1L - 2.49) \\
 & - 5.63(T_1BH - 0.50) - 7.31(T_2BW - 1.59) + 10.36(WL - 4.48)
 \end{aligned}$$

Table 2. Classification results for group comparisons through discriminant analysis in *Protopolybia exigua exigua*. (Other explanations in the text).

Actual group	Predicted Group frequency (percentage)			Total
	Workers	Intermediates	Queens	
Workers	12 (42.86)	8 (28.57)	8 (28.57)	28 (100.00)
Intermediates	12 (32.43)	23 (62.16)	2 (5.41)	37 (100.00)
Queens	1 (3.33)	0 (0.00)	29 (96.67)	30 (100.00)

For determining CAN_1 (Table 1), minimum interorbital distance (IDm), width of mesoscutum (MSW), length of gastral tergum I (T_1L), and, especially, basal height of T_1 (T_1BH), were the most important among the characters examined and in CAN_2 , head width (HW), minimum interorbital distance (IDm), basal width of tergum II (T_2BW), and, especially, wing length (WL) were the most important among the characters examined. The Mahalanobis distances (D^2 : Anderson, 1968) calculated through the CDA were 4.95 between queens and workers, 5.63 between queens and intermediates and, 1.84 between intermediates and workers. These values indicate slight separation between inseminated (queens) and uninseminated (workers and intermediates) females. At the same time, workers and intermediates were not significantly differentiated, as suggested above.

Comparing actual groups with predicted groups through discriminant analysis (Table 2) it is evident that, although the values of Mahalanobis distances are low, queens form together a distinct group (96.67%) while workers and intermediates are scattered among the three predicted groups, but intermediates are more distinct (62.16%) than workers (42.86%).

DISCUSSION

Protopolybia exigua exigua presents slight caste differentiation between queens and uninseminated females (workers and intermediates), at least in the early stages of nest development, as compared to other taxa, for example *Agelaia* spp (*A. flavipennis*, Evans and West-Eberhard, 1970; *A. areata*, Jeanne and Fagen, 1974; *A. pallipes* and *A. multipicta*, Simões et al., in prep.; *A. vicina*, Noll et al., in prep.) that have well-developed caste differentiation and intermediates absent. Notwithstanding, group comparisons (Table 2) showed queens as the unique well defined group and intermediates and workers less differentiated. In addition, workers and intermediates are also slightly separated by CAN_2 , values what suggest that these two groups are not well-defined and the intermediates could be a workers' ovary-development phase as suggested by Simões (1977).

The role of the intermediates remains largely unknown (Richards, 1978). Recent studies have provided some new insights about them. There are direct observations on their frequent egg-laying and oophagy in *Protopolybia exigua* (Simões, 1977) and *P. acutiscutis* (Naumann, 1970). Presently, ongoing morphological studies on caste differences have been providing interesting results on their distribution, morphological and physiological identities, etc. Intermediates were detected in *Protopolybia acutiscutis* (cited as *P. pumila* by Naumann, 1970), *P. pumila* (Letizio-

Machado, 1972), *P. exigua exigua* (Letizio-Machado, 1974; Simões, 1977), *Brachygastra lecheguana* (Letizio-Machado et al., 1988) and *B. scutellaris* (Carpenter and Ross, 1984); which have quite distinct morphological castes. In addition, intermediates are equally frequent in groups with caste scarcely evident on morphological grounds only (Richards and Richards, 1951; Richards, 1978).

Caste differences in Epiponini can be ordered into three main groups (see introduction). Compared to other taxa that have been studied *P. exigua exigua* has slight caste-differentiation and presents intermediates comparable to *Pseudopolybia vespiceps* (Shima et al., in prep.). However, different from *P. vespiceps*, *P. exigua* has queens more distinct from workers and intermediates (in *P. vespiceps* intermediates are more distinct), which is comparable to *Protonectarina sylveirae* (Shima et al., 1996b) and higher Mahalanobis distances (1.51, 1.12 and 0.99 for queens-intermediates, intermediates-workers and queens-workers, respectively, for *P. vespiceps*.) suggesting that *P. exigua* shows a more clear-cut caste differentiation than *P. vespiceps*.

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**A NEW SPECIES OF *CHAROXUS*
(COLEOPTERA: STAPHYLINIDAE) FROM NATIVE FIGS
(*FICUS* SPP.) IN FLORIDA**

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Abstract.—Adults of *Charoxus spinifer* Frank, from Florida, USA are described and illustrated. They bring to six the number of species in this Neotropical genus which is here transferred to the tribe Athetini (Coleoptera: Staphylinidae: Aleocharinae). Adults of *C. spinifer* were collected at ultraviolet light at night, in flight before dusk, and in syconia (fruits) of *Ficus aurea* Nuttall and *F. laevigata* Vahl (*F. citrifolia* P. Miller sensu DeWolf 1960), two fig species native to Florida, before the fruits ripened and fell from the trees. They are associated in fig syconia with adults of fig-pollinating wasps (Agaonidae) and other hymenopterous inhabitants and have been observed to prey on the wasps.

This paper was prompted by the acquisition in south Florida in 1983 of a series of adults of an undescribed species of *Charoxus*, a genus of uncertain systematic position within Aleocharinae. Five species of *Charoxus* already were described from the Neotropical region, and some of these were believed to be in some way associated with *Ficus* syconia (Kistner 1981).

Investigation of the ecology and behavior of *C. spinifer* still is incomplete and will be presented in a later paper. Bronstein (1988) showed that *Charoxus bicolor* Kistner is a predator of fig wasps (Hymenoptera: Agaonidae) in syconia of *Ficus pertusa* L. in Costa Rica. The new species is described here.

MATERIALS AND METHODS

Specimens were examined under reflected light microscopes and drawings were made using a linear scale in one eyepiece. Dissections were made in dilute alcohol, the dissected parts were dehydrated in xylene, mounted in Canada balsam on microscope slides, and drawn with the aid of a camera lucida attached to a Zeiss compound microscope.

CHAROXUS SHARP, 1883

The type species is *C. fodiens* Sharp (1883), described from one male specimen from Panama. Neither additional species nor new distributional records were added until Kistner (1981) redescribed the genus and described four new species. Two of these are known from both Mexico and Jamaica, one from Paraguay, and one from Costa Rica. Specimens of two of the species were collected from *Ficus* trees.

Charoxus spinifer Frank, new species

Figs. 1-3

Description: Length 3.0-3.6 mm. Robust, cylindrical head and thorax, with abdomen linear and feebly inflated (Fig. 1). Head and pronotum ferruginous but in some individuals entire pronotum and head except for frontal area darkly infuscate. Elytra with metallic luster, pale golden over most of their surface, but with scutellum and basal fifth, and apical quarter diagonally, darkly infuscate (Fig. 3a). Abdomen pale ferruginous but much of surface darkly infuscate, with segment VI very darkly infuscate leaving only paratergites and narrow apical border of some specimens paler, other segments less infuscate at least apically. Antennae, mouthparts and legs ferruginous but with femora and tibiae and apical half of last antennomere infuscate.

Head quadrate, its surface covered with moderate punctures separated by $<2\times$ their diameter, surface between punctures with strong isodiametric microsculpture, the punctures bearing short, fine setae; eyes large and \pm equal in length to tempora; frontal suture absent; postclypeus extremely short, frons transverse, and thus antenna inserted at lateral corner of vertex; gular sutures parallel and separate throughout; maxillary acetabula extending as far posteriorly as posterior tentorial pits (which have a forward location relative to their position in some other members of the family); completely margined latero-ventrally by postgenal carina. Inner margin of right mandible with 2 teeth, the proximal one much broader and blunter; inner margin of left mandible without teeth. Maxillary palpus of 4 articles; galea slightly longer than lacinia and with apical tuft of fine setae; lacinia fringed medially with fine setae (Fig. 2a). Labial palpus of 3 articles; basal article longer than second, shorter than apical; apical article with terminal group of minute sensilla; ligula with median cleft (Fig. 2a). Antennomeres I-II slightly elongate, III quadrate, IV-X transverse, VII-X strongly so, XI capitate and without coeloconic sensilla. Pronotum slightly longer than broad, slightly broader than head, hind angles obtuse and rounded to base, punctate and sculptate as head, anterior margin bearing 1 pair of dark macrosetae and lateral margins 4 pairs. Mesosternal process about as long as metasternal and narrowly separated from it; mesocoxae narrowly separated, with margined acetabula; posterior coxae transverse; metasternum with a longitudinal row of about 12 punctures on each side of midline. Scutellum punctate as pronotum. Elytra glossy, the pale area with golden metallic luster, without microsculpture, punctures sparse, not arranged serially, with short, pale, fine setae, with a pair of dark macrosetae at anterior angles. Wings present, functional.

Abdominal tergites sparsely punctate, feebly sculptate except for VII and VIII, posterior margins of IV-VI each with 3 pairs of dark macrosetae, III with 2 pairs, posterior margin of tergite IV of male with a pair of strong spine-like processes (Fig. 2b); tergite VII of male with broad, U-shaped, median, elevated area (better developed in some specimens than in others), bearing a small tubercle just anterior to posterior margin, this tergite with 3 pairs of dark macrosetae anterior to apical margin (Fig. 2c); setal arrangement in female similar but tergite lacks U-shaped area and tubercle; tergite VIII of male and female similar, truncate apically, with 5 pairs of dark macrosetae (Fig. 2d); tergite IX of female divided longitudinally to accept tergite X, dentate apico-laterally, with 4 pairs of dark macrosetae, tergite X rounded

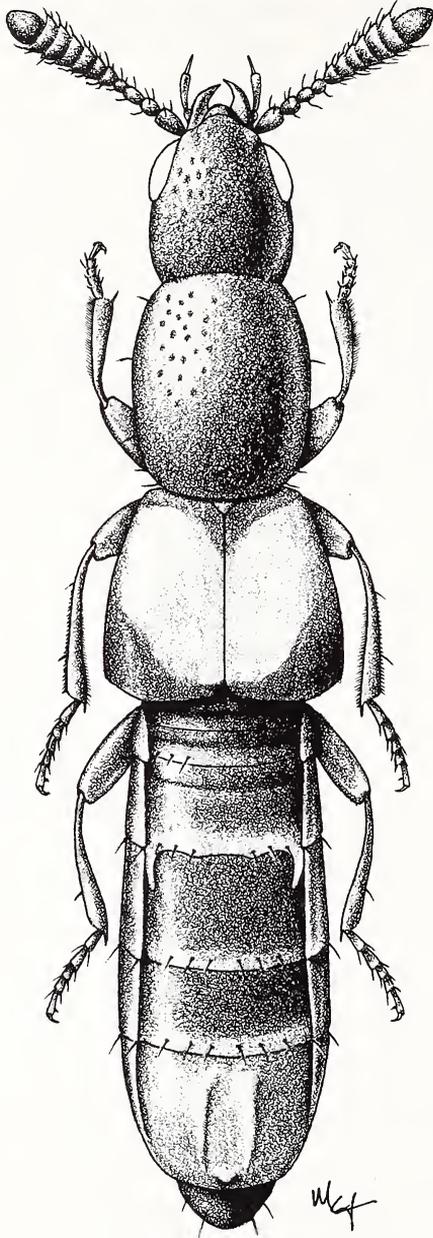


Fig. 1. Habitus of male *Charoxus spinifer*. Length 3.0-3.6 mm.

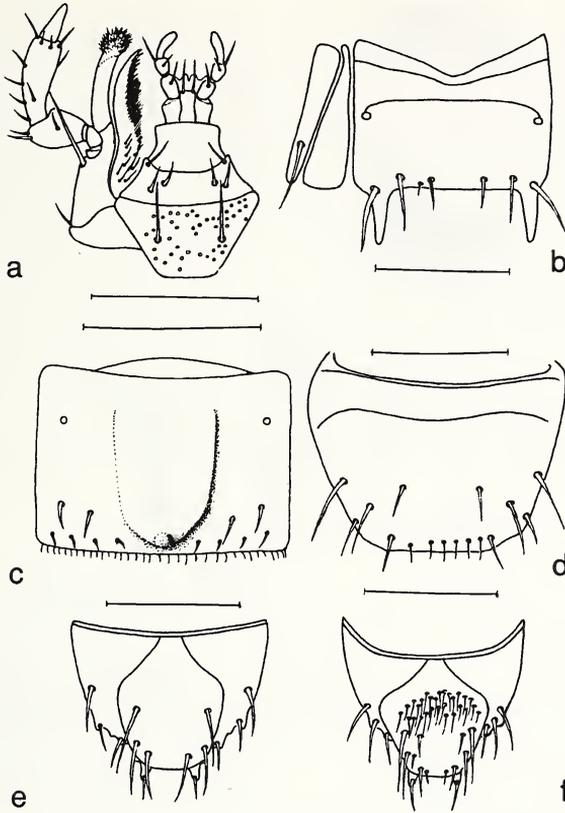


Fig. 2. Structures of *Charoxus spinifer*: (a) right maxilla and labium from below; (b) tergite IV of male with left paratergite and parasternite; (c) tergite VII of male; (d) tergite VIII of female; (e) tergites IX and X of female; (f) tergites IX and X of male; (g) protibia and tarsus; (h) mesofemur, tibia and tarsus; (i) metafemur, tibia and tarsus; (j) spermatheca; (k) lateral view of median lobe of aedeagus (AB = athetine bridge); (l) ventral view of median lobe of aedeagus with parameres. Scale line = 0.25 mm.

apically, with 3 pairs of dark macrosetae (Fig. 2e); tergites IX and X of male similar to those of female except that X bears a central group of pale setae (Fig. 2f).

Tarsi 4-5-5 segmented; protibia bordered externally with a row of short, stout spines (Fig. 3b); mesotibia bordered externally with a row of short spines which are less stout than those of protibia, and with 2 longer setae (Fig. 3c); metatibia without row of short spines but with a single long spine, basal article of metatarsus about equal in length to apical, slightly longer than article II, as long as III and IV together (Fig. 3d).

Spermatheca sclerotized (Fig. 3e). Median lobe of aedeagus strongly curved and bulbous partially divided, each paramere with 4 apical setae (Fig. 3f, g).

Types: A total of 84 adult specimens each glued with water-soluble glue to a 3 × 10 mm card rectangle; some of them partially dissected, with parts mounted in

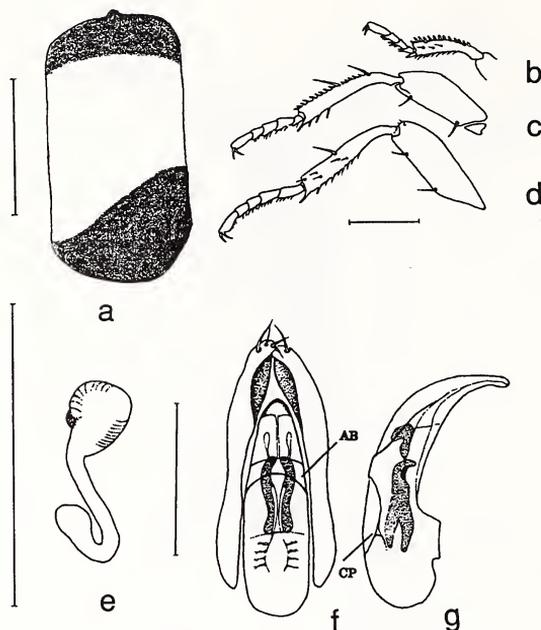


Fig. 3. Structures of *Charoxus bicolor* (a) and *C. spinifer* (b-g): *C. bicolor* (a): right elytron. *C. spinifer*: (b) protibia + protarsus; (c) mesotibia + mesotarsus; (d) metatibia + metatarsus; (e) spermatheca, (f) ventral view of median lobe of aedeagus with parameres (AB = athetine bridge); (g) lateral view of median lobe of aedeagus with one paramere removed (CP = compressor plate). Scale line = 0.25 mm.

Canada balsam on a celluloid rectangle beneath the card rectangle; parts of two specimens mounted on microscope slides. Labels: /USA, Florida, Dade Co., Camp Mahachee, 6-IX-1983 [31 specimens thus, 55 specimens 14-IX-1983]/ u.v. light trap, L. Parker/ *Charoxus spinifer* Frank HOLOTYPE [or PARATYPE]/. Holotype male and 4 paratypes in the Florida State Collection of Arthropods, others to be placed as follows: 4 paratypes in the Field Museum of Natural History, 4 in the Canadian National Collection, 4 in the British Museum (Natural History), 4 in the U.S. National Museum of Natural History, 4 in the Snow Museum (University of Kansas), the remainder in the collection of J. H. Frank.

Type locality: U.S.A., Florida, Dade Co., Camp Mahachee. This is an area of tropical hardwood trees, including *Ficus aurea*, adjoining Matheson Hammock park.

Etymology: The specific epithet was chosen because of the pair of spine-like processes of tergite IV of the adult male. Elsewhere in Staphylinidae it has been used for *Eupiestus spinifer* Fauvel and *Phytosus spinifer* Curtis.

Diagnosis: Specimens have been compared directly only with specimens of *C. bicolor*; comparative information on the other species is taken from Kistner (1981). This is the only known species of the genus in which tergite IV of the male has paired spine-like processes. It differs from *C. hermani* Kistner [most other species were not examined in detail because of insufficiency of specimens from which to

make slide preparations (Kistner 1981)] in that the labial palpus has 3 articles and lacks an apical pseudosegment, and in that it is the right maxilla (not the left) which has 2 teeth on the interior margin. It differs from *C. hermani* and *C. bicolor* Kistner in that only the male (not the female) has a group of pale macrosetae on tergite X [compare Fig. 2e and 2f with Fig. 3d, 3e in Kistner (1981)]. Specimens may be distinguished from those of other described species by the key below, modified from Kistner (1981).

Natural history: The specimens of the type series were collected at ultraviolet light operated for M. C. Thomas. An adult ♀ landed on the wrist of H. Nadel, at an *F. aurea* tree in Miami, Dade Co., at 6 p.m. on 20-V-1991. An adult ♀ was taken from a syconium of *F. laevigata* on Key Largo, Monroe Co., on 26-IX-1988 by H. Nadel, a ♂ from a syconium of *F. aurea* in Miami on 11-V-1989 by J. H. Frank and H. Nadel, three adults from syconia of *F. aurea* in Miami on 27-II-1991 by C. M. Mannon and L. Mason, and numerous adults from syconia of *F. aurea* in Miami on 10-14-V-1994 by J. H. Frank and H. Nadel. Dissected syconia yielded observations of adults feeding on adults of *Pegoscapus* and *Idarnes* (Chalcidoidea).

KEY TO ADULTS OF SPECIES OF *CHAROXUS*

- | | | |
|----|---|--------------------------------|
| 1 | Head smooth between many deep punctures | 2 |
| 1' | Head with microsculpture between punctures | 3 |
| 2 | Tergite VI with 6 macrosetae (middle 2 shorter and more slender than others) | |
| | | <i>C. major</i> Kistner |
| 2' | Tergite VI with 8 macrosetae | <i>C. fodiens</i> Sharp |
| 3 | Tergites VI–VII with 2 macrosetae | 4 |
| 3' | Tergites VI–VII with 6 macrosetae | 5 |
| 4 | Elytral apex dark (center pale, base dark) | <i>C. bicolor</i> Kistner |
| 4' | Elytral apex pale (center and base dark) | <i>C. blackwelderi</i> Kistner |
| 5 | Elytra pale with small, lateral dark spot anterior to outer apical angle | |
| | | <i>C. hermani</i> Kistner |
| 5' | Elytra pale with base and outer apical angle dark (Fig. 1); tergite IV of ♂ with pair of prominent spines (Fig. 1); microsculpture between pronotal punctures strong; tergite VIII of ♂ and ♀ truncate apically (Fig. 2d); aedeagus as in (Fig. 3f, g); spermatheca as in Fig. 3e | <i>C. spinifer</i> Frank |

DISCUSSION

This discussion mainly concerns tribal placement of *Charoxus* in the subfamily Aleocharinae. Sharp (1883) was unsure of its placement, but noted resemblance to the Old World genus *Porus* Westwood, now in the tribe Lomechusini. An illustration of an adult of *Porus bissauensis* Pace (Pace 1988:22) is evocative of this resemblance. Kistner (1981) placed it in Aleocharini.

Charoxus spinifer traces to Lomechusini (as Zyrasini) in the key to tribes given by Lohse (1974) and has the characters of the tribe Lomechusini as given by Lohse (1974) as well as agreeing to some extent with the longer tribal description of Lomechusini (as Myrmedoniini) as given by Seevers (1978). Application of the tribal name Lomechusini for the name Zyrasini as used by Lohse (1974) and Kistner (1981), and for the name Myrmedoniini as used by Sharp (1883) and Seevers (1978),

is explained by Newton and Thayer (1992). Application of the tribal name Athetini for the name Callicerini as used by Lohse (1974) is also explained by Newton and Thayer (1992). Application of the tribal names Homalotini and Phytosini below also follows Newton and Thayer (1992).

Because of the presence of an additional (4th or pseudo-) segment of the labial palpus in *C. hermani*, and because of the structure of the antenna, the antennal insertion, the structure of abdominal segment IX, and the shape of the meso- and metanotum, Kistner (1981) transferred *Charoxus* from Lomechusini to Aleocharini. Kistner (1981) admitted that the position in Aleocharini is anomalous because Aleocharini have 4 articles in the labial palpus and 5 in the maxillary palpus, and he thought a new tribe may have to be named to contain it. Our finding of only 3 articles in the labial palpus of *C. spinifer* makes the position in Aleocharini even more anomalous. The tribal name Aleocharini is used differently by different authors. Kistner (1981) used it in the broader sense of Lohse (1974) and not the narrower sense of Seevers (1978). Seevers (1978), ambiguously, separated genera with tarsal formula 4-5-5 from Aleocharini as the tribe Hoplandriini, even though he stated that tarsal formula is not a tribal character.

Of the other generic characters used by Kistner (1981) in assigning *Charoxus* to Aleocharini, none was used in defining Aleocharini by Lohse (1974), or Aleocharini or Hoplandriini by Seevers (1978).

Adult *Charoxus* bear a superficial resemblance to *Rhopalocerina* Reitter [tribe Homalotini] (see Lohse 1974:41). The spinose pro- and mesotibiae resemble those of *Phytosus* Curtis [tribe Phytosini] (see Lohse 1974:40) and *Acanthostilbus* Cameron and *Porus* [tribe Lomechusini] (see Cameron 1939). The spine-like processes of tergite IV as well as the tubercle of tergite VII of the male of *C. spinifer* are reproduced in the male of *Zyras nigripennis* Bernhauer (see Cameron 1939:510) [tribe Lomechusini]. The fine, fringing setae of the maxillary galea (as in *Charoxus*) are used as a key-character by Lohse (1974) to separate Lomechusini from Oxyopini-Falagriini-Athetini (but see Sawada 1984:451 and Pace 1984:317 who show this character in Athetini). Margined mesocoxal acetabula [as noted by Kistner (1981) in *Charoxus*] occur in many tribes, but not in some termitophiles and myrmecophiles (Seevers 1978). The above characters do not suggest that *Charoxus* belongs to Aleocharini, but rather to Athetini or Lomechusini.

In Aleocharinae, the ventral side of the median lobe [the aspect opposite the vas deferens, *vide* Tikhomirova (1973)] bears a sclerotized compressor plate, continuous proximally with the bulb, and attached to the median lobe laterally and distally by a thin membrane. The function of this compressor plate, which is attached to the internal dorsal surface of the median lobe by dorsoventral muscles, is to increase hydrostatic pressure within the median lobe and to cause eversion of the internal sac. Distal to the compressor plate on the ventral surface in Athetini alone (Seevers 1978), the sides of the median lobe are connected by a transverse, sclerotized strip, the "athetine bridge". Seevers (1978) credited this athetine bridge as the most promising tribal characteristic of Athetini, a group otherwise difficult to define. It occurs in *Charoxus* (Fig. 3d), together with a shallowly-divided bulb [it is deeply divided in Lomechusini (Seevers 1978)] and narrow intercoxal processes [they are broad in Lomechusini (Seevers 1978)]. For these reasons, *Charoxus* is transferred here from Aleocharini to Athetini.

It is unfortunate that nothing has been published on the natural history of *Porus*, and that the Pace (1988) did not expand or comment upon the diagnosis by Cameron (1939). Resemblances between *Charoxus* and *Porus* are here assumed to be the result of convergent evolution in members of different tribes. However, without detailed comparison of specimens of *Porus* and *Charoxus*, we are uncertain that they belong to different tribes.

Ficus occurs worldwide in the tropics and subtropics. Could there be an Old World counterpart to *Charoxus*—an aleocharine genus associated with syconia of *Ficus*? We regret that we have not had the opportunity to collect insects in *Ficus* syconia in the Old World tropics. Although there are numerous reports of Hymenoptera associated with Old World *Ficus*, other arthropods that may occur there seem to have been ignored, whereas a rich specialized fauna is associated with such syconia in the New World (next paragraph).

Now that the association with *Ficus* syconia is clear, it should be possible for collectors to assemble good series of specimens, giving more adequate material for systematic study than has been available. At the same time, collectors should endeavor to obtain reliable identifications for the *Ficus* trees with which each *Charoxus* species is associated, forming a basis for ecological study. Some of the organisms inhabiting syconia of *Ficus* spp. in south Florida have been characterized by Roskam and Nadel (1990), Nadel et al. (1992), and Giblin-Davis et al. (1995). They include Nematoda, Acarina, Coleoptera, Diptera, and Hymenoptera.

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**THE BIOLOGY OF *NOLA PUSTULATA* (WALKER)
(LEPIDOPTERA: NOCTUIDAE; NOLINAE)¹**

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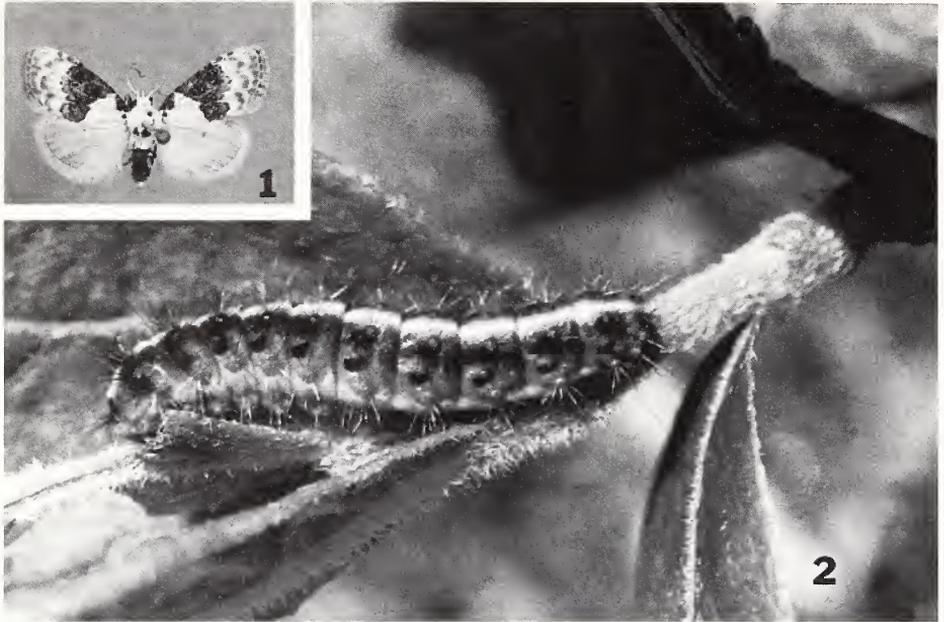
Abstract.—The larva and pupa of *Nola pustulata* (Walker) are described and illustrated. *Lyonia ligustrina* (L.) DC. [Ericaceae] is established as a host. The moth is much more restricted in distribution than its food plant. The species is univoltine, overwintering as an egg that is deposited on the twigs of the food plant. Hatching coincides with bud burst. A keel-shaped cocoon is produced and adults emerge in early June. A parasitoid, *Distatrix* sp. (Hymenoptera: Braconidae), and a predator, *Nabis inscriptus* Kirby (Heteroptera: Nabidae) are reported.

Most moths will freely oviposit even in the absence of their food-plant. The resulting first-instar larvae can be given a selection of potential food-plant species. The most difficult host associations to unravel are those where the appropriate food-plant's presence is necessary to induce oviposition. For a small species whose ova overwinter, such as *Nola pustulata*, the problems are compounded by low survival rates in culture. Through field work I was fortunate in discovering late instar larvae of *Nola pustulata* (Walker, 1865) on the leaves of *Lyonia ligustrina* (L.) D.C. [Ericaceae] very early in the spring at Hawley Bog in western Massachusetts. Later I found first instar larvae on the buds of *L. ligustrina* in the Pine Bush near Albany, New York. The host plant occurs from New York south to Florida and Texas (Fernald, 1950) a much larger range than that of *N. pustulata*. *Nola pustulata* is a species normally associated with boggy or swampy habitats from central New York to the mountains of North Carolina (Franclemont, 1960).

Nola species are typically monophagous with overwintering eggs or pupae, depending on the species (Franclemont, 1960). *Nola pustulata* is univoltine with adults appearing in June and July. Eggs, laid singly or in twos and threes in crevices on the twigs of *Lyonia*, remain dormant until spring. Hatching occurs in the spring, coincident with bud burst. The newly eclosed larva crawls to a bud and feeds on the outside, occasionally entering a bud large enough to accommodate its size. The larva develops rapidly, maturing in as little as 14 days under field conditions. The mature larva uses fragments of bark and silk to spin a keel-shaped cocoon (Fig. 8) typical of the Nolinae, Sarothripinae and Chloephorinae (Hampson, 1900; Franclemont, 1960). In addition, Richards (1932) considered these subfamilies to be related by tympanal similarities. Butler (1989) gives a detailed description of *Meganola spodia* Franclemont cocoon construction agrees with that of *N. pustulata*. *Nola pustulata* pupa lacks the spines on the fifth abdominal segment found in the sarothripine *Characoma nilotica* (Rogenhofer) (Mosher, 1969).

Parasitoids and predators recorded include *Distatrix* sp. (Hymenoptera: Braconidae), and *Nabis inscriptus* Kirby (Heteroptera: Nabidae). Two *Distatrix* sp. emerged on May

¹ Contribution number 733 of the New York State Science Service.



Figs. 1-2. *Nola pustulata*. 1. Adult (inset), wingspan 18 mm. 2. Mature larva (head to the left) on twig of *Lyonia ligustrina*, length of caterpillar 14 mm.

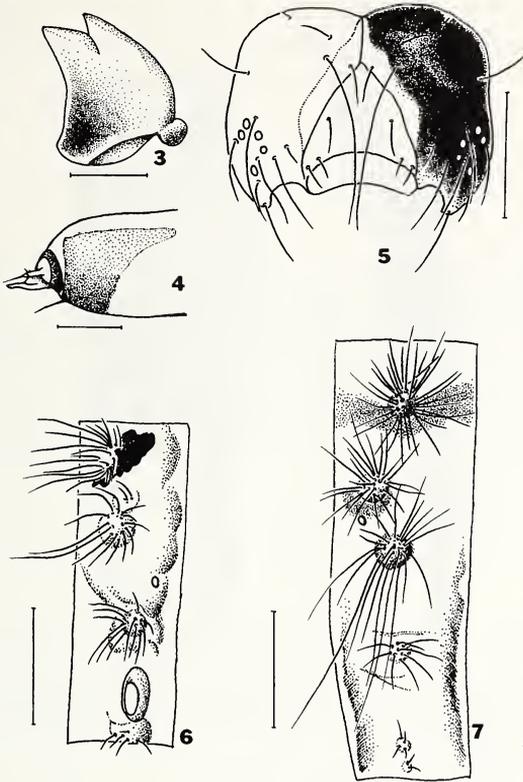
25, 1980 from a last instar larvae that had been reared from the Hawley bog site. The *Distatrix* specimens agree very well with Mason's (1981) description of the genus, but appear to be an undescribed species. The *Nabis* was observed feeding on a larva on May 15, 1982 at the Pine Bush site.

MATURE LARVA

Length 14 mm (N = 12). Head black, adfrontal area lightly pigmented, frons black (not darkened in Fig. 5 in order to show setae). Mouthparts: mandible with two prominent teeth (Fig. 3); hypopharynx as illustrated (Fig. 4). Prothorax (Fig. 6) with verrucae D accompanied by heavily chitinized remnant of prothoracic shield. Thorax and abdomen with moderately hairy verrucae; a broad white middorsal stripe bordered by a black to gray-black subdorsal stripe running through D verrucae (see Fig. 7); lateral region, between subdorsal stripe and L verrucae, orange-brown. A few examples with SD verrucae black, giving appearance of a series of black lateral spots (as in Fig. 2). Other larvae with SD verrucae concolorous orange-brown; white below L verrucae. Abdominal proleg 3 absent as in other Nolidae (Franclemont, 1960; Kitching, 1984). Abdominal prolegs well developed on segments 4, 5, 6 & 10. Crochets a uniordinal, homoideous mesoseries with an average of 16 crochets per proleg.

COCOON AND PUPA

Cocoon: Boat-shaped with prominent "keel", 12 mm long (Fig. 8). Pupa: Nearly parallel sided, 8 mm long (N = 2); juncture of A6 & A7 slightly broadened (Fig. 9).



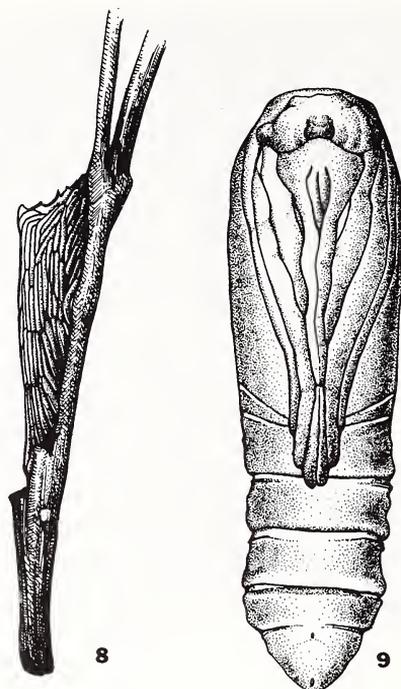
Figs. 3–7. Last instar larva of *Nola pustulata*. 3. Oral face of left mandible. Scale line = 0.25 mm. 4. Hypopharyngeal complex, lateral view. Scale line = 0.14 mm. 5. Head capsule, frontal view. 6. Prothorax, semidiagrammatic view from middorsal line to midventral line. 7. First abdominal segment, semidiagrammatic view from middorsal line to midventral line (anterior to the left in figs. 6 & 7). Scale lines = 0.50 mm for Figs. 5–7.

Cremaster absent. No spines on fifth abdominal segment. Prothoracic and mesothoracic legs extending from the eye-piece nearly to, or beyond, the caudal margin of A5.

Specimens examined: Larvae (5): Hawley bog, Franklin Co., Mass., lat. 42.34.31 long. 73.53.27, 21 May 1980, elev. 540 meters (tIm 80-41). Larval parasitoids emerged 25 May 1980; (6) Pine Bush, Albany, Co., N.Y., lat. 42.42.43 long. 74.52.53, 15 May 1982, elev. 100 meters (tIm 82-24); (1) same locale, 17 May 1981 (tIm 81-27); Pupae (2): same locale, 21 May 1985, elev. 100 meters (tIm 85-4).

ACKNOWLEDGMENTS

I thank Patricia Eckel of the Buffalo Natural History Museum for the illustrations. Voucher specimens are in the New York State Museum.



Figs. 8-9. *Nola pustulata*. 8. Cocoon on twig, lateral view (total length 12 mm). 9. Pupa, ventral view (total length 8 mm).

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KEY TO FIRST AND SECOND INSTARS OF SIX SPECIES OF COCCINELLIDAE (COLEOPTERA) FROM ALFALFA IN SOUTHWEST VIRGINIA

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Abstract.—A key is given that allows identification of either live or alcohol preserved first and second instars of *Coccinella septempunctata* Linnaeus, *Coleomegilla maculata* (De Geer), *Cycloneda munda* (Say), *Harmonia axyridis* Pallas, *Hippodamia convergens* Guerin, and *H. parenthesis* (Say). These six species are the most commonly collected Coccinellidae in alfalfa fields in Montgomery County, Virginia. The main emphasis in this key is on the relative placement and characteristics of the most prominent setae on the tergum of the abdomen. This is the first key ever written specifically for early instars, and the first that does not rely on color patterns of live larvae.

Key words: Coccinellidae, identification, key, larvae, alfalfa, Virginia.

Keys for identifying larvae of Coccinellidae have traditionally been based on the morphology of the final instar. One of the most comprehensive keys for North American genera was published recently by Rees et al. (1994). It included several species, but was restricted to late instar larvae. This reliance on late instar larvae is largely due to the drastic changes in appearance from the first instar to the last. First and second instars usually lack the color patterns and the distinctive setal armature that often characterize third and fourth instars.

Although Palmer (1914) did not provide a key, she did describe some early instars of eight species of Coccinellidae from Colorado. Her brief descriptions refer mainly to color patterns, and not all first and second instars are individually described. Strouhal (1927) included more detail, noting both color patterns and basic descriptions of setae for first, second, and third instars of 17 Palearctic species. His key does not distinguish one instar from another. Storch (1970) made a significant contribution to knowledge of early instar larvae of North American Coccinellidae when he gave basic descriptions, also based on color patterns of living larvae, for all instars of five species found in potato fields in Maine. He prepared a key to larvae of those species, but the key does not sort one instar from another, nor is it useful for any of the first instars or the second instar of *Adalia bipunctata* (Linnaeus) because, according to his observations, these instars lacked any color variation.

Not everyone is fortunate enough to have living larvae when making identifications. Often the only specimens available have been preserved in alcohol, and although it is sometimes still possible to distinguish light from dark areas on such specimens, most true colors are not discernible. Therefore, characters other than color are necessary for identification. The key presented here is a new approach because it relies heavily on setal characteristics, and does not depend on color. It

will separate first and second instars, either living or alcohol preserved specimens, for six species of Coccinellidae commonly found in alfalfa in southwest Virginia—*Coccinella septempunctata* Linnaeus, *Coleomegilla maculata* (De Geer), *Cycloneda munda* (Say), *Harmonia axyridis* Pallas, *Hippodamia convergens* Guerin, and *H. parenthesis* (Say).

METHODS

Larvae were reared from known adults of these six species, then first and second instars were examined and compared to find distinguishing characters. All specimens used in the preparation of this key are preserved in alcohol and are housed in the author's department. In the interest of making the key useful to a wide audience, technical terminology has been kept to a minimum. One term which is necessary when referring to setal structures is parascolus. It is used here as defined by Gage (1920), i.e., a projection of the body wall that is usually two, and not more than three, times as long as wide, and that bears a few short branches, each with a seta at the tip. Good illustrations of various types of setal armature of larval Coccinellidae, including a parascolus, can be found in Rees et al. (1994). However, illustrations in that publication were made from late instar larvae. In second instar larvae parascoli are much less pronounced, and they are not present in any first instar larvae of the six species described here.

The shape of the claw is important in distinguishing some species, but cannot be relied on in other species because the appearance changes from early to late instars. For example, both *H. axyridis* and *C. munda* have a claw with a definite rectangular base that is easy to see from the first to the fourth instar. In contrast, the rectangular claw base of *C. septempunctata* is not apparent in the first instar, but can be distinguished beginning with the second instar. Van Emden (1949) noted this fact in his key in the couplet that separates out the genus *Coccinella*. The simple hook-shaped claws of *H. convergens*, *H. parenthesis*, and *C. maculata* remain the same through all instars.

The most commonly used characters in this key are on the tergum of the abdomen. The convention of calling the setal areas on the dorsal abdominal tergum "lobes," and referring to them as dorsal, dorsolateral, and lateral is adopted here for simplicity, as it has been by Storch (1970) and Gordon and Vandenberg (1991, 1993). These lobes have been abbreviated in the key as: D = dorsal lobes; DL = dorsolateral lobes; L = lateral lobes. The relative placement and characteristics of the most prominent setae on these lobes help distinguish each species. A purely diagrammatic representation of the setal patterns of the most prominent setae on the dorsal lobes, and for *H. axyridis* the dorsolateral lobes, is shown in Fig. 1. The pattern is the same for *H. convergens* and *H. parenthesis*.

Annotations that appear in brackets [] after a couplet give supplemental information that may help in making a determination, but that cannot be used to unambiguously distinguish among taxa or instars.

Color patterns of the dorsal abdominal lobes have been included in this key as "light" or "dark" only. Table 1 is a schematic representation of these color patterns so that all six species can be compared at a glance.

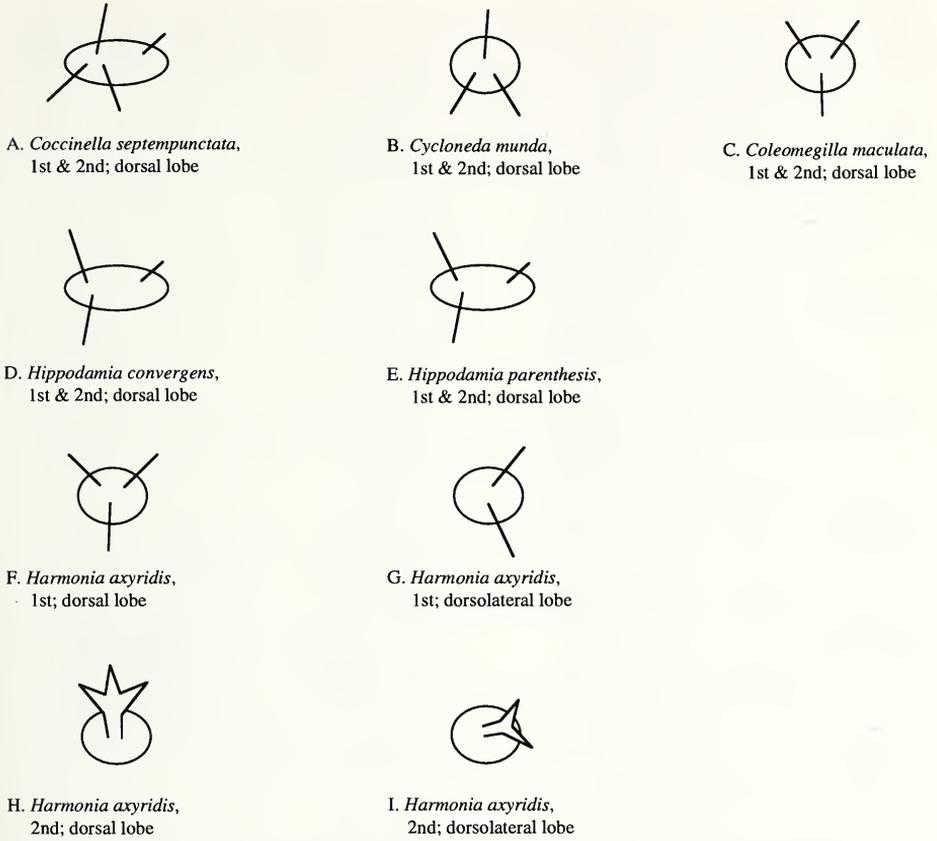


Fig. 1. Diagrammatic representation of setal patterns of the most prominent setae on the dorsal and dorsolateral lobes of first and second instars of six species of coccinellids. Setae are not drawn to scale, so widths and lengths cannot be compared. The type of base is not indicated, nor are any of the less conspicuous setae.

KEY TO FIRST AND SECOND INSTAR LARVAE

1. D with 3 setae or spines, DL with 2 setae or spines (Fig. 1, F-I); pronotum heavily sclerotized, with the appearance of one solid plate, and with stout projections rather than individual setae (except in very early 1st instars, which have individual setae on pronotum); claw with definite rectangular base 2
- Both D and DL with 3 or more setae; sclerotization of pronotum variable, but not as one solid plate; pronotum with individual setae; claw variable 3
2. D and DL with stalked bi- and tri-forked spines rather than setae (Fig. 1, H & I), only DL of first abdominal segment light (some trace of light color may be seen in other DL lobes extending posteriorly from 1st segment in older 2nd instars), rest of lobes dark (Table 1) *Harmonia axyridis*, 2nd instar
- D and DL with stout, prominent dark setae, not forked at tip (Fig. 1, F & G); all lobes uniform in color (Table 1) *Harmonia axyridis*, 1st instar

Table 1. Pattern of light and dark lobes on the first through fourth dorsal abdominal segments for first and second instars of six species of coccinellids. X = dark lobe; O = light lobe. Space between letters represents midline of dorsum, so beginning from left, lobes are as follows: L, DL, D (left side of body), then D, DL, and L (right side).

Species	1st instar	2nd instar	early 2nd instar
<i>Coccinella septempunctata</i>	XXX XXX	OOX XO0 (1st)	
	XXX XXX	XXX XXX	
	XXX XXX	XXX XXX	
	XXX XXX	XXX XXX (4th)	
<i>Coleomegilla maculata</i>	OOX XO0	OOX XO0	
	XXX XXX	XXX XXX	
	XXX XXX	XXX XXX	
	OOO OOO	OOO OOO	
<i>Cycloneda munda</i>	OOX XO0	OOX XO0	
	XXX XXX	XXX XXX	
	XXX XXX	XXX XXX	
	XXX XXX	OOO OOO	
<i>Harmonia axyridis</i>	XXX XXX	XOX XOX	
	XXX XXX	XXX XXX	
	XXX XXX	XXX XXX	
	XXX XXX	XXX XXX	
<i>Hippodamia convergens</i>	OOX XO0	OOX XO0	OOX XO0
	XXX XXX	XXX XXX	XXX XXX
	XXX XXX	XXX XXX	XXX XXX
	XXX XXX	OOX XO0	XOX XO0
<i>Hippodamia parenthesis</i>	OOX XO0	OOX XO0	
	XXX XXX	XXX XXX	
	XXX XXX	XXX XXX	
	OOX XO0	OOX XO0	

3. D with only 3 prominent dark setae, widely and equidistantly spaced, 2 anteriorly and 1 posteriorly (Fig. 1, C) [arising from broad rounded areas of derm]
 - D with 3 or 4 prominent setae; either not equidistantly spaced, or, if so, then only 1 long seta anteriorly and 2 posteriorly 5
4. Pronotum with light spot on anterior, outer corner; L with 2 prominent long, dark, stout setae, along with several shorter, fine setae [claw hook-shaped; color pattern: DL and L light on 1st abdominal segment; all lobes light on 4th (Table 1)]
 - Pronotum without light spot; L with only 2 prominent dark, stout setae, one longer than the other [claw hook-shaped; color pattern: DL and L light on 1st; all lobes light on 4th (Table 1)] *Coleomegilla maculata*, 2nd instar
 - *Coleomegilla maculata*, 1st instar
5. D with 3 prominent dark, stout setae, about equal in length and equidistantly spaced, 1 anteriorly and 2 posteriorly, plus 1 shorter, dark, stout seta laterad to the three (Fig. 1, A) 6
 - D with 3 prominent setae, not stout but fine, clear or brown; if other shorter setae are present, they are fine and clear, not stout and dark 7
6. D and DL with several fine, short setae in addition to prominent long, stout, dark

- setae; setae arising from short parascoli [color pattern: DL and L light on 1st, all lobes dark on 4th (Table 1)] *Coccinella septempunctata*, 2nd instar
- D and DL with dark stout setae only; setae arising from surface of integument, not from parascoli [color pattern: all lobes uniform in color (Table 1)]
..... *Coccinella septempunctata*, 1st instar
- 7. Claw with obvious rectangular base; D with 3 prominent long, brown, fine setae (other shorter setae may be present also), widely and equidistantly spaced and about equal in length (Fig. 1, B); setae arising from broad, rounded areas on integument 8
- Claw hook-shaped; D with 3 prominent setae (other shorter setae may be present also), 2 medial and 1 laterad (Fig. 1, D & E); setae of unequal lengths, clear or light brown, arising from raised bases or parascoli 9
- 8. L with 2 long, fine setae, ca. equal in length; D with only 3 prominent long, brown setae [color pattern: DL and L light on 1st; all lobes dark on 4th (Table 1)]
..... *Cycloneda munda*, 1st instar
- L with several fine setae of varying lengths; D with several setae besides the 3 prominent ones [legs long, 1st pair longer than the other two, tibia longer than femur; color pattern: DL and L light on 1st; all lobes light on 4th (Table 1)]
..... *Cycloneda munda*, 2nd instar
- 9. L with setae of varying lengths, longest one not twice length of any other; length of front femur half to $\frac{2}{3}$ the width of pronotum (in 1st instar length may = width of pronotum); setae clear, very fine 10
- L with 1 prominent seta, if other setae are present, main one is ca. twice as long as any other; length of front femur ca. equal to or > width of pronotum; setae either brown or clear, stiff, like bristles 11
- 10. L with only 3 setae of different lengths [color pattern: DL and L light on both 1st and 4th (Table 1)] *Hippodamia parenthesis*, 1st instar
- L with other setae in addition to 3 prominent ones, of various lengths [color pattern: DL and L light on both 1st and 4th lobes (Table 1)]
..... *Hippodamia parenthesis*, 2nd instar
- 11. L with only 1 seta [color pattern: DL and L light on 1st; all lobes dark on 4th (Table 1)] *Hippodamia convergens*, 1st instar
- L with 1 prominent long seta but several other shorter setae also present; [color pattern: DL and L light on 1st; on 4th segment variable, from some color on DL to both DL and L light (Table 1)] *Hippodamia convergens*, 2nd instar

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**SEASONAL OCCURRENCE OF *BRACHYMERIA INTERMEDIA*
(HYMENOPTERA: CHALCIDIDAE), A PARASITOID OF THE
GYPSY MOTH, *LYMANTRIA DISPAR*
(LEPIDOPTERA: LYMANTRIIDAE), IN
WESTERN MASSACHUSETTS**

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Abstract.—To document the life history of *Brachymeria intermedia* in the U.S., we monitored the presence of reproductively active wasps in the field using trap hosts over an 8-week time period in early summer. The overall level of recovery of wasps was low (8% peak parasitism on average), yet, all parasitism occurred within one week. Reproductively active *B. intermedia* seemed to be fairly synchronized with gypsy moth pupation, suggesting that they might be univoltine and monophagous. However, we cannot conclude unequivocally that *B. intermedia* is monophagous, because these wasps appear to disperse readily to other habitats where their behavior is unknown.

Key words: Host finding.

Brachymeria intermedia (Nees) was introduced from Europe to the United States as a potential biological control agent against the gypsy moth, *Lymantria dispar* L. It was released repeatedly from 1908 through 1963 (Hoy, 1976; Clausen, 1978), but its establishment was not confirmed until 1966 (Leonard, 1966). Dowden (1935) reported that in Europe *B. intermedia* completes one generation on the gypsy moth in late spring. A second generation develops on other lepidopteran hosts in late summer. However, owing to differences in climate between the Mediterranean areas where wasps were collected and New England, and therefore to differences in the phenology of the gypsy moth, it was suggested then that the life cycle of *B. intermedia* might differ if the wasp established in the United States. Howard and Fiske (1911) hypothesized that adult wasps lived long enough to allow a single generation life cycle with the gypsy moth as a sole host. Conversely, Dowden (1935) suggested that American *B. intermedia* might have a first generation on alternate hosts in the spring. Then, a second generation would develop on the gypsy moth (with a possible late third generation on alternate hosts.)

Thirty years after the establishment of *B. intermedia*, the life cycle of the wasp in the United States is still unclear. Recoveries of wasps from species other than the gypsy moth have been rare (Prokopy, 1968; Leonard, 1975), yet many species are accepted as hosts in the laboratory (Dowden, 1935; Minot and Leonard, 1976; Roth-ray et al., 1984; Dindo, 1990; Drost and Cardé, 1992a). Whether *B. intermedia* parasitizes other species before gypsy moth pupae are available in the field remains unknown. Although it was verified that females overwinter as adults (Waldvogel and

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Brown, 1978; Schaefer, 1993), we do not know when wasps become active in the spring. In this study, we monitored the presence of reproductively active *B. intermedia* in the field, before, when, and after wild gypsy moth pupae were present.

MATERIALS AND METHODS

Study sites: The study was conducted in three sites, Ludlow, Amherst and Montague, Massachusetts. These sites were selected for their high densities of gypsy moth the preceding years. The sites in Ludlow and Amherst were dominated by oaks (*Quercus rubra* L., *Q. alba* L. and *Q. prinus* L.). The site in Montague was a mixed stand of birch (*Betula populifolia* Marshall), oaks (*Q. rubra*, *Q. ilicifolia* Wengenheim), pines (*Pinus rigida* Miller) and willows (*Populus tremuloides* Michaux).

Monitoring: We monitored the presence of actively reproductive wasps by exposing trap hosts continuously in the field from June 2, to July 21, 1994 in Ludlow (8 weeks) and June 6 to July 21, 1994 in Amherst and Montague (7 weeks). Trap hosts are nonparasitized hosts reared in the laboratory, placed in the field and recovered after short intervals of time to be checked for parasitism (Van Driesche et al., 1991). At each site, one cage holding 10 two to five day-old male gypsy moth pupae, reared from eggs on artificial diet in the laboratory (Bell et al., 1981), was stapled on 10 trees, 3 to 5 meters apart (oak in Ludlow and Amherst and birch in Montague). Thus, 100 pupae were exposed at each site. Cages were made of 7 mm wire mesh and placed ca. 2 m above ground level on the south side of trees. Pupae were renewed weekly and subsequently reared in the laboratory at $24 \pm 1^\circ\text{C}$, 60–70% relative humidity with a 16 L:8 D light cycle. They were checked daily for emergence of moths or *B. intermedia*. Deaths due to predation in the field and to unexplained causes were also recorded. Mortality rates were computed as the marginal rates of attack, i.e., the rates of mortality due to each mortality agent in the absence of other contemporaneous agents (Buonaccorsi and Elkinton, 1990; Elkinton et al., 1992). Mortality due to predators was computed as the observed death rate. Mortality due to *B. intermedia* and unexplained causes was computed as the marginal rates of attack for two contemporaneous indiscriminate parasitoids (with $c = 0.5$).

RESULTS

The outcome of the rearing of pupae exposed in Ludlow, Amherst and Montague is presented in Fig. 1a, 1b and 1c, respectively. Overall, most pupae escaped parasitism and survived to the adult stage at all three sites (69, 49 and 77% average adult emergence, respectively), with little variation over the course of the experiment. Parasitism by *B. intermedia* was low at all sites and occurred only during one week: 15% parasitism (12 wasps recovered) at Ludlow on week 3 (mid-June), 1% parasitism (1 wasp recovered) at Amherst on week 5 (early July) and 9% parasitism (8 wasps recovered) at Montague on week 5. Predators (beetles, hemipterans, and ants) had a low impact (8, 35 and 3% average predation, respectively), although a high predation rate (77% on average), mainly attributed to ants, was observed the last three weeks of study at Amherst. Larger predators including mice, were excluded by the cages. Mortality due to undermined factors averaged 24, 39 and 19%, respectively.

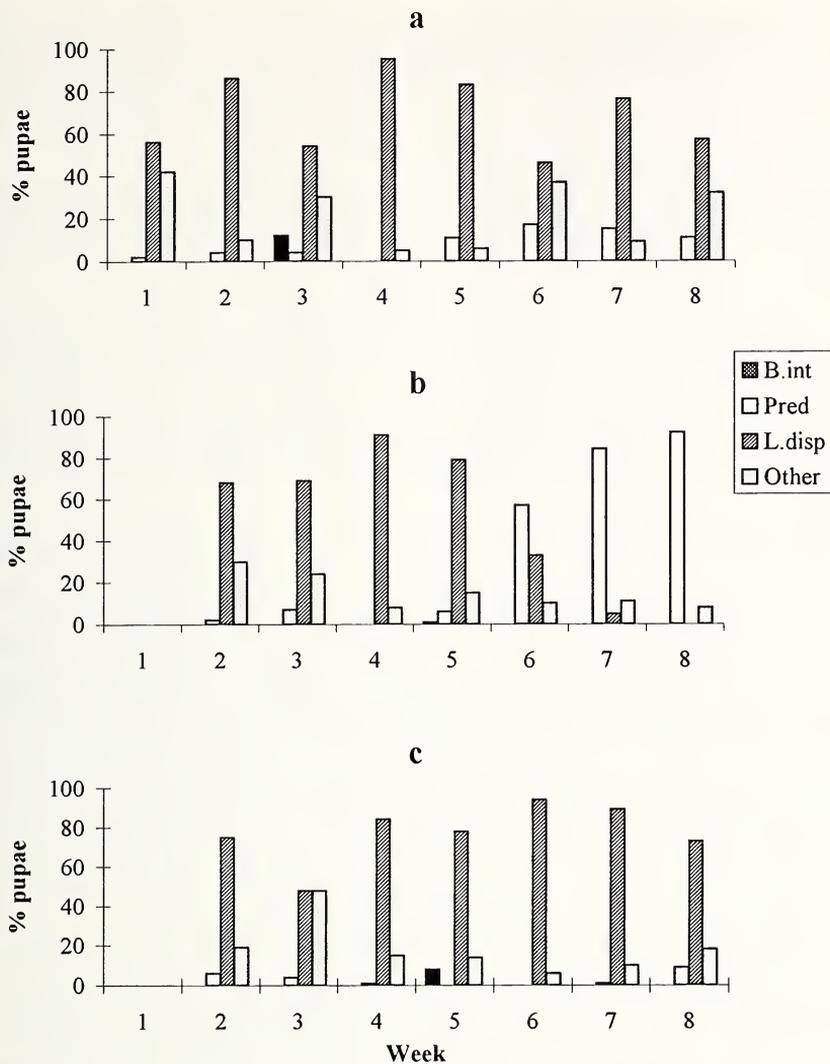


Fig. 1. Fate of gypsy moth pupae exposed weekly in the field from June 2 to July 21, 1994 at three study sites (a- Ludlow, b- Amherst and c- Montague, MA) and subsequently reared in the laboratory. (B.int: emergence of *B. intermedia*, Pred: killed by predators, L.disp: moth emergence, Other: unexplained death. Weekly total of pupae equals 100.)

DISCUSSION

B. intermedia is a parasitoid with the most impact in high density gypsy moth populations. The incidence of parasitism has been correlated with egg mass counts, larval and pupal densities of gypsy moth, and percentage of defoliation (Reardon, 1976; Ticehurst et al., 1978; Williams et al., 1993). Although densities of gypsy

moths were fairly high at the study sites the preceding years, density of pupae was low at all sites in 1994 because larvae were decimated by an epizootic of nuclear polyhedrosis virus and fungal pathogen *Entomophaga maimaiga* Humber, Schimazu and Soper. Therefore, none of the sites was defoliated during this study and few field pupae were available for the wasps to parasitize. Coincidentally, the number of wasps recovered in our experiment was low at all three sites.

Considering the scarcity of pupae in the field, one might have expected that trap hosts would be particularly attractive to the wasps should they be present. If *B. intermedia* is monophagous on the gypsy moth, one might expect peak levels of parasitism to occur when the host population declines following an outbreak (delayed density dependence). However, Ticehurst et al. (1978) also observed a collapse of parasitism concurrent with the collapse of the host population. The low level of parasitism of trap hosts, suggests that either the small number of pupae was not sufficient to retain the wasps in the area, or that the wasps located sparsely distributed hosts with difficulty. Blumenthal et al. (1979) suggested that *B. intermedia* readily dispersed *en masse* from sparse infestation sites and colonized high density populations.

Although trap hosts were present in the field for eight or seven weeks, it is striking that wasps were recovered within a single week at each site. These hosts were parasitized approximately two weeks before peak pupation (gypsy moth development was almost two weeks advanced at Ludlow compared to the other two sites). Apparently, *B. intermedia* was present in the field for a limited period of time, somewhat synchronized with pupation of the gypsy moth. The sites of Amherst and Montague had been visited weekly from late spring to early summer to search for *B. intermedia*. The leaf litter, dead trees and crevices were examined within ca. 5,000 square meters around the study sites of Amherst and Montague as they might have sheltered aggregated overwintering wasps (Dowden, 1935; Waldvogel and Brown, 1978), but no wasps were located. This suggests that *B. intermedia* was not present on these sites early in the season and that the wasps arrived near the time of pupation of gypsy moth larvae. In the absence of sufficient numbers of pupae, *B. intermedia* might have emigrated elsewhere, as suggested by Blumenthal et al. (1979).

Even when wasps did parasitize trap hosts, only a small fraction was parasitized. While 12 pupae out of 100 were parasitized in Ludlow, 54 were evidently not, as adults emerged later. In Montague 8 pupae were parasitized and 78 were not. In Amherst one pupa was successfully parasitized and 79 were not. In addition, the pupae in a cage were never all parasitized. In Ludlow, 6 pupae were parasitized in two cages on neighboring trees. In Montague, the 8 parasitized pupae were found in 5 different cages. Female *B. intermedia* produce 5 offspring on average per day (Dowden, 1935; Barbosa et al., 1986), and can successfully parasitize up to 11 pupae in a row in the laboratory (Drost and Cardé, 1992b). Therefore, a single wasp potentially could parasitize most of the pupae in a cage on a single visit. However, previous direct observations of the behavior of *B. intermedia* in the field (in 1993 in Montague, unpublished data) revealed that the wasps almost always visited only one pupa within a cluster. The present results corroborate these findings.

Despite the small number of wasps recovered, our results indicate that the population of reproductively active *B. intermedia* was reasonably synchronized with the availability of gypsy moth pupae. Yet, the life history of *B. intermedia* in the field

remains equivocal as the apparent synchrony with the gypsy moth population may indicate that the wasps either use the gypsy moth as a unique host or parasitize alternate hosts in other habitats.

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GROUND BEETLES OF NANTUCKET ISLAND, MASSACHUSETTS: 1995 (COLEOPTERA: CARABIDAE)

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Abstract.—A single season (1995) of ground beetle collecting on Nantucket Island, Massachusetts yielded 102 species in 18 tribes (Coleoptera: Carabidae). Fifty-seven species not previously recorded from the island were taken, including five species not currently listed for Massachusetts. Globally rare habitats including Maritime Heath/Grasslands, Morainal Frost Bottoms and Coastal Plain Ponds were intensively assayed. A high species turnover rate is implied by this preliminary analysis.

The eastern United States has been surveyed for insects since the early nineteenth century. Throughout this region, the ground beetle fauna is generally very well known, but Nantucket Island, Martha's Vineyard and the Elizabeth Islands off Massachusetts south of Cape Cod in particular seem to have been especially neglected by entomologists, as measured by published research, due at least in part to their relative inaccessibility. Their isolation coupled with rarity of the maritime sandplain habitats developed there ironically makes these islands especially likely to contain unique assemblages of carabids, as well as species that may be rare elsewhere. Modern floristic studies on the islands present corresponding parallels (Peter W. Dunwiddie, pers. comm.).

This report provides a checklist (Table 1) of 102 ground beetles that presently occur on Nantucket Island. Collections were made from early May to mid-September 1995, principally with pitfall traps containing propylene glycol-based preservative, using standard techniques. Voucher specimens are held at the Sandplains Bioreserve office of The Nature Conservancy, Vineyard Haven, Massachusetts.

Several special island habitats, unique for their floristics, geology, hydrology and/or microclimate, were singled out for intensive study, including the following sites, accounting for the large majority of ground beetle species collected in 1995:

Miacomet Plains Maritime Heath/Grassland: near coastal sand dunes at southern end of Somerset Road; flat open terrain with scattered pitch pine, arrowwood copses and black cherry; also present: dwarf blueberry, huckleberry, *Rubus*, *Rosa*, *Baptisia*, *Carex*, trailing arbutus, bearberry, bracken fern, dense foliose lichen, and such old field seral forb types as milkweed, wood lily, thistle and *Solidago*. Morning fog, salt spray from the nearby south coast surf, lower ambient temperatures (relative to Nantucket town) and frequent sand-bearing onshore winds also define this habitat; an approximately 10 day lag in floral phenology compared with the town was apparent.

Oak Barrens: xeric site west of Sankaty Head in the east central moors south of the Barnard Valley Road, dominated by thickets of mixed *ilicifolia/prinoides* scrub oaks (*Quercus*). In late May 1995 a profound frost here killed much foliage and twigs. Other plants include *Rubus*, arrowwood, huckleberry, *Carex* and grasses.

Table 1. Ground beetles (Coleoptera: Carabidae) collected on Nantucket Island in 1995. Tribes and genera in phylogenetic sequence (basal to derived), from Bousquet and Larochelle (1993); species listed alphabetically, noting European introductions.

Ground Beetle Taxa		in Johnson (1930)
Notiophilini		
Notiophilus nemoralis Fall		
Notiophilus semistriatus Say		
Loricerini		
Loricera pilicornis (F.)		
Cicindelini		
Cicindela hirticollis Say		*
Cicindela punctulata Olivier		*
Cicindela repanda Dejean		*
Cicindela sexguttata F.		*
Carabini		
Calosoma calidum F.		*
Carabus nemoralis Müller		*
Cydrini		
Sphaeroderus stenostomus lecontei Dejean		
Omophronini		
Omophron americanum Dejean		*
Omophron tessellatum Say		*
Brachinini		
Brachinus cyanipennis Say		*
Brachinus fulminatus Erwin		
Brachinus janthinipennis (Dejean)		
Brachinus medius Harris		
Clivinini		
Dyschirius integer LeConte		
Dyschirius setosus LeConte		
Clivina americana Dejean		
Clivina bipustulata (F.)		
Bembidiini		
	INTRODUCED	

NEW RECORD FOR MASSACHUSETTS

Table 1. Continued.

Ground Beetle Taxa	in Johnson (1930)
Bembidion confusum Hayward	
Bembidion constrictum (LeConte)	*
Bembidion contractum Say	
Bembidion frontale (LeConte)	
Bembidion impotens Casey	
Bembidion mimus Hayward	
Bembidion patrule Dejean	*
Bembidion rapidum (LeConte)	
Bembidion transparens (Gebler)	
Bembidion versicolor (LeConte)	
Elaphropus incurvus (Say)	*
Elaphropus xanthopus (Dejean)	
Patrobini	
Patrobis longicornis (Say)	*
Pterostichini	
Poecilus lucublandus (Say)	*
Pterostichus commutabilis (Motschulsky)	*
Pterostichus corvinus (Dejean)	*
Pterostichus luctuosus (Dejean)	*
Pterostichus melanarius (Illiger)	
Pterostichus mutus (Say)	
Pterostichus patruelis (Dejean)	*
Zabrinii	
Amara aenea (DeGeer)	
Amara chalcea Dejean	
Amara convexa LeConte	
Amara littoralis Mannerheim	
Amara lunicollis Schiodte	
Amara quenseli (Schonherr)	
Oodini	

NEW RECORD FOR MASSACHUSETTS

INTRODUCED

INTRODUCED

Table 1. Continued.

Ground Beetle Taxa	in Johnson (1930)
<i>Oodes amaroides</i> Dejean	*
Chlaeniini	
<i>Chlaenius pennsylvanicus</i> Say	*
<i>Chlaenius sericeus</i> (Forster)	*
<i>Chlaenius tricolor</i> Dejean	*
Licinini	
<i>Dicaelus elongatus</i> Bonelli	*
<i>Diplocheila obtusa</i> (LeConte)	
<i>Badister notatus</i> Haldeman	
Harpalini	
<i>Notiobia terminata</i> (Say)	
<i>Anisodactylus harrisii</i> LeConte	*
<i>Anisodactylus nigerimus</i> (Dejean)	*
<i>Anisodactylus rusticus</i> (Say)	*
<i>Anisodactylus sanctaecrucis</i> (F.)	
<i>Amphasia sericea</i> (Harris)	
<i>Stenolophus conjunctus</i> (Say)	*
<i>Stenolophus fuliginosus</i> Dejean	
<i>Stenolophus lineola</i> (F.)	
<i>Stenolophus megacephalus</i> Lindroth	
<i>Stenolophus ochropezus</i> (Say)	*
<i>Stenolophus plebejus</i> Dejean	*
<i>Bradycellus congener</i> (LeConte)	
<i>Bradycellus lecontei</i> Csiki	
<i>Bradycellus nigriceps</i> LeConte	
<i>Bradycellus rupestris</i> (Say)	
<i>Bradycellus tantillus</i> (Dejean)	
<i>Acupalpus nanellus</i> Casey	
<i>Acupalpus pumilus</i> Lindroth	
<i>Harpalus affinis</i> (Schrank)	*

NEW RECORD FOR MASSACHUSETTS

NEW RECORD FOR MASSACHUSETTS

INTRODUCED

Table 1. Continued.

Ground Beetle Taxa	in Johnson (1930)
Harpalus compar LeConte	*
Harpalus pensylvanicus (DeGeer)	*
Harpalus puncticeps (Stephens)	
Harpalus rufipes (DeGeer)	
Harpalus somulentus Dejean	
Selenophorus ellipticus Dejean	*
Platynini	
Calathus opaculus LeConte	
Synuchus impunctatus (Say)	
Oxypselaphus pusillus (LeConte)	
Agonum aeruginosum Dejean	*
Agonum darlingtoni Lindroth	
Agonum decorum (Say)	
Agonum fidele Casey	
Agonum gratosum (Mannerheim)	*
Agonum lutulentum (LeConte)	*
Agonum melanarium Dejean	*
Agonum mutatum (Gemminger & Harold)	*
Agonum retractum LeConte	*
Agonum tenue (LeConte)	*
Platynus cincticollis (Say)	*
Platynus decentis (Say)	*
Lebini	
Cymindis americanus Dejean	
Cymindis cribricollis Dejean	
Cymindis neglectus Haldeman	
Cymindis pilosus Say	
Cymindis platycollis (Say)	
Apenes sinuatus (Say)	*
Axinopalpus bipagiatus (Dejean)	
Syntomus americanus (Dejean)	*

INTRODUCED
INTRODUCED

NEW RECORD FOR MASSACHUSETTS

Coastal Plain Ponds: a cluster of three small permanent kettle ponds ca. 1 km southwest of Sachacha Pond in the central moors, with characteristic broad sparsely vegetated sandy-mud beach and declining water levels throughout the summer. Rolling terrain dominated by dense scrub oak, *Smilax* and northern arrowwood thickets, the upper beach perimeter dominated by high bush blueberry, *Kalmia*, *Clethra*, black huckleberry (*Gaylussacia baccata*), dangleberry (*G. frondosa*), *Spirea* and *Cyperus*, with *Xyris* and several *Drosera*, low grasses and sedges colonizing the broad open beach.

Frost Bottom: small deep depression in gently rolling terrain of central moors adjacent to the Oak Barrens trapping site; this area was also affected by the hard frost of late May 1995. [Frost bottoms on Nantucket are small depressions in the morainal landscape of the central moors; they drain air poorly and undergo large temperature swings including occasional midsummer frost events (Alan Rinehart, pers. comm.)]. In May this site contained a shallow lens of water that had disappeared by 4 July. Characteristic plants include several ferns, *Scirpus*, other sedges and grasses, *Rubus*, *Sphagnum*, sweet fern, bayberry, bluet, bearberry, beach plum, dwarf blueberry, bird's-foot violet, trailing arbutus and scattered scrub oaks.

In addition to these special sites, ground beetles were taken at many other island locations. Particularly productive in terms of diversity or noteworthy for uniqueness were the following sites: xeric juniper/arrowwood/grape shrub thickets at Nantucket Field Station (University of Massachusetts) east of Folgers Marsh in Quaise north of the Polpis Road, sandy south beach of Maxcys Pond, Head of Hummock Pond, the Polpis Road cranberry bogs, Masquetuck along the west shoreline of Polpis Harbor, sloughs behind rear dunes at Fishers Landing by the Eel Point Road and the south shore of brackish Sachacha Pond [Note: this conservative spelling of the well-known pond is taken from the *Historical Map of Nantucket*, surveyed and drawn in 1869 by Rev. F. C. Ewer, D. D. and published by the Old Colony R. R. Line in 1877, that labels the pond and nearby village of Sachacha without the gratuitous emendation of an added silent initial syllable as used on some recent maps; Johnson (1930) and his editors at the Nantucket Maria Mitchell Association also used this spelling].

DISCUSSION

A season of field collecting in 1995 on Nantucket Island revealed 102 ground beetle species including five that constitute new records for Massachusetts (Bousquet and Larochele, 1993). These five are *Clivina bipustulata* (F.), *Bembidion impotens* Casey, *Bradycellus tantillus* (Dejean), *Acupalpus nanellus* Casey and *Apenes sinuatus* (Say). Fifty-seven of the species found are new records for this island, pointing to the likelihood that more fieldwork on the islands off southeastern Massachusetts, straddling one of the major Atlantic biotic transition zones, will provide important new biogeographical information on carabids. Ancillary collections of ground beetles in 1995 on Marthas Vineyard and on Naushon (Elizabeth Islands) by The Nature Conservancy yielded species, some common, that apparently do not exist on Nantucket.

Charles Willison Johnson, who curated insects and mollusks for the Boston Society of Natural History, intermittently collected carabid beetles and other insects on

Nantucket in the 1920's, adding his records to others made there before and since the turn of the century in a checklist (Johnson, 1930) which included about 84 ground beetle species, a few still represented by voucher specimens housed at the Nantucket Maria Mitchell Association on Vestal Street. His list provides a view into island post-agricultural habitat states preceding the next era of profound ecological alterations that accompanied development, a ground beetle necrocoenose.

MacArthur and Wilson's (1967) keystone work on island biogeography outlines a theory of immigration and extinction rates reaching toward dynamic equilibrium (balanced turnover) as available niches are exploited, vacated and re-filled. Held in the light of the present 1995 accounting, Johnson's list gives the impression of a very high species turnover rate: in about 75 years half the 84 species he reported seem to have disappeared, and of today's 1995 list half the 102 carabid species are new. This evidently high turnover rate may result in part from the enhanced immigration potential from increasingly frequent maritime and airport arrivals. Immigrant taxa most likely are principally drawn from staging areas with environments not unlike Nantucket, arriving on aircraft that departed New Jersey, Long Island, Boston and Hyannis. Surface arrivals have similar origins, mostly via autos funneled through the Hyannis ferryhead. In this way austral faunal elements as well as boreal have had continued access to the island.

Present-day patterns of ground beetle distribution on Nantucket Island conform with expectations leading from previous studies (e.g., Will *et al.*, 1995; Purrington and Horn, 1994; Paoletti *et al.*, 1991; Purrington *et al.*, 1989), with certain exceptions. *Dicaelus elongatus* was not anticipated at the Miacomet Plains since it is a typically forest species elsewhere. Frequent coastal fog, combined with the evergreen character of the many heathland plants at this site, may account for its seemingly anomalous presence. Other carabids found at Miacomet also suggest the uniqueness of that habitat. For example, both *Clivina bipustulata* and *Apenes sinuatus* occurred there although neither has been previously recorded from Massachusetts (Bousquet and Laroche, 1993). The only large caterpillar hunter remaining on the island, *Calosoma calidum*, of four congeners listed by Johnson (1930), occurs in this unique heathland as well, but nowhere else on the island, reinforcing concern for the globally rare heath grassland habitat at this site. Although species diversity was relatively high and several unique carabids occurred, numbers here were low.

Permanent water at the Coastal Plains Pond site no doubt led to the observed uniqueness in carabids collected there compared to the Frost Bottom, where no open water remained after early July. Both sites contained a high ground beetle diversity of 22 species each, with only nine common to both. Whereas three *Brachinus* occurred at the Coastal Plains Pond area none were found at the Frost Bottom, underscoring the complex niche requirement of these very host-specific parasites of aquatic beetles.

Another carabid that may need special protection for its habitat on Nantucket is *Agonum darlingtoni*, which turned up sporadically at the Polpis Road cranberry bog area and in sloughs behind Fishers Landing near Eel Point. This rare species, described in 1955, is known only from a restricted area in eastern Canada, a few sites in eastern Massachusetts and Connecticut and one site in New Jersey (Lindroth, 1961–1969). *Stenolophus megacephalus*, another very rare ground beetle described in 1968, shares a similar circumscribed distribution. On Nantucket it was found at

only one site, west of Nantucket town on the south shoreline of Head of Hummock Pond. Both these species are extremely hygrophilous: when pursued they quickly enter the water and hide there in debris.

In addition to the inevitable deleterious physical changes accompanying soaring growth and development pressures on Nantucket, there is a steady shift towards floristic uniformity in the central moors where two aggressive scrub oak species, *ilicifolia* and *prinoides*, have all but eliminated open heath/grassland and savanna vegetational types that were long present historically. This trend towards a *Quercus*-dominated seral climax is well documented by Dunwiddie (1992) in a series of photographs (accompanying a pithy text) that compares late nineteenth and early twentieth century Nantucket landscapes with those of the present.

The influence of floral diversity on ground beetle species richness is manifested by collections made in 1995 in the central moors Oak Barrens site. Here, along a ridge in dense mature *ilicifolia/prinoides* oaks a depauperate ground beetle fauna of only four species occurred, overwhelmingly dominated by *Synuchus impunctatus*, an aggressive newcomer since 1930 with relaxed niche requirements. By contrast, traps at the adjacent Frost Bottom site with much higher phyto-diversity (and moisture regime) yielded a robust 22 species and several co-dominants, plus some uncommon and unique species.

An ongoing program of prescribed burning on Nantucket has opened up the scrub oak climax on the central moors and elsewhere, returning some areas of that landscape to earlier seral stages and higher plant diversity by generating successional mosaics over area and time. Eventually this effort will restore a more varied and ecologically benign set of habitat states to certain parts of the island.

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NOTES AND COMMENTS

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LECTOTYPE DESIGNATION AND NEW COMBINATION FOR *LYGIDEA MORIO* REUTER (HETEROPTERA: MIRIDAE)

During a recent trip to the Finnish Museum of Natural History (MZH), to study the types of species described by B. Poppius and O. M. Reuter in the genus *Lygus*, I found within the first drawer of specimens examined the syntype series of *Lygidea morio* Reuter. This note is the first treating *L. morio*, except for four catalog citations, since Reuter's original description (see refs. below). cursory examination showed that this species belongs to the genus *Irbisia* Reuter. Closer inspection revealed that the four specimens comprising the series actually represented four different species of *Irbisia*. Reuter assumed that the pale markings on the ventral region of the head and base of the cuneus represented intraspecific variation, incorrectly concluding that all the material on hand was conspecific. There is no way of determining if the specimens were collected contemporaneously at the same locality; however in my experience such has been the case (Schwartz, 1984).

Reuter (1909) described *L. morio* based on two male and two female syntypes received from an unknown locality (or localities) in California. The male bearing Reuter's new species label is here designated as the lectotype. It is conspecific with the newly recognized junior synonym, *I. setosa* Van Duzee. The three other syntypes, here recognised as paralectotypes, are individuals of *I. cuneomaculata* Blatchley, *I. incompta* Bliven, and *I. silvosa* Bliven.

The type data (specimens glued on card, label data printed unless otherwise noted), lectotype measurements, and synonymy are given below. Lectotype male (here designated) with seven labels as follows: Label 1, "Californie" (handwritten on green card); 2, "*Lygidea morio* n.sp. (handwritten, by Reuter) O.M. Reuter det."; 3, "Mus. Zool. H:fors. Spec. typ. No. 9942 *Lygidea morio* Reuter" (handwritten, in-house at MZH by H. Lindberg); 4, "SYNTYPE" (red label, here added); 5, "Mus. Zool. Helsinki Loan Nr. HE 96-84" (yellow label, here added); 6, "*Irbisia setosa* Van Duzee det: M.D. Schwartz 1996" ("96" handwritten, here added); 7, "LECTOTYPE *Lygidea morio* Reuter (handwritten) Des. M. D. Schwartz 1996" (here added). The lectotype is in good condition, except antennal segments 3 and 4 missing, left antennal segment 2 missing apical half, and head slightly disarticulated from pronotal socket; measurements of lectotype (in millimeters): body length from apex of tylus to apex of wing membrane 5.50; greatest width across hemelytra 1.86; width across eyes 1.04; vertex width 0.46; labial length 1.40; length of antennal segments 1, 0.47; 2, 1.54; medial pronotal length 0.88; posterior width of pronotum 1.61.

All three paralectotypes and two additional specimens, lack Reuter's determination label (label 2, above), and are in good condition except for broken or missing antennal segments. Details are as follows: One male with six labels as lectotype except for 3, "9943"; 5, "96-85"; 6, "*Irbisia silvosa* Bliven"; 7, "PARALECTOTYPE

Lygidea morio Reuter (handwritten) Recognised by: M.D. Schwartz 1996" (here added). One female with six labels: 3, "9944"; 5, "96-86"; 6, "*Irbisia cuneomaculata* Blatchley"; 7, (as above). One female with five labels (no label 3): 5, "96-87"; 6, "*Irbisia incompta* Bliven"; 7, (as above).

Additional specimens (no labels 2-4, 7 but with same labels 1, 5, 6 as lectotype except as otherwise noted): Two males (on one card)—5, "96-88, 89"; 6, "*Irbisia cuneomaculata* Blatchley".

Irbisia morio (Reuter), **new combination**

Lygidea morio Reuter, 1909: 47 (n. sp.); Van Duzee, 1917: 339 (cat.); Carvalho, 1959: 112 (cat.); Henry and Wheeler, 1988: 313 (cat.); Schuh 1995, 791 (cat.).

Irbisia setosa Van Duzee, 1921: 149 (n. sp.); Schwartz, 1984: 269 (n. syn., diag., descr., disc., hosts, male and female genitalia); Schuh, 1995: 784 (cat.). **NEW SYNONYMY.**

Head structure was the apparent reason Reuter placed his new species *morio* in *Lygidea*. In the key to the genera of North American "Capsaria" (Reuter, 1909), *Lygidea* was distinguished from *Irbisia* by the height of the gena/eye junction, level with or lower than, the anterior junction of the lorum/jugum in lateral view. At that time, the constituent species of *Irbisia* were, *brachycera* (Uhler), *pacifica* (Uhler), and *sericans* (Stål), all of which have rather small eyes with the gena/eye junction much higher than the lorum/jugum junction. Head structure, as in *morio*, is a symplesiomorphy of the 23 species included in *Irbisia* by Schwartz (1984) and does not adequately diagnose the genus.

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TAXONOMIC AND GEOGRAPHIC NOTES ON SOME HALICTINE BEE SPECIES (HYMENOPTERA: HALICTIDAE)

As part of ongoing investigations on the halictine bees, a number of taxonomic changes have cropped up which require attention and are accordingly dealt with here. I have also taken this opportunity to provide further information on the distributions of some species which were previously known from only a few geographically restricted specimens.

The following abbreviations are used for frequently mentioned institutions: American Museum of Natural History, New York, J. G. Rozen, Jr. (AMNH); The Natural History Museum, London, G. Else and S. Lewis (BMNH); Cornell University Insect Collection, Ithaca, J. K. Liebherr (CUIC); Museum National d'Histoire Naturelle, Paris, J. Casevitz-Weulersse (MNHN); Division of Entomology (Snow Entomological Collections), Natural History Museum, University of Kansas, Lawrence, R. W. Brooks (KSEM); and the Museum für Naturkunde der Humboldt-Universität zu Berlin, F. Koch (ZMHB).

TRIBE AUGOCHLORINI MOURE

Andinaugochlora joannisi (Vachal), **new combination**

Halictus joannisi Vachal, 1904, p. 20, 24.

Augochlora joannisi (Vachal); Michener, 1951, p. 1126.

Corynura (*Callochlora*) *joannisi* (Vachal); Moure and Hurd, 1987, p. 214.

Discussion: The lectotype female of the species is located in the Museo Civico di Storia Naturale "Giacomo Doria", Genoa (designated by Moure and Hurd, 1987) while the 3 males Vachal used in his description are in the MNHN. This species was previously recorded from Ecuador (Pifo and Riobamba) and known only from the type series.

New records: COLOMBIA, San Lorenzo Mts., Forest Station, 13 March 1976, on composite (9 males, CUIC). 1 male, same information as previous males, except found in wood (CUIC). VENEZUELA, Aragua, 3 km W. Colonia Tovar, 10 March 1995, 2,300 m, R. W. Brooks, #075, ex: flying along bank (6 males, KSEM). PERU, Lima Prov., Canta, 2,800 m, 26 June 1954, C. D. Michener (1 male, KSEM).

Ariphanarthra palpalis Moure

Ariphanarthra palpalis Moure, 1951, p. 137.

Discussion: The genus *Ariphanarthra* is represented solely by the type species and is distinguished by the elongated maxillary palpi which in repose can reach the apex of the metasoma. This species has been previously recorded from southern Brazil and Paraguay. Herein I provide new locality information which greatly extends the range of this species.

New records: ARGENTINA, Misiones, 23–29 January 1986, L. E. Peña (1 female, AMNH). COLOMBIA, Caqueta, Yuruyaco, 73 km SW Florencia, 1 February 1979, M. Cooper, B.M. 1979-106 (1 male, BMNH). PERU, Dept. Loreto, 1.5 km N Teniente Lopez, 2°35.66'S 76°6.92'W, 18 July 1993, 210–240 m, R. Leschen, #117, flight intercept trap (1 female, KSEM). PERU, Loreto, Boqueron Abad, 19 October 1962, J. M. Schunke, B.M. 1962-683 (1 female, BMNH).

Augochlora (Oxystoglossella) thalia Smith

Augochlora thalia Smith, 1879, p. 46.

Halictus continens Vachal, 1911, p. 42, 47. NEW SYNONYMY.

Halictus eucnemis Vachal, 1911, p. 49. NEW SYNONYMY.

Discussion: The type of *Augochlora thalia* is in the BMNH, while those of *Halictus continens* and *H. eucnemis* are located in the MNHN. This is a common species of *Augochlora* ranging from southern Brazil to Costa Rica.

Augochloropsis (Paraugochloropsis) aenigma, new name

Rivalisia metallica Strand, 1921, p. 270.

Augochloropsis (Paraugochloropsis) metallica (Strand); Eickwort, 1969a, p. 519.

Preoccupied by *Augochloropsis metallica* (Fabricius), 1793.

Etymology: The new specific epithet is the Latin word *aenigma*, meaning “inexplicable”, and is a reference to the uncertain taxonomic status of the species.

Discussion: In synonymizing the genus *Rivalisia* Strand with *Augochloropsis* Cockerell, Eickwort (1969a) created the new combination *Augochloropsis metallica* (Strand). Although Eickwort noted at the time that the name was preoccupied in *Augochloropsis* by *A. metallica* (Fabricius), he suggested that the species might be a junior synonym of *A. argentina* (Friese) and, despite retaining *A. metallica* (Strand) as a valid species of the genus, did not propose a new name for it. Moure and Hurd (1987) followed Eickwort's assessment of the species in their catalog of Western Hemisphere halictid bees and did not propose any official taxonomic changes (neither synonymy nor a new name). Thus, there are still two *metallica* species in *Augochloropsis*, and since there is little reason at this time to consider Strand's species a synonym of *A. argentina*, the above name change is proposed.

Augochloropsis (Paraugochloropsis) vesta (Smith)

Augochlora vesta Smith, 1853, p. 78.

Halictus nigricopis Vachal, 1903, p. 127. NEW SYNONYMY.

Halictus pendens Vachal, 1903, p. 128. NEW SYNONYMY.

Discussion: The type of *Augochlora vesta* is in the BMNH while both Vachal types can be found in the MNHN. This species is commonly found from Ecuador and Venezuela north to Mexico.

Halictillus glabrescens (Cockerell), **new combination**

Halictus glabriventris Friese, 1916, p. 561. Preoccupied by *Halictus glabriventris* Crawford, 1907, p. 21.

Halictus glabrescens Cockerell, 1926, p. 219. Replacement name for *Halictus glabriventris* Friese, 1916.

Halictillus glabriventris (Friese); Eickwort, 1969b, p. 658.

Discussion: The name and generic placement of this species has been of considerable confusion. The taxon was originally described by Friese (1916) as a species of *Halictus* and was recently treated as a synonym of *Dialictus spinolae* (Reed) in a catalog of Western Hemisphere halictid bees (Moure and Hurd, 1987). Dr. Frank Koch (ZMHB) has recently examined the type specimens of *Halictus glabriventris* Friese for me, and the species belongs in the augochlorine genus *Halictillus*. The assignment of this species to *Halictillus* was noted earlier by Eickwort (1969b), although Eickwort did not examine the type series. As if this mild confusion were not enough, almost all authors (except Moure and Hurd, 1987) have overlooked that *glabriventris* is preoccupied in *Halictus*, and in fact, that Cockerell (1926) had already provided a replacement name for the species as *H. glabrescens* (erroneously listed by Moure and Hurd, p. 131, as having been originally designated *Chloralictus glabrescens* Cockerell). The correct name and combination is given above.

The biology of this species has been discussed by several authors under a variety of names: Claude-Joseph (1926) as *H. galbriventris*; Sakagami and Michener (1962) as *Lasioglossum aricense* (Schrottky); and Eickwort (1969b) and Eickwort and Sakagami (1979) both as *Halictillus glabriventris*.

Neocorynura cercops (Vachal), **resurrected combination**

Halictus cercops Vachal, 1904, p. 124, 139.

Neocorynura cercops (Vachal); Moure, 1944, p. 69.

Corynura (Callochloa) cercops (Vachal); Moure and Hurd, 1987, p. 213.

Discussion: The lectotype of Vachal's species is located in the MNHN and was officially designated by Moure and Hurd (1987). This species is neither a *Halictus* nor a *Corynura* species. It was correctly placed in *Neocorynura* by Moure (1944), where to it is here returned.

TRIBE HALICTINI THOMSON

Zonalictus bluthgeni, **new name**

Halictus andreniformis minor Blüthgen, 1929, p. 35. Preoccupied by *Halictus minor* Morawitz in Fedchenko, 1876, p. 233.

Zonalictus minor (Blüthgen); Michener, 1978, p. 515.

Etymology: The specific epithet is a patronymic honoring Dr. Paul Blüthgen (1880–1967). A brief account of Dr. Blüthgen's life is given by Königsmann (1970).

Discussion: The original specific epithet, despite its placement in *Zonalictus*, is preoccupied through primary homonymy. The holotype female is in the ZMHB.—*Michael S. Engel, Department of Entomology, Comstock Hall, Cornell University, Ithaca, NY 14853.*

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BOOK REVIEWS

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Psocoptera. pp. 1-79, 333-335 (App. I-II), 363-372 (Index) in Wells, A. (ed.) **Zoological Catalogue of Australia. Vol. 26** (Psocoptera, Phthiraptera, Thysanoptera).—C. N. Smithers. 1996. Melbourne: CSIRO Publishing (\$74.95 for the volume).

Order Psocoptera constitutes the first section of volume 26 of the Zoological Catalogue. An editorial preface at the beginning of the volume states that each section will cite by name and original reference all species known to occur in Australia. It also notes that a computer program provides consistent format and style of presentation, and that authors are responsible only for the information content. The preface also defines the geographic area covered as, in addition to Australia proper, the distant islands of Norfolk, Macquarie, McDonald, Christmas, and Cocos, as well as the Australian Antarctic Territory.

The format specifies a few introductory pages in which the order is diagnosed; some general accounts are cited dealing with morphology, biology, ecology, and taxonomy; the modern classification, biology, and zoogeography pertaining to Australia are briefly discussed. There follow acknowledgments and a bibliography of references to the works cited in the introductory pages. Each family is then introduced with two brief paragraphs for each. In these the number of genera and species worldwide, the number in the Australian fauna, the distribution of the species worldwide and the sorts of habitats that they occupy are discussed. The family may be diagnosed morphologically, as was done for each of the Psocopteran families. Taxa above the level of family are neither named nor diagnosed in the body of the catalogue (which results in much repetition of characters in the family diagnoses), but the families are entered in a sequence pertaining to their arrangement by suborders and family groups. For the Psocoptera these higher taxa are named in a conspectus of the families included in the introductory pages. Following the two introductory paragraphs for a family is a list of references which aims (apparently) to include important papers on taxonomy, biology, and Australian fauna. Within each family the genera are arranged alphabetically. Under each genus the reference to the original description is entered, followed by the type species with mode of designation and literature reference where necessary. This is followed by a complete synonymy of the genus with literature reference to each generic synonym with type species and mode of its designation for each. A useful feature following each list of synonyms for both genera and species is a brief paragraph entitled "Taxonomic decision for synonymy" in which the literature citations are entered in which each synonym has been proposed. Following the generic synonymy is a paragraph entitled "Extralimital distribution" in which is listed each country or region of the world from which the genus has been reported. The list is often long but seemingly in no order. Under each genus is a heading for each species recorded from Australia. Under each species heading the name is repeated, followed by a complete reference to the work in which the original description appeared. There follow the type data: sex, location, and

accession number for the holotype, and the same for all paratypes, where known. The type locality follows. Each synonym is then entered as a separate paragraph with the same data as for the valid name. This is followed by the "Taxonomic decision for synonymy" paragraph. There follows a paragraph on distribution (within and outside Australia) and habitat.

Dr. Smithers is immanently qualified to provide the information content of the Psocoptera section. He has lived in Australia for 36 years, and throughout that period he has devoted most of his entomological efforts to the study of Australian Psocoptera. It is notable that of the 252 species listed Smithers is either the sole or first author of 100 of them. A veteran catalogue writer, Smithers remains here true to his earlier policy of making no changes of taxonomic status in a catalogue. Thus there are no entries for the Psocoptera in appendix III "Taxonomic decisions made in this work." As a result of this policy, a few items which strike this reviewer as wrong are reported exactly as they stand in the literature (through the author's stated cut-off date of June 30, 1994), and can not be viewed as errors of the author.

Despite the author's rigid adherence to format and policy, a few errors of commission and omission were noted. On page 1 is the statement that Mockford and Garcia Aldrete (1976) replaced Pearman's family group Caecilietae with two superfamilies, Asiopsocoidea and Caecilioidea. Pearman (1936), I believe correctly, assigned to his family groups a status "somewhat superior to that of a superfamily." Mockford and Garcia Aldrete (1976) clearly stated that these two superfamilies ranked as subdivisions of the group Caecilietae. Under Psyllipsocidae (pg. 17) is the statement "Polymorphism related to crowding and light intensity has been reported . . ." This refers to *Psyllipsocus ramburii* Selys-Longchamps, in which Badonnel (1949) showed that polymorphism at ordinary temperatures is based completely on group size, whether or not the insects are exposed to any light. On page 18, the synonymy of *Psocathropos microps* (Enderlein 1903) with *P. lachlani* Ribaga 1899 by Lienhard and Halperin (1988) was overlooked, resulting in these two names being listed as separate species. The English text is almost completely free of typographical errors, but bibliographic entries in French, German, and Spanish did not fare so well. I found 15 typos in these.

Australia has a large and varied psocid fauna, and Dr. Smithers has presented an important reference work which will be essential for the libraries of all psocid systematists and of all biogeographers concerned with the Southern Hemisphere.—Edward L. Mockford, Dept. of Biological Sciences, Illinois State University, Normal, IL 61790-4120.

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Zoological Catalogue of Australia. Vol. 27.3A. HEMIPTERA. Heteroptera (Coleorrhyncha to Cimicomorpha).—Prepared by G. Cassis and G. F. Gross. Australian Biological Resources Study. CSIRO. xv + 506 pp. Price US\$79.95.

The preparation of systematic catalogs of insects, and particularly those dealing with the Heteroptera, appears to be in an especially active phase at the moment. The current entries fall into two groups, those dealing with groups and those dealing with faunas.

We might cast back to 1923 when a General Catalogue of the Hemiptera was conceived at a meeting of the American Association for the Advancement of Science in Cincinnati. Although volumes for most, if not all, families of Auchenorrhyncha, were completed, the Heteroptera fared less well. Under the original General Catalogue banner, only the Mesoveliidae (Horvath, 1929) and Pyrrhocoridae (including Largidae) (Hussey, 1929) were ever completed. Nonetheless, Carvalho (1957-1960) indicated that he considered his monumental work on the Miridae to be a part of the original grand scheme. Drake and Ruhoff (1965—Tingidae) and Slater (1964—Lygaeidae) represent the other two remaining significant earlier efforts. Of the major groups it is only the Coreidae and Pentatomidae which do not have modern catalogs, and whose taxonomy is still in need of synthesis (Schuh and Slater, 1995). We can anticipate seeing the Pentatomoidea in the near future, with the Tessaratomidae already in print (Rolston et al., 1993). It is not clear that anyone has mustered the courage to tackle the Coreidae as yet.

Current day monographers and curators are no doubt pleased to see a renaissance in cataloging efforts with notable entries for groups including world catalogs of the Reduviidae by Putshkov and Putshkov (1986-1989) and the late J. Maldonado (1990), a supplement to the Lygaeidae (Slater and O'Donnell, 1995), an updated volume for the Miridae by Schuh (1995), and the much smaller Catalog of Leptopodomorpha (Schuh et al., 1987).

On the faunistic front the work of Henry and Froeschner (1988) updated coverage for North America from the badly outdated 1917 volume by E. P. Van Duzee. Volume 1 of the Catalog of the Heteroptera of the Palearctic Region (Auchema and Rieger, eds., 1995), represents the first such attempt since that of Oshanin (1906-1909).

Last, but not least, is the current treatment of the Australian fauna as prepared by Gerasimos Cassis and Gordon F. Gross. This work is part of the larger Zoological Catalogue of Australia series, all volumes being published in the same format. This work (the first of two dealing with the Australian Heteroptera) establishes a point of reference for continuing work on what remains probably the most poorly known arthropod fauna in the world.

The classification around which the catalog is based is up-to-date, although not without a few wrinkles. Nonetheless, the work will serve well anyone who wishes to deal with Australia but who may not have at hand references for all groups on a world basis.

The work is organized such that each family receives a short, but extremely informative, introductory section dealing with the history of the study of the group, and something about its biology, both aspects including citations of major papers. These sections offer a nice complement to the necessarily sketchy family treatments to be found in the insects of Australia (CSIRO, 1991).

The catalog itself offers a welter of information, including synonymies, type data, type localities, type depositions, distributions, ecological information (sometimes extrapolated), and lists of references. Information on taxa as they occur outside Australia is given, including synonymies, references, and distributions for genera and species. This approach is in marked contrast to the North American catalog (Henry and Froschner, 1988) in which all such information was restricted to North America north of Mexico, even though nominal taxa occurring outside that area may have been involved in synonymies and distributions may have been broader.

If the Australian catalog series has a drawback, it is that the format demands the repetition of author, title, and page for all references in the catalog every time they appear, making the total length of the catalog greater than would probably have been the case if abbreviated citations and a terminal list of references had been included. Furthermore, the user often must wade through many references strung together in paragraph form, and is at the same time unable to appreciate at a glance the contributions of individual authors to our knowledge of the Australian fauna.

Major catalogs have always facilitated—and probably spurred—many of the more comprehensive taxonomic efforts. With the status is the Australian Heteroptera now clearly revealed, it remains to be seen to what degree this volume reflects actual diversity in the antipodean fauna. I eagerly await the appearance of Vol. 2, which deals with generally larger and more conspicuous, and—as a consequence—slightly better known organisms.—*Randall T. Schuh, Department of Entomology, American Museum of Natural History, New York, New York 10024 USA.*

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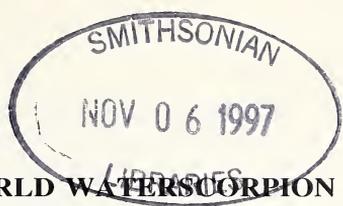
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SYSTEMATICS OF THE NEW WORLD WATERSCORPION
GENUS *CURICTA* STÅL (HETEROPTERA: NEPIDAE)

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Abstract.—The neotropical waterscorpion genus *Curicta* Stål 1861 (Heteroptera: Nepidae) is comprehensively reviewed for the first time, based on examination of type specimens from all but three previously named species as well as approximately 1,200 nontype specimens. Three invariant characters are unique to the genus among waterscorpion genera: absence of an ejaculatory reservoir in the male phallus, presence of a tubular vesicle rod in the phallus, and convergence of sutures delimiting the abdominal sterna and parasterna on the midline of abdominal segment 6 in males. Examination of male and female genitalia failed to reveal species specific characters. Therefore, species decisions were made on the basis of perceived disjunctions in nonreproductive morphological characters. Because many of the nongenital characters used previously in the taxonomy of the genus, e.g., pronotal, antennal, and paramere shape, were found to vary significantly within well defined morphospecies, a species concept that emphasizes polymorphism has been adopted. Characters that have proven useful for species delimitation include: shape of the profemur, number and position of profemoral teeth, presence or absence of profemoral sulcal teeth, presence or absence of granulations on the pronotum and hemelytra, presence or absence of longitudinal carinae on the last abdominal tergum and on the mesosternum, and shape of the prosternum. On the basis of these and other characters, one new species (*C. decarloi*, from eastern Brazil) and 13 new synonymies are designated, reducing the number of species in the genus from 29 to 16. All 16 species are described, or redescribed, and a key to these species is provided.

A numerical cladistic analysis of species within the genus, using the waterscorpion genera *Nepa* and *Telmatotrepes* as outgroups, produced a single most parsimonious cladogram of length 98 and RC 0.481. Seven synapomorphies supported the monophyly of the genus but only six of thirteen hypothesized clades within the genus received unambiguous support. Thus, further study will be required to elucidate, with more assurance, the cladistic relationships of curictan species.

The New World waterscorpion genus *Curicta* Stål (Heteroptera: Nepidae) has never had a comprehensive taxonomic review in which most of the specimens collected to date are studied. The primary goal of this study was to provide such a review. A second objective was to undertake the first cladistic analysis of the species in the genus.

BIOLOGY

Little is known about the biology of curictan waterscorpions. Curictans seem to prefer the shallow water of pond margins or small streams, usually in the presence of emergent vegetation. In June, 1922, Wiley (1924) collected two specimens of *Curicta scorpio* Stål "clinging to vegetation along the bank of a large creek where the water was deep." Later in the summer, Wiley was able to find large numbers of this same species aggregating in the small pools left by the receding creek. I have collected *scorpio* at two locations in Texas and observed the same pattern of curictan

abundance. Along a stream outside Alice in Jim Wells County, I found less than a dozen specimens clinging to long grasses overhanging the stream banks. At Skull Creek in Colorado County, the same locality where Wiley found her specimens, I collected dozens of specimens in a small pool isolated from the nearby, but lower, creek. Nieser (1975), collecting in Suriname, found *C. doesburgi* De Carlo exclusively in shallow, stagnant bodies of water. John and Dan Polhemus collected *C. granulosa* De Carlo in the tangled vegetation along the margins of boggy ponds in a pasture in Colombia and in a flooded borrow pit in Bolivia and found *C. carinata* Kuitert in Bolivia among the emergent vegetation and tangled sticks along the margins of a flooded watercourse.

Wiley (1922, 1924) studied the life history of *C. scorpio* taken from Skull Creek, Texas in summer 1922. During the course of two years of laboratory maintenance of curictan cultures she discovered that this species had five nymphal instars which she figured in her 1924 publication. Females preferentially oviposited in mud, a characteristic shared with *Nepa apiculata* Uhler (McPherson and Packauskas, 1987), in contrast with *Ranatra* species which preferentially oviposit in vegetation (Packauskas and McPherson, 1986). The average stadia lengths of the five instars, respectively, were 14, 22, 22, 23, and 40 days. Keffer et al. (1994) studied the life history of two populations of *C. scorpio*: one taken from Skull Creek, Texas and the other from Alice, Texas. They found that females laid about half their eggs in mud and the other half in sand. The average stadia lengths for the five instars derived from the two populations were 8.54, 15.29, 13.65, 18.56, and 18.87 days.

Wiley (1922) also observed the copulatory behavior of laboratory specimens of *C. scorpio*. Keffer and McPherson (1993) provided a more detailed study of *C. scorpio* copulation and compared their observations with what is known about copulation in other waterscorpion species. They tentatively concluded that one aspect of curictan copulatory posture, i.e., "the use of the [male's] protibia/protarsus to grasp the female's head" (ibid., p. 76) may be unique to, and therefore diagnostic for, *Curicta*.

TAXONOMY

Nomenclatural History of the Genus

Curicta was separately described by three different workers between 1862 and 1895. First, Stål erected the genus in 1862 for a single species, *C. scorpio*, with the type locality of Mexico. Second, Berg, unaware of Stål's work, described the genus *Helotenthes* in 1879 for a single species, *H. bonaërensis*, collected from Buenos Aires, Argentina. Third, Montandon erected the genus *Nepoidea* in 1895 for the new species *N. volxemi* from "Sta Cruz, Mexique." Three years later in 1898, Martin, unaware of the work of either Stål or Berg, added four new species to *Nepoidea*: *N. tibialis* from Rio Grande (presumably Brazil); *N. intermedia* from Parzudaki, Colombia; *N. falloui*, also from Rio Grande; and *N. montandoni* from Mexico. In 1901 Champion, writing the chapter on the Rhynchota (Heteroptera) in the *Biologia Centrali-Americana*, proposed that *Nepoidea* and *Curicta* were one and the same, and further that *N. montandoni* was synonymous with *C. scorpio*. In 1903, Montandon, working from the literature, provided the first review of *Curicta*. He concurred with Champion's new combination of *Nepoidea* and *Curicta* and also recognized that

Berg's *H. bonaerensis* belonged in *Curicta* and that Martin's *N. falloui* was a synonym of *bonaerensis*. Montandon also added two more species to the genus, *C. suspecta* from Brazil and *C. borellii* from northern Argentina. In 1906 Kirkaldy provided a list of heteropteran genera and their type species. Kirkaldy and Torre Bueno's 1909 catalogue provided citations and locality data for the seven species then known for the genus. Montandon made his last contributions to the genus with two papers in 1909 in which he described two new species, *C. schoutedeni* from São Paulo, Brazil (1909a) and *C. howardi* from Texas (1909b), and synonymized his own *C. suspecta* with *C. tibialis* (Martin). In 1922, Hungerford described another new species from Texas, *C. drakei*.

Curicta then lay dormant taxonomically until 1947, when a graduate student of Hungerford's, Louis Kuitert, reviewed all the waterscorpion taxa of the New World. Kuitert's thesis, which included a key to species of *Curicta*, was never published, but descriptions of his five new curictan species, i.e., *C. pronotata* from Arizona, *C. hungerfordi* from Mexico, *C. peruviana* from Peru, *C. bilobata* from Brazil, and *C. carinata* from Paraguay, were published in 1949(a). Kuitert (1949a) also noted that Hungerford's *drakei* was a synonym of *C. howardi*. Kuitert based his taxonomic decisions and descriptions on the holdings of the Snow Entomological Museum, University of Kansas, and on the notes Hungerford had made while studying some of the curictan types held in European collections.

Then, in 1951, Jose De Carlo of the Natural History Museum in Buenos Aires, Argentina redescribed all the previously described species in *Curicta*, provided a key to species, and described ten new species: *C. grandis* (Argentina), *C. paraguayensis* (Paraguay), *C. longimanus* (Brazil), *C. brasiliensis* (Brazil), *C. lenti* (Brazil), *C. riggii* (Argentina), *C. dureti* (Argentina), *C. granulosa* (Brazil), *C. dilatata* (Paraguay), and *C. pelleranoi* (Argentina). De Carlo's review was based on specimens he had seen, i.e., those that were in his collection at the museum in Buenos Aires (approximately 100 specimens, judging from the material loaned to me by that institution) or had been sent to him for processing, and on a study of the literature. Thus, like Kuitert's unpublished study four years earlier, De Carlo's review was not based on a personal examination of all known species. In 1956, De Carlo added three new species: *C. bachmanni* from Paraguay, *C. sanmartini* from northern Argentina, and *C. beckeri* from Rio Grande do Sul, Brazil. He described two more species in 1960, *C. venezolana* from Venezuela and *C. montei* from northeastern Brazil and synonymized his own *dilatata* with Kuitert's *carinata*. De Carlo's last taxonomic contribution to the genus occurred in 1967 with the description of *C. doesburgi* from Suriname.

In a monograph devoted to the Nepomorpha of the Guyanas in 1975, Nieser provided a key to the waterscorpion genera of the New World and a key and discussion of the two curictan species, *C. granulosa* and *C. doesburgi*, found in the Guyanas. The last species added to the genus was *C. femoralis*, described by Roback and Nieser in 1974 for specimens collected in Colombia.

Thus, at the outset of this review the genus *Curicta* held 29 species: four from Mesoamerica and the rest from South America. De Carlo had authored 15 species; Kuitert, five; Montandon, four; Martin, two; and Stål, Berg, and Roback and Nieser one each. Five species had been previously synonymized.

Before closing this section on nomenclatural history I should mention a curious

work by Eugen von Ferrari, published in 1888. Dr. Ferrari, in this his only paper devoted to waterscorpion taxonomy, synonymized all the genera then known for the family Nepidae with the genus *Nepa*. Thus, both *Curicta scorpio* and *Helotenthes bonaerensis* were redescribed as *Nepa* species. Champion returned *scorpio* to *Curicta* in 1901, but as far as I know no one has ever bothered to reverse Ferrari's judgment concerning *bonaerensis*. I formally do so in this review with the citations for *bonaerensis*.

Materials and Methods

Approximately 1,200 *Curicta* specimens, borrowed from university and private collections and from museums throughout North and South America and Europe, were studied for this review. The types were examined for all but three species: *C. longimanus*, *C. lenti*, and *C. borellii* were not seen. The types of *longimanus* and *lenti* are purportedly deposited in the Oswaldo Cruz Institute in Rio de Janeiro, Brazil (De Carlo, 1951). I was unsuccessful in determining whether in fact these specimens are deposited at that institution. The type for *C. borellii* has not been located. The type is supposed to be in Turin, Italy (Montandon, 1903), but Dr. Antonio Rolando of the Dipartimento Di Biologia Animale of the Università Di Torino has informed me that this species is not represented in the Montandon material deposited in his university (in litt.). Fortunately, I have a specimen identified by Montandon as *borellii* five years after his original description and have used it in this study.

For each species a complete list of taxonomic citations is given. In order to keep the descriptions brief, species descriptions do not repeat information that is generally applicable across the genus. Dorsal habitus and line drawings of important taxonomic characters are provided to aid in identification of species.

Full locality, temporal, and collector data are recorded only for type specimens. Under "Additional Material Examined" the following data are recorded: collection dates summarized by numbers of specimens per month, specimen depositories, and locality data summarized by country. Because temporal data are often not included on the labels accompanying specimens, the specimens collected per month when totaled usually do not equal the total number of specimens examined. Collector names are omitted except for type specimens. Museum and collection abbreviations are given in the acknowledgments. Geographic distributions for each species are figured on maps that follow the species descriptions.

The key to species of *Curicta* is based on the one in Kuitert's unpublished dissertation (1947). De Carlo's 1951 key was also consulted.

The genitalia of approximately 120 male and 30 female specimens were dissected and examined. The dissection protocol followed for both sexes was a modified version of Ivor Lansbury's (Keffer et al., 1990). Dried specimens were relaxed by placing them in hot, but not boiling, water for up to 10 minutes. (With alcohol preserved specimens one could proceed directly to dissection.) After carefully lifting up and spreading laterally the hemelytra and mesothoracic wings, the tergum of abdominal segment 6 was cut along the midline with iridectomy scissors (tergum 7 is naturally separated along the midline into two lateral plates). (This method is to be preferred to that reported in the 1990 paper wherein it was suggested that the outer margins of ventral laterotergites 6 and 7 be cut. There is less mutilation of the

specimen following this modified protocol). With abdominal terga 6 and 7 gently spread apart, it is then possible to cut away the membranes holding the genitalia to the lateral respiratory siphons and underlying operculum. With the genitalia free, the mesothoracic wings and elytra are returned to their position over the abdomen. Care must be taken at this point to make sure that the elytra are secured in their matching grooves along the lateral margins of the abdomen. Otherwise there may be substantial curling of the wings during subsequent drying.

Dissected genitalia were soaked in 10% KOH at room temperature for approximately 24 hours and then rinsed thoroughly in distilled water. Clearing was accomplished with clove oil and/or glycerin. Often both clearing agents were used at different times to see some of the smallest structures.

Male genitalia are composed of three layers: an outermost genital capsule enclosing a phallus which in turn houses an assortment of rods and levers (see generic description). The phallus is exposed in large specimens by spreading the posterior opening of the capsule with forceps and then, with iridectomy scissors, cutting the apodemes holding the basal plates of the phallic articulatory apparatus to the surfaces of the parameres internal to the capsule. In small specimens the capsule must be opened by cutting dorsolaterally from the dorsoanterior to the posterior openings. The deep structures of the phallus can be exposed by cutting away, from one side, the phallothecal plate and anterior diverticulum.

Soft tissue in the female genitalia such as the spermatheca and bursa copulatrix were most advantageously examined after staining with chlorazol black following the protocol outlined by Carayon (1969).

Completed dissections were placed in glycerin-filled plastic genitalia vials and mounted underneath dry-pinned specimens.

Measurements were made with an ocular micrometer on a Zeiss SR stereo microscope and recorded in millimeters. The measurement methodology is illustrated in Fig. 1. Only one measurement needs explanation. Total body length is exclusive of siphons and is measured from the anterior margin of the maxillary plates to the end of the last abdominal tergum. Some workers measure total length beginning anteriorly at the tip of the beak, but as that structure is usually pointing ventrally on curictans, it has proven more practical to measure instead from the maxillary plates which are always visible from a dorsal view. All measurements are based on approximately 40 specimens (20 per sex) unless otherwise stated.

All line drawings were prepared with a drawing tube mounted on a Zeiss SR stereo microscope. Dorsal habitus paintings of two species were prepared with an airbrush using a water base acrylic paint, supplemented with charcoal, and pastels.

It is a common practice in taxonomic monographs to cluster all illustrations pertaining to each taxon described. I have followed this convention with two exceptions. First, some of the illustrations relating to the discussion concerning character variability accompany that discussion and thus precede the species descriptions. Second, distribution maps for all species have been placed at the end of the species descriptions.

Discussion of Characters

Figure 2 illustrates the characters referred to in the taxonomic descriptions. Many other characters used in prior work on curictan taxonomy have been found in this

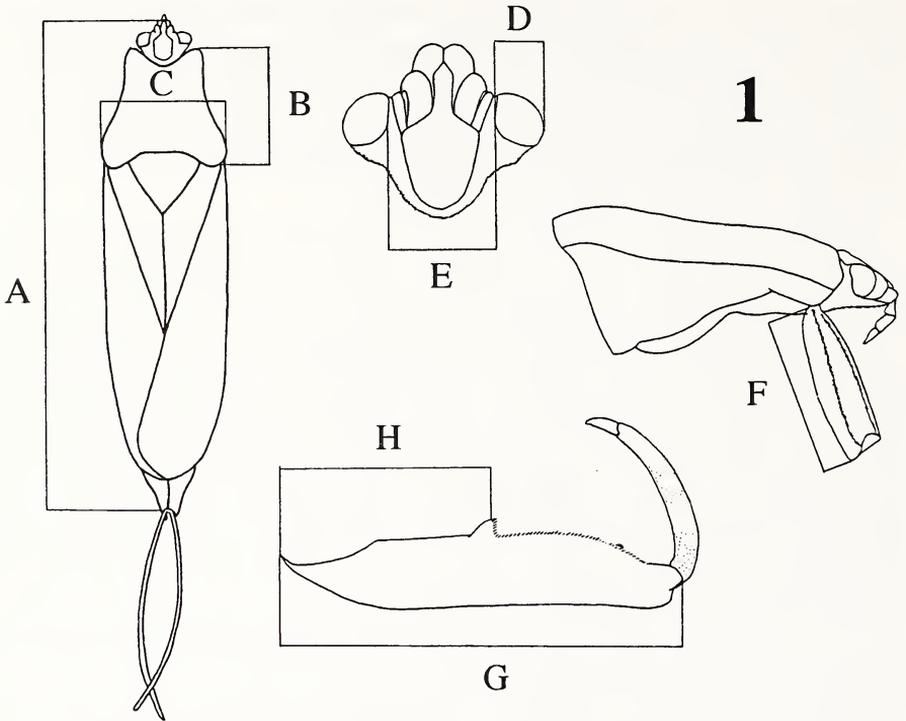


Fig. 1. Measurement protocol: A = total body length; B = lateral pronotal length; C = posterior pronotal width; D = eye width; E = interocular distance; F = procoxal length; G = profemoral length; H = length from base of profemur to tip of anteroventral profemoral tooth.

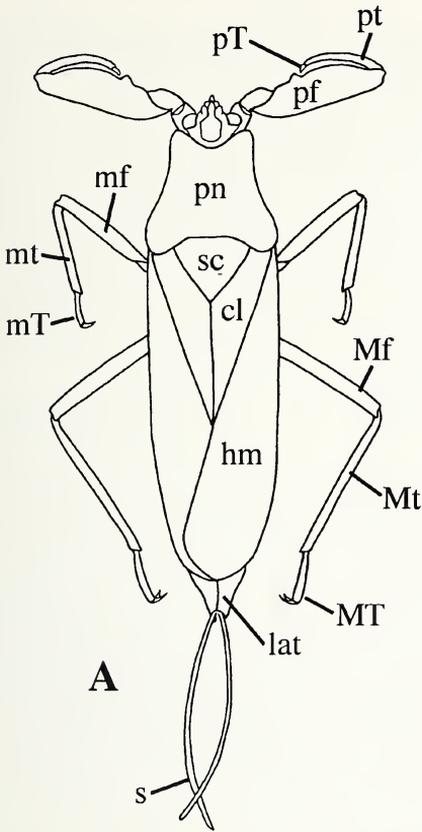
study to be of little value for species delimitation. Therefore, I offer the following discussion of characters that appear to work, and not work, in curiptan taxonomy.

Sexual dimorphism. Curiptan females are, on average, larger than males in each species of the genus. There is also a tendency in some species for female hemelytral width to be at a maximum just anterior to the base of the membranes, while male hemelytra are widest just posterior to the pronotum.

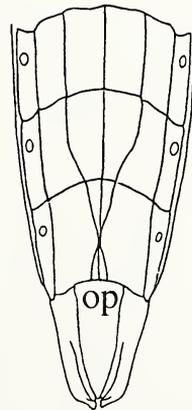
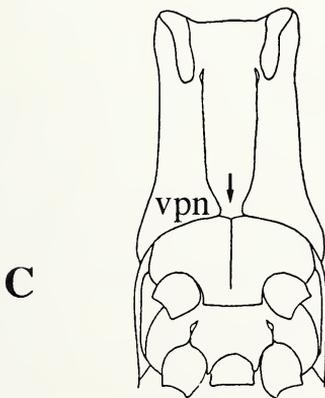
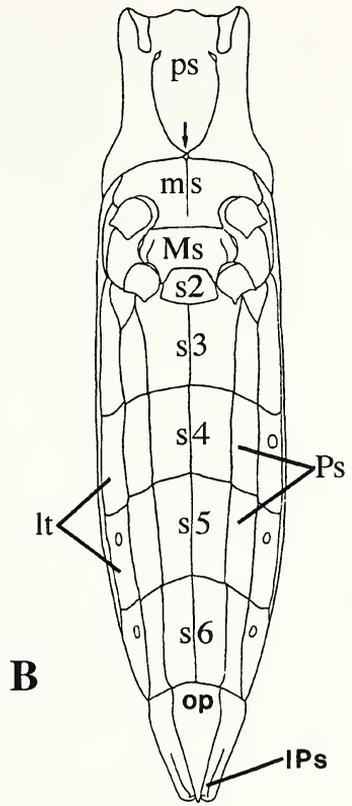
Color. The true color of curiptan specimens is usually obscured by substrate and vegetation adhering to the bugs when collected. When clean specimens were not available for a species, the uncertainty in color is indicated by the word “apparently.” The presence or absence of a dark medial annulus on the protibia is usually apparent. However, in some specimens the entire protibia is a dark amber. I suspect

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Fig. 2. A. Dorsal habitus showing the major morphological features referred to in taxonomic descriptions. B-D. Ventral habitus drawings showing the major morphological features referred to in taxonomic descriptions: B) thoracic and abdominal habitus, *C. scorio* female; C) thoracic habitus, *C. doesburgi*; D) terminal abdominal habitus, *C. scorio* male. Abbreviations: cl, clavus;



2



hm, hemelytra; lat, last abdominal tergum; IPs, last parasternum; lt, laterotergum; mf, mesofemur; Mf, metafemur; mt, mesotibia; Mt, metatibia; mT, mesotarsus; MT, metatarsus; op, operculum; pn, pronotum; ps, prosternum, pf, profemur, pt, protibia, pT, protarsus; s, siphon; sc, scutellum; s2-6, abdominal sterna 2-6; vpn, ventral extension of pronotum.

this is a postmortem change which, when present, makes a determination of this character difficult.

Adhering material often obscures more than just color on curictan specimens. Carinae on the vertex and mesosternum and bands of tomentose hair on the last abdominal tergum and mesosternum may be obscured in part, or entirely, by mud or bits of vegetation. Collectors who wish to see the true topography of curictan carinae and bands of hair should wash their specimens with a stream of water before studying them or pinning them for later study. Dried specimens can be cleaned somewhat by first relaxing them in hot water (see Taxonomic Methods) and then brushing them with a fine brush or gently rubbing with a finger. Abrading the specimens or treating them with chemicals (as has apparently been done to a number of specimens that I have seen, including some type specimens) is not recommended because such treatment removes all the surface hair, thus eliminating an important set of traits.

Head. The presence or absence of a midlongitudinal carina on the vertex has been used extensively in the past in species identification, but study of *C. scorpio* and *doesburgi*, species for which there are long series, has shown that this trait is not invariant. The former species usually has a prominent, elevated carina on the vertex while the latter usually has none. However, in some specimens of *scorpio* the carina can be reduced such that the vertex appears subcarinate. In *doesburgi* it is not uncommon for specimens to have a slight but noticeable carina running the entire midlength of the vertex. Care must therefore be taken with this character. The shape of the paraclypea is diagnostic in one species, *C. pronotata*. However, it is important to note that head shape and size varies with the robustness of the specimen. Several species exhibit a continuum of pronotal robustness (see discussion below), and the wider pronotal forms usually have wider heads with a broadly convex posterior margin, while specimens with narrower pronota have narrower heads with a more narrowly convex posterior margin (Fig. 3A). Further, I have also observed specimens from the same population differing noticeably in head width without differences in pronotal width. Eye width is usually $0.5\times$ the interocular distance and is relatively invariant across the genus. However, in a couple of species the eye width exhibits a tendency to being greater than $0.5\times$ the interocular space.

Antennae. Antennae have figured prominently in the curictan species descriptions of De Carlo (1951, 1956, 1960, 1967) and Roback and Nieser (1974). However, antennae have been found to be extremely plastic in related groups, including the genus *Abedus* (Menke, 1960) in the Belostomatidae, the sister family to the Nepidae, and the waterscorpion genus *Nepa* (Seidenstucker, 1963, Taminini, 1974). Therefore, it should not be too surprising that variability also occurs in *Curicta*. Figure 3B illustrates antennal variability found in *C. pronotata*. Note in particular the differences found in the length of the lobe of segment 2 relative to the length of 3 and in the shape of 3. Both of these traits have been previously used diagnostically in curictan taxonomy. When antennae were examined in single, homogeneous populations, e.g., *C. grandis* (Fig. 3C) and *C. granulosa* (Fig. 3D), the differences were less dramatic than those found across the range of a species, but they still exceeded the differences used by Roback and Nieser (1974) to separate *C. intermedia* [misidentification] and *C. doesburgi*. Therefore, I believe that antennae are also unreliable indicators of species status in *Curicta*.

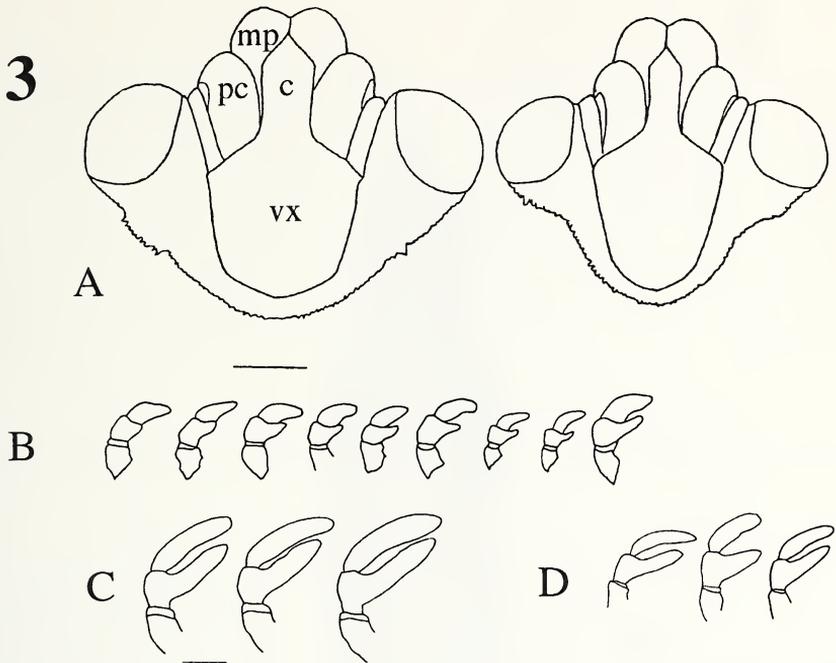


Fig. 3. Head and antennal variation in *Curicta*: A) differences in head shape correlated with pronotal robustness; B) *C. pronotata* antennae taken from across the species' range; C) *C. grandis* antennae taken from a single population in Suriname; D) *C. granulosa* antennae taken from a single population in Joao Pessoa, Brazil (0.25 mm). Abbreviations: c, clypeus; mp, maxillary plate; pc, paraclypeus; vx, vertex.

Pronotum. Two aspects of the pronotum require discussion: shape and sculpturing. Pronotal shape, i.e., the outline of the pronotum in dorsal silhouette, has been used extensively in curictan taxonomy. However, Lansbury (1972) found pronotal shape to exhibit intraspecific variability in the waterscorpion genus *Ranatra* and I have found this trait to be unreliable in curictan species identification. For example, *C. pronotata*, a species defined by four good diagnostic characters (see description), exhibits a wide range of pronotal shapes (Fig. 4A). Study of this variation reveals that pronota differ in length, width, and divergence of the humeral lobes. *C. hungerfordi* also displays considerable pronotal variation, exhibiting shapes that range from the subrectangular to trapezoidal (Fig. 4B). Roback and Nieser (1974) also found pronotal shape too variable to be of use in their study of curictan species found in Colombia. It is clear, therefore, that pronotal shape is quite plastic in this genus and should not be used in species determinations.

Pronotal sculpturing refers to the depth and completeness of the three longitudinal sulci (one median and two lateral) and the prominence, roundedness and carination of the four longitudinal ridges (two medial and two lateral). In some species these characters in aggregate contribute to a diagnosis. For example, in *C. pronotata* (Fig. 5), the median sulcus is always obsolescent posteriorly and the median ridges are

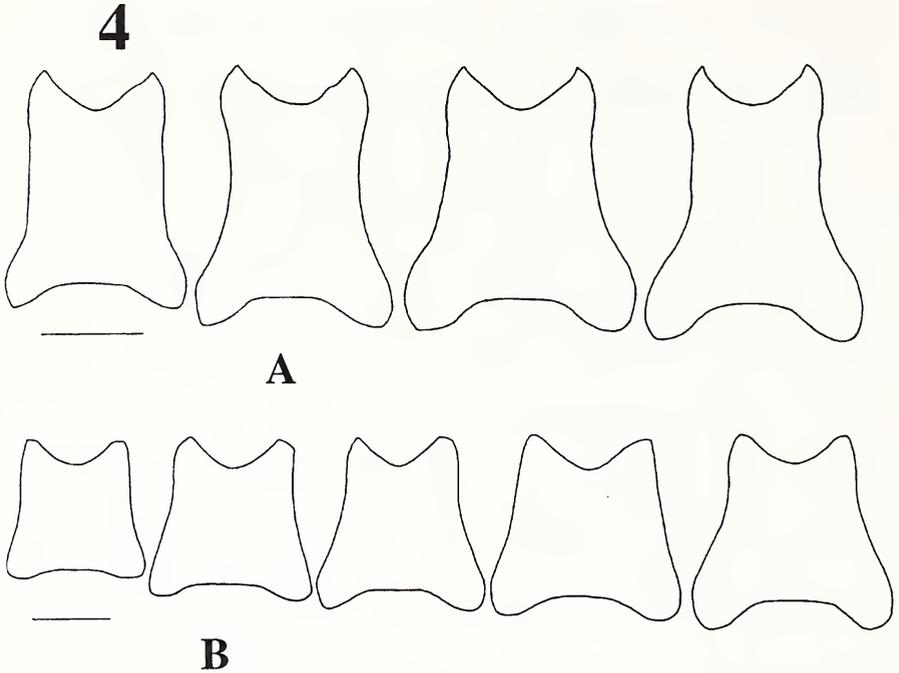


Fig. 4. Pronotal variation in *Curicta*: A) *C. pronotata* (2 mm); B) *C. hungerfordi* (2 mm).

always prominently elevated and rounded. However, in other species sculpturing can be variable. In *C. hungerfordi* (Fig. 6) the median ridges may be elevated and rounded or less elevated and carinate. In *C. doesburgi* the median sulcus may be complete or obsolescent posteriorly, and the median ridges may vary in the degree of prominence and carination. Sometimes variability in sculpturing is apparently correlated with robustness; e.g., in *C. borellii* the more robust forms tend to have subcarinate pronotal ridges while the narrower specimens have more rounded ridges. Thus, pronotal sculpturing can be helpful in curictan species identification but must be used with care.

In many species the presence or absence or degree of granulation on the dorsum of the prothorax contributes to the diagnosis. These granulations are round and dark. They usually are found on the pronotal ridges and on the humeral lobes. The scale-like, adpressed hairs that cover the bodies of curictans obscures the degree to which the granulations are elevated above the underlying cuticle.

Scutellum. The trident pattern on the scutellum can be secondarily helpful but not conclusive in species identification. Of particular interest are the patterns of carination and coloration of the trident, i.e., which parts are elevated above and/or darker than the surrounding scutellum. These traits can be variable, so they should never be considered definitive but might be used to help confirm an identification based on other diagnostic characters. The parts of the scutellum are described in Figure 7.

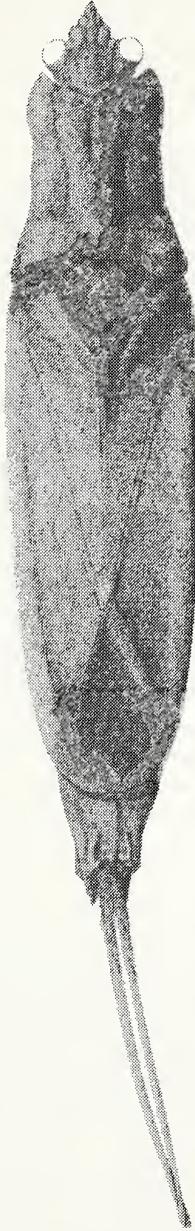


Fig. 5. Dorsal habitus of *C. pronotata* showing pronotal sculpturing (5 mm).

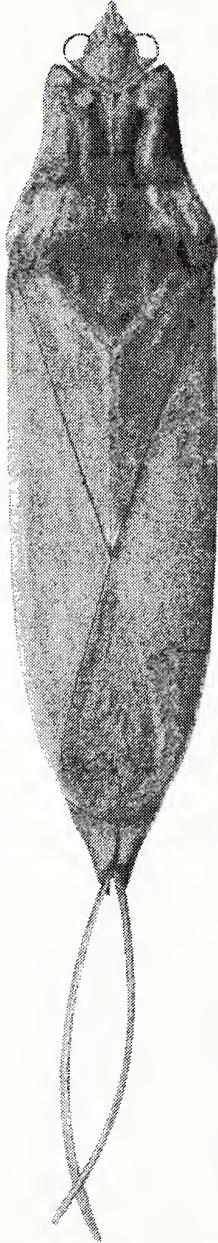


Fig. 6. Dorsal habitus of *C. hungerfordi* showing pronotal sculpturing (5 mm).

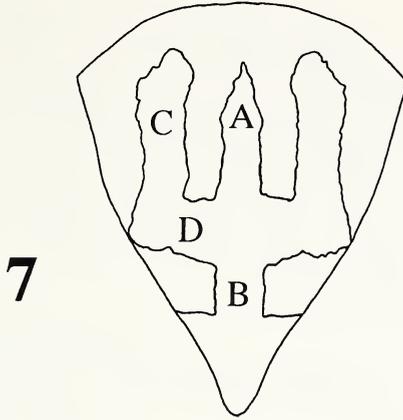


Fig. 7. Diagrammatic rendering of scutellar trident: A = medial prong; B = handle; C = longitudinal section of lateral prong; D = transverse section of lateral prong.

Note that the lateral prongs have two parts, a posterior transverse segment and a more anterior longitudinal segment.

Hemelytra. There is little of taxonomic value in the features of the mesothoracic wings. Species do differ in where the hemelytra are widest: anteriorly, just behind the pronotum, or at a level just anterior to the base of the hemelytral membranes. Hemelytra are also usually beset, sometimes heavily, with granulations similar to those found on the pronotum.

Metathoracic wings. Metathoracic wing venation usually varies intraindividually (Fig. 8) as well as intraspecifically and therefore is of no value in species determination.

Last abdominal tergum. The last abdominal tergum is not covered by the hemelytra and is divided medially into two lateral plates. Two species have raised, longitudinal carinae, one on each plate, which are definitive for those species (Figs. 20B, 21B). Other taxa have distinct parallel rows of hairs, tomentose plates with longer hairs medially seeming to form two rows, or simply tomentose plates without any evidence of rows or carinae.

Respiratory siphons. Many of the specimens examined had broken siphons or were lacking siphons altogether. Further, it was not unusual to encounter a few specimens within each species with siphon lengths quite a bit longer than usual. Therefore, caution must be used when basing species identifications on the siphon lengths given in the species descriptions. Nevertheless, lengths of the siphons relative to total body length have proved useful in delimiting some species.

Prosternum. The shape of the prosternum in lateral view (e.g., Fig. 23B) has been useful in diagnosing several species although this trait can exhibit intraspecific variability (Fig. 22).

Mesosternum. A number of traits of unknown homology occur on the mesosternum. Some species are heavily tomentose on the mesosternum without any carinae or bands of hair evident. Other species have longitudinal, parallel ridges that in one species, *carinata*, are significantly elevated (Fig. 25C). Still other species have par-

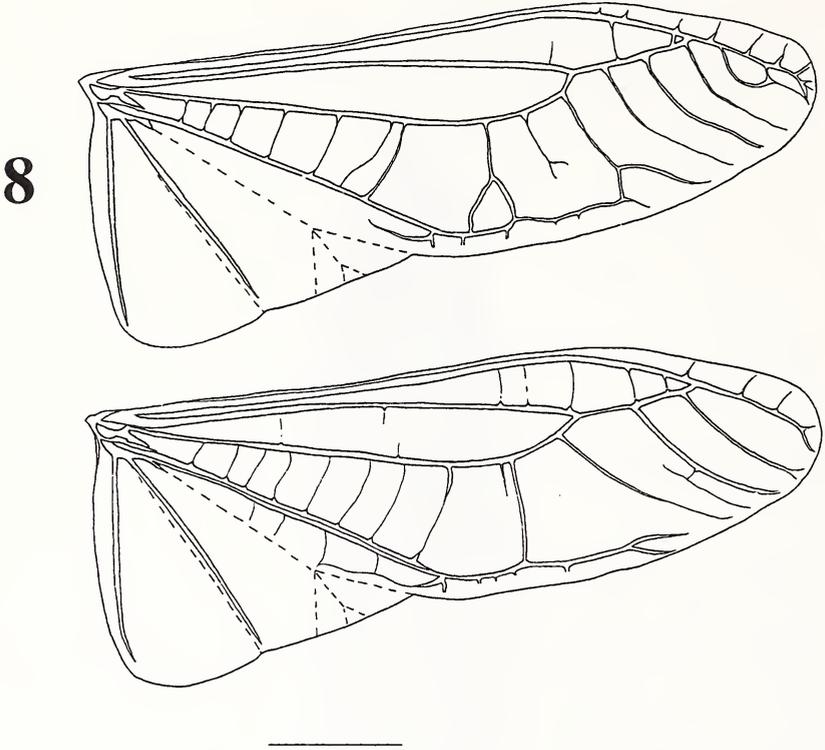


Fig. 8. Metathoracic wings from a single specimen of *C. carinata* (2 mm).

allel (Fig. 27C) or oblique (Fig. 28C) bands of dense hairs. All of these traits have been useful in species delimitation. However, there can be enough intraspecific variability with these bands of hair to warrant caution. For example, the parallel bands on the mesosternum of *granulosa* specimens (Fig. 27C) can be incomplete or even largely absent. The oblique bands of *borellii* (Fig. 28C) may be reduced to patches of dense hair in the posterolateral corners of the mesosternum medial to the mesocoxae. Therefore, for both these taxa the reduction or absence of these traits cannot be taken as grounds for rejecting a *granulosa* or *borellii* determination.

Metasternum. The posterolateral processes of the metasternum have been used in species determinations in other waterscorpion groups but have not been used in curictan taxonomy. In any event, I concur with the observation of Roback and Nieser (1974) that the metasternal processes are too variable to be of value in curictan taxonomy. The shape of these processes can correlate positively with pronotal robustness which, as noted above, can exhibit considerable intraspecific variability. However, I have employed this character to help separate two species pairs: *C. bonaerensis* (Fig. 16b) and *pelleranoi* (Fig. 17B); and *C. doesburgi* (Fig. 30B) and *intermedia* (Fig. 31B). The former pair have good diagnostic characters in addition to the metasternal differences. The latter pair are very close and the metasternal differences may be an artifact of preservation. The metasternal processes of the

intermedia holotype appear to be reflected dorsoposteriorly which makes them appear shorter than those found on *doesburgi* specimens.

Parasterna of the last abdominal segment. The posteromedial shape of the parasterna flanking the operculum has been taxonomically useful. The precise delineation of parasterna and laterotergites in this last of the externally visible abdominal segments (more terminal abdominal segments in the adult are invaginated into the abdomen dorsal to the operculum to form the male and female genitalia) is not clear, because suture lines between these two abdominal components are not as evident as they are in the preceding abdominal segments (Fig. 2B). However, for purposes of this taxonomic treatment, I am assuming that the sclera immediately adjacent to the operculum (sternum 7) constitute the parasterna. The parasterna may end simply, without posterior lobes or processes (Fig. 21C); with broad ventrally produced processes (Fig. 23C); with digitate processes (Fig. 25D); or with thumblike processes (Fig. 29B). These last two character states are respectively differentiated by the absence or presence of dorsal swelling when seen in lateral view.

Operculum. The male operculum is somewhat variable but the more evident differences in opercular shape only tend to confirm the diagnoses of the more distinct species and are of little help with species that are very close in their diagnosis, e.g., *C. volxemi* and *doesburgi* (Fig. 29B and 30D). The female subgenital plate, or operculum (also referred to as abdominal sternum 7), is invariant across the genus (Fig. 2B).

Profemur. Several characters of the profemur have been found useful in delimiting groups of species and, in combination with other characters, providing species diagnoses. The number and position of the profemoral teeth are straightforward and should cause little difficulty in their use (Fig. 9A, B). The presence/absence of profemoral sulcal teeth can be problematic (Fig. 9C). These teeth occur distally in the profemoral sulcus as two elevations, often rounded but sometimes more carinate, with the proximal tooth more elevated than the distal one. The height of these teeth can vary intraspecifically; sometimes the teeth will be quite apparent in lateral view as two dark bumps exceeding the dense hair flanking the profemoral sulcus while at other times the teeth will not be so apparent and one must look obliquely into the sulcus to see them. Small, black tubercles, arranged in a row of varying length, are also found in the profemoral sulcus (Fig. 9C) and these tubercles usually are densely packed on the sulcal teeth and are often absent or reduced in number between the sulcal teeth.

Meso- and metathoracic legs. The mesothoracic legs have no value in curictan taxonomy. The length of the metathoracic legs when extended posteriorly relative to abdominal sternum 6, has been used successfully in the species systematics of the waterscorpion genus *Ranatra* (Hungerford 1922; Kuitert 1949b; Nieser 1975). There is interspecific variation in this character in *Curicta*, but there is also enough intraspecific variation to disallow precise statements about the metafemora relative to sternum 6. Therefore, in the species description I simply report whether the metafemora reach onto the anterior or posterior half of sternum 6.

Male genitalia. Two male genitalic structures, a tubular vesical rod and lack of an ejaculatory reservoir, have been discovered to be diagnostic for the genus (see Genus Description). However, approximately 120 dissections of curictan specimens revealed that male genitalic structures are not useful for species determination (see

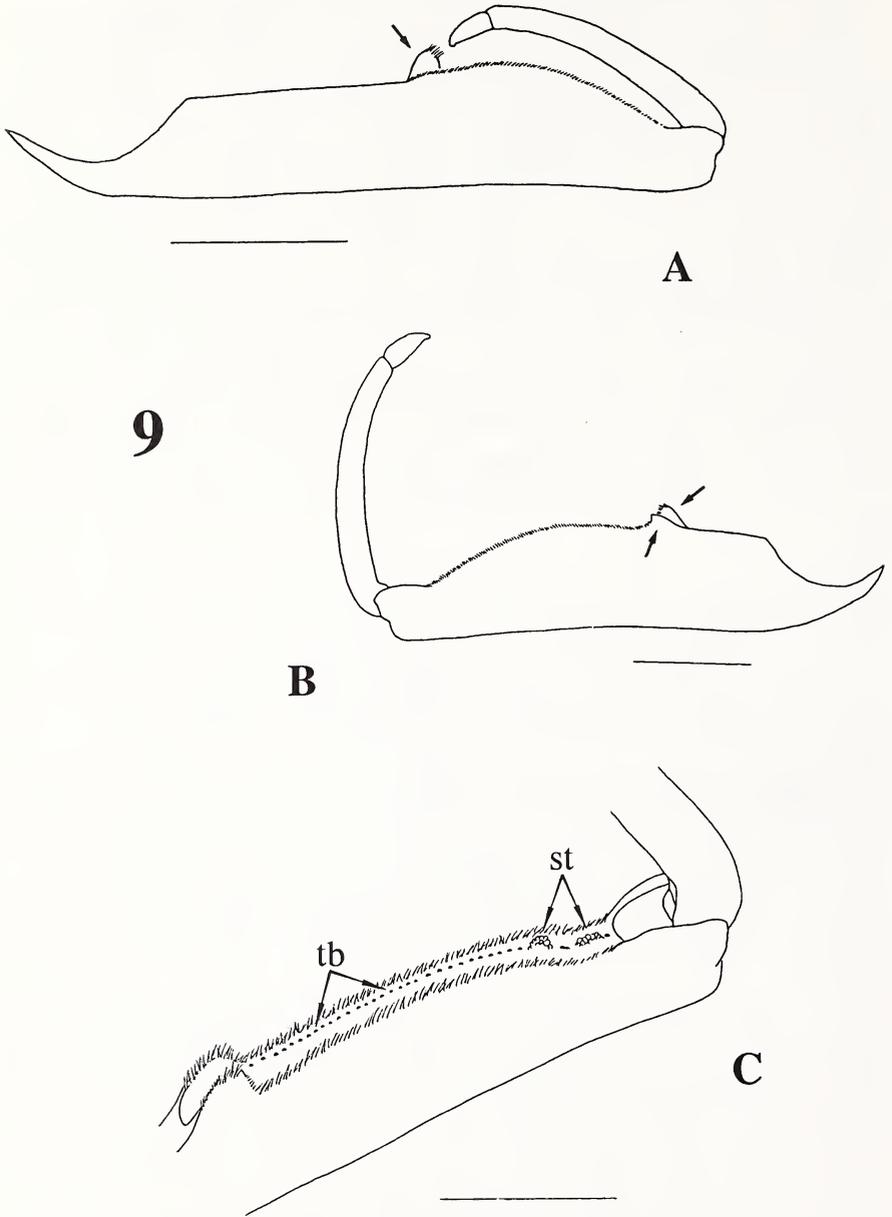


Fig. 9. Important profemoral characters in *Curicta*: a) profemur of *C. pelleranoi* showing the single anteroventral profemoral tooth, posterior view (1 mm); b) profemur of *C. scorpio* showing two profemoral teeth, posterior view (1 mm); c) profemur of *C. doesburgi* showing two profemoral sulcal teeth and tubercles (1 mm). Abbreviations: st, sulcal teeth; tb, tubercles.

Species Concept). Very slight differences in paramere shape have been used by previous workers to delimit species. However, I have found paramere shape to be another plastic trait in this genus. Figure 20F illustrates paramere variability found in specimens of *C. pronotata*. Note the differences in the shapes of the shaft and the dorsoposterior angle. Smaller differences were found in the parameres from single, homogeneous populations of *C. granulosa* (Fig. 27G) and *C. doesburgi* (Fig. 30F) but these differences were equal to those used by previous workers to delimit new species. Note also that in these latter two series both right and left parameres from the same individual are illustrated (pairs with the facing hooks are taken from the same individual) and exhibit differences from side to side. The right and left parameres are illustrated from throughout the range of the homogeneous species *C. grandis* in Fig. 23G. Note once again the intraindividual as well as intraspecific variability that is evident. One would be hard-pressed to describe the typical *grandis* paramere other than to say that the hook is elongate and divergent. Unfortunately, other species also possess a similar hook shape, e.g., *C. peruviana* (Fig. 18F). Representative parameres from most curictan species are illustrated to give the reader a fuller appreciation of the variability in this character. In sum, male genitalia, including the parameres, are of little value in the determination of curictan species.

Female genitalia. Differences in the shape of the 2nd gonapophyses (gp2) divides the genus into two broad groups. All the other female genitalic characters are invariant across the genus.

Genus Description

Genus *Curicta* Stål

Curicta Stål, 1862 (1861):202–03 [Type species by monotypy: *Curicta scorpio* Stål, 1862 (1861):203]; 1865:185; Champion, 1901:352; Montandon, 1903:97–99; Kirkaldy, 1906:154; Kirkaldy and Torre Bueno, 1909:202; Hungerford, 1922:429; De Carlo, 1951:385–421; Roback and Nieser, 1974:40–42; Gonsoulin, 1975:23–25; Nieser, 1975:130–133; Menke, 1979:70–72; Polhemus, D., 1988:518–520; Lee, 1991:61.

Helotenthes Berg, 1879a:72 [Type species by monotypy: *Helotenthes bonaerensis* Berg, 1879a:73 (1879b:195) (originally *H. bonäerensis*)] [Syn. by Montandon, 1903:97]; 1879b:194.

Nepa, Ferrari, E. von, 1888:162–63, 191.

Nepoidea Montandon, 1895:476 [Type species by monotypy: *Nepoidea volxemi* Montandon, 1895:476–477] [Syn. by Champion, 1901:352]; Martin, 1898:66–68.

Redescription

Size. Females on average larger than males in each species. Range in length (exclusive of respiratory siphons): males, 13.0–28.0; females, 13.2–31.3. Profemoral lengths: males, 3.3–9.3; female, 3.4–9.8. Siphon lengths: males, 7.7–26.0; females, 9.0–31.0.

Color. Often masked by adhering habitat substrate and vegetation; when clean variable shades of gray and brown. Pronotum and hemelytra usually mottled with lighter areas, particularly on humeral lobes and in transverse sulcus of the pronotum. Pro-

sternum uniform dark color. Abdominal dorsum uniformly red to dark reddish brown. Abdominal venter dark with lighter mottling usually evident which in some species form longitudinal bands of variable number on sterna and parasterna. Protibia and tarsus yellow; protibia with dark basal annulation, often with dark medial annulation. Profemur dark with variable lighter mottling. Meso- and metathoracic legs dark, light brown, or golden in color.

Structural characteristics. Body covered with dense, short, adpressed hairs. Body elongate, length exclusive of siphons 3.8 to 6.0× maximum width.

Head width always less than anterior width of pronotum. Eye width usually 0.5× interocular distance. Vertex flat to convex, slight to pronounced midlongitudinal carina may be present; in lateral view, vertex always above dorsal margin of eyes. Clypeus (tylus) exceeds paraclypea (juga); maxillary plates meet in front of clypeus. Paraclypea separated laterally from eyes by dense band of short hairs. Posterior margin of head fringed with short hairs. Antennal tubercles ventral to eye, posterior to maxillary plates; antennae directed posteriorly in antennal trough, three segmented, second segment with lobe of varying length. Beak three-segmented.

Pronotum subquadrate to very elongate; lateral length 1.0 to 1.6× posterior width. Anterior and posterior margins concave. Lateral margins subparallel to divergent anterior to humeral lobes. Transverse sulcus usually incomplete, absent in medial third of pronotum. Median longitudinal sulcus deep or shallow; complete or obsolescent posteriorly. Median longitudinal ridges flank median sulcus, and become united as a single ridge in specimens where the median sulcus is obsolescent posteriorly. Lateral sulci concave medially, extending anteriorly from transverse sulci. Lateral ridges flank and follow contour of the lateral sulci, extending from transverse sulci to anterior margin of pronotum. Median and lateral ridges may be rounded or carinate, with or without granulations. Anterior pronotal width less than width across humeral lobes. Posteroventral extensions of pronotum may or may not meet in ventral midline at junction of pro- and mesosterna.

Scutellum acuminate, usually longer than broad, elevated above hemelytra. Trident pattern evident in widely varying degrees; composed of a handle, medial prong, and lateral prongs in two segments, longitudinal and transverse.

Hemelytra elongate, longer than broad; greatest width occurring either anteriorly, just posterior to pronotum, or just anterior to base of membranes; often beset with dark granulations, particularly along lateral margins and in clavus. Claval commisures often raised slightly above rest of hemelytra; a small white triangular area present at claval apex. Hemelytral membrane with many small cells, separated from corium by a row of short, dense golden hairs. Last abdominal tergum not covered by hemelytra; divided into pair of plates by midlongitudinal suture; may have pair of longitudinal carinae, or bands of hairs posteromedially, one per plate. Posteriorly, lateral connexiva associated with these two plates curl ventrally, exceeding posterior margin of ventral operculum (sternum 7). Metathoracic wings usually full-size, only one species (*C. pronotata*) with reduced wing length. Venation variable intraspecifically, even intraindividually. Two large cells are present and invariant across genus.

Prosternum delimited laterally by coxal rims and a pair of longitudinal depressions which begin anteriorly in small vestigial sulci, proceed posteriorly, and converge at the anterior margin of the mesosternum. Prosternum, in lateral view, may appear moderately to dramatically swollen in posterior one-half. Mesosternum longer than

metasternum along midline; midlongitudinal groove often present which in some species is flanked by elevated carinae or bands of dense hairs. Metasternum usually tomentose, emarginate posteriorly producing toothlike processes medial to metacoxae.

Abdominal sternum 2 raised above remaining sterna and visible only between metathoracic coxae. Sterna 3–7 convex along creased midline; each successive sternum subequal to slightly longer than preceding along midline. Sterna wider than parasterna which in turn are subequal to slightly wider than ventrolateral terga. In males, sutures delimiting sterna and parasterna converge towards midline in segment 5 and meet in 6. Sutures in females remain parallel. Parasterna of last abdominal segment usually ending in processes of variable shape. Male operculum, overall, elongate-triangular, variable shape distally. Female operculum lanceolate; convex.

Prothoracic legs raptorial. Procoxa robust, elongate, usually prismatic, shorter than profemora, 0.40 to 0.57 \times profemoral length. Protrochanter shorter than procoxa. Profemur robust with one or a pair of toothlike ventral projections (profemoral teeth); when two teeth present, the anteroventral one always more prominent; distance from base of profemur to tip of anteroventral profemoral tooth 0.30–0.64 \times profemoral length. Narrow ventral sulcus extends from distal end of profemur to profemoral teeth and is lined on both sides by fringe of short, dark hairs which extend part way up medial surfaces of profemoral teeth. Inside sulcus is row of varying length of small, black tubercles; two or more toothlike projections may also occur distally (profemoral sulcal teeth). Profemur arched in varying degrees distal to profemoral teeth. Protibia slender, ventral surface carinate with row of tiny, black tubercles medially flanked by rows of short hairs. Tarsus one-segmented, ending distally in blunt claw; carinate ventrally with row of tubercles and flanking hairs as in tibia.

Meso- and metacoxae subglobular and subequal in length to trochanters; mesocoxae set slightly wider apart than metacoxae. Mesofemora shorter than profemora. Metafemora equal to or longer than profemora. Mesotibia shorter than mesofemora. Metatibia subequal in length to metafemora. Metafemora when extended posteriorly reaching onto anterior or posterior half of sternum 6. Meso- and metafemora and tibiae slightly laterally flattened, femora more robust than tibiae; many long, fine hairs apparent. Meso- and metatibia distally with comb of spines along all but dorsal surface. Tarsae one-segmented, with two or more rows of short spines on ventral and ventrolateral surface; two claws of equal length.

Male genitalia

Capsule (Fig. 10). Short, narrow, boat-shaped, tapering to narrow anterodorsal projection. Lateral plates heavily sclerotized, ventrally variably membranous. Posterior to anterodorsal opening mostly membranous with some variable light sclerotization laterally. Anal cone well sclerotized, forms open hood ventrally under which posterior part of coiled vesica lies when at rest. Parameres hook-shaped.

Phallus (Fig. 11A). Bridge and basal plates broad (Fig. 11B), well sclerotized, darkly pigmented. Lateral arms of basal plates hyaline with darkly pigmented core; entire. Ventrally, lateral arms unite to form lamina ventralis. Anterior diverticulum delimited from phallosoma only by incomplete vertical suture; posterodorsally anterior diverticulum extends superior to phallosomal plates to which anterior diverticulum is fused. Phallosomal plates subrectangular and elongate; distally with oblique,

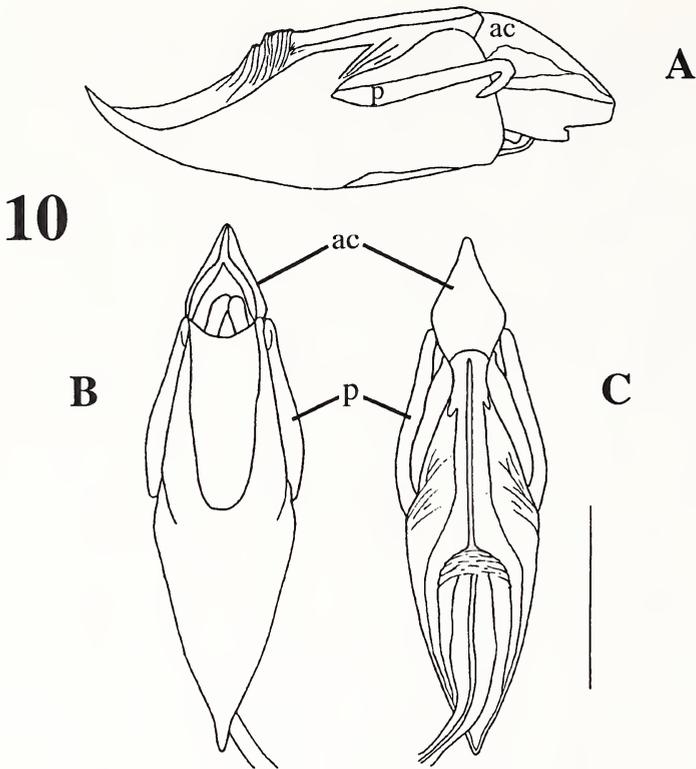


Fig. 10. Male Genitalia: genital capsule of *C. borellii*: A) lateral view; B) ventral view; C) dorsal view (1 mm). Abbreviations: ac, anal cone; p, paramere.

concentric ridges against which proximal coils of vesica lie when at rest. Posterior diverticulum usually membranous, infrequently weakly sclerotized; ends distally as bilobed process, turned dorsally at 45° angle.

Deep structures (Fig. 11C). Median central strut hyaline; articulating anteriorly with ventral surface of vesica rod; fused posteriorly with distal end of lamina ventralis; often nearly horizontal in lateral view, but can exhibit varying degrees of convexity and sinuosity; in ventral view irregularly sinuate (Fig. 12A). Posteriorly central strut ends in pair of processes which flare laterally and fuse with secondary struts, forming an irregular "H-shape" (I. Lansbury, in litt.) in ventral view (Fig. 12B). Paired secondary struts heavily sclerotized, darkly pigmented, dorsoventrally flattened; attached anteriorly via hyaline membranes to median walls of phallosheath plates; posteriorly, secondary struts pass beneath posterior diverticulum, extending to, and sometimes beyond, posteroventral margin of posterior diverticulum. Ejaculatory duct surrounded by thick muscular envelope. No ejaculatory reservoir. Vesical rod well sclerotized and pigmented; tubular except for anterior cup-shaped structure which is open dorsally and receives entering ejaculatory duct. Vesical rod straight to mildly sinuate, thinning distally, becoming hyaline and merging with flagellate

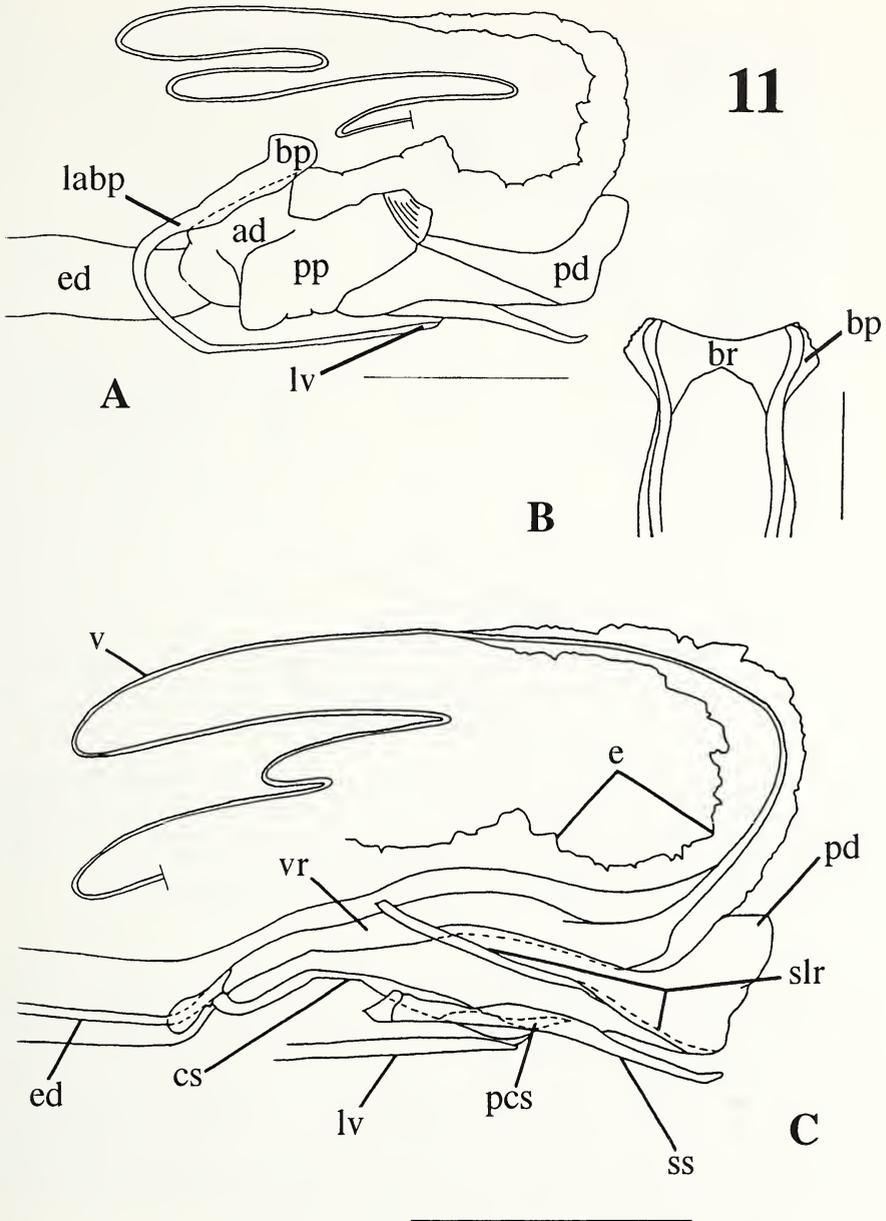


Fig. 11. Male Genitalia: A) phallus, *C. scorpio*, lateral view (1 mm). B) bridge and basal plates, *C. scorpio* phallus, dorsal view (0.25 mm). C) deep structures, *C. scorpio* phallus, lateral view (1 mm). Abbreviations: ad, anterior diverticulum; bp, basal plate; br, bridge; cs, central strut; e, endosoma; ed, ejaculatory duct; labp, lateral arms of the basal plate; lv, lamina ventralis; pcs, process of the central strut; pd, posterior diverticulum; pp, phallothecal plate; slr, sclerotized lever rod; ss, secondary strut; vr, vesical rod; v, vesica.

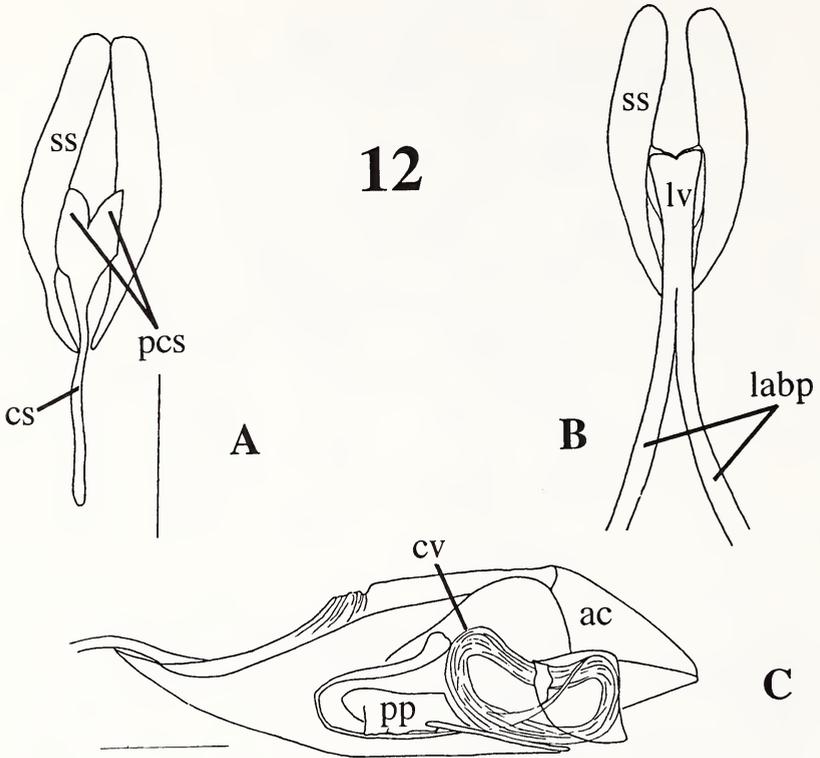


Fig. 12. Male Genitalia: A) central strut and secondary struts, *C. scorio*, ventral view (0.5 mm). B) lamina ventralis and secondary struts, *C. scorio*, ventral view (0.5 mm). C) phallus inside genital capsule showing coiling of vesica, *C. scorio*, lateral view (1 mm). Abbreviations: ac, anal cone; cv, coiled vesica; cs, central strut; labp, lateral arms of the basal plate; lv, lamina ventralis; pcs, processes of the central strut; pp phalothecal plate; ss, secondary strut.

vesica. At rest, vesica coiled with anterior loop held against grooved surface of one of phalothecal plates and posterior loop held under open hood of anal cone (Fig. 12C); when stretched to full length can equal length of adult male body. Vesical rod and vesica enclosed proximally in puffy, membranous endosoma which is attached to distal margins of anterior diverticulum, dorsal edge of the phalothecal plates, and dorsal surface of central strut. Endosoma reduced beyond junction of vesical rod and vesica, forming a simple sheath around the vesica. Paired sclerotized lever rods attached anteriorly to lateral surfaces of vesica rod, posteriorly forming ventrolateral borders of posterior diverticulum; distally meeting in midline.

Female genitalia

First gonocoxae elongate, dorsal angles produced, anteriorly more than posteriorly; well sclerotized (Fig. 13A); many long hairs on posterior half of lateral surface often obscuring distal margin. First gonapophyses broadly triangular in lateral view; well

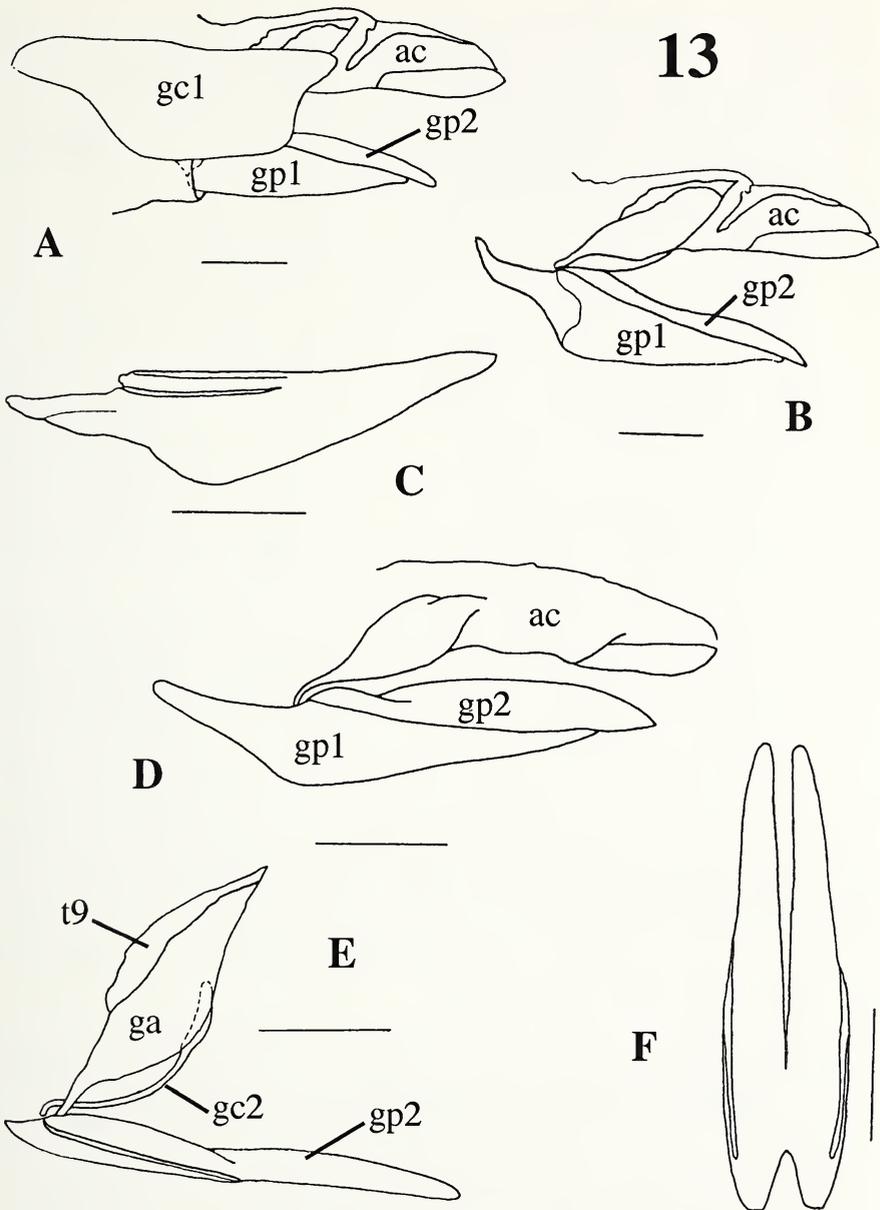


Fig. 13. Female genitalia: A) lateral view, *C. borellii*; B) 1st gonocoxa removed, *C. borellii*, lateral view; C) 1st gonapophysis, *C. borellii*, medial view; D) 1st gonocoxa removed, *C. scorio*, lateral view; E) 1st gonocoxa, 1st gonapophysis, and anal cone removed, *C. borellii*, lateral view; F) 2nd gonapophyses, *C. borellii*, dorsal view (Scale in all drawings, 0.5 mm). Abbreviations: ac, anal cone; ga, gonangulum; gc1, 1st gonocoxa; gc2, 2nd gonocoxa; gp1, 1st gonapophysis; gp2, 2nd gonapophysis, t9, tergum 9.

sclerotized (Fig. 13B); covered with short hairs; posterior half of dorsomedial edge with sclerotized ramus (Fig. 13C); ventromedially connected to pair of membranous lobes which are covered with hairs dorsally and extending to form floor of genital chamber. Second gonapophyses lanceolate; dorsoventrally flattened (Fig. 13B) to slightly arched medially (Fig. 13D); extending posteriorly beyond posterior margin of first gonapophysis; sclerotized ramus along basal lateral edges, interlocking with 1st gonapophysis ramus; fused basally (Fig. 13E). Gonangula well sclerotized, subtrapezoidal; articulating with 1st gonapophyses anteriorly; not always clearly delimited from 9th tergum by suture (Fig. 13E). Second gonocoxae articulating anteriorly with 2nd gonapophyses; slender, well sclerotized; when viewed from ventral aspect two 2nd gonocoxae usually form an "hour-glass" shape ending posteriorly in 2 plates which may be connected medially by weak sclerite. (Much of the structure of the 2nd gonocoxae obscured by long dense hairs.) No gonoplacs found in any species. Single, saclike, dorsal bursa copulatrix attached to anterior margins of fused 2nd gonapophyses, to medial margins of dorsal prolongations of 1st gonapophyses, to dorsal margin of proximal spermatheca, and to lateral margins of ventral membranous projections (Fig. 14A, B). Spermatheca also dorsal, anterior to bursa; at its base and extending anteriorly in dorsal wall of common oviduct is weakly bilobed, thick spermathecal pad with pair of sclerites flanking entrance to spermathecal lumen (Fig. 14A, C); spermatheca proper very elongate and coiled.

Discussion. Three invariant morphological features are unique to the genus *Curicta* among waterscorpion genera: the absence of an ejaculatory reservoir in the male phallus; the tubular vesical rod in the male phallus; and the convergence of the sutures delimiting the abdominal sterna and parasterna on the midline of the sixth abdominal sternite in males. All other genera of Nepidae have an ejaculatory reservoir anteriorly in the male phallus; the vesical rod is an inverted U- or V- shaped in cross section; and the sternal-parasternal sutures of the abdomen are either parallel or, if convergent, they do not meet in the midline on the sixth abdominal segment.

There are no known diagnostic features unique to curictan females. Too little is known about other nepid female genitalia to be certain if anything about the genitalic structure described here is unique.

Male or female specimens of *Curicta* are easily distinguished from members of the other three genera of waterscorpions in the New World, *Nepa*, *Telmatotrepes*, and *Ranatra*, by using the following key:

- 1a. Parasterna visible 2
- 1b. Parasterna not visible *Ranatra*
- 2a. Broad bugs, length less than $3\times$ maximal width; profemoral sulcus complete. 3
- 2b. More elongate bugs, length $3\times$ or greater than maximal width; profemoral sulcus incomplete. *Curicta*
- 3a. Respiratory siphons short, siphon length less than or equal to $0.22\times$ body length; South America *Telmatotrepes*
- 3b. Respiratory siphons longer, siphon length approximately $0.40\times$ body length; eastern North America *Nepa*

Distribution. Nearctic and Neotropical: New Orleans and southern Arizona, U.S.A. to Managua, Nicaragua. South America: cosmopolitan except west of the Andes along the Pacific coast and south of the Argentine province of Buenos Aires.

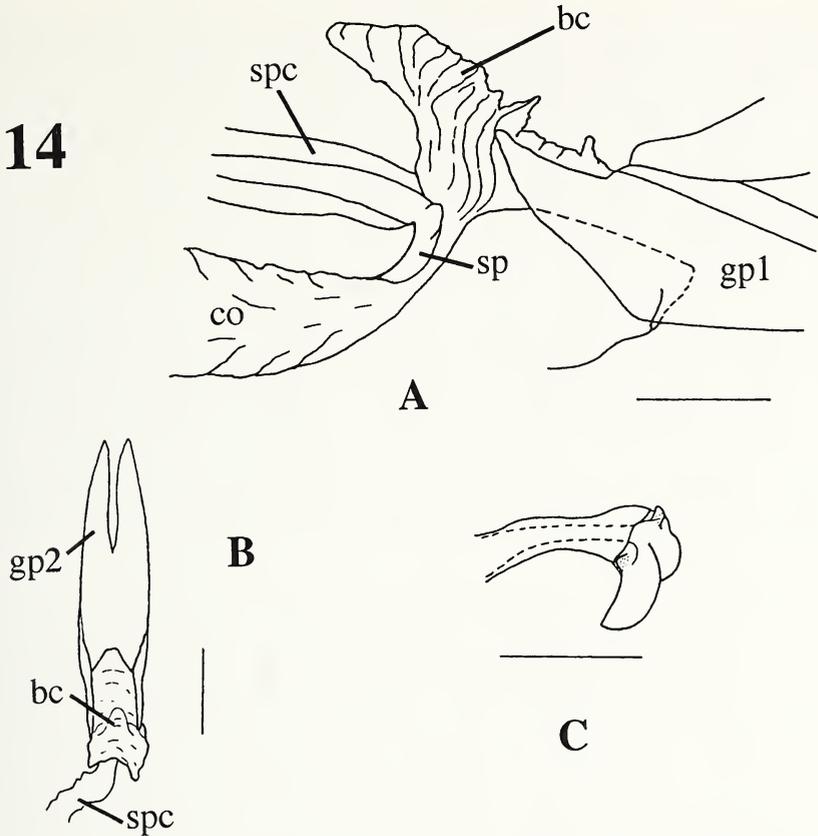


Fig. 14. Female genitalia: A) bursa copulatrix and spermatheca, *C. carinata*, lateral view; B) bursa copulatrix and 2nd gonapophyses, *C. scorio*, dorsal view; C) spermathecal pad, *C. carinata*, posterodorsolateral view. (All drawings, 0.5 mm). Abbreviations: bc, bursa copulatrix; co, common oviduct; gp1, 1st gonapophysis; gp2, 2nd gonapophysis; sp, spermathecal pad; spc, spermatheca.

Etymology. Stål did not explain his choice of a name for this genus. However, *Curicta* may be derived from an ancient Greek name, Kurikta, for the island of Krk (also known as Veglia) in the northeastern Adriatic Sea along the coast of the former Yugoslavia (D. King, pers. comm.). Stål appears to have taken several of his generic names from classical references related to water or the sea. For example, the genus *Duilius* was probably named after a Roman general of the same name who won a naval battle off the coast of Sicily in the third century B.C. The genus *Phintius* may have been named after Phintias, the founder of a Sicilian town. What, if any, special significance led Stål to the selection of *Curicta* as a name for New World water-scorpions remains obscure.

Species concept

Rarely do systematists discuss the species concept employed in their revisionary work. However, the choice of a particular concept of species can have a marked

impact on determining the appropriate boundaries which define each taxonomic species. Therefore, I take this opportunity to make explicit my preferences in species concept, both ideally and in the execution of this review of *Curicta*.

The dominant species concept of the last 50 years has been Ernst Mayr's Biological Species Concept (BSC): "Species are groups of actually or potentially interbreeding populations which are reproductively isolated from other such groups" (Mayr, 1942). For the systematist, the BSC offers a single definitive criterion for species delimitation, the inability of groups to interbreed when in sympatry, and herein lies the epistemological difficulty with the BSC. Rarely are systematists actually able to put this criterion to work in their revisionary studies. For Mayr, however, this was not an insurmountable difficulty. According to Mayr, reproductive isolation develops as a byproduct of the genetic and phenotypic changes occurring during speciation. Therefore, differences in morphology should correlate well with reproductive disjunction and thus can be used with confidence in species delimitation. However, Donoghue (1985) has examined this assumed correlation between phenotypic gaps and reproductive isolation and found scant evidence in its support. Further, such correlation as can be found is weakened by counter examples, ranging from reproductively disjunct but morphologically indistinguishable sibling species to species and even subgenera that exhibit disjunct morphologies without reproductive isolation.

During the 1980's there was an important refocusing of the BSC by Paterson (1985) and Eldredge (1989), the Recognition Species Concept (RSC). According to Paterson, "a species is that most inclusive population of individual biparental organisms which share a common fertilization system." The shift in emphasis from the BSC to the RSC is a subtle but very important one. Both concepts are explicitly oriented toward species as reproductive communities. But the BSC emphasizes what keeps individuals of different species apart, i.e., isolating mechanisms. In contrast, the RSC focuses on what brings individuals of the same species together, i.e., specific mate recognition systems. Specific mate recognition systems include those suites of morphological, behavioral, and biochemical attributes used by individuals of each species to find, court, and successfully copulate with other individuals of the same species. The implications of this shift in emphasis for species taxonomy are important. First, unlike the BSC, the RSC is nonrelational. The BSC requires assessment of interbreeding potential between sympatric groups for species determination, while the RSC delimits species, whether sympatric or allopatric, on the basis of differences in mate recognition systems. Second, the RSC specifies which characters must be used in definitive species delimitation, namely, the reproductive attributes of a specific mate recognition system. The BSC does not differentiate between types of characters in species delimitation; any phenotypic disjunction will do. Thus, species delimitation using the RSC would require the demonstration of invariant differences in characters such as genitalia, courtship behavior, and/or pheromones used in attracting or finding a mate. Phenotypic differences not associated with the specific mate recognition system, e.g., differences in feeding morphology, could not be considered definitive indications of species status.

Paterson's RSC accords well with common taxonomic practice in insect systematics. Genitalia, particularly of the male, are generally given very high weight by insect taxonomists in their species decisions. The high degree of species specificity of male genitalia in animals is a commonly noted phenomenon that has been ac-

corded a book length treatment by Eberhard (1985). In my own previous work with species of the waterscorpion genus *Nepa* (Keffer et al., 1990), I found that male genitalia had generic, species-group, and species specific value. I was hopeful therefore that I could successfully apply the RSC in my delimitation of species in the genus *Curicta*.

However, after approximately 120 dissections of male genitalia representing nearly all the putative curictan species, I found that genitalic structures were either invariant across the genus or varied from individual to individual within populations. Two of the primary structures of intromission, the vesical rod and the secondary struts, varied in shape but with no discernible pattern across the genus. A third intromittent structure, the posterior diverticulum, varied hardly at all from individual to individual. I also found that the parameres varied intraspecifically and even intraindividually (see Discussion of Characters), although these structures have often been used for species determination in other taxa. A final candidate for a species invariant reproductive character was the tremendously elongate vesica which, when uncoiled, was longer than the male's body. Study of this character, however, proved impossible because in all but one of the 120 dissections, the vesica had uncoiled, presumably at death, and had projected back into the abdomen of the male, via the anal cone and anterodorsal opening of the capsule, where it was wound around the digestive and reproductive organs. Retrieval of the entire vesica from alcohol preserved specimens in my own collection required considerable mutilation of the abdomen and therefore would not have been feasible with specimens on loan from museums. Further, in most of the dried specimens examined for this structure, the vesica had adhered to the remnants of the abdominal organs and the abdominal walls and was therefore irretrievable. However, future study of this trait over a large number of specimens might yet yield species specific differences.

Female genitalia are usually not species-specific although that may be an artifact of inadequate sampling by systematists (Eberhard 1985:30–33). Nevertheless, when male genitalia failed to delineate curictan species, I examined female genitalia. Unfortunately, 30 dissections demonstrated to me that female genitalic structures offered nothing of use in species determination, although one character, the shape in lateral view of the 2nd gonapophysis, varied enough between groups of species to be of value in the phylogenetic analysis of the genus.

With the failure of both male and female genitalia to reveal useful taxonomic characters, I was forced to abandon the RSC as my operational species concept for this revision. The species concept employed instead is of necessity a morphological one, based on perceived disjunctions in whatever phenotypic traits I found were useful (see Discussion of Characters). I do not know if the species thus recognized constitute *bona fide* reproductive communities *sensu* Paterson (1985). Therefore, my species determinations must be regarded as provisional hypotheses to be tested by future field and laboratory work.

KEY TO SPECIES OF *CURICTA* STÅL

- 1a. One tooth on anteroventral edge of profemoral sulcus (Fig. 9A) 2
- 1b. Two teeth on profemur on either side of profemoral sulcus (Fig. 9B). 4
- 2a. Single profemoral tooth truncate, inconspicuous (Fig. 15C); Espirito Santo, Brazil
 *C. bilobata* Kuitert

- 2b. Single profemoral tooth pointed, conspicuous (Fig. 16D) 3
- 3a. Profemur dramatically arched beyond femoral tooth (Fig. 16D); northeastern Argentina, Uruguay *C. bonaerensis* (Berg)
- 3b. Profemur moderately arched beyond femoral tooth (Fig. 17D); northeastern Argentina, southeastern Brazil. *C. pelleranoi* De Carlo
- 4a. Profemoral teeth nearer proximal end than distal: distance from base of profemur to tip of anteroventral profemoral tooth $0.45\times$ or less total profemoral length. 5
- 4b. Profemoral teeth usually nearer distal end than proximal: distance from base of profemur to tip of anteroventral profemoral tooth greater than $0.45\times$ total profemoral length 8
- 5a. Respiratory siphons greater than $0.7\times$ body length; protibia with broad, dark annulus medially (Fig. 18E); Peru *C. peruviana* Kuitert
- 5b. Respiratory siphons up to $0.60\times$ body length; protibia with, or without, medial annulus 6
- 6a. Last abdominal tergum without pair of longitudinal carinae; pronotal width along rear margin subequal to lateral pronotal length (Fig. 19A); central Mexico *C. hungerfordi* Kuitert
- 6b. Last abdominal tergum with pair of distinct longitudinal carinae (males) (Figs. 20B, 21B); pronotal width along rear margin less than lateral pronotal length. 7
- 7a. Paraclypea noticeably swollen (Fig. 3A); paired longitudinal carinae on last abdominal tergum in males slender with small medially directed lobes usually occurring beyond midlength (Fig. 20B); northwestern Mexico, southern Arizona. *C. pronotata* Kuitert
- 7b. Paraclypea not swollen; paired longitudinal carinae on last abdominal tergum prominent with large, medially directed lobes usually occurring midway along length (males) (Fig. 21B); Louisiana and Texas to Nicaragua *C. scorpio* Stål
- 8a. Posterior half of prosternum markedly swollen (Fig. 23B); parasterna of last abdominal segment ending in broad processes which extend posteriorly beyond posterior margin of operculum (sternum 7) (Figs. 23C, D); Argentina, Paraguay, Suriname *C. grandis* De Carlo
- 8b. Posterior half of prosternum not markedly swollen; parasterna of last abdominal segment ending in digitate (Fig. 25D) or thumblike processes (Fig. 29B) which may or may not exceed posterior margin of operculum 9
- 9a. Distinct notch in lateral margin of profemoral sulcus present distally; profemoral sulcal teeth noticeably large (Fig. 24C); southeastern Brazil, Uruguay *C. tibialis* (Martin)
- 9b. Distinct notch in lateral margin of profemoral sulcus absent or reduced distally; profemoral sulcal teeth variable 10
- 10a. Profemoral sulcal teeth absent; pronounced longitudinal carina on vertex present (Fig. 25B) 11
- 10b. Profemoral sulcal teeth present (Fig. 9C); pronounced longitudinal carina on vertex present or absent. 12
- 11a. Dark medial annulus on protibia present (Fig. 25F); pair of elevated, longitudinal carinae on mesosternum; dorsum covered with granulations particularly on pronotal ridges and hemelytral margins; parasterna of last abdominal segment ending in digitate processes (Fig. 25D); respiratory siphons up to $0.7\times$ body length; Paraguay, Bolivia, Ecuador, Colombia, Trinidad, Panama. *C. carinata* Kuitert
- 11b. Dark, medial protibial annulus present but faint (Fig. 26C); carinae on mesosternum present but not distinctly elevated; dorsum apparently not covered with granulations; parasterna of last abdominal segment ending in swollen processes (Fig. 26B); respiratory siphons greater than $0.8\times$ body length; Pernambuco, Brazil. . . *C. decarloi*, n. sp.

- 12a. Pronotum heavily beset with dark granulations, particularly on pronotal ridges and humeral lobes. 13
- 12b. Pronotum not heavily beset with black granulations 14
- 13a. Pronounced carina on vertex usually present (Fig. 27B); dark, medial annulus on protibia usually present (may be reduced or even absent, particularly in females) (Fig. 27F); longitudinal pronotal ridges carinate; longitudinal pronotal sulci deep; mesosternum usually with pair of broad, parallel, longitudinal, tomentose bands (Fig. 27C); body lengths: males, 18–22; females, 20–25; Brazil, Paraguay, Bolivia, Peru, Colombia, Venezuela. *C. granulosa* De Carlo
- 13b. Pronounced carina on vertex absent, slight but distinct carina usually present (Fig. 28B); dark, medial annulus on protibia usually absent (when present usually incomplete) (Fig. 28F); longitudinal pronotal ridges rounded to subcarinate in more robust specimens; longitudinal pronotal sulci shallow; mesosternum usually with pair of oblique, tomentose bands arising at junction of posterior margin of mesosternum and metacoxae, extending medioanteriorly up to half the length of mesosternum (Fig. 28C); body lengths: males, 21.6–26; females, 24–30; Argentina, Paraguay, Brazil. *C. borellii* Montandon
- 14a. Body elongate (males > 26 mm, females > 29 mm); noticeably long-legged, length of profemur always longer than lateral length of pronotum by more than 1 mm; southeastern Brazil, Colombia *C. volxemi* (Montandon)
- 14b. Body shorter (males ≤ 26 mm, females ≤ 27 mm); not noticeably long-legged, length of profemur longer than lateral length of pronotum by up to 1 mm 15
- 15a. Parasterna of last abdominal segment posteriorly ending in large, thumblike processes (Fig. 30C); vertex usually without pronounced carina; posterolateral metasternal processes as in (Fig. 30B); Venezuela, the Guyanas, northern Brazil. *C. doesburgi* De Carlo
- 15b. Parasterna of last abdominal segment posteriorly ending in digitate but not thumblike processes (Fig. 31C); vertex with pronounced carina; posterolateral metasternal processes as in (Fig. 31B); Colombia *C. intermedia* (Martin)

Species Descriptions

Curicta bilobata Kuitert

Figs. 15, 32

Curicta bilobata Kuitert, 1949a:61–62; De Carlo, 1951:419.

Redescription

Measurements. Holotype male (no other specimens known): length, 19.2; profemoral length, 5.9; siphons, 12.5.

Color. Light brown. Lighter mottling not apparent on thoracic or hemelytral dorsa. Abdominal dorsum reddish. Abdominal venter dark with four thin, lighter longitudinal bands on sterna 3 and 4 and a single broad band on parasterna 3–6. Protibia somewhat darker basally; no dark medial annulation evident. Protarsus absent on the one prothoracic leg present with specimen. Meso- and metathoracic legs apparently light brown.

Structural characteristics. Body elongate (Fig. 15A): length 5.5× maximum width.

Eye width 0.5× interocular distance. Vertex broadly convex, domelike; without median longitudinal carina. Lobe of antennal segment 2 greater than 0.5× length of 3.

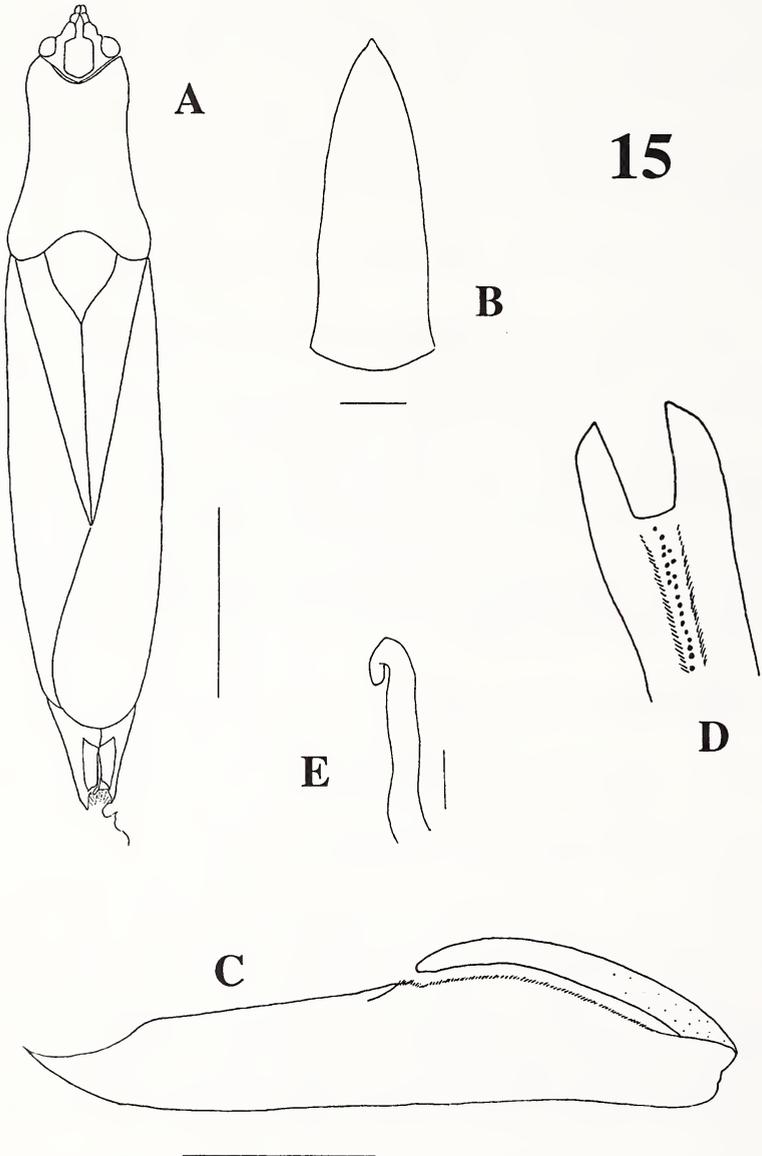


Fig. 15. *C. bilobata*: A) dorsal habitus (5 mm); B) Male operculum (0.5 mm); C) Profemur, anterior view (0.5 mm); D) Distal fifth of profemur showing tubercles in sulcus, dorsal view (0.5 mm); E) Paramere (0.25 mm).

Pronotum elongate; lateral length $1.5\times$ posterior width. Lateral margins parallel anteriorly, divergent posteriorly. Transverse sulcus incomplete. Median longitudinal sulcus very shallow; obsolescent posteriorly. Median longitudinal ridges rounded; converging posterior to obsolescent median sulcus into single rounded ridge which continues to posterior margin of pronotum. Lateral sulci shallow. Lateral ridges rounded. Ridges and humeral lobes apparently without granulations. Posteroventral extensions of pronotum meet in ventral midline at junction of pro- and mesosterna (Fig. 2B).

Scutellum width less than length. Trident pattern indistinct; transverse sections of lateral prongs slightly darker than rest of trident.

Hemelytra widest just anterior to base of membranes; apparently no granulations present. Metathoracic wings fully developed.

Plates of last abdominal tergum deformed by partially protruding phallus; no longitudinal carinae or bands of hairs; apparently not tomentose.

Prosternum in lateral view not swollen. Mesosternum with midline groove present; pair of narrow, parallel ridges on either side of the groove faintly apparent. Parasterna of last abdominal segment ending in small, slender digitate processes which do not extend posteriorly beyond posterior margin of the operculum. Male operculum, Fig. 15B.

Procoxae $0.59\times$ profemoral length. Single truncate profemoral tooth anteroventral to profemoral sulcus (Fig. 15C); distance from base of femur to tip of anteroventral profemoral tooth $0.52\times$ total femoral length. Profemur moderately arched beyond profemoral teeth. Single row of tubercles in profemoral sulcus evident in distal half, becoming an irregular double row close to the tibia (Fig. 15D); no teeth in sulcus distally.

Metafemora reaching onto proximal half of abdominal sternum 6 when extended posteriorly.

Paramere, Fig. 15E (drawn from paramere mounted on plastic card beneath specimen; dissection of male genitalia not done in order to preserve condition of last abdominal tergal plates [see above]). Female genitalia not examined (known only from male holotype).

Discussion. Kuitert diagnosed this species by the "shape of the anterior femur and by two large longitudinal plates on the dorsum of the last abdominal segment for which the species receives its name" (1949a: 62). The abdominal plate deformation, as noted above, is caused by a protruding phallus and therefore cannot be considered diagnostic. However, the single, truncate profemoral tooth is diagnostic. This species cannot be confused with the other species known to occur on Brazil's coast, *C. volxemi*, *doesburgi*, and *decarloi*, because all three of these species have two profemoral teeth. In addition, *volxemi* and *doesburgi* have large thumblike parasternal processes while *bilobata* has small, slender processes. Finally, *decarloi* has a carina on the vertex, a dark, medial protibial annulus, and carinate pronotal ridges, while *bilobata* has none of these features.

Distribution (Fig. 32). Brazil: Espirito Santo.

Material Examined. HOLOTYPE, male: Espirito Santo, Brazil, leg. Fruhstorfer (no temporal data). Deposited in the Snow Entomological Museum, University of Kansas.

Curicta bonaerensis (Berg)

Figs. 16, 32

Helotenthes bonaerensis Berg, 1879a:72; 1879b:194. Lectotype here designated.

Nepa bonaerensis von Ferrari, 1888:191.

Nepoidea falloui Martin, 1898:66–68. Syn. by Kirkaldy and Torre Bueno, 1909:202.

Curicta bonaerensis, Montandon, 1903:98–99.

Curicta falloui, Montandon, 1903:98–99.

Curicta bonaerensis, Kirkaldy and Torre Bueno, 1909:202; De Carlo, 1951:414–415.

Redescription

Measurements. Males: length, 13.0–13.5; profemoral length, 3.3–3.7; siphons, 7.7–8.4. Females: length, 13.2–16.0; profemoral length, 3.4–3.8; siphons, 6.2–9.0.

Color. Light brown. Lighter mottling not evident on thoracic or hemelytral dorsa. Abdominal dorsum brownish red. Abdominal venter dark, usually with four lighter, longitudinal bands on sterna 3–6; one such band per parasterna 3–6. Protibia with dark basal annulation, occasionally dark distally but no dark medial annulation present. Meso- and metathoracic legs light brown to golden.

Structural Characteristics. Body elongate (Fig. 16A); length 4.2–4.5× maximum width.

Eye width usually slightly greater than 0.5× interocular distance. Vertex broadly convex; infrequently subcarinate medially. Lobe of antennal segment 2 usually up to 0.5× length of 3.

Pronotum subelongate; lateral length 1.1× posterior width. Median longitudinal sulcus shallow, complete or obsolescent posteriorly. Transverse sulcus incomplete. Median longitudinal ridges rounded. Lateral sulci shallow. Lateral ridges rounded. Ridges and humeral lobes without granulations. Posteroventral extensions of pronotum do not meet in ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width slightly less than length. Trident pattern usually indistinct; uniform color.

Hemelytra widest anterior to base of membranes; some granulations evident along hemelytral margins. Metathoracic wings fully developed.

Last abdominal tergum variable: some specimens exhibit two narrow, postero-medial, parallel bands of hairs, while others are simply tomentose with no apparent bands.

Prosternum in lateral view moderately swollen in posterior half. Mesosternum: midline groove present; longitudinal, parallel, tomentose bands often present, usually irregular and limited to posterior half. Metasternum tomentose; posterolateral processes robust (Fig. 16B). Parasterna of last abdominal segment ending in small, digitate processes which are subequal posteriorly to posterior margins of male and female opercula. Male operculum, Fig. 16C.

Procoxae about 0.54× profemoral length. Single, pronounced profemoral tooth on the anteroventral margin of profemoral sulcus; distance from base of profemur to tip of anteroventral profemoral tooth about 0.59× total femoral length. Profemur dramatically arched beyond profemoral tooth (Fig. 16D). Profemoral sulcus curvilinear, convex posteriorly (Fig. 16E); no tubercles or sulcal teeth.

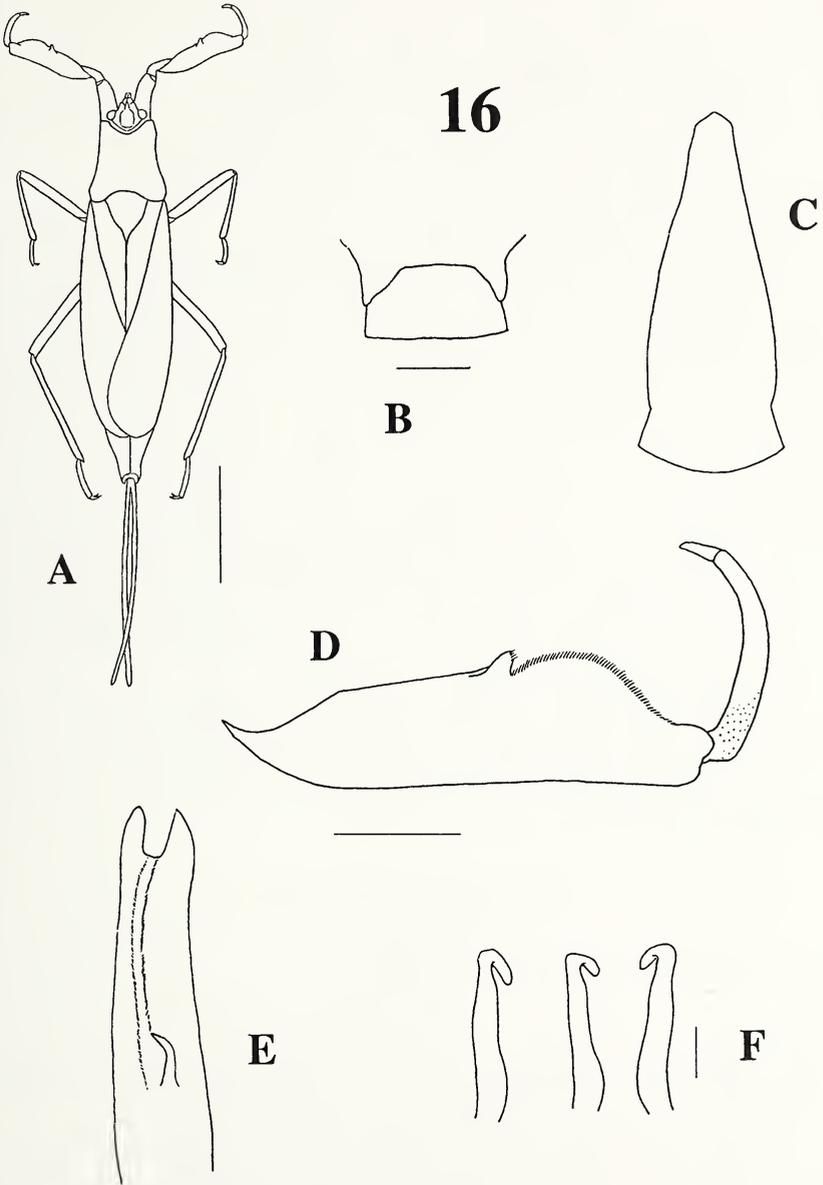


Fig. 16. *C. bonaerensis*: A) dorsal habitus (5 mm); B) posterolateral metasternal processes, ventral view (0.5 mm); C) male operculum (0.5 mm); D) profemur, anterior view (1 mm); E) profemur, ventral view (1 mm); F) parameres (0.25 mm).

Metafemora reaching onto proximal half of abdominal sternum 6 when extended posteriorly.

Parameres, Fig. 16F Female genitalia: Gp2 arched dorsomedially (Fig. 13D).

Discussion. The characters of the profemur readily separate this species from all other *Curicta* spp.: single elongate profemoral tooth; profemur dramatically arched beyond the profemoral tooth; and curvilinear profemoral sulcus. *C. pelleranoi* is similar to *bonaerensis* having a single profemoral tooth, a curvilinear sulcus, and similar parameres. However, *pelleranoi*'s profemur is not so dramatically arched beyond the profemoral tooth. In addition, *bonaerensis* specimens have a moderately dilated prosternum in lateral view while *pelleranoi* specimens do not.

Distribution (Fig. 32). Argentina: Buenos Aires, Entre Rios. Uruguay: Durazno.

Material examined. Berg did not designate a type specimen for this species and it is unclear from his original description whether he was looking at a series or a single specimen. One of the specimens loaned from the Natural History Museum of the National University of La Plata has a determination label on it in Berg's handwriting (Horn and Kahle, 1937, Volume 3, Table XXII, no. 9). I therefore am designating this specimen a lectotype. The type for *Nepoidea falloui* Martin bears a handwritten determination label with the species name, the word "type," the name "J. Martin," and the date "28 fe'r 1898." It is clear from Martin's original description that he was looking at a single specimen ("un exemplaire de la collection G. Fallou", p. 66) therefore the specimen I have before me must be the holotype and I have so labeled it. LECTOTYPE, female: *Helotenthalis bonaerensis* Berg. Argentina, Buenos Aires, leg. Guenther. No temporal data. Deposited in Natural History Museum of the National University of La Plata (MLP). HOLOTYPE, female: *Nepoidea falloui* Martin. Rio-Grande, leg. G. Fallou, "259-95." No temporal data unless the three numbers listed are the date collected, e.g., 25 September 1895. Deposited in the Museum National D'Histoire Naturelle, Paris (MNHN).

Additional material examined. 26 specimens collected in March (2), April (1), Sept. (1), Dec. (1) (the remaining 21 specimens without temporal data); deposited in JTFC, MACN, MLP, NMNH, MNHN, SEMC. ARGENTINA. Buenos Aires: Buenos Aires; Chascomas; Escobar; La Plata; Lujan; Rosas-F. C. Sud. Entre Rios: Lazo. URUGUAY: Durazno: Castillo.

Curicta pelleranoi De Carlo

Figs. 17, 32

Curicta pelleranoi, De Carlo, 1951:415-416.

Redescription

Measurements. Male (1 specimen): length, 13.2; profemoral length, 3.5; siphons, 8.0. Females (2 specimens): length, 15.2, 17.1; profemoral length, 4.1, 4.9; siphons, 8.0 (the larger specimen lacks siphons).

Color. Female holotype: light brown; lighter mottling not apparent on thoracic or hemelytral dorsa. Second female light brown, lighter mottling evident on dorsum. Male apparently dark brown. Abdominal dorsum brownish red. Abdominal venter dark with four thin, lighter longitudinal bands on sterna 3-6 and a single broad band on parasterna 3-6, except on holotype where parasterna have lighter mottling but no

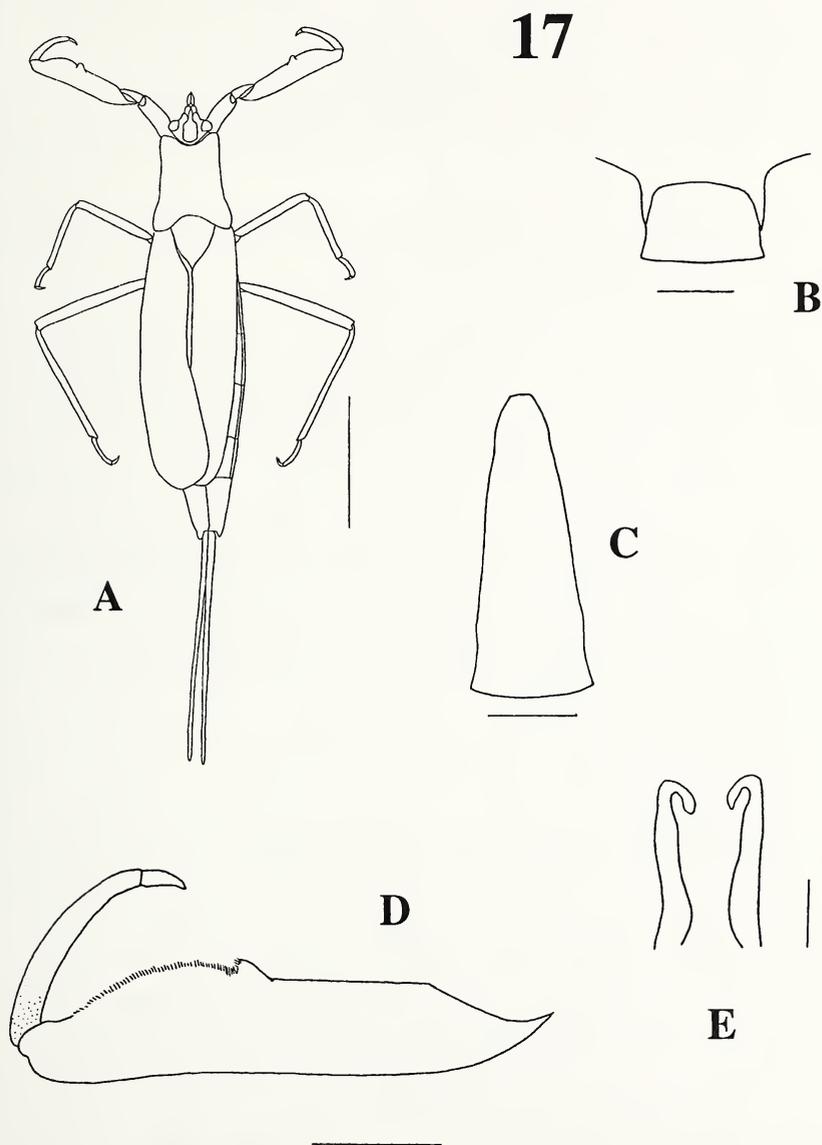


Fig. 17. *C. pelleranoi*: A) dorsal habitus (5 mm); B) posterolateral metasternal processes, ventral view (0.5 mm); C) male operculum (0.5 mm); D) profemur, anterior view (1 mm); E) parameres (0.25 mm).

bands. Protibia with dark basal annulation; no medial annulation. Meso- and meta-thoracic legs concolorous with body.

Structural characteristics. Body elongate (Fig. 17A); length 5.0–5.6× maximum width.

Eye width 0.5× interocular distance. Vertex slightly convex; no median carina. Lobe of antennal segment 2, 0.5× (or slightly more than 0.5×) length of 3.

Pronotum elongate; lateral length approximately 1.2–1.6× posterior width. Transverse sulcus incomplete. Median longitudinal sulcus shallow, obsolescent posteriorly. Median longitudinal ridges indistinct, rounded. Lateral sulci shallow. Lateral ridges rounded. Ridges and humeral lobes with black granulations (not apparent on female holotype). Posteroventral extensions of pronotum do not meet in ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width less than length. Trident not apparent; black where handle and transverse parts of lateral prongs would be.

Hemelytra widest anterior to base of membranes; black granulations along margins and in clavus. Metathoracic wings fully developed.

Last abdominal tergum without carinae or parallel bands of hairs; not tomentose.

Prosternum in lateral view not swollen in the posterior half. Mesosternum with midlongitudinal groove present; carinae or bands of hair absent. Metasternum tomentose; posterolateral processes elongate, slender (Fig. 17B). Parasterna of last abdominal segment ending in small, digitate processes which do not extend posteriorly beyond the posterior margins of male and female opercula. Male operculum (Fig. 17C).

Procoxae 0.5–0.57× profemoral length. Single, pronounced profemoral tooth on the anteroventral margin of profemoral sulcus; distance from base of profemur to tip of profemoral tooth 0.57–0.60× total profemoral length. Profemur strongly arched beyond profemoral tooth (Fig. 17D) but not as dramatically as in *C. bonaerensis* (Fig. 16D). Profemoral sulcus curvilinear, convex posteriorly; no tubercles or sulcal teeth present.

Metafemora just reaching anterior margin of abdominal sternum 6 when extended posteriorly.

Parameres, Fig. 17E. Female Genitalia: Gp2 arched dorsomedially (Fig. 13D).

Discussion. This species is similar to *C. bonaerensis*. Both species have a single profemoral tooth, a curvilinear profemoral sulcus, tubercles and sulcal teeth absent in the femoral sulcus, and similar male parameres. However, four characters separate these species: in *bonaerensis* the pronotum is subelongate and the pronotal median sulcus is complete, the prosternum is swollen in the posterior one-half, and the scutellar trident is faint but evident; whereas in *pelleranoi*, the pronotum is more elongate and the median sulcus obsolescent posteriorly, the prosternum not swollen, and the trident pattern not apparent except for the dark patches noted in the species description above. In addition, all three of the *pelleranoi* specimens have black granulations on the abdomen and two of them (the female from São Paulo and the male) have granulations on the thorax as well. None of the *bonaerensis* specimens have these markings. Clearly, more collecting of this interesting species will further aid our understanding of the relationship between these two closely related species.

Distribution (Fig. 32). Argentina: Corrientes. Brazil: São Paulo.

Material examined. HOLOTYPE, female: *Curicta pelleranoi* De Carlo: Argentina,

Corrientes, Santo Tomé, 10-928. No collector data with specimen but De Carlo indicates in his description (1951:416) that G. Pellerano was the collector.

Additional material examined. Two specimens. ARGENTINA. Corrientes: Est. Galzarza; 4 April 1980; leg. A. O. Bachmann. BRAZIL. São Paulo: Cap. Rua Sorocaba 45; 30 March, 1961; leg. C.G.F.

Curicta peruviana Kuitert

Figs. 18, 32

Curicta peruviana Kuitert, 1949:65–66; De Carlo, 1951:419–420; 1960:51.

Redescription

Measurements. Males: Length, 22.2–23.5; profemoral length, 7.3–7.6; siphons, 17.5–19.0. Females (2 specimens): Length, 25.5–25.8; profemoral length, 8.1; siphons, 19.8–20.3.

Color. Uniformly dark brown; no lighter areas evident on thoracic or hemelytral dorsa. Abdominal dorsum brownish red. Abdominal venter dark, no lighter areas evident. Protibia with dark basal annulation; broad, dark medial annulation (one specimen has amber colored protibia which makes it difficult to see the dark medial annulation). Meso- and metathoracic legs uniformly dark.

Structural characteristics. Body elongate (Fig. 18A); length 4.3–4.8× maximum width.

Eye width approximately 0.5× interocular distance. Vertex flat; median, longitudinal band of darker hairs that bifurcates anteriorly; posterior crescent-shaped band of darker hairs distinct. Lobe of antennal segment 2 usually $\geq 0.5 \times$ length of 3.

Pronotum elongate; lateral length approximately 1.3–1.4× posterior width. Transverse sulcus nearly complete in some specimens but quite shallow in medial third. Median longitudinal sulcus shallow, obsolescent posteriorly. Median longitudinal ridges prominent, rounded, merging posterior to obsolescent median sulcus, gradually declivent to transverse sulcus. Lateral sulci shallow. Lateral ridges rounded, indistinct. Ridges and humeral lobes covered with small, black granulations. Posteroventral extensions of pronotum meet in ventral midline at junction of pro- and mesosterna (Fig. 2B).

Scutellum width less than length. Trident not very distinct; vague outline provided by darker hairs.

Hemelytra widest just anterior to base of membrane (females more so than males whose hemelytral margins between humeral lobes and hemelytral membranes tend to be subparallel); dark granulations present, heaviest along margins and in clavus. Metathoracic wings fully developed.

Last abdominal tergum of both sexes with distinct pair of parallel, longitudinal bands (one per plate) of dense, long hairs (Fig. 18B).

Prosternum in lateral view swollen in the posterior half. Mesosternum with midline groove present; heavily tomentose, appearing granular. Metasternum also heavily tomentose. Parasterna of last abdominal segment ending in broad, ventrally produced processes flanking operculum (Fig. 18C) which posteriorly extend noticeably beyond the posterior margins of the male and female opercula (Fig. 18D). Male operculum (Fig. 18D).

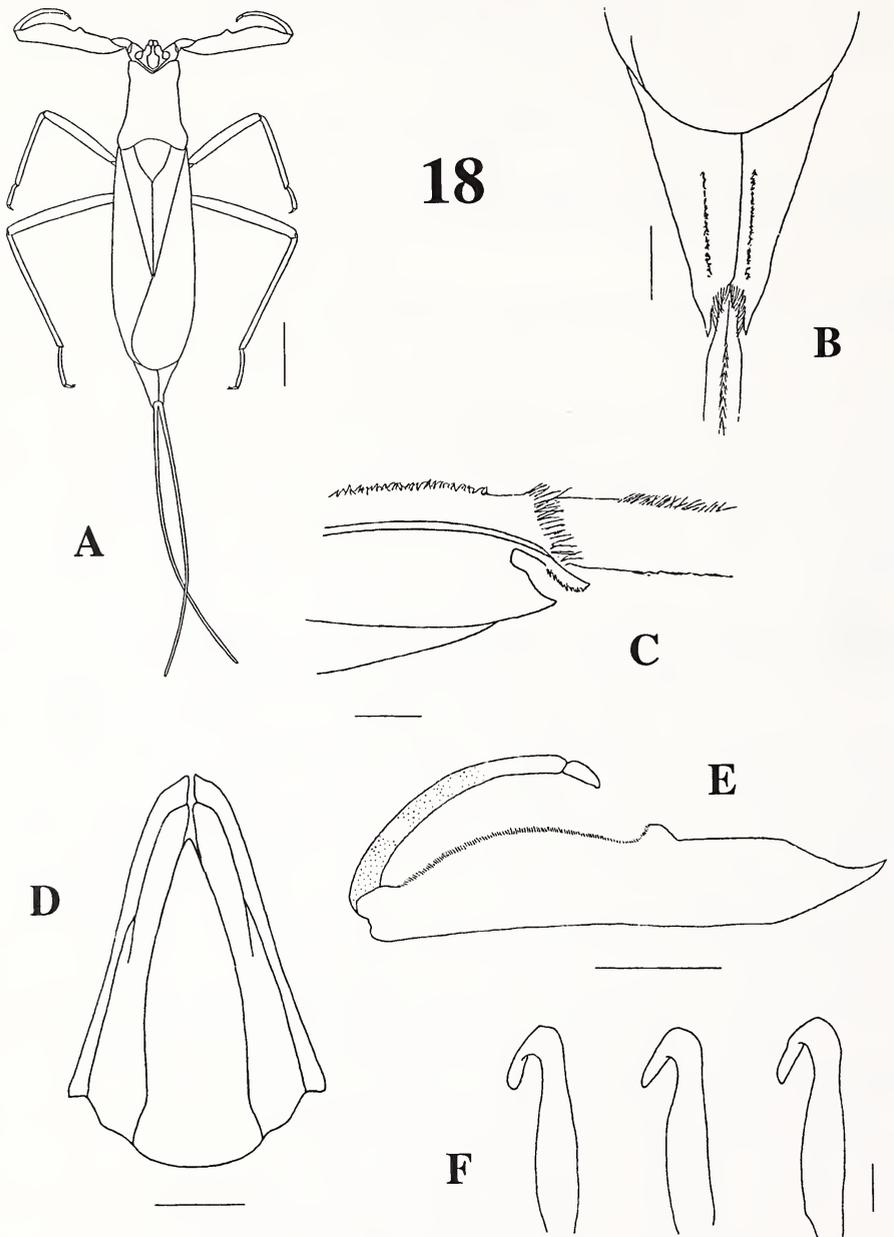


Fig. 18. *C. peruviana*. A) dorsal habitus (5 mm); B) last abdominal tergum (1 mm); C) last abdominal segment, lateral view (0.5 mm); D) last abdominal segment, ventral view (1 mm); E) profemur, anterior view (2 mm); F) parameres (0.25 mm).

Procoxae approximately $0.45\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth approximately $0.44\times$ total femoral length (Fig. 18E). Profemur moderately arched beyond profemoral teeth. Profemoral sulcus with single row of less than dozen tubercles distally; no sulcal teeth.

Metafemora reaching onto posterior half of abdominal sternum 6 when extended posteriorly.

Paramere Fig. 18F. Female genitalia: Gp2 dorsoventrally flattened (Fig. 13B).

Discussion. Four characters in combination are diagnostic for this species: proximal profemoral teeth; distinct longitudinal bands of long, dense hair on the last abdominal tergum; respiratory siphon length greater than $0.7\times$ body length; and a broad, dark medial annulus on the protibia. *C. pronotata* from western Mexico shares the first and last characters with *peruviana*. However, in *pronotata*, the last abdominal tergum has a pair of elevated carinae with medial projections (males only; in females this trait is obscure) and the siphons are less than $0.6\times$ the length of the body.

Distribution (Fig. 32). Peru: Sani Beni and Satipo.

Material examined. HOLOTYPE, male: Vic. Sani Beni, Peru, 890 m.a.s.l., small pool, 17 Oct. 1935, leg. F. Woytkowski. Deposited in Snow Entomological Museum, University of Kansas. ALLOTYPE, female: same locality data except listed as collected in "jungle pools." Deposited in Snow Entomological Museum, University of Kansas. PARATYPES, four males: same locality data except: three collected in "jungle pools", one in "small pools;" one date given as 19 October 1935. Deposited in Snow Entomological Museum, University of Kansas.

Additional material examined. 14 specimens collected in October (12) and November (2); deposited in SEMC. PERU. Sani Beni; Satipo.

Curicta hungerfordi Kuitert
Figs. 19, 33 (See also 4B, 6)

Curicta hungerfordi Kuitert, 1949a:64–65; De Carlo, 1951:396.

Redescription

Measurements. Males: Length, 12.5–16.8; profemoral length, 3.4–4.5; siphons, 7.0–8.2. Females: Length, 14.1–18.9; profemoral length, 4.1–5.1; siphons, 8.2–9.2.

Color. Dark brown in larger specimens to light brown in smaller specimens; lighter mottling evident on thoracic and hemelytral dorsa. Abdominal dorsum red. Abdominal venter heavily mottled with lighter areas but without longitudinal bands. Protibia dark basally, becoming gradually lighter distally, with or without an indistinct, dark medial annulation. Meso- and metathoracic legs concolorous with body.

Structural Characteristics. Body elongate (Fig. 19A); length $3.8\text{--}4.2\times$ times maximum width.

Eye width about $0.5\text{--}0.7\times$ interocular space. Vertex convex; slight median longitudinal carina evident. Lobe of antennal segment 2 greater than $0.5\times$ length of 3.

Pronotum subquadrate (Fig. 4B); lateral length subequal to posterior width. Transverse sulcus complete in most specimens but shallow in medial third of pronotum. Median longitudinal sulcus shallow; usually obsolescent posteriorly, infrequently complete. Median longitudinal ridges prominent, rounded and elevated or subcari-

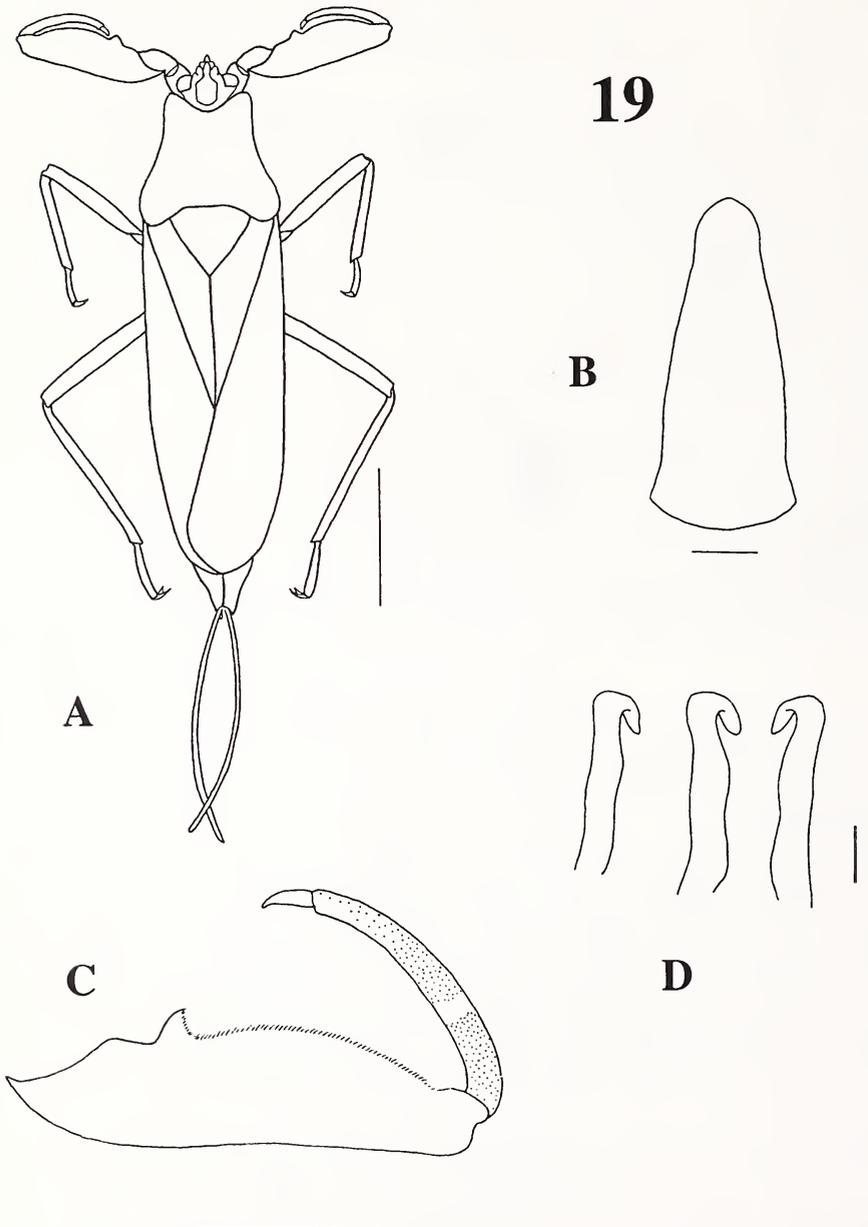


Fig. 19. *C. hungerfordi*: A) dorsal habitus (5 mm); B) operculum (0.5 mm); C) profemur, anterior view (2 mm); D) parameres (0.25 mm).

nate; fused posterior to obsolescent median sulcus, gradually declivent to transverse sulcus. Paired lateral sulci shallow. Paired lateral ridges rounded, prominent. Ridges and humeral lobes with some granulations; this particularly evident in larger specimens. Posteroventral extensions of pronotum meet on ventral midline at junction of pro- and mesosterna (Fig. 2B).

Scutellum width subequal to length. Trident pattern not distinct but elevated above rest of scutellum; lateral prongs subcarinate and arched medially; longitudinal parts of lateral prongs and handle usually darker.

Hemelytra usually widest just anterior to base of membranes; some of larger specimens have subparallel hemelytral margins between humeral lobes and hemelytral membranes; granulations evident along margins and in clavus in larger specimens. Metathoracic wings fully developed.

Last abdominal tergum without carinae; parallel, longitudinal bands of longer hairs, one per plate, present in less than one-third of specimens examined.

Prosternum in lateral view swollen in the posterior half. Mesosternum with neither midline groove, carinae, nor bands of hair evident. Metasternum tomentose. Parasterna of last abdominal segment usually ending without terminal processes; a few specimens with short, digitate processes which do not extend posteriorly beyond posterior margins of male and female opercula. Male operculum, Fig. 19B.

Procoxae $0.40\text{--}0.45\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth $0.30\text{--}0.40\times$ total profemoral length (Fig. 19C). Profemur strongly arched beyond profemoral teeth. Profemoral sulcus with single row of tubercles throughout its length; no sulcal teeth.

Metafemora reaching onto proximal third abdominal sternum 6 when extended posteriorly.

Parameres, Fig. 19D. Female genitalia: Gp2 arched dorsomedially (Fig. 13D).

Discussion. Profemoral teeth occurring at 0.30 to $0.40\times$ the length of the profemur and the large eye width relative to the interocular distance are diagnostic for this species. Compared to the other two species occurring in Mexico, *C. scorpio* and *C. pronotata*, *hungerfordi* is smaller, has profemoral teeth more proximal, and lacks carinae on the dorsum of the last abdominal tergum.

Three characters vary continuously between the smaller and larger specimens in this species. In the smaller specimens (principally a series from Tlalpam, Federal District) the pronotal humeral lobes are not markedly produced posterolaterally (Fig. 4B), eye width begins at approximately $0.5\times$ the interocular distance, and the dorsum of the body has few apparent granulations. As body size increases, the humeral lobes tend to become more divergent posterolaterally, eye width increases up to approximately $0.7\times$ the interocular space, and the dorsum of the thorax and abdomen is increasingly likely to have granulations.

Finally, it should be noted that two of the three specimens comprising the syntype series for *C. scorpio* are actually *C. hungerfordi* (see the discussion for *C. scorpio*). *Distribution* (Fig. 33). Mexico: Federal District, Morelos, Jalisco, Michoacan, Hidalgo.

Material examined. HOLOTYPE, male: Mexico, Real de Arriba, District of Temascaltepec, Alt. 1960 m, May–June 1933, leg. H. E. Hinton. Deposited at the Snow Entomological Museum of the University of Kansas. ALLOTYPE, female: Mexico, Real de Arriba, Temascaltepec, 25 May 1933, leg. R. L. Usinger. Deposited at the

Snow Entomological Museum of the University of Kansas. PARATYPES, three females: Mexico, Pachuca, Mor., Hgo Hgw 65 120 km, 21 September 1946, leg. J. G. Shaw (2); Morelos, 14 July 1936. Deposited at the Snow Entomological Museum of the University of Kansas.

Additional material examined. 33 additional specimens collected in June (1), July (2), and September (27); deposited in AMNH, ISNB, JTPC, NHRS, SEMC. MEXICO. Federal District: Tlalpam; Xochimilco. Hidalgo: Pachuca, Hwy 65-120 km. Jalisco: 12 km W Ojuelos de Jalisco. Michoacan: Patzcuaro, 7,200', 4 mi. W. Cuidad Hidalgo.

Curicta pronotata Kuitert

Figs. 20, 33 (See also 3A, 3B, 4A, 5)

Curicta howardi [sic], Hungerford, 1922:430-431. (Misidentification)

Curicta pronotata Kuitert, 1949a:66-68; De Carlo, 1951:39; Polhemus, J., 1976: 207-208; DuBois, 1978:207; Polhemus, D., 1988:529-530.

Redescription

Measurements. Males: Length, 19.0-22.5; profemoral length, 5.8-7.0; siphons, 9.5-12.7. Females: Length, 20.0-26.0; profemoral length, 6.5-8.2; siphons, 10.0-13.8.

Color. Grayish-brown; lighter mottling only faintly apparent on thoracic and hemelytral dorsa. Abdominal dorsum reddish. Abdominal venter with two lighter spots on each of sterna 3-6; no lighter longitudinal bands. Protibia dark basally with wide, dark medial annulation. Distal tibia and tarsus dark. Meso- and metathoracic legs dark.

Structural characteristics. Body elongate (Fig. 20A); total length 4.5-5.0× maximum width.

Eye width 0.5× interocular distance. Vertex convex, median, longitudinal band of darker hairs present, bifurcates anteriorly in about half of specimens; posterior crescent-shaped band of darker hairs distinct. Paraclypea noticeably swollen, rounded (Fig. 3A). Lobe of antennal segment 2 up to 0.5× length of 3.

Pronotum elongate; lateral length 1.1-1.5× posterior width. Transverse sulcus incomplete. Median longitudinal sulcus shallow, obsolescent posteriorly. Median longitudinal ridges very prominent and elevated, quite rounded, fused posterior to obsolescent median sulcus, gradually declivent to transverse sulcus. Lateral sulci deep. Lateral ridges rounded, prominent. Many small granulations on ridges and humeral lobes; this particularly evident on smaller, less robust specimens. Posteroventral extensions of pronotum meet on ventral midline at junction of pro- and mesosterna (Fig. 2B).

Scutellum width less than length. Trident pattern fairly distinct; lateral prongs carinate; middle prong indistinct.

Hemelytra with maximum width varying from just posterior to pronotum to approximately midway to base of membranes; small, black granulations throughout, heaviest along membrane margin, claval, and hemelytral lateral margins. Metathoracic wings short, usually reaching anterior margin of penultimate tergum; infrequently fully developed.

Last abdominal tergum sexually dimorphic: males with 2 parallel, longitudinal

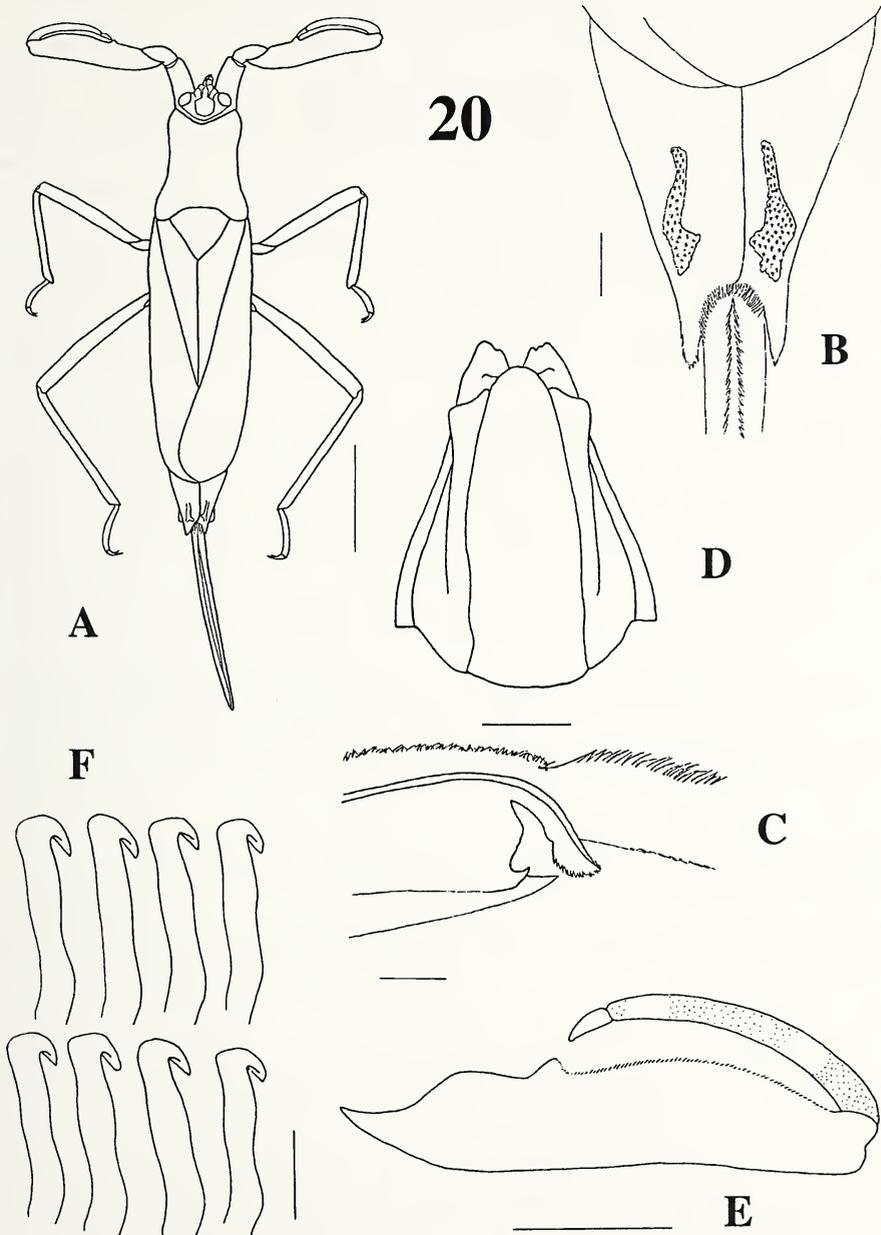


Fig. 20. *C. pronotata*: A) dorsal habitus (5 mm); B) last abdominal tergum (0.5 mm); b) last abdominal segment, lateral view (0.5 mm); c) last abdominal segment, ventral view (1 mm). E) profemur, anterior view (2 mm); F) parameres (0.25 mm).

carinae (1 per plate) with modest, medially directed swelling, or projection, occurring distally (Fig. 20B); females without carinae, some specimens have two parallel strips of dense hairs, others are simply tomentose on the two tergal plates.

Prosternum in lateral view swollen in the posterior half. Mesosternum with midline groove not present; usually tomentose, in some specimens two parallel, longitudinal bands of dense hairs apparent. Metasternum tomentose laterally. Parasterna of last abdominal segment ending in small ventromedial processes flanking operculum (Fig. 20C); posterior margins of male and female opercula usually extend well beyond parasternal processes (Fig. 20D); in dorsal view parasterna project beyond lateral margins of overlying connexiva (Fig. 20A). Male operculum, Fig. 20D.

Procoxae $0.42\text{--}0.46\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth $0.41\text{--}0.47\times$ total profemoral length (Fig. 20E). Profemur moderately arched beyond profemoral teeth. Profemoral sulcus with single row of tubercles in distal third to half; no sulcal teeth.

Metafemora reaching onto posterior half of abdominal sternum 6 when extended posteriorly.

Parameres, Fig. 20F. Female genitalia: Gp2 arched dorsomedially (Fig. 13D).

Discussion. The swollen paraclypea, posteromedial swellings on the carinae on the last abdominal tergum in males, and the laterally projecting last abdominal parasterna are diagnostic for this distinctive species. In addition, although a number of species have median pronotal ridges that fuse posterior to an obsolescent median sulcus, these ridges in *pronotata* are particularly prominent and therefore can also be considered diagnostic. Finally, the occurrence of short metathoracic wings in most specimens of this species appears to be unique in the genus. This species is readily separated from the other two species occurring in Mexico, *C. hungerfordi* and *C. scorpio*, by the swollen paraclypea and laterally projecting last abdominal parasterna which are not found in either of these latter two species. Males of *scorpio* have carinae on the last abdominal tergum but, in contrast to the slender carinae with a posterior, medially directed swelling occurring in *pronotata*, the carinae of *scorpio* are more robust and have medially directed swellings occurring midway along the length of the carinae.

There is considerable variability in pronotal (Fig. 4A), antennal (Fig. 3B), and paramere (Fig. 20F) shape in this species. Forms with a more robust pronotum generally have shorter respiratory siphons and more elongate lobes on antennal segment 2 and are found in southern Arizona and northern Sonora, while more slender specimens with longer respiratory siphons and shorter antennal lobes tend to be found at the southern extreme of the species' range at La Quemada, Nayarit. However, there does not appear to be clinal variation in these characters, as the specimens occurring at other localities do not exhibit either incremental or continuous change with latitude. For example, the least robust specimen was collected at the northernmost part of the species range outside Tucson, Arizona; and specimens collected around Tepic, Nayarit, have widely divergent, robust humeral lobes but are quite narrow more anteriorly. Specimens collected in southern Sonora localities exhibit no particular tendency in pronotal robustness, with some specimens resembling the northern robust form and others the more slender La Quemada specimens. Clasper variation exhibits no trend at all. In sum, it would appear that this is a particularly variable species, but that variability exhibits no obvious geographic pattern. Further

collecting of this distinctive species throughout its range, with particular emphasis on Sinaloa where only one specimen has been taken, will further elucidate the pattern of variability.

Distribution (Fig. 33). United States: southern Arizona. Mexico: Sonora, Chihuahua, Sinaloa (?), Nayarit.

Material examined. HOLOTYPE, male: U.S.A.: Huachuca Mts. No collector or temporal data. Deposited at the Snow Entomological Museum of the University of Kansas. PARATYPES, two males: U.S.A.: Huachuca Mts. No collector data, one specimen dated 1899. Deposited at the Snow Entomological Museum of the University of Kansas. One of the paratypes has a "*C. howardi*, det. Drake" label on it. Kuitert notes in his original description of this *pronotata* that Hungerford relied on this misidentification by Drake for his 1922 redescription of "*howardi*."

Additional material examined. 70 specimens collected in April (6), May (6), June (9), July (1), August (25), September (1), October (1), November (4), and December (17); deposited in ASU, CINCB, JTPC, LACM, and UA. U.S.A. Arizona: Sabino Canyon (nr. Tucson); Ramsey Canyon, 1820m, Huachuca Mtns., Cochise Co. MEXICO. Sonora; Canyon de Evans, Sierra de los Ajos; El Cobre; 1 mi. E. Maicova; 10 and 11 mi. E. Yecora; 17 mi. S. Bacanora. Chihuahua: Sierra Madres, 3 mi. W. Rio Negro. Sinaloa: Sierra Suratato, 7300', La Bufa Suratato (No such locality has been located. John Polhemus believes the site is probably in southwestern Sonora, pers. comm.). Nayarit: 20, 22, 23, 26, and 30 mi. SE Tepic. Jalisco: La Quemada.

Curicta scorpio Stål

Figs. 21, 22, 34 (See also, 2B, 2D, 9B, 11, 12, 13D)

Curicta scorpio Stål, 1862 (1861):203 [Lectotype here designated]; Stål, 1865:185; Champion, 1901:352–353; Montandon, 1903:98; Kirkaldy and Torre Bueno, 1909:202; De Carlo, 1951:395; Keffer, 1993:434–435.

Nepa scorpio, Ferrari, E. von, 1888:191 [Champion, 1901:353, placed *scorpio* back in *Curicta*].

Nepoidea montandoni Martin, 1898:68 [Syn. by Champion, 1901:353].

Curicta howardi Montandon, 1909b (1910):181–183 [Syn. by Keffer, 1993:434–435]; Kuitert, 1949a:68; De Carlo, 1951:395; Polhemus, J., 1976:208; Polhemus, D., 1988:529.

Curicta drakei Hungerford, 1922:432–433 [Syn. by Kuitert, 1949a:68]; De Carlo, 1951:395; Gonsoulin, 1975:25.

Redescription

Measurements. Males: Length, 16.0–20.5; profemoral length, 4.5–5.5; siphons, 6.2–9.0. Females: Length, 18.4–22.8; profemoral length, 4.8–5.7; siphons, 6.7–9.5.

Color. Dark brown; lighter mottling on thoracic and hemelytral dorsa evident. Abdominal dorsum red. Abdominal venter heavily mottled with lighter areas but without longitudinal bands. Protibia dark basally; medially variable, with or without dark medial annulus; when present irregular, i.e., may lighten distally, be indistinct, or even appear as two indistinct annuli. Meso- and metathoracic legs dark.

Structural characteristics. Body elongate (Fig. 21A); length 4.5–5.5× maximum width.

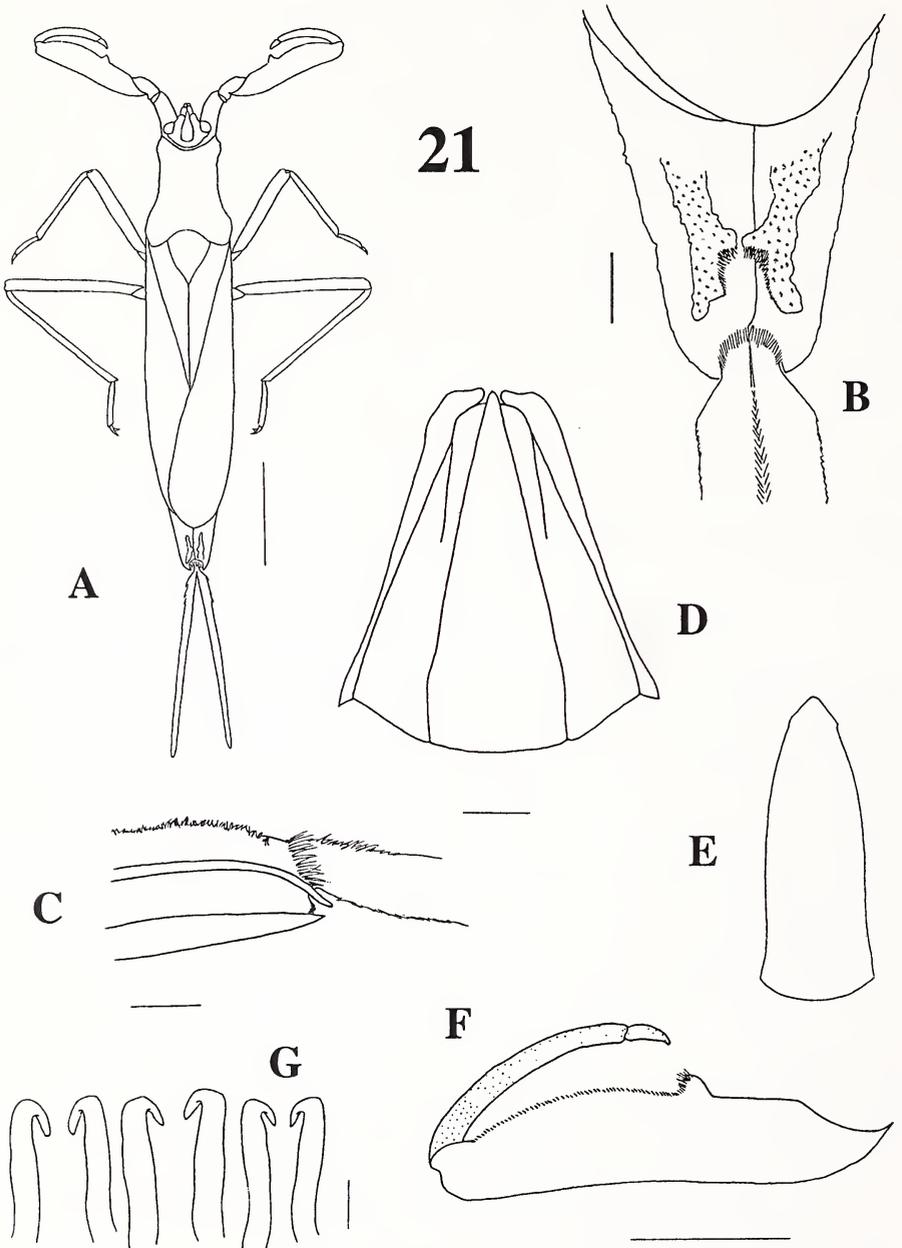


Fig. 21. *C. scorpio*: A) dorsal habitus (5 mm); B) last abdominal tergum (0.5 mm); C) last abdominal segment, lateral view (0.5 mm); D) last abdominal segment, ventral view (0.5 mm); E) male operculum (0.5 mm); F) profemur, anterior view (2 mm); G) parameres (0.25 mm).

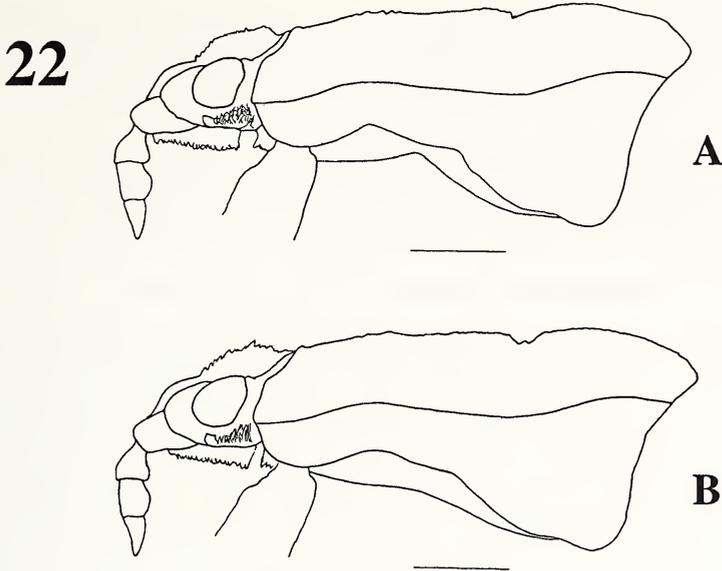


Fig. 22. *C. scorio*: A) head and prothorax (Oaxaca, Mexico), lateral view (1 mm); B) head and prothorax (Texas, U.S.), lateral view (1 mm).

Eye width approximately $0.5\times$ interocular distance. Vertex convex; prominent median longitudinal carina (Figs. 22A, B) with anterior bifurcation apparent infrequently; crescent-shaped band of hair posteriorly also evident. Lobe of antennal segment 2 usually greater than $0.5\times$ length of 3.

Pronotum elongate; lateral length approximately $1.1\text{--}1.3\times$ posterior width. Transverse sulcus incomplete. Median longitudinal sulcus deep to moderately deep and complete, in some specimens becoming shallower posteriorly. Median longitudinal ridges prominent, carinate. Lateral sulci deep. Lateral ridges rounded. Entire pronotum heavily tomentose, appearing very granular on ridges and humeral lobes. Posteroventral extensions of pronotum meet on ventral midline at junction of pro- and mesosterna (Fig. 2B).

Scutellum width less than length. Trident distinct; carinate and usually darker than rest of scutellum.

Hemelytra widest just anterior to base of membranes (females more so than males whose hemelytral margins between humeral lobes and hemelytral membranes may be subparallel); moderately to heavily covered with granulations particularly along lateral margins and in clavus. Metathoracic wings fully developed.

Last abdominal tergum sexually dimorphic: males with two robust, parallel, longitudinal carinae (one per plate) with a prominent medial swelling, or projection, occurring midlength (Fig. 21B); females with straight carinae without medial projection, less robust.

Prosternum in lateral view variable: swollen in posterior half (Fig. 22A) to declivent from anterior to posterior (Figs. 22B). Mesosternum with midline groove prominent; tomentose; two parallel, longitudinal ridges, slightly elevated occurring later-

ally. Metasternum heavily tomentose. Parasterna of last abdominal segment without apparent distal processes (Figs. 21C, D); posterior parasternal margins extend subequally to posterior margins of male and female opercula. Male operculum, Fig. 21E.

Procoxae $0.40-0.46\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth $0.40-0.45\times$ total profemoral length (Fig. 21F). Profemur moderately arched beyond profemoral teeth. Profemoral sulcus with a single row of tubercles usually throughout length of sulcus; no sulcal teeth.

Metafemora reaching onto proximal fourth of abdominal sternum 6 when extended posteriorly.

Parameres Fig. 21G. Female genitalia: Gp2 arched dorsomedially (Fig. 13D).

Discussion. Prominent carina on the vertex, proximal profemoral teeth, and two parallel carinae on the last abdominal tergum are, in combination, diagnostic for this species. *C. scorpio* shares with *pronotata* proximal profemoral teeth and carinae on the last abdominal tergum. However, in *scorpio* the carinae are prominent in both sexes and, in the male, there is a medially directed swelling midway along the length of each carinae, whereas in *pronotata* the carinae are very faint in females and the swelling in males occurs distally. In addition, *scorpio* is heavily tomentose and covered with granulations on its dorsum and thoracic sternum; *pronotata* is less tomentose and has fewer, and smaller granulations. Finally, *scorpio* lacks *pronotata*'s swollen paraclypea. *C. scorpio* can be differentiated from the other species occurring in Mexico, *C. hungerfordi*, by the above mentioned abdominal carinae, which are absent in *hungerfordi*.

Finally, it is worth noting that the synonymy of *C. drakei* by Louis Kuitert was rather informal. Writing at the end of the discussion of his new species, *C. pronotata*, he stated that one of his *pronotata* type specimens had previously been incorrectly determined by Carl Drake as *C. howardi*. Thus, says Kuitert, Hungerford, relying on this determination, then went on to describe *drakei*, actually *howardi*, as a new species.

Distribution (Fig. 34). United States: southern Louisiana, southeastern Texas. Mexico: Tamaulipas, Vera Cruz, Nayarit, Jalisco, Colima Michoacan, Guerrero, Morelos, Federal District, Oaxaca, Chiapas, Mexico. Guatemala. Honduras. Nicaragua. This is the only curictan species with specimens found both in North and Central America. All other species have either a South American or a North American distribution.

Material examined. LECTOTYPE, female: *Curicta scorpio* Stål. Mexico, Sallé. Deposited in the Rijksmuseum Van Natuurlijke Historie, Stockholm. This specimen bears a red type label. Two other specimens were loaned from Stockholm with this holotype and the three specimens together were called syntypes on the museum loan invoice. All three specimens bear two small typed or printed labels saying, "Mexico" and "Sallé." The *scorpio* type also has a printed label which reads "sp. Figured." referring, presumably, to the Figure 1 in Champion, 1901 (Stål did not provide figures with his original description). There is no way of knowing how many specimens Stål looked at, his original description being mute on this matter, although he gives only one set of measurements. What makes all this so interesting is that the other two specimens are clearly *hungerfordi* and not *scorpio*. Both these *hungerfordi* specimens have printed labels indicating that H. B. Hungerford looked at them during

his 1928 European trip and one of the specimens has a Hungerford handwritten determination label reading, "*C. scorpio*?" Apparently, Hungerford had his doubts as to whether these three specimens were a good series. It remained for his student, Louis Kuitert, studying specimens collected subsequent to Hungerford's European trip and deposited in SEMC, to describe *hungerfordi*, which matches these two Stockholm specimens. Kuitert does not mention the Stockholm specimens in his description of *C. hungerfordi*. In order to avoid confusion in the future over these specimens, I will assume that the three specimens did originally constitute a series as the curatorial staff in Stockholm believes. Therefore, I hereby designate the *scorpio* specimen as a lectotype. The other two specimens now bear my determination label as *C. hungerfordi*. HOLOTYPE, male: *Nepoidea montandoni* Martin. Mexique. Sallé. Bears a handwritten determination label reading, "Nepoidea, Montandoni, type J. Martin, 23 fev. 1898." There is also a printed label reading "type." Deposited in the Museum National D'Histoire Naturelle, Paris. I do not know if this Sallé specimen might originally have been part of the Stockholm Sallé series discussed above. It is clear from Martin's original description that he looked at one specimen so I am affixing a holotype label to the specimen. HOLOTYPE, female: *Curicta howardi* Montandon. Victoria, Texas. 12 June 1904. There is no collector label. Montandon dedicates the naming of the specimen to L. O. Howard but there is no indication that Howard was the collector. The case for synonymizing this species with *scorpio* is discussed in detail in Keffer, 1993. There is a handwritten determination label reading, "Curicta, Howardi, Montandon, type 1909 Dec." Deposited in the National Museum of Natural History, Washington, D.C., type no. 26224. HOLOTYPE, male: *Curicta drakei* Hungerford. Rock Island Co., Texas. 30 August 1922, leg. Grace Wiley. Deposited in the Snow Entomological Museum at the University of Kansas. ALLOTYPE, female: *Curicta drakei* Hungerford. Same locality, temporal, and collector data as holotype. Deposited in the Snow Entomological Museum at the University of Kansas. PARATYPES, 10 females; five males: *Curicta drakei* Hungerford: Colorado Co., Texas, 22 August 1922 (8), leg. Grace Wiley; Colorado Co., Texas, 24 June 1922, leg. Grace Wiley (1); Colima, Mexico, leg. L. Conradt (no temporal data) (1); New Orleans, La., May, 1916, no collector data (2). Deposited at the Snow Entomological Museum of the University of Kansas (12) and in the general type collection (1) and in the Carl Drake Collection (2), both of the National Museum of Natural History, D.C. One of the Kansas paratypes bears a R. I. Sailer determination label identifying the specimen as *C. howardi*, "compared with type." The *drakei* paratype in the general type collection of the National Museum of Natural History, Washington, D.C. bears a similar determination label by Sailer.

Additional material examined. 310 specimens collected in the United States in March (1), April (3), June (3), July (58), August (179), September (3), October (6), and in Mexico to Nicaragua in February (1), March (2), May (2), June (13), July (15), August (16), October (1), and December (7); deposited in USNM, JTPC, SEMC, CAS, AMNH, LSU, LACM, TAM, SIU, USU, UCD, and ERIAC. U.S.A. Texas: Colorado Co., Skull Creek; Galveston Co., nr. Hitchcock; Brazos Co., 8 mi W Bryan; College Station; Postoak Lake; Little Brazos River; Live Oak Co., 10 mi. SWGeorge West; Liberty Co., 4 mi. W Moss Hill; Jim Wells Co.; Travis Co., Austin; Gonzales Co., Ottine Palmetto St. Pk; Jackson Co., Ganado; Walker Co., Sam Houston State Park. Louisiana: Iberville Par., Gabriel Exp Sta.; Roux Lafourche Par.; Charles Par.,

trib. Lanaux Canal at US 90E jct. Hwy 3060; Baton Rouge; New Orleans. MEXICO. Tamaulipas: 5 mi S Ciudad Victoria; 1/4 mi N San Jose de las Rusas. Vera Cruz: 15 mi W and 20 mi S Vera Cruz; near Perote; 15 mi NW Acayucan; 3 mi W Paso de Ovejas; 13 km WNW Potrero. Nayarit: Tepic; Compostela; N of Compostela. Michoacan: El Sabino, Uruap.; Patzcuaro. Jalisco: Atenquique. Colima: Colima. Guerrero: Rio Balsas jet Ocapulca. Morelos: 5 mi E Cuernavaca; Temixco; Rio Amacuzca, 133 km S Mexico City. Oaxaca: Tapanatepec, 17 mi E Oax. Chiapas: Ocozocoautla; W. Rizode de Oro. San Luis Potosi: C. Valles. Villa Warez Valles (state unknown). GUATEMALA: E of Quirigua. HONDURAS: Escuela Agricola Panamericana; 1 km N Las Moras; 2 km S Las Capucas Que Brada de Bijao. NIC-ARAGUA: Managua; 6 mi N Managua; 22 mi S Rivas.

Curicta grandis De Carlo

Figs. 23, 35

Curicta grandis De Carlo, 1951:396-397.

Curicta paraguayensis De Carlo, 1951:397-399. NEW SYNONYMY.

Curicta borellii [sic], De Carlo, 1951:399-401. (Misidentification)

Redescription

Measurements. Males: Length, 26.3-29.0; profemoral length, 7.1-8.3; siphons, 21.0-27.0. Females: Length, 29.2-32.5; profemoral length, 7.5-8.5; siphons, 23.0-31.0.

Color. Dark brown; lighter mottling evident on the thoracic and hemelytral dorsa. Abdominal dorsum reddish brown. Abdominal venter with lighter mottling, infrequently aggregating into two longitudinal bands on sterna 3-6. Protibia dark basally; no medial annulation; protibia is dark at the junction with the protarsus which is also dark. Meso- and metathoracic legs golden with some dark mottling.

Structural characteristics. Body elongate (Fig. 23A); length 5.0-5.3× maximum width. Eyes large; width 0.5-0.6× interocular distance. Vertex slightly convex; rudimentary median, longitudinal band of darker hairs present posteriorly, rarely continues anteriorly but when it does anterior bifurcation present; crescent-shaped band of hairs evident posteriorly. Lobe of antennal segment 2 elongate, usually just a little shorter than length of 3.

Pronotum elongate; lateral length 1.3-1.4× posterior width. Transverse sulcus incomplete. Median longitudinal sulcus very shallow, sometimes complete, usually obsolescent posteriorly. Median longitudinal ridges prominent, elevated, rounded. Lateral sulci very shallow. Lateral ridges rounded, not pronounced. A few black granulations on ridges and humeral lobes, but these not pronounced. Posteroventral extensions of pronotum meet on ventral midline at junction of pro- and mesosterna (Fig. 2B).

Scutellum width less than length. Trident pattern distinct; area delimited by lateral prongs elevated above rest of scutellum; all parts of trident carinate and darker.

Hemelytra widest just posterior to humeral lobes; granulations along elytral lateral margins. Metathoracic wings fully developed.

Last abdominal tergum tomentose usually with two distinct subparallel mediolongitudinal bands of long hairs (1 per plate).

Prosternum in lateral view dramatically swollen in posterior half (Fig. 23B). Me-

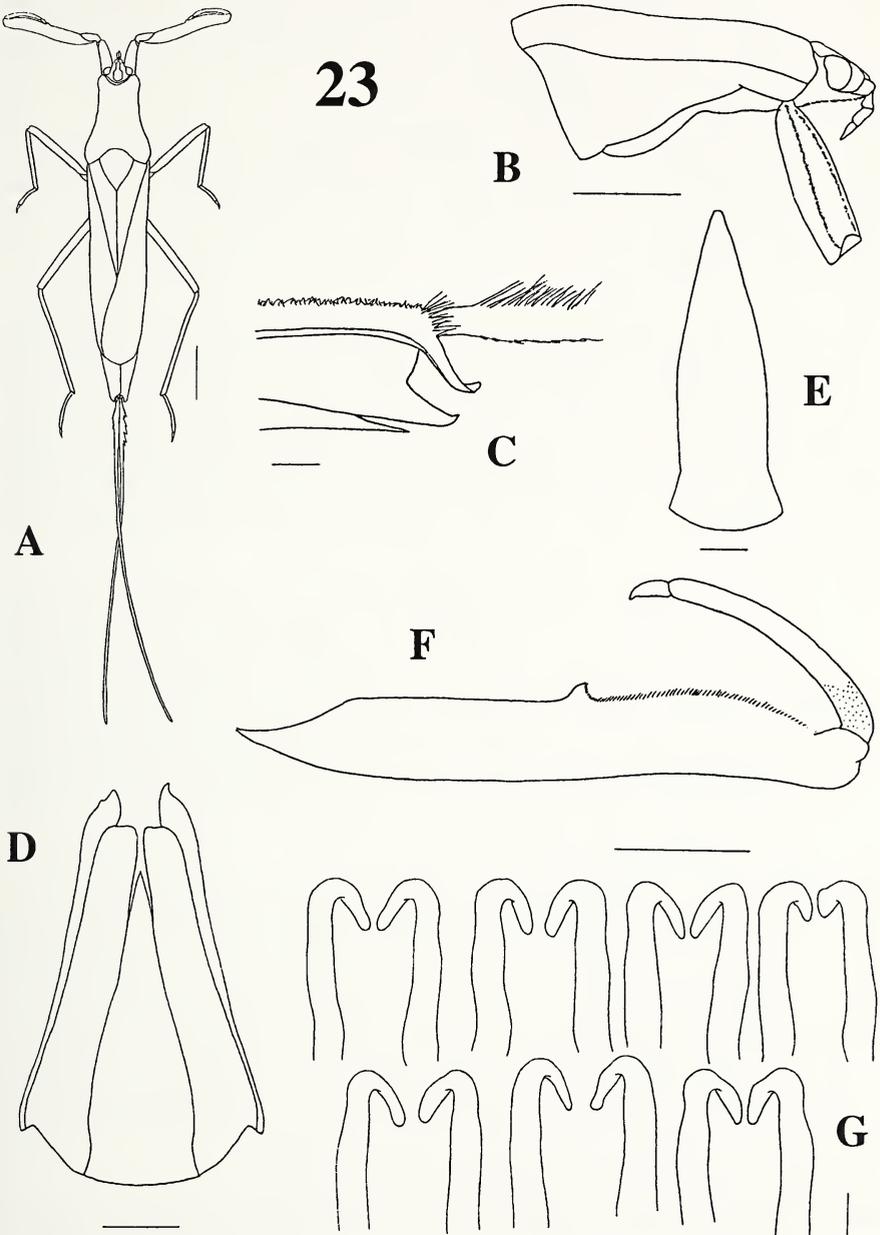


Fig. 23. *C. grandis*: A) dorsal habitus (5 mm); B) head and prothorax, lateral view (3 mm); C) last abdominal segment lateral view (0.5 mm); D) last abdominal segment, ventral view (1 mm); E) male operculum (0.5 mm); F) profemur, anterior view (2 mm); G) parameres (0.25 mm).

sosternum with midline groove and two broad, parallel, longitudinal bands of dense, short hair present. Metathoracic sternum tomentose. Parasterna of last abdominal segment ending in very broad processes (Fig. 23C), ventrally produced, which posteriorly extend noticeably beyond the posterior margins of the male and female opercula (Fig. 23D). Male operculum, Fig. 23E.

Procoxae slightly less than $0.50 \times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth just a little over $0.50 \times$ total profemoral length (Fig. 23F). Profemur only slightly arched beyond profemoral teeth. Profemoral sulcus with incomplete row of tubercles on distal sixth; no sulcal teeth distally.

Metafemora reaching onto anterior half abdominal sternum 6 when extended posteriorly.

Parameres, Fig. 23G. Female genitalia: Gp2 dorsoventrally flattened (Fig. 13B).

Discussion. The dramatically swollen prosternum, distal profemoral teeth, absence of profemoral sulcal teeth, and the large size of the body and siphons are diagnostic for this species. Only *peruviana* approaches the size of *grandis*, has a swollen prosternum, and also lacks sulcal teeth in the profemora. However, *peruviana* is usually smaller in both sexes, is less dramatically swollen in the prosternum, has the profemoral teeth more proximal (as opposed to halfway in *grandis*), and has a broad medial annulus on the protibia which is lacking in *grandis*.

The history of this species is closely linked with that of *borellii*. De Carlo described two species with the same general facies as his understanding of "*borellii*," *C. grandis* and *paraguayensis*. *C. grandis* was said to resemble "*borellii*" in pronotal, prosternal, and mesosternal characteristics, and to differ from "*borellii*" by being larger with longer siphons (De Carlo, 1951:395).

Yet none of the "*borellii*" specimens in De Carlo's collection match Montandon's original (1903) description for *borellii*. Instead, these specimens, and also De Carlo's type for *paraguayensis*, do match the description given here for *grandis*. They display the characteristic swollen prosternum of *grandis* while lacking the profemoral sulcal teeth of *borellii*. Nevertheless, except for the types of *grandis* and *paraguayensis*, De Carlo (1951) believed all his specimens to be Montandon's *borellii*. In contrast, the single available specimen that was determined by Montandon to be *borellii* (the syntypes for *borellii* have not been located) does indeed match Montandon's original (1903) *borellii* description. De Carlo's "*borellii*" specimens do, however, resemble De Carlo's own type for *grandis* (and for *paraguayensis*, see below), at least within the range of variability found intraspecifically in other species of *Curicta*. Thus, the swollen prosternum as an attribute of "*borellii*," reported by De Carlo and repeated by Kuitert (1947: 43-44, unpub.), appears to be erroneous. De Carlo's "*borellii*" specimens, which have a swollen prosternum and lack profemoral sulcal teeth, are therefore here determined to be *grandis*. For a more detailed account of this confusion, see the discussion of *C. borellii*.

According to De Carlo (1951), *C. paraguayensis* differed from *grandis* because of a narrower prothorax, less convex pronotum, more distinct longitudinal sulci on the pronotum, more slender profemora, and a slightly wider body (ibid: 399). Both species, *grandis* and *paraguayensis*, were also said to differ from each other (as well as from "*borellii*") in antennal shape. However, all the structural differences cited by De Carlo between *grandis* and *paraguayensis* are slight and well within the range

of variability found intraspecifically in other species of *Curicta*. I therefore synonymize *paraguayensis* with *grandis*. In the absence of priority for either name, I elect *C. grandis* for this species because of its robust form.

Distribution (Fig. 35). Northern Argentina, Paraguay, Bolivia, and Suriname. This species has a curiously disjunct distribution with the southern and northern populations separated by the wide expanse of the Amazon Basin. Further collecting is needed to determine if *C. grandis* is truly absent from the Amazon.

Material examined. HOLOTYPE, female: *C. grandis* De Carlo. Girardet, S. del Estero, Argentina. Collected in June, day and year illegible. No collector label but De Carlo obtained the specimen from Juan M. Bosq (ibid: 397). HOLOTYPE, female: *C. paraguayensis* De Carlo. Villarrica, Paraguay. April, 1938. No collector label but De Carlo stated that the specimen was obtained from Federico Schade (ibid: 398).

Additional material examined. 96 specimens collected in February (2), March (18), May (28), June (11), July (17), August (1), September (9), November (1), and December (2); deposited in JTPC, MACN, MZSP, NMNH, and SEMC. ARGENTINA. Salta: Tartagal; Acambuco. Formosa: Ing. Juarez. Santiago del Estero: Las Juries. Chaco: Sante Fe. Sante Fe: Fires Lille. PARAGUAY. Concepcion: Vallemi. Guaira: Villarrica. Chaco: P. N. Defensores del Chaco, Madrejón.: Estancia Postillon Puerto Max at Rio Paraguay (province unknown). BOLIVIA. Santa Cruz: Santa Cruz. SURINAME: Marowijne: Christian Kondre.

Curicta tibialis (Martin)

Figs. 24, 35

Nepoidea tibialis Martin, 1898:66.

Curicta tibialis, Montandon, 1903:98; Kirkaldy and Torre Bueno, 1909:202; Montandon, 1909a:144; De Carlo, 1951:401–402.

Curicta suspecta Montandon, 1903:99–100. Syn. by Montandon, 1909a:144.

Curicta beckeri De Carlo, 1956:6. NEW SYNONYMY.

Redescription

Measurements. Males: Length, 26.8–28.0; profemoral length, 6.7–7.4; siphons, 19.5 (*beckeri* HT with broken siphons-not measured). Females: Length, 29.3–31.3; profemoral length, 7.5–8.1; siphons, 20.1–24.8.

Color. Grayish brown. Lighter mottling on thoracic and hemelytral dorsa evident. Abdominal dorsum dark reddish brown. Abdominal venter with lighter, irregular longitudinal bands on sterna and parasterna 3–6. Protibia dark basally; medial annulation variable; complete (two specimens), partial (one), absent (five). Meso- and metathoracic legs dark.

Structural characteristics. Body elongate (Fig. 24A); length 5.2–5.5× maximum width.

Eye width approximately 0.5× interocular distance. Vertex convex, with slight to pronounced median longitudinal carina. Lobe of antennal segment 2 usually slightly less than length of 3.

Pronotum elongate; lateral length approximately 1.3–1.4× posterior width. Transverse sulcus incomplete. Median longitudinal sulcus deep, becoming shallow or obsolete posteriorly. Median longitudinal ridges prominent, rounded. Lateral sulci

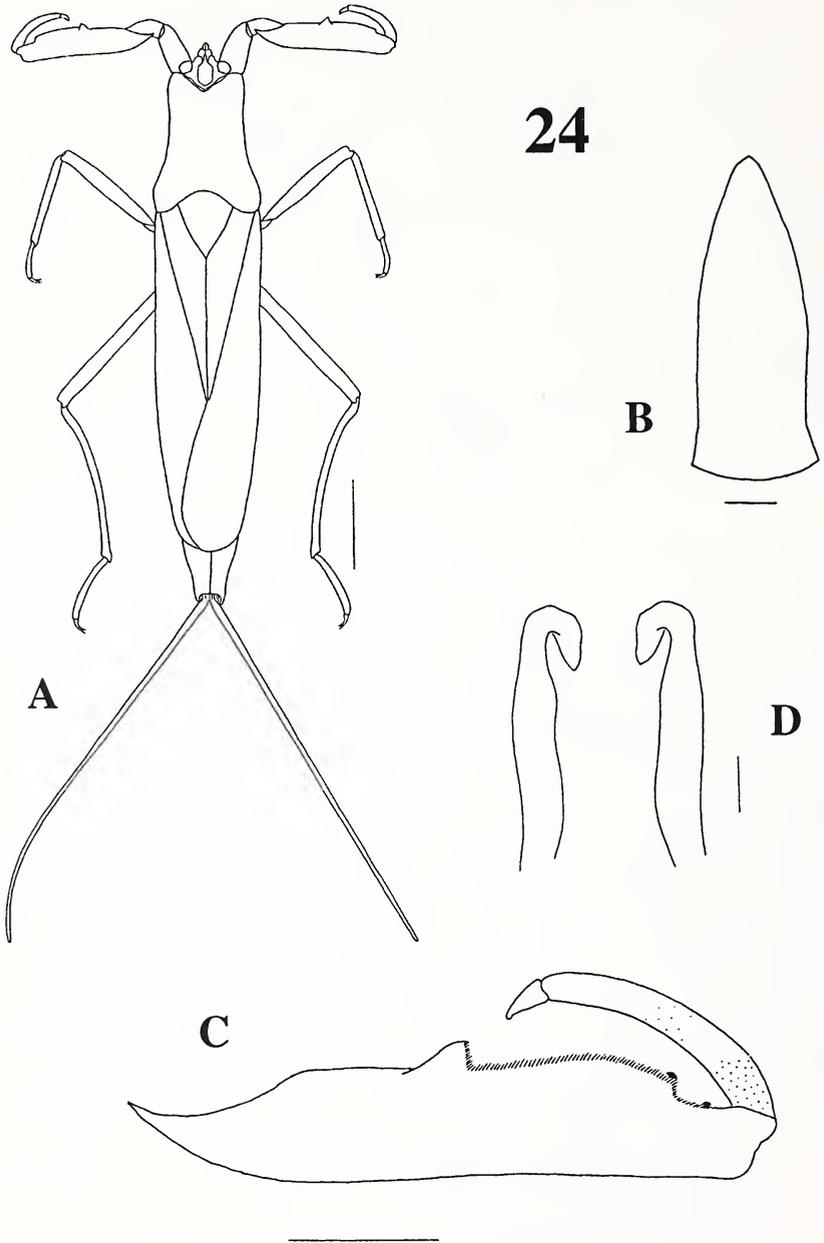


Fig. 24. *C. tibialis*: A) dorsal habitus (5 mm); B) operculum (0.5 mm); C) profemur, anterior view (2 mm); D) parameres (0.25 mm).

deep. Lateral ridges rounded, prominent. Few granulations evident on ridges and humeral lobes. Posteroventral extensions of pronotum do not meet on ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width less than length. Trident pattern distinct, all parts carinate and darker.

Hemelytra with lateral margins subparallel from pronotum to base of membranes; granulations faintly apparent along lateral margins. Metathoracic wings fully developed. Last abdominal tergum tomentose with longer hairs medially forming indistinct mediolongitudinal bands.

Prosternum in lateral view not swollen in the posterior half. Mesosternum tomentose; midline groove present in some specimens and apparently absent in others; broad, hairy, rather indistinct, parallel bands present in one specimen, absent in others. Metasternum tomentose. Parasterna of last abdominal segment ending in large, thumb-like processes (as in Fig. 29B) which, in all but one specimen, extend posteriorly slightly beyond posterior margins of male and female opercula. Male operculum, Fig. 24B.

Procoxae approximately $0.50\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth $0.50\text{--}0.60\times$ total femoral length. Profemur moderately arched beyond profemoral teeth. Profemoral sulcus, in lateral view, notched on distal sixth, appearing to "step-down" (Fig. 24C); complete row of tubercles; two prominent sulcal teeth distally; tubercles form a single row proximally but proliferate on the two sulcal teeth.

Metafemora reaching onto anterior half of abdominal sternum 6 when extended posteriorly.

Parameres, Fig. 24D. Female genitalia: Gp2 dorsoventrally flattened (Fig. 13B). *Discussion.* The large body size and distal notch in the profemoral sulcus together are diagnostic for this species. Only one other species, *C. grandis*, attains a comparable body length. However, *C. grandis* lacks profemoral sulcal teeth and the step-down feature of *tibialis*' profemoral sulcus.

De Carlo thought his *beckeri* to be the same as *tibialis* in body and siphon lengths, and prosternal and profemoral attributes. He differentiated these two species only on the basis of differences in antennal and pronotal shape, and the vertex. The differences between the types in the two former characters are small and well within the limits of variability found for other species described in this review of *Curicta*. The reference to vertex differences is puzzling. According to De Carlo, *tibialis* has a midlongitudinal carina on the vertex but his species, *beckeri*, does not. This character is difficult to evaluate on the holotype for *beckeri* because that specimen has been abraded or chemically treated on the head, pronotum, and scutellum, leaving a hairless and narrowly convex vertex. All the other specimens of the species have a carina on the vertex, accentuated by a band of upright hairs, which vary in their prominence. Interestingly, the specimen with the least prominent carina is a female identified by De Carlo as *tibialis*. Another female, identified by De Carlo as *beckeri*, has a very noticeable carina. In sum, the differences between the specimens for this trait are not significant and I therefore am confident in synonymizing *beckeri* with *tibialis*. *Distribution* (Fig. 35). Brazil: Rio Grand do Sul. Uruguay: Durazno. Paraguay(?): Concepcion.

Material examined. HOLOTYPE, female: *Nepoidea tibialis* Martin. Locality: Rio

Grande; Coll. G. Fallou, 259-95; no temporal data or information as to who actually collected the specimen. Deposited in the Museum National D'Histoire Naturelle, Paris. The locality given for this specimen is simply, "Rio Grande," which probably referred to Rio Grande do Sul, Brazil. This specimen bears a handwritten determination label with the species name, the word "type," the name "J. Martin," and the date "28 fe'r 1898." It is clear from Martin's original description that he had a single specimen ("un exemplaire de la collection G. Fallou", p. 66) therefore the specimen I have before me must be the holotype, and I have so labeled it. HOLOTYPE, female: *Curicta suspecta* Montandon. Locality: S. Leopoldo. No collector label or temporal data. Determination label by Montandon, dated 1903. Deposited in the Naturhistoriska Riksmuseet Stockholm (NRS). S. Leopoldo probably refers to São Leopoldo in Rio Grande do Sul, Brazil. It is clear that Montandon studied only a single specimen when first describing *suspecta* ("un exemplaire unique", p. 99) and therefore the specimen I have before me from the Stockholm Museum with Montandon's determination label and a "typus" label must also be a holotype and I have so labeled it. HOLOTYPE, male: *Curicta beckeri* De Carlo. Brazil, Rio Grande do Sul, Osorio; May (5), 1950; leg. J. Baker. De Carlo lists the collection date for this specimen as "I-1950" (p. 6) but the handwritten label indicates a number 5 for the month. In his original description, De Carlo states that a microscope preparation #3273 exists (this probably was of the genital parameres since none are to be found on the specimen's phallus). I have received 11 microscope slides from the MACN, De Carlo's home museum, but none by that number. Presumably the slide exists somewhere in the MACN.

Additional material examined. four specimens collected in April (1) and July (1) (two specimens without temporal data); deposited in HNHM, MACN, and RMNH. BRAZIL. Rio Grande do Sul: São Leopoldo. URUGUAY. Blanquillo, Durazno. PARAGUAY(?). Concepcion (this locality is given without a country).

Curicta carinata Kuitert

Figs. 25, 35

Curicta carinata Kuitert, 1949a:62-64; De Carlo, 1956:6; 1960:51.

Curicta dilatata De Carlo, 1951:412-414. [Syn. by De Carlo, 1960:51.]

Redescription

Measurements. Males: Length, 17.5-20.0; profemoral length, 5.2-5.8; siphons, 10.0-12.2. Females: Length, 17.3-24.0; profemoral length, 5.5-7.0; siphons, 11.5-15.0.

Color. Dark brown. Lighter mottling evident only on the humeral lobes of the prothorax. Abdominal dorsum brownish red. Abdominal venter lighter brown with lighter mottling and faint indications of longitudinal bands on sterna and parasterna 3-6. Protibia with dark basal annulation; distinct, dark medial annulation. Meso- and metathoracic legs golden.

Structural characteristics. Body elongate (Fig. 25A); length approximately 4.5-5.7× maximum width.

Eye width 0.5× interocular space. Vertex with prominent medial, longitudinal carina (Fig. 25B). Lobe of antennal segment 2 usually greater than 0.5× length 3.

Pronotum elongate; lateral length approximately 1.4-1.5× posterior width. Trans-

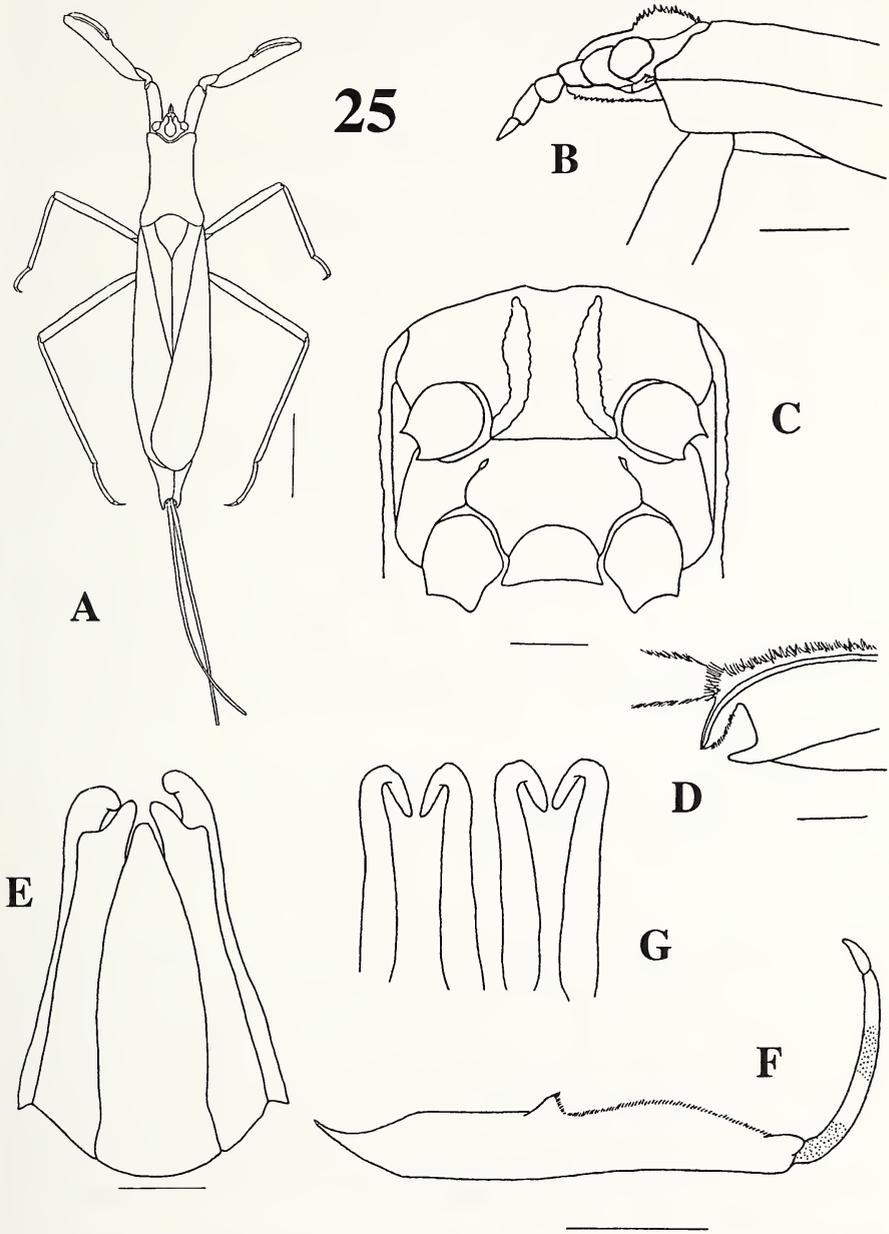


Fig. 25. *C. carinata*: A) dorsal habitus (5 mm); B) head and anterior prothorax, lateral view (1 mm); C) meso- and metasterna (1 mm); D) last abdominal segment, lateral view (0.5 mm); E) last abdominal segment, ventral view (0.5 mm); F) profemur, anterior view (2 mm); G) parameres (0.25 mm).

verse sulcus incomplete. Median longitudinal sulcus deep to moderately deep, complete. Median longitudinal ridges prominent, carinate. Lateral sulci deep. Lateral ridges subcarinate. Ridges and humeral lobes densely covered with granulations. Posteroventral extensions of pronotum do not meet on ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width less than length. Trident pattern distinct; longitudinal section of lateral prongs, medial prong, and handle carinate and black; transverse section of lateral prongs lighter, indistinct.

Hemelytra widest just anterior to elytral membranes (more so in females than males); large, dark granulations on entire hemelytral surface, heaviest along lateral margins and in clavus. Metathoracic wings fully developed.

Last abdominal tergum tomentose with pair of parallel, mediolongitudinal bands of long hairs.

Prosternum in lateral view not swollen in posterior half. Mesosternum without midline groove; two prominently elevated, narrow, parallel, longitudinal carinae present (Fig. 25C). Metasternum subglabrous medially, tomentose around lateral and posterolateral margins. Parasterna of last abdominal segment ending in slender digitate processes (tending to be larger, less slender in females) (Fig. 25D), which extend subequal to slightly beyond the posterior margins of male and female opercula (Fig. 25E). Male operculum, Fig. 25E.

Procoxae about $0.45-0.55\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth approximately $0.47-0.52\times$ total femoral length (Fig. 25F). Profemur moderately arched beyond profemoral teeth. Profemoral sulcus with a single row of tubercles in distal third which are often obscured by the bands of short, dense hair flanking sulcus; no sulcal teeth.

Metafemora reaching approximately halfway onto abdominal sternum 6 when extended posteriorly.

Parameres, Fig. 25G. Female genitalia: Gp2 dorsoventrally flattened (Fig. 13B).

Discussion. This a very distinctive, and homogeneous, species. The pronounced carinae on the mesosternum and vertex, dark medial protibial annuli, heavily granular dorsum, and the absence of sulcal teeth on the profemora are, in combination, diagnostic. *C. carinata* might conceivably be confused with two other species, *granulosa* and *decarloi*, since all three species have carinae on the vertex and protibial annuli. *C. granulosa* also has a heavily granular dorsum but, unlike *carinata*, has profemoral sulcal teeth and broad tomentose parallel bands on the mesosternum rather than the distinctly elevated carinae of *carinata*. The respiratory siphons of *decarloi* are approximately $0.9\times$ the body length, whereas the siphons of *carinata* attain a maximum of $0.7\times$ body length. Both *decarloi* and *carinata* lack profemoral sulcal teeth but the tubercles in the profemoral sulcus distally of *decarloi* are irregular while in *carinata* the row of tubercles is regular throughout. Also, *decarloi* has slight carinae on the mesosternum and not the pronounced carinae of *carinata*. Finally, *decarloi* apparently lacks the heavy granulation on the thoracic and hemelytral dorsa found in *carinata*.

Distribution (Fig. 35). Paraguay, Bolivia, Peru, Ecuador, Colombia, Trinidad, and Panama. This is the only curictan species with specimens found both in South and Central America. All other species have either a South American or a North American distribution.

Material examined. HOLOTYPE, male: *Curicta carinata* Kuitert: Caravene, Paraguay; 15 February 1925; leg. F. Schade. Deposited in the Snow Entomological Museum, University of Kansas. ALLOTYPE, female: *Curicta carinata* Kuitert: Villarrica, Paraguay [separate label reads, Coraveni]; 21 September 1924; leg. Fran. Schade. Deposited in the Snow Entomological Museum, University of Kansas. PARATYPES, three males, three females: *Curicta carinata* Kuitert: 4 collected in Villarrica, Paraguay [Coraveni] on 10 April 1923, 18 April 1923, 11 September 1923, 12 January 1924; 1 collected in Caraveni, 15 June 1924; and 1 collected in Villarrico, 19 January 1926. I assume the differences in spellings for Coraveni and Villarrica are typographical errors and do not reflect different localities. Deposited in the Snow Entomological Museum, University of Kansas HOLOTYPE, female: *Curicta dilatata* De Carlo: Villarrica, Paraguay; 19 May 1938; leg. F. Schade. Deposited in Museo Argentino de Ciencias Naturales "Bernadino Rivadavia" ADDITIONAL Material Examined. 140 specimens collected in January (75), February (3), March (5), April (11), May (1), June (15), August (3), September (16), November (2), and December (1); deposited in AMNH, FSCA, JTPC, NMNH, NNC, SEMC, and ZMH. PARAGUAY. Villarrica: Villarrica, Coraveni. Aregua, 20 mi E Asuncion. BOLIVIA. Santa Cruz: Neuva Moka. El Beni: 2 km E San Borja. La Paz: 3 km SE Sapecho. PERU. Madre de Dios: Parque Mana, Pakitza. ECUADOR. Napo-Pastaza: Santa Cecilia, 340 m. COLOMBIA. Antioquia: Chigorodo, Rio Leon. TRINIDAD: Chatham. PANAMA. Panama: 3 km SE Ipeti; 3 km S of Ipeti. Herrera: N. fork of Rio Paritas.

Curicta decarloi, new species

Figs. 26, 35

Description

Measurements. Female (1): Length, 25.5; profemoral length, 7.3; siphons, 22.0

Color. Largely obscured by dirt, appears dark reddish brown; lighter markings obscured on both dorsum and venter. Abdominal dorsum reddish brown. Legs concolorous with body.

Structural characteristics. Body elongate (Fig. 26A); total length $5.4\times$ maximum width.

Eye width $0.5\times$ interocular distance. Vertex convex with a pronounced midlongitudinal carina. Lobe of antennal segment 2 slightly greater than $0.5\times$ length of 3.

Pronotum elongate; lateral length $1.5\times$ posterior width. Transverse sulcus incomplete. Median longitudinal sulcus complete, uniformly deep. Median longitudinal ridges carinate. Lateral sulci deep. Lateral ridges carinate. Granulations not apparent on ridges or humeral lobes. Posteroventral extensions of pronotum do not meet on ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width less than length. Trident distinct; carinate; longitudinal section of lateral prongs, medial prong, and handle black, transverse section of lateral prongs not dark, indistinct.

Hemelytra widest just anterior to base of membrane; without apparent granulations. Metathoracic wings fully developed.

Last abdominal segment tomentose, paired carinae or bands of hair not apparent.

Prosternum in lateral view not swollen. Mesosternum without midline groove;

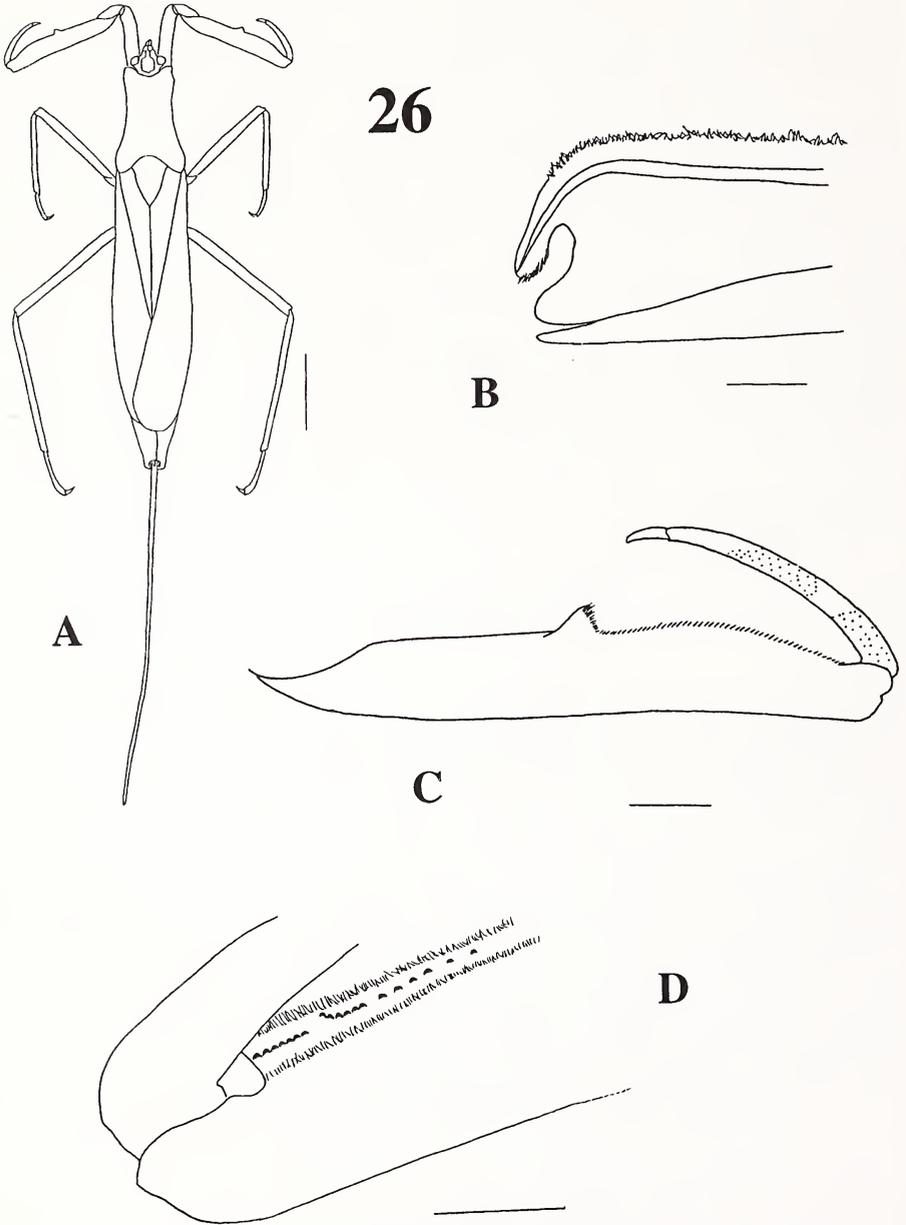


Fig. 26. *C. decarloi*: A) dorsal habitus (5 mm); B) last abdominal segment, lateral view (0.5 mm); C) profemur, anterior view (2 mm); D) profemur, ventrolateral view (0.5 mm).

parallel, longitudinal carinae present, slightly elevated. Metasternum tomentose. Parasterna of last abdominal segment ending in large processes (Fig. 26B) which extend subequally to posterior margin of operculum.

Procoxae $0.54\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth, $0.52\times$ total femoral length (Fig. 26C). Profemur moderately arched beyond profemoral teeth. Profemoral sulcus with row of tubercles on distal third; these becoming more closely spaced distally except for gap occurring near junction with protibia (Fig. 26D); no sulcal teeth distally.

Metafemora reaching almost halfway onto abdominal sternum 6 when extended posteriorly. Parameres: species known only from female holotype. Female genitalia: Gp2 dorsoventrally flattened (Fig. 13B).

Diagnosis. This species' very long respiratory siphons ($0.86\times$ body length), long profemora, protibial medial annulus, prominent carinae on the vertex and pronotal ridges, and absence of profemoral sulcal teeth are, in combination, diagnostic. These diagnostic characters plus the absence of profemoral sulcal teeth in *decarloi* distinguish this species from the other long-legged species found along Brazil's coast (*C. volxemi* and *doesburgi*). *C. decarloi* is very close to *C. carinata*. Both species have dark medial protibial annuli, a prominent carina on the vertex, carinate pronotal ridges, and carinae on the mesosterna. However, *carinata*'s mesosternal carinae are quite prominently elevated while *decarloi*'s are not. In addition, *carinata* has evenly spaced tubercles in the profemoral sulcus while in *decarloi* the tubercles become clustered distally with a gap just before the end of the sulcus. Finally, *decarloi* has proportionally longer respiratory siphons, approximately $0.9\times$ body length, while the siphons of *carinata* females attain only $0.7\times$ body length. It is interesting to note that the largest female *carinata*, which in size equal *decarloi*, occur in Ecuador and Colombia, i.e., the northern part of that species' range. Further collecting across northern South America may well uncover specimens linking the northern *carinata* with the coastal *decarloi*. If that proves to be the case then the species status of *decarloi* will have to be reevaluated.

Distribution (Fig. 35): Tapera, Pernambuco, Brazil.

Material examined. HOLOTYPE, female: *Curicta decarloi* Keffer. Tapera, Pernambuco, Brazil; 4 May 1938; no collector data. Deposited in the Snow Entomological Museum, University of Kansas, Lawrence, Kansas.

This species is dedicated to the memory of Dr. Jose De Carlo whose career at the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia" in Buenos Aires, Argentina, was devoted to the study of the aquatic Heteroptera of South America.

Curicta granulosa De Carlo

Figs. 27, 36

Curicta granulosa De Carlo, 1951:411–412; Nieser, 1974:131–133.

Curicta venezolana De Carlo, 47–48; 1967 (1966):35. NEW SYNONYMY.

Curicta intermedia [sic], Roback and Nieser, 1974:40–41. (Misidentification)

Redescription

Measurements. Males: Length, 18.0–22.0; profemoral length, 4.9–6.2; siphons, 7.0–15.0. Females: Length, 20.0–25.0; profemoral length, 5.6–7.3; siphons, 12.5–20.0

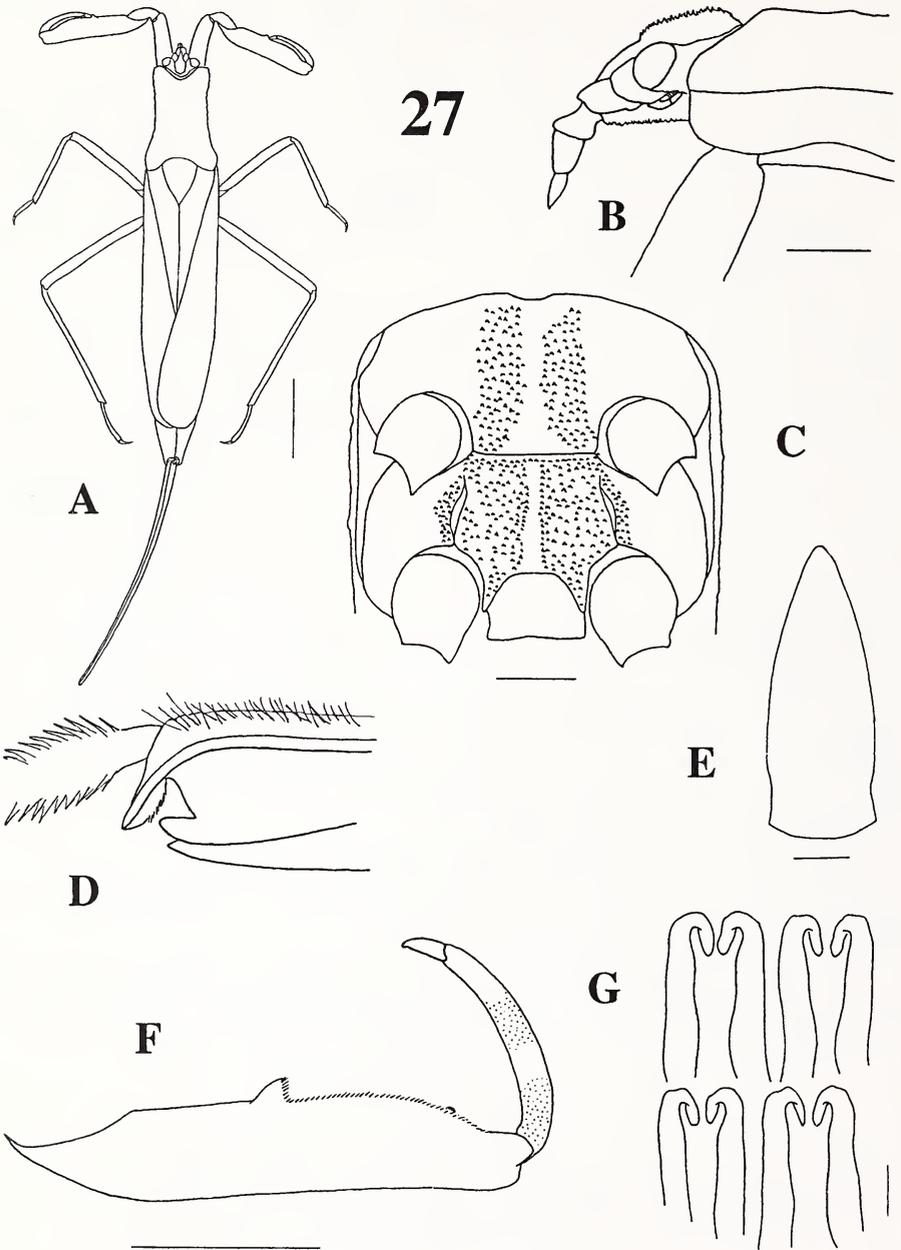


Fig. 27. *C. granulosa*: A) dorsal habitus (5 mm); B) head and anterior prothorax, lateral view (1 mm); C) meso- and metasternum (1 mm); D) last abdominal segment, lateral view (0.5 mm); E) male operculum (0.5 mm); F) profemur, anterior view (2 mm); G) parameres (0.25 mm).

Color. Dark brown. Lighter mottling evident, particularly on the humeral lobes and hemelytra. Abdominal dorsum dark brownish red. Abdominal sterna 3–6 with four irregular, longitudinal bands of lighter color; parasterna with one such streak but fainter and less distinct. Protibia with dark basal annulation; distinct, dark medial annulation usually present. Meso- and metathoracic legs light brown to golden. Structural characteristics. Body elongate (Fig. 27A); length $5.3\text{--}5.8\times$ maximum width.

Eye width $0.5\times$ interocular distance (in females a slight tendency for eye width to be slightly less than $0.5\times$ interocular distance). Vertex usually with pronounced mediolongitudinal carina (Fig. 27B). Lobe of antennal segment 2 usually greater than $0.5\times$ length of 3.

Pronotum elongate; lateral length approximately $1.3\text{--}1.5\times$ posterior width. Transverse sulcus incomplete. Median longitudinal sulcus deep, often becoming shallower posteriorly; complete. Median longitudinal ridges prominent, carinate. Lateral sulci deep. Lateral ridges rounded. Ridges and humeral lobes almost always densely covered with granulations. Posteroventral extensions of pronotum do not meet on ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width less than length. Trident pattern distinct, carinate; longitudinal section of lateral prong, medial prong, and handle black; transverse section of lateral prong lighter, often indistinct.

Hemelytral greatest width variable, occurring in anterior fourth or just anterior to base of hemelytral membranes; many granulations evident, particularly along hemelytral margins and in clavus. Metathoracic wings fully developed.

Last abdominal tergum tomentose with a pair of parallel, mediolongitudinal bands of longer hairs.

Prosternum in lateral view not swollen in the posterior half. Mesosternum with midline groove present; usually two prominent, wide, parallel, longitudinal, tomentose bands present (Fig. 27C). Parasterna of last abdominal segment ending in small digitate lobes (Fig. 27D) which extend subequally to posterior margin of male and female opercula. Male operculum, Fig. 27E.

Procoxae $0.45\text{--}0.55\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth $0.48\text{--}0.54\times$ total profemoral length (Fig. 27F). Profemur moderately arched beyond profemoral tooth. Profemoral sulcus with a sparse, single row of tubercles in distal half; sulcal teeth distally, often pronounced.

Metafemora usually reach onto anterior half of abdominal sternum 6 when extended posteriorly (infrequently, the metafemora of females may fail to reach the anterior margin of sternum 6 when extended).

Parameres Fig. 27G. Female genitalia: Gp2 dorsoventrally flattened (Fig. 13B).

Discussion. This a very distinctive species. A pronounced carina on the vertex, dark, medial protibial annulus, heavily granular dorsum, broad, hairy bands on the mesosternum and the presence of profemoral sulcal teeth are, in combination, diagnostic. It should be noted, however, that one or more of these diagnostic characters may often be missing from individuals within a given *granulosa* population. In particular, the protibial annulus may be incomplete, faint, and, in a few individuals even absent; the mesosternal bands may be incomplete, or spotty; the carina on the vertex may not be as pronounced as figured (the carinae and bands of hair are often difficult to

evaluate because adhering substrate may be matting down the hair that gives the carinae some, or even most, of their form; see Discussion of Characters); and/or the amount of dorsal granulation may be reduced (the same problem with the carinae applies here; in addition certain killing and/or preserving protocols reduce hairy surficial features by matting all the hair together). All specimens of *granulosa* throughout its range have profemoral sulcal teeth. Rarely, one finds individuals within populations of *granulosa* that have profemoral sulcal teeth and the general facies of the other members of the population but that lack a protibial band (absent more in females than in males), and apparently also lack carinae on the vertex, bands of hair on the mesosternum, and much of any granulation on the dorsum. More commonly just one of these four characters will be absent or not found to the degree discussed. For example, a series from Itabuna, Brazil has one female lacking both a protibial annulus and mesoternal bands. However, the specimen does have carinate pronotal ridges and granulations on the dorsum and by general facies resembles the other members of the series, so I have identified it as *granulosa*.

The synonymy of *C. venezolana* De Carlo with *granulosa* is clear. The type for *venezolana* possesses all the diagnostic features for *granulosa*. Curiously, in his original description for *venezolana*, De Carlo (1960:47-48) does not compare his new species with his own previously described species, *granulosa*. Instead, he contrasts *venezolana* with Kuitert's *carinata* and *peruviana* using paramere shape and a perceived difference in medial protibial annuli. According to De Carlo, *carinata* has a well defined medial annulus on the protibia while *venezolana* and *peruviana* do not. This is incorrect. His holotype for *venezolana* has a well defined, albeit narrow, annulus and *peruviana* has a distinctive, wide annulus. In addition to De Carlo's type, three long series of *granulosa* have been collected at sites in Venezuela. Like the longer series from Brazil, most of the specimens in the Venezuelan series possess all or most of the diagnostic characters for *granulosa* discussed above.

There are three species with which *granulosa* might be confused. The first is *carinata*. Both *granulosa* and *carinata* have pronounced carinae on the vertex, dark, medial protibial annuli, similar head shapes, and dense coverings of granulations on the thoracic and hemelytral dorsa. However, *carinata* has narrow, elevated mesosternal carinae while *granulosa* has broad, tomentose bands that are not elevated. In addition, *carinata* never has profemoral sulcal teeth as does *granulosa*.

The second species that is close to *granulosa* is *borellii*. Both of these species have granulations on the dorsum and light colored meso- and metathoracic legs. However, *borellii* has only a slight median carina on the vertex (Fig. 28B), oblique, tomentose bands on the mesosternum (Fig. 28C), rounded pronotal ridges, and almost always lacks a dark medial annulus on the protibia. In contrast, *granulosa* usually has a pronounced carina on the vertex (Fig. 27B), parallel bands on the mesosternum (Fig. 27C), distinctly carinate pronotal ridges, and the protibial annulus. Also, *borellii* males and females are generally larger and have longer profemora than *granulosa* specimens. Finally, the median pronotal sulcus of *borellii* usually becomes quite shallow posteriorly and even obsolescent in some specimens, whereas *granulosa* specimens all have a deeper median sulcus which may become shallower posteriorly but not to the extent evident in *borellii*.

The third species which may cause some confusion is *C. intermedia*. This is an enigmatic species which is not particularly distinctive in any way and, moreover, is

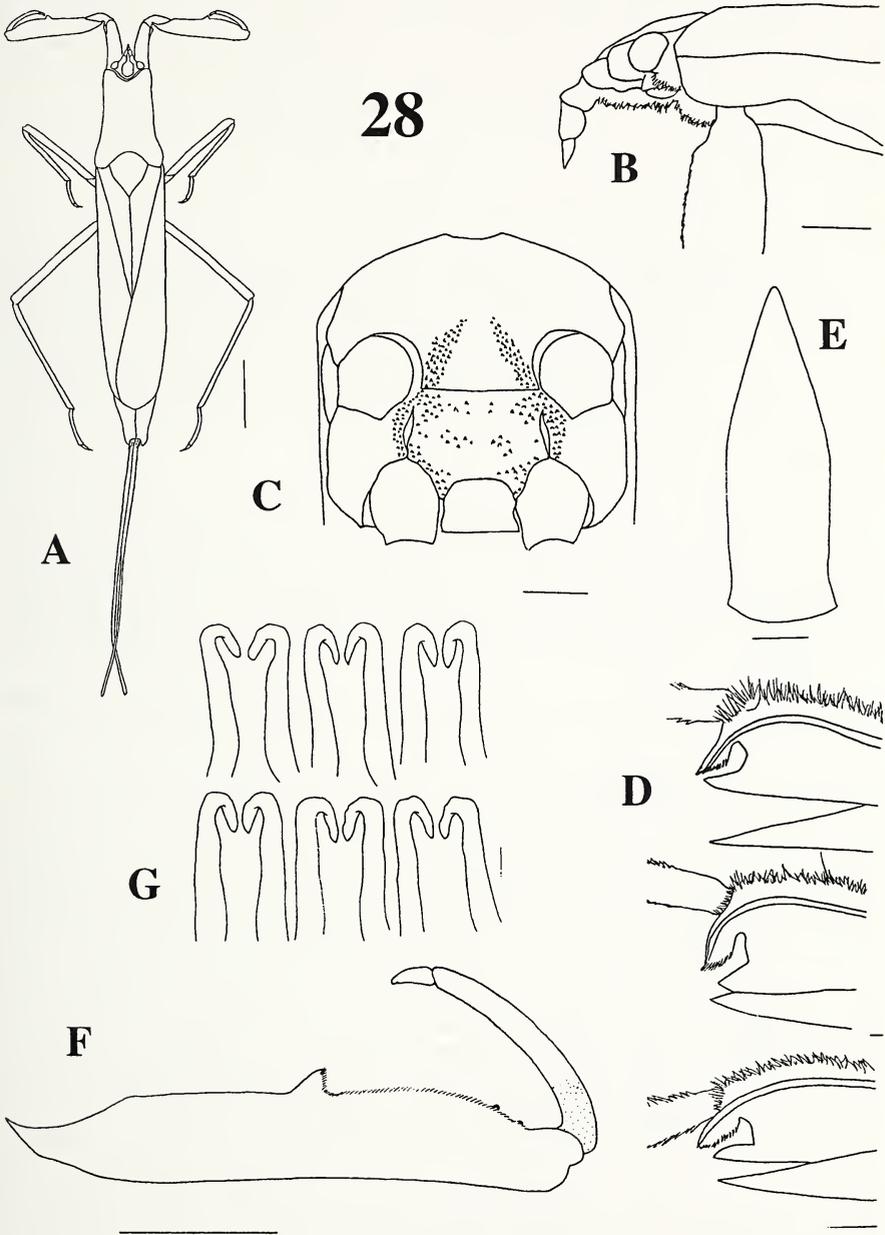


Fig. 28. *C. borellii*: A) dorsal habitus (5 mm); B) head and anterior prothorax, lateral view (1 mm); C) meso- and metasternum (1 mm); D) last abdominal segment, lateral view (1 mm); E) male operculum (0.5 mm); F) profemur, anterior view (2 mm); G) parameres (0.25 mm).

known only from the holotype. *C. intermedia* has neither mesosternal bands of hair nor dorsal granulations like *granulosa* but it does have a prominent carina on the vertex, a faint, and incomplete medial protibial annulus, and profemoral sulcal teeth. The problem here is that *intermedia* does not look dissimilar by general facies from those few individuals of *granulosa* that also are lacking the same *granulosa* characters. (Several workers have previously identified specimens of what I now recognize as *granulosa* as *intermedia*. For example, Nico Nieser identified a series from Puerto Lopez, Meta, Colombia, as *intermedia* and then used those specimens as a template in a discussion comparing "*intermedia*" with *doesburgi*. *C. doesburgi* has very large, thumblike parasternal lobes while *intermedia* has smaller lobes; however, like *doesburgi*, *intermedia* lacks carinate pronotal ridges and heavy granulations on the dorsum so these two species are often confused; in fact, they might be the same species—see discussion for *intermedia*. But Nieser's specimens have carinate pronotal ridges, dorsal granulations, mesosternal bands, vertex carinae, and protibial annuli so they are clearly *granulosa*. Similarly, H. B. Hungerford identified two specimens from Bolivia as *intermedia* but again, the specimens possess the diagnostic characters for *granulosa*.) Thus, it may be that *intermedia* is simply a *granulosa* outlier; however, given that the single *intermedia* specimen is not part of an identifiable *granulosa* series, I have chosen not to consider such a possibility. In fact, I consider the synonymy of *granulosa* with *intermedia* extremely unlikely; there are too many distinctive characters separating them (see discussion of *intermedia*).

Distribution (Fig. 36). Brazil, Paraguay, Bolivia, Peru, Colombia, Venezuela. It is of interest to note that *C. granulosa* is the only South American species that has been collected widely across the northern half of South America and throughout the Amazon Basin.

Material examined. HOLOTYPE, male: *Curicta granulosa* De Carlo: Amazonas, Mana'os, Brazil; 1899, leg. Bicego. Deposited in the Museu de Zoologia da Universidade de São Paulo. ALLOTYPE, female: *Curicta granulosa* De Carlo: same locality, temporal, and collector data as holotype. Deposited in the Museu de Zoologia da Universidade de São Paulo. PARATYPES, two females, one male: *Curicta granulosa* De Carlo: 2 specimens with the same locality, temporal, and collector data as holotype; 1 specimen without any data. Deposited in the Museu de Zoologia da Universidade de São Paulo (1 female) and the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia" (1 female, 1 male). HOLOTYPE, male: *Curicta venezolana* De Carlo: Sosa, Guarico, Venezuela; 6-5-1951; leg. Roze. Deposited in the Carl Drake Collection, National Museum of Natural History, Washington. Two other paratypes for this species reported to be in the NMNH and the MACN were not seen. Additional Material Examined. 153 specimens collected in January (3), February (9), March (3), May (1), June (34), July (34), August (1), September (59), October (3), November (1), and December (1); deposited in AMNH, JTPC, INPA, LACM, MACN, NMNH, and SEMC. BRAZIL. Paraiba: Vic. João Pessoa (São Phe- lip), River Juruá. Bahia: 15 km E Itabuna. Para: Rio Iriri, Cam (62°40'W, 3°50'S) Altamira (ca. 100 km S). São Paulo: Landerwald. Goiás: Santa Isabel, Ilha do Bananal, Rio Araguaia. Matto Grosso: Corumba; Cuiabá; Rio Araguaia, Santa Isabel. Rondonia: Porto Velho. Acre: Espiritu, Rio Yacuma, Estanque Pto. Espirito, Sarmiento. PARAGUAY. Boquerón: Puerto Casado, along Paraguay River bank in tide holes, etc. BOLIVIA. Beni: 20 km W San Borja; Ivon Beni (only locality given),

del Sara (province unknown). PERU. Ayachuco: Prov. L. Mar Sivia, jungle, 790 m, in stagnant pools. San Martin: 8 km ENE Tarapoto, 550 m. Huanuco: Tingo, Maria. COLOMBIA. Antioquia: 2 km W Puerto Triunfo. Meta: 16 km SW Puerto Lopez, Hacienda Mosambique, temp. ponds. VENEZUELA: Portuguesa: Guanare estado. Guarico: 15 km S Calabozo; Hato Las Lajas, cr. Calabozo; 20 km N San Rafael de Orituco. Monagas: 60 km SE Maturín. Barinas: Carrotera National, 5.1 km W of Puente Ben Paez on Rio Bocomo.

Curicta borellii Montandon

Figs. 28, 36

Curicta borellii Montandon, 1903:100–101. Neotype here designated.

Curicta riggii De Carlo, 1951:406–408; 1967 (1966):35. NEW SYNONYMY.

Curicta dureti De Carlo, 1951:408–409. NEW SYNONYMY.

Curicta carinata [sic], De Carlo, 1951:409–411. (Misidentification)

Curicta bachmanni De Carlo, 1956:4–5. NEW SYNONYMY.

Curicta sanmartini De Carlo, 1956:5. NEW SYNONYMY.

Redescription

Measurements. Males: Length, 21.5–26.0; profemoral length, 6.1–7.0; siphons, 14.0–19.5. Females: Length, 24.0–30.0; profemoral length, 6.2–7.3; siphons, 14.0–20.0.

Color. Dark brown. Lighter mottling evident on thoracic and hemelytral dorsa. Abdominal dorsum dark reddish-brown. Abdominal sterna 3–6 with four lighter irregular, longitudinal bands; light mottling on parasterna not quite coalescing into bands. Protibia with dark basal annulation, very infrequently with medial annulation or spot. Meso- and metathoracic legs golden.

Structural characteristics. Body elongate (Fig. 28A); length 5.5–6.0× maximum width.

Eye width 0.5× interocular distance (but sometimes slightly greater). Vertex slightly convex to almost flat (Fig. 28B), usually with a slight medial, longitudinal carina. Lobe of antennal segment 2 usually greater than 0.7× the length of 3.

Pronotum elongate; lateral length 1.4–1.5× posterior width. Transverse sulcus incomplete. Median longitudinal sulcus shallow, usually becoming even shallower posteriorly; usually obsolescent posteriorly, infrequently complete. Median longitudinal ridges rounded to subcarinate in more robust specimens; when median sulcus obsolescent posteriorly ridges fuse posteriorly to become single rounded ridge. Lateral sulci shallow. Lateral ridges rounded. Both pairs of ridges and humeral lobes beset with small black granulations. Posteroventral extensions of pronotum do not meet on ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width less than length. Trident pattern distinct, carinate; longitudinal section of lateral prongs, medial prong, and handle black, transverse section of lateral prongs often lighter, less distinct.

Hemelytral width greatest just posterior to pronotum or margins subparallel from pronotum to base of membranes; hemelytral margins and clavus beset with dark granulations. Metathoracic wings fully developed.

Last abdominal tergum tomentose, often with pair of parallel, mediolongitudinal bands of longer hairs occurring medially.

Prosternum in lateral view not swollen in posterior half. Mesosternum with midline groove present; two oblique, tomentose bands, which begin posterolaterally, anterolaterally to metacoxae, and slant convergently toward midline, also present (Fig. 28C) (rarely, the carinae turn and continue anteriorly as parallel carinae). Metasternum tomentose. Parasterna of last abdominal segment end in digitate lobes, variable in shape: slender-elongate to subtriangular (Fig. 28D); usually extending posteriorly beyond the posterior margins of the male and female opercula. Male operculum, Fig. 28D.

Procoxae approximately $0.45\text{--}0.53\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth typically $0.50\text{--}0.55\times$ total femoral length (Fig. 28F). Profemur moderately arched beyond profemoral teeth. Profemoral sulcus with single row of tubercles usually throughout sulcus length (may be missing in proximal fourth); sulcal teeth present, often pronounced.

Metafemora just reaching anterior margin, or reaching onto anterior fourth, of abdominal sternum 6 when extended posteriorly. (Females usually exhibit the former condition, males the latter.)

Parameres. Figure 28G. Female genitalia: Gp2 dorsoventrally flattened (Fig. 13B).

Discussion. The granulations on the dorsum, lack of a pronounced carina on the vertex, absence of a dark, medial, protibial annulus, and tomentose, oblique mesosternal bands are, in combination, diagnostic for this species.

C. borellii might be confused with two other species, *C. granulosa* and *C. doesburgi*. Both *borellii* and *granulosa* have granulations on the dorsum and light colored legs. However, *borellii* has only a slight carina on the vertex (Fig. 28B), oblique mesosternal bands (Fig. 28C) (which only rarely continue anteriorly as parallel bands), no medial protibial annuli (Fig. 28F) (with only a couple of rare exceptions), and a shallow, and usually posteriorly obsolescent, median pronotal sulcus, while *granulosa* has a pronounced carina on the vertex (Fig. 27B), parallel mesosternal bands (Fig. 27C), medial protibial annuli (27F), and a deep and complete median pronotal sulcus. In addition, *borellii* males and females are larger and have longer profemora than *granulosa* specimens although there is some overlap in their respective measurements (see "Measurements" for both species).

Both *borellii* and *doesburgi* have light colored meso- and metathoracic legs, and similar profemoral lengths and pronotal traits. They also overlap in overall length measurements although *borellii* specimens are, on average, larger. However, *borellii* has parasternal lobes that are variable in shape but rarely thumblike, while *doesburgi* has consistently large, thumblike parasternal lobes. In addition, *doesburgi* usually lacks oblique mesosternal bands. Nevertheless, small *borellii* and large *doesburgi* specimens are easily confused, particularly if the *borellii* specimen lacks heavy granulation on the dorsum and has reduced mesosternal bands. There are three such specimens from Paraguay which I have identified as *borellii* because they lack the parasternal trait of *doesburgi*, but in all other ways they closely resemble *doesburgi*. Further collecting, particularly across Brazil between Paraguay and Suriname, will help illuminate the relationship between these two species. (*C. grandis* has a disjunct distribution with populations in northern Argentina/Paraguay and Suriname. The closeness of the Argentine and Paraguayan *borellii* and the Suriname *doesburgi* might be the result of the same processes that produced the *grandis* disjunction.)

It is important to note that like *C. pronotata* in western Mexico, *borellii* exhibits a continuum of robustness. Specimens from the mountainous area of northwestern Argentina generally have broader heads and pronota. In specimens from north central Argentina and Paraguay, head and pronotal widths exhibit continuous variation: in some specimens these characters are nearly identical with those seen in specimens from higher altitudes.

The history of *borellii* has become somewhat confused. Unfortunately, syntypes for *borellii* have not been located. Montandon wrote that the specimens for *borellii* were in his collection and in the Museum of Turin. Dr. Antonio Rolando of the Dipartimento Di Biologia Animale of the Universita De Torino has informed me that *borellii* is not represented in the Montandon material deposited in his university (in litt.). However, I do have a specimen determined by Montandon in 1908 to be *borellii*, five years after the original description. At 22 mm it is smaller than the syntype series which measured 29–30 mm in length (Montandon, 1903). The syntype series represents the upper range of lengths for other females I have examined and determined to be *borellii*.

De Carlo (1951:399–401), apparently without ever seeing any of the *borellii* syntypes, came to believe that specimens from Paraguay with very swollen prosterna were *borellii*. However, the specimen determined by Montandon to be *borellii* does not have a swollen prosternum, nor does Montandon's original description mention this very noticeable character. Curiously, Kuitert (1947:43–44, unpub. diss.) apparently agrees with De Carlo on the determination of *borellii* when he writes in his redescription of *borellii*, under the heading "Additional Structural Characteristics," "The posterior portion of the prosternum prominently inflated and swollen. . ." Yet one must believe that a careful observer like Montandon would certainly have noticed this outstanding prosternal shape and then included the trait in his description. Furthermore, in all the specimens with the swollen prosternum, believed by De Carlo to be "*borellii*," the eye width strongly tends to be greater than $0.5\times$ the interocular distance. Yet this dimension was described as smaller for *borellii* ("... des yeux qui sont plus petits avec l'espace interoculaire plus de deux fois plus large que le diametre de l'oeil," Montandon, 1903:100). Finally, unlike Montandon's *borellii* specimen but like De Carlo's type for *grandis*, De Carlo's specimens with the swollen prosternum do not display profemoral sulcal teeth.

For these several reasons, I therefore believe that De Carlo and Kuitert were mistaken in the opinion that "*borellii*" specimens have a swollen prosternum. Instead, I believe these specimens with this character should be classified as *C. grandis*, whose description they do in fact match (as discussed under *C. grandis*).

The synonymy of the four De Carlo species, *riggii*, *dureti*, *bachmanni*, and *sanmartini*, with *borellii* is clear. All four De Carlo type specimens, and the specimen determined by Montandon in 1908 to be *borellii*, exhibit the diagnostic characters given above. De Carlo contrasts his four species with characters that are highly variable intraspecifically such as antennal and pronotal shape, body length and color. For example, he contrasts *bachmanni* and *dureti* (1956:4) on the basis of a 2 mm difference in total length and a blackish versus light brown color difference. But a 2 mm difference in body length in all but the smallest of curictan species is well within the normal range of overall lengths and it is apparent upon studying the types that the difference in color is probably due to sediment covering these specimens.

In another example, De Carlo compares *sanmartini* and *riggii* saying (1956:5) that the two species are similar in body length, siphon length, and in characteristics of the prosternum, pronotum, and vertex but the species can be differentiated by antennal shape and the presence of pale longitudinal bands on the abdominal venter on *riggii* which are absent on *sanmartini*. However, inspection of the types reveals that both specimens have the abdominal bands, and the variability in antennal shape is well within the norm for curictan species. In sum, I have no hesitation about synonymizing these four De Carlo species with *Curicta borellii* Montandon.

Finally, it should be noted that De Carlo originally confused his future *sanmartini* with Kuitert's *carinata* (De Carlo, 1951:409-410) because Kuitert failed to mention the presence of a dark, medial protibial annulus in his original description of *carinata* (Kuitert, 1949:62-64). Having learned from a colleague of this *carinata* trait, De Carlo realized that the specimens he had determined to be *carinata* in 1951 were instead a new species which he described as *sanmartini* (De Carlo, 1956:6).

Distribution (Fig. 36). Argentina, Paraguay, Brazil.

Material examined. NEOTYPE, male: *Curicta borellii* Montandon: Paraguay, Venzenyi, Asuncion; no temporal or collector data. As discussed above the syntypes for *C. borellii* Montandon have not been located. Therefore, I here designate the 1908 Montandon determined specimen of *borellii* as a neotype. The specimen has two determination labels, one handwritten underneath another label which is dated 1908 and has "det. Montand." printed and the species name, author, and date in script. This specimen is deposited in the Hungarian Natural History Museum. HOLOTYPE, female: *Curicta riggii* De Carlo: Salta, Argentina; leg. Daguerre; no temporal data associated with the specimen although De Carlo (1951:407) lists a date of June, 1934. Microscope slide #3014 contains one antenna. Both specimen and slide deposited in the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia," Buenos Aires. De Carlo never designated an allotype for this species but one specimen loaned from the MBR has an allotype label. Someone in the museum in Buenos Aires subsequently caught the mistake and affixed a handwritten "no es tipo" label. HOLOTYPE, female: *Curicta dureti* De Carlo: El Naranjo, Salta, Argentina; leg. Duret. De Carlo writes in his description that the specimen was collected by Duret and Mr. Martinez (1951:409). No temporal data are associated with the specimen but De Carlo gives a date of January, 1944 in the description of the species (ibid: 409). Slide preparation #3013 of an antenna. Both specimen and slide deposited in the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia," Buenos Aires. HOLOTYPE, female, *Curicta bachmanni* De Carlo: Puerto Vallemí, Concepción, Paraguay; July, 1952; leg. Bachmann. Deposited in the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia," Buenos Aires. Another specimen bears a paratype label for this specimen and two handwritten labels reading, "no es tipo" and "no publicado." De Carlo did not publish any record of a paratype for this specimen. HOLOTYPE, female: *Curicta sanmartini* De Carlo: Paso de la Patria, Corrientes, Argentina; September, 1940; no collector data. Microscope slide #3015 is of antenna. Both specimen and slide deposited in the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia," Buenos Aires. ALLOTYPE, male: *Curicta sanmartini* De Carlo: Villarrica, Paraguay; June, 1938; leg. Schade. Microscope slide #3016 is of antenna. Both specimen and slide deposited in the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia," Buenos Aires. PARATYPES, both male: *Curicta*

sanmartini De Carlo: Villa Rica, Paraguay; June, 1938; no collector data but De Carlo attributes the specimen to F. Schade (1956:5). San Cosme, Corrientes, Argentina; September, 1938; leg. Wurth. Microscope slide #3017 for the Paraguay specimen; the other specimen has a labeled slide with no identifying slide number. Both specimens and slides deposited in the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia," Buenos Aires.

Additional material examined. 65 specimens collected in January (1), February (2), March (1), April (28), May (7), September (20), and November (1); deposited in HNHM, INSB, JTPC, LACM, MACN, and NMNH. ARGENTINA. Salta: Salta. Tucuman: Horco Mollo; S. Javier; La Aquadita. Formosa: Gran Guardia. PARAGUAY. Asunción: Asunción; Laguna nr Ita. Paraguari: Caacupa; Parq. Nac. Ybycui; Lagunas - Ruta, La Rosada, Ybycui Park; 10 km E Ybycui. Guaira: Villarrica. Arroyo Yaqua Resaíi Y pacai; Areguá (provinces unknown). BRAZIL. Acre: Rio Yacumpe, Pto. Espirito, Esfanque.

Curicta volxemi (Montandon)

Figs. 29, 36

Nepoidea volxemi Montandon, 1895:476–477.

Curicta volxemi, Champion 1901:353; Montandon, 1903:98; Kirkaldy and Torre Bueno, 1909:202; De Carlo, 1951:395.

Curicta schoutedeni Montandon, 1909a:143–144; De Carlo, 1951:417–418. NEW SYNONYMY

Curicta brasiliensis De Carlo, 1951:404–405. NEW SYNONYMY.

Curicta femoralis Roback and Nieser, 1974:41–42. NEW SYNONYMY.

Redescription

Measurements. Males: Length, 24.0–27.0; profemoral length, 7.6–9.3; siphons, 18.0–21.0. Females: Length, 24.5–30.5; profemoral length, 8.0–9.8; siphons, 19.0–24.5.

Color. Dark brown. Lighter on thoracic and hemelytral dorsa. Abdominal dorsum red to reddish brown. Abdominal venter often with two lighter, irregular longitudinal bands on sterna 3–6; parasterna with lighter mottling. Protibia dark basally; no dark medial annulation. Meso- and metathoracic legs apparently variable: dark to light colored.

Structural characteristics. Body very elongate (Fig. 29A); total length 5.4–5.9× maximum width.

Eye width slightly less than to subequal to 0.5× interocular distance. Vertex nearly flat to slightly convex; slight median longitudinal carina evident in about half of specimens. Lobe of antennal segment 2 greater than half the length of 3.

Pronotum elongate; lateral length 1.5–1.6× posterior width. Transverse sulcus incomplete. Median longitudinal sulcus variable: complete and shallow, becoming very shallow posteriorly; or shallow anteriorly, becoming obsolescent posteriorly. Median longitudinal ridges rounded; in specimens with incomplete median sulcus median ridges fuse posteriorly to become single, broad ridge. Lateral sulci shallow. Lateral ridges rounded. Ridges and humeral lobes with very few granulations evident; these occur more frequently on narrower specimens. Posteroventral extensions of pronotum do not meet in ventral midline at junction of pro- and mesosterna (Fig. 2C).

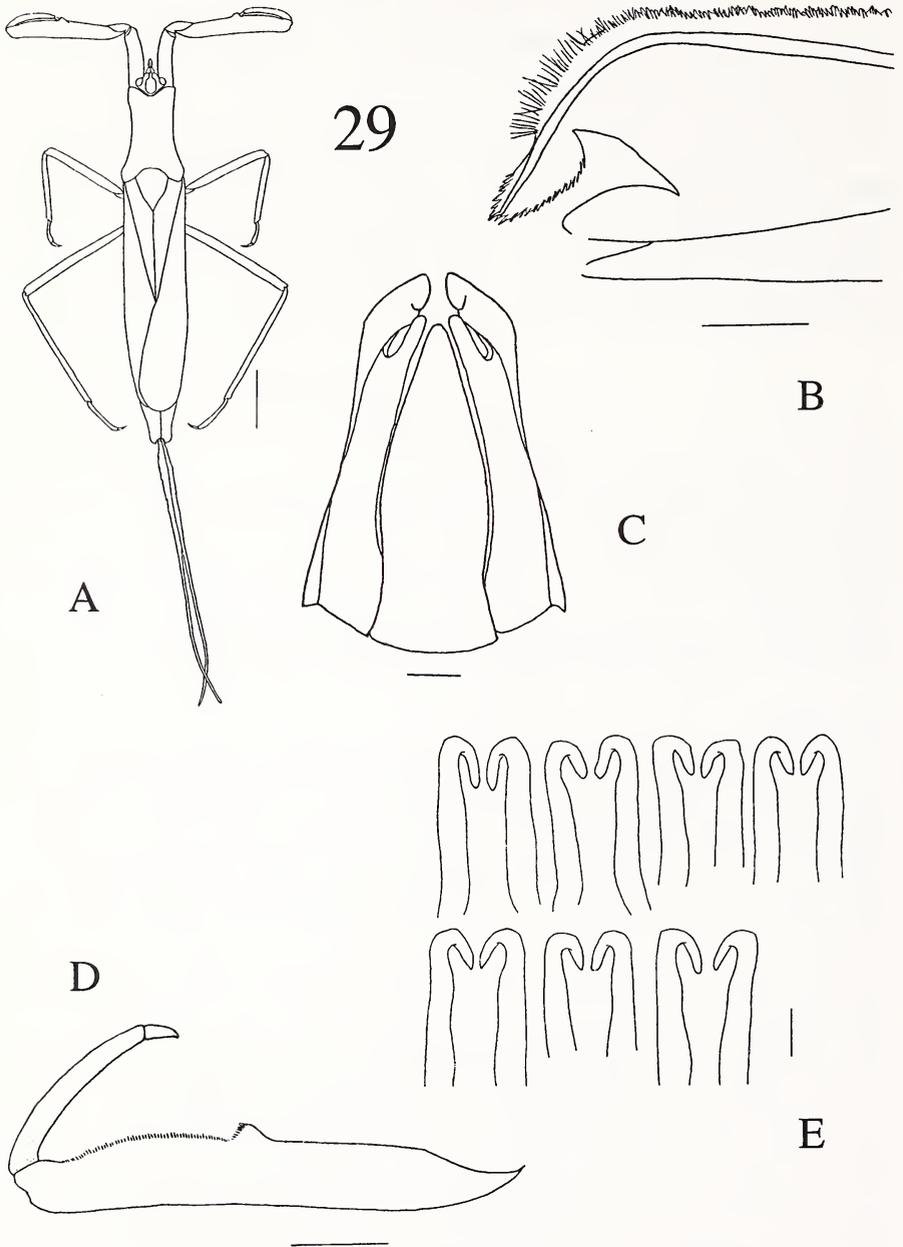


Fig. 29. *C. volxemi*: A) dorsal habitus (5 mm); B) last abdominal segment, lateral view (0.5 mm); C) last abdominal segment, ventral view (1 mm); D) profemur, anterior view (2 mm); E) parameres (0.25 mm).

Scutellum width less than length. Trident distinct: medial prong, handle, and longitudinal sections of lateral prongs black.

Hemelytra usually widest posterior to humeral lobes; granulations along hemelytral margins apparent but not heavy. Metathoracic wings fully developed.

Last abdominal tergum tomentose laterally; longer hairs medially form two indistinct, parallel mediolongitudinal bands.

Prosternum in lateral view not swollen in posterior half. Mesosternum has midline groove but no carinae or bands of hairs. Metathoracic sternum tomentose. Parasterna of last abdominal segment ending in large, thumblike processes (Fig. 29B), which usually extend slightly beyond posterior margin of male and female opercula (Fig. 29C). Male operculum, Fig. 29C.

Procoxae typically $0.48\text{--}0.52\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth $0.55\text{--}0.64\times$ total femoral length (Fig. 29D). Profemur only very slightly arched beyond profemoral teeth. Profemoral sulcus with a complete row of tubercles; two sulcal teeth distally, often prominent.

Metafemora reaching onto proximal half of abdominal sternum 6 when extended posteriorly.

Parameres, Figure 29E. Female genitalia: Gp2 dorsolaterally flattened (Fig. 13B).

Discussion. The very elongate profemora and pronota, the protibia without a dark medial annulus, and the large, thumblike parasternal lobes are, in combination, diagnostic for this species. Two other species share the parasternal characters with *volxemi*: *C. tibialis* and *doesburgi*.

C. tibialis is separated from *volxemi* by having shorter profemora that rarely exceed the lateral length of the pronotum, less elongate pronotum (lateral length/posterior width <1.4 ; *volxemi* >1.5), and deeper sulci and more pronounced ridges on the pronotum than *volxemi*. In addition, *volxemi* lacks the unique "step-down" notch along the lateral margin of the profemoral sulcus found in *tibialis* (Fig. 24C). The two species form a continuum of expression of the carina on the vertex. In *tibialis* the carina can be slight to pronounced, while in *volxemi* the range is from slight to absent.

C. doesburgi has shorter profemora that only rarely equal the lateral length of the pronotum and a pronotal length to posterior width ratio (1.4–1.5) that is usually less than *volxemi*'s. However, it should be noted that the larger *doesburgi* specimens overlap in body length with the smaller *volxemi* and have profemora that can attain lengths up to 1 mm longer than the lateral pronotal length, and the larger *doesburgi* females have profemoral lengths matching the smallest female *volxemi*. Also, pronotal sculpturing in *doesburgi* is variable, with the sculpturing evident in *volxemi* also found in *doesburgi*. In short, there could be confusion between these two species at the junction of the larger *doesburgi* and smaller *volxemi*. *C. volxemi* is found in southeastern Brazil, Mato Grosso, and Meta, Colombia while *doesburgi* is found across northern South America from Venezuela to Brazil east of the mouth of the Amazon. Further collecting, particularly in the Amazonian interior and along Brazil's northeastern coast will help determine the degree of intermediacy between these two species.

The synonymy of *C. schoutedeni*, *C. brasiliensis*, and *C. femoralis* with *volxemi* is based on the common possession of the profemoral, pronotal, and parasternal

diagnostic characters discussed above. The type for *volxemi* is the smallest male but otherwise matches the other specimens I have seen. The type for *schoutedeni* has one of the more robust pronota of the male specimens but there are other male specimens collected from São Paulo that are even more robust. The types for *femoralis* are among the most slender pronotally of this species, a feature shared with specimens from Mato Grosso and Rio de Janeiro, Brazil. *C. brasiliensis* is in the middle of the *volxemi* pronotal shape distribution. In short, although there is pronotal variation in this species it is no more than that judged as within the bounds of acceptable intraspecific variation for other species in the genus.

Roback and Nieser (1974) compared their *femoralis* with five other curictan species: *brasiliensis*, *lenti*, *longimanus*, *riggii*, and *montei* writing that all these species have a relatively long profemur but that *femoralis* is distinctive because its femoral teeth are "distinctly distad of the middle of the fore femur and the process of the second antennal segment [is] shorter." Antennae have apparently little value in the taxonomy of this group (see, Discussion of Taxonomic Characters) and distinctly distal profemoral teeth (ratio of distance to teeth to femoral length ≥ 0.55) are shared by *C. tibialis*, *volxemi*, and *doesburgi*, but not *C. riggii* which I have determined to be synonymous with *C. borellii*. The apparent geographic disjunction of *volxemi*, most specimens collected in southeastern Brazil, and *femoralis*, from central Colombia, is somewhat mitigated by the single specimen of this species collected in Utiariti, Mato Grosso and the fact that the precise locality of the *volxemi* type is at present unknown (see below). I would predict that other specimens of this species will be found in the geographic interval between the Mato Grosso site and Colombia, either following an Andean arc or across the Amazonian lowlands.

De Carlo compared *brasiliensis* with another of his curictan species, *C. longimanus*, writing (De Carlo, 1951:404) that the two species have the same characteristics of the head, prothorax, and profemur but that *brasiliensis* is shorter in body length and siphon length. However, the lengths of both of these type specimens fall within the range determined for *volxemi*: *brasiliensis*, a male measured 27 mm and *longimanus*, a female, measured 29.8 mm. in body length and the two specimens measured 20.8 mm and 27 mm respectively in siphon length. The siphon measurement for *longimanus* exceeds that recorded by me for specimens of *volxemi* but most of the *volxemi* specimens have broken siphons or are missing the siphons altogether. Therefore, it is likely, in my opinion, that De Carlo's *longimanus* is also a synonym of *volxemi*. However, I have not succeeded in attempts to secure the loan of the type for *C. longimanus*. (This specimen is reported to be deposited in the Fundacao Instituto Oswaldo Cruz, Rio de Janeiro, Brazil (ibid: 404) but officials of that institution have not responded to my numerous requests for loan of the type.) Therefore, although I believe that *C. longimanus* De Carlo is probably the same as *C. volxemi* Montandon, I will refrain from placing it in synonymy until such time as I can study the *longimanus* type.

Distribution (Fig. 36). Brazil: Minas Gerais, São Paulo, Rio de Janeiro, Rio Grand do Sul, Mato Grosso. Colombia: Meta.

Material examined. HOLOTYPE, male: *Curicta volxemi* (Montandon). Sta. Cruz, Mexique; leg. Camille Van Volxem. No temporal data given. Locality and collector data are printed on an Institut Royal des Sciences Naturelles de Belgique label. After receiving this specimens on loan from Belgium I realized that it could not be from

Central America as the museum label indicates. The three species of *Curicta* occurring in Mexico, *scorpio*, *hungerfordi*, and *pronotata*, all have proximal profemoral teeth, i.e., distance from base of profemur to tip of the anteroventral profemoral tooth $<0.45 \times$ profemoral length, while *volxemi*'s occur at $0.56 \times$ profemoral length. Further, the elongate profemora and thumblike parasternal lobes of *volxemi* seemed to place it in the Brazilian fauna. I consulted with Dr. John Polhemus (Englewood, Colorado) on this matter and he was subsequently able to discover that the collector of the *volxemi* type, Camille Van Volxem, had made a collecting trip to Brazil shortly before his death at the age of 27 (Deyrolle, 1875). Where Van Volxem and his two companions, MM. Van Beneden and Walter de Selys-Longchamps, collected in Brazil is still unknown. G. Schmitz, curator of Hemiptera at the Musée Royal de l'Afrique Centrale in Tervuren, Belgium, has checked through the archives in his museum for information about that collecting trip and only found mention of the trip in the biography of Walter Selys-Longchamps' father, E. de Selys-Longchamps (in litt.). However, Dr. Polhemus thinks it highly likely that Van Volxem collected at the Santa Cruz locality that is near Rio de Janeiro. Therefore, I have recorded this locality on the Distribution map for the species (Fig. 36). This specimen is deposited in the Institut Royal des Sciences Naturelles de Belgique. SYNTYPE, male: *Curicta schoutedeni* Montandon. Piqueté, São Paulo, Brazil; leg. Schouteden; no temporal data. Montandon refers to other specimens in his and Schouteden's collections but I have only seen this one specimen. Deposited in the Institut Royal des Sciences Naturelles de Belgique. HOLOTYPE, female: *Curicta braziliensis* De Carlo. Therethafroli [Therespolis?], Est. do Rio., leg. A Miranda Ribeiro; March 1918. De Carlo indicates in his description that a paratype was deposited in the Paranaense Museum. Dr. William Overal, director of this museum in Curitiba, Paraná, Brazil has informed me that this type is not to be found in his museum (in litt.). HOLOTYPE, male: *Curicta femoralis* Roback and Nieser. Colombia: Meta, 32 km ENE Puerto Lopez, Pond at Hacienda El Viento; 10 December 1969; leg. S. S. Roback. Deposited in the Academy of Natural Sciences of Philadelphia. ALLOTYPE, female: *Curicta femoralis* Roback and Nieser. Colombia: Meta, Laguna Humacita nr. Las Bocas Del Guyuriba; 12 December 1969; leg. S. S. Roback. Deposited in the Academy of Natural Sciences of Philadelphia. A male and female paratype of this species, indicated in the original description to be in the collection of Dr. Nico Nieser, were not seen.

Additional material examined. 21 specimens collected in March (1), April (8), June (2), July (3), August (1), and December (1); deposited in JTPC, MACN, MZSP, NMNH, RMNH, and SEMC. BRAZIL. Paraná: Curitiba. São Paulo: Sto. André; Itaquaquecetuba; Rio das Pedras, Palmeiras. Minas Gerais: Bello Horizonte; Rio dos Velhos. Rio de Janeiro: Manguinho. Mato Grosso: Rio Papagaio, Utiariti. Rio San Francisco (eastern Brazil, state unknown); Repressa da E. E.; E. le Moul, Mendes (state unknown); Jtann[h]aeu (state unknown).

Curicta doesburgi De Carlo

Figs. 30, 37

Curicta doesburgi De Carlo, 1967 (1966):33; Nieser, 1975:131–132.

Curicta montei De Carlo, 1960:48–49. NEW SYNONYMY.

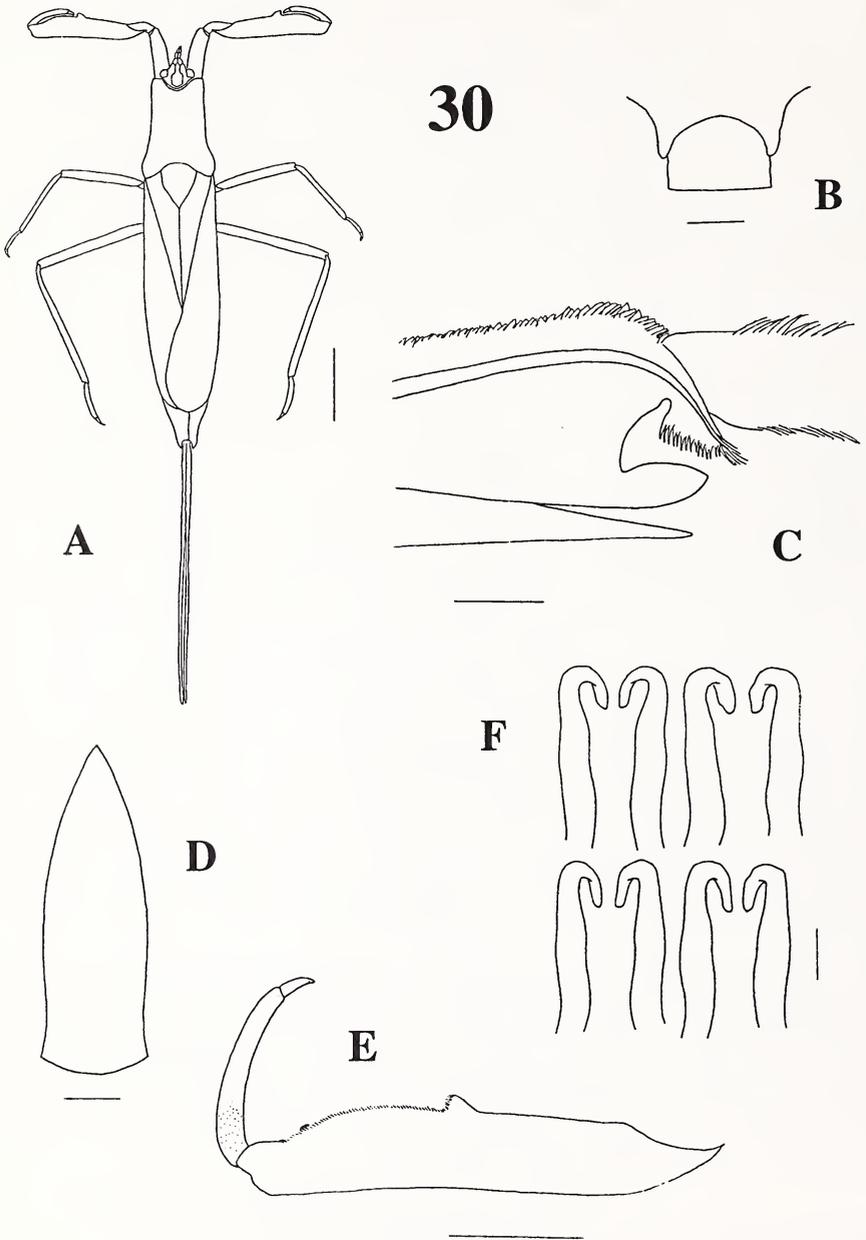


Fig. 30. *C. doesburgi*: A) dorsal habitus (5 mm); B) posterolateral metasternal processes, ventral view (0.5 mm); C) last abdominal segment lateral views (0.5 mm); D) male operculum (0.5 mm); E) profemur, anterior view (2 mm); F) parameres (0.25 mm).

Redescription

Measurements. Males: Length, 18.0–23.0; profemoral length, 5.6–6.9; siphons, 14.0–18.0. Females: Length, 20.0–27.0; profemoral length, 6.2–7.8; siphons, 14.0–24.0.

Color. Dark brown. Lighter areas evident on the thoracic and hemelytral dorsa. Abdominal dorsum reddish brown. Abdominal venter mottled with lighter areas; often with two-four lighter, irregular longitudinal bands on sterna 3–6. Protibia dark basally; no dark medial annulation. Meso- and metathoracic legs golden.

Structural characteristics. Body elongate (Fig. 30A); total length $4.9\text{--}5.8\times$ maximum width.

Eye width typically $0.5\times$ interocular distance. Vertex nearly flat to convex; median longitudinal carina often apparent, infrequently prominent. Lobe of antennal segment 2 greater than half length of 3.

Pronotum elongate; lateral length approximately $1.3\text{--}1.5\times$ posterior width. Transverse sulcus incomplete. Median longitudinal sulcus variable: usually shallow anteriorly becoming obsolescent posteriorly; or shallow and complete, usually becoming shallower posteriorly. Median longitudinal ridges rounded; in specimens with incomplete median sulcus median ridges fuse posteriorly to become single, broad ridge which may either be gradually declivent to level of transverse sulci or continue horizontally to the posterior margin of pronotum. Lateral sulci shallow. Lateral ridges rounded. Ridges and humeral lobes with few granulations evident. Posteroventral extensions of pronotum do not meet on ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width less than length. Trident varies in distinctness: pattern subcarinate to carinate, usually somewhat darker on all parts than surrounding scutellum.

Hemelytra usually widest posterior to humeral lobes; granulations along hemelytral margins present but less numerous and distinct than found in *C. granulosa* and *C. borellii*. Metathoracic wings fully developed.

Last abdominal tergum tomentose laterally, longer hairs form two indistinct, parallel mediolongitudinal bands.

Prosternum in lateral view not swollen in posterior half. Mesosternum has prominent midline groove; often tomentose posterolaterally but no extended bands of hairs or carinae present. Metathoracic sternum tomentose; posterolateral processes variable in shape but always noticeably prolonged (Fig. 30B). Parasterna of last abdominal segment ending in large, thumblike processes (Fig. 30C) which usually extend posteriorly slightly beyond posterior margin of opercula. Male operculum, Fig. 30D.

Procoxae typically $0.50\text{--}0.55\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth $0.52\text{--}0.58\times$ total profemoral length (Fig. 30E). Profemur slightly arched beyond profemoral teeth. Profemoral sulcus with a complete row of tubercles; two sulcal teeth distally, often prominent.

Metafemora usually reach halfway onto abdominal sternum 6 when extended posteriorly.

Parameres, Fig. 30F. Female genitalia: Gp2 dorsolaterally flattened (Fig. 13B).

Discussion. The large, thumblike parasternal lobes, the profemora up to 1 mm longer

than the lateral length of the pronotum, and the protibia without a dark medial annulus are, in combination, diagnostic for this species.

C. doesburgi is close to three other species, *C. volxemi*, *C. borellii*, and *C. intermedia*. *C. doesburgi* has shorter profemora (M, 5.6–6.9; F, 6.2–7.8) that only rarely equal the lateral length of the pronotum, while *volxemi* has more elongate profemora (M, 7.6–9.3; F, 7.8–9.8) that always exceed the lateral pronotal length by at least 1 mm. *C. doesburgi*'s pronotal length to posterior width ratio (1.36–1.54) is usually less than *volxemi*'s (1.50–1.60). However, the larger *doesburgi* specimens overlap in body length with the smaller *volxemi* and have profemora that can attain lengths equal to (but not exceeding) 1 mm longer than the lateral pronotal length; larger *doesburgi* females have profemoral lengths matching the smallest female *volxemi*. Also, pronotal sculpturing in *doesburgi* and *volxemi* is very similar. In short, there could be confusion between these two species at the junction of the larger *doesburgi* and smaller *volxemi*. *C. volxemi* is found in southeastern Brazil, Mato Grosso, and Meta, Colombia while *doesburgi* is found across northern South America from Venezuela to Brazil east of the mouth of the Amazon. Further collecting, particularly in the Amazonian interior and along Brazil's northeastern coast will help determine the degree of intermediacy between these two species.

C. doesburgi and *borellii* specimens can also be very difficult to separate in the interval where their body measurements overlap (*doesburgi*: M, 18.0–23.0; F, 20.0–27.0; *borellii*: M, 21.5–26.0; F, 24.0–30.0). Both *doesburgi* and *borellii* have light colored meso- and metathoracic legs and similar profemoral lengths and pronotal traits. However, *borellii* has parasternal lobes that are variable in shape but rarely thumblike (Fig. 28D), while *doesburgi* has consistently large, thumblike parasternal lobes (Fig. 30C). In addition, *doesburgi* lacks the oblique mesosternal bands of *borellii*, although many *doesburgi* specimens are tomentose in the posterolateral corners of the mesosternum, a condition which resembles that found in *borellii* specimens with reduced oblique bands. However, large *doesburgi* and small *borellii* specimens are easily confused particularly if the *borellii* specimen lacks heavy granulation on the dorsum and has reduced mesosternal bands. There are three such specimens from Paraguay that I have identified as *borellii* because they lack the parasternal trait of *doesburgi* but in all other ways they closely resemble *doesburgi*. It is worth noting that *C. grandis* has a disjunct distribution with populations in northern Argentina/Paraguay and Suriname. The closeness of the Argentine and Paraguayan *borellii* and the Suriname *doesburgi* might be the result of the same processes that produced the *grandis* disjunction. Further collecting, particularly across Brazil, between Suriname and Paraguay, is needed to help understand the relationship between these two species.

C. intermedia is known from only a single specimen; the relationship between this specimen and *C. doesburgi* is examined in the discussion of *intermedia*.

Mention should also be made of the possible synonymy of *doesburgi* with *C. lenti* De Carlo. The type specimen for *C. lenti* was not seen for this review, but a single specimen from Manguinhos, Brazil appears to match De Carlo's original description (see "Comments" for *lenti*). Interestingly, this *lenti*-like specimen has the thumblike parasternal processes of *volxemi* and *doesburgi* and resembles by general facies the more pronotally robust specimens of *doesburgi* from Suriname. Further collecting is clearly needed to determine the relationship between these two species.

The synonymy of *C. montei* with *doesburgi* is clear. *C. montei* has one of the more elongate pronota of the *doesburgi* specimens but the difference is within the bounds of pronotal differences found in other species, e.g., *C. pronotata* (Fig. 4A). Otherwise *montei* exhibits all the *doesburgi* traits. The *montei* holotype is one of four specimens of *doesburgi* from Brazil (Fig. 37). All four specimens are at the upper end of the measurement distribution for *doesburgi*. It would be interesting to see if further collecting between the mouth of the Amazon and the state of Pernambuco (the current easternmost locality for *doesburgi*) produces specimens that are consistently on the upper end of the measurement distribution for *doesburgi*. Also, as noted above, the larger specimens of *doesburgi* including these Brazilian specimens, approach the lower end of the measurement distribution for *volxemi*. Thus, collecting for *doesburgi* and *volxemi* along Brazil's eastern and northeastern coast will further our understanding of the separation of these two species.

Finally, mention should be made of the excellent monograph by Dr. Nico Nieser on the Nepomorpha of Suriname (1975) which contains detailed information concerning collecting localities for *C. doesburgi*.

Distribution (Fig. 37). Venezuela: Guárico. Guyana: East Demerara. Suriname: Suriname. Brazil: Maranhão, Ceará, Pernambuco.

Material examined. HOLOTYPE, male: *Curicta doesburgi* De Carlo. Suriname, leg. P. H. v. Doesburg, Jr. Temporal data given as 1014, 19-. Deposited in Rijksmuseum Van Natuurlijke Historie. ALLOTYPE, female: *Curicta doesburgi* De Carlo. Same data as holotype. Deposited in Rijksmuseum Van Natuurlijke Historie. There is also supposed to be a male paratype of *doesburgi* deposited in the Museo Argentino de Ciencias Naturales "Bernadino Rivadavia" but I have not seen this specimen. Two females with *doesburgi* paratype labels were loaned to me from that museum but they cannot be paratypes because they were not mentioned in the original description. Accordingly, someone in Buenos Aires has affixed handwritten labels to both of these specimens saying, "no es tipo." HOLOTYPE, male: *Curicta montei* De Carlo. Ceara, Brazil. No temporal or collector data. Deposited in the C. J. Drake Collection of the National Museum of Natural History, Smithsonian Institution.

Additional material examined. 167 specimens collected in January (14), March (35), April (56), May (2), July (21), August (16), September (2), October (6), and November (2); deposited in JTPC, MACN, NMNH, NNC, and SEMC. (Most of these specimens were collected at the Guyana locations and are deposited in SEMC.) VENEZUELA. Guárico: Camaguan. El Limon (state unknown). GUYANA: East Demerara: Georgetown Br., Guiana Botanic Gardens; Georgetown Br., Guiana Ponds, Trenches; Lamash Conservatory, E. Coast Demerara; Plantation Ogle, E. Coast Demerara. Mazaruni -Potaro: Kangaroo B Supuruni Creek (province unknown). SURINAME: Suriname: Paramaribo; Paramaribo Bot. Gard.; Paramaribo, Munderpark; pond at Wilhelmina's Brug; Oost-West Verfinding. SARACCA: Verlengde Garnizoenspad, 4 km W Saramacca River; Garnizoenspa, jarikabakreek, km 24-25. Commewijne: edge of marsh at Belwaarde plantation; Road to Moengo, 7-8 km E Meerzorg; Road to Moengo, 7 km E Meerzerg. Road to Damburg; Tobejuba, D.A. (provinces unknown). FRENCH GUIANA. [no specific locality given]. BRAZIL. Maranhão: São Luiz, Fonte d'aqua. Ceará: [no specific locality given]. Pernambuco: Tapera.

Curicta intermedia (Martin)

Fig. 31, 37

Nepoidea intermedia Martin, 1898:66-67.*Curicta intermedia*, Montandon, 1903:98; Kirkaldy and Torre Bueno, 1909:202; De Carlo, 1951:417.*Redescription*

Measurements. Male holotype: Length, 19.7; profemoral length, 6.0; siphons, absent. *Color.* Dark brown. Lighter mottling evident on thoracic and hemelytral dorsa. Abdominal dorsum dark reddish brown. Abdominal venter with paler longitudinal streaks on sterna 3-7; lighter spots on parasterna. Protibia dark basally, dark area continues dorsally and dorsolaterally half way along protibia. Mesothoracic and metathoracic legs light brown.

Structural characteristics. Body elongate (Fig. 31A); length $5.2\times$ maximum width.

Eye width $0.5\times$ interocular distance. Vertex convex, with pronounced median longitudinal carina. Lobe of antennal segment 3 greater than half length of 3.

Pronotum elongate; lateral length $1.4\times$ posterior width. Transverse sulcus incomplete. Median longitudinal sulcus complete, becoming shallower posteriorly. Median longitudinal ridges rounded. Lateral sulci shallow. Lateral ridges not prominent. Faint granulations on humeral lobes, none apparent on ridges. Posteroventral extensions of pronotum do not meet in ventral midline at junction of pro- and mesosterna (Fig. 2C).

Scutellum width less than length. Trident distinct: lateral prongs and handle carinate, dark; medial prong less carinate but dark and visible.

Hemelytra widest just posterior to humeral lobes; granulations along lateral margins and in clavus present but not dense. Metathoracic wings fully developed.

Last abdominal tergum tomentose laterally, longer hairs form two indistinct, parallel mediolongitudinal bands.

Prosternum in lateral view not swollen in posterior half. Mesosternum has midline groove; tomentose posterolaterally but no extended bands of hair or carinae. Metathoracic sternum tomentose; posterolateral processes do not appear elongate (Fig. 31B). Parasterna of last abdominal segment ending in digitate processes (Fig. 31C) which apparently do not extend beyond posterior margin of operculum. The characters of the last abdominal segment are difficult to evaluate because this area of the specimen has been roughly handled. The connexiva have apparently been cut or broken off distally; the parasternal lobes have been abraded and are therefore missing their covering of hair; and the operculum has been pried ventrally leaving it deformed in the posterior fourth. The operculum was therefore not illustrated.

Procoxae $0.48\times$ profemoral length. Two profemoral teeth; distance from base of profemur to tip of anteroventral profemoral tooth $0.51\times$ total femoral length (Fig. 31D). Profemur slightly arched beyond profemoral teeth. Profemoral sulcus with complete row of tubercles; two sulcal teeth distally.

Metafemora missing; therefore, their length relative to abdominal sternum 6 unknown.

Parameres not examined (unique specimen considered to delicate for dissection). Female genitalia unknown.

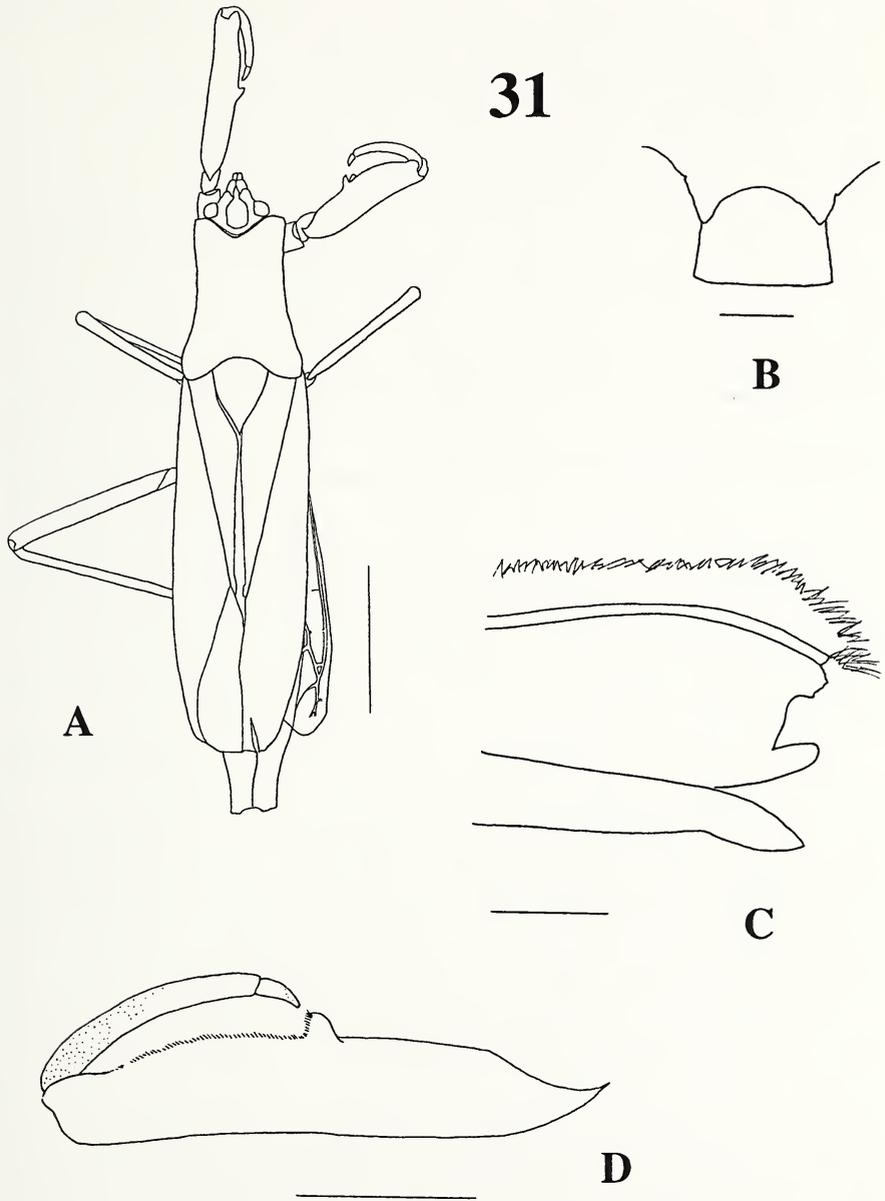


Fig. 31. *C. intermedia*: A) dorsal habitus (5 mm); B) posterolateral metasternal processes, ventral view (0.5 mm); C) last abdominal segment, lateral view (0.5 mm); D) profemur, anterior view (2 mm).

Discussion. This species is something of an enigma. For diagnostic characters I can only say at this time that it does not really fit satisfactorily into any of the other curictan species. By size it could be confused with two other species, *C. granulosa* and *C. doesburgi*. H. B. Hungerford and Nico Nieser are two previous workers who have identified *granulosa* specimens as *intermedia*. Louis Kuitert identified several *doesburgi* specimens from the Guyanas as *intermedia*.

Like *granulosa*, particularly the smaller specimens from Venezuela, *intermedia* appears to have digitate parasternal lobes and a carina on the vertex. However, *granulosa* specimens usually have a heavily granulated dorsum, a distinct protibial medial annulus, and parallel bands of hair on the mesosternum. *C. intermedia* lacks heavy dorsal granulations (although some do occur on the pronotal humeral lobes and on the hemelytra); has the dark basal protibial annulus on the dorsal surface continuing up to the half way point on the tibia but no separate, distinct annulus; and is without mesosternal bands. However, as is pointed out in the discussion of *granulosa*, not all *granulosa* specimens have all that of species' diagnostic characters. All three of these characters may be reduced, incomplete, or even absent. The protibial and mesosternal characters seem particularly prone to reduction and absence. A series of specimens collected from Puerto Triunfo, Colombia by John and Dan Polhemus illustrates this problem. The three males and four females from this series all have a carina on the vertex, but not as pronounced as is usual for *granulosa*; granulations on the dorsum, but not as prolific as is usual for *granulosa*; faint, incomplete, or absent medial protibial annuli; and parallel mesosternal bands. None of these specimens have all the *granulosa* characters but neither do they resemble closely by gestalt the *intermedia* type. Therefore, I have identified them as *granulosa*. Usually, however, enough of the characters are present to make *granulosa* identifications readily apparent. Therefore, the differences between these two species are generally distinctive enough that I think it very unlikely that they are the same species.

A more likely candidate for synonymy with *intermedia* is *doesburgi*. *C. intermedia* shares with *doesburgi* a lack of dorsal granulations but has similar general facies including all measurements and related ratios. It differs from *doesburgi* by apparently having digitate parasternal lobes (Fig. 31C), rather shortened posterolateral metasternal processes, and a distinctive carina on the vertex. *C. doesburgi* has large, thumblike parasternal lobes (Fig. 30C). Metasternal processes vary in shape in *doesburgi* but the processes are always more elongate (Fig. 30B) than is apparent in *intermedia* (Fig. 31B). However, the difference in the metasternal character may be more apparent than real, as it appears that the posterolateral processes of *intermedia* are reflected dorsoposteriorly. When the *intermedia* holotype is seen from a posteroventral view, the mesosternal projections appear more elongate and not dissimilar from the *doesburgi* condition. Carinae on the vertex do appear on *doesburgi* specimens but only rarely do they approach the prominence found on *intermedia*.

In sum, further collecting is needed in Colombia, and probably throughout northern South America, to help solve the puzzle of *intermedia*. We need to know the stability of the vertex and metasternal characters found on *intermedia*. Carinae on the vertex can vary in their prominence in species of *Curicta*, and the metasternal processes have been used sparingly in this review because of their plasticity. (Roback and Nieser, 1974, also found metasternal processes "too variable to be of much use"

[p. 41] in curictan taxonomy.) Thus, the distinctions between *intermedia* and *doesburgi*, based on these characters, should not be considered strong hypotheses of species difference.

There is one female specimen from Colombia, identified by Louis Kuitert as *intermedia*, that bears mentioning. This specimen lacks dark protibial medial annuli, mesosternal carinae, and granulations on the dorsum so it probably is not *granulosa*. Further, it has small parasternal processes so it is unlikely that it belongs in *doesburgi*. However, it also lacks a carina on the vertex like the holotype for *intermedia*. Nevertheless, since it cannot be definitively placed in either *granulosa* or *doesburgi* and because it was collected in Colombia, I am letting Kuitert's determination stand. The measurements for this specimen are as follow: length, 21.8; profemoral length, 5.9; siphon length, 16.0.

Distribution (Fig. 37). Colombia. (Listed in original description as Parzudaki, Colombia.)

Material examined. HOLOTYPE, male: *Curicta intermedia* (Martin). Colombia. There is no other locality, temporal, or collector data associated with the specimen. In Martin's description he lists the specimen's data as follows: "Columbie, Parzudaki, 1840."

Additional material examined. 1 specimen from NMNH with the following data: Armero Tolima, Colombia; 1939; Coll 8 No 95; leg. F. L. Gallego M. (See above for discussion of this specimen.)

Species Not Seen

Curicta longimanus De Carlo

Fig. 37

Curicta longimanus De Carlo, 1951:402–404. (Original description and notes translated from the Spanish; all figures refer to the original text; my comments follow the translation.)

Description: Female. Width of the interocular distance plus eyes 2.6; vertex without median longitudinal carina and not too convex; antennae (Fig. 22).

Prothorax long, narrow, slightly robust. Pronotum (Fig. 21) anterior to transverse sulci slightly narrower than humeral lobes; length along midline 5.6; greatest width anteriorly 3.6, posteriorly 4.7; anterior margin angular, but a little rounded apically; anterior to the transverse sulci the prothorax is a little convex, with the longitudinal sulci visibly distinct. Prosternum posteriorly almost flat, very little convex. Mesosternum almost flat, with the median groove well defined.

Scutellum as in *C. tibialis*, but only slightly carinate.

Abdomen narrow, measuring at the level of the hemelytral membrane apex [base?] 4.9.

Profemora markedly long, robust (Fig. 23), 10 mm in length, with the teeth located just distal to the middle of the profemur; the upper part of both sides of the profemur without an oblique whitish band; procoxae 5.8 mm which is longer than the 4.5 mm procoxae of *C. paraguayensis* n. sp.; protibia a light yellowish color throughout except for a small dark area proximally; meso- and metafemora without a whitish band distally. *Measurements*: Holotype. Body length, 29.8; siphon length, 27.



Fig. 32. Distribution map for *C. bilobata*, *C. bonaerensis*, *C. pelleranoi*, and *C. peruviana*.

Distribution: Gov. Valdares, Minas, Brazil, leg. Cabral-Oliveira, August 1942.

Observations: This species, so notable for the evident length of the procoxae and protibiae, can be easily distinguished from *C. paraguayensis* sp. nov. and *C. grandis* sp. nov. not only by the characteristics mentioned above but also by the flat prosternum and the light yellow color of the anterior legs.

HOLOTYPE: In the collection of the Colección de Instituto Osvaldo Cruz, Río de Janeiro, Brazil [Fig. 86]. It was made available to me by Dr. Herman Lent."

Comments: I believe that this species is probably a synonym of *C. volxemi*. See the discussion for that species.

Curicta lenti De Carlo

Fig. 87

Curicta lenti De Carlo, 1951:405-406. (Original description and notes translated from the Spanish; all figures refer to the original text; my comments follow the translation.)



Fig. 33. Distribution map for *C. hungerfordi* and *C. pronotata*.



Fig. 34. Distribution map for *C. scorio*.



Fig. 35. Distribution map for *C. grandis*, *C. tibialis*, *C. carinata*, and *C. decarloi*.

“*Description*: Male. Width of the interocular distance plus eyes 2.3; vertex without median longitudinal carina and not too convex; antennae (Fig. 51).

Prothorax slightly robust. Pronotum (Fig. 24) anterior to transverse sulci slightly narrower than humeral lobes; anterior margin angular; length along midline 4.8; greatest width anteriorly 3.3, posteriorly 4.4; anterior to the transverse sulci the prothorax is only slightly convex, with the longitudinal sulci very distinct. Prosternum posteriorly almost flat, hardly elevated at all above the flanking sulci. Mesosternum almost flat, with the median groove well defined.

Scutellum moderately elevated; a median and two lateral carinae evident.

Abdomen narrowing in a distinct way posteriorly, measuring at the level of the hemelytral membrane apex [base?] 4.5. Parameres Fig. 53.

Profemora somewhat robust, 7.8 mm in length (Fig. 25), with the teeth located just distal to the middle of the profemur; the upper part of both sides of the profemur without an oblique whitish band; protibia and protarsus as in *C. longimanus* n. sp.; posterior [meta-?] femur visibly thick.



Fig. 36. Distribution map for *C. granulosa*, *C. borellii*, and *C. volxemi*.

Measurements: Holotype (unique). Body length, 25; siphon length, 19.5.

Distribution: Manguinhos, Rfo de Janeiro, Brazil [Fig. 87], leg. H. S. López, February 1942.

Observations: This species is separated from *C. brasiliensis* sp. nov. by a pronotum which is less convex and which is almost as long in the midline as across the posterior margin; and by the shape of the antennae and parameres.

HOLOTYPE: In the collection of the Colección de Instituto Oswaldo Cruz, Rfo de Janeiro, Brazil. The specimen was made available to me by the distinguished hemipterologist Dr. Herman Lent, to whom I have the pleasure of dedicating this species."

Comments: Although De Carlo indicates that he deposited the type for this species in the Oswaldo Cruz Institute, Dr. José Carvalho, retired curator at the Museu Nacional in Rio de Janeiro (now deceased), informed me that his former institution housed the *lenti* type (in litt.). In any event, I solicited the type from both museums.



Fig. 37. Distribution map for *C. doesburgi*, *C. intermedia*, *C. longimanus*, and *C. lenti*.

The Museu Nacional, by mistake, sent the type for *Ranatra lenti*. The Oswaldo Cruz Institute did not respond to my inquiries.

I have seen one specimen from Manguinhos, Brazil that is close to De Carlo's description for *lenti*. The specimen, a female, has the following measurements: length, 25.1; profemoral length, 7.4; length from base of profemur to tip of anteroventral profemoral tooth, 4.2; procoxal length, 4.0; lateral pronotal length, 6.4; posterior pronotal width, 4.4; and median pronotal length, 4.7. This specimen has the thumblike parasternal processes found in *C. volxemi*, *doesburgi*, and *tibialis*. By general facies it resembles the more pronotally robust specimens of *doesburgi* from Suriname. The specimen's profemoral length to lateral pronotal length ratio is right at the cusp between *volxemi* and *doesburgi*. Therefore, I have tentatively determined this specimen to be *C. lenti* but with the understanding that *lenti* and *doesburgi* may prove to be synonyms. Further collecting is clearly needed from southeastern Brazil to Suriname in order to resolve this uncertainty.

Table 1. Characters and character states used in cladistic analysis.

-
1. Vertex carina: (0) absent; (1) present but slight; (2) present and pronounced; (3) present as band of hair which bifurcates anteriorly
 2. Pronotal median sulcus: (0) obsolescent posteriorly; (1) complete
 3. Pronotal median ridges: (0) carinate; (1) rounded
 4. Pronotal lateral sulci: (0) deep; (1) shallow
 5. Pronotal granulations: (0) heavy; (1) light; (2) absent
 6. Abdominal width: (0) greatest at base of hemelytral membranes; (1) greatest anteriorly; (2) subparallel margins
 7. Last abdominal tergum: (0) carinae and bands absent; (1) parallel carinae present; (2) distinct parallel bands of hair present; (3) indistinct parallel bands of hair present
 8. Prosternum: (0) not swollen; (1) swollen
 9. Pronotum ventrally: (0) lobes don't meet ventrally; (1) lobes meet midventrally
 10. Mesosternal groove: (0) present; (1) absent
 11. Mesosternal carinae and bands: (0) carinae and bands absent; (1) parallel carinae present; (2) parallel bands of hair present; (3) oblique bands of hair present
 12. Parasternal process shape: (0) processes absent; (1) digitate; (2) broad; (3) thumblike
 13. Parasternal process length: (0) processes end anterior to posterior margin of operculum; (1) processes end ca. equal to posterior margin of operculum; (2) processes end posterior to posterior margin of operculum
 14. Profemoral teeth number: (0) Two; (1) One
 15. Profemoral teeth position: (0) at base of femur; (1) proximal (distal to base of femur and less than halfway); (2) distal (greater than halfway)
 16. Profemoral sulcus tubercles: (0) absent; (1) present throughout sulcus; (2) present in distal one-half of sulcus only
 17. Profemoral sulcus teeth: (0) absent; (1) present
 18. Profemoral sulcus shape: (0) linear; (1) curvilinear
 19. Gp2: (0) arched dorsomedially; (1) dorsoventrally flattened
 20. Ejaculatory reservoir of phallus: (0) present; (1) absent
 21. Vesical rod of phallus: (0) open ventrally; (1) closed ventrally (tubular)
 22. Abdominal sutures: (0) sutures delimiting sterna and parasterna don't converge on midline of 6th segment; (1) sutures delimiting sterna and parasterna converge on midline of 6th abdominal segment
-

CLADISTIC ANALYSIS

Methods and Materials

The characters and character states used in the cladistic analysis are listed in Table 1. Twenty-two characters were employed of which 13 were binary and 9 were multistate. The character states for each character for all three matrices were coded numerically, e.g., 0,1,2,3, etc. The numbers thus assigned did not specify anything about the order or polarity of the character states (see below). Based on my study of the cladistic relationships of waterscorpion genera (Keffer, in prep.) the genera *Nepa* and *Telmatotrepes* were selected as outgroups. The full 22 characters by 18 taxa data matrix is found in Table 2.

The computer program PAUP, version 3.1 (Swofford, 1993), was used to generate cladistic hypotheses. Multistate characters were specified as unordered (the Fitch

Table 2. Character by taxon data matrix.

	1	2	3	4	5	6	7	8	9	11	11	11	11	11	11	2	2
	0	1	2	3	4	5	6	7	8	9	0	1	2				
<i>Nepa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Telmatotrephes</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>C. bilobata</i>	0	1	1	1	2	0	0	1	0	1	2	0	1	2	0	0	1
<i>C. bonaerensis</i>	0	0	1	1	2	0	0	1	1	2	0	0	1	0	1	1	1
			1	1	2			2									
<i>C. pelleranoi</i>	0	1	1	1	0	0	0	0	0	2	0	1	2	0	0	1	1
<i>C. peruviana</i>	3	1	1	0	0	2	1	1	0	0	1	2	0	1	2	0	0
<i>C. hungerfordi</i>	1	0	0	1	1	0	2	0	0	1	1	0	0	1	1	0	0
			1	1				2									
<i>C. pronotata</i>	3	1	0	0	0	0	1	1	0	2	0	0	1	2	0	0	1
			1	1				2									
<i>C. scorpio</i>	2	0	0	0	0	0	1	0	1	0	1	0	0	0	1	1	1
	3						1										
<i>C. grandis</i>	3	0	1	1	1	2	1	1	0	2	1	0	2	2	0	0	1
	1																
<i>C. tibialis</i>	1	0	1	0	1	2	3	0	0	0	3	2	0	2	1	1	0
	2	1								1	2						
<i>C. carinata</i>	2	0	0	0	0	2	0	0	1	2	1	0	2	0	1	1	1
										2							
<i>C. decarloi</i>	2	0	0	2	0	0	0	1	1	2	0	2	0	0	1	1	1
<i>C. granulosa</i>	2	0	0	0	0	2	0	0	2	2	1	2	1	2	1	1	1
									1						2		
<i>C. borellii</i>	0	0	0	1	0	0	0	3	2	1	0	2	1	1	0	1	1
	1	1	1	2				2	2								
<i>C. volxemi</i>	0	0	1	1	1	3	0	0	0	3	2	0	2	1	1	0	1
	1																
<i>C. doesburgi</i>	0	0	1	1	1	3	0	0	0	3	2	0	2	1	1	0	1
	1																
										2							
<i>C. intermedia</i>	2	0	1	1	1	2	0	0	0	3	0	0	2	1	1	0	1

parsimony option), because alternatives, e.g., Camin-Sokal parsimony, Dollo parsimony, and Wagner parsimony, assume knowledge, not available for this group, about how character states actually evolve. Multiple character states within any taxon were treated as polymorphisms, which they were; the alternative option, treating multiple character states as uncertainties, would have discarded those polymorphic states that increase tree lengths. Character polarities were not specified a priori. Instead, parsimony was used to assess character polarity and tree length simultaneously (ibid, p. 2). Character weightings were not employed because there was no a priori reason for believing that any of the characters chosen are more significant than any others. ACCTRAN optimization and the MULPARS option were both used. Heuristic search algorithms were utilized because of the size of the data set. All of the heuristic algorithms available in PAUP were tried. The TBR (tree-bisection-reconnection) and SPR (subtree-pruning-regrafting) heuristic algorithms both yielded the shortest length tree.

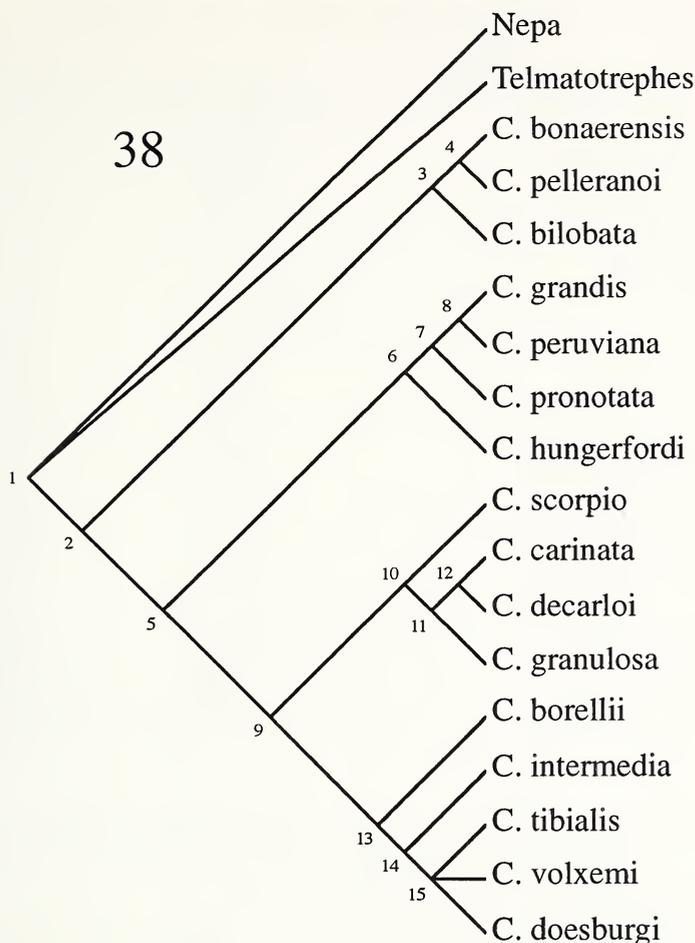


Fig. 38. Single most parsimonious cladogram for *Curicta* species.

Results

The analysis yielded a single most parsimonious cladogram (Fig. 38) of length 98 and Rescaled Consistency Index 0.481. The low RC indicates that there is considerable homoplasy in the data. Indeed, inspection of both the RC for each character (Table 3) and the list of the state changes for each tree node (Table 4) reveals that there are few unique synapomorphies, most of those being found near the base of the curictan tree.

Node 2, the ingroup node, receives strong support from seven unique synapomorphies: rounded pronotal ridges (3-1); shallow lateral pronotal sulci (4-1); digitate parasternal processes (12-1); profemoral teeth occurring distally (15-2); absence of an ejaculatory reservoir (20-1); tubular vesical rod (21-1); and convergence of sutures on the 6th abdominal venter (22-1). However, character 3 reverses in the *C.*

Table 3. Consistency index and rescaled consistency index for all characters used in cladistic analysis.

Character	CI	RC
1. Vertex carina	0.909	0.779
2. Pronotal median sulcus	0.889	0.667
3. Pronotal median ridges	0.750	0.600
4. Pronotal lateral sulci	0.250	0.143
5. Pronotal granulations	0.333	0.167
6. Hemelytral width	0.833	0.625
7. Last abdominal tergum	0.889	0.741
8. Prosternum	0.667	0.500
9. Pronotum ventrally	0.333	0.200
10. Mesosternal groove	0.500	0.167
11. Mesosternal carinae & bands	0.750	0.375
12. Parasternal process shape	0.750	0.625
13. Parasternal process length	0.500	0.312
14. Profemoral teeth number	1.000	1.000
15. Profemoral teeth position	0.667	0.333
16. Profemoral sulcus tubercles	0.600	0.450
17. Profemoral sulcus teeth	0.500	0.400
18. Profemoral sulcus shape	1.000	1.000
19. Gp2	0.333	0.167
20. Ejaculatory reservoir	1.000	1.000
21. Vesical rod	1.000	1.000
22. Abdominal sutures	1.000	1.000

scorpio clade and in *C. hungerfordi* and *C. borellii*. Similarly, character 4 also reverses in the *C. scorpio* clade with parallel reversals occurring in *C. pronotata* and *C. tibialis*. Thus, support for node 2 from these two characters is strong only in the context of the other five characters described.

Node 3, consisting of *C. bilobata* and node 4, is supported by one unambiguous synapomorphy, a single profemoral tooth (14-1), and a single homoplasious synapomorphy, the absence of pronotal granulations (5-2), which is also found in *C. decarloi*.

Node 4 includes *C. bonaerensis* and *C. pelleranoi* and is diagnosed by a single unique synapomorphy, a curvilinear profemoral sulcus (18-1).

Node 5 consists of nodes 6 and 9, i.e., all curictan species other than the *C. bilobata* clade. This node is supported by a single unambiguous synapomorphy, tubercles present throughout the length of the profemoral sulcus (16-1). Two other homoplasious synapomorphies help to diagnose the node: a slight carina on the vertex (1-1) and distinct parallel bands of hair on the last abdominal tergum (7-2). Both of these character states are also found in *C. bonaerensis*.

Node 6, composed of *C. hungerfordi* and node 7, is supported by four highly homoplasious synapomorphies: swollen prosternum (8-1), also found in *C. bonaerensis* and *C. scorpio*; pronotal lobes meeting midventrally (9-1), also found in *C. bilobata* and *C. scorpio*; mesosternal groove absent (10-1), also diagnosing node 12

Table 4. List of character changes (*denotes unique synapomorphy).

Node	Character (Change)
2	3(0→1)*; 4(0→1)*; 12(0→2)*; 15(0→2)*; 20(0→1)*; 21(0→1)*; 22(0→1)*
3	5(0→2); 14(0→1)*
4	18(0→1)*
5	1(0→1); 7(0→2); 16(0→1*)
6	8(0→1); 9(0→1); 10(0→1)*; 15(2→1)
7	1(1→3); 16(1→2)
8	10(1→0); 12(2→1)*; 13(0→2)
9	2(1→0); 19(0→1)
10	1(1→2); 3(1→0); 4(0→1); 11(0→1)
11	13(0→1); 16(1→2)
12	10(0→1)
13	6(0→1); 13(0→2); 17(0→1)
14	5(0→1); 12(2→3)*
15	7(2→3)*
<i>C. bilobata</i>	9(0→1); 11(0→1); 16(0→2)
<i>C. bonaerensis</i>	1(0→0,1); 2(1→0,1); 7(0→0,2); (0→1); 13(0→1)
<i>C. pelleranoi</i>	5(2→1); 19(0→1)
<i>C. grandis</i>	2(1→0,1); 5(0→1); 6(0→1); 11(0→2); 15(1→2); 19(0→1)
<i>C. pronotata</i>	4(0→1); 6(0→0,1); 7(2→0,1,2); 11(0→0,2)
<i>C. hungerfordi</i>	2(1→0,1); 3(1→0,1); 5(0→1); 7(2→0,2)
<i>C. scorpio</i>	1(2→2,3); 7(2→1); 8(0→0,1); 9(0→1); 12(2→0); 15(2→1)
<i>C. carinata</i>	10(0→1); 15(2→1,2)
<i>C. decarloi</i>	5(0→2); 7(2→0)
<i>C. granulosa</i>	6(0→0,1); 11(1→2); 15(2→1,2); 17(0→1)
<i>C. borellii</i>	1(1→0,1); 2(0→0,1); 3(1→0,1); 6(1→1,2); 7(2→0,2); 11(0→3); 13(2→1,2); 16(1→1,2)
<i>C. intermedia</i>	1(1→2); 13(2→0)
<i>C. doesburgi</i>	1(1→0,1,2); 2(0→0,1)
<i>C. volxemi</i>	1(1→0,1); 2(0→0,1)
<i>C. tibialis</i>	1(1→1,2); 2(0→0,1); 4(1→0); 6(1→2); 10(0→0,1); 11(0→0,2)

[see below] and *C. tibialis*; and profemoral teeth occurring proximally (15-1), also found in *C. scorpio*, *C. granulosa* and *C. carinata*.

Node 7 includes *C. pronotata* and node 8 and is diagnosed by two homoplastic synapomorphies: a band of hair on the vertex (1-3) also found in *C. scorpio*; and tubercles present in the distal one-half of the profemoral sulcus (16-2), present also in *C. bilobata*, *C. borellii*, and diagnosing node 11 [see below].

Node 8 is composed of *C. grandis* and *C. peruviana*. One unique synapomorphy, broad parasternal processes (12-2) and one reversal, mesosternal groove present (10-0) support this node.

Node 9, consisting of nodes 10 and 13, is supported by two homoplasious synapomorphies: pronotal median sulcus obsolescent posteriorly (2-0), also found in *C. bonaerensis*, *C. hungerfordi*, and *C. grandis*; and Gp2 dorsoventrally flattened (19-1), also found in *C. pelleranoi* and *C. grandis*.

Node 10 includes *C. scorpio* and node 11. Two homoplasious synapomorphies help to diagnose this node: pronounced carina on the vertex (1-2), also found in *C. intermedia*, *C. tibialis*, and *C. doesburgi*; and parallel carinae on the mesosternum (11-1), also found in *C. bilobata*. In addition, two reversals support this node: carinate pronotal median ridges (3-0), also present in *C. hungerfordi* and *C. borellii*.

Node 11, consisting of *C. granulosa* and node 12, is supported by two homoplasious synapomorphies: parasternal processes ending equal to posterior margin of operculum (13-1), also found in *C. bonaerensis* and *C. borellii*; and tubercles found only in the distal one-half of the profemoral sulcus (16-2), also found in *C. bilobata*, *C. borellii*, and diagnosing node 7 (see above).

Node 12 is composed of *C. carinata* and *C. decarloi* and is diagnosed by a single homoplasious synapomorphy, mesosternal groove absent (10-1), which also diagnoses node 6 (see above) and *C. tibialis*.

Node 13 includes *C. borellii* and node 14. Three homoplasious synapomorphies support this node: abdominal width greatest anteriorly (6-1), also present in *C. pronotata*, *C. grandis*, and *C. granulosa*; parasternal processes ending posterior to posterior margin of operculum (13-2) which also supports node 8 (see above); profemoral sulcus teeth present (17-1), also found in *C. granulosa*.

Node 14 consists of *C. intermedia* and node 15. One unique synapomorphy, thumb-like parasternal processes (12-3) and one homoplasious synapomorphy, light pronotal granulations (5-1), which is also found in *C. hungerfordi* and *C. grandis*, diagnose this node.

Node 15, a trichotomy of *C. tibialis*, *C. volxemi*, and *C. doesburgi*, is supported by a single unique synapomorphy, indistinct bands of hair on the last abdominal tergum (7-3).

In sum, there is strong, unequivocal support for the monophyly of *Curicta* as evidenced by the seven synapomorphies diagnosing node 2. However, for the 13 hypothesized groups within the genus, only six receive unambiguous support, i.e., *C. bilobata* clade (node 3); *C. bonaerensis* + *C. pelleranoi* (node 4); node 5 (all curictan species other than the *C. bilobata* clade); *C. peruviana* + *C. grandis* (node 8); *C. intermedia* clade (node 14); and *C. tibialis* + *C. volxemi* + *C. doesburgi* (node 15). The remaining groups are supported by homoplasious synapomorphies (parallelisms) and reversals. Thus, the hierarchic relationships of curictan species as hypothesized by this cladogram, particularly those grouped under node 5, must be considered highly provisional. Clearly, a better resolution of curictan species relationships will require further study with additional characters.

Discussion

Although curictan species geographically form disjunct South and North American groups neither of these geographical assemblages appear to be monophyletic. Indeed, the hypothesized cladistic relationships of the South and North American species are rather complex. The three species in the basal *C. bilobata* clade are all South American. Then, more distally, the North American species form clades with South American species. Two of the three North American species, *C. hungerfordi* and *C. pronotata*, form a clade with the South American *C. peruviana* and *C. grandis*. The third North American species, *C. scorpio*, forms a clade with the South American *C.*

granulosa, *C. carinata*, and *C. decarloi*. The *scorpio* clade in turn is the sister group to a clade composed of the five remaining South American species.

This cladistic hypothesis appears to present an unusual biogeographic pattern, i.e., the species of the basal *bilobata* clade are all found at the southern extreme of the genus' range and two of the four species in the next most basal group, the *hungerfordi* clade, are found at the northern geographical extreme. However, by combining what is known about the geological history of South, Central, and North America and the Caribbean with two aspects of the geographical distribution of extant *Curicta* species (there are no fossil curictans) one can construct a plausible historical scenario that is compatible with the cladistic hypothesis and biogeographic pattern.

We can begin by outlining, in brief, the major geologic events that are believed to have occurred at the intersection of South, Central, and North America (Hallam, 1994; Brown and Gibson, 1983). In the Jurassic, North and South America were joined together and Central America, as we know it today, i.e., the land between the Isthmus of Tehuantepec and Colombia, did not exist. In the early Cretaceous, North and South America separated just to the south of the Yucatan peninsula. Subsequently, volcanic islands appeared in the marine interval between southern Mexico and Colombia. These islands were pushed northeastward by the Farallon Plate, beginning in the mid-Cretaceous, to form Cuba, the Greater Antilles, and the islands off the coast of Venezuela. By the early Oligocene, another series of islands had been created between South and North America establishing a Central American Isthmus, albeit with marine gaps. The land corridor between South and North America was completed in the Pliocene with the emergence of the Isthmus of Panama and northwestern Colombia.

The aspects of curictan distributional data that may be relevant to this geologic history are two. First, curictan species are primarily either South American or North American with only two species with representation in Central America, i.e., *C. carinata*, a South American species that is also found in southeastern Panama, and *C. scorpio*, a North American species that is also found in the northern part of Central America. Second, there are no curictan species found in the Caribbean islands (with the exception of one specimen of *C. carinata* found on Trinidad).

The geologic history, distributional data, and cladistic hypothesis for *Curicta* can be synthesized in the following scenario. First, we must assume that curictan species were found, prior to the separation of South and North America, from Mexico to northern Argentina. The species in North America were phylogenetically related to those in South America through at least two lineages, of which the *hungerfordi* and *scorpio* clades are extant representatives. With the divergence of South and North America, the two faunas were separated from one another. The absence of curictan species on the present day Caribbean islands suggests that there was no colonization from either South or North America of the islands that were pushed out into the Caribbean by the Farallon Plate. The presence of just two species in present day Central America can be explained as colonization events, from the north by *C. scorpio* and from the south by *C. carinata*, subsequent to the completion of the Central American Isthmus in the Pliocene (although it is also possible that *C. scorpio*'s dispersal southward could have occurred earlier as the Central American islands were linked in the post-Oligocene; *C. carinata*'s dispersal northward however, would have had to wait for the emergence of the Isthmus of Panama and northwest Colom-

bia, the last geologic event completing the land bridge between South and North America).

This ad hoc scenario, based on a cladistic hypothesis and distributional data for only one genus of 16 species, will need to be tested against cladograms and biogeographic data for other groups of organisms, including those that can be dated from fossil remains.

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- AMNH American Museum of Natural History—Randall T. Schuh
 ANSP Academy of Natural Sciences of Philadelphia—Donald Azuma
 ASU Arizona State University—Michael E. Douglas
 CAS California Academy of Sciences, San Francisco—Paul H. Arnaud, Jr.
 CNCIB Canadian National Collection of Insects, Biosystematics Research Institute, Research Branch, Agriculture Canada—L. Masner
 CNCIE Canadian National Collection of Insects, Entomology Research Institute, Research Branch, Agriculture Canada—K. G. A. Hamilton
 FSCA Florida State Collection of Arthropods—Frank W. Mead
 HNHM Hungarian Natural History Museum—Tamás Vásárhelyi
 INPA Instituto Nacional de Pesquisas da Amazonas—José Albertino Rafael
 ISNB Institut Royal des Sciences Naturelles de Belgique—L. Baert
 JTPC John T. Polhemus Collection, Englewood, Colorado
 LACM Los Angeles County Museum of Natural History—Charles Hogue
 LSU Louisiana State University, Department of Entomology—David A. Rider
 MACN Museo Argentino de Ciencias Naturales "Bernadino Rivadavia"—Axel Bachmann
 MLP Museo de la Plata, Universidad Nacional de La Plata—R. A. Ronderos
 MNHN Museum National D'Histoire Naturelle—D. Pluot-Sigwalt
 MNRJ Museu Nacional, Rio de Janeiro—Miguel A. Monné
 MZSP Museu de Zoologia da Universidade de São Paulo—F. C. do Val
 NHMB Entomology Department, Natural History Museum, Basel—M. Brancucci
 NHRS Naturhistoriska Riksmusset, Stockholm—Per Lindskog
 NNC Nico Nieser Collection
 NMNH National Museum of Natural History, Washington, D.C.—R. C. Froeschner
 RMNH Rijksmuseum Van Natuurlijke Historie—Jan van Tol
 SIUC Southern Illinois University, Entomological Collection—J. E. McPherson
 SEMC Snow Entomological Museum, University of Kansas, Lawrence, Kansas—Robert W. Brooks
 TXAM Texas A&M University, Department of Entomology—Joseph C. Schaffner
 UA University of Arizona, Department of Entomology—Floyd G. Werner
 UCD Bohart Museum of Entomology, University of California, Davis—Robert Schuster
 USU Utah State University, Department of Biology—Wilford J. Hanson

ZMH Zoological Museum University of Helsinki—Antti Jansson

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**A NEW NEOTROPICAL FUNGUS GNAT
(DIPTERA: SCIAROIDEA: KEROPLATIDAE) WITH
MYRMECOPHAGOUS LARVAE**

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Abstract.—The imago of *Proceroplatus belluus* n. sp. from Panama, a Keroplatidae with myrmecophagous larvae, is described. Other than its biology, the species is remarkable by its pectinate antennae, up to now unknown in *Proceroplatus*. Its taxonomic position is discussed; the species belongs to an inferred monophyletic group comprising two other species from Paraguay and Bolivia.

The larvae of Keroplatidae have very contrasting trophic specializations, being either ferocious predators, killing their prey by way of toxic diffuse nets (*Arachnocampa*, *Macrocera* and most *Orfeliini*), or fungicolous insects, spinning sheet-like webs to gather the spores of polyporous fungi (most Keroplatini) (see Matile, 1997, for a phylogenetic classification of the family). A phylogenetic study has shown that predation is most probably the ancestral diet of the Keroplatidae (Matile, 1997), and in the last few years, three species of Keroplatidae with ant-eating larvae have been discovered. Two of them are Oriental and belong to the genera *Truplaya* Edwards and *Platyzeridion* Tollet (Kovac and Matile, in press, Chandler and Matile, in prep.); the larva of the first spins its web in bamboo internodes, that of the second in the internodes of an ant-plant (Krombein, pers. comm.). The third one is Neotropical (Panamá) and belongs to *Proceroplatus* Edwards. The purpose of this paper is to provide a name and description for this Neotropical species, the biology of which is discussed elsewhere in this journal (Aiello and Jolivet, 1996). The larva of this very interesting species will be described in another paper.

Proceroplatus is a mainly pantropical genus of Orfeliini comprising 33 described species, with a few northern representatives such as *Proceroplatus elegans* (Coquillett), which covers North America from Florida to Quebec (Laffoon, 1965). A fossil species, *P. hennigi* Schmallfuss is also known from the Oligocene-Miocene Dominican amber (Schmallfuss, 1979). The species described here differs from all the previously described species of the genus by its pectinate antennae. Nothing was known until now of the biology of any *Proceroplatus*; the larvae of *Proceroplatus belluus* have been discovered in one of the two pouches of ant-plants of the genus *Besleria* (Gesneriaceae), where they prey on the ants living in the other pouch (Jolivet, 1996; Aiello and Jolivet, 1996; Windsor and Jolivet, in press)—it is not yet known whether other species of *Proceroplatus* worldwide are associated with ants.

MATERIAL AND METHODS

In the course of the present study, I have studied 13 of the 16 described Neotropical species of the genus [not seen: *P. borgmerieri* (Shaw), *variventris* (Edwards)]

and *vitattus* (Fisher)], and about twice this number of undescribed ones; they stand in the collections of the Muséum national d'Histoire naturelle, Paris, or in Lane's material kept in the Museo de Zoologia, São Paulo, and kindly loaned by Dr. N. Papavero. I also have examined about 20 described or undescribed species from various other biogeographical regions.

The morphological terminology follows Matile (1990). The drawings have been done under the camera lucida, for the genitalia after treatment with potassium hydroxyde (KOH). By convention, the macrochaetae of the genitalia are represented on the left side of the drawing only. Measurements were taken by means of ocular and objective micrometers. The holotype, in perfect condition, is glued at the tip of a triangular piece of cardboard; the pregenital segments and genitalia are stored in a microvial with glycerine.

DESCRIPTION

Proceroplatus belluus, new species

(Fig 1, 2)

Description (male only).—A *Proceroplatus* with pectinate antennae and wings strongly darkened at apex but without clear round spots (fig. 1). Length of wing: 4.4 mm.

Head: occiput brown black. Three ocelli near middle of frons, the outer large, the median punctiform. Ocellar calli black. Frons dark brown. Antennae: scape and pedicel discoid, the scape black brown, the pedicel yellow. Flagellum: segments 1–13 with long and simple pectinations bearing dense fine setae. First flagellomere yellow, the following brownish yellow, the pectinations brown, narrowly yellowed at basis. Face brownish yellow, palpi brown black, the last palpomere yellow.

Thorax: prothorax, scutum, scutellum and mediotergite yellow. Pleurae and laterotergite yellow, mesanepisternite brownish, with a group of small dorsal setae, mesokatepisternite light brown. Laterotergite with long erect posterodorsal setae.

Coxae and legs yellow, the tarsi darkened. Spurs black, the I and outer II–III minute, the inner II–III very long. Protarsus I longer than tibia (5.5:4).

Wings yellow with brown spots. A costal median spot, reaching to C and M4; R4 narrowly seamed with brown, a wide apical spot, apex of M2 and M4 narrowly brownish, Culb widely seamed with brown at apex, and a weaker spot in the anal field. Costa reaching middle of section R5–M1. Subcosta short, ending in costa a little after level of rs. R4 strongly oblique, as long as costal section R1–R4. Radiomedian fusion much shorter than stem of anterior fork (0.8: 3.2). Anal long and fine, reaching wing margin. Halteres orange yellow.

Abdomen: Pattern obscured by the ciliation. Tergite I yellow, II yellow, apex slightly brownish; III brown, indistinctly yellow a little before apex; IV yellow dorsally, with a narrow postbasal brown band; V yellow, VI–VII brown, dark yellow at basis. Sternites with the same pattern as tergites.

Hypopygium (Fig. 2) yellow on basal half, brown on distal half. Ninth tergite shorter than synsclerite, wider than long, concave at basis, slightly convex at apex. Cerci wide, subtriangular with rounded corners. Synsclerite simple, with a wide triangular ventral notch. Gonostyles deeply divided into two strongly sclerotized arms, the anterior regularly pointed, the posterior one wider at basis.

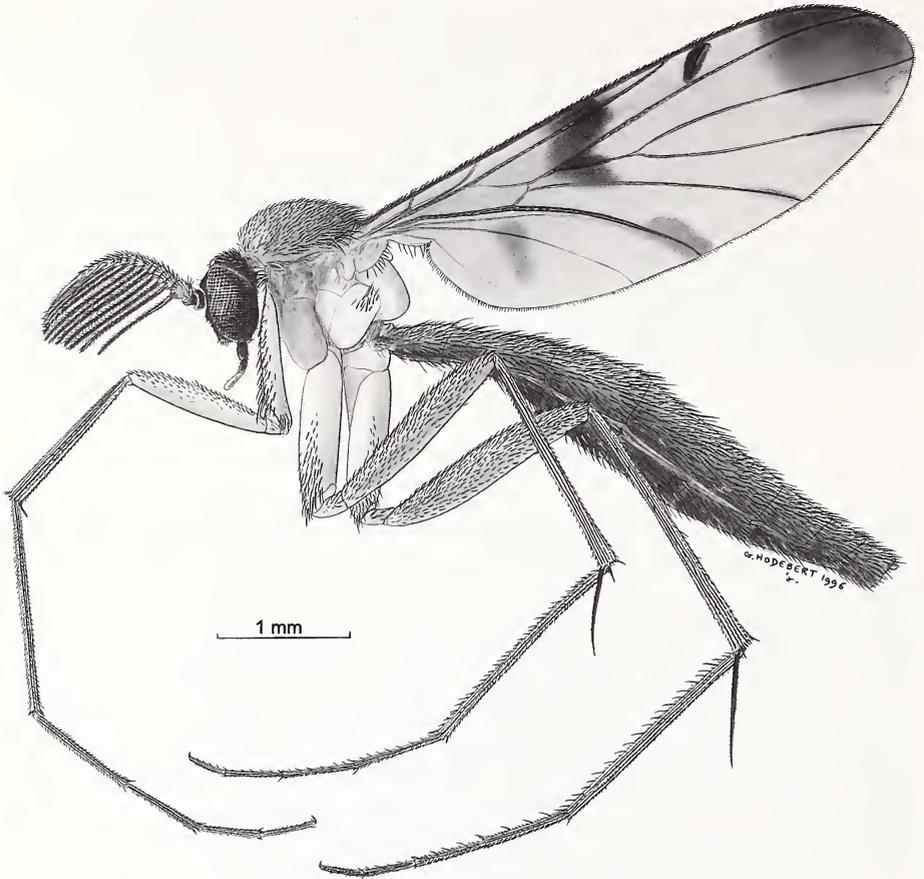


Fig. 1. *Proceroplatus belluus* n. sp., male holotype, habitus.

Holotype: male, "Panama, Cocle Prov. above El Copé, ex larva, 8 Nov. 1992 (Jolivet, Windsor, Aiello)/Ant-eating larva on silk inside inflated lvs of *Besleria formicaria*. Adult fly 3 Jan 1984 Aiello Lot 92-87 #3." Muséum national d'Histoire naturelle, Paris.

Etymology: From the Latin *belluus*, monster, as the larva of this species was first nicknamed by its discoverers.

DISCUSSION

In his very short generic description, Edwards (1925) mentioned the antennae of *Proceroplatus* as "much flattened, the flagellar segments deeper than long, and generally articulated above the middle." This is the condition of the males of all known species except the present one (the state of the character is attenuated in females). Pectination has appeared several times in different clades of the Keroplatinae and the Sciaroidea (see Matile, 1990:395, for a discussion of this character and its re-

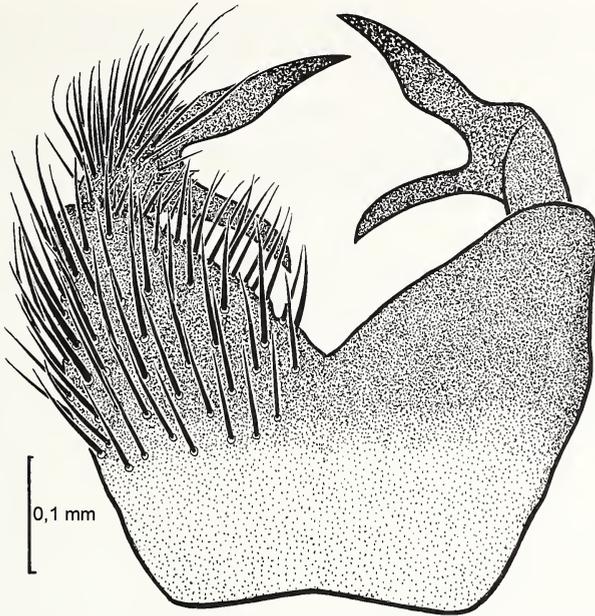


Fig. 2. *Proceroplatus belluus* n. sp., male holotype, synclerite and gonostyles, ventral view.

partition), and no other imaginal character has been found to support a generic distinction between the species described here and the rest of *Proceroplatus*. A similar situation exists in the mycetophilid genus *Metanepsia*, from the Old World tropics, where the male flagellum is very similar to *Proceroplatus*, except for an Afrotropical species that has pectinate antennae (Matile, 1980).

The two-armed structure of the male gonostyles of *P. belluus* is of the common *Proceroplatus* type, found worldwide in many species. This structure probably corresponds to the groundplan of the genus, and is therefore of little use in assessing the phylogenetic relationships of the new species.

However, the description of *P. variventris* Edwards, a Bolivian species known only from the female holotype (Edwards, 1931), agrees rather closely with that of *P. belluus*, notable differences being the antennal scape and the whole palpi, "ochreous" instead of black in the Bolivian species, and the pleural sclerites entirely yellow. The coloration of the abdomen is also different, being more strikingly banded.

Most *Proceroplatus* have pictured wings with roundish apical and marginal clear spots, usually between C and R5 and between each of the posterior veins. *Proceroplatus belluus* and *P. variventris* differ from these species by having the wing mainly clear and deprived of these round spots, while the apex of the wing is more markedly brown. A female from Paraguay shows a similar wing pattern, the main difference from the other two species being the presence of a complete transverse dark band through the posterior fork, instead of a single spot above Culb. In most *Proceroplatus* worldwide as well as in the Cenozoic species, the wings are orne-

mented with round clear spots which are sometimes more or less completely fused, and I have little doubt that this is the plesiomorphic state of the genus (an autapomorphy with regards to the other genera of Orfeliini). On the basis of this deviation from the groundplan, it thus can be inferred that *P. variventris*, *P. belluus* and the Paraguayan undescribed species together form a monophyletic group. It is of course impossible to know whether the males of the two South American species have also pectinate antennae, and if the biology of these species is the same.

ACKNOWLEDGMENTS

I am very grateful to Drs Annette Aiello (Smithsonian Tropical Research Institute, Panamá) and Pierre Jolivet, who gave me the opportunity to describe this interesting species and generously deposited the holotype in the Muséum national d'Histoire naturelle, Paris, and to Dr Nelson Papavero (Museu de Zoologia, Sao Paulo) for the loan of the Orfeliini of Lane's collection. Thanks are heartily given to Gilbert Hodebert (Laboratoire d'Entomologie, Muséum national d'Histoire naturelle, Paris) for the fine illustration of the habitus of the new species.

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TWO NEW SPECIES OF *MEGASTYLUS* FROM THE NEW WORLD (HYMENOPTERA: ICHNEUMONIDAE; ORTHOCENTRINAE)

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Abstract.—Two new species of the orthocentrine genus *Megastylus*, *Megastylus fallax* and *Megastylus panamensis*, are described. *Megastylus panamensis* constitutes the first record of this genus from the Neotropical Region. The systematics of New World *Megastylus* are briefly discussed. Orthocentrinae are shown to be koinobiont endoparasitoids.

The orthocentrine genus *Megastylus* is distributed worldwide with about 30 described species. As with many ichneumonid genera, this represents only a fraction of the total number of species. In the New World, no species have been described south of the United States. Dr. Annette Aiello and her colleagues in Panama recently reared a *Megastylus* from a dipterous (Keroplastidae) ant-predator. It is a new species and is described here as *Megastylus panamensis* to complement the biological studies of the host. An unforeseen byproduct of this study is the discovery of a new species of Nearctic *Megastylus* from Arizona that was confused with *petilus* Dasch; it is described here as *Megastylus fallax*.

Specimens examined in this study are in the American Entomological Institute (Gainesville, Florida: AEIC). Morphological terminology mostly follows Townes (1969) as modified by Wahl (1989), with the exception that the "apical transverse carina" is referred to as the *posterior transverse carina*. *MSI* stands for the first metasomal segment. *T1*, *T2*, *S1*, *S2*, etc., are used for the various metasomal tergites and sternites. When the lengths of the body and wing are given, the values in parentheses are those of the holotype.

NEW WORLD MEGASTYLUS

The genus *Megastylus* is monophyletic, defined by the autapomorphies of: 1) an inflated scape that has the posterior margin membranous and infolded, and 2) long notauli that extend to the mesoscutal center (Wahl and Gauld, unpublished ms.). Ichneumonologists have previously been aware of its presence in the Neotropical Region, although no species have been described from there. The late Henry Townes sorted out 38 Neotropical species in the American Entomological Institute collection; they are distributed from Mexico to Chile. Ian Gauld (pers. comm.) has found 24 undescribed species in Costa Rica alone.

Dasch (1992) recognized 14 Nearctic species, dividing them into the *Megastylus* Group (10 species) and the *Dicolus* Group (4 species). These are defined as having the "anterior transverse groove of propodeum" close to the metanotum in the *Megastylus* Group or separated by about 0.3× the propodeal length (as measured from the metapostnotal posterior margin to the propodeal apex) in the *Dicolus* Group. Dasch's "anterior transverse groove" is the metapostnotum (Wahl, 1985) and the

Dicolus Group's condition represents an apparent lengthening of the metapostnotum; this is apomorphic within the subfamily. The *Megastylus* Group is therefore non-monophyletic and should not be recognized. The name of the *Dicolus* Group is based upon *Dicolus* Förster, a junior synonym of *Megastylus*. Since I believe that the informal use of generic names should be reserved for genus-groups, the *Dicolus* Group is henceforth referred to as the *insectator* species-group, (*insectator* Förster is the type-species of *Dicolus*). The American Entomological Institute has five undescribed species from Argentina, Brazil, and Peru that belong to this species-group.

Using Dasch's (1992) keys to Nearctic *Megastylus* species, *fallax*, *panamensis*, and *petilus* run to the "*Megastylus*" group. In couplet 1 of the key to the species of this group, *petilus* is taken off by several characters, foremost of which is the elongate (7.7–9.0× as long as wide) first flagellomere. This character, however, may well be homoplastic. Townes' sorting of the American Entomological Institute's Neotropical *Megastylus* segregated a group of 12 species that lack the occipital carina, most of which also have the first flagellomere elongate; *fallax* and *panamensis* belong to this group. Not only do these two species differ from *petilus* by the lack of an occipital carina, they differ in other characters as well (dimensions of the hind femur, number of bullae in vein 2m-cu, presence/absence of the posterior transverse carina). I suspect that the three species are not closely related, and the characters of the elongate first flagellomere and absent occipital carina are homoplastic.

While it is generally established that orthocentrines are parasitoids of nematocercous Diptera (Mycetophilidae and Sciaridae; Wahl, 1990), the inference that they are koinobiont endoparasitoids has been based upon larval morphology and the biology of related taxa (Wahl, 1990). The rearing of *M. panamensis* provides direct confirmation.

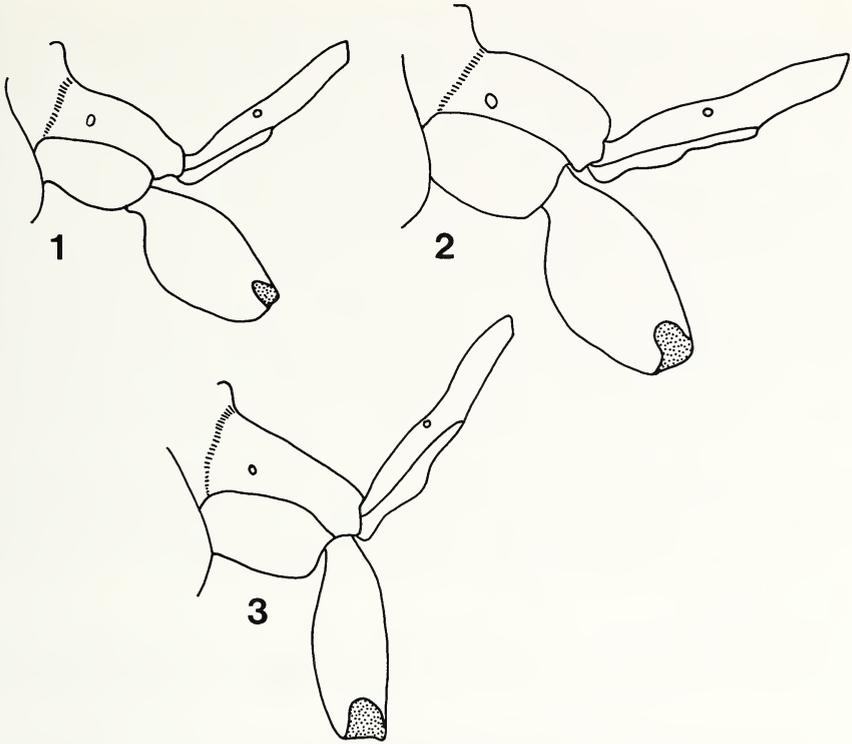
Megastylus fallax, new species

(Fig. 1)

Diagnosis. This species can be recognized by the strongly convex clypeus which drops sharply away from the midline, weakly granulate to smooth mesopleuron, one bulla of vein 2m-cu of the fore wing, complete vein 2-cu of the hind wing, absence of the posterior transverse carina, and flattened S1.

Female. Unknown.

Male. Structure. 1. Flagellomere 1 10.0–10.6× as long as wide; flagellomere 15 with numerous erect and semi-recumbent setae, erect setae about 0.5× as long as flagellomere; 28–36 flagellomeres present. 2. Clypeus strongly convex, dropping sharply away from midline; clypeal apex weakly concave medially. 3. Occipital carina absent. 4. Mesopleuron weakly granulate to smooth, strongly shining. 5. Metapostnotum about 0.1× as long as propodeum. 6. Posterior transverse carina of propodeum absent; lateral outlines of metapleuron and pronotum as in fig. 1. 7. Ventral surface of fore coxa with basal transverse carina present. 8. Hind femur 6.2–6.7× as long as wide. 9. Vein 2m-cu of fore wing with one bulla. 10. Vein 2-cu of hind wing complete. 11. Lateral outline of MS1 as in fig. 1; glymma of T1 absent; S1 flat in lateral profile and with its apex opposite spiracle of T1; T1–2 strongly granulate and without rugulae. **Color.** As in *M. petilus*. **Length.** 3.3–3.8 mm (3.8 mm); fore wing 2.9–3.5 mm (3.5 mm).



Figs. 1–3. Lateral aspect of propodeum and MS1. 1, *Megastylus fallax* Wahl; 2, *Megastylus panamensis* Wahl; 3, *Megastylus petilus* Dasch.

Specimens examined. Holotype ♀, UNITED STATES, Arizona, Cochise Co., 10.viii.1974, H. & M. Townes [AEIC]. Condition of holotype: intact. Paratypes: 1 ♂, same collection data as holotype except collected 22.viii.1974; 1 ♂, UNITED STATES, Arizona, Gila Co., nr. Roosevelt Lake, 24.v.1947, H. & M. Townes [AEIC].

Comment. The holotype and paratypes were described as paratypes of *petilus* Dasch (Dasch, 1992).

Etymology. From the Latin, *fallax*, deceitful or false, in reference to its previously cryptic identity.

***Megastylus panamensis*, new species**

(Fig. 2)

Diagnosis. This species can be recognized by the moderately and uniformly convex clypeus, weakly granulate mesopleuron, extensive brownish-red coloration of the mesosoma, two bullae of vein 2m-cu of the fore wing, complete vein 2-cu of the hind wing, presence of the posterior transverse carina, and convex S1.

Female. Structure. 1. Flagellomere 1 about 8.0× as long as wide; flagellomere 15 with numerous erect and semi-recumbent setae, erect setae about 0.4× as long as

flagellomere; 35 flagellomeres present. 2. Clypeus moderately convex, evenly rounded; clypeal apex truncate medially. 4. Occipital carina absent. 5. Mesopleuron weakly granulate, shining. 5. Metapostnotum about $0.1\times$ as long as propodeum. 6. Posterior transverse carina of propodeum present; lateral outlines of metapleuron and pronotum as in fig. 2. 7. Ventral surface of fore coxa with weak basal transverse carina present. 8. Hind femur about $5.8\times$ as long as wide. 9. Vein 2m-cu of fore wing with two bullae. 10. Vein 2-cu of hind wing complete. 11. Lateral outline of MS1 as in fig. 2; glymma of T1 absent; S1 convex in lateral profile and with its apex apicad spiracle of T1; T1-2 strongly granulate and without rugulae. *Color.* Head with mandible, clypeus, paraocular area (extending to 0.5 distance between antennal socket and apex of eye), margin of antennal socket, whitish; remainder of supraclypeal area, scape, pedicel, deep brownish-red; head otherwise fuscous. Mesosoma (excepting legs) brownish-red except for white of ventral pronotal margin, and fuscous of metapleuron, propodeum, and metathoracic venter. Fore and middle legs with coxa, trochanter, and trochantellus, white; femur, tibia, and tarsus light brownish-red except for slightly darker tint of middle tarsus. Hind leg with basal 0.5-0.8 of coxa (margin of brownish-yellow area irregular), trochanter, anterior surface of trochantellus, basal 0.1 and median 0.4 of tibia, and tibial spurs, brownish-yellow; remainder of leg dark brown with diffuse longitudinal light streaking on femur. Metasoma fuscous except for brown median 0.3 of T3. *Length.* 5.0 mm; fore wing 3.7 mm.

Male. Unknown.

Type material. Holotype ♀, PANAMA, *Cocle*, above El Copé, 8.xi.1992, "Aiello lot 92-87, #4", P. Jolivet—D. Windsor—A. Aiello [AEIC]. Condition of holotype: intact.

Comments. *M. panamensis* was reared from *Proceroplatus belluus* Matile, a kero-platid predaceous upon ants (Matile, 1997; Aiello and Jolivet, 1997). The adult wasp emerged 31 Dec. 1992.

The larva of *panamensis* was torn during preparation and the relationship of the hypostomal—pleurostomal process to the labial sclerite, as well the presence or absence of the mandible, is unclear. It is very similar to the larva of *Megastylus* sp. 1 figured in Wahl (1986); the labial sclerite appears identical.

Etymology. The specific name is derived from Panama, where the specimen was collected.

Megastylus petilus Dasch

(Fig. 3)

Megastylus petilus Dasch, 1992:134. Type: ♀ [AEIC].

Diagnosis. This species can be recognized by the moderately and uniformly convex clypeus, strongly granulate mesopleuron, one bulla of vein 2m-cu of the fore wing, basally incomplete vein 2-cu of the hind wing, absence of the posterior transverse carina, and convex S1.

Female. Structure. 1. Flagellomere 1 $9.3-10.8\times$ as long as wide; flagellomere 15 with numerous erect and semi-recumbent setae, erect setae about as long as flagellomere; 42-48 flagellomeres present. 2. Clypeus moderately convex, evenly rounded; clypeal apex truncate medially. 3. Occipital carina absent. 4. Mesopleuron strongly granulate. 5. Metapostnotum about $0.1\times$ as long as propodeum. 6. Posterior trans-

verse carina of propodeum absent; lateral outlines of metapleuron and pronotum as in fig. 3. 7. Ventral surface of fore coxa with basal transverse carina present. 8. Hind femur 8.0–8.3× as long as wide. 9. Vein 2m-cu of fore wing with one bulla. 10. Vein 2-cu of hind wing basally incomplete. 11. Lateral outline of MS1 as in fig. 3; glymma of T1 absent; S1 convex in lateral profile and with its apex apicad spiracle of T1; T1–2 strongly granulate and without rugulae. *Color.* Overall color dark brown, the following brownish-yellow: malar space; clypeus; supraclypeal area; propleuron; pronotum except for ventral margin; ventral 0.5–0.6 of mesopleuron; basal 0.5–0.8 of hind coxa (margin of brownish-yellow area irregular); femora; fore and middle tibia and tarsi. The following white: mandible; ventral margin of pronotum; fore and middle coxae, trochanters, and trochantelli; dorsal surface of hind trochanter and trochantellus. The following brownish-yellow: hind femur and tibia except for dark brown stripe on basal 0.3 of posterior surface; T2 except for posterolateral corners; basal 0.3 of T3. *Length.* 4.3–4.9 mm (4.9 mm); fore wing 3.6–3.8 mm (3.8 mm).

Male. *Structure.* As in female. *Color.* As in female. *Length.* 4.4–5.6 mm; fore wing 3.5–4.3 mm.

Specimens examined. Holotype ♀, UNITED STATES, *Arizona*, Cochise Co., Portal, 22.viii.1974, H. & M. Townes [AEIC]. Condition of holotype: intact. Paratypes: two ♀, ♀ and one ♂, same collection data except collected 25.viii.1974, 5.ix.1974, and 24.viii.1987.

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NOTES AND COMMENTS

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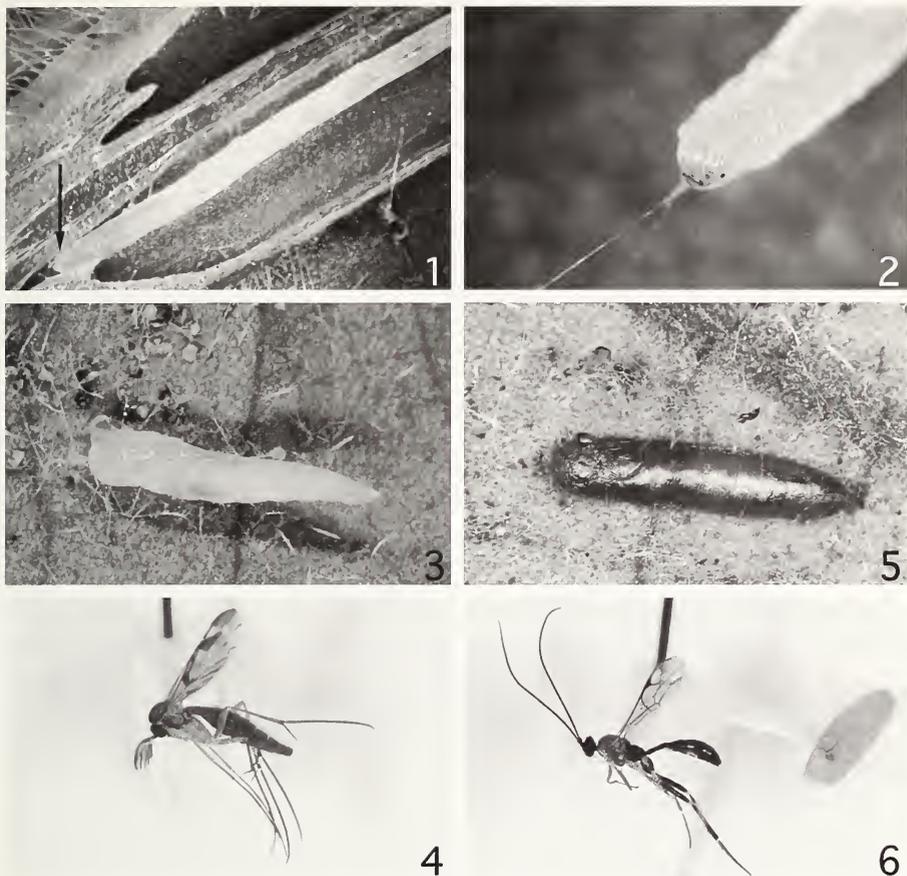
MYRMECOPHILY IN KEROPLATIDAE (DIPTERA: SCIAROIDEA)

The Keroplatidae, a family of the Sciaroidea (fungus gnats), are a cosmopolitan group, and, although they are encountered frequently, very little has been published on their biology. Matile (1990) revised the Arachnocampinae, Macrocerinae and Keroplatini, and included information, where known, on immature stages.

Keroplatid larvae spin silk webs and are either predaceous or fungal spore feeders. The most complete account of the natural history of any predaceous member of this family can be obtained from the numerous papers on the New Zealand Glow worm, *Arachnocampa luminosa* (Skuse), a fungus gnat with luminous larvae (see Pugsley, 1983, 1984, for a review of the literature and ecology of the species, and Matile, 1990, for morphology and a summary of biology). The biology of the Palearctic spore-feeder *Keroplatus tipuloides* Bosc is fairly well known (Santini, 1982). As regards the Neotropical region, very few larvae of keroplatids have been discovered, but there are good accounts of the behavior of the predaceous larvae of *Neoditomyia* Lane & Stürm (Stürm, 1973; also Jackson, 1974, under the generic name *Orfelia*, and Decou, 1983, for a cave-dwelling species). Duret (1974) and Matile (1982) reported the discovery of presumably spore-feeding larvae belonging respectively to *Platyroptilon* Westwood, in Argentina, and *Placoceratias* Enderlein, in Guadeloupe, on rotten wood invaded by polyporaceous fungi, but no description of the morphology or ethology of these larvae has been given.

We here present information on the larva and pupa of a carnivorous keroplatid, *Proceroplatus belluus* Matile, from El Copé (elevation 750 m), Republic of Panama. It is a predator of ants, as are recently discovered Oriental species of keroplatids belonging to the same tribe, but to different genera (Kovacs and Matile, in press; Matile and Chandler, in press.; Krombein et. al., in press).

On 9 November 1992, during a study of the ant-plant *Besleria formicaria* Nowicke (Gesneriaceae), the inflated vesicles near the base of the leaf blade of that plant were sliced open longitudinally to permit examination of the ants (*Pheidole* sp.), ant brood, and ant refuse deposits inside (Windsor and Jolivet, 1996). Seven of these vesicles were occupied by peculiar elongate larvae (one per vesicle) that were 1.5-2 cm long and about 1 mm in diameter (Figs. 1, 2). The larvae were clear, except for a brownish head, and were rounded at the head end and narrowed towards the posterior end. The head bore brown mandibles, a lateral reddish spot in the position where stemmata might be expected, and above and in front of each reddish spot, a large, clear circle representing the antennae. The head was followed by three telescoped thoracic segments and an elongate, seemingly segmentless body. Each larva rested on a strand of silk that ran the length of the vesicle and was held in position, at intervals, by perpendicular silk threads that connected it to the vesicle walls. Elongate, white, septate blobs of sticky mucus were present on some of the short silk threads. The



Figs. 1–6. Figures 1–4. The fly, *Proceroplatus belluus*. 1. Fly larva (the black arrow points to the head end) in its natural position within the plant vesicle (sliced open longitudinally); 2. Head end of the fly larva, resting on its mucus-covered silk strand; 3. Fly pupa, suspended among silk lines; 4. Adult fly. Figures 5 and 6. The wasp, *Megastylus panamensis*. 5. Wasp cocoon, with pupa within; 6. Adult wasp and empty cocoon.

larvae, which appeared to have neither prolegs nor true legs, glided along the silk threads on a bed of clear slime. They reversed direction by turning the head and doubling back on themselves, on the same silk thread.

Not knowing what the larvae were feeding upon, we placed the occupied vesicles into individual petri dishes inside of ZipLoc bags, numbered them, and attempted to keep the larvae moist but well ventilated, while waiting for them to present some useful clues. On 12 November, all seven larvae still were alive, but five of them had abandoned their vesicles and gone between the leaf and the petri dish or were found gliding about the dish. We returned each to its vesicle.

On 14 November, larva no. 6 was consumed by a fungus that sent out white fluff all along its body. We placed the larva in water, brought it to a boil, then preserved

it in 80% ethanol. One by one, more larvae succumbed to the same fate, until by 17 December only two were left.

On 23 November, when there were still three larvae left (nos. 3-5), it occurred to us that the larvae might be feeding on dead ants or other dead animal matter, so we added several freshly crushed *Pheidole* ants taken from a potted *B. formicaria*. The next day, we found that the ants had been dismembered and the larvae had dark, irregular fragments in their guts.

On 1 December, because the original vesicles were decomposing, we placed each larva on top of a fresh piece of *B. formicaria* leaf. The leaf pieces had a variety of creatures living in the water film among the trichomes on them: mites, Collembola, small worms (nematodes?), and tiny clear Crustacea. We added several freshly crushed *Pheidole* and some ant garbage from the vesicles of a fallen *B. formicaria* leaf. By the next day, all three larvae had set up fresh silk-mucus threads, their guts were full of dark brown particles, and the ants had been dismembered and compacted into mucus-covered masses.

On 9 December, we added a live mosquito to each of two dishes. The next day, the two larvae in those dishes had full guts, and the third one did not. The mosquitoes had been caught on the silk and were partially dismembered and coated with mucus. It appears that the larvae are able to capture live prey, not just scavenge.

By 15 December, the fly larvae were becoming opaque. On 17 December, larva no. 5 died. On 24 December larva no. 4 was consumed by the endoparasitic larva of a parasitoid wasp. We must assume that the fly larva already was parasitized when collected, as there was virtually no possibility of access by a wasp when in culture. Upon termination of feeding, the wasp larva made a pale beige, fine silk cocoon (Fig. 5), 7 mm long and 2 mm in diameter, and rounded at the ends. The cocoon was transparent enough that a white, annulated larva could be seen inside. Incorporated into the head end of the cocoon were the remains of the fly larva. It was not possible to discern exactly when pupation took place, but on 29 December the wasp pupa began to take on color; the petiole and the sides of the abdominal segments were black, and the thorax was brown. By the next day, the adult had emerged but remained inside the cocoon. A pool of amber liquid and a compressed white shed skin filled the posterior end of the cocoon. On 31 December, an adult ichneumonid wasp emerged (Fig. 6). It had an orangish thorax and clear wings with black markings; the rest of the body was black. Dr. David Wahl identified the ichneumonid as a previously undescribed species of *Megastylus* (subfamily Orthocentrinae); it is described as *Megastylus panamensis* Wahl (Wahl, 1997). Orthocentrines are presumed to be koinobiont endoparasitoids of nematoceros Diptera (Wahl, 1990, 1997), and this rearing represents the first direct confirmation.

Meanwhile, on 26 December, fly larva no. 3 shortened and the thorax became wider than the head. On 28 December, it pupated among the silk strands; no cocoon was made (Fig. 3). The pupa began to darken on 1 January 1993. The thorax was beige, the legs were dark gray because of the darkening setae on them, the eyes were black, and setae were beginning to show on the dorsum of abdominal segments 1-4. By 2 January, the fly appeared to be fully formed inside the pupal skin. The antennae were very broad and pectinate, the wings were dusky, the legs were black with setae, and the abdomen was clothed in black setae. The adult fly (Fig. 4) eclosed on 3 January. Dr. Loïc Matile identified the fly as belonging to the sciaroid family

Keroplastidae, Keroplastinae, tribe Orfelliini and representing an undescribed species of *Proceroplatus* with pectinate antennae. He named it *P. belluus*, in reference to the pet name, "monster," that we applied to the larva. All known larvae of Orfelliini are predaceous (Matile, pers. comm.).

The fly specimen is in the collection of the Paris Museum, and the wasp is at the American Entomological Institute (Gainesville, Florida). Both are labelled as Aiello Lot 92-87.—Annette Aiello and Pierre Jolivet, Smithsonian Tropical Research Institute, Box 2072 Balboa, Ancon, Republic of Panama; and 67 Boulevard Soult, 75012 Paris, France.

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BOOK REVIEWS

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Studies on Hemipteran Phylogeny.—C. W. Schaefer (ed.). 1996. Proceedings, Thomas Say Publications in Entomology. 244 pp. Entomological Society of America, Lanham, Maryland.

The editor introduces this volume with the hope that included papers will stimulate further discussion of hemipteran phylogeny. I offer in the following paragraphs comments on some of the issues raised by the contributors.

The 11 included papers were presented in a symposium at the 18th International Congress of Entomology held in Vancouver, British Columbia, Canada, in 1988. As is typical of symposia at such congresses, the list of contributors is international. Hemiptera, as used in the title, is in the broad sense. There is broad general agreement concerning the monophyly of the Hemiptera and of the Heteroptera. My comments will concentrate to a great degree on the recognition of groups and interrelationships among the classic Homoptera.

If this book is about Hemiptera, there is also one thing that it is not about—cladistics. Don't get me wrong, there are branching diagrams, some called cladograms, and lists of characters, some called apomorphies, but the sum of the discussion is not cladistic. Although the term cladistics is used many times, there is little coherence of method, and certainly much doubt expressed concerning the usefulness of cladistic methods. Although this may seem odd for a group of papers on phylogeny prepared in the late 1980s by which time the current methods were well tested and entrenched, it may seem less surprising when one considers that many of the arguments and much of the data come from paleontology. Because of the varied approaches of the contributors, I found interpretation and comparison of approaches and results difficult.

Within the Hemiptera, fossil representation of groups not known in the Recent fauna appears to be greatest in the classic Homoptera. K.G.A. Hamilton (Ottawa) attempts to resolve some discrepancies in the classification of the Auchenorrhyncha through the use of Cretaceous fossils from the Santana formation of the Northeast of Brazil; many of these represent the oldest known fossils which possess bodies and appendages in addition to wings. Hamilton begins by saying, "One of the most widely used techniques for elucidating [evolutionary] relationships is cladistics, the deducing of sister groups and their common ancestors by the distribution of derived characters in modern taxa. This still remains a controversial technique." He then proceeds to give a brief summary of the superfamilies in which Mesozoic fossil "Homoptera," represented primarily by wings, might be placed.

Hamilton draws several conclusions, primarily from study of the Santana fossils. The most general is that "Fossils frequently exhibit character states that cannot be predicted by cladistic analysis of recent forms." The states which seem most problematic, in his mind, are those that are suppressed altogether or totally transformed in modern lineages. No wonder that cladistics could not predict them.

Hamilton concludes that four monophyletic "suborders" can be recognized within

the Hemiptera: Psyllomorpha (=Sternorrhyncha), Cicadomorpha (Auchenorrhyncha less Fulgoroidea and possibly including Aleyrodoidea), Fulgoroidea, and Heteropteroidea (or Heteropterodea). Hamilton presents branching diagrams to portray the composition and relationships of these groups. Unfortunately, he fails to include the Heteropterodea in these diagrams, and therefore leaves unclear the position of that group within the Hemiptera.

In a similar vein, D. E. Shcherbakov (Moscow) offers a paleontological view of auchenorrhynchan evolution. His fossil-based presentation has higher groups evolving from other higher groups, as for example, "Bugs (Heteroptera) arose from some scytinopteroids, possibly from Paraknightiidae. . . ." His discussion is so replete with such characterizations that nearly every group mentioned must be considered paraphyletic. His most compelling conclusion may be that although in the Triassic now extinct groups of Auchenorrhyncha still dominated, in the Cretaceous the fauna looked like the modern one.

J. Koteja (Krakow) reviews the morphology of the scale insects, offering a list of characters that he hopes will be of value in phylogenetic work. Neither he, nor any other author, argues that the Coccoidea (or Coccinea) are not a monophyletic group. Koteja devotes most of his effort to determining what the ground plan of the scale insects should be, but little space is given to placing the scale insects in a broader phylogenetic perspective, which made it difficult for me to judge many of his arguments about the polarity of characters. This paper will be particularly interesting to coccidologists.

H. Derreck Blocker (Manhattan, Kansas) reviews the largely pre-cladistic literature dealing with auchenorrhynchan relationships. Blocker's review makes it clear that there are virtually as many published schemes of higher group relationships within the "Homoptera" as there are possible topologies for those groups.

Y. A. Popov and D. E. Shcherbakov (Moscow) portray evolution in the Coleorrhyncha as evidenced by the fossil record. This paper has the trappings of being cladistic, offering a list of characters and a cladogram. Yet, all other aspects of the paper suggest classic paleontological reasoning. Some quotes may serve to make the point. First, "Coleorrhyncha, regarded as a suborder of Hemiptera (sensu lato), forms a phyletic lineage somewhat parallel to but nevertheless distinct from Heteroptera, both descending independently from primitive Auchenorrhyncha Cicadomorpha." Second, "Paleontological data confirm the auchenorrhynchous affinities of the Peloridiidae [=Coleorrhyncha in part] beyond doubt, so the suggested synapomorphies of the family and Heteroptera should be reconsidered." And, "Except for their flattened habitus, bugs [=Heteroptera] and Coleorrhyncha disagree in fundamental apomorphies. . . . The evidence discussed above forces us to reject Schlee's Heteropterodea [Coleorrhyncha + Heteroptera] and treat both Heteroptera and Coleorrhyncha as suborders of Hemiptera along with Auchenorrhyncha and Sternorrhyncha." There may be merit in the conclusion of Popov and Shcherbakov that the Peloridiidae are relict in the far Southern Hemisphere. Their remaining conclusions are far less persuasive.

M. H. Sweet (College Station, Texas) offers one of the most character-rich contributions in his paper on the pregenital abdomen. Most of his treatment is devoted to homologizing sclerites, the first such effort, according to him, since 1893. He proposes the pleural origin of the connexival sclerites, adopting the terms "hypo-

pleurite" and "epipleurite" for the dorsal and ventral (or inner and outer) laterotergites, respectively. The value of such an undertaking would be to understand morphological change in the pregenital abdomen irrespective of the notoriously inconstant spiracle positions, if such were actually possible.

In my view Sweet's contribution has some obvious merits and some equally obvious drawbacks. On the positive side, he recognizes four apparently monophyletic suborders within the Hemiptera (Sternorrhyncha, Auchenorrhyncha, Coleorrhyncha, Heteroptera) on the basis of long appreciated and apparently apomorphic characters, rather than agonizing over variability in group-defining characters, especially for the Auchenorrhyncha. The drawbacks may be of two types. First, the characters he discusses are nearly all in the pregenital abdomen, hardly a complete sampling of morphological diversity in any of the groups. Second, many of his arguments for the apomorphic nature of characters are functional, and almost nowhere does he attempt to bring his concept of apomorphy into agreement with optimization of characters on a cladogram.

Some of Sweet's arguments are patently unconvincing. He notes, for example, that the pregenital abdomen in the Cicadellidae is relatively uniform in structure. In contrast, he finds the pregenital abdomen in the Cercopidae to be morphologically much more diverse, and concludes that there is merit in raising the latter group to superfamily rank, especially if the Cicadellidae are raised to superfamily through elevation of some subfamilies to family rank.

Sweet observes that at least some Fulgoroidea have fields of trichobothria on certain abdominal sterna and hypopleurites, as earlier pointed out by Ossiannilsson (1978). China (1962) and Carver, Gross, and Woodward (1991) observed similar setae in the Peloridiidae. Sweet conjectures that the "trichobothria" in these two groups may be homologous with the abdominal trichobothria in pentatomomorph Heteroptera. I would observe that trichobothria exist on many parts of the heteropteran body, including the head, antennae, scutellum, femora, and in apparently non-homologous forms on the abdomen in several families. These well-documented observations would seem to weaken Sweet's tentative theory of abdominal trichobothrial homology for the Fulgoroidea, Peloridiidae, and Trichophora.

Sweet argues that the ground plan of the Heteroptera has ventral spiracle bearing hypopleurites. He proposes a new infraordinal name—Aradomorpha—for the Aradoidea (Aradidae + Termitaphididae). He justifies this on the basis of abdominal structure, saying that the "turned over" connexivum of the Leptopodomorpha and Pentatomomorpha sensu Sweet [=Trichophora] in which the hypopleurites are dorsalized and the epipleurites are infolded is "strictly homologous and constitute[s] a synapomorphy relating these infraorders. . .," presumably more closely than either is related to the Aradoidea.

The similarity of abdominal structure noted by Sweet in the Leptopodomorpha and Trichophora is not unique. Examination of abdominal structure in the Cimicomorpha, for example, reveals great variation, including ventral "hypopleurites" and dorsal "epipleurites" with spiracles 2–8 ventral on the hypopleurites in many Reduviidae and Nabidae, for example, and a completely dorsalized connexivum with spiracles 2–8 ventral on the mediosternite in the Miridae and Tingidae. He does not resolve the incongruence of spiracle position in the trichophorous Pentatomomorpha

(ventral on the mediosternite, except in some Lygaeoidea) and Leptopodoidea (dorsal on the "hypopleurite," except in *Leotichius*).

Furthermore, Sweet disregards several other attributes which argue for the monophyly of the Pentatomomorpha sensu lato. Possibly most obvious among these is the remarkably similar structure of the pretarsus—unique among the Heteroptera—in all recognized families in the group, the claws being large and curved with a proximally attached pulvillus extending nearly the length of the claw (see scanning micrographs in Schuh and Slater, 1995:figs. 10.5 G-I); the parempodia always exist as a single, symmetrical, setiform pair; and median dorsal and ventral arolia are absent in all life stages as far as is known. Also, uniquely among Heteroptera, the eggs of all Pentatomomorpha, including Aradoidea, have distinctive micropylar processes. By way of contrast, the pretarsus in Leptopodomorpha is unlike that of Pentatomomorpha, most notably possessing arolia in some life stage as do all "lower" Heteroptera and lacking pulvilli; the eggs of Leptopodomorpha do not possess micropylar processes. Finally, the modest amount of available DNA sequence data groups Aradidae (not the Leptopodomorpha) with the Trichophora (Wheeler et al., 1993).

In sum, Sweet's arguments for the Aradomorpha are constructed in a phylogenetic vacuum and on the basis of a single character system which shows little consistency with other characters which show great constancy of form and which consistently argue for the monophyly of the Pentatomomorpha sensu lato.

D. B. Thomas (Weslaco, Texas) reviews chromosome numbers in the Heteroptera, attempting to determine whether polyploidy has played a role in the evolution of the group. His survey of the literature makes it clear that the story told by existing knowledge is far from clear. The reasons can be stated as follows: 1) the sample of taxa is small, with little accounting for within-group variation; 2) the phylogenetic relationships he postulates to explain chromosome data are often questionable; and 3) his assumptions about the plesiomorphic condition in many groups are at most a guess. These are the obvious limitations of his analysis.

Perhaps much more important is the problem of homology. Does simple counting of similar-appearing chromosomes actually represent a valid comparison? Thomas presents the results of some studies of chromosome volume that indicate otherwise. Furthermore, no banding patterns are known, thus, we might conclude that all theories of chromosome homology are outright suspect. Possibly symptomatic of the larger question is the so-called "m" chromosome, or micro-chromosome. This karyotypic feature has been used in establishing schemes of relationships within the Pentatomomorpha, yet it also occurs in such distantly related groups as the Nepomorpha. I can only conclude from Thomas' survey that karyology has a long way to go before it is capable of making a useful contribution to understanding mechanisms of diversification or establishing schemes of phylogenetic relationships within the Heteroptera.

Four additional papers offer further observations, primarily on the Heteroptera, but provide little in the way of phylogenetic context. These are: P. Stys (Prague) on some groundplan characters in the Heteroptera; R. J. Wootton (Exeter, England) on the functional aspects of hemipteran wings; J. R. Aldrich (Beltsville, Maryland) on the status of knowledge of pheromones; and H. Mori (Tokyo) on coalescence of ventral nerve ganglia from an embryological perspective.

Summarizing my impressions of the papers of this volume, I would say the following.

The application of the paleontological methods flaws the conclusions of all papers dealing with fossils. There seems great reluctance on the part of the paleontologists to view classifications as being based on characters, rather than some abstract concept of taxa which allows one group to be descended from another. Because the Paleozoic and early Mesozoic Hemiptera are largely represented by wings, there may be little hope that the taxa can be precisely characterized. This hardly seems a justification for continuing to treat these extinct groups as ancestral (and paraphyletic) simply because they appear early and disappear early.

Two works widely cited are those of Carver et al. (1991) and Sorensen et al. (1995). The former is cited as a justification for rejecting the Homoptera as a natural group. The latter is cited as a source of evidence for that conclusion. All contributors in this volume echo the view that the classic Homoptera must be abandoned as a group, yet draw little in the way of coherent conclusions as to what the new scheme should be.

Nonetheless, the desire to create a new subordinal nomenclature, even with little evidence to support it, seems to be great. This drive may be most conspicuous in the work of Sorenson et al. (1995) who coined several new names in a study using 18s rDNA data. In the present volume K.G.A. Hamilton is of a like mind, noting that the suborders should be designated with equivalent names. One might conclude from reading these papers that scientific problems can be solved simply by proposing new higher-group names. I fail to see what those problems are.

Clearly, the most pressing grand scale problem in hemipteran phylogenetics is to refine the diagnoses of higher groups within the Homoptera and to form a stable scheme of interrelationships within those groups. The consistent application of the core principles of cladistics—the use of character congruence to test theories of homology and the use of outgroups to determine character polarity—would go a long way toward achieving that objective.—*Randall T. Schuh, Department of Entomology, American Museum of Natural History, New York, New York 10024.*

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The Butterflies of Venezuela, Part 1: Nymphalidae I (Limenitidinae, Apaturinae, Charaxinae).—Andrew F. E. Neild, Meridian Publications, Greenwich, London. 144 pp. and 32 color plates. ISBN 0 9527657 0 5.

General review of the book

This attractive book is the first of an ambitious series of four parts to be published (tentatively) over the next five years, covering the Nymphalidae, Papilionidae and Pieridae of Venezuela. Neild has done an admirable job combining descriptions of adult butterflies and what is known of their behavior and life histories with the excellent color plates of material from the Natural History Museum (London), photographed by Bernard D'Abrera. In general, this collaboration provides a significant advance beyond D'Abrera's indispensable picture books of the neotropical butterflies (which contain little information beyond identified photographs of specimens) for people seeking to identify Venezuelan material, and as such will be a useful addition to libraries and the shelves of serious butterfly collectors.

The book is organized clearly, with three introductory sections before the main text. "A guide to the contents and use of this book" covers the meanings of terms in the species and generic accounts and in the plate legends, and offers a brief introduction on systematics, classification and nomenclature. For Neild, species correspond to actually or potentially reproductively isolated units (the biological species concept of Mayr, 1940), while subspecies are diagnosably different populations which do not intergrade (the phylogenetic species concept of Cracraft, 1983, and Nixon and Wheeler, 1990). In practice, very few Venezuelan species have been tested for biological isolation, and almost all are recognized on the basis of consistent differences in morphology where they occur in sympatry. Thus, Neild's distinction between species and subspecies is rather arbitrary from a practical perspective, even in his own descriptions of new taxa (see below).

"The study and collection of butterflies" helpfully includes a description of the rather daunting procedures that must be followed to obtain permits to collect and export butterflies from Venezuela. Neild reports that, "permits are not given for private collecting for personal benefit," which implies that the main utility of this book to private individuals will be to curate collections that have already been amassed. Instructions for study of life histories and the photography of living butterflies are also given. The section on preparing a butterfly collection contains some rather poor advice related to the aesthetic qualities of specimen preservation: Neild recommends removing abdomens of large, fatty species such as *Morpho* to degrease them (and reattaching them afterwards). Such procedures greatly reduce the scientific value of a specimen, since it can never be known if the abdomen originally belonged to that specimen or was scavenged from some other specimen and pasted on to replace a missing one, for aesthetic purposes (I have found *Heliconius erato* abdomens attached to *H. melpomene* specimens, and Lamas [1996] commented on a published generic description based on such a "glue job"). Given that non-scientific collection of butterflies is apparently not legal in Venezuela, instructions on the prettification of specimens seem superfluous and, if they lead to compromises of scientific data, inappropriate. Neild also describes homemade spreading boards that

require manipulation of insects after they are removed from the boards, to adjust their height on the pin. This procedure seems undesirable and unnecessary, given the widespread availability of commercially-built spreading boards that allow pins to be placed at the proper depth from the outset. Boards could also be built that allow this problem to be avoided.

The short section on Venezuelan biogeography is supplemented by rather grainy black-and-white habitat photos, mostly of cloud forest, and by more useful political and physical maps on the front and rear endplates.

Neild employs the up-to-date classification scheme of Harvey (1991) and cites other recent works that address higher-level nymphalid relationships (e.g., Otero, 1990; de Jong et al., 1996), resulting in a review of nymphalid classification above the generic level that reflects the state of current knowledge (in many cases rather scant, unfortunately). Descriptions of genera are also carefully researched, and significant revisionary works are generally cited. Some species are split from familiar inclusive genera into separate, smaller genera, such as *Mesotaenia* from *Perisama* and *Fountainea* from *Memphis* (and *Memphis*, in turn, split from *Aenea*). The issue of monophyly of these groups is not addressed. In addition to providing his own field observations, Neild often quotes at length from DeVries (1987) and other authors who have written on the natural history and early stages of particular groups. Sometimes, this practice seems excessive, such as the six verbatim paragraphs on *Eunica* from Jenkins (1990) on pp. 63–64.

Species accounts contain the following subsections: range, subspecies, identification, habits and foodplants. Range succinctly indicates the distribution of the entire species, while the distributions of individual subspecies are addressed in more detail in the subspecies section. Descriptions of new subspecies (discussed further below) are also presented here. The identification section is usually the most extensive, describing wing-pattern and other features that allow discrimination of subspecies and of similar species from one another. The diagnostic characters of the various taxa are described in discursive paragraphs which may be rather long—the notes on identification of *Memphis arachne* run for almost an entire page. Keys are provided for some but not all confusing groups. The habits include altitudinal range, preferred haunts, and behavior. Many larval foodplant records are drawn from DeVries (1987), while others were contributed by Venezuelan colleagues.

The plates are excellent, reproduced at 90% of life size. Many holotype, paratype and syntype specimens from the Natural History Museum in London are figured, some for the first time. Illustration of types is a nice feature because it provides an authoritative view of the specimen with which a particular name is associated. In some instances, the verso and recto figures of particular species represent different specimens, which is slightly confusing (especially when they are paratypes of new taxa, such as *Memphis maria* Pycz and Neild). The figures are numbered consecutively, and refer to numbers given at the top of text pages, making reference between the two simple. Locality data for figured specimens are presented in an appendix. Also included are a checklist, a glossary of terms, and a quite extensive bibliography. The index is a bit unusual, in that it refers primarily not to page numbers but to figure numbers. However, once this is realized, it is easy to use. There is also a gazetteer of some common collecting localities, related by grid quadrants to the map in the front endplate.

Descriptions of new taxa

In this book, Neild and coauthors describe 24 new subspecies and two new species. In my view, this is extremely inappropriate, for a number of reasons. First, it is unclear whether or not these descriptions were subject to peer review. Second, one species (*Memphis viloriae* Pycz and Neild) and three subspecies are described from single specimens, resulting in the third problem, which is that many of the descriptions are not clearly based on consistent differences between demonstrably distinct taxa. The genitalia of only one of the new taxa are illustrated. Fourth, three of the holotypes reside in private collections, with no indication of intentions to deposit them in a permanent and publicly accessible museum. Fifth (and perhaps most important), it is not clear to what extent Neild and colleagues have sought collections outside Britain and Venezuela, and in particular in the United States, to examine additional material.

While this review is not the place for a thorough investigation of these problems, I make the following observations as an indication of the importance of thorough exploration of known collections before describing new taxa: I have seen seven specimens of the "new" subspecies *Adelpha olynthia pyrczi* in the Smithsonian, and five additional specimens in the American Museum of Natural History (three of which are identified as *Adelpha olynthia inachia* Fruhstorfer, a name not mentioned in Neild's book). It is ironic that although Neild dedicates the book to (among others) William Beebe, he has not examined Beebe's material from Rancho Grande, which is in the AMNH (nine of Neild's new subspecies occur in the Rancho Grande region). Furthermore, I have found at least one species of *Adelpha* in the Smithsonian, evidently collected in Venezuela, that Neild does not mention or illustrate in the book. That I was able to find these records with relatively little effort or expertise in the groups concerned is a clear indication of Neild's need to study material from a greater diversity of collections before publishing subsequent volumes of this series.

While not without its flaws, I think this is an attractive, useful, and generally well-executed book. As stated at the outset, it is a clear improvement over D'Abrera's *Butterflies of the Neotropical Region*, at least for Venezuela, and will be a helpful tool for curating even large butterfly collections like those of the AMNH and NMNH. Given the complexity of the neotropical butterfly fauna, and the extent of our ignorance regarding its systematics and biogeography, Neild is to be congratulated for attempting to match DeVries' (1987) standard with a guide to a larger and more diverse South American country.—*Andrew V. Z. Brower, Dept. of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.*

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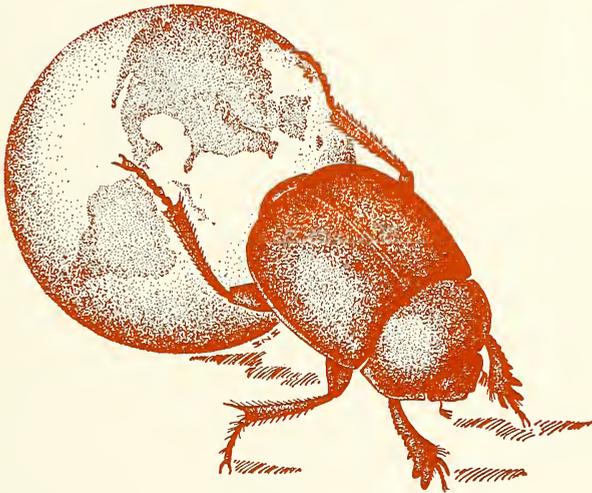
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AN ANALYSIS OF THE GENUS *STENOMACRA*
STAL WITH DESCRIPTION OF FOUR NEW
SPECIES, AND SOME TAXONOMIC REARRANGEMENTS
(HEMIPTERA: HETEROPTERA; LARGIDAE)

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Abstract.—Four new species of *Stenomacra* Stal from Costa Rica, Ecuador, and Brazil are described and illustrated. *Stenomacra cliens* (Stal), *Stenomacra gracilis* Schmidt, and *Stenomacra marginella* var. *mexicana* Schmidt are synonymized under *Stenomacra marginella* (Herrich-Schaeffer); *Theraneis ferruginea* Mayr is transferred to the genus *Stenomacra* and synonymized under *Stenomacra scapha* (Perty); *Theraneis dissimilis* Distant is transferred to the genus *Stenomacra*, resulting on the new combination *Stenomacra dissimilis* (Distant). New distributional data are included for each species. A key to the known species of *Stenomacra* is also given.

Key words: Insecta, Heteroptera, Largidae, *Stenomacra*, new species, Costa Rica, Ecuador, Brazil.

The Neotropical genus *Stenomacra* Stal (1870) had never been revised. However, the discovery of four undescribed species and several taxonomical problems made necessary the present analysis, which incorporates new distribution data and a key to separate the known species.

The genus is characterized by a slender to elongate body, nearly parallel-sided, with the head in dorsal view and between eyes flat or slightly convex, eyes small and barely pedunculate, ocelli absent, antennal segment I uniformly slender, bucculae short, slightly elevated, and scarcely extended backward as far as the antenniferous tubercle, rostrum just reaching the posterior margin of the mesothorax, pronotum with the anterior lobe not globose and the humeral angles rounded, hemelytra macropterous or eventually submacropterous, anterior coxae unarmed and fore femora armed with two or three subdistal spines (middle and hind femora unarmed), metathoracic peritreme never auriculate, and the abdominal sternite VII of the female mesally cleft.

Largulus Hussey (1927) is somewhat similar to *Stenomacra*, but the rostrum reaches the metathorax, and the body and legs are remarkably more slender.

Previously, only five species of *Stenomacra*, *S. cliens* (Stal), *S. gracilis* Schmidt, *S. limbatipennis* (Stal), *S. marginella* (Herrich-Schaeffer) and *S. scapha* (Perty), and one variety, *S. marginella mexicana* Schmidt were known (Hussey and Sherman, 1929 and Schmidt 1931). In this contribution we add four new species collected in Costa Rica, Brazil and Ecuador; one species, *Theraneis dissimilis* Distant (1883), is transferred to the genus *Stenomacra*, forming the new combination *Stenomacra dissimilis*; *Theraneis ferruginea* Mayr (1865) is also transferred to *Stenomacra* but

synonymized under *S. scapha*; and *Stenomacra cliens*, *S. gracilis* and *S. marginella* var. *mexicana* are placed as new synonyms within *S. marginella*.

After this contribution, the current number of species belonging to *Stenomacra* is fixed at eight.

The following institutional abbreviations are used in the text: American Museum of Natural History, New York (AMNH); the Natural History Museum, England (BMNH); California Academy of Sciences, San Francisco, California (CAS); Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Heredia, Costa Rica (INBIO); Museo Miguel Lillo, Tucumán, Argentina (MLTA); Muséum National d'Histoire Naturelle, Paris, France (MNP); Museum National, Rio de Janeiro, Brazil (MNR); Naturhistorisches Museum, Wien, Austria (NMW); Naturhistoriska Riksmuseet, Stockholm, Sweden (NRE); Texas A. & M. University, College Station (TAMU); Instituto de Biología, Universidad Nacional Autónoma de México (UNAM); Utah State University, Utah (USU).

Synonyms and references of *Stenomacra* should be consulted in the catalogs of Hussey and Sherman (1929) and Henry and Froeschner (1988) to avoid repetition and save space. All measurements are in millimeters.

***Stenomacra turrialbana*, new species**

Fig. 1

Female. Dorsal coloration. Head bright orange brown, with tylus and antennal segments I to IV black; pronotum light orange brown with sides of apical one third yellowish, center longitudinally and collar light orange brown, and basal third medially yellowish; scutellum light orange brown with a wide yellow longitudinal stripe extending from the base to apex; hemelytra light orange brown with following areas yellow: costal margin, basal angle of the corium, inner angle of the apical margin of corium, claval commissure, and anal border; hemelytral membrane ambarine, with outer margin darker; connexival segments with upper margin yellow, and lower one orange brown; abdominal segments bright orange brown. **Ventral coloration.** Bright reddish brown to orange brown, with bucculae, mesial gular region, prosternum, mesosternum and metasternum, upper third of acetabulae, anterior margin of mesothorax and metathorax, close stripe near posterior margin of mesothorax and metathorax, and the area neighbouring to metathoracic peritreme black; following areas yellow: quadrate spot in the anterior margin of prothorax, metathoracic peritreme, mesial and wide longitudinal stripe running from III to VI abdominal sterna, pleural margin of abdominal sterna III to VII, paratergite VIII and external margin of paratergite IX; rostral segments I and IV bright black, II bright orange brown, and III bright orange brown with apical third bright black; legs reddish black, with trochanters dirty yellow. **Structure.** Body slender, nearly parallel-sided; head, pronotum, scutellum, clavus, corium, thorax, and abdominal sterna with long, slender, erect setae, intermixed with short decumbent silvery setae. **Head.** Dorsally between eyes almost flat; eyes barely pedunculate; bucculae short, elevated, extending only to anterior margin of antenniferous tubercles; rostrum reaching posterior margin of mesothorax. **Thorax. Pronotum.** Trapezoidal, wider than long, and markedly bilobed with transverse impression deeply punctate; collar wide; anterior pronotal lobe with lateral margins rounded; posterior pronotal lobe with lateral margins obliquely

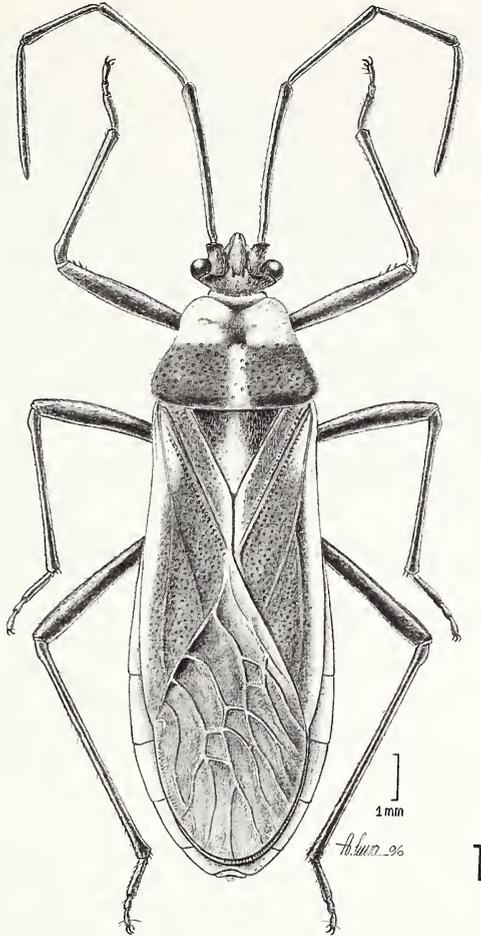


Fig. 1. *Stenomacra turrialbana*, new species, dorsal view.

straight; anterior lobe impunctate; posterior lobe with scattered punctation; posterior border straight; humeral angles rounded. *Legs*. Covered with fine adpressed silvery setae, intermixed with long silvery setae; fore femora armed with three single ranked, of long subapical spines; middle and hind femora unarmed. *Scutellum*. Triangular, slightly longer than wide, and flat; each side of anterior third of scutellar disc punctate. *Hemelytra*. Macrpterous, reaching the apex of the last abdominal segment; clavus and corium punctate; costal margins virtually straight.

Measurements. Length head: 2.00; width across eyes: 2.12; interocular space: 1.20; preocular distance: 1.08; length antennal segments: I, 3.72; II, 2.12; III, 1.32; IV, 2.68. Pronotal length: 2.68; maximum width of anterior lobe: 2.40; maximum width of posterior lobe: 3.76. Scutellar length: 1.72; width: 1.66. Total body length: 14.10.

Variation. 1. Rostral segments II and III bright black.

Male. Unknown.

Holotype female. COSTA RICA: PROVINCIA CARTAGO: Grano de Oro, Chirripo, Turrialba (1120 mts.), IX.1992. P. Campos. Deposited in INBIO.

Paratypes. Five females: COSTA RICA: PROVINCIA CARTAGO: Grano de Oro, Chirripo, Turrialba (1120 mts.), 8-30.VII.1992, 8-31.VIII.1992 and IX.1992. P. Campos. Deposited INBIO and UNAM.

Discussion. This new species is very distinct. The pronotum is light orange brown with the sides of its apical third, as well as a wide longitudinal stripe extending from its base to the middle third, yellowish. *Stenomacra dissimilis* (Distant), also recorded from Costa Rica, has the corium black with costal and apical margins, as well as the basal angle and claval suture yellow. The pronotal disc has another type of coloration. In *S. turrialbana* the corium is light orange brown with only the costal margin, the basal angle and the inner angle of the apical margin yellow.

Etymology. Named for the type locality, Turrialba.

Stenomacra tungurahua, new species

Fig. 2

Male. *Dorsal coloration.* Head, including antennal segments and rostral segments black, with basal join of antennal segment I red orange; pronotum red orange with callar region black; scutellum black with apex red orange; clavus and corium red orange; hemelytral membrane white; connexival segments black with upper border red orange; abdominal segments black. *Ventral coloration.* Black, with the external margin of bucculae, anterior, lateral and posterior margin of prothorax, apex of metathoracic peritreme, pleural margins of abdominal sterna and posterior margin of the genital capsule red orange. *Structure.* Similar to *S. turrialbana*. Rostrum reaching anterior third of metathorax. Scutellar disc scattered punctate. *Genital capsule.* Posteroventral edge entire, almost straight.

Measurements. Length head: 1.44; width across eyes: 1.84; interocular space: 1.08; preocular distance: 1.03; length antennal segments: I, 3.28; II, 1.88; III, 1.12; IV, 2.76. Pronotal length: 2.00; maximum width of anterior lobe: 2.08; maximum width of posterior lobe: 3.44. Scutellar length: 1.60; width: 1.56. Total body length: 12.85.

Female. *Coloration.* Similar to the male. Connexival segments VIII and IX red orange; abdominal segment VIII black with posterior margin red orange, and IX red orange; genital plates black with external margin red orange. *Measurements.* Length head: 1.56; width across eyes: 1.88; interocular space: 1.20; preocular distance: 1.00; length antennal segments: I, 2.96; II, 1.80; III, 1.08; IV, 2.40. Pronotal length: 2.28; maximum width of anterior lobe: 2.12; maximum width of posterior lobe: 3.32. Scutellar length: 1.40; width: 1.52. Total body length: 12.90.

Variation. 1. Posterior margin of abdominal sternite VII red orange.

Holotype male. ECUADOR: PROVINCIA TUNGURAHUA: Baños, 24.VII.75. J. Longino. Deposited in UNAM.

Paratypes. Two males, two females: ECUADOR: PROVINCIA TUNGURAHUA: Baños (1800 mts.), 4-5.IV.58. W. Weyrauch. Deposited in MLTA and UNAM. One female: ECUADOR: Baños, 20.II.37. S. W. Frost. Deposited in USNM. One male, one female: ECUADOR: Quito, 1930. R. Benoist. Deposited MNP.

Discussion. As in *Stenomacra scapha* (Perty), the clavus and corium are red orange,

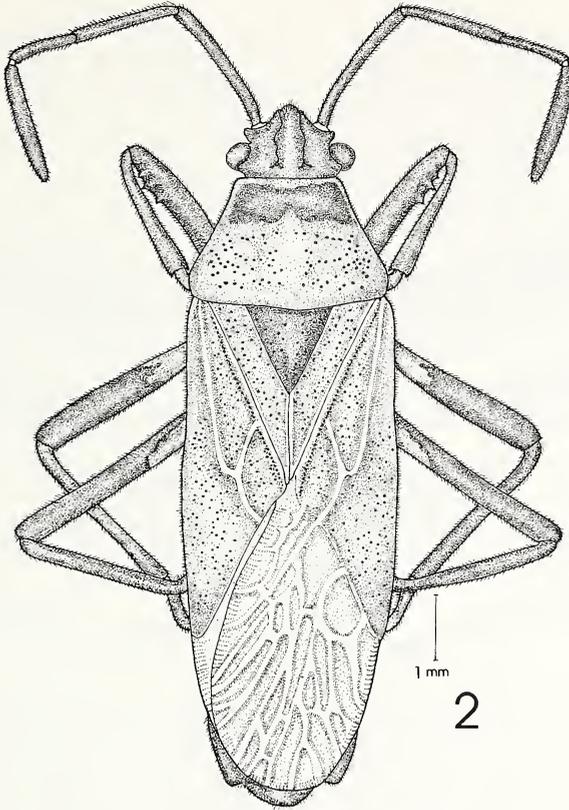


Fig. 2. *Stenomacra tungurahuana*, new, species, dorsal view.

and the hemelytral membrane is white. However *S. tungurahuana* is macropterous, the hemelytra reaching the apex of the last abdominal segment; antennal segments I to III, the callar region of the pronotal disc, and the tibiae are black. *S. scapha* is submacropterous, the hemelytra reaching the posterior margin of abdominal segment VI; antennal segments I to III, the callar region and the tibiae are red orange to pale orange.

Etymology. Named for its occurrence on Tungurahua.

***Stenomacra magna*, new species**

Fig. 3

Male. Dorsal coloration. Head including antennal segment I to III bright orange chestnut; antennal segment IV with anterior half bright orange chestnut, and posterior half dark brown; pronotum light yellow with callar region and punctures bright orange chestnut; scutellum bright orange chestnut; clavus and corium light yellow with diffuse brown shadow area; hemelytral membrane light ambarine; connexival segments bright orange with upper and lower margin yellow; abdominal segments

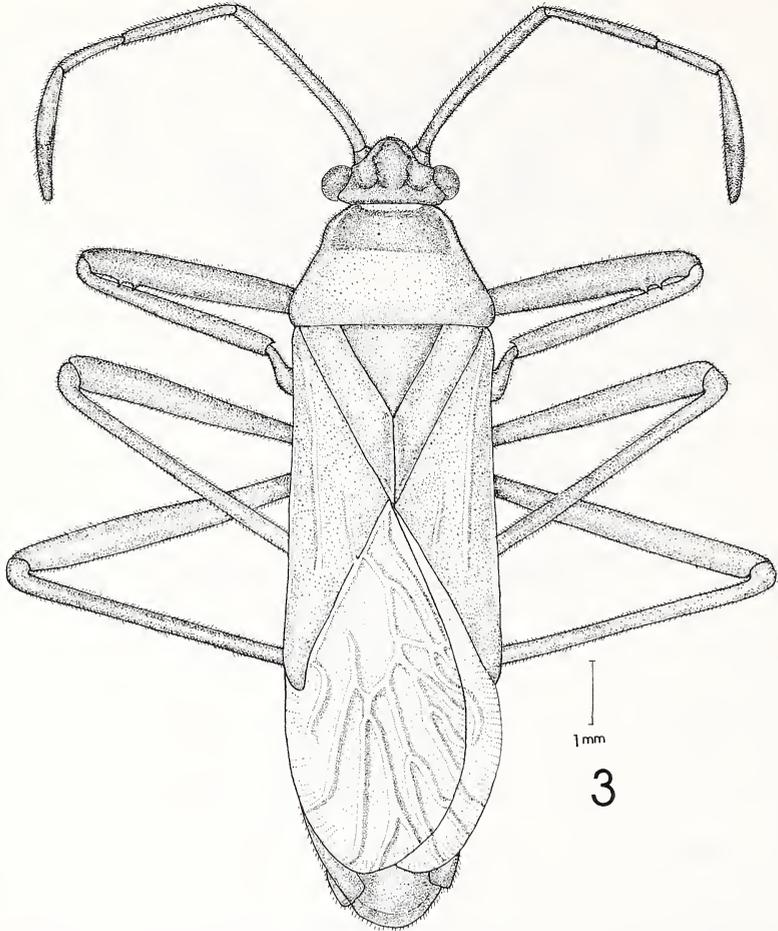


Fig. 3. *Stenomacra magna*, new species, dorsal view.

bright orange. *Ventral coloration.* Head including rostral segments I to III bright orange chestnut; rostral segment IV black with basal third bright orange chestnut; thorax bright orange chestnut with sternal region black, and following areas yellow: acetabulae, anterior and posterior margin of the prothorax, posterior margin of mesothorax and metathorax, and metathoracic peritreme; legs bright orange; abdominal sterna bright orange, with pleural margin yellow, and anterior margin of each sternite black; genital capsule bright orange, with yellow spot on the middle of the body. *Structure.* Similar to *S. turrialbana*. Rostrum reaching posterior third of mesothorax; scutellum wider than long or as longer as wide. *Genital capsule.* Posteroventral edge entire, almost straight.

Measurements. Length head: 1.40; width across eyes: 2.00; interocular space: 1.16; preocular distance: 1.00; length antennal segments: I, 3.44; II, 1.64; III, 1.06; IV,

2.80. Pronotal length: 2.24; maximum width of anterior lobe: 2.08; maximum width of posterior lobe: 3.08. Scutellar length: 1.32; width: 1.32. Total body length: 13.00.

Female. *Color.* Similar to male. Connexival segments, abdominal segments, and genital plates bright orange yellow; metathoracic peritreme bright orange. *Measurements.* Length head: 1.48; width across eyes: 2.08; interocular space: 1.20; preocular distance: 1.00; length antennal segments: I, 3.56; II, 1.80; III, 1.08; IV, 2.64. Pronotal length: 2.44; maximum width of anterior lobe: 2.24; maximum width of posterior lobe: 3.56. Scutellar length: 1.48; width: 1.56. Total body length: 14.40.

Holotype male. BRAZIL: NOVA TEUTONIA: Santa Catarina, 27 11'N-52 23'W, XII.1967. F. Plaumann. Deposited in TAMU.

Paratype female. One female: BRAZIL: NOVA TEUTONIA: Santa Catarina, 27 11'N- 52 23'W, 28.I.1967. F. Plaumann. Deposited in UNAM.

Discussion. This unique species can be distinguished by having antennal segments I to III bright orange, and IV bicolorous, the clavus and corium light yellow with a diffuse brown area, and the legs entirely bright orange.

In *Stenomacra limbatipennis* (Stal), antennal segments I to IV and the legs are black to reddish brown, and the corium is never entirely yellow; the clavus of *S. limbatipennis* is black with the claval commissure yellow.

Etymology. Named for its large size; from the Latin word, *magnus*.

***Stenomacra atra*, new species**

Fig. 4

Male. *Dorsal coloration.* Head, antennal segment I, anterior pronotal lobe, and scutellum (apex dark orange) black; antennal segments II to IV yellow with basal third of II and apical third of IV reddish brown to black; posterior pronotal lobe dark orange red; clavus yellow; corium yellow with the apical margin and a longitudinal median stripe, covered the endocorium reddish brown; hemelytral membrane dirty white; connexival segments I to V orange, and VI and VII black, with upper and anterior margin orange; abdominal segments orange with diffuse brownish spots. *Ventral coloration.* Including rostral segments I to IV and legs reddish brown to black; posterior margin of prothorax orange brown; tarsi bright chestnut orange; abdominal sterna with pleural margins III to VII, and posterior margin of VII orange; metathoracic peritreme with the lobe dirty yellow; genital capsule black with median body yellow. *Structure.* Similar to *S. turrialbana*. Rostrum reaching anterior third of metathorax. Scutellar disc scattered punctate. *Genital capsule.* Posteroventral edge entire, narrow, and almost straight. *Pubescence.* Head, exposed parts of thorax, abdomen, scutellum, legs, clavus and corium with short, fine, suberect pubescence, intermixed with long erect hairs; head in dorsal view densely set with silvery adpressed hairs; thoracic pleura and lateral areas of abdominal sternite III to V, and eventually VI with patches of very dense, felted silvery pubescence.

Measurements. Length head: 1.60; width across eyes: 2.16; interocular space: 1.20; preocular distance: 1.12; length antennal segments: I, 3.80; II, 1.84; III, 1.18; IV, 3.20. Pronotal length: 2.40; maximum width of anterior lobe: 2.20; maximum width of posterior lobe: 3.20. Scutellar length: 1.44; width: 1.32. Total body length: 14.10.

Female. Color and structure similar to the male. Anterior pronotal lobe black with callar region bright orange; scutellum dark orange with lateral margins black; ab-

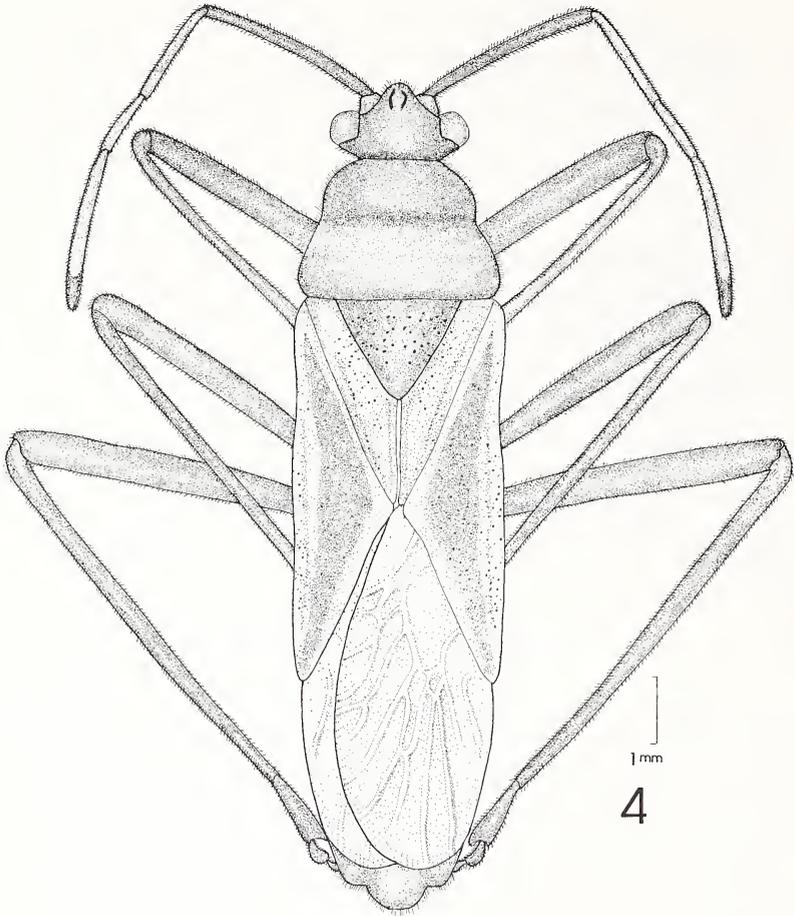


Fig. 4. *Stenomacra atra*, new species, dorsal view.

dominal segments light orange with anterior margin brown; abdominal sterna reddish brown with pleural margins III to V yellow, and VI and VII dark orange to reddish brown; genital plates yellow.

Measurements. Length head: 1.68; width across eyes: 2.24; interocular space: 1.34; preocular distance: 1.12; length antennal segments: I, 3.92; II to IV absent. Pronotal length: 2.56; maximum width of anterior lobe: 2.42; maximum width of posterior lobe: 3.40. Scutellar length: 1.48; width: 1.42. Total body length: 14.52.

Holotype male. BRAZIL: Bahia (without data). Deposited NMW.

Paratype. One female: BRAZIL (without data). Deposited UNAM.

Discussion. This new species superficially resembles *Stenomacra limbatipennis* (Stal) in size and shape. Both have completely reddish brown to black legs. It is however readily distinguishable by the yellow clavus, as well as by the yellow corium with its apical margin and a large irregular elongate brown stripe. In addition

the hemelytral membrane is dirty white. In *S. limbatipennis* the clavus and corium are black with the anal border, claval commissure, and costal margin of the corium yellow, with the hemelytral membrane dark brown.

Etymology. From the Latin, *atra*, black.

Stenomacra limbatipennis (Stal)

Theraneis limbatipennis Stal, 1860: 45

This is a readily recognizable species by virtue of its completely black to reddish brown antennal segments I to IV, and legs, and by having the pronotum, scutellum, and hemelytra black with following areas yellow: posterior margin of pronotum, apex of scutellum, anal border and claval commissure, and costal margin of the corium; hemelytral membrane dark brown.

The relation of this species with *S. atra* is given under the preceding species.

Types. Stal (1860) described this species from a single female specimen. The type of *Theraneis limbatipennis*, housed in the Naturhistoriska Riksmuseet, Stockholm, Sweden, was examined. The label data for the holotype specimen is Brazil, F. Sahlb. The type locality is Rio de Janeiro.

Bergroth (1905) recorded this species from Minas Gerais, Brazil.

Material examined. One male from Brazil (without data) and one female from, BRAZIL. RIO DE JANEIRO, Itatiaya Maromba, 20.I.1925. J. F. Zikan. Deposited in AMNH and UNAM.

Distribution. Brazil.

Stenomacra dissimilis (Distant), **New Combination**

Theraneis dissimilis Distant, 1883: 225.

Theraneis dissimilis Brailovsky, 1991: 636.

Individuals of this species are medium sized with the head (bucculae black or yellow), antennal segments I to IV, and legs black; pronotal disc black with each margin yellow; corium yellow with a large, irregular and elongate median black spot; hemelytral membrane dark brown, and connexival segments light yellow.

Stenomacra marginella (Herrich-Schaeffer) has antennal segments I to IV, tibiae and tarsi black, but the antenniferous tubercles, coxae, trochanters, and femora (except the black dorsal subapical face) light orange yellow, and the connexival segments are black with upper margin yellow.

Types. Distant (1883) described *Theraneis dissimilis* from at least three specimens, two from Costa Rica (Cache) and one from Panama (Bugaba). The types are housed in the Natural History Museum, London. A female paralectotype was examined. The label data are Panama, Bugaba, Champion.

Material examined. One female, COSTA RICA: Provincia Alajuela, sector San Ramon, 620 mts., 11-15.IV.1994. E. Lopez. Deposited in INBIO. Two females, COSTA RICA: Provincia Alajuela, 20 km., S. Upala, 1-10.VIII.1991 and 10-21.V.1991. F. D. Parker. Deposited in USU. Six females, COSTA RICA, Provincia Guanacaste, Parque Nacional Guanacaste, Estación Pitilla, 9 km., S. of Sta. Cecilia, 700 mts., VII.1988, I.1989, XII.1989, II.1990, 29.IV.1992. Deposited in INBIO and UNAM. One female, COSTA RICA, Provincia Guanacaste, Estación Cacao, SW., side of

Volcan Cacao, 1000-1400 mts., (Malaise Trap), 1988-1989 (without data). Deposited in INBIO.

Distribution. Costa Rica and Panama.

Stenomacra marginella (Herrich-Schaeffer)

Largus marginellus Herrich-Schaeffer, 1850: 182.

Theraneis cliens Stal, 1862: 315. NEW SYNONYMY.

Stenomacra marginella: Stal, 1870: 98.

Stenomacra cliens: Stal, 1870: 98.

Stenomacra cliens: Hussey & Sherman, 1929: 25.

Stenomacra marginella: Hussey & Sherman, 1929: 26.

Stenomacra marginella: Schmidt, 1931: 44.

Stenomacra marginella var. *mexicana* Schmidt, 1931: 44. **New Synonymy.**

Stenomacra gracilis Schmidt, 1931: 45. **New Synonymy.**

Stenomacra marginella: Blöte, 1931: 99.

This is a readily recognizable species by virtue of having antennal segments I to IV, rostral segments I to IV, tibiae and tarsi completely black to reddish brown, and by having the following areas always orange to orange yellow: antenniferous tubercles, bucculae, pronotal margins including the collar, costal margin of the corium, anal suture and commissure claval, apex of scutellum, upper margin of connexival segments, acetabulae, coxae, and trochanters.

Variation. This species is extremely variable in coloration, and several color forms can be found into the same population. 1. Head in dorsal view black or light orange, or only with the space close to the eyes black. 2. Anterior lobe of the pronotum orange or yellow and posterior lobe black, with or without median longitudinal orange to yellow stripe, or anterior and posterior lobe black with a median longitudinal yellow stripe, or both lobes with a diffuse yellow mark on a light brown background. 3. Scutellum black with the apex orange to yellow, or scutellar disc orange to yellow with basal third black. 4. Femora completely black or reddish brown, or completely bright orange, or well intermixed with basal third orange and the rest black, or orange with only the dorsal face of the apical third black, and other variants.

Types. Herrich-Schaeffer (1850) described *Largus marginellus* from Brazil but the type could not be located. The description, however, is adequate enough to fit this species. Stal (1862) described *Theraneis cliens* from Mexico and the type located in the Naturhistoriska Riksmuseet, Stockholm, was examined. Schmidt (1931) described *Stenomacra marginella* var. *mexicana* from Mexico and *Stenomacra gracilis* from Colombia but the types could not be located, however more than 150 specimens were examined and compared with the original descriptions which fit this species. Until further evidence is discovered, it seems best to produce these nominal taxa as synonyms due to the lack of morphological characters that would allow us to separate the taxa, as well as the extraordinary chromatic variation found among the long series of specimens examined.

Walker (1873) recorded this species from two Mexican localities Orizaba in the State of Veracruz and from Oaxaca. Distant (1880-1893) recorded this species from México including Coahuila (Parras, and Saltillo); Jalisco; Morelos (Cuernavaca);

Guerrero (Amula, Chilpancingo, and Xucumanatlan); Veracruz (Jalapa, and Orizaba). Guatemala (Capetillo, and San Gerónimo). Nicaragua (Chontales). Panama (Volcan de Chiriqui). Colombia (Bogota, and Antioquia). As well as from Brazil. Barber (1910) mentioned this species from Arizona (Huachuca Mts.) in the United States of America, and Blöte (1931) from California (United States of America) and from San Jose (Costa Rica). Henry and Froeschner (1988) in their catalogue recorded this species from the United States of America (California, Arizona, and New México).

Material examined. Three males from UNITED STATES OF AMERICA: Arizona, Portal (S.W. Res. Sta.) (5400'), 10.VI.1969. W. M. Nunes and T. H. Halstead. Deposited UNAM. Two males, three females from MEXICO: Nayarit, km., 98 road Guadalajara-Tepic, 27.VII.1984. E. Barrera and A. Ibarra. Deposited UNAM. One male, three females from MEXICO: Durango, 10 mi., N.W. Las Nieves (6500'), 1.VII.1971. C. W. O'Brien. Deposited UNAM. One male, one female from MEXICO: Durango, Presa Peña, 6.VIII.1979. E. Barrera. Deposited UNAM. One male, one female from MEXICO: Colima, Colima, IX.1940. C. Hoffmann. Deposited UNAM. One male from MEXICO: Jalisco, Teocatliche, 22.VIII.1970. B. Villegas. Deposited UNAM. Three males from MEXICO: Jalisco, km., 93 road Guadalajara-Ixtlan, 7.VII.1982. H. Brailovsky. Deposited UNAM. Five females from MEXICO: Jalisco, Chamela, 3.XII.1976. H. Brailovsky. Deposited UNAM. One male, two females from MEXICO: Michoacan, 8 mi., W. of Patzcuaro (7600'), 14.VIII.1982. O'Brien and Wibmer. Deposited UNAM. One female from MEXICO: Guerrero, Chapa, 26.VII.1975. R. Medellin. Deposited UNAM. One female from MEXICO: Guerrero, Chichihualco (1250 mts.), 6.VII.1979. H. Brailovsky. Deposited UNAM. 19 males, 14 females from MEXICO: Morelos, Cautla, 17.VI.1966, 22.VI.1969, 8-12.V.1970, 28.VIII.1970, 15.VIII.1984, 20.V.1989. H. Brailovsky. Deposited UNAM. Six males, 8 females from MEXICO: Morelos, Yautepec, 6.VI.1981. H. Brailovsky. Deposited UNAM. Nine males, eleven females from MEXICO: Morelos, Tepoztlan, 6.VI.1976, 25.II.1977, 9.IX.1977, 5.V.1980, 3.IV.1981. E. Mariño, E. Gonzalez, J. Butze, E. Barrera. Deposited UNAM. Two females from MEXICO: Morelos, Tetela del Volcan, 30.VI.1982. A. Ibarra. Deposited UNAM. Two males, one female from MEXICO: Estado de Mexico, Malinalco, 28.IV.1984. H. Brailovsky. Deposited UNAM. Two males, four females from MEXICO: Estado de Mexico, Valle de Bravo, 3.VII.1969, 18.V.1973. H. Brailovsky. Deposited UNAM. 12 males, 17 females from MEXICO: Distrito Federal, Pedregal de San Angel (Jardin Botanico, UNAM), 17.IV.1968, 11.V.1968, 12.VI.1968. H. Gonzalez Almada. Deposited UNAM. One male, one female from MEXICO: Distrito Federal, Jalpan, 26.IV.1975. C. Beutelspacher. Deposited UNAM. Three males, three females from MEXICO: Distrito Federal, Xochimilco (Tepepan), 10.V.1969, 11.IV.1975, 2.VII.1990. L. Rivera, W. Brailovsky, E. Martin. Deposited UNAM. Two males, three females from MEXICO: Hidalgo, Tasquillo, 15.VII.1979. H. Brailovsky. Deposited UNAM. Two males from MEXICO: Hidalgo, Tecozautla, 18.V.1996. E. Barrera, H. Brailovsky. Deposited UNAM. Three females from MEXICO: Hidalgo, Santiago de Anaya, 21.IV.1990. C. Mayorga. Deposited UNAM. Two females from MEXICO: Guanajuato, Guanajuato, 29.V.1975. P. Rojas. Deposited UNAM. One female from MEXICO: Guanajuato, Salamanca, 25.IX.1975. J. Bueno. Deposited UNAM. Two males from MEXICO: Queretaro, Queretaro, 6.IV.1977. J. Garcia Figueroa. Deposited UNAM. Three males, one female from MEXICO: Puebla, Tecamachalco, 27.II.1992. G. Ortega Leon, C.

Mayorga, E. Barrera. Deposited UNAM. Four females from MEXICO: Puebla, San Esteban (Necoxcalco), 27.IX.1992, 15.X.1992. E. Barrera, H. Brailovsky, C. Mayorga. Deposited UNAM. Two males, three females from MEXICO: Puebla, Tehuacan, 27.II.1992, 27.IX.1992. E. Barrera, C. Mayorga, G. Ortega Leon. Deposited UNAM. One female from MEXICO: Puebla, Atlixco (La Trinidad), 25.IV.1994. E. Barrera, H. Brailovsky. Deposited UNAM. Three males, four females from MEXICO: Veracruz, Las Minas, 16.IX.1982. E. Barrera, H. Brailovsky. Deposited UNAM. One male, one female from MEXICO: Veracruz, Estación de Microondas de Fortin, 15.VII.1980. E. Barrera. Deposited UNAM. One male from MEXICO: Veracruz, Conejos, 13.VIII.1984. H. Brailovsky. Deposited UNAM. One female from MEXICO: Veracruz, Orizaba (1880 mts.), 15.VIII.1975. A. N. Garcia Aldrete. Deposited UNAM. One female from MEXICO. Oaxaca, Mitla, 26.V.1970. H. Brailovsky. Deposited UNAM. One male from MEXICO: Oaxaca, Portillo del Rayo (Jalatengo), 21.X.1982. H. Brailovsky. Deposited UNAM. One male, one female from MEXICO: Oaxaca, Monte Alban, 27.III.1990. E. Barrera, A. Cadena. Deposited UNAM. One female from MEXICO: Oaxaca, km., 193 road Teotitlan-Oaxaca, 15.III.1989. A. Cadena, L. Cervantes. Deposited UNAM. Three males, seven females from MEXICO: Oaxaca, km., 47 road Huajuapán de Leon-Oaxaca (2010 mts.), 8.VII.1995. E. Barrera, G. Ortega Leon. Deposited UNAM. One male from MEXICO: Chiapas, Unión Juárez, 21.IV.1983. E. Barrera. Deposited UNAM. One female from MEXICO: Chiapas, Reserva El Triunfo, 6.VII.1993. C. Mayorga. Deposited UNAM. Three males, three females from COSTA RICA: San Jose (Sta. Maria de Dota), 30.IV.1984. E. Barrera. Deposited UNAM. Two females from COLOMBIA: 27 mi., South of Pasto Narino (1960 mts.), 28.II.1955. E. I. Schlinger, E. S. Ross. Deposited CAS. One female from VENEZUELA: Merida, km., 20 road Merida-El Morro, 20.XI.1992. Deposited UNAM.

Stenomacra scapha (Perty)

Lygaeus scapha Perty, 1833: 172.

Largus incisus Herrich-Schaeffer, 1850: 182.

Theraneis ferruginea Mayr, 1865: 436. **New Synonymy.**

Brailovsky (1991) revised the genus *Theraneis* Spinola. He described four new species and included a key to separate the known taxa. However, *T. constricta* Stal, *T. ferruginea* Mayr, and *T. isobel* Hussey were not included in the key since there were no specimens available and the corresponding types not located at the time. Recently, the authors had the opportunity to examine the type of *T. ferruginea*, which is deposited in the Naturhistorisches Museum, Wien. As a result, this species has been transferred to the genus *Stenomacra* and synonymized under *S. scapha* (Perty). The latter species is distinguished by submacropterous individuals with whitish hemelytral membrane; also the head, antennal segments, pronotum, legs and abdomen are reddish brown. Its distributional range is restricted to Brazil, the same area from where its new synonym was collected.

Types. Perty (1833) described this species from a single male specimen. The type was not located, but the description and figure, are adequate to determine its identify. The type specimen of *Largus incisus* Herrich-Schaeffer (1850) was not examined, but the figure in the original description is of a specimen identical to *S. scapha*.

Mayr (1865) described *Theraneis ferruginea* and the type specimen is a female located in the Naturhistorisches Museum, Wien. The type was examined and it has the following label data: Brasilien, Schott. The latter species has been transferred to the genus *Stenomacra* and synonymized under *S. scapha*. Hussey (1929) recorded this species from Rio de Janeiro and Minas Geraes in Brazil.

Material examined. One female from, BRAZIL: Petropolis, II. 1857. In MNP. One male, two females from BRAZIL: Rio de Janeiro, Itatiaya, 1200 mts., 26.XII.1953, Seabra and Alvarenga. Deposited in AMNH and UNAM. Three males, one female from BRAZIL: Rio de Janeiro, Itatiaya, 29.XII.1950. C. Leite, Seabra and Zickan. Deposited in MNR and UNAM.

KEY TO *STENOMACRA* SPECIES

1. Antennal segment I bright orange 2
- 1' Antennal segment I black to dark reddish brown 3
2. Antennal segment IV black with basal third orange; submacropterous, with the hemelytral membrane reaching anterior margin of abdominal segment VI; posterior lobe of the pronotum, clavus and corium light orange red (Brazil) *scapha* (Perty)
- 2' Antennal segment IV orange with apical third black; macropterous, with the hemelytral membrane almost reaching the apex of the last abdominal segment; posterior lobe of the pronotum, clavus and corium yellow (Brazil) *magna*, new species
3. Antennal segments II and III yellow (Brazil) *atra*, new species
- 3' Antennal segments II and III black 4
4. Clavus and corium bright orange red; hemelytral membrane white (Ecuador)
. *tungurahua*, new species
- 4' Clavus and corium never bright orange red; hemelytral membrane light brown 5
5. Anterior margin of the pronotum and collar black to bright reddish brown 6
- 5' Anterior margin of the pronotum and collar yellow to orange 7
6. Pronotum black with humeral angles and posterior margin yellow; scutellum black with apex ochre; lower margin of acetabulae yellow (Brazil) *limbatipennis* (Stal)
- 6' Pronotum light orange brown with sides of apical one third, and basal third medially yellowish; humeral angles light orange brown; scutellum light orange brown with a wide yellow longitudinal stripe running from the base to the apex; lower margin of acetabulae reddish brown (Costa Rica) *turrialbana*, new species
7. Coxae and trochanters black; antenniferous tubercle black (Costa Rica, Panama)
. *dissimilis* (Distant)
- 7' Coxae and trochanters bright orange yellow; antenniferous tubercle bright orange yellow (United States of North America, México, Guatemala, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Brazil) *marginella* (Herrich-Schaeffer)

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A NEW SUBGENUS AND TWO NEW SPECIES OF THE
GENUS *MACHILINUS* (MEINERTELLIDAE,
ARCHAEOGNATHA = MICROCORYPHIA, "APTERYGOTA",
INSECTA) FROM MEXICO

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Abstract.—*Protomachilinus* NEW SUBGENUS, *M. (P.) mexicanus* NEW SPECIES and *M. (P.) oaxacensis* NEW SPECIES are described. The new subgenus is more plesiomorphic than any of the other three subgenera of *Machilinus*. Ecological and biogeographical aspects of the genus are discussed.

The genus *Machilinus* has a special position within the Meinertellidae, a family which is more derived than the other family of extant Archaeognatha, the Machilidae. There are three reasons for this. From the morphological point of view the *Machilinus* species described up until now are highly derived, e.g. by sublateral ocelli which are round to elliptical and hyaline to light red; the absence of a horizontal process on the base of the maxillary palp (a process which is present in all other genera of Meinertellidae); the absence of coxal stylets on all legs; the absence of coxal vesicles on abdominal coxosternite I and the highly reduced chaetotaxy on gonapophyses VIII and IX of the females (Sturm and Bach, 1993).

The ecology of this taxon also shows some peculiarities. Contrasting with nearly all other genera most *Machilinus* species are active during full daylight (The only other species for which daylight activity is described is *Bachilis multisetosa* of the family Machilidae: Mendes, 1977). Some species were found in very dry localities and one species collected at 4500 m above sea level, near Tucuman, Argentina (Wygodzinsky, 1967). Noteworthy is also the biogeographical aspect. The species of the genus described since then were collected in the western part of North America, the southern part of South America, the mediterranean area, the middle of the Sahara and in South Africa. As a result *Machilinus* is second only to the genus *Machiloides* (Meinertellidae) in being the most widespread genus of the Archaeognatha (Wygodzinsky, 1967 Sturm, 1984).

The present work reports a new subgenus from Mexico. This finding takes on added importance by the fact that this subgenus shows several plesiomorphic characters and is doubtless the most primitive of the four subgenera of *Machilinus*. Some of its characteristics establish a connection between the genus *Machilinus* fairly isolated before and the other genera of the Meinertellidae. These characters also make it necessary to redescribe some generotypic features. As a result of the discovery of the new subgenus in Mexico questions arise about biogeography and evolution of the genus, discussed after the description.

Protomachilinus Sturm, New Subgenus

Type species: *Machilinus (P.) mexicanus*, new species

Diagnosis: As subgenus *Machilinus* s.str. except: Lateral ocelli big, elliptic, with

black pigment situated on an indentation of the ventral margin of the eyes; 4 distal teeth of mandible without distinct pigment.—Maxillary palps: Horizontal projection on the dorsal basis present; article 2 of male without distinct specializations referring to form and chaetotaxy.—Labial palps: Article 3 distinctly broadened, in males more than in females.—Abdomen: Sternocoxites I with 1 + 1 functioning coxal vesicles. **Etymology:** The subgenus is named after the accumulation of plesiomorphic characters: protos (Greek) = first (in the sense of original).

Discussion: The combination of characteristics mentioned above distinguish the subgenus from the 3 other subgenera of the genus. They are (with exception of the broadened article 3 of labial palps) plesiomorphic and are present either in all other genera of Meinertellidae (horizontal process on the basis of maxillary palps) or the majority of the taxa (lateral ocelli with distinct black pigment, teeth of mandible without pigment, coxal vesicles on sternocoxite I present). Certainly the interrupted pattern of macrochaetae on gonapophyses VIII and IX of female (ovipositor-type IV after Sturm and Bach, 1993) is present but it is more weakly developed than in the other 3 subgenera (see Figs. 25, 26).

On the other hand in view of the number of differences with the other subgenera the question arises if this taxon could should actually be a genus. The main reason against this possibility are the many derived common characteristics, shared with the other subgenera of the genus *Machilinus* (Sturm and Bach, 1992), e.g. sublateral position of lateral ocelli and their ovoid or elliptical form, size and form of eyes, similar distribution of spiniform setae on the margins of thoracic tergites I–III (Sturm and Messner, 1995); absence of coxal stylets on legs, presence of characteristic setae near the basis of abdominal stylets; penis with thin straight setae on characteristic bumps; derived chaetotaxy of female gonapophyses.

***Machilinus* (*Protomachilinus*) *mexicanus* Sturm, New Species**

Types: Holotype male, body length 7.5 mm; MEXICO, Chiapas, 5 mi W San Cristobal, pine-oak-forest, 24.VIII.1966, J. & W. Ivie coll.—Allotype female, 8.5 mm, same data as type. Paratypes: 1 female 9.5 mm; 1 juvenile 4.5 mm, same data as type. All specimens deposited in AMNH (3 adult specimens prepared on slides: Euparal inclusion).

Etymology: the species is named after the country of origin, Mexico.

Description: Body length ca. 7–10 mm; hypodermal pigment dark brown, extended especially on head, mandibles, maxillary palps, labium, legs and thoracic sternites (see Figs. 1, 4, 6–9).

Head (Fig. 1): Eyes large; ratio of width of eyes : width of head = 0.75–0.83; length of eyes : width ca. 0.8; line of contact of the eyes : length of eyes = 0.6–0.7.—Paired ocelli sublateral; contrasting with the other subgenera by black pigment and great size; width reaching nearly half width of eyes.—Antennae (Figs. 2, 3) shorter than body, up to 6.5 mm long, with weak and uniform light brown pigmentation; scapus short, ratio length to width = 1.5–1.9, distal chains of the flagellum with up to 11 articles, obviously limited by jointlets.—Mandibles distally with 4 teeth of equal size, without distinct pigmentation.—Maxillary palps (Figs. 4, 5): On the dorsal base a horizontal process is present; such a process is absent in all other subgenera of *Machilinus* but present in all other Meinertellidae; hook on article 2 of male and

chaetotaxy on articles 2 + 3 without distinct peculiarities; number of spines on articles 7/ 6/ 5 = ca. 10/ 13/ 3; ratio length of articles 7:6:5:4:3 = 1:1.7–2:1.85–2.05:1–1.1:0.9–1 (for the 2 females), articles 4–7 in the male absent (broken).—Labium (Figs. 6, 7): Article 3 of palps distally distinctly broadened, in the male more than in the female.

Thorax: Number of lateral marginal spiniform setae on tergites I/II/III = 12–15/35–47/10–16 (cf. Sturm and Messner, 1995).—Legs (Figs. 8, 9): Coxal stylets absent; some dark spiniform setae on tarsal articles 1 + 2 of legs I.

Abdomen: Coxites I–VII each with 1 + 1 functioning coxal vesicles, II–IX with stylets; all sternites small, terminal spines of stylets long (Figs. 12, 13), ratio length of terminal spine: length of stylet for segments II = 0.4–0.5:1 for V = 0.8–1.0:1; for IX = 0.6–0.65:1 (determined only in male); distance between inner margins of basis of abdominal stylets only slightly different, ratio of distance segment IV:II = 1.2–1.35 (cf. description of the other subgenera in Sturm and Bach, 1992); coxites II + III with small fields of setae lateral to the base of stylets, setae up to ca. 0.15 mm long, straight and of brown colour (Fig. 11); stylets IX ventrad and mediad with brown spiniform setae, up to 0.45 mm long (Fig. 13).—Penis (Fig. 14): distinctly shorter than $0.5 \times$ length of coxite IX; aperture pointed oval, surrounded by 1–3 rows of straight setae (up to 0.03 mm long) rising on small characteristic bumps. Ovipositor extended far beyond terminal spines of stylets IX; gonapophyses with more than 60 articles, only on the distal third with macrochaetae; terminal spine of middle size, reaching the length of 2–3 terminal articles; 3–5 setae per article on the four most distal articles, proximally reduced to 1–3; lateral macrochaetae in this latter area not present on each article (interrupted pattern of distribution after Sturm and Bach 1993).—Cerci with long straight terminal spines (Fig. 18).

Diagnosis: The species can be determined by the characteristics of the subgenus and the differences which are given in the diagnosis of *Machilinus (P.) oaxacensis*.

***Machilinus (Protomachilinus) oaxacensis* Sturm, New Species**

Types: Holotype male, body length 6.5 mm; MEXICO, Oaxaca county, near Tlacolula, 96.27 W, 16.57 N, under cliff, 30.IV.1963, Gertsch & Ivie coll.—Allotype: female, body length 7 mm, same data as holotype; paratypes 1 male, 4 females, same data as holotype.—Paratypes: 2 females, 6.5 and 8 mm; MEXICO, Oaxaca, 3 mi SE Tlacolula 96.25 W, 16.56 N, 30 VIII. 1966, J.& W. Ivie coll.—All types deposited on AMNH, 6 adult specimens prepared on slides (Euparal inclusion).

Etymology: The species name refers to the province Oaxaca (Mexico) where the species was collected.

Description: Body length (inclusive of head) ca. 6–8 mm; hypodermal pigment dark brown, more pronounced than in the first species.

Head: Hypodermal pigment on frons V-shaped, with small median stripe (Fig. 19).—Ratio of width of eyes: width of head = 0.75–0.85; length of eyes: width = 0.75–0.9; length line of contact of eyes: length of eyes = 0.55–0.65; width of ocelli: width of eyes = 0.45–0.55 ($n = 6$ for all values); ocelli black. Antennae distinctly shorter than the body, maximum length measured = 3.5 mm; maximum number of articles per chain within the distal half = 9; patches of hypodermal pigment on scapus and pedicellus only; flagellum uniformly light brown; scapus short, ratio length: width

= 1.5–1.9—Maxillary palps especially on article 3 stronger pigmented than in the first species; setae on the medial side of article 2 forming an indistinct whorl (Fig. 20); ratio length of articles 7:6:5:4:3 = 1:1.4–1.6:1.7–2.3:1.1–1.3:1.1–1.5 (n = 12); number of spines on articles 7/6/5 = 5–7/9–11/1–2.—Broadening on article 3 of labial palp of female weak, of male very distinctive.

Thorax: Legs more intensive and more extended pigmented than in the first species; spiniform setae on all legs present (Fig. 22); maximum numbers on femur/tibia/tarsus 1/tarsus 2 for leg I = –/3/3/5; for II = 2/5/4/4; for III = 3/5/4/4. Maximum number of lateral marginal setae on tergites I/II/III = 19 (partially in double rows)/>50/16.—All sternites with big patches of hypodermal pigment.

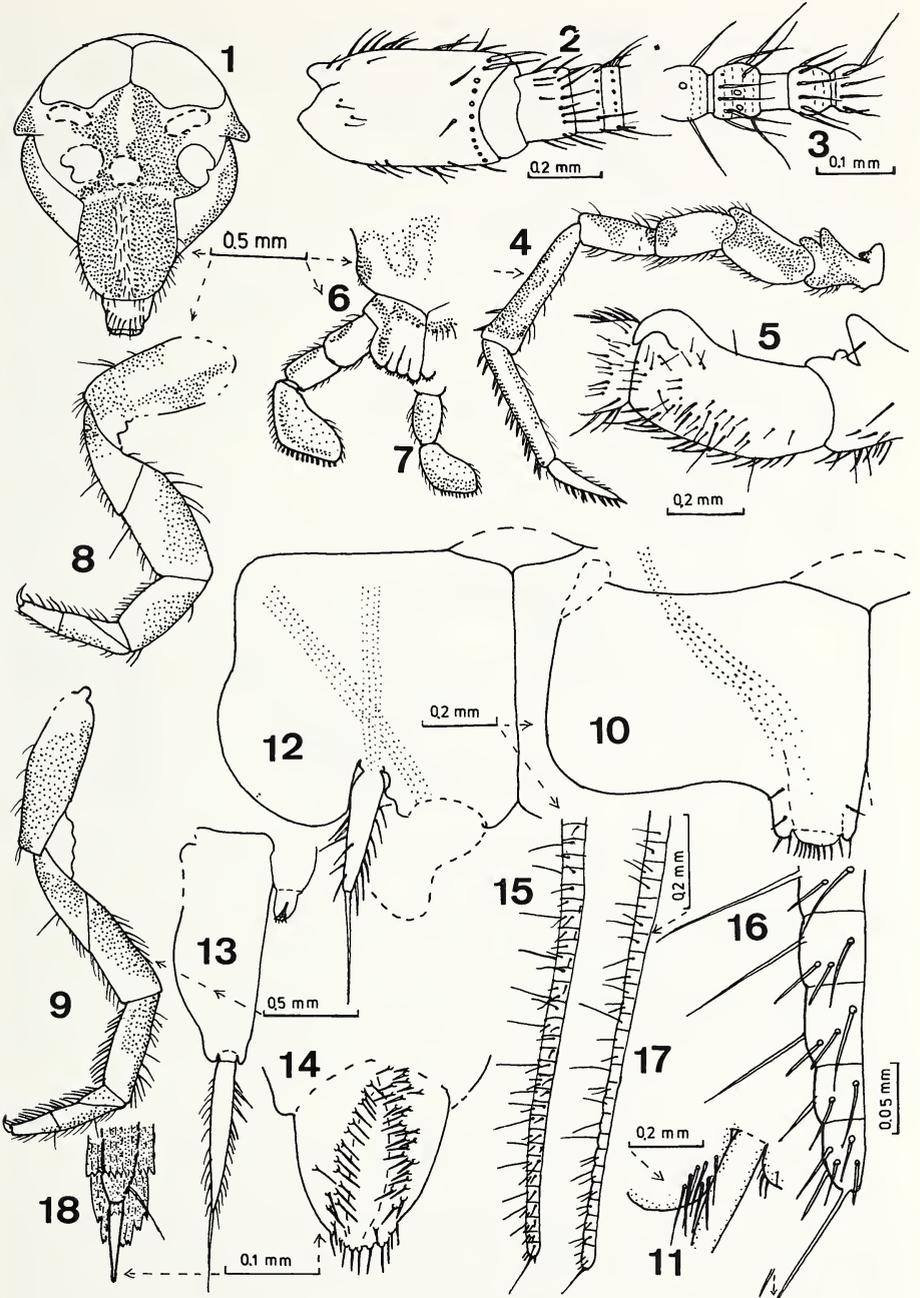
Abdomen: Coxal vesicles on coxites I–VII; stylets on II–IX; coxites I with a small band of setae on the anterior border (Fig. 23); fields of setae near the base of stylets on coxites II–VIII present; terminal spines on stylets long; ratio of length of spine : length of stylet on segment II ca. 0.5, on V ca. 0.5–0.6, on IX ca. 0.35–0.45. Penis: Aperture great, pointed triangular; structure and taxis of setae similar to those of the first species. Ovipositor thin, extended well past the ends of terminal spines IX; chaetotaxy similar to the first species. Filum terminale and cerci with many dark brown spiniform setae; cerci up to 3.3 mm long with one terminal spine of medium size.

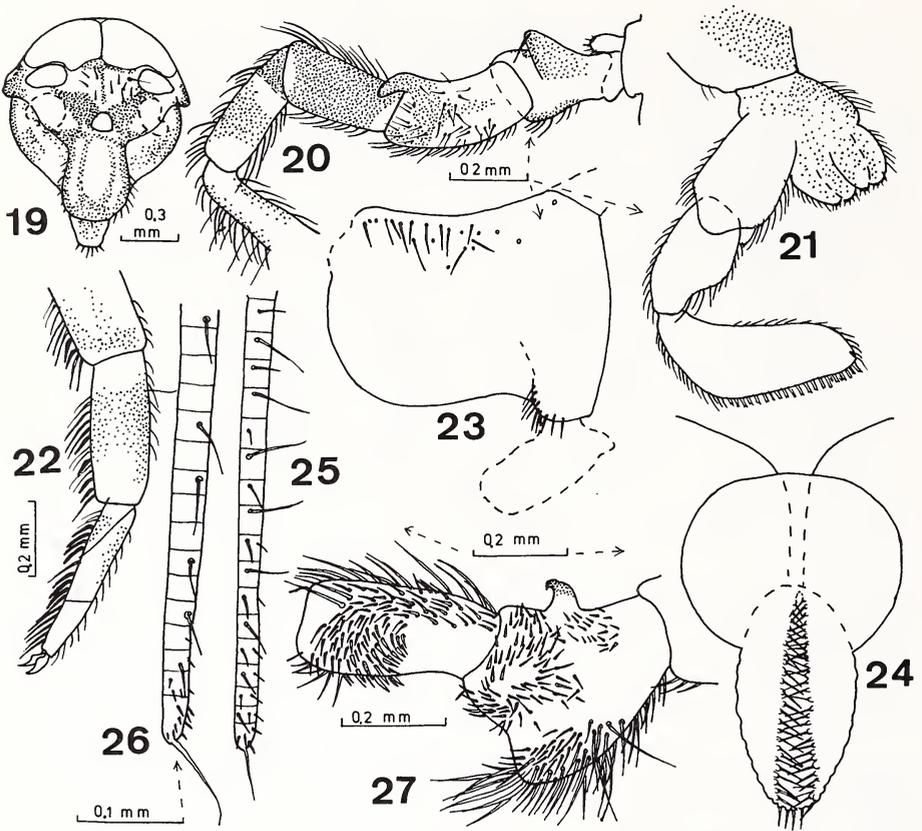
Diagnosis: *Machilinus (P.) oaxacensis* is distinguished from the other species of the subgenus e.g. by the shorter body length, the different pigment pattern on the frons and maxillary palps, different ratios of length of articles on maxillary palps, the strong broadening of article 3 on the labial palps of the male, presence of dark spiniform setae on the tibia and tarsus of all legs, and the presence of fields of setae near the bases of stylets II–VIII.

Discussion: The species presents all characteristics of the subgenus. Specimens which were collected in 1966 at a locality near the type locality included a female (9 mm body length) with a distinctly different ratio of distances between stylets on segments II and IV (= 1,14) and some other peculiarities. It can not put to this species but indicates that there are probably more species of the subgenus which contrasts with the subgenus *Nearctolinus* with only one species and a much larger distribution.

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Figs. 1–18. *Machilinus (Protomachilinus) mexicanus*, new species. 1. Head (male), frontal view. 2. + 3. Antenna, female; 2. Basal part with scapus + pedicellus; 3. Distal part, ca. 4 mm from base. 4. Maxillary palp (female), lateral view. 5. Articles 1–3 of male maxillary palp, median side, article 2 with hook. 6. Left half of labium with labial palp (male), ventral view. 7. Labial palp (female), articles 2 + 3. 8. Leg I (male). 9. Leg III (male). 10. Half of coxosternite I (male), ventral view. 11. Part of coxite III (male) with base of stylet and lateral setal area, ventral view. 12. Half of coxosternite V (male) with muscles (dotted) and coxal vesicle, ventral view. 13. Coxite IX (male) with penis, ventral view. 14. Penis of Fig. 13 by higher magnification. 15. + 16. Distal parts of gonapophyses VIII (female), ventral view. 17. Distal part of gonapophysis IX (female), ventral view. 18. Distal end of cercus (female) with big terminal spine.





Figs. 19–26. *Machilinus (Protomachilinus) oaxacensis*, new species; hypodermal pigment dotted. 19. Head (male), frontal view. 20. Maxillary palp (male), articles 1–5, lateral view, inner side. 21. Left half of labium (male) with labial palp, ventral view. 22. Distal part of leg III (male) with spiniform setae. 23. Half of sternocoxite I with coxal vesicle and fields of setae, ventral view. 24. Penis, ventral view. 25. Distal part of gonapophysis IX (female), ventral view. 26. Distal part of gonapophysis IX of *Machilinus (Nearctolinus) aurantiacus*: Interrupted pattern of macrochaetae more significant than in 25.; ex Sturm and Bach 1992. 27. *Machilinus (Neotropolinus) chilensis* Sturm and Bach, 1992: Maxillary palp (male), articles 2 + 3: high specialized chaetotaxy and form of article 2; ex Sturm and Bach 1992.

ECOLOGICAL AND BIOGEOGRAPHICAL ASPECTS OF THE GENUS *MACHILINUS*

The localities where specimens of the genus were found show very different ecological conditions: rocks or stones of very different composition, sand dunes, bark of fallen trees, litter, heath and grassland. The range of altitude reaches from marine beaches (Mendes, 1977) up to 4500 m above sealevel (Argentina: Wygodzinsky, 1967). Peculiar for Archaeognatha is the activity in full light. It was described by different authors (e.g. Wygodzinsky, 1952, Bitsch, 1968, Smith, 1970, Mendes, 1977) and is probably valid for most of the *Machilinus* species. For nearly all other

genera activity during night or dusk is regular. Only for *Bachilis multisetosa* (Machilidae) Mendes (1977) mentioned a less pronounced daylight activity. Perhaps the light or reddish colour described for the three other subgenera of *Machilinus* and for *Bachilis m.* is connected with this form of activity. The black colour of the paired ocelli in the subgenus *Protomachilinus* corresponds to that of nearly all other Archaeognatha and it remains unclear if it indicates activity in darkness or twilight. The hygrophily is apparently developed differently within the genus. Besides species or populations which are living in habitats with high relative humidity (e.g. *M. chilensis* in the forests of Chile; Sturm and Bach, 1992) or *M. gredosi* in the Serra da Estrela, Portugal, an area with 1900 mm precipitation per year: Mendes 1977) there are some species living in dry areas (e.g., *M. aurantiacus* on the sand dunes near Los Angeles [collected by R. Mattoni, Beverly Hills: VII. + VIII. 1993 in pitfall traps] and on dry localities in Utah and New Mexico (Mendes, 1996) or active for long time in full sunlight. In the latter cases a regular production of dew during the night could stabilize the water balance. But it is an enigma why *M. aurantiacus* often living in dry habitats would have strongly reduced coxal vesicles. For other bristle-tails the uptake of water by means of the coxal vesicles is regular (Bitsch, 1974). It may be that the genus *Machilinus* in connection with the daylight activity has achieved other means of water balance.

The genus *Machilinus* does not enter tropical lowlands. The collecting localities in Mexico are lying at altitudes of more than 1000 m, those at Tibesti Mountains and in Yemen at more than 2000 m.

The geographic distribution of the genus *Machilinus* is characterized by a multitude of isolated and widely distributed areas. Three of these areas are situated in America, each harboring one subgenus. The number of species decreases from South to North with South America having 6, Mexico 2, North America 1 (Fig. 28). The fourth subgenus is restricted to the Western part of the Old World and distributed in at least 4 clearly separated areas (at the basis of the data known at the present time). Old data referring to the occurrence on the Cape Verde Islands (Silvestri, 1908) could not be confirmed. The area with the highest number of species (18) is the Mediterranean. The remaining areas are very small, each harboring 1 species. The occurrences in Tibesti, Yemen and South Africa could be relicts, that in Madeira perhaps a result of dispersal.

Within the four subgenera of *Machilinus*, *Protomachilinus* undoubtedly shows the most plesiomorphic characters, which makes the genus morphologically more similar to the other genera of Meinertellidae.

An undescribed specimen from the Lebanese amber (collection of the American University at Beirut, number 194/35) gives evidence for the existence of typical representatives of the family Meinertellidae some 110–120 millions of years ago. The splitting within this family must have been happened distinctly earlier, perhaps at the beginning of the Mesozoic. An explanation for the present distribution on the basis of the known historical, biogeographic and morphological data remains difficult, but a comparison with the distribution of another taxon of the Meinertellidae, the genus *Machiloides* could be helpful. *Machiloides* is not only the most plesiomorphic genus in the Meinertellidae (e.g. coxal stylets on legs II and III, lateral ocelli sole-shaped, chaetotaxy on genital appendages not specialized) but it shows also the most extensive distribution within the extant Archaeognatha (Table 1).

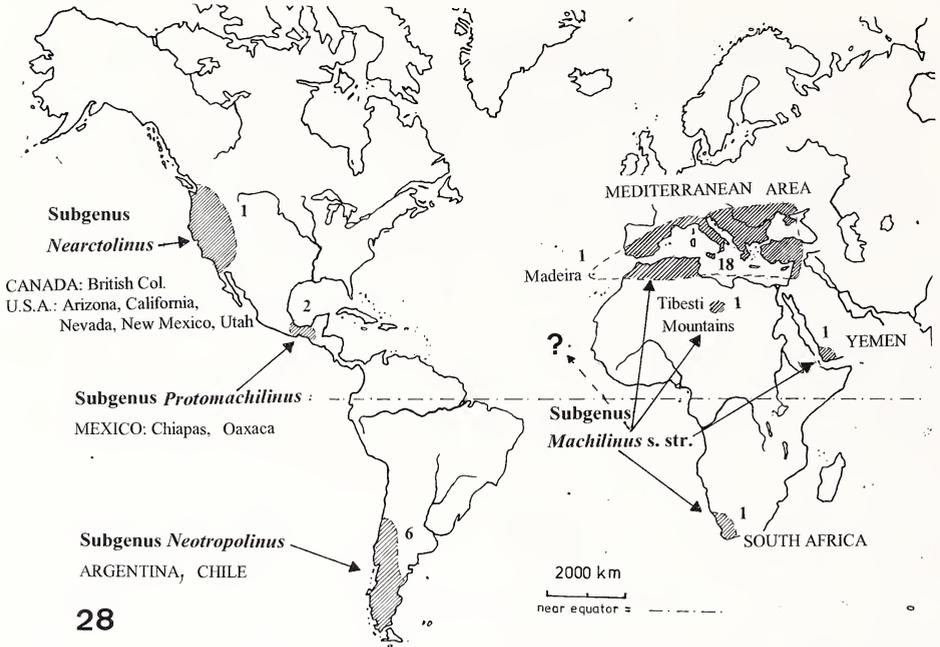


Fig. 28. Geographical distribution of the 4 subgenera of the genus *Machilinus*; areas hatched; numbers = number of species per area; ? = occurrence uncertain.

The fact that no other genus of Archaeognatha shows such an extensive distribution as these two genera suggests the long period of time necessary to reach such a wide distribution and morphological differentiation. Probably the origin of both genera and of all Archaeognatha was in the northern hemisphere, where presently occur the most plesiomorphic species of *Machilinus* and *Machiloides* (*Machilinus* [*Protomachilinus*] in Mexico and *Machiloides tenuicornis* in Spain). If Laurasian in origin, the dispersal of *Machiloides* began earlier than that of the more derived genus *Machilinus*, which apparently never reached the Austral-malesian area. A similar pattern of distribution is in the genus *Araucaria* (Gymnospermae) during the Mesozoic, especially during the Cre-

Table 1. Distribution and number of species for each region for the genera *Machilinus* and *Machiloides* (Meinertellidae).

	<i>Machilinus</i>	<i>Machiloides</i>
North America	1	2
Central America	2	—
South of South America	6	10
South and East Africa	1	25
Mediterranean Region	19	1
Australia/Tasmania	—	>2

taceous period, and included North America, Southern South America, Europe, South Africa, India and the Australian region (Ehrendorfer, 1978).

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**A REVIEW OF THE GENUS *LIMNOMETRA* MAYR IN
NEW GUINEA, WITH THE DESCRIPTION OF A VERY LARGE
NEW SPECIES (HETEROPTERA: GERRIDAE)**

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Abstract.—The species of the water strider genus *Limnometra* occurring on New Guinea and proximate islands are reviewed, and a very large new species, *L. grallator*, is described from the southern flanks of the central highlands. On the basis of male endosomal sclerotization, this new species appears to be most closely related to *L. kallisto* (Kirkaldy), a much smaller species also endemic to greater New Guinea. A key to all New Guinea *Limnometra* species is provided, accompanied by illustrations of the male endosomal sclerites and range maps.

The genus *Limnometra* consists of a group of large, long legged water striders that are widely distributed across tropical Asia and eastward into the southwestern Pacific and northern Australia. The last complete generic revision of the genus was that of Hungerford and Matsuda (1958), following which no additional species were described for over 40 years. Recently, however, Nieser and Chen reviewed the Indo-Australian fauna (1992), describing 9 new species and producing a partial key. Subsequently, Andersen and Weir (1997) revised the genus for Australia, describing one new species, *L. cilioides*, keying the Australian taxa, and correcting certain errors contained in Nieser and Chen, including synonymy of their *L. poliakanthina* from Queensland. While Andersen and Weir's work was in press, the first author (DAP) collected examples of still another very large new species from New Guinea, described herein as *L. grallator*, during the course of biological surveys in the Kikori Basin of southern Papua New Guinea and the Timika area of southern Irian Jaya. This latter species is the largest known from New Guinea, and it seems rather ironic that it was the last to be collected.

This spate of recent taxonomic work and collecting has necessitated the current review of *Limnometra* in New Guinea. The present paper includes a key to the 5 species known to occur on the island, a description of *L. grallator*, and distribution maps and records for all species treated. The geographical coverage includes New Guinea proper, and certain proximal islands (Salawati, Biak, Yapen, Woodlark, Normanby), but excludes the Bismarcks and Solomons, where certain unresolved taxonomic problems remain. Distributional information for taxa occurring in the Bismarcks is thus included only for those species also occurring on New Guinea proper. Of the 5 species now known to occur on New Guinea, three, *L. kallisto* (Kirkaldy), *L. cilioides* Andersen and Weir, and *L. lipovskii* Hungerford and Matsuda, are widespread within the island. The remaining two species are more circumscribed in their distributions; *L. ciliata* Mayr is found only in the northern half of the island and in the Papuan Peninsula, areas which represent geological terranes accreted to New Guinea from the Miocene onward, while *L. grallator*

n. sp. is found only south of the central mountains on portions of the island that are part of the original Australian craton.

Since *Limnometra* are large and obvious, they are captured by general collectors more often than other aquatic Heteroptera. As a result, a large historical specimen base exists, particularly at the Bishop Museum in Honolulu. These previous collections have been further augmented over the last five years through surveys by the authors in poorly known sections of Irian Jaya and southern Papua New Guinea. The maps presented herein thus provide relatively detailed depictions of species distributions within the island.

All measurements are given in millimeters. CL numbers following certain localities refer to a coding system used by the authors to cross-reference specimens and collection data.

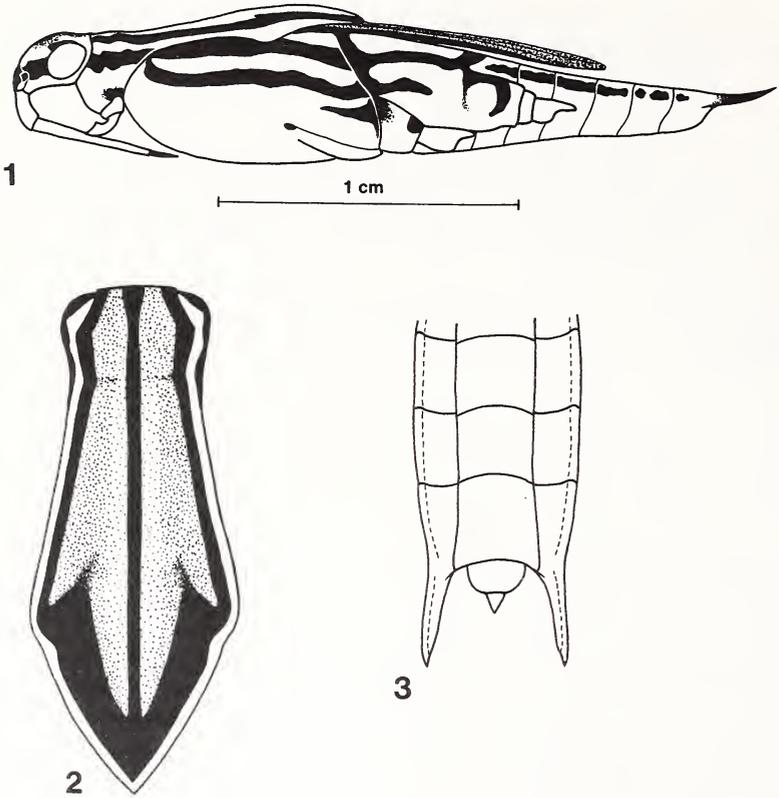
KEY TO SPECIES OF *LIMNOMETRA* OCCURRING ON NEW GUINEA

1. Connexival spines not reaching beyond apex of genital segments; eighth abdominal segment (first genital segment) of male with a backward pointing tooth-like projection on either side ventrally *L. lipovskyi* Hungerford and Matsuda
- Connexival spines reaching beyond apex of genital segments (Fig. 3); eighth abdominal segment (first genital segment) of male without a backward pointing tooth-like projection on either side (may be produced laterally, but not in a tooth-like projection) 2
2. Middle and hind femora dark on basal half, distinctly pale yellowish distally; only macropterous form present *kallisto* (Kirkaldy)
- Legs unicolorous; both macropterous and reduced winged forms may be present 3
3. All legs uniformly pale and straw colored; connexival spines very long, curved from base (Fig. 3); mid femora without long cilia *grallator* D. and J. Polhemus
- All legs dark colored; connexival spines shorter, straight; mid femora with long cilia 4
4. Eighth abdominal segment (first genital segment) of male produced laterally on either side ventrally; macropterous forms with medial dark stripe on pronotum bordered to either side by pale stripes that increase in width posteriorly, these stripes often becoming greatly expanded to form broad pale patches that cover most of the pronotal disk; paired dark stripes on mesopleura always well defined, usually with an area of pale whitish coloration between them *ciliata* Mayr
- Eighth abdominal segment (first genital segment) of male not, or only very weakly, produced laterally on either side ventrally; macropterous forms with medial dark stripe on pronotum bordered to either side by narrow pale stripes of similar width to the medial stripe, these pale stripes retaining an even width throughout their length, not becoming expanded posteriorly; paired dark stripes on mesopleura often obscure or absent, if present then usually lacking a pale whitish area between them *cilioides* Andersen and Weir

***Limnometra grillator*, n. sp.**

Figs. 1-6, 11

Diagnosis: Recognized by its large size (body length in brachypterous males exceeding 19.0 mm), yellowish-brown ground color with sharply contrasting black stripes (Fig. 1), straw colored legs without dark markings, and asymmetrical, V-shaped ventral endosomal sclerite in the male (Fig. 6).



Figs. 1-3. *Limnometra grallator* n. sp. 1. Male, lateral habitus; legs omitted. 2. Male pronotum, showing pattern. 3. Male terminal abdomen, dorsal view, showing length and shape of connexival spines.

Description: *Size.* Macropterous male, length 17.0-17.2, body width 4.9-5.1, head width 2.7-2.8; brachypterous male, length 19.0-21.5, body width 6.0-6.5, head width 2.7-2.8; macropterous female, length 16.5-17.0, body width 4.0-4.5, head width 2.4-2.5; brachypterous female unknown.

Color. Head and pronotum yellowish brown in ground color with very distinct black or dark brownish markings (Figs. 1, 2). Head between eyes with median pair of indistinct longitudinal stripes, these stripes divergent anteriorly, meeting posteriorly; a well defined dark stripe also present along inside margin of each eye; antennae brown, unicolorous, without white markings. Pronotum with relatively narrow, black, longitudinal median stripe bordered by broad pale bands, this median stripe of relatively uniform width throughout. Lateral and posterior portions of pronotum bearing black stripe parallel to margin, this stripe wider posteriorly; entire margin of pronotal lobe outside of this black stripe narrowly yellow (Fig. 2). Thoracic pleura yellowish; propleuron with broad black band behind eye; mesopleuron with two longitudinal black stripes, the upper one continued as an irregular dark stripe on the metapleuron.

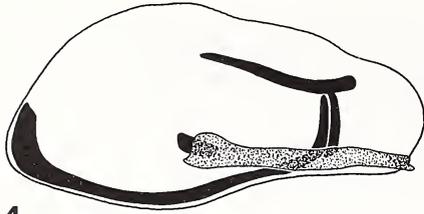
Proacetabulum with an irregular dark spot posteriorly; meso- and metacetabulae each with a dark stripe dividing two pale areas (Fig. 1). Fore wings medium brown to orange brown, with sharply contrasting dark brownish or blackish veins, but without pale subcostal markings. Fore femur and tibia uniformly yellowish brown, infuscated ventrally, fore tarsi dark brown; middle and hind legs uniformly pale yellowish brown, without pale annulations or dark apical markings. Abdomen (when visible in brachypterous form) black dorsally, with connexival margins narrowly yellow; connexival spines dark. Ventral surfaces of head, thorax and abdomen pale yellowish.

Brachypterous male elongate, length $3.4\times$ greatest body width (17.2:5.1). *Head* between eyes (anterior interocular) $1.7\times$ longer than wide (2.0:1.2); lengths of antennal segments I–IV: 5.3, 3.7, 4.5, 5.0; third and fourth rostral segments together about $1.3\times$ maximum head width across eyes (4.1:3.1). *Thorax* with pronotum long (7.9), anterior part $0.8\times$ wide as head (2.7:3.1), pronotal lobe with slightly divergent sides, widest at humeri (3.2), posterior margin angulate; meso- and metasternum with pale recumbent pubescence. *Leg* segments with lengths as follows (femur: tibia: tarsal 1: tarsal 2): fore leg, 8.5, 7.0, 1.2, 1.9; middle leg, 37.5, 38.0, 6.0, 1.0; hind leg, 39.0, 38.0, 2.3, 0.8; fore femora straight and relatively slender, maximum width distinctly less than width of middle femora (0.4:0.6); fore tibia straight; middle femur densely clothed with minute, slender, black, spine-like setae ventrally, and bearing 6–10 short, stout, black, tooth-like spinules distally, but lacking any fringe of long hairs; middle tibia similarly setiferated, bearing a longitudinal row of tiny, slender black spines along entire length; setiferation of hind femur and tibia similar to that of middle leg, but hind femur lacking tooth-like spinules distally. *Wings* narrow, only partially developed, extending half the length of abdomen *Abdomen* long and nearly parallel-sided, widening slightly posteriorly, maximum width about $0.27\times$ total length along dorsal midline (2.7:10.0); lengths of abdominal tergites IV–VI (only segments visible beyond wings) as follows: 1.0, 1.0, 1.2. Connexival spines very long, parallel to slightly divergent and basically horizontal, curving from bases, well over $2\times$ as long as the visible genital segments when viewed from above (Fig. 3); abdominal venter distinctly carinate, sternite VII shorter than sternite VI, with hind margin simply concave. *Genital segments* relatively small; venter of segment VIII distinctly shorter than that of segment VII; pygophore parallel sided, rounded distally; parameres small, rounded distally, sparsely set with extremely short setae; proctiger conical distally; vesical armature relatively simple; dorsal plate not well defined; dorsal sclerite robust, symmetrical, with distinctly widened and curved short distal part, basal part divided (Fig. 5); lateral sclerites extremely large and long (Fig. 4); accessory sclerites not evident; ventral sclerite V-shaped, asymmetrical (Fig. 6).

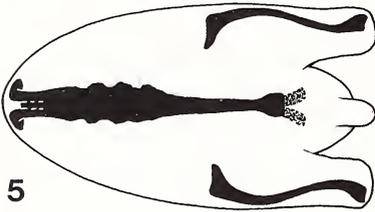
Macropterous female considerably smaller than brachypterous male, but otherwise similar in general structure and coloration, with following exceptions: forewings long, reaching to tips of connexival spines, coloration brown with darker veins, lacking pale subcostal markings; gonocoxae relatively small, exposed ventrally; proctiger small, elongate, semi-acuminate.

Macropterous male: Similar to brachypterous male in general structure and coloration, but smaller in overall body dimensions (see above). Wings medium brown, with slightly darker brown venation, lacking pale subcostal markings, extending to tips of abdominal connexival spines.

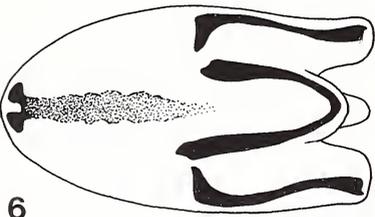
Brachypterous female: Unknown.



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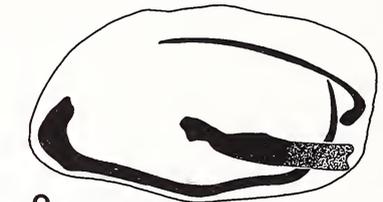
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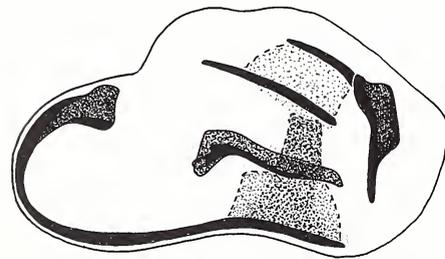
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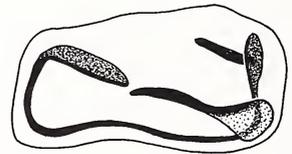
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Figs. 4-6. Male endosomal structures of *Limnometra grallator* n. sp. 4. Lateral view. 5. Dorsal view. 6. Ventral view (note asymmetrical, V-shaped ventral sclerite).

Figs. 7-10. Male endosomal structures of *Limnometra* species occurring on New Guinea (all shown in lateral view). 7. *Limnometra ciliata* Mayr. 8. *Limnometra ciliodes* Andersen and Weir. 9. *Limnometra kallisto* (Kirkaldy). 10. *Limnometra lipovskii* Hungerford and Matsuda.

Table 1. Comparison of external structural characters between *Limnometra grallator* n. sp. and *Limnometra ciliodes* Andersen and Weir:

Character	<i>ciliodes</i>	<i>grallator</i>
Leg color	Dark brown	Yellow
Setae on middle femur	Long	Short
Length of legs	Long	Extremely long
Ratio of antennal segments II/IV	25/18 (male)	23/38 (male)
Color of figures on head vertex	Black	Brown
Macropterous pronotal margins	Broadly dark	Narrowly dark
Mesopleural coloration	Light, or with two modest stripes	With two strong black stripes
Connexival spines	Long, straight, and slightly divergent distally	Extremely long, curved from base

Etymology: The name *grallator* (Latin, masculine), means “one who walks on stilts”, and refers to the extremely long legs of the brachypterous males in this species.

Discussion: Among New Guinea *Limnometra* species, *L. grallator* n.sp. is superficially most similar to *L. ciliodes* Andersen and Weir, but may be separated by the external characters given in the comparison table above.

The structure of the endosomal sclerites is also very different between the two species (compare Figs. 4 and 8). In particular, *L. grallator* has an asymmetrical, V-shaped ventral sclerite (Fig. 6) quite unlike the symmetrical, U-shaped ventral sclerite of *L. ciliodes*, but similar to the state seen in *L. kallisto*. The endosoma of *L. ciliodes* also bears several accessory lateral sclerites similar to those seen in *L. ciliata* (compare Figs. 7 and 8); such accessory sclerites are lacking in *L. grallator* and *L. kallisto* (Figs. 4, 9).

Based on current records, *L. grallator* is confined to the premontane foreland of the central mountain ranges in southern New Guinea, from the Kikori River basin westward to at least the Timika area (Fig. 11). Individuals prefer small, shaded forest streams, where they skate on sheltered pools, often occurring sympatrically with *L. kallisto*. In contrast to most *Limnometra* species, in which macropterous morphs predominate, the macropterous forms of *L. grallator* appear to be very uncommon, with only a few examples currently known.

Distribution: Southern New Guinea (Fig. 11).

Material examined (all specimens brachypterous unless otherwise noted):

HOLOTYPE, brachypterous male, PAPUA NEW GUINEA, Southern Highlands Prov., branch of upper Kara Creek (trib. to Digimu River), 5.5 km. S. of Moro oil camp, on road to Ridge camp, 900 m., water temp. 20°C., 12 March 1995, D. A. Polhemus (BPBM).

PARATYPES: PAPUA NEW GUINEA, Gulf Prov.: 2 males, 1 female (macropterous), Omo River at Omo, 40 m., water temp. 24°C., 28 February 1995, D. A. Polhemus (BPBM); 1 male (macropterous), Lubu River above Omo, 50 m., water temp. 19°C., 1 March 1995, D. A. Polhemus (BPBM); 1 male, 3 females, Wamivei Creek, near Veiru Creek, Kikori River delta, SW of Kikori, 40 m., water temp. 25°C., 5 March 1995, D. A. Polhemus (BPBM). Southern Highlands Prov.: 15 males, 8 females, same data as holotype (BPBM, USNM, JTPC); 2 males, 1 female, branch

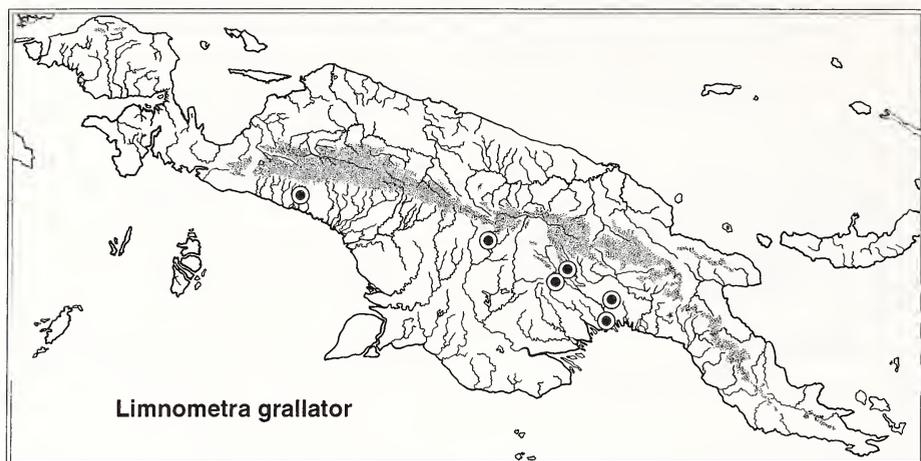


Fig. 11. Distribution of *Linnometra grillator* n. sp. in New Guinea. Stippling indicates areas above 2000 m.

of upper Kara Creek (trib. to Digimu River), 3.5 km. S. of Moro oil camp, on road to Ridge camp, 900 m., water temp. 20°C., 13 March 1995, D. A. Polhemus (BPBM); 1 male, 1 female, small rocky creek in disturbed forest, approx. 1.0 km. N. of Tubage, NE of Moro, 1000 m., water temp. 21°C., 14 March 1995, 14:30–15:00 hrs.; 22 March 1995, D. A. Polhemus (BPBM); 1 male, small rocky creek approx. 1.25 km. N. of Tubage, NE of Moro, 1000 m., water temp. 20°C., 14 March 1995, 15:00–15:30 hrs.; 22 March 1995, D. A. Polhemus (BPBM); 1 male, rocky stream at Ludesa Mission, N. of Mt. Bosavi, 700 m., water temp. of stream 23°C., 20 March 1995, D. A. Polhemus (BPBM). Western Prov.: 1 male, 2 females, Olsobip, Fly River, 400–600 m., August 1969, J. and M. Sedlacek (BPBM).

INDONESIA, Irian Jaya Prov.: 2 males, 1 female, Tributary to Iwaka River, approx. 3 km. W. of Kuala Kencana, N. of Timika, 4°24.08 S, 136°50.10 E, 300 ft., water temp. 25°C., pH 6.95, 17 January 1997, 09:30–12:00 hrs., CL 7042, D. A. Polhemus (NMNH, LIPI); 6 males, 7 females, same locality as preceding except 26 March 1997, D. A. Polhemus, J. T. Polhemus, and T. Tabuni (JTPC, LIPI); 6 males, trib. to upper Minajerwi River, approx. 1 km. E of Mile 50 tank farm on Tembapapura Road, 4°16.99 S, 137°01.56 E, 1650 ft., water temp. 23°C., 24 January 1997, 12:00–14:00 hrs., CL 7061, D. A. Polhemus (NMNH, LIPI).

Linnometra ciliata Mayr

Figs. 7, 12

Linnometra ciliata Mayr 1865, Verh. zool.-bot. Ver. Wien, 15: 444 (Type, male, Java, NHMW)

Discussion: This is the most widespread of all *Linnometra* species, occurring in lowland habitats from Indochina through the Malay Archipelago to New Guinea, the Bismarcks, the Solomons, Fiji and Guam.



Fig. 12. Distribution of *Limnometra ciliata* Mayr in New Guinea. Stippling indicates areas above 2000 m.

Distribution: New Guinea (Fig. 12), Solomons (Guadalcanal), New Britain, Guam, Fiji, Halmahera, Ambon, Bali, Sumatra, Borneo, Celebes, Mindanao, Luzon, Marinduque, Thailand, Malaysia.

New Guinea records:

PAPUA NEW GUINEA: Central Prov.: 1 female, Brown River, 5 m., stream pools, 23 October 1960, J. L. Gressitt (BPBM). East Sepik Prov.: 1 male, Brandi School, nr. Wewak, CL 1795, 10 September 1983, D. A. and J. T. Polhemus (JTPC); 1 male, Mandi Creek, E. of Wewak, CL 1797, 10 September 1983, D. A. and J. T. Polhemus (JTPC); 1 male, Yemogu Creek, 2 km. W. of Tring, CL 1805, 12 September 1983, D. A. and J. T. Polhemus (JTPC); 2 males, 2 females, waterfall nr. Pasam, CL 1798, 10 September 1983, D. A. and J. T. Polhemus (JTPC); 3 females, Ramura, NW of Wewak, CL 1801, 11 September 1983, D. A. and J. T. Polhemus (JTPC). Madang Prov.: 1 male, 1 female, Friedrichwilhelmshafen, 1901, Biro (JTPC). Milne Bay Prov.: 1 male, S. of Alotau, 29 September 1989, R. N. B. Prior (OXUM). East New Britain Prov.: 2 males, 4 females, Kerawat, Gazelle Peninsula, 60 m., 29–31 August 1955, J. L. Gressitt (BPBM). West New Britain Prov.: 2 males, West New Britain, Tamari, rainwater tank, 14 January 1989, R. N. B. Prior (OXUM); 2 males, 2 females, West New Britain, Buluma, nr. Dami, rain water pit, 17 January 1989, R. N. B. Prior (OXUM); 1 male, West New Britain, Blalla Apulpu village, freshwater creek, 27 January 1989, R. N. B. Prior (OXUM).

INDONESIA: Irian Jaya Prov.: 1 male, Manokwari, T. Barbour (JTPC); 7 males, 6 females, Yapen Is., Kabupaten Waropen, small rocky stream at Kainsami, 22 October 1991, CL 2661, R. Ubaidillah (JTPC, BPBM).

Limnometra cilioides Andersen and Weir

Figs. 8, 13

Limnometra cilioides Andersen and Weir 1997, Invert. Taxon., 11 (2): 242 (Type, macropterous male, N. Queensland, Australia, ANIC)



Fig. 13. Distribution of *Limnometra ciliodes* Andersen and Weir in New Guinea. Stippling indicates areas above 2000 m.

Discussion: All previous records of *Limnometra cursitans* from New Guinea apparently represent this species instead. It is a species of the lowlands, with no records from above 50 m. elevation (Fig. 13). Further discussion of this species' structural characters and relationships, along with a detailed map of its distribution within Australia, is provided in Andersen and Weir (1997).

Distribution: Australia, New Guinea (Fig. 13).

New Guinea records:

PAPUA NEW GUINEA: Gulf Prov.: 6 males, 15 females, roadside ponds in lowland forest, 2 km. S. of Kopi oil camp, N. of Kikori, 20 m., water temp. 24°C., 27 February 1995, D. A. Polhemus (BPBM). Western Prov.: 3 males, 4 females, Fly River above Kiunga, CL 1774, 3 September 1983, D. A. and J. T. Polhemus (JTPC).

INDONESIA: Irian Jaya Prov.: 6 macropterous males, Tanamerah, Station 31, creek in rainforest, 13 June 1957, D. F. M. (ANIC); 2 macropterous males, 5 macropterous females, 3 apterous males, 8 apterous females, Merauke, 27 March 1939, R. G. Wind (SEMK); 1 female, Bernhard Camp, 50 m., July 1938, J. Olthof, Neth. Ind.-American New Guinea Exp. (RMNH); 1 female, Teluk Bintuni, Babo, 13 August 1941, E. Linquist (NC); 1 male, 1 female, River Tor (mouth), 4 km. E. of Hol Maffin, 4 July 1959, T. C. Maa (BPBM); 5 males, 3 females, swamp forest pond S. of Walio oil field, nr. Kasim, 7 m. (20 ft.), CL 2620, water temp. 30°C., 29 Sept. 1991, J. T. and D. A. Polhemus (JTPC, BPBM).

Limnometra cursitans (Fabricius)

Gerris cursitans Fabricius 1794, Entomol. Syst. 4: 192 (Type, macropterous male, Nova Hollandia [= Australia], ZMUC)

Limnometra cursitans Banks 1909, Phila. J. Sci. 4: 583.

Limnometra poliakanthina Nieser and Chen 1992, Tijdschr. Entomol. 135: 23 (Type,



Fig. 14. Distribution of *Limnometra kallisto* (Kirkaldy) in New Guinea. Stippling indicates areas above 2000 m.

macropterous male, N. Queensland, Australia, OXUM). Syn. by Andersen and Weir 1997, *Invert. Taxon.* 11: 236.

Discussion: *Limnometra cursitans* has been recorded from New Guinea in the literature, but these records were based on misidentifications, since the true identity of this species was misinterpreted by Hungerford and Matsuda (1958) in their revision of *Limnometra*, an error subsequently followed by Nieser and Chen (1992). As now reinterpreted by Andersen and Weir (1997), *L. cursitans* is restricted to Australia, with all previous records of this species in New Guinea being referable to *L. ciliodes* Andersen and Weir.

Distribution: Australia.

New Guinea records: none known.

Limnometra kallisto (Kirkaldy)

Figs. 9, 14

Gerris kallisto Kirkaldy 1899, *Ann. Soc. Entomol. Belg.* 43:506 (Type, female, Mysol [= Misool Is.], supposed to be in ISNB, apparently lost).

Limnometra kallisto Lundblad 1933, *Arch. Hydrobiol., Suppl.* 12, *Tropische Binnengewasser* 4: 371.

Discussion: This is the most common and widespread species of *Limnometra* in New Guinea, and the only species, other than the highly precinctive *L. grallator*, to be found regularly at elevations above 100 meters (Fig. 14). It occupies a wide range of habitats, and individuals from different localities can vary greatly in size. In contrast to other New Guinea *Limnometra* species, which prefer slow waters, *L. kallisto* is often found in sheltered eddies along the margins of swift upland streams. Adults will fly readily if disturbed or pursued, alighting amid streamside vegetation. This well developed capacity for flight likely accounts for the species' broad distri-

bution within New Guinea, and for its tendency to exploit temporary habitats such as rain pools in forest roads.

Distribution: Misool (type locality), Aru, Morotai, New Guinea (Fig. 14), New Ireland, Solomons (Bougainville, Guadalcanal, Kolombangara, Malaita, San Cristoval, Vella Lavella, Choiseul).

New Guinea records:

PAPUA NEW GUINEA: Central Prov.: 1 male, 2 females, 3 km. S. of Vanapa, Brown River road, 200 m., 17–26 May 1965, around forest pool, W. A. Steffan (BPBM); 1 male, Mt. Suckling, 14 June 1972, W. H. Ewers (BPBM); 3 males, 1 female, Eio Creek, nr. Baruanumu, CL 1840, 22 September 1983, D. A. and J. T. Polhemus (JTTC). East Sepik Prov.: 1 male, Suanimbu, E. of Maprik, 180 m., 14 January 1960, T. C. Maa (BPBM); 1 female, Bainyik, nr., Maprik, 225 m., 20–21 July 1961, J. L. and M. Gressitt (BPBM). Eastern Highlands Prov.: 1 male, Kassam Pass, 1460 m., 18 August 1963, J. Sedlacek (BPBM); 1 male, 18 km. S. of Okapa, 1300 m., 2 June 1967, on water trickle, G. A. Samuelson (BPBM). Gulf Prov.: 2 males, 2 females, Lubu River above Omo, 50 m., water temp. 19°C., 1 March 1995, D. A. Polhemus (BPBM); 1 female, Wamivei Creek, near Veiru Creek, Kikori River delta, SW of Kikori, 40 m., water temp. 25°C., 5 March 1995, D. A. Polhemus (BPBM). Madang Prov.: 1 male, 1 female, Seleo, Berlinhaf. [Berlinhafen], 1896, Biro (JTTC); 1 female, Adelbert Mtns., Wanuma, 800–1000 m., 26 October 1958, J. L. Gressitt (BPBM). Milne Bay Prov.: 3 males, 2 females, Modewa Bay, Modewa, 0–50 m., 22 December 1956, L. J. Brass, Fifth Archbold Expedition to New Guinea (JTTC); 1 female, Woodlark Is., Murua, Kulumadau Hill, 16 February 1957, W. W. Brandt (BPBM); 9 males, 4 females, Normanby Is., Wakaiuna, Sewa Bay, 11–20 December 1956, W. W. Brandt (BPBM); 1 male, 3 females, Naura, 5 km. W. of Milne Bay, 7 November 1965, R. Straatman (BPBM); 1 female, Mt. Dayman, Maneau Range, 700 m., N. slope, 13–20 July 1953, G. M. Tate (JTTC); 1 male, 1 female, S. of Alotau, 29 September 1989, R. N. B. Prior (OXUM). Morobe Prov.: 2 males, 4 females, Garaina, 800 m., 15–16 January 1968, J. and M. Sedlacek (BPBM); 1 female, 16 km. W. of Mumeng, 80 km. N. of Wau, 900–1500 m., May 1962, J. Sedlacek (BPBM); 4 males, 7 females, Huon Peninsula, Finschhafen, 80–200 m., 13 April 1963, J. Sedlacek (BPBM); 1 male, Huon Peninsula, Pindiu, 870–1500 m., 21–22 April 1963, J. Sedlacek (BPBM); 1 male, Ulap, 800–1100 m., September 1968, N. L. H. Krauss (BPBM); 1 female, Lae, July 1944, F. E. Skinner (BPBM); 1 female, Wampit Vally, nr. Gurakor village, 950 m., 7 July 1957, D. E. Hardy (BPBM); 1 female, Mt. Lawson, N. Kakoro Gulf, 50–200 m., 16 March 1974, Gressitt and Reni (BPBM). New Ireland Prov.: 3 males, 8 females, Gilingil Plain, 2 m., 16 July 1956, J. L. Gressitt (BPBM); 2 males, ridge above "Camp Bishop", 15 km. up Kait River, 250–750 m., 14 July 1956, J. L. Gressitt (BPBM); 1 male, 1 female, old German road W. of Karu Plateau, 40 km. N. of Namatanai, 9 December 1969, J. E. Tobler (JTTC). Southern Highlands Prov.: 1 male, slow trib. to Mubi River, SE of Kantobo, 380 m., water temp. 22°C., 8 March 1995, D. A. Polhemus (BPBM); 2 males, 4 females, Auwa Creek, nr. Kafka, NW of Kantobo, 520 m., water temp. 22°C, 9 March 1995, D. A. Polhemus (BPBM); 2 males, 2 females, swift clear trib. to Digimu River, 1 km. above Sorotage, 400 m., water temp. 23.5°C., 10 March 1995, D. A. Polhemus (BPBM); 3 males, 7 females, Ofake Creek, trib. to Mubi River, 2 km. NW of Kantobo, 380 m., water temp. 23.5°C., 11 March 1995, D. A.

Polhemus (BPBM); 1 male, 4 females, branch of upper Kara Creek (trib. to Digimu River), 3.5 km. S. of Moro oil camp, on road to Ridge camp, 900 m., water temp. 20°C., 13 March 1995, D. A. Polhemus (BPBM); 3 males, 2 females, small forest tributary to upper Mubi River at Swinging Bridge, nr. Tubage, NE of Moro, 900 m., water temp. 20°C., 14 March 1995, D. A. Polhemus (BPBM); 2 males, 1 female, small rocky creek in disturbed forest, approx. 1.0 km. N. of Tubage, NE of Moro, 1000 m., water temp. 21°C., 14 March 1995, 14:30–15:00 hrs.; 22 March 1995, D. A. Polhemus (BPBM); 1 male, impounded roadside stream in forest at Moro oil camp, 840 m., water temp. 25°C., 14 March 1995, 16:00–17:00 hrs.; 24 March 1995, D. A. Polhemus (BPBM); 7 males, 5 females, small rocky stream on N. slope of Mt. Bosavi, 1250 m., water temp. 19°C., 16 March 1995, 14:30–17:00 hrs.; 17 March 1995, D. A. Polhemus (BPBM); 3 males, 2 females, swift rocky stream in moss forest on N. slope of Mt. Bosavi, 1400 m., water temp. 18°C., 19 March 1995, D. A. Polhemus (BPBM). East New Britain Prov.: 1 male, Gazelle Peninsula, upper Warangoi, 250–600 m., 28–30 November 1962, J. Sedlacek (BPBM). West Sepik Prov.: 1 male, Amok [nr. Aitape], 165 m., 6 January 1960, T. C. Maa (BPBM); 1 male, 3 females, Dreikkir, 350 m., 23 June 1961, J. L. and M. Gressitt (BPBM); 3 males, Telefomin, March–June 1971, A. B. Mirza (BPBM); 2 females, Torricelli Mtns., Mobitei, 750 m., 1–15 April 1959, W. W. Brandt (BPBM). Western Prov.: 1 male, Fly River, Olsobip, 400–500 m., August 1969, J. and M. Sedlacek (BPBM); 7 males, 3 females, Fly River above Kiunga, CL 1774, 3 September 1983, D. A. and J. T. Polhemus (JTPC). Western Highlands Prov.: 1 male, Baiyer River, 1150 m., 17 October 1958, J. L. Gressitt (BPBM); 1 male, Kukur, upper Jimi Valley, 1000 m., 13 July 1955, J. L. Gressitt (BPBM).

INDONESIA: Irian Jaya Prov.: 1 female, Humboldt Bay Dist., Pukusam Dist., W. of Tami River, June 1937 (JTPC); 7 males, 4 females, Bernhard Camp, 100 m., 13 April 1939, L. J. Toxopeus, Neth. Ind.-American New Guinea Exp. (RMNH); 2 males, 5 females, Vogelkop, Bomberi, 700–900 m., 6 June 1959, T. C. Maa (BPBM); 3 males, 3 females, Biak Is., Kampong Landbouw, 50–100 m., 29 May 1959, J. L. Gressitt (BPBM); 1 male, Nabire, S. Geelvink Bay, 0–30 m., 2–9 July 1962, J. L. Gressitt (BPBM); 5 males, 3 females, Waris, S. of Hollandia, 450–500 m., 24–31 July 1959, T. C. Maa (BPBM); 3 males, Genjam, 40 km. W. of Hollandia, 100–200 m., 1–10 March 1960, T. C. Maa (BPBM); 1 male, 3 females, Kebar Valley, W. of Manokwari, 550 m., 4–31 January 1962, S. Quate (BPBM); 1 female, Hollandia (Kota Bharu), 13 March 1960, T. C. Maa (BPBM); 3 males, 2 females, Central Mtns., Archbold Lake, 760 m., 26 November–3 December 1961, S. and L. Quate (BPBM); 4 males, 7 females, W. of Sentani, 90+ m., 24 January 1959, T. C. Maa (BPBM); 3 males, 4 females, Fak Fak, S. coast Bomberai, 9 June 1959, T. C. Maa (BPBM); 2 males, 1 female, Star Mtns., Sibil Valley, 1245 m., 31 October 1961, S. Quate (BPBM); 12 males, 7 females, Salawati Is., Wajaar River, Wagon Mountains, W. of Sorong, CL 2623, 0–30 m. (0–100 ft.), water temp. 28°C., 30 Sept. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 2 males, 5 females, small forest trib. to Klagalo River at old Klagagi oil field, SE of Sorong, CL 2628, 45 m. (150 ft.), water temp. 25.5°C., 1 Oct. 1991, D. A. Polhemus (JTPC, BPBM); 4 males, 4 females, pools in muddy lowland rain forest streambed, 28 km. NE of Kasim on pipeline road, CL 2630, 15 m. (50 ft.), 2 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 5 males, 5 females, 8 immatures, upper Kali Mati River, 10 km. N. of Fak Fak, CL 2633,

275 m. (900 ft.), water temp. 23°C., 10 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 1 male, pools in dry bed of middle Kali Mati River, 8 km. N. of Fak Fak, CL 2634, 230 m. (750 ft.), 10 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 8 males, 7 females, Mupi River, above Warkomi, Arfak Mountains, 38 km. S. of Manokwari, CI 2646, 150 m. (500 ft.), water temp. 19°C., 18 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 7 males, 5 females, Saumarin River, nr. Warkomi, Arfak Mountains, 42 km. S. of Manokwari, CL 2647, 90 m. (300 ft.), water temp. 25°C., 18 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 4 males, 2 females, Kabori River, nr. Warkomi, Arfak Mountains, 41 km. S. of Manokwari, CL 2648, 15 m. (50 ft.), water temp. 25°C., 18 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 3 males, 3 females, small rocky stream at Aimasi Hulu, Arfak Mountains, 65 km. SW of Manokwari, CL 2649, 140 m. (450 ft.), water temp. 25°C., 19 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 7 males, 3 females, intermittent stream with pools at Kuala Kencana light industrial park, N. of Timika, 4°26.21 S, 136°51.84 E, 300 ft., water temp. 25°C., 17 January 1997, 14:00–15:00 hrs, and 20 January 1997, 09:30–11:30 hrs., CL 7043, D. A. Polhemus (USNM, LIPI); 4 males, 4 females, small forest streams and pools along Kopi River road, NE of Timika, 4°25.25 S, 136°56.44 E, 400 ft., water temp. 27°C., 18 January 1997, 08:00–11:00 hrs., CL 7044, D. A. Polhemus (USNM, LIPI); 4 females, small rocky stream at Mile 50 storage tank site on Tembapapura Road, 34 km. N. of Timika, 4°16.99 S, 137°00.86 E, 2000 ft., water temp. 22°C., 19 January 1997, 09:00–10:00 hrs., CL 7046, D. A. Polhemus (USNM, LIPI); 1 male, pond and blackwater stream 2.4 km. S. of Mile 50 storage tank site on Tembapapura Road, 31.5 km. N. of Timika, 4°17.93 S, 136°59.98 E, 1900 ft., water temp. 25°C., 19 January 1997, 11:15–12:00 hrs., CL 7047, D. A. Polhemus (USNM); 1 male, 5 females, sago swamp and swift roadside drainage ditch at Km. 22 on Portsie road, 15 km. S. of Timika, 4°38.74 S, 136°53.93 E, 50 ft., water temp. 27°C., pH 7.45, 21 January 1997, 11:00–11:30 hrs., CL 7054, D. A. Polhemus (USNM, LIPI); 4 males, 5 females, upper Minajerwi River and swift tributary, approx. 1 km. E. of Mile 50 tank farm on Tembapapura Road, 4°16.99 S, 137°01.56 E, 1650 ft., water temp. 23°C., 24 January 1997, 12:00–14:00 hrs., CL 7061, D. A. Polhemus (USNM, LIPI); 3 males, 3 females, small rocky stream along N. side of P. T. Freeport Indonesia Etna Bay exploration camp, head of Etna Bay, 0–60 m. (0–200 ft.), 3°58.10'S, 134°57.68'E, water temp. 25–27°C., 28–29 March 1997, CL 7077, D. A. and J. T. Polhemus (USNM). Maluku Prov.: 2 males, 1 female, Aru Archipelago, Trangan Is., 1 km. S. of Popjetur, 6°48'S, 134°4'E, 10 July 1994, A. H. Kirk-Spriggs (NMWC).

Limnometra lipovskii (Kirkaldy)

Figs. 10, 15

Limnometra lipovskii Hungerford & Matsuda 1958, Univ. Kansas Sci. Bull. 39: 399 (Type, macropterous male, Guadalcanal, SEMK).

Discussion: *Limnometra lipovskii* is rather uncommon and localized in New Guinea, being found only in the coastal lowlands or along larger rivers (Fig. 15), and few series from the island are present in major collections. This species was overlooked completely by Nieser and Chen (1992) in the review of *Limnometra* of the Indo-



Fig. 15. Distribution of *Limnometra lipovskii* Hungerford and Matsuda in New Guinea. Stippling indicates areas above 2000 m.

Australian region; neither it or any other of the species occurring in New Guinea is included in their key.

Distribution: New Guinea (Fig. 15), Solomons (type locality: Guadalcanal), Australia, Halmahera.

New Guinea records:

PAPUA NEW GUINEA: Gulf Prov.: 2 males, 2 females, roadside ponds in lowland forest, 2 km. S. of Kopi oil camp, N. of Kikori, 20 m., water temp. 24°C., 27 February 1995, D. A. Polhemus (BPBM). Western Prov.: 1 male, 1 female, Fly River above Kiunga, CL 1774, 3 September 1983, D. A. and J. T. Polhemus (JTPC); 1 male, 1 female, Fly River at Kiunga, CL 1864, 5 September 1983, D. A. and J. T. Polhemus (JTPC). East Sepik Prov.: 1 female, Ramumba, NW of Wewak, CL 1801, 11 September 1983, D. A. and J. T. Polhemus (JTPC).

INDONESIA, Irian Jaya Prov.: 2 males, 1 immature, Biak Is., Kampong Landbouw, 50–100 m., 27 May 1959, J. L. Gressitt (BPBM); 2 males, 3 females, swamp forest pond S. of Walio oil field, nr. Kasim, CL 2620, 7 m. (20 ft.), water temp. 30°C., 29 Sept. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 2 males, 1 female, Salawati Is., Wajaar River, Wagom Mountains, W. of Sorong, CL 2623, 0–30 m. (0–100 ft.), water temp. 28°C., 30 Sept. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 10 males, 18 females, Batuputih River nr. Krooy, 3 km. NW of Kaimana, CL 2639, 30 m. (100 ft.), water temp. 26°C., 12 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 1 male, Airtiba River, 3 km. NW of Krooy, NW of Kaimana, CL 2640, 15 m. (50 ft.), water temp. 26°C., 13 Oct. 1991, J. T. and D. A. Polhemus (JTPC, BPBM); 1 male, wetlands in former Ajkwa River channel near Km. 21 on Portsited road, 16 km. S. of Timika, 4°39.91 S, 136°53.83 E, 50 ft., water temp. 26.5°C., pH 7.4, 21 January 1997, 10:00–11:00 hrs., CL 7053, D. A. Polhemus (NMNH); 3 males, 2 females, pond and blackwater stream 2.4 km. S. of Mile 50 storage tank site on Tembagapura Road, 31.5 km. N. of Timika, 580 m., 4°17.93 S, 136°59.98

E., water temp. 25°C., 5 March 1997, 11:00–12:00 hrs., CL 7047, D. A. and J. T. Polhemus (USNM, JTPC). Maluku Prov.: 1 male, 1 female, Aru Archipelago, Trangan Is., 1 km. E. of Ngalgull, 90 m., 6°48'S, 134°4'E, 29 July 1994, A. H. Kirk-Spriggs (NMWC).

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The holotype of *Limnometra grillator* is deposited in the Bishop Museum, Honolulu (BPBM); paratypes are held in that collection, the J. T. Polhemus collection, Englewood, Colorado (JTPC), and the Museum Zoologicum Bogoriense, Bogor (LIPI).

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A NEW SPECIES OF LEAF-MINING *OULEMA* FROM PANAMA (COLEOPTERA: CHRYSOMELIDAE; CRIOCERINAE)

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Abstract.—A new species of leaf-miner, *Oulema pumila* (Chrysomelidae:Criocerinae), from central Panamá is described and illustrated. Host plant and life history data are given. One of the smallest species, it is only the second record of the leaf-mining habit and the first host record from the Piperaceae recorded for the subfamily. Leaf-mining appears to be derived in this instance and we offer some observations on its evolution.

In 1994, one of us (A.A.) reared three beetles from mines in the leaves of an unidentified cultivated species of *Peperomia* (Piperaceae) in Arraiján, Panamá Province, Panamá. The new beetle belongs to the genus *Oulema* Des Gozis (Coleoptera: Chrysomelidae) and is one of the smallest members of the shining leaf beetle subfamily Criocerinae. The Criocerinae are a cosmopolitan group of nearly 2000 species noted for their smooth, often colorful appearance, narrow, unmarginated pronotum and excrement-covered, folivorous larvae. Our report of leaf-mining larvae for this species is only the second one for the Criocerinae. Moreover, it is the first shining leaf beetle recorded from the Piperaceae.

Although there is no universal agreement as to whether *Oulema* is a genus in its own right, or merely a subgenus within *Lema* (see for example Mohr, 1985), our use of *Oulema* follows the concept of White (1993) and Monrós (1960). Members of the genus *Oulema* have the following distinguishing characteristics: antennal tubercles very close together or touching; angle of grooves separating vertex from the frons less than 90°; the vertex is often produced into tubercles; pronotal constriction weak, sub-medial to basal; antennae length longer than ½ the body length; elytra without color patterning; 9th stria frequently interrupted for 2–8 punctures; aedeagus with lateral lobes more or less parallel and not concealing the medial lobe.

Measurements were made with an ocular micrometer. Dimensions were taken from prominent morphological features: elytral length from humerus to apex, and total length from vertex to elytral apex along the meson because the head is directed downward. The habitus drawing was made using india ink, chalk, negro and charcoal pencils on Coquille board.

Oulema pumila, new species

Fig. 1

Diagnosis: Head and pronotum narrower than the elytra, claws connate. Extremely small size of 2.6 to 2.9 mm total length. The head, pronotum and abdomen are

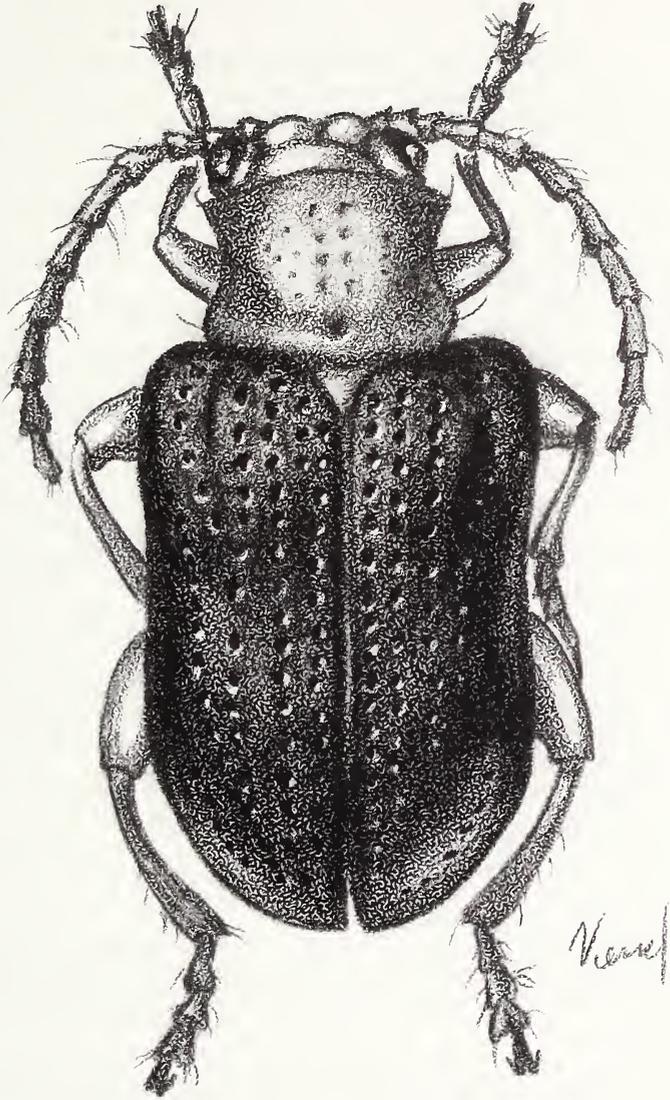


Fig. 1. *Oulema pumila*, dorsal habitus, holotype female.

yellowish orange. The head, is distinctly bituberculate at the vertex. The elytra are black with an iridescent violet tint.

Description: Form sub-cylindrical. Total length 2.6 to 2.9 mm including the tubercles of the vertex. *Head:* yellowish orange, shiny, much narrower than the anterior width of the pronotum. Clypeus, labrum and mouth parts brownish black. Frons separated from the vertex by deep grooves that form an "X" with the angle between them less than 90°, the antennal tubercles almost touching and much closer together than the frons-vertex junction. Vertex deeply divided by a broad, longitudinal groove and produced laterally into two elliptical tubercles. Antennae dark brown, longer than ½ the length of the body, eleven segmented, filiform but widening very gradually toward the apex. Eyes very weakly notched by less than ¼ their width; head moderately constricted behind the eyes. *Pronotum:* Pale orange with a yellowish cast, shiny and emarginate; slightly wider than long; the apex slightly wider than the basal width. A shallow transverse constriction, 94% of the apical width, divides the pronotum sub-medially at its basal ⅓ and bears a large medial pit. Disc with two longitudinal, medial rows of 5–6 medium-sized pits. *Elytra:* Violet-black and shiny with an iridescent reflection; a transverse depression at the basal ⅓; punctuation of the 10 striae medium in size and widely spaced but well aligned; the 9th stria incomplete for 4–5 punctures; scutellum orange. *Ventral side:* Pale orange with brownish melanism, shiny and covered with sparse setae; punctuation of mesosternum coarse, sparse and most dense near anterior edges; coxae pale yellowish orange. *Legs:* entirely light yellow with a brownish cast to the dorsal surfaces; two apical tarsal spurs; claws brownish-black, connate and simple.

Holotype. Female: PANAMA, Panama province, Arraiján, 24 Sept. 1994. A. Aiello.
Location: United States National Museum.

Paratypes. 1 female and 1 male, same data as holotype. The female is deposited in the United States National Museum. The male is in the senior author's collection.

Variation. Paratype female 2.8 mm in length; paratype male 2.65 mm long with a brownish cast to ventral surfaces and the 9th stria interrupted for only 3 punctures.

Pupation. 10 Sept. 1994.

Eclosion. 24–25 Sept. 1994.

Pupation Chamber. White, foamy in texture, 3.5 mm long, 2.1 mm wide.

Host Plant. *Peperomia* sp. (Piperaceae).

Etymology. From the Latin meaning dwarfish.

Remarks: Although the aedeagus of the single male at our disposal was lost during dissection, it was observed to have had the sides of the lateral lobes parallel and not concealing the medial lobe, which conforms to the aedeagal characteristics for the genus *Oulema*.

Oulema pumila is most closely allied to Lacordair's (1845) second division that includes *Lema* species, *sensu lato*, that are distinguished by having red bodies and blue elytra with the 9th stria interrupted. Among the smallest species in the division, *Oulema pumila* can be differentiated from: *L. tenella*, by lacking a black abdomen; *L. jocosa* and *L. concinna* by lacking elytral markings of any kind; *L. vidua* and *L. impura* by lacking yellow elytra; *L. stolidia* by lacking an entirely black body; and from *L. gilveola* by having a notched eye.

Discussion: This tiny species is a rare denizen of Caribbean rain forest where it is a miner in the leaves of epiphytic pipers. This is the first host record for the Cri-

ocerinae from the Piperaceae. Examination of herbarium material revealed *Peperomia macrostachya* specimens with mines large enough to have been made by an insect the size of *O. pumila*. In addition, one pupal chamber in the leaf mesophyll was lined with a white, foamy substance typical of the buccal material produced by members of the subfamily Criocerinae to form pupation chambers.

Monrós (1960) mentions *Lema quadrivittata* de Borre as a leaf-miner of plants in the Commelinaceae of South America. *Oulema pumila* can be differentiated readily from *L. quadrivittata* by (1) the lack of elytral stripes, (2) size smaller than 4.2 mm and, (3) disparate host association.

The genus *Oulema* as proposed by Des Gozis (1886), embraces New and Old World Lemiini that fall into the red body/blue elytra category. This cosmopolitan genus of leaf beetles, recently augmented by White (1993), now includes 20 North American species, of which host plants are known for 15. It is interesting to note that the larvae of Old World species feed on the Poaceae while their New World cousins feed mainly on members of the dayflower family Commelinaceae. This may well indicate that a very old split in the genus occurred well before the appearance of the grasses, perhaps as a consequence of the break-up of Gondwana some 135 million years ago. The total number of species assigned to the genus undoubtedly will increase following much needed revision and reassignment of Central and South American species. The addition of *O. pumila* brings the number of Panamanian species in the subfamily Criocerinae to 34 (Vencl, *in prep.*).

Larvae of the entire subfamily Criocerinae are noteworthy for their peculiar habit of accumulating excrement on their backs to form fecal shields. Recently, fecal shields were demonstrated to contain predator deterrent chemicals derived entirely from host-plant metabolites (Morton and Vencl, 1998). When forced to feed on the surface, stem boring and probably leaf mining larvae form fecal shields (Richardson, 1893; Kaufmann, 1967; Vencl, pers. ob.). The retention of the shield-forming potential suggests that mining and boring are derived behaviors. Internal feeding modes obviate the need for a shield defense. When the proposed sister taxa to the Chrysomelidae, the Bruchidae and Cerambycidae, all with internally feeding larvae, are considered together with the numerous instances of gallicoly, stem, root and leaf-mining larvae within the Chrysomelidae itself, it becomes evident that surface folivory by leaf beetle larvae is a derived mode of feeding (Crowson, 1981). We suspect this to be the case because folivorous larvae, which are physically exposed, soft bodied and flightless, are more vulnerable to predators and parasitoids than are eggs, pupae or adults. These observations implicate natural enemies as major determiners of feeding behavior in leaf beetles in general and perhaps of leaf-mining in *O. pumila* in particular. Endophytism, which is uncommon in related criocerines, is a specific adaptation by *O. pumila* to the threat of predation and may well represent an evolutionary reversal. However, we cannot exclude the possibility that mining in this instance is a retained, ancestral habit until the host is analyzed for the presence or absence of compounds known to be effective in the shield defenses of *Oulema pumila*'s relatives.

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**NECTARINELLA XAVANTINENSIS, A NEW NEOTROPICAL
SOCIAL WASP (HYMENOPTERA: VESPIDAE; POLISTINAE)**

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Abstract.—*Nectarinella xavantinensis*, a new epiponine species from the Neotropics, is described and the nest illustrated. This is the second known species in the genus and the first described from South America. A comparison with the other species from this genus is made. Comments regarding the biogeographical distribution of the genus are added.

Nectarinella Bequaert is a monotypic genus of social wasps. It belongs to the tribe Epiponini (Carpenter, 1993) of the family Vespidae, composed of polygynous, swarm-founding wasps. The only previously known species, *Nectarinella championi* (Dover, 1924) is recorded from Central America (Richards, 1978) and Colombia (Schremmer, 1977) and presents astelocytarous nests (Richards, 1978; Wenzel, 1991). This paper describes a new species, *Nectarinella xavantinensis*, found in Mato Grosso, center-western Brazil.

Nectarinella xavantinensis, new species

Diagnosis: Predominantly brownish. Malar area reduced and bare, epistomal suture sinuate with rounded corners (Fig. Aa), clypeus wider than high (Fig. A). Head with sparse punctures with erect hairs, the interantennal area elevated forming a V-shaped protuberance (Fig. Bb). Pronotum grossly punctured with evident pronotal lip, acute pronotal lobule (Fig. Cc). Mesonotum and scutellum grossly punctured, there is a small space between the epistomal suture and the inner orbital margin in the lower part of the eye (Fig. Af).

Description:

Female: Mean forewing length 5.85 mm. *Structure:* frons sparsely punctured, with hairs in each minute puncture, covered with short pubescence. Clypeus wider than high and sinuous, usually with two short longitudinal indefinitely shaped markings, delimited by the epistomal suture (Fig. 1Aa). Epistomal suture with curved angles (Fig. 1Aa). Interantennal area forming an elevated protuberance (Fig. 1Bb). Malar area reduced and bare. Pronotum grossly punctured with hairs; dorsal pronotal carina evident, pronotal lobule forming an acute angle (Fig. 1Cc). Mesonotum with a reduced carina. Scutellum with hairs arising from large punctures. Mesoscutum sparsely punctured with short hairs and two stripes extending longitudinally, wider at the edges (Fig. 1Cd). Post-scutellum slightly narrower than scutellum, with parallel sides, anterior margin transverse, posterior margin rounded, shiny and almost impunctate; propodeum wider than long, broadly and shallowly depressed medially,

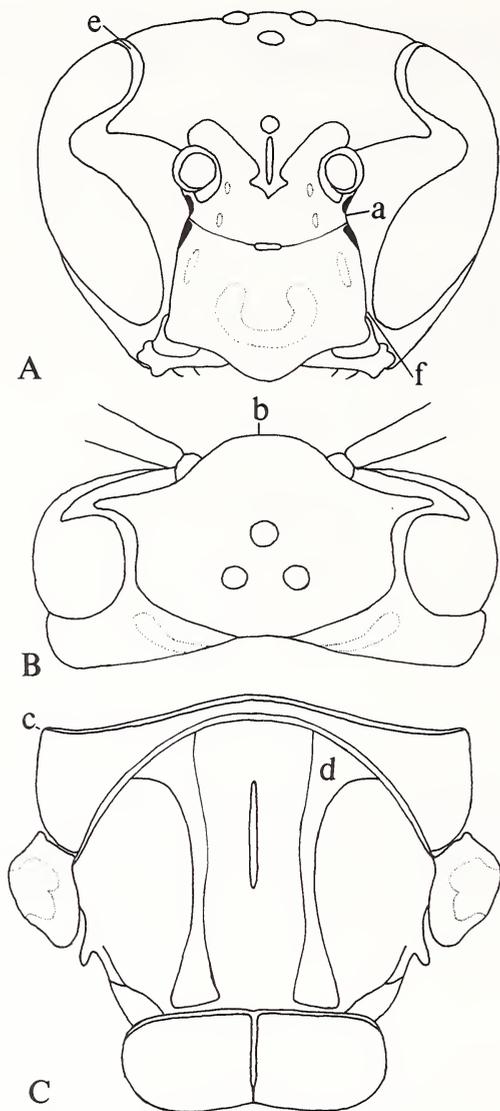


Fig. 1. Head (A, B) and thorax (C) of *Nectarinella xavantinensis*. Other explanations in the text.

more or less impunctate, with comparatively long hairs on the sides. The first two segments of the abdomen with recumbent hairs arising from fine punctures, giving a finely striated appearance; succeeding segments very closely punctate with short hairs. Legs with pubescent hairs maculae close to the articulations.

Color—head black and yellow, covered with short golden pubescence, clypeus yellow with hairs, usually with two brownish-light markings; interantennal area yellow,

genae yellow having an ochraceous area extending to the occiput just behind the middle of each posterior ocellus; paraocular spot yellow, continuous, reaching the occiput, frons black with median line above the antennal sockets. Eyes dark brown; antennae mostly ochraceous, lighter on the underside, outer side of flagellum, except the three apical articles, brownish-dark. Mandibles light brown, pronotum ochraceous with short golden brown hairs arising from large punctures, yellow line at the superior margin of the dorsal pronotal carina. Mesonotum yellow-ochraceous, scutellum predominantly yellow with golden brown hairs. Mesoscutum predominantly black with golden short hairs and two curved stripes. Post-scutellum yellow, propodeum yellow with comparatively long golden brown hairs on the sides. Abdomen brownish, the first two segments with dark brown short hairs, succeeding segments with short golden hairs, third to sixth segments brownish-light with lateral margin yellow; seventh segment ochraceous. Legs ochraceous with yellow maculae close to articulations, wings iridescent-hyaline, with cubito-radial and costal area darker than the rest, veins brownish-light with short hairs, tegulae ochraceous.

Male: Unknown.

Type material: holotype female, Brazil: Novo São Joaquim (Mato Grosso - April 04, 1996), Nova Xavantina region (14°45'S, 52°55'W). Collected by Mateus, S. & Noll, F.B. Holotype and two paratypes deposited in the collection of Museu de Zoologia—USP, Brazil; two paratypes in the Museu E. Goeldi, Brazil; two paratypes in the American Museum of Natural History.

Etymology: the specific name *N. xavantinensis* is a reference to the brazilian town of Nova Xavantina in the state of Mato Grosso.

Nest: *Astelocytarus*. Found Apr. 04 1996, 80 km west of Nova Xavantina (center-western Brazil). The nest was located 3.5 meters high in a *Psidium* sp. tree (Myrtaceae), in a secondary branch with 30° slope in relation to the ground. Comb with 103 cells, all of them with eggs; no meconia were found, indicating that the nest was very young.

Envelope: Made of vegetal fibers mixed with salivary substances, predominantly light gray; with longitudinal green stripes (Fig. 2). Nest entrance located in the lower portion of the envelope, ring-shaped and 5 mm in diameter. As in *N. championi* the bark around the envelope showed small droplets of sticky substance which may serve against ant protection (Schremmer, 1977).

Comb: Located centrally, with lateral spaces between the envelope and cells, 2 cm wide above and 4 cm below. All cells were sessile, directly built on the substrate using the same material as the envelope. The cells were 3.5–3.7 mm wide. At the center of the comb, complete cells were 4 mm high. Lower cells usually 1 mm high were located at the periphery of the comb (Fig. 2). The cells had no paper bottom and the eggs were laid on the cell walls very close to the bottom. No droplets of stored nectar were found in any of the cells.

Remarks: *Nectarinella xavantinensis*, presents several morphological differences distinguishing it from *N. championi*. The most conspicuous features separating *N. xavantinensis* from *N. championi* are as follows.

Head: *Nectarinella xavantinensis* has sparsely punctures with erect hairs. The inter-antennal area is more elevated in *Nectarinella xavantinensis* (Fig. 1Bb), forming a V-shaped protuberance. The paraocular spot reaches the occiput in *Nectarinella xavantinensis* (Fig. 1Ae) but in *Nectarinella championi* it is interrupted in the ocelli

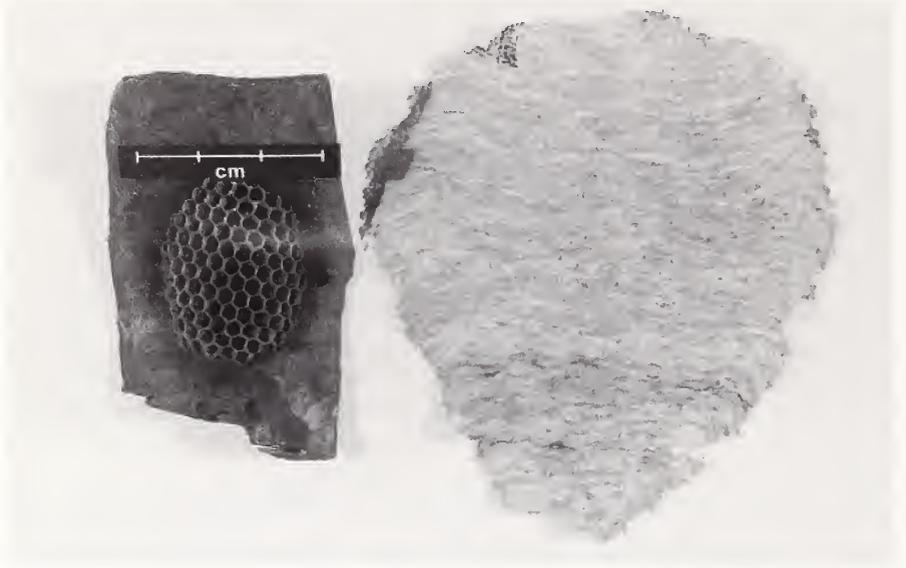


Fig. 2. Nest (comb—left and envelope—right) of *Nectarinella xavantinensis*.

height. The clypeus is wider than high in *Nectarinella xavantinensis* (Fig. 1A), in *Nectarinella championi* it is as wide as high. In *Nectarinella xavantinensis* epistomal suture is sinuate, with rounded corners, especially in the anterior tentorial fovea. There is a small space between the epistomal suture and the inner orbital margin in the lower part of the eye (Fig. 1Af). In *Nectarinella championi* the space between the tentorial fovea and the epistomal suture forms a 90° angle. This suture reaches the mandible passing through the inner orbital margin.

Pronotum: In *Nectarinella xavantinensis* grossly punctured with short hairs and the pronotal lip is much more evident than in *Nectarinella championi*. The pronotal lobule in *Nectarinella xavantinensis* (Fig. 1Cc) is acute and in *Nectarinella championi* is around.

Mesonotum: grossly punctured with a small sulcus in the anterior part. In *Nectarinella championi* this sulcus is more evident with iridescent hairs and short bristles. The scutellum in *Nectarinella xavantinensis* is grossly punctured with erect bristles. In *Nectarinella championi* the punctures are thinner.

Abdomen: *Nectarinella xavantinensis*—Brownish with fine punctures, short hairs and erect bristles close the margins. First segment with central spot, second segment with marginal maculae and sparse hairs. Other segments with stripes of yellow spots near the margins, short hairs and erect bristles. In *Nectarinella championi* the abdomen is predominantly ochraceous with stripes at the distal margins, and short hairs.

Legs: *Nectarinella xavantinensis* has maculae close to articulations and pubescent hairs. In *Nectarinella championi* these maculae are absent.

Wings: *Nectarinella xavantinensis*—veins brownish-light with short hairs and the area between the cells Cu radial and costal are darker than the rest. In *Nectarinella championi* short hairs are spread in all wings regions.

Finally, the biogeographic distribution of both *Nectarinella* species is remarkable especially because it differs from other groups with wide distribution such as *Agelaisia* and *Polybia* (Richards, 1978). These two species are vicariant. However, their presence in two disjunct areas reflects either scarce field collections or truly disjunct distribution. Evidently, the solution will depend on additional collecting.

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**DESCRIPTION OF IMMATURE STAGES OF TWO SPECIES OF
PSEUDOLAMPSIS (COLEOPTERA: CHRYSOMELIDAE) AND THE
ESTABLISHMENT OF A NEW COMBINATION IN THE GENUS**

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Abstract.—The taxonomic history of species of *Pseudolampsis* is discussed and a new combination, *Pseudolampsis darwini* is formed. *Distigmoptera darwini* which had previously been synonymized with *P. guttata* is shown to be a unique species based on characters of larval and genitalic morphology. The immature stages of *Pseudolampsis guttata* and the third instar larva and pupa of *Pseudolampsis darwini* are described and figured. These larvae are compared with other known larvae of Alticini.

Resumen.—Se discute la historia taxonómica del género *Pseudolampsis* y se forma la nueva combinación de *Pseudolampsis darwini*. Se demuestra que *Distigmoptera darwini*, previamente sinonizada con *P. guttata* es especie única, basándose en las características de la larva y la morfología de la genitalia. Se describen y trazan las etapas inmaduras de *Pseudolampsis guttata* y el último estadio y la pupa de *Pseudolampsis darwini*. Estas larvas se comparan con otras larvas conocidas de Alticini.

One of the easiest to recognize but most poorly known groups in the Alticini are the “monoplatines”, a group of small elongate beetles with continuous pubescence covering body and elytra, with very enlarged metafemora, globosely swollen last tarsal segment and nine elytral striae (Scherer, 1962). This is a neotropical group with 37 genera, over half described by Clark (1860) and first proposed as a group, as the Monoplatites, by Chapuis (1875). The monoplatines are not collected in large numbers and are poorly understood both taxonomically and biologically (Flowers and Tiffer, 1992). Despite the phenetic similarity of the monoplatine genera, the tribe Monoplatini (Leng, 1920) has not been universally accepted (Furth, 1988; Seeno and Wilcox, 1982) nor have any hypotheses of relatedness among the genera been proposed. Only one species of monoplatine larva has been described previously (Buckingham and Buckingham, 1981) and few species have corroborated records of host plant (Jolivet and Hawkeswood, 1995; Flowers and Janzen, 1997) or breeding habits (Flowers and Tiffer, 1992).

The larvae of Alticini are in general poorly known, especially given the large size of the tribe (but see Lawson, 1991, for review). This may be due to life history of larvae, some larvae are nocturnal (Duckett, unpublished data), others are root or stem feeders (Lawson, 1991). However difficult larval data can be to obtain, larval morphology can be significant to the identification of closely related taxa as well as the resolution of higher level taxonomic relationships (Lawrence and Newton, 1995; Reid, 1995). Here we present a detailed study of larval morphology of *Pseudolampsis*, a monoplatine feeding on the waterfern, *Azolla*, to make these data available to

coleopterists working at higher taxonomic levels, as well as to aide general understanding of larval Chrysomelidae and of the monoplattines. We also present the taxonomic history of genus *Pseudolampsis* and discuss the adult characters which support the formulation of a new taxonomic combination in the genus.

TAXONOMIC HISTORY

Pseudolampsis was first described in 1889 by Horn, who transferred *Hypolampsis guttata* Leconte 1884 to *Pseudolampsis*. This genus was thought to be known only from the southern U.S. until Balsbaugh (1969) synonymized *Distigmoptera darwini*, known only from Uruguay and Mato Grosso, Brazil with *P. guttata*. Immatures of *P. guttata* from the U.S. were initially described by Buckingham and Buckingham (1981).

Immatures of *Pseudolampsis* were collected in São Paulo State, Brazil, and as the original larval description (Buckingham and Buckingham, 1981) lacked detailed chaetotaxy and description of mouthparts, redescription was warranted. During the course of preparing the larval description (and study of the adult) it became apparent that the specimens collected in São Paulo (Fig. 1) represent a distinct species from those collected in Florida, USA. Specimens collected in Florida represent *Pseudolampsis guttata* (LeConte), a species known to feed on *Azolla* (Buckingham and Buckingham, 1981; Habeck, 1979). Specimens collected in São Paulo State proved to be conspecific with *Distigmoptera darwini* Scherer, 1964. *Distigmoptera darwini* is congeneric with *Pseudolampsis*, but the differences existing in the male and female genitalia as well as the larva support its individual identity.

Balsbaugh figured the median lobe of the aedeagus of *Distigmoptera darwini*, collected in Mato Grosso, Brazil. This material obviously shows a groove in the ventral surface of the aedeagus, not present in *P. guttata* (cf. figs. 4 and 5 in Balsbaugh, 1969). This groove is present in a paratype of *Distigmoptera darwini* (which proved to be male on dissection despite Scherer's assertion that all specimens were female (Scherer, 1964:298)), as well as in the São Paulo material.

Dissection of the female genital system reveals a very similar system to that of *Microdonacia* (Reid, 1992: fig. 44). The bursa copulatrix is elongate, as are the vaginal palpi; the palpi are also presented in a unified pair apically (Figs. 2C–E), however, the basal area (or internal apodeme of Reid, 1992) is fused in *Pseudolampsis* and dorsally recurved. The eighth sternite (Fig. 2B) (spiculum gastrale, or tignum of Konstantinov (1994)) has an elongate basal portion, widens to a truncate setose apex; the epiproct and pygidium are also apically setose.

In *Pseudolampsis* the spermathecae of both species are practically identical (see Fig. 2A); both possessing a flange on the pump, an enlarged proximal spermathecal duct, and a greatly enlarged gland valve. The vaginal palpi, however, are significantly different (Figs. 2C–E); in *P. guttata* (Fig. 2D, E) the internal apodeme is basally wider than the apex and in *P. darwini* it is narrower (Fig. 2C). Both possess 7 setae per palp. The bursa copulatrix in *P. darwini* is vested with microtrichea over its entire surface. In *P. guttata* only the opening of the bursa has microtrichea, which are significantly longer than those in *P. darwini*. The eighth sternite also differs between species in setation, which is much sparser in *P. darwini*.

Differences in the larvae will be described and discussed below. These and the

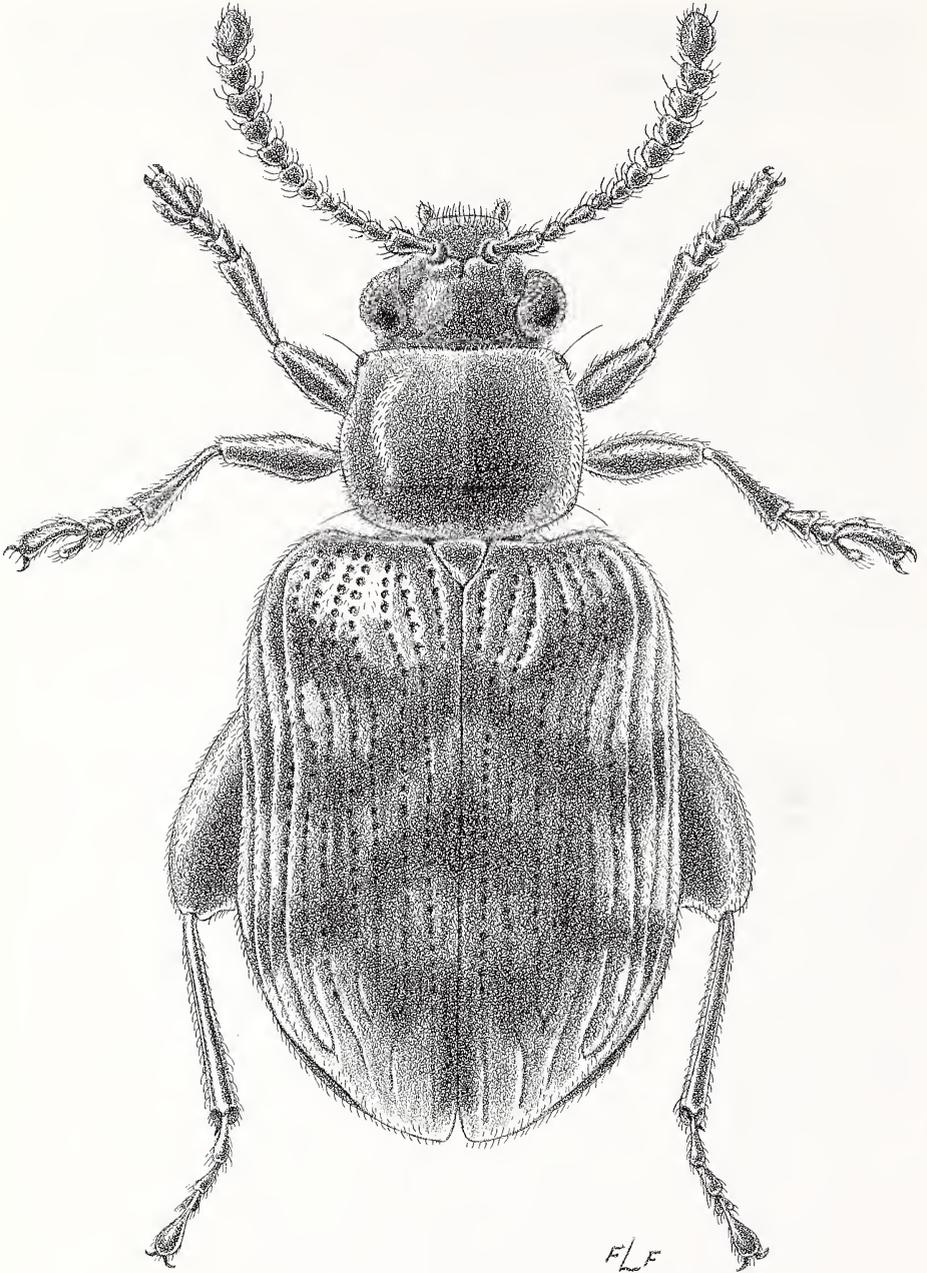


Fig. 1. *Pseudolampsis darwini* (Scherer), dorsal habitus, length 2.2 mm.

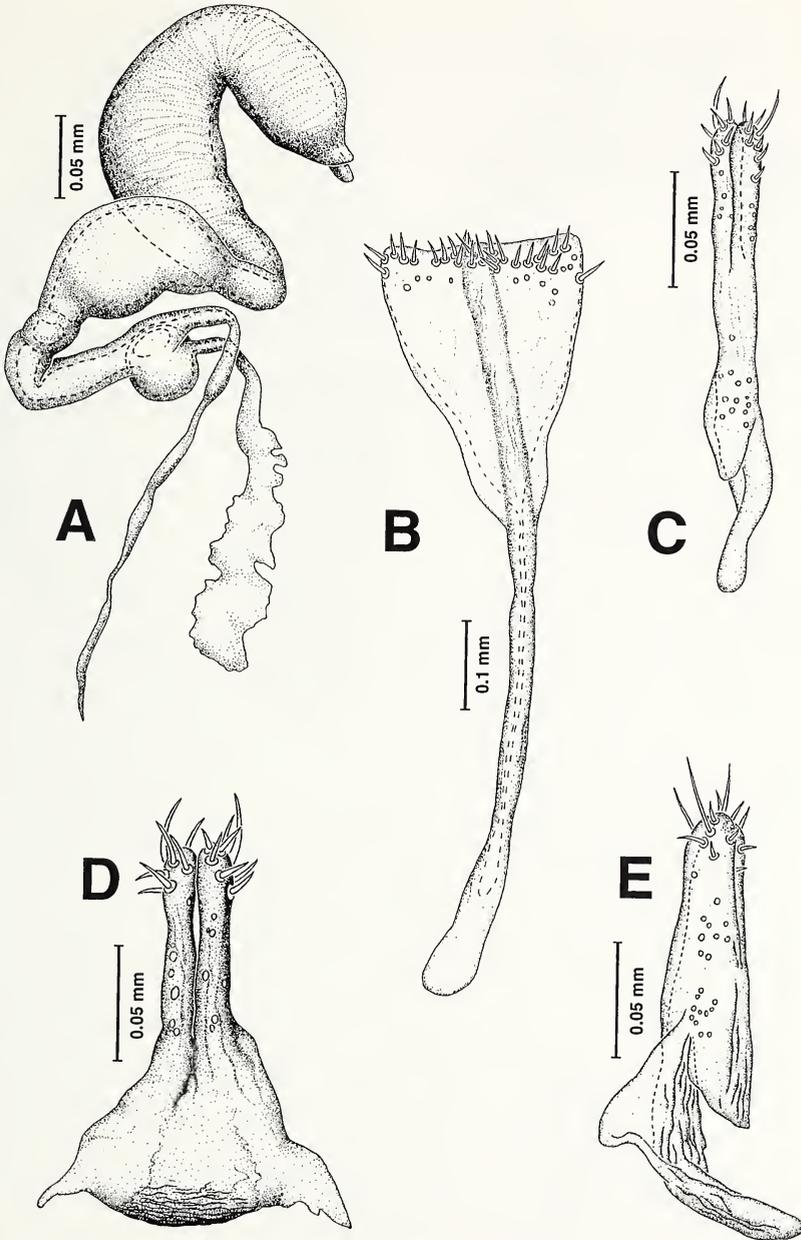


Fig. 2. *Pseudolampsis* Female genitalia. A, spermatheca; B, eighth sternite ventral view, *P. guttata*; C, vaginal palpi *P. darwini* (dorsal view); D–E, vaginal palpi *P. guttata* (dorsal, lateral).

mentioned characteristics of the genitalia warrant the establishment of a new combination. The formal synonymy is as follows:

Pseudolampsis darwini n. comb.

Distigmoptera darwini Scherer, 1964

Pseudolampsis guttata Balsbaugh, 1969

Pseudolampsis darwini (Scherer, 1964)

Figs. 3A-H, 4A-J

Larva (Figs. 3A,B)

Length: 2-5 mm.

General integument whitish; head brown with mandible yellowish-brown; antennae, maxillae and labium partially membranous; thorax and abdominal segments 1-8 densely asperate, with sclerites bearing prominent setae and small pigmented spots; segments separated by grooves; spiracles annular located in darker sclerites.

Head rounded (Fig. 3C, D) moderately pigmented and sclerotized; frontal arms V-shaped; epicranial stem short; endocarina extending anteriorly to epicranial stem, not reaching anterior margin. Frons bearing 3 pairs of hairy setae and 1 pair short scamiform setae; each epicranial half bearing 10 setae (7 dorsal, 3 ventrolateral). One convex, pigmented stemma each side. Antenna 2-segmented (Fig. 4E); membranous socket band-like, located at the end of frontal arms; basal segment partially membranous, bearing 2 dorsal sensoria on membranous area; distal segment cupuliform, sclerotized basally. Clypeus (Fig. 4A) transverse, narrow, sclerotized at basal half, bearing 2 setae on each side. Labrum (Fig. 4A) transverse, subtrapezoidal, slightly emarginate anteriorly, bearing 2 pairs of setae (lateral longer) and 1 pair of sensory pores. Epipharynx (Fig. 4B) densely covered by microtrichiae, concentrated in median anterior region; anterior margin bearing 6 pairs of stout pedunculate setae, 2 groups of campaniform sensillae near anterior margin and 2 groups at base on membranous area; 2 elongate darker areas near middle, each bearing a minute seta at apex. Mandibles (Figs. 4F, G) symmetrical, palmate, 5-toothed, dentae 2 and 3 serrate; external face bearing 2 setae and 2 sensory pores; penicillus formed by ramified setae. Maxilla (Figs. 4C, D): stipes elongate with 2 sclerotized areas, one small transverse, near palp bearing 3 setae (1 short) and other basal larger, bearing laterally 2 ventral and 1 dorsolateral setae; cardo elongate, glabrous; mala bearing 6 moderately long pedunculate setae ventrally and 8 stout pedunculate dorsally (4 basal serrate and bunched); mala bearing microtrichiae dorsally; maxillary palp 3-segmented, 2 basal segments sclerotized at base; basal segment band-like bearing 1 ventral sensory pore; 2nd segment bearing 2 ventral and 1 dorsal setae; distal segment bearing ventrally 1 lateral sensory pore and dorsally 1 short seta and 1 sensillum placodeum. Labium (Figs. 4C, D): prementum membranous with a transverse sclerotized area bearing 2 setae; postmentum membranous bearing 1 well developed and 1 short seta and 1 sensory pore on each side and 2 minute setae near base; labial palp 2-segmented; basal segment with a ventrolateral sensory pore; distal segment with 1 ventrolateral sensory pore and 1 seta and 1 placoid sensillum dorsal. Hypopharynx (Fig. 4D) membranous, partially covered by microtrichiae; anteriorly bearing 6 setae (4 minute and 2 short); 2 longitudinal sclerites. Gular area absent. Prothorax narrower than other thoracic segments; pronotum with sclerotized setose shield-like plate, divided at mid-line by whitish narrow band; each

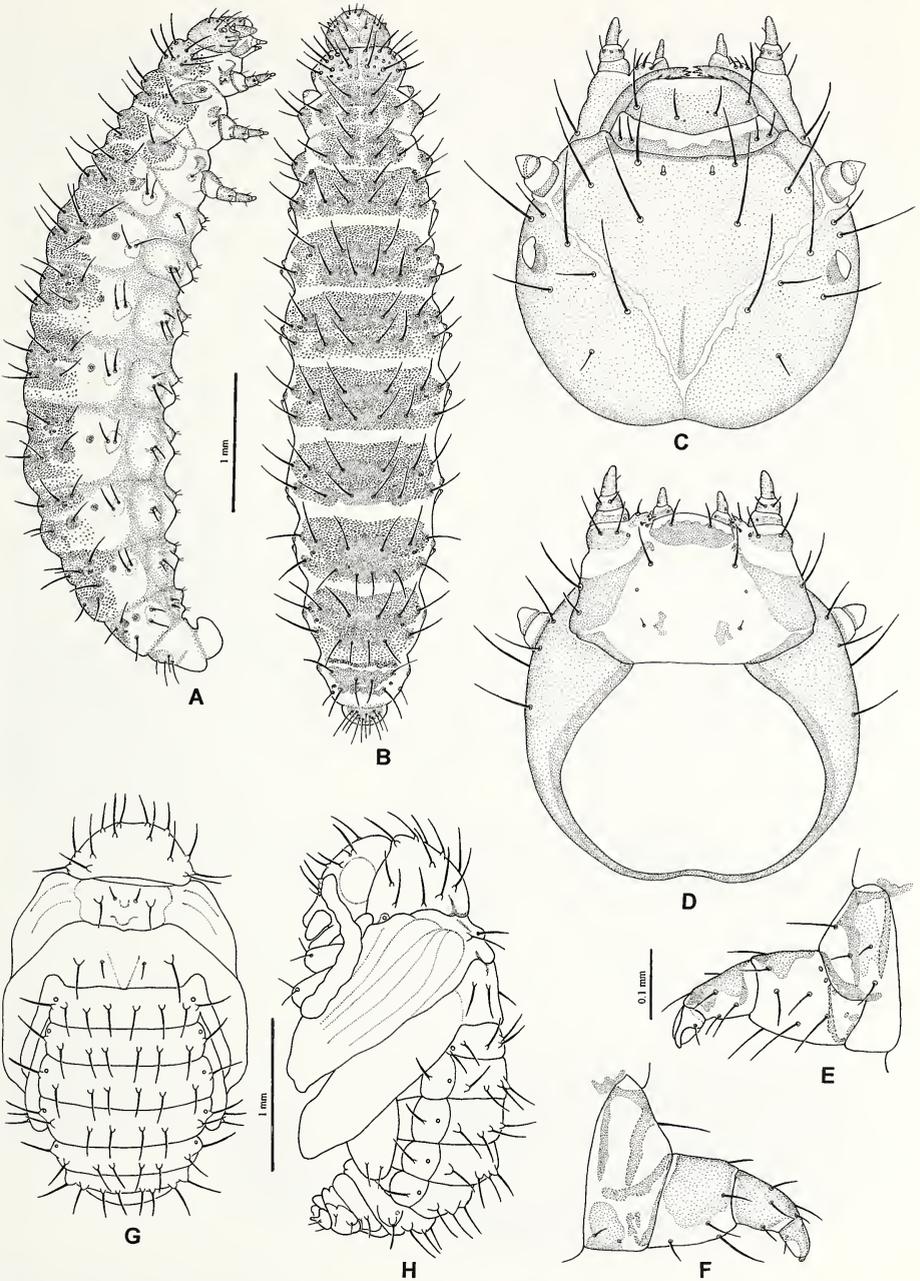


Fig. 3. *Pseudolampsis darwini* (Scherer). Larva: A, B, habitus (lateral, dorsal); C, D, head (dorsal, ventral); E, F, prothoracic leg (laterointernal, laterosternal). Pupa: G, H, dorsal, lateral. Figs. A, B; C–F; G, H, respectively to same scale.

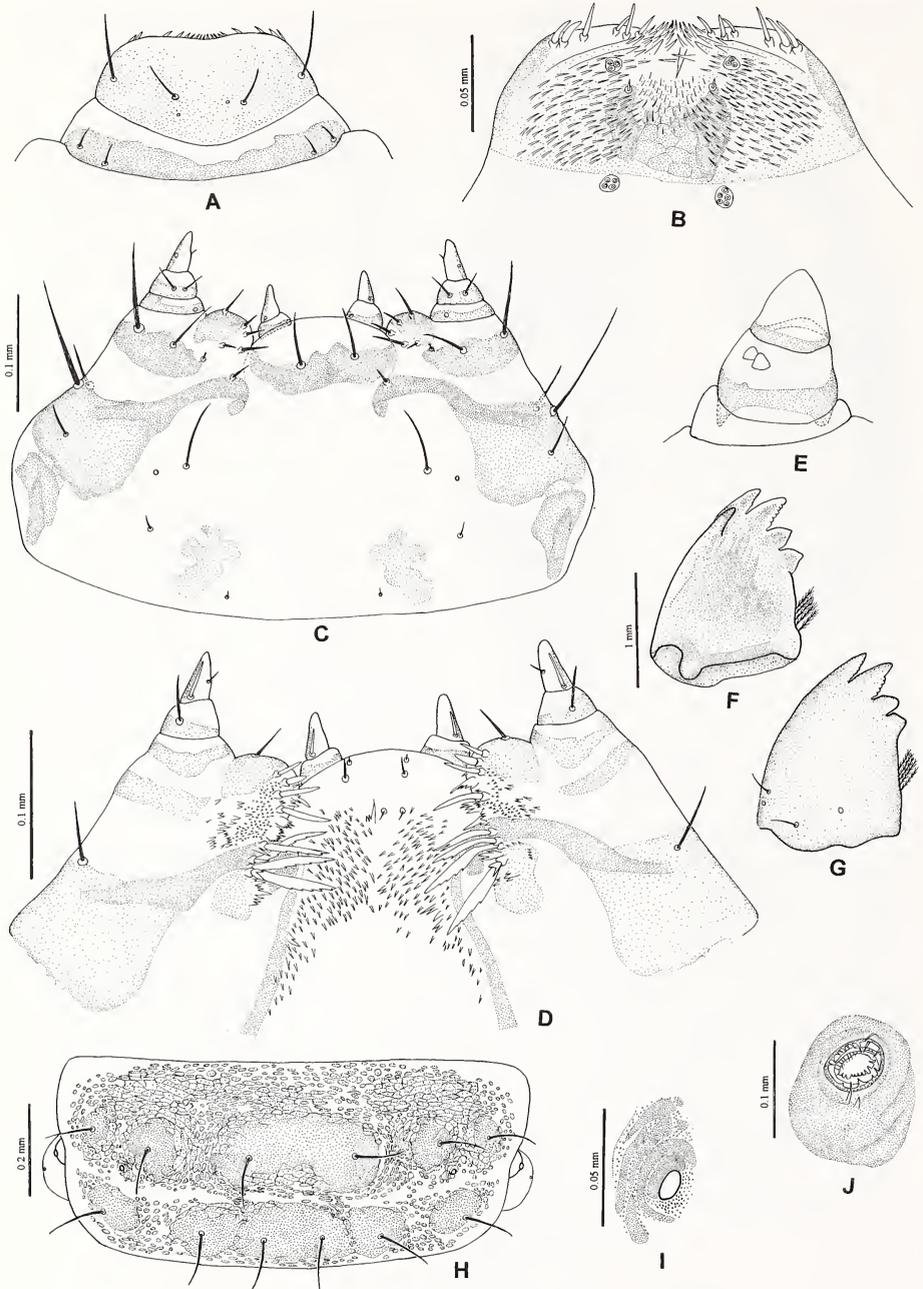


Fig. 4. *Pseudolampsis darwini* (Scherer). Larva: A, clypeus and labrum; B, epipharynx; C, D, maxillae and labium (ventral, dorsal); E, antenna (dorsal); F, G, mandible (internal, external); H, 6th tergite; I, 5th glandular opening; J, mesothoracic spiracle. Figs. A, C; E, I; F, G, respectively to same scale.

side bearing 7 setae and minute darker spots scattered among them. Meso- and metathorax gradually wider than prothorax; both with a transverse median groove forming 2 plicae and identical arrangement of sclerites: 2 rounded sclerites on 1st plica, each bearing one seta, and 4 smaller sclerites on 2nd plica, each bearing 1 seta; each side with one dorsolateral sclerite bearing 2 setae; small sclerotized pigmented spots densely scattered among larger sclerites making irregular plates; intersegmental area between pro- and mesothorax with a lateral membranous prominence bearing an annular spiracle (Fig. 4J). Thoracic segments with 1 sclerite and 1 small lobe bearing 1 seta, lateral to each coxa. Legs (Figs. 3E–F) increasing in size from pro- to metathorax, 4-segmented setose and partially membranous; basal segment bearing 5 setae; 2nd segment bearing 10 setae; 3rd segment bearing 7 setae; tarsungulus bearing 1 seta and pulvillus.

Abdominal segments 1–7 divided dorsally by a transverse groove forming 2 plicae; segment 1 with 2 series of sclerites arranged into transverse rows: one with 4 and other with 6 rounded sclerites each bearing 1 seta; segments 2–5 with 2 rows of sclerites, each with a median larger sclerite bearing 2 setae (larger on first row) and 2 smaller on each side, each bearing 1 seta; segments 6–7 (Fig. 4H) with 1st plica similar to the preceding one and larger median sclerite of 2nd plica fused to one lateral on each side and bearing 4 setae; segment 8 with an irregular sclerite bearing 6 dorsal setae; segment 9 almost totally sclerotized dorsally, bearing 10 setae. Segments 1–8 with paired dorsolateral glandular opening (Fig. 4I): first opening located anterior to the sclerite on first plica; 2–7 located posterior to rounded lateral sclerite on first plica, near groove; 8 near apex. Segments 1–8 with lateral paired annular spiracles located in sclerotized rounded lobe and paired lateral partially sclerotized lobes each bearing 2 setae. Ventrally, segments 1–8 with 3 membranous lobes at middle (disposed in a triangle) each bearing 2 setae and 1 slightly sclerotized lobe, each bearing 3 setae.

Pupa (Figs. 3G–H)

Length: 2.5–2.8 mm

Cream, bearing long brownish setae inserted in small tubercles. Head invisible from above, bearing 6 pairs of setae (2 pairs shorter). Prothorax bearing 7 pairs of dorsal setae and 1 pair of lateroposterior round spiracles; meso- and metanotum bearing 2 pairs of setae each; each femur bearing 1 pair of setae near apex. Abdominal segments 1–6 bearing 4 pairs of dorsal setae; segments 1–5 bearing a pair of laterodorsal round spiracles; segment 6 with a pair of vestigial rounded spiracles; segments 7–8 apparently bearing 2 pairs of short lateral setae; segment 9 with 2 distal projections, each bearing 2 short setae near base.

Material examined. BRAZIL. São Paulo: Guapiara, Fazenda Intervales (Sede de Pesquisa) (marsh), 09.xi.1992. (MZSP), 36 larvae, 7 pupae inside pupal cocoons and 4 adult fixed (MZSP). Larvae were prepared in glycerine.

Pseudolampsis guttata (LeConte, 1884)

Figs. 5A–G, 6A–N

First instar larva (Fig. 5A)

Length: 1.0–1.5 mm

General integument (including head) dorsally brownish, almost totally sclerotized, covered by setose sclerites very closely placed or fused; ventrally, membranous, whitish.

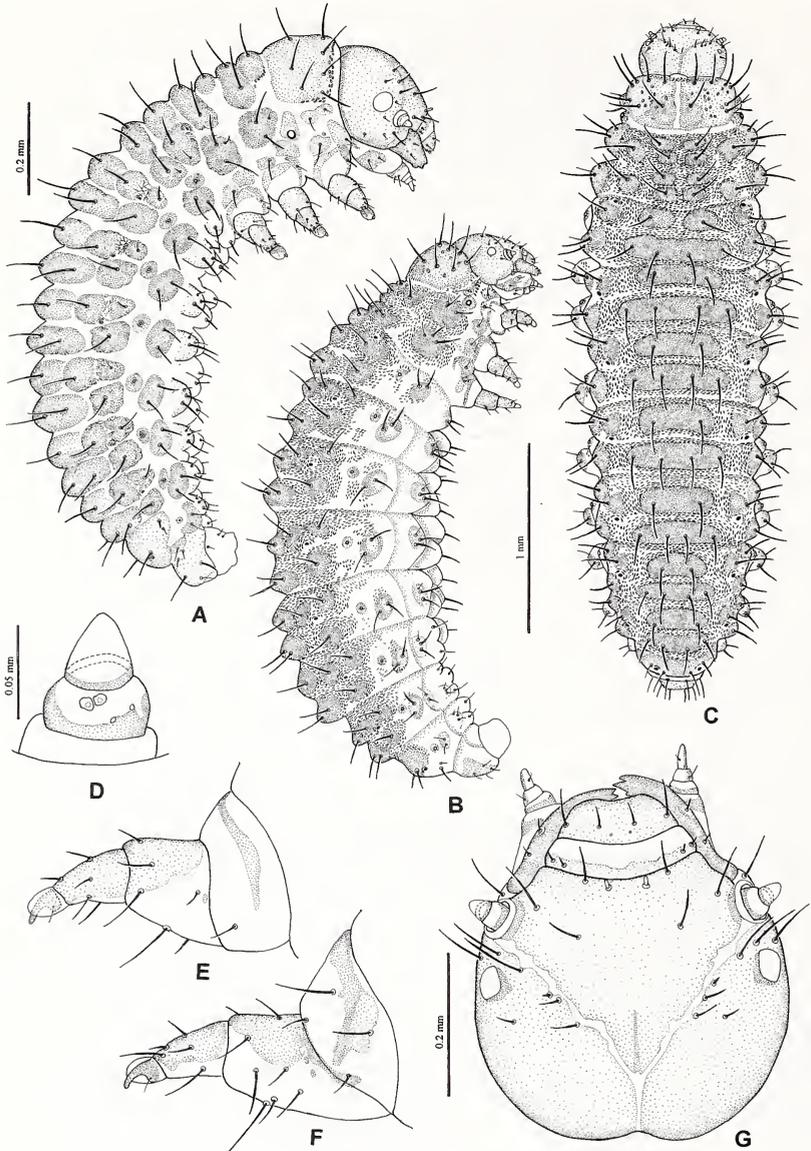


Fig. 5. *Pseudolampsis guttata* (LeConte), Larva: A, first instar (lateral); B, C, mature (lateral, dorsal); D, antenna; E, F, prothoracic leg (laterosternal, laterointernal); G, head (dorsal). Figs. B, C; E-F, respectively to same scale.

Head and mouth parts similar to mature larva. Stemmata large and translucent. Prothorax: pronotum with shield-like plate divided at middle by whitish narrow band, each side bearing 7 setae; each side with 1 lobe slightly sclerotized bearing 2 setae and 2 small sclerites each bearing 1 seta near coxa. Meso- and metathorax with a transverse median groove forming 2 plicae and an identical arrangement of sclerites: each plica with 1 dorsal transverse sclerotized plate; plate of first plica shorter, partially divided by reticulate area bearing 2 setae, the second, entire bearing 4 setae; each side with a rounded plate bearing 3 setae; 2 sclerites lateral to each coxa, the posterior bearing 1 seta; intersegmental area between pro- and mesothorax with a lateral sclerite bearing an annular spiracle. Legs similar to mature larva.

Abdominal segments 1–7 divided dorsally by a transverse groove forming 2 plicae with an identical arrangement of sclerites: first plica with a median sclerite bearing 2 setae and 2 smaller sclerites on each side, each bearing 1 seta; 2nd plica with a larger median sclerite bearing 4 setae and 1 smaller seta on each side, each bearing 1 seta; these sclerites are very near each other, separated only by a small groove; segments 8–9 with a larger dorsal sclerite bearing respectively 2 and 6 setae. Segments 1–8 with a paired dorsolateral glandular opening at same position as mature larva; each with lateral paired annular spiracles located in sclerotized rounded lobe; each segment with a lateral sclerotized lobe bearing 2 setae; ventrally with 3 membranous lobes at middle (arranged in a triangle) each bearing 2 setae and 1 larger sclerite each side, bearing 3 setae.

Mature larva (Figs. 5B, C)

Length 2.5–4.0 mm

General integument whitish; head brown with mandibles clearer; antennae, maxilla and labium partially membranous; thorax and abdominal segments 1–8 densely asperate, with sclerites, bearing long setae and small pigmented spots giving dorsal integument a brown appearance; spiracles annular, located in darker sclerites.

Head rounded (Fig. 5G), pigmented and sclerotized; frontal arms V-shaped; epicranial stem short; endocarina extending anteriorly of epicranial stem, not reaching anterior margin; frons bearing 3 pairs of hairy setae and 1 pair of shorter and scamiform setae medioanteriorly; each epicranial half bearing 10 setae (1 pair very short). One convex pigmented stemma on each side. Antenna 2-segmented (Fig. 5D); membranous socket band-like located at the end of frontal arms; basal segment partially membranous bearing 2 dorsal sensoria on membranous area and 2 sensory pores at border of sclerotized area; distal segment cupuliform, sclerotized basally. Clypeus (Fig. 6C) transverse, narrow, slightly sclerotized on basal half, bearing 2 short setae on each side. Labrum (Fig. 6C) transverse, slightly sclerotized, emarginate anteriorly bearing 2 pairs of setae (lateral longer) and 1 pair of sensory pores. Epipharynx (Fig. 6D) apparently partially covered by microtrichiae, more concentrated and longer at median anterior region; anterior margin bearing 7 pairs of stout pedunculate setae (2 pairs near middle shorter; 1 pair bifurcate), 2 groups of sensillae near anterior margin, 2 groups near base and 2 larger sensillae near middle. Mandibles (Figs. 6G, H) symmetrical, palmate, 5-toothed; external face bearing 2 setae and 2 sensory pores; penicillus well developed, formed by ramified setae. Maxilla (Figs. 6A, B): stipes elongate with 2 sclerotized areas, one small, transverse, near palp bearing 3 setae, other area basal, longer, bearing 2 ventral and 1 dorsolateral setae; cardo elongate, glabrous; mala ventrally bearing 8 pedunculate setae, and dorsally partially

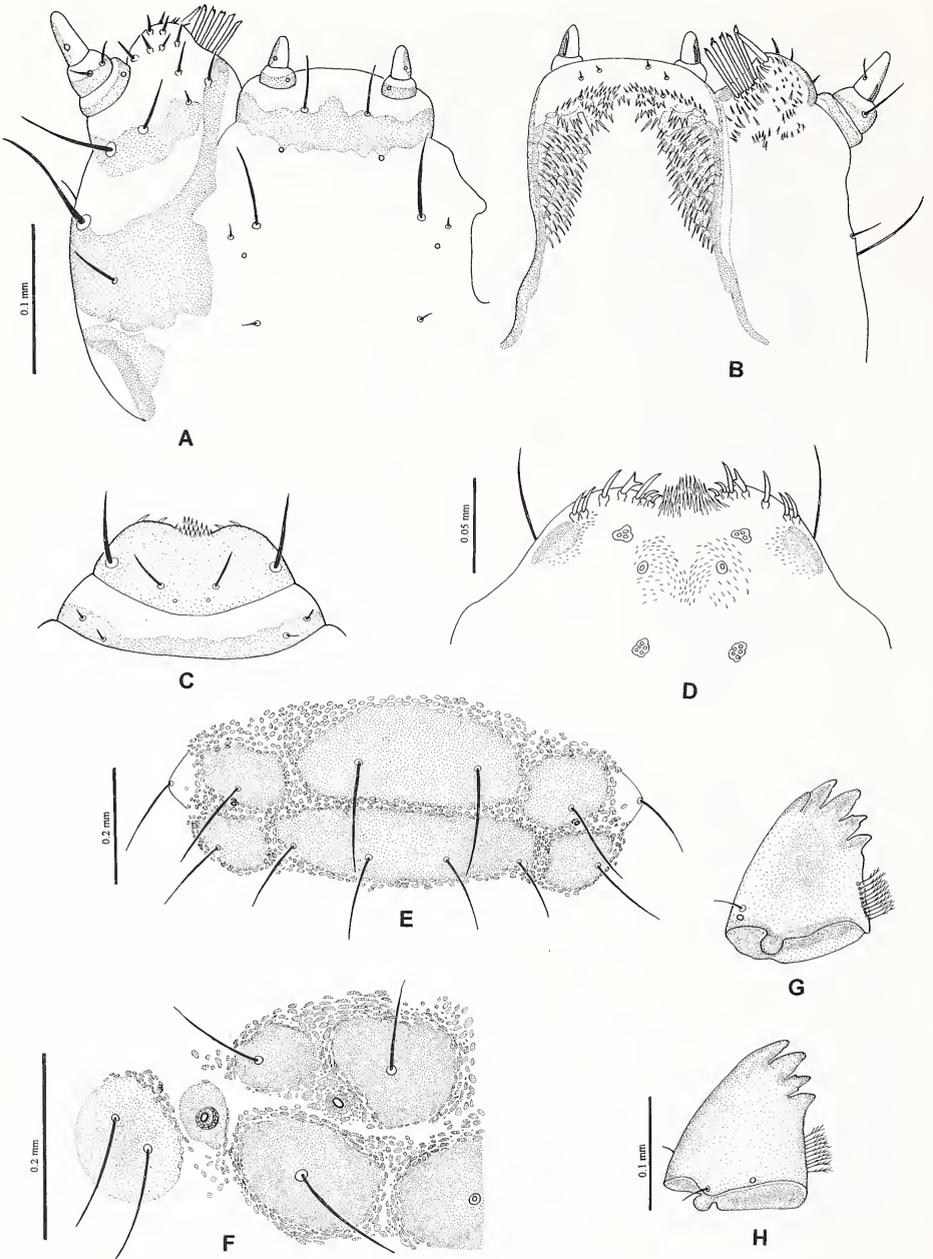


Fig. 6. *Pseudolampsis guttata* (LeConte), Larva: A, B, maxilla and labium (ventral, dorsal); C, clypeus and labrum; D, epipharynx; E, 6th tergite; F, abdominal segment 2 (lateral) showing the glandular opening and spiracle; G, H, mandible (internal, external). Figs. A, B; C, G, H, respectively to same scale.

covered by microtrichiae, and bearing 6 stout pedunculate setae with serrate apex; maxillary palp 3-segmented; 2 basal segments sclerotized at base; basal segment band-like, bearing 1 ventral sensory pore; 2nd segment bearing 2 ventral and 1 dorsal setae; distal segment bearing ventrally 1 lateral sensory pore and dorsally 1 seta and 1 sensillum placodeum. Labium (Figs. 6A, B): prementum with a transverse sclerotized area bearing 2 setae on anterior border and 2 sensory pores on posterior; postmentum membranous, each side bearing 1 long and 1 minute seta and 1 sensory pore, 2 minute setae near base; labial palp 2-segmented; basal segment with a ventrolateral sensory pore; distal segment with a ventrolateral sensory pore and a dorsolateral placodeum sensillum. Hypopharynx (Fig. 6B) membranous, partially covered by microtrichiae, bearing 6 minute setae; 2 longitudinal sclerites. Gular area absent.

Prothorax narrower than other thoracic segments; pronotum with sclerotized setaceous shield-like plate, divided at mid-line by whitish narrow irregular band, each side bearing 7 setae with minute darker spots scattered among them; one ventral lobe slightly sclerotized bearing 2 setae near coxa. Meso- and metathorax gradually wider than prothorax, both with a transverse median groove forming 2 plicae and an identical arrangement of sclerites: on first plica 2 small rounded sclerites, each bearing 1 long setae. On 2nd plica 2 sclerites of same size at middle, and 1 larger each side, each bearing one seta; each side with a large sclerotized tubercle each bearing three setae (1 shorter); small sclerotized pigmented spots densely scattered among larger sclerites; intersegmental area between pro- and mesothorax with a slightly sclerotized lobe bearing an annular spiracle. Each thoracic segment lateral to coxae with 1 sclerite and 1 lobe, each bearing 1 seta. Legs (Figs. 5 E, F) increasing in size from pro- to metathorax; 4-segmented, setaceous and partially membranous; basal segment bearing 5 setae; 2nd segment bearing 11 setae; 3rd segment bearing 6 setae; tarsungulus bearing 1 setae and pulvillus.

Abdominal segments 1-7 divided dorsally by a transverse groove forming two plicae; segment 1 with 4 sclerites on 1st plica, each bearing 1 seta, 2nd plica with 1 median larger sclerite bearing 4 setae and 1 smaller sclerite on each side, each bearing 1 seta; segments 2-7 (Fig. 6E) with 1 median larger sclerite bearing 2 setae and 2 smaller sclerite each side, each bearing 1 seta, and 2nd plica with 1 median larger sclerite bearing 4 setae and 1 lateral smaller sclerite each side, each bearing 1 setae, segment 8 with 1 dorsal irregular sclerite bearing 6 setae and 2 short setae, each side, on membranous area; segment 9 slightly sclerotized dorsally almost totally, bearing 10 setae; segment 10 membranous and ventral. Segments 1-8 with a paired dorsolateral glandular opening (Fig. 6F): first opening anteriorly to lateral sclerite of first plica; 2-7 between the 2 lateral sclerites on first plica near groove; 8 near apex. Segments 1-8 with lateral paired annular spiracles located in a rounded sclerite, and with paired lateral lobes (behind spiracle) each with sclerotized apex, each bearing 2 setae. Ventrally, segments 1-8 with 3 median small lobes disposed in a triangle, each bearing 2 setae and 1 larger lobe each side, each bearing 3 setae.

Pupa

Similar to *P. darwini*, differing only by presence of 5 pairs of setae on the head (6 in *P. darwini*).

Material examined. USA. Florida. Alachu + Citrus Cos.; Gainesville and Crystal River, X. 1979, M. & G. Buckingham cols., 21 first instar and 35 mature larvae, 11

pupae fixed (MZSP) and 7 adults (2 MZSP and 5 collection C.N. Duckett). Larvae were prepared in glycerine for dissection.

BIOLOGICAL NOTES

Larvae and adults of *Pseudolampsis darwini* were collected on the *Azolla* sp. (Azollaceae) that was covering the pond surface. The pupae were found inside cocoons attached under or among the *Azolla* stems. The material of *P. guttata* was collected on *Azolla caroliniana*. Alticini larvae live on leaves or stems, on roots or underground parts of plants (Lawson, 1991).

REMARKS

Comparing the first instar with mature larva of *Pseudolampsis guttata* we verified that in the first instar the dorsal sclerites are larger or fused covering the dorsal integument almost entirely and the stemmata are larger and translucent, while in the mature larva the sclerites are smaller surrounded by small pigmented spots and the stemmata are pigmented. Other similarities are morphology of mouthparts, pronotum bearing 14 setae, abdominal segments 1-8 with a paired glandular opening and paired annular spiracles located in sclerotized lobes.

Comparing the mature larva of *Pseudolampsis darwini* with *P. guttata*, they present different arrangement of sclerites of the abdominal segments (Figs. 3B, 4H; 5C, 6E, F) and different number of setae on anterior margin of epipharynx (Figs. 4B; 6D), mala (Figs. 4C, D; 6A, B), and legs (Figs. 3E, F; 5E, F). Both species present similar frontal arms (Figs. 3C; 5G), and equal number of setae on pronotum (Figs. 3B; 5C), frons and epicranium (Figs. 3C; 5G), clypeus and labrum (Figs. 4A; 6C), prementum (Figs. 4C, 6A) and hypopharynx (Figs. 4D; 6B), and antennae 2-segmented (Figs. 4E; 5D), 1 pigmented stemma on each side (Figs. 3C; 5G), mandibles 5-toothed with penicillum ramified (Figs. 4F, G; 6G, H), maxillary palpi 3- and labial palpi 2-segmented (Figs. 4C, D; 6A, B), and legs 4-segmented (Figs. 3E, F; 5E, F).

The comparison of the larvae of *Pseudolampsis* spp. with other described Alticini is difficult because some characters are not clear in the description or/and illustrations. A good comparison with *Chaetocnema denticulata* (Illiger) and *C. pulicaria* Melsheimer was possible based on the detailed description of Anderson (1938). Comparing the larvae of these two genera, only *Pseudolampsis* present abdominal segments divided transversally into 2 parts (Figs. 3B, 5C), glandular openings laterally on segments 1-8 (Figs. 3A, 5B), endocarina short (Figs. 3C, 5G), and cardo glabrous (Figs. 4C, 6A).

Other than *Pseudolampsis*, no larvae are known in the monoplatine genera. Some workers place monoplattines as close to the oedionychine flea beetles possibly based on the swollen hind tarsi and femora both shared (Seeno and Wilcox, 1982). However, Bechyné and Bechyné (1975) separate the oedionychine and disonychine groups from the rest of the Alticini ("Alticidae") based on apomorphies of the median lobe of the aedeagus. Known larva of oedionychine genera *Kushelina* (Lawson, 1991), *Alagoasa* (Samuleson 1985, Duckett unpublished) and *Asphaera* (Duckett, unpublished) all lack stemmata and show considerably less sclerotization of the body than larvae of *Pseudolampsis*.

ACKNOWLEDGMENTS

We are grateful to Cleide Costa of the Museo de Zoología de Universidade do São Paulo (MZSP) for her offer of material of *Pseudolampsis darwini* and for bringing this problem to our attention, and to Gary Buckingham for this generous gift of *P. guttata* material, without which this study could have been much poorer. The second author thanks Vilma Savini; MIZA-Museo del Instituto de Zoología Agrícola, Maracay Venezuela, Philip Perkins; MCZ- Museum of Comparative Zoology, Harvard, and Sharon L. Shute; BMNH- The Natural History Museum, London for their help and many kindnesses during visits to collections in their care. She also thanks David G. Furth, Smithsonian Institution, for discussion and comparison with the material in his collection. Terry Seeno and R. Wills Flowers kindly supplied needed bibliography. Comments from Wills Flowers and an anonymous reviewer greatly improved the manuscript. Maria Berio and Aurora Lauzardo kindly helped translate the abstract. We thank Frances L. Fawcett for the habitus drawing and Julio Garay for genitalic drawings. This study was partially supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) to S.A.C. and by Universidad de Puerto Rico Grants "Fondos Institucionales para Investigación" (FIPI) numbers 8-80-624, and 8-80-716 to C.N.D.

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TYPE SPECIMENS OF LEPIDOPTERA IN THE TEPPER COLLECTION AT MICHIGAN STATE UNIVERSITY

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Abstract.—Holdings of Lepidoptera type material in the Tepper collection at Michigan State University are completely evaluated and annotated. Acquired in 1889, the collection contains types of 180 nominate Lepidoptera, predominately noctuids described by H. K. Morrison. A brief curatorial history of the collection as well as handwriting examples for authors of the type material in the collection is presented. The types are completely annotated with bibliographic citation, type locality, condition, and a complete discussion of the status of each type. The following Morrison lectotypes are also designated: *Tarache crustaria*, *Agrotis decolor*, *Calocampa germana*, *Hadena congermana*, *Agrotis acclivis*, *Segetia orbica*, *Tarache patula*, and *Eurois astricta*.

Key words: Lepidoptera, Types, Tepper, Cook, Morrison, Lectotypes.

For slightly over 100 years Michigan State University (MSU) has been the repository of the Tepper Collection of Lepidoptera. The collection of over 12,000 specimens (8,000 species) of butterflies and moths was purchased in 1889 from Fred Tepper of Brooklyn, New York. Included in this collection were a number of type specimens of mostly North American Macrolepidoptera; the majority being species described by Mr. H. K. Morrison.

Although biographical information on Tepper is lacking, we know that Tepper was an avid collector, was active in his interactions with specialists and was an early member of a nucleus of individuals who formed the Brooklyn Entomological Society (Franclemont, pers. comm. 1994). He also purchased the collection of H. K. Morrison, probably sometime in 1876, before Morrison's departure to California and the Washington Territory to collect Lepidoptera. The collection contains 180 types (or putative types), the vast majority of these described by H. K. Morrison. In addition, a lesser number of types of Edwards, Grote, Hulst, Smith and Tepper are found in this collection. The majority of the types are noctuids, but sesiids, geometrids, sphingids, notodontids, saturniids, and limacodids are also represented. Over the years, this collection has been an important resource for workers of North American Lepidoptera. It has also been the source of some of their frustrations; this project in part is an attempt to ameliorate the problem by presenting an accurate account of the types in the Tepper collection.

The collection was acquired by MSU in 1889, through the efforts of then professor of Entomology A. J. Cook. In the summer of 1888 Cook learned from "a noted professor in one of our Eastern colleges" (probably J. B. Smith of Rutgers) that the Tepper collection was for sale (Anonymous, 1889). Shortly after, Cook and then MSU President Willits approached the State Board of Agriculture with an appeal for the purchase the collection, for \$5,000. Senator James MacMillan, upon hearing of the request, wrote Cook stating "I have considered the matter of the Tepper Collec-

tion, and have decided to authorize you to make the purchase of this collection of insects" (Anonymous, 1889). Cook then traveled to New York to arrange for its shipment and the collection arrived at Michigan State on March 5, 1889.

I began this study on the request of Fred Stehr that I "quickly catalog" the Lepidoptera types that we had in the MSU collection to be placed in a separate part of the collection. It soon became clear that there were numerous curatorial mistakes and inconsistencies, many that were quite serious. These errors included the loss of the original combination associated with some specimens, loss of the specific epithets, non-type specimens mixed in with the type series, inaccurate dates, misspellings, etc. It was also believed that there might be types "hiding" in the general Lepidoptera collection that were not recognized as types. This project was undertaken because it was almost certain that if a lepidopterist did not soon attend to these errors, these problems would only worsen with time. It was clear that an accurate accounting of the type material in the Tepper collection was long overdue and that the holdings of types in the collection should be accurately communicated to the research community before knowledge of the location of a type, or type specimens, was lost. Moreover, potential changes in the Zoological Code of Nomenclature necessitate that future workers have the best opportunity to study all relevant type material, since the conclusion of the last principle reviser as to the application of names in synonymy will take precedence following publication (Terry Erwin, pers. comm. 1994).

EARLY CURATION

When the Tepper collection was received at MSU, Professor A. J. Cook made an effort to record all the species (and number of specimens) received in a notebook. The presence of this catalogue was brought to my attention by M. C. Nielsen, and is still in our possession. On the first page of these notes, on MSU Stationery of that period, is written "Catalogue of the MacMillan Collection of Lepidoptera made in 1889 from the collection as received from Mr. Tepper." These notes proved invaluable because they indicate which species in the collection were represented by types. It appears that based on this typed inventory of the Tepper collection, each type specimen was labeled, perhaps by Cook, with a unique yellow, rhomboidal label (Fig. 1). Apparently, no effort was made to add information to this material other than the addition of the yellow rhomboidal type label. Therefore, if a type was

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Fig. 1. Example of the type label and handwriting of A. J. Cook, from the type of *Lithocodia penita* Morrison.

Fig. 2. Example of Frederick Tepper type label from the type of *Drynobia tortuosa* Tepper.

Fig. 3. Tepper locality label from type of *Oncocnemis riparia* Morrison.

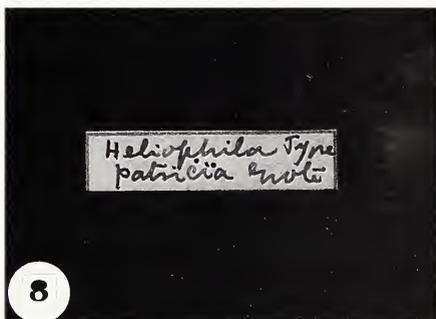
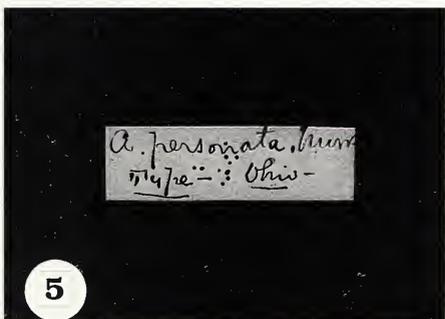
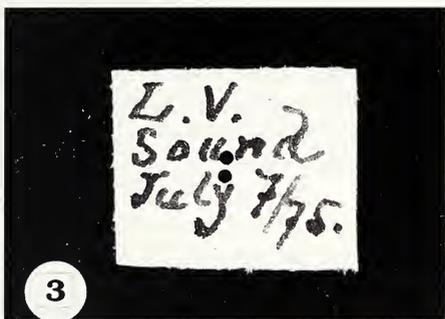
Fig. 4. Handwriting and typical label shape of Morrison from the type of *Mamestra teligera* Morrison.

Fig. 5. Type label of *Agrotis personata* Morrison, atypical of Morrison's label design.

Fig. 6. Type label and handwriting example from the type of *Heliophila patricia* Grote.

Fig. 7. Type label and handwriting from the type of *Nemoria tepperaria* Hulst.

Fig. 8. Type label of *Mamestra dodgei* Morrison in an unknown hand, perhaps Dodge.



without a label indicating either the author or the specific epithet, it was to remain this way. While this situation may seem chaotic to us today, in the late 19th century, type concepts were in a state of flux, and curation of types, and placement data on specimens was far from standardized. Therefore, unless the authors did so themselves, the specimens often did not have the original name, or the word "type" associated with the specimen (Franclemont, pers. comm. 1994). In the case of the Tepper collection, this has resulted over the years in the inaccurate curation, and even worse, the "loss" of type material. In more than a few cases the recovery of "lost" types has been accomplished by a careful search of the general collection.

We know that initially the collection was housed separately from the main collection in "MacMillan Cabinets" (Anonymous, 1889). Some time later, this material was interpolated into the general collection as the collection began to expand. The types remained scattered throughout the general collection until the 1950's when "all" the types were pulled from the collection by Roland Fischer and housed separately. But only those specimens with the rhomboidal "type" label were removed; any material not so labeled, or with a hidden "type" label, was apparently overlooked. In an effort to recapture any potential "lost" types, I searched through the entire collection looking for types (mostly Morrison) which may have been overlooked in the past.

BACKGROUND AND TREATMENT OF THE TYPES

There are a number of features of the type collection worthy of careful explanation that were not fully appreciated by earlier workers of the material. In nearly all cases at least one specimen of an original type series bears the yellow rhomboidal "type" label (Fig. 1) that was erroneously interpreted by many as a Tepper "type" label (Todd, 1982). This label, however, is probably in Cook's, not Tepper's hand; examples of Tepper's handwriting can be seen in Figs. 2-3. Through careful study of the entire collection, it was discovered that this rhomboidal label was also associated with other non-lepidopterous type material described from the collection in the 19th century, and also matches the hand of the individual who wrote "type" in the original accession notes. It seems likely that this label was added *after* the collection was received at MSU, and was likely done so by Cook or other worker and appears to have been a general policy in the treatment of all types in the collection near the turn of the century.

Except in a few instances, regardless of the number of specimens in the type series, only one specimen in a type series is labeled "type" with this rhomboidal label. This has resulted in the inclusion or exclusion of additional specimens from the type series and has necessitated referring to the original descriptions in order to clearly define the limits of the original type series.

Morrison's types comprise the bulk of the Lepidoptera type collection. This is fortunate because Morrison usually adequately labeled the specimens with the specific name and "Morr." He usually employed a distinctively shaped label (Fig. 4), that he rarely deviated from (Fig. 5) and which frequently included the location and date of capture. In all but a few cases, only one specimen in an otherwise syntypic series has this detailed label. Other specimens in a type series often lack data labels of any kind, or more frequently, only the state or territory of capture. Based on

Morrison's type labeling protocol, there is some evidence that suggests that Morrison had an operational holotype concept at this time, in part due to his practice of selecting only one specimen for this detailed label. His specimens reflect this well, for where there is more than one in a type series, only a single specimen is labeled with the word "type" on his peculiar label.

Other authors have described species from material in the Tepper collection, and more often these were originally described from Morrison's collection before it was purchased by Tepper. Smith described a number of noctuids from the Tepper collection, some of which Todd (1982) recognized as valid types in his work on the Smith type material. Unfortunately, he seems to have missed a number of types and historical specimens with notes written by Smith which were still "hidden" in the general collection. I have not endeavored to recapture type material that Todd overlooked since lectotypes and type identities were fixed for all Smith names in Todd's work. Todd (1982) designated a number of Tepper types as lectotypes, but in only one case was a lectotype label affixed to the specimen; lectotype labels have since been added to the proper specimens based upon Todd's publication. In addition, types of Grote (Fig. 6), Tepper (Figs. 2,3), and Hulst (Fig. 7), can be found in the type collection. In addition, there are several data labels whose authorship I have been unable to trace (Fig. 8).

There were a number of sources used to assist in the recovery of additional type material and to confirm the present location of many types. Smith (1893), in his *Catalog of Lepidoptera*, discussed the location of the type, and whether he had examined it or not. Taxa which he explicitly mentioned having seen in the Tepper collection, were cross-referenced with the type, and general collections. The general collection has also been checked against all (or most) of the Morrison names resulting in the discovery of 28 unlabeled types (some putative types). Many of these types were previously believed lost. Poole's (1989) catalog of the Noctuidae was also used for clues as to the location of type material, recognizing Poole's assertion that he often was not certain of the location of types, but was making educated guesses.

I have attempted to be as accurate as I can when making decisions as to the number of types in the original series and the validity of "type" material. It was not uncommon during this period for a new species to be described from a number of specimens from private collections. Usually these specimens were returned to the private collector; and therefore types for a single name may presently be found in a number of collections. Therefore, for example, it is not uncommon to expect material to be both at MSU, and the AMNH. These non-MSU specimens were not tracked at other institutions, but published lists and access to Internet data bases were used to check type holdings at other museums.

On several occasions lectotypes are designated, and the rationale for doing so is stated in the species accounts; I have endeavored to do so only when there are no closely related species and when it is reasonably certain that there is not additional type material at other institutions. In addition, lectotypes are not designated in taxonomically difficult genera or species groups. At no time in the work do I make nomenclatorial decisions, or take such action as removing specimens from the type series when clear evidence was not found to support such action. My primary goal

in this work is to communicate exactly what is in the collection so that future workers might be better informed when studying this collection.

The types are listed alphabetically by species name within each family. For each type(s) the original combination, citation, and a quote from the description as to the type locality and, when stated, the source (collector) of the specimen is given. Also included is a list of specimens noting the sex and the data from each label listed in order (separated by "'") from highest to lowest label on the pin with notes or questionable letters in brackets []. After each label the author's handwriting is indicated in brackets []: (M = Morrison, T = Tepper, H = Hulst, C = Cook (yellow rhomboidal label), G = Grote, ty = type print, S = Smith). Horn and Kahle (1935-1937) was used to confirm the handwriting identity, however, this was not possible in the case of Tepper, Cook, or Morrison. The condition of the specimen is given following label information. For each species I give relevant remarks pertaining to the material, my conclusion as to the validity of the type material, the present combination and the Hodges (1983) number (RWH). In some instances there was non-type material mixed with the type(s); these specimens have been removed, and no indication of doing so is made when such action was not ambiguous. I have referred to, whenever possible, publications by the last principle reviser to cross check conclusions that they may have reached regarding the location of type material.

The material is available for study by qualified specialists, and we encourage the use of this valuable type collection in future revisionary projects. Workers should be aware that most of the Tepper material is still extant, in the general collection. I have gone through much of the collection trying to recover the Morrison types, however, the larger task of cross-checking all the Grote names with their original descriptions, and the possibility of overlooked Morrison and Hulst types remains a possibility. It is likely that not all of the types have been retrieved from the general collection. Suggestions as to other types that we should search for are welcome.

Sesiidae

Aegeria albicornis Hy. Edwards, 1881b:201.

Type locality. "1 male. Nevada. (Morrison). Type. Coll. F. Tepper."

Male, "Nevada"[T]; "Type"[C]; "Female"[symbol] [In good condition]

Remarks: The holotype (Englehardt, 1946). *Synanthedon* (RWH 2570).

Aegeria brunneipennis Hy. Edwards, 1881b:191.

Type locality. "1 female. Georgia. (Morrison). Type. Coll. F. Tepper."

Female, "Ga"; "F. T."[T]; "Type"; "Female"[symbol] [Type in poor condition; the abdomen and legs missing, the left antenna is broken near middle]

Remarks: The holotype. Englehardt (1946) gives no indication as to the location of the type. Eichlin and Duckworth (1988) give MSU as the respiratory. A synonym of *Synanthedon rileyana* (Hy. Edw.) (RWH 2552).

Sciapteron graefi Hy. Edwards, 1881b:183.

Type locality. "1 male. 2 females. Nevada (Morrison.)" "Type. Coll. E. L. Graef
..."

Female, "Nevada"[T]; "F. T."[T] "Type"[C]; "Female" [In good condition]

Female, "Nevada"[T]; "F. T."[T]; "Type"[C]; "Female" [In good condition]

Remarks: Syntypes. Englehardt (1946) and Eichlin and Duckworth (1988) both state that the U.S.N.M. has the type. However, it is likely that the two females at MSU are also types and were obtained by Tepper through his purchase of the Morrison collection. A synonym of *Synanthedon exitosa* (Say) (RWH 2583).

Pyrrhotaenia helianthi Hy. Edwards, 1881b:203.

Type locality. "1 Male, 1 female. Virginia City, Nevada. (H. E.) On *Helianthus*, sp. Types. Coll. Hy. Edwards."

Female, "Nevada"[T]; "F. T."[T]; "Female" [Specimen in very good condition]

Remarks: Englehardt (1946) states that the type is in the AMNH. Eichlin and Duckworth (1988) state the type is at MSU. This is probably the holotype. A synonym of *Synanthedon polygona* (Hy. Edw. 1881) (RWH 2581).

Aegeria inusitata Hy. Edwards, 1881b:201–202.

Type locality. "White Mts. N. H. (Morrison.) Andover, Mass. (F. G. Sanborn.)" "Types. Coll. F. Tepper."

Female, "W. Mts. N. H."[M]; "Type"[C]; "female"[symbol] [In very good condition]

Male, "W. Mts. N. H."[M] "86"[?] "male"[symbol] [In very good condition]

Remarks: Undoubtedly part of the original syntype series. Engelhardt (1946) makes no reference to the location of the type(s) of this name. Eichlin and Duckworth (1988) make reference only to the Andover specimen which is in the AMNH. They make no reference to the location of the NH specimen(s). A synonym of *Synanthedon pictipes* (G.&R.) (RWH 2550).

Carmenta minuta Hy. Edwards, 1881b:185.

Type locality. "1 male. Georgia. (Morrison.) Type. Coll. F. Tepper."

Male, "Georgia"[T]; "Type"[C]; "*minuta* Hy Ed"[M]; "female."[symbol] [In poor condition, the abdomen and right forewing missing]

Remarks: The holotype (Eichlin and Duckworth 1988). A synonym of *Osminia ruficornis* (Hy. Edw.) (RWH 2545).

Albuna montana Hy. Edwards, 1881b:188.

Type locality. "21 examples." "White Mountains, N. H. (Morrison. Grote.) Nevada, Colorado. (Morrison.) Anticosti Isld. (Couper.) Ser. Nevada, Cal. (H. E.). Colls. Tepper, Graef, Neumoegen, W. Grey, Dr. Bailey, Hy. Edwards, etc., etc."

Female, "W. Mts. N. H."[T]; "F. T."[T]; "Type"[C]; "female"[symbol] [In good condition, the meso legs missing]

Male, "W. Mts. N. H."[T]; "F. T."[T]; "male"[symbol] [In good condition, the right meso and meta leg missing]

Male, "W. Mts. N. H."[T]; "F. T."[T]; "male"[symbol] [In good condition]

Male, "Anticosti"[T]; "F. T."[T]; "male"[symbol] [In poor condition, antennae missing, meso legs missing, considerable development of verdigris]

Female, "W. Mts. N. H."[T]; "F. T."[T]; "female"[symbol] [Damage by dermestids to the abdomen, and antennae broken near base]

Male, "Mt. Hood"[T]; "male"[symbol] [In fair condition, the left meso leg missing]

Remarks: Syntypes. Englehardt (1946 p. 165) states that "the type (a single fe-

male) is in the American Museum." Eichlin and Duckworth (1988) state the type from Colorado is in the AMNH. A synonym of *Albuna pyramidalis* (Wlk.) (RWH 2533).

Aegeria opalescens Hy. Edwards, 1881b:199.

Type locality. "3 males. Virginia City, Nevada. (H.E.)." "1 female. Colorado. (Morrison.)."

Male, "Nevada"[T]; "F. T."[T] [In fair condition, the pro and meso legs missing]

Male, "Nevada"[T]; "F. T."[T] [In good condition]

Remarks: Syntypes. The collection should have the Morrison female from Colorado, but I have been unable to locate it. Eichlin and Duckworth (1988) state that the type from Nevada is in the USNM; these two males are likely not part of the original syntypic series. A synonym of *Synanthedon exitosa* (Say) (RWH 2583).

Pyrrhotaenia orthocarpi Hy. Edwards, 1881b:204.

Type locality. "3 males. 1 female. On *Orthocarpus luteus*. Nutt. Washoe Lake, Nevada, (H. E.). "Type Coll. Hy. Edwards."

Male, "Nevada"[T]; "male"[symbol] [In good condition, left meta and right meso leg missing]

Male, "Nevada"[T]; "male"[symbol] [In very good condition]

Male, "Nevada"[T]; "male"[symbol] [In good condition, antennae are missing]

Remarks: The status of these specimens is not known. No mention was made by Engelhardt (1946) as to location of the type of this species. Eichlin and Duckworth (1988) state that the type is in the AMNH. A synonym of *Synanthedon polygoni* (Hy. Edw.) (RWH 2581).

Aegeria proxima Hy. Edwards, 1881b:201.

Type locality. "White Mts. N. H. (Morrison.) Type. Coll. F. Tepper."

Male, "W. Mts N. H."[T]; "F. T."[T]; "Type"[C] [In good condition, left antenna missing]

Remarks: The holotype (Engelhardt 1946) and (Eichlin and Duckworth, 1988). *Synanthedon proxima* (Hy. Edw.) (RWH 2572).

Aegeria seneciodes Hy. Edwards, 1881b:198-199.

Type locality. "1 male. California. On *Senecio douglassii*. D. C. (H. E.) 1 female. Nevada. (H. K. Morrison.) Types. Coll. Hy. Edwards. F. Tepper."

Male, "Nevada"[T]; "F. T."[T]; "Female"[symbol] [Left pro and meso and right meso leg missing; otherwise in fair condition]

Remarks: Engelhardt (1946) states that the male type of *Aegeria seneciodes* is in AMNH. Eichlin and Duckworth (1988) stated the type from California is in the AMNH. This is also a type. A synonym of *Synanthedon mellinipennis* (Bdv.) (RWH 2580).

Pyrrhotaenia tepperi Hy. Edwards, 1881b:203.

Type locality. "1 male. Georgia, (Morrison.)" "Type. Coll. F. Tepper . . ."

Female, "Georgia"[T]; "Type"[C]; "female"[symbol] [In poor condition, the antennae are glued to the frons, the legs missing, and portions of the wings torn]

Remarks: Engelhardt (1946) and Eichlin and Duckworth (1988) state that the (holo)type is in MSU. A synonym of *Synanthedon acerni* (Clem.) (RWH 2554).

Aegeria verecunda Hy. Edwards, 1881b:190.

Type locality. "1 male. 2 females. Colorado. (Morrison.)" "Type. Coll. Hy. Edwards. F. Tepper.

Female, "Col"[T]; "F. T."[T]; "Type"[C]; "female"[symbol] [In good condition]

Remarks: The holotype (Eichlin and Duckworth 1988). *Carmenta* (RWH 2615).

Urodidae

Penthetria parvula Henry Edwards, 1881a:80.

Type locality. "1 male, Indian River, Florida, 1 female, Georgia." "Types Coll. Hy. Edwards. F. Tepper."

Male, "Georgia"[T]; "Type"[T] [Type in very good condition]

Remarks: Syntype. The sex of the specimen from Georgia in the original description was probably misdetermined. *Urodus* (RWH 2415).

Geometridae

Acidalia cacuminaria Morrison, 1874f:195.

Type locality. "Massachusetts, about the first of July, Collection of H.K. Morrison."

Female, "cacuminaria Morr. Type, Mt. [H]orn Ms. July 6, 79"[M] [In fair condition, abdomen glued, upside down (Covell 1970).

Remarks: The holotype (Covell, 1970). *Scopula* (RWH 7157).

Endropia decoloraria Hulst, 1886:207.

Type locality. "2 males Coll. Graef and Tepper. No locality with either specimen."

Male "Type"[H] [In poor condition, the abdomen missing, only the right pro leg present]

Remarks: Syntype. This is a valid type specimen; the other male type is in the AMNH (Rindge, 1955). *Cepphis* (RWH 6834).

Drepanodes effascinaria Hulst, 1886:204–205.

Type locality. "2 females S. C. and Fla: coll. Neumoegen and Tepper. 42 mm."

Female, "S. Car."[?], "Type"[H] [In fair condition, the abdomen glued to the thorax]

Remarks: Syntype. The female syntype from South Carolina is in the AMNH (Rindge, 1955). A synonym of *Eusarca fundaria* (Gn.) (RWH 6933).

Boarmia floridaria Hulst, 1886:215.

Type locality. "1 male, 1 female, Fla."

Female, "Type"[H]; "Florida"[T] [Abdomen and antennae missing]

Remarks: Syntype. There is no indication in the original type series as to the source of the material. The AMNH has the male syntype from Florida (Rindge, 1955). A synonym of *Idaea violacearia* (Wlk.) (RWH 7120).

Boarmia furfuraria Hulst, 1888:214.

Type locality. "3 males, Col." "Expands 42mm."

Male, "Col"[T]; "Type"[H] [In good condition, the meta legs and the left antenna missing]

Remarks: Paralectotype. The lectotype of this species from Colorado is in the AMNH (Rindge, 1958). *Glena* (RWH 6446).

Chlorosea graefiaria Hulst 1886:123.

Type locality. "2 females, Nevada, Coll. Graef, Tepper."

Female, "Nevada"[T]; "Type"[H] [The well marked specimen missing both meta and the right meso thoracic legs]

Remarks: Syntype. The Graef specimen is in the USNM (Ferguson, 1985). *Che-teoscelis* (RWH 7068).

Endropia helveolaria Hulst, 1881:33-34.

Type locality. "One specimen, also one in collection of Mr. Fred Tepper, Colorado.

Male, "Col"[T] [In good condition]

Remarks: This syntype was found in the general collection. A male syntype from Colorado is also in the AMNH (Rindge, 1955). *Lychnosea* (RWH 6857).

Endropia hilumaria Hulst, 1886:206-207.

Type locality. "2 males Colorado. Coll. Graef, Tepper."

Male, "Col"[T]; "Type"[H] [In very good condition]

Remarks: Syntype. There is also a syntype of this species in the AMNH (Rindge, 1955). *Caripeta* (RWH 6871).

Endropia manubiaria Hulst, 1886:207-208.

Type locality. "2 males, 1 female Colorado. Coll. Tepper, Hulst."

Male, "Col"[T], "Type"[H] [In poor condition, the right wings, both antennae, and the right meso and meta legs destroyed]

Remarks: Syntype. *Euchlaena* (RWH 6736).

Tetracis mellitularia Hulst, 1886:202-203.

Type locality. "Five males, 3 females. Ariz., Nev., Cal; Coll. Hy. Edwards, Tepper, Hulst."

Male, "Nevada"[T] [In very good condition]

Remarks: Paralectotype. The lectotype is in the AMNH (Rindge, 1955). A synonym of *Pharene placheraria* (Gn.) (RWH 6949).

Endropia occantaria Hulst, 1886:207.

Type locality. "Two females Nev.: Coll. Graef, Tepper."

Female, "Nevada"[T] [In very poor condition, extensive dermestid damage to the abdomen and thorax, head missing]

Remarks: The holotype. Rindge (1955) reported from AMNH "a female labeled "type" from [the] Washington Territory. This is probably spurious, because the type locality is said to be Nevada." A synonym of *Euchlaena mollisaria* (Hulst) (RWH 6730).

Hybernia olivacearia Morrison, 1874f[1875]:200.

Type locality. "Massachusetts. From April 20th to May 5th."

Male, "*olivacearia* Morr. Type. Cambridge. M[s] 4. 30 155"[M] [In very good condition]

Male, "5.20"[M]; "Cambridge"[M] [In excellent condition]

Female, "4/25"[M]; "Cambridge"[M] [In very good condition]

Remarks: Paralectotypes. Rindge (1955) designated a male in the MCZ as the lectotype. A synonym of *Phigalia strigataria* (Minot) (RWH 6660).

Tornos robiginosus Morrison, 1874g[1875]:218.

Type locality. "Waco, Texas."

Female, "Bastrop Texas"[M] [Right antenna missing, otherwise in good condition]

Remarks: Paralectotype. This specimen was found in the general collection. I have dissected this specimen and it is *scolopacinaris*. The lectotype is in the USNM (Rindge, 1954). *Tornos scolopacinaris* (Gn.) (RWH 6486).

Nemoria tepperaria Hulst 1886:122.

Type locality. "1 male, 1 female, Ga. N. Car. Coll Edwards, Tepper."

Male, "Ga"[H]; "Type"[H] [The type is in poor condition. The antennae are broken near base, the right pro and meso and left pro legs are also missing]

Remarks: Syntype. This male was part of the original type series. Ferguson (1985) stated that the (syn)type from N. Car. is in the USNM. *Chloropteryx* (RWH 7075).

Tephrosia texanaria Hulst, 1888:216.

Type locality. "Eight males, six females."

Male, "Tex."[ty]; "Type"[H] [Abdomen and antennae missing]

Male, "Tex."[ty] [The well marked specimen is in good condition, only the right prothoracic leg is missing]

Remarks: Paralectotype. The original description gave no information on the location of the types, but the male marked "Type" is in Hulst's hand and is typical (red border) for his type labels. Given the large number in the original series, it is likely that the other males marked with the same small "Tex" and the other without information are also part of the type series. The lectotype of this species was designated by Rindge (1973). *Glenoides* (RWH 6443).

Boarmia wrightiaria Hulst, 1888:215.

Type locality. "4 females." "Taken at San Bernardino, Calif."

Male, "So. Cal."[ty]; "Type"[H] [In poor condition, only the left meta leg present, the right antenna missing and the abdomen destroyed by dermestids. The genitalia appear to be intact]

Remarks: Paralectotypes. The lectotype of this species is in the AMNH (Rindge, 1955, 1970). *Hulstina* (RWH 6547).

Limacodidae

Parasa fraterna Grote, 1881c:4–6.

Type locality. "N.Y., Mass., Mr. Roland Thaxter; also in Mr. Tepper's collection."

Female, "Type"[T] [Very good condition]

Male, "ex L. June 17, 74." [T]; "Type" [T] [Very good condition]

Remarks: Syntypes. A synonym of *Parasa chloris* (H.-S.) (RWH 4698).

Saturniidae

Attacus cinctus Tepper, 1883:65–67, 1 plate.

Type locality. "Eight specimens served as types. Southern Arizona."

Female, "Arizona"[T]; "Original Type"[T] [In fair condition, right antenna missing, left meso and meta legs missing]

Female, "Arizona"[T]; "Original Type"[T] [In poor condition, dermestid damage to the abdomen]

Remarks: Paralectotypes. The lectotype was designated by Ferguson (1972). *Rothschildia cincta* (RWH 7760).

Sphingidae

Sphinx albescens Tepper, 1881:1-2.

Type locality. "One male from Colorado, taken by Mr. H. K. Morrison, in my coll."

Female, "Col"[T]; "Type"[T] [In poor condition, the abdomen is partially destroyed by dermestids, and reglued to the specimen]

Remarks: The holotype. This type was found in the general collection. A synonym of *Sphinx vashti* (Stkr.) (RWH 7803).

Notodontidae

Drynobia tortuosa Tepper, 1881:2, plate 2 figure 2.

Type locality. "One male from Colorado collected by Mr. H. K. Morrison. Type in my collection."

Male, "Col"[T]; "Type"[T] [In very good condition]

Remarks: This holotype was found in the general collection. *Hyperaeschra* (RWH 7918).

Noctuidae

Charadra decora Morrison, 1875:55.

Type locality. "California."

Female, "Calif" [T] [In poor condition, left antenna, left and right meta legs missing, dermestid damage to abdomen]

Remarks: The holotype. This specimen was found, unlabeled, in the general collection. *Lichnoptera* (RWH 9187).

Agrotis acclivis Morrison, 1875f:93-94.

Type locality. "New York from the Tepper collection."

Male, "Long Island 191"[M]; "Type"[C] [In fair condition; some dermestid damage, right antenna missing]

Male, "1706"; "Type"[C] [In fair condition; both meso legs missing, the right antenna and the valves partly destroyed]

Remarks: The male, from Long Island, is selected, labeled, and designated as the lectotype. *Loxagrotis* (RWH 10870); *Richia* Poole (1989).

Hadena adnixa Grote, 1880a:243.

Type locality. "Nevada; Tepper. *Expanse* 38 mil."

Male, "Nevada"[T]; "Type"[T] [In very good condition, the right antenna missing]

Remarks: This specimen was found in the general collection with a 'type' label hidden under the first label. Poole (1989) stated the type was at the BM, but Smith (1893) indicated the type(s) was in the Tepper collection. In the absence of additional Tepper type material, this is likely the holotype. *Aseptis* (RWH 9533).

Hadena albina Grote, 1874b:157.

Type locality. "California (Mr. Behrens, No. 78, Sauzalito, May 15). Two specimens."

Female, "Calif"[T]; "Type"[C] [In good condition; the left meso and meta and the right pro and meta legs missing]

Remarks: Smith (1893 p. 138) states that "the 'type' is in the British Museum; but I am not sure it is a fair representative of the species Mr. Grote meant to describe. It seems to be really a form of *castanea*, as Mr. Grote suggested; but the specimen in the Tepper collection also marked type by Mr. Grote, is more nearly allied to *arctica*, and is a good species as shown in my Revision." The remark by Smith would suggest that the specimen in MSU was labeled type by Grote, but the presence of the rhomboidal label brings this conclusion into question since this is a Cook label. This makes it uncertain if indeed this specimen was seen by Grote at the time of description. Poole (1989) stated that the type is in the BM, however, in Cook's accession notes, "type" is written next to the name in his hand. The type status of this specimen remains uncertain, but is likely not a type. A synonym of *Apamea castanea* (Grote) (RWH 9347).

Hypena albopunctata Tepper, 1881:2, plate 1, figure 5.

Type locality. "One male from Wash. Ter., collected by Mr. H. K. Morrison, in my collection."

Male, "W.T."[M]; "Type"[T] [Poor condition, legs and antennae missing]

Remarks: The holotype. A synonym of *Hypena humuli* Harris (RWH 8461).

Orthosia americana Morrison, 1875c [1876]:434.

Type locality. "Mr. W. V. Andrews of Brooklyn has been so kind as to send me from his collection a specimen taken in N.J."

Male, "N.J."[?]; "Type"[C] [A well marked specimen in fair to poor condition, dermestid damage to thorax and abdomen, left antenna missing]

Remarks: The holotype. A synonym of *Agrochola lota* (Clerck) (RWH 9956).

Acronycta aspera Morrison, 1874b[1875]:132.

Type locality. "Adirondack Mts., N.Y."

Female, "N.Y."[T]; "*aspera* Morr Type. [A]dr Mts. N. Y. 124"[M] [Type in very good condition]

Remarks: The holotype. A synonym of *Andropolia contacta* (Wlk.) (RWH 9564).

Mamestra assimilis Morrison, 1874c:113.

Type locality. "Massachusetts. Collection of H. K. Morrison."

Male, "Tepper"[ty]; "Type"[C] [Specimen in fair condition, right antenna and meso and meta legs missing, valves partly destroyed]

Remarks: The holotype (McCabe, 1980). *Melanchra* (RWH 10295).

Eurois astricta Morrison, 1874b[1875]:135.

Type locality. "New Hampshire."

Male, "W. M." [M] [In good condition]

Female, "W. M." [M] [In fair condition, left antenna missing, right wings broken off]

Remarks: These specimens from the White Mountains of NH were found in the general collection. They are likely the types of this species. The male, is hereby selected, labeled and designated as the lectotype of *E. stricta*. Poole (1989) states that the type is in MSU (RWH 10930).

Metahadena atrifasciata Morrison, 1875c[1876]:431-432.

Type locality. "Orono, Maine. (Prof. C. H. Fernald)."

Female, "Maine" [M]; "121"; "Tepper" [ty]; "Type" [C] [Condition of specimen is quite poor, considerable damage from verdigris]

Male, "Maine" [M?] [Very good condition]

Male, "Maine" [T] [Very good condition]

Remarks: Syntypes. The two males were found in the general collection. It is uncertain whether these specimens were part of the original series. Smith (1893) states types are in both Tepper collection and BMNH. A synonym of *Oncocnemis piffardi* (Wik.) (RWH 10123).

Orthosia belangeri Morrison, 1874b[1875]:149.

Type locality. "Quebec, Canada."

Male, "Canada" [T]; "Type" [C] [Type in good condition, right antenna, pro and meso legs missing]

Remarks: The holotype. Type material for this species was not found at the BMNH (Mikkola, pers. comm. 1992). A synonym of *Apamea inficita* (Wik.) (RWH 9369).

Agrotis binominalis Smith, 1888a:451.

Type locality. "California, Washington Territory."

Male, "W.T." [M]; "Type" [T] [In poor condition, verdigris damage to the abdomen, both pro and right meso leg missing]

Male, "W.T." [M]; "Type" [C] [In poor condition]

Remarks: Paralectotypes. Todd (1982) found three specimens, two males from W.T. and a female from California curated as types of *binominalis*. He chose not to recognize the MSU specimens as types and went ahead and labeled a specimen in the AMNH as the lectotype. What he probably did not realize was that the type of *exsertistigma*, a female, was curated under a more recent combination, *Rhynchagrotis* [sic] *binominalis*. This female, discussed in Todd (1982) under *binominalis*, is probably the type of *exsertistigma*. Like many types of the time, no name is affixed to the type. The males above were part of the original type series of *binominalis*, and are therefore paralectotypes of this name. A synonym of *Rhynchagrotis exsertistigma* (Morr.) (RWH 11047); misspelled as *exertistigma* in Hodges (1983).

Eucalyptera bipuncta Morrison, 1875f:104.

Type locality. "Massachusetts. Taken at Belmont, Aug. 17, 1874."

Male, "*bipuncta* Morr Type. Cam. Ms. Aug 7 275" [M]; "Type" [C] [Type slightly worn, the abdomen and right antenna missing]

Remarks: The holotype. The type locality "Belmont" in the original description

vs. "Camb" on the specimen are not in agreement, as is the date which was likely a transcriptional error. Belmont, however, is very near Cambridge and is probably referable to this specimen, the date discrepancy is likely a transcriptional error. A synonym of *Gabara subnivosella bipuncta* (RWH 8522a).

Agrotis bocha Morrison, 1874b[1875]:163.

Type locality. "Nebraska, Colorado."

Female, "Colorado 202"[M]; "Tepper"[ty] [Right forewing damaged; the left forewing missing and only the left pro leg present]

Remarks: This holotype was found in the general collection, unlabeled. M.C. Nielsen brought this specimen to my attention as a suspected type. Hardwick (1970:156) stated that the "monotype of *bocha* should be in the Tepper Collection at MSU, but a thorough search has failed to uncover the specimen and it must be presumed lost." The Colorado specimen was not found in the general collection. *Crassivesica* (RWH 10913).

Luceria burgessi Morrison, 1874c:109.

Type locality. "Tuckernuck Island, near Nantucket. Four specimens taken by Mr. Bigelow, and now in the collection of Edward Burgess and H. K. Morrison."

Male, "Type"[C]; "Nantucket 43"[M] [Excellent condition]

2 Females, no data [Excellent condition]

Remarks: Syntypes. Although Poole (1989) indicated that the types are in the BMNH, Kauri Mikkola (pers. comm. 1992) was unable to find it there; his feeling is that these three specimens comprise what remain of the original type series. Although uncommon, sometimes Morrison's additional specimens do not bear any other data when taken at the same locality. The fourth specimen of the type series must be presumed lost. In a forthcoming publication, Mikkola and Lafontaine will designate the male listed above as the lectotype (Mikkola, pers. comm. 1995). *Crymodes* (RWH 9378).

Heliothis californicus Grote, 1873c:149.

Type locality. "California (Mr. Hy. Edwards, No. 9). Four specimens examined."

Male, "*californicus* Grt, Type. California 299"[M] [Left meta leg absent, left antenna broken at base, abdomen whole but excavated by dermestids, genitalia destroyed]

Remarks: Paralectotype. A total of six specimens were curated as types for *sueta* Grote, one of which was the male type of *californicus*. The Tepper collection accession notes indicate types of *californicus* were received with the Tepper collection. Smith (1893) state that one type was in Tepper's collection, another in the BMNH. Hardwick (1958, 1996) designated the specimen in the BMNH as the lectotype. *Schinia sueta californica* (RWH 11088a).

Thalpocharis carmelita Morrison, 1875c [1876]:434–435.

Type locality. "Dallas, Texas (Mr. Boll)."

Male, "Dallas Tex. Boll"[ty]; "Type"[C] [Specimen in excellent condition, verdigris building around the thorax of the specimen]

Remarks: Syntype. The original extent of the type series is not known. Poole (1989) states that the type is in the MCZ, but this specimen is also likely a type. A synonym of *Eumicremma minima* (Gn.) (RWH 9076).

Hadena castanea Grote, 1874b[1875]:156.

Type locality. "California (Mr. Behrens, three specimens with the number 10 and 20)."

Male, "Calif. "[T]; "Type" [C] [In very good condition]

Remarks: The status of this type is not known. A total of 6 specimens were curated as types for this name, 5 poor specimens were Tepper's from the Washington Territories. The species was described from California, and the male so marked is probably the only potentially valid type, however, the absence of the red number labels indicated by Grote in the original description places this conclusion into question. A total of 8 specimens were noted in the Tepper collection accession notes, and "type" is written next to the name in Cook's hand. *Apamea* (RWH 9349).

Hadena characta Grote, 1880a:243.

Type locality. "Nevada; Mr. Tepper."

Female, "Nevada" [T] [In very good condition]

Remarks: The status of this type is not known. This specimen was found in the general collection without a type label. Smith (1893) stated that the type was in the BM and that "another typical specimen" was in the Tepper collection. I have not been able to confirm the presence of this type in the BM. *Aseptis* (RWH 9543).

Agrotis comosa Morrison, 1876:238.

Type locality. "Colorado T. L. Mead."

Male, "Type" [C]; "Colorado Aug 7 1872 193" [M] [In poor condition; the abdomen and legs and left antenna missing]

Remarks: The holotype (LaFontaine, 1987). *Euxoa* (RWH 10780).

Agrotis confusa Smith, 1888a:452.

Type locality. "Washington Territory."

Female, "W. T." [M]; "Type" [C] [In very good condition]

Female, "W. T." [M]; "Type" [C]; "1599" [?] [Extensive damage by verdigris on thorax]

Remarks: Paralectotypes. Todd (1982) designated a specimen at the USNM as the lectotype. A synonym of *Rhynchagrotis insularis* (Grt.) (RWH 11048).

Hadena congermana Morrison, 1874d:106.

Type locality. "A rare species. *Hab.* New York, and one specimen taken at Beverly, Mass., June 24, 1867, by Mr. Edward Burgess . . ."

Male, "Beverly Ms. June 24, 1867 25" [M]; "Type" [C] [In excellent condition, left antenna missing]

Female, "N.Y. State" [M] [In excellent condition]

Male, "N.Y. State" [M] [In poor condition, extensive dermestid damage to the thorax, head missing]

Remarks: The data of the male from MA matches perfectly with the original description; it is selected and hereby designated as the lectotype. *Sideridis* (RWH 10266).

Taeniocampa confluens Morrison, 1874b[1875]:159-160.

Type locality. "St. Louis, Mo. Prof. C. V. Riley."

Female, "*confluens*, Morr Type, Cen. Missouri 413" [M] [In poor condition, antennae missing, abdomen and thorax severely excavated by dermestids.]

Remarks: The holotype. A synonym of *Orthosia hibisci* (Gn.) (RWH 10495).

Homophoberia cristata Morrison, 1875b:125.

Type locality. "Hoboken, N.J. One specimen kindly presented to us by Mr. Herman Sachs."

Female, "N.J." [?] [In very good condition, the antennae missing]

Remarks: This specimen was found unlabeled in the general collection and is probably the holotype of *cristata* (RWH 9056).

Tarache crustaria Morrison, 1875d:70–71.

Type locality. "Nebraska. Described from material given us by Mr. G. M. Dodge."

Male, "Type" [C]; "Type Nebraska 258" [M] [In good condition]

Male, "Nebr" [?]; "Type" [C] [In poor condition; the specimen damaged by dermestids, the abdomen and wings glued onto the specimen]

Remarks: The male in good condition marked type by Morrison is selected, labeled and now designated as the lectotype. *Pseudacontia* (RWH 10172).

Mamestra curta Morrison, 1875f:96.

Type locality. "Colorado, July 20 and 22."

Male, "Colorado" [T]; "*curta*, Morr, Type. Colorado. 7. 22 220" [M] [A well marked specimen in poor condition; dermestids appear to have excavated the thorax and abdomen but the genitalia appear to be intact. The legs are absent and the abdomen has been glued at the base of the thorax.]

Female, "*curta* Morr Type. Colo July 20 220" [M] [In very good condition]

Remarks: The holotype. A subspecies of *Lasiestra impingens* (RWH 10339a).

Agrotis decolor Morrison, 1874b[1875]:162.

Type locality. "New York; Massachusetts; Maine."

Male, "New York" [M] [Very good condition, left hindwing margin partially damaged]

Male, "New York" [M] [In fair condition, head missing]

Female, "New York" [M] [In excellent condition, left antenna missing]

Remarks: This material was found in the general collection and not labeled as a type. Poole (1989) states the type is in MSU. LaFontaine (1987) declared the type lost. The specimens before me agree with the original description and all were probably in the original type series. I hereby designate the first male as the lectotype. A synonym of *Euxoa declarata* (Wlk.) (RWH 10755).

Syneda deducta Morrison, 1874g[1875]:220–221.

Type locality. "Waco, Texas."

2 females, "Texas" [?] [In very good condition]

Remarks: Syntypes. These specimens were found in the general collection. There is also an unsexed specimen from "Tex" in the MCZ. *Bulia* (RWH 8614).

Caradrina derosa Morrison, 1875b:121.

Type locality. "New Jersey. Received from Mr. W. V. Andrews."

Female, "N.J." [T] "Type" [T], "Fr. Australia=*nitocris capularis*." [S] [The antennae, right legs and abdomen destroyed by dermestids]

Remarks: The holotype; extralimital. A synonym of *Rictonis capularis* (Gn.) (Poole, 1989).

Agrotis digna Morrison, 1875b:115.

Type locality. "Texas."

Male, "21/9[?]" ; "Texas"[T] [In very good condition]

Female, 4/8.[?]" ; "Texas"[T] [Right antenna missing, otherwise in good condition]

Remarks: Status uncertain. This type was found unlabeled in the general collection. Smith (1893) stated that the type, a single specimen, was in the Tepper collection and another in the Peabody Academy of Sciences. *Euagrotis* (RWH 10908).

Orthosia differta Morrison, 1875d:67.

Type locality. "New York. Received from. . . Mr. Fred Tepper."

Male, "Type"[M]; "*differta* U.S. Morr"[T] [A well marked specimen with all legs missing except the right metathoracic]

Remarks: The holotype. Hardwick (1996) had no information regarding the location of this type. A synonym of *Rhodoecia aurantiago* (Gn.) (RWH 11065).

Heliothis diminutivus Grote, 1873c:148-149.

Type locality. "California (Mr. Hy. Edwards, No 204). Ten specimens examined."

Female, "California"[M]; "Type[C] [In good condition, right antenna missing]

Female, "Cal."[?] [In good condition, only right pro and meso legs present]

Female, no labels. [Right pro and meso legs missing, in good condition]

Remarks: Paralectotypes. Hardwick (1996) designated a specimen in the USNM as the Lectotype. Smith (1893: 291) stated that the "types are in the Tepper Collection and in the British Museum." *Heliothodes diminutivus* (RWH 11058).

Lithophane disposita Morrison, 1874c:109.

Type locality. "Canada, Mass., New York. In April and May."

3 males, "New York"[M] [All three in very good condition except one without an abdomen]

Remarks: Syntypes. These specimens were found in the general collection and probably were part of the original type series of *disposita* (RWH 9892). Type(s) at MSU (Poole 1989).

Demas diversicolor Morrison, 1874b[1875]:132-133.

Type locality. "New York. From my collection. Massachusetts, Sept. 16, 1874. (Mr. Roland Thaxter)."

Male, "Tepper"[ty]; "Massachusetts 232"[M] [Type in good condition with left forewing torn]

Male, no data. [Left legs missing, well marked]

Female, no data. [Legs and left antenna missing]

Remarks: Only one type in the collection is labeled, and this is the MA specimen. The status of the two unlabeled specimens is not known. Smith (1893: 146) states that "the type is in the Tepper collection; another specimen is in the British Museum and is also marked type" while Poole (1989) states the type is at MSU. Lynnette Warshaw (pers. comm. 1994) indicated 2 specimens from the 14th and 31st of September from Newtonville MA with the label R[oland].T[haxter].C[ollection]. at the MCZ. It is not known whether types of this species are at the BMNH. The MCZ material is likely the better candidate for lectotype designation. *Meropleon* (RWH 9427).

Mamestra dodgei Morrison, 1875a:90–91.

Type locality. “Nebraska (G.M. Dodge).”

Male, “Nebr”[?]; “*Mamestra Dodgei*, Type Mor”[M] [In very good condition, right antenna missing]

Remarks: The holotype. A synonym of *Lacinipolia lorea* (Gn.) (10405).

Heliaca dubitans Tepper, in Smith 1883:246.”

Type locality. “Nevada.”

Male, “Type”[C]; “Nevada”[T] [In excellent condition]

Remarks: Holotype (Hardwick 1996). A synonym of *Schinia perminuta* (Hy. Edw.) (RWH 11091).

Taeniocampa earina Morrison, 1874b[1875]:158–159.

Type locality. “California.”

Female, “*earina*, Morr Type California 412”[M] [Some verdigris at the base of the pin, right antenna missing]

Remarks: The holotype. The author of *earina* is not Harvey in (Hodges, 1983). A synonym of *Lasionycta insolens* (Grt.) (RWH 10366).

Dicopsis electilis Morrison, 1875b, 114–115.

Type locality. “Easton, Penn. From Mr. W. H. Stultz.”

Female, “Type”[C] [In poor condition with dermestid damage to abdomen and maculation somewhat rubbed]

Remarks: The holotype (Poole, 1994). *Psaphida* (Poole, 1989, 1994) (RWH 10012).

Agrotis exsertistigma Morrison, 1874b[1875]:166.

Type locality. “California.”

Female, “So Cal”[T]; “Ty[pe]”[C] [Specimen in excellent condition]

Remarks: This female was curated as a type of *binominalis* (see *binominalis*) but I have reason to believe that this is the Morrison type of *exsertistigma*, and curated under the Smith name. In Smith (1893) he states that “this is the *exsertistigma* of the Edwards collection, and like one specimen so labeled [*exsertistigma*] in Mr. Tepper’s collection.” Which may be interpreted as stating that the type of *exsertistigma* is to be found at MSU even though there was no type for that name curated in the collection. I would expect the type for *exsertistigma* to be at MSU since it is a Morrison name, and it is likely that the female above, curated with male types of *binominalis*, is in fact the type for *exsertistigma*; (RWH 11047); misspelled as *exertistigma* in Hodges (1983). A synonym of *Rhynchagrotus formalis* (Crt.).

Agrotis extranea Smith, 1888a:459.

Type locality. “Montana. A single female specimen from Mr. Tepper.”

Female, “Mt. Hood”[T]; “Type”[C]; “*Euxoa* slide MSU No. 12.”[In very good condition, the prothoracic legs missing]

Remarks: The holotype (Lafontaine, 1987). *Euxoa* (RWH 10708).

Segetia fabrefacta Morrison, 1874b[1875]:146–147.

Type locality. “One specimen taken at Tuckernuck Island near Nantucket, and now in the collection of A. R. Grote. Another taken at Brooklyn, N.Y., in my possession.”

Male, "Tepper"[T]; "New York 103"[M]; "Type"[C] [The well marked specimen is in poor condition, the right wing has fallen off, the abdomen is lost to dermestid damage, and the legs and right antenna are missing.]

Remarks: Syntype. The male above is likely the Morrison specimen mentioned in the original description. There is no specimen in the series labeled Nantucket or Tuckernuck Island, and since this was in Grote's collection, it is presumed that this specimen is in the BMNH (Poole, 1989). A synonym of *Platysenta sutor* (Gn.) (RWH 9699).

Lithophane fagina Morrison, 1874c:115-116.

Type locality. "Cambridge Mass., April 15, 1874. From my collection."

Male, "Type"[C]; "*fagina* Morr. Type. Camb. Ms 4,15 1874"[M] [The thorax severely damaged by verdigris and the right wings appear to have been glued to the thorax]

Remarks: The holotype (RWH 9917).

Agrotis fauna Morrison, 1876:237.

Type locality. "Guadaloup island, lower Cal."

Male "Type"[C]; "*Euxoa* slide MSU No. 15"[ty] [Type in poor condition, legs broken and damaged by dermestids, left antenna missing]

Remarks: The holotype. Smith (1893: 98) states that the "type, a miserable specimen, is in the Tepper Collection." Extralimital (Poole, 1989).

Pachnobia ferruginoides Smith, 1890:56.

Type locality. "Montana."

Male, "Montana"[T]; "Type"[C] [In good condition]

Female, "Montana"[T]; "Type"[C] [Excellent condition]

Remarks: Paralectotypes. Todd (1982) designated a USNM specimen as the lectotype. A synonym of *Paradiarsia littoralis* (Pack.) (RWH 10992).

Dryobota fibulata Morrison, 1874c:112.

Type locality. "Quebec. Can., in my collection from F.X. Belanger."

Female, "*Dryobota fibulata* Morr Can Type"[M,T] [Abdomen and antennae absent, markings prominent]

Remarks: The holotype. The specimen is unusual in that Morrison departs from his trademark triangular label and uses a square label. The words "*Dryobota fibulata* Morr Can" appear to be in Morrison's hand, and a portion of the "Q" in Quebec appears to have been cut off the label. "Type," on the other hand, is written in red ink in Tepper's hand. A synonym of *Eremobina claudens* (Wlk.) (RWH 9396).

Segetia fidicularia Morrison, 1874b[1875]:145.

Type locality. "Adirondack Region, N. Y. A single specimen in the collection of my friend Mr. F. C. Bowditch, of Harvard Law School."

Female, "Milford N. H. 94"[M]; "*Segetia fidicularia* Morr. 94"[M] [Right antenna, left pro and meso and right meso and meta legs missing, mold damage]

Remarks: This specimen was found, unlabeled in the general collection. The locality of this specimen does not match the original description; it is not known if this is the type. Neither Smith (1893) or Poole (1989) indicated the location of the type. It is, however, possible that the locality discrepancy is an error in the original

description. In the absence of other convincing type material, this specimen with a determination by Morrison, may be a good candidate as a type. A synonym of *Caradrina multifera* (Wlk.) (Poole, 1989) (RWH 9657).

Heliophila flabilis Grote, 1881a:15.

Type locality. "Long Island, near the sea shore, in May; Mr. Tepper."

Male, "L. I. May 20 [18]77,"[T]; "Type"[C] [Type in fair condition; both meso legs and right antenna missing]

Remarks: Syntype. Smith (1893 p. 189) states the "types are in the Tepper collection and in the British Museum. The species was described from material taken by Mr. Tepper." Poole (1989) states that the type is in the BMNH. A synonym of *Leucania extincta* (Gn.) (Poole, 1989) or subspecies of *L. extincta flabilis* (RWH 10439a).

Agrotis flavicollis Smith, 1888a:456.

Type locality. "Montana. One female specimen from Mr. Tepper's collection."

Female, "Montana"[T]; "Tepper"[ty]; "Type"[C]; "Euxoa slide MSU No. 13"[ty] [In good condition, but only the right meso and left meta leg present]

Remarks: The holotype (Todd, 1982). *Euxoa* (RWH 10864).

Homohadena fortis Grote, 1880a:257.

Type locality. "Nevada."

Female, "Nevada"[T]; "Type"[C] [In very good condition, the left pro and right pro and meso legs and right antenna missing]

Remarks: Status uncertain. Poole (1989) states that the types are in the BMNH. Smith (1893) stated the type was in the Tepper collection. In the absence of other material, this is probably the holotype. *Homoncoenemis* (RWH 10068).

Ablepharon fumosum Morrison, 1874a:275.

Type locality. "Massachusetts. May 24th and 26th. Coll. H. K. Morrison."

Male, "Cambridge, Ms 5/21 288"[M]; "Type"[C] [In excellent condition]

Male, "Cambridge, Ms 5/30 288"[M]; "Type"[C] [In excellent condition]

Remarks: Status uncertain. Although the precise day of May is not in agreement with the original description, it is difficult to conclude that these are not syntypes. A synonym of *Simyra henrici* (Grt.) (RWH 9280).

Hadena fuscimacula Grote, 1881b:262.

Type locality. "No locality given."

Male, "Florida"[T]; "Type"[C] [In very good condition]

Female, "Florida"[T]; "Type"[C] [In good condition, left antenna missing]

Remarks: Poole states that the types are in the BMNH. It is not known if this specimen is also a part of the original type series. *Elaphria fuscimacula* (Grote) (RWH 9675).

Homoptera galbanata Morrison, 1875c[1876]:435–436.

Type locality. "Glencoe, Nebraska. From Mr. G. M. Dodge (No. 48)."

Male, "48"; "Type"[C] [In excellent condition]

Remarks: Probably the holotype. *Zale* (RWH 8692).

Calocampa germana Morrison, 1874e:192.

Type locality. "Adirondack Mountains. (Mr. Bowditch)."

2 males, 1 female, "New York" [?] [In very good condition]

Remarks: Syntypes. These specimens were found in the general collection without type labels. Poole (1989) states that the type is at MSU. Smith (1893) did not indicate the location of the type. The handwriting of the three specimens is not known, but may be that of Bowditch. A male from the above series has been selected and labeled the lectotype. A subspecies of *Lithomoia solidaginis* (RWH 9878a).

Agrotis gladiaria Morrison, 1874b[1875]:162-163.

Type locality. "Massachusetts."

Male, "Cambridge Mass. 177" [M]; "Type" [C] [Right antenna missing, otherwise in very good condition]

Remarks: The original number of types at the time of description is not known. If no other type material of this species is found, this is probably the holotype. There may be additional material for this species at other collections (RWH 10648).

Melicleptria graefiana Tepper, 1883:245.

Type locality. "Southern California."

Male, "So Cal" [T] [In fair condition, only left pro leg present, left antenna broken]

Male, "So Cal" [?] [In good condition, the right antenna missing]

Female, "So Cal" [T] [Only left meso leg is present]

Remarks: The specimens above were curated as types for this species but are not, the holotype is at the USNM (Hardwick, 1996). Hardwick (1958) acknowledged the above specimens as *Schinia pulchripennis* (Grt.). Since California is the type locality for *Schinia pulchripennis*, there is a strong chance that the type(s) above represent the type series for *pulchripennis*, types which Hardwick (1996) presumed lost.

Valeria grotei Morrison, 1874a:274.

Type locality. "Massachusetts. Specimens taken in Cambridge from April 10th to 26th, coll. H. K. Morrison."

Male, "grotei, Morr. Type, Cambridge M[a]", April 14, 331" [M]; "Type" [C] [A well marked specimen in good condition; left pro and meso legs and antenna missing]

Remarks: The holotype (Poole, 1994). The location of the other specimens indicated in the description is not known, nor does Poole (1994) mention these other specimens. *Copivaleria* (RWH 10021).

Schinia hultstia Tepper, in Smith 1883:228.

Type locality. "1 female Texas? Type, Coll. Tepper."

Female, "Texas" [?]; "Type" [C] [In fair condition]

Remarks: The holotype (Hardwick, 1996) (RWH 11193).

Mamestra illabefacta Morrison, 1874c:141-142.

Type locality. "Beverly, Mass. June 26, 1869, Edward Burgess."

Male, "illabefacta Morr. Type Beverly, Mass 18" [M] [In very good condition, the left pro and meta leg and left antenna missing]

Remarks: Smith (1893: 123) stated that there is a type "in the Tepper collection, and another . . . in the British Museum." McCabe (1980) did not indicate the location of the type. Given all the trademarks of Morrison, and despite the discrepancy in the date of capture, this is likely the holotype. A synonym of *Lacanobia lilacina* (Harvey) (RWH 10307); *Trichordestra* (Poole, 1989). Misspelled as *illebefacta* in Hodges (1983).

Acronycta increta Morrison, 1874c:131.

Type locality. "New York. Several specimens received from Messrs. Fred Tepper and E. L. Graef. Types in the collections of the Buffalo Society of Natural Sciences, and H. K. Morrison."

Female, "Brooklyn N. Y." [M]; "Type" [T] [The well marked specimen has the right wing missing]

Remarks: Syntype. The location of the other specimens is not known. *Acronycta* (RWH 9249).

Laphygma inflexa Morrison, 1875d:65–66.

Type locality. "Jacksonville, Fla."

Female, "Florida" [T]; "[illegible]"; "Type" [C]; "=*Lyssa* (*Laphygma filifera* Wlk.)" [Sm] [In good condition]

Remarks: The holotype. A synonym of *Collomena filifera* (Wlk.) (RWH 8982).

Agrotis infracta Morrison, 1875b:115.

Type locality. "Colorado (T. L. Mead); Texas (Belfrage)."

Female, "Col" [T]; "Type" [C]; "*Euxoa* slide MSU No. 3" [ty] [In fair condition]

Male, "Col" [ty]; "male." [symbol] [In poor condition, the antennae are missing and the right valve missing]

Remarks: The male was found in the general collection. Lafontaine (1987) stated that he had designated the female as the lectotype, but no such label was found on the specimen. I have since added a lectotype label. *Euxoa* (RWH 10850).

Hadena inordinata Morrison, 1875d:63.

Type locality. "Massachusetts, in June from our collections."

Female, "Mass" [M]; "Newtonville June 16, 1874" [M]; "Type" [C] [In very good condition]

Remarks: The original "from our collections" hints that there were a number of specimens. The absence of an explicit indication of the name *inordinata* is not typical of Morrison. In the absence of more convincing material, this may be a good candidate for lectotype designation. This is certainly a type if no other types exist. *Apamea* (RWH 9353).

Taeniocampa intractata Morrison, 1874b[1875]:160–161.

Type locality. "Habitat, St. Louis, Mo., Prof. C. V. Riley."

Male, "*intractata*, Morr Type, Cen. Missouri 414" [M]; "Type" [C] [In good condition, antennae missing]

Female, no data. [Right hindwing and antennae missing]

Male, no data. [Extensive dermestid damage to abdomen and thorax]

Remarks: Syntypes. The status of the male and female without data is not known. The labeled male is undoubtedly a valid type, however, Poole (1989) also indicates that a type is at the USNM. *Himella fidelis* (RWH 10502).

Oncocnemis iricolor Smith, 1888b:19.

Type locality. "Colorado. Three specimens, all females, 1 Coll. U.S. National Museum (Smith Coll.) the others Coll. F. Tepper."

Female, "Col" [T]; "Type" [C] [In fair condition, some dermestid damage to the abdomen, left pro leg missing]

Female, "Col"[T]; "Type"[C] [Antennae missing, well marked]

Remarks: The females above are paralectotypes. Todd (1982) designated a specimen in the USNM as the lectotype (RWH 10092).

Plusia laticlavia Morrison, 1875f:98.

Type locality. "New York. July 10, 1872. Described from a single specimen in good condition received from Mr. Fred Tepper."

Male, "L. I. July 10, 1872"[T]; "Type Morr"[M]; "laticlavia"[?] [In very good condition, right meta leg missing]

Remarks: The holotype. There were fully three different plusiine species in this "type" series. From the original description, however, it is clear that Morrison had but a single specimen at the time of description. A synonym of *Argyrogramma basigera* (Wlk.) (RWH 8886).

Panthea leucomelana Morrison, 1875c[1876]:428.

Type locality. "Maine."

Male, "Maine"[T] [Both metathoracic legs missing]

Remarks: This specimen was found in the general collection without a type label. This is very likely the holotype. Poole (1989) states the type is at MSU. A synonym of *Panthea acroncytoides* (Wlk.) (RWH 9177).

Luceria loculata Morrison, 1874c:110.

Type locality. "Mass., New York. Four specimens examined and one of var. *conspicua*."

Male, "*loculata*, Morr Type Boston, MS, 44"[M] [A well marked specimen with hollow abdomen, genitalia appear intact]

2 males, no data. [Well marked but with some verdigris on thorax]

Remarks: Syntypes. The location of the additional type material, or the status of the two unlabeled males is not known. A synonym of *Luperina passer* (Gn.) (RWH 9391).

Luceria loculata var. *conspicua* Morrison, 1874c:111.

Type locality. "Mass., New York. Four specimens examined and one of the var. *conspicua*."

Male, "Boston Ms 59"; "Type"[M] [In good condition, extensive damage to abdomen and genitalia]

Remarks: One specimen is indicated and presumed to be the holotype. The type locality of *conspicua* is not clearly indicated in the original description. A synonym of *Luperina passer* (Gn.) (RWH 9391).

Heliothis lucens Morrison, 1875d:69.

Type locality. "Mass., Nebraska."

2 males, 3 females, "Nebr."[M] [In very good condition]

Remarks: Paralectotypes (Hardwick 1996). These five specimens were in the general collection and not labeled as types. Only one label appears to be in Tepper's hand, the other in Morrison's. *Schinia* (RWH 11174).

Penthetria majuscula Henry Edwards, 1881a:80.

Type locality. "Georgia. H. K. Morrison. Type. Coll Hy. Edwards. Female. Type. F. Tepper."

Female, "Ga"[T]; "female"[?]; "Type"[C] [In fair condition, the antennae missing]
 Remarks: Syntype. The male syntype is at the AMNH (Poole, 1989). A synonym of *Cydosia aurivitta* (RWH 8999).

Agrotis manifesta Morrison, 1875d:116.

Type locality. "Described from specimens in the collection of Mr. Fred Tepper. Hab. New York. In May."

Female, "Flatb[ush] May 25/72"[T]; "Type"[T] [In very good condition]

Male, "Flatb[ush] May 25/72"[T]; "Type"[C] [In poor condition, dermestid damage to head, thorax, and abdomen]

Remarks: Syntypes. Lectotypes have not been designated due to the poor quality of this material. Hodges (RWH 10666).

Agrotis manifestolabes Morrison, 1874b[1875]:166.

Type locality. "Massachusettes, in the early spring."

Male, "*manifestolabes* Morr. Type. Cambridge, April 29, 187[2] 183"[M] [In fair condition, the right legs and left antenna missing]

Remarks: The holotype. A synonym of *Cerastis tenebrifera* (Wik.) (RWH 10994).

Oncocnemis meadiana Morrison, 1875d:60–61.

Type locality. "Colorado, Aug. 18 (No. 47, Mr. T. L. Mead)."

Female, "Colo Aug, 18, 1872 216"[M]; "Type"[C] [Specimen in good condition]

Remarks: The holotype (RWH 10098).

Caradrina meralis Morrison, 1875g:215.

Type locality. "Maine. Collection H. K. Morrison."

Male, "Maine"[M]; "Type"[C] [In excellent condition].

Remarks: The original extent of the type series is not known. This is probably the holotype. *Caradrina* Poole (1989)(RWH 9654).

Carneades messoria var. *confracta* Smith, 1890:170.

Type locality. "One form. . . has been named var. *confracta*. by Mr. Morrison in Mr. Tepper's collection (Smith 1890)." Extracted from Todd (1982).

Female, "Agrotis Messoria var. Confracta Morr. U.S."[T]; "Euxoa slide MSU No. 8."[ty] [Type in fair condition, right antenna missing]

Remarks: The holotype (Todd, 1982). The name *confracta*, discussed by Smith (1890) was a manuscript name. The mention of a MSS name is attributed to Smith who formally published a discussion of a name which constitutes a valid description. A synonym of *Euxoa pleuritica* (RWH 10727).

Zanclognatha minoralis Smith, 1895:34, Plate 2, fig. 6, plate 10 figs. 28, 29.

Type locality. "Long Island, New York, probably."

Male, "*Megachyta minoralis* Smith, Type"; "6" "Lectotype, *Zanclognatha minoralis* by Todd" [Right palpus missing, otherwise in good condition]

Remarks: This specimen was found by J. E. Zabloutny in a slide box in a drawer of unsorted bees in the general collection. The lectotype of *minoralis* (RWH 8343) was designated by Todd (1982).

Orthosia minuscula Morrison, 1874b[1875]:147.

Type locality. "Tuckernuck Island, near Nantucket. Mr. Edward Burgess."

Female, "Tepper"[ty]; "Nantucket 46"[M]; "Type"[C] [In fair condition, antennae missing and markings somewhat rubbed]

Remarks: It appears he had but a single specimen when he described it since he indicated displeasure in the "badly rubbed" specimen and hoped that "perhaps the discovery of a better specimen will show that this species should be referred to a different genus." It is not known which, if either, is the holotype. *Oligia* (RWH 9416).

Carneades misturata Smith, 1890:156.

Type locality. "Colorado."

Male, "Col"[T]; "Type"[C]; "Euxoa Slide MSU No. 7"[ty] [Left meso leg missing, antennae missing]

Remarks: Todd (1982) stated that the type "in the Michigan State University collection has been selected, labeled, and is now designated the lectotype." There is no lectotype label affixed to this specimen. I have since added a label. *Euxoa* (RWH 10766) of Morrison manuscript name.

Taeniocampa modifica Morrison, 1874b[1875]:150-151.

Type locality. "Massachusetts. A male from my collection captured July 16, 1874.

A female from the collection of Mr. F. C. Bowditch, kindly lent me for determination."

Male, "July 14, 1874 Cambridge, Ms 414"[M]; "Type"[C] [The left antenna missing]

Male, [no labels, in very good condition]

Remarks: The labeled male is probably the holotype. The male type was obviously collected by Morrison and is likely the specimen he mentions despite the discrepancy in the date on the specimen and that of the original description. The location of the Bowditch female is not known. The status of the unlabeled male is unknown. A synonym of *Ulolonche culea* (Gn.) (RWH 10567).

Agrotis montana Morrison, 1875f:94-95.

Type locality. "Mountains of Colorado, above 12,000 feet, July 22 to Aug. 12.

One specimen in the possession of Dr. A. S. Packard, Jr., and another in our own collection."

Female, "Col"[T]; "*montana* Morr. Type Colorado above 12,000 ft 172"[M] [Dorsally flattened, abdomen eaten by dermestids, in extremely poor condition]

Female, "Col"[T] [In fair condition]

Remarks: Syntype. Morrison does not list the sex of the two specimens he had before him at the time of the description; the first female is probably a type. Smith (1893: 141) states that "Mr. Morrison's type is in the Tepper collection, and is from the east." Poole (1989) and Lafontaine (1987) state the type is at the MCZ. Lynette Warshaw (pers. comm. 1995) stated the type(s) are at MCZ, however, there is no information associated with this entry on the Internet at this time. The presence of the trademark Morrison label suggests that the female, labeled *montana* by Morrison is also a (syn)type and probably refers to the "in our own collection" specimen. *Euxoa* (RWH 10856).

Eutricopsis nexilis Morrison, 1875f:102-103.

Type locality. "Colorado, June 18."

Male, "Colorado"[M]; "Type"[C] [In good condition, antennae missing]

Remarks: Paralectotype. Hardwick (1996) designated a lectotype, now in the USNM. The locality label is one of Morrison's and is in his handwriting, but he does not indicate the specific name on the label, which is unusual for a Morrison type (RWH 11062).

Tarache obatra Morrison, 1875b:124

Type locality. "Louisiana."

Female, "Louisian[a]"[T]; "Type"[C] [In very good condition, antennae missing]

Remarks: The holotype. *Spragueia* (RWH 9130).

Eustrotia obaurata Morrison, 1874b[1875]:154.

Type locality. "Massachusetts."

Female, "*obaurata*, Morr Type. Mass 250"[M] [In fair condition, only the left meta leg complete]

Remarks: The original number of specimens in the type series is not known; probably the holotype. A synonym of *Nola pustulata* (Wlk.) (RWH 8989).

Mamestra olivacea Morrison, 1874b[1875]:143.

Type locality. "New York; New Hampshire."

Female, "N. Y. State"[M] [In good condition, the abdomen is broken off, and is associated with the specimen in a genitalia vial]

Remarks: This specimen was found in the general collection and not labeled as a type. Six other specimens were associated with it, all in Tepper's hand, and from western North America. The location of the material from NH is not known. If the NH material cannot be found, this is probably the holotype. Poole (1989) states type is at MSU. *Lacinipolia* (RWH 10406).

Agrotis olivia Morrison, 1876:238.

Type locality. "Utah (T.L. Mead)."

Male, "Utah 186"[M]; "Type"[C] [In good condition, only the right pro leg present]

Remarks: The holotype (Lafontaine, 1987). *Euxoa* (RWH 10741).

Agrotis opipara Morrison, 1874b[1875]:165–166.

Type locality. "The alpine region of Mt. Washington."

Female, "Mt. Washington, July 11, 1874."[ty] [In good condition]

Remarks: This specimen was found in the general collection, is unlabeled and is likely a type. Lafontaine (1987) stated that the type is in the BMNH. The MSU specimen also appears to be a syntype. A synonym of *Euxoa dissona* (Mosch.) (RWH 10706).

Segetia orbica Morrison, 1874g[1875]:216–217.

Type locality. "Waco, Texas."

Female, "*orbica* Morr. Type. Waco. Tex. 7 28 125"[M]; "Tepper"[ty]; "Type"[C] [In good condition, the right pro and both meso legs and the left meso leg and left antenna are missing]

Male, "19"[?] [In good condition, the antennae are missing]

Remarks: Another putative type of *orbica* is at the MCZ (L. Warshow, pers.

comm. 1995). The unsexed specimen is at the MCZ, without specific label data and is not likely a type. The male is of uncertain validity, so the female above is selected and designated as the lectotype. A synonym of *Amyna octo* (Gn.) (RWH 9070).

Agrotis orbicularis Smith, 1888a:460.

Type locality. "Colorado (Bruce). A single female is in Mr. Tepper's collection."

Female, "Nevada"[T]; "Type"[C]; "Euxoa slide MSU No. 14"[ty] [In very good condition]

Remarks: Despite the discrepancy in label data, Lafontaine (1987) recognized this specimen as the holotype. A synonym of *Euxoa cooki* McD. (RWH 10858).

Heliophila oxygala Grote, 1881a:14.

Type locality. "One specimen in Mr. Tepper's collection, one male in my own."

Female, "Col."[T]; "Type"[T] [The well marked specimen is in poor condition, the left pro leg the right antenna is missing, and glue appears to have been applied to the left wings and the right hindwing. Thorax damaged by dermestids]

Remarks: Syntype. Poole recognized types in both BMNH and MSU. Smith (1893 p. 185) states that the "type is in the British Museum. I have a specimen carefully compared with it. Another specimen, also marked type, is in the Tepper collection." The red inked labels "Col." and "Type" are in Tepper's hand. *Aletia* (RWH 10436).

Hadena paginata Morrison, 1875d:64-65.

Type locality. "Florida (Mr. C. J. Maynard)."

Male, "Florida"[T]; "Tepper"[ty]; "Type"[C] [In poor condition; the abdomen destroyed by dermestids]

Remarks: Probably the holotype. A synonym of *Elaphria nucicolora* (Gn.) (RWH 9676).

Aedophron pallens Tepper, In Smith 1883:215.

Type locality. "Southern California."

Remarks: Type presumed lost. This species was described from the Tepper collection in a paper by Smith. I have been unable to find a specimen of this species in the collection. *Nocloa* (RWH 9795).

Agrotis pallipennis Smith, 1888a:461-462.

Type locality. "Colorado. Specimens are with Messrs. Hulst, Graef, and Tepper."

Female, "Col."[T]; "Tepper"[ty]; "Type"[C] [In good condition]

Male, "Col"[T] [In fair condition]

Remarks: Paralectotypes. Todd (1982) mentions only one specimen at MSU and makes no mention of the male above. In addition, he stated that the female MSU specimen was in poor condition and that the abdomen appeared glued to the thorax. I have been unable to find any indication that the abdomen was glued. A lectotype of this species was designated from the U.S.N.M. (Todd 1982). *Euxoa* (RWH 10765).

Heliophila patricia Grote, 1880c:46.

Type locality. "Colorado. Coll. of Mr. Tepper."

Female, "Cal"[T]; "*Heliophila patricia* Grote Type"[G] [In excellent condition]

Remarks: The holotype. *Neleucania* (RWH 10610).

Tarache patula Morrison, 1875d:69–70.

Type locality. Texas. September 11. Expanse 15mm.”

Male, “Type”[M]; Texas, Sept. 11. 263”[M]; “Type”[C] [In good condition]

Remarks: Two female specimens from Texas were also in the type series. Both specimens have handwritten labels, apparently written by two different individuals—neither appears to be in Morrison’s hand; they are not likely types but have not been removed from the type series. The male, is selected and designated as the lectotype. A synonym of *Eublemma recta* (Gn.) (Poole, 1989); *Eumestleta recta* (Gn.) (RWH 9078).

Mamestra passa Morrison, 1874b[1875]:139–140.

Type locality. “California. From my collection.”

Female, “Cal”[M]; “Type”[C] [Right meso, left meso and meta legs and antennae missing]

Remarks: *Graphania* (Poole 1989), extralimital, Lower California (Baja).

Syneda pavitensis Morrison, 1874f[1875]:221.

Type locality. “Waco, Texas.”

Female “*pavitensis*, Morr. Type. Sept. 7 Waco. Tex. 368”[M] [In good to fair condition, the right meso leg missing, and verdigris building around the base of the pin]

Remarks: Syntype. Smith (1893: 325) states that the “type[s] are in the Museum of Comparative Zoology at Cambridge and have been correctly referred as sexes of the same species.” A duplicate type of *pavitensis* is in the Tepper collection.” No indication as to the number of specimens in the original type series. A synonym of *Bulia deducta* (Morrison) (RWH 8614).

Heliothis pauxillus Grote, 1873b:118, pl. 3 fig. 6.

Type locality. “Colorado Territory, (Coll. Theo. L. Mead No. 9).”

Male, “*pauxillus* Gr Type Colo July 7 300”[M] [Well marked specimen in fair condition, antennae missing, right meso and meta and left meso legs missing]

Remarks: The male is unusual is that it is a Grote name in Morrison’s handwriting. The specimen is the holotype (Hardwick, 1996). A synonym of *Schinia villosa* (Grt.) (RWH 11083). The year of publication (1875) is in error for *pauxillus* in Hodges (1983).

Lithacodia penita Morrison, 1875d:71.

Type locality. “New York. One female specimen received from Mr. Fred Tepper.”

Female, “Type”[C]; [Specimen in poor condition, verdigris expanding in thorax, left antenna missing]

Remarks: The holotype. This is the presumed type of *penita*, however, labels that would associate the specimen with Tepper are not present. Poole (1989) indicates the type is at MSU. A synonym of *Spartiniphaga includens* (Wik.) (RWH 9434).

Morrisonia peracuta Morrison, 1874c:114.

Type locality. “Doubtful, probably Texas, perhaps California. In the collection(s) of H. K. Morrison.”

Male, “Cal”[M]; “Type”[C] [The left antenna missing, otherwise the type in very good condition]

Remarks: The holotype. The locality information on this specimen is incorrect; it is an Australian species, a synonym of *Persectania ewingii* Westwood (Poole, 1989).

Bryophila percara Morrison, 1874g[1875]:213-214.

Type locality. "Waco Texas."

Female, "Texas"[T]; "Type"[C] [In very good condition]

3 Males, "Tex"[ty] [In good condition]

Remarks: Syntypes. It is not clear how many specimens were in the type series; there can be little doubt that the female is from the original type series, the males, however are more problematic. Each specimen is labeled with a typewritten "Tex." on white paper compared to the female which is in Tepper's hand and written in red ink. I retain the three specimens, but I suspect they were added at a later date. There are also syntypes of this species at MCZ (L. Warshaw, pers. comm. 1995). *Emarginia* (RWH 9718).

Scotogramma perplexa Smith, 1888a:469.

Type locality. "Colorado. The type is a unique female in the collection of Mr. Tepper."

Female, "Col"[T]; "Type"[C] [In fair condition]

Remarks: The holotype (Todd, 1982). *Lasionycta* (RWH 10352).

Agrotis perpolita Morrison, 1876:237.

Type locality. "Orono Maine."

Male, "Maine"[M]; "Type"[C]; "Euxoa Slide MSU No. 4"[ty] [In good condition]

Remarks: The holotype (Lafontaine, 1987). *Euxoa* (RWH 10865).

Orthosia perpura Morrison, 1875d:66.

Type locality. "New York"

Female, "perpura, Morr Type Colo. July 20 495"[M] [Left meso and meta and right pro and meso legs and right antenna missing]

Remarks: The holotype. A synonym of *Lasiestra impingens* (RWH 10339).

Heliothis persimilis Grote, 1873b:117-118, pl.3, fig. 11.

Type locality. "Colorado Territory (coll. Theo. L. Mead, No. 6)."

Female, "Colo"[M]; "Type"[C] [Type in fair condition, the right meso and meta legs, and left meso leg missing]

Remarks: The holotype (Hardwick 1996). *Schinia* (RWH 11103).

Agrotis personata Morrison, 1876:238-239.

Type locality. "*personata* comes only from Central Illinois."

Female, "Ohio"[M], *A. personata*, Morr. Type Ohio"[M]; "Euxoa Slide MSU No. 2"[ty] [Left hindwing missing, right forewing chipped at the apex]

Remarks: Despite the disagreement in the type locality, this is the holotype (Lafontaine 1987). A synonym of *Euxoa detersa* (Wlk.) (RWH 10838). Hodges (1983) is in error for *personata* as a Grote name.

Agrotis plagigera Morrison, 1874b[1875]:163.

Type locality. "Colorado. Expanse 33 mm."

Female, "Tepper"[ty] [In good condition, right antenna missing]

Remarks: This specimen was found unlabeled in the general collection. In the absence of any probable type specimens at the time of his study, Lafontaine (1987) declared the type lost. This is a likely candidate for type, despite the fact that no locality information is associated with the specimen. The original accession notes of the Tepper collection states that the type of this species was in this collection; evidently Cook did not label it as a type. *Euxoa* (RWH 10804).

Agrotis proclivis Smith, 1888a:453–454.

Type locality. “Arizona. One male (Tepper) and One female (Neum.).”

Male, “Arizona”[T]; “Type”[C] [In poor condition, the head, thorax and abdomen is severely damaged by dermestids and the right valve of the genitalia broken]

Remarks: Todd (1982) designated the female in the MSU as the lectotype. No such label is found on the specimen, it has since been added. *Loxagrotis* (RWH 10871).

Mamestra promulsa Morrison, 1875f:97.

Type locality. “Colorado (Mr. T. L. Mead), July 20.”

Female, “Col. July 219”[M]; “Type”[C] [Left pro meso, and right pro, meta legs missing, somewhat rubbed and dorsoventrally depressed]

Female, “Col”[T]; “Type”[C] [Legs absent, right antenna missing]

Remarks: Syntypes. *Lasionycta* (McCabe, 1997, pers. comm.) (RWH 10344).

Acronycta pudorata Morrison, 1875f:93.

Type locality. “New York; Canada. Specimens received from Messrs. Fred. Tepper and F.X. Belanger.”

Male, “[Qu]ébec Can”[M]; “*pudorata*, Morr Type”[M] [In fair condition, the right legs missing and the right forewing torn off at the apex]

Remarks: Syntype. The male, is clearly a Morrison type, and is unusual in having two of the trademark Morrison labels. No Cook (rhomboidal) type label is associated with these specimens. Smith (1893: 31) gives Tepper collection as location of the (holo)type. Poole (1989) gives the BMNH as the location of the type. A synonym of *Acronycta grisea* (Wlk.) (RWH 9212).

Mamestra quadrannulata Morrison, 1875c[1876]:430–431.

Type locality. “Glencoe, Dodge Co., Nebraska. From Mr. G. M. Dodge (No. 38).”

Male, “38”[?]; “Tepper”[ty]; “Type”[C]; [A well marked specimen, left valves and tegumen nearly completely destroyed]

Remarks: This specimen lacks the trademark Morrison label or any handwriting resembling Morrison’s, but matches the original description in having the number 38. This is likely a type. *Faronta* (RWH 10430).

Hadena rasilis Morrison, 1874b[1875]:158.

Type locality. “St. Louis. From my collection; received through the kindness of Mr. C. V. Riley, State Entomologist.”

Female, “*rasilis*, Morr Type. St Louis, Mo 34”[M] [In good condition, the abdomen missing]

Remarks: The holotype of *rasilis*. A synonym of *Elaphria grata* Hub. (RWH 9684).

Agrotis redimicula Morrison, 1874b[1875]:165.

Type locality. "Colorado (T. L. Mead); Albany N. Y. (J. A. Lintner):Massachusetts."

Female, "Cambridge Mass"[?]; "Type"[C]; "Euxoa Slide MSU 6."[ty] [A very well marked specimen; both antennae broken near head]

Remarks: The label "Cambridge Mass," is in an unfamiliar hand. Lafontaine (1974) designated the MSU specimen as the lectotype, but no such label is associated with this specimen; I have since added a lectotype label. *Euxoa redimicula* (RWH 10851).

Homohadena retroversa Morrison, 1874b[1875]:157-158.

Type locality. "Central Missouri. Prof. C. V. Riley."

Male, "Mo"[M]; "June 22, 1872"[M]; "Type"[C] [In good condition, antennae missing]

Remarks: Smith (1893) states that type is in the Tepper collection and a duplicate in the USNM. Poole (1989) states that the type is at MSU. A synonym of *H. infixa* (Wik.) (RWH 10065).

Agrotis rileyana Morrison, 1874b[1875]:166.

Type locality. "St. Louis, Mo."

Male, "Mo"[M]; "Missouri 188"[M]; "Type"[C] [In good condition]

Female, "Mo"[M] [In very good condition]

Remarks: Possibly the holotype; the original number of specimens is not known. *Onychagrotis* (RWH 10669).

Oncocnemis riparia Morrison, 1875e:213.

Type locality. "Mr. Fred Tepper has just sent me a pair of insects taken on the shore of Long Island."

Male, "L. I. Sound, July 7/75"[T] [In very good condition]

Female, "Tepper"[ty] [Meso and meta legs and antennae missing]

Remarks: Syntype(s). The types of this species were found in the general collection and probably are types. Smith (1893) stated the type was in the BM and the Tepper collection. Poole (1989) gives MSU as the type location. The lectotype should not be designated until the BMNH can be checked for types of this name (RWH 10135).

Eutolype rolandi Grote, 1874c:198-199.

Type locality. "Massachusetts, April 8th to 15th (Mr. Roland Thaxter, No. 1019); Missouri, April (Prof. C. V. Riley)."

Male, "April 15th 1874 Nville Mass R. Thaxter S[?]p. No. 1019" [In very good condition]

Remarks: Paralectotype. This specimen was found in the general collection and was not labeled as a type. It is clearly part of the original series, with a label that is presumably in Thaxter's hand. Poole (1994) designated a specimen in the BMNH with Grote's type label as the lectotype. This is also a paralectotype. *Psaphida* (RWH 10014).

Mamestra rufula Morrison, 1875d:62.

Type locality. "Massachusetts, New York, Illinois, Missouri, Indiana."

Male, "G. L. July 4/74"[T] [In poor condition, antennae and abdomen missing]

Remarks: The holotype. This type was found in the general collection. McCabe (1980) was unable to find the type in other collections. Poole (1989) indicated MSU as the location of the type. A synonym of *Spiramater lutra* (Gn.) (Poole 1989) RWH 10301.

Mamestra rugosa Morrison, 1875b:119.

Type locality. "Maine. From Prof. C. H. Fernald, of Orono."

Male "Maine"[M] [Abdomen partly destroyed by dermestids, the valves partly broken]

Remarks: This specimen was found in the general collection and not labeled as the lectotype. In his revision of the *Polia* complex, McCabe (1980), designated this specimen as the lectotype. However, no such label could be found on this specimen; a label has since been added. *Lacanobia* [*Trichordestra*] (RWH 10302).

Agrotis scropulana Morrison, 1874b[1875]:165.

Type locality. "The alpine region of Mount Washington."

Male, "Mt. Washington July 18, 1874"[ty] [In excellent condition]

Remarks: The holotype. *Xestia* (Poole, 1989) type at MSU. Probably the holotype. *Pachnobia* (RWH 10938).

Hydroecia semiaperta Morrison, 1874d:105.

Type locality. "Mass., New York. Not uncommon. Coll. of H. K. Morrison."

Female, "*semiaperta*, Morr. Type. Beverly, Ms 7.8.72 107"[M] [In excellent condition]

Remarks: Syntype. The location of the other specimen(s) is not known. A synonym of *Tricholita signata* (Wlk.) (RWH 10627).

Lithophane semiusta Grote, 1873a:34.

Type locality. "Male and female, (Mr. J. Pettit)."

Male, "Type"[C]; "*semiusta* Grote Type Eastern State 77"[M] [In good condition, the right antenna broken near base]

Female, "N. Y. State"[M] [In poor condition, abdomen missing]

Male, "N. Y. State"[M] [In excellent condition]

Remarks: The status of the male marked type by Morrison is not known. The specimens marked "N Y State" are probably not types, but could possibly be types since "Eastern State" is ambiguous. Poole (1989) states the type is in the BMNH while Smith (1893 p. 228) stated that the "type is in the BMNH and another in the Tepper collection." (RWH 9885).

Glaea sericea Morrison, 1874b[1875]:151.

Type locality. "Boston Mass."

Female, "Boston Ms 114"[M]; "Type"[C] [In excellent condition]

Remarks: It is not known whether types are in other institutions. Poole (1989) states that the type is in MSU. Probably the holotype. *Chaetagleae* (RWH 9950).

Agrotis serricornis Smith, 1888a:458.

Type locality. "Southern California."

Male, "So Cal"[T]; "Tepper"[ty]; "Type"[C]; "Euxoa Slide MSU 10"[ty] [In

poor condition, the right hindwing partly destroyed, the right antenna missing and the valves partly destroyed]

Remarks: Todd (1982) concluded that this was the holotype by the absence of any other specimens labeled "Type." *Euxoa* (RWH 10744).

Agrotis simplicius Morrison, 1874b[1875]:164.

Type locality. "Texas."

Female, "Texas." [M] [The specimen is in very good condition]

Remarks: Syntype. This specimen was found in the general collection and is probably a type. Lynette Warshow (pers. comm. 1995) indicates their unsexed specimen as the holotype. It is likely that both are syntypes, and the MCZ specimen is not the holotype. Poole (1989) stated that the type is at MSU. *Euagrotis* (RWH 10907).

Agrotis stigmata Morrison, 1874b[1875]:163.

Type locality. "Mass. N. Y." [Morrison]

Male, "*stigmata* Morr Type, Camb. MS. June, 166" [M] [Abdomen missing, otherwise in good condition]

Male, "Mass." [M] [In fair condition, the abdomen is missing]

Remarks: The second male specimen was found in the general collection, and is also likely a type. Poole (1989) stated that the type is at MSU. There are no specimens of this name at MCZ. I hereby designate the male, marked and labeled "*stigmata*," as the lectotype. RWH (10658).

Hadena stipata Morrison, 1875d:64.

Type locality. "Illinois. One specimen received from Thos. E. Bean."

Female, "Illinois" [?]; "Type" [C]; Type in very poor condition, abdomen missing, thorax destroyed by dermestids, wings tattered and worn, head missing]

Remarks: Probably the holotype in the absence of other Morrison material. Poole (1989) stated the type is at MSU. *Luperina* (RWH 9393).

Taeniocampa subterminata Smith, 1888a:476-477.

Type locality. "Northeastern and Middle States." "It is much more common than *alia*, and I have found specimens in almost every collection I have seen."

Female, "N.Y. State" [M]; "Type" [C] [In excellent condition]

Remarks: Todd (1982) designated the MSU specimen as the lectotype and stated that it "has been selected, labeled, and is now designated . . ." I could find no lectotype label associated with the type. A lectotype label has been added to the specimen. A synonym of *Orthosia revicta* (Morr.) (RWH 10490).

Heliothis suetus Grote, 1873b:117, pl. 3, fig. 10.

Type locality. "Colorado Territory (coll. Theo. L. Mead, No. 7)."

Male, "*suetus* Grt. Type. Colorado 298" [M] [In good condition, the antennae missing]

Remarks: The holotype. In addition to containing another Grote name (see *californicus*), there were additional specimens included with the type but not from the type locality, since the description is based on only one specimen. The male marked with a Morrison label "*suetus*" is the only valid type in this collection (Hardwick, 1958, 1996). Hardwick (1958) recognized the male labeled in Morrison's hand and marked "*suetus*" as the only remaining type from the series. *Schinia* (RWH 11088).

Hadena suffusca Morrison, 1875d:61–62.

Type locality. “Mass., Conn., Colorado.”

Female, “Type”[C]; “Massachusetts 216”[M] [Well marked specimen in poor condition; the abdomen missing]

Remarks: Syntype. The description clearly shows that a number of specimens were used to describe this species. In the original description, Morrison refers to “a poor specimen. . .from Massachusetts, in the collection of the Boston Society of Natural History. . .[and] several specimens at Nahant, Mass.” The locations of the other material is not known. A synonym of *Apamea alia* (Gn.) (RWH 9351).

Mamestra teligera Morrison, 1874g[1875]:215–216.

Type locality. “Waco, Texas.”

Male, “Adir. N.Y.”[T]; “Tepper”[ty]; “*teligera*, Morr Type. Texas Oct 13 241”[M] [In good condition, the right antenna missing]

Female, “19/10”[?] [In poor condition, fragments of legs glued back on specimen, abdomen glued back on]

Remarks: Syntypes. I can find no explanation for the two locality labels on the type; my only guess is that a label from another specimen fell off another specimen (perhaps the female) and was inadvertently added to the type. The male is likely the type, given all the trademark features of a Morrison label, however, Lynette Warshow (pers. comm. 1995) states that syntypes of *teligera* are at MCZ. Their specimens are not the best candidates for type, however, since data cited indicate simply “Tex” with no mention of the name *teligera* associated with the specimen. A lectotype of this species should be designated, but until the MCZ material can be studied carefully, such action should not be taken. *Lasionycta* (RWH 10393).

Oncocnemis tenuifascia Smith, 1888b:18–19.

Type locality. “Colorado. A single female in Mr. Tepper’s Collection.”

Female, “Co.”[T]; “Tepper”[ty]; “Type”[C] [In very good condition]

Remarks: Todd (1982) recognized this specimen as the holotype (RWH 10080).

Lithophane tepida Grote, 1873a:27.

Type locality. “Female Examined. Mass., Mr. H. K. Morrison, No. 908.”

Female, “*tepida* Grote, Type Camb. Ms. 3/18/74 74”[M]; “Type”[C] [In excellent condition, the left antenna missing]

Remarks: The status of this type is not known. Smith (1892:229) states that “a type is in the British Museum; another in the Tepper collection.” Poole (1989) states that the type is in the BMNH (RWH 9909).

Schinia tepperi Morrison, 1875d:68–69.

Type locality. “Texas, September 15.” “Anterior tibia absent in the single specimen of the species before us, which is otherwise in good condition.”

Male, “15/9”[?]; “Texas”[?]; “Type”[C] [All legs missing except right meta leg, antennae missing, wings in good condition]

Female, “15/9”[?]; “Texas”[T] [In good condition]

Remarks: Syntypes. It is clear that Morrison had but a single specimen before him at the time of description, however, there were two specimens with identical data and it is not possible to distinguish which is the type. *Plagiomimicus* (Poole 1989); *Polenta* (RWH 9755).

Agrotis tepperi Smith, 1888a:452-453.

Type locality. "Montana. The unique female type is in Mr. Tepper's collection."

Female, "Montana"[T]; "Type"[C] [The type in very good condition, the right antenna and meso leg missing]

Remarks: Todd (1982) recognized this specimen as the holotype. *Euagrotis* (RWH 10910).

Oncocnemis terminalis Smith, 1888b:19-20.

Type locality. "Colorado. A single female in Mr. Tepper's Collection."

Female, "Col"[T]; "Tepper"[ty]; "Type"[C] [Left meso and meta leg missing, in very good condition]

Remarks: Todd (1982) recognized this as the holotype (RWH 10085).

Mamestra thecata Morrison, 1875d:59-60.

Type locality. "Glen Valley, near Mt. Washington, N. H., and Plymouth, Mass.

The former specimen was received from Mr. S. H. Scudder, the latter from Mr. Edward Burgess, and was taken July 23, 1867."

Female, "thecata, Morr Type, Plymouth M[s], July 23, 1867, 118"[M] [In fair condition, left forewing with nick, right antenna missing]

Remarks: Syntype. The location of the other material is not known. A synonym of *Anhimella contrahens* (Wik.) (RWH 10530).

Hadena tortilis Grote, 1880c:46.

Type locality. "Washington Territory. Coll. of Mr. Tepper."

Female, "W. T."[M]; "Type"[C] [Left wings glued to thorax, right pro and meso legs missing; antennae missing]

Remarks: It is not known how many specimens were utilized in the original description. In the absence of any other Tepper material of this species, the above specimen is assumed to be the holotype. *Fishia* (RWH 9968).

Agrotis trifasciata Smith, 1888a:460.

Type locality. "Mt. Hood. One female specimen from Mr. Teppers Collection."

Female, "Mt. Hood"[T]; "Tepper"[ty]; "Type"[C]; "Euxoa Slide MSU No. 11"[ty] [In very good condition]

Remarks: Todd (1982) recognized the MSU specimen as the holotype. *Euxoa* (RWH 10717).

Agrotis unica Smith, 1890:70.

Type locality. "I have somewhere named a very distinctly marked specimen without any confusing shades *unica*." Extracted from a longer quote in Todd (1982).

Male, "N. Car."[T]; "11"; "Tepper"[ty]; "*Agrotis unicus* Type Smith"[S] [In good condition]

Remarks: The holotype. While not intended as a published name, the mention of the name is ruled a valid description (Todd 1982). A synonym of *Peridroma saucia*; (RWH 10915); number not assigned in Hodges (1983).

Homoptera uniformis Morrison, 1875h:148.

Type locality. "Georgia. Received from my friend, Mr. George W. Peck, of Brooklyn."

Female, "Type"[C] [In poor condition, extra pin hole verdigris, only the right pro and meso legs complete, and portions of the left fore and hindwing torn]

Remarks: Status uncertain. Unusual for a Morrison type, there is no label, only the yellow Cook type label. Smith (1893) stated the type is in the Tepper collection. A synonym of *Zale declarans* (Wlk.) (RWH 8691).

Agrotis unimacula Morrison, 1874b[1875]:166.

Type locality. "Atlantic States."

Female, "Buffalo, N.Y."[ty] [The antennae and right forewing partly broken]

Remarks: The specimen was found unlabeled, in the general collection. Presumably Morrison had specimens from several states at the time of description. It may be a type if no other material is found in other collections. Poole (1989) stated that the type is at MSU. A synonym of *Graphiphora haruspica* (Grt.) (RWH 10928).

Taeniocampa vegeta Morrison, 1875c[1876]:432–433.

Type locality. "Dallas, Texas (Boll). From the collection of H. K. Morrison."

Male, "Dallas Tex. Boll"[ty]; "Type"[C] [In excellent condition]

Remarks: The holotype. A synonym of *Cissusa spadix* (Cram.) (RWH 8592).

Copipanolis vernalis Morrison, 1874b[1875]:133–134.

Type locality. "Massachusetts. One specimen taken on April 8, by Mr. Roland Thaxter."

Female, "Mass"[M] [In very good condition]

Remarks: Syntype. This specimen was found unlabeled in the general collection. The status of this type is in question. In addition to this specimen, there was another male specimen collected in Massachusetts by Thaxter which matches in every way the original description of another *Eutolype* described by Grote (see *rolandi*). Poole (1994) indicated the presence of another specimen of *vernalis* at the MCZ, but was uncertain as to its validity. The MCZ specimen appears to be the better candidate. A synonym of *Psaphida rolandi* (Grote) Poole (1989, 1994); (RWH 10014).

Hadena vulgivaga Morrison, 1874b[1875]:144–145.

Type locality. Nebraska; New York. The two specimens before me of species are variable. The one from Nebraska, received through the kindness of Mr. G. M. Dodge, I consider the typical form."

Male, "Tepper"[ty]; "Glencoe Ne[b] 91"; "Type"[M] [In excellent condition]

Remarks: From the description it is clear that there were two specimens before him; it is not clear where the other New York specimen is. A synonym of *Oligia fractilinea* (Grt.) (RWH 9406).

Telesilla vesca Morrison, 1875f:103.

Type locality. "Texas; Wisconsin."

Female, "vesca, Morr. Type. Wisconsin 261"[M] [In very good condition]

Female, no labels.

Remarks: The location of the Texas specimen is not known; in the absence of a suitable candidate the Wisconsin specimen is the holotype. A synonym of *Galgula partita* Gn. (RWH 9688).

Agrotis wilsoni Grote, 1873c:135.

Type locality. "California."

Male, "Cal"[T] [In fair condition, antennae and pro legs missing]

Remarks: This specimen was found in the general collection and not labeled as a type. Hardwick (1970) concluded that a specimen in the BMNH was probably not a type. He believed the type to be lost; this may be the type. *Euxoa* (RWH 10867).

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ADDENDA

Dr. Tim McCabe had the opportunity to study the types after receiving the galleys, and suggests that both *Mamestra teligra* and *Glaea sericea* are names presently misapplied to other species.

COMPETITION AND COEXISTENCE OF ANTS IN A SMALL PATCH OF RAINFOREST CANOPY IN PERUVIAN AMAZONIA

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Abstract.—A structurally complex patch of forest canopy in Manu National Park (Peruvian Amazonia), consisting of two trees and eleven associated vines, was sampled using insecticidal fog. Approximately 62,000 ants were collected and sorted to species. The total biomass (dry weight) of adult ants in the sample was close to 49 g. *Dolichoderus bispinosus*, the dominant species in the sample, made up 64.2% of the ant biomass and 69.0% of the individual ants. The four most abundant species (*Dolichoderus bispinosus*, *Dolichoderus decollatus*, *Azteca* sp. 1, and *Paraponera clavata*) together comprised nearly 95% of the biomass and individuals in the sample. In spite of the clear dominance of the sample by a few species, a total of 85 species in 29 genera were found, making this the most species-rich point sample of a canopy ant fauna ever documented.

Sampled at the level of a small number of trees, the rainforest canopy ant fauna reveals a pattern of remarkable species richness accompanied by strikingly low equitability in the rank-abundance distribution, or ecological diversity. A small number of species overwhelmingly dominate the ant assemblage but fail to exclude other ant species. Competition appears to limit the number of dominant species that can coexist in small areas, but a large majority of species present do not compete with the dominants and exist to a greater or lesser extent independently of them. The low ecological diversity observed in the sample may be in part a function of the spatial scale of sampling, and increased sampling should lead to a change in this pattern. The extent to which the species abundance distribution would become more equitable cannot be determined at this time. Finally, the structural complexity of the canopy may promote high species richness by creating microhabitat-linked species associations that effectively function as separate, non-competing ant assemblages.

Key words: Formicidae, ants, rainforests, ecology, Amazon, Peru, canopy, biological diversity.

Until recently, information on the biology of arboreal ant assemblages was derived from isolated observations and sporadic collections carried out on treefalls. With the development of canopy fogging (Erwin, 1989a), more precise information has been gathered about the relative importance of ants in canopy arthropod communities (Moran and Southwood, 1982; Erwin, 1983b; Adis *et al.*, 1984; Majer *et al.*, 1990; Stork, 1991; reviewed by Tobin, 1995) and about the taxonomic composition of canopy ant assemblages (Wilson, 1987; Harada and Adis, 1994; Tobin, ms.; Tobin and Cover, ms.). The next logical stage in the examination of canopy ant assemblages involves characterizing them in terms of the relative importance of their component species. At this stage, however, little work has addressed this aspect of arboreal ant biology (but see Majer, 1990; Stork, 1991).

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In this paper I characterize for the first time the entire ant fauna of a small patch of tropical rainforest canopy in terms of both its taxonomic composition and of the numbers and biomass of the component species. This effort grew out of an attempt to determine the numbers of arthropod specimens and species per major taxon in a small, discrete patch of tropical forest canopy surrounding the Pakitza research station in Manu National Park, Madre de Dios, Peru (Erwin, 1989a, 1989b). Erwin reported already on these collections, and summarized data on the relative abundance of the major arthropod groups based on about two-thirds of the total sample (Erwin, 1989b). After nearly 82,400 arthropods had been sorted, 69.6% of these were ants. The rest of the arthropods were primarily beetles (9.1%), psocopterans (4.0%), dipterans (2.5%), collembolans (2.2%), and spiders (2.0%). A preliminary report on the ants in these collections, based on partial samples, was published already (Tobin, 1991). This paper represents a final report based on the entire ant fauna, and contains a complete species list including changes resulting from recent taxonomic revisions (e.g., Shattuck, 1992).

Little has been published on the relative importance of the component species in arboreal ant assemblages, and there are few studies of the taxonomic composition of point samples that can be used for comparison with this study. Wilson (1987) found 43 ant species in 26 genera in a single tree in Tambopata, Peru. Harada and Adis (1994), working in Brazilian Amazonia, sampled a number of trees and found as many as 77 species in individual trees. Tobin (ms.) found between 22 and 44 species in point samples collected along a transect in central Panama. These figures appear to be larger than comparable ones for Asia (Stork, 1991) and Australia (Majer, 1990).

On first impression, the extreme skew in the ranked species abundance in this sample appears to be extraordinary. One species comprises the majority of the numbers and biomass in the sample. The steep distribution includes a very long tail of species represented by numbers and/or biomass that are trivially small. This stands in contrast to the shallower, more equitable distribution of other tropical canopy arthropods such as beetles (Morse et al., 1988). I will argue, however, that the unusual distribution of ant species abundances may be an artifact of the spatial scale of the sample.

METHODS

A discrete patch of canopy, consisting of two adjacent trees and eleven associated vines, was selected for sampling. The trees were identified as *Matisia cordata* (Bombacaceae) and *Hirtella triandra* (Chrysobalanaceae). In selecting the sampling area, the aim was to maximize the diversity of arthropods in the resulting point sample; thus the size and structural complexity of the trees, and the amount of associated epiphytic growth, were the main criteria used. A total of 93.6 m² (1008 square feet) of plastic sheeting was hung in the understory to collect the falling specimens, and the selected area of canopy was treated with insecticidal fog (Erwin, 1983a, 1983b, 1989a). The resulting specimens were preserved in 70% ethanol for subsequent sorting and processing.

In the lab, the arthropods in the sample were sorted to order, with the exception of the family Formicidae, which was separated from the rest of the Hymenoptera

(Erwin, 1989a, 1989b). Following this first sort, I sorted the ants to species. Species determinations were made at the Museum of Comparative Zoology (M.C.Z.), Harvard University, on the basis of comparisons with available specimens and of published and unpublished keys. Voucher specimens are deposited at the M.C.Z.

Following the identifications, biomass and the numbers of individuals were determined for each species. For species with less than approximately 500 workers, the number of individuals was determined by direct counts or estimated from subsamples. Biomass was estimated based on the number of workers and the average dry weight of specimens of each species or of other species of similar size and body type. For the most abundant species, biomass was determined directly by weighing all the specimens of each species; the number of specimens per species was estimated from the total biomass of each species and the average dry weight of workers of that species. Samples were dried at 60°C until weight was stable.

RESULTS

A total of 85 ant species belonging to 29 genera and 5 subfamilies were found in the samples (Table 1). One species, *Dolichoderus bispinosus* (formerly known as *Monacis bispinosa*; Shattuck, 1992), dominated the sample, comprising approximately 65% of the biomass and 69% of the individuals in the collection (Table 2). Only four species (*Dolichoderus bispinosus*, *Dolichoderus decollatus*, *Azteca* sp. 1, and *Paraponera clavata*) contributed more than 1.0 g to total biomass (dry weight). Other important species were *Anochetus* sp. nov., *Pachycondyla* sp. 1, and *Camponotus* sp. 3. The contribution to biomass of the majority of species in the sample was trivial, amounting to no more than a few milligrams (Fig. 1). In addition, 1.43 g of assorted ant brood were found in the sample; these have not been included in Table 2.

In terms of numbers, the dominant species were *D. bispinosus* (43,200 workers), *Azteca* sp. 1 (14,500), *D. decollatus* (1,620), and *Azteca* sp. 2 (1,560). All other species were represented by fewer than 1,000 individuals. Among these nondominant species are, in decreasing order of abundance, *Crematogaster* sp. 1, *Solenopsis* sp. 4, *Tapinoma* sp. 1, *Solenopsis* sp. 3, and *Anochetus* sp. nov. Of these, only *Anochetus* sp. nov. made a contribution of more than 1% to total biomass. Fifty-one species, or nearly 60% of the total, were represented by ten or fewer individuals.

DISCUSSION

A large body of evidence documents the critical role of competition in determining ant community structure in a wide variety of habitats (Hölldobler and Wilson, 1990 and references therein). Numerous studies have documented dominance hierarchies in which certain species predictably displace others from foraging and nesting sites (e.g., Vepsäläinen and Pisarski, 1982; Savolainen and Vepsäläinen, 1988). Research on the spatial distribution of ant territories in tropical canopies has invoked competition to explain the commonly observed pattern of territorial exclusion by dominant species, known as an ant mosaic (Room, 1971; Majer, 1972; Leston, 1978; reviewed by Jackson, 1984). Under this view, colonies of dominant species partition the canopy into a series of mutually exclusive territories, and each of these codominant species is positively or negatively associated with a series of nondominant

Table 1. Ant species collected in trees nos. 12 and 13, Zone 02/18/08, Pakitza, Manu National Park, Madre de Dios, Peru. A total of 85 species in 29 genera were found.

PONERINAE	DOLICHODERINAE
<i>Anochetus</i> sp. nov.	<i>Azteca</i> sp. 1
<i>Gnamptogenys acuta</i>	<i>A.</i> sp. 2
<i>G. concinna</i>	<i>Dolichoderus attelaboides</i>
<i>Hypoponera</i> sp. 1	<i>D. bidens</i>
<i>H.</i> sp. 2	<i>D. bispinosus</i>
<i>Odontomachus haematodus</i>	<i>D. decollatus</i>
<i>Pachycondyla cavinodis</i>	<i>D. diversus</i>
<i>P. crenata</i>	<i>D. lutosus</i>
<i>P. unidentata</i>	
<i>P.</i> sp. 1	MYRMICINAE
<i>Paraponera clavata</i>	<i>Allomerus octoarticulatus</i>
	<i>Crematogaster</i> sp. 1
FORMICINAE	<i>C.</i> sp. 2
<i>Brachymyrmex</i> sp. 1	<i>C.</i> sp. 3
<i>B.</i> sp. 2	<i>C.</i> sp. 4
<i>Camponotus bideus</i>	<i>Cyphomyrmex</i> sp. 1
<i>C. bradleyi</i>	<i>Leptothorax anduzei</i>
<i>C. heathi</i>	<i>L.</i> sp. 1
<i>C. lancifer</i>	<i>Ochetomyrmex</i> sp. 1
<i>C. latangulus</i>	<i>Pheidole</i> sp. 1
<i>C. novogranadensis</i>	<i>P.</i> sp. 2
<i>C.</i> sp. 1	<i>P.</i> sp. 3
<i>C.</i> sp. 2	<i>P.</i> sp. 4
<i>C.</i> sp. 3	<i>P.</i> sp. 5
<i>C.</i> sp. 4	<i>P.</i> sp. 6
<i>C.</i> sp. 5	<i>P.</i> sp. 7
<i>C.</i> sp. 6	<i>P.</i> sp. 8
<i>C.</i> sp. 7	<i>P.</i> sp. 9
<i>C.</i> sp. 8	<i>P.</i> sp. 10
<i>C.</i> sp. 9	<i>P.</i> sp. 11
<i>C.</i> sp. 10	<i>Procryptocerus</i> sp. 1
<i>Dendromyrmex fabricii</i>	<i>Rogeria</i> sp. 1
<i>Myrmelachista</i> sp. 1	<i>Sericomyrmex</i> sp. 1
<i>Paratrechina</i> sp. 1	<i>Smithistruma</i> sp. 1
	<i>Solenopsis</i> sp. 1
PSEUDOMYRMECINAE	<i>S.</i> sp. 2
<i>Pseudomyrmex browni</i>	<i>S.</i> sp. 3
<i>P. dendroicus</i>	<i>S.</i> sp. 4
<i>P. godmani</i>	<i>S.</i> sp. 5
<i>P. laevifrons</i>	<i>Strumigenys subdentata</i>
<i>P. oculatus</i>	<i>Wasmannia auropunctata</i>
<i>P. pupa</i>	<i>Zacryptocerus</i> sp. 1
<i>P. simplex</i>	<i>Z.</i> sp. 2
<i>P. tenuis</i>	<i>Tapinoma</i> sp. 1
<i>P. tenuissimus</i>	<i>T.</i> sp. 2
<i>P.</i> sp. 1	

Table 2. Biomass and numbers of dominant ant species.

Species	Biomass (grams)	% Total biomass	Number of individuals ¹	% Total numbers
<i>Dolichoderus bispinosus</i>	31.51	64.2	43,200	69.0
<i>Dolichoderus decollatus</i>	11.68	23.8	1,620	2.6
<i>Azteca</i> sp. 1	1.67	3.4	14,500	23.1
<i>Paraponera clavata</i>	1.39	2.9	20	n.c. ²
All other species ³	2.80	5.7	3,300	5.3
Total	49.05	100.0	62,640	100.0

¹ The numbers in this column are estimates based on subsamples.

² *P. clavata* made a negligible contribution to numbers.

³ This includes 81 species represented in the collections by workers and/or queens.

species. Thus dominant ants are seen as the major determinants of ant community structure.

Most ant mosaic research, however, has been carried out in tropical agroecosystems (principally in cacao plantations), which lack the structural and ecological complexity of natural forest canopies. To what extent principles derived from ant mosaic theory might be generalizable to natural forest canopies has been a matter of some controversy. Leston (1978) working in a forest near Bahia, Brazil, showed that dominant canopy ant species hold mutually exclusive territories and form a three-dimensional mosaic. In natural forest canopies, then, dominants are present and competition may determine the spatial distribution of dominant ant species *inter se*, as it does in

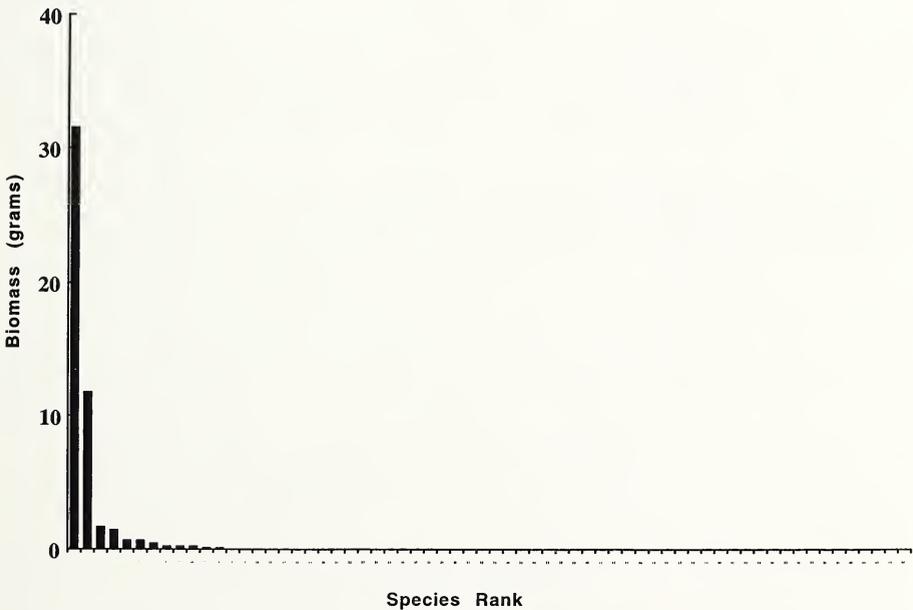


Fig. 1. Ranked species: Abundance plot.

tropical plantations. However, the little available evidence from natural forests does not tell us to what extent dominants may be the organizing agents vis-à-vis the nondominant species, which comprise the majority of the species richness. The evidence I present here, as well as evidence from natural forest canopies in Panama (Tobin, ms.), strongly indicates that dominant ant species do not determine ant community composition as a whole in undisturbed tropical rainforest canopies.

That dominant species do not always determine the composition and structure of canopy ant assemblages is suggested by a striking feature of the data presented in this and earlier, comparable studies. A surprisingly high fraction of the total ant species richness at a site can be found in any point sample collected at that site. For example, Wilson (1987) reported finding 135 species in an extensive series of collections across four forest types in the Tambopata Reserved Zone, Peru. In one, particularly diverse point sample he found 46 species, or nearly 35% of the entire fauna; only 6 of those species were not found in other samples from the area. Tobin (ms.), working in Panama, found that as many as 39% of the ant species in an extensive series of collections were found in a single point sample. Also, numerous species were present in a large number of samples irrespective of the dominant species in the sample. Thus dominant ant species are not linked to a few co-occurring nondominant species, as in classical ant mosaics. The picture that emerges is one of a mosaic of mutually exclusive dominant species superimposed upon an assemblage of species that are found throughout the forest but only in small numbers and biomass. This assemblage of nondominants appears, at least to some extent, to exist irrespective of the presence or absence of the dominant species.

The diverse assemblage of nondominant species raises important questions. Wilson (1987), upon documenting the coexistence of 43 species of ants in one point sample, asked how it was possible for so many species to occupy the same site. With nearly twice that number of species in the present study, the question seems all the more pressing. One possibility is that many nondominants are not territorial, and are coexisting by means that do not involve aggressive mutual exclusion, thus allowing higher local diversities. This is almost certainly true in part. The spatial scale of canopy foggings, however, may be too coarse to resolve ant mosaics of small nondominant species, to the extent that they exist. Competition may still play a role in structuring assemblages of nondominant ants that is presently invisible, given our current sampling methods.

The data in the present study reveal a local ant assemblage in which one species preempts over two-thirds of the biomass space, the amount of biomass that an assemblage can sustain given the energy entering the system and the conversion efficiencies of its component species (Tobin, 1994) (Fig. 1). While puzzling, this degree of dominance is a natural consequence of the spatial scales of both the dominant ant mosaics and the sampling regime in the present study. As seen already, a typical canopy sample, covering an area of approximately 100 m², may reveal 25-50% of the total ant fauna of the area but only one or a small number of dominants. A second fogging sample would expose a few more nondominants in the tail of the species abundance distribution, but may reveal an entirely different dominant species.

As similar samples are pooled, the tail of the distribution might only be between two and four times as long as that of the original sample, but a number of other dominant species would be revealed. The effect of this pooling would be to fill out the left side of the distribution without greatly increasing the length of the tail, thus

reducing its skewness and making it comparable to other, more typical distributions. Hence the scale of individual fogging samples, though large in terms of the number of individual arthropods collected, is too small to reveal the true species abundance distribution of an area.

The ultimate explanation for high local ant diversity may reside in the extreme structural complexity of the canopy environment itself (Lawton, 1983, 1986; Morse *et al.*, 1985; Gunnarsson, 1992; see also Terborgh, 1985). Abiotic factors, such as temperature and humidity, range widely from the forest floor to the canopy (Parker, 1995), and different levels of the canopy are associated with different epiphytes and their attendant arthropod faunas. Epiphytic cacti may be common in the same forest that is thick with ferns near the ground. From the point of view of sensitive plants and small arthropods, then, the range of conditions along this altitudinal gradient results not in a single, homogeneous canopy habitat but in a series of more or less distinguishable microhabitats superimposed upon each other from the understory to the high canopy. As in the case of the marine intertidal, alpha diversity in a tropical forest canopy may be more a function of a gradient of physical conditions over a small distance which can be finely partitioned, than of any one set of conditions in particular.

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**RADIOGRAPHIC STUDY OF THE RESPONSE OF JAPANESE
BEETLE LARVAE (COLEOPTERA: SCARABAEIDAE) TO
SOIL-INCORPORATED MYCELIAL PARTICLES OF
METARHIZIUM ANISOPLIAE (DEUTEROMYCETES)**

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Abstract.—Mycelial particles of the entomopathogenic fungus, *Metarhizium anisopliae* (Metsch.) Sorokin, were grown in 0%, 0.025%, 0.25%, 1%, and 5% tryptone and incorporated into soil to test for effects on the behavior of Japanese beetle larvae, *Popillia japonica* Newman. In radiograph chambers, Japanese beetle larvae avoided soil containing mycelial particles beginning by 48 or 96 hr, and continuing until 192 hr (the end of the study). Differences in Japanese beetle responses to mycelia grown in various levels of tryptone were observed after 48 hr. Japanese beetle larval response was first observed at 96 hr in treatments of mycelial particles grown in 0.25% and 5% tryptone compared to 48 hr for particles grown in 0%, 0.025%, and 1% tryptone. Results show that fungal nutrition can influence the avoidance of *M. anisopliae* by Japanese beetles.

Key words: *Metarhizium anisopliae*, *Popillia japonica*, tryptone, mycelium.

Interest in the fungus *Metarhizium anisopliae* (Metsch.) Sorokin as a biological control agent against Japanese beetles has increased recently as studies show that this fungus can cause high levels of mortality in the laboratory (Krueger et al., 1992; Krueger et al., 1991). Field applications of entomopathogenic fungi, however, are often less successful (Rath, 1992; McCoy, 1990). One explanation is that many confounding parameters influence host-pathogen interactions in the field. Effective use of *M. anisopliae* as a control agent will rely on a thorough investigation of complex interactions among fungus, soil environment, and insect population (Villani and Wright, 1990).

Villani et al. (1994) showed that Japanese beetle grubs avoid soil that contains mycelial particles of *M. anisopliae* grown in 0.25% tryptone. There has been a lack of evidence concerning the effects of fungal culture method on insect response to this fungus. Therefore, our study investigated the behavioral responses of Japanese beetle grubs to mycelial particles of *M. anisopliae* grown in 0%, 0.025%, 0.25%, 1%, and 5% tryptone.

MATERIALS AND METHODS

Third instar Japanese beetle grubs from Horseheads and Tuscarora, NY, collected during September 1994, were used in all studies. Grubs were placed in moist soil,

covered with sod and stored at $10 \pm 1^\circ\text{C}$, 0 h light, and 90% humidity until used in the experiment. To ensure that acceptably healthy grubs were used, they were removed from cold storage approximately fifteen minutes before all bioassays, and placed in individual cups. If no movement was observed, grubs were replaced. The soil used in the bioassays was unsterilized and screened using a 2 mm² screen. The soil was classified as a loam with a particle size distribution of 46.2% sand, 39.0% silt, and 14.8% clay. The organic matter content was determined to be 1.60%, the pH 6.96 and the loose bulk density 1.19 g/cm³. Initial soil moisture was measured between 8.2–12.4% for the study.

The strain of *M. anisopliae* used (ARSEF 2547 Entomopathogenic Fungus Culture Collection, USDA-ARS Plant Protection Unit, Cornell University, Ithaca, NY 14853), was originally isolated from a European Chafer (*Rhizotrogus majalis*) grub collected near Syracuse, New York. Mycelial materials were prepared and stored as described by Krueger et al. (1992).

The x-ray system used for radiographs was a Hewlett-Packard Faxitron (Model 43855B, Hewlett-Packard Company, Palo Alto, CA). Voltage was set at 50 kVp for 5 seconds. A Kodak Industrex Instant Processor (Model P-1, Kodak, Rochester, NY) was used to process the radiographs (Villani and Wright, 1988).

Mycelial particles prepared using the method described in Krueger et al. (1992) were used to inoculate SDAY (Sabouraud's Dextrose Agar supplemented with 1.0% yeast extract) plates. After approximately 14 days, conidia were harvested by flushing the plates using 2 ml of sterile, distilled water plus 0.02% Tween 80 (Aldrich, Milwaukee, WI) and scraping gently with a sterile glass slide. Conidia and water were removed using a sterile pipette, then suspended in 10 ml of water plus 0.02% Tween 80 in a sterile test tube. The soaked conidia were stored for 24 hours at $4 \pm 1^\circ\text{C}$. A mean number of 1.52×10^7 (S.E. = 0.14×10^7) conidia/ml was used in this experiment.

Twenty g of dextrose (Fisher, Fair Lawn, NJ), 10 g of yeast extract (Amberex, Juneau, WI), and 3.75 ml of antifoam (Dow Corning, Midland, MI) were dissolved in 1,000 ml of deionized water. After mixing thoroughly, 100 ml portions were dispensed into ten, 250 ml Erlenmeyer flasks. The following quantities 0.000 g (0%), 0.025 g (0.025%), 0.250 g (0.25%), 1.000 g (1%), and 5.000 g (5%) of tryptone (Marcor, Hackensack, NJ) were each added to two Erlenmeyer flasks for a total of 10 flasks. The flasks were sterilized for 20 minutes in the autoclave. When the liquid media had cooled in the flasks, 0.0124 g of Penicillin G (Sigma, St. Louis, MO, 1609 units/mg), 0.025 g of Streptomycin Sulfate (Sigma, St. Louis, MO, 763 units/mg), and 0.200 ml of the conidial suspension were added. The flasks were then placed in an automatic rotary shaker at 150 r.p.m. for five days at $25 \pm 2^\circ\text{C}$.

After five days, each mycelial culture was harvested by vacuum filtering the growth medium through filter paper (Fisher, Pittsburgh, PA, P8 "coarse"), using a Büchner funnel (approx. 9 cm). The resulting mycelial mats were immediately separated from the filter paper using forceps, placed in petri dishes and dried at room temperature for 48 hours. Dried mycelial mats were placed in zip-lock freezer bags and crushed by hand until all pieces were <2 mm². Mycelial particles were stored at $0 \pm 1^\circ\text{C}$ until use in the radiographic study.

Sixty chambers (Fig. 1) were constructed using 120, 17 × 100 mm polystyrene

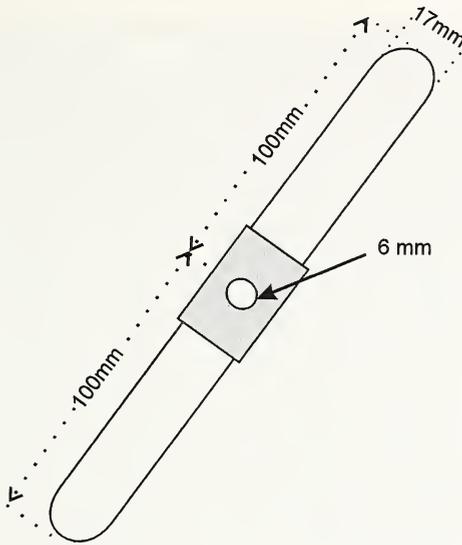


Fig. 1. Radiograph chambers. Chambers were created with dimensions of $17 \times 17 \times 200$ mm. For treatment chambers, one side of each chamber was filled with soil containing mycelial particles and the other side with clean soil. Japanese beetle larvae were placed in center holes and observed over 192 hrs.

culture tubes (Fisher, Pittsburgh, PA)—two for each chamber. A plastic test tube cap (Bellco “Kap-uts” Vineland, NJ) was modified to make it open at both ends. The two culture tubes were held together using the cap to attach them. After the two tubes were firmly held in place by the plastic cap, a 6 mm hole for larval introduction was drilled into the center of entire assembly. Using a heated paper-clip, two additional air holes (approx. 1 mm) were made, one at each end of the chamber. The chambers were then numbered from 1–60. The chambers were held horizontally during the experiments. To standardize the orientation of the chambers, one end was arbitrarily assigned as “top.” A random number generator (Microsoft Excel, Version 5.0) was used to determine which end of the chamber was filled first (fungus or clean) since variations in soil compaction can affect grub movement (Villani, unpublished data). In addition, the order of the chambers on x-ray plates and the position of fungus (fungus “top” or “bottom”) were randomly assigned.

Treatment groups with 10 chambers/treatment were: mycelial particles cultures in 1) 0% tryptone, 2) 0.025% tryptone, 3) 0.25% tryptone, 4) 1% tryptone, 5) 5% tryptone, and 6) the corresponding control—noninoculated soil.

All chambers, regardless of treatment, were filled before final assembly with 40 g of soil (20 g/tube) with a pinch of grass seed placed at both ends of the chamber. For those chambers which contained fungus, 0.15 g of mycelial particles were mixed thoroughly with 20 g of soil for a rate of 7.5 mg mycelial particles/g of soil. Using a small plastic funnel, one tube of each treatment chamber was filled with the soil/fungal mixture, the other with clean soil. In the control chambers, both tubes were

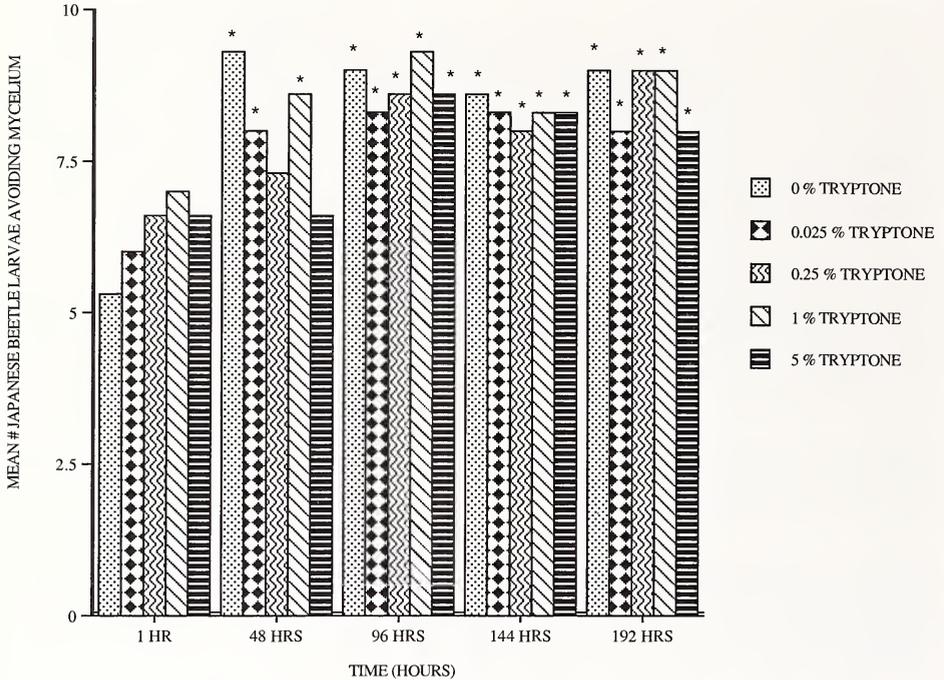


Fig. 2. Mean number of Japanese beetle larvae avoiding mycelial particles grown in 0%, 0.025%, 0.25%, 1%, and 5% tryptone after 1 hr, 48 hrs, 96 hrs, 144 hrs, and 192 hrs. Comparisons with an expected even distribution that proved to be significant at $P = 0.05$ are indicated with an asterisk (*).

filled with clean soil. After the tubes were filled, they were reassembled and placed on x-ray trays. The chambers were secured using tape and stored horizontally. The holes of the filled chambers were covered with masking tape until infestation with the grubs to prevent water loss.

After 24 hours, a third instar Japanese beetle grub was placed head first in the center hole of each chamber. Once the grubs had crawled completely into the hole of the chambers, the holes were again covered with tape. The chambers were stored at $25 \pm 1^\circ\text{C}$, 60% humidity, and 16:8 (light : dark) during the experiment.

Radiographs were taken at 1, 48, 96, 144, and 192 hr after infestation. The location of each grub was marked on the radiograph and recorded as "in" or "out" of the side of the chamber with fungus.

Three replicates were performed at different times during February, 1995. The experimental design was a randomized complete block with fixed effects using treatment replicate as the blocking factor (Milton, 1992). ANOVAs were carried out using Microsoft Excel, Version 5.0. The analysis compared the total number of Japanese beetle grubs out of the fungus side of the chambers to an expected even distribution (50-50) at each sampling date. A Tukey test was used to compare the mean number of larvae avoiding fungus among treatments (Keppel, 1991).



Fig. 3. Radiograph of mycelium containing chambers and control chambers one hour after grubs were placed in center holes. Mycelium incorporated soil was placed in one half of each treatment chamber and is designated by a line. Grub location is indicated by a dot. A coin was used to mark the top of the tray. Grubs can be seen moving away from mycelium in a few of the chambers.

RESULTS

The mean number of Japanese beetle larvae avoiding incorporated mycelial particles over time are shown in Fig. 2. After 1 hour, avoidance of the fungus was not observed ($F = 0.723$; $df = 5, 10$; $P = 0.619$) (Fig. 3). After 48 hr, the number of Japanese beetle grubs avoiding the mycelial particles grown in 0%, 0.025%, and 1% tryptone was significant ($F = 5.234$; $df = 5, 10$; $P = 0.013$). At 96 hr, the number of Japanese beetle grubs out of the side of the chamber with fungus was significant for all treatments ($F = 6.135$; $df = 5, 10$; $P = 0.007$). Japanese beetle grubs continued to avoid all treatments of fungus after 144 hr ($F = 5.389$; $df = 5, 10$; $P = 0.012$), as well at 192 hr ($F = 5.534$; $df = 5, 10$; $P = 0.011$) (Fig. 4).

A significant number of Japanese beetle grubs that entered the fungus side of the chambers after one hr, had left the fungus side after 48 hrs ($F = 31.013$, $df = 1, 24$, $p = 0.000$). The number of grubs which switched to the fungus side after 48 hrs, having entered the clean sides after one hour, was not significant ($F = 3.045$, $df = 1, 24$, $p = 0.094$). The side of the chamber filled first had no effect on Japanese beetle grub position ($F = 0.653$; $df = 6, 12$; $P = 0.689$). The number of grubs at the "top" of the control chambers did not differ from an expected even distribution ($F = 0.955$; $df = 6, 12$; $P = 0.493$).



Fig. 4. Radiograph of mycelium containing chambers and control chambers eight days after grubs were placed in center holes. Grubs can be seen moved away from mycelium incorporated soil in all but one treatment chamber.

DISCUSSION

After one hour, Japanese beetle grubs did not avoid mycelial particles of *M. anisopliae* in soil. The number of Japanese beetle grubs which avoided incorporated mycelial particles was significant after 96 hr. These results are consistent with previous studies of grub behavior in response to mycelium of *M. anisopliae* (Villani et al., 1994).

Most grubs that entered the sides of the chambers with incorporated fungus at the first sample date had moved into clean soil by the second sample date. Those grubs that entered the sides of the chambers with clean soil at the first sample date remained in the clean soil at the second sample date. These data support the hypothesis that grub behavior is influenced by the presence of *M. anisopliae*.

After 48 hr, there was a difference between the avoidance by the grubs among the treatments. Japanese beetle larvae response to particles grown in 0.25% and 5% tryptone was delayed when compared to particles grown in 0%, 0.025%, and 1% tryptone. It has been hypothesized that repellent factors (i.e. metabolites) released by growing mycelium in the soil may be responsible for fungal avoidance by grubs (Villani et al., 1994). The variations in grub responses to the mycelium grown in different levels of tryptone after 48 hours suggest that the nutritional history of the fungus influences the repellent factor in mycelium.

Previous studies have shown that the nutritional culture history of *M. anisopliae* influences fungal growth (Barnes et al., 1975; Campbell et al., 1978; Dillon and

Charnley, 1990). There has been a lack of information on the behavioral responses by insects to these fungi grown under different nutritional regimes. Although the hypothesis was not tested directly, our study suggests that chemical factors associated with growing mycelium may be influenced by the nutritional culture history of the fungus and that larval Japanese beetles are repelled by these factors. These results may help to explain some inconsistencies in results that occur when *M. anisopliae* is used for pest control in the field.

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BOOK REVIEWS

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The Wild Silk Moths of North America. A natural history of the Saturniidae of the United States and Canada.—Paul M. Tuskes, James P. Tuttle, and Michael M. Collins. 1996. Cornell University Press, Ithaca, N.Y. Hardcover, 250 pp., 30 color plates, 19 black-and-white illustrations, 22 drawings, 38 maps and overlays, 5 tables, 8 1/2 × 11. Cloth ISBN 0-8014-3130-1 \$75.00.

The Saturniidae are simply the non plus ultra of big, dazzling moths: the charismatic megafauna of the insect world. Often mistaken for butterflies by non-entomologists, they are the specimens that collectors trot out for their relatives at Thanksgiving as examples of moths that are *not* small and brown (with occasional shades of gray). Saturniid workers never have to fish for complements or argue the attraction of their group by appealing to our appreciation for their subtle beauty. And as the most glaringly obvious examples of showy lepidoptera that are not butterflies, saturniids are at once the poster children for invertebrate conservation efforts and the standard bearers for moth biologists who wish a more widespread audience for their work. Perhaps most significantly, they provide the model for the “Lunar Moth” that carried away Dr. Doolittle at the end of Richard Fleisher’s 1967 classic (actually, it resembles a Polyphemus more than it does a Luna; but at least 20th Century Fox got the subfamily right).

Tuskes et al.’s volume represents the first synthesis of the natural history of North American saturniids that combines taxonomic treatments with high quality color photographic plates of both adults and larvae. Pending the publication of LeMaire’s eagerly awaited volume on the Hemileucinae, no single treatment or series of treatments has covered the North American fauna since Ferguson’s (1971–72) Moths of North America (MONA) fascicle. In no case have the larvae or the life history details of the North American fauna been so thoroughly treated. Collins and Weast’s (1961) volume was taxonomically restricted, treating only the Saturniinae and *Automeris*; and the works of Dyar (1902), Packard (1905, 1914), and Michener (1952) were more limited with respect to their coverage of natural history and/or the taxa and life stages figured. No work has attempted to figure as much of the range of North American saturniid larvae since Packard’s (1905, 1914) excellent renderings of saturniid larvae at various instars. The Wild Silk Moths of North America thus fills a gap in the layman-friendly but thorough treatments of North American Lepidoptera. In a word, the summary of decades of life history work in this volume is masterful, and the large format, coffee-table style will make the book attractive to laymen as well as conservation biologists and expert and professional lepidopterists.

The Wild Silk Moths of North America is divided into two primary sections, plus an introduction, two appendices, a bibliography and two indices. Part One (“Behavior and Ecology”) comprises seven chapters, of which the first four (Life History Strategies, Parasitism, Diseases of Saturniidae, and Populations, Species, and Taxonomy) are strictly biological in focus. Chapter One (Life History Strategies) is a broad but excellent primer on the holobiology of saturniids. Chapters two and three

(Parasitism, Diseases of the Saturniidae) comprise less than six full pages of text between them, prompting one to wonder why their subject matter was divided out into separate chapter headings. Chapter two, at least, is complemented by Appendix 1 (pp. 217–223) which summarizes referenced records of parasitization and hyperparasitization of the North American saturniid fauna. Chapter Four's discussion of population biology, speciation, systematics, and "the subspecies problem" is trite and largely misled, relying heavily on what appear to be the a priorist paradigms associated with long-outdated Mayrian evolutionary taxonomy. Chapter 5 provides a number of important collecting tips to the novice; likewise Chapter 6 is an excellent road map to the powers and pitfalls of rearing. Chapter 7, "Silk Moths and Human Culture", briefly summarizes the economic roles of saturniids in silk production, food, native american art, and as crop pests and medical hazards.

Part Two, Species Accounts, comprises the bulk of the volume's text and all of the plates. All three of the saturniid subfamilies with representatives in North America are treated; 85 taxa in total, of which all are figured as adults and 75 as larvae. The larval plates are among the selling points of this volume. The quality of the color plates is excellent, and will enable virtually anyone encountering these organisms in the field to identify them painlessly. As most biologists will recognize, showy colors and spectacular designs in nature rarely go unaccompanied by fascinating behavioral, ecological, and evolutionary features. The Saturniidae are no exception, and Tuskes et al. do an excellent job of asking intriguing questions and, to some extent, providing novel data towards answering them.

As it has for North American birds and butterflies, the systematics of North American saturniids appears to have reached a point where most of the genera are more or less stable and where taxonomic changes consist largely of subspecific transfers, elevations, or synonymies. Although it does not purport to be a phylogenetic revisionary work, and does not describe any new taxa, it effectively revises the North American saturniid fauna at the alpha level. Only one change is made at the generic level: *Syssphinx* is resynonymized under *Sphingicampa*; the reverse was the single generic change in Lemaire (1988) (Rindge, 1989). The other taxonomic changes in Tuskes et al. are as follows: ten subspecies are sunk to within the nominate form (*Eacles imperialis nobilis*, *Anisota stigma fuscata*, *Anisota virginiensis pellucida*, *Anisota virginiensis discolor*, *Dryocampa rubicunda alba*, *Coloradia pandora lindseyi*, *Hemileuca chinatiensis conwayae*, *Hemileuca nuttalli uniformis*, *Automeris io lilith*, and *Antherea polyphemus olivacea*); one species is synonymized (*Hemileuca artemis* with *nevadensis*); two are elevated (*Antherea oclea*) or re-elevated (*Eacles oslari*) to species status; and three species are reduced (*Agapema anona platensis*) or re-reduced (*Hemileuca hera magnifica*, *Agapema anona dyari*) to subspecific rank. By comparison, Ferguson (1971–2) described two new species (*Sphingicampa blanchardi* and *Agapema solita*); four new subspecies (*Anisota stigma fuscata*, *Anisota virginiensis discolor*, *Hemileuca eglanterina annulata*, and *Automeris iris hesselorum*); created two new combinations (*Hemileuca hualapai* and *Hemileuca chinatiensis*); synonymized one variety (*Pseudohazis hera* var. *arizonensis* with *Hemileuca nuttalli nuttalli*) and one subspecies (*Pseudohazis washingtonensis* with *Hemileuca nuttalli nuttalli*); elevated three subspecies or varieties (*Eacles imperialis oslari*, *Sphingicampa heiligbrodti hubbardi*, *Sphingicampa* [= *Adelocephala*] *hogeii* var. *montana*) to species status; elevated one variety to subspecific rank (*Sphingicampa*

[=*Adelocephala*] *quadrilineata occlusa*); sunk two species to subspecies (*Coloradia pandora lindseyi*, *Coloradia pandora davisii*); and transferred one subspecies (*Hemileuca eglanterina uniformis* to *H. nuttalli uniformis*).

It will be observed that many of the taxonomic decisions of Ferguson (and others) are reversed in Tuskes et al.'s treatment. Such is the nature of the systematic endeavor: to pursue progress over stability. But one must wonder whether there continues to be undue focus at the infraspecific and infrasubspecific levels, given that none of the most recent volumes on the Saturniidae have made much of an attempt at phylogeny reconstruction. (The most rigorous attempt to address the phylogeny of the Saturniidae to date was that of a hymenopterist [Michener, 1952] during his tenure at the American Museum of Natural History, and was strongly contested by lepidopterists [Forbes, 1952].) As a phylogenetic systematist, I find this emphasis not uncoincidental with the authors' adherence to the biological species concept, and I fear that the shift away from macroevolutionary taxonomic questions to species-level taxonomic questions attributable to Mayr has been slow to reverse itself in the lepidopterist community.

Relatedly, the volume suffers, in my opinion, from a chronic problem in its portrayal of species delineation and speciation. The author's application of hybridization studies to the delimitation of species is foreshadowed in what can only be seen as a rather outdated discussion of the species problem (pp. 3–4), and in the somewhat weak attempt in Chapter 4 to integrate evolution within populations and speciation. Throughout the book the discussion of specific (and infraspecific) delineation (their "evolutionary view of the species") is couched in Mayrian terms of interbreeding, hybridization, and subspecific process-related assumptions. The *Hemileuca maia* complex is referred to as a "superspecies" (p. 111); following Tuskes and Collins (1981), *Saturnia mendocino* and *S. walterorum* are referred to as "semispecies" (P. 163). *Automeris io lilith* is synonymized under nominate *io* on the grounds that it "does not have a distribution pattern consistent with the subspecies concept" (p. 152). In fact, such terminology does not serve to clarify, but rather to confuse the logical relationship between alpha systematics and phylogeny reconstruction. It serves as well to misdirect the focus of systematic research away from recovering an underlying pattern from within which to test hypotheses, and towards an assumption-laden, process-oriented approach from within which hypothesis testing is impossible.

One of the primary purposes of systematics is to provide an independent framework for the examination of biological processes. In contrast, Tuskes et al. (p. 32) state: "A consideration of the process of speciation is important in order to understand the controversy over what constitutes a species and what taxonomic rank should be assigned to a given population". And later in the same paragraph: "Any theory of speciation must explain the transition from one stable, harmonious system of interacting genes to another such system." Throughout the volume, the authors conflate the discovery operations used by systematists to delineate species with the process of speciation itself. Interbreeding and hybridization are thus seen as a tool for taxonomy rather than a phenomenon to be examined following character-based phylogenetic reconstruction. Reproductive isolation is repeatedly referred to as a "test" of species status. This approach, with its obligate reliance on the ability to produce fertile offspring, effectively abandons character-based systematic inference; indeed, one of the authors refers to morphological attributes as "indirect" (Collins, 1997). But the practice of systematics depends ulti-

mately on character-based species diagnoses. Only character-based diagnoses can lead to hypotheses of phylogenetic schemes and classifications if they are to be based on synapomorphies. Species may certainly be “lost” by hybridization, which obscures phylogenetic pattern, but it is not acceptable to lump historically distinct entities because of what may (or may not) happen in the future.

The authors’ adherence to the biological species concept is troublesome for other reasons. Tuskes et al. do not address the requirement that a species criterion must be consistent and operational if it is to apply to all organisms, and that not only are requirements of interfertization impossible to use consistently (they are irrelevant for asexual taxa, for example), the ability to interbreed may be plesiomorphic as well. In fact, Tuskes et al.’s Appendix Two “Saturniid Hybrids” (pp. 224–5), includes a number intergeneric crosses. It must be recognized that hybridization experiments such as those conducted by the authors are at best one-sided tests. Failure to produce fertile offspring may well be sufficient evidence from which to conclude that two putative species are distinct, as do Tuskes et al. for *Eacles oslari* and *Antheraea oclea*. But the ability to interbreed—the author’s primary justification for re-synonymizing *Hemileuca artemis* with *H. nevadensis*—cannot be invoked as de facto “proof” of legitimately character-based identification of conspecificity. Nonetheless, the authors are rather conservative in their taxonomic changes, sinking many more taxa than they elevated. Almost every such synonymy is based on refutation of allegedly diagnostic characters, the exceptions being *Hemileuca artemis* and *Hemileuca nuttalli uniformis* (whose distribution, the authors state on p. 144, “is inconsistent with that of a subspecies”). Perhaps the authors of this volume should either have included a review of higher level saturniid relationships (to the extent possible) or not devoted as much space trying to reconcile their notions of species with character data.

Distributions, flight times, calling times, and host plant records (as well as at least one first-time larval description; *Hemileuca hualapai*, p. 108) are among the most valuable aspects of the volume’s content. The volume is noteworthy for describing rangewide variation in flight times and development. The text is chock-full of useful basic natural history information and is at times downright entertaining. I was delighted to learn that the etymology of the Buck moth derives from the belief that the moth larvae developed in the heads of deer and that the adults fly from the bucks’ nostrils (p. 111). Likewise the anecdote of the polyphemus caterpillars’ sharing similar optical spectra with harvested plums and getting sorted mechanically into the prune processing machinery (p. 177) was most amusing. With almost 550 references, the bibliography is extensive, drawing on reports and season summaries by amateurs as well as revisionary and other empirical work by professionals. It serves as the most complete guide to the saturniid literature of which I am aware.

Tuskes, Tuttle, and Collins are to be congratulated for their synthesis of North American saturniid life histories. This volume is an up-to-date compilation of available natural history data that serves admirably both as a field guide and as an introduction to students, natural historians, and other biologists with an interest in silk moth biology. While their philosophy of systematics leaves something to be desired, their obvious dedication and diligence with respect to addressing basic natural history questions has resulted in one of the best lepidopteran natural history texts I have ever seen, and one that will no doubt set the standard for North American moth life history books for decades to come.—

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Click beetles: Genera of the Australian Elateridae (Coleoptera).—Andrew A. Calder. 1996. 401 pp., 420 figs. including 90 excellent habitus drawings. About \$100.00 U.S.

This appears to be an excellent reference to the genera of Australian click beetles. The illustrations are excellent, especially the habitus ones. The treatment for each genus starts with the original citation, synonymy if any, and the type species. This is followed with a very detailed description that is the equivalent of just over two pages plus about three more pages of illustrations. Finally, there is a short section on geographical distribution (world and Australian), a list of the Australian species,

biology, and comments. The distribution of Australian species is usually given as one locality and state or else state or area of Australia.

There are 420 illustrations, including the 90 habitus drawings (one or two per genus). The other illustrations are of the male genitalia, female genital tract, and excellent SEM photographs of other parts (tarsi, heads, pronota, etc.).

The subfamilies are briefly described each with a list of included genera and arranged in phylogenetic order, but the genera under each are arranged in alphabetical order, which I find distracting; on the other hand, everyone knows the alphabet! In the key, it would have been very useful to have included a page reference for each genus.

The 660 Australian species are placed in 70 genera (48 are endemic) and eight subfamilies. A brief description and a list of genera is given for each subfamily. Fifteen new genera and seven new species are described; there are 13 species that remain unplaced and thus excluded from the fauna. Three other species, originally described as from Australia, could not possibly have come from Australia and thus are dropped from the list. Also dropped from the list is *Lacon modestus*, which was described from Australia, but has never been found "amongst the tens of thousands of Australian elaterids examined."

On the other hand, the more I looked at the "fine print," the more I wondered if anyone really paid any attention to the smaller details.

In many cases, the wording in the key does not match those in the descriptions. For example, in couplet 19 [the word prothorax should have been used, not pronotum], "antennae inserted into a U-shaped depression (Figs. 33, 42)" [Fig. 33 is dorsal view of habitus and Fig. 42 is the hind wing!]. This sentence is redundant to the first one except there Fig. 43 is that of the female genital tract. Furthermore, antennae is plural and therefore depression should also be plural or use the word each—this is a fairly common mistake throughout the book. "Tarsomeres 1-4 each . . . (Figs. 37, 44)" [respectively these figures show the claw plus the distal part of tarsomere 5 and the female genital tract].

Also in couplet 19, the phrase "hind coxal cavity distally closed (rear wall of cavity not visible)" stumped me at first. Had the author stated "not visible ventrally" or even better, as in the descriptions (pp. 36, 40, 45), "hind coxal plate with distal width same as greatest proximal width" it would have made sense. In the descriptions, it is stated, ". . . ; hind coxal cavity closed distally (rear wall of cavity not visible)." Actually the rear wall of the cavity is visible from an oblique view if the hind leg is pulled backwards.

Couplet 23, for *Diadysis*, "anterior section of pronotosternal suture not grooved" vs. "anterior portion of polished band along inner margin of hypomeral border." Are these characters the same?

Many of the illustrations do not match the key characters or even the description. For example, for *Glypheus*, compare couplet 25, "tarsomere 1 shorter than tarsomeres 2-4 combined" with the description on p. 182 that notes, ". . . slightly longer . . ." or measure these tarsomeres in Fig. 193 (slightly shorter), Fig. 194 (as long as). If this is because I am measuring them from different angles, then the author should have explained this in the introduction (dorsal or lateral view, from base to extreme tip including lobe, if any).

The enlarged illustrations of the lateral lobes of the male genitalia are good, but

they certainly do not like the overall illustrations (compare Figs. 313 with 314 or 367 with 368).

Many descriptions state "Prothorax . . . anterior angles not strongly produced, only covering half of eye (at most)," yet many illustrations show anterior angles not touching the eyes (see Figs. 79, 229, 265, 355, etc.). This "deception" could be the result of the fact that the head may be extended or protracted in relation to the prothorax.

Lacon is listed as a valid genus from Australia (see p. vi), yet on p. ix it is removed from the list. The information on *Lacon* on p. 97 should have been placed on p. 384 along with the other excluded species?

Despite my comments above, I still think that this a very useful book and worth the price. To prove the value of this book, the first Australian specimen I tried to identify was lacking the elytra, antennae, and tarsi, nevertheless, by thumbing through the habitus illustrations I was able to get a generic name, which I then verified by looking at the collection.—*Edward C. Becker, Agriculture Canada, Ottawa, ON, KIA OC6, Canada.*

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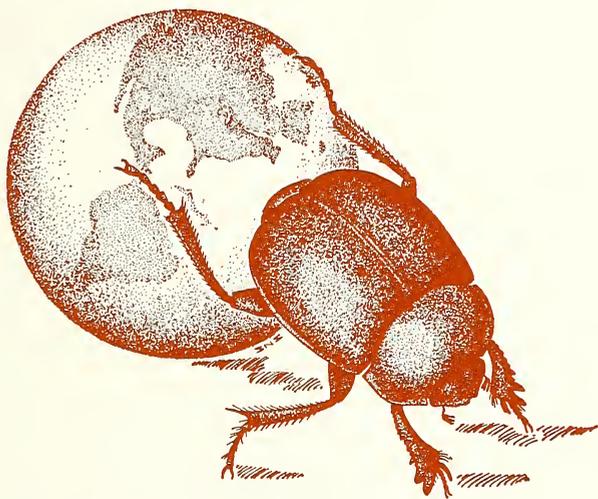
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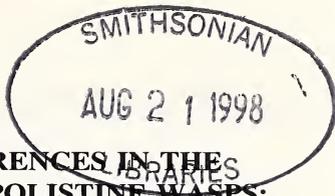
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**MORPHOLOGICAL CASTE DIFFERENCES IN THE
NEOTROPICAL SWARM-FOUNDING POLISTINE WASPS:
PARACHARTERGUS SMITHII (HYMENOPTERA: VESPIDAE)**

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Abstract.—As part of a series of papers aimed at studying caste in epiponine wasps, this paper deals with *Parachartergus smithii*. The whole female population of a mature nest (131 workers, 14 intermediates and 5 queens) was measured and dissected. Canonical discriminant analyses indicated slight morphological caste differentiation. Mahalanobis distances for queen-worker, queen-intermediate and intermediate-worker were 10.33, 10.86 and 0.90, respectively. However, ovaries were much more developed in queens than in workers and intermediates indicating clear physiological differences. In addition, castes were distinguished by color patterns in the frons, clypeus, mandibles, gena and wings. A brief comparison of caste differences in the Epiponini reveals both allometric and non-allometric patterns.

Key words: Polistinae, Epiponini, *Parachartergus smithii*, caste differences, multivariate analyses.

The worker caste in social Hymenoptera consists of unfertilized females, normally incapable of fertilization and with undeveloped ovaries. In ants and honey bees workers are distinguished from the queen by discontinuous morphological characters. However, where such clear-cut distinctions are absent difficulties in distinguishing castes arise. For example, in the polistine tribe Epiponini, the presence of intermediate females (Richards and Richards, 1951), which are characterized by ovary development in the absence of insemination, seems to be widespread. They appear in *Protopolybia acutiscutis* (cited as *P. pumila*, Naumann, 1970), *P. exigua exigua* (Simões, 1977; Noll et al., 1996), *Pseudopolybia vespiceps* (Shima et al., in prep.). According to Richards (1971) the significance of the intermediates is practically unknown (but see Gastreich et al., 1993). However, there are direct observations on their frequent egg laying and oophagy in *Protopolybia acutiscutis* (cited as *P. pumila*) and *P. exigua exigua* by Naumann (1970) and Simões (pers. comm.), respectively.

In epiponines, queens tend to be somewhat larger than workers. In *Protonectarina silveirae* the queens are larger than workers (Shima et al., 1996b), but the most conspicuous size and color differences among epiponine wasps were found in some *Agelaia* spp. (= *Stelopolybia*), such as *A. flavipennis* (Evans and West-Eberhard, 1970), *A. areata* (Jeanne and Fagen, 1974), and *A. vicina* (Sakagami et al., 1996). In *Pseudopolybia vespiceps* caste differences are slight and intermediates are present (Shima et al., in prep.). In *Parachartergus fraternus* (Richards, 1978) and *Chartergellus communis* (Mateus et al., 1996) differences are very slight or undetectable externally: queens are not obviously different from workers and intermediates. How-

ever, in some groups, queens are significantly smaller than workers in some characters and larger in others (Richards, 1971, 1978; Shima et al., 1994). According to Jeanne et al. (1995), who studied *Apoica pallens*, this is considered as non-size-based allometry, probably due to a reprogramming in growth parameters (Wheeler, 1991). Such a pattern was detected also in *Epipona guerini* (Hunt et al., 1996), *Pseudopolybia difficilis* (Jeanne, 1996), *Apoica flavissima* (Shima et al., 1994), and *Polybia dimidiata* (Shima et al., 1996a).

As the seventh report on our on going series related to caste differences in the swarm-founding polistine wasps, this paper deals with *Parachartergus smithii*. Other than the information summarized in Richards (1978) and the description of the initial steps of nest establishment (Itô, 1996), this taxon is poorly known.

MATERIAL AND METHODS

A mature colony of *Parachartergus smithii* (de Saussure) was collected (Dec. 6, 1994) in Cajurú, São Paulo State, SE Brazil. In the collected population 150 females and 25 males were found. The adults were put in Dietrich's fixative for 72 hr and thereafter kept in 70% ethanol. In order to detect caste differences the following fifteen external body parts (Fig. 1) were manually measured in each female: (1) head width (HW), (2) head length (HL), (3) maximum interorbital distance (IDX), (4) minimum interorbital distance (IDm), (5) gena width (GW), (6) eye width (EW), (7) mesosomal height (MSH), (8) mesoscutellar length (MTL), (9) mesoscutellar width (MSW), (10) pronotum width (PW), (11) metasomal height (MH), (12) basal width tergum I (T1BL), (13) basal length tergum II (T2BL), (14) maximum width tergum II (T2ML), (15) partial length of forewing (WL). In addition, color patterns and other morphological characteristics were examined for 5 queens, 20 workers and 14 intermediates. We examined ovarian conditions by using stereomicroscope. In order to analyse insemination the spermatheca was removed and put on a slide in a solution of glycerine and alcohol (70%) in the same proportion. The presence of sperm cells was assessed by using a microscope. Statistical analyses including canonical discriminant analyses (CDA: Rao, 1973) and generalized Mahalanobis distances (D^2) were performed with the SAS Program Package for PC computers. Kruskal-Wallis one way analyses of variance was used to detect differences for each character. If a difference was found, Dunn's method for multiple comparisons was applied using the program Sigma Stat for Windows version 1.0. Two secretory organs, i.e., van der Vecht's organ (sixth gastral sternal gland) and Richards' gland (fifth gastral sternal gland), were examined in 5 queens, 10 intermediates, and 20 workers.

RESULTS

Nest architecture and colony composition. The nest was found at five meters height attached to a wooden post. The adult population comprised 150 females and 25 males. Ovarian dissection and the insemination test revealed the females to be 5 queens, 14 intermediates and 131 workers. The envelope was light gray with many brown and dark gray striated spots, producing a camouflage for the nest (Fig. 2A). It was 25 cm in length and 15 cm wide. The largest of thirteen combs had 136 cells and the smallest 7 cells; each comb was attached to the substrate by a single central

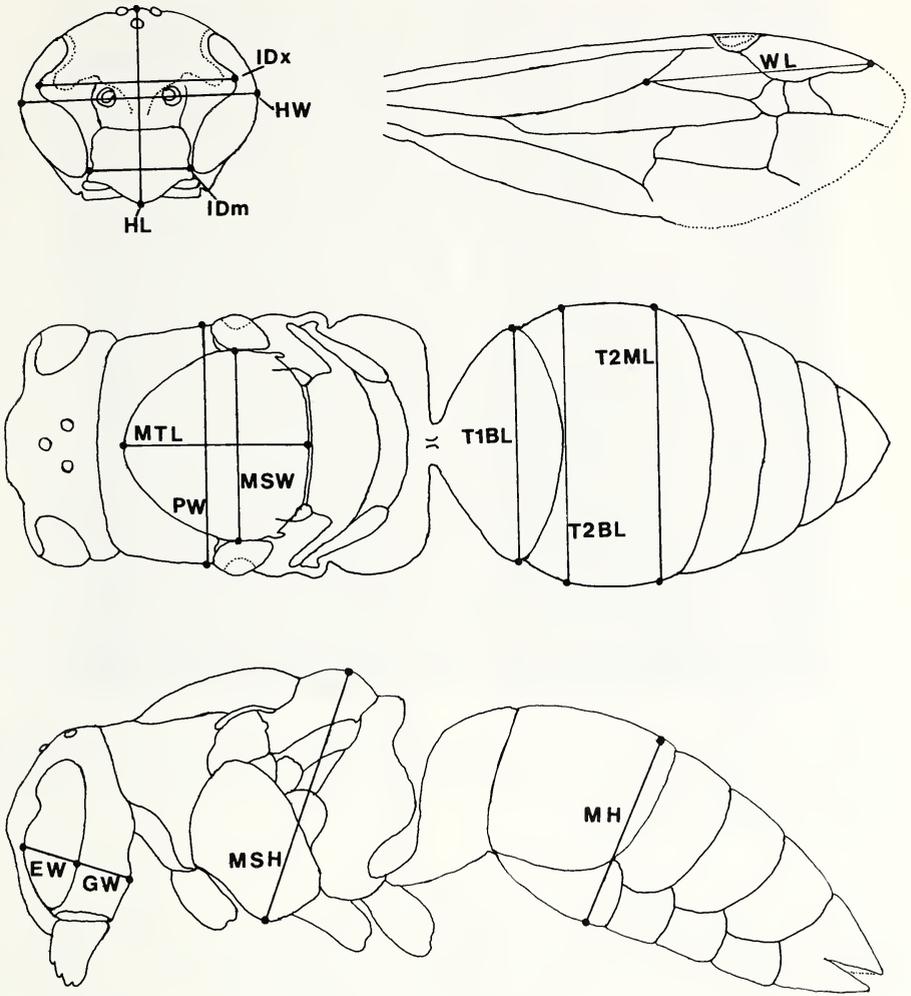


Fig. 1. Illustration of the measured characters in the females of *Parachartergus smithii*. HW: head width, HL: head length, IDx and IDm: maximum and minimum interorbital distances respectively, GW: gena width, EW: eye width, PW: pronotum width, MH: metasomal height, T₁BL: basal width tergum I, T₂BL: basal length tergum II, T₂ML: maximum width tergum II, WL: partial length of the forewing.

peduncle. The wood surface inside the envelope was partially covered by the same material used to build the combs (Fig. 2B).

The total number of cells was 848, divided into 86 empty (most of them located in the periphery of the combs), 180 cells with eggs, 129 with small larvae, 80 with medium larvae, 61 with large larvae and 312 cells with pupae. The number

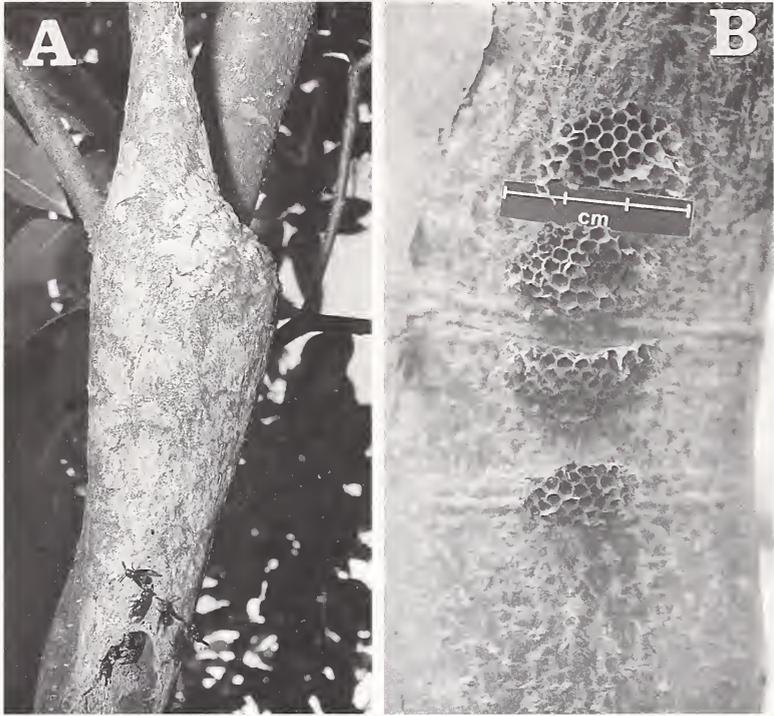


Fig. 2. Nest of *Parachartegus smithii* built on a branch. (A) bottom view with some wasps near the entrance and (B) an abandoned nest showing attachment of the combs to the substrate and the substrate surface partially covered by the same material used in the envelope and combs photographs taken by S. Mateus.

of meconia was counted for each cell in order to evaluate the number of generations produced. There were found 184 cells with one meconium, 206 cells with two, 152 cells with three, 74 cells with four and 68 cells with five meconia. In this way, the total number of individuals produced was estimated at 1688.

Ovary development and spermathecal contents. The ovariole number was always three in each ovary, and the following types of ovarian development were distinguished (Fig. 3): Type A subdivided into A₁ (N = 43) with filamentous ovarioles which had no visible oocytes (Fig. 3A₁) and A₂ (N = 31) with some very small oocytes (Fig. 3A₂). Type B was subdivided as B₁ (N = 57) bearing some young oocytes (Fig. 3B₁) and B₂ (N = 14) with one or more mature oocytes in each ovarioles (Fig. 3B₂). Type C: (N = 5) with well developed and very long ovarioles with at least one mature egg, which were contorted inside the gaster (Fig. 3C). Insemination was confirmed only in females with type C ovaries.

Color pattern differences. The principal color differences were on the head, metasoma and wings. They were: 1—mandibles light brown in queens, while chestnut in workers, although brown at the apex for both (Fig. 4, E vs. F); 2—the clypeus,

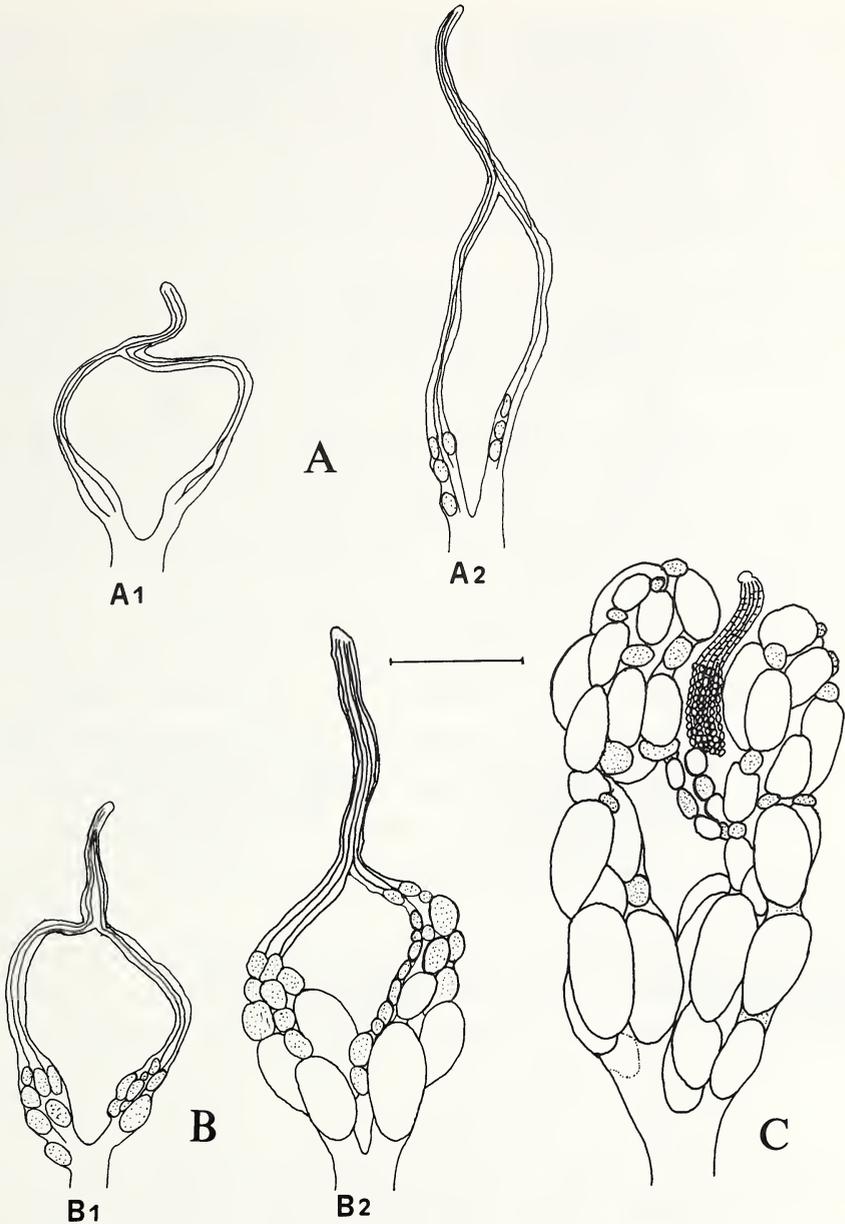


Fig. 3. Kinds of ovary development found among the females of *Parachartergus smithii*: Type A (A1—with filamentous ovarioles which had no visible oocytes and A2—with some very small oocytes) Type B (B1—bearing some young oocyte and B2—with one or more mature oocytes in each ovarioles). Type C: well developed ovary present in inseminated females. Scale bar = 1 mm.

supra-antennal area and paraocular spots light yellow in queens while yellow in workers (Fig. 4, A vs. B); 3—the supra-antennal lateral area and the lower margin of the clypeus white in queens (pigment is absent) while yellow in workers (Fig. 4, A vs. B); 4—the lower genal area close to mandibles white in queens (pigment is absent) and the upper part light-yellow, while in workers these are yellow and light-brown (Fig. 4, C vs. D); 5—bands on metasomal terga narrow and light-brown in queens, wider and dark-brown in workers; 6—radial cell areas of wings light-brown to chestnut in queens, while in workers this area is dark-brown to light-brown (Fig. 4, G vs. H).

External glands. Richards' gland was present and van der Vecht's gland was absent in all analysed females. In queens the glandular tissue filled a third of the upper margin of the fifth sternum and was most abundant at the lateral borders. In workers and intermediates the amount of glandular tissue was smaller than that found in queens.

Queen-worker differences in relation to morphometry. Among the fifteen analyzed characters all of them did not differ significantly among queens, workers and intermediates (Table 1). Canonical discriminant analyses (CDA) based on the fifteen analyzed characters indicated a slight difference among queens, workers and intermediates. Queens were located between -2 and 6 for CAN_1 values and workers and intermediates between -2 and 2.3 .

The following equation was used in order to calculate CAN_1 :

$$\begin{aligned} CAN_1 = & -21.8(HW - 2.29) - 9.57(HL - 1.82) + 2.90(IDx - 1.93) \\ & + 6.16(IDm - 1.00) - 6.79(GW - 0.53) - 13.29(EW - 0.56) \\ & + 11.89(MSH - 2.48) + 11.48(MTL - 1.68) - 12.42(MSW - 2.34) \\ & + 21.07(PW - 1.85) - 1.43(MH - 2.26) - 3.75(T1BL - 2.32) \\ & - 0.10(T2BL - 2.78) - 4.47(T2ML - 2.86) + 0.28(WL - 2.88) \end{aligned}$$

For determining CAN_1 mesoscutellar length (MTL), width of mesoscutum (MSW), head width (HW) and especially pronotum width (PW) were the most important among the analyzed characters.

No differences in CAN_2 values were found for the three groups. The following equation was employed in order to calculate CAN_2 :

$$\begin{aligned} CAN_2 = & +15.41(HW - 2.29) - 0.99(HL - 1.82) - 6.37(IDx - 1.93) \\ & - 15.78(IDm - 1.00) + 22.97(GW - 0.53) + 10.12(EW - 0.56) \\ & + 3.16(MSH - 2.48) - 3.06(MTL - 1.68) - 11.89(MSW - 2.34) \\ & + 7.38(PW - 1.85) + 8.36(MH - 2.26) - 1.84(T1BL - 2.32) \\ & - 5.84(T2BL - 2.78) - 0.22(T2ML - 2.86) + 6.18(WL - 2.88). \end{aligned}$$

Minimum interorbital distance (IDm), head width (HW), mesoscutellar width (MSW) and especially metasomal height (MH) were the most important for determining CAN_2 .

Mahalanobis distances between queen/worker, queen/intermediate and intermediate/worker were 10.33, 10.86 and 0.90 respectively, showing that queens are much

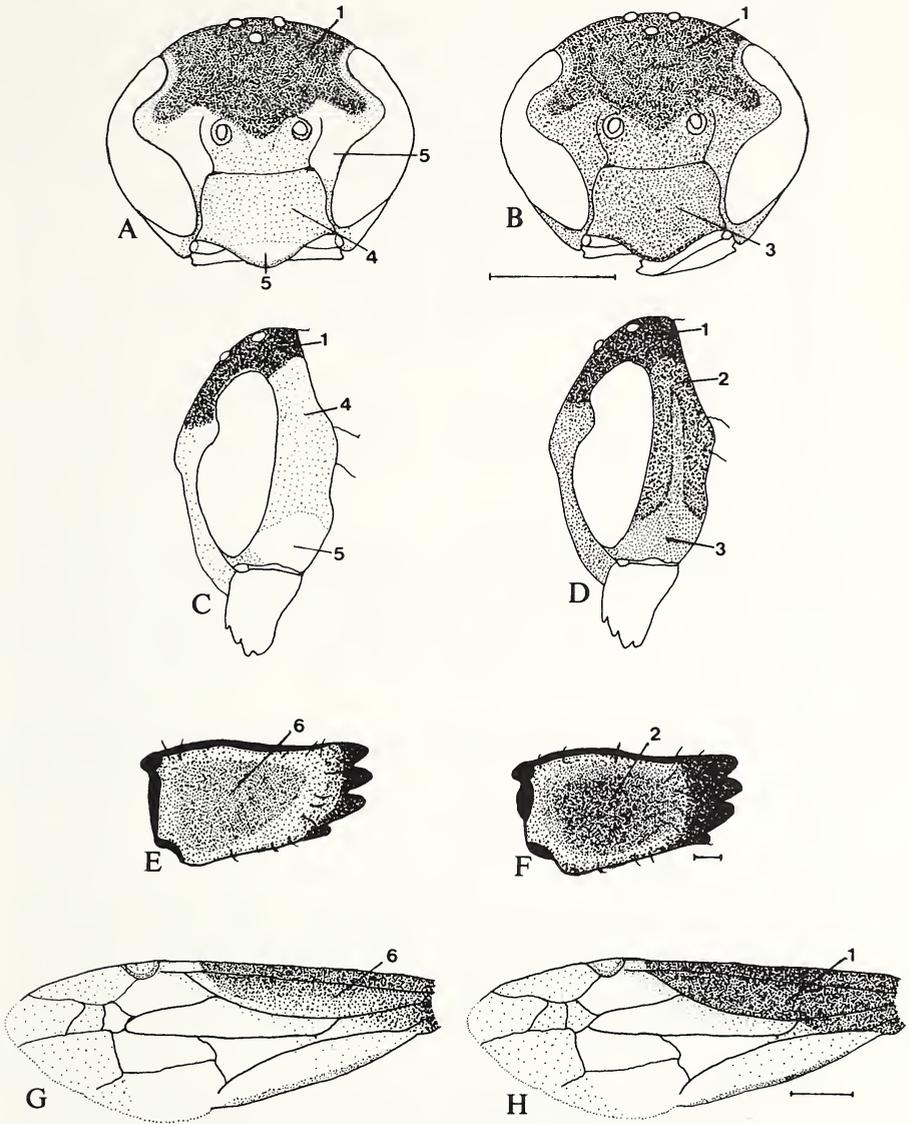


Fig. 4. Queen/worker differences in color patterns on clypeus and supra-antennal area (A, B), gena (C, D) (scale bar = 1 mm), mandible (E, F) (scale bar = 0.1 mm) and wing (G, H) (scale bar = 1 mm) of *Parachartergus smithii*. Numbers indicate color patterns: 1 dark-brown, 2 light-brown, 3 yellow, 4 light-yellow, 5 white and 6 chestnut.

Table 1. Means, CAN_1 and CAN_2 values for 15 characters used for caste discrimination in *Parachartegus smithii*. *Kruskal-Wallis One Way Analyses of Variance indicated that queens, workers and intermediates had no difference among the analyzed characters. All values were not statistically significant ($P < 0.0001$).

Character	Analyses of variance*					CAN_1		CAN_2	
	Means			H	P	Standardized	Raw	Standardized	Raw
	Queens (N = 5)	Intermediates (N = 14)	Workers (N = 131)						
Head									
HW	2.33 ± 0.05	2.30 ± 0.04	2.29 ± 0.04	4.74	0.09	-0.81	-21.83	0.57	15.41
HL	1.84 ± 0.04	1.82 ± 0.02	1.82 ± 0.03	0.82	0.66	-0.26	-9.57	-0.03	-0.99
IDx	1.94 ± 0.05	1.93 ± 0.03	1.93 ± 0.04	1.51	0.47	0.10	2.90	-0.23	-6.37
IDm	0.99 ± 0.04	1.00 ± 0.02	1.00 ± 0.02	0.01	0.99	0.15	6.16	-0.38	-15.78
GW	0.53 ± 0.03	0.53 ± 0.02	0.53 ± 0.02	1.93	0.38	-0.13	-6.79	0.45	22.97
EW	0.57 ± 0.03	0.56 ± 0.02	0.56 ± 0.02	0.37	0.83	-0.24	-13.29	0.18	10.12
Mesosoma									
MSH	2.46 ± 0.07	2.48 ± 0.04	2.48 ± 0.04	3.33	0.19	0.47	11.89	0.12	3.16
MTL	1.66 ± 0.04	1.68 ± 0.04	1.68 ± 0.05	1.78	0.41	0.51	11.48	-0.14	-3.06
MSW	2.35 ± 0.07	2.33 ± 0.04	2.33 ± 0.05	0.26	0.88	-0.61	-12.42	-0.58	-11.89
PW	1.80 ± 0.08	1.87 ± 0.05	1.85 ± 0.05	0.32	0.52	1.12	-21.07	0.39	7.38
Metasoma									
MH	2.26 ± 0.06	2.30 ± 0.06	2.25 ± 0.09	3.20	0.20	-0.13	-1.43	0.76	8.36
T1BL	2.35 ± 0.07	2.33 ± 0.07	2.32 ± 0.06	0.44	0.80	-0.24	-3.75	-0.12	-1.84
T2BL	2.81 ± 0.08	2.78 ± 0.05	2.78 ± 0.07	0.20	0.91	0.01	0.10	-0.41	-5.84
T2ML	2.88 ± 0.09	2.86 ± 0.06	2.85 ± 0.07	0.09	0.96	-0.32	-4.47	-0.02	-0.22
Wing									
WL	2.86 ± 0.06	2.90 ± 0.06	2.88 ± 0.06	2.06	0.36	0.02	0.28	0.37	6.18

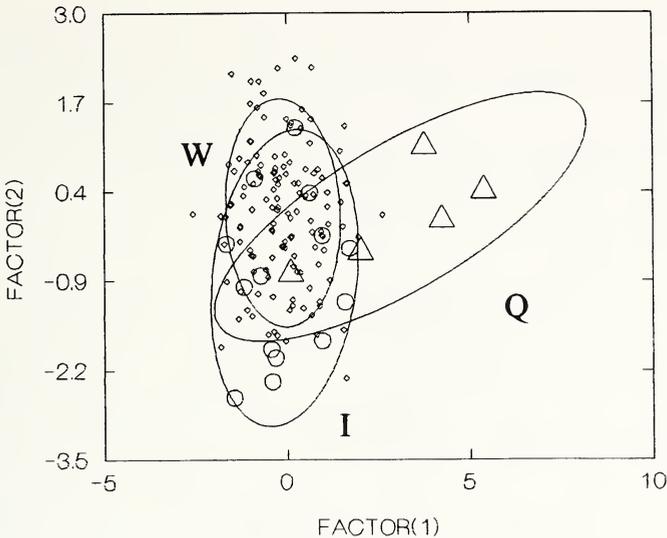


Fig. 5. Discrimination among intermediates (I), workers (W) and queens (Q) of *Parachartergus smithii* based on the canonical discriminant analyses using 15 metric characters. Each ellipse encompasses 67% of the variation found in each group.

more different from workers and intermediates than are workers and intermediates from one another.

DISCUSSION

Caste differentiation in wasps is certainly more conspicuous in the Vespinae, especially in the subgenus *Vespula* (Blackith, 1958; Spradbery, 1972). Although caste differences in the Polistinae are much less conspicuous, such traits are probably more complex here than in Vespinae. The occurrence of intermediates, which were first recorded by Richards and Richards (1951), adds complexity to the problem of caste differentiation. These ovary-developed but unseminated females have been recorded in the colonies of *Polybia* (*T.*) *chrysothorax*, *P. jurinei*, *Parachartergus fraternus*, *Angiopolybia* spp., *Chartergellus communis* (Richards and Richards, 1951; Mateus et al., 1996), *Brachygastra scutellaris* (Carpenter and Ross, 1984), *Pseudopolybia vespiceps* (Shima et al., in prep.), *Protopolybia exigua* (Noll et al., 1997) and *Parachartergus smithii* (present results). Naumann (1970), Simões (1977) and Noll et al. (1996) found intermediates in two taxa showing clear morphological caste distinction, *P. acutiscutis* (= *P. pumila*) and *P. exigua exigua*. The observations by Naumann (1970) and Simões (1977) showed that in both cases the eggs laid by the intermediates were invariably eaten by the layer herself, which strengthens the conclusion by Naumann (1970) that these are trophic eggs that play a role in energy circulation in insects that lack adequate ways of storing protein food (see Hunt, 1991).

Slight but significant caste differences were detected in *P. smithii*. Using Canonical Discriminant Analyses, queens tended to be slightly larger than workers and intermediates, and intermediates were morphologically close to workers. In *P. exigua exigua* (Noll et al., 1996) a similar result was found, although in *Pseudopolybia vespiceps* (Shima et al., in prep.), intermediates were closer to queens. In addition, color patterns found in *P. smithii* reinforce the close relationship between workers and intermediates and their clear differences from the queens. In *P. vespiceps* (Shima et al., in prep.) color patterns of queens and workers were very similar, especially in the head and gaster.

According to Richards (1978) at least three caste differentiation forms are found: 1—Conspicuous size and allometric differences present, with queens larger than workers in the absence of intermediates (*Agelaia* spp: *A. areata*, Jeanne and Fagen, 1974; *A. pallipes* and *A. multipicta*, Noll et al., in prep.; *A. vicina*, Sakagami et al., 1996; *Protonectarina sylveirae*, Shima et al., 1996b); 2—Conspicuous dimorphism present, with queens smaller than workers and no intermediates present (*Apoica flavissima*, Shima et al., 1994; *Polybia dimidiata*, Maule-Rodrigues and Santos, 1974; Shima et al., 1996a); 3—Morphological differences slight or indistinct, and intermediates present (*Pseudopolybia vespiceps*, Shima et al., in prep.; *Protopolybia exigua*; Noll et al., 1996). *P. smithii* resembles the first case, but some differences can be pointed out. Queens can be well separated from workers and intermediates not only by their clear physiological differences related to ovary development but also by color patterns. These characteristics indicate that caste differentiation in epiponine wasps can be derived from non-allometric growth as pointed out by Jeanne et al. (1995). However, allometric growth can also be expected in Epiponini (see above). Thus the evolution of caste differentiation in epiponine wasps has both allometric and non-allometric aspects, possibly related to bionomic differences among the groups such as nest perenniality, hygienic methods, nest size and protection, etc. (Jeanne, 1991)

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TWO NEW NEOTROPICAL GENERA OF EMBIIDAE (EMBIOPTERA, INSECTA)

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Abstract.—Two new genera of Embiidae, *Gibocercus* and *Biguembia*, are described. *Gibocercus* and *Biguembia* contain four and two species, respectively, all newly described: *G. chaco* (Argentina), *G. beni* (Bolivia), *G. urucumi* (Brasil), *G. nanai* (Perú), *B. copo* (Argentina) and *B. cocum* (Brasil). The new genera form a monophyletic group and they are the sister group of *Parhagadochir* plus *Scelembia*; the four genera share, among other characters, a node on the left paraproct and a bifid process on the 10th left hemitergite. The relationships of the new genera, and their species, are discussed.

As currently delimited, Embiidae is one of the largest families of Embioptera, with representatives in all continents except Australia, including 117 species (only 28 of which are from the Neotropical region).

Davis (1940) suggested that Embiidae was a polyphyletic group, defined on the basis of convergences. A preliminary cladistic analysis of the higher classification of the order (Szumik, 1996) supported Davis' idea.

A more detailed (and unpublished) analysis of the order, with many more characters and taxa (including 104 characters and 90 species of 40 genera, with a better representation of Neotropical taxa), allows recognition of two new genera, *Gibocercus* and *Biguembia*, in the polyphyletic "Embiidae." In this new analysis the neotropical Embiidae (except *Microembia*) and *Scelembia* form a monophyletic group, which in turn is the sister group of Oligotomidae and Teratembiiidae (Fig. 1). *Gibocercus* and *Biguembia* appear as the sister group of *Pararhagadochir* and *Scelembia* (Embiidae from South America and Africa, respectively); this is suggested by similarities in mandibular, alar and abdominal characters. These four genera share at least four synapomorphies: 1) cross-veins absent between Ma and Mp veins; 2) Rs+Ma forking from Cu, and a cross-vein between R1 and Rs+Ma; 3) a bifid process of the left hemitergite; and 4) the left paraproct with a nodule and denticles. *Gibocercus* and *Biguembia* were represented in this new analysis by their six constituent species, and both resulted as well supported monophyletic groups (Fig. 1). A full discussion of the entire analysis is beyond the scope of this paper; only the results relevant for the relationships of *Gibocercus* and *Biguembia* are included below.

MATERIAL AND METHODS

The material used here was available as a courtesy of John E. Rawlins, Carnegie Museum of Natural History, Pittsburgh (CMNH); Abraham Willink, Instituto-Fundación Miguel Lillo, Tucumán (IFML); Stefan P. Cover, Museum of Comparative

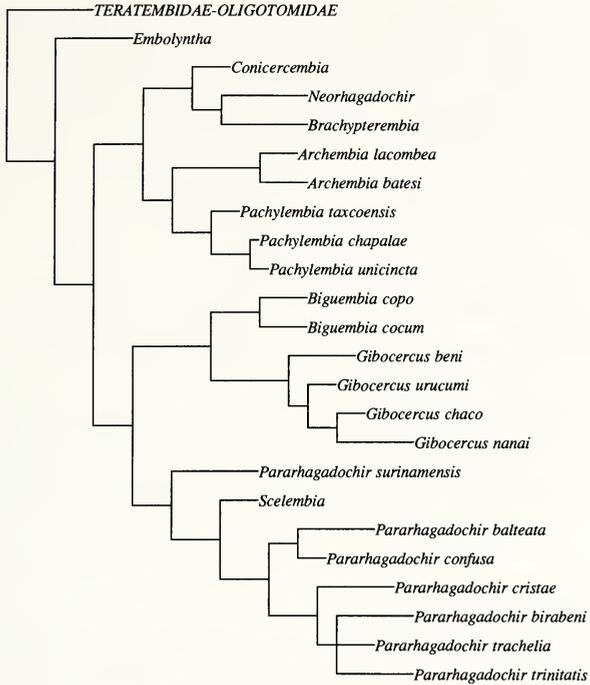


Fig. 1. Partial Cladogram (showing the relationships of Neotropical Embiidae) from the most parsimonious tree (104 characters scored for 90 Embioptera).

Zoology, Cambridge (MCZ); Alcide Costa and Ricardo Pinto da Rocha, Museu de Zoologia, São Paulo (MZSP); David A. Nickle, United States National Museum of Natural History, Washington (USNM).

All measurements are given in millimeters. Ocular ratio is defined in Szumik (1991). The abbreviations used are: Mm, mentum; Sm, submentum; 10T, tenth tergite; 10L, tenth left hemitergite; 10R, tenth right hemitergite; 10Lp, process of the left hemitergite; 10Rp1, posterior process of the 10R; 10Rp2, anterior process of the 10R; H, hypandrium or ninth abdominal sternite; Hp, process of the ninth sternite; Ep, epiproct; Lpp, left paraproct; Rpp, right paraproct; LC1, basal left cercus; LC1dp, distal process of the LC1; LC2, apical left cercus; RC1, basal right cercus; RC2, apical right cercus.

Gibocercus, new genus

Type species: Gibocercus chaco, n. sp.

Etymology: The generic name corresponds to one of the generic autapomorphies, a semispheric convexity (gibba) on the dorsal face of LC1dp.

Diagnosis: 10Lp with inner tip very large and sclerotized (Fig. 2H), outer tip very small, conical, fleshy along its apical half or more. Oblique depression at base of 10Lp and 10L. LC1dp conical, very well developed (more than twice longer than

the width of the LC1); setae not very numerous, in the apex of the process; with a rounded convexity on the dorsal face of process. LC1 with a second latero-internal basal process (absent in *G. nanai*), with numerous setae (Fig. 2F).

Description (male): Robust, total length 9-16. Mm sclerotized, separated from Sm by a membranous area (completely fused in *G. nanai*). Mandibles as in many tropical Embiidae, with 3-2 incissives, 2-1 molar. Wings: Rs+Ma originating from Cu, near this origin a very short transverse vein joins them with R1; Cu and Ma forked; Sc, R1, Rs+Ma, Rs, Cub and A conspicuous; Ma1, Ma2, and Mp tenuous, specially near the wing edge (except *G. beni*); Cua tenuous along full length (except *G. beni*); transverse veins generally present between C-R1, R1-Rs, Rs-Ma1, Ma-Mp (no transverse veins between Rs-Ma1 in *G. chaco*). 10T typical of Embiidae: two well differentiated plates, with regular inner edges, joined only by a thin but well sclerotized bar. A large unsclerotized area in basal half of 10R. 10Rp2 very short and wide (in other neotropical embiids, long and thin), well sclerotized, with a wide rounded edge. Distal process of LC1 very developed, conical, directed forwards; LC1dp setae restricted to the apex of the process (in other taxa, setae cover most of the process). LC1 with a second process (except in *G. nanai*), basal and latero internal, finger-shaped, with numerous setae. Lpp with nodule and microtrichiae. Hp with transversal keels.

Distribution: The new genus is found in the southern part of the Neotropical Region (Argentina, Brasil, Perú and Bolivia).

Relationships: In the cladistic analysis, *Gibocercus* appears as sister group of *Biguembia* sharing the 10Rp1 non-bifid, with microtrichiae, 10Lp with the base short and wide, and tips of the 10Lp completely separated.

The monophyly of *Gibocercus* is supported by LC1dp conical, a nodule with setae on the inner-basal face of the LC1 (absent in *G. nanai*), a semispheric convexity on the dorsal face of the LC1dp, the shape of the 10Lp tips (see diagnosis), and 10Rp2 wide and rounded. The nodule on the inner-basal face of the LC1 is very unusual; comparable structures are known for very few embiids. *Pachylembia* has a similar but less conspicuous and acuspulate process; *Pseudembia* and *Dinembia* have a sort of wart, but set on the dorsal face of the process, and the cuspules are not confined to the wart. Both the morphological differences, and the distribution of other characters, indicate that the conditions in *Pachylembia*, *Pseudembia* and *Dinembia* are not homologous with the one in some *Gibocercus*.

G. chaco and *G. nanai* share the presence of one cross-vein between Rs+Ma and Mp and the absence of cross-veins between Ma-Mp (characters with a lot of homoplasy). *G. chaco*, *G. nanai*, and *G. urucumi* form a monophyletic group (excluding *G. beni*, see Fig. 1), supported by having two cross-veins between Rs-Ma1 (a character with homoplasy).

KEY TO SPECIES OF *GIBOCERCUS* (MALES)

1. Inner-basal face of the LC1 without a nodule, Mm and Sm not separated by a membranous band (Fig. 5B) *G. nanai*
- Inner-basal face of the LC1 with a nodule with setae (Fig. 2H), Mm and Sm separated by a membranous band (Fig. 2B) 2
2. 10Lp with a flat base (Fig. 3F), outer tip of the 10Lp constricted basad (Fig. 3F) *G. urucumi*

- 10Lp with a globose base, outer tip of the 10Lp no constricted basad (Fig. 2H) 3
- 3. Cross-vein between Ma1-Ma2 present, outer tip of the 10Lp small (less a fifth longer than the inner tip length) (Fig. 4D), nodule of the LC1 with rounded apex *G. beni*
- Cross-vein between Ma1-Ma2 absent, outer tip of the 10Lp big (a half longer than the inner tip length) (Fig. 2H), nodule of the LC1 with oblique apex (Fig. 2F) *G. chaco*

***Gibocercus chaco*, n. sp.**

(Fig. 2A–H)

Type: Male holotype IFML, from ARGENTINA: Santiago del Estero, Reserva Copo, 7-24-X-1990, J. Lopez de Cazenave.

Etymology: The specific name corresponds to the phytogeographic region of the type locality.

Diagnosis: *G. chaco* can be distinguished of the other species of the genus by having 2 or 3 cross-veins between Rs-Ma, no cross-veins between Rs-Ma1, and medial bladder of the hind basitarsus small and close to the external face. *G. chaco* can be distinguished of *G. urucumi*, by the outer tip of the 10Lp thin with longitudinal keels and the nodule of the Lpp well developed and conical. The apex of the LC1bp is obliquous and not rounded as *G. beni* and *G. urucumi*.

Male (Holotype): Thorax brownish, head brown with a dorso-posterior more or less circular brownish area, the rest orangish brown.

Total length: 15.2. Head (Fig. 2A): width/length, 0.80; eyes (Fig. 2A) with OR: 0.58. Mandibles as Figure 2A. Sm as Figure 2B. Wing length: fore, 10.80; hind, 9.28. Wing venation: Sc, R1, Cub and A well developed, Cua inconspicuous, the rest conspicuous. Cross-veins: fore wing, C-R1: 6 or 8, R1-Rs: 2 or 3, Rs-Ma: 2 or 3, Rs+Ma-Mp: 1; hind wing, C-R1: 5, R1-Rs: 2 or 3, Rs-Ma: 0 or 1, Ma-Mp: 1. Hind basitarsus (Fig. 2C) with numerous setae on inner and outer face, length: 0.62, width/length: 0.39, medial bladder small compared to the other species of the genus, closest to the outer face of the tarsus, medial bladder diameter/basitarsus width: 0.38.

Terminalia (Fig. 2D–H): 10Rp2 broad and well sclerotized, 10Rp1 with microtrichiae (Fig. 2G); basal region of the 10Lp with a semispheric convexity (Fig. 2D, H). Hp with transversal keels. Nodule of the Lpp conical (Fig. 2E) with microtrichiae, Rpp no sclerotized. Longitudinal ratio of LC1/LC2: 1.11. LC1bp conical (Fig. 2F), short, with apex obliquely truncated in latero-dorsal view.

Female: Unknown.

***Gibocercus urucumi*, n. sp.**

(Fig. 3A–H)

Type: Male holotype MZSP, from BRASIL: Mato Grosso, Serra do Urucum-Corumba, 30-XI-1960, K. Lenko.

Etymology: The specific name refers to one of the names of the type locality.

Diagnosis: Medial bladder of the hind basitarsus large (more than 50% longer than the basitarsus width); apical third of inner face of the basitarsus without setae. Cross-veins present between Mal-Mp, Mp-Cua. Base of the 10Lp flat (not with a semispheric convexity like *G. chaco* and *G. beni*), outer tip of the 10Lp long and sharp, with a constriction on the base (absent in *G. chaco* and *G. beni*); inner tip of the

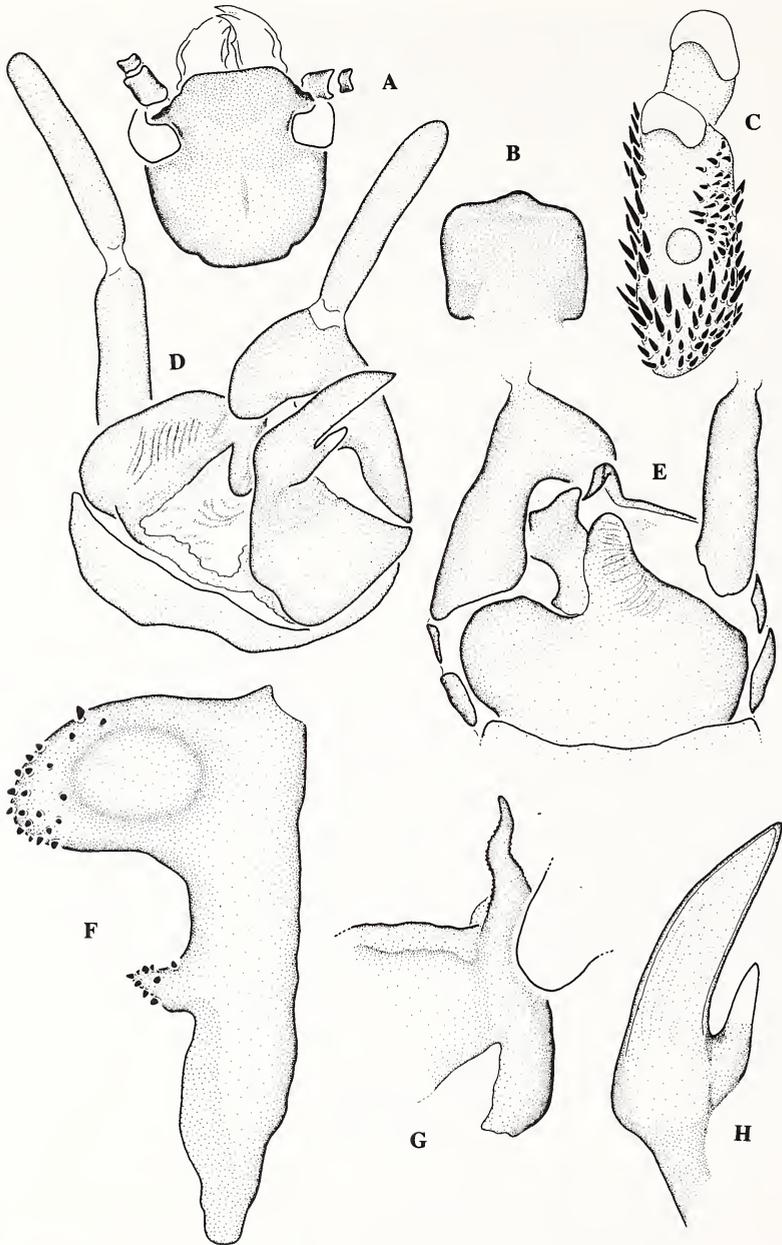


Fig. 2. *Gibocercus chaco*, male. A, head; B, Mm+Sm; C, hind basitarsus; D, terminalia, dorsal view; E, terminalia, ventral view; F, LC1, dorsal view; G, 10Rp1, latero-external view; H, 10Lp, dorsal view.

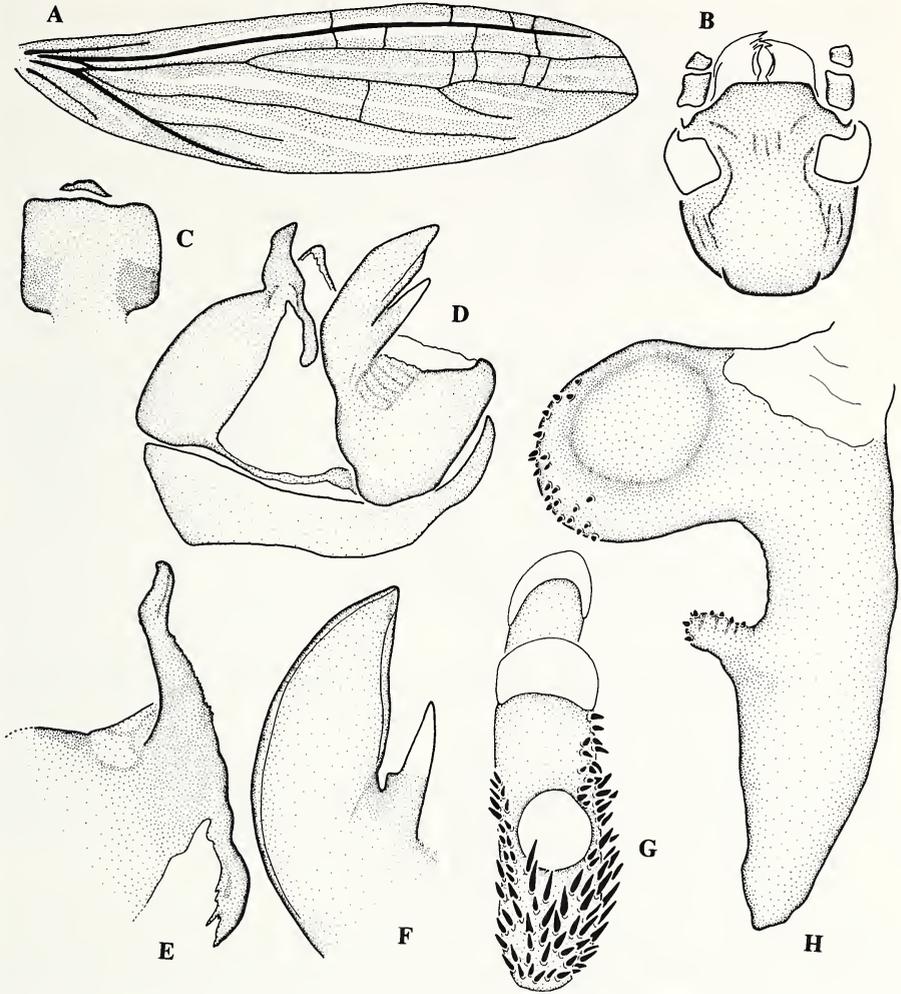


Fig. 3. *Gibocercus urucumi*, male. A, fore wing; B, head; C, Mm+Sm; D, terminalia, dorsal view; E, 10Rp1, latero-external view; F, 10Lp, ventral view; G, hind basitarsus; H, LC1, dorsal view.

10Lp broad, without longitudinal keels. LC1bp with rounded apex, setae on the apex and the caudal face of the process.

Male (Holotype): Head, 1° to 18° antennal segment, tibiae and tarsi, and terminalia brown, the rest orangish brown.

Total length: 16.16. Head (Fig. 3B): width/length, 0.79; OR: 0.50. Mandibles as Figure 3B. Sm as in Figure 3C. Wing length: fore, 12.00; hind, 10.88. Wing venation (Fig. 3A): similar to *G. chaco*; Ma2 and Cua tenuous. Cross-veins: fore wing, C-R1: 4, Rl-Rs: 3 or 4, Rs-Ma: 1, Rs-Ma1: 2 or 5, Ma-Mp: 1 or 3, Ma1-Mp: 1; hind

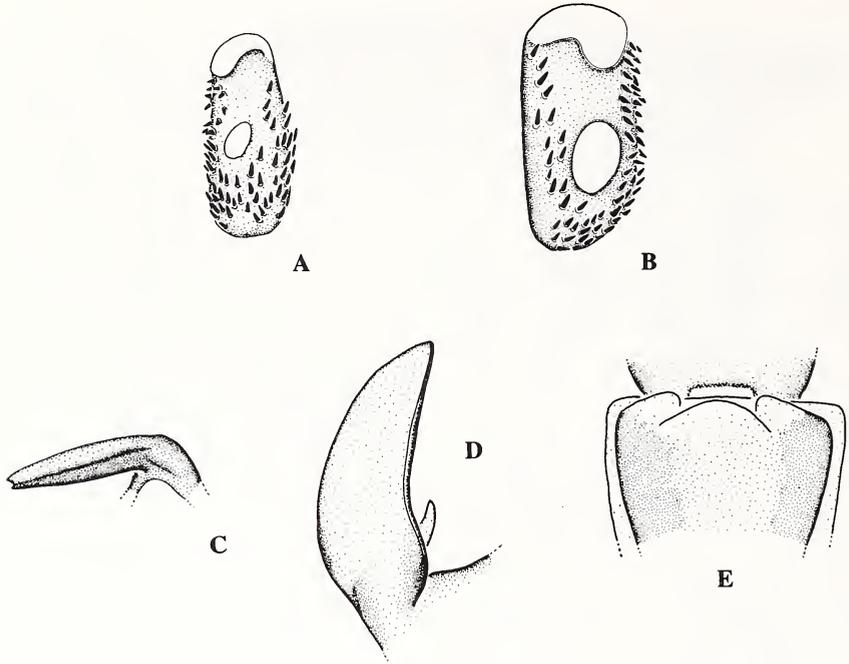


Fig. 4. *Gibocercus beni*. A, hind basitarsus, male; B, hind basitarsus, female; C, 10Rp1, latero-external view; D, 10Lp, dorsal view; E, terminalia, female.

wing, C-R1: 8, R1-Rs: 4 or 6, Rs-Ma: 1 or 2, Rs-Ma1: 1 or 2, Ma-Mp: 1 or 2, Mp-Cua: 1. Hind basitarsus (Fig. 3G), length: 0.78, width/length: 0.31, medial bladder big, diameter of the medial bladder/width of the basitarsus: 0.67.

Terminalia (Fig. 3D-F, H), 10Rp2 narrow and short, 10Lp flat, with inner tip broad, basal half of the outer tip well sclerotized (Fig. 3D, F), 10Rp1 with microtrichiae (Fig. 3E). Hp with transversal keels. Nodule of the Lpp rounded with microtrichiae. Longitudinal ratio of LC1/LC2: 0.95. LC1bp with rounded apex (Fig. 3H).

Female: Unknown.

***Gibocercus beni*, n. sp.**

(Fig. 4A-E)

Type: Male holotype MCZ, from BOLIVIA: Beni, Rurrenabaque, X-XI-1956, L. Peña.

Etymology: The specific name corresponds to the type locality.

Diagnosis: Hind basitarsus with 3 or 4 setae on the distal third of the inner face; outer tip of the 10Lp small (less than a fifth longer than the inner tip length) and well sclerotized; basal nodule of the LC1 small, with few setae; dorsal tip of the 10Rp1 with a well developed longitudinal keel with microtrichiae.

Male (Holotype): Antennae, prothorax, meso, metathoracic sternites yellowish; legs

and terminalia (except cerci) brownish, the rest dark brown; head with two elliptical areas: anterior one darker, posterior one (between eyes) lighter. The abdominal pleurites and sternites have a longitudinal yellowish band.

Total length: 10.70. Head, width/length, 0.70, OR: 0.66. Mm present, Sm with anterior margin membranous and base broad. Wing length: fore, 8.80; hind, 7.10. Wing venation: with two pigmented bands parallels to R1, all the longitudinal vein conspicuous, except Cua, all veins finished on the wing margin. Cross-veins: fore, C-R1: 6, R1-Rs: 4, Rs-Ma1: 1, Ma1-Ma2: 0 or 1, Ma-Mp: 1; hind, C-R1: 3, R1-Rs: 2 or 3, Rs-Ma1: 1 or 2, Ma-Mp: 1. Hind basitarsus (Fig. 4A) length: 0.43, width/length: 0.35, medial bladder diameter/basitarsus width: 0.50, the medial bladder is near the outer face of the basitarsus.

Terminalia (3C–D): Outer tip of the 10Lp small, starts obliquely from the inner tip; inner tip same as *G. chaco*. 10Rp2 short and narrow; 10Rp1 longer and well sclerotized with a longitudinal keel well developed. Nodule of the Lpp similar to *G. chaco*. Apex of the basal nodule of the LC1 rounded.

Female (Beni): General coloration brown blackish, joints between sclerites yellowish, head as in male.

Total length: 16.70. Head width/length: 0.85, OR: 0.85. Hind basitarsus (Fig. 4B): both bladders larger, apical bladder with conspicuous microtrichiae; 6 setae present on the third apical half of the inner tarsal face. Terminalia (Fig. 4E): apical cerci more longer than the basal cerci. Medial plate (8°S) and 1° valvifers conspicuous well differentiated on the caudal margin.

Biology: The nets were found on bark, 4 meters high. The nets were large (15 to 30 cm of diameter) and conspicuous (P. Goloboff pers. comm., from material of Buena Vista).

Other material examined: BOLIVIA: 7 females, 5 juvs. females & 2 males same data as the holotype. Santa Cruz: 2 females & 9 juvs. Buena Vista, 8-10-I-1991, P. Goloboff, J. Santisteban & J. Mc Hugh (IFML).

Gibocercus nanai, n. sp.

(Fig. 5A–F)

Type: Male holotype USNM, from PERÚ: Loreto, Callicebus Res. Station, Mishana, Rio Nanay, 25 km SW Iquitos, 10-17-I-80, S. B. Heppner.

Etymology: The specific name refers to one of the names of the type locality.

Diagnosis: Eyes well developed; Mm and Sm fused, without a membranous band between them; hind basitarsus with only one setae on the apical third of the inner face; cross-veins absent between Rs-Ma, Ma1-Ma2, Ma1-Mp, Mp-Cua, present between Rs-Ma1, Rs+Ma-Mp; apical cerci clearly longer than the basal cerci; inner tip of the 10Lp well sclerotized, with 2 or 3 longitudinal keels; outer tip blunt, rounded, with irregular surface; LC1dp longer, more than twice longer than the width of the LC1, semispheric convexity on the dorsal base of the LC1dp elliptical; second basal and latero internal process of the LC1 absent.

Male (Holotype): General coloration brownish, 16° antennite to the tip yellowish brown.

Total length: 9.92. Head (Fig. 5A) width/length, 0.81; OR: 0.45. Mandibles as Figure 5A. Mm and Sm fused (Fig. 5B). Wing length: fore, 6.72; hind, 6.08. Wing

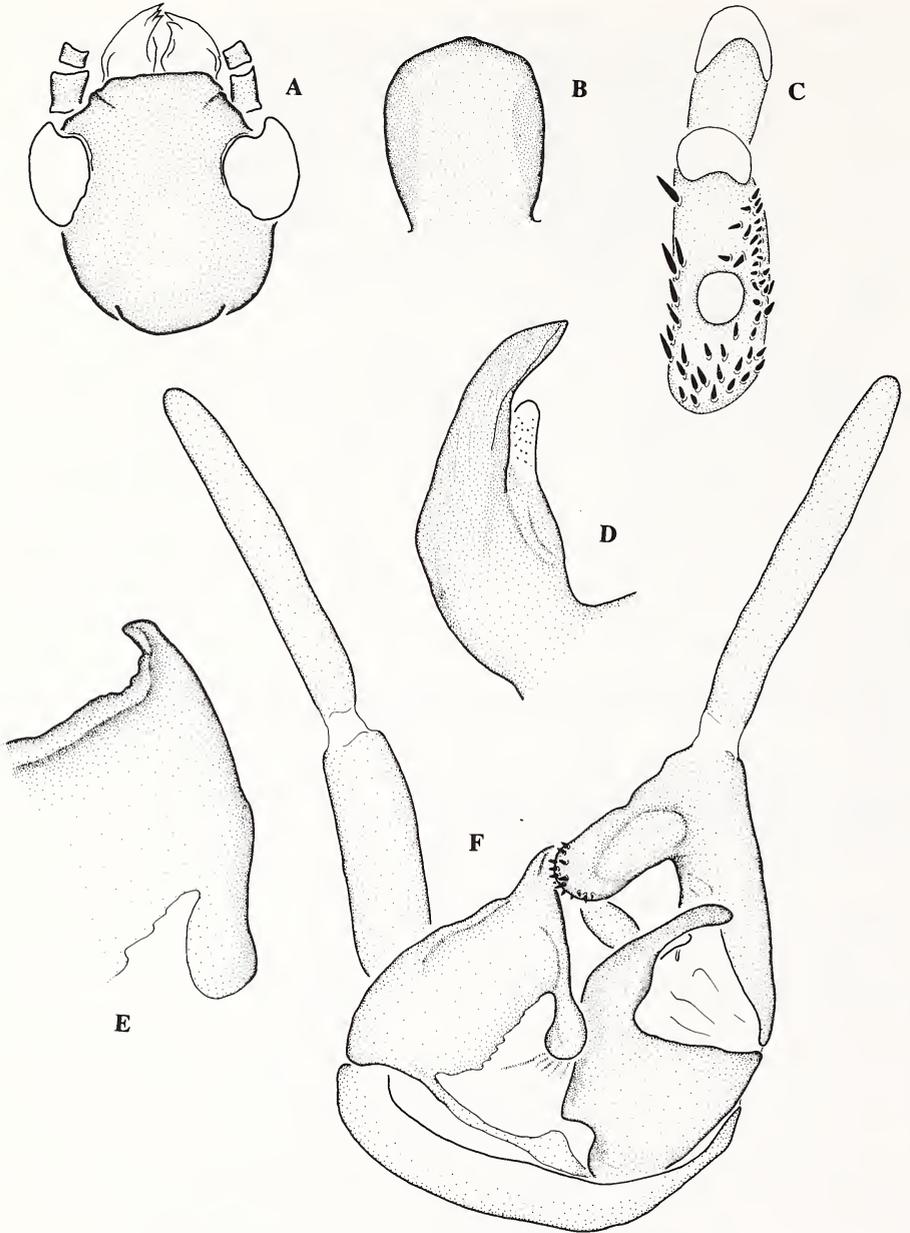


Fig. 5. *Gibocercus nanai*, male. A, head; B, Mm+Sm; C, hind basitarsus; D, 10Lp, latero-external view; E, 10Rp1, latero-external; F, terminalia, dorsal view.

venation: longitudinal veins less conspicuous than in other species of the genus. Cross-veins: fore wing, C-R1: 3, R1-Rs: 1 or 3, Rs-Ma1: 2, Rs+Ma-Mp: 1; hind wing, C-R1: 3 or 4, R1-Rs: 3 or 4, Rs-Ma1: 1 or 3, Ma-Mp: 1. Hind basitarsus (Fig. 5C), length: 0.34, width/length: 0.29, medial bladder bigger, diameter of the medial bladder/width of the basitarsus: 0.60.

Terminalia (Fig. 5D–F): LC1dp longer, extending anteriorly (Fig. 5E). Longitudinal ratio LC1/LC2: 0.85. 10Rp1 short, microtrichiae inconspicuous (Fig. 5C). Inner tip of the 10Lp well sclerotized (Fig. 5D). Hp with transversal keels. Rpp sclerotized, microtrichiae only on the nodule of the Lpp.

Female: Unknown.

Biguembia, new genus

Type species: *Biguembia copo* n. sp.

Etymology: The generic name is a combination of two words, 'bigu' (arbitrary combination) and 'embia'.

Diagnosis: LC1dp strongly cubical, flattened in lateral view. 10Rp1 simple, extending posteriorly as an arm with a hunch on its base. Sm quadrangular, base of the Sm broad. Tips of the 10Lp with equal shape, thin and conical, the inner tip more sclerotized and with keels, the outer tip less sclerotized; the process (10Lp) does not have a base.

Description (male): Bigger, total length 16–18. Medial bladder present. Sm with anterior margin straight and diffuse, Mm sclerotized. Winged, Cu forked, all the longitudinal veins conspicuous, with a cross-vein between Mp and Cua; R1 without longitudinal pigmented bands; Rs+Ma originating from Cu and R1. Hind basitarsus broad, bladders well developed.

Terminalia: 10T with membranous area small. 10Rp2 well sclerotized as the rest of the terminalia, without a membranous area between it and the 10R. Lpp with a nodule, more or less sclerotized, with microtrichiae. Rpp sclerotized and conspicuous. Ep sclerotized. LC1dp as in diagnosis; apical cerci longer than the basal cerci.

Distribution: This new genus was found in only two localities from Santiago del Estero (Argentina) and one from Mato Grosso (Brasil).

Relationships: The synapomorphies of *Biguembia* are mostly wing characters. Others are: the tips of the 10Lp with equal shape, thin and conical, the hunch at the base of the 10Rp1 and the flattened LC1dp.

Biguembia copo, n. sp.

(Fig. 6A–H)

Type: Male holotype IFML, from ARGENTINA: Santiago del Estero: Reserva Provincial de Copo, X-1989, J. P. Pelotto.

Etymology: The specific name refers to the type locality.

Diagnosis: *Biguembia copo* can be distinguished from *Biguembia cocum* by the 10Rp1 with a sharply pointed, inwardly curved process, with a longitudinal keel, the keel starts in the basal hunch of the process. Outer tip of the 10Lp less sclerotized and short (two third longer than the length of the inner tip), the inner tip does not have longitudinal keels. The inner face of the hind basitarsus has many setae. The general coloration is not homogeneous.

Male (Holotype): Head, wings and terminalia brown, thorax, legs and abdominal

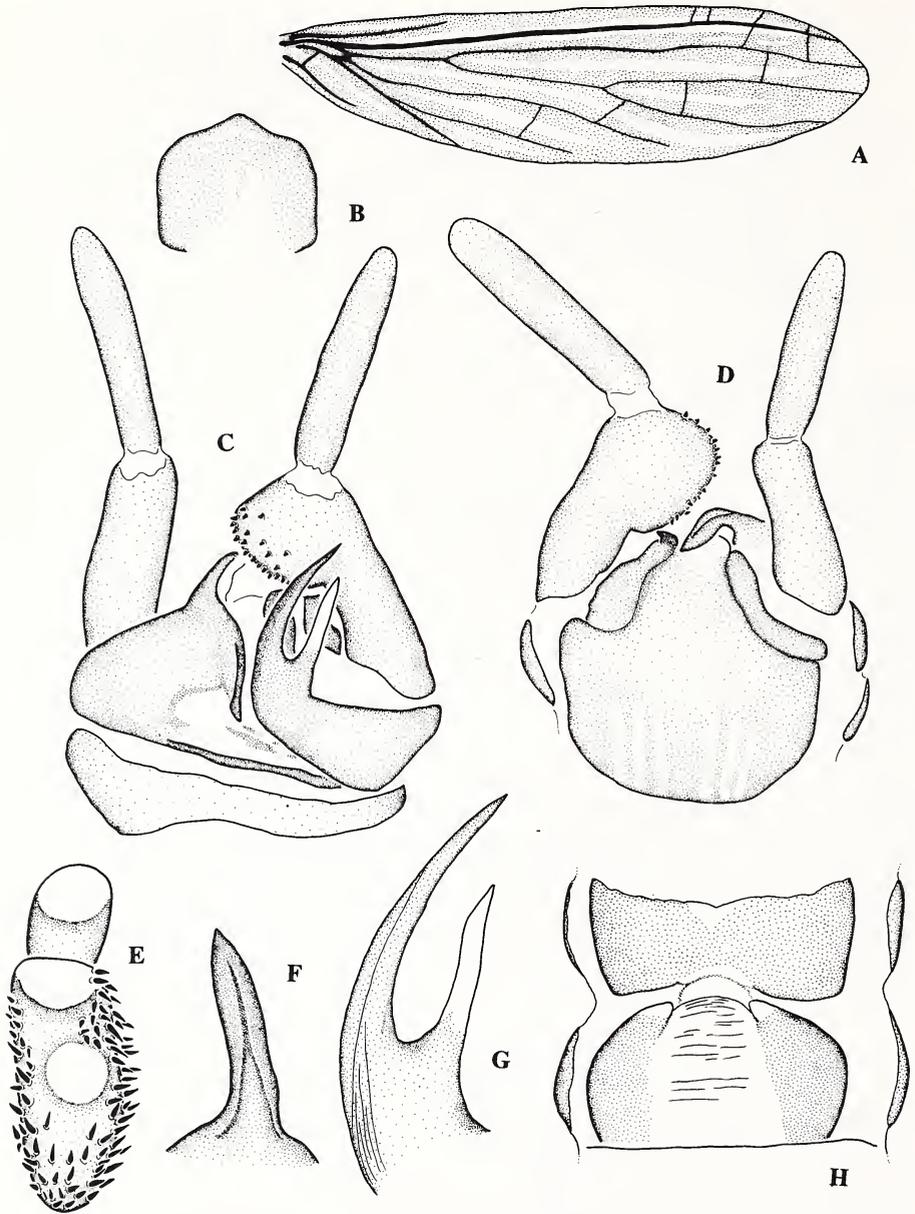


Fig. 6. *Biguembia copo*. A, fore wing; B, Mm+Sm; C, terminalia male, dorsal view; D, terminalia male, ventral view; E, hind basitarsus; F, 10Rp1, dorsal view; G, 10Lp, dorsal view; H, terminalia female.

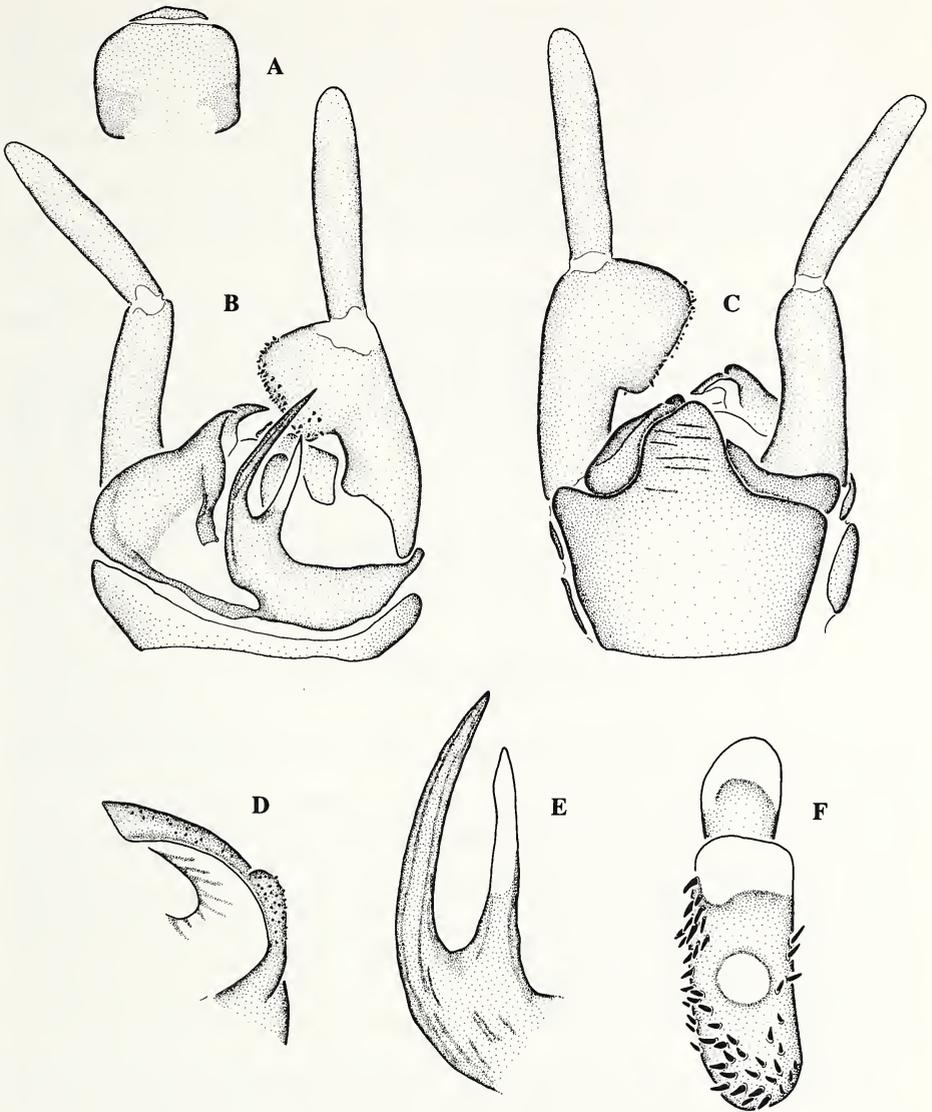


Fig. 7. *Biguembia cocum*, male. A, Mm+Sm; B, terminalia, dorsal view; C, terminalia, ventral view; D, 10Rp1, latero-external view; E, 10Lp, dorsal view; F, hind basitarsus.

tergites brownish, abdominal sternites yellowish white. Antenna: 1° to 25° antennite brown, 26° to 28° antennite brownish, 29° antennite to the tip yellowish white.

Total length: 16.32. Head width/length: 0.82. RO: 0.48. Sm as Figure 6B. Wing length: fore. 10.40; hind, 9.28. Wing venation (Fig. 6A): Rs+Ma and Mp start from a cross-vein between Cu and R1; Ma and Cu forked; R1, Cub and A strongly de-

marcated, Cua diffuse, the rest conspicuous, none of the veins reaches the wing margin. Cross-veins, fore: C-R1: 5, R1-Rs: 4 or 6, Rs-Ma1: 3, Ma1-Ma2: 1 or 2, Ma-Mp: 1 or 2, Ma2-Mp: 1 or 2, Mp-Cua: 2 or 3; hind: C-R1: 4, R1-Rs: 4 or 5, Rs-Ma1: 3 or 4, Ma1-Ma2: 1 or 2, Ma-Mp: 1, Ma2-Mp: 0 or 1, Mp-Cua: 1 or 3. Hind basitarsus (Fig. 6E) length: 0.60, width/length: 0.37, medial bladder diameter: 0.12, medial bladder diameter/width of the tarsus: 0.55, at 0.22 from apex.

Terminalia as in Figure 6C-D and 6F-G; longitudinal ratio of LC1/LC2: 0.93.

Female (Hickmann): Head blackish brown, prothorax orangish brown, the rest dark brown.

Total length: 18.00. Hind basitarsus: outer and ventral face with 5 to 6 lines of setae (ending close to the medial bladder), inner face with 4. 1° valvifers semifused to the central plate (Fig. 6H), 2° valvifers and secondary gland present.

Biology: The nets from Hickmann were collected on wet soil. The nets were constituted by many cross tunnels with a lot of spongy web. The time from first instar to adult male (6 specimens from Hickmann) was 291-346 days. The adult females live for more than 250 days.

Other material examined: ARGENTINA: Santiago del Estero: 1 male Paratype, same data as Holotype. Salta: 13 males and 10 females Paratypes 2 Km W Hickmann, Ruta Nac. 81, 27-I-1995, C. Szumik & P. Goloboff (IFML).

Distribution: Known only from two localities from Northwestern Argentina.

***Biguembia cocum*, n. sp.**

(Fig. 7A-F)

Type: Male holotype MZSP, from BRASIL: Mato Grosso: Serra do Urucum-Corumba, 30-XI-1960, K. Lenko.

Etymology: The specific name is an arbitrary combination of letters.

Diagnosis: *Biguembia cocum* can be distinguished from *Biguembia copo*, by the 10Rp1 with a straight apex, the arm is inwardly curved but does not have a longitudinal keel, as *Biguembia copo*; the outer tip of the 10Lp is longer than the length of the inner tip, and the first one is esclerotizad in its basal third; the inner tip has many longitudinal keels. The inner face of the hind basitarsus has only 5 to 10 setae. The general coloration is homogeneous.

Male (Holotype): General coloration brown orangish, fore basitarsus and terminalia darker than the rest.

Total length: 17.76. Head width/length: 0.79; RO: 0.48. Sm as in Figure 7A. Wing length: fore, 10.88; hind, 9.76. Wing venation: Rs+Ma and Mp start same as in *B. copo*; Ma and Cu forked. Cross-veins, fore: C-R1: 6, R1-Rs: 7, Rs-Ma1: 2, Ma-Mp: 1; hindwing: C-R1: 4, R1-Rs: 3 or 4, Rs-Ma1: 1 or 2, Ma1-Ma2: 0 or 1, Ma-Mp: 0 or 1, Mp-Cua: 0 or 1. Hind basitarsus (Fig. 7F) length: 0.64, width/length: 0.31, diameter of the medial bladder: 0.10, diameter of the medial bladder/width of the basitarsus: 0.50, at 0.24 from apex.

Terminalia as in Figure 7B-E, Lpp and Rpp more strongly sclerotized than H; Lpp with microtrichiae; Hp with transversal keels. Longitudinal ratio of LC1/LC2: 0.95.

Female: Unknown.

Variation: Two male paratypes have teratological terminalia. In some wings Ma is unforked and Mp forked.

Other material examined: 5 males Paratypes, same data as the holotype.

Distribution: Only known from the type locality.

ACKNOWLEDGMENTS

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**A REVIEW OF THE GENUS *HELIOTHrips* (THYSANOPTERA;
THRIPIDAE), WITH A NEW SISTER-SPECIES OF THE
GREENHOUSE THRIPS FROM SOUTH EASTERN BRAZIL**

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Abstract.—*Heliothrips zucchi* is described as a new species from south eastern Brazil. It is very similar in structure to *H. haemorrhoidalis*, the greenhouse thrips. Because nearly all known males of *H. haemorrhoidalis* have been found in the western part of the Amazon basin, it is suggested that this is the area of origin of this worldwide pest. The only other member of the genus is from southern Africa, and a key is provided to distinguish the three species.

The Greenhouse Thrips, *Heliothrips haemorrhoidalis* (Bouché), is known as a pest on many different plants worldwide (Kudo, 1992; Wilson, 1975). However, males are never found in these pest populations. The female bias in such populations is reflected in the accumulated Thysanoptera collections at the natural history museums in London and Washington, D.C., which contain about 800 females of this species but only 21 males (Mound, 1976). Of these males 13 were from Brazil. Moreover, Mound and Marullo (1996) recorded one field sample from southern Peru in which 30% of the adults were males. Although thrips are haplo-diploid, arrhenotokous parthenogenesis is common amongst species that have been distributed widely by human activities, and the presence of males in a sample is considered sometimes to indicate the area of original distribution of a species. Therefore, the presence of males of *H. haemorrhoidalis* in Brazil, and particularly this relatively large number of males in a sample from Peru, is considered likely to indicate that this species is native to South America, in particular to the western side of the Amazon basin. *Heliothrips* previously included only one other species, *H. sylvanus* Faure from southern Africa, and this pair of species presumably reflects an ancient vicariance event related to the break-up of Gondwanaland.

The purpose of this paper is to describe a third member of the genus, structurally very similar to *H. haemorrhoidalis*, that has been found recently in south eastern Brazil at sites between Rio de Janeiro and São Paulo. The two South American species presumably represent a subsequent vicariance event, involving the eastern and western borders of the Amazon basin. A similar vicariance pattern within South America is found in other organisms, such as certain butterflies (see Brown, 1996, for references), and is possibly related to the extensive zone of lower rainfall that largely separates the forests bordering the Atlantic from those of western Brazil.

Two of the species in this genus are known to be highly polyphagous. However, they seem to be specific to plants with hard leaves and do not breed on herbs. Moreover, they are normally found breeding on older leaves and not on young apical leaves. This suggests that their host-plant acceptance behaviour is cued by factors

that are rather different from those used by the many species of thrips that show some level of specificity to particular plant taxa.

Genus *Heliothrips* Haliday

Heliothrips Haliday, 1836:43. Type-species *H. adonidum* Haliday, a junior synonym of *Thrips haemorrhoidalis* Bouché, by monotypy.

This genus is a member of the thripid sub-family Panchaetothripinae, known at one time as the Heliothripinae (Wilson, 1975). Within this sub-family it is related to a group of primarily tropical genera that includes *Australothrips* Bagnall and *Phibalothrips* Hood (Marullo and Mound, 1997). The members of these genera all have simple sense cones on the third and fourth antennal segments, and minute venal setae on the forewings. However, these genera are currently placed in a tribe, Panchaetothripini, with several other taxa that seem to be considerably more distantly related (Kudo, 1992).

Generic definition. Color golden brown to dark brown; head, body and legs with extensive reticulate sculpture; head almost parallel-sided but sharply constricted at base, vertex concave near margins of compound eyes; setae minute. Antennae with 8 segments; segment VIII slender, at least 3 times as long as VII; sense cones on III and IV simple; no microtrichia on III or IV. Thoracic nota with extensive reticulate sculpture. Pronotum transverse, setae minute. Mesonotum divided only in posterior third. Metanotum with median triangle of sculpture bearing a marginal craspedum of variable length. Macropterous; first vein of forewing fused to costa; venal setae minute; wing widened at base, apex rounded and bearing long cilia; postero-marginal cilia straight on distal half of wing but several cilia near cross vein wavy. Tarsi 1-segmented. Abdominal tergites II–VIII with extensive reticulate sculpture laterally, reticles also present in front of antecostal ridge; tergite VIII with postero-marginal comb of microtrichia; tergite X dorsally with complete longitudinal division. Sternites with 3 pairs of small marginal setae, all arising in front of margin. Males with stout setae dorsally on tergite IX; sternites with glandular area.

KEY TO SPECIES OF *HELIOTHRIPS* (FEMALES)

1. Tibiae and tarsi dark brown; forewing anterior margin without cilia; head relatively long, length/width ratio 0.9; tergites II–V with median pair of setae minute, less than 15 microns, and far apart; tergite VIII with teeth of posteromarginal comb broadly based, and with a few teeth absent medially; tergite IX without microtrichia dorsally near posterior margin; tergite X 0.7 times as long as tergite IX *sylvanus*
 - Tibiae and tarsi yellow, much paler than abdomen; forewing anterior margin with cilia present on distal half of wing; head shorter, length/width ratio 0.8 or less; tergites II–V with median pair of setae longer, 30 to 50 microns, and closer together than their length; tergite VIII with teeth of posteromarginal comb uniformly long and slender; tergite IX with many microtrichia dorsally near posterior margin; tergite X shorter, 0.5 to 0.6 times as long as IX 2
2. Femora as yellow as tibiae; antennal segment VI yellow at least in basal third, sometimes almost completely yellow; antennal segment IV at least 0.75 as long as III; ventral sense cone on antennal segment IV short and slender, 0.4–0.5 times as long as the segment *haemorrhoidalis*
 - Femora dark brown in contrast to yellow tibiae; antennal segment VI dark brown, or

slightly paler at base; antennal segment IV shorter, 0.65 as long as III; ventral sense cone on antennal segment IV longer and stouter, 0.75 as long as the segment *zucchi*

Heliothrips haemorrhoidalis (Bouché, 1833: 42)

Wilson (1975) recognised *H. haemorrhoidalis* var. *ceylonicus* Schmutz as a species distinct from *H. haemorrhoidalis* on the basis of the sculpture of the metanotum. Moreover, because of variation in the sternal glands of males, he considered that *H. haemorrhoidalis* in South America consisted of several cryptic species. Neither of these views was accepted by Mound (1976), who pointed out that the metanotal craspedum varies considerably between individuals, both within and between populations from different parts of the world. Mound also suggested that the extreme rarity of the production of males in *H. haemorrhoidalis* indicates that they are spanandric, that is that they are generally not involved in reproduction and that their variation is therefore not relevant to distinguishing species. Because 19 of the 21 known males of this species had been collected in neotropical countries, particularly Brazil, Mound (1976) predicted that a bisexual population of *H. haemorrhoidalis* might exist somewhere in the Neotropics. Subsequently, a sample was studied that had been taken from a population on a tree in southern Peru using an insecticide fogging technique, and this sample comprised 35 females and 15 males, this being the highest proportion of males to females for any sample of this species ever studied (Mound and Marullo, 1996). On the basis of the presence of these males, *H. haemorrhoidalis* is considered likely to be native to the western side of the Amazon basin.

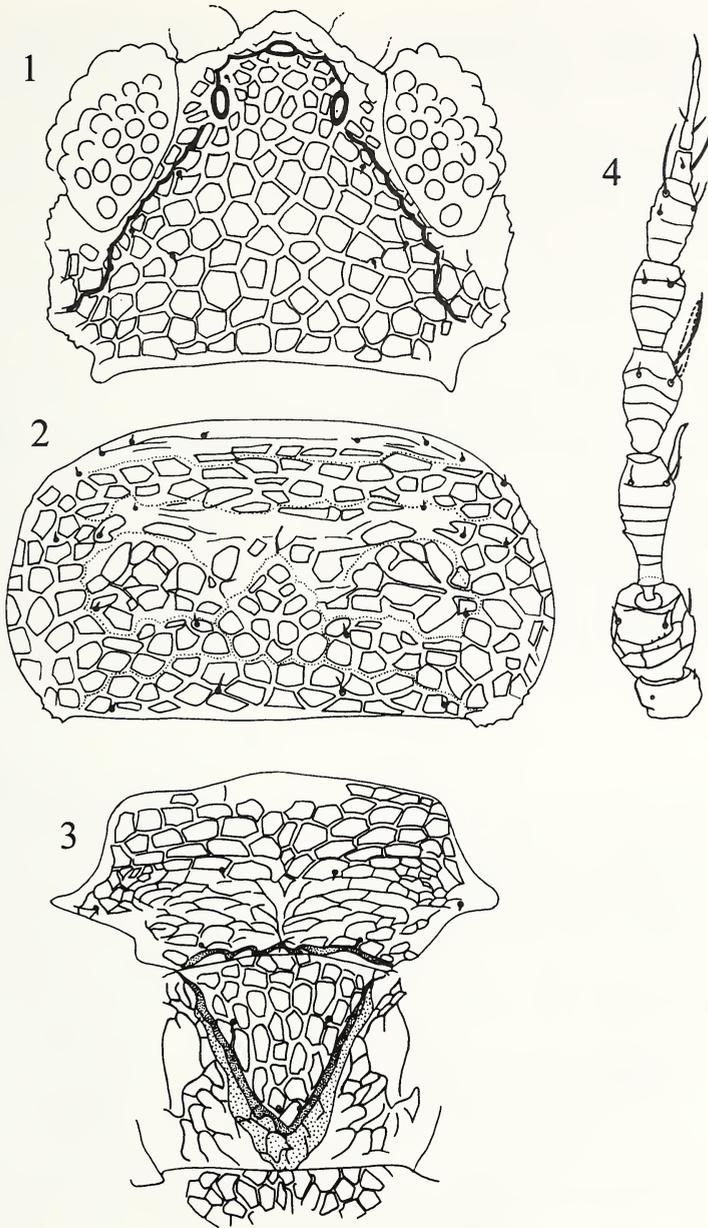
The females of this species are variable in size and color. Each female takes several days to achieve full mature coloration, and so specimens with the abdomen yellow are collected commonly. The variation in size is equally surprising, because not only are the antennae longer in larger individuals, but the slender dorsal sense cone on antennal segment IV is much longer in large individuals. In the largest females studied, this slender dorsal sense cone extends from segment IV almost to the mid-point of antennal segment VI.

Heliothrips sylvanus Faure, 1933: 1

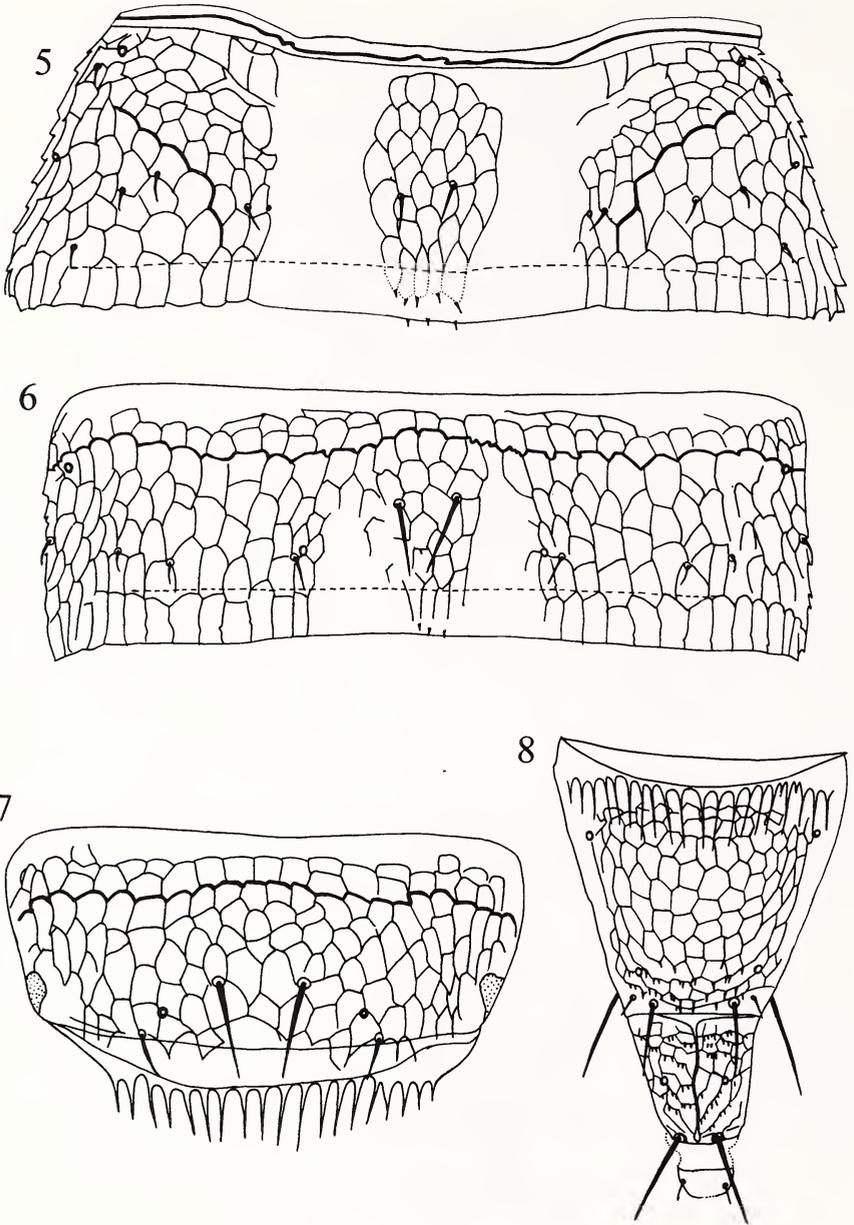
As indicated in the generic definition, this species from southern Africa shares many characters with the two South American species. However, the longer head, short median tergal setae, and lack of cilia on the forewing anterior margin, all suggest a relationship to *Phibalothrips* species. Abdominal tergite I has a pair of specialised reticulate areas laterally that extend antero-dorsally; these areas seem to represent a plastron associated with the spiracles.

***Heliothrips zucchi*, new species**

Female macroptera: Color of head, body and femora dark brown, abdominal segments VIII–X golden yellow, tibiae and tarsi yellow; forewing yellow but shaded along veins and at base, wing scale brown; antennal segments I–II light brown, III–V yellow, VI mainly dark brown with base variably paler, VII–VIII light brown; major setae yellowish brown. Abdomen paler in younger individuals.



Figs. 1-4. *Heliotrips zucchi*, 1. Head. 2. Pronotum. 3. Meso- and metanotum. 4. Antenna.



Figs. 5-8. *Heliothrips zucchi*, 5. Abdominal tergite II. 6. Abdominal tergite V. 7. Abdominal tergite VIII. 8. Abdominal tergites IX and X.

Head typical of genus with cheeks slightly concave (Fig. 1). *Antennae* (Fig. 4) with segment IV bearing 2 sense cones, the dorsal slender cone much shorter than in *haemorrhoidalis*, and the ventral cone longer and stouter. Pro-, meso-, and metanota (Figs. 2 and 3), also legs and wings, typical of genus. *Abdomen* with tergites very similar to *haemorrhoidalis* (Figs. 5–8).

Measurements (holotype female in microns): Body length 1,400. Head, length 140; width 180. Pronotum, length 120; width 210. Forewing, length 670; distal width 40. Tergite V median setae length 30. Tergite VIII median setae length 50. Tergite IX length 120. Tergite X length 60. Antennal segments III–VIII length 60, 38, 32, 27, 10, 35; sense cone on III length 25, ventral sense cone on IV length 28.

Material studied: Holotype female: Brazil, State of São Paulo, Campinas, Santa Genebra Reserve, from leaves of ?Meliaceae, 2.vii.1996 (LAM and RCM), in Museu do Departamento de Entomologia, ESALQ. Paratypes: 2 females collected with holotype; State of São Paulo, Piracicaba, ESALQ Campus, 2 females from leaves of shrubs, 13.iii.1997 (LAM, 3133), in ESALQ and BMNH, London; State of Rio de Janeiro, Rio de Janeiro, Jacarepagua, 3 females from dead branches, 9.v.1948 (J. D. Hood and T. Borgmeier), in USNM, Washington.

Comments: This new species is closely related to *H. haemorrhoidalis*. Both species differ from *H. sylvanus* in having the head and tergite X shorter, but the median tergal setae longer, and in possessing cilia on the anterior margin of the forewing. The clearest discriminating character states for the two South American species, apart from the striking difference in color of the femora, are the shorter antennal segment IV and its longer ventral sense cone in *H. zucchi* in comparison to *H. haemorrhoidalis*.

ACKNOWLEDGMENTS

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**TWO NEW ENIGMATIC *MELOPHORUS* SPECIES
(HYMENOPTERA: FORMICIDAE) FROM AUSTRALIA**

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Abstract.—Two new species of the Australian ant genus *Melophorus* are described. *M. majeri* new species is morphologically very distinct from all the other species with spines on the propodeum, and the worker caste extremely elongate. It has so far only been collected at two localities in Western Australia in heath vegetation. *M. anderseni* new species was found once in the backyard of the CSIRO labs in Darwin. It displayed a perplexing behavioral pattern, with hugging and rubbing intimately the worker of the meat ant *Iridomyrmex sanguineus*, rushing into their nest and carrying out their larvae without being interrupted by the hosts. A possible reaction of the meat ant might be the blocking of the nest entrance of the robbers by piling up little stones over their nest entrance.

Melophorus is one of the more specious and dominant ant genera in Australia. The 21 currently known species (Bolton, 1995) are quite an underestimate of the total number of species which will certainly exceed the number of 100 species (Agosti, unpubl.). *Melophorus* ants are endemic to Australia, and their main radiation was in the arid to hyper arid ecosystems, from open forested land to almost barren desert, where they are often found foraging during the hottest hours of the day, with surface temperature above 60°C (Christian and Morton, 1992; Andersen, 1997), and reports on nocturnal activities could not be confirmed (Taylor and Brown, 1985). Nests are found even in the driest habitats such as between sand dunes or in salt pans, where they are one of the main food sources for lizards (Brown, 1955). Almost all the species are diurnal, and forage usually individually, but recruiting to food sources is possible as well (Agosti, unpubl.).

Various food sources are used, from harvesting seeds (e.g., Buckley, 1982), scavenging, exploiting extrafloral nectaries to lestopiosis (see below). One species group with such aberrant species as *M. fulvihirtus* with a very stout body, short, bristle like hairs and appendages, is known to live on or near nests of the large *Iridomyrmex purpureus* group (Greenslade, pers. comm.; Hölldobler and Wilson, 1990). It is thought that the often extreme life style of *Melophorus* ants is due to the competition with the dominant *Iridomyrmex* species (e.g., Andersen and Patel, 1994).

Nests are mostly small, normally with one queen, and in the ground. Mating flights take place in form of swarms few meters above ground, with the female and male in cupola falling on the ground. The female then starts immediately to dig a whole into the ground, which is closed from inside within a few hours (Observed for six species, including *M. bagoti* north of Alice Springs in January 1991 after heavy rainfall (Agosti, unpubl.)).

In many respects, the biology of *Melophorus* is very similar to the vicariant genera in the deserts on other continents, whereby the genus *Melophorus* seems to have the

widest spectrum of behavioral patterns (Andersen, 1997; Dlussky, 1981; Wehner et al., 1994).

The ants of the genus *Melophorus* are morphologically easily recognized. They belong to the ant subfamily Formicinae, characterized and best recognized by a fringe of hairs at the tip of the gaster (acidopore; see also Bolton, 1994:42 for an exhaustive diagnosis and visual documentation). They belong to the *Formica* genus group with the petiole insertion cavity not reaching in front of the hind coxal cavities, and the first gastral segment's tergite and sternite meeting ventrally of the helcium (the gastral part of the petiole-gaster joint) in a straight line (Agosti, 1991). The combination of a low number of mandibular denticles, a palp formula with 6 maxillary and 4 labial palps with the maxillary palps usually longer than half the head length, the insertion of the antennae adjacent to the clypeus, the presence of a psammophore with long J-shaped hairs inserted slightly set back to the anterior margin of the clypeus, often on the anterior margin of the clypeus, always on the maxillary stipes and sometimes the gula, the often extremely long, slit shaped propodeal spiracle, and internally the short, asepalous proventricule is unique. Phylogenetically, they are supposedly basal to most of the Formicinae (Agosti, 1994).

Despite their ecological importance, the systematics of this group are poorly known, and no modern monographic revision exists. Most of the samples in collections are indirectly collected in ecological studies or conservation surveys. Thus, the major *Melophorus* collections are at the Australian National Insects Collection in Canberra (ANIC: collected by Greenslade), the School of Environmental Biology, CURTIN University of Technology in Perth (CURTIN: collected by Majer), and the Division of Wildlife and Ecology at CSIRO in Darwin (CSIRO-TERC: collected by Andersen). The exception to this is the collection of the avid ant collector Lawrey at ANIC. Noteworthy collections outside Australia are at the Museum of Comparative Zoology, Harvard University, Cambridge (MCZ: mostly collected by Brown), the American Museum of Natural History in New York (AMNH: collected by Agosti). The Forel collection in Geneva, Switzerland (MHNG) and The Natural History Museum, London (BMNH) include mostly type material. Additional images and documentation are accessible at <http://research.amnh.org/entomology/socialInsects>.

The following description of the two new species is an outcome of a travel grant to DA, which allowed collecting specifically *Melophorus* species in Australia's dry land, and checking through the collections in Australia during 1990/91. Though there are many more species to be described, the two species mentioned below deserve special attention. *M. anderseni* has an outstanding behavior, and *majeri* is morphologically very distinct.

Measurements are given in mm: CI cephalic Index ($HW \times 100/HL$); HL head length, from the anterior most point on the clypeus to the posteriormost on the occiput; HW head width, largest width of the head in full frontal view, below the eyes; SL scape length; SI scape index ($SL \times 100/HW$); TL mesosoma length, measured from the anteriormost point of the pronotum to the posteriormost on the propodeum. A series of images on the behavior of *Melophorus* ants is accessible on the World Wide Web (<http://research.amnh.org/entomology/socialInsects>).

Melophorus anderseni, new species

Holotype worker: Australia, NT, Darwin, CSIRO, backyard of Division of Wildlife and Terrestrial Ecology. 3.ii.1991, D. Agosti. Holotype deposited at ANIC. Figures 1–5.

Paratypes. 8 workers and 1 female; Australia, NT, Darwin, CSIRO, backyard of Division of Wildlife and Terrestrial Ecology. 3.ii.1991, D. Agosti. Paratypes deposited at AMNH, ANIC, BMNH, CSIRO-TERC, MCZ, MHNG.

Holotype worker: TL 1.84, HL 1.06, HW 1.00, SL 1.34, EL 0.26, CI 94, EI 26, SI 134.

Paratype workers (N = 7): TL 1.82–1.99, HL 1.08–1.14, HW 1.0–1.10, SL 1.24–1.48, EL 0.24–0.26, CI 91–96, EL 23–26, SI 127–148; *female* (N = 1) TL 2.92, HL 1.68, HW 2.08, SL 1.24, EL 0.38, CI 124, EI 18, SI .60

Description: Worker:

- Clypeus pointed and keeled, slightly projecting anteriorly
- Maxillary and labial palps extremely thin, not longer than half the head length
- long psammochaeta: J-shaped hairs on the clypeus, gula and maxillary stipes
- Long scape
- Mesosoma elongate with pronotum in cross-section dorsally rounded, and propodeum smoothly rounded
- Petiole nodiforme
- Short erect hairs on mesonotum, propodeum, petiole, gaster and legs.
- Body color reddish orange, with the gaster at most slightly darker
- Body not shining, and without a distinct sculpture

Female:

- same as worker, but with a complete set of wing sclerites, and the following differences
- larger than the worker
- distinctly much wider head than the worker.

Material examined: Holotype and paratypes.

Comment: The above combination of characters is unique within the genus. Other ants related to *Iridomyrmex* species are usually characterized by a stout body shape, short appendages and an excessive number of long hairs, or short and thick hairs, e.g., *fulvhiirtus* (Clark, 1941). No large workers were observed, but, as it was a unique nest in perfect position to be observed further, it was not dug out completely. In many respects, this species with the nodiforme petiole, the smooth shining surface, and the few hairs resembles more *M. bagoti*.

Biology: *M. anderseni* was discovered whilst collecting a sample of *Iridomyrmex sanguineus* on the large pebble nest in the garden of the CSIRO Division of Terrestrial Ecology in Darwin, which just had the males leaving in the late morning. This very dominant species has little nest entrances, which three workers at a time seal off when threatened (Fig. 1). The seal is so tight that it is impossible to remove this plug, without tearing off the antennae of the workers. At the very time, it did not take the guards long to step aside, as the nest was just swarming and many males were leaving and entering the nest. The meat ant, *I. sanguineus*, is a very distinct species. It is easily recognized by the large soil material scattered around the nest

entrances, their steady pace, the bright red head and mesosoma, the relatively wide, heart-shaped head with the rather narrowly set eyes, and if there are any doubts left, there stinking smell when squeezed between the fingers.

It was then very remarkable to discover, that there was a second species of ants intermingled with the workers, which even entered and left the nest entrances—albeit at a higher speed—with the *Iridomyrmex* workers (Fig. 2). Some of the *anderseni* were even carrying larvae out of the *sanguineus* nest. Following these workers, they disappeared into entrances at the outskirts of the *sanguineus* nest, with much narrower entrances, so that only these workers and not the *sanguineus* could enter. Obviously, the *sanguineus* workers did not care at all about the robbery. However, two more observations point out that this is a more complex interaction. In two cases, workers of *anderseni* were seen staying above the *sanguineus*, seemingly rubbing their bodies against one of the *sanguineus* (Fig. 3), which during this period did not move at all, but behaved similarly to an ant encountering a larger, non-conspecific ant. One way to react in such a situation is cowering on the ground, with legs and antennae as drawn up as possible, which is in this case with the smaller ant dominating over the larger. After about a minute, *anderseni* left without any further interactions with the meat ant. It seems as if the *anderseni* workers acquires the very pungent smell of the *sanguineus*, making her chemically invisible.

Cuticular hydrocarbons are assumed to be used as recognition cues (Nowbahari et al., 1990). The breakdown of nest mate recognition has been documented within species (Jeral et al., 1997), between ant species (e.g., Hölldobler, 1973; Lenoir et al., 1997), in many cases of the lycaenid-ant relationship, or many myrmecophiles (Hölldobler and Wilson, 1990). At least three types of breakdowns are known. In the thief ant *Ectatomma ruidum* a decreased amount of cuticular compounds might play the facilitator role (Jeral et al., 1997). Other ants and guests acquire the host odor either passively or actively by licking the host (known from many myrmecophilous beetles or ants of the genus *Formicoxenus*). Finally, the compounds are actively biosynthesized by the guests (Lenoir et al., 1997, Lorenzi et al., 1996). *M. anderseni* undoubtedly must belong to the second category.

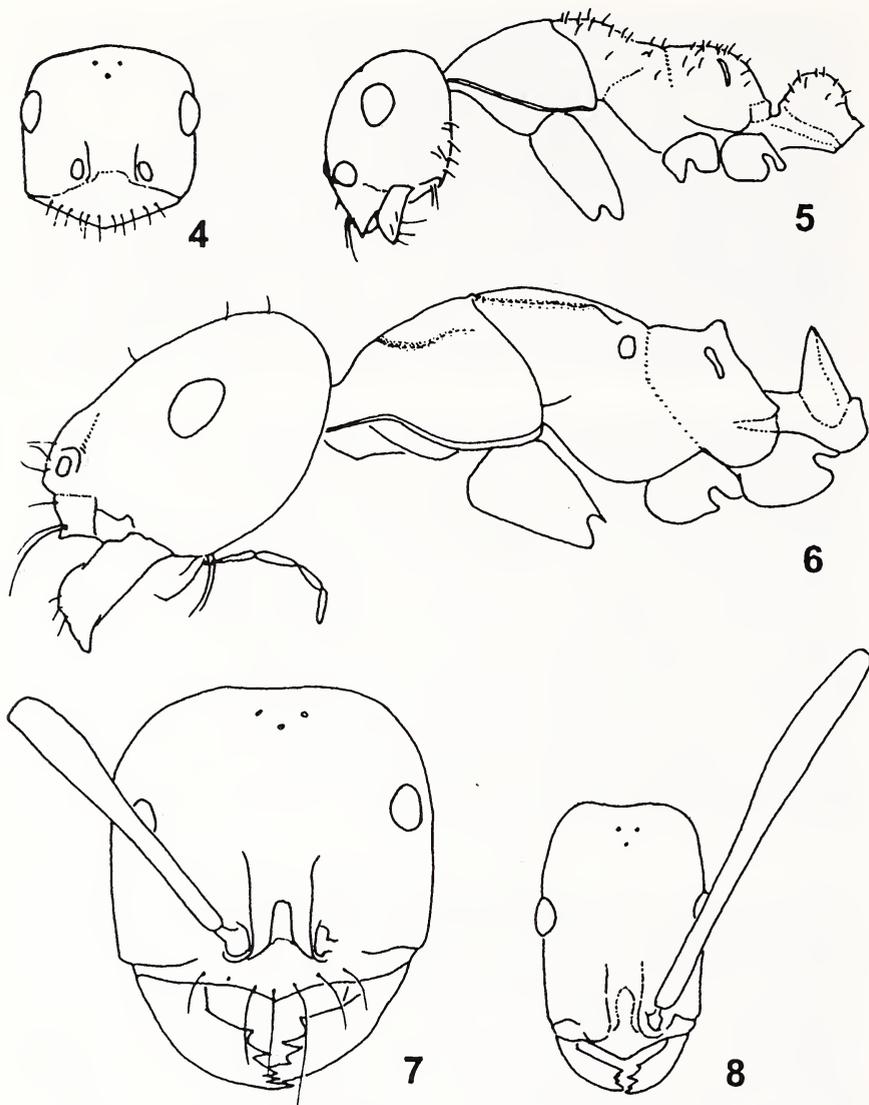
Among Australian ants, robbing of ant nests by other species seems to be rather widespread. More nest entrances are locked up after periods of activities in Australia than in other regions of the world. *Cerapachys* species can be seen quiet often carrying away brood from other ant nests, during the hottest ours of the day, or early in the morning (Clark, 1941; Agosti, unpubl.). Whereas raids of ant nests by *Cerapachys* include a number of workers, often accompanied by intense fights between the hosts, the two known *Melophorus* species, *fulvihirtus* and *anderseni*, operate singly, and are not recognized by their hosts (Clark, 1941). In some cases, when a meat ant seemed to notice an *anderseni* worker, the latter stopped moving for a moment, and almost played dead.

The other significant observation was that the *sanguineus* workers started to cover the nest entrance of the *anderseni* with small pebbles, until a distinct heap was formed, similar to the nest plugging described in North American desert ants (Möglich and Alpert, 1979; Gordon, 1988).

Robbing of meat ant larvae was described by Clark, 1941. *M. fulvihirtus*, a morphologically very distinct species, also lives at the outskirts of meat ant nests.



Figs. 1-3. Behavior of *Melophorus anderseni*. 1. The impassable living nest plug of *Iridomyrmex sanguineus*, formed of heads ant heads. 2. *M. anderseni* entering and leaving the *sanguineus* nest unmolested. 3. Rubbing of *M. anderseni* on *I. sanguineus*. This procedure lasts less than a minute, without any defense of *sanguineus* worker.



Figs. 4-5 *Melophorus anderseni* (Holotype worker): 4 head in full frontal view; 5 lateral view of head and mesosoma (TL = 1.84 mm). Figs. 6-8 *Melophorus majeri* (Paratype soldier and worker): 6 lateral view of head and mesosoma of soldier (TL = 1.32 mm); 7 head in full frontal view (soldier); 8 head in full frontal view (worker).

***Melophorus majeri*, new species**

Holotype worker: Australia, WA, Hassel Road, Jerramungup - Albany (15km SW Wellethead), at Mettler Lake Road 100 m left side. 34°40'S 118°36'E. WA, 23.iv.1988, B. Heterick; Holotype deposited at ANIC.

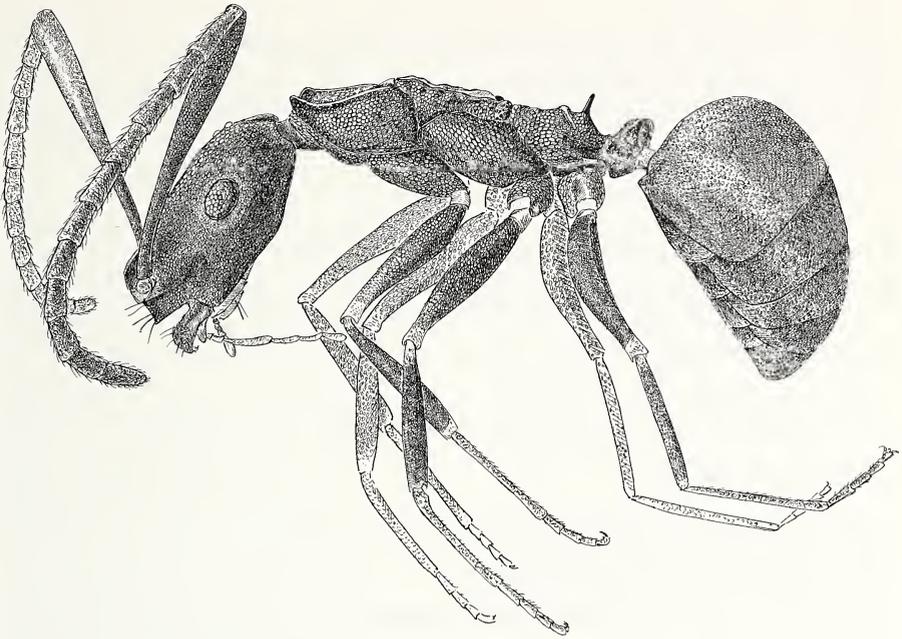


Fig. 9. *Melophorus majeri* (Paratype worker) in lateral view.

Paratypes: 17 workers, Australia, WA, Hassel Road, Jerramungup - Albany (15km SW Wellethead), at Mettler Lake Road 100 m left side. 34°40'S 118°36'E. WA, 23.iv.1988, B. Heterick; 18 workers Australia, WA, Hassel Road, Jerramungup - Albany (15km SW Wellethead), at Mettler Lake Road 100 m left side. 34°40'S 118°36'E. WA, 28.x.1990, D. Agosti; 1 worker, Australia, WA, Cape Arid NP, Yokinup Bay, xi.1988, A. H. Burbidge. Heath vegetation on quartz soil; pitfall trap. Paratypes deposited at AMNH, ANIC, BMNH, CSIRO-TERC, MCZ, MHNG.

Holotype worker: TL 1.08, HL 0.75, HW 0.45, SL 1.14, EL 0.14, CI 60, EI 31, SI 253.

Paratype workers ($N = 7$): TL 1.08–1.08, HL 0.70–0.75, HW 0.42–0.45, SL 1.04–1.16, EL 0.12–0.14, CI 58–63, EI 29–33, SI 231–267; large workers (soldiers) ($N = 2$): TL 1.32–1.32, HL 0.92–0.94, HW 0.90–0.94, SL 0.92–0.92, EL 0.18–0.18, CI 98–100, EI 19–20, SI 98–102.

Description: *Worker*:

- Maxillary palps almost as long as head, brownish and rather wide; not flattened
- Maxillary stipes with long erect hairs
- Mandible with four subequal teeth slightly decreasing in size from apical to basal, and with a distinct basal tooth
- Frontal carinae distinctly raised, closely set, forming almost an enclosure for the frontal triangle and the anterior part of the clypeus, which is slightly protruding behind the insertion of the antennae
- Extremely long antennal scape

- Extremely elongate head
- Humeri on pronotum well developed and projecting laterally
- Mesosoma laterally completely flat
- Propodeal spiracle very long, slit shaped, reaching the dorsal outline of the propodeum
- Propodeum armed with two distinct lateral spines
- Petiole almost rectangular, wider than long
- Insertion of petiole into the metanotum not reaching beyond a line spanned between the anteriormost point of the hind coxal cavities
- First gastral segment of *Formica* type (helcium at the antero-ventral part of the first gastral tergite, and the tergite and sternite meeting in a straight line)
- Proventricule short, asepalous
- Body almost without any pubescence
- Body color grayish black
- Surface sculpture densely reticulate; surface matte.

Soldier (large worker):

- Same as worker with the following differences;
- Head with a much wider and larger
- Mesosoma stouter, relatively much higher
- Propodeal spiracle less extended and not reaching the dorsal outline of the propodeum
- Propodeal spine short and blunt
- Petiole squamiform.

Material examined: Holotype and paratypes.

Comment: The morphology of the worker is unique among *Melophorus* ants. The most conspicuous feature is the elongation of the whole body (Fig. 9), the propodeal spines, as well as the blackish gray coloration. The presence of the dimorphic worker caste, sharing all the diagnostic characters of *Melophorus*, seems to justify the inclusion of this new species within *Melophorus*.

Biology: This species was collected in a nest under a piece of wood in a clearing in heath vegetation, and in a pitfall trap. Little is known of this species. It is moving rather nervously on the ground with the antenna almost fully stretched out, almost without an angle between the scape and the funiculus.

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Jonathan Majer and Alan Andersen are both extremely successful promoters of Australian ants around the globe, but nevertheless very cooperative and helpful, and curious about the identity of their ants. They both were very instrumental for this successful field trip to Australia. Brian Heterick was selfless to let me have his one and only vial of *Melophorus majeri*, and also let me know where to find more. Ian Nauman and Ebbe Nielsen were very generous in letting me have the base camp at the ANIC in Canberra, and to work through the melophorine collection. John Greenslade let me have his notes, both verbally and on paper. Nicolette Layover prepared the lavish drawing of *M. majeri*. Alan Andersen and Alain Lenoir made some useful comments on an earlier draft of the manuscript. Field work was generously supported by a fellowship of the Janggen-Poehn Foundation, St. Gall, Switzerland.

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**A NEW MEXICAN SPECIES OF *HOMIOISTERNUS*
(COLEOPTERA: MELOLONTHIDAE; RUTELINAE)**

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Abstract.—A new Mexican species of *Homoioisternus* Ohaus is described and illustrated. Character states of the new species appear to be intermediate between species of *Homoioisternus* Ohaus and *Plesioisternus* Morón. We discuss taxonomically useful characters for these genera and provide a key to the genera and species of *Mesosternus* Morón, *Plesioisternus* and *Homoioisternus*.

The subtribe Heterosternina (Rutelinae) consists of 11 genera and 16 species which are distributed from northwestern and northeastern Mexico to Ecuador. The highest taxonomic richness of the group is in Mexico with nine genera and 13 species (Morón, 1983, 1987; Morón and Howden, 1992).

Genera of this subtribe have been largely characterized by sexually dimorphic characters, especially of the male hind legs. The genus *Plesioisternus* Morón currently contains to *P. setosus* Morón and *P. punctatus* Morón and Howden. According to Morón (1983), *Plesioisternus* is the sister genus to *Macropoides* Guérin-Meneville. Both genera exhibit sexual dimorphism in hind legs. Morón (1987) suggested that *Homoioisternus beckeri* Ohaus is closely related to the genus *Mesosternus* Morón based on the absence of sexual dimorphism.

Here we describe a new species of *Homoioisternus*, and comment on its character states that appear to be transitional between the characters states of *Homoioisternus* and *Plesioisternus*. We propose new diagnostic characters for these genera and a key to separate the species of *Mesosternus*, *Plesioisternus* and *Homoioisternus*.

***Homoioisternus canorum*, new species**
(Figs. 1, 5, 8, 11, 14, 17, 20, 23, 26, 29)

Description: Holotype male. Length 34.5 mm; maximum width (at basal 3/5 of elytra) 18.8 mm. Body oval; dorsal color and legs tan, lateral regions of pygidium and tarsi slightly darker, ventral color reddish brown. Clypeus semitrapezoidal, apex rounded, margins moderately reflexed, disc distinctly convex; clypeus with dense and moderate punctures, punctures becoming confluent laterally; frontoclypeal suture fine, almost straight and weakly pigmented; frons with sparse punctures on sides; antennal club subequal to stem; mentum with apical margin broadly emarginate and a weak notch at center; mandibles with an external, distinct preapical tooth and three acute teeth on cutting edge; ratio of cephalic length/pronotal length 0.60.

Pronotum with anterior angles slightly obtuse; pronotal basal bead complete; central third of pronotum with punctures small and sparse, gradually becoming larger and denser at sides but not confluent. Elytra feebly swollen at central third; sides slightly recurved at the metacoxal level; apex rounded; elytral disc with dense punc-

tures and some shallow rugae, punctures slightly larger than those of head; elytral sutures and lateral edges with narrow brown margin. Meso- and metasternum clothed with dense, long, yellowish setae; mesosternal process very short, shape subtriangular with blunt point and almost vertical in lateral view. Abdomen longer at middle than meso- and metasternum combined (1.1:1.0); longitudinal central third of abdominal sternites with moderately dense and short setae, denser and longer laterally; abdominal sternites 2–4 slightly sinuate at apex. Pygidium wide, evenly convex; surface very rugose with dense, long, yellowish setae.

Protarsus with inner claw strongly thickened and split apically; protarsomeres 1–4 wider than long (Fig. 1). Mesotibiae narrower than metatibiae; mesotarsi short and thickened; mesotarsal outer claws moderately curved with teeth weakly separated (Fig. 5). Metacoxae not prominent; posterior border of metatrochanter without projections and with dense setae, apex produced to same level of posterior border of metafemur (Fig. 8); metafemora moderately enlarged and swollen, posterior process not strongly produced, situated at about basal $\frac{2}{5}$ of posterior border (from apex of trochanter) (Fig. 8); metatibiae moderately bent with moderately dense setae on the internal face (Fig. 11), apex with four minute bristles on ventrolateral edge and produced to apex of first tarsomere; metatibial spurs slender, long, flattened, with blunt apex (Fig. 14); metatarsi short and thickened; metatarsal outer claws slightly curved with teeth moderately separated (Fig. 17). Male genitalia with parameres narrowed toward apex, tip scarcely bent and rounded (Figs. 20, 23); aedeagus long, covered with fine, dense setae.

Allotype female. Length 31.8 mm; maximum width (at middle of elytra) 16.7 mm. Similar to male except as follows: body oval-elongate, pygidium completely tan; clypeal margins more reflexed, clypeal disc slightly convex. Punctuation of head denser; emargination and notch of mentum shallower; ratio of cephalic length/pronotal length 0.67; pronotal basal bead lacking in front of central eighth of base of scutellum; pronotum less transverse than male, pronotal punctation denser but not confluent; elytral disc without rugae, punctures similar in size to those of head; abdomen longer at middle than meso- and metasternum combined (1.3:1.0), central third of abdominal sternites with setae denser; inner claw of protarsus not thickened and widely toothed; meso- and metatarsi long and narrow with outer claws widely toothed; metatrochanter produced weakly beyond posterior border of metafemur (Fig. 26); metafemora not enlarged or swollen, posterior process weaker than male (Fig. 26); metatibiae straight, shorter and stouter, apex not extended, internal face with sparse setae, ventrolateral edge of apex with eight minute to small bristles or setae; internal metatibial spur with apex rounded (Fig. 29).

Variation. Length of males varies from 30.1 mm to 32.2 mm and maximum width (at basal $\frac{2}{5}$ of elytra) varies from 17.2 mm to 17.6 mm; length of females varies from 29.1 mm to 32.1 mm and maximum width (at middle of elytra) varies from 15.5 mm to 16.8 mm. Variation is mainly noted for (common state is mentioned first): body shape (both sexes) oval to oval-elongate, pygidium tan to tan with lateral regions reddish; clypeal apex varies from rounded to weakly truncate, margins moderately to slightly reflexed, disc distinctly to slightly convex and with punctures dense to very dense; medial notch of apical margin of mentum indistinct to lacking; ratio cephalic length/pronotal length 0.58 to 0.65; pronotal anterior angles slightly obtuse to right-angled, pronotal basal bead lacking in front of central eighth of base of

scutellum to complete, discal punctures small to moderate and sparsely to moderately dense; elytra feebly swollen to evenly convex, discal punctures sparse to dense and larger or similar in size to those of head, with or without rugae; mesosternal process subtriangular to rounded at apex and declivous to vertical in lateral view; ratio of abdominal length—meso-metasternal length 1.1 to 1.4; abdominal sternites in longitudinal central third with setae dense to sparse in males and dense to very dense in females; ventrolateral edge of metatibial apex with 4–8 minute bristles or setae; outer claws of metatarsi in males slightly or moderately curved.

Type material: Holotype male: México, Guanajuato, Guanajuato, Sierra de Santa Rosa, Cañada de la Virgen, Alt. 2,330 m, 5-VII-95, luz fluor., J. Cano col. Allotype female and six males and two females paratypes same data as holotype, except: 6-VII-95, dentro de tronco podrido de aliso, M.Cano y L. Delgado cols. One female paratype same data as anterior, except: Sierra de Santa Rosa, Pícones, Alt. 2,250 m, 31-VIII-95, luz fluor., J. Cano col.

Holotype and allotype deposited in the Instituto de Ecología, A.C. (Xalapa, Mexico); paratypes deposited in the collections of Museum für Naturkunde der Humboldt-Universität zu Berlin (Germany), H. & A. Howden (Ottawa, Canada), M.A. Morón (Xalapa, Mexico), J.P. Beraud (Cuernavaca, Mexico), J. Blackaller (D.F., Mexico) and L. Delgado (D.F., Mexico).

Etymology: We take pleasure in naming this species after the family Cano, who live in the Sierra de Santa Rosa. The Cano family first collected this species. They assisted and showed hospitality to senior author in his collecting trips to this region.

Distribution: *Homoiosternus canorum* is known from two close localities situated at the Sierra de Santa Rosa, in the central state of Guanajuato, Mexico (Fig. 31). Both localities have altitudes of 2,250 m to 2,330 m and a subhumid temperate climate. The habitat is mature, undisturbed oak-alder forest which occupies the wet ravines (Estrada, 1996). The species was not present in disturbed oak forests, early succession forests, or dry forests in the same region.

The region that *H. canorum* inhabits is located between the distributional ranges of *H. beckeri* and *Plesio sternus* spp. (Fig. 31). The subhumid climate with a long dry season in combination with the oak forest of this region are similar habitat requirements for *H. beckeri*. The genus *Plesio sternus*, however, requires a humid climate with a short dry season and cloud forest habitat.

DISCUSSION OF TAXONOMIC CHARACTERS FOR *HOMIOI STERNUS* AND *PLESIO STERNUS*

Homoio sternus canorum is a species that relates the genera *Homoio sternus* and *Plesio sternus*, since it exhibits most character states intermediate between both genera (Table 1). *Homoio sternus canorum* shares with *Plesio sternus* the character states present in 2a, 9a, 10a and 11a, and with *H. beckeri* those present in 5a and 13a (Table 1). However, character states of 2a and 5a represent small differences of degree, and the characters 9a, 10a, 11a and 13a refer to sexual dimorphism, just as the characters 1b and 2b (shared between *H. canorum* and *Plesio sternus*, Table 2) and 4c and 5c (shared between *H. canorum* and *H. beckeri*, Table 3). The character states of *H. canorum* present in 1a, 3a, 4a, 6a, 7a, 8a and 12a are shared with both *H. beckeri* and *Plesio sternus*; to note that characters 4a and 6a were previously used for separating these genera (cf. Morón and Howden, 1992).

Table 1. Transitional character states of *Homioiosternus canorum*.

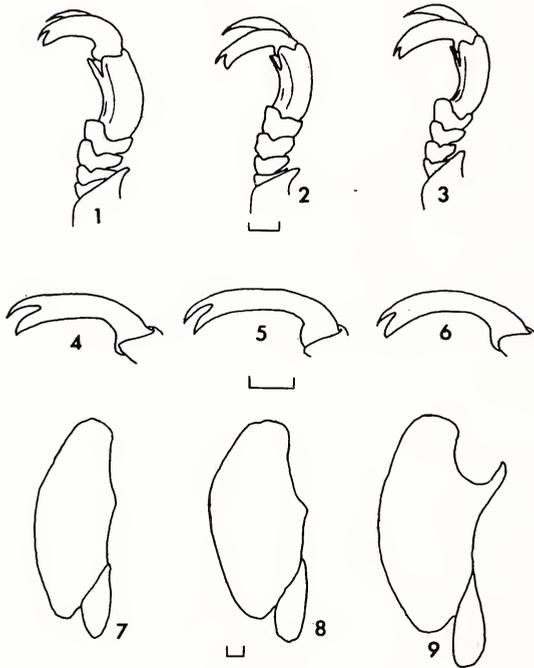
No.	Character		
	<i>H. beckeri</i>	<i>H. canorum</i>	<i>Plesioiosternus</i> spp.
1a	Distinctly to weakly truncate	Rounded to weakly truncate	Rounded to weakly truncate
2a	Distinctly reflexed	Moderately to slightly reflexed	Slightly reflexed
3a	Flat to slightly convex	Distinctly to slightly convex	Distinctly convex
4a	On disc little dense, on sides separate to confluent	On disc little dense to very dense, on sides confluent	On disc dense to very dense, on sides confluent to rugose
5a	Ratio cephalic length/pronotal length	0.52-0.61	0.70-0.71
6a	Elytral disc	With dense punctures, confluent or not, larger than those of head; with rugae	With sparse to dense punctures, not confluent, similar or smaller than those of head; without rugae
7a	Setae on central third of sternites	Sparse to little dense (δ & f)	Dense to sparse (δ), dense to very dense (f)
8a	Ventrolateral edge of apex of metatibiae	8-11 bristles or setae, most of them very short	1-5 bristles or setae, most of them minute
9a	Metatibiae δ	Almost straight; apex up to the half of first tarsomere (Fig. 10)	Moderately bent; apex up to the apex of second tarsomere (Fig. 12)
10a	Setae on internal face of metatibia δ	Sparse to little dense	Very dense
11a	Mesotarsal outer claws δ	Slightly curved; teeth moderately separate (Fig. 4)	Distinctly curved; teeth closer (Fig. 6)
12a	Metatarsal outer claws δ	Slightly curved; teeth widely separate (Fig. 16)	Moderately curved; teeth closer (Fig. 18)
13a	Metafemoral process f	At basal $\frac{1}{3}$ of posterior edge (Fig. 25)	At middle of posterior edge (Fig. 27)

Table 2. Character states shared between *Homoio sternus canorum* and *Plesio sternus*.

No.	Character	<i>H. canorum</i> and <i>Plesio sternus</i>	<i>H. beckeri</i>
1b	Meso and metatarsi ♂	Short and thickened	Long and narrow
2b	Metafemora ♂	Enlarged (Figs. 8, 9)	Narrow (Fig. 7)

The character 2c (Table 3) has been largely used to separate the genera of this subtribe into two groups, one with distinct and complete or briefly broken pronotal basal bead (*Homoio sternus* and *Plesio sternus*) and another with pronotal basal bead absent or only slightly impressed near the posterior angles (Morón, 1983, 1987); discovery of a second species of *Plesio sternus* and additional specimens of *P. setosus* with absent or feebly marked pronotal basal bead led to redefine the character states for *Plesio sternus* (Morón and Howden, 1992). In our opinion, this character should be secondarily used to separate *Homoio sternus* and *Plesio sternus*, due to its scarcely discernible character states. On other hand, similar shapes of male genitalia of the species of both genera not provide differences at the generic level (Figs. 19–24).

We alternatively propose the characters 1c and 3c to recognize these genera (Table



Figs. 1–9. *Homoio sternus* and *Plesio sternus* spp. 1–3. Male protarsus. 1) *H. canorum*; 2) *H. beckeri*; 3) *P. setosus*. 4–6. Male mesotarsal outer claw. 4) *H. beckeri*; 5) *H. canorum*; 6) *P. setosus*. 7–9. Male metatrochanter and femur (anterior to left). 7) *H. beckeri* (type); 8) *H. canorum*; 9) *P. setosus*. Scale = 1 mm.

Table 3. Character states of *Homoiosternus* and *Plesiosternus*.

No.	Character	<i>Homoiosternus</i>		<i>Plesiosternus</i>
1c	Anterior angles of pronotum	Slightly obtuse to right (♂ ♀)		Distinctly (♂) or slightly acute (♀)
2c	Pronotal basal bead	Complete or at most lacking in front of central third of scutellum		Absent or present up to the base of scutellum
3c	Metatibial spurs	♂ slender, long and flattened (Figs. 13, 14) ♀ external elongate, internal narrow (Figs. 28, 29)		♂ stout, short and conical (Fig. 15) ♀ external oval, internal broad (Fig. 30)
4c	Pygidium ♂	Evenly convex		Basal half convex, apical half concave
5c	Metafemoral process ♂	Not modified (Figs. 7, 8)		Spiniform (Fig. 9)

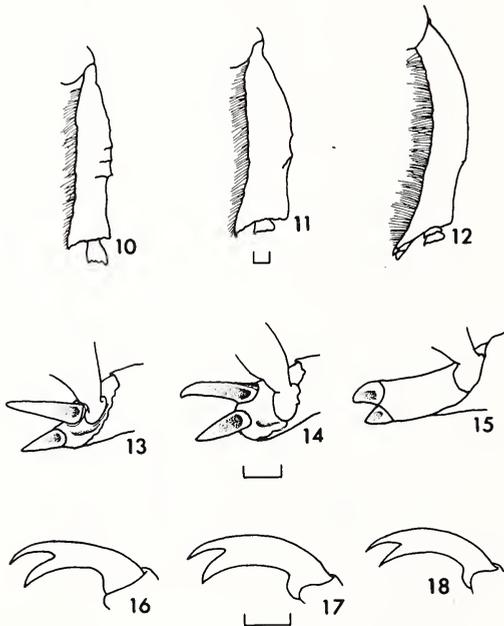
Table 4. Unique character states of *Homoiosternus canorum*.

No.	Character	<i>H. beckeri</i>	<i>H. canorum</i>	<i>Plesio sternus</i> spp.
1d	Color of pygidium, femora and tibiae	Reddish brown to brown	Mostly tan	Brown (pygidium), mostly brown with tan (legs)
2d	Protarsi and inner claw ♂	Moderately thickened (Fig. 2)	Strongly thickened (Fig. 1)	Moderately thickened but longer (Fig. 3)

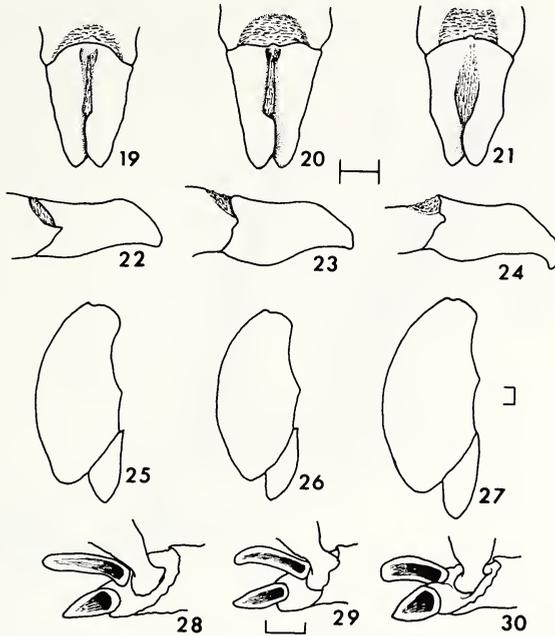
3), these characters are based on shape of structural features and, thus provide greater reliability at the generic level. Nevertheless, a future phylogenetic analysis and, perhaps, the discovery of new species might support the presence of only one lineage.

The unique character states of *H. canorum* (Table 4) only represent interspecific variation, since these refer to color and degree of thickness; others characters useful to separate the two species of *Homoiosternus* are 2a (not-dimorphic) and 9a, 10a, 11a, 1b and 2b (sexually dimorphic) (Tables 1 and 2).

We propose the following key to separate these genera and species together with *Mesosternus halfferi* Morón, a species previously related to these taxa (Morón,



Figs. 10-18. *Homoiosternus* and *Plesio sternus* spp. 10-12. Male metatibia. 10) *H. beckeri* (type); 11) *H. canorum*; 12) *P. setosus*. 13-15. Male metatibial spurs. 13) *H. beckeri* (cotype); 14) *H. canorum*; 15) *P. setosus*. 16-18. Male metatarsal outer claw. 16) *H. beckeri*; 17) *H. canorum*; 18) *P. setosus*. Scale = 1mm.



Figs. 19–30. *Homoiosternus* and *Plesiosternus* spp. 19–24. Parameres of male genitalia (19–21, dorsal view; 22–24, lateral view). 19, 22) *H. beckeri* (type); 20, 23) *H. canorum*; 21, 24) *P. setosus*. 25–27. Female metatrochanter and femur (anterior to left). 25) *H. beckeri* (coty-
 type); 26) *H. canorum*; 27) *P. setosus*. 28–30. Female metatibial spurs. 28) *H. beckeri* (coty-
 type); 29) *H. canorum*; 30) *P. setosus*. Scale = 1 mm.

1987); however there is necessary a future redefinition of the last genus on basis of new not-dimorphic characters. This key replaces couplets 4 and 5 in Morón’s (1987) key to the *Heterosternina*.

- 1. Ventral color with metallic green reflections, femora and tibiae with iridescent tinges. Pronotal punctation strongly contrasting: on central third fine and sparse and on lateral thirds reticulate-rugose *Mesosternus halfieri*
- 1’. Ventral color and legs shining or dull but without metallic reflections and iridescent tinges. Pronotal punctation gradually becoming denser and larger to sides 2
- 2. Anterior angles of pronotum obtuse or right. Male metatibial spurs slender, long and flattened; female metatibiae with the external spur elongate and the internal one narrow *Homoiosternus* . . . 3
- 2’. Anterior angles of pronotum acute. Male metatibial spurs stout, short and conical; female metatibiae with the external spur oval and the internal one broad . . . *Plesiosternus* 4
- 3. Color of pygidium, femora and tibiae reddish brown or brown. Clypeal margins distinctly reflexed *H. beckeri*
- 3’. Color of pygidium, femora and tibiae mostly tan. Clypeal margins moderately to slightly reflexed *H. canorum*
- 4. Pronotal and elytral punctures sparse and small. Outer apex of metatrochanter lacking tooth *P. setosus*



Fig. 31. Distribution of *Homoio sternus* and *Plesio sternus* in relation to the Mexican mountains. a = *H. beckeri*. e = *H. canorum*. o = *P. setosus*. u = *P. punctatus*.

- 4'. Pronotal and elytral punctures dense and moderately large. Outer apex of metatrochanter with small but distinct tooth *P. punctatus*

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We gratefully acknowledge to Dr. Manfred Uhlig of the Museum für Naturkunde der Humboldt-Universität zu Berlin for the loan of type specimens of *H. beckeri*. We also thank Fundación Ecológica de Guanajuato for appreciable logistic support, Angélica Estrada for donation of literature, and The Morales-Delgado family for assistance to senior author during collecting trips. We greatly appreciate the helpful revisions and comments provided by two anonymous referees.

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A NEW SPECIES OF *METAPOLYBIA* DUCKE FROM CENTRAL AMERICA (HYMENOPTERA: VESPIDAE; POLISTINAE)

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Abstract.—A new species of the paper wasp genus *Metapolybia* Ducke is described, and its similarities to other species of the genus are discussed.

Metapolybia Ducke is a small genus of neotropical paper wasps in the tribe Epiponini of the subfamily Polistinae. The tribe is of interest for its behavior of founding colonies by swarms of multiple queens accompanied by workers, and the genus is of interest because the phenomenon of cyclical oligogyny. West-Eberhard (1978), studying *Metapolybia aztecoides* Richards, observed that, although the swarm initiating a colony began with multiple egg-layers, only one egg-layer remained by the time that reproductive progeny were produced. This type of colony cycle, termed cyclical oligogyny by Strassmann et al. (1991), is considered to be important in the maintenance of eusociality in swarm-founding wasps, by raising relatedness among queens.

Metapolybia was described as a genus by Ducke (1905: 7, 10, 17) for *Polybia pediculata* de Saussure, 1854 (now considered a synonym of *cingulata* (Fabricius, 1804)). Ducke (1905: 17) also stated that *Polybia suffusa* Fox, 1898, must belong to the genus, but in his revision of 1910 treated the genus as monotypic, with several color varieties. A subsequent revision by Araujo (1945) recognized five species; the most recent revision (Richards, 1978) recognized 11 species.

The presently described species has not been properly recognized as a distinct taxon. It has been the subject of behavioral study by Drs. Istvan Karsai and John Wenzel of Ohio State University, and we are describing the species in order that the name be available for publication of their work.

Metapolybia mesoamerica, new species

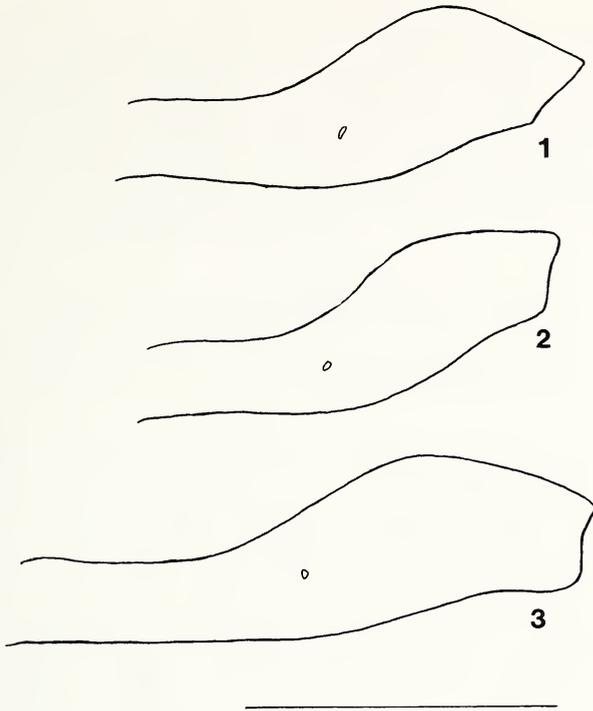
(Figs. 3, 5)

Diagnosis

Pronotum with humeri gently rounded, not projecting. Anterior pronotal carina distinct, obtuse, effaced ventrally. Pretegular carina smoothly curved, not interrupted anteriorly. Mesepisternal punctures moderately abundant, shallow. Propodeal hairs relatively abundant, long and erect. Propodeal sculpture weakly striate. First metasomal tergum posterior to spiracle gently but distinctly convex. Medium-sized species; color brownish, reddish and yellow.

Description

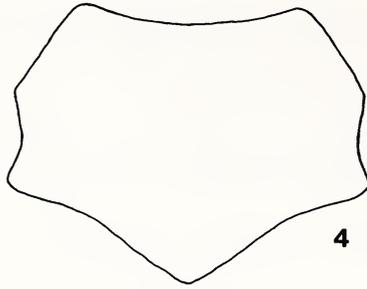
Female: Forewing length 7.9 mm. *Structure*—cuticle finely reticulate, moderately punctured on head and mesosoma, shallower punctures on metasoma; clypeus slight-



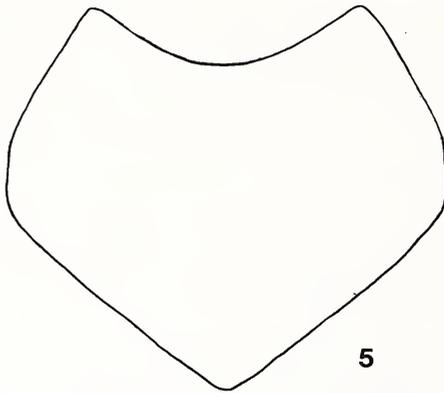
Figs. 1–3. First metasomal segment in lateral view. 1. *Metapolybia docilis*. 2. *M. suffusa*. 3. *M. mesoamericana*. The scale bar is 2 mm.

ly wider than high (Fig. 5); ventral margin of eye rounded, not subangulate; inter-antennal prominence very weak with weak median furrow, slightly convex when viewed from above; posterior ocelli separated by a distance slightly more than their diameter; gena narrows abruptly to vertex from top quarter of eye; anterior margin of pronotum with well developed transparent lamella dorsally, lamella not projecting ventro-laterally; anterior pronotal carina raised laterally, obtuse, effaced dorsally and ventrally; humeri very gently rounded and scarcely projecting in front of tegula; pretegular carina raised, projecting anteriorly, forming uninterrupted curve; scutellum convex, with complete medial line, distinctly raised anteriorly, becoming lower posteriorly; propodeum with median furrow not developed dorsally, only weakly developed ventrally, very weakly striate; first metasomal tergum with spiracles sharply projecting, moderately convex after the spiracles (Fig. 3); metasoma with sparse, shallow punctures posteriorly on terga III–VI.

Color—ground color reddish brown to dark brown; head, brown to black: margin of mandibular teeth, ventral margin of mandible, mandibular condyle, and ventral margin of clypeus, yellow; clypeus with orange tinge above; antennae with scape and pedicel testaceous brown, flagellum dark brown, scape yellow beneath; abundant yellow to orange markings, including between epistomal suture and lower third of eye, spot ventrally on gena, anterior pronotal carina with stripe extending ventrally



4



5

Figs. 4-5. Clypeus in frontal view. 4. *Metapolybia suffusa*. 5. *M. mesoamerica*. The scale bar is 1 mm.

the same width as carina, posterior dorsal margin of pronotum, margins of propleuron weakly, stripe extending along scrobal furrow, most of tegula, tinge on ventral margin of mesepisternum, most of scutellum (orange), the axilla, laterally bifid mark anteriorly on metanotum, spot on upper margin of metapleuron, spots ventrally on propodeum, forecoxae anteriorly, spots on meso- and metacoxae, posterior margins of first tergum posterior bands on terga II-V, posterior bands on sterna II-V, weak on V; wings hyaline with brown venation.

Vestiture—body covered with appressed pubescence and more scattered short outstanding bristles anteriorly on propleura, ventrally on mesepisternum, anteriorly on coxae, postero-laterally on terga, sterna; longer hairs on lower margin of clypeus, conspicuous on propodeum (up to twice an ocellar diameter long) and posterior metasomal segments.

Variation—The color pattern described above varies primarily in the ground color, from dark brown in Costa Rica and Mexico to reddish in Panamá. Specifically, the Panamanian specimens are reddish to testaceous brown laterally on the mesosoma, scutellum, and metasoma. The Panamanian specimens have a stronger medial line on the metanotum and stronger yellow band on tergum V, and the pale markings tend toward orange; the Costa Rican specimens have yellow markings. The Costa Rican specimens are somewhat larger with mean forewing length of 8.2 mm, compared to 7.8 mm in the Panamanian specimens.

Male: unknown.

Nest: astelocytarus; envelope and comb composed of brittle, brownish paper, envelope with extremely numerous “windows” of clear salivary secretion, with “eaves” extending laterally (Nest 901212-1, taken on the side of a building).

Distribution: Costa Rica. Limón, La Selva; Panamá: Panamá, Bocas del Toro; Mexico: Vera Cruz.

Type material: holotype female COSTA RICA: Rio Danta, 4 km W Guápiles, 9 December 1990, Carpenter & Wenzel, Nest 901209-2. Paratypes: MEXICO: Vera Cruz, Cordoba, 2319, 1 female [determined as *Metapolybia suffusa* by Richards]; COSTA RICA: Puntarenas, Golfito, 30 July 1957, Truxal & Menke, 3 females; Prov. Limón, Amubri, 30 Jan. 1979, C. K. Starr, Nest series no. 93, 2 females; Finca La Selva Research Station, 3–14 March 1986, D. Bowers, 1 female; Rio Danta, 4 km W Guápiles, 9 December 1990, Carpenter & Wenzel, Nest 901209-2, 10 females, + 268 females preserved in ethanol; PANAMÁ: Boc. Toro, Changuinola Dist., April 1924, J. C. Bradley, 1 female; Canal Area, Barro Colorado Isl., 12 December 1990, Carpenter & Wenzel, Nest 901212-1, 11 females, + 90 females preserved in ethanol; Barro Colorado Island, 1 November 1995, Karsai and Wenzel, 4 females.

Holotype in the American Museum of Natural History. Paratypes in the American Museum of Natural History, U.S. National Museum of Natural History, Ohio State University, Universidad de Costa Rica and Smithsonian Tropical Research Institute.

Etymology: The specific name is a reference to the geographic range of the species, in Central America, and is to be treated as a noun in apposition.

COMPARATIVE REMARKS

Metapolybia mesoamerica has a number of similarities to *M. azteca* Araujo, *M. docilis* Richards and *M. suffusa*. One of the features shared with *M. azteca* and *M. suffusa* is the presence of numerous long, erect hairs on the propodeum. Richards (1978:183) used this as a primary character in separating the species of *Metapolybia* in his key. *Metapolybia azteca* and *M. suffusa* possess these hairs in a roughly equivalent density, with *M. suffusa* having hairs that are somewhat longer and more robust in the specimens we have seen. *Metapolybia mesoamerica* is similar to *M. suffusa*, with propodeal hairs that are both relatively abundant and long. *Metapolybia docilis* largely lacks these hairs, having only a few, scattered long hairs.

Another key character in this genus is the shape of the humeri on the pronotum. In this feature, *M. azteca* and *M. suffusa* are similar in that their humeri are subangulate but do not project. *Metapolybia docilis* has humeri that are gently rounded and project almost not at all. *Metapolybia mesoamerica* has humeri that differ in

shape from *M. azteca* and *M. suffusa* in that they are gently rounded, and do not project, like *M. docilis*.

Metapolybia azteca and *M. docilis* have a first metasomal tergum that is quite convex posterior to the spiracles (Fig. 1). *Metapolybia suffusa* differs in having the first tergum very little convex posterior to the spiracles (Fig. 2). *Metapolybia mesoamerica* has a distinctly though gently convex first tergum posterior to the spiracle (Fig. 3). In this its condition is intermediate between the convexity of *M. docilis* and *M. suffusa*.

Metapolybia azteca has a clypeus that is almost as high as wide, while in *M. suffusa* the clypeus is clearly wider than high (Fig. 4). *Metapolybia docilis* and *M. mesoamerica* have the clypeus slightly wider than high (Fig. 5).

Metapolybia azteca and *M. suffusa* lack striae on the propodeum lateral to the median furrow. *Metapolybia docilis* has quite distinct striae. *Metapolybia mesoamerica* bears weak striae on the propodeum lateral to the median furrow. Here again, *M. mesoamerica* has a condition intermediate between *M. docilis* and *M. suffusa*.

Species of *Metapolybia* also differ in the degree and depth of mesepisternal punctures. The mesepisternal punctures of *M. mesoamerica* are moderately abundant, like those of *M. azteca* and *M. docilis*. *Metapolybia suffusa* has somewhat less abundant punctures. *Metapolybia azteca* and *M. docilis* bear somewhat deeper punctures; *M. mesoamerica* is more similar to *M. suffusa* in having shallower mesepisternal punctures.

Metapolybia azteca and *M. suffusa* have a relatively acute anterior pronotal carina when compared to *M. mesoamerica*. The anterior pronotal carina of *M. docilis* is more obtuse and less distinct than that of *M. mesoamerica*. All four species of *Metapolybia* have the anterior pronotal carina becoming effaced ventrally. *Metapolybia azteca*, *M. suffusa* and *M. docilis* have the carina extending into the ventral angle of the pronotum. The ventral limit of the carina corresponds to a distinct projection of the anterior margin of the pronotum, which has the anterior lamella narrowed at the projection. There is no projection of the anterior pronotal carina in *M. mesoamerica*, and the anterior lamella is not narrowed, thus *M. mesoamerica* has a more smoothly curved anterior margin to the pronotum.

Finally, *M. azteca* and *M. docilis* have a less distinct pretegular carina than *M. suffusa*. *Metapolybia suffusa* also has a distinct anterior interruption in the pretegular carina at the spiracular lobe. *Metapolybia mesoamerica* has a distinct, anteriorly projecting pretegular carina with a smooth anterior curve.

The species-level phylogeny of *Metapolybia* has not been investigated. There has yet to be any kind of infrageneric classification. *Metapolybia mesoamerica* shares some features with each of the other three species discussed above, although it is not clear at this time which of these features constitute apomorphies within the genus. In the key of Richards (1978: 183-184), *M. mesoamerica* runs to the fourth couplet, where *M. azteca* and *M. suffusa* are keyed. These latter two species are separated by size, color and mesepisternal punctation. In size like *M. azteca*, in color more like *M. suffusa*, *M. mesoamerica* is intermediate in mesepisternal punctation. Other salient features (clypeal dimensions, the obtuse anterior pronotal carina, the pretegular carina, and propodeal sculpture and) clearly differentiate *M. mesoamerica* from these species. One of the most important features for differentiating among the *suffusa-mesoamerica-docilis* complex is the convexity of the first tergum posterior to

the spiracle. The intermediate condition of *M. mesoamerica* in this character, as in others, suggests that cladistic analysis is necessary to determine sister-group relationships of the species.

ACKNOWLEDGMENTS

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**A NEW SPECIES OF *LONEURA* (PSOCOPTERA:
PTILONEURIDAE) FROM CHIAPAS, MEXICO**

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Abstract.—*Loneura ocotensis* n.sp., is described and illustrated on basis of one male collected at the Biosphere Reserve "El Ocote", in western Chiapas. It is the ninth species known in the genus, and the third one to be recorded in México.

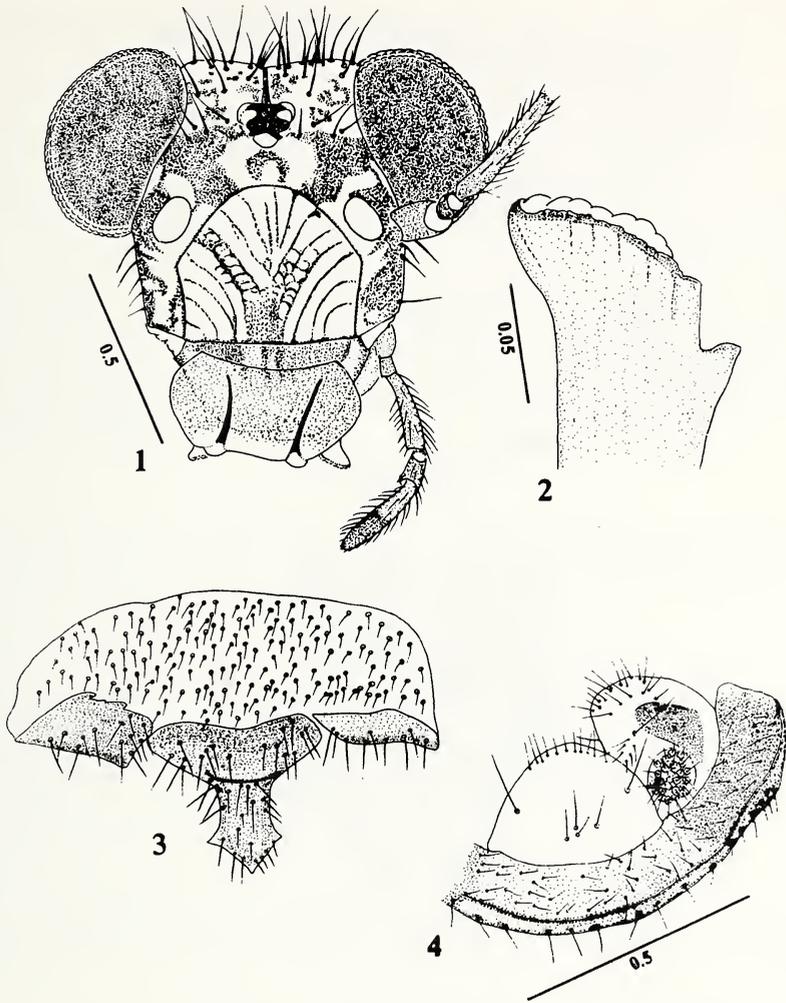
Resumen.—*Loneura ocotensis* n.sp., es descrita e ilustrada, en base a un ejemplar macho recolectado en la Reserva de la Biósfera "El Ocote", en el extremo occidental de Chiapas. Es la novena especie que se conoce en el género y la tercera que se registra en México.

The eight species known in the genus *Loneura* (*L. amazonica* New, *L. boliviana* Williner, *L. brasiliensis* Roesler, *L. crenata* Navas, *L. erwini* New and Thornton, *L. leonilae* García Aldrete, *L. quinarya* Navas, and *L. splendida* Mockford), extend from Southern Mexico to Brazil. Besides these two countries, they have been recorded in Guatemala, Belize, Costa Rica, Bolivia and Perú, and Mockford (1993) indicates that an undescribed *Loneura* occurs in Arizona. Assignment of species to this genus is still based on wing venation characters (García Aldrete, 1995). The purpose of this paper is to describe a new *Loneura* from the Mexican state of Chiapas. The other species known in the country are *L. leonilae* García Aldrete, from Yucatán and Campeche, and *L. splendida* Mockford from Chiapas, Puebla and Veracruz.

The head, right legs and wings, and genital parts, were mounted in Euparal. Measurements of parts mounted were taken with a filar micrometer whose measuring unit is 1.36 microns for wings, legs and flagellomeres, and 0.53 microns for other parts. Parts measured, or counted, are abbreviated as follows: FW = fore wing; HW = hind wing; F = femur; T = tibia; t_1 , t_2 , t_3 , = tarsomeres of right hind leg; P_4 = fourth segment of right palpus; $f_1 \dots f_n$ = flagellomeres of right antenna; IO = minimum distance between compound eyes; D = antero-posterior diameter of right compound eye; d = transverse diameter of right compound eye; PO = d/D (IO, D and d measured in front view of the mounted head on the slide). The type of the species here described is deposited in the National Insect Collection, Instituto de Biología, UNAM (IBUNAM), México City.

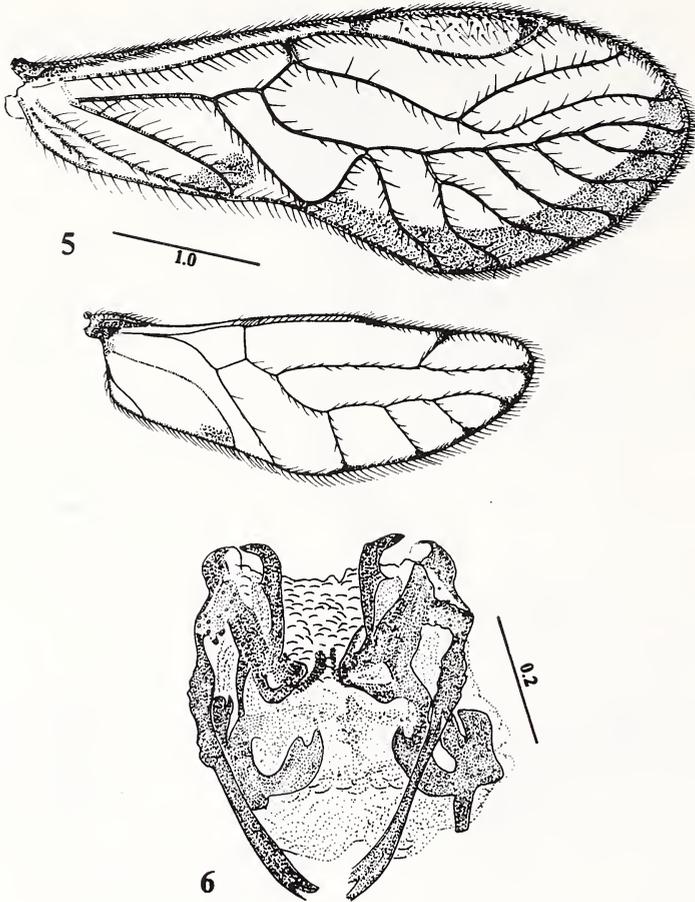
***Loneura ocotensis*, n. sp. (Male)**

Color (in 80% alcohol): Ground color creamy white, with dark brown areas, as indicated below. Head pattern (Fig. 1). Antennae: scape and pedicel brown; flagellomeres pale brown, with apices white. Maxillary palps brown, Mx4 with distal half slightly more pigmented. Fore and hind coxae creamy white, with apices brown; middle coxae brown; trochanters, femora, tibiae and t_1 pale brown, t_2 - t_3 dark brown.



Figs. 1-4. *Loneura ocotensis* n. sp. Male. 1. Front view of head. 2. Apex of right lacinia. 3. Hypandrium. 4. Clunium, epiproct and left paraproct. Scales in mm. Figure 3 to scale of Figure 4.

Hind femora each with a distal brown spot, hind tibiae distally dark brown. Prothorax creamy white, with two dark spots on each side. Tergal lobes, scutellae and pleurae of meso and metathorax dark brown, with episterna more pigmented than epimera. Wings mostly hyaline, veins brown. Hind wings with dark spots at distal ends of veins (Fig. 5). Fore wings with a brown band along margin, as illustrated (Fig. 5), and a large spot at the distal ends of Cu_2 -IA. Pterostigma with a brown spot on each end. Abdomen creamy white, with dark brown subcuticular rings, more conspicuous dorsally. Clunium dark brown at both ends, light brown dorsally, in area next epi-



Figs. 5-6. *Loneura ocotensis* n. sp. Male. 5. Fore and hind wings. 6. Phallosome. Scales in mm.

proct; epiproct unpigmented, paraprocts also unpigmented, except for an elongate, light brown area next sensory fields.

Morphology: Lacinial tips (Fig. 2). Areola postica high, almost reaching M, connected to it by a short crossvein; M with five branches, the anterior-most bifurcated. Hind wings with M four branched (Fig. 5). Hypandrium (Fig. 3) consisting of a central piece, flanked by two smaller pieces, setose as illustrated; central piece with a posterior projection, arrowhead-shaped (Fig. 3). Phallosome (Fig. 6) complex, posteriorly with two distinct, short, stout, distally acuminate phallic sclerites. Paraprocts (Fig. 4) broad, posteriorly rounded; sensory fields with 26-28 trichobothria set on small basal rosettes. Epiproct (Fig. 4) broad, posteriorly rounded, with a large seta on each side, a row of setae along posterior margin and a group of four setae in the middle.

Measurements: FW: 4488; HW: 3026; F: 1150; T: 1904; t_1 : 790; t_2 : 108; t_3 : 141; P_4 : 216; f_1 : 870; f_2 : 773; f_3 : 616; f_4 : 549; f_5 : 382; f_6 : 374; f_7 : 310; f_8 : 277; f_9 : 254; f_{10} : 217; f_{11} : 231; IO: 432; D: 494; d: 310; IO/D: 0.87; PO: 0.62.

Type Material: MEXICO, Chiapas, Biosphere Reserve "El Ocote", 50 km NW Ocozacoautla, 790m, I.V. 1993, attracted to UV trap, A.N. García Aldrete & E. Barrera, holotype male (IBUNAM).

Comments: The specimen on which this species is based is aberrant in front wing venation: the right fore wing has a tall areola postica connected to the M stem by a short crossvein, but in the left fore wing the areola postica is free, Mockford (in litt.) has observed the same anomaly in other specimens of this species. The species is placed in *Loneura* on basis of male genital characters and wing venation; with *L. crenata* Navas (New, 1976), and *L. leonilae* García Aldrete (1995) constitute a complex of closely related species that have in common the forewing pattern, the M next to the areola postica forked, the same hypandrium plan and similar phallosomes with two stout, acuminate, anterior sclerites.

ACKNOWLEDGMENTS

I thank E. L. Mockford (Illinois State University; Normal, Illinois) for his comments on a former version of this manuscript, in which the species here described had been treated, erroneously, as a species of *Ptiloneuropsis*.

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A NEW SPECIES OF *PROBOLOMYRMEX* (HYMENOPTERA: FORMICIDAE) FROM GUANACASTE, COSTA RICA

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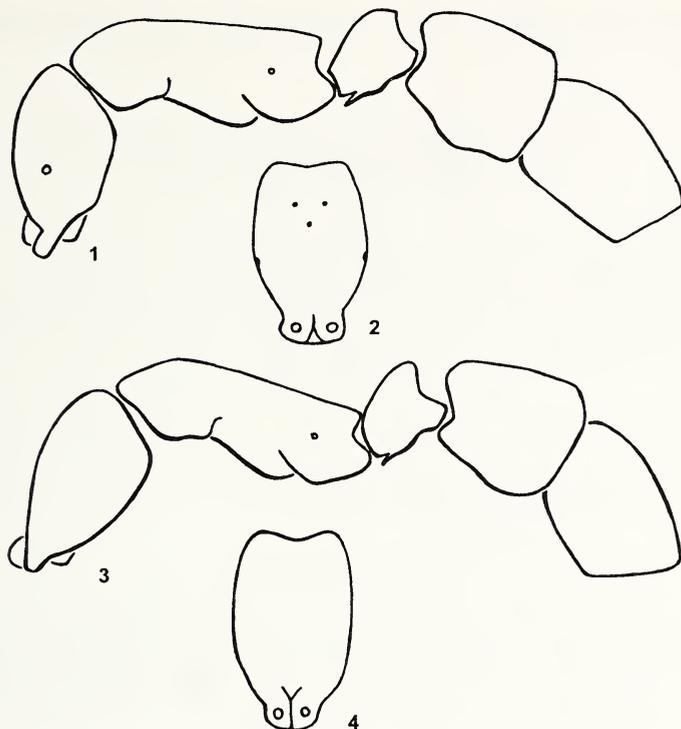
Abstract.—*Probolomyrmex guanacastensis* (n. sp.) from Guanacaste, Costa Rica is described from a queen and worker collected from sifted leaf debris in a riparian habitat. This is the fourth known species of *Probolomyrmex* in the New World extending the northern distribution limit from Barro Colorado Island, Panama to Guanacaste, Costa Rica. It is also the first record of an ergatoid queen in the *Probolomyrmex*. A revised key to the species is given.

The genus *Probolomyrmex* was recently revised by Agosti (1994) for South America and Taylor (1965) for the world. Three species have been described from South America (*P. boliviensis* Mann from Barro Colorado Island, Panama, and Bolivia; *P. brujitae* Agosti from Argentina; and *P. petiolatus* Weber from Barro Colorado Island, Panama). This new species was found while conducting a survey of an ant fauna in riparian habitats near Bagaces, Costa Rica, and represents not only a northern extension of the range of members of the genus from southern Panama to northern Costa Rica, but is the first record of this genus for Costa Rica. No further *Probolomyrmex* spp. were collected in South America, despite extensive leaf litter and soil core samples around Manaus and in the Atlantic Forest in Brazil. The total of more than 2,000 samples so far, which led otherwise to the discovery of extremely rare new species of leptanilloidine ants (Brandão et al., 1998), and the presence of an ergatoid queen, makes it worthwhile to describe this new species.

The format follows that of Agosti (1994) and indices were calculated according to Taylor (1965).

REVISED KEY TO THE SPECIES OF NEOTROPICAL *PROBOLOMYRMEX*

- 1. Petiole in lateral view with a ventral, rectangular process *petiolatus* Weber
- Petiole in lateral view with a ventral process directed towards the mesosoma 2
- 2. Larger body size (TL > 0.95 mm), longer scape (SI > 105). Sculpture with large pits with chagrination in between. First gastral segment ventro-anterior with a distinct collar which is bent ventrally. Head with a distinct carina along the posterior ventral face, which is darker than the adjacent surface. Ventral process of petiole in lateral view distinctly more darkly colored than the tergite *boliviensis* Mann
- Small body size (TL < 0.95 mm), short scape (SI < 105). Sculpture fine and densely set. First gastral segment ventrally without a collar. Head with a bulge along the posterior ventral face, which, in lateral view is not darker than the adjacent surface. Ventral process of petiole in lateral view of the same color as the adjacent tergite 3
- 3. Head smaller (HL 0.57–0.60 mm, HW 0.35–0.36 mm), scape shorter (SL 0.35 mm) *brujitae* Agosti



Figs. 1–4. *Probolomyrmex guanacastensis* n. sp. 1–2. Ergatoid female (paratype). 1. lateral view. 2. head in full frontal view. 3–4. Worker (holotype). 3. lateral view. 4. head in full frontal view.

– Head larger (HL 0.63–0.65 mm, HW 0.39–0.40 mm), scape longer (SL 0.40–0.41 mm)
 *guanacastensis* n. sp.

***Probolomyrmex guanacastensis*, new species**

Holotype: 1 worker, Costa Rica, Guanacaste, 8.5 km NW Bagaces, Plazuela Hacienda Monteverde, 31-VIII-1996, S. O’Keefe, sift leaf debris. Holotype deposited at InBio, Costa Rica.

Paratype: 1 queen, same data as holotype. Deposited in American Museum of Natural History.

QUEEN. HL 0.63, HW 0.41, SL 0.40, TL 0.81, CI 66, SI 97, Figures 1, 2 (1 examined).

WORKER. HL 0.65, HW 0.39, SL 0.41, TL 0.79, CI 0.60, SI 106, Figures 3, 4 (1 examined).

Comments: This species is easily separated from *P. petiolatus* by the shape of the petiolar process, and from *P. boliviensis* by the smaller size, shorter scape, lack of a gastral collar, and similar coloration of the petiolar process and tergite. The ergatoid

female has eyes and ocelli, but flight sclerites are not developed. This species is phenotypically very similar to *P. brujitae*, but differs in having a relatively larger head and longer scape.

Despite repeated sampling in July 1995, February 1996, and July 1996, only two specimens were collected of this genus from the type locality and none were collected in nearby localities of similar habitat. The specimens were found in sifted debris processed through a modified Berlese-Tulgren funnel from a riparian habitat that included *Ochroma pyramidale*, *Albizia samen*, *Anacardium excelsum*, *Ceiba pentadra*, *Hymenia courbaril*, *Bursera simiruba*, *Andira inermis*, *Spondias mombin*, *Sweetenia macrophylla*, *Cedrela odorata*, *Enterolobium cyclocarpum*, *Hirtella racemosa*, and *Ardesia revoluta*. This site is unique in that numerous (>150) specimens of *Homoconnus* (Coleoptera: Scydmaenidae) were collected, while less than five were collected at all other sites sampled combined.

P. guanacastensis is the first record of an ergatoid female in this genus, in which all the other known sexuals are of the normal winged type (Taylor, 1965). This species belongs to the exceptions among ants with ergatoid queens, which normally have large colonies (Peeters, 1997). The only completely collected colony so far included only 20 workers (Taylor, 1965: 360).

ACKNOWLEDGMENTS

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NEW SPECIES AND A NEW NAME FOR ANTILLEAN BUPRESTIDAE (COLEOPTERA)

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Abstract.—Two species of Buprestidae are added to the Antillean insect fauna. *Agrilus jamaicensis* is described as the second member of that genus known from the island of Jamaica. *Taphrocerus chalumeaui* is reported from Guadeloupe, taken on the leaves of the palm *Euterpe globosa*. Both species are more closely related to Central American forms than to known Antillean species. *Agrilus hispaniolae* is proposed as a new name to replace *A. klapperichi* Hespeneheide, a primary homonym of *A. klapperichi* Obenberger.

Fisher's (1925) revision of Antillean Buprestidae reports only one species from the island of Jamaica now considered to belong to the genus *Agrilus* (Hespeneheide, 1974), *A. albicollis* (Waterhouse), originally described as the type of the genus *Paradomorphus*. Examination of collections during study of the genus *Agrilus* (Hespeneheide, 1974, 1979) yielded two Jamaican specimens that did not agree with these or the other species known from the Antilles. These specimens represent an unnamed species that is described below. More recently, F. Chalumeau has sent specimens of a species of *Taphrocerus* from Guadeloupe that is also unknown previously and described here.

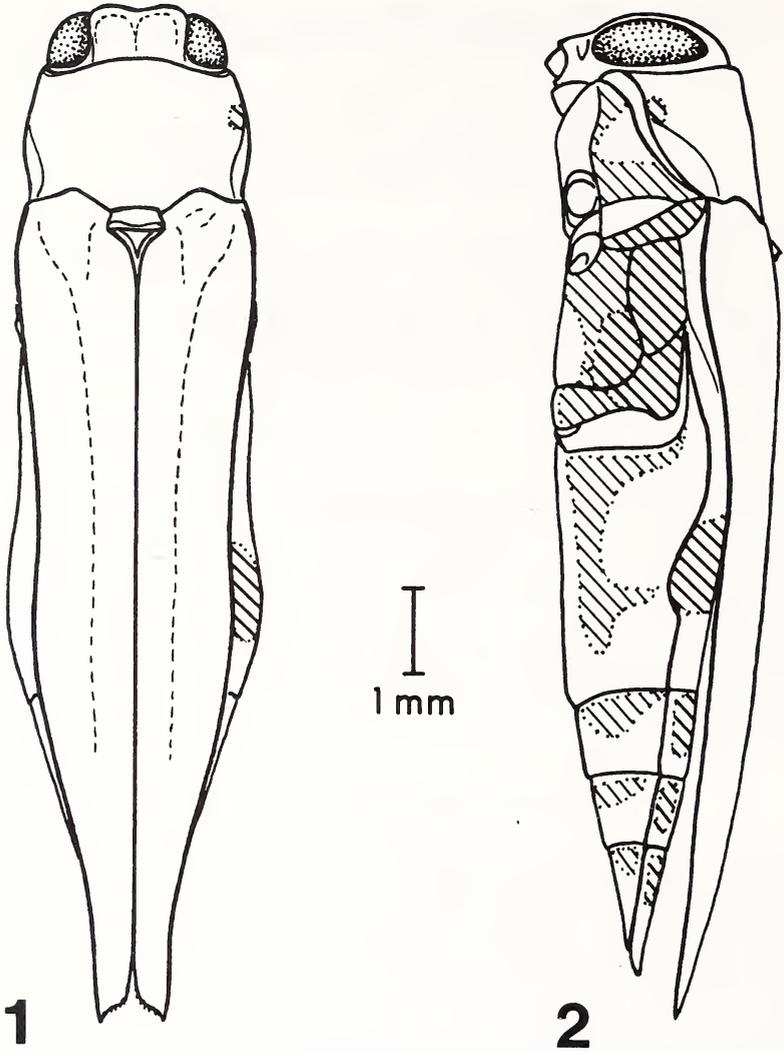
Agrilus jamaicensis, new species (Figs. 1-2)

Description: Holotype female: Elongate, strongly flattened above; black with dark metallic blue green reflections throughout except for black median stripe on pronotum and small purplish spot on upper middle of front; small spot of golden setae at anterior angles of pronotum, narrow line of white setae along elytral suture for distal $\frac{1}{2}$; 12.5 mm long, 3.0 mm wide.

Head with front depressed along midline and transversely above middle; surface moderately rugose on upper half, finely punctate on lower half, sparse white setae along midline below middle and above epistoma; antennae reaching posterior angles of pronotum when laid alongside, serrate from segment 5.

Pronotum widest at basal $\frac{1}{3}$; marginal and submarginal carinae separated along anterior $\frac{2}{3}$, median lobe of anterior margin very shallow; basal margin angulate-emarginate at middle of each elytron; disk moderately convex with shallow transverse depressions along base and before middle, narrowly depressed on lateral margins; prehumeral carinae prominent, arcuate, joining marginal carina beyond middle; surface transversely, finely but distinctly rugose, not visibly punctate.

Elytral margins undulate, gradually converging to tips; tips narrowly produced, divergent, narrowly angulate, each with prominent tooth on exterior edge; disk nearly flat with strong, small depressions at base and rather strong depressions along suture;



Figs. 1-2. *Agrilus jamaicensis* Hesperheide, n. sp.; line indicates scale. Figure 1, dorsal view; Figure 2, lateral view. Shaded regions indicate areas of dense setae.

surface polished imbricate-punctate on outer halves, finely transversely rugose on inner halves.

Prosternum glabrous, posterior process bilobed, expanded behind procoxae; prosternal lobe subtruncate. Metacoxae shallowly emarginate on posterior margin, posterolateral angle produced; lateral half of metacoxae and adjacent portions of metasternum and epimeron with dark orange setae, medial half and adjacent metasternum with pale yellow setae. Abdomen with suture between sterna 1 and 2 strongly indicated at sides; apex of lateral portion of sternum 1 broadly rounded and expanded,

sterna 1 and 3–5 with dark orange setae; pale yellow setae in broad triangular patches at anterior margins of vertical portions of sterna 1–5, patches of sterna 1 and 2 joined. Tarsal claws with inner teeth broader, rather long and parallel.

Male unknown.

Holotype: “Jamaica,” without precise locality (CASC).

Paratype: “Jamaica,” without precise locality (BMNH).

Comments: This striking species is very similar to *A. dentifer* Waterhouse, described from México without more precise locality. A specimen of *A. dentifer* in my collection from Barro Colorado Island, Panamá, differs from *A. jamaicensis* as follows: *A. dentifer* is black with an indistinct spot of sparse white setae along the suture of the elytra at the middle, and lacks the extensive areas of pale setae on the metasternum and sides of the abdomen; the prehumeral carina is only narrowly separated from the marginal carina and the disk of the pronotum is visibly punctate and less strongly rugose; the front is very finely punctate below and nearly smooth on the upper half; the lateral portion of abdominal sternum 1 is only slightly expanded at its apex and the dorsal portions of sterna 3–5 have white rather than orange setae. Although these two species are distinct, they are clearly related, and are part of a larger group of species that includes *A. apicatus* Waterhouse, *A. lentulus* Waterhouse, *A. cibarius* Fisher, *A. uvarovi* Obenberger and others. All share a convex or weakly depressed pronotum with prehumeral carinae that join the marginal carinae, elongate elytral apices with strong external teeth and a narrow sutural stripe of setae, and similar colorations and patterns of setae on the lateral and ventral portions of the body.

Agrilus albicollis from Jamaica is a black species with some golden reflections, measures less than 10 mm in length, and has the dorsal surface of the pronotum almost entirely obscured by white setae. It is certainly not closely related to *A. jamaicensis*, which is not very similar to the other Antillean *Agrilus*: *A. denticornis* Chevrolat from Cuba is a much smaller species (<5 mm); *A. dominicanus* Thomson from Cuba and Hispaniola is similar in size, but is uniformly and inconspicuously setose, has a depression along the midline of the pronotum, and has rounded and strongly dentate elytral apices (Fisher, 1925).

That this large, striking species has not been collected recently probably only reflects the general lack of insect collections from the Antilles. Recent collections from Hispaniola have yielded unusual genera and new species, including another *Agrilus* (Hespenheide, 1990, and below), and systematic collecting in Jamaica or elsewhere in the West Indies is likely to be equally profitable.

Taphrocerus chalumeau, new species

(Fig. 3)

Description: Holotype Female: Moderately broad and flattened above, strongly shining; olive green above, except darker spot on each elytron and scutellum and pronotum with coppery reflections; front yellowish green; beneath more convex in cross-section, black with greenish reflections; length 4.3 mm, width 1.5 mm.

Head with narrow medial depression, stronger above middle; surface strongly shagreened, irregularly punctate except for transverse impunctate band across middle of front, punctures small and shallow; sparse area of inconspicuous setae above epistoma, epistomal pores small, separated by own diameter; eyes not prominent.

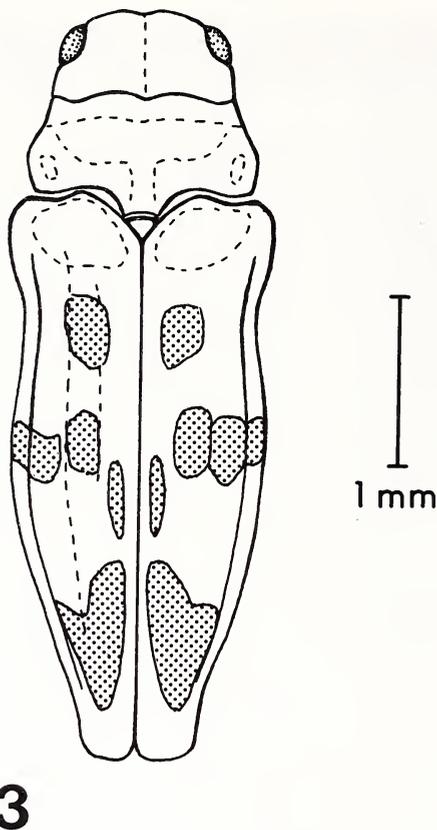


Fig. 3. *Taphrocerus chalumeaui* Hesperheide, n. sp., dorsal view. Line indicates scale. Shaded regions indicate areas of dense setae.

Pronotum 2 times as wide as long; moderately convex, narrowly transversely depressed along anterior margin and more broadly and deeply so along posterior margin but interrupted at middle, and irregularly so parallel to sides; short linear prehumeral protuberance in posterior angles; sides strongly angulate, widest behind middle; surface strongly shagreened, with ocellate punctures along all margins, sparser on anterior margin and densest in posterior angles, each puncture with semirecumbent seta. Scutellum strongly shagreened.

Elytra at base wider than pronotum, widest at humeri, constricted behind humeri then shallowly arcuate to tips which are broadly, separately rounded and minutely denticulate; surface shagreened, more strongly so at tips and nearly smooth in oval area behind middle; punctures coarser at base becoming indistinct beyond the middle, second and fourth intervals slightly raised on basal half, suture and sixth interval more strongly raised for entire length (sixth interval subcarinate), especially toward apex, creating narrow triangular depression before apex; transversely depressed at

base; setae condensed in spots at basal $\frac{1}{4}$, at middle, and then along suture to triangular spot in subapical depression.

Antennal grooves on prosternum rather broad and very shallow. Metacoxae conspicuously setose. Abdomen beneath indistinctly shagreened, sparsely minutely punctate and setose; terminal segment broadly subtruncate at apex, apical groove following outline of apical margin, except slightly indented at middle, and overlain with row of long semi-erect setae.

Holotype: Guadeloupe: Morne a Louis, 6.II.1972, F. Chalumeau, "adulte s[ur] feuille de *Eut[erpe] globosa*" (IREC).

Paratype: same data (IREC).

This is the first species of *Taphrocerus* known from the Lesser Antilles and the first member of the genus from the Antilles definitely associated with a species of palm. Other Antillean *Taphrocerus* are associated with sedges (Cyperaceae), although only the Jamaican *T. albomaculatus* Fisher has been reared (T. W. Sherry and Hesperheide, unpublished).

T. chalumeaui appears to be closely related to a group of species that in Central America includes *T. albofasciatus* Fisher (Panamá) and several undescribed forms. This group is characterized by larger size and flattened shape, metallic red, blue or green colors instead of the black typical of most *Taphrocerus*; laterally carinate elytra; and elytral setation patterns similar to that of *T. chalumeaui*. *T. chalumeaui* differs from the species mentioned above in having a color pattern that is olive-green rather than red or blue, in lacking definite lateral elytral carina, as well as in many finer details of morphology. The overall color and the pattern of setae on the elytra will separate it from all other known Antillean species.

***Agrilus hispaniolae*, new name**

A. klapperichi Hesperheide, 1990:402 (primary homonym of *A. klapperichi* Obenberger, 1940:183).

Dr. Charles Bellamy has kindly pointed out that the name of my recently-described species from the Dominican Republic was preoccupied by that of a Chinese species not included in the most recent catalogue for the genus (Obenberger, 1936).

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THE ANT (HYMENOPTERA: FORMICIDAE) TYPES IN ARGENTINIAN COLLECTIONS

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Abstract.—Type specimens of 114 species and subspecific ant taxa in Argentinian insect collections are listed, including 14 holotypes and 5 lectotypes. Most of the types are Neotropical, with the exception of a series of Karavajev types from South East Asia.

The two collection at the Division Entomologia, Museo Argentino de Ciencias Naturales in Buenos Aires includes (MACN) and the Fundacion e Instituto Miguel Lillo, Universidad Nacional de Tucuman in Tucuman (IMLA), house all ant types in Argentina. The collection of 50 Kusnezov types at IMLA, the Bruch collection and thirteen Karavajev types from SE-Asia in MACN is the most important holding because of the 14 holotypes and 2 lectotypes. The latter includes one holotype of each W. L. Brown, Jr., Th. Borgmeier, and W. Kempf.

The Karavajev types are in a small separate box in MACN, which is labeled as follows: "Donacion Dr. Alejandro A. Oglobin" and "Hormigas tejedoras, Formicidae, gen. *Oecophylla*, *Polyrhachis*, tipos del mirmecology Karawajew". The box includes also 19 further species identified by Karawjew. Bruch's collection is at MACN, but his extensive photographic documentation is at the Museo de la Plata in La Plata (MLPA).

Type designation in myrmecology has in the past been rather loose. Ants, being social, led to a long upheld practice of not designing a holotype, but rather designate syntypes, types, including a series of specimens.

The list is organized alphabetically following subfamilies and genera. Only the often fragmentary information provided on the labels are listed. The taxa are listed following the valid combination. If this does not agree with the label data, the original genus used on the label is provided in brackets. Types for which no corresponding description can be found are nevertheless listed. Further information on the species can be found in Bolton (1995). The abbreviations of the collections follows Arnett et al. (1993), which includes also the addresses of the collections.

CERAPACHYINAE

Acanthostichus femoralis Kusnezov Syntypes 17 workers, #10449; Argentina, Formosa, Ing. Juarez, N. Kusnezov, viii. 1958, IMLA [manuscript name?].

Cerapachys silvestrii Mann Cotype 3 workers P.R. Rio Pideras, Insular Expedition Station, F. Sein Jr., Feb. 5, 30. IMLA. In soil in sugar cane [manuscript name?].

DOLICHODERINAE

Dolichoderus (Monacis) andinus Kempf. Paratypes 2 workers, 1145, Peru Pichita, Caluga, 2,150 m, Weyrauch, 18.9.1960. IMLA.

- Dolichoderus (Monacis) lobicornis* Kempf. Paratypes 3 workers. Blumenau, M. Witte, 10.12.1921. IMLA.
- Dorymyrmex (Dorymyrmex) emmaericaellus* Kusnezov. Holotype and paratypes 6 workers. Bolivia, Cochabamba, La Paz. IMLA.
- Forelius (Neoforelius) tucumanus* Kusnezov. Syntypes 2 females. #5617, Tucuman, N.Kusnezov. IMLA.

ECITONINAE

- Eciton mexicanum argentinum* Borgmeier. Holotype 1 female. #32890, Roque Saenz Peria (Chaco), F. Ohnehider. MACN.
- Eciton setigaster* Borgmeier. Cotype 1 female. #11804, Bolivia. MACN.
- Neivamyrmex Eciton hetschkoi oglobini* Santschi. Typus 1 female. Argentina, Misiones Dr. A. A. Oglobin. MACN.
- Neivamyrmex hetschkoi* Mayr. Cotype 1 worker. #2001, Argentina, Misiones, Est. Exp., Loreto, Dr. A. A. Oglobin. MACN.
- Neivamyrmex impudens* W. M. Mann. Cotypes 3 workers. Honduras, Progresso, W. M. Mann. IMLA.
- Neivamyrmex laevigatum* Borgmeier. Cotypes 2 workers, 1 male. #2580, Argentina, Rogne (?), S. Pena, N. Kusnezov, 13.6.48. IMLA.
- Neivamyrmex (Eciton) pseudops grandipseudops* Bruch. Typus 1 female. Argentina, Alta Gracia, La Granja, Sierras de Cordoba, C. Bruch. MACN.

FORMICINAE

- Acropyga (Rhizomyrma) wheeleri* Mann. Cotypes 3 workers. Honduras, Lombardia. IMLA.
- Camponotus aguilerai* Kusnezov. Syntypes 10 workers. Argentina, Jujuy, 6.1.1949. IMLA.
- Camponotus goeldii* Forel. Syntype 1 worker. Brazil, Rio de Janeiro. IMLA.
- Camponotus guayapa* Kusnezov. Holotype and paratypes 6 workers. La Rioja, Guayapa, 12.8.1948. IMLA.
- Camponotus phytophilus* Wheeler. Cotypes 4 workers. #2834/sk., Mexico, Guernavaca, E. Skwarra, 6.26.1929. IMLA.
- Camponotus quercicola* M. R. Smith. Paratypes 6 workers. USNM paratype #62025, Los Angeles, Tambark flat, T. C. Laurence, 7.15.1952. IMLA.
- Myrmelachista ina* Kusnezov. Holotype and paratypes 36 workers. Argentina, Misiones, Manuel Belgrano, N. Kusnezov, 7.26.1949. IMLA.
- Myrmelachista schachovski* Kusnezov. Syntypes 2 workers. Argentina, San Martin de Los Andes, S. Shajovskoi. IMLA.
- Myrmelachista ute* Kusnezov. Holotype and paratypes 20 workers. Argentina, Misiones, M. Belgrano, N. Kusnezov, 7.27.1947. IMLA.
- Myrmelachista vicina* Kusnezov. Holotype (male), paratypes 1 male, 2 females, 1 worker. Neuqueu, Lago Cacar, Schachovskoi. IMLA.
- Camponotus mucronatus hirsutifrons* [manuscript name?]. Types 6 workers. Guatemala, Zacapa W. M. Wheeler, 12.13.1911. IMLA.
- Paratrechina dichroa* Karavajev. Typus 1 worker. #2399, Prinseneiland, Karavajev. MACN (Karawajew).

- Paratrechina koningsbergeri* Karavajev. Typus 1 worker. #3869, Java, Jibodas, Karavajev. MACN (Karawajew).
- Polyrhachis flavoflagellata* Karavajev. Typus 1 worker. #2875, Java, Buitenzorg, Karavajev. MACN (Karawajew).
- Polyrhachis keratifera* Karavajev. Typus 1 worker. #2505, Amboina, Karavajev. MACN (Karawajew).
- Polyrhachis mystica* Karavajev. Typus 1 worker. #2353, Java, Buitenzorg, Karavajev. MACN (Karawajew).
- Polyrhachis ochracea* Karavajev. Typus 1 worker. #35090, Java, Buitenzorg, Karavajev. MACN (Karawajew).
- Polyrhachis rastellata javana* Karavajev. Typus 1 worker. #2875, Java, Buitenzorg, Karavajev. MACN (Karawajew).
- Polyrhachis rotundiceps* Karavajev. Typus 1 worker. #3004, Wammar, Ins. Aru, Karavajev. MACN (Karawajew).
- Polyrhachis schang gracilior* Karavajev. Typus 1 worker. #2503, Amboina, Karavajev. MACN (Karawajew).
- Polyrhachis tibialis orientalis* Karavajev. Typus 1 worker. #2439, Tifoc (Bocroc (?)), Karavajev. MACN (Karawajew).
- Polyrhachis tibialis robustior* Karavajev. Typus 1 worker. #2583, Wammar, Ins. Aru, Karavajev. MACN (Karawajew).
- Polyrhachis tubifex* Karavajev. Typus 1 worker. #2359, Java, Buitenzorg, Karavajev. MACN (Karawajew).
- Pseudolasius carinatus* Karavajev. Typus 1 worker. #2537, Aroe, Karavajev. MACN (Karawajew).

MYRMICINAE

- Atta opaciceps* Borgmeier. Paratype 1 worker. Brazil, Tapera, Pernambuco, F. Carvalho, 1.941. IMLA.
- Atta robusta* Borgmeier. Paratypes 2 workers. Brazil, Rio de Janeiro, São Bento, F. Torres, 15.x.935. IMLA.
- Basiceros singularis* F. Smith. Lectotype (designated by W. L. Brown) 1 worker. B. G., Kurupung, H. C. Lang. IMLA.
- Basiceros squamifer* Borgmeier. Syntypes 3 workers. #5510, Rio de Janeiro, Angra dos Reis, Jussaral, Lopes and Lent. IMLA (ex coll. Borgmeier).
- Chelistruma lilloanus* (Brown). Holotype and paratypes 3 workers. Argentina, Tucuman, N. Kusnezov, iii.20.48. IMLA.
- Crematogaster hyperphyes* Kusnezov. Paratype 1 female. #7080, Bolivia, Chapare, Marcus, 1.7.49. IMLA.
- Crematogaster hyperphyes* Kusnezov. Paratypes 1 worker and 1 male. #7079, Bolivia, Chapare, Marcus, 27.viii.49. IMLA [no type labels, but same blank red standard labels].
- Leptothorax pergandei* Emery. Cotypes 2 workers. USNM Cotype #54078, USA, DC, Washington, 9.10. IMLA.
- Monomorium minimum cyaneum* Wheeler and Mann. Paratypes 3 workers. #128, Mexico Hidalgo, Guerrero Mill, Mann. IMLA.

- Monomorium (Monomorium), minimum emersoni* Gregg. Paratypes 3 worker USNM type #57292, USA, Texas, Austin, A. Emerson, iv.6.1937. IMLA.
- Neostruma zeteki* Brown. Paratypes 2 workers. #5059, Panama, Barro Colorado Island, Zetek, Feb-March 43. IMLA.
- Pheidole eglobini* Kusnezov. Paratypes 2 workers. #4699, Argentina, Misiones, Yacuy. IMLA [manuscript name?].
- Cyphomyrmex hillbramus* Kusnezov. Paratypes 2 workers. Argentina, Salta, R. Soladillo, R.55-km 1442, 25.1.948. IMLA [manuscript name?].
- Cyphomyrmex ulemi* Kusnezov. Syntype 1 worker. #8849, Argentina, El Rey, Salta, 6.2.53. IMLA [manuscript name?].
- Ochetomyrmex (Brownidris) argentinus* (Kusnezov). Syntypes 1 female, 5 workers. Argentina, Misiones, Loreto, Dr. A. A. Oglobin. IMLA.
- Ochetomyrmex (Brownidris) argentinus* (Kusnezov). Syntype 1 female. Tucuman, Trancas, ii.1947. IMLA.
- Ochetomyrmex (Brownidris) bolivianus* (Kusnezov). Holotype 1 female. Bolivia, entre Warnes y Montero, Sta. Cruz, Wygodzinsky, 27/28-1-1958. IMLA.
- Octostruma stenognatha* Borgmeier and Kempf. Paratype 1 worker. Brazil, Nova Teutonia, 27°11'S, 52°23'W, 3-500 m, Fritz Plaumann, vi.1957. IMLA.
- Oligomyrmex (Erebomyrma) eidmanni* (Menozzi). Syntypes 6 workers. Resistencia Chaco, 6.17.948. IMLA.
- Oligomyrmex (Erebomyrma) eidmanni* (Menozzi) Syntypes 3 workers. Brazil, Mendes, H. Eidmann, 3.10.33. IMLA.
- Oligomyrmex stenopterus* Kusnezov. Types 2 females. #6087, Argentina, Misiones, Est. Exp., Loreto, Dr. A. A. Oglobin. IMLA.
- Orectognathus clarki* Brown. Paratype 1 worker. Australia, Victoria, Ferntree Gully, W. L. Brown, 1.1.58. IMLA.
- Oxyepoecus (Martia) inquilina* (Kusnezov). Holotype 1 worker. #1832, Argentina, Tucuman, Jardin Ins. M. Lillo, N. Kusnezov, 2.v.1948. IMLA.
- Oxyepoecus (Martia) minuta* (Kusnezov). Holotype 1 worker. Tucuman, Quebrada Cainzo, N. Kusnezov, 8-iv.1948. IMLA.
- Pheidole bambusarum* Forel. Cotypes 9 workers. Brazil, São Paulo, Grand bambou forêt, Lutz. IMLA.
- Pheidole carapunco* Kusnezov. Syntypes 1 soldier, 6 workers. #1295, Argentina, Tucuman, Carapunco, 2,600 m, N. Kusnezov. IMLA [1 worker lectotype designated by E. O. Wilson].
- Pheidole descolei* Kusnezov. Lectotype and paralectotypes 9 workers. Argentina, Salta, Apolinario, Saravia, F. E. Luna, 1948. IMLA [1 worker Lectotype designated by E. O. Wilson].
- Pheidole gavrilovi* Kusnezov Lectotype 1 worker, paralectotypes 1 female, 6 workers. #5137, Argentina, Misiones, Loreto, 19.vi.949. IMLA [1 worker Lectotype designated by E. O. Wilson].
- Pheidole (Elasmopheidole) lilloi* (Kusnezov). Holotype 1 female. Tucuman, 7.i.48, IMLA.
- Pheidole minutissima* Kusnezov. Lectotype worker, paralectotypes 5 workers. #5348, Argentina, Misiones, Eldorado, N. Kusnezov. IMLA [1 worker Lectotype designated by E. O. Wilson].
- Pheidole (Elasmopheidole) subaberrans* (Kusnezov). Paratypes 2 workers. #1679,

- Salinas, 16.4.48; 1 female. #4586, Salta, Oran, 23.11.48; 2 females. Rio Calera, 25.4.48; 1 worker. #1792, ?. IMLA.
- Pheidole (Eriopheidole) symbiotica* (Kusnezov) Paratypes 1 female, 1 male, 7177, La Picaga, N. Kusnezov, v.1951. IMLA.
- Pogonomyrmex anergismus* Cole. Paratypes 2 females. #2911, USA, New Mexico, A. C. Cole, Sept. 12, 1961. IMLA.
- Pogonomyrmex guatemaltecus* Wheeler. Cotypes 3 workers. MCZ-Cotype 20-24 20577, Guatemala, Zacapa, W. M. Wheeler, Dec. 12, 1911. IMLA.
- Pogonomyrmex longibarbis andinus* Kusnezov. Paratypes 3 females, 2 males, 3 workers. #5712, San Antonio de los Cobres, 22.12.49. IMLA.
- Pogonomyrmex longibarbis andinus* Kusnezov. Paratypes 3 workers. La Rioja, San Refugio del Penon, 4,000m, Monros, 1.47. IMLA.
- Pogonomyrmex marculi lobatus* Kusnezov. Paratypes (?) 3 workers. Bolivia, Cochabamba, La Paz, N. Kusnezov. IMLA [unlabeled standard red type label].
- Pogonomyrmex meridionalis leonis* Kusnezov. Paratypes 4 workers. #5834, Santa Cruz, Canadon, N. Kusnezov. IMLA.
- Pogonomyrmex odoratus* Kusnezov. Paratypes 3 males, 6 workers. #3553, Cerro Olto, 6.2.49. IMLA.
- Pogonomyrmex odoratus* Kusnezov. Paratypes 1 female, 1 worker. Bariloche, 6.2.49. IMLA [unlabeled red type label].
- Pogonomyrmex rugosus* Emery. Cotype 1 worker. USNM type #54071, USA, California, S. Jacinto, T. Pergand. IMLA.
- Procryptocerus marginatus* Borgmeier. Paratype 1 worker. Brazil, Bahia, Uruçuca, P. Silva, 1947. IMLA.
- Procryptocerus montanus* Kempf. Paratypes 12 workers. #1645, Brazil, SP, Campos do Jordão, Kempf, 14.xi.1956. IMLA.
- Solenopsis (Labauchena) acuminata* (Borgmeier). Cotype 1 female. Luna. IMLA.
- Solenopsis basalis major* Forel. Cotypes 6 workers. #12085, Argentina, La Plata, Bruch, 9.10.1912. IMLA.
- Solenopsis clyptemnestra bruchi* Forel. Cotypes ? #12093/92, Argentina, La Plata, Bruch, 1892. IMLA.
- Solenopsis clyptemnestra orestes* Forel. Cotypes 22 workers. Brazil, Ceara, Roche. IMLA.
- Solenopsis (Synsolenopsis) egregia* (Kusnezov). Paratypes 4 females, 11 workers. #1298 Argentina, Tucuman, Tafi del Valle, N.K., 3.10.48. IMLA.
- Solenopsis (Synsolenopsis) eximia* (Kusnezov). Syntype 1 worker. #2411, Uriburu, Formosa, 6.21.48. IMLA.
- Solenopsis globularia* Forel. Syntypes 2 workers. IMLA.
- Solenopsis hammari carhuensis* Forel. Cotype 1 worker. Buenos Aires, Bruch. IMLA.
- Solenopsis latastei hoffmanni* Forel. Syntypes 5 workers, 7 females. IMLA.
- Solenopsis (Bisolenopsis) sea* (Kusnezov). Syntypes 4 males, 4 females. #752, Argentina, Santa Fé, Villa Ana, H. Willink, 2.1946. IMLA.
- Solenopsis (Paranamyrmex) solenopsidis* (Kusnezov). Paratypes 2 females. #7122, La Picaga, E. Rios, N. Kusnezov. IMLA.
- Solenopsis (Paranamyrmex) solenopsidis* (Kusnezov). Paratype 1 female. #4996, Misiones, Iguazu, N. Kusnezov, 25.7.49. IMLA.

- Solenopsis spei* Forel. Cotypes 6 workers. Esperanza, A. Forel, in nest of *Atta cephalotes*. IMLA.
- Strumigenys planeti* Brown. Paratypes 2 workers. Bolivia, Beni, Huachi, W. M. Mann, 1921-22, Mullford Exp. IMLA.
- Strumigenys praecava* Brown. Paratypes 3 workers. MCZ-Paratype #29293, Panama, Barro Colorado Island, W. M. Wheeler, 6.27.24. IMLA.
- Tetramorium (Triglyphothrix) desertorum* (Forel). Syntypes 8 workers. IMLA.
- Wasmannia williamsoni* Kusnezov. 1 worker. #6060, Gral, Pico. IMLA [unlabeled red type label]
- Zacryptocerus (Paracryptocerus) borgmeieri* (Kempf). Holotype and paratypes 6 workers. #5330, Misiones, Iguazu, N. Kusnezov, 29.7.49. IMLA.
- Zacryptocerus (Paracryptocerus) borgmeieri* (Kempf). Paratype 1 worker. Misiones, Iguazu, N. Kusnezov. IMLA.
- Zacryptocerus (Paracryptocerus) coffeae* (Kempf). Paratype 1 female, 1 worker. Colombia, Cundinamana, Tibacuy, 18.iii.952. IMLA.
- Zacryptocerus (Paracryptocerus) coffeae* (Kempf). Paratype 1 worker. Colombia, Cundinamana, 1500m, Bernel + Mendoza, 13.3.1952. IMLA.

PONERINAE

- Ectatomma regis* Kusnezov. Holotype 1 worker. Argentina, Salta, El Rey, Nogues N. Kusnezov, 14.ii.1953; paratype 1 worker. #6185, Argentina, Tucuman, Ruta 9 km 1335; paratype 1 worker, Argentina Rio Sali, 40 km of Tucuman 10.1.48 IMLA.
- Metapone hewitti* Wheeler. Paratype 1 worker. F946, Malaysia, Borneo, Kuching, J. Hewitt. IMLA.
- Metapone tillyardi* Wheeler. Cotype 1 female. MCZ-Cotype 1-2 20787, Mt. Tambourine, A. M. Lea. IMLA.
- Pachycondyla (Neoponera) goldbachii goyana* (Kusnezov) Holotype and paratype 2 workers. #4792, Argentina, Misiones, Iguazu, 7.24.1949. IMLA.
- Probolomyrmex brujitae* Agosti. Holotype, female. Argentina, Jujuy Aguas Blancas-Yaculica (Argentinian-Bolivian frontier), 22°43'44"S 64°22'25"W, 460 m, 25 October 1994, D. Agosti & J. M. Carpenter.

PSEUDOMYRMECINAE

- Pseudomyrmex acanthobia cocae* Santschi. Typus 6 females, 3 males, 7 workers. Argentina, Alta Grande, La Granja, Sierras de Cordoba, C. Bruch, 1.922. MACN.
- Pseudomyrmex arborissanctae symbioticus* Forel. Cotypes 6 workers, #12010, Colombia, Dibulla. IMLA.
- Pseudomyrmex (Pseudomyrma) championii haytiana paulina* (Forel). Cotypus 1 female, 1 worker Argentina, Bruch, 989. MACN.
- Pseudomyrmex flavidula laevivertex lizeri* Santschi. Cotype 1 worker. #1144, Bolivia. MACN.
- Pseudomyrmex (Pseudomyrma) gracilis argentina* (Santschi). Typus 2 workers. #2026, Argentina, Misiones, Loreto (Est. Exp.), Dr. A. A. Oglobin. MACN.
- Pseudomyrmex (Pseudomyrma) gracilis glabriventris* (Santschi). Typus 1 worker, cotypus 1 female. #1170, Bolivia. MACN.

Pseudomyrmex (Pseudomyrma) gracilis sericata (Santschi). Typus 4 workers. Paraguay. MACN.

Pseudomyrmex oglobini Santschi. Cotypes (?) 9 workers. #2088, Argentina, Misiones, Loreto, Dr. A. A. Oglobin; Nido ne las tamas de lapacho (Tecoma Ipe) de 35 mts de altura - Patoreo (Grande) IMLA.

ACKNOWLEDGMENTS

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NOTES ON THE GENUS *THASUS* (HEMIPTERA: COREIDAE)

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Abstract.—New distributions are given for *Thasus neocalifornicus* Brailovsky and Barrera, *T. gigas* (Klug), *T. acutangulus* (Stål), *T. luteolus* Brailovsky and Barrera, and *T. rutilus* Brailovsky and Barrera. Measurements of several instars and a key to the last three instars of the first three species are given. These new country records are given: *T. acutangulus*, El Salvador; *T. luteolus*, Panama; *T. rutilus*, Bolivia. The distribution of *T. neocalifornicus* is discussed, as are differences among its populations and between them and *T. gigas*. We conclude, tentatively, that *T. neocalifornicus* from the United States-Mexican landmass more closely resembles the *neocalifornicus-gigas* common ancestor than do *T. neocalifornicus* populations from Baja California Sur.

The genus *Thasus* (Coreinae: Nematopodini) was revised recently by Brailovsky et al. (1995b). Since the publication of that revision, some additional data have become available, which we present here. These data are new distributional records for five species, and an account of the immatures of three of them. We also discuss the distribution of *Thasus neocalifornicus* Brailovsky and Barrera and distributional differences in the relative length of its third and fourth antennal segments; this relative length is a feature that sets this species apart from others in the genus.

NEW DISTRIBUTIONAL RECORDS OF *THASUS* SPP.

- Thasus acutangulus* (Stål)**— El Salvador: [new country record]: Mt. San Salvador, 4,000–6,400 ft; 2 mi down from Cerro Verde summit
Guatemala: Antigua; Acatenango
Honduras: [no other data]
México: Chiapas, nr. Slope of Cerro Bola; Chiapas, Municipio de Angel Albino Corzo, mountain rain forest; Municipio de Las Rosas, 3 km SE Aguacatenango, 1,671 m.
- Thasus gigas* (Klug)**— Guatemala: [new country record]: Cunea, 6,000 ft; Chichicastenango, 6,000 ft.
México: San Luis Potosi, 31 km SE of S.L. Potosi, 1,500 m; 2 mi SE of Pedro Montoya. Guadalajara [no further data]. Chiapas, 5 km SE of Jitotol, 1,676 m; Chiapas [sic], Escuintla
Note: In the San Luis Potosi Pedro Montoya specimens, the fourth antennal segment is pale red-brown, like that of *T. neocalifornicus* (see diagnosis of the latter in Brailovsky, et al. [1995b])

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- Thasus neocalifornicus*— México: Sinaloa, Los Mochis; 40 mi s. Culiacan. Sonora, Alamos; Llano; Minas Nuevas; Agua Zarca; E. of Carbo
- United States: Texas, Lyford (Willacy Co.)
- Thasus rutilus* Brailovsky and Barrera— Bolivia: [new country record]: Prov. Sara
- Thasus luteolus* Brailovsky and Barrera— Panama: [new country record]: Boquete, Chiriqui, 800 ft.

The new distributional records for *Thasus gigas* and *T. rutilus* do not extend the ranges of these species notably. The distribution of *T. neocalifornicus* is considered in more detail below. We have also a specimen of *T. neocalifornicus* labeled simply "California, Wickham." We cannot find a Wickham in California, and believe the label to be an error.

If, as we suggest (Brailovsky et al. 1995b), the Costa Rican record of *T. acutangulus* is based on a misidentification, the present El Salvador record extends the range of this species somewhat further south. The new Panama record for *T. luteolus*, hitherto known only from Costa Rica (Brailovsky et al. 1995b), also extends this species' range to the south.

NYPHS OF *THASUS*

Among the specimens assembled for the revision were a few third through fifth instars, including some of the closely related genus (Brailovsky et al. 1995b) *Pachylis*. These nymphs were all dried, on pins. Because of their shriveled condition and because color varies markedly in *Thasus* (and probably in *Pachylis* too), we do not describe these nymphs, but record some measurements (Table 1). We give a key to separate the two genera and the first three instars of the three *Thasus* species available. The egg and the nymphs of *Thasus gigas* have been described and measured by Brailovsky et al. (1995a).

KEY

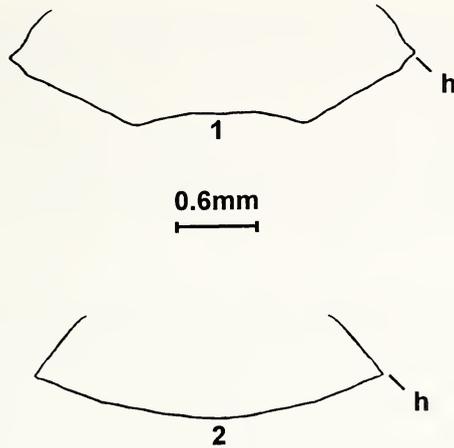
1. Humeral angles obtuse, but with small spine (if spine removed, angle obtuse); posterior border of pronotum with shallow median depression (Fig. 1); hind-tibial dilation asymmetrical on each side of medial tibial ridge (as in adult); one small but distinct tooth subapically on hind tibia *Pachylis*
- Humeral angles sharp, acuminate, sometimes with spine (if spine removed, angle remains acuminate); posterior border of pronotum straight (Fig. 2); hind-tibial dilations symmetrical on each side of medial tibial ridge (as in adult); two small but distinct teeth of equal size subapically on hind tibia (*Thasus*) 2
2. Pronotum almost entirely dark, sometimes with pale central area; humeral angle with small acuminate point *T. gigas*
- Pronotum not almost entirely dark, either lighter or with pale margins; humeral angle with large acuminate point 3
3. Pronotum dark with white or yellow lateral and posterior margins; fourth antennal segment 1.5 times longer than third *T. acutangulus*
- Pronotum yellow to red on disc, this sometimes spreading to margins; fourth antennal segment subequal to or slightly longer than third *T. neocalifornicus*

Table 1. Measurements (mm) of *Thasus* nymphs.

	<i>Thasus gigas</i>		
	Third instar (N = 3)	Fourth instar (N = 3)	Fifth instar (N = 5)
Total length	15.5 (13.8–17.1)	17.8 (17.3–18.7)	25.2 (21.1–28.3)
Width at widest point (abdomen)	8.1 (7.5–8.4)	10.4 (10.3–10.5)	12.5 (10.9–14.0)
Antennal segments: 1	4.6 (4.4–4.9)	6.2 (6.0–6.5)	6.2 (5.9–6.8)
2	3.7 (3.6–3.7)	5.1 (4.5–6.5)	5.0 (4.5–5.8)
3	3.6 (3.6)	5.0 (4.9–5.1)	4.8 (4.6–5.1)
width of 3	2.4 (2.3–2.5)	3.0 (2.9–3.2)	2.5 (2.1–2.9)
4	3.6 (3.6)	4.9 (4.6–5.1)	5.2 (4.9–5.5)
Hind tibia: length	8.5 (8.4–8.9)	12.4 (12.2–12.8)	12.2 (11.5–13.0)
width	2.0 (2.0)	2.9 (2.7–3.0)	2.7 (2.3–2.9)
	<i>Thasus neocalifornicus</i>		
	Second instar (N = 2)	Fifth instar (N = 8)	
Total length	10.7 (10.0–11.4)	25.7 (22.6–28.6)	
Width at widest point (abdomen)	5.5 (5.3–5.6)	11.6 (9.8–13.6)	
Antennal segments: 1	3.2 (3.1–3.2)	6.1 (5.1–6.8)	
2	2.5 (2.5)	4.9 (4.6–5.5)	
3	2.6 (2.6)	4.6 (3.5–5.2)	
width of 3	1.2 (1.2)	1.9 (1.0–2.9)	
4	2.5 (2.4–2.5)	4.6 (4.3–4.8)	
Hind tibia: length	5.2 (5.2)	11.4 (10.4–12.1)	
width	0.9 (0.9)	2.5 (2.2–2.8)	
	<i>Thasus acutangulus</i>		
	Second instar (N = 1)	Fifth instar (N = 4)	
Total length	10.6	21.6 (17.2–27.4)	
Width at widest point (abdomen)	6.2	10.7 (9.2–12.6)	
Antennal segments: 1	—	6.2 (6.0–6.4)	
2	—	4.9 (4.7–5.1)	
3	—	4.8 (4.7–4.9)	
width of 3	—	2.6 (2.4–2.6)	
4	—	6.6 (6.2–6.9)	
Hind tibia: length	6.0	11.4 (11.4–11.7)	
width	0.8	2.8 (2.6–3.1)	

THE DISTRIBUTION AND POPULATIONS OF *THASUS NEOCALIFORNICUS*

Thasus neocalifornicus had long masqueraded as *T. gigas* or *T. acutangulus*, until its status as a separate species was recognized (Brailovsky et al. 1995b). *T. gigas* is the sister species of *T. neocalifornicus*, and the two together compose the sister clade



Figs. 1–2. Pronotum of fifth instar. 1, *Pachylis* sp. h = humeral angle. 2, *Thasus acutangulus*. h = humeral angle.

of *T. acutangulus* + *carchinus*; the differences, similarities, and intraspecific variations of these species have been described (Brailovsky et al. 1995b).

Most of the several hundred *Thasus neocalifornicus* we have seen (and others recorded in Brailovsky et al. [1995b]), are from Baja California Sur, and the United States. Oddly, until now no one has noted that the United States *T. neocalifornicus* is almost completely restricted to the Tucson, Arizona, area, in southern Arizona (Pima, Cochise, and Santa Cruz counties); no specimen among the several hundred seen from the U.S. (including a large collection from Texas A&M University) has been found from west of this area, and only two specimens from east of it. Despite earlier listings of *T. neocalifornicus* (sometimes as *Pachylis gigas*) from New Mexico (e.g., Uhler, 1876; and see Brailovsky et al. [1995b] for summary), we have found no specimen from this state, although it begins only 100 miles east of the Arizona populations.

The two specimens we have seen from east of Arizona were collected on August 19, 1975, in Lyford (Willacy Co.), Texas, which is about 40 miles north of Brownsville. These specimens are somewhat darker than many others, but they fall well within the considerable range of color variation in this species.

Another Texas population of *Thasus neocalifornicus* may be in the making. Dr. Walker Jones (USDA, Weslaco, Texas) writes (September 1993 and, in more detail, March 1995) that in 1992 he accidentally released a few females at Weslaco and, to his surprise, found nymphs the following spring; these he collected when they became adults but, if others avoided capture, a population may develop on *Prosopis glandulosa*, which is readily available. (Note: in his account of these bugs' biology, Jones [1993] referred to them as *Thasus* "*neomexicanus*," a *lapsus calami*.) Weslaco is some 30 miles south of Lyford.

The Mexican populations of *Thasus neocalifornicus* are concentrated at the southern tip of Baja California Sur, in Miraflores, Sierra Laguna, La Paz, Todos Santos, El Triunfo, Cabo San Lucas, San Bartolo, and San Domingo; these are all within 50

miles of Cabo San Lucas, at the tip of the peninsula. In addition, we have seen specimens from Mulege, halfway up the inner coast, and from Rosario, on the outer coast some 150 miles south of the U.S. border. All these Baja California specimens were collected over half a century (1919–1971) by different people, most of whom were Americans. It seems likely then that these collectors did not travel only to the tip of the peninsula, but collected down its length and back up. In other words, the abundance of these bugs at the tip of Baja California Sur does not reflect collector bias; these bugs occur here in greater numbers than they do elsewhere on the peninsula.

They occur here in much greater numbers also than elsewhere in México. We have specimens—only a few in each case—from only eight other localities, Los Mochis and near Culiacan (Sinaloa); and Santa Ana (Brailovsky et al. 1995b), Alamos, Llano, Minas Nuevas, Agua Zarca, and near Carbo (Sonora). Los Mochis is on the coast of the Gulf of California, not far from the Baja-tip populations; and Culiacan is some 100 miles south, also on the coast, near the tip of Baja California Sur. Santa Ana and Llano are equally close to the Arizona populations; Carbo is about 50 miles south of Santa Ana and roughly the same distance from the Gulf of California; but Alamos is far removed from any other population of *T. neocalifornicus*; we cannot find the other two Sonora localities on our atlases, but the entire state of Sonora is no more than 200 miles from the Gulf of California, and is across the Gulf from Baja California.

We have examined representatives of these populations closely, seeking both intra- and interspecific relationships. We looked particularly closely at characters that separate the species, especially *T. neocalifornicus* from *T. gigas*. We wondered if perhaps mainland *T. neocalifornicus* might more closely resemble *T. gigas* (also mainland) than do peninsular (Baja California) *T. neocalifornicus*.

Genitalia.—The degree of spermathecal coiling and the shape of the tooth on the second valvula are the same in both Baja California and Arizona *T. neocalifornicus*, and differ from those in *T. gigas*: less coiling and more deeply bifid, respectively, in *T. neocalifornicus* than in *T. gigas*. With respect to the inner medial projection of the ventral rim of the male's genital capsule, the variation between *T. neocalifornicus* and *T. gigas* is as great as that between *T. neocalifornicus* from Sonora and Sinaloa, and as that between *T. neocalifornicus* from Arizona and Baja California; also within this range of variation are specimens of *T. gigas* from Oaxaca, San Luis Potosi, and Guadalajara. The genital capsule of the single Texas male resembles those from Sonora more than those from elsewhere.

Thus these genitalic characters neither support nor refute the idea that *T. neocalifornicus* from mainland México (and Arizona) more closely resemble *T. gigas* than do *T. neocalifornicus* from Baja California.

Color of fourth antennal segment.—This antennal segment in *Thasus neocalifornicus*, although usually reddish, may be as dark brown as that of *T. gigas*. The latter occurs farther south in México, and the fourth antennal segment of the adult is longer than its third, never subequal. Also, the dark brown of the *T. neocalifornicus* fourth segment often pales to reddish distally. It is interesting in this regard that the third and fourth antennal segments of nymphal *T. gigas* are subequal (Table 1).

The proximal half of the *T. neocalifornicus* second antennal segment may be paler than the distal half, rather than the more usual concolorous. Indeed, this segment in

several specimens from the Huachuca Mountains of Arizona is as red as in *T. acutangulus*, with which these specimens may be confused. However, antennal segments three and four are subequal in these specimens, proving them to be *T. neocalifornicus*.

Humeral angles.—In *Thasus neocalifornicus* the humeral angles are produced as a small spine (Figs. 3–5). The spines of its sister species, *T. gigas*, are more blunt (Fig. 6). In the sister clade (*T. acutangulus* + *carchinus*) of both these species, the humeral angles of *T. carchinus* are more produced than they are in *T. neocalifornicus*, and the angles of *T. acutangulus* are sharp but not produced (Brailovsky et al. 1995b).

The humeral angles of the Arizona and Mexican-mainland (Sinaloa, Sonora) *T. neocalifornicus* are somewhat less acute and produced (Figs. 3, 4) than are the angles of the Baja California Sur populations (Fig. 5). The former bugs' humeral angles therefore resemble those of *T. gigas* slightly more closely than do those of the latter.

Thus of the characters so far compared, only the humeral angles suggest that some populations of *T. neocalifornicus* may be more closely related to *T. gigas* than are other populations. This is insufficient evidence to suggest that *T. neocalifornicus* and its sister species *T. gigas* arose from their common ancestor on the Mexican mainland, although certainly the distribution of the two species supports such a suggestion.

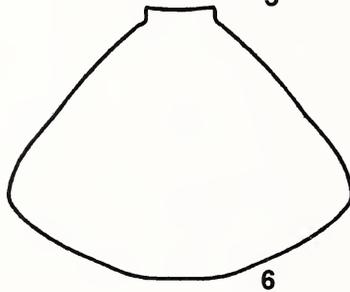
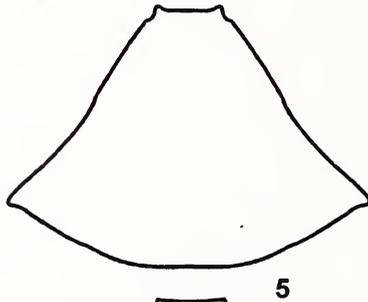
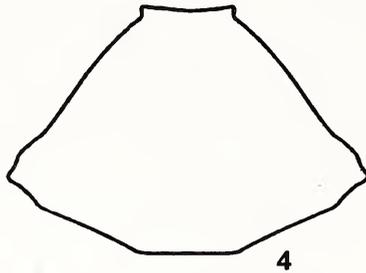
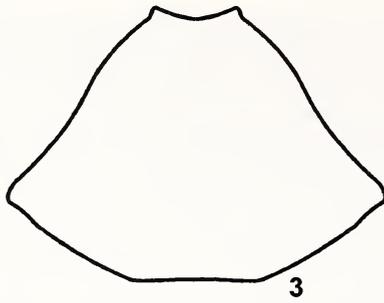
Ratio of third and fourth antennal segments.—*Thasus neocalifornicus* is alone in the genus in having the third and fourth antennal segments equal or subequal; the fourth is longer than the third in the other species, as it also is in the sister genus, *Pachylis* (Brailovsky et al. 1995b). We measured these segments in specimens from several *T. neocalifornicus* and *T. gigas* populations to see what differences there might be among populations, and if populations of one species geographically closer to the other might also be closer in third:fourth antennal segment ratios.

The third and fourth antennal segments of *Thasus neocalifornicus* are equal (ratio of 1.0) to subequal (lowest ratio 0.85, from the Santa Rita Mountains and the Texas specimens) (Table 2). In *T. gigas*, on the other hand, the third is consistently shorter than the fourth (highest ratio 0.80, from Cuernavaca).

The two segments from Baja California specimens are more nearly equal than are those from other localities' specimens; in some of these Baja California specimens, the third antennal segment is actually slightly longer than the fourth (Table 4). All these Baja California specimens came from the tip of the peninsula; unfortunately, the specimens from further north were not available for measuring.

The ratio of the U.S. (0.90) and of the mainland Mexican (0.87) *T. neocalifornicus* are lower (third and fourth less equal) than those of the Baja California (0.95) (third and fourth more nearly equal). The U.S. and mainland *T. neocalifornicus* ratios thus approach those of *T. gigas* (0.77) more closely than do those of the Baja California specimens.

Conclusions.—The scant evidence presented here suggests (but only suggests) that the Baja California populations are isolated and have diverged more from the *neocalifornicus-gigas* common ancestor than have the *T. neocalifornicus* populations on the United States-Mexican landmass. These latter populations are somewhat similar to *T. gigas* in the shape of their humeral angles and in the relative lengths of their third and fourth antennal segments.



6.5mm

Figs. 3-6. Pronota of adult *Thasus*. 3, *T. neocalifornicus* (México: Sinaloa: Los Mochis). 4, *T. neocalifornicus* (U.S.: Arizona: Tucuman). 5, *T. neocalifornicus* (México: Baja California Sur: Miraflores). 6, *T. gigas* (holotype) ("México").

Table 2. Ratios of third to fourth antennal segments of different populations of *Thasus neocalifornicus* and *T. gigas*.

		<i>Thasus neocalifornicus</i>	
Locality		Third : fourth ratio	N
Mexico:	Sonora	0.85	7
	Sinaloa	0.90	6
Mexico: mainland		0.87	13
Arizona:	Tucson	0.95	3
	Baboquivari Canyon	0.93	1
	Patagonia	0.87	12
	Santa Rita Mountains	0.85	2
	"Arizona"	0.91	1
	Santa Catalina Mountains	0.94	2
	Fairbank	0.93	1
Arizona: all		0.90	21
Texas:		0.85	1
Baja California Sur	Triunfo	0.97	16
	San Domingo	1.05	1
	Cabo San Lucas	0.92	2
	San Bartolo	0.90	3
	Miraflores	1.02	10
	Sierra Laguna	0.96	7
Baja California Sur: all		0.95	39
		<i>Thasus gigas</i>	
Locality		Third : fourth ratio	N
Jalisco		0.75	11
México	Ternascaltepa, Cuernavaca	0.82	3
Chiapas		0.73	2
Hidalgo		0.77	3
San Luis Potosi		0.78	8
México: all		0.77	27

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THE REAL IDENTITY OF
DISCOELIUS STRIGOSUS COSTARRICENSIS BERTONI
(HYM.: VESPIDAE: EUMENINAE)

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Abstract.—The identity of *Discoelius strigosus costarricensis* Bertoni = *Zethus strigosus* Saussure revised status, is solved and *Zethus smidtianus* n. sp. is described based on the mis-identification of *costarricensis* by Bohart and Stange, 1965 and subsequent authors.

In 1925 Bertoni described *Discoelius strigosus costarricensis*, based on material from San José, Costa Rica. Forty years later, Bohart and Stange (1965) elevated the name *costarricensis* to species, based on material they believed they determined correctly, despite that they did not examine the type, considered to be—with the rest of Bertoni collection—locked in the basement of a bank in Asunción, probably the Banco de Fomento (Willink, 1982; Carlos Aguilar pers. comm.).

In 1991, thanks to the negotiations of Dr. Blanca Barrios, the Instituto Agronómico Nacional (IAN) gave as donation to the Museo Nacional de Historia Natural del Paraguay, Inventario Biológico Nacional (IBNP) an insect collection that belonged to A. W. Bertoni. In 1995, thanks to the encouragement given by James Carpenter, Abraham Willink and Arnold Menke, I started to work this collection, finding in it a large amount of vespidae type material described by Bertoni as well as interesting additional material that included specimens determined with unpublished names. The collection said to be deposited in the Banco de Fomento is no longer there and seem to be referable to the one IAN donated to the IBNP. Another insect collection that belonged to Bertoni was deposited in Puerto Bertoni (Garcete Barrett, 1996), until very recently, when John Kochalka and I brought it to the IBNP to be fully curated due its poor state of conservation. The complete restoration of these collections still awaits a long time, but in the mean while the discovery of the type of *Discoelius strigosus costarricensis* and a specimen identified under an unpublished name give light to a problem that may not be overlooked.

Zethus strigosus Saussure, 1875

Zethus strigosus Saussure, 1875. Smithsonian Misc. Coll. 254: 42. Lectotype male, Orizaba, Veracruz, México (Genève).

Zethus fortistriolatus Cameron, 1907. Entomologist 40: 82. Holotype female, Nicaragua (London).

Zethus mimus Zavattari, 1912. Arch. f. Naturgesch. 78 (Abt. A), Heft 4: 64. Holotype female, "Brasilien" (Berlin).

Discoelius strigosus costarricensis Bertoni, 1925. Rev. Soc. Cient. Paraguay (2) 1: 75. Lectotype female, San José, Costa Rica (Bertoni collection, IBNP), here designated [examined], **revised status**.

The description given by Bertoni (1925) for *Discoelius strigosus costarricensis* is as follows:

"*Foem.* Atra, obscure sericea; abdominis primo segmento nitido, apice flavo; alis nigris, apice albis. clypeo truncato, striato-punctato[*sic!*]; fronte striata.

Se le acerca la var *d* de Saussure (Am. Sol. Wasps. p. 42). La forma típica de Méjico es más clara y adornada, con las alas sub hialinas. Se asemeja en el peciolo a los *Zetamenes* W. Bertoni y en el color imita a *Mischocyttarus smithi*, etc.

Col. Bertoni, San José de Costa Rica (C. Amér.)."

This is a very short description but fits perfectly with a single female in the Bertoni collection, and labeled "Costa Rica, S. José", "3167.", "*Discoelius strigosus* Sss. var. *e* ined.". I also labeled it with the reference number "B. 209" as part of the recovery work. It bears no type label, but judging from the external evidence (Rec. 72B of the International Code of Zoological Nomenclature) there is no doubt this is a type specimen, and I designate it as Lectotype according with Rec. 73F and Art. 74b of the International Code of Zoological Nomenclature, taking into account that Bertoni did not mention how many specimens he saw.

The specimen fits with the key and description given by Bohart and Stange (1965) for *Zethus strigosus* Saussure, but is darker, with yellow marks as follows: conspicuous mandibular band and subapical band on tergum I, this last suddenly becoming thinner and briefly disappearing medially; less conspicuous are: scrobal spots, tiny spot in the inner orbit, tiny spot behind the posterior angle of the eye, mostly beneath flagelomeres II-X, a pair of indistinguishable tiny humeral spots, a pair of thin longitudinal bands on the posterior face of the propodeum, and lateral, almost indistinguishable, indications of subapical bands on terga II, IV-V and sterna III, IV-V, as well as basolateral spot on tergum VI. The wings are more or less black, mainly along the costal area of the forewing, this last having a whitish tip.

I compared this specimen with reference material of *Zethus strigosus* determined by Bohart and Stange: Mexico: Nayarit, 6 mi. E. San Blas, 4. ii. 64, 1 female (E. I. Schlinger col.) y 1 male (M. E. Irwin col.), UCD; Veracruz, Jalapa, 1 female, UCD; Oaxaca, 12 mi S. Chivela, 18. viii. 1958, 1 male (L. A. Stange y A. S. Menke cols.), UCD; Panama: Potrerillos, 5. v. 35, 2 males UCD.

I was unable to find any structural difference between the Lectotype of *strigosus costarricensis* and the reference material. About the color pattern I must say that it is still in the range of variation within the species, existing only a remarkable reduction of the yellow markings, the male from Nayarit is the closest in this respect. The only really remarkable difference is the wing pattern, almost uniformly hyaline yellowish in all the additional specimens.

***Zethus smidtianus*, n. sp.**

[*Zethus costarricensis*: Bohart and Stange, 1965. Univ. Calif. Pub. Entom. 40: 97. Subsequently: Stange, 1978. Acta Zool. Lilloana 33: 78 (key); West-Eberhard et al., 1995. Hym. Costa Rica: 574. Misidentification].

I use this name in order to commemorate Bertoni's memory, who labeled with it a female specimen that perfectly fits with the key and description given by Bohart and Stange (1965) for their concept of *Zethus costarricensis*.

Holotype female (Figs. 1, 2): Length from antennal insertions to apex of tergum

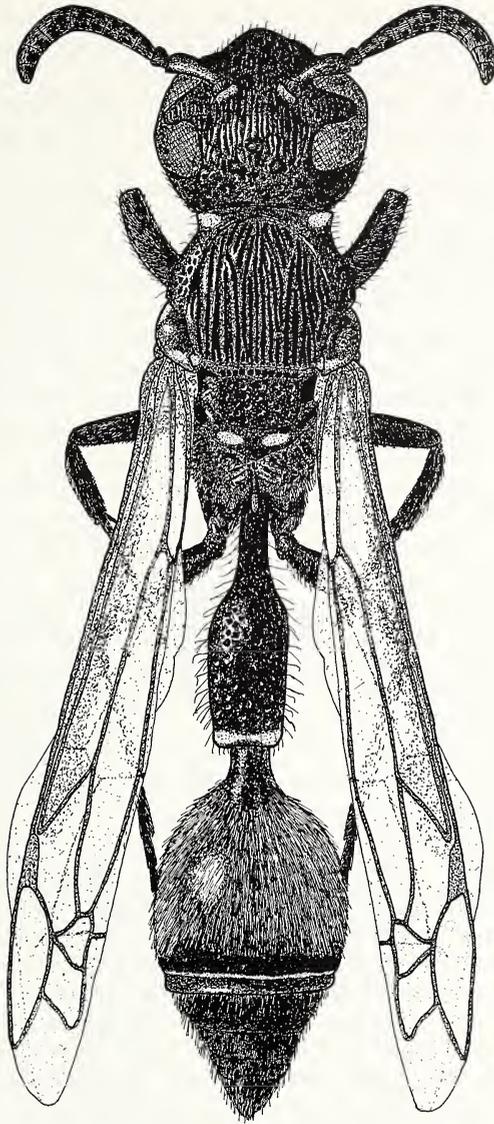
**1**

Fig. 1. *Zethus smidtianus* n. sp., female habitus.

II about 13 mm. Black with yellow as follows: subapical and lateral marks on clypeus, scrobal spots, humeral spots, anterior and inner posterior corners of the tegulae, parategulae, a pair of oval transversal spots on metanotum, subapical bands on terga I-II and sternum II, longitudinal anterior line on fore and mesotibiae. Wings hyaline yellowish with light brownish infuscation along the costal region of the forewing. Venation dark brown.

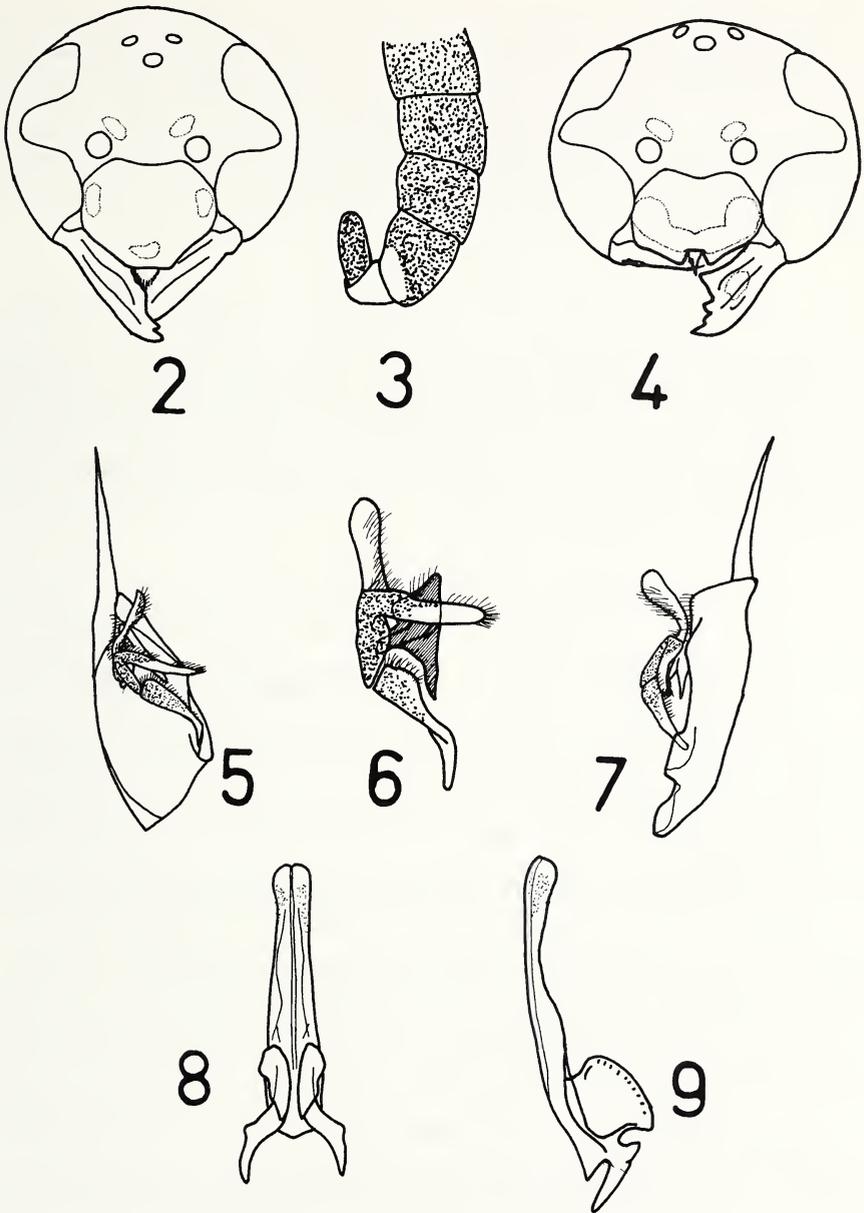
Clypeus striatopunctate, frons longitudinally, rather irregularly striate and with strong punctures into the striae, ocular sinus striatopunctate, vertex and gena with strong punctuation, pronotum strongly punctate, some longitudinal wrinkles present on the subhumeral area, mesoscutum longitudinally, rather irregularly striate and with punctuation more casual than on frons, disk of scutellum flat, polished and with large, sparse, rather shallow punctures and very rare almost absent micropunctuation on the intervals, upper face of metanotum sculptured as scutellum, posterior face of metanotum without macropunctures, upper and posterior face of propodeum with coarse reticulation that obscures the transversal striae that otherwise are well developed towards the middle, lateral face of the propodeum with large, very sparse punctures that progressively concentrate towards the anterior corner, mesopleura strongly punctate, tergum I polished and with strong punctuation except for the subapical band, that lacks punctures, tergum II moderately punctate and with macropunctures concentrated on a polished subapical band, this last having a very narrow impunctate apical region followed by a narrow crenulated furrow preceding the apical lamella, which is slightly raised, tergum III subapically with macropunctures finer than those on tergum II, almost immediately followed by a very narrow crenulated furrow that precedes the apical lamella, this one not raised at apex.

Head, mesoscutum and tergum I with pale, sub-erect, sparse pilosity, specially sparse on the latter, remaining terga with fulvous, decumbent, relatively dense pilosity, denser on tergite II. Metanotum and mainly propodeum with pale, decumbent, relatively dense pilosity as well as suberect pilosity.

Clypeus truncated apically, interantennal carina well developed and entering into the clypeus, OOL: POL = 3 : 2, 2, notauli almost complete, propodeum with a distinct medial longitudinal carina, tergum I in dorsal view suddenly expanding after the stem and more or less parallel sided, subapical polished band longer submedially, here it is longer than the apical band, this last being longer than a midocellar diameter, midtibia with two spurs, the hind one being a bit longer.

Male (Figs. 3, 4, 5, 6, 7, 8 and 9): Similar to the female. Length from antennal insertion to the apex of tergum II about 8 mm. Yellow color on clypeus forming a wide U-shaped mark, also yellow are a mandibular spot and the inner apex of flagellomere VIII, as well as almost the whole inner face of flagellomeres IX and X (in the UCD male there is not yellow on flagellomere VIII and flagellomere IX is yellow only at apex). The punctuation on frons and mesoscutum is more evident than in the female, being the sculpture almost striatopunctate. Clypeus with an apical notch. Genitalia similar to those figured by Bohart and Stange (1965: 201, figs. 304 y 305) for *Z. evansi*, but the mast ("asta" following Giordani Soika, 1978: 7, fig. 1) of the cuspis lacks pilosity on the lower margin and the apex of the basivolsella is more expanded.

Holotype: Costa Rica: San José, 3168, female, Bertoni Collection, IBNP (I labeled it with the reference number "A: 41" as part of the recovery work).



Figs. 2–9. *Zethus smidtianus* n. sp. 2, female. 3–9, male. 2 and 4. Head in frontal view. 3. Last antennal segments. 5. Paramere and volsella in inner profile view. 6. Detail of the volsella. 7. Ventral view of paramere and volsella. 8. Ventral view of the aedeagus. 9. Profile view of the aedeagus.

Paratypes: Guatemala: Sacatepéquez, Capetillo, 5000 ft. 20. viii. 1974, 1 female (C. y P. Vaurie cols., F. Johnson leg.), UCD. Costa Rica: San José, 1913, 1 male, UCD; San José, San Antonio de Escazú, 1300 msnm, 1 male, AMNH.

There are additional specimens known (Bohart and Stange, 1965) but I was unable to examine: Colombia: Cauca, Villa Elvira, 1 female, Giordani Soika Collection; Costa Rica: San José, 1 female, UCD; San José, 1 female (M. Valerio col.), USNM. According to Menke (in litt.), who sent to me the complete data, this later specimen seems to be conspecific with photographs of the holotype I sent to him.

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OBSERVATIONS ON PHENOLOGY, DEVELOPMENT, AND MORTALITY OF LARVAE OF THE HAZELNUT WEEVIL (*CURCULIO OBTUSUS* (BLANCHARD): CURCULIONIDAE) IN NUTS OF BEAKED HAZELNUT (*CORYLUS CORNUTA* MARSHALL: BETULACEAE) IN THICKETS IN MAINE¹

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Abstract.—Little is known about the biology of the hazelnut weevil *Curculio obtusus* (Blanchard), though closely-related species are widespread and well studied. The objective of this study was to document details of development of larvae in nuts, including mortality factors, assessment of the infrequent phenomenon of multiple infestation of nuts, and confirmation of 4 larval instars. Samples of beaked hazelnuts taken every 4 days over the course of the summer, 1995, revealed the development of larvae through 4 instars, beginning with eggs in early June and progressing through 4th-stage grubs exiting nuts in late August. At the peak of infestation, in early August, 71% of the sampled nuts were infested with weevil larvae. Decay and non-formation of nut kernels accounted for an estimated 10% mortality among the larvae. Multiple infestation accounted for an additional 8% mortality due to interference competition. Nut predation also caused mortality of an estimated 10% of larvae.

The genus *Curculio* (Curculionidae; Curculioninae) is comprised of 27 species of nut- and acorn-infesting weevils in North America (Gibson, 1969). Most (23 species) inhabit oak trees (*Quercus* spp.); only *C. obtusus*, the hazelnut weevil, is known to specialize in hazelnuts (*Corylus* spp.) in the eastern half of the United States (Hamilton, 1890; Brooks, 1910; Gibson, 1969, 1985a, 1985b). This weevil exploits the nuts of wild (*Corylus americana* Walter) and beaked (*C. cornuta* Marshall) hazelnut not only for food at all stages but also for oviposition sites (Gibson, 1969).

Adult *Curculio* species emerge from the soil in early summer and fly to the nearest host tree or shrub where they feed on immature nuts or acorns and mate (Gibson, 1969; Raney and Eikenbary, 1968). The species are dimorphic; the females' rostra are somewhat to much longer than those of males, depending on species, and are used to excavate egg chambers in the nuts as well as to feed (Brooks, 1910; Gibson, 1969).

The vermiform *Curculio* grubs are reported to pass through 4 instars feeding inside their host nuts, destroying the nut kernel in the process. At maturity in the fall, they chew an exit hole in the nutshell and drop to the ground where they immediately burrow almost straight down, to depths from 9 to 28 cm among pecan weevils (*C.*

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caryae [Horn]) (Gibson, 1969; Harris, 1975; Harp and Van Cleave, 1976; Harrison et al., 1993), and enter a state of diapause. *Curculio* species pass the majority of their lives as subterranean diapausing larvae. The length of diapause varies within species; Menu and Debouzie (1993) found, for example, that up to 4 years could be spent underground by a small proportion of chestnut weevil (*C. elephas* Gyllenhal) grubs in France; 32–56% emerged after 2 to 3 years.

The few references to the hazelnut weevil *C. obtusus* consist mainly of early naturalist descriptions (e.g., Hamilton, 1890; Brooks, 1910; Hutchings, 1927). Few details have been reported about its biology, though its host species range from Quebec to Georgia and westward into the midwestern U.S. (Fernald, 1950; Gibson, 1969). Furthermore, its host species have at times been considered to have commercial potential, particularly in Canada (e.g., Hutchings, 1927; St. Pierre, 1992).

Curculio obtusus larvae develop singly in a nut, unlike many of their congeners. Vrabl et al. (1979, p. 363) assert, of the European hazelnut weevil *C. nucum* L., that ≤ 4 eggs can be found in the shell of cultivated hazelnuts (*Corylus avellana* L.) in Slovenia, "but into the fruit itself there creeps only 1 larva." Multiple infestation, which occurs at a low level among *C. obtusus* (Gibson, 1969), is maladaptive; as with *C. nucum*, only 1 larva will succeed in nuts containing >1 larva (pers. obs.).

Interior galls and other deformities in the nutshell are caused by this species in wild and beaked hazelnuts and also by the European hazelnut weevil in cultivated hazelnuts (Rabaud, 1913; Gibson, 1969; Meyer, 1987). *Curculio obtusus*, unlike the other *Curculio* species, has been reported to pass 2 instars feeding in the soft shell and shell lining before passing into the kernel (Gibson, 1969).

The objective of the current study was to investigate and document details of larval development of the hazelnut weevil, including an assessment of the phenomenon of multiple infestation, determination of mortality factors, and confirmation of the number of larval stages. These observations were part of a larger study that included documentation of adult behavior and intershrub movements detailed by Treadwell (1996).

MATERIALS AND METHODS

Study site and host plant descriptions: The study was conducted in a secondary succession of woodland in T32 MD, Hancock County, Maine (44°58'N, 68°27'W), at an elevation of ca. 82 m, on land owned by Champion International Corporation and minimally maintained for primitive camping. The plant community consisted of a grey birch (*Betula populifolia* Marshall)-beaked hazelnut-blueberry (*Vaccinium angustifolium* Aiton) sere on sandy soil. The site was chosen because of a profusion of "brush-stage" (Hsiung, 1951) hazelnut thickets and observations of a high degree of hazelnut weevil activity in the area the previous summer.

Beaked hazelnut, so-called for the projecting involucre of united bracts which enclose its nut, is a monoecious shrub distributed throughout woodlands and forests of central North America. It is one of only 3 species of *Corylus* native to North America and is grouped by some in the hazel family, Corylaceae, along with *Ostrya* Scopoli and *Carpinus* L. (ironwood), *Betula* L. (birch), and *Alnus* B. Ehrhart (alder) (Fernald, 1950). Others place *Corylus* in the family Betulaceae (Hsiung, 1951). It sprouts vigorously from underground modified stems and, in New England and the

Adirondacks, is one of the 6 most common shrub-stratum species in successional progressions from overgrown pastures to climax forests of hemlock (*Tsuga canadensis* [L.] Carrière.), beech (*Fagus grandifolia* F. Ehrhart), and sugar maple (*Acer saccharum* Marshall) (Hsiung, 1951). In situations of high light intensity, found by Hsiung (1951) to be the critical factor in density of *Corylus cornuta*, the shrub attains maximum vegetative reproduction and can appear as dense thickets.

Larval development of the hazelnut weevil: Samples of 75–>100 nuts (\bar{x} = 103 ± 18 nuts, N = 22 samples) were collected haphazardly from thickets every 4 days from 12 June to 4 September 1995 for dissection, to monitor larval development as well as progression of nut damage. Nuts were transported on ice and immediately stored in a freezer until dissection under a microscope within 3 days. Dissected nuts were categorized as (a) intact (no damage to nut meat), (b) no kernel (shell fully formed but containing only a cottony lining), (c) decayed, (d) weevil-infested (containing eggs, larvae, or exit hole), and (e) damaged but not infested (i.e., outwardly punctured and/or deformed). Weevil eggs and larvae at each of 4 stages found in dissected nuts were counted and preserved in 70% ethanol. Twenty-four individuals of each of the 4 assumed larval stages were selected randomly and the width of their head capsules measured with an ocular micrometer in a dissecting microscope.

RESULTS

A total 2,269 nuts were collected and dissected between 12 June and 4 September 1995 at 4-day intervals. Of these, 873, or 38.5%, were infested with weevil eggs or larvae, with a peak 70.6% infestation occurring on 7 August (Fig. 1a). Decayed nuts peaked at 30.4% on 18 July (Fig. 1b).

Eggs were first found in the layers of nutshells on 20 June (Fig. 2), 17 days after the first adults were observed and 2 days after adults were first observed mating (Treadwell, 1996). First instars were found feeding in nut shell layers or interior galls beginning on 6 July, about 2 weeks after the onset of oviposition. Fourth instars were found beginning on 7 August, when percentage of total nuts infested with this stage suddenly increased from 0 to >17%. Exit holes were first observed in the 11 August sample. Complete larval development, from egg to exit, thus takes about 36 days.

Weevils had emerged from 71.4% of the infested nuts in the 4 September sample. Sampling was discontinued at this date because predation on nuts, presumably by the many red squirrels (*Tamiasciurus hudsonicus gymnicus* [Bangs]) and chipmunks (*Tamias striatus* L.) in the area, had become noticeably heavy on 27 August. Empty shells were more and more frequently found strewn under the shrubs and thickets, and natural nut drop had also begun by this date; thus nuts for sampling were difficult to find. Additionally, the proportion of nuts with no kernel increased from ca. 20% on 27 August to almost 40% on 4 September (Fig. 1b).

Multiple infestation occurred in 70 nuts, or 8% of the total 873 infested, and peaked on 30 July, when 22.6% of infested nuts contained >1 larva (Fig. 1a). The majority of multiple inhabited nuts contained 2 larvae, though 10.4% contained 3 larvae and a single nut contained 4 larvae (Fig. 3). In only 2 cases was a 4th-stage larva found in association with another larva. In one of these, surprisingly, the 4th instar was found partially consumed by a much smaller 2nd instar.

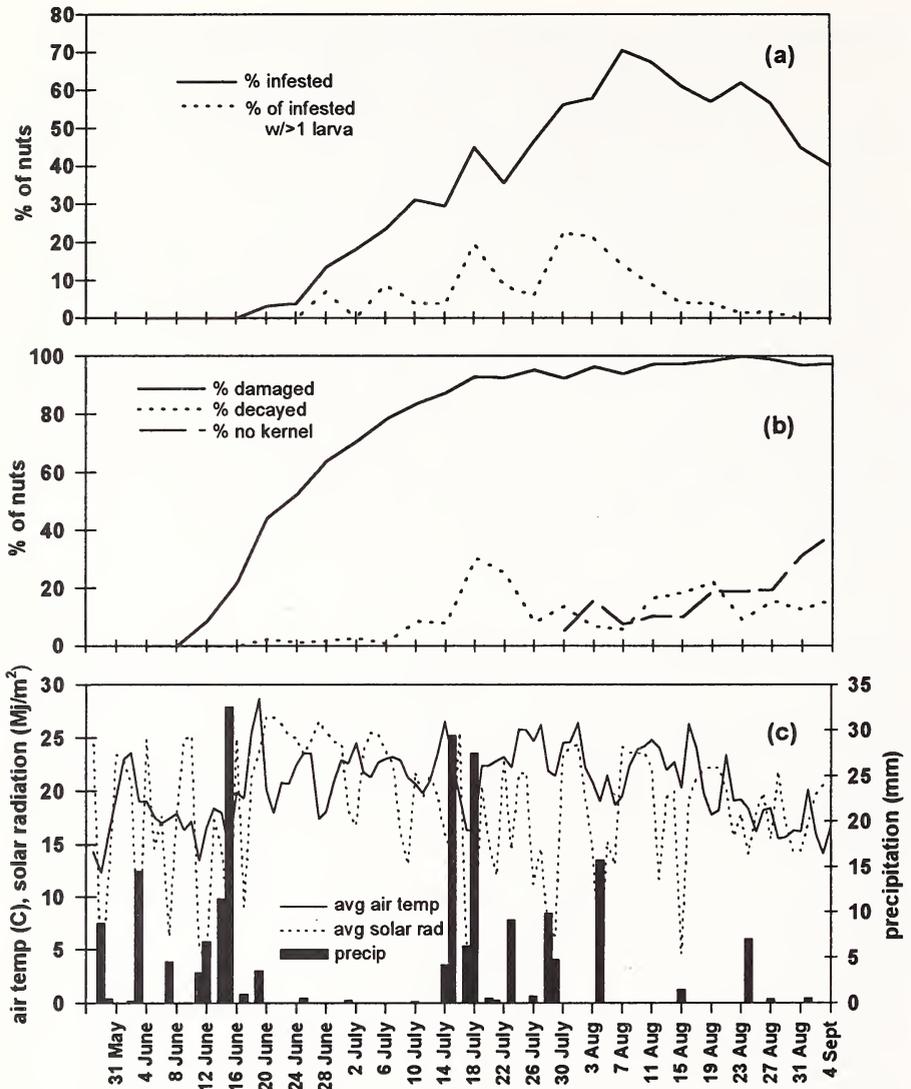


Fig. 1. Hazelnut weevil larval infestation, beaked hazel nut conditions, and climatic conditions at T32 MD, Hancock County, Maine, 28 May–4 Sept. 1995. (a) Percent of nuts infested, and percent of infested nuts containing >1 larva, in samples collected at 4-day intervals; (b) percent punctured/damaged, decayed, and no-kernel nuts in samples collected at 4-day intervals; (c) daily rainfall, solar radiation, and average air temperatures.

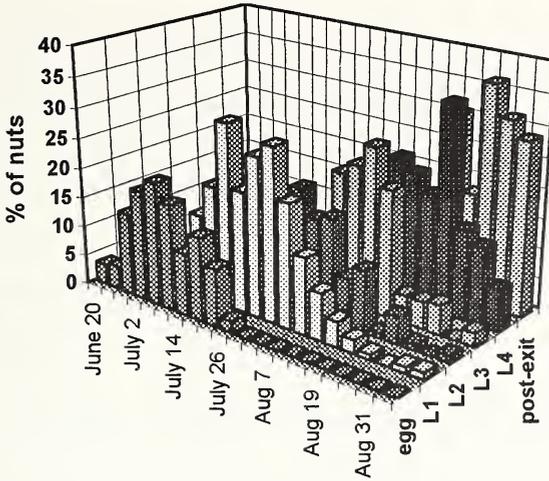


Fig. 2. Percent of larval weevil instars among sequential samples of beaked hazelnuts, 20 June to 4 Sept. 1995, T32 MD, Hancock County, Maine.

Eggs appeared most often in the top 1/3 or 1/4 of the shell. First instars were observed to feed first within the shell layers, sometimes within the exaggerated thickness of a gall, until breaking through to the shell lining. They then fed in the lining in a fairly straight line down to the bottom of the nut. Entry into the kernel was made at a distinctive round hole chewed through the thin skin, and ecdysis to the 2nd stage occurred soon after this. There was no evidence for feeding in the shell lining by 2nd instars.

In the early stages, multiple larvae could easily be found by looking for multiple entry holes into the kernel. Sometimes, however, one larva could be tracked between holes connected by longitudinal ruts in the lining; some would apparently sample the nut kernel before settling down to feeding.

Mean head capsule widths among the 4 stages appeared to vary only slightly from the predictions of Dyar's Law (Dyar, 1890); i.e., a constant ratio (in this case ca. 0.60) between the head capsule widths of each successive stage (Fig. 4).

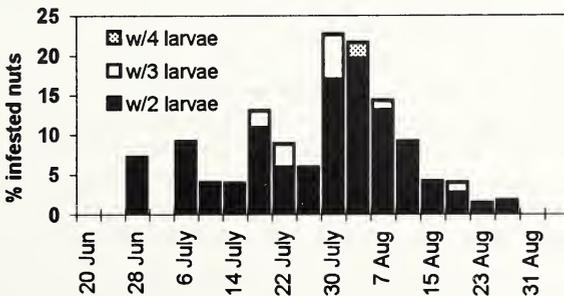


Fig. 3. Proportions of infested nuts containing 2, 3, or 4 larvae.

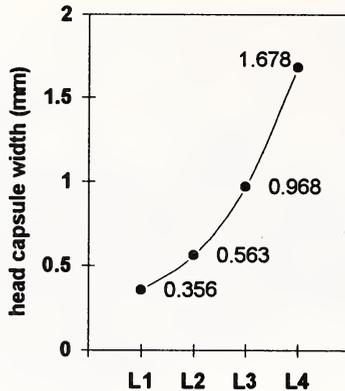


Fig. 4. Mean width of larval head capsules at 4 stages ($N = 24/\text{stage}$).

DISCUSSION

Anomalous trends in the data: A peak and then decline in proportions of infested nuts seems counter-intuitive: the proportion of nuts infested by weevils should level off at some point, since the nuts do not renew themselves and infestation is a permanent state. Pucci (1992: 9) reported a similar trend in data for European hazelnut weevils *C. nucum* infesting commercial hazelnuts in Italy, and attributed it to "the fruit drop effect": hazelnuts with larval exit holes tended to drop earlier than uninfested nuts. A similar phenomenon among beaked hazelnuts infested by *C. obtusus* would mean that the chances of picking an uninfested nut improve after a peak of infestation in early August, though the chances of its being decayed or unfilled are also greater (Fig. 1a). Probably these latter are lighter, lack abscissive mechanisms (why waste resources on an unfruitful shell?), and are instinctively passed over by nut predators; thus they will appear in greater proportions at the end of the season.

Two reasons might be given for the large proportion of 1st instars found in the sequential samples of nuts (Fig. 2). First, because eggs were deposited in shell layers it is likely that an unknown number were overlooked in dissection. An effort was made to examine all punctures and wounds in the shell, but eggs were observed to rupture and spill extremely easily, so some "disappeared" in the dissection process; numbers of eggs are most likely under-reported. For these reasons, occurrence of >1 egg is no doubt also under-reported.

Secondly, some first instars lingered into the final sample, a full 8 weeks after this stage had first appeared. An extended first larval stage would cause an exaggeration of their abundance proportionate to the other stages; members of the same cohort would be counted >1 time. Lowered quality or availability of nutrients has been shown to inhibit ecdysis in many insect species. Sehnal (1985) found, for example, that caterpillars of the greater wax moth *Galleria mellonella* (L.) molted after 15 hours on a normal diet but required 40 hours when the diet was mixed equally with sawdust. Release of prothoracicotropic neurohormone, which stimulates release of molt-inducing ecdysteroid, has been shown to be dependent on attainment of a certain "critical" body size increment (Sehnal, 1985).

First instars in the last few samples were all found in decaying nuts or nuts with no kernel. Apparently the cottony parenchyma of no-kernel nuts can sustain the life of a weevil larva but does not provide sufficient nutrients or appropriate cues for ecdysis. Besides obviously decaying and unfilled nuts, many "normal-appearing" kernels might have been affected by some factor, such as the long period of no rain as nuts were forming (Fig. 1c), which lowered their quality enough to inhibit ecdysis. **Factors in mortality of larvae:** Conditions of unfilled nuts and decay appear to be major mortality factors among young weevil larvae. Females unwittingly deposit eggs into shells in which kernels do not form and/or into which fungi and mycetophilous flies enter, in many cases, ironically, through the weevil oviposition puncture (Winston, 1956), and initiate a decay process. Larvae hatch into an environment unsuitable for growth and development but many subsist for weeks before dying of desiccation or starvation.

Ten percent of the nuts in sequential samples over the season showed evidence of rot or decay, with or without ubiquitous, unidentified microscopic maggots—from 1 to 15 in any one nut. Winston (1956) reported *Fusarium* sp. and *Penicillium* sp. responsible for initiating decay in acorns of red oak (*Quercus rubra* L.) in Illinois. He also found maggots, identified as *Mycodiplosis* sp. and *Rubsoamenia* sp. (Cecidomyiidae), to be spreading spores of the fungi. As in the case of maggots observed in hazelnuts, they created areas of decay around themselves; weevil larvae in maggot-infested nuts are certain not to survive.

An unconscious sampling bias might have been introduced against decayed nuts in the field because of their often obvious appearance. A more accurate estimate of their effect on larval populations can be gained by analyzing an absolute sample of nuts ($N = 1,246$) collected from 33 discrete beaked hazelnut shrubs on 3 August 1995 (Treadwell, 1996). Here 15.3% of the total were in a state of decay that rendered the nut kernel unfit for weevil sustenance. An accurate count of larvae in decaying nuts could not be kept because the cadavers were also broken down by invading hyphae and maggots. Decay and no-kernel conditions together claim ca. 25% of a hazelnut crop. If 40% of those nuts are weevil-infested (Treadwell, 1996), an estimated 10% of total larvae do not survive because of pathological nut conditions.

Since it appears that ca. 30 days are required to complete larval development after ecdysis into the 2nd instar, grubs that were still at 1st instar on 15 August, 9–10% of the larval population, most likely did not survive. Quality of mature nuts can be assumed to be quite different from that of young developing kernels with which early instars normally coincide. Additionally, the fate of the hazelnut itself became more and more tenuous as the summer came to an end.

As mentioned, red squirrels and chipmunks were observed at this site and were noted by Hsiung (1951) to consume or bury "the great proportion of the [beaked] hazelnut crop" at a Minnesota study site. It is not known whether these two rodents have any preference for uninfested nuts. Grey squirrels (*Sciurus carolinensis* Gmelin), however, have been observed to detach and sniff or taste European hazelnuts infested with *C. nucum* before discarding them (Lloyd, 1968). White-footed mice (*Peromyscus leucopus* Thomas) prey on detached acorns of white oak (*Q. alba* L.) with no preference for those infested or uninfested by larvae of the weevils *Curculio pardalis* (Chittenden) and *Conotrachelus naso* LeConte (Semel and Andersen, 1988).

Additionally, detached nuts were observed in the laboratory either to desiccate or to start decaying within a few days.

Multiply-infested nuts account for another 8% of larval mortality. These represent larvae that were selected out by a critical interference competition between nut-mates. Since multiple larvae reached levels of >20% of infested nuts in the sequential random samples, a competitive "edge" inside the nutshell might seem a measure of fitness.

In the similar case of the cowpea weevil *Callosobruchus maculatus* (Fabricius), small beans can sustain only 1 larva to maturity. Among the larva of this species, in any bean regardless of size one larva will out-compete any others in survival. Mitchell (1983) speculates that interference competition, "activity which directly or indirectly limits a competitor's access to a resource" (Prokopy et al., 1984, p. 307), might have evolved to ensure the success of at least one larva, rather than a situation of exploitation competition in which both would die if consuming a small bean equally until it was depleted. For the hazelnut weevil there can be no doubt as to the optimum competition strategy; 1 larva can and usually does consume an entire kernel.

In summary, then, these observations suggest almost 30% mortality among nut-infesting hazelnut weevil larvae due to decay, interference competition, and nut predation.

Conclusions: The inside of a hazelnut seems a relatively secure, insulated habitat for growth and development. At the scale of a weevil, however, this environment presents a variety of hazards to which the insect has adapted and evolved. Evidence of parasitization of nut-inhabiting larvae was not detected, but rearing of larvae extracted from nuts, in a controlled environment, would reveal whether parasitization has taken place. Additionally, a longer-term study would shed some light on questions regarding synchronicity of life cycle with host plant phenology.

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SENSORY STRUCTURES OF THE ANTENNAE OF *NANNOTRIGONA TESTACEICORNIS* (APIDAE: MELIPONINAE)¹

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Abstract.—The total number and distribution per antennal flagellomere of sensilla placodea (olfactory disks), sensilla coeloconica, sensilla ampullacea and sensilla campaniformia were determined in workers of *Nannotrigona testaceicornis* Lepeletier a stingless bee species quite common in Brazil. The distribution of the sensilla was uniform, with the largest number occurring in flagellomere 10 and gradually decreasing in the direction of the basal flagellomeres in a way similar to that observed in *Scaptotrigona postica* Latreille.

Nannotrigona testaceicornis had a larger number of sensilla ampullacea and a smaller number of sensilla coeloconica and sensilla campaniformia than *Scaptotrigona postica*. Although *Nannotrigona testaceicornis* does not communicate through the formation of pheromone trails, this species presents a larger quantity of sensilla placodea (relative to the length of the flagellum) than *Scaptotrigona postica*.

Nannotrigona testaceicornis, a stingless bee species quite common in Brazil, is found from the north of Paraná up to Mexico (Nogueira Neto, 1970). This species presents on average populous colonies, generally consisting of 2,000 to 3,000 individuals (Lindauer and Kerr, 1960).

Nannotrigona testaceicornis has been studied from different aspects such as oviposition behavior (Sakagami and Zucchi, 1966), communication (Kerr and Esch, 1965), glandular system (Cruz-Landim, 1967), taxonomy (Moure, 1951), nest structure (Nogueira Neto, 1970) and morphometry (Cunha, 1973). On the other hand, only little information exists with respect to the antennal sensilla placodea of the workers of this species (Johnson and Howard, 1987).

In order to expand the knowledge about the outer morphology of Brazilian stingless bees, we determined the number and distribution of sensilla placodea, sensilla coeloconica, sensilla ampullacea and sensilla campaniformia of the antennae of *Nannotrigona testaceicornis* workers.

MATERIAL AND METHODS

Samples of *Nannotrigona testaceicornis* Lepeletier workers were collected from colonies maintained at the Animal House of the Biosciences Institute of Rio Claro. The bees were anesthetized and killed in an ether chamber, fixed in modified Karnovsky (2% glutaraldehyde and 2% paraformaldehyde in 0.1 M phosphate buffer, pH 7.2) for 24 hours and stored in 70% alcohol. The antennae were separated from

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the head, treated with ultrasound for 1 minute to remove dirt particles and glued to a metal support.

The antennae were then sputtered with a thin gold layer using an Edwards Sputter apparatus, model S_{150B}, and observed with a model T_{330A} Jeol scanning electron microscope of the Chemistry Institute, UNESP, Araraquara.

For sensilla placodea (olfactory disks) counts, the antennal flagellomeres were separated and opened with the aid of two entomology pins and mounted on balsam between a slide and a coverslip. Each flagellomere was photographed with a Zeiss photomicroscope II, and the film was projected onto a paper screen where the sensory structures were counted.

The ratio number of sensilla placodea to length of the flagellum was also studied. The length of the flagellum was measured under a dissecting microscope equipped with an optical micrometer.

Ten worker bees were used for the observations and counts.

RESULTS

In flagellomere 10 the set of sensilla campaniformia was located above the sets of sensilla coeloconica and sensilla ampullacea (Fig. 1A), with these two types of sensilla (coeloconica and ampullacea) being clearly distinguishable.

The total number of sensilla ampullacea in *Nannotrigona testaceicornis* workers was larger than that of sensilla coeloconica, with the largest number of these sensilla and of sensilla placodea occurring in flagellomere 10 and decreasing in the direction of the most basal flagellomeres (Table 1).

The set of sensilla campaniformia was only observed in flagellomere 10, having on average 5.800 ± 0.421 units (Table 1). No set of these sensilla was observed in the other flagellomeres below flagellomere 10 of the antennae of *Nannotrigona testaceicornis* workers (Fig. 1B), and an isolated sensilla campaniformia rarely occurred.

DISCUSSION

The location of the set of sensilla campaniformia above the sets of sensilla coeloconica and sensilla ampullacea in flagellomere 10 of the antennae of *Nannotrigona testaceicornis* workers is similar to that observed in *Scaptotrigona postica* (Stort and Barelli, 1981; Stort and Moraes-Alves, 1997) and differs from what occurs in *Apis mellifera* where the set of sensilla campaniformia is located laterally to the set of sensilla coeloconica + ampullacea (Dietz and Humphreys, 1971; Stort and Moraes-Alves, 1997).

The morphological differences between sensilla coeloconica and sensilla ampullacea observed in *Nannotrigona testaceicornis* are similar to those observed in *Scaptotrigona postica* (Stort and Barelli, 1981).

Nannotrigona testaceicornis workers possess a smaller total number of sensilla coeloconica and a larger total number of antennal sensilla ampullacea (Table 1) than *Scaptotrigona postica* (Stort and Moraes-Alves, 1997).

Regarding the total sum of these two types of sensilla (sensilla coeloconica + sensilla ampullacea), *Nannotrigona testaceicornis* presents a smaller quantity (mean: 48.100 ± 5.606) than *Scaptotrigona postica* (mean: 52.800 ± 5.266). According to

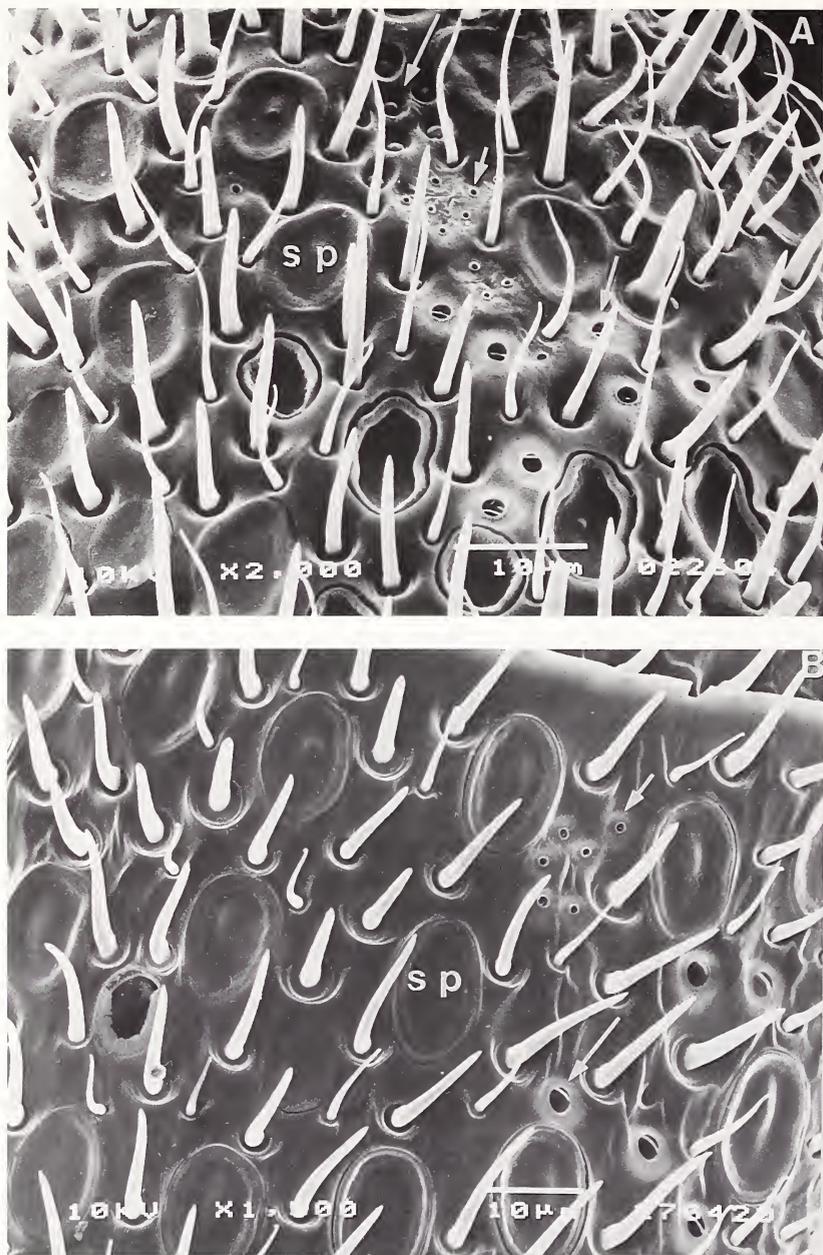


Fig. 1. Scanning electron microscopy micrographies of the antennal flagellomeres of *Nannotrigona testaceicornis* worker. A—flagellomere 10 showing sensilla campaniformia (long arrow), sensilla ampullacea (short arrow), sensilla coeloconica (median arrow) and sensilla placodea (S P). B—flagellomere 9 showing sensilla ampullacea (short arrow), sensilla coeloconica (long arrow) and sensilla placodea (S P).

Table 1. Means (\pm standard deviations) of the number of sensilla placodea, sensilla coeloconica, sensilla ampullacea and sensilla campaniformia of the antennal flagellomeres (F) of *Nannotrigona testaceicornis* workers.

	Sensilla placodea	Sensilla coeloconica	Sensilla ampullacea	Sensilla campaniformia
F ₁₀	145.600 \pm 5.274	4.300 \pm 0.823	6.800 \pm 0.918	5.800 \pm 0.421
F ₉	104.800 \pm 4.638	3.900 \pm 0.994	5.400 \pm 1.577	—
F ₈	103.600 \pm 4.247	3.500 \pm 0.707	4.300 \pm 2.057	—
F ₇	87.300 \pm 4.762	3.400 \pm 0.843	3.100 \pm 0.994	—
F ₆	87.500 \pm 3.719	2.300 \pm 1.159	3.200 \pm 1.988	—
F ₅	76.800 \pm 7.656	1.800 \pm 0.788	1.900 \pm 0.737	—
F ₄	76.700 \pm 4.990	1.700 \pm 0.483	1.800 \pm 1.135	—
F ₃	64.300 \pm 4.243	0.400 \pm 0.699	0.300 \pm 0.483	—
F ₂	48.200 \pm 4.825	—	—	—
Total	794.800 \pm 22.592	21.100 \pm 2.960	27.000 \pm 4.876	5.800 \pm 0.421

Kuwabara and Takeda (1956), these structures are hygroreceptor organs, a fact that was confirmed by Lacher (1964). *Nannotrigona testaceicornis* would therefore be less sensitive in detecting the degree of environmental humidity than *Scaptotrigona postica*. In contrast, Africanized *Apis mellifera*, which present on average 71.900 ± 7.311 sensilla coeloconica + ampullacea (Stort and Rebutini, 1997), appear to be more sensitive in detecting humidity than these two stingless bee species.

Both *Nannotrigona testaceicornis* and *Scaptotrigona postica* have one set of sensilla campaniformia in flagellomere 10 and rarely present other sensilla of this type, even isolated, together with sensilla coeloconica and sensilla ampullacea in the flagellomeres below number 10.

Nannotrigona presents a smaller quantity of sensilla campaniformia (Table 1) than *Scaptotrigona* (Stort and Moraes-Alves, 1997). Therefore, this species should be less sensitive to temperature and CO₂ since these sensilla are related to the perception of these environmental parameters (Dietz and Humphreys, 1971). According to Stort and Rebutini (1997), Africanized *Apis mellifera* workers have a larger quantity of sensilla campaniformia (mean: 18.700 ± 2.710) since these sensilla are present in all antennal flagellomeres, and this species may therefore be more sensitive to these environmental factors than the two stingless bee species mentioned here.

The total number of sensilla placodea (olfactory disks) per antenna in *Nannotrigona testaceicornis* was on average 794.800 ± 22.592 (Table 1), a number 30.397% smaller than that observed in the antenna of *Scaptotrigona postica* (Stort and Barelli, 1981) and 327.126% smaller than that observed in Africanized *Apis mellifera* (Stort, 1979). The total number of sensilla placodea of *Nannotrigona testaceicornis* obtained in the present study disagrees completely with the number ($1,858 \pm 338$) found by Johnson and Howard (1987).

The total number of sensilla placodea, however, when considered in relation to the length of the antenna which was determined by calculating the number of sensilla placodea/flagellum length ratio, showed a difference. The ratios obtained were 24.380 for *Nannotrigona*, 24.102 for *Scaptotrigona* and 39.877 for Africanized *Apis*. This means that *Nannotrigona* presents, proportionally to the size of the flagellum,

a slightly larger quantity of antennal sensilla placodea than *Scaptotrigona*, and *Apis* presents a larger quantity than these two. It is important to analyze the number of sensilla in relation to the size of the bee since Johnson and Howard (1987) have shown that these two characters are highly correlated.

According to Kerr (1969), *Nannotrigona testaceicornis* has a barely evolved system of communication between workers. It has been shown that the worker that has found a food source enters the colony and produces a characteristic sound. The workers surrounding this bee immediately start to produce the same sound and in less than one minute the entire colony will be buzzing, imitating this sound, and at this time several bees leave the colony looking for food (Kerr and Esch, 1965). Thus, the bee that found the source alerts the colony in terms of the existence of this source but does not provide any indication of the location. The source is only found based on the smell of the food.

In contrast, *Scaptotrigona postica* presents a more evolved communication system. The bee that found the food source leaves a scent trail between the source and the colony, marking flowers, leaves and branches every 1 to 2 meters with a drop of secretion (rich in compounds such as 2-heptanone, 2-nonanone and benzaldehyde) produced by the mandibular glands (Lindauer and Kerr, 1958; Kerr et al., 1963). Due to the type of communication, i.e., formation of a pheromone trail, it may be expected that *Scaptotrigona postica* presents a larger quantity of antennal sensilla placodea (olfactory disks) than *Nannotrigona testaceicornis*, which is not the case when the size of the flagellum is also considered. In this respect, the number of antennal sensilla placodea of *Scaptotrigona postica*, in addition to not agreeing with the type of communication they possess when compared to *Apis mellifera* and *Melipona quadrifasciata* (Silva de Moraes and Cruz-Landim, 1972; Stort and Barelli, 1981), also does not agree with the type of communication they possess when compared to *Nannotrigona testaceicornis*. These results support the observation that the number of antennal sensilla placodea is not simply related to the use of pheromones for the recruitment of individuals to the food source, but may play a broader role in the complex number of activities performed by bees (Johnson and Howard, 1987).

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NOTES AND COMMENTS

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***COCCIDULA FERRUGINEA* GORHAM, A SENIOR SYNONYM OF *EREMOCHILUS HOWDENI* GORDON AND VANDENBERG (COLEOPTERA: COCCINELLIDAE: EPILACHINAE)**

Gordon and Vandenberg (1994) described *Eremochilus howdeni* based on two female specimens from Mexico. Roger Booth, International Institute of Entomology, London, recognized the similarity between that description and a syntype of *Coccidula ferruginea* Gorham (1888) in the Natural History Museum, London. He kindly arranged a loan of the syntype, and examination of that specimen resulted in confirmation of the suspected synonymy. *Coccidula ferruginea* is here transferred to *Eremochilus* as a senior synonym of *E. howdeni*. The male syntype labeled "Type (orange bordered disc)/Toxpam/Mexico, Salle Coll.?2300(green paper)/Coccidula? ferruginea Gorh." is designated and labeled as the lectotype of *C. ferruginea*. Male genitalia are illustrated in Fig. 1 and constitute the first figure published for this species. The genitalia differ in configuration from the congeneric *E. weisei* Gordon and Vandenberg (1987) (the only other species for which a male is available) primarily in possessing a tubular siphro with a much reduced capsule and an unmodified apex of the basal lobe.—Robert D. Gordon and Natalia J. Vandenberg, *Systematic*

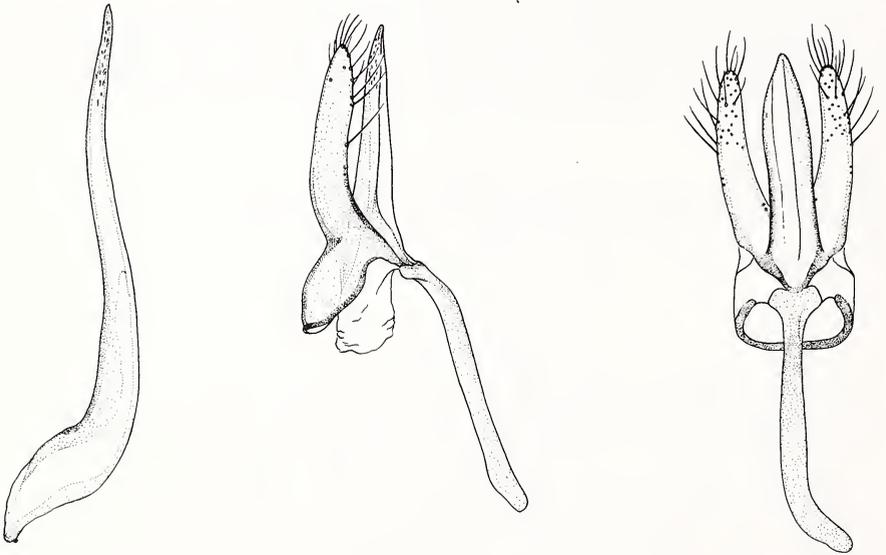


Fig. 1. *Eremochilus ferruginea* (Gorham) (lectotype). Male genitalia: siphro (left), phallobase and trabes from lateral and ventral views (right).

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JACQUES CARAYON
(1916-1997)
AN APPRECIATION

With the death of Professor Jacques Carayon hemipterology has lost one of its greatest and certainly one of its most versatile students. This is not a formal obituary as I am certain that the tributes from his European colleagues will discuss more completely than I am able the many contributions of this outstanding man. Here I hope to be able to informally express my appreciation of the accomplishments of one of the outstanding figures in twentieth century entomology.

Prof. Carayon unquestionably deserves a place, not only as one of the leaders in Hemipterology in this century, but as one of the leading figures in the entire history of the science.

Carayon is best known for his outstanding pioneering work on "traumatic insemination" which he explored in a wide variety of cimicomorph taxa and demonstrated the remarkable extent of this seemingly unlikely method of copulation and sperm transmission. He discussed and illustrated this phenomenon in a series of truly exquisitely composed papers. For this work alone he stands in a unique position among his contemporary colleagues.

However, Carayon's interests and abilities extended far beyond the fine work on insemination mechanisms. His work on the integumentary glands is not only outstanding for its morphological and histological thoroughness, but also for its importance to our understanding of higher group relationships within the Hemiptera.

It certainly would be misleading to portray Jacques Carayon as primarily a morphologist and a field biologist. He was always a first class taxonomist and frequently his papers combined the wonderful histological work that he did with his wife with new classification schemes and often the descriptions of new taxa. Perhaps the most seminal of these papers was his large summation of the classification of the Anthocoridae. This paper proposed the first really modern schema of relationships in the family since the work of Reuter many years previously. Some Hemipterists may not be aware of the background of the subsequent series of events that have led to the present ambiguities in the classification of this group. After Carayon published his major classification of the Anthocoridae it seemed an appropriate time for a young worker to concentrate upon the taxonomy of the group. With Dr. Carayon's approval I suggested this project to a promising young graduate student in my laboratory named Laurine Ford. Ms. Ford, who had a mastery of French, took the sum of Dr. Carayon's work on the Anthocoridae together with all of his contributions to traumatic insemination in related families and constructed a phylogenetic "tree" of relationships. Unfortunately she left the field with this unpublished but available in thesis form. It served as part of the analysis (together with the work of Kerzhner), for a detailed cladistic analysis by Schuh & Stys in 1991 which resulted in the removal of a portion of the Anthocoridae to a separate family position. Prof. Carayon did not agree with this classification, but his accident and subsequent ill health unfortunately made it impossible for him to share with us his reasons for disagree-

ment. I believe the loss of Carayon's opinion to be a most unfortunate loss for Hemipterology.

Carayon also published the first work of real consequence on several groups. Important among these was his innovative study of the peculiar family Plokiophilidae whose members live in the webs of Embioptera and spiders and which Carayon was able to show were part of the traumatic insemination complex. His work on the Pachynomidae was equally innovative and raised questions concerning the homology of trichobothria in this family relative to the Pentatomomorpha. In a similar way he treated the Nabidae as part of this complex group and made his usual original contributions so ably carried on by Dr. Kerzhner. In point of fact it is not an exaggeration to say that when Jacques Carayon studied a group it invariably resulted in published work that was not only remarkably complex but added new dimensions to our knowledge of the group both taxonomically and biologically, resulting from the morphological information that was always new and provocative.

His contributions alone do not tell the complete story of his contributions to Hemipterology. Of all the French workers of his generation he was perhaps the most generous of his time and in imparting his knowledge to students and to workers from other countries. He was unfailingly polite and helpful to those who visited his laboratory, spending much time with even the youngest visitors. After his mastery of English improved he was pleased to discuss scientific matters with visiting colleagues whose lack of knowledge of French must have been frustrating to him.

Carayon was perhaps first of all a naturalist, one who was always interested in the biology of the Hemiptera. To him is due our knowledge of the remarkable mating behavior in the lygaeid bugs of the genus *Stilbocoris* wherein the males impale small seeds upon their "beak", partially digest them and offer them to females to enhance mating acceptance. Almost as an aside Carayon discovered during this work that the various species were ovoviviparous; to my knowledge, still the only known case of this in the Lygaeoidea. His work on this genus also unfortunately points up the many studies that he did not complete. Nearly two decades ago he told me of experiments he had conducted in his laboratory with *Stilbocoris natalensis* and a series of other species of *Stilbocoris*. In every case where both species were confined together *S. natalensis* would within a short period completely eliminate the other species. Both of us had hoped to follow these observations in the field, for the genus is speciose in Africa and beautifully adapted to move quickly into an area, exploit a crop of *Ficus* seeds, and move out. Carayon visualized a group of species that survived by adapting to getting to a seed crop quickly, producing a generation before each was overwhelmed by the ubiquitous *S. natalensis*. Carayon wished to revise this genus and I unfortunately dissuaded him believing another worker was already engaged. Unfortunately the revision remains to be completed.

My first personal acquaintance with Prof. Carayon also involved his observations as a field naturalist. My wife and I visited his laboratory in January of 1961 during the time I was working at the then British Museum (Natural History). Carayon had discovered that a species of lygaeid of the genus *Mizaldus* occurred in West Africa in the nests of plover birds and that it fed upon beetle larvae living in the nests. This was remarkable as previously only members of one tribe in the large subfamily to which *Mizaldus* belonged were known to be predatory (and they fed upon vertebrate blood). This incidentally led to an amusing exchange between us which

perhaps illustrates his character and which I have always treasured. Carayon could not identify the insect and asked if I would attempt it. I did discover that it was an undescribed species and wrote a preliminary draft of a paper describing it and discussing the biological information that Prof. Carayon had given me. I sent a draft to Paris for Prof. Carayon to look over as a paper by "J. Carayon and J. Slater". In due time it was returned with the authorship reversed. I wrote pointing out that the formal description of the new species was not the most significant part of the paper as compared to the discovery of insect feeding by a member of a tribe in which such food habits had not previously been known to occur. The answer was polite, but to the point. He, Carayon, said that he thought he was able to ascertain who had done the most significant work on the paper and who must be the senior author. There seemed no further room for discussion, I was dismissed! It was of course an act of kindness on his part, but even today I believe the authorship sequence is inaccurate.

Some of my most treasured memories are of his visit to the International Congress of Entomology in Washington D.C. in 1976. I had been asked to organize a symposium on the status and advances in Hemipterology. It was natural to ask Jacques Carayon to be the first speaker. The symposium went well, Jacques gave it a stimulating start, so much so that we organized an informal discussion of relationships within the order later in the meeting. At this meeting excitement was immediate and centered around disagreements between Carayon and René Cobben of the Netherlands, as I recall chiefly concerning the position of the Reduvidioidea. The air was blue with the smoke from Cobben's cigar and with the words "Jamais, jamais, c'est impossible!" that kept erupting from Carayon. I don't think the matter was really ever settled, but it stimulated all of us. That same evening Carayon gave a more technical paper and when he arose to do so he announced that it was necessary for him to give this paper in French. His enthusiasm seemed to wane when he slowly came to realize that much of his audience was not able to follow the details of his discussion. I am convinced that he was not really aware that suddenly he began to discuss the paper in English and only occasionally lapsed into French thereafter. Thus, one remembers him not only as a scientist of the first class but also as a very human man, friendly, cooperative and a pleasure to have known personally as well as to respect professionally.

Jacques Carayon was born November 11, 1916 in Toulouse France. He was the eldest of three children. His father was a medical doctor whose premature death in 1938 together with an earlier illness of his own prevented Jacques from following his father into the medical profession. He had been interested in the Natural Sciences since he was eleven years old and when it became financially impossible for him to enter medical studies he turned to natural history and entered the University at Paris in the Natural Sciences.

In 1975 Carayon fortunately summarized his career and his contributions as part of his application for the Headship of the Laboratory of Entomology at the National Museum in Paris (which he obtained). In this important summary entitled "Titres et Travaux Scientifiques de M. Jacques Carayon" he not only analyzed what he considered his most important scientific work, but also fortunately one finds here the various academic and administrative positions that he held as well as his formal honors.

In 1947 he married Gabrielle Carayon. This marriage was very important for his career as she was a skilled technician who became his assistant and to her must go much credit for the exquisite histological work that graced so many of his outstanding papers.

Not all of his foreign colleagues realize that Carayon was not only a fine scientist but also from childhood until his death a devoted naturalist. He had a house in Provence where he spent long summer periods working in the field as well as on his various manuscripts and where he taught his grandchildren the joys of knowledge of the natural world.

Prof. Carayon spent his entire career in Paris where he held numerous offices involving senior administrative responsibilities both at the University of Paris, the National Museum and its affiliation with the Zoological Institute of National Agronomy. Thus throughout his career he carried an extensive administrative burden which makes his scientific contributions even more remarkable and impressive.

This informal recognition of his status is not intended to discuss in detail his many offices and distinctions, but one should certainly mention his Presidency of the Entomological Society of France as early as 1956, his expeditions to West Africa and the Cameroons in 1946 and 1947, his participation in many international entomological and zoological congresses such as those in Stockholm, Amsterdam, Vienna, Moscow, Copenhagen, London, Washington, etc. culminating with his election to the Permanent Committee on International Entomological Congresses at the Kyoto Congress in 1980 (announced appropriately by his long time colleague J. C. M. Carvalho). He rose steadily through the administrative and scientific hierarchy in France and became Head of the Laboratory of Entomology of the Museum in 1975, a position which he held until his retirement in 1986. During his career he was always involved in administrative duties and he never left his obligations to economic aspects of entomology. At the time of his retirement a volume of the *Annals of the Entomological Society of France* was dedicated to him and included scientific articles from his colleagues around the world (this included an especially important tribute by his colleague Claude Dupuis that summarized Carayon's life and work in exemplary fashion. Dupuis says appropriately after lauding Carayon's work on traumatic insemination and on integumentary glands the following: "L'ensemble, sàc-compagnant, toutes les fois que nécessaire, de données écologiques et de taxinomie descriptive, constitue une oeuvre remarquablement cohérente qui vous vaut une position de leader parmi las connaisseurs du sous-ordre.")

Following his formal retirement Prof. Carayon continued to work actively, especially upon the integumentary glands which he had studied for many years.

In 1990 he was involved in a terrible automobile accident during a trip to Turkey which left him for a time in a coma and many months in the hospital. While he recovered mentally he really never did recover physically from this traumatic accident and was unable to carry on his research program. His mind was active to the end and he never lost his interest in what his colleagues were accomplishing.

There is a sadness that Carayon was not able to finish many of the important projects that he was engaged in, but we can rejoice that he was able to accomplish so much. He was a scientist of the first order of magnitude and able to do outstanding work while carrying administrative burdens and in being a stimulus and guide to many students. Hemipterology has lost one of its greatest men, a man whose accom-

plishments will continue to be recognized and honored so long as the science continues to be a subject of study.

Since this is not a formal obituary I take the liberty of citing here a few of his works that I believe will give the flavor of a few of his many important contributions.

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