













# ENTOMOLOGICAL NEWS

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(Continued on inside of back cover)

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## ON THOMAS SAY'S ENTOMOLOGICAL PUBLICATIONS PRINTED IN NEW HARMONY, INDIANA<sup>1</sup>

Yves Bousquet<sup>2</sup>

**ABSTRACT:** All entomological papers published by Thomas Say and printed in New Harmony, Indiana, are briefly commented upon. The dates and citations of all new taxa and new replacement names of Coleoptera proposed in these papers are presented in a table. Four of Say's names, previously considered as junior synonyms, have priority: *Chlaenius circumcinctus* Say, 1830, in place of *C. perplexus* Dejean, 1831; *Chlaenius soccatus* Say, 1830, in place of *C. melanarius* Dejean, 1831; *Dytiscus confluens* Say, 1830, in place of *D. dauricus* Gebler, 1832; *Tenomerga cinerea* (Say, 1831), in place of *T. concolor* (Westwood, 1835).

From January 1826 to October 10, 1834, the date of his death, Thomas Say lived in New Harmony, a small community in southwestern Indiana located along the Wabash River. Say published most of his entomological and conchological observations while in New Harmony first in the journal "The Disseminator of useful knowledge" which became "The Disseminator" on June 29, 1830. The journal was suspended on June 26, 1831 and reappeared only in 1834. During that interval, Say published his descriptions in several pamphlets, printed in New Harmony, which have become extremely rare. Some of these pamphlets were reprinted, with minor editorial changes, in scientific journals and this action has created confusion over the dates of many new species described by Say.

The purpose of this publication is to briefly comment on each of Say's entomological papers published in New Harmony and give the proper publication dates of all new taxa and new replacement names of beetles published in these papers.

1. Say, T. 1830. Correspondence relative to the insect that destroys the cotton plant. *The Disseminator of useful knowledge; containing hints to the youth of the United States from the "School of industry"* 3: 19-21.

The journal, usually abbreviated as "The Disseminator of useful knowledge" was a semi-monthly publication, printed in octavo form. The first issue appeared on January 16, 1828 and the last one (vol. 3, no. 9) on May 12, 1830. Three volumes were published (not two as noted in

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Titus, 1965): the first in 1828, the second in 1829, and the third, which was not completed, in 1830. The third volume is extremely rare and the only copy I am aware of is in The Public Library of Cincinnati & Hamilton County, Department of Rare Books and Special Collections (Ian MacPhail, personal communication).

This paper consists of a letter, dated January 1827, from C.W. Capers, University of Pennsylvania, to Say and Say's response, dated November 1, 1827, in which he describes the moth *Noctua xyлина* (= *Alabama argillacea* Hübner, 1823). The paper was first published in 1828 in the "Southern Agriculturist" (volume 1, page 203) (Horn and Schenkling 1928) and subsequently reproduced with minor changes by A. Fitch in 1858 in the Transactions of the N.Y. State Agricultural Society (volume 17, pages 813-814). The version reproduced by J.L. LeConte (in Say 1859a: 369-371) is that published by Fitch.

2. Say, T. 1830. Descriptions of new species of North American insects, and observations on some already described. The Disseminator of useful knowledge; containing hints to the youth of the United States from the "School of industry" 3: 67-69, 133-135.

This paper appeared in number 5 (March 17 issue, pages 67-69) and number 9 May 12 issue, pages 133-135). It contains descriptions of some taxa of Carabidae, including cicindelids, and observations on others. The content of this paper was reprinted in Say (1830c) and (1834b).

3. Say, T. 1830. Descriptions of new species of North American insects and observations on some already described. The Disseminator 1(1):[3]; 1(3):[3]; 1(4):[3]; 1(5):[3]; 1(6):[3]; 1(7):[3].

"The Disseminator" continued "The Disseminator of useful knowledge". It was published weekly, in folio, numbered separately, but with the pages unnumbered. The first volume was published from June 29, 1830 (number 1) to June 25, 1831 (number 52). The journal reappeared on June 1834, under the same title but as a new series, and ceased in April 1841. Seven volumes of the new series were published (Titus 1965).

The paper contains the descriptions of several species of Carabidae which appeared on the third pages of numbers 1 and 3-7. Its content was reprinted in Say (1830c) and (1834b).

4. Say, T. 1830-1834. Descriptions of new species of North American insects, and observations on some of the species already described. School Press, New Harmony [Indiana]. 81 pages (numbered [1]-73, 73 1/2-80).

The first 17 pages of this pamphlet, which are not numbered, are unaltered reprints of Say's papers published in the third volume of "The Disseminator of useful knowledge" (pages [1-4] in double columns) and the first volume of "The Disseminator" (pages [5-17] in single columns). The next pages are numbered 18 to 65 with an unnumbered blank page before page 18, two unnumbered blank pages before pages 50 and 58, and one unnumbered blank page before page 66 (numbered 46). The next eight pages are incorrectly numbered 46 to 53 (instead of 66 to 73) and the last eight pages are numbered 73 1/2 to 80.

The cover page of the pamphlet bears the date 1829-1833 and at the bottom of page 18 is printed "August 20, 1830." There are no other dates indicated on the pamphlet. The publication dates of the pages, however, were discussed by T.W. Harris in a letter addressed to J.L. LeConte dated Nov. 29, 1852: "The last eight pages [of this pamphlet] were printed after the title page, and only a short time before his [Thomas Say] last sickness and death. About one half of the whole work, ending with the description of *Lathrobium dimidiatum*, was actually printed and distributed in 1830. Thence to *Anthophagus verticalis* inclusive, in 1831; thence to *Aleochara semicarinata* inclusive, in 1832; . . . Thence to *Agrilus politus*, in 1833; and the remainder, to *Elater exstriatus* inclusive, in 1834" (Harris 1869: 222-223). Therefore, pages [1]-41 were published in 1830 (with pages 18-41 likely printed on August 20), pages 42-49 in 1831, pages 50-57 in 1832, pages 58-73 in 1833, and pages 73 1/2-80 in 1834 (before October 10). The dates indicated on the cover page are incorrect and should have read 1830-1834.

I know of five copies of this pamphlet. The copy in the Library of New Harmony Workingmen's Institute contains only the pages 18-65 (Rosemary Alsop, personal communication). The Library of Congress has a copy in its Rare Books Section which has the printed pages 18-65, and the first 17 pages and a few of the remaining pages in a handwritten form. The American Museum of Natural History Library possesses the copy of S.H. Scudder which includes pages [1]-73. The copy was previously owned by J.L. LeConte and includes a few of his manuscript notes on margins of pages [information written on front cover and copied from Sherman Catalogue no. 6]. The American Museum of Natural History Library also has a photostat of the pages 73 1/2-80 "made from Harvard University copy March 1948". The Houghton Library, Harvard University, holds two copies of this pamphlet. One copy has only the pages 18-65, and the second copy is complete. Byrd and Peckham (1955) reported the presence of additional, incomplete copies of this pamphlet in the libraries of the Indiana University, the University of Minnesota, the Case Western Reserve University, and the Academy of Natural Sciences.

Pages [1]-57 of the pamphlet were republished with minor editorial changes in 1834 in the New Series of the Transactions of the American Philosophical Society (volume 4, pages 409-470) and pages 58-80 were republished with minor editorial changes and scientific comments of T.W. Harris in 1839 in the same journal (volume 6, pages 155-190). The last 14 pages of the 1839 publication contain descriptions and notes not previously published and were likely taken from manuscripts sent after Say's death by his wife, Lucy W. Say, to T.W. Harris (Weiss and Ziegler 1931). The version reproduced by J.L. LeConte (in Say 1859*b*: 521-629) is that of the Transactions of the American Philosophical Society.

Carus and Engelmann (1861) correctly recorded the dates (1830-34) and the number of pages (81 pages) of this pamphlet. Hagen (1863) listed it as published in 1829-1833 and containing 65 pages. Horn and Schenkling (1928) catalogued the pamphlet as "Disseminator of useful knowledge, New Harmony, 1829-33, sep. p. 1-81". Summers (1982) reported it as printed in 1834 and "included material originally published in the Disseminator". I am not aware of any taxonomic works citing this pamphlet except Blackwelder (1952) who listed it in the "Bibliography" section as published in 1830. The reproduction in the Transactions of the American Philosophical Society of 1834 and 1839 is the reference cited by most taxonomists and the publication dates of that journal (i.e. 1834, 1839) are those which are, erroneously, attached to Say's scientific names.

**5. Say, T. 1831. Descriptions of new species of North American insects, found in Louisiana by Joseph Barabino. School Press, New Harmony [Indiana]. 17 pp.**

This pamphlet, published in March 1831, as indicated on the title page, had 17 printed pages which were numbered 3-19. Scudder (1899) called attention to this work which had been omitted by J.L. LeConte (in Say 1859*a, b*). As discussed by Bequaert (1950), Horn and Schenkling (1928) incorrectly cited this pamphlet and the one published in January 1832 (item #8) as the same publication with different titles.

The publication contains the description of 22 species, 12 Coleoptera, four Hemiptera, five Hymenoptera, and one Diptera. All but two of the descriptions were already published (Say 1830*b* and/or 1830*c*), or were republished later (Say 1831*d*, 1835, 1836, or 1837).

**6. Say, T. 1831. Descriptions of new species of curculionites of North America, with observations on some of the species already known. School Press, New Harmony [Indiana]. 30 pp.**

This publication was published in July 1831, as indicated on the front page. The title reported here appears on the front page, but the second page bears another title "Descriptions of North American Curculionides & an arrangement of some of our known species agreeably to the method of Schoenherr". Pages 25-30 constitute the "supplement" and could have been published later, possibly in 1832 (Anonymous 1861). However, because there is no tangible evidence supporting that interpretation, the year indicated on the pamphlet (i.e. 1831) should be accepted for nomenclatural purposes. The paper was republished, under the title on the second page, with short comments by J.L. LeConte (in Say 1859a: 259-299).

**7. Say, T. 1831. Descriptions of new species of heteropterous Hemiptera of North America. School Press, New Harmony [Indiana]. 39 pp.**

This pamphlet was published in December 1831, as indicated on the cover page. It was reproduced by A. Fitch, in 1858, in the Transactions of the N.Y. State Agricultural Society (volume 17, pages 755-812). Fitch (1858) reported that although the title page bears the date 1831, only the first four pages were printed that year, because Say mentioned, on page 5, his pamphlet of January 1832 (item #8). However, since both pamphlets appeared nearly simultaneously (December 1831 and January 1832), it is likely that both were printed concurrently. Say, who was involved in the printing process (Weiss and Ziegler 1931), had access to the plates of the January 1832 pamphlet and could have modified the plates of the December 1831 pamphlet. Obviously, it is also possible that the cover date is incorrect but, in my opinion, it is unlikely that some pages were published in 1831 and others later. Because of the uncertainty concerning the publishing date, I believe that the year on the cover page (i.e. 1831) should be accepted for nomenclatural purposes. The version reproduced by J.L. LeConte (in Say 1859a: 310-368) is that published in the Transactions of the N.Y. State Agricultural Society.

**8. Say, T. 1832. New species of North American insects, found by Joseph Barabino, chiefly in Louisiana. School Press, New Harmony [Indiana]. 16 pp.**

This publication was published in January 1832, as indicated on the cover page. It contains the descriptions of 19 species, seven Coleoptera, nine Hemiptera, one Hymenoptera, and two Diptera. The descriptions of some Hemiptera species were partly reprinted from the December

1831 pamphlet (item #7). The paper was republished with short comments by J.L. LeConte (in Say 1859a: 300-309).

Because of the scarcity of the New Harmony pamphlets and the subsequent reproductions of some of them, the dates associated with many species described by Say are often given incorrectly. This is mainly true for species of Coleoptera. Table 1 lists all new taxa and new replacement names of beetles proposed by Say and published in New Harmony, with their references (including their subsequent reproductions, with the exception of Say [1859a, b,]) and valid names. By employing the correct dates, four of Say's names, previously considered as junior synonyms, have priority. They are: *Chlaenius circumcinctus* Say, 1830 [not 1834] in place of *Chlaenius perplexus* Dejean, 1831; *Chlaenius soccatus* Say, 1830 [not 1834] in place of *Chlaenius melanarius* Dejean, 1831; *Dytiscus confluens* Say, 1830, [not 1834] in place of *Dytiscus dauricus* Gebler, 1832; and *Tenomerga cinerea* (Say, 1831) [not 1834] in place of *Tenomerga concolor* (Westwood, 1835) [not 1830].

Table 1. Alphabetical list of new taxa and new replacement names of Coleoptera proposed by Say and printed in New Harmony, with references and valid names (i.e. correct scientific names for the taxa).

Say's Taxa	References	Valid Names
<i>Acanthocinus quadrigibbus</i>	1831a: 9; 1835: 195	<i>Acanthoderes quadrigibbus</i> (Say, 1831)
<i>Acupalpus debilipes</i>	1830c: 21; 1834b: 435	<i>Bradycellus rupestris</i> (Say, 1823)
<i>Acupalpus obsoletus</i>	1830c: 22; 1834b: 435	<i>Bradycellus obsoletus</i> (Say, 1830)
<i>Agonum orbicollis</i>	1830b: (4)[3]; 1830c: [11]; 1834b: 423	<i>Agonum punctiforme</i> (Say, 1823)
<i>Agonum suturale</i>	1830b: (4)[3]; 1830c: [10]; 1834b: 422	<i>Agonum suturale</i> Say, 1830
<i>Agraphus</i>	1831b: 13	<i>Agraphus</i> Say, 1831
<i>Agrilus atiosus</i>	1833: 68(48); 1839: 163	<i>Agrilus atiosus</i> Say, 1833 [not otiosus]
<i>Agrilus fallax</i>	1833: 66(46); 1839: 163	<i>Agrilus fallax</i> Say, 1833
<i>Agrilus putillus</i>	1833: 67(47); 1839: 163	<i>Agrilus putillus</i> Say, 1833
<i>Aleochara bilobata</i>	1833: 59; 1839: 156	<i>Aleodorius bilobatus</i> (Say, 1833)
<i>Aleochara exigua</i>	1833: 59; 1839: 156	<i>Oligota exigua</i> (Say, 1833)
<i>Aleochara falsifica</i>	1833: 58; 1839: 155	? <i>Xenota falsifica</i> (Say, 1833)
<i>Aleochara fasciata</i>	1832b: 56; 1834b: 469	<i>Phanerota fasciata</i> (Say, 1832)
<i>Aleochara indentata</i>	1832b: 56; 1834b: 469	<i>Philhygra indentata</i> (Say, 1832)
<i>Aleochara lustrica</i>	1832b: 55; 1834b: 468	<i>Aleochara lustrica</i> Say, 1832
<i>Aleochara minima</i>	1833: 59; 1839: 156	? <i>Xenota minima</i> (Say, 1833)
<i>Aleochara obscuricollis</i>	1832b: 55; 1834b: 468	<i>Aleochara obscuricollis</i> Say, 1832
<i>Aleochara propera</i>	1832b: 57; 1834b: 470	<i>Amischa propera</i> (Say, 1832)
<i>Aleochara semicarinata</i>	1832b: 57; 1834b: 470	? <i>Funda semicarinata</i> (Say, 1832)
<i>Aleochara simplicicollis</i>	1833: 58; 1839: 155	<i>Crataraea suturalis</i> (Mannerheim, 1830)
<i>Aleochara verna</i>	1833: 58; 1839: 156	<i>Aleochara verna</i> Say, 1833

<i>Aleochara 4-punctata</i>	1832b: 57; 1834b: 470	? <i>Xenota quadripunctata</i> (Say, 1832)
<i>Aleodorus</i>	1833: 60; 1839: 157	<i>Aleodorus</i> Say, 1833
<i>Altica exapta</i>	1832a: 6	<i>Altica carinata</i> Germar, 1824
<i>Altica mellicollis</i>	1831a: 10; 1835: 199	? <i>Disonycha mellicollis</i> (Say, 1831)
<i>Altica ocreata</i>	1832a: 7	<i>Monomacra tibialis</i> (Olivier, 1808)
<i>Amara dolosa</i>	1830b: (7)[3]; 1830c: [15]; 1834b: 429	<i>Amara dolosa</i> Say, 1830
<i>Amara furtiva</i>	1830b: (7)[3]; 1830c: [16]; 1834b: 429	<i>Amara exarata</i> Dejean, 1828
<i>Amara grossa</i>	1830b: (7)[3]; 1830c: [16]; 1834b: 430	<i>Euryderus grossus</i> (Say, 1830)
<i>Amara sera</i>	1830b: (7)[3]; 1830c: [16]; 1834b: 429	<i>Amara sera</i> Say, 1830
<i>Amblycheila</i>	1830a: 67; 1830c: [1]; 1834b: 409	<i>Amblycheila</i> Say, 1830
<i>Anchomenus collaris</i>	1830b: (4)[3]; 1830c: [10]; 1834b: 421	<i>Agonum collare</i> (Say, 1830)
<i>Anisodactylus dilatatus</i>	1830c: 18; 1834b: 431	<i>Anisodactylus anthracinus</i> (Dejean, 1829)
<i>Anthonomus calceatus</i>	1831b: 15	<i>Odontopus calceatus</i> (Say, 1831)
<i>Anthonomus erythropterus</i>	1831b: 25	<i>Anthonomus suturalis</i> LeConte, 1824
<i>Anthonomus musculus</i>	1831b: 15	<i>Anthonomus musculus</i> Say, 1831
<i>Anthonomus quadrigibbus</i>	1831b: 15	<i>Anthonomus quadrigibbus</i> Say, 1831
<i>Anthonomus signatus</i>	1831b: 25	<i>Anthonomus signatus</i> Say, 1831
<i>Anthophagus verticalis</i>	1831c: 49; 1834b: 463	<i>Geonomicus verticalis</i> (Say, 1831)
<i>Anthribus brevicornis</i>	1831b: 4	<i>Phaenithon brevicorne</i> (Say, 1831)
<i>Anthribus cornutus</i>	1831b: 4	<i>Toxonotus cornutus</i> (Say, 1831)
<i>Aphrastus</i>	1831b: 9	<i>Aphrastus</i> Say, 1831
<i>Apion segnipēs</i>	1831b: 6	<i>Apion segnipēs</i> Say, 1831
<i>Aracanthus</i>	1831b: 9	<i>Aracanthus</i> Say, 1831
<i>Aretharea</i>	1830a: 68; 1830c: [2]; 1834b: 411	<i>Aretharea</i> Say, 1830
<i>Aretharea helluonis</i>	1830a: 69; 1830c: [2]; 1834b: 411	<i>Aretharea helluonis</i> Say, 1830
<i>Ateuchus humectus</i>	1832a: 4	<i>Canthon humectus</i> (Say, 1832)
<i>Bagous aereus</i>	1831b: 29	<i>Tyloderma aereum</i> (Say, 1831)
<i>Bagous mamillatus</i>	1831b: 28	<i>Bagous mamillatus</i> Say, 1831
<i>Bagous simplex</i>	1831b: 29	<i>Lissorhoptrus simplex</i> (Say, 1831)
<i>Balaninus nasicus</i>	1831b: 16	<i>Curculio nasicus</i> (Say, 1831)
<i>Balaninus nasutus</i>	1831b: 16	<i>Curculio proboscideus</i> (Fabricius, 1775)
<i>Balaninus rectus</i>	1831b: 16	<i>Curculio proboscideus</i> (Fabricius, 1775)
<i>Baridius acutipennis</i>	1831b: 27	<i>Craptus acutipennis</i> (Say, 1831)
<i>Baridius nigrinus</i>	1831b: 26	<i>Pseudobaris nigrina</i> (Say, 1831)
<i>Baridius scolopax</i>	1831b: 26	<i>Aulobaris scolopax</i> (Say, 1831)
<i>Baridius striatus</i>	1831b: 17	<i>Baris striata</i> (Say, 1831)
<i>Baridius transversus</i>	1831b: 18	<i>Baris transversa</i> (Say, 1831)
<i>Baridius trinitatus</i>	1831b: 17	<i>Trichobaris trinitata</i> (Say, 1831)
<i>Baridius undatus</i>	1831b: 17	<i>Craptus undatus</i> (Say, 1831) [not undulatus]
<i>Barynotus erinaceus</i>	1831b: 12	<i>Panscopus erinaceus</i> (Say, 1831)
<i>Barynotus granulatus</i>	1831b: 12	<i>Anametis granulata</i> (Say, 1830)

Say's Taxa	References	Valid Names
<i>Barynotus rigidus</i>	1831 <i>b</i> : 11	<i>Phyxelis rigidus</i> (Say, 1831)
<i>Bembidium ephippiatum</i>	1830 <i>c</i> : 25; 1834 <i>b</i> : 439	<i>Pericompsus ephippiatus</i> (Say, 1830)
<i>Bembidium incurvum</i>	1830 <i>c</i> : 26; 1834 <i>b</i> : 440	<i>Elaphropus incurvus</i> (Say, 1831)
<i>Bembidium postremum</i>	1830 <i>c</i> : 23; 1834 <i>b</i> : 437	<i>Bembidion postremum</i> Say, 1830
<i>Bembidium semifasciatus</i>	1830 <i>c</i> : 25; 1834 <i>b</i> : 438	<i>Bembidion semifasciatum</i> Say, 1830
<i>Bembidium sigillare</i>	1830 <i>c</i> : 24; 1834 <i>b</i> : 437	<i>Bembidion punctatostriatum</i> Say, 1823
<i>Bembidium tripunctatum</i>	1830 <i>c</i> : 26; 1834 <i>b</i> : 439	<i>Elaphropus tripunctatus</i> (Say, 1830)
<i>Brachinus stygicornis</i>	1830 <i>b</i> : (1)[3]; 1830 <i>c</i> : [5]; 1834 <i>b</i> : 415	<i>Brachinus quadripennis</i> Dejean, 1825
<i>Bruchus mimus</i>	1831 <i>b</i> : 2	<i>Gibbobruchus mimus</i> (Say, 1831)
<i>Bruchus musculus</i>	1831 <i>b</i> : 3	<i>Meibomeus musculus</i> (Say, 1831)
<i>Bruchus obsoletus</i>	1831 <i>b</i> : 2	<i>Acanthoscelides obsoletus</i> (Say, 1831)
<i>Bruchus obtectus</i>	1831 <i>b</i> : 1	<i>Acanthoscelides obtectus</i> (Say, 1831)
<i>Bruchus oculatus</i>	1831 <i>b</i> : 2	<i>Acanthoscelides oculatus</i> (Say, 1831)
<i>Bruchus transversus</i>	1831 <i>b</i> : 3	<i>Althaeus hibisci</i> (Olivier, 1795)
<i>Bruchus triangularis</i>	1831 <i>b</i> : 1	<i>Acanthoscelides triangularis</i> (Say, 1831)
<i>Buprestis acornis</i>	1833: 63; 1839: 159	<i>Actenodes acornis</i> (Say, 1833)
<i>Buprestis impedita</i>	1833: 63; 1839: 160	<i>Cypriacus striata</i> (Fabricius, 1775)
<i>Buprestis thureura</i>	1832 <i>a</i> : 3	<i>Descarpentriesina thureura</i> (Say, 1832)
<i>Buprestis ultramarina</i>	1833: 64; 1839: 160	<i>Buprestis salisburyensis</i> Herbst, 1801
<i>Callopius</i>	1831 <i>b</i> : 9	<i>Compsus Schönherr</i> , 1823
<i>Centrinus scutellum album</i>	1831 <i>b</i> : 21	<i>Odontocorynus scutellum album</i> (Say, 1831)
<i>Ceutorhynchus curtus</i>	1831 <i>b</i> : 29	<i>Acanthoscelidius curtus</i> (Say, 1831)
<i>Ceutorhynchus inaequalis</i>	1831 <i>b</i> : 20	<i>Craponius inaequalis</i> (Say, 1831)
<i>Ceutorhynchus triangularis</i>	1831 <i>b</i> : 20	<i>Rhinoncus triangularis</i> (Say, 1831)
<i>Chlaenius circumcinctus</i>	1830 <i>b</i> : (3)[3]; 1830 <i>c</i> : [7]; 1831 <i>a</i> : 3; 1834 <i>b</i> : 418	<i>Chlaenius circumcinctus</i> Say, 1830
<i>Chlaenius soccatus</i>	1830 <i>b</i> : (3)[3]; 1830 <i>c</i> : [8]; 1834 <i>b</i> : 419	<i>Chlaenius soccatus</i> Say, 1830
<i>Chlaenius vigilans</i>	1830 <i>b</i> : (3)[3]; 1830 <i>c</i> : [8]; 1834 <i>b</i> : 419	<i>Chlaenius tricolor</i> Dejean, 1826
<i>Cleogonus sedentarius</i>	1831 <i>b</i> : 30	<i>Pseudomus sedentarius</i> (Say, 1831)
<i>Cleonus trivittatus</i>	1831 <i>b</i> : 10	<i>Cleonidius trivittatus</i> (Say, 1831)
<i>Colymbetes gutticollis</i>	1830 <i>c</i> : 29; 1834 <i>b</i> : 442	<i>Rhantus gutticollis</i> (Say, 1830)
<i>Coptotomus</i>	1830 <i>c</i> : 29; 1834 <i>b</i> : 443	<i>Coptotomus</i> Say, 1830
<i>Coptotomus serripalpus</i>	1830 <i>c</i> : 30; 1834 <i>b</i> : 443	<i>Coptotomus serripalpus</i> Say, 1830
<i>Cossonus corticola</i>	1831 <i>b</i> : 24;	<i>Cossonus corticola</i> Say, 1831
<i>Cossonus multiforus</i>	1831 <i>b</i> : 30	<i>Cossonus multiforus</i> Say, 1831
<i>Cossonus platalea</i>	1831 <i>b</i> : 24	<i>Cossonus platalea</i> Say, 1831
<i>Cryptorhynchus anaglypticus</i>	1831 <i>b</i> : 18	<i>Conotrachelus anaglypticus</i> (Say, 1831)
<i>Cryptorhynchus bisignatus</i>	1831 <i>b</i> : 19	<i>Eubulus bisignatus</i> (Say, 1831)
<i>Cryptorhynchus cribricollis</i>	1831 <i>b</i> : 28	<i>Pheloconus cribricollis</i> (Say, 1831)
<i>Cryptorhynchus elegans</i>	1831 <i>b</i> : 18	<i>Conotrachelus elegans</i> (Say, 1831)
<i>Cryptorhynchus ferratus</i>	1831 <i>b</i> : 28	<i>Apteromechus ferratus</i> (Say, 1831)
<i>Cryptorhynchus foveolatus</i>	1831 <i>b</i> : 19	<i>Tyloderma foveolatum</i> (Say, 1831)
<i>Cryptorhynchus obliquus</i>	1831 <i>b</i> : 28	<i>Cryptorhynchus obliquus</i> Say, 1831
<i>Cryptorhynchus palmacollis</i>	1831 <i>b</i> : 27	<i>Rhyssomatus palmacollis</i> (Say, 1831)

Say's Taxa	References	Valid Names
<i>Cryptorhynchus retentus</i>	1831 <i>b</i> : 27	<i>Conotrachelus retentus</i> (Say, 1831)
<i>Cryptorhynchus tubulatus</i>	1831 <i>b</i> : 20	<i>Idiostethus tubulatus</i> (Say, 1831)
<i>Cupes cinerea</i>	1831 <i>a</i> : 6; 1835: 167	<i>Tenomerga cinerea</i> (Say, 1831)
<i>Cymindis laticollis</i>	1830 <i>a</i> : 134; 1830 <i>c</i> : [3]; 1834 <i>b</i> : 413	<i>Cymindis laticollis</i> Say, 1830
<i>Deracanthus pallidus</i>	1831 <i>b</i> : 9	<i>Aracanthus pallidus</i> (Say, 1831)
<i>Dermestes nubilus</i>	1832 <i>a</i> : 3	<i>Dermestes caninus</i> Germar, 1824
<i>Dryophthorus corticalis</i>	1831 <i>b</i> : 24	<i>Dryophthorus americanus</i> Bedel, 1885
<i>Dytiscus bimarginatus</i>	1830 <i>c</i> : 28; 1831 <i>a</i> : 5; 1834 <i>b</i> : 442	<i>Hydaticus bimarginatus</i> (Say, 1830)
<i>Dytiscus confluens</i>	1830 <i>c</i> : 27; 1834 <i>b</i> : 440	<i>Dytiscus confluens</i> Say, 1830
<i>Dytiscus habilis</i>	1830 <i>c</i> : 27; 1834 <i>b</i> : 441	<i>Dytiscus habilis</i> Say, 1830
<i>Elaphrus fuliginosus</i>	1830 <i>b</i> : (1)[3]; 1830 <i>c</i> : [6]; 1834 <i>b</i> : 417	<i>Elaphrus fuliginosus</i> Say, 1830
<i>Elaphrus ruscarius</i>	1830 <i>b</i> : (1)[3]; 1830 <i>c</i> : [6]; 1834 <i>b</i> : 417	<i>Elaphrus ruscarius</i> Say, 1830
<i>Elater agonus</i>	1834 <i>a</i> : 75; 1839: 171	<i>Limonium agonus</i> (Say, 1834)
<i>Elater apicatus</i>	1834 <i>a</i> : 74; 1839: 170	<i>Ampedus apicatus</i> (Say, 1834)
<i>Elater armus</i>	1834 <i>a</i> : 75; 1839: 171	<i>Limonium stigma</i> (Herbst, 1806)
<i>Elater attenuatus</i> <sup>1</sup>	1833: 70(50); 1839: 166	<i>Parallostethus attenuatus</i> (Say, 1825)
<i>Elater baridius</i>	1834 <i>a</i> : 79; 1839: 176	<i>Hemicrepidius memnonius</i> (Herbst, 1806)
<i>Elater bilobatus</i>	1834 <i>a</i> : 78; 1839: 174	<i>Hemicrepidius bilobatus</i> (Say, 1834)
<i>Elater cardisce</i>	1834 <i>a</i> : 73½; 1839: 169	<i>Cardiophorus cardisce</i> (Say, 1834)
<i>Elater choris</i>	1834 <i>a</i> : 76; 1839: 172	<i>Negastrius choris</i> (Say, 1834)
<i>Elater curiatus</i>	1834 <i>a</i> : 77; 1839: 173	<i>Horistonotus curiatus</i> (Say, 1834)
<i>Elater discalceatus</i>	1834 <i>a</i> : 73½; 1839: 169	<i>Elathous discalceatus</i> (Say, 1834)
<i>Elater ectypus</i>	1833: 72(52); 1839: 167	<i>Limonium ectypus</i> (Say, 1833)
<i>Elater exstriatus</i>	1834 <i>a</i> : 80; 1839: 177	<i>Drapetes exstriatus</i> (Say, 1834) <sup>2</sup>
<i>Elater fallax</i>	1834 <i>a</i> : 74; 1839: 170	<i>Ctenicera fallax</i> (Say, 1834)
<i>Elater hamatus</i>	1834 <i>a</i> : 74; 1839: 170	<i>Ctenicera hamata</i> (Say, 1834)
<i>Elater hieroglyphicus</i>	1834 <i>a</i> : 75; 1839: 172	<i>Ctenicera hieroglyphica</i> (Say, 1834)
<i>Elater inquinatus</i>	1834 <i>a</i> : 78; 1839: 175	<i>Glyphonyx inquinatus</i> (Say, 1834)
<i>Elater mellillus</i>	1834 <i>a</i> : 76; 1839: 173	<i>Aeolus mellillus</i> (Say, 1834)
<i>Elater oblessus</i> <sup>3</sup>	1833: 70(50); 1839: 165	<i>Ampedus oblessus</i> (Say, 1833)
<i>Elater obliquus</i>	1834 <i>a</i> : 77; 1839: 174	<i>Ampedus areolatus</i> (Say, 1823)
<i>Elater pectoralis</i>	1834 <i>a</i> : 76; 1839: 173	<i>Paradonus pectoralis</i> (Say, 1834)
<i>Elater soleatus</i>	1834 <i>a</i> : 79; 1839: 176	<i>Ischiodontus soleatus</i> (Say, 1834)
<i>Elater sulcicollis</i>	1833: 70(50); 1839: 168	<i>Ctenicera sulcicollis</i> (Say, 1833)
<i>Erirehinus ephippiatus</i>	1831 <i>b</i> : 25	<i>Elleschus ephippiatus</i> (Say, 1831)
<i>Erirehinus mucidus</i>	1831 <i>b</i> : 14	<i>Dorytomus mucidus</i> (Say, 1831)
<i>Erirehinus rufus</i> [as rufous]	1831 <i>b</i> : 25	<i>Elleschus ephippiatus</i> (Say, 1831)
<i>Erodiscus myrmecodes</i>	1831 <i>b</i> : 15	<i>Myrmex myrmex</i> (Herbst, 1797)
<i>Feronia deparca</i>	1830 <i>b</i> : (6)[3]; 1830 <i>c</i> : [13]; 1834 <i>b</i> : 426	<i>Amara deparca</i> (Say, 1830)
<i>Feronia oblongo-notata</i>	1830 <i>b</i> : (6)[3]; 1830 <i>c</i> : [13]; 1834 <i>b</i> : 425	<i>Pterostichus adstrictus</i> Eschscholtz, 1823
<i>Feronia obscura</i>	1830 <i>b</i> : (5)[3]; 1830 <i>c</i> : [12]; 1834 <i>b</i> : 425	<i>Pterostichus sayanus</i> Csiki, 1930

Say's Taxa	References	Valid Names
<i>Feronia obsoleta</i>	1830b: (5)[3]; 1830c: [12]; 1834b: 424	<i>Cyclotrachelus obsoletus</i> (Say, 1830)
<i>Feronia permunda</i>	1830b: (6)[3]; 1830c: [14]; 1834b: 426	<i>Pterostichus permundus</i> (Say, 1830)
<i>Graphorhinus</i>	1831b: 8	<i>Graphorhinus</i> Say, 1831
<i>Graphorhinus operculatus</i>	1831b: 9	<i>Epicaerus operculatus</i> (Say, 1831)
<i>Graphorhinus vadosus</i>	1831b: 8	<i>Graphorhinus vadosus</i> Say, 1831
<i>Gyrinus obtusus</i>	1830c: 34; 1834b: 447	<i>Gyrinus obtusus</i> Say, 1830
<i>Gyrinus parvus</i>	1830c: 34; 1834b: 448	<i>Gyrinus parvus</i> Say, 1830
<i>Harpalus amputatus</i>	1830c: 19; 1834b: 432	<i>Harpalus amputatus</i> Say, 1830
<i>Harpalus ocreatus</i>	1830c: 20; 1834b: 433	<i>Notiobia terminata</i> (Say, 1823)
<i>Hydrocanthus atripennis</i>	1830c: 33; 1834b: 447	<i>Hydrocanthus atripennis</i> Say, 1830
<i>Hydrophilus castus</i>	1831a: 7; 1835: 170	<i>Hydrobiomorpha casta</i> (Say, 1831)
<i>Hydroporus bifidus</i>	1830c: 31; 1834b: 444	<i>Potamonectes bifidus</i> (Say, 1830)
<i>Hydroporus discicollis</i>	1830c: 32; 1834b: 446	? <i>Hydroporus dichrous</i> Melsheimer, 1846
<i>Hydroporus interruptus</i>	1830c: 32; 1834b: 445	<i>Potamonectes griseostriatus</i> (DeGeer, 1774)
<i>Hydroporus nudatus</i>	1830c: 31; 1834b: 444	? <i>Potamonectes aequinoctialis</i> (Clark, 1862)
<i>Hydroporus sericatus</i>	1830c: 31; 1834b: 445	<i>Hydroporus sericatus</i> Say, 1830
<i>Hypsonotus alternatus</i>	1831b: 10	<i>Trichalophus alternatus</i> (Say, 1831)
<i>Lamia crypta</i>	1832a: 5	<i>Ataxia crypta</i> (Say, 1832)
<i>Lathrobium armatum</i>	1830c: 40; 1834b: 453	<i>Lathrobium armatum</i> Say, 1830
<i>Lathrobium cinctum</i>	1830c: 40; 1834b: 454	<i>Astenus cinctus</i> (Say, 1830)
<i>Lathrobium confluentum</i>	1831c: 43; 1834b: 456	<i>Sunius confluentus</i> (Say, 1831)
<i>Lathrobium dimidiatum</i>	1830c: 41; 1834b: 455	<i>Lobrathium dimidiatum</i> (Say, 1830)
<i>Lathrobium millepunctatum</i>	1831c: 42; 1834b: 456	<i>Achenomorphus corticinus</i> (Gravenhorst, 1802)
<i>Lathrobium similipenne</i>	1830c: 40; 1834b: 453	<i>Ochtheophilum similipenne</i> (Say, 1830)
<i>Lathrobium sphaericolle</i>	1831c: 42; 1834b: 455	<i>Apocellus sphaericollis</i> (Say, 1831)
<i>Lepyrus geminatus</i>	1831b: 12	<i>Lepyrus palustris</i> (Scopoli, 1763)
<i>Listroderes lineatulus</i>	1831b: 11	<i>Listronotus sparsus</i> (Say, 1831)
<i>Listroderes porcellus</i>	1831b: 11	<i>Listronotus porcellus</i> (Say, 1831)
<i>Listroderes sparsus</i>	1831b: 11	<i>Listronotus sparsus</i> (Say, 1831)
<i>Listroderes squamiger</i>	1831b: 11	<i>Listronotus squamiger</i> (Say, 1831)
<i>Lixus concavus</i>	1831b: 14	<i>Lixus concavus</i> Say, 1831
<i>Lixus lateralis</i>	1831b: 14	? <i>Lixus lateralis</i> Say, 1831
<i>Lixus marginatus</i>	1831b: 13	? <i>Lixus marginatus</i> Say, 1831
<i>Lixus musculus</i>	1831b: 14	? <i>Lixus musculus</i> Say, 1831
<i>Metonius</i>	1833: 68(48); 1839: 164	<i>Pachyschelus</i> Solier, 1833
<i>Metonius laevigatus</i>	1833: 69(49); 1839: 164	<i>Pachyschelus laevigatus</i> (Say, 1833)
<i>Metonius purpureus</i>	1833: 69(49); 1839: 164	<i>Pachyschelus purpuratus</i> (Say, 1833)
<i>Molosoma</i>	1831c: 48; 1834b: 462	<i>Osorius</i> Dejean, 1821
<i>Noterus bicolor</i>	1830c: 33; 1831a: 5; 1834b: 446	<i>Hydrocanthus bicolor</i> (Say, 1830)
<i>Nothiophilus porrectus</i>	1830b: (3)[3]; 1830c: [7]; 1834b: 418	<i>Notiophilus aeneus</i> (Herbst, 1806)
<i>Odontopus</i>	1831b: 15	<i>Odontopus</i> Say, 1831
<i>Oedemera apicalis</i>	1831a: 9; 1835: 188	<i>Nacerdes melanura</i> (Linné, 1758)
<i>Olisthopus cinctus</i>	1830b: (5)[3]; 1830c: [11]; 1834b: 424	<i>Olisthopus parvatus</i> (Say, 1823)

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<i>Omalius marginatus</i>	1832b: 50; 1834b: 463	<i>Eusphalerum marginatum</i> (Say, 1832)
<i>Omalius rotundicollis</i>	1832b: 50; 1834b: 464	<i>Olophrum obtectum</i> Erichson, 1840
<i>Oodes parallelus</i>	1830b: (3)[3]; 1830c: [8]; 1831a: 4; 1834b: 420	<i>Lachnocypris parallela</i> (Say, 1830)
<i>Ophryastes</i>	1831b: 13	<i>Ophryastes</i> Say, 1831
<i>Orchestes ephippiatus</i>	1831b: 16	<i>Tachyerges ephippiatus</i> (Say, 1831)
<i>Orchestes pallicornis</i>	1831b: 16	<i>Rhynchaenus pallicornis</i> (Say, 1831)
<i>Oxyporus stygicus</i>	1831c: 46; 1834b: 459	<i>Oxyporus stygicus</i> Say, 1831
<i>Oxytelus cordatus</i>	1831c: 47; 1834b: 461	<i>Bledius cordatus</i> (Say, 1831)
<i>Oxytelus emarginatus</i>	1831c: 48; 1834b: 461	<i>Bledius emarginatus</i> (Say, 1831)
<i>Oxytelus rugulosus</i>	1831c: 47; 1834b: 460	? <i>Anotylus rugulosus</i> (Say, 1831)
<i>Paederus cinctus</i>	1831c: 44; 1834b: 457	<i>Homaeotarsus cinctus</i> (Say, 1831)
<i>Paederus discopunctatus</i>	1831c: 43; 1834b: 457	<i>Astenus discopunctatus</i> (Say, 1831)
<i>Peritelus bellicus</i>	1831b: 13	<i>Agraphus bellicus</i> (Say, 1831)
<i>Peritelus chrysorrhaeus</i>	1831b: 13	<i>Cercopeus chrysorrhaeus</i> (Say, 1831)
<i>Phytonomus comptus</i>	1831b: 12	<i>Hypera compta</i> (Say, 1831)
<i>Phytonomus trivittatus</i>	1831b: 12	<i>Hypera trivittata</i> (Say, 1831)
<i>Pterocolus</i>	1831b: 5	<i>Pterocolus</i> Say, 1831
<i>Rhynchites aeratus</i>	1831b: 5	<i>Pselaphorhynchites aeratus</i> (Say, 1831)
<i>Rhyncholus latinasus</i>	1831b: 30	<i>Cossonus corticola</i> Say, 1831
<i>Rhynchophorus cicatricosus</i>	1831b: 22	<i>Sphenophorus cariosus</i> (Olivier, 1807)
<i>Rhynchophorus immunis</i>	1831b: 23	<i>Sphenophorus venatus</i> (Say, 1831)
<i>Rhynchophorus inaequalis</i>	1831b: 23	<i>Sphenophorus inaequalis</i> (Say, 1831)
<i>Rhynchophorus interstitialis</i>	1831b: 21	? <i>Sphenophorus interstitialis</i> (Say, 1831)
<i>Rhynchophorus placidus</i>	1831b: 23	<i>Sphenophorus venatus</i> (Say, 1831)
<i>Rhynchophorus praepotens</i>	1831b: 21	<i>Cleonidius trivittatus</i> (Say, 1831)
<i>Rhynchophorus rectus</i>	1831b: 22	<i>Sphenophorus rectus</i> (Say, 1831)
<i>Rhynchophorus truncatus</i>	1831b: 22	<i>Sphenophorus pertinax</i> (Olivier, 1807)
<i>Rhynchophorus venatus</i>	1831b: 22	<i>Sphenophorus venatus</i> (Say, 1831)
<i>Rugilus dentatus</i>	1831c: 44; 1834b: 457	<i>Rugilus dentatus</i> Say, 1831
<i>Scymnus terminatus</i>	1831a: 11; 1835: 203	<i>Diomus terminatus</i> (Say, 1831)
<i>Sitona indifferens</i>	1831b: 10	<i>Sitona indifferens</i> Say, 1831
<i>Sitona scissifrons</i>	1831b: 10	<i>Sitona scissifrons</i> Say, 1831
<i>Spheracra</i>	1830a: 133; 1830c: [3]; 1834b: 412	<i>Leptotrachelus Latreille</i> , 1829
<i>Staphylinus apicalis</i>	1830c: 37; 1834b: 451	<i>Hesperus apicalis</i> (Say, 1830)
<i>Staphylinus connexus</i>	1830c: 35; 1834b: 448	<i>Belonuchus connexus</i> (Say, 1830)
<i>Staphylinus dimidiatus</i>	1830c: 37; 1834b: 450	<i>Philonthus sericans</i> (Gravenhorst, 1802)
<i>Staphylinus ephippiatus</i>	1830c: 35; 1834b: 448	<i>Belonuchus ephippiatus</i> (Say, 1830)
<i>Staphylinus inversus</i>	1830c: 36; 1834b: 449	<i>Quedius capucinus</i> (Gravenhorst, 1806)
<i>Staphylinus iracundus</i>	1830c: 35; 1834b: 449	<i>Quedius fulgidus</i> (Fabricius, 1787)
<i>Staphylinus tachiniformis</i>	1830c: 37; 1834b: 450	<i>Philonthus tachiniformis</i> (Say, 1830)
<i>Stenolophus cinctus</i>	1831c: 20; 1834b: 434	? <i>Bradycellus rupestris</i> (Say, 1823)
<i>Stenus colon</i>	1831c: 45; 1834b: 458	<i>Stenus colon</i> Say, 1831
<i>Stenus femoratus</i>	1831c: 45; 1834b: 459	<i>Stenus femoratus</i> Say, 1831
<i>Stenus geniculatus</i>	1831c: 44; 1834b: 458	<i>Stenus flavicornis</i> Erichson, 1840
<i>Stenus quadripunctatus</i>	1831c: 46; 1834b: 459	<i>Carpelimus quadripunctatus</i> (Say, 1831)
<i>Stenus stygicus</i>	1831c: 45; 1834b: 458	<i>Stenus stygicus</i> Say, 1831
<i>Stomis granulatus</i>	1830b: (6)[3]; 1830c: [14]; 1834b: 427	? <i>Stomis granulatus</i> Say, 1830

Say's Taxa	References	Valid Names
<i>Tachinus cincticollis</i>	1832b: 51; 1834b: 465	<i>Lordithon thoracicus thoracicus</i> (Fabricius, 1776)
<i>Tachinus humidus</i>	1832b: 52; 1834b: 465	? <i>Mycetoporus humidus</i> (Say, 1832)
<i>Tachinus obsoletus</i>	1832b: 51; 1834b: 464	<i>Lordithon obsoletus</i> (Say, 1832)
<i>Tachinus trimaculatus</i>	1832b: 51; 1834b: 464	<i>Lordithon thoracicus venustus</i> (Melsheimer, 1846)
<i>Tachyporus acaudus</i>	1832b: 54; 1834b: 467	<i>Tachyporus jocosus</i> Say, 1832
<i>Tachyporus faber</i>	1832b: 55; 1834b: 468	<i>Tachyporus nitidulus</i> (Fabricius, 1781)
<i>Tachyporus fumipennis</i>	1832b: 52; 1834b: 466	<i>Tachinus fumipennis</i> (Say, 1832)
<i>Tachyporus jocosus</i>	1832b: 53; 1834b: 466	<i>Tachyporus jocosus</i> Say, 1832
<i>Tachyporus moestus</i>	1832b: 53; 1834b: 466	<i>Sepedophilus crassus</i> (Gravenhorst, 1802)
<i>Tachyporus opicus</i>	1832b: 54; 1834b: 467	<i>Sepedophilus opicus</i> (Say, 1832)
<i>Tachyporus ventriculus</i>	1832b: 53; 1834b: 466	<i>Coproporus ventriculus</i> (Say, 1832)
<i>Tanymecus confusus</i>	1831b: 9	<i>Tanymecus confusus</i> Say, 1831
<i>Tenebrio rufinasus</i>	1831a: 8; 1835: 187	? <i>Alphitobius rufinasus</i> (Say, 1831)
<i>Thamnophilus barbatus</i>	1831b: 6	<i>Magdalis barbata</i> (Say, 1831)
<i>Thamnophilus pallidus</i>	1831b: 7	<i>Magdalis armicollis</i> (Say, 1824)
<i>Thamnophilus pandura</i>	1831b: 7	<i>Magdalis pandura</i> (Say, 1831)
<i>Thecestermus</i>	1831b: 8	<i>Thecestermus</i> Say, 1831
<i>Thylacites microps</i>	1831b: 9	<i>Minyomerus microps</i> (Say, 1831)
<i>Trox aequalis</i>	1832a: 5	<i>Trox aequalis</i> Say, 1832
<i>Trox alternatus</i>	1831a: 7; 1835: 179	<i>Trox suberosus</i> Fabricius, 1775
<i>Tychius amoenus</i>	1831b: 26	<i>Smicronyx amoenus</i> (Say, 1831)
<i>Tychius aratus</i>	1831b: 26	<i>Tychius aratus</i> Say, 1831
<i>Tylodes clavatus</i>	1831b: 29	<i>Acalles clavatus</i> (Say, 1831)
<i>Xantholinus cephalus</i>	1830c: 39; 1834b: 452	<i>Nudobius cephalus</i> (Say, 1830)
<i>Xantholinus hamatus</i>	1830c: 39; 1834b: 453	<i>Neohypnus hamatus</i> (Say, 1830)
<i>Zygops quercus</i>	1831b: 20	<i>Cylindrocopturus quercus</i> (Say, 1831)

<sup>1</sup> Obviously, Say (1833) intended, on page 70, to describe a new species under the binomen *Elater attenuatus*. He apparently overlooked the fact that he already had described an *Elater attenuatus* in 1825, on page 257. The descriptions are slightly different but seem to apply to the same taxon (E. Becker, personal communication). *Elater attenuatus* Say, 1833 is a primary homonym and probably also a junior synonym of *Elater attenuatus* Say, 1825.

<sup>2</sup> This species is usually listed under the name *Drapetes geminatus* (Say, 1825). However, Say's name, described under the binomen *Elater geminatus*, is a primary homonym of *Elater geminatus* Germar, 1824 and so is invalid (ICZN, 1985, art. 57 [b]). Say (1834a) explicitly proposed the name *Elater exstriatus* as a replacement name for *E. geminatus* Say, 1825.

<sup>3</sup> Say explicitly proposed the name *Elater oblessus* as a new replacement name for *Elater discoideus* Fabricius, 1801, a primary homonym of *Elater discoideus* Weber, 1801. Despite Say's (1833: 70) comments which show that he simultaneously applied the new name to a different species, his name remains nevertheless the valid one for the species described as *Elater discoideus* Fabricius, 1801 (ICZN, 1985, art. 72 [e]), not *Elater sellatus* Leng, 1918 as given by some authors.

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I thank A. Wheeler, Commonwealth of Pennsylvania, Harrisburg (PA), S. Granato, The American Museum of Natural History Library, New York, A. Kleine-Kreutzmann, Public Library of Cincinnati & Hamilton County, Cincinnati, and R. Alsop, Library of New Harmony Workingmen's Institute, New Harmony, for providing xerox copies of some of Say's publications and S. Sherman, Entomology Research Library, Agriculture Canada, Ottawa, for her help locating various publications. My colleagues A. Smetana and S. Laplante of the Centre for Land and Biological Resources Research, Ottawa, and I. MacPhail, The Morton Arboretum, Lisle (IL), reviewed the manuscript and offered useful comments.

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## BOOK REVIEW

THOMAS SAY: NEW WORLD NATURALIST. Patricia Tyson Stroud. 1992. University of Pennsylvania Press, Philadelphia. 340 pp. \$24.95.

Entomologists have often maligned Thomas Say for the inadequacies of his descriptions and the loss of most of his specimens. George Ord's Memoir, read before the American Philosophical Society two months after Say's death in 1834, was not wholly flattering, speaking of Say's "neglect of literature" and his "want of technical precision." Ord, "a small man of sour impulses," (in Peter Mathiessen's words) did go on to praise Say's "industry and zeal" and his "integrity" and "veracity". It remained for Weiss and Ziegler, in their 1931 biography, to clarify Say's status as America's first systematic entomologist.

In a carefully researched and lavishly illustrated new biography, Patricia Tyson Stroud paints Say in much broader strokes, not only as an entomologist but as a pioneer naturalist of major stature. He did, after all, describe many birds, mammals, reptiles, and shells as well as insects, and he was acquainted with most of the naturalists of his time. The Thomas Say that emerges from these pages is indeed a "strong, self-determined, highly motivated, even driving character," as Stroud promises in her Introduction.

Say did not attend the initial gathering of Philadelphia naturalists on June 25, 1812, but he did attend the following meeting, when the group decided to call itself the Academy of Natural Sciences of Philadelphia, with Say listed as a founding member. (Ord spoke of these initial meetings as "a club of humorists" which met for "the purpose of amusement.") Over the next few years Say served as the Academy's curator, librarian, and editor of the *Journal*. In between his field trips to Florida and to the Rockies and the Red River of the north he remained active in the Academy, and after his move to New Harmony he often longed for the atmosphere of "the Athens of America." Say was never a success at earning money, and because of his dependence on William Maclure's patronage he was never to escape the isolation and drudgery that marked the final decade of his life.

Stroud's quotations from many of Say's previously unpublished letters reveal a more forceful (though sometimes cranky and discouraged) Say than has been appreciated. He had little use for Rafinesque's conceits, and was disturbed by Rafinesque's not wholly favorable review of his *American Entomology*. He criticized John E. LeConte for disregarding some of his species descriptions and for sending specimens abroad for identification—for Say believed strongly in American taxonomic self-sufficiency. (Ironically, it was LeConte's son, John L., who in 1859 collected Say's scattered publications in two lavish volumes.) But Say did have fast friends, for example Philadelphian Reuben Haines and naturalists Charles Lucien Bonaparte and Charles Lesueur.

Lucy Say also emerges as a stronger personality than previously apparent. After her husband's death she saw to the disposition of his collections and effects and even learned to engrave the plates for the seventh part of *American Conchology*. "I am looked upon as being very singular [she wrote to a friend], particularly since I have commenced Engraving—a gentleman remarked 'Well! at what do you think the ladies will stop?'. I replied, I hoped at nothing... that we were tired of cramping our genius over the needle and the distaff." Lucy Say was the first woman to be elected to the Academy of Natural Sciences. She outlived her husband by half a century.

There are a few minor points in Stroud's biography that bothered me. Dermestid beetles are not really "microscopic predators," and the drink that Say noted on his Mexican trip, pulque, is not the same as tequila, though both are derived from agave. As an entomologist, I would have enjoyed being reminded of some of the exciting discoveries Say

made on his various field trips, such as the remarkable tiger beetle *Amblycheila cylindriiformis* and the fiery tarantula hawk *Pepsis formosa*. But Stroud's objective was to place Say securely as a leading figure in the awakening of Americans to their biological riches, and in this she has been most successful.

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## BOOK REVIEW

**FLORISSANT BUTTERFLIES: A GUIDE TO THE FOSSIL AND PRESENT DAY SPECIES OF CENTRAL COLORADO.** Thomas C. Emmel, Marc C. Minno, and Boyce A. Drummond. Stanford Univ. Press, Ca. 1992. \$14.95 paper; \$35.00 cloth.

Having pleasant memories of two visits to the Florissant area, I was delighted when asked to review this book. Boyce Drummond's stunning cover photograph of two *Paranassius phoebus sayii* immediately catches one's attention.

This book about an area renowned for the quantity of well preserved insect and plant fossils begins with information on insect fossils and the Earth's geological record. This first section contains descriptions and photographs of the twelve butterfly fossil species found at Florissant. The next section covers the ecology of the Florissant region's extant butterflies and gives detailed habitat accounts of both plants and butterflies. Other topics include butterfly diversity, biology, behavior and survival. The authors described the ninety-seven species recorded in the area, and black and white photographs of the larvae, pupae, and adults accompany many of these entries. In addition, ten color plates, showing both male and female forms, illustrate all ninety-seven species. At the end of the book one finds references, an excellent glossary, and a checklist of the present day butterflies of the Florissant Region and Central Colorado. In addition, there are general and plant indexes.

*Florissant Butterflies* contains a great deal of information and is a pleasure to read. Although a field guide version would be more practical than the current, 8 x 11 inch format, the book will still appeal to the serious lepidopterist as well as the traveler and the naturalist interested in Colorado.

Jane Ruffin, naturalist and  
amateur lepidopterist.

# THE PHYLOGENETIC POSITION OF *CHLORONIELLA PERINGUEYI* (MEGALOPTERA: CORYDALIDAE) AND ITS ZOOGEOGRAPHIC SIGNIFICANCE<sup>1</sup>

Norman D. Penny<sup>2</sup>

**ABSTRACT:** Male and female genitalia of *Chloroniella peringueyi* are illustrated for the first time, and phylogenies of all genera of Corydalinae are presented, based both on morphological analysis and plate tectonics. A possible general pattern of megalopteran evolution is suggested.

When Glorioso (1981) published his revision of the Corydalinae, he did not include the South African genus *Chloroniella* in his phylogenetic analysis because he was "unable to obtain specimens of the only known species due to its scarcity in collections." Further attempts to locate additional specimens by the present author have also been unsuccessful. In November 1986 Drs. John T. Doyen and Charles E. Griswold collected 14 specimens of a species that compares well with the original description of *Chloroniella peringueyi* Esben-Petersen at Algeria Forest Camp in the Sederberg mountains of Cape Province, South Africa. Thus, the time seems appropriate to revise the original cladistic analysis to include all known genera.

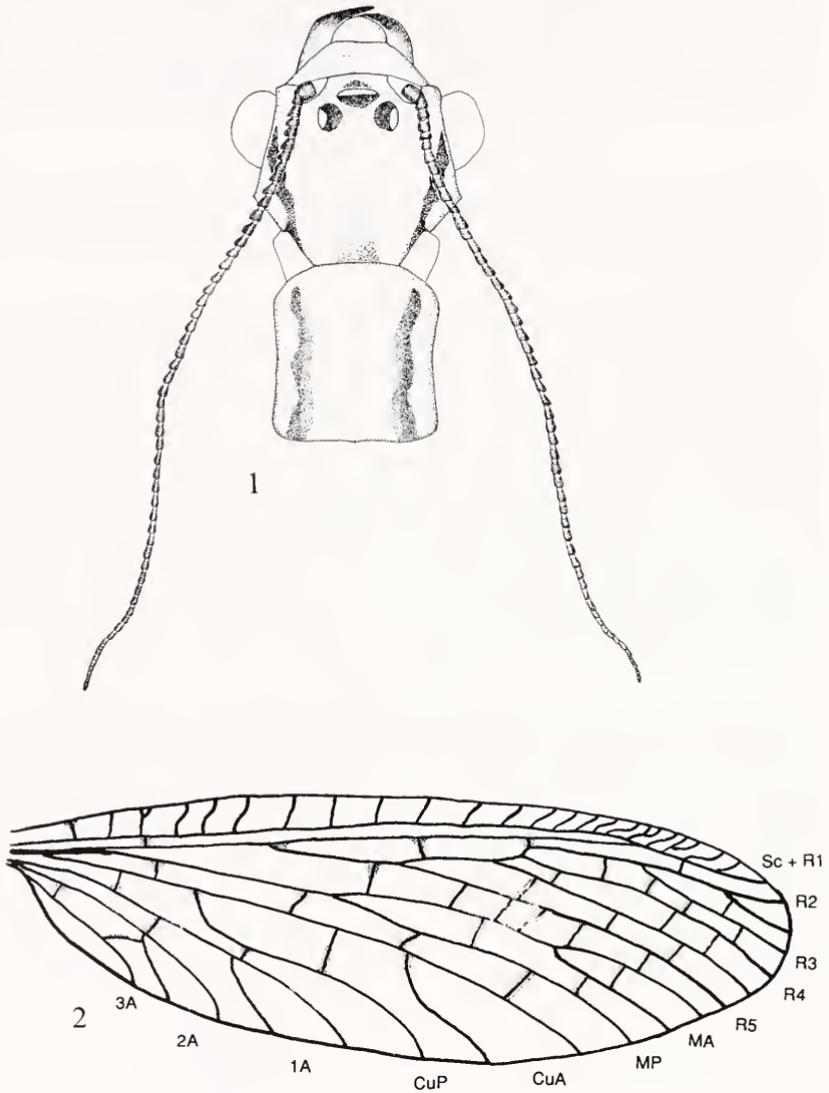
## METHODS

The cladistic analysis utilized the 70 character states from Glorioso's study with a few modifications. His character 18, the stipal setae, was found to be too variable for inclusion. Characters 30 and 41, the 1A branches and male ninth sternal setae respectively, were not included in his cladogram, but are included here. His first three character states are common to all Corydalinae, and thus are uninformative about relationships within the subfamily and have not been included. Five additional characters have been found and are incorporated, four of them exist in *Chloroniella*, two of them being unique to this genus (Table 1). Three of these new characters are autapomorphies<sup>3</sup> within the subfamily, and two are shared with only one other genus. As in Glorioso's study, the apomorphic state was derived from a comparison with genera in Chauliodinae, these being considered the outgroup. In all, 71 charac-

<sup>1</sup> Received February 5, 1990. Revision received and accepted September 12, 1992.

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<sup>3</sup> Autapomorphies are also uninformative about relationships, but do provide evidence about the monophyly of a group.

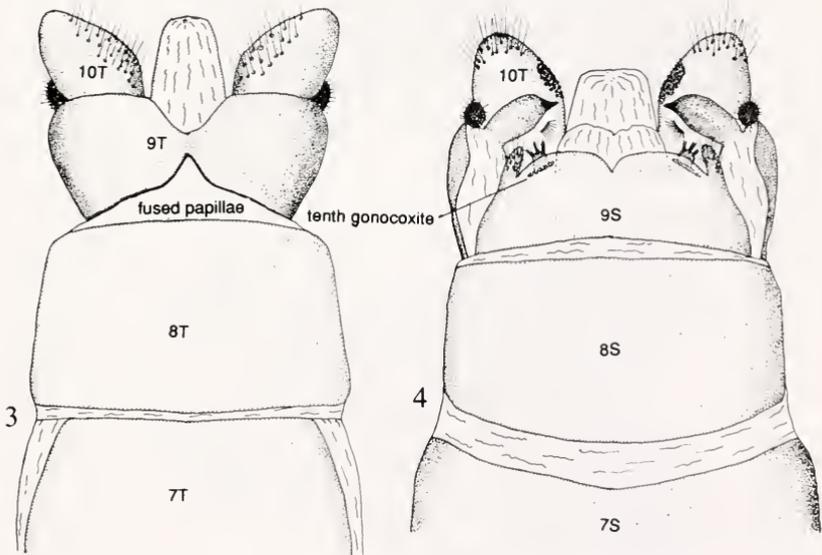


Figures 1-2. *Chloroniella peringueyi*. 1. Head in dorsal view (10X). 2. Right forewing (5X).

ters are considered in this analysis. To help construct the most parsimonious cladogram, the PAUP computer program was used. Illustrations were made utilizing a Wild M6 binocular microscope with a camera lucida attachment. Genitalia were studied after clearing in 10% cold KOH for 24 hours and female genitalia were stained with Chlorazol Black E. The terminology is the same as that used by Glorioso.

## RESULTS

Individuals of *Chloroniella* have forewings with mostly plesiomorphic character states, although a few apomorphic modifications have arisen, such as reduced apical forks of R5 and MP (Fig. 2). The male genitalia (Figs. 3, 4) provide the most distinctive characters, with medially notched ninth sternum, medially fused papillae, a tuft of setae at the base of the tenth tergites, and medially divided tenth gonocoxites. Other useful characters are found in the female genitalia (characters 62 to 71) (Figs. 5, 6). The pale coloration with dark markings of *Chloroniella* superficially resembles that of the New World *Chloronia* and the Asiatic *Neuromus* (Fig. 1). Utilizing these and the other characters listed by Glorioso, only one most parsimonious cladogram is generated by the



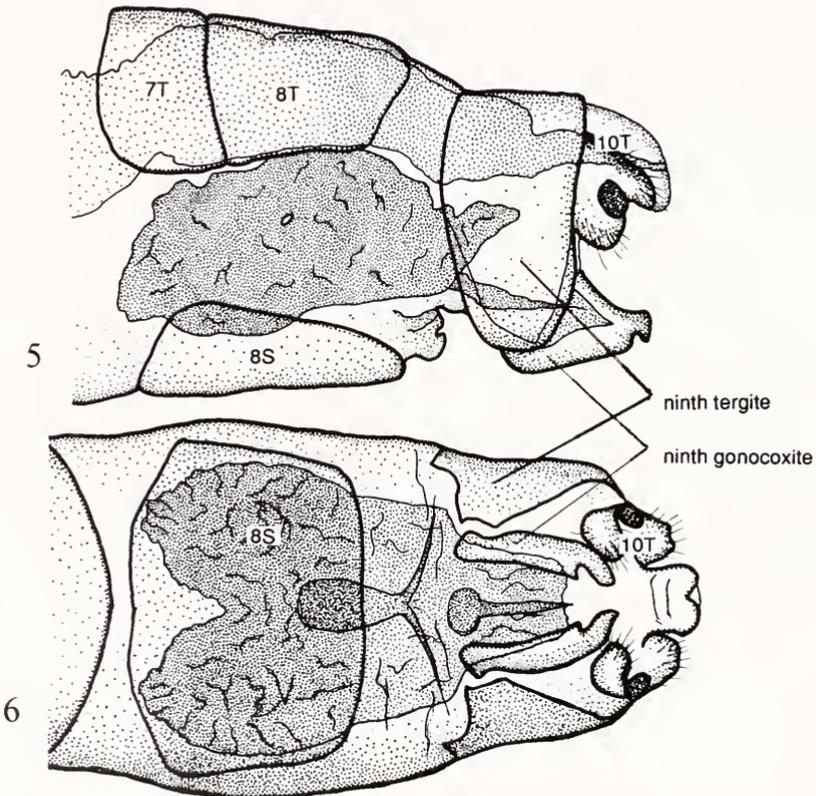
Figures 3-4. *Chloroniella peringueyi* apex of male abdomen (25X). 3. Dorsal view. 4. Ventral view.

PAUP program (Cladogram 1), with a consistency index of 0.688. This cladogram has 109 steps.

### CONCLUSIONS

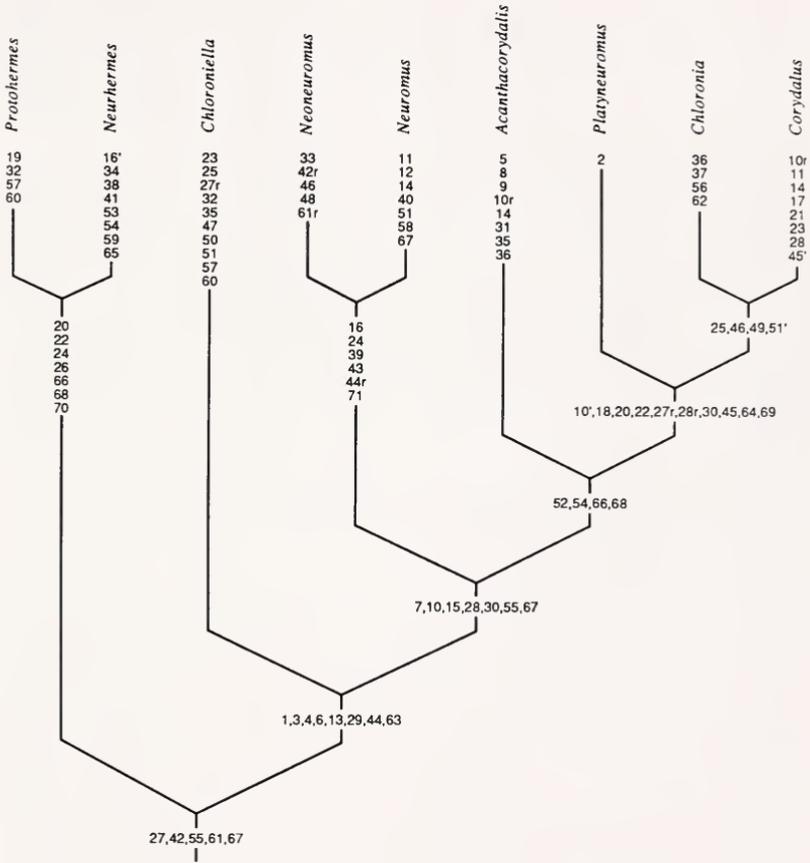
The cladogram generated by PAUP is very similar to that presented by Glorioso. Except for the addition of *Chloroniella*, there are no other changes.

Megalopterans are today highly dependent on fresh water and there is no reason to believe that previous ancestors behaved differently. Adults are heavy-bodied, weak flyers and are seldom found far from streams and lakes. Eggs are laid in large masses on land, and pupae are



Figures 5-6. *Chloroniella peringueyi* apex of female abdomen (25X). 5. Lateral view. 6. Ventral view.

found on land in the substrate near the margins of water courses. Larvae of all megalopterans are aquatic, and with the exception of Pacific Coast *Neohermes* and *Protochauliodes* are all confined to permanent bodies of water. Thus, the ability to disperse is highly restricted, and present day distribution patterns probably closely reflect past climatic and plate tectonic events. Ancestral forms in Laurasia and Gondwanaland would have suffered drastic distributional and richness reductions as "continental effects produced extensive aridity as the land-mass drifted



CLADOGRAM 1

Cladogram 1. Phylogenetic position of corydaline genera using PAUP analysis. Numbers refer to apomorphic states in Table 2.

through middle latitudes in the late Permian and Triassic" (Riek, 1970). There would have been a polarizing effect during the Triassic as "the lower-latitude zone featured high aridity to about 45°N and 55°S, except in western Europe, where somewhat greater humidity characterized the higher latitude areas" (Frakes, 1979). At the same time, where aquatic habitats continued to exist, the ameliorating local environment may have allowed primitive forms to survive long after terrestrial forms became extinct. Subsequent improving climatic conditions in lower latitudes during the Paleogene (65 to 22.5 mya) would have allowed plates, such as South America and India, drifting into the tropical zones, to retain and even expand their high latitudinal faunas, while these same faunas were being eliminated closer to the poles—"an abundance of atmospheric moisture at high latitudes seems to have retreated equatorward through the interval, and the first glaciers since the Paleozoic formed and expanded in Antarctica" (Frakes, loc. cit.).

The three suprageneric groups of Megaloptera (Sialidae, Chauliodinae and Corydalinae) all show elements of a previous austral distribution (Maps 1-3). Each of the three groups has at least one endemic species in South Africa, and Sialidae and Chauliodinae each have endemic species in Madagascar. No megalopterans are known from other parts of sub-Saharan Africa. An endemic sialid species is known from southern Asia, as well as five genera of Corydalinae and four genera of Chauliodinae. In the U.S.S.R. and Europe only *Sialis* occurs today, although fossil evidence indicates that Corydalidae was previously present.

In the Australian Region, two endemic groups of Sialidae occur in Australia. One additional genus of Chauliodinae, *Archichaulidoes* is confined to Australia, New Zealand and Chile.

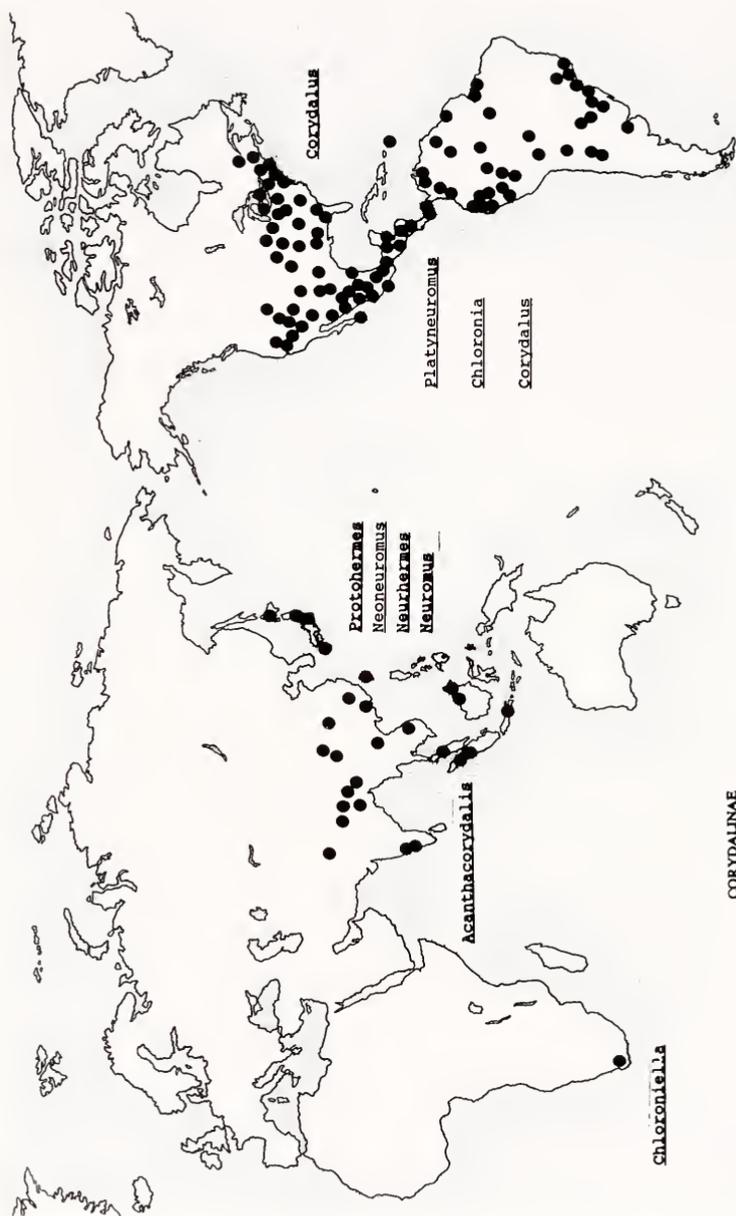
The Neotropical Region contains endemic sialid species formerly placed in *Protosialis*, as well as a very distinctive Chilean species, *Protosialis chilensis*. This region also shares two endemic genera of Corydalinae and two genera of Chauliodinae with the Australian Region.

The only other genus of Corydalinae found in the Neotropical Region, *Corydalus*, as well as the chauliodine *Protochauliodes*, may provide clues to the largest anomaly of the Gondwanian distribution pattern. *Corydalus* is not only found throughout South and Central America, but also occurs throughout most of North America as well. However, as Glorioso pointed out, "Because of the diversity and presence of the most primitive species of *Corydalus* and *Playneuromus* in the Amazonian region, I hypothesize this as the ancestral range of the common ancestor of these genera, with subsequent range extension into Central America." (p. 273). To this could also be added the genus

*Chloronia* (Penny & Flint, 1982). *Protochauliodes* has a broad distribution, which may be explained in a similar manner. In addition to being found in Australia, New Zealand, and Chile, it is also present in the western United States. This genus probably has moved northward from its previous Gondwanian distribution. The Chauliodinae also contain four other genera that are endemic to North America. As indicated by the distribution of *Corydalus* and *Protochauliodes*, there appears to have been a pathway for northward movement from South America into the western United States. However, this pathway was probably of early origin, as primitive chauliodine eggs have been found in Tertiary deposits of the Laramie Formation. Thus, the western Nearctic Region may have become a secondary center of evolution within the Chauliodinae at a relatively early date.

This theory of Gondwanian distribution would have to hypothesize a few other factors. Corydalinae would have had to become extinct in Madagascar and Australia. The geographical pattern of *Sialis* would be best explained by a Laurasian, rather than Gondwanian evolution, perhaps from an earlier vicariant event. It should also be noted that the higher classification of Sialidae is badly in need of revision. Such a study could affect the zoogeographical analysis of this family.

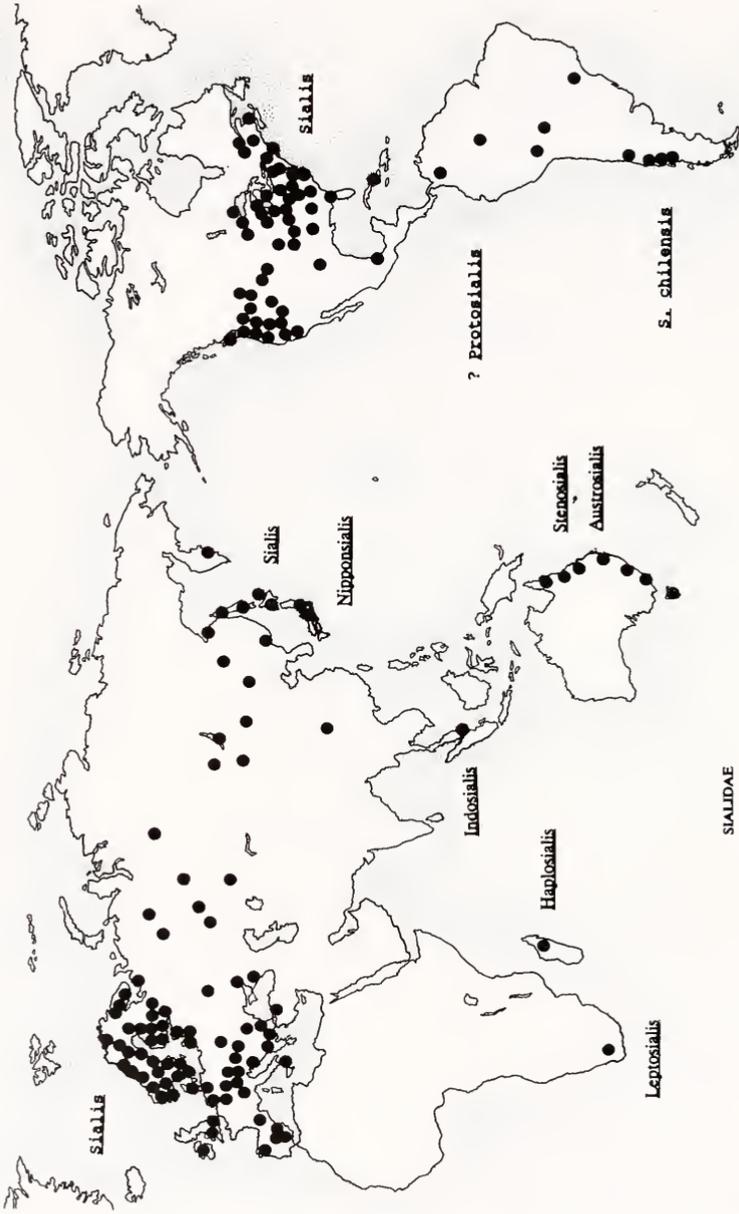
The cladogram generated in this study provides another anomaly to a Gondwanian distribution. Although the majority of genera fit well into such a pattern, such as the three South American genera and two primitive lineages in southern Asia, the presence of *Chloroniella* in South Africa in this scenario necessitates either a later evolution of this genus or a movement of an ancestral *Chloroniella* from Asia and into southern Africa. As mentioned earlier, there are no megalopterans today in tropical Africa, and an early extinction with subsequent reintroduction from Asia seems doubtful. A non-parsimonious cladogram, with *Chloroniella* evolving from a position completely compatible with what we know of plate tectonics, is presented in Cladogram 2. In this case, all five Asiatic genera are together at the base of the cladogram. Some of these five genera in three clades could have either been present in southern Asia from a previous vicariant event (perhaps the split of Laurasia and Gondwanaland), or been present as a single or multiple ancestor on the Indian subcontinent as it drifted northward, later forming the genera *Protohermes*, *Neurhermes*, *Neoneuromus*, *Neuromus*, and *Acanthacorydalus*. As the continents of Africa and South America separated, they took with them the ancestors of *Chloroniella*, and *Platyneuromus*, *Chloronia*, and *Corydalus*, respectively. Although not the most parsimonious cladogram, there are only four more steps (113 steps; consistency index 0.664) than the most parsimonious cladogram, and in view of the general



Map 1. Geographical distribution of the genera of Corydalinae.



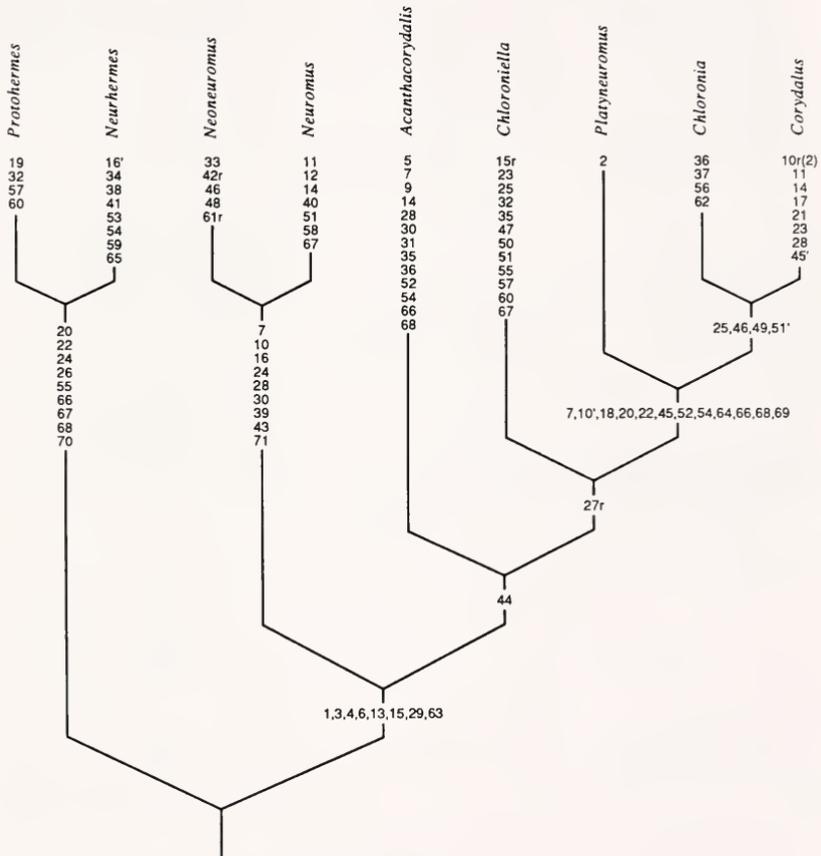
Map 2. Geographical distribution of the genera of Chaulioidinae.



Map 3. Geographical distribution of the genera of Sialidae.

indications of a Gondwanian distribution, it is felt that this non-parsimonious modification is justified.

Because of similar biologies and restrictions to fresh water environments, the three main groups of megalopterans may have had similar histories of speciation and vicariant events. Much of this early evolution may have been caused by plate tectonics, leading to the similar worldwide distribution patterns evident today. Further studies of sialid and chauliodine phylogeny may reveal whether geographically associated



CLADOGRAM 2

Cladogram 2. Phylogenetic position of corydaline genera reflecting geographical distributions.

genera of the three groups had similar cladistic histories, or not. They may also reveal which of the two cladograms presented best fits a general megalopteran evolution pattern.

Table 1. Characters of the Corydalinae with their plesiomorphic and apomorphic states.

Character	Plesiomorphic	Apomorphic
1. Head shape	Robust	Flattened
2. Postocular flange	Absent	Present
3. Postocular spine	Feebly developed	Moderately to well developed
4. Posterior tentorial pits	Linear	Arcuate
5. Cranial disk	Without spines	With spines
6. Antennae	Feebly subserrate	Filiform
7. Clypeal margin	Entire	Incised medially
8. Male mandibles	Not enlarged	Enlarged
9. Female mandibles	Three-fourths head length or shorter	Length of head
10. Labrum shape	Triangular	Ovoid
10'. Labral position	Over mandibles	Broadly truncate
11. Labral anterior margin	Sparsely setose	Between mandibles
12. Maxilla shape	Short and broad	Fimbriate
13. Lacinia apex	With three elongate setae	Relatively elongate
14. Galeal setae	Flattened, lanceolate	Without elongate setae
15. Galeal sensory peg	Well developed	Bristlelike
16. Maxillary palp	Five-segmented	Poorly developed
17. Maxillary palp apex	Conical	Absent
18. Maxillary palp setae	Long	Four-segmented
19. Maxillary palp sensory areas	One at apex	Broadly rounded
20. Labial palp	Four-segmented	Short
21. Labial palp sensory areas	one at apex	Two at apex
22. Last branch of radial sector	Bifurcate	Three-segmented
23. M1 + 2 branches	Two	Two at apex
24. M3 + 4 branches	Two	Not bifurcate
25. 1A branches	Two	Four or more
26. R1-Rs crossveins	Three	One
27. Medial crossveins	Two	Three
28. M-Cu crossveins	Three	Four or more
29'. Cubital accessory crossveins	Absent	Three or more
30. Costal crossveins	Vertical or oblique	Four
31. Male ninth sternum	Hind margin not notched	Six or more
32. Male ninth sternum	More or less quadrate	Present
33. Male ninth sternum	More or less quadrate	Reticulate
		Hind margin notched
		Attenuate

Table 1. Character states (*continued*)

Character	Plesiomorphic	Apomorphic
34. Male ninth sternum	Without median projection	With median projection
35. Male ninth sternum	Without posterolateral lobes	With posterolateral lobes
36. Male ninth sternum	Without setiferous lateral protuberances	With setiferous lateral protuberances
37. Male ninth sternum	With normal setae	With short, stout setae
37 <sup>1</sup> .		With fine setae
38. Male ninth sternum	Not sclerotized dorsally	Sclerotized dorsally
39. Male ninth sternum	Without internal ridges	With internal ridges
40. Male ninth sternum	Not locking with tenth sternite	Locking with tenth sternite
41. Male ninth tergum	More or less quadrate	Short, with broad median incision
42. Male ninth tergum	With dorso-lateral incisions	Without dorso-lateral incisions
43. Ninth tergal internal inflection	Without median fossa	With median fossa
44. Ninth tergal internal inflection	Arched	Inverted V-shaped
45. Membrane between 9th & 10th sternites	Thin	Thickened, bilobate
45 <sup>1</sup> .		Thickened, regularly convoluted
46. Genital papillae	Present	Absent
47. Genital papillae medially	Separated	Fused
48. Tenth gonocoxites	Without median projection	With median projection
49. Tenth gonocoxites	Antero-lateral corner without acute projection	Antero-lateral corner with acute projection
50. Tenth gonocoxites	Medially joined	Medially separated
51. Tenth gonostylus	Digitiform	Short, broad
51 <sup>1</sup> .		Papilliform
52. Ninth gonostylus	Unguiform	Clavate
53. Ninth gonostylus	Relatively short	Long, bent
54. Ninth gonostylus	Sparsely setose	Densely setose
55. Ninth gonostylus apodeme	Parallels ninth tergum	Directed medially
56. Tenth tergites	Short	Long, thin
57. Tenth tergites	Without sensory field on apical surface	With sensory field on apical surface
58. Tenth tergites	Rounded	Laterally compressed
59. Tenth tergites	Uniramous	Biramous
60. Tenth tergites	Not bearing basal tuft of hairs	Bearing basal tuft of hairs
61. Eleventh tergum	Present	Absent
62. Lateral sclerite of ovipositor	Well sclerotized	Weakly sclerotized

Table 1. Character states (*continued*)

Character	Plesiomorphic	Apomorphic
63. Gonostylus	Articulated with gonocoxite	Fused with gonocoxite
64. Sternal pouch	Absent	Present
65. Sclerites between 8th sternum & gonopore	Absent	Present
66. Bursa copulatrix	Not saclike	Saclike
67. Number of spermathecae	Two	One
68. Spermathecal duct	Continuous with bursa	Separate from bursa, T-shaped
69. Accessory glands	Present	Absent
70. Accessory glands	Short	Long
71. Accessory glands	Sigmoid	Linear

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## A NEW SPECIES OF *POLYCENTROPUS* (TRICHOPTERA: POLYCENTROPODIDAE) FROM ARKANSAS<sup>1</sup>

David E. Bowles<sup>1</sup>, Michael L. Mathis<sup>2</sup>, Steven W. Hamilton<sup>3</sup>

**ABSTRACT:** *Polycentropus stephani*, a new species from Arkansas, is described and illustrated. This species is a member of the *confusus* species-group and is most closely related to *P. chelatus*, *P. floridensis* and *P. neiswanderi*, but differs primarily in having a prominent spur on the basoventral swelling of the phallus. Known only from the interior highlands, *P. stephani* may be endemic to that region.

The *Polycentropus confusus* species-group (Trichoptera: Polycentropodidae) consists of 16 previously described species with all occurring in eastern North America (Hamilton *et al.* 1990). During a survey of the Trichoptera of the interior highlands of Arkansas (Bowles and Mathis 1989), some undescribed adult caddisflies belonging to the *Polycentropus confusus* species-group were collected with ultraviolet-light traps. These caddisflies were initially identified as *Polycentropus* species B and C (Bowles and Mathis 1989), but were subsequently determined to be conspecific. Herein, we describe that species. Morphological terminology follows that of Hamilton (1986) and Hamilton *et al.* (1990).

The holotype and allotype are deposited at the National Museum of Natural History (NMNH), Washington, DC. Paratypes are deposited at the Royal Ontario Museum (ROM), Florida State Collection of Arthropods (FSCA), Illinois Natural History Survey (INHS), University of North Texas (UNT), and the NMNH. All material is preserved in 70% ethanol.

### *Polycentropus stephani*, new species (Figures 1-4)

*Polycentropus* species B and C. Bowles and Mathis, 1989:237

**Adult.** Length of forewing: Male, 5.1 mm; female, 6.1 mm. Body and wing color light brown. Setae on dorsum of head and thorax tan.

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**Male genitalia.** Abdominal sternite IX large, semicircular in lateral view, anterior margin rounded, posterior margin sinuate. Intermediate appendages apically free, slightly decurved, proximally fused to membranous dorsum of segment IX. Body of each preanal appendage short, with broad emargination of posterior margin; dorsal process long and decurved. Each inferior appendage with elongate ventral portion, in lateral view only slightly narrowed distad, in ventral aspect narrowing gradually distad; dorsobasal arm of inferior appendage large, curving posterad, in lateral view narrowing abruptly into ventral portion, with turned-in blade-like portion at base, in caudal view this part broadly triangular with apex rounded. Phallobase tubular, moderately decurved, basoventral swelling bearing a prominent caudally directed spur; phallic sclerite elongate.

**Female genitalia.** Sternite VIII broad, membranous; lateral lobes elongate, expanded at mid-point, tapering posteriorly. Vaginal sclerites forming vase-shaped sac; vulvar sclerite circular, with rimmed opening posteriorly.

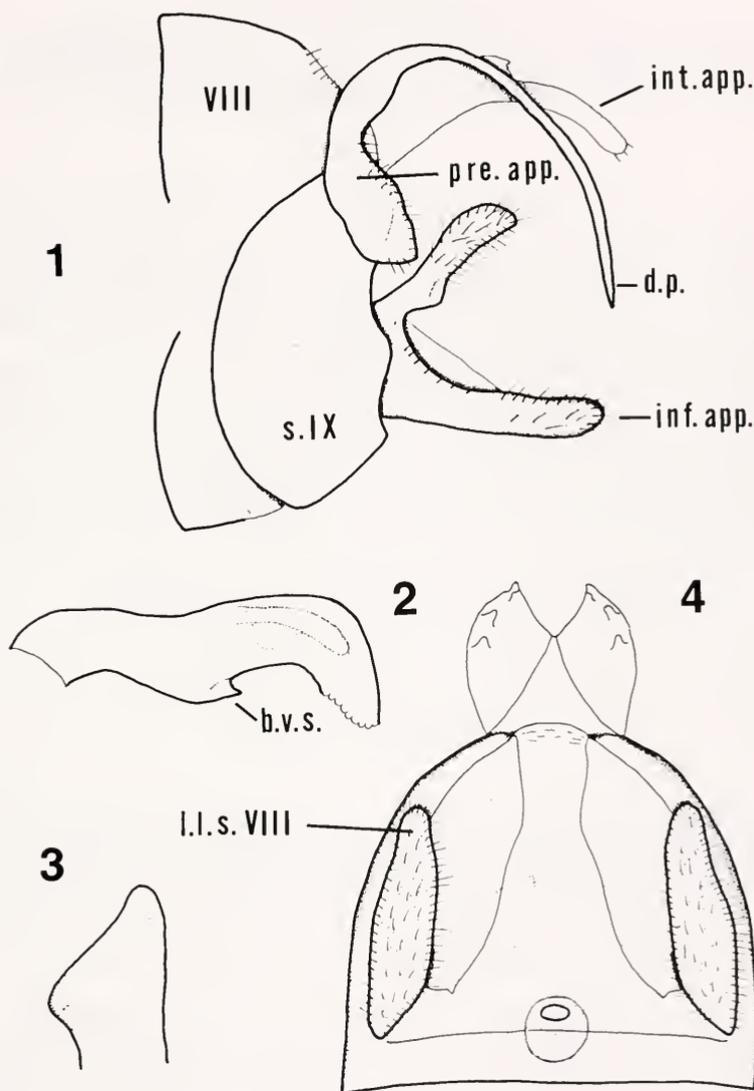
**Type Material:** United States, Arkansas. **Holotype.** ♂, Logan Co., Mt. Magazine, Green Beach, Gutter Rock Creek, 1 May 1987, R. Leschen, UV-light (NMNH). **Allotype.** ♀, same data as holotype (NMNH). **Paratypes.** 1 ♂, 1 ♀, same data as holotype (FSCA); 1 ♂, 1 ♀, same data as holotype (ROM); 2 ♂♂, Independence Co., unnamed intermittent stream, 18 April 1987, P. Harp (NMNH, UNT); 2 ♂♂, 2 ♀♀, Washington Co., Devil's Den State Park, 22 April 1989, C. E. Carlton, blacklight (NMNH); 1 ♂, Washington Co., 2 mi. N Bugscuffle, dirt road at Hwy 265, near Strickler, 20 April 1987, R. Leschen, at light (INHS).

**Etymology.** We name this species in honor of Karl Stephan whose unfailing enthusiasm for collecting insects has been invaluable in the development of the interior Highlands caddisfly inventory.

## DISCUSSION

This species belongs in the *confusus* species-group and exhibits characters similar to several species within that group. The broadly emarginate basal portion of the preanal appendage is similar to that observed for several members of the *confusus* species-group including *P. floridensis* Lago and Harris, *P. neiswanderi* Ross, and *P. thaxtoni* Hamilton and Holzenthal. The phallus of *P. stephani* is most similar to that of *P. chelatus* Ross and Yamamoto from which it differs in the presence of a prominent spur situated on the basoventral swelling of the phallobase. This spur is unique among the species of the *confusus* species-group. The female of *P. stephani* bears resemblance to several other species in the *confusus* species-group. However, the females of *P. chelatus*, *P. floridensis* and *P. thaxtoni* are unknown and detailed comparisons among these species can not be completed at this time.

This species has been collected only from the interior highlands of Arkansas and may be endemic to the region. *Polycentropus centralis* Banks was the only other member of the *confusus* species-group collected in conjunction with *P. stephani*. Small intermittent streams are the probable habitat of the immatures based on collection of the adults. However, nothing is known about the biology of this species. A description of the type locality was presented by Mathis and Bowles (1989), and a description of a paratype locality by Flint and Harp (1990).



Figs. 1-4: *Polycentropus stephani* n. sp. 1. Male genitalia, lateral. 2. Male phallus, lateral. 3. Dorsobasal arm of inferior appendage, caudal. 4. Female genitalia, ventral. Abbreviations: b.v.s., basoventral spur; d.p., dorsal process of preanal appendage; l.l.s. VII, lateral lobe of eighth sternite; pre. app., preanal appendage; s. IX, ninth sternite; VIII, eighth tergite.

## ACKNOWLEDGMENTS

We thank Chris Carlton and Richard Leschen for providing us specimens of this species. Oliver Flint kindly provided some additional information about paratypes and reviewed this manuscript. Chad McHugh and Stephen R. Moulton II gave commentary on earlier versions of this manuscript.

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 SOCIETY MEETING OF OCTOBER 28, 1992

 INSECTS IN THE CLASSROOM—  
 TURNING KIDS ON TO SCIENCE WITH BUGS

Dr. Harold B. White, organizer  
 University of Delaware

A diverse set of speakers and styles highlighted a presentation on teaching entomology in schools. This meeting, more in line with a workshop than a lecture, featured presentations by five entomologists drawn from the Science Alliance's Speakers Bureau, a resource "pool" of professionals available for speaking to students in Delaware schools. The objectives of this meeting, as outlined by Dr. White, were twofold: to give teachers ideas on presenting science (and particularly entomology) to their students, and to provide encouragement to entomologists to make themselves available for presentations in the schools. Dr. White also highlighted the Society's educational activities, including the Field Day and the Calvert Prize.

Dr. Douglas Tallamy, University of Delaware, talked on "Introducing Insect Behavior" and featured an excellent series of slides related to the subject. A major point he attempts to bring out to students is to consider how an insect's appearance is related to its behavior, e.g., defensive, mimicry, crypsis, etc. and in so doing attempts to get beyond many students' impressions that insects are grotesque. An impressive set of slides focused on the monarch butterfly and other milkweed insects and illustrated how this complex of insects is able to avoid the latex flow when feeding on milkweed leaves. Another interesting series of slides

Continued on page 38

**A NEW SPECIES IN THE  
*POLYCENTROPUS CINEREUS* GROUP  
(TRICHOPTERA: POLYCENTROPODIDAE)  
FROM ARKANSAS AND TEXAS<sup>1</sup>**

Stephen R. Moulton II, Kenneth W. Stewart<sup>2</sup>

**ABSTRACT:** *Polycentropus harpi*, a new species belonging to the *P. cinereus* group, is described and illustrated. The species was collected from the Edwards Plateau physiographic subregion of southcentral Texas and the Ouachita Mountains of Arkansas. This addition brings the total number of species belonging to the *P. cinereus* group to three.

The diversity of caddisflies in Texas is still poorly known despite earlier attempts to document the fauna (Edwards 1973). In order to better understand the species composition and distribution of caddisflies in Texas, a long term study was undertaken to intensively sample all major physiographic subregions in the state. The caddisfly fauna of the Interior Highlands (Ozark and Ouachita Mountains), though better known than Texas (Unzicker *et al.* 1970, Bowles and Mathis 1989, Mathis and Bowles 1992), still needs a thorough analysis of its biogeographic affinities. Current research of the senior author is addressing those needs. In the course of examining recent collections from the Edwards Plateau physiographic subregion of central Texas and the Ouachita Mountains in Arkansas, we have discovered an undescribed species belonging to the *Polycentropus cinereus* group. Herein we describe and illustrate the new species, and discuss its relationship to other members of the group.

Morphological terminology follows that of Hamilton *et al.* (1990). Type material is deposited in the collections of Clemson University (CU), Illinois Natural History Survey (INHS), National Museum of Natural History (NMNH), and the University of North Texas (UNT). All material is preserved in 70% ethanol.

***Polycentropus harpi*, new species**

Male. Length of forewing 4.0-7.0 mm. Thoracic pleura, sterna and legs yellow; nota and dorsum of head darker brown with numerous clear-yellow, erect setae. Forewings covered with a mixture of yellow and brown setae; membranes interspersed with small indistinct pale spots; stigmal region with spots coalesced to form a large pale area (not evident in

<sup>1</sup> Received June 29, 1992. Accepted August 27, 1992.

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material older than one year). Fork 1 of hind wing present; discoidal cell closed. Male genitalia (Figs. 1-4): Abdominal sternite IX (s.IX) in lateral aspect broad basally, tapering dorsally; ventrally concave. Preanal appendages (pre. app.) broad, short and rounded apically. Membranous terga IX and X fused (IX+X), inferior appendage (inf. app.) roughly quadrate in lateral aspect; posterior margin deeply emarginate; dorsomesal processes (dm.pr.) in lateral view acute and projecting posteriorly, their mesal surfaces with two to three clear, stout setae projecting mesally; ventromesal lobes of each inferior appendage broadly rounded with dark, truncate peg-like setae covering the apicodorsal and apicoventral surfaces. Phallobase broad and deeply concave in lateral view; apicodorsal area of phallus membranous; in dorsal aspect, left phallic rod (l. ph. r.) lanceolate and curving

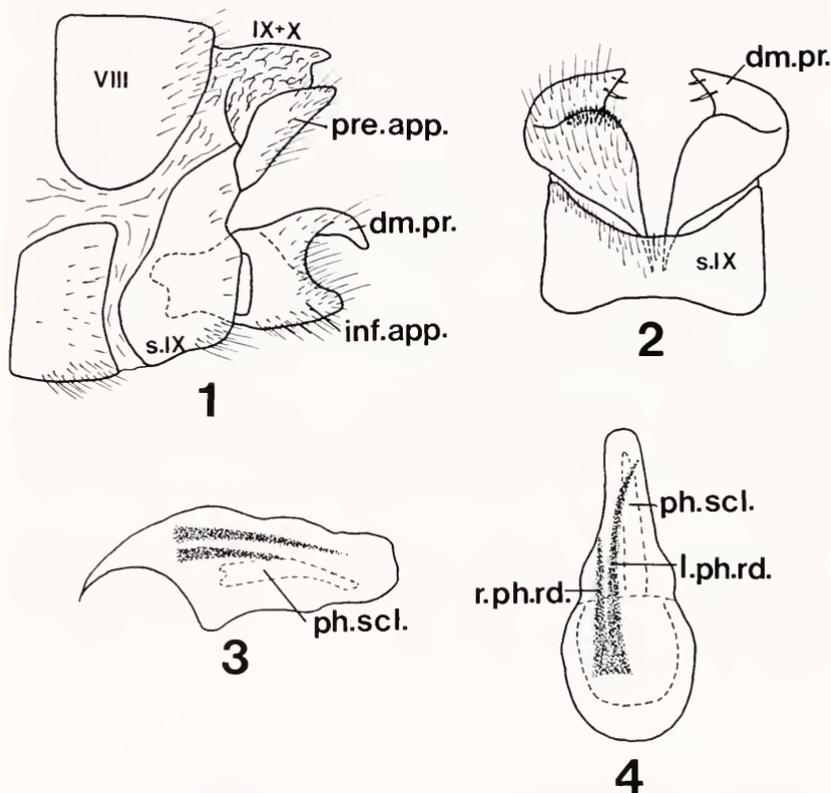


Fig. 1-4. *Polycentropus harpi* n.sp. 1, male genitalia, lateral. 2, sternite IX and inferior appendages, ventral. 3, phallus, lateral. 4, phallus, dorsal. VIII = abdominal segment 8, s.IX = abdominal sternite 9, IX+X = fused, membranous abdominal segments 9 and 10, pre.app. = preanal appendage, inf.app. = inferior appendage, dm.pr. = dorsomesal process, ph.scl. = phallic sclerite, r.ph.rd. = right phallic rod, l.ph.rd. = left phallic rod.

gradually to left; right phallic rod (r. ph. r.) shorter and straight; phallic sclerite (ph. scl.) straight and gradually tapering to a point in dorsal view; in lateral view, phallic sclerite slightly bowed with anterior end emarginate.

Female. Unknown.

Immatures. Unknown.

**Material.** **Holotype, male:** U.S.A., Texas, Kendall Co., Cibolo Creek below confluence with Ranger Creek, Boerne, 17-III-1992, K. W. Stewart, UV light, (NMNH). **Paratypes.:** same data as holotype, 1 male, (NMNH); same as holotype but 18-IV-1992, D. E. Bowles, 1 male, (INHS); Arkansas: Garland Co., Bear Creek at Camp Clear Fork, 27-IX-1986, D. E. Bowles, 1 male (NMNH); Montgomery Co., Strawn Spring, 0.5 mi E Caddo Gap, 12-IX-1980, H. W. Robison, 4 males, (INHS); same as previous but Jones's Creek at AR Hwy 8, Caddo Gap, 2 males (CU); Fourche Mt., E Mena District Rifle Range, ca. 10 mi NW Mena, 11-VI-1991, B. Ewing, 2 males, (CU); Polk Co., Ewing Farm, 7 mi W Mena, 26-VI-1991, B. Ewing, 2 males, (UNT); same data as previous but 27-VI-1991, 1 male, (NMNH).

**Etymology:** We name this species in honor of George L. Harp (Arkansas State University) who has made extensive contributions to our understanding of aquatic insects in Arkansas.

## DISCUSSION

*Polycentropus harpi* is most closely related to *P. cinereus* Hagen. It is readily distinguished from the latter by the following combination of male characters: (1) much deeper posterior emargination of the inferior appendage, (2) left dorsal phallic rod curved to the left; this structure is straight in *P. cinereus*, and (3) general convex outline of the dorsomesal processes of the inferior appendages when viewed ventrally; this outline is straight in *P. cinereus*. *Polycentropus harpi* and *P. cinereus* are easily distinguished from *P. sabulosus* Leonard and Leonard on the basis of the posterior emargination of the inferior appendage. Specimens of *P. harpi* from Arkansas are much smaller than those from Texas and may have the left phallic rod angled more sharply to the left.

The *P. cinereus* group contains two species recorded from North America (Armitage and Hamilton 1990), in addition to *P. harpi*. The nominate species, *P. cinereus*, is transcontinental (Armitage and Hamilton 1990). *Polycentropus sabulosus* is known only from Michigan. *Polycentropus harpi* is known only from the type series. In Texas *P. harpi* has been collected with *P. picana* Ross while in Arkansas it has been collected with *P. centralis* Banks.

## ACKNOWLEDGMENTS

We thank D. E. Bowles, B. Ewing, and H. W. Robison for collecting additional specimens of *P. harpi*. M. L. Mathis allowed the senior author to examine material in the University of Arkansas Arthropod Collection. We thank S. W. Hamilton and J. Kennedy for reviewing an early draft of the manuscript. The comments of three anonymous reviewers were appreciated. This study was supported in part by the National Science Foundation (DEB-9200895) and a UNT Faculty Research Grant to KWS.

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Continued from page 34

showed the entire process of silphid beetles burying a mouse carcass and the development of the beetle brood. He also showed how the carrion beetle life cycle could be replicated in the classroom. A related presentation, by Dr. Judith Hough-Goldstein, entitled "Amazing Insects", also used slides to illustrate many basic ideas concerning insects such as body characteristics, major orders, metamorphosis, etc. She also stresses to students that insects can be competitors to humans, and ends her presentation with live insects, including a hissing cockroach. In addition, she brings to the classroom a collection of striking and interesting specimens.

Dr. Elzie McCord Jr., of the Stine Haskell DuPont Labs, presented "Insect Show and Tell". He goes to the classroom to promote insects as interesting, not "yucky", to encourage participation by the students, introduce students to what scientists do and show that scientists can come from diverse backgrounds. He attempts to develop with the students lots of interactions and much exposure to live insects, aptly demonstrated by his talk to the society, and he tries to leave the students with a setup of live insects for their classroom. Dr. Susan Whitney, University of Delaware, in "Bug Out", presented an overview of a wonderful series of lessons she has developed for 6-10 year olds entitled Bug Out. This series incorporates interaction, observation, projects and short lectures to illustrate many aspects of insect biology (available at low cost through North Carolina State University). She ended by having the entire audience participate in a sample lesson of drawing a "mystery" bug and then identifying it; the trick here is that the children receive much information about how an insect is constructed while participating in a fun game. Dr. Harold White, University of Delaware, ended the session with "Aquatic Insects." As an amateur entomologist (he is a biochemistry professor) he stresses this aspect of the science to kids, and sees his presentations as a way to get children interested in science per se, not just entomology. His demonstrations were simple but effective, and relied only on a petri dish, overhead projector and a few live aquatic insects. By simply placing the insects in water in the dish on the projector, locomotion, morphology and respiration of aquatic insects all can be illustrated. He stressed, above all, that the best experience for the kids is to take them outside to a pond!

Over 50 society members, guests and teachers attended this meeting at the University of Delaware.

Jon K. Gelhaus,  
Corresponding Secretary

# INTERACTIONS OF PREDACEOUS KATYDIDS (ORTHOPTERA: TETTIGONIIDAE) WITH NEOTROPICAL SOCIAL WASPS (HYMENOPTERA: VESPIDAE): ARE WASPS A DEFENSE MECHANISM OR PREY?<sup>1</sup>

Sean O'Donnell<sup>2</sup>

**ABSTRACT:** Field observations of interactions between predaceous tettigoniids, *Phlugis poecila* and *Ancistrocercus inficitus*, and neotropical eusocial wasps, *Polistes instabilis* and *P. versicolor*, show that tettigoniids prey on unguarded wasp nests and may employ chemical or tactile cues to distinguish the nests. Tettigoniids prey on brood in *P. instabilis* nests from which adult wasps are experimentally removed. *Polistes instabilis* and *Polybia occidentalis* wasp workers are not tolerant of tettigoniids roosting near their nests, and tettigoniids near wasp nests behave as if avoiding detection by adult wasps. These observations suggest that predation on brood is an important feature of tettigoniid associations with neotropical wasp nests.

Associations of tettigoniids with active colonies of social wasps in the neotropics have been interpreted as a commensalistic or mutualistic relationship, wherein the tettigoniids gain protection from predators for the duration of their diurnal inactive period and the wasps gain additional warning of predator approach (Downhower and Wilson 1973; Richards 1978). Here I report a case of predation on a wasp colony by the katydid *Phlugis poecila* Hebard (Orthoptera: Tettigoniidae). Combined with observations of interactions of social wasps and green-faced katydids, *Ancistrocercus inficitus* (Walker), roosting near their nests, and with the results of experimental removal of adult *Polistes* wasps from nests with katydids roosting nearby, these observations suggest that an important component of the association is predation on wasp broods by katydids.

## Nest predation observations

On 3 August 1990 at 1200h, I discovered a small, newly-founded (pre-adult emergence) nest of *Polistes versicolor* (Olivier) (Hymenoptera: Vespidae) 2 m above the ground under a *Heliconia* sp. leaf at the edge of a clearing near Gamboa, Republic of Panama. The nest was attended by a single female wasp, presumably the foundress, during observations. A female tettigoniid, *Phlugis poecila*, was resting on the same leaf at a dis-

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tance of 5 cm when the nest was discovered. *Phlugis poecila* is predaceous, though little else is known of its behavior (D. Nickle, pers. comm.).

The *P. poecila* female approached the nest at approximately 5 min intervals over the course of 45 min following nest discovery. On each approach the tettigoniid remained at a distance roughly equal to her antennal length and gently touched both the nest and adult wasp with the distal ends of her antennae; whenever her antennae contacted the wasp the katydid retreated to a distance of between 10 and 30 cm from the nest and remained motionless until the next approach. The wasp made no obvious response to the tettigoniid throughout this period. The wasp departed for 4 minutes on a foraging trip, but the katydid did not approach during this time.

After 50 min of observation I removed the wasp from the nest and placed her in a sealed container. The tettigoniid approached and antennated the unoccupied nest 5 min later, then retreated 3 cm. After 4 min the tettigoniid returned, antennated the nest, then approached and touched the nest petiole and the bases of the cells with her labial and maxillary palpi. The tettigoniid climbed onto the nest and touched the brood cell entrances with her palpi before climbing back to the base of the nest. At this point she held the nest with her forelegs and chewed at the bottom of one brood cell near its attachment to the nest petiole. This chewing continued for 10 min, at the end of which I collected the nest and the tettigoniid.

The damage to the wasp nest was clearly visible at 8X magnification as holes chewed into brood cell bases. A total of three cells bore similar damage, suggesting that the nest had been attacked before my observations. All cells contained larvae, however.

### Nest predation experiment

I surveyed 45 active *P. instabilis* de Saussure colonies for the presence of katydids roosting within 1 m of their nests on 8 July 1992 at Palo Verde National Park, Costa Rica. Green-faced katydids were found near 71% of the nests surveyed ( $\bar{X}$  number katydids present = 2.96,  $sd = 3.45$ , range = 0 to 17); over 90% of the katydids were roosting within 10 cm of the nests. The number of adult wasps occupying the nests at the time of the survey ranged from 2 to 11 ( $\bar{X} = 5.2$ ,  $sd = 2.28$ ). None of the wasp nests bore damage, for example holes or tears in brood cell walls, which might suggest attempted katydid predation.

Downhower and Wilson (1973) noted that a green-faced katydid roosting near a *Polistes* sp. nest in Costa Rica fed on wasp pupae after the nest had been moved and the adult wasps had been removed. I removed all adult wasps from five *P. instabilis* colonies on 13 July 1992 between

1930h and 2030h, after nearby katydids had left to forage, to test the hypothesis that brood in unguarded wasp nests would be preyed upon by katydids. I did not otherwise manipulate the nests or katydids. At 600h the following morning 4 to 12 green-faced katydids were present at four of the treated nests. Brood cells in these four nests were apparently chewed open on the sides and their contents partially removed (number of cells damaged ranged from 6 to 15). No katydids were present at the remaining nest, which was undamaged. Four surveys of the manipulated nests were conducted over the ensuing 36 hours. The number of cells damaged increased on the four nests with katydids present, and katydids were observed chewing through cells and consuming brood on each of these nests. The nest without katydids present was not damaged.

Downhower and Wilson (1973) found that *A. inficitus* were able to relocate two *Polistes* sp. nests in the morning after the nests were displaced 1 m from their original site the previous night, and that the nest petioles were especially attractive to the tettigoniids; the adult wasps placed in a nearby cage were not attractive. These results, combined with my observations, suggest that some tettigoniid species are capable of distinguishing wasp nests using chemical or tactile cues, and that the tettigoniids can discriminate between the nest and the adult wasps using these cues. In the case of *P. poecila*, substrate-borne cues were apparently employed in discriminating between the nest and the adult wasp.

### Wasp responses to tettigoniids

*Ancistrocercus inficitus* often perch on twigs within 10 cm of wasp nests, adopting the cryptic posture described for other neotropical orthopterans (Robinson 1969). My observations in Guanacaste, Costa Rica in 1988 and 1991 showed that *A. inficitus* roosting near eusocial wasp (*Polistes instabilis* and *Polybia occidentalis* [Olivier]) colonies were attacked and occasionally driven away after being detected by wasp workers. Though roosting tettigoniids often remained motionless for several hours, initial detection was probably visual, since the wasps often oriented to and approached the tettigoniids following movement. Wasp workers that contacted tettigoniids with their antennae raised their wings, elevated their bodies, and bit the intruders repeatedly (observed on several occasions at one *Polistes instabilis* nest in 1988 and at two *Polybia occidentalis* nests in 1991). When attacked by wasps, *A. inficitus* slowly raised the body part being bitten and only moved away if the wasp worker was especially persistent. A similar response to tettigoniids was noted at a *Synoeca* sp. colony in Costa Rica (Downhower and Wilson 1973). Social wasps are not tolerant of roosting tettigoniids, though this may be a general response by workers to foreign insects near the nest.

Roosting near wasp colonies may afford protection to predaceous tettigoniids, but it is unclear which potential predators of tettigoniids would be repelled by the wasps (Downhower and Wilson 1973). Both wasp nests and green-faced katydids are fed to nestling trogons (*Trogon* sp.) by their parents in Guanacaste (F. Joyce, pers. comm.).

Association with wasp nests during the daylight hours maximizes the probability that the nest will be unoccupied or occupied by few wasps, since social wasp foragers return to and cluster on their nests at night. This is especially true in relatively young colonies of independent-founding wasps such as *Polistes* spp., however, even a small number of adult wasps present on the nest can apparently deter katydid predation. Further observations of tettigoniids roosting near small wasp colonies are needed to establish the frequency of predation on unmanipulated nests and the impact of tettigoniid predation on wasp colony success.

#### ACKNOWLEDGMENTS

Thanks are extended to Donald Windsor who served as my Smithsonian research advisor during field work in Panama. Ann Fraser, Bruce Howlett, John Lill, Karen London, and Adrienne Nicotra of Organization for Tropical Studies course 92-3 provided valuable suggestions and assisted ably with the wasp nest survey in Costa Rica. David Nickle identified the tettigoniid from Panama and supplied useful background information on its habits. Robert Jeanne, Tom Phillips, and two anonymous reviewers read and commented on an earlier version of the manuscript. Financial support was provided by a Short Term Fellowship from the Smithsonian Tropical Research Institute, a grant from the University of Wisconsin-Madison Graduate School, and an Organization for Tropical Studies/Pew Charitable Trust Tropical Fellowship.

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## RECORDS OF BAT FLIES FROM JORDAN, LIBYA AND ALGERIA<sup>1</sup>

Z. S. Amr, M. B. Qumsiyeh<sup>2</sup>

**ABSTRACT:** Eight species of bat flies (Insecta: Diptera: Streblidae and Nycteribiidae) collected from bats from Jordan, Libya and Algeria are listed along with their respective hosts. *Brachytarsina flavipennis*, *Stylidia biarticulata*, *Stylidia integra* and *Basilisa nana* are new records for Jordan.

In the course of extensive collecting throughout Jordan, Libya and Algeria in 1981, several species of ectoparasites were removed from bats. Although the Chiroptera of Jordan and North Africa have been studied (Qumsiyeh 1980, Qumsiyeh *et al.* In press, Hufnagl 1972, Hayman and Hill 1971), little information is available on their associated bat flies.

The only record of a bat fly from Jordan was reported by Kock and Nader (1979). Anciaux de Faveaux (1976) provided a list of parasitic insects from Algerian bats and Hurka (1982) reported on the bat flies of coastal Libya.

This paper provides additional records of bat flies from Libya, Algeria and Jordan.

### MATERIALS AND METHODS

Bats were collected by mistnet or while roosting in caves or crevices. A total of 63 bats were collected: 12, 15 and 36 from Jordan, Libya and Algeria respectively. Each bat was individually examined and their ectoparasites were stored in vials containing 75% alcohol. "n" designates the number of bats examined.

### Systematic List

#### Family Streblidae

##### *Brachytarsina flavipennis* Macquart 1851

#### Material examined:

Jordan: Wadi Khanzairah (W.Araba), 9.2.1981, ex 2M, *Rhinolophus blasii* (n = 7).

Libya: Kuf National Park, 13.3.1981, ex 6M, *Rhinolophus mehelyi* (n = 9).

Algeria: Misserghin Cave, 7.5.1981, ex 1F, *Myotis blythi* (n = 10).

<sup>1</sup> Received May 4, 1992. Accepted August 26, 1992.

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Remarks: This species has been reported from *Miniopterus schreibersi* and several species of the genus *Rhinolophus* (Theodor 1967). Hurka (1982) indicated its presence on *R. mehelyi*.

### Family Nycteribiidae

#### *Stylidia biarticulata* (Harmann 1864)

Material examined:

Jordan: Wadi Khanzairch (W. Araba), 9.2.1981, ex 2M, *Rhinolophus blasii* (n = 7).

Libya: Kuf National Park, 13.3.1991, ex 1M, *R. mehelyi* (n = 9).

Algeria: Misserghin Cave, 7.5.1981, ex 1M, 2F, *Myotis blythi* (n = 10).

Tipasa, 5.7.1981, ex 1M, 1F, *Miniopterus schreibersi* (n = 2).

Tipasa, 5.7.1981, ex 1M, *R. mehelyi* (n = 1).

Remarks: Theodor (1967) reported *Stylidia biarticulata* from *Rhinolophus euryale*, *R. ferrumequinum*, *R. hipposideros minimus*, *R. blasii*, *Myotis myotis* and *Miniopterus schreibersi*. Hurka (1982) considered *Stylidia biarticulata* to be a westpalaearctic species.

#### *Stylidia integra* (Theodor and Moscona 1954)

Material examined:

Jordan: Dibbin National Park, 27.2.1981, ex 1M, *Rhinolophus hipposideros* (n = 1).

Remarks: Kock and Nader (1979) commented on the distribution of *S. integra* and they suggested this species represents a saharosindian faunal element. It is known from *Rhinolophus blasii* and *R. acrotis* (Theodor 1965).

#### *Basilina nana* Theodor and Moscona 1954

Material examined:

Jordan: Dibbin National Park, 27.2.1981 and 9.8.1981, ex 1M, 3F, *Myotis nattereri* (n = 1).

Remarks: It seems that *Basilina nana* is host-specific for the genus *Myotis*. Theodor (1965) reported *Myotis nattereri* and *M. myotis* as hosts for *Basilina nana*.

#### *Basilina daganiae* Theodor and Moscona 1954

Material examined:

Libya: Kuf National Park, 15-16.3.1981, ex, 1M, 3F, *Pipistrellus pipistrellus* (n = 5).

8 km SSE Haniya, 3.4.1981, ex 1M, *P. pipistrellus* (n = 1).

Remarks: Theodor (1965) reported that *Basilia daganiae* parasitized *Pipistrellus Kuhlii* in Deganya.

*Penicillidia dufouri* (Westwood 1835)

Material examined:

Algeria: Misserghin Cave, 7.5.1981, ex 4M, 3F *Myotis blythi* (n = 10).

Cap Aokas, 23.6.1981, ex 1M, 3F, *M. blythi* (n = 3).

Tipasa, 5.7.1981, ex 1M, *Miniopterus schreibersi* (n = 2).

Tipasa, 5.7.1981, ex 1M *Rhinolophus euryale* (n = 11).

Remarks: *Rhinolophus hipposideros* was reported as host of this bat fly (Theodor 1967).

*Nycteribia pedicularia* Latreille 1796

Material examined:

Algeria: Misserghin Cave, 7.5.1981, ex 1F, *Myotis blythi* (n = 10).

Remarks: *Rhinolophus hipposideros minimus*, *R. euryale* and *Miniopterus schreibersi* are known hosts for *Nycteribia pedicularia* (Vermeil 1960, Theodor 1967).

*Nycteribia schmidlii* Schiner 1853

Material examined:

Algeria: Misserghin Cave, 7.5.1981, ex 1M, 3F, *Miniopterus schreibersi* (n = 8).

Sig cave, 9.5.1981, ex 1M, 3F, *M. blythi* (n = 1).

Tipasa, 5.7.1981, ex 2M, 1F, *R. euryale* (n = 1).

Tipasa, 5.7.1981, ex 2M, 6F, *Miniopterus schreibersi* (n = 2).

Remarks: In addition to the above species, *Nycteribia schmidlii* has been taken from *Rhinolophus ferrumequinum* and *Myotis mehelyi* (Falcoz 1923, Theodor 1967).

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## SOCIETY MEETING OF NOVEMBER 18, 1992

### ECOLOGY OF PAVEMENT ANTS

Mr. Thomas King,  
Peerless Pest Control  
Philadelphia, PA

We are all well aware of the detrimental effects of increasing urbanization and development on the natural environment, including the loss of diverse habitats and the numerous insect denizens which occur there. The informative and humorous presentation by Mr. Thomas King, drawing upon his own observations and those of others, reminds us that there are numerous insects, among these the pavement ant, *Tetramorium caespitum* (Linnaeus), who find in urbanization an opportunity for range expansion and population growth.

The pavement ant, although probably evolved in Europe or Africa, is now found scattered throughout the world, including diverse places as Belize, Chile, North America and Australia. Although possibly arriving in North America with the early European colonists, it continues its rapid spread at a local level even today. For example, a monograph on the ants of Colorado in the early 1960's stated that *Tetramorium caespitum* was absent from Denver; during a recent trip to Denver, Mr. King found the ant abundant everywhere he looked. The success of the pavement ant in cities is most probably related to the habitat in which it originally evolved, i.e., open areas of scarce, low vegetation. It is equally at home in the wall-to-wall pavement of any major city (thus its apt common name), or in the lawns of the suburbs.

Mr. King's interest in ants in general extends back to age 7. More recently, his ant research has included one year studying the fire ant at Texas Tech University, and continues with observations on interactions between the introduced *Tetramorium caespitum* and other ant species in the Philadelphia area. Surprisingly, although the pavement ant is well adapted to the urban and disturbed environment, it does face severe competition from

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## A CHAMBER FOR MASS HATCHING AND EARLY REARING OF PRAYING MANTIDS (ORTHOPTERA: MANTIDAE)<sup>1</sup>

Frederick R. Prete, Robert J. Mahaffey<sup>2</sup>

**ABSTRACT:** A rugged, easily maintained polycarbonate and lucite chamber for the mass hatching and early rearing of praying mantises is described. The chamber is sealed after eggs are introduced so that even the smallest prey (e.g., *Drosophila*) cannot escape. An aquarium pump forces fresh air through a water bottle into the sealed chamber. Gas exchange and the introduction of prey, food, and water occur through several holes that are plugged with foam rubber. If necessary, the temperature of individual chambers can be raised above ambient by placing an incandescent light bulb at the appropriate distance.

The praying mantis' dramatic method of prey capture and the relative ease with which the predatory strike can be elicited in the laboratory have made this insect an important investigatory tool for the study of visually guided behaviors (e.g., Barnes, 1979; Barnes and Mote, 1980; Collet, 1987; Liske and Mohren, 1984; Kirmse, 1985; Horridge, 1986; Rossel, 1986; Prete, 1991; Prete, 1992a, b; Prete, *et al.*, 1992a, b).

In spite of the popularity of mantises among professional and amateur entomologists, information regarding methods of mass rearing and maintaining these insects remains primarily anecdotal. A few informative reports on small scale rearing have appeared (e.g., Heath, 1980), but problems unique to those rearing large numbers of mantises remain unaddressed in the literature. Here, we describe a chamber in which egg cases can be incubated and young (e.g., up to fourth or fifth instar *Tenodera* or *Sphodromantis*) mantises can be easily raised prior to being placed in individual containers. The chamber solves several of the problems that mantis breeders face—for instance: maintaining high humidity, maintaining high prey densities, feeding the introduced prey, and preventing the escape of small prey.

### MATERIALS AND METHODS

The chambers are easily built and, with reasonable care, have an indefinite life. The materials needed for the construction of one chamber are these (measurements are given in inches for appropriate items): i) a polycarbonate rodent cage (51 x 41 x 22 cm; Fisher Scientific); ii) one piece of clear lucite (53 x 42 x 0.64 cm); iii) eleven foam rubber plugs ( $\approx 3.5$

<sup>1</sup> Received June 27, 1992. Accepted July 18, 1992.

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x 4 cm; e.g., standard *Drosophila* vial plugs); iv) 42 cm long x 3.8 cm (1.5 inches) wide aluminum piano hinge; v) 42 cm long x 1.3 cm (.5 inch) wide aluminum angle; 2.5 cm long (1 inch) 6-32 round head bolts, 1.6 cm long (.625 inch) 10-32 flat head bolts, 1.6 cm long (.625 inch) 6-32 flat head bolts, appropriate washers and nuts. A finished chamber is pictured in Fig. 1.

The first step is to cut the lucite into two sections across its width. One piece will serve as a door, the other as the permanently attached portion of the top. The width of the door can be varied to suit individual preferences but we suggest cutting the lucite into two approximately equal sections. This allows sufficient access to the chamber interior when removing mantises and cleaning without having to remove the entire top. The two pieces of lucite are connected with the piano hinge on the outside of the chamber. If the hinge is not pre-drilled, the 10-32 flat head screws are spaced 10 cm between centers with the heads recessed into the lucite. The aluminum angle is attached to the lip of the door with the 6-32 flat head screws, also spaced 10 cm between centers and recessed into the lucite. Fewer screws should not be used in that one purpose of the hinge and angle is to prevent the lucite from warping. If the two top pieces do not fit snugly under the hinge, the gap can be filled with a strip of .64 cm (.25 inch) wide adhesive foam rubber weather stripping (e.g., Door & Window Weather Strip, Macklanburg-Duncan, Oklahoma City, OK). The top is affixed to the bottom with the 6-32 round head screws. Holes should be drilled through the top such that the screws pass through the center of the rolled lip of the box; The 6-32 nuts will fit snugly within the lip. Holes should be drilled for four bolts on each side (two on each side of the top and two on each side of the door) and for three along the back edge of the top. This is the minimum number sufficient to prevent the top from warping.

Seven 3.2 cm (1.25 inch) holes are drilled in the sides of the box, and four in the top (see Fig. 1 for placement). Foam rubber plugs are inserted into each hole. Standard *Drosophila* vial plugs work well; however, larger holes may be drilled as long as the plugs used fit snugly. Prey, and food for the prey are introduced through these holes.

Fresh humid air is supplied to the chamber by a standard aquarium pump attached to an 8 oz (237 ml) polyethylene wash bottle (Carolina Biological) containing water. After clipping off the thin tip to increase air flow, the nozzle of the bottle is inserted into the chamber through the center of one of the foam rubber plugs. Any mid-sized pump ( $\approx 2500$  cc/min at 4 PSI) is sufficient to aerate two chambers. If chambers become too humid, any number of foam rubber plugs can be replaced with square pieces of fine screen taped over the holes and/or the wash bottle



Figure 1. Finished hatching and rearing chamber. Photo by Carl Leet.

can be emptied. Internal chamber temperature can be monitored by an aquarium thermometer and, if necessary, the temperature can be raised above ambient by placing an incandescent light bulb at the appropriate distance.

Perch sites for the mantises are supplied by a continuous (2.5 meter) length of 15 cm high heavy ( $\geq 5$  x mm) plastic mesh folded back and forth inside of the chamber (e.g., Co-Polymer Gutter Guard, Allumax Home Products, Lancaster, PA).

## RESULTS AND DISCUSSION

Prior to hatching, egg cases are hung from the plastic mesh with wire hooks and the door is bolted closed. Generally, we incubate simultaneously four to eight egg cases of about the same age in one chamber. Although the chamber is relatively easy to use, precautions are necessary.

For over two hundred years, those who have written about keeping mantises have continually reminded their readers that cannibalism can be held to a minimum by supplying the mantises with sufficient prey (Prete and Wolfe, 1992). This is easily done with a chamber from which prey cannot escape and, if fed, survive well until eaten. For early instars, we suggest the following procedure: just before the mantises hatch and prior to bolting the chamber lid closed, place a jar (approximately 50 x 110 cm) half filled with commercial *Drosophila* food on its side under one of the foam rubber plugs. Placing the jar on its side prevents mantises from becoming entrapped in the food. Shortly after the first hatching (and then as needed) anesthetized flies can be added by pouring them through a funnel inserted into one of the holes in the top of the chamber. If the foam rubber plug is kept in place during the procedure and is just pushed aside by the funnel's spout, flies and mantises cannot escape. When the jar needs refilling, it can be righted easily by means of a long sturdy wire with 1.5 cm of the tip bent at a right angle. The wire is inserted through a hole in the top of the chamber (with the plug kept in place), and hooked under the lip of the jar. Then, with the jar's base pushed against the side of the chamber, it is pulled upright and slid, if necessary, directly under the foam rubber plug. With practice, this procedure takes only seconds. Once upright, the jar can be refilled with *Drosophila* food through a funnel and returned to its side with the wire hook.

Obviously, other prey, such as crickets of any size, can be introduced into the chamber through a funnel of appropriate size. Prey can be supplied with slices of vegetables impaled on a thin stainless steel wire that is bent at the tip and inserted through one of the holes in the top. The wire

should extend sufficiently far beyond the top to prevent it from falling into the chamber. Although crickets can be maintained on just vegetables with high water content, such as potatoes, if they become thirsty or hungry they will prey on the mantises. To avoid this problem, we also supply the crickets with powdered laboratory rodent food and fresh water. The former is simply poured through a funnel into the chamber. Water is supplied in a slice of wet sponge impaled on a thin stainless steel wire as is done with vegetables. The sponge should not be so wet that it loses water into the chamber. We have found it best to place a small plastic dish into which the crickets can climb (such as a small jar lid) under the sponge to keep excess water off the chamber floor. This can be done by placing the dish under the hole through which the sponge will be inserted before the lid is bolted down or by first threading the wire on which the sponge is impaled through the center of the dish. Obviously, if the latter method is used, a hole large enough to accept the dish has to be cut in the lid.

Once mantises reach approximately the sixth instar (depending on species), we transfer them into aquaria with screen tops; immediately after their final molt, they are placed in individual containers.

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many species it did not initially evolve with, including native species of *Pheidole* and *Monomorium* ants, and even small rodents like mice and rats. For example, *T. caespitum* won't forage in bright sunlight and the resultant heat, therefore limiting its foraging times in warm areas to night and morning hours; some species of ants can forage at much higher temperatures during the day, and mice probably compete with the pavement ant for food during the nocturnal periods. Other factors which may impact the competitiveness of *T. caespitum* are the large nest sizes and foraging areas it maintains (nests may be up to 7 square meters, foraging areas may be up to 40 square meters), its tolerance of other ant species in its area and its high investment in reproductives (up to 50% of the colony's energy may go toward reproductives).

There were several notes of local entomological interest preceding Mr. King's talk. Concerning the widely publicized decline in monarch butterfly populations due to severe cold and logging in their overwintering forests in Mexico, Dale Schweitzer suggested that local factors may have also played an additional factor. He reported that population levels in Cumberland Co., New Jersey appeared to be building in July, but never appeared as a flush of adults in August as expected, possibly due to cooler summer temperatures and/or disease. Mildred Morgan stated that numbers of monarchs tagged at Cape May, New Jersey by Jane Ruffin and herself was one-tenth that of the previous year. Barbara Kirschenstein reported on small flies (family Phoridae) attracted to iodized salt. Society president Joe Sheldon urged everyone to attend the traveling insect exhibition, "Backyard Monsters" at the Franklin Institute, Philadelphia, which features monstrous robotic insects, a marvelous collection of OH MY! insects from around the world, interactive exhibits and an operational scanning electron microscope. The meeting at the Academy of Natural Sciences was attended by 27 members and their guests.

Jon K. Gelhaus,  
Corresponding Secretary

## ELMIDAE OF TAIWAN PART II: REDESCRIPTION OF *LEPTELMIS FORMOSANA* (COLEOPTERA: DRYOPOIDEA)<sup>1</sup>

Ming-Luen Jeng, Ping-Shih Yang<sup>2, 3</sup>

**ABSTRACT:** *Leptelmis formosana* is the only member of the genus known from Taiwan. It is redescribed and the male genitalia and other characters are illustrated. Because of similar male genitalia but somewhat different external morphology, we regard *Leptelmis vietnamensis* from Vietnam as a subspecies of *L. formosana*. A key is modified from Brown and Thobias (1984) to include all known *Leptelmis* species of Asia.

The genus *Leptelmis* Sharp was reviewed recently by Brown and Thobias (1984). More than twenty species are known from Asia and Africa. *Leptelmis formosana* Nomura is the only species known from Taiwan. Nomura described this species in 1962 based on two adults collected by Yano in 1938. The descriptions only pointed out the differences between *L. formosana* and *L. parallela* Nomura from Japan. Brown and Thobias omitted these two species in their key to Asian species of *Leptelmis* since the original diagnoses were too ambiguous to separate them from *L. gracilis* Sharp from Japan. Actually, *L. gracilis* is quite distinct in elytral shape. Because its humeri are not prominent and the elytra are very broad at their apical 1/3, the body looks expanded posteriorly. Both *L. formosana* and *L. parallela* have prominent humeri and their elytra are subparallel-sided (Fig. 1). However, it is necessary to note that the wing polymorphism may accompany morphological change of pronotum and elytra (Delève 1945; Brown, personal communication).

While examining the insect collections of Taiwan Agricultural Research Institute (TARI), three specimens of *Leptelmis formosana* were found. We redescribe and illustrate the species here. In addition, we regard *Leptelmis vietnamensis* Delève from Vietnam as a subspecies of *L. formosana* due to its similar male genitalia but somewhat different external morphology. A key to all known Asian species, modified from Brown and Thobias (1984), is provided to include *L. formosana* and *L. parallela*.

The following description of coloration is based on alcoholic specimens viewed under a white light source. Body length is measured from apex of pronotum to apex of elytra.

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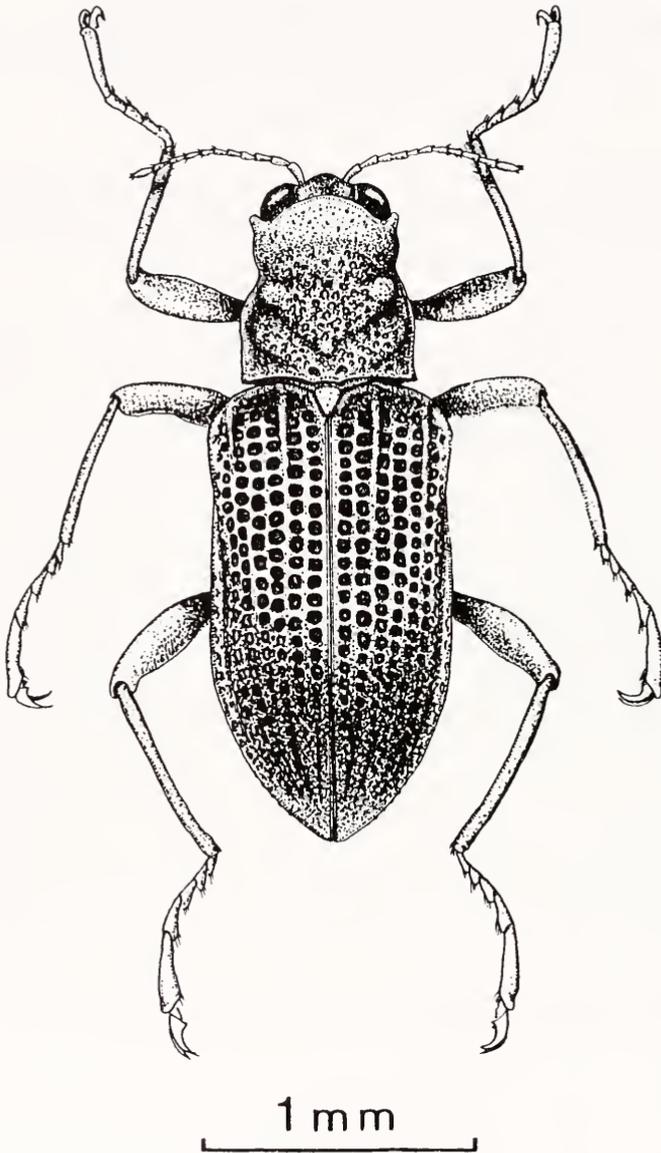


Fig. 1. *Leptelmis formosana formosana* Nomura, dorsal aspect.

*Leptelmis formosana formosana* Nomura

*Leptelmis formosana* Nomura, 1962, Tôhō Gakuhō 12:48.

: Brown and Thobias, 1984, Pan-Pacific Entomol. 60(1):28.

Length 2.3–2.4 mm, width 0.8–0.9 mm. Body elongate, subparallel-sided, convex dorsally. General coloration brown, with elytra feebly shining. Epicranium darker than other portions; venter lighter than dorsum; antennae, palpi, tarsi and genitalia translucently testaceous.

Head retractable within prothoracic collar; visible portion finely granulate and pubescent. Vertex concave at middle, impressed in a band on each side toward antennal base. Frons convex at middle, about 3/5 as broad as width across eyes. Eyes rather large. Frontoclypeal suture indistinct. Labrum transverse, anterior margin feebly truncate with frontal angle round. Antennae 11-segmented, barely reaching pronotal base; apex of distal segment acute.

Pronotum longer than broad by about 1.1 times; widest at basal 2/5, thence subparallel posteriorly to base; narrowest at middle transverse impression. Anterior pronotal margin arcuate and projecting over the vertex; anterior angles subacute, slightly protruding outwards; sides conspicuously bisinuate, not crenate; posterior margin feebly sinuate; basal angles subquadrate. Surface finely and sparsely granulate anteriorly, coarsely and deeply punctate at transverse impression and posterior portion. A subtriangular elevation located behind the transverse impression; two upper tubercles of the elevation very prominent; the lower tubercle smaller, with an indistinct ridge posteriorly; an indistinct impression composed of some punctures extending from transverse impression to near lower tubercle of the elevation. Two oblique, convergent grooves behind the subtriangular elevation deep, with two oblique elevations posteriorly. Base with two small, round feeble impressions.

Scutellum flat, very sparsely granulate.

Elytra 2.4 times as long as pronotum; humeri prominent; sides subparallel in anterior 2/3, thence tapering posteriorly to a rounded apex; feebly depressed at base, but convex at humeri. Each elytron bearing 9 punctate-striae; the 3rd and 4th striae merge on apical declivity. Strial punctures on disk rather large, subquadrate, separated from one another by less than half their diameters; punctures on apical declivity smaller and shallower. Strial intervals on disk narrower than half diameter of punctures; the third interval (between 2nd and 3rd striae) elevated at base. Lateral borders feebly margined and finely serrate. Epipleura narrowed gradually towards apex.

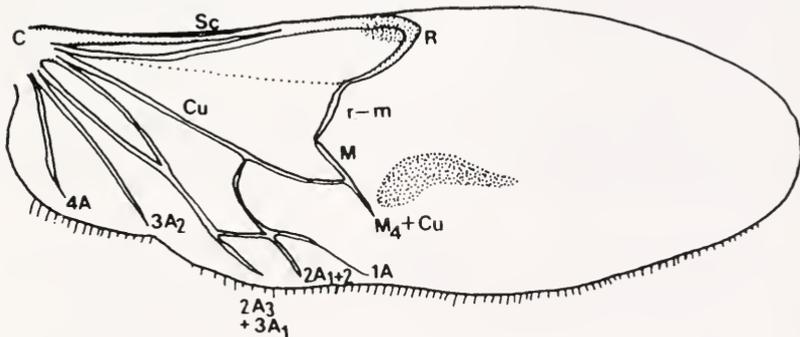


Fig. 2. Hind wing of *L. formosana formosana*.

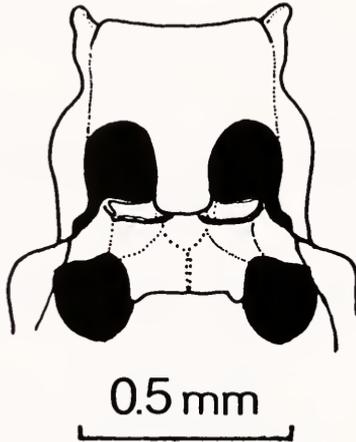


Fig. 3. Prosternum and mesosternum of *L. formosana formosana*.

Hind wing with venation as in Fig. 2. Venation essentially like that of the *Cyloepus* (Hinton 1940, Figs. 251, 252); Veins  $3A_1$  and  $3A_2$  separated near base.

Prosternum coarsely punctate posteriorly. Prosternal process with sides subparallel or slightly expanded posteriorly; apex truncate (Fig. 3).

Metasternum with inconspicuous, blunt hind angles.

Metasternum with large, deep punctures; punctures separated at most by 1/2 their diameters. Anterior position bare between mesosternum and longitudinal sulcus.

Abdomen with first two visible sterna with large, deep punctures similar to those on metasternum; punctures on the last three sterna finer and sparser. Apex of last sternum feebly truncate in males and round in females; males with two tufts of hairs and a semicircular depression at the apex of 5th sternum.

Legs long and slender, with fine pubescence and sparse granules. Tibiae with inconspicuous rows of small setae present along inner distal margins. Tarsi 5-segmented, that of foreleg shortest and hindleg longest; segments progressively longer from base to apex; apical segment as long as segments 1-4 combined, without ventroapical tuft of setae; claws large, each with a basal tooth.

Male genitalia as shown in Fig. 4. It is noteworthy that while the genitalia are connected ventrally with sternum IX, the parameres are parallel-sided, but when sternum IX is removed, the parameres expand outward as illustrated.

Variation: In one specimen the pronotum has its broadest width at base.

Specimens examined: 1♂, Tamsui, Taihoku (Taipei Hsien), 24-VIII-1941, S. Miyamoto leg.; 2♀♀, Heito (Pintong Hsien), V-1933, Y. Miwa leg. These specimens are deposited in Department of Applied Zoology, TARI.

**Distribution:** The type locality of this species is Takezaki (Chuchi, Chiayi Hsien). When more specimens become available we expect that this species may be distributed from northern to southern Taiwan. At present, the only known specimens are the two type specimens (in National Science Museum, Tokyo) and the three specimens reported here.

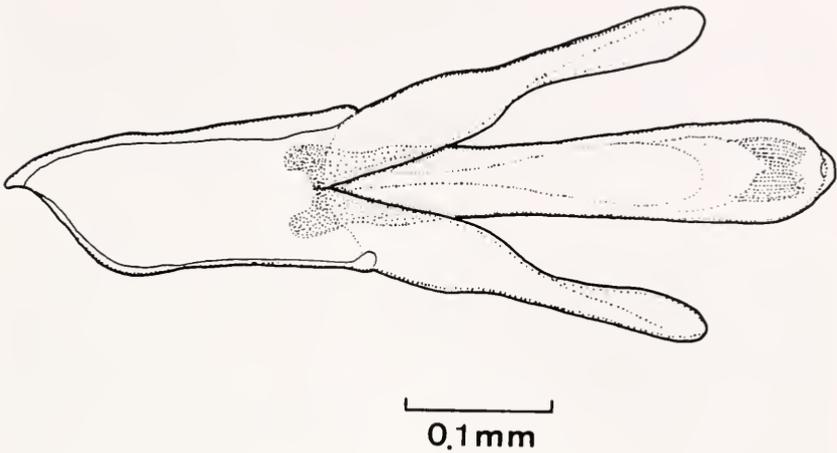


Fig. 4. male genitalia of *L. formosana formosana*.

### *Leptelmis formosana vietnamensis* Delève

*Leptelmis vietnamensis* Delève, 1968, Ann. Hist.-Nat. Mus. Nat. Hung., Pars Zool. 60:154.  
 \_\_\_\_\_: Brown and Thobias, 1984, Pan-Pacific Entomol. 60(1):27.

Since the male genitalia of this taxon is so similar to that of *L. formosana*, we regard it as a subspecies of the later. Compared with the nominate subspecies, the pronotum of this subspecies has (1) a smaller elevation; (2) more indistinct upper tubercles; (3) a longer ridge behind the lower tubercle and (4) a conspicuous longitudinal impression at anteromiddle of the elevation. Its body size is a little smaller than the nominate subspecies. These differences are shown in Fig. 5a and b.

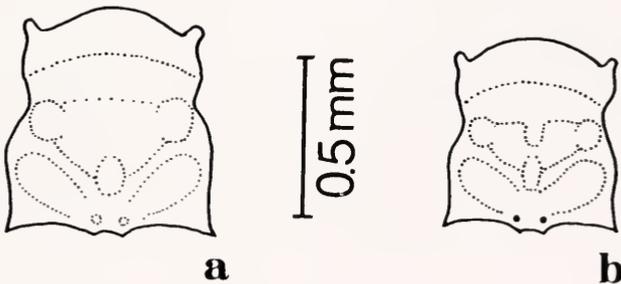


Fig. 5a. Pronotum of *L. formosana formosana*; b. of *L. formosana vietnamensis*.

Specimens examined: Holotype male, labelled "Vietnam, Prov. Ha-Tinh, forêtière Hùong-sôn, 150 m, forêt trop. pluv./à la lumière, 15. VIII, 1963, T. Pócs./Prépar. genit. No. 21266.2". Paratypes, 1♂, 1♀, with identical data; Prépar. genit. No. 21266.1 and 21266.3 respectively.

The following key is modified from Brown and Thobias, 1984, to include *L. formosana* and *L. parallela*.

### Key to Asiatic Species and Subspecies of *Leptelmis*\*

1. Elytra maculate ..... 2  
Elytra essentially uniform in color or with the humeri lighter ..... 5
2. Each elytron with 5 yellow spots (Vietnam) ..... *L. signata*  
Elytra with fewer than 5 spots or markings ..... 3
3. Elytra without vitta in apical half on intervals, with only humeral and apical markings; larger (3.0 mm) (Sumatra) ..... *L. stricticollis*  
Elytra with both vitta, humeral and apical markings; smaller (less than 2.5 mm) ..... 4
4. Elytra with strial interval 3 raised from base to apex; smaller (1.8 mm) (Philippines) ..... *L. tawitawiensis*  
Elytra with strial interval 3 raised only at base; larger (2.3 mm) (Vietnam) ... *L. basalis*
5. Elytra without prominent humeri ..... 6  
Elytra with prominent humeri ..... 7
6. Elytra expanded posteriorly; venter punctate; larger (2.5-2.8 mm) (Japan) ... *L. gracilis*  
Elytra not expanded posteriorly; venter granulate; smaller (2.15 mm) (South India) ..... *L. philomina*
7. Tarsi 4-segmented (South China) ..... *L. flavicollis*  
Tarsi 5-segmented ..... 8
8. Elytra with humeri paler ..... 9  
Elytra uniform in coloration; or if the elytra with humeral spot and /or paler 3rd strial interval, the body size less than 2.5 mm ..... 10
9. Larger (2.5-2.6 mm) (Japan) ..... *L. parallela*  
Smaller (2.0 mm) (North India) ..... *L. fracticollis*
10. Elytra with strial interval 3 raised from base to apex ..... 11  
Elytra with strial interval 3 raised at base only or extending to apical 1/3 ..... 13
11. Male genitalia with parameres subparallel in apical half (Sumatra, Java) ... *L. sulcata*  
Male genitalia with parameres tapering from base to apex ..... 12
12. Penis subparallel laterally, longer than basal piece by 1.7 times (Sri Lanka) ..... *L. cederholmi*  
Penis dilated at apical 1/4 and thence tapering basally, longer than basal piece by 1.5 times (Vietnam) ..... *L. obscura*
13. Two upper tubercles of triangular elevation on pronotum very prominent; longitudinal impression at anteromiddle of the pronotal elevation inconspicuous (Taiwan) ..... *L. formosana formosana*  
Upper tubercles of triangular elevation on pronotum not very prominent; longitudinal impression at anteromiddle of the pronotal elevation distinct (Vietnam) ..... *L. formosana vietnamensis*

\* The species *L. nietneri* was transferred to the genus *Podelmis* by Jach (1984).

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We thank Department of Applied Zoology (Liang-Yih CHOU), Taiwan Agricultural Research Institute, R.O.C. and Természettudományi Múzeum (Ottó MERKL), Hungary, for lending us the precious specimens. We also express gratitude to Harry G. NELSON (Field Museum of Natural history, Chicago), Harley P. BROWN (Dept. of Zoology, Univ. of Oklahoma, Norman, U.S.A.) and M. A. JÁCH (Naturhistorisches Museum Wien, Austria) for revising the English manuscript.

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## BOOK REVIEW

**A SYNTHESIS OF THE HOLARCTIC MIRIDAE (HETEROPTERA): DISTRIBUTION, BIOLOGY, AND ORIGIN, WITH EMPHASIS ON NORTH AMERICA.** A. G. Wheeler, Jr. and T. J. Henry. 1992. Thomas Say Foundation, Vol. 15. Entomological Society of America, Lanham, MD. 282 pp. \$30 (members), \$50 (non-members).

The authors have determined that about 5% (98 spp.) of New World mirids also occur in the Old World, and thus appear to have Holarctic distributions. However, they present good evidence that 61 of these species (3%) have been introduced into North America through commerce, so actually only 37 spp. (2%) are likely Holarctic. Distinguishing these two types of origins are important to those in the biological control, quarantine, and biogeography fields.

Although the adults and nymphs of most mirid species are not hardy or long-lived, diapausing mirid eggs imbedded in plant tissue can easily survive long ocean voyages, and were the likely means of dispersion. Many mirids were not detected until years after their initial establishment, as commonly happens with immigrant species. A number of them were first found by one or both of the authors.

A total of 98 species are included in this book, arranged by subfamily. For each species, the known distribution (with a map), host plant and habits, and zoography is discussed, with references cited. Most species are phytophagous, but some are predators. Several are economically important pests. Ten additional species formerly thought to be Holarctic are discussed briefly.

Five tables follow the text. These list indigenous mirids (species present since the Beringian land connection), and species which were introduced through eastern, north-western southern, and multiple ports of entry. The tables place the species in functional groups, but the contents (or index) must be used to locate the discussion on each species in the text.

There are two indices, listing the common and Latin names of the mirid species and of their host plants. There are also ca. 500 references, for those who wish further information. However, this list is the most comprehensive for taxonomic papers, and is less complete for economic and biocontrol citations, especially after 1986. There was a refreshing absence of misspellings and other errors throughout the book.

This small volume contains a wealth of information. it will be useful to taxonomists, economic entomologists, and quarantine and biological control specialists.

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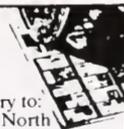
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## A NEW SPECIES OF *ALEODORUS* (COLEOPTERA: STAPHYLINIDAE) FROM COSTA RICA, AND GENERIC REASSIGNMENT OF *FALAGRIA COSTARICENSIS* TO *ALEODORUS*<sup>1</sup>

E. Richard Hoebeke<sup>2</sup>

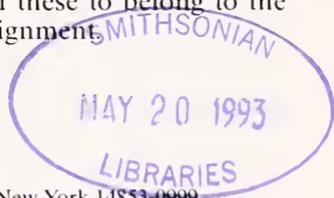
ABSTRACT: *Aleodorus maurenae*, new species of falagriine Staphylinidae, is described from Costa Rica. *Falagria costaricensis* Bernhauer is redescribed and transferred to *Aleodorus*. A lectotype is designated.

The genus *Aleodorus* was established by Say (1833) for the North American species *Aleochara bilobata*, also described by Say that same year. *Chitalia* was proposed by Sharp (1883) to accommodate four new species (*crenata*, *granigera*, *debilis*, and *dubius*) collected at various localities in Mexico and Central America. The latter genus was later determined to be a junior synonym of *Aleodorus* (Fenyés, 1912).

Members of *Aleodorus* are restricted to the Western Hemisphere. At present, four species are known to occur in America north of Mexico, with the Nearctic species having been revised by Hoebeke (1985). Blackwelder (1944) lists five species from Mexico and Central America, and one species from South America. Pace (1989, 1990) added 4 taxa to the existing South American fauna by describing 3 new species from Argentina, Peru, and Brazil, and by reassigning *Falagria discisa* Erichson (Brazil) to *Aleodorus*. The Neotropical species have not been revised.

In March and April 1973, specimens of a distinctive, yet unrecognized, species of *Aleodorus* were collected from Berlese samples of leaf mold and leaf litter in virgin forest in Puntarenas and Guanacaste provinces, Costa Rica, by J. Wagner and J. Kethley of the Field Museum of Natural History (Chicago). Specimens of this new species, which I discovered among recently prepared and unidentified Staphylinidae in the Field Museum collection (FMNH), are described below.

Furthermore, after examination and dissection of syntypes of *Falagria costaricensis* Bernhauer, I have found these to belong to the genus *Aleodorus* and herein propose this reassignment.



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## *Aleodorus maureenae*, new species

(Figs. 1-6)

**Diagnosis.** In overall adult body size and in pronotal shape, *Aleodorus maureenae* is similar to *A. granigerus* (Sharp), but differs most noticeably by the very roughened surface of the head, thorax, and elytra caused by a dense, uniform covering of setiferous asperities.

**Description.** Agreeing with generic characters given by Hoebeke (1985).

Length 2.8-3.4 mm ( $n = 9$ ,  $\bar{x} = 3.2$  mm). Body color uniformly dark rufo-brunneous, with distal antennal articles, mouthparts, and, in some specimens, last two abdominal segments rufo-testaceous. Habitus as in Figs. 1-2.

Head (Fig. 1) quadrate, slightly longer than wide, posterior angles broadly rounded, posterior margin slightly arcuate to truncate. Eyes moderately large, prominent, their longest diameter nearly subequal to length of temple. Dorsal surface with a dense, uniform covering of asperities, each bearing a short, erect microseta; dorsum with narrow, median area between posterior margins of eyes, and median frontal prominence between antennal bases devoid of asperities smooth and glossy (see Fig. 1) (some specimens with smooth, glossy area between eyes appearing as small dimple, or absent altogether); cuticular surface between asperities smooth, glossy. Gena and ventral surface of head without asperities, smooth and glossy. Antennae moderately long, reaching anterior 0.4 of elytra; distal articles beyond article IV compactly organized; scape somewhat incrassate, nearly equal to length of article II; article II and III elongate, II slightly shorter than III; article IV somewhat quadrate, but slightly longer than wide; articles V-X becoming gradually more transverse; article XI obovate, slightly shorter than IX + X.

Pronotum (Fig. 1) slightly wider than head, broadest across anterior third, strongly narrowed and converging behind towards base; posterior angles nearly acute; posterior margin broadly truncate. Disc narrowly and deeply channeled along median line, channel terminating in deep, subbasal fovea; surface on either side of channel densely and uniformly covered with setiferous asperities; cuticular surface between asperities smooth and glossy. Scutellum large, flat, densely punctured (punctures minutely asperate), on either side of a broad smooth, slightly impressed, median channel.

Elytra (Figs. 1-2) about as long as prothorax, humeri well developed, lateral margins broadly arcuate posteriorly, posterior angles sinuate, posterior margin truncate; surface with a dense, uniform covering of setiferous asperities; in some specimens, asperities tending to be arranged in longitudinal series, and thus appearing somewhat costate; cuticular surface between asperities smooth, glossy.

Abdomen (Fig. 2) broad at base, but narrower than elytra. Terga III-V (first three visible tergites) broadly, transversely impressed at base; impressions coarsely foveate, each fovea limited laterally by distinct, flattened ridge; basins of foveae smooth and glossy, without microsculpture. Tergite VI slightly impressed at base with several obsolete ridges and foveae. Tergal surfaces posterior to basal impressions moderately densely punctured and pubescent, some punctures at most minutely asperate; cuticle smooth and glossy. Sterna III-V strongly constricted at base; basal constriction coarsely foveate (often visible in lateral view).

**Male.** Eighth tergite with apical margin broadly arcuate at middle, with comb of minute denticles. Median lobe of aedeagus as in Figs. 3-4. Paramere and apical lobe of paramerite as in Fig. 5.

**Female.** Eighth tergite with apical margin as in male. Spermatheca as in Fig. 6.

**Secondary sexual characteristics.** None apparent.

**Material examined.** Holotype: male, COSTA RICA: Puntarenas; OTS Sta. finca Las Cruces, 4000 ft.; San Vito; III:18:1973, 82°58'W-8°46'N, leg. J. Wagner, J. Kethley/FM(HD)#73-322, 73CRIII-18d FLC Berlese 1500cc. leaf litter in stream bed, away from

flowing water, steep banks, virgin forest cover. Terminalia, aedeagus and parameres mounted (in Euparal) on microslide and affixed below specimen. The holotype is deposited in the Field Museum of Natural History, Chicago (FMNH).

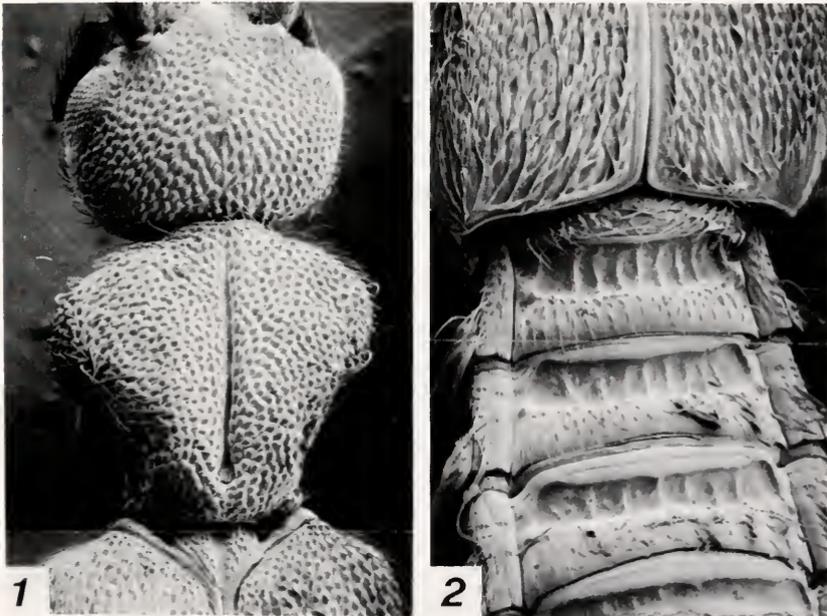
Paratypes, 9: Same data as holotype, 1; same data, except III:16:1973, 4; same data, except II:19:1973, 2; COSTA RICA: Guanacaste; Canas, Miravalles Volcano, 10°42'N-85°7'W; IV:8:1973, leg. J. Wagner, J. Kethley/FM(HD) #73-385, 73CRIV-8e; Berlese 2 liters conc. leaf litter + soil in dry rivulet #1, 1; same data, except FM(HD) #73-386, 73CRIV-8f, 1. Eight paratypes deposited in the FMNH; 1 paratype (female), with same data as holotype, except with the date III:16:1973, is deposited in the Cornell University insect Collection (CUIC).

**Etymology.** This elegant species is named for my wife, Maureen, who, over the years, has graciously provided encouragement and constant support of my work on the Staphylinidae.

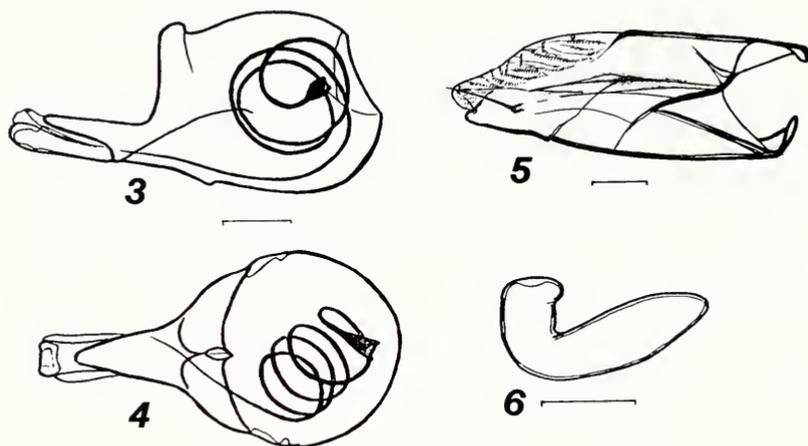
**Geographic distribution.** Known only from the type localities in Puntarenas and Guanacaste provinces, Costa Rica.

**Bionomics.** Little is known about the habitat of this species, but specimens at hand have been collected from Berlese samples of leaf litter in stream beds, in dry rivulets, and on slopes above stream banks in virgin forests of Costa Rica.

**Remarks.** Only slight external morphological variation exists between the populations from Puntarenas and Guanacaste provinces. The



Figs. 1-2. *Aleodorus maureenae* n. sp. (OTS Sta. finca Las Cruces, Puntarenas province, Costa Rica), scanning electron photomicrographs. 1, head, thorax, scutellum, and upper one-third of elytra, dorsal aspect. 2, lower two-thirds of elytra, and abdominal segments III-VI, dorsal aspect.



Figs. 3-6. *Aleodorus maureenae* n. sp. 3. Median lobe of aedeagus, lateral aspect. 4, Median lobe of aedeagus, dorsal aspect. 5, Paramere. 6, Spermatheca. Scale line, 0.1 mm.

ten specimens from Puntarenas province are slightly larger than those from Guanacaste province (2 specimens) (cf. 3.1-3.4 mm vs. 2.8 mm, respectively). Furthermore, the setiferous asperities on the heads of the Guanacaste specimens are slightly less dense (asperities separated by slightly more than their diameters) than on the heads of the Puntarenas specimens (asperities separated by less than or equal to their diameters). The density of the asperities on the thorax and elytra of the Puntarenas and Guanacaste specimens is similar. For all other external characters, specimens from the two Costa Rican localities are identical.

#### Generic Reassignment and Redescription of *Falagria costaricensis* Bernhauer

Bernhauer (1940) described *Falagria costaricensis* from Costa Rica. All subsequent authors and cataloguers have followed this original generic placement. The diagnostic morphological features of *Falagria* species [type species *Falagria caesa* Erichson, 1837 = *sulcata* (Paykull, 1789) nec (Müller, O. F., 1776)] include a bicarinate scutellum, comb of minute denticles on the apical margin of tergum VIII, margined hypomera, deep pronotal sulcus, and uniform elytral punctation.

I have carefully examined specimens of the syntype series of *F. costaricensis* and found them to belong to the genus *Aleodorus* Say [type species *Aleochara bilobata* Say]. Members of this genus are characterized

by the unique mesosternum which is on a different plane from that of the metasternum (mesosternum appears elevated), the short, abbreviated mesosternal process which does not extend between the coxae, and the long, generally coiled flagellum of the male aedeagus.

***Aleodorus costaricensis* (Bernhauer), new combination**

(Figs. 7-9)

*Falagria costaricensis* Bernhauer, 1940:159. Lectotype here designated: La Caja: 8 kil[ometers]. w[est]. San José, C[osta].R[ica]., Schmidt 1934/Handwritten "costaricensis Brnh. Typ" (white label)/Handwritten "costaricensis Brh. Typus Falagria" (red label)/Chicago NHMus. M. Bernhauer Collection/ LECTOTYPE *Falagria costaricensis* Bernhauer, desig. E. R. Hoebeke 1992 (red label) (FMNH).

Paralectotypes, 5, here designated: Same data as lectotype, with the additional labels: Syntypus (red label)/Bernhauer det./Coll. DEI Eberswalde/PARALECTO-TYPE *Falagria costaricensis* Bernhauer, desig. E. R. Hoebeke 1992 (red label) (IPFE).

**Redescription.** In agreement with generic characters given by Hoebeke (1985).

Length 2.1-2.6 mm. ( $n = 5$ ,  $\bar{x} = 2.4$  mm). Body color rufo-brunneous, with antennae (especially toward apices), mouthparts, and legs generally rufo-testaceous; in some specimens, basal three abdominal segments light rufo-brunneous.

Head somewhat quadrate, nearly as long as wide, posterior angles somewhat obtuse, posterior margin truncate to slightly arcuate; neck very slender, about 0.3 x head width across eyes. Eyes moderate in size, longest diameter slightly greater than temple length. Dorsal surface smooth and glossy, moderately sparsely, but uniformly punctured and pubescent, except for broad median area; punctures very fine, non-asperate. Antennae moderately long, reaching posteriorly to near 0.5 elytral length; articles I-III elongate; article III slightly longer than II; article IV somewhat quadrate, slightly longer than wide; articles V-X becoming gradually broader, more transverse; article XI obconical, pointed apically, slightly shorter than IX + X.

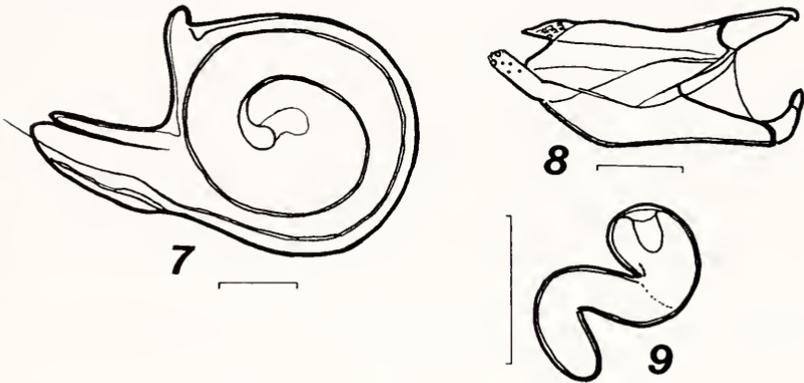
Pronotum subequal to width of head, broadest across anterior third, gradually narrowing and converging behind toward base; posterior angles acute; posterior margin truncate. Disc narrowly and deeply sulcate along median line, terminating in deep, subbasal fovea; surface on either side of sulcus sparsely punctured and pubescent; punctures very fine, non-asperate; surface between punctures smooth, glossy. Scutellum large, flattened, with fine, asperate punctures on either side of a broad, smooth, median channel.

Elytra approximately 1.2 x longer than pronotum, humeri well developed, lateral margins broadly arcuate in posterior half, posterior angles sinuate, posterior margin truncate; surface with moderately dense and uniform covering of very fine punctures and microsetae; area adjacent to scutellum with slightly more dense punctures; cuticular surface between punctures smooth and glossy.

Abdomen slightly narrower than elytra, parallel-sided, tapering to apex; terga III-V transversely impressed at base; impressions of terga III + IV with large, rather coarse, foveae, each bordered laterally by fine, slightly elevated, ridges (less so on tergum V); basins of large foveae obscurely granulate (with imbricate microsculpture); tergal surface posterior to basal impressions of terga III-V moderately sparsely punctured, pubescent; cuticle smooth and glossy.

**Male.** Eighth tergite with apical margin broadly arcuate at middle, with comb of minute denticles. Median lobe of aedeagus as in Fig. 7. Paramere and apical lobe of paramerite as in Fig. 8.

**Female.** Eighth tergite with apical margin as in male. Spermatheca as in Fig. 9. Secondary sexual characteristics. None apparent.



Figs. 7-9. *Aleodorus costaricensis* (Bernhauer). 7, Median lobe of aedeagus, lateral aspect. 8, Paramere. 9, Spermatheca. Scale line, 0.1 mm.

**Remarks.** The syntype series of *F. costaricensis* bears a striking resemblance to specimens identified as *Aleodorus dubius* (Sharp) from Mexico, Guatemala, and Costa Rica. There is close agreement in body length, coloration, pronotal configuration, punctation, and, more importantly, the genitalic characters of both sexes (shape of median lobe and coiled flagellum of aedeagus, apical lobe of paramerite, and spermatheca); these latter genitalic characters are virtually identical for the two species. Based on this evidence, I strongly suspect that these species are conspecific. However, I have not, as yet, examined the type series of *A. dubius*, and have studied only a limited number of identified specimens. Therefore, this hypothesis must remain tentative until a comprehensive revision of the Neotropical *Aleodorus* is completed.

#### ACKNOWLEDGMENTS

I am thankful to the following institutions and individuals for providing all specimens studied (codens identify the collections in the text): (FMNH) Field Museum of Natural History, Chicago, Illinois, A. F. Newton, Jr. and M. K. Thayer; and (IPFE) Institut für Pflanzenschutzforschung, Kleinmachnow der Akademie der Landwirtschaftswissenschaften, Eberswalde-Finow, Federal Republic of Germany, L. Zerche. J. Howard Frank (University of Florida, Gainesville) and James K. Liebherr (Cornell University) each provided helpful suggestions and critical review of the manuscript.

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SYSTEMATICS AND ECOLOGY OF THE SUBGENUS *IXODIOPSIS* (ACARI: IXODIDAE: *IXODES*). R.G. Robbins & J.E. Keirans. 1992. Thomas Say Fd., Entomol. Soc. Amer. 159 pp. \$25.00 ESA member. \$40.00 other.

The publisher states this is the first cladistic analysis within the Ixodidae and the first quantitative investigation of *Ixodes*. For the seven species of *Ixodiopsis*, all known host and distributional data are summarized, and dichotomous identification keys, accompanied by scanning electron photomicrographs, are provided.

CLASSIFICATION, CLADISTICS, AND NATURAL HISTORY OF NATIVE NORTH AMERICAN *HARPALUS* LATREILLE (INSECTA: COLEOPTERA: CARABIDAE: HARPALINI), EXCLUDING SUBGENERA *GLANODES* AND *PSEUDOPHIONUS*. G.R. Noonan. 1991. Thomas Say Fd., Entomol. Soc. Amer. 310 pp. \$30.00 ESA member. \$50.00 other.

This work revises the native North American species of *Harpalus* and includes keys to separate all North American members of the genus from those of other genera of No. Amer. Harpalini.

## EGG SURFACE ULTRASTRUCTURE IN *MANTISPA INTERRUPTA* (NEUROPTERA: MANTISPIDAE)<sup>1</sup>

Bruce Cutler<sup>2</sup>

**ABSTRACT:** The egg chorion of *Mantispa interrupta* was examined by scanning and transmission electron microscopy. The egg surface consists of reticulations connected by bridges that rise from the inner chorion surface. The egg stalk surface is featureless even at high magnifications. This same morphology is seen in the Chrysopidae, as reported by Hinton (1981).

The eggs of mantispids are white ovals on short stalks and are found on the undersides of exposed surfaces, such as leaves and anthropogenic structures (Kuroko 1961; Redborg and MacLeod 1983, 1984, 1985; Rice 1986). They greatly resemble those of Chrysopidae, except that the stalks are rarely more than 2-3 times the length of the egg and usually less. Illustrations of gross morphology are found in Hungerford (1936), Kuroko (1961), and Merti (1940).

### METHODS

A female *Mantispa interrupta* Say was found on West Campus, University of Kansas, Lawrence, Douglas County, Kansas, on October 13, 1990, laying eggs on a slightly curled red leaf of a 3 m tall planted sugar maple (*Acer saccharum* Marshall). Accessible leaves were examined for 90 minutes, but no additional *Mantispa* were found. The *Mantispa* female was enclosed in a glass container with the sides lined with chromatography paper. Eggs were laid in the laboratory on October 15, 20, 27, 30, November 3, 9, 13. The female died November 14. Larval emergence was from 13-17 days after laying. Approximate egg counts were 200-300 per batch, with a total of about 1500.

Eggs to be fixed were cut out of the main batch of eggs along with the chromatography paper to which the stalks were fastened. Fixation was in 2.5% glutaraldehyde in 0.1 M, 7.3 pH sodium cacodylate buffer at room temperature for 1 hour, followed by fresh fixative at 4°C for 2-3 days. For scanning electron microscopy, eggs were then rinsed in buffer, run through a dehydration series of ethanol to 100% ethanol, then placed in two 10 minute changes of HMDS (hexamethyldisilazane) and air

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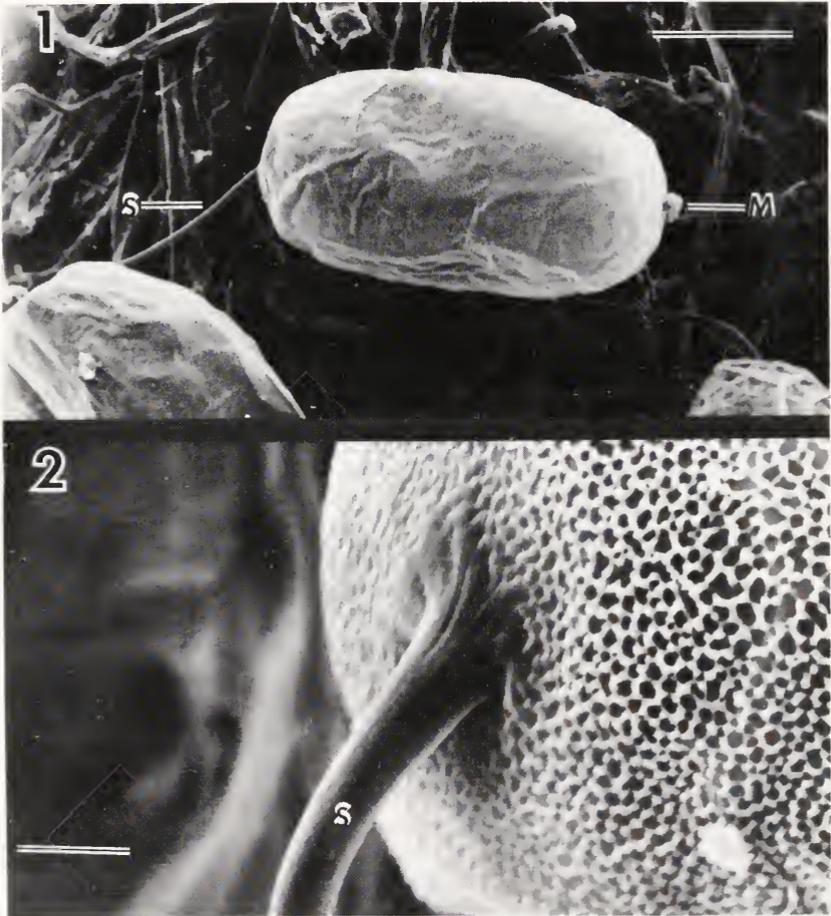
dried from the HMDS. Many eggs, regardless of developmental stage, were subsequently seen to be collapsed. A few remained intact, and these were the ones studied. In retrospect, critical point drying would probably have produced greater numbers of non-collapsed eggs. The paper containing the eggs was glued to a stub and sputter-coated with 200-250 Å of gold-palladium alloy. Specimens were examined with a Philips 501 scanning electron microscope.

For transmission electron microscopy, eggs were rinsed in buffer, postfixed in 1% osmium tetroxide in the same buffer at 4°C for 2.5 hours. After rinsing in buffer, eggs were dehydrated in an ethanol series to 100% ethanol, followed by 100% acetone and ultimately embedded in the epoxy resin, EM-BED 812 (Electron Microscopy Sciences). Silver to silver-gold sections were cut with a diamond knife, stained with uranyl acetate and lead citrate, and examined with a JEOL 1200 EX II transmission electron microscope.

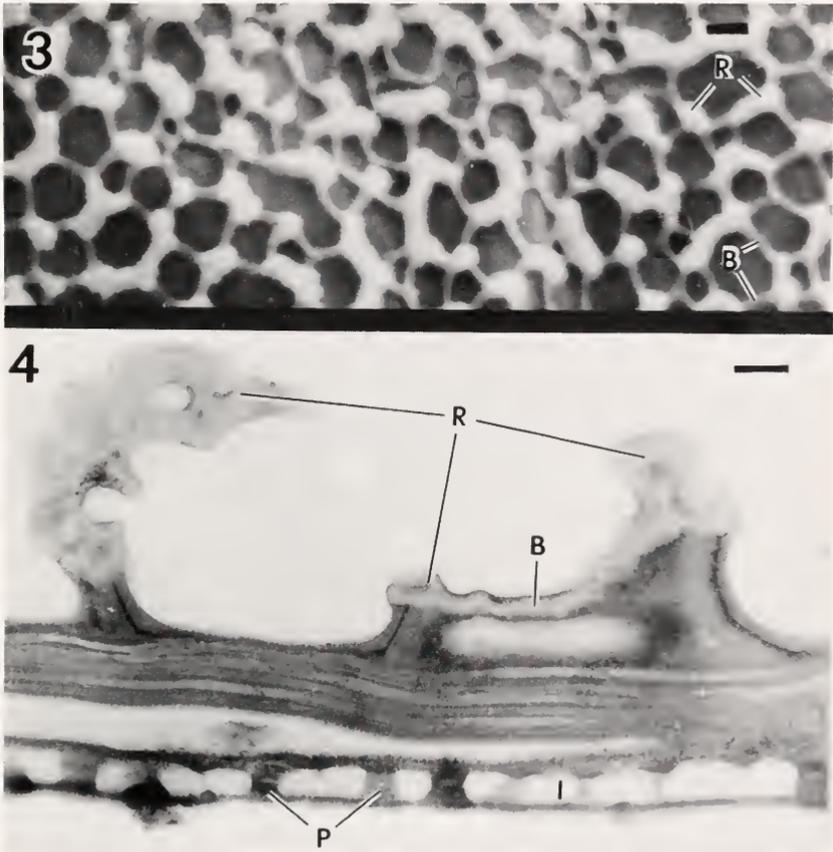
## RESULTS AND DISCUSSION

The surface of the eggs of *Mantispa interrupta* was virtually identical to that of *Chrysopa* species illustrated by Hinton (1981, figs. 50A-E). Figure 1 shows a whole egg in side view. The micropyle is also very similar to the micropyle of *Chrysopa*, and the reticulations of the micropyle are identical to those of the general egg surface. The only published electron micrograph of a *Mantispa* egg is Hinton's fig. 50F, showing a view of the side surface of *M. interrupta*. The reticular surface is clearly identical to that of figure 3 here. Figure 2 shows the base of the stalk and the posterior pole of the egg. As in the *Chrysopa* egg in Hinton's fig. 50E, the reticulations disappear at the base of the stalk, which is featureless at magnification up to 20,000X. Figure 4 shows the details of chorionic structure in cross section. The outer reticulations and inner chorion give no indication of an aeropyle. The reticulations are essentially solid and arise from a solid layer sitting on the inner chorion. The outer portion of the reticulations is more electron lucent than the base, and this less dense appearing material also forms the bridges. The inner chorion consists of two layers of chorionin bridged by pillars. Nowhere in examined sections are there connections between the spaces between pillars and the outside. Similar inner (but not outer) chorionic structure is found in the stick insect *Carausius* (Hinton, 1981, fig. 180A). In *Carausius* the pillars arise from the inner layer and are capped at the outer end. In *Mantispa* the pillars appear to arise from both layers and join in the middle. Hinton (1981) refers to transmission electron micrographs of *Chrysopa*, but does not illustrate them. His statement that "there is no

space for a film of air" implies that the outer chorionic layer sits on the inner as in *Mantispa*. To reiterate, the resemblance to the eggs of *Chrysopa* is great. Certainly, on the basis of the ultrastructure of the egg surface of those species of Chrysopidae and Mantispidae examined, one could not distinguish one family from the other.



Figures 1-2. *Mantispa interrupta* egg. 1. Side view of egg, S = stalk, M = micropyle, scale line = 100  $\mu\text{m}$ . 2. Base of egg stalk(s), scale line = 10  $\mu\text{m}$ .



Figures 3-4. *Mantispa interrupta* egg: chorion structure. 3. Surface view, R = reticulation, B = bridges, scale line - 1 μ. 4. Section through chorion, see text for detailed explanation, R = reticulation, B = bridge, I = inner chorion, P = pillars, scale = 0.2 μm.

#### ACKNOWLEDGMENTS

I would like to thank Kevin Hoffman, Clemson University, South Carolina, for identifying the *Mantispa*; and Hank Guarisco, Kansas Biological Survey, for sharing information and reviewing the manuscript. Byron Alexander, University of Kansas, also reviewed the manuscript. The adult female specimen and some eggs and larvae are deposited in the Snow Entomological Museum, University of Kansas, voucher number BC 101390.

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## BOOKS RECEIVED AND BRIEFLY NOTED

THE HOT-BLOODED INSECTS. B. Heinrich. 1993. Harvard Univ. Press. 597 pp. \$75.00

This author of *Bumblebee Economics* and *Ravens in Winter* presents here what is now known about thermoregulation in all of the major insect groups, offering new insights into physiology, ecology, and evolution. By describing the environmental opportunities and challenges faced by a wide range of insect life, Heinrich attempts to explain their great variety of physiological and behavioral adaptations for survival in their world.

INSECT PATHOLOGY. Y. Tanada & H.K. Kaya. 1993. Academic Press. 666 pp.

Originally intended as an update of Steinhaus' 1949 text, "Principles of Insect Pathology", this book developed into a new text on insect pathology, on the different types of diseases in insects, and on their biological control. Each of the 16 chapters ends with a very comprehensive listing of additional references.

THE BIOLOGY OF MOSQUITOES. Volume 1. DEVELOPMENT, NUTRITION, AND REPRODUCTION. A.N. Clements. 1992. Chapman & Hall. 509 pp. \$99.50

This is the first of two volumes arising from the rewriting of "The Physiology of Mosquitoes", published in 1963, so it is written from the viewpoint of a physiologist. This first volume covers subjects such as genetics, embryology, larval biology, growth & development, metamorphosis, adult physiology, and nutrition of adults and larvae.

## A RECLARIFICATION OF THE MALES OF *ALLOPERLA CONCOLOR* AND *A. NEGLECTA* (PLECOPTERA : CHLOROPERLIDAE), WITH NEW DISTRIBUTION RECORDS FOR BOTH SPECIES<sup>1</sup>

Boris C. Kondratieff,<sup>2</sup> Ralph F. Kirchner<sup>3</sup>

**ABSTRACT:** Historically, there has been confusion concerning the identification of *Alloperla concolor* Ricker and *Alloperla neglecta* Frison. Studies of types and specimens determined by S.W. Hitchcock (United States National Museum of Natural History), T.H. Frison (Illinois Natural History Survey), and material in the author's collections revealed new characters allowing for accurate separation. Figures of the male epiproct of both species showing specific details are presented. New distribution records are also noted.

Adults of the genus *Alloperla* are generally recognized by their delicate habitus and lime green or yellow coloration *in vivo*. Presently, this genus includes 28 Nearctic species. Many of these species are regionally endemic and often are only locally abundant.

Ricker (1935) described *Alloperla concolor* from Horning's Mills, Ontario, Canada based on a male and two females. Frison, also in 1935 described *Alloperla neglecta* from North Carolina near Newfound Gap based on three males. In 1942, Frison synonymized *A. concolor*, after concluding that this species was "specifically identical with *neglecta*." Ricker apparently concurred with this opinion. However, Hitchcock (1968) presented morphological evidence that *Alloperla concolor* was a valid species, based on the shape of the male epiproct. He again in 1974 mentioned that both species were specifically distinct, based on the characters of the epiproct, Surdick (1985) listed *A. concolor* as being north-eastern in distribution and *A. neglecta* restricted to the southern Appalachian Mountains of North Carolina and Tennessee.

After we collected specimens of *A. concolor* from West Virginia in 1990, a review of the taxonomic status of both species was undertaken. Types of both species were examined, but unfortunately the male terminalia of the holotype of *A. concolor* had been lost (G. W. Wiggins, Royal Ontario Museum, personal communication). Additionally,

<sup>1</sup> Received September 15, 1992. Accepted September 16, 1992

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<sup>4</sup> The views of the second author do not purport to reflect the position of the Department of the Army or the Department of Defense.

material determined by Hitchcock (United States National Museum of Natural History) and Frison (Illinois Natural History Survey) were also examined.

## RESULTS AND CONCLUSIONS

Figs. 1-6 illustrate the apex of the epiproct of both species. Contrary to Hitchcock's (1968) observations that the epiproct of *A. neglecta* lacked distal serration, both species have these serrations (Fig. 1). In lateral view the epiproct of *A. concolor* resembles the head of a duck, flattened and forming a distinct serrated edge at the top (Figs. 2A, 3), whereas *A. neglecta* has subparallel margins with the tip rounded (Figs. 2B, 5). In dorsal aspect the epiproct of *A. concolor* is nearly as wide as long, but in *A. neglecta* the epiproct is two times as long as wide (Figs. 1B, 5, 6). Specimens collected from southwestern Virginia, which were thought to be *Alloperla concolor* by Kondratieff and Kirchner (1987), are *A. neglecta*. This represents a northern range extension. The records of *A. concolor* from West Virginia represent a new state record and a southern range extension for this species. Map 1 indicates the recorded distribution of both species, including the records listed below.

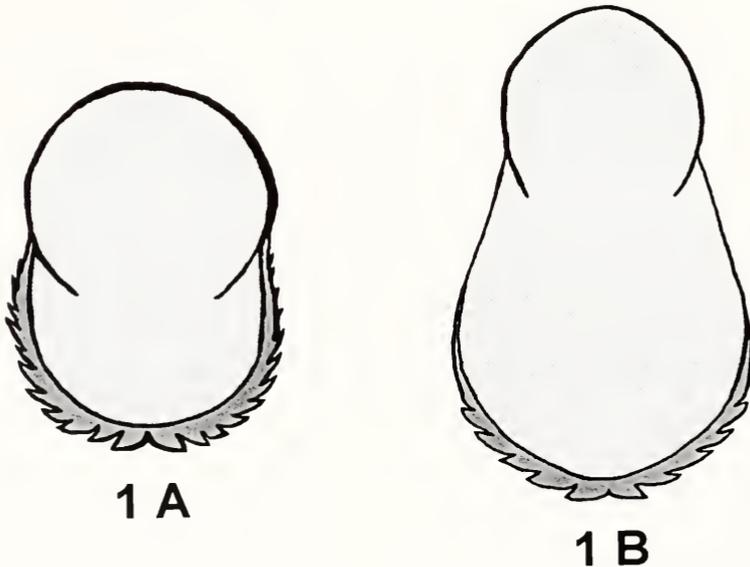


Fig. 1. Apex of epiproct, dorsal view. A., *A. concolor*; B., *A. neglecta*.

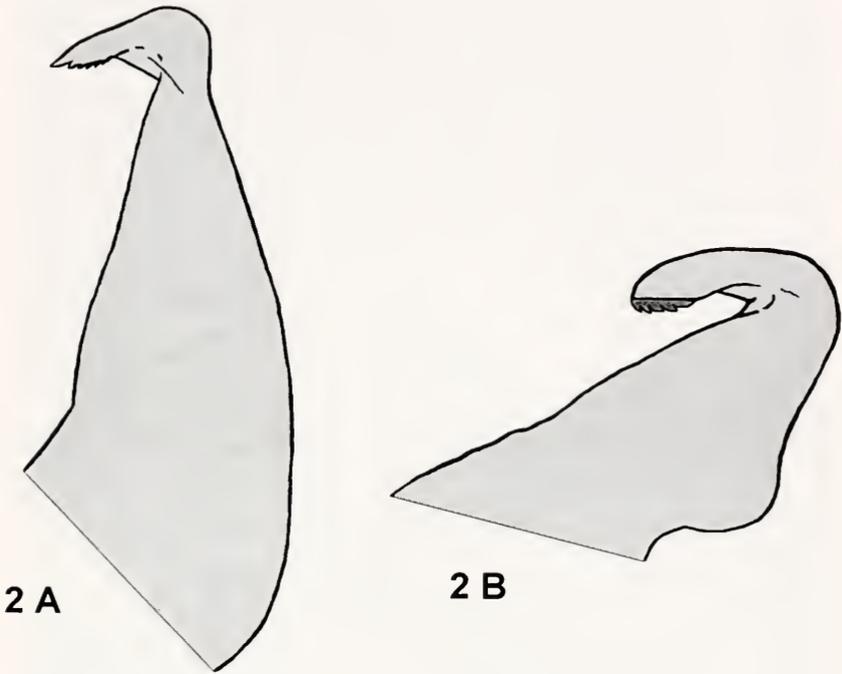
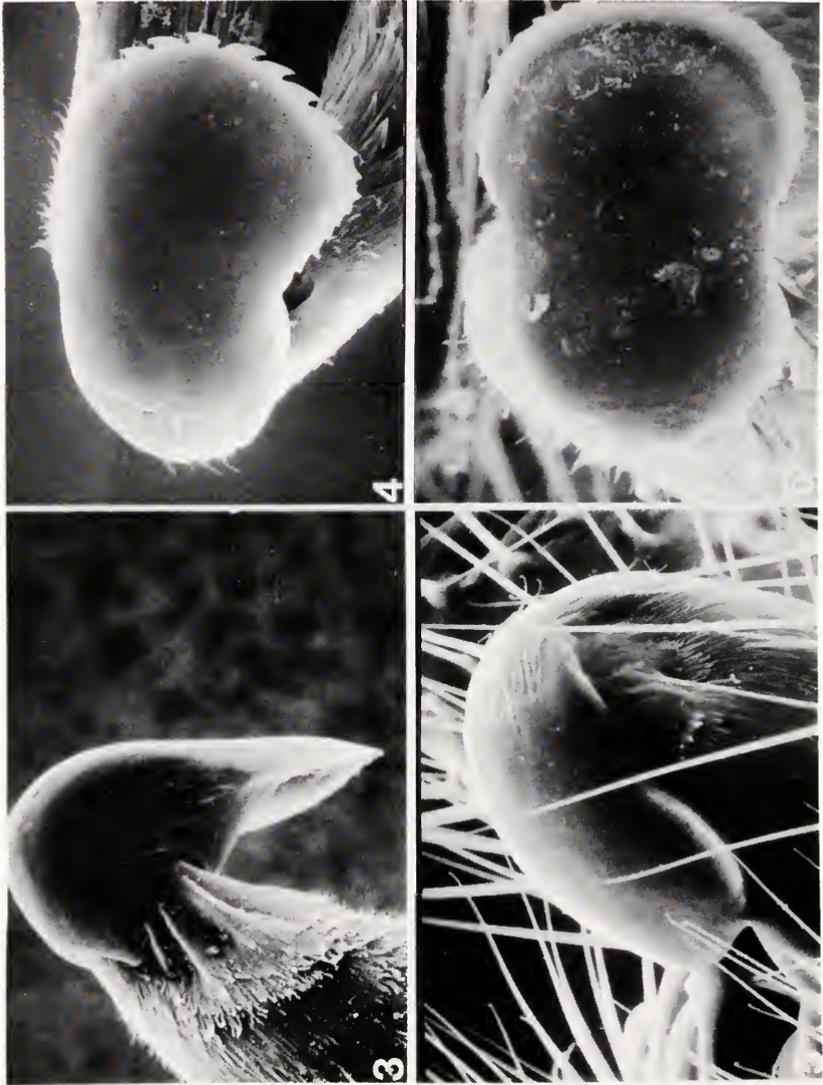


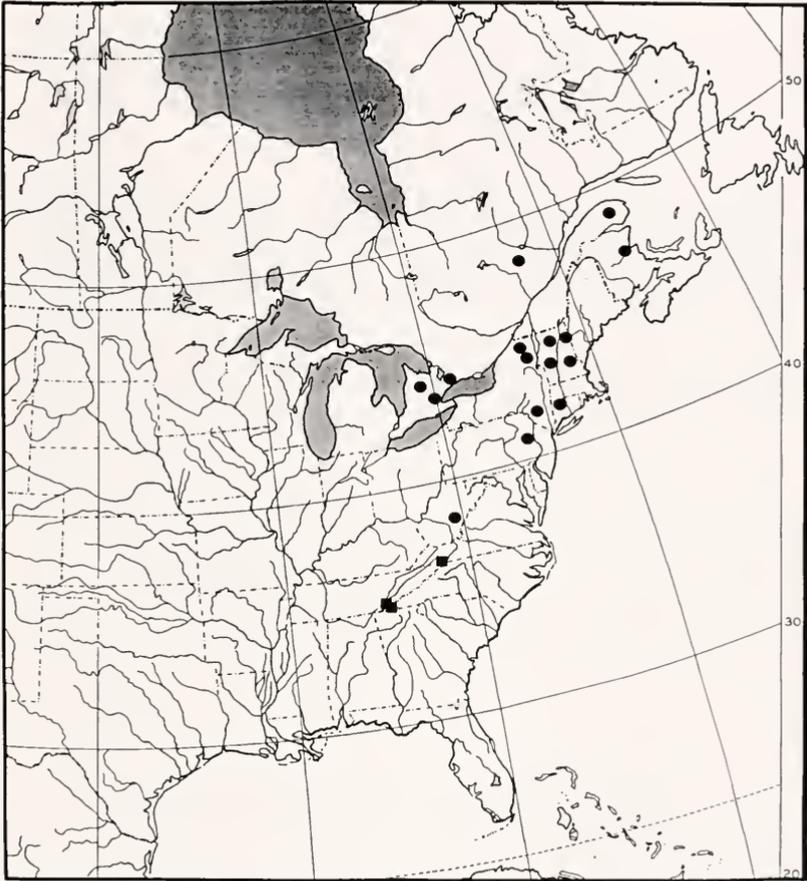
Fig. 2. Epiproct, lateral view. A., *A. concolor*; B., *A. neglecta*.

**Material Examined:** *Alloperla concolor*: Ontario, Canada: Horning's Mills, 1 m pinned (holotype), 2 f pinned. Connecticut: Hartland, 14-VI-1966, SW Hitchcock, 1 m, 1 f. Barkhamstead, 1-VI-1967, SW Hitchcock, 4 m 3 f. New Hampshire: North Woodstock, 13-VI-1964, SW Hitchcock, 3 m, 8 f. West Virginia: Nicholas Co., near Richwood, North Fork Cherry River, 14-V-1990, B. C. Kondratieff, J. L. Welch & R. F. Kirchner, 2 m, 1 f; same but 2-VI-1992, 1 m.

*Alloperla neglecta*: North Carolina: Swain Co., (near) Newfound Gap, 3560 ft, 28-V-1934, TH Frison, 1 m (paratype); Haywood Co., Shining Rock Natl. Rec. Area, East Fork Little Pigeon River, 17-V-1983, BC Kondratieff & RF Kirchner, 18 m; same but 23-V-1990, BC Kondratieff, RF Kirchner & JL Welch, 7 m, 6 f. Tennessee: Sevier Co., (West Prong) Little Pigeon River, (near) Newfound Gap, 14-V-1939, TH Frison & HH Ross, 4 m; Sevier Co., Gatlinburg, 14-VI-1940, TH Frison *et al.*, 1 m 5 f. Virginia: Grayson Co., Lewis Fork, 2-VII-1978, RF Kirchner & GT Voreh, 4 m; same but 18-V-1990, BC Kondratieff, RF Kirchner & JL Welch, 58 m, 35 f.



Figs. 3-6. Epiproct, *A. concolor*; 3. Lateral (680X), 4. apex, dorsal view (810X). *A. neglecta*; 5. lateral (600X), 6. apex, dorsal view (925X).



Map 1. Distribution of *A. concolor* (●), *A. neglecta* (■).

#### ACKNOWLEDGMENTS

We thank Oliver S. Flint, Jr. (United States Museum of Natural History), Glenn B. Wiggins (Royal Ontario Museum), and Kathryn C. McGiffen (Illinois Natural History Survey) for providing critical material for study. Additionally, we appreciate the comments on this project by the participants of the XI International Symposium on Plecoptera (August 17-20), Tomahawk, Wisconsin.

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## BOOKS RECEIVED AND BRIEFLY NOTED

**CATERPILLARS. ECOLOGICAL AND EVOLUTIONARY CONSTRAINTS ON FORAGING.** N.E. Stamp and T.M. Casey, eds. 1993. Chapman & Hall. 587 pp. \$75.00

This volume provides a framework for a unified theory of foraging, taking into account how two or more constraints influence caterpillars. Ranging from behavioral and nutritional ecology to insect physiology and biophysics, it will serve as a valuable resource for courses in insect-plant interactions, insect ecology, population and community ecology, and biological control.

**INSECT LEARNING. ECOLOGICAL AND EVOLUTIONARY PERSPECTIVES.** D.R. Papaj and A.C. Lewis, eds. 1993. Chapman & Hall. 398 pp. \$54.95

This volume challenges the widespread view that insect behavior is rigidly programmed and inflexible. There is increasing recognition that there is plasticity in the behavior of insects that can be explained only by learning. This book surveys a number of studies on the ecology, evolution, and mechanisms of learning in a number of insect species, both social and non-social.

## NEW RECORDS OF SPIDERS (ARANEAE) FROM CAPE COD, MASSACHUSETTS, INCLUDING TWO POSSIBLE EUROPEAN IMMIGRANTS<sup>1</sup>

Robert L. Edwards<sup>2</sup>

**ABSTRACT:** *Trochosa ruricola* (Lycosidae) and *Lepthyphantes tenuis* (Linyphiidae), the former previously known only from Europe and Asia, the latter only from Europe and the west coast of North America, occur and appear to be well established on Cape Cod, Massachusetts, USA. Six southerly distributed species, *Gladicosa pulchra*, *Lycosa acompa*, *Drassylus dixinus*, *Thymoites expulsa*, *Grammonota vitatta*, and *Dictyne pixi* also are commonly found here.

This paper is presented as a reference to use in connection with Kaston's Spiders of Connecticut, revised in 1981, which is still a widely used volume and the only one of its kind. Kaston recorded 478 species of spiders in Connecticut. So far I have recorded 465 species from Cape Cod (Edwards, unpubl.). There are some uncertainties in the list, some are yet to be identified, and a few are almost certainly undescribed. After five years of intensive sampling, additions to the list continue to show up with regularity. The study area is on the southwestern tip of Cape Cod, township of Falmouth, and extends for 15 km north from the village of Woods Hole to Hatchville. The area is dominated by suburban developments, salt and brackish marshes and a few extensive tracts of second growth pine and deciduous woodland.

The widely distributed palearctic species, *Trochosa ruricola* (De Geer) is common here, with mature specimens found throughout the year. In the British Isles this species is regularly taken in the same habitats with *Trochosa terricola* Thorell (Roberts 1985). *Trochosa ruricola* and *T. terricola* are the most common of the four *Trochosa* species found in the British Isles. These two species are common on Cape Cod, occupying somewhat separate habitats. *Trochosa ruricola* and *T. terricola* are most abundant in open areas such as fields, lawns and gardens, marsh environments, and edges of woods. *Trochosa ruricola* is more abundant in wetter areas and closer to the shore.

Both sexes and all instars of *Trochosa ruricola* have a claw on their palp, including the cymbium; *T. terricola* does not. In addition, males of *T. ruricola* have a unique ridge on the fang, nearer the proximal end of the anterior margin. The male palp of *T. terricola* has a loop near the ter-

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minus of the embolus (Brady 1979, fig. 30); whereas that of *ruvicola* is barely curved. The epigyna of *T. ruvicola* and *T. terricola* are very much alike, but the presence or absence of a claw on the female palp suffices to separate the two species.

On Cape Cod, *T. ruvicola* outnumbers *T. terricola* in pitfall traps by a factor of two or more. Adults of *T. ruvicola* have been taken year round, with females carrying egg sacs taken May through July. During the day, females can be found in shallow, often silk-lined burrows in dry, matted grass, old mouse nests, and under boards and rocks. Four sacs of *T. ruvicola* contained from 72 (July) to 171 (May) eggs. For further details on the diagnosis and ecology of *Trochosa terricola* see Brady 1979; for *T. ruvicola*, see Roberts 1985.

*Lepthyphantes tenuis* (Blackwall) (Linyphiidae) is commonly taken in tall grass in wet boggy areas and around pools. It has been found in association with small ( $\pm 10$  cm), horizontal sheet-like webs, usually well above ground level. Mature specimens have been taken July through October. Immatures could easily be mistaken for those of *Lepthyphantes zebra* (Emerton). The genitalia of the adults are well illustrated in Roberts 1985. This species also occurs on the west coast of North America. It has been recorded from the state of Washington by Crawford 1988, and from British Columbia, Canada by West *et al.* 1984.

There is a distinct southern element in the other species newly found on Cape Cod. The following six species illustrate this. B. J. Kaston's treatise (op. cit.) included all known New England species, but did not include these. All six species are well established on Cape Cod.

*Gladicosa pulchra* (Keyserling) (Lycosidae) is a handsome, strikingly marked lycosid found on tree trunks, especially the rough barked trunk of pitch pine (*Pinus rigida*). It is also found in holes and other protective shelters on the trunks of more smoothly barked trees, such as the scarlet oak. This lycosid matures late in the summer and descends to the ground in the fall where it is taken in pitfall traps during a brief period in October and early November. Young spiders appear on tree trunks in the spring, usually before the end of April. *Gladicosa pulchra* has been taken as far north as Long Island, but is generally found south of the Mason-Dixon line (Brady 1986).

*Lycosa acompa* Chamberlin is common on Cape Cod in open grassland, deciduous forest litter and old gravel pits where it is taken in pitfall traps. The few records of *L. acompa* in the literature suggest that it is typically a southern species. Young *et al.* 1989, note that it is a common species in Washington County, Mississippi.

*Drassyllus dixinus* Chamberlin (Gnaphosidae) is taken from June to August as adults in pitfall traps in old fields. The northernmost pub-

lished record is for Patrole, Maryland, (Platnick and Shadab, 1982).

*Tymoites expulsa* Gertsch and Mulaik (Theridiidae) is found on dune grass in the salt marsh near the ocean. Adults have been found in the spring and fall. When Levi (1957) revised the genus, the northernmost record was from North Carolina.

*Grammonota vitatta* Barrows (Linyphiidae) has been regularly collected as immatures and adults along the edges of brackish and freshwater marshes during the colder months of the year. Previously, the northernmost record was the type locality, Cape May, New Jersey, (Bishop *et al.* 1932).

*Dictyna pixi* Chamberlin and Gertsch (Dictynidae) adults have been taken in June by sweeping old fields dominated by such forbs as false indigo and sweet fern. Immatures and subadults have been taken in pit-fall traps in October. The type locality is Washington Crossing, New Jersey; and it has been recorded from North Carolina, Arkansas, and Michigan (Chamberlin and Gertsch, 1958).

The erigonines constitute about 20% of the total spider fauna in the study area (Edwards, unpubl.). One species Kaston considered ubiquitous and extremely common in Connecticut, *Ceraticelus fissiceps* (O. P.-Cambridge), has yet to be taken in the study area. On Cape Cod, apparently *C. fissiceps* has been replaced by *C. alticeps* (Fox). Sixteen species Kaston did not find in Connecticut but from Massachusetts or farther north have been taken on Cape Cod. And among the erigonines he recorded from Long Island and/or further south but not Connecticut or elsewhere in New England are *Grammonota maculata* Banks, *G. pallipes* Banks and *Ceraticelus laticeps* (Emerton). All are found on Cape Cod and are common. These data also suggest that there may be a tendency for more southerly distributed species to extend their range northward along the coast.

With regard to the possible immigrants from Europe, it is a matter of record that this region has been studied and collected by individuals interested in spiders for over 100 years. Earlier investigators might have missed *Lepthyphantes tenuis*. It is a small spider and could easily have been misidentified as one of the other two common *Lepthyphantes* species. The relatively large size and abundance today of *Trochosa ruricola*, as well as the lack of records elsewhere in New England, suggests a more recent arrival. Since the 1880's, Woods Hole, Cape Cod, has been an area of considerable activity, principally focused on the marine environment. The several institutions are often visited by scientists and research vessels from various parts of the world, especially from Europe, thus providing many opportunities for stowaways, including spiders.

## ACKNOWLEDGMENTS

This study was funded in part by a grant from the natural Heritage & Endangered Species Program of the State of Massachusetts.

Allen Brady (Hope College) kindly provided me with the initial identifications of *Trochosa ruricola* and *Lycosa acompa*. He was most helpful in discussions of lycosid species, their diagnosis and ecology and with comments on this manuscript. Daniel Jennings (Univ. of Maine) thoroughly critiqued the final draft with his usual care and thoughtfulness. Charles Dondale and James Redner (BRC, Canada) assisted with helpful comments, and information on the distribution of *Lepthyphantes tenuis*. I am grateful to Vincent Roth, Portal, Arizona, who provided my first assist in coping with a number of taxonomic problems concerning lycosids, and to Jonathan Coddington (USNM) for his comments and suggestions on an early draft of the paper.

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## FIRST KARYOTYPIC DATA ON A CUPEDID BEETLE (COLEOPTERA: ARCHOSTEMATA) SHOWING ACHIASMATIC MEIOSIS<sup>1</sup>

J. Galián<sup>2,3</sup>, J.F. Lawrence<sup>2</sup>

**ABSTRACT:** The chromosomes of a species of Cupedidae, *Distocupes varians* (Lea) were studied for the first time. The male diploid chromosome number of the species is  $2n = 19$  and the male sex chromosome system is of the XO type. The presence of 9 pairs of autosomes agrees with the hypothesis that suggests that this number is the ancestral condition for the whole Order Coleoptera. On the other hand the analysis of the spermatogenesis reveals an achiasmatic meiosis pattern. The occurrence of this kind of meiosis in Cupedidae (never recorded in Polyphaga, but present in some groups of Adephaga) is in agreement with hypotheses that relate Archostemata with Adephaga.

The suborder Archostemata is a primitive group of beetles which includes three families, Cupedidae, Micromalthidae and Ommatidae (Lawrence *et al.* 1987). The only species of Micromalthidae so far karyotypically studied is *Micromalthus debilis* LeConte (Scott, 1936, 1941) which has haplodiploidy, males with  $n = 10$  and females with  $2n = 20$ . The family Cupedidae has 25 species worldwide and is represented in Australia by the monotypic genus *Distocupes* and four species of *Adinolepis* (Neboiss, 1984). To date nothing has been published on the karyotypes of these species.

The relationships between Archostemata and the other three suborders of Coleoptera are still in dispute. Crowson (1955, 1960) considers that there are three ancestral stocks: Archostemata, Adephaga and Myxophaga plus Polyphaga. Lawrence and Newton (1982) and Kukalová-Peck and Lawrence (in press) suggest that Archostemata, Myxophaga and Adephaga may form a monophyletic group based on wing venation and folding.

In the present paper information on the chromosomes of the species *Distocupes varians* (Lea) is reported and the relationships of its karyotype with those of the other suborders is discussed.

### MATERIALS AND METHODS

Five individuals of *Distocupes varians* were collected in December

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1990 from a permanent colony living in a garden in O'Connor, Canberra, Australia. The beetles are deposited in the Australian National Insect Collection, Canberra. Male specimens were injected with a 0.04 M sodium acetate plus 0.05% colchicine solution for ten minutes and then anesthetized. The testes were dissected out, fixed in 3:1 ethanol:acetic acid solution, and then squashed in a drop of 1% lacto-propionic orcein.

## RESULTS

The male diploid chromosome number of *Distocupes varians* is  $2n = 19$  with nine pairs of autosomes plus X. The karyogram made from metaphase II cells (Fig. 1) shows 9 pairs of metacentric and submetacentric chromosomes gradually decreasing in size. The X chromosome seems to be a metacentric element about the size of the second pair.

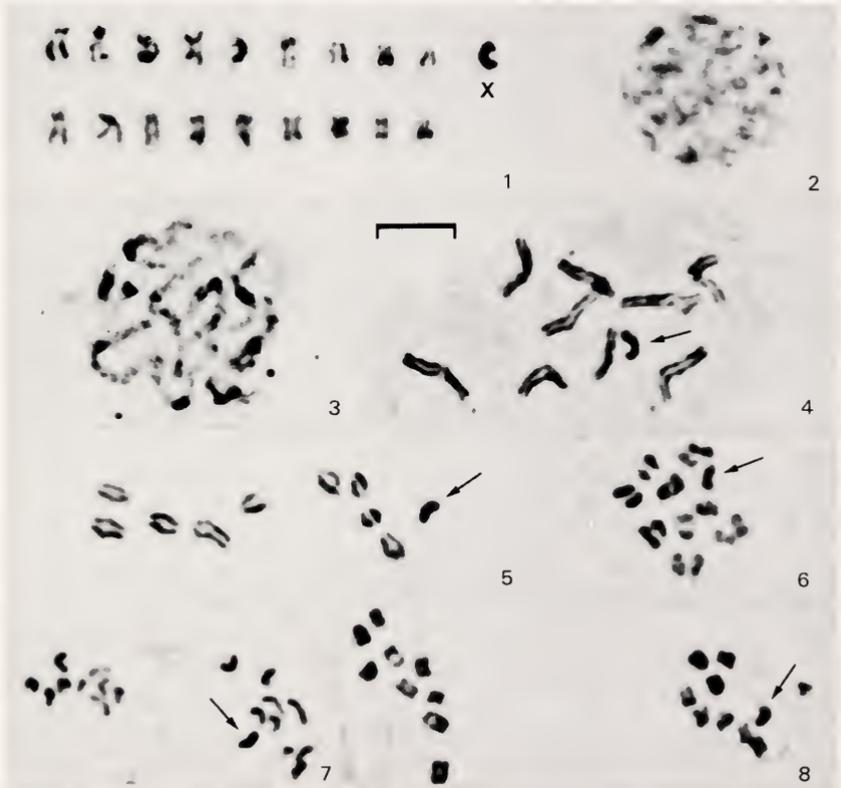
In meiosis during early prophase I the homologues condense (Fig. 2, 3) and at zygotene the central regions of the bivalents, probably of heterochromatic nature, are heavily stained while the rest is weakly stained (Fig. 3). During pachytene (Fig. 4) to metaphase I (Fig. 5) the homologues remain in parallel alignment without showing any trace of chiasmata. Homologous centromeres appear more deeply separated in some bivalents (Fig. 5). The onset of anaphase I is denoted by a parallel separation of homologues, which is delayed in the telomeric regions of some bivalents (Fig. 6). At prophase II chromosomes appear as single structures (Fig. 7). The two chromatids are seen again at metaphase II, but they remain parallel instead of the typical cruciform figure due to chromatid repulsion (Fig. 8). The X chromosome condenses precociously (Fig. 4) and moves undivided to one pole at anaphase I, and divides its chromatids during anaphase II.

During specimens preparation, the testes of this species were found to be of the normal follicular type, in which a number of small sperm tubes are attached individually to the vas deferens (Snodgrass, 1935), rather than the tubular type (Jeannel, 1941), which consists of a single, coiled tube. This feature is of phylogenetic importance (see below).

## DISCUSSION

Male meiosis of *Distocupes varians* resembles the achiasmatic pattern that was previously described in Adephaga (Carabidae: Bembidiini, Pogonini and perhaps Harpalini) by Serrano (1981a). Since achiasmatic meiosis is considered to have evolved secondarily (John, 1990), this character represents a specialized condition within the Cupedidae, an

unexpected result in view of the supposed archaic nature of the group. However, it may also be considered as a latent tendency of the first coleopterans that may appear in particular groups or species. Given the lack of reports of achiasmatic meiosis in the suborder Polyphaga, in spite of the large number of species studied (2000 in Smith and Virkki, 1978, and many more since then), the occurrence of this kind of meiosis is in agreement with the hypotheses that relate the suborder Archostemata with the suborder Adephaga (Lawrence and Newton, 1982; Kukulová-Peck and Lawrence, in press).



Chromosomes of *Distocupes varians*. Figure 1. Karyogram made from two metaphase II cells with  $n = 9 + X$  (above) and  $n = 9$  (below). Figure 2. Early zygotene. Figure 3. Zygotene. Figure 4. Postpachytene stage. Note the precocious condensation of the X chromosome. Figure 5. Metaphase I. Figure 6. Anaphase I. Figure 7. Prophase II with  $n = 9$  (left) and  $n = 9 + X$  (right). Figure 8. Metaphase II. Arrows show the X chromosome. The bar equals 5  $\mu\text{m}$ .

On the other hand, the chromosome number of *Distocupes varians*  $2n = 19$ , is very close to that found in other primitive coleopteran groups (Table 1), thus supporting the hypothesis that the  $2n = 20$  karyotype is ancestral for the Order Coleoptera, and that higher numbers developed thereafter in the adepghan and polyphagan stocks, with disappearance of the ancestral karyotype in modern Adepgha.

If the lack of the typical polyphagan Xyp sex-chromosome mechanism in *D. varians* is corroborated in other species of Archostemata, it will indicate that this system is characteristic of the suborder Polyphaga but is not found in the other suborders of Coleoptera (Table 1). Thus the Xyp system evolved when Polyphaga became separated from the other suborders and represents an apomorphy for the suborder.

Finally, the occurrence of follicular testes in *D. varians*, as well as in two other Cupedidae, *Priacma serrata* LeConte and *Prolixocupes lobiceps*

Table 1. Chromosome numbers in Coleoptera

Suborder	Species	References(*)
ARCHOSTEMATA		
CUPEDIDAE	<i>Distocupes varians</i> $n (\sigma) = 9 + X$ $2n (\sigma) = 19$ Male achiasmatic meiosis	1
MICROMALTHIDAE	<i>Micromalthus debilis</i> $n (\sigma) = 10$ $2n (\varphi) = 20$ Sex-chromosome mechanism by haplo-diploidy (arrhenotoky)	2
MYXOPHAGA	<i>Ytu zeus</i> $n (\sigma) = 9 + XY$ $2n (\sigma) = 20$	3
ADEPHAGA	Ancestral karyotype $n (\sigma) = 18 + X$ $2n (\sigma) = 37$	4
POLYPHAGA	Ancestral karyotype $n (\sigma) = 9 + Xyp$ (parachute) $2n (\sigma) = 20$	5

(\*) 1, Present study; 2, Scott (1936); 3, Mesa and Fontanetti (1985); 4, Serrano (1981b); 5, Smith and Virkki (1978).

(LeConte) (K.W. Cooper, pers. comm.) conflicts with the reports of tubular testes in *Prolixocupes latreillei* (Solier) and also in *Tetraphalerus wagneri* Waterhouse (family Ommatidae) (Vidal-Sarmiento, 1969). It appears that tubular and follicular testes, which characterize Adephaga and Polyphaga, respectively, both occur within the suborder Archostemata. If this is the case, it suggests that modern Archostemata are not monophyletic or that this character has undergone reversal. However, more data is needed to confirm the presence of tubular testes in either Ommatidae or Cupedidae.

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## AN ECOTONAL STUDY OF CARRION BEETLES (COLEOPTERA: SILPHIDAE) IN THE GREAT SWAMP NATIONAL WILDLIFE REFUGE, NEW JERSEY<sup>1</sup>

Paul P. Shubeck<sup>2</sup>

**ABSTRACT:** Carrion beetles were collected in chicken breast baited traps situated at 15 meter intervals, along a 60 m base line intersecting a woodland and field in Great Swamp National Wildlife Refuge, NJ. There was no evidence, for any species, of a declining linear gradient in numbers of carrion beetles from their preferred to their secondary habitat. An abrupt edge effect was noted for one species, *Nicrophorus orbicollis*, which was taken in the woodland and at the woodland/field interface, but not in the field proper. On the other hand, *Necrophila americana*, *Oiceoptoma noveboracense*, and *Oiceoptema inaequale* were each approximately equally abundant on either side of the actual interface of their preferred and secondary habitat. Furthermore, this junction zone (ecotone) may end between 15 m and 30 m into the field for *Necrophila americana* since it was found to be significantly more abundant at 30 m into the field (its preferred habitat).

Two previous studies have shown that carrion beetles (Silphidae) manifest slight to strong preferences for particular habitats. Anderson (1982) observed species preferences, in Canada, for coniferous forests, deciduous forests, fields and marshes. Shubeck (1983) observed species preferences when trapping carrion beetles in woodland, field, and marsh habitats in NJ. These findings are especially interesting in view of an earlier study which showed there is much random flight when carrion beetles search for carrion (Shubeck, 1968). In the New Jersey study it had been found that eight species of carrion beetles had slight or strong preferences for woodland or field habitats. Only 5% of the individuals were taken in a marsh.

Neither of the above habitat studies discussed ecotonal aspects of boundaries between habitats. According to Odum (1971), "An ecotone is a transition between two or more diverse communities as, for example, between forest and grassland . . ." He further stated, "It is a junction zone or tension belt which may have considerable linear extent but is narrower than the adjoining community areas themselves."

In this current study an attempt was made to determine what influence, if any, the ecotone might have on carrion beetle populations in terms of numbers. Specific objectives included an attempt to determine if there might be (1) a declining linear gradient in numbers of car-

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rion beetles, along a base line, from the preferred habitat to the secondary habitat, and (2) an abrupt drop in numbers at the interface between the preferred habitat and the secondary habitat. In other words, does the change occur at the interface itself or at 15 or 30 m inside of either habitat.

The study was conducted in the Great Swamp National Wildlife Refuge, Basking Ridge, NJ. Collections were made during June, July and August 1984, and April and May 1985.

## MATERIALS AND METHODS

Carrion beetles were trapped in five No. 10 food cans (3.78 l), each of which was concealed in a wooden box having 1.27 cm wire mesh at the top and a rain cover 5 cm over the opening. These have been described elsewhere (Shubeck, 1976). A base line of 60 meters length was established which intersected the boundary at which a deciduous woodland and an old field were adjacent to each other. These habitats have been described in a previous paper (Shubeck, 1983).

The five traps were situated along the base line so that one trap was 30 m into the woodland, a second was 15 m into the woods, a third was at the edge of the woods where the field began, a fourth 15 m into the field, and a fifth was 30 m into the field. One chicken breast was placed in each trap a week before the first collection, a second added when collections began, and each week thereafter the older in each trap was replaced with a fresh chicken breast.

Traps were examined each week, carrion beetles were removed, identified, and the data recorded. There was a total of 21 weekly collections — 12 during June, July, and August in 1984, and 9 during April and May in 1985. A previous study (Shubeck *et al.*, 1981), which ran from April through November, had shown that over 98% of silphids collected in Great Swamp were taken from early April through August.

## RESULTS AND DISCUSSION

A total of 1,173 carrion beetles (Silphidae) was collected during this study (Table 1). In rank order of abundance they were: 1. *Necrophila americana* (525); 2. *Oiceoptoma noveboracense* (349); 3. *Oiceoptoma inaequale* (206); 4. *Nicrophorus orbicollis* (66); 5. *Nicrophorus tomentosus* (12); 6. *Nicrophorus pustulatus* (6); 7. *Necrodes surinamensis* (5); 8. *Nicrophorus marginatus* (4). In view of the small numbers for the last 4 species this analysis and discussion will be limited to the four most abundant species whose larger numbers may be treated statistically.

Table 1 shows total numbers, for 1984 and 1985, of species trapped

along the base line intersecting the woodland and field interface. The data, for each species, show how many beetles were trapped 30 m into the woodland habitat, 15 m into the woodland, at the edge of woodland/field, 15 m into the field, and 30 m into the field.

Table 1 shows that no species exhibits a linear gradient in numbers collected from their preferred to their secondary habitat. Even the 4 species found in low numbers seem to bear this out (Table 1).

Only for *Nicrophorus orbicollis* was an abrupt edge effect noted. This species was trapped in approximately equal numbers at the edge of the woodland, and at 15, as well as 30 m into the wooded area. No individual of this species was taken within the field proper. These data seem to indicate that for *N. orbicollis*, the interface of its woodland habitat with a field can be a very real "barrier," or edge, beyond which this species seldom ventures in search for food. Although in a previous habitat study (Shubeck, 1983) 10 of a total of 73 individuals (13.7%) were taken in the field, the great majority (86.3%) was collected in the forest—their preferred habitat.

On the other hand, the 3 most abundant species behaved very differently. *Necrophila americana*, *Oiceoptoma noveboracense*, and *Oiceoptoma inaequale* were captured in somewhat similar numbers along the base line (with the possible exception of *N. americana* since 30% of its numbers were taken 30 m into the field). It seems clear for these species there is a definite ecotone, or zone, which extends from within one habitat, across the edge into its adjacent habitat. Within this zone it appears these beetles were approximately equally abundant on either side of the actual interface of the preferred and the secondary habitat. In order to support this observation the chi square statistic was used to determine if the numbers of individuals from each of these 3 species, taken on either side of the interface (i.e. forest vs. field) were significantly different. The total number of individuals collected at 15 m and at 30 m into the forest was compared with the total number collected at 15 m and 30 m into the field for each of these species respectively. It was found there was no significant difference in the total number taken on either side of the actual interface (but within the 60 m wide margin tested) in the case of 2 species; *Oiceoptoma noveboracense* ( $X^2 = 1.39$ ,  $df = 1$ ,  $P > .2$ ) Table 1, *Oiceoptoma inaequale* ( $X^2 = 1.16$ ,  $df = 1$ ,  $P > .2$ ) Table 1. Chi square analysis of *Necrophila americana*, on the other hand, indicated there is a significant difference in the numbers on either side of the interface ( $X^2 = 9.43$ ,  $df = 1$ ,  $P > .01$ ) Table 1. However, the data in Table 1 may indicate the junction zone, or tension belt (Odum, 1971), may end between 15 and 30 m into the field for this species, since it has been noted that *N. americana* manifested somewhat larger numbers 30 m into the

field. Chi square treatment of the numbers when all five collections for this species are included indicate a significant difference in the numbers ( $X^2 = 34.26$ ,  $df = 4$ ,  $P > 0.001$ ). On the other hand, when the latter collection numbers (30 m into the field) are excluded, and the remaining four collections are subjected to chi square analysis, no significant difference in collection numbers is noted ( $X^2 = 0.945$ ,  $df = 3$ ,  $P > .8$ ). The very obvious difference is the large number of beetles taken 30 m into the field. I believe this can be accepted as evidence that this species may have been clear of the ecotone at that point, since the field is its preferred habitat (Shubeck, 1983), and larger numbers of individuals would be expected to be there.

This study appears to indicate that there is a zone (ecotone), at least 15-30 m wide on either side of the field/woodland interface, within which there are no significant differences in the numbers collected (on either side of the interface) of *Oiceoptoma noveboracense*, *Oiceoptoma inaequale*, and *Necrophila americana*. *Nicrophorus orbicollis*, however, seemed to manifest an abrupt edge effect in that its numbers were taken in the woods and at the interface but not in the field. It appears for this species that the habitat preference for the woods is so strong that the concept of "ecotone" may be meaningless.

Table 1. Totals of carrion beetles collected (1984 & 1985) at 15 meter intervals along a base line which intersected a woodland and an adjacent field in Great Swamp National Wildlife Refuge, N.J.

SILPHIDAE	WOODS/ FIELD					TOTAL
	WOODS 30 m	WOODS 15 m	FIELD 0 m	FIELD 15 m	FIELD 30 m	
<i>Necrophila americana</i>	99	86	91	91	158	(525)
<i>Oiceoptoma noveboracense</i>	63	76	90	47	73	(349)
<i>Oiceoptoma inaequale</i>	58	21	61	24	42	(206)
<i>Nicrophorus orbicollis</i>	24	20	22	—	—	(66)
<i>Nicrophorus tomentosus</i>	—	2	5	1	4	(12)
<i>Nicrophorus pustulatus</i>	1	—	1	2	2	(6)
<i>Necrodes surinamensis</i>	—	1	4	—	—	(5)
<i>Nicrophorus marginatus</i>	—	2	—	—	2	(4)

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# TECHNIQUES FOR OBTAINING ADULT-ASSOCIATED IMMATURE STAGES OF PREDACIOUS TACHYDROMIINE FLIES (DIPTERA: EMPIDOIDEA), WITH IMPLICATIONS FOR REARING AND BIOCONTROL<sup>1</sup>

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**ABSTRACT:** Gravid females of four species of tachydromiine flies, namely *Mega-grapha exquisita*, *Platypalpus holosericus*, *P. aequalis*, and *P. melleus* were induced to oviposit by decapitation. Eggs were placed on a saline nutrient agar medium prior to hatching. Ovaries containing fully mature eggs were additionally dissected from females of *P. holosericus*. These eggs were transferred *in situ* in each ovary to agar plates, where they embryonated and hatched, demonstrating parthenogenesis in this species. First instar larvae of all four species were held in agar medium for several weeks, and were presented with various prey organisms and other food materials. Only those that fed on *Drosophila melanogaster* larvae, or on each other, developed to later larval instars. In one instance, a fully mature larva of *M. exquisita* pupated after diapausing, and developed as far as the teneral adult stage. Implications of the results of this study are discussed in terms of the potential for obtaining taxonomic and phylogenetic information on previously unknown immature stages, and for rearing Tachydromiinae as biological control agents of agricultural pests.

The beneficial nature of empidoid flies as predators of insect pests has long been recognized (reviewed for example by Smith, 1969, p. 18), with the potential economic importance of one subfamily, the Tachydromiinae, recently attracting considerable interest<sup>3</sup>. For example, adult tachydromiines have been identified as important regulators of small Diptera, Thysanoptera and aphid pests in cereal and oil seed crops (Berest, 1987; Brunel *et al.*, 1989; Chvála, 1975; Crook and Sunderland, 1984; Jones, 1965, 1969, 1976a, 1976b; Potts and Vickerman, 1974; Stark, 1990; Stark and Wetzel, 1987; Sunderland *et al.*, 1985), leaf-mining flies in greenhouse and field situations (Kovalev, 1966; Rotheray, 1989; Whitfield, 1925), as well as psyllids and phytophagous mites in orchards (Chvála, 1975; Fleschner and Ricker, 1953).

Despite this interest, effective use of tachydromiines as biological control agents of agricultural pests has been severely hindered by a lack

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<sup>3</sup> Classification of the Tachydromiinae within either the Empididae or Hybotidae is discussed in Cumming and Cooper (1992).

of information about immature stages and life histories of empidoid flies in general. For example, no empidid species has ever been successfully reared through all life stages in the laboratory. Even the informative outline of the life cycle of *Empis tessellata* Fabricius, described by Hobby and Smith (1961), was pieced together from collections of mature larvae taken from leaf litter (reared to adults) and from eggs obtained from mated females (hatched to first instar larvae). The entire literature on the structure and habits of immature stages of the Tachydromiinae, essentially amounts to brief descriptions of the larva of a *Platypalpus* species by Beling (1888), the larva and pupa of a *Drapetis* species by Malloch (1917), and the larva of *Crossopalpus curvipes* (Meigen) by Smith (1989). Smith (1989) additionally lists rearing records of adults of *Crossopalpus* sp. from dung, *C. nigrifellus* (Zetterstedt) from fungi, *Elaphropeza ephippiata* (Fallén) from woodland soil, and *Tachypeza nubila* (Meigen) from fungi and under bark, indicating that the immatures of Tachydromiinae appear to occupy various terrestrial habitats.

The primary purpose of this paper is to add to our knowledge of the Tachydromiinae by reporting on techniques used to obtain adult-associated immature stages and on preliminary investigations into the establishment of a rearing method for members of the subfamily. In addition, a procedure is described for determining female reproductive mode.

## PROCEDURE AND RESULTS

**Rearing Method.** Adult females of *Megagrapha exquisita* (Malloch), *Platypalpus holosericus* Melander, *P. aequalis* Loew, and *P. melleus* Melander were netted locally during the summer months and placed individually in plastic tubes containing moistened tissue paper, for transport back to the laboratory<sup>4</sup>. Gravid females with fully mature eggs were induced to oviposit by decapitation, following the method described by Linley (1965) for the ceratopogonid fly species *Leptoconops bequaerti* (Kieffer). This was most easily achieved after slightly anaesthetizing a specimen with CO<sub>2</sub> and transferring it to moistened filter paper before removing the head with fine dissecting scissors. Decapitated females generally started ovipositing immediately and sometimes continued to lay eggs for up to an hour after oviposition commenced.

Following oviposition, eggs from each female were transferred with a fine brush to the surface of a saline nutrient agar medium that had been allowed to set to a depth of approximately 4 mm in a 50 X 9 mm seal-tight

<sup>4</sup> Voucher specimens are deposited in the Canadian National Collection of Insects and Arachnids (CNC).

petri dish (Fig. 1). The saline nutrient agar medium used to rear specimens of Tachydromiinae was originally developed for rearing predacious larvae of the ceratopogonid fly species *Culicoides melleus* (Coquillett) and is fully described by Linley (1985). The advantages discussed by Kettle *et al.* (1975) in using agar to rear *Culcoides* larvae, and the necessity demonstrated by Linley (1985) of adding supplementary vitamins for rearing predacious larvae such as *Culicoides* (see below under "Food Requirements"), appear generally applicable to the rearing procedure employed here. Seal-tight petri dishes, which are designed with tight-fitting lids (Fig. 1), are a necessary modification, essential in containing the small highly motile tachydromiine larvae in the agar medium.

The agar-filled petri dishes were maintained in the dark, in an environmental chamber at a constant 20° C. Darkening of the chorion of the egg on the first day denoted initiation of embryogenesis in all four species, and indicated that the eggs were either fertilized during oviposition, or were developing parthenogenetically. In all four species, larval cephalic structures and segmentation usually became visible through the semi-transparent chorion towards the end of the first week after oviposition (Fig. 2), with the eggs generally hatching by the end of the second week. In some eggs of *P. holosericus*, hatching was delayed up to at least four weeks after oviposition without noticeable developmental effects, by keeping the eggs at 11° C.

First instar larvae of all four species appeared to burrow through the agar medium easily (Figs. 3-4), and could be kept alive in the tightly sealed petri dishes with little maintenance for several weeks. Larvae seemed unaffected by fungus and bacteria, even when some older cultures became heavily contaminated with these microorganisms, and often appeared somewhat attracted to these contaminants (Fig. 6). Those that fed (see below under "Food Requirements") appeared to progress through three larval instars, as described for the distantly related empidoid, *Liancalus virens* Scopoli (Vaillant, 1948). The larval growth rate for all species varied considerably as experimentation to determine food requirements progressed, although in one batch of eggs of *M. exquisita*, final instar larvae (Fig. 5) developed relatively rapidly, within approximately five weeks from the time of hatching. Final instar larvae of all species that were still alive towards the end of the summer were cooled down and allowed to diapause at 1° C for three months. Most larvae survived the diapause period, and in one instance, a single larva of *M. exquisita* pupated (without forming a cocoon) in the agar medium approximately five weeks after the temperature was increased to 15° C. Within three weeks the pupa developed to the teneral adult stage (Fig. 8).

but died before eclosion occurred.

**Food Requirements.** Attempts were made to determine the food requirements of the larvae, since the diet of larval tachydromiines is unknown. Although never directly established, tachydromiine larvae have been assumed to be predacious (Chvála and Kovalev, 1989), based on limited observations of other empidoid species (reviewed by Smith, 1969, p. 6). First instar larvae of all four tachydromiine species were offered various small soil organisms, such as nematodes belonging to the genus *Panagrellus*, all stages of the oribatid mite species *Oppia nitens* C.L. Koch, and an inoculum of protozoans, but feeding on these microorganisms was not observed. In addition, early as well as later instar larvae did not appear to scavenge on dead organisms, or on moistened pieces of highly proteinaceous dried puppy meal, which were also added to some cultures.

Finally, small larvae of the pomace fly, *Drosophila melanogaster* Meigen, were presented as prey. Larvae of all four species of tachydromiines readily fed on the *Drosophila* larvae within the agar medium (Fig. 7). The smaller first instar tachydromiine larvae however, were only able to overpower the smallest (first instar) *Drosophila* larvae. Later tachydromiine instars fed on *Drosophila* larvae of various sizes, and occasionally these older predacious larvae also cannibalized smaller sibling larvae in the same culture. Since *Drosophila* larvae could survive in the agar medium for one or two days before starving, periodic replacement of prey larvae was required to sustain the tachydromiine larval cultures.

**Reproductive Mode.** Females of *P. holosericus* are suspected of reproducing parthenogenetically (as has been suggested by Tuomikoski, 1935 and Chvála, 1975 for some Palearctic species of *Platypalpus*), since males of this common Nearctic species are not represented in the main North American empidoid collections, and have never been collected locally. To determine the reproductive mode in *P. holosericus*, ovaries were dissected from four gravid females and transferred individually to eight agar plates for observation. During dissection each ovary, containing an average of approximately 30 fully mature eggs, was surgically removed from the lateral oviduct to prevent any possibility of accidental fertilization. Despite heavy fungal contamination of the ovariole tissue, the occurrence of parthenogenesis in *P. holosericus* was convincingly demonstrated when most of the eggs in all eight of the dissected ovaries hatched.

## DISCUSSION

The results obtained to date provide a first step in the development of a general procedure for rearing tachydromiine flies, which will aid in the accumulation of valuable taxonomic and life history data. Most impor-



Figs. 1-8. 1, Seal-tight petri dish filled with saline nutrient agar medium for rearing Tachydromiinae (0.6 X); 2, eggs of *Platypalpus holosericus* Melander containing developing larvae (33 X); 3, first instar larvae of *P. holosericus* in agar medium (18 X); 4, first instar larva of *P. holosericus* in agar medium (36 X); 5, late instar larva of *Megagrapha exqu Coast* (Malloch) on top of agar medium (12 X); 6, first instar larvae of *P. holosericus* amongst fungal contamination of agar medium (27 X); 7, late instar larva of *P. holosericus* feeding on early instar larva of *Drosophila melanogaster* Meigen (18 X); 8, lateral view of pupa of *M. exqu Coast* containing teneral adult (14 X).

tantly, induction of oviposition behavior by decapitation, in conjunction with maintenance of the eggs in agar-filled petri dishes to avoid desiccation, appears to be a useful technique for obtaining adult-associated first instar larvae (and possibly later stages) of Tachydromiinae.<sup>5</sup> The technique may work with, and should be attempted on, other poorly known Empidoidea (e.g. Atelestinae, Brachystomatinae, Ceratomerinae, Microphorinae, and *Nemidina*) and taxonomically problematic Cyclorrhapha (e.g. Opetidae), for which immature stages are not known (see for example Sinclair, 1992). Even if the first instar larvae obtained are not reared successfully to a further stage, the taxonomic information gained from having properly associated immatures of any stage for such groups, would be valuable for testing previously proposed classifications and formulating new phylogenetic hypotheses.

Dissection of ovaries from parthenogenetic species, such as *P. holosericus*, can also yield large numbers of first instar larvae. Of perhaps greater significance however, is the use of this dissection procedure for determining whether certain females within a species, or all females, are able to reproduce parthenogenetically rather than bisexually. Parthenogenesis is presumed to occur in certain species of the genus *Platypalpus*, where males have been rarely collected, or remain unknown. In the Palearctic Region, some species are thought to be entirely parthenogenetic [e.g. *P. major* (Zetterstedt) (Chvála, 1975, 1989)], or partially parthenogenetic [e.g. *P. ecalceatus* (Zetterstedt) (Chvála, 1989; Tuomikoski, 1935)] throughout their range, whereas others [e.g. *P. candicans* (Fallén) and *P. cursitans* (Fabricius) (Chvála, 1975; Frey, 1943; Tuomikoski, 1935)] appear to exhibit geographic parthenogenesis. Conclusive determination of reproductive mode for species of *Platypalpus* at the population level could be important for future screening of possible biological control agents. This is because increased reproductive potential associated with parthenogenesis can be a desirable attribute for beneficial insects being considered for release programs (Aeschlimann, 1990; Douth *et al.*, 1976), and mating requirements for parthenogenetic females can be effectively ignored.

Larval food requirements of empidoids in general are poorly understood, and no information is available for Tachydromiinae. The procedures outlined here however, allow for experimentation with various prey organisms and other food materials to determine which broad categories of food types can be consumed by larvae. The results

<sup>5</sup> Morphological study of the immature stages of the Tachydromiinae will be dealt with in subsequent papers.

obtained on the four species studied here, indicate that larvae of many if not all Tachydromiinae are predacious, probably on small soil or litter inhabiting organisms such as other Diptera larvae, rather than being saprophagous or microorganism feeders. The use of larval Diptera as the major source of prey for the larvae of some other empidoid groups, has been noted by Smith (1969). The apparent attraction of the larvae of all four tachydromiine species towards areas of heavy fungal and bacterial contamination in older cultures, suggests that natural organisms captured by these predacious larvae probably include small mycetophagous or saprophagous Diptera larvae, or other soft-bodied prey.

A general procedure for rearing tachydromiine flies could have important implications for biological control programs targeted against a variety of small-sized insect pests. For example, the predatory activity of many adult tachydromiines appears to be both intense and of long duration (Chvála, 1975; Stark and Wetzel, 1989; Whitfield, 1925), and adults are considered to occupy small-sized predator niches not generally shared by other (usually larger-sized) predators (Chvála, 1975). This, in conjunction with the ability of several species to reach very high population densities (e.g. recorded as high as 40 to 60 individuals of *Platypalpus* per meter<sup>2</sup> in cereal crops by Stark, 1990), and the apparent lack of a fixed diapause stage in at least some species of *Crossopalpus*, *Platypalpus*, and *Silpon* (Chvála, 1975) suggests potential benefits for the development of future mass-rearing programs for this group of predacious flies. Common parthenogenetic species like the relatively large, voracious *P. holosericus* in North America, or the very similar European *P. major*, appear to be ideal candidates for further research.

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## ESTABLISHMENT OF *HIPPODAMIA VARIEGATA* AND NEW RECORDS OF *PROPYLEA* *QUATUORDECIMPUNCTATA* (COLEOPTERA: COCCINELLIDAE) IN THE EASTERN UNITED STATES<sup>1</sup>

A. G. Wheeler, Jr.<sup>2</sup>

**ABSTRACT:** *Hippodamia variegata* is a Palearctic coccinellid known previously in North America from a few areas of eastern Canada. It has been released in eastern and western states for biological control of aphids, but its establishment in the United States has not been documented. On the basis of late-season surveys in the northeast in 1992, *H. variegata* is reported from 38 counties in eight states from northern New England to eastern Pennsylvania and northern New Jersey. All localities surveyed are mapped. Its abundance relative to other coccinellines collected on weeds in disturbed habitats and its plant associations are indicated; the origin of U.S. populations is discussed. Records for *Propylea quatuordecimpunctata*, another Old World coccinellid, are given for Massachusetts, New Hampshire, New York, and Vermont.

*Hippodamia (Adonia) variegata* (Goeze) is an Old World coccinellid first recorded from North America by Gordon (1987). He reported its establishment in the vicinity of Montreal, Quebec, noting that Nearctic populations may be adventive rather than the result of intentional releases. This aphid predator was released in the United States (Arizona, California, Florida, and Georgia) beginning in 1957-1958, but no record of Canadian releases is available (Gordon 1985, 1987).

*Hippodamia variegata* (South African strain) was evaluated in the laboratory (and eventually released) as a potential biological control agent of the greenbug, *Schizaphis graminum* (Rondani), that could increase the diversity of coccinellid predators in Texas sorghum fields (Michels and Bateman 1986). Invasion of the western United States by the Russian wheat aphid, *Diuraphis noxia* (Mordvilko), in 1986 (Stoetzel 1987), led to foreign exploration for natural enemies of this introduced pest and the introduction of various strains of *H. variegata* from Eurasia. In 1987, it was released in several eastern and western states by the USDA's Animal and Plant Health Inspection Service (APHIS) (Obrycki and Orr 1990, Flanders *et al.* 1991). Several biological studies on this introduced aphidophagous coccinellid have been conducted in North America, including its developmental rates at several constant temperatures (Michels and Bateman 1986) and an evaluation of several

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aphid species as suitable prey (Obrycki and Orr 1990).

Despite numerous releases in western and eastern states since 1987 (including Colorado, Kansas, Maryland, Massachusetts, New Mexico, Pennsylvania (Flanders *et al.* 1991), and New Jersey (R. Chianese, personal communication), *H. variegata* has been recorded in North America only from Quebec and Ontario (Gordon and Vandenberg 1991, McNamara 1991). Since 1990, participants in the USDA's Cooperative Agricultural Pest Survey (CAPS) have been asked to look for *H. variegata* in the northeast.

The purpose of this paper is to document the establishment of *H. variegata* in eight northeastern states, map the known U. S. range, and provide information on its abundance relative to other coccinellids occurring in the same habitats. In addition, new records are given for *Propylea quatuordecimpunctata* (L.), another coccinellid that CAPS participants have been asked to search for in northeastern states.

## METHODS

After I discovered *H. variegata* in New York and Vermont in late August 1992, surveys were begun to help determine the extent of its northeastern range. The habitats surveyed (11-13, 18-20, and 27 September, and 6 October) were those that seemed likely to support a diverse coccinellid fauna, particularly disturbed, weedy sites such as railroad yards and urban vacant lots. Mowed roadside vegetation generally yielded few coccinellids, and cropland was not surveyed because of the time that would have been needed to obtain permission for sampling.

Herbaceous vegetation was swept with a standard insect net, and all adult Coccinellini and numbers of each species (except in late August and early October) were recorded. At some sites, particular plant species were examined to determine host associations of *H. variegata*. Totals of all species at a site include adults collected by both techniques. Even though the duration of sampling (usually 10-15 minutes), number of sweeps, and vegetation varied among the sites, the numbers of coccinellines recorded at a given locality allow comparisons of relative density between *H. variegata* and other coccinellids present during September.

Specimens thought to represent *H. variegata* (and those of several other species that could not be identified accurately in the field) were collected for subsequent determination. Voucher material of *H. variegata* and *Propylea quatuordecimpunctata* has been deposited in collections at Cornell University, Ithaca, NY (CUIC); National Museum of Natural History, Washington, DC (USNM); and Pennsylvania Department of Agriculture, Harrisburg (PADA).

## RESULTS

Eleven coccinelline species in six genera were encountered during surveys for *Hippodamia variegata* (Table 1). Nearly 250 specimens of *H. variegata* were obtained at 48 localities in eight states: Connecticut (5 counties), Massachusetts (6), New Hampshire (2), New Jersey (1), New York (16), Pennsylvania (3), Rhode island (1), and Vermont (4). Positive and negative sites for *H. variegata*, as well as recent release sites in Massachusetts, New Jersey, and Pennsylvania, are shown in Fig. 1.

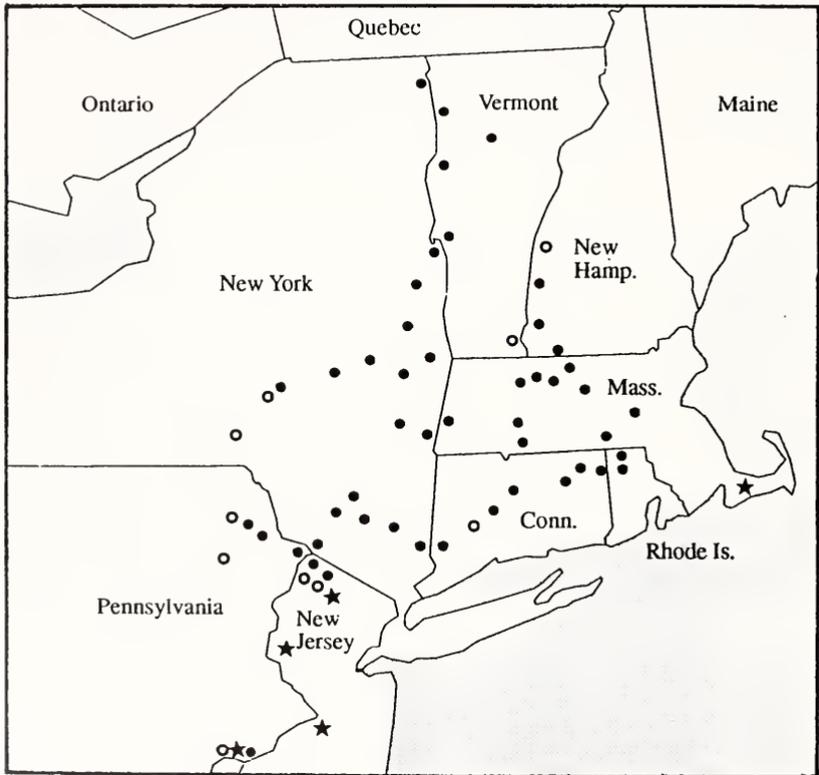


Figure 1. Known U.S. distribution of *Hippodamia variegata*. Dots = detection sites; circles = sites where the coccinellid was not found; stars = recent release sites in Massachusetts, New Jersey, and Pennsylvania (not shown are 1957-1958/1987 release sites in Delaware, Maine, and Maryland).

The following new records document the establishment of *H. variegata* in the eastern United States; all collections were made by the author from 28 August to 6 October 1992.

CONNECTICUT: Fairfield Co., Danbury; Hartford Co., New Britain; New Haven Co., Waterbury; Tolland Co., Mansfield; Windham Co., Abington and Dayville. MASSACHUSETTS: Berkshire Co., Rt. 41 S. of Housatonic; Franklin Co., Erving and Greenfield; Hampden Co., Springfield; Hampshire Co., Northampton; Middlesex Co., Marlborough; Worcester Co., Athol, Gardner, Millbury, and Winchendon. NEW HAMPSHIRE: Cheshire Co., North Walpole and Troy; Sullivan Co., Claremont. NEW JERSEY: Sussex Co., McAfee and Rt. 23 E. of Montague. NEW YORK: Albany Co., Rt. 90E, Service Plaza, Town of Rotterdam nr. Albany; Clinton Co., junc. rts. 87 & 456 E. of Beckmantown; Columbia Co., Hillsdale; Dutchess Co., Fishkill; Greene Co., Leeds; Orange Co., Newburgh and Port Jervis; Otsego Co., Cooperstown Junction; Putnam Co., Brewster; Rensselaer Co., Brunswick; Saratoga Co., Ballston Spa; Schenectady Co., Duanesburg; Schoharie Co., Cobleskill; Sullivan Co., Wurtsboro; Ulster Co., Kerhonkson; Warren Co., Glens Falls; Washington Co., Whitehall. PENNSYLVANIA: Philadelphia Co., Philadelphia; Pike Co., Matamoras; Wayne Co., Hawley and Waymart. RHODE ISLAND: Providence Co., Chepachet and Nasonville. VERMONT: Addison Co., Vergennes; Chittenden Co., Colchester; Rutland Co., Fair Haven; Washington Co., Montpelier.

In northern New England and northeastern New York, *H. variegata* was found at 20 of 29 sites sampled during 11-13 September. It was either the only coccinellid species or the most numerous one at 13 of those sites. During 18-20 September, it was present at 22 of 24 sites in southern New England, southeastern New York, and eastern Pennsylvania and was most abundant at 11 sites. It was taken at 4 of 9 sites in northeastern Pennsylvania and northern New Jersey on 27 September and was most numerous at 2 sites. It was found at one location in Philadelphia during limited surveys in southeastern Pennsylvania on 6 October.

*Hippodamia variegata* was frequently taken by sweeping legumes such as red clover (*Trifolium pratense* L.) and sweet clover (*Melilotus* spp.) that were infested with pea aphids, *Acyrtosiphon pisum* (Harris), or by beating inflorescences of horseweed (*Conyza canadensis* (L.) Cronquist). It was also observed on volunteer alfalfa (*Medicago sativa* L.) and on composites such as aster (*Aster* spp.), chicory (*Cichorium intybus* L.), goldenrod (*Solidago* spp.), mugwort (*Artemisia vulgaris* L.), ragweed (*Ambrosia artemisiifolia* L.), spotted knapweed (*Centaurea maculosa* Lam.), and tansy (*Tanacetum vulgare* L.). A mating pair was found under a mat of knotweed (*Polygonum aviculare* L.).

An adult *H. variegata* collected 20 September at Marlborough, Massachusetts, was not killed right away. A few days later a parasitoid cocoon was observed beneath its body, and the braconid *Dinocampus coccinellae* (Schrank) emerged on 3 October. This Holarctic species is a

known parasitoid of *H. variegata* (and other coccinellids) in Europe. The Massachusetts record from *H. variegata* is noteworthy because this coccinellid had proved unsuitable as a host (100% mortality) in laboratory studies using North American *D. coccinellae* (Obrycki 1989). Successful parasitism of Canadian populations of *H. variegata* has since been reported (Orr *et al.* 1992).

*Propylea quatuordecimpunctata* was collected in 16 counties in four states: Massachusetts (1 county), New Hampshire (1), New York (9), and Vermont (5). It occurred at 11 of 29 sites during 11-13 September (and was most abundant at 1 site) and 3 of 24 sites the following week. It was not found during surveys of northeastern Pennsylvania and northern New Jersey on 27 September or in the limited southeastern Pennsylvania surveys on 6 October. The largest number of specimens (>20; not shown in Table 1) was observed in late August at the Clinton Co., New York, site listed below. The following records of *P. quatuordecimpunctata* were obtained from 28 August to 27 September 1992.

MASSACHUSETTS: Franklin Co., Greenfield. NEW HAMPSHIRE: Grafton Co., West Lebanon. NEW YORK: Albany Co., Rt. 90E, Service Plaza, Town of Rotterdam nr. Albany; Clinton Co., junc. rts. 87 & 456 E. of Beekmantown; Dutchess Co., Fishkill; Orange Co., Newburgh; Putnam Co., Brewster; Rensselaer Co., Brunswick; Saratoga Co., Ballston Spa; Warren Co., Glens Falls; Washington Co., Whitehall. VERMONT: Addison Co., Vergennes; Chittenden Co., Colchester; Rutland Co., Fair Haven; Washington Co., Montpelier; Windham Co., Brattleboro.

## DISCUSSION

*Hippodamia variegata* should be considered a common and widespread coccinellid in the northeastern states; the localities reported herein can be regarded as the first records of establishment in the United States. It was generally present in the areas surveyed except in more western portions of eastern New York and in parts of northern New Jersey and eastern Pennsylvania.

The current U.S. range of *H. variegata* could reflect expansion of Canadian populations discovered in 1984 (Gordon 1987). As noted earlier, it cannot be determined if this coccinellid's occurrence in Quebec is the result of a fortuitous importation with commerce or deliberate introduction associated with biological control work. Its extensive northeastern distribution suggests *H. variegata* was present in the United States when Gordon (1987) gave Quebec as the first North American record.

Rather than having spread rapidly from the Montreal area, this coccinellid may be present in the eastern states as a result of earlier U.S. releases (probably those since 1987 rather than ones during 1957-1958)

that led to its establishment, which is only now being documented. Schaefer *et al.* (1987) offered a similar hypothesis as one explanation of the North American origin of *Coccinella septempunctata*: that establishment from earlier biocontrol releases went undetected for several years. Northeastern and southeastern Pennsylvania populations of *H. variegata* may be discontinuous, and its occurrence in Philadelphia may be the result of 1987 releases there, even though recovery attempts have been unsuccessful (Flanders *et al.* 1991). Similarly, the New Jersey populations may be the result of establishment from 1991 releases (see Fig. 1).

Evidence for evaluating the status of *H. variegata* in the New World—adventive or indigenous—is meager, emphasizing a general need for more field work and documentation of insect distributions. It also points to the desirability of recording all sites where nonindigenous organisms are released for biological control purposes and of conducting thorough recovery surveys to determine whether establishment has taken place. Areas well removed from release sites should be surveyed to allow for dispersal by highly mobile species.

That *H. variegata* was the most abundant coccinellid occurring at several sites was surprising. The comments to be made on other species collected during the survey are speculative because numerous factors affect the composition and abundance of coccinellid communities (Hagen 1962, Hodek 1973, Honek 1985), and widely distributed species can vary intraspecifically in various diapause characteristics (Hodek 1973; Obrycki and Tauber 1981, 1982; Tauber *et al.* 1986).

The small numbers of *Adalia bipunctata* taken on herbaceous plants during the survey were expected because it prefers arboreal habitats (Hodek 1973, Honek 1985). The generalist *P. quatuordecimpunctata*, which was not abundant in the survey, tends to occur at relatively low densities (Honek 1985). This is a distinctive, easily recognized coccinellid, and, in contrast to *H. variegata*, its establishment and spread in the United States have been documented (Dysart 1988, Wheeler 1990). *Coccinella septempunctata*, a Palearctic species that has spread rapidly to become the most common member of the genus east of the Rocky Mountains (Gordon and Vandenberg 1991), was found in relatively low numbers during the September survey. The convergent lady beetle, *H. convergens*, superficially resembles *H. variegata* in dorsal color pattern, and the abundance of this native species was thought to be hindering detection of *H. variegata* in the East. Only one adult *H. convergens*, however, was collected during the survey.

The small numbers of *C. septempunctata* and *H. convergens* seen in September do not necessarily indicate low densities for the entire season.

In a New Jersey study, the number of both species that were swept from herbaceous weeds declined rapidly through August from much higher June-July levels and were low in September. *Coccinella septempunctata* shows a prolonged aestival-autumnal-hibernal diapause (Obrycki and Tauber 1981), and in New Jersey it began to aggregate as early as mid-July (Angalet *et al.* 1979). *Hippodamia convergens* does not enter aestival diapause in the Ithaca, New York, area (Obrycki and Tauber 1981), but it probably also would have been more abundant in the present study if sites had been sampled earlier in the season.

In contrast, the failure to collect *Coccinella novemnotata* during the survey possibly reflects its current scarcity. Biological control releases of the Palearctic *C. septempunctata* may be contributing to the declining numbers observed recently in populations of the native *C. novemnotata*.<sup>3</sup> In Virginia, the dominance of *C. septempunctata* is thought responsible for the disappearance of both *C. novemnotata* and *H. convergens* from alfalfa fields.<sup>4</sup>

Detection of *H. variegata* at additional northeastern localities is favored by the absence or low density of *H. convergens* in late season. Where these species co-occur in the East, *H. variegata* adults generally can be recognized in the field by their smaller size compared to the convergent lady beetle. Field identifications must be substantiated by microscopically observing a fine raised margin or bead at the pronotal base (absent in *H. convergens* and similar-appearing eastern species of the genus) and the white anterior coxae (black in *H. convergens*). Gordon (1987) and Gordon and Vandenberg (1991) provide additional characters for recognizing this quite variable coccinellid.

Further survey work undoubtedly will show that *H. variegata* is even more widely distributed in eastern North America. Its continued spread in the East, establishment in agroecosystems, association with various aphid prey and impact on their densities, and possible effects on populations of native coccinellids such as *H. convergens* require further study.

<sup>3</sup> "Biological Control, Predators, and Strategy," a paper presented by R. D. Gordon, 24 September 1991, at annual meeting of the Eastern Branch, Entomological Society of America, Richmond, Virginia.

<sup>4</sup> "Apparent Displacement of the Convergent Lady Beetle by the Sevenspotted Lady Beetle," a paper presented by R. L. Pienkowski, 24 September 1991, at the annual meeting of the Eastern Branch, Entomological Society of America, Richmond, Virginia.

Table 1. Adult Coccinellini collected during surveys for *Hippodamia variegata* in north-eastern United States, September 1992.<sup>a</sup>

Species	No. of Specimens	No. of Sites	Maximum No. Collected
<i>Adalia bipunctata</i> L.	3	2	2
<i>Coccinella septempunctata</i> L.	66	23	12
<i>C. transversoguttata richardsoni</i> Brown	1	1	1
<i>C. trifasciata perplexa</i> Mulsant	8	5	3
<i>Coleomegilla maculata lengi</i> Timberlake	67	29	12
<i>Cycloneda munda</i> (Say)	92	24	23
<i>Hippodamia convergens</i> Guerin	1	1	1
<i>H. glacialis glacialis</i> (F.)	7	4	3
<i>H. parenthesis</i> (Say)	102	30	22
<i>H. variegata</i> (Goeze)	210	45	27
<i>Propylea quatuordecimpunctata</i> L.	24	14	5

<sup>a</sup> Numbers of *H. variegata*, *Propylea quatuordecimpunctata*, and other species collected during 28-29 Aug. and 6 Oct. 1992 are not included.

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**EPILOCHNA VIGINTIOCTOPUNCTATA  
(COLEOPTERA: COCCINELLIDAE),  
NEW RECORD FOR WESTERN HEMISPHERE,  
WITH A REVIEW OF HOST PLANTS<sup>1</sup>**

Robert F. W. Schroder,<sup>2</sup> Michael M. Athanas,<sup>2</sup> Crodowaldo Pavan<sup>3</sup>

**ABSTRACT:** The first discovery of the phytophagous coccinellid *Epilachna vigintioctopunctata* (F.) in the Western Hemisphere was made October 8, 1990 on wild cucurbit plants near Curitiba, Parana, Brazil. New records since that discovery are given for Paranagua, Parana and Itajai, Santa Catarina. Host plants of agricultural importance are given.

*Epilachna vigintioctopunctata* (F.) is reported for the first time in the Western Hemisphere. It was not known to occur in the Western Hemisphere prior to this report (Anonymous 1992). Gordon (1975) makes no mention of this pest in the Western Hemisphere.

Nine adult beetles were collected on October 8, 1990 feeding on wild cucurbit vines (species unknown) found along Highway 101 about 10 kilometers south of Curitiba, Parana, Brazil. No eggs or larvae were found at the site. The adults were similar in appearance and size to *Epilachna varivestis* Mulsant, having a brownish yellow color with dark brown spots on the elytron. Four specimens were identified by Robert D. Gordon, USDA, Systematic Entomology Laboratory, as the phytophagous coccinellid *E. vigintioctopunctata* (*E. 28-punctata*). During a trip to Brazil in April 1992, we visited with Sonia M. N. Lazzari, a specialist in taxonomy of Coleoptera, Department of Zoology, Federal University of Parana, Curitiba. She indicated that on December 31, 1991, they collected one *E. 28-punctata* adult from a pepper plant at Paranagua, a coastal town east of Curitiba. On April 26, 1992, 25-30 adults were found defoliating *Solanum americanum* along the coastal highway near Itajai, Santa Catarina, Brazil. Adults sent to R. D. Gordon were also identified as *E. 28-punctata*. During the period from April 26 to May 5, 1992, we did not find any other specimens in the regions surveyed near Passo Fundo (RS), Ponta Grossa (Parana) and Campinas (SP). Voucher specimens are deposited in the Federal University of Parana, Department of Zoology Insect Collection.

Schaefer (1983) indicates that this coccinellid is a serious pest in Asia

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and is reported on a wide range of host plants of agricultural importance including potato, eggplant, tomato, tobacco, bitter melon, sweet melon, ribbed melon, snake melon, cucumber, pumpkin, zucchini, beet, sugar-beet, marrow, cotton melon, rock melon, squash, cowpea, peanut, okra, alfalfa, vetch, clover, cotton and banana. This list does not include weeds and grasses that Schaefer mentions.

According to Richards and Filewood (1990), there were 3 different Australian species of *Epilachna* that were incorrectly referred to as *E. 28-punctata*. He identified them as subspecies in the *E. 28-punctata* complex, all occurring in Australia. Two of the subspecies, *E. 28-punctata pardalis* (Boisduval) and *E. vigintisexpunctata vigintisexpunctata* (Boisduval) feed on solanaceous plants, and *E. cucurbitae* Richards feeds on cucurbits. Another subspecies in the complex, *Epilachna 28-punctata 28-punctata* (Fabricius) is not known to occur in Australia, but is found in India, Pakistan, Japan, SE Asia and Oceania. All are important pests of agricultural crops. Richards at least clarified the situation for Australia. Because of the existing confusion over identification, or species limits, much greater uncertainty exists over the host plants list for *E. 28-punctata* compiled by Schaefer. This is only one example of a greater problem that exists throughout the range of this species.

There is reason to be concerned about this new pest in the Western Hemisphere, because it is reported as a serious pest on many economically important crops in Asia. Since it looks very similar to *E. varivestis*, its presence may go undetected in regions of the Western Hemisphere where *E. varivestis* is known to occur. *Epilachna 28-punctata* is a new introduction, restricted to the coastal region of Brazil. Other than the defoliation of the *S. americanum* plants from which we collected the beetle, there are no other reports of it causing any damage to plants. Therefore, the opportunity exists to delineate its distribution, restrict its spread and maximize the use of a wide range of biocontrol agents (Schaefer 1983) to reduce the potential threat of this pest to agriculture in Brazil.

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(Continued on inside of back cover)

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## IDENTIFICATION OF *OSMIA KENOYERI* AND *O. VIRGA* (HYMENOPTERA: MEGACHILIDAE), TWO BLUEBERRY POLLINATORS<sup>1, 2</sup>

Richard W. Rust<sup>3</sup>, Eben A. Osgood<sup>4</sup>

**ABSTRACT:** The sexes of *Osmia kenoyeri* and *O. virga* are associated and the females of both are described. Both species visit lowbush blueberry, *Vaccinium* spp. for pollen and nectar. The nesting biology of *O. kenoyeri* is described.

The genus *Osmia* contains over 130 species in North America (Sandhouse 1939, Hurd 1979). Many of the species are only known by one sex, often the male, because of distinctive abdominal sternal and genitalic characters. Here we associate the sexes and describe for the first time the females of *Osmia kenoyeri* Cockerell and *O. virga* Cockerell. Both species have been collected on *Vaccinium angustifolium* Art. and *V. myrtilloides* Michx. in the lowbush blueberry complex in Maine (Boulanger *et al.* 1967, Stubbs *et al.* 1992).

### *Osmia* (*Acanthosmioides*) *kenoyeri* Cockerell

Female: Length 10 mm; fore wing 6.5 mm; head width 3.5 mm. Color dark greenish-blue; antennae, mandibles, legs dark reddish-brown to black; tegulae black with greenish-blue apical edge. Pubescence of vertex, pronotum, scutum, scutellum white; metasomal tergum 1 white with some black hairs; tarsi with white to reddish brown hairs; rest of body including scopa black. Head wider than long, densely covered with punctures, all punctures of approximately similar diameter; compound eyes slightly convergent below; dorsal 1/3 of gena visible beyond compound eye, gena wider than compound eye; clypeal margin broadly concave, apical margin narrowly impunctate, clypeus in profile slightly convex, densely punctate; hypostomal carina moderately raised, abruptly reduced before angle to half its height; ocelli equally spaced between compound eyes and each other; length of flagellomere 1 only slightly less than 2 and 3 together; mandible with 4 teeth (Fig. 1), apical distance (between teeth) twice width of median constriction, carinae parallel, lower twice as wide as upper, upper tooth oblique, next tooth smallest of the 4 with ventral margin truncate, third tooth triangular, fourth tooth (lowest) longest; maxillary palpal segments 2 and 3 subequal, equalling length of 4 and 5 together; labial palpal segments 1 shorter than 2, 3 equal to 4; ventral margin of galea with dense, short hairs. Thorax densely covered with fine punctures, equalling those on head; propodeal triangle minutely rugose; propodeal pit oval shining; hind tibial spurs straight, only apical 1/5 bent; strigilis with velum shallow concave, amlus long, acutely pointed; fore wing with apical papillae small, cells covered

<sup>1</sup> Received July 21, 1992. Accepted December 18, 1992.

<sup>2</sup> Contribution No. 1656 from the Maine Agricultural Experiment Station.

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with few, short, light hairs, vein A 3 times B. Metasomal terga 1-4 with wide apical impunctate bands, bands 1/4 to 1/3 punctate portion.

**Male:** The male of *O. kenoyeri* is extremely distinctive and can be distinguished from all other *Osmia* by the structure of mid tarsus 1, the shape of the genitalia and metasomal sternum 2 (Sandhouse 1939).

**Type:** The holotype of *Osmia kenoyeri*, a male, is from Nebraska Hill, Colorado and was collected on *Trifolium*. It is located at the University of Colorado Museum, Boulder, Colorado. Males from Maine were identical with the holotype.

**Distribution:** *Osmia kenoyeri* is known from Deblois, Washington County, Maine; Grand Sable Dunes, Alger County, Michigan (M. Arduser, pers. comm.); and Sandhouse (1939) reported it from Colorado, California, Alberta, and the Yukon.

**Remarks:** In White (1952), the female of *O. kenoyeri* keys out with *O. integra* Cresson (couplet 18) but differs from *O. integra* in the small size of the fore wing papillae and the white pubescence on the dorsum of the thorax. In Mitchell (1962), the female of *O. kenoyeri* also keys to *O. integra* (couplet 12) and the male keys with *Osmia felti* Cockerell (couplet 9) but is easily separated by the globose first segment of the mid tarsus.

Sandhouse (1939) placed *O. kenoyeri* in the subgenus *Acanthosmioides*. White (1952) excluded *O. kenoyeri* from *Acanthosmioides* and placed it in the subgenus *Melanosmia* (equals *Centrosmia*). His decision was based primarily on character similarities with *Osmia bucephala* Cresson. Hurd (1979) placed *O. kenoyeri* in the subgenus *Acanthosmioides*. He provided no explanation for the placement. However, with the correct association of the female, *O. kenoyeri* appears to be more closely associated with *Acanthosmioides*. In the female, the broad apical width of the mandible, general body and pubescence coloration, and apical margins of terga and in the male, the body coloration, mandible, metasomal sterna 2 to 7, genitalia, and leg characters strongly suggest *Acanthosmioides*.

Sandhouse (1939) suggested that *Osmia hendersoni* Cockerell may be the female of *O. kenoyeri*. The type of *O. hendersoni* (U.S. National History Museum #27891) was examined and found not to be the female of *O. kenoyeri*. The shape of the mandible and hypostomal carina, and impunctate bands on abdominal terga 2 and 3 were different. The type of *O. hendersoni* is extremely worn with badly torn wings and missing flagellomeres.

**Biology:** A nesting site of *O. kenoyeri* was found on the "blueberry barrens" in Deblois, Washington County, Maine (EAO). Females were observed to excavate burrows in the sandy loam soil in late May and adult activity continued to mid June. Burrows varied from 40 to 75 mm in diameter and were not symmetrical in construction. They entered the ground at about a 30° angle and terminated in a series of linear cells within 2 to 3 cm of the soil surface. One nest contained 3 urn-shaped cells, 2 with developing larvae while the third was open and not pro-

visioned. Cells were approximately 80 x 110 mm and composed of a mixture of fine plant fibers, not leaf or leaf pieces, and soil. Cell walls varied from 0.75 to 1.5 mm thick. Cells were easily separated from the surrounding soil and remained intact when excavated. Larvae were mature by early July and in cocoons. The cocoon was composed of two layers. The outer layer was a dense mat of silk fibers that adhered to the soil-fiber cell wall and the inner layer was thinner. A highly polished red brown matrix with individual silk threads was visible and easily separated from the outer layer. The outer anterior surface of the cocoon was formed by a large, flat white nipple which separated the cocoon from the top of the soil-fiber cell. Nineteen males and 9 females were collected the following May from a 30 x 30 cm screened area of the nesting site. No parasites or predators were recovered from the cages.

Examination of the pollen grains remaining in the fecal pellets showed both the tetrad grain structure of Ericaceae (*Vaccinium*) and a smaller, tricolporate grain, perhaps a Fabaceae.

### *Osmia* (*Chenosmia*) *virga* Sandhouse

**Female:** Length 10 mm; fore wing 7.0 mm; head width 3.0 mm. Color olive-greenish blue; flagellomeres, legs reddish brown, scape black, mandible red brown with black edges. Pubescence white; mandibles, tarsi with golden to red brown hairs, scopa black. Head slightly wider than long, punctures continuous and of similar size; gena with upper 1/3 visible beyond compound eye, twice as wide as compound eye; inner margin of compound eye convergent below; lateral ocelli 2½ diameters distant from compound eye, less than 1 diameter from median ocellus; clypeal apical margin truncate, slightly wavy, narrowly impunctate; hypostomal carina low, uniform, not toothed; mandible with 4 teeth (Figure 1), apical width only slightly greater than mid width, carinae divergent, lower twice as wide as upper; flagellomere 1 longer than 2 or 3; maxillary palpal segment 3 longer than 2, twice 3

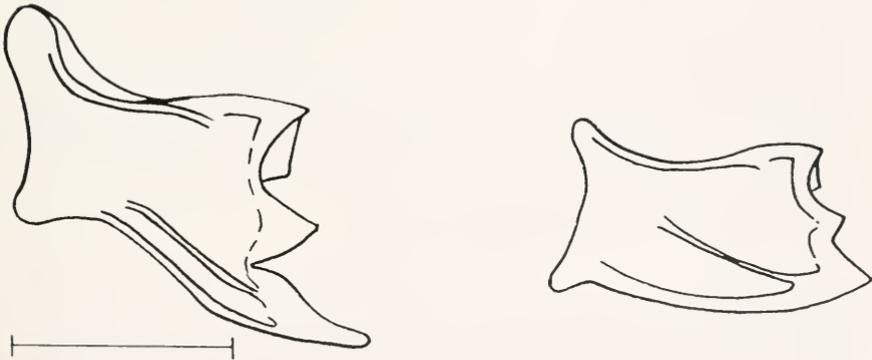


Figure 1. Female mandibles of *Osmia kenoyeri* Cockerell (left) and *Osmia virga* Cockerell (right), scale line is 1.0 mm.

and 4 together, galea ventral surface with numerous short straight hairs, dorsal surface with few scattered, straight hairs; labial palpal segment 2 longer than 1. Thorax densely and evenly punctate, puncture size similar to vertex; propodeal triangle rugose above, granular below; propodeal pit narrow, parallel sided; tegulae almost impunctate; wings minutely and evenly haired, vein A twice B; strigilis with malus margin truncate, velum very short. Abdomen with impunctate bands of metasomal terga 1 to 3½ as wide as punctate portion, 4 to 6 narrower.

**Male.** The male of *O. virga* is easily identified by the wide impunctate bands on metasomal terga 1 to 4, the truncate margin of metasomal sternum 4, and the structure of the genitalia, especially the broad penis valves (Sandhouse 1939, Mitchell 1962).

**Type.** The type specimen is from Water Tank, Pennsylvania and is located in the United States Natural History Museum, Washington, D.C. (Holotype #52883). Maine males were identical to the holotype.

**Distribution:** We have seen specimens from Deblois and Orono, Maine. Sandhouse (1939) reported *O. virga* from Massachusetts, New Jersey, Connecticut, and Virginia and Mitchell (1962) added Wisconsin and Pennsylvania.

**Remarks:** In Mitchell (1962), the female of *O. virga* keys out as *O. atriventris* Cresson (couplet 17) from which it differs in body color, hypostomal carina, mandibular carinae, impunctate bands of metasomal terga 4 and 5, structure of the strigilis, and scopal color.

Stubbs *et al.* (1992) reported 99% *Vaccinium* pollen from the pollen load of *O. virga* from Maine.

## DISCUSSION

The distributional pattern seen in *O. kenoyeri*, Rocky Mountains and northeastern U.S. and Canada, is not uncommon within the genus. *Osmia integra*, *O. bucephala*, *O. subaustralis* Cresson, *O. inermis* (Zetterstedt), and *O. nigriventris* (Zetterstedt) show similar distributions with the northeastern and Rocky Mountain distributions connected through northern Canada and Alaska (Sandhouse 1939, Mitchell 1962, Rust 1974). The latter two species are Holarctic. Biologically, *O. kenoyeri* groups with two other *Acanthosmioides*, *O. nigrobarbata* Cockerell and *O. unca* Michener, in excavating burrows in the ground where the cells are lined with plant materials and soil (Rust *et al.* 1974). Also, the two layered construction of the cocoon and the large, flat white nipple area are characteristics observed in other *Acanthosmioides* species.

## ACKNOWLEDGMENTS

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## BOOKS RECEIVED AND BRIEFLY NOTED

CATALOGUE OF THE CYPHOPALPATOIRES AND BIBLIOGRAPHY OF THE HARVESTMEN (ARACHNIDA, OPILIONES) OF GREENLAND, CANADA, U.S.A., AND MEXICO. J.C. Cokendolpher & V.F. Lee. 1993. Distributor: The Wishing Well, 1200 Clover Drive, Burkburnett, TX 76354. 82 pp. paperback. \$9.50 incl. shipping.

The goal of this publication is twofold: a catalogue and geographical checklist are provided to the 225 species and 50 genera of Cyphopalpatores and second, a complete literature survey, including newspapers, theses, dissertations, and government reports, is provided for both fossil and recent species. All topics are covered, including folklore.

NYMPHS OF NORTH AMERICAN STONEFLY GENERA (PLECOPTERA). K.W. Stewart and B.P. Stark. 1993. Univ. of North Texas Press. 464 pp. 244 illus. paperback. \$34.50.

This book is a reprint of the 1988 edition published by the Entomological Society of America as Volume XII of the Thomas Say Foundation. It is a baseline reference for serious study of North American Plecoptera and for stream ecological studies.

## TABANIDAE AS DIETARY ITEMS OF RAFINESQUE'S BIG-EARED BAT: IMPLICATIONS FOR ITS FORAGING BEHAVIOR<sup>1</sup>

Susan E. Ellis<sup>2,3</sup>

**ABSTRACT:** Lepidopterans and dipterans formed the entire diet of a maternity aggregation of Rafinesque's big-eared bat (*Plecotus rafinesquii*) in a single-sample analysis of fecal pellets. Tabanidae made up 31% of the total sample volume. The presence of male Tabanidae as prey items may be significant, because few natural predators have been identified for this insect. Literature concerning the behavior of tabanids is reviewed and compared to the sparse information concerning *P. rafinesquii* foraging. The foraging habits of this bat species are apparently more varied than previously reported. The unusual presence of tabanids as prey items suggests that this bat could be of use in tabanid control.

Knowledge of the life histories of insects in the diets of insectivorous vertebrates may give insight into the foraging habits of these predators. From an economic perspective, identifying the prey of insectivorous bats could have important implications for biological control. Predation on flying insects, usually reproductively competent adults, can have a much greater impact on insect populations than predation on immature stages (Buckner, 1967).

Rafinesque's big-eared bat, *Plecotus rafinesquii* Lesson has been described as "the least known" bat species of the eastern United States (Harvey, 1992; Barbour and Davis, 1969). Information about the natural history of this insectivorous bat is fragmentary. Most studies have focused on its distribution and roosting ecology (e.g., Jones, 1977; Whitaker and Winter, 1977; Hall, 1963), and there is but one study of its feeding ecology (Clark, 1991). Harvey (1992) reports that "almost nothing is known about their feeding behavior." Information about this bat's diet comes from an examination of the stomach contents and fecal material collected from a single animal which had eaten moths (Hamilton, 1933).

The purpose of this study is to report on items included in the diet of a North Carolina aggregation of *P. rafinesquii* as determined by fecal analysis, and discuss the foraging habits of the bats in relation to the habits of their insect prey.

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## MATERIALS AND METHODS

A sample of sixty fecal pellets was collected from a maternity roost of *P. rafinesquii* from Chowan County, North Carolina in late July, 1992. This material was analyzed by: 1) percentage frequency and 2) percentage volume of insect taxa in the pellets, as described by Whitaker (1988). After the fecal material was softened in 70% isopropyl alcohol for at least two hours, individual fecal pellets were teased apart under a binocular microscope at 45X, and the volume of each taxa in each pellet was visually estimated. Fragments were identified to order and family using standard insect identification keys (Borror, *et al.*, 1989; Arnett, 1985; Borror and White, 1970) and by comparing structures of wet mounted fragments with those of pinned specimens in the museum collection at the University of Delaware.

## RESULTS

Lepidoptera occurred in 78.3% of the samples and composed 67% of the sample volume. Three types of lepidopteran eggs were present in the samples, occurring in 27.6% of the pellets containing lepidopterous fragments. Dipterans occurred in 60% of the samples, composed 33% of the sample volume, and included Tabanidae (horse flies, or *Tabanus* spp.) and Tipulidae (crane flies). Tabanids constituted 31% of the total sample volume and occurred in 46.6% of the pellets. The balance of the dipterans consisted of tipulids (less than 2% volume, 8% frequency) and other fragments, unassignable to family. Three of the tabanids were identified as males: one by the aedeagus; two by the holoptic head capsule characteristic of males. No tabanid eggs were found in the pellets, and no recognizable female structures were found among the tabanid fragments.

## DISCUSSION

The North Carolina maternity aggregation of *P. rafinesquii* preys heavily on lepidopterans and dipterans in at least part of its active season. Extrapolating prey size from the fragments of legs in the pellets and by comparison with museum specimens, I estimate that these prey were all within a 20-25 mm range in body length.

The presence of male tabanids provides clues about the foraging habits of the bats. Tabanid flies are considered economically-important pests because the females are obligate blood-feeders, capable of both inflicting a "vicious bite" and of transmitting pathogens (Pedigo, 1989). In at least 34 *Tabanus* spp., males hover in groups as a prelude to mating

(Gaugler and Schutz, 1989). These authors described the mating behavior of tabanid flies as a "potential weak link" in their life cycles and propose that disrupting the equilibrium of tabanid populations might be achieved through controls exerted on hovering males. Corbet and Haddow (1962) suggest that hovering swarms of these flies should be vulnerable to predation, however they cite only one report (Blickle, 1959), in which an adult *Bembex belfragei* Cresson (Hymenoptera: Sphecidae) captured a hovering male *Tabanus bishoppi* Stone in Florida. Corbet and Haddow (1962) postulate that swarming by males at low light levels may reduce their detectability by diurnal predators. *Plecotus rafinesquii* appears to be one of the few predators exploiting this weak link, and may exert some measure of population control on these flies.

Males of *Tabanus* species usually gather at dawn and dusk around a landmark, where they hover in a fairly stationary group "a few feet above ground level" (Gaugler and Schutz, 1989; Bailey, 1948). Landmarks vary, but share the common feature of being relatively open and free of obstruction. Some reported landmarks are: forest-meadow margins, roads (Gaugler and Schutz, 1989), shrubs, and a driveway (Bailey, 1948). Tabanids are strong omni-directional fliers capable of holding a defined territorial position over a landmark and within a swarm (Downes, 1969).

The timing of swarming probably depends on temperature, light or other environmental cues (Gaugler and Schutz, 1989; Bailey, 1948), however a response to low light intensity appears to be the primary initiator of swarming by tabanids (Corbet and Haddow, 1962). Low light intensity may act as a species-specific cue, coordinating the activity times of males and females (Gaugler and Schutz, 1989; Corbet and Haddow, 1962). The onset of hovering is closely synchronized and may continue for 10-23 minutes; cessation is more variable, probably because factors such as fatigue and thoracic heating affect individual males differently (Corbet and Haddow, 1962). However, thresholds of light intensity probably also provide the cue for cessation of hovering (Corbet and Haddow, 1962). All studies report a diurnal to crepuscular time window for hovering by these flies (Schutz and Gaugler, 1992; Gaugler and Schutz, 1989; Downes, 1969; Corbet and Haddow, 1962; Bailey, 1948).

Two conclusions may be drawn from this. First, foraging *P. rafinesquii* shares space with these hovering flies. This indicates that *P. rafinesquii* forages near ground level and bears out observations made by Clark (1991) of light-tagged *P. rafinesquii* flying "about 1 m above ground level". Barbour and Davis (1969) observed *P. rafinesquii* confined in a small room and reported that it was capable of hovering, and of swift and maneuverable flight. The presence of male tabanids in the diet of *P. rafinesquii* indicates that these bats forage to some extent in open areas containing tabanid landmarks. However, the flying agility ascribed to

them would allow them to navigate within the clutter of forested areas where they have been observed foraging (Clark, 1991).

Second, *P. rafinesquii* shares some activity time with its prey, indicating that these bats forage in early morning or early evening, an observation that contrasts with reports that the species does not forage at twilight (Harvey, 1991; Jones, 1977; Barbour and Davis, 1969).

Although Tipulidae accounted for less than 2% of the volume and occurred in only 8% of the samples, these flies form "discrete assembly stations" for mating, comparable in form if not behavioral complexity, to those of *Tabanus* species (Downes, 1969). An additional inference concerning *P. rafinesquii* foraging habits is that it may sometimes exploit clumped resources. Since I was unable to identify lepidopterans below the ordinal level, I cannot cite specific behaviors of these insects that might further support this inference. It is possible, however, that individuals of *P. rafinesquii* prey on swarms of hovering flies while enroute to forested areas, then switch to moths after entering the forest. In the absence of site-specific data this speculation seems reasonable, because *P. rafinesquii* has often been associated with forested areas (Clark, 1991; Whitaker and Winter, 1977; Barbour and Davis, 1969).

## SUMMARY

The limited data presented in this single-sample prey analysis from one maternity roost of *P. rafinesquii* provides evidence that these bats preyed on 20-25 mm lepidopterans (67% volume) and dipterans (33% volume), including tabanids (31% volume) and tipulids (less than 2% volume). Male *Tabanus* spp. exhibit diurnal to crepuscular group hovering behavior in open areas, indicating that the spatial and temporal foraging repertoire of *P. rafinesquii* may be more varied than previously assumed.

*Plecotus rafinesquii* exploits what some tabanid researchers (i.e., Gaugler and Schutz, 1989) have identified as a potential weak link in the life cycles of *Tabanus* species. Other tabanid researchers (i.e., Corbet and Haddow, 1962), have indicated that this weak link is apparently rarely exploited by other predators. Thus, *P. rafinesquii* may have some impact on populations of these economically important insects by preying on hovering males. It seems likely, from the percentage of lepidopteran eggs occurring in the sample (27.6%), that *P. rafinesquii* predation also has an impact on moth populations. Specifically, by limiting oviposition by moths, *P. rafinesquii* affects proliferation of the destructive larval stages of these insects.

Insectivorous bats extend their impact beyond individual prey numbers by removing reproductive adult insects, thus limiting mating and

oviposition. These are effective methods of regulating insect populations (Pedigo, 1989; Buckner, 1967). Further investigation of the foraging habits of *P. rafinesquii* and other insectivorous bats could yield important information about the biological control potential of these predators.

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## A HUGE NEST OF THE COMMON YELLOWJACKET, *PARAVESPULA VULGARIS* (HYMENOPTERA: VESPIDAE), IN CALIFORNIA<sup>1</sup>

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**ABSTRACT:** A large, perennial colony of *Paravespula vulgaris* was collected in California in July 1992. The envelope was ca 97 diam and had multiple entrances. The colony consisted of 220 nonfunctional queens, 2 developing queens, 10 functional queens, ca 84,000 workers, and ca 32,000 males. The 22 combs consisted of ca 220,000 worker and 9,000 reproductive cells; 64% were empty. The colony was estimated to be 2-3 years old.

Yellowjackets typically have a one year life cycle, and the only members of the colony to overwinter are inseminated queens. They start new colonies in the spring. However, some colonies continue for more than one season (Akre and Reed 1981) and these colonies are always polygynous (Carpenter 1989). Large, perennial colonies have previously been reported for *Paravespula germanica* (F.) in New Zealand (Thomas 1960, Plunkett *et al.* 1989, Clapperton *et al.* 1989), Tasmania (Spradbery 1973a), Algeria and Morocco (Vuillaume *et al.* 1969), and Chile (Jeanne 1980, Chiappa *et al.* 1987). Perennial colonies are unusually large, and Spradbery (1973a) estimated one nest weighed 1,000 pounds. *Vespula squamosa* (Drury), the southern yellowjacket, has perennial colonies in the southern United States, especially in Florida (Tissot and Robinson 1954, Akre *et al.* 1981, Ross and Matthews 1982) and in Texas. Perennial colonies of the common wasp occur in New Zealand (Plunkett *et al.* 1989) and a perennial colony of *P. vulgaris* (L.) was recorded in California years ago (Duncan 1939). Unconfirmed reports indicate many more perennial colonies are being found in southern California where winter temperatures are mild, and prey populations are high enough to sustain a colony through the winter months. One *P. vulgaris* colony persisted from its discovery in 1984 until at least 1986 in Berkeley, CA (Alameda Co.) (Gambino 1986). A two year colony of *P. pensylvanica* (Saussure) was reported in British Columbia (Spencer 1960), and Nakahara (1980) recorded a huge perennial colony of *P. pensylvanica* (Saussure) in Hawaii (see also Gambino *et al.* 1990). The purpose of this paper is to present a detailed analysis of a nest of *P. vulgaris* collected in Burlingame (San Mateo Co.), California.

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above a creek bank. The nest was ca 62 cm wide X 76 cm tall X 35 cm thick, with a circumference of 244 cm, a diameter of 97 cm (measurements were estimated from a photograph), somewhat heart-shaped, and had multiple entrances (ca 120 on each side). The colony was killed the week of 12 July 1992, and all nest material and occupants were shipped to Washington State University at Pullman for study. The nest, as collected, complete with severed vines, weighed ca 64 kg. The nest was stored in a freezer at  $-5.0^{\circ}$  F until the occupants and combs were counted and analyzed. Males were individually counted first, and it was determined that 1,385 fit into a 250 ml graduate cylinder when it was vigorously tapped on the substrate to settle and compact them. The count was stopped when they no longer settled. Similarly, 2,011 workers were needed to fill a 250 ml cylinder. All remaining individuals, except queens, were measured volumetrically to estimate number of workers and males in the colony. Queens were individually tallied, injected with Kahle's to preserve them, and placed into 70% ETOH until they were dissected for ovarian development.

All combs of the nest were analyzed for the presence of pupal caps, larvae, and eggs. A 12 in grid divided into 1 in squares facilitated the count (MacDonald *et al.* 1974). In some sections the cells were individually counted. The nest was sectioned in California to fit into the shipping containers, and we tried to reconstruct comb placement before the analysis began. Sections were numbered and flagged as they were unpacked to aid us in this endeavor.

## RESULTS

The colony consisted of ca 84,000 workers, 32,000 males, and 232 queens (Table 1). The total number of cells in the 22 comb layers of the

Table 1. Numbers and types of adults collected with the colony. Functional, developing, and nonfunctional queens (parens) add up to "Queens."

Adult Type	Number Counted
Queens.....	232
Functional.....	(10)
Developing.....	(2)
Nonfunctional.....	(220)
Males.....	31,811
Workers.....	83,784
Total Adults.....	115,827

nest was ca 230,000, but 146,000 of these cells were empty (Table 2). Dissections of the queens revealed that 10 had fully functional ovaries that filled the gaster (eggs are 1.0-1.5 mm when ready to lay). Two had a slight development of the ovarioles but no eggs were >1 mm. All functional queens had multiple age spots or dark discolorations on the gaster (Ross 1984). The remaining 220 queens showed no ovarian development.

## DISCUSSION

Although large, this colony was probably entering a period of decline as evidenced by the great number of empty cells. Ten functional queens should have been able to lay eggs in many of these empty cells unless there was conflict and fighting among workers and/or queens in the nest. We could not determine any spheres of influence for any of the queens because of the state of the nest when received.

The large number of males in the colony suggests that workers were laying eggs and producing at least some or perhaps most of these males.

Questions asked of neighbors suggested that this nest was observed for 30 years. We have no evidence to support this claim and indeed, the nest analysis, including the construction of reproductive cells on the periphery of some combs, suggested that the nest was probably 2 years old, at most.

Photoperiod is probably the stimulus that allows new queens to circumvent reproductive diapause and to start egg development after they are inseminated (Spradbery 1973b, Ross and Matthews 1982). Queens frequently rejoin the parent colony if the photoperiod is still increasing

Table 2. Occupants of cells from the 22 combs. Small, medium, and large larval counts (parens) add up to "Larvae."

	Worker	Reproductive	Total
Eggs .....	2,884	82	2,966
Larvae .....	26,938	437	27,375
Small .....	(4,089)	(93)	(4,182)
Medium .....	(11,925)	(170)	(12,095)
Large .....	(10,924)	(174)	(11,098)
Pupae .....	51,553	972	52,525
Empty cells .....	138,954	7,779	146,733
Total .....	220,329	9,270	229,599

(up to 21 June) in that geographical area, and if the winter temperatures are mild. They can also rejoin the colony as nondiapausing, functional queens when the daylight is very short as the "window" of receptiveness seems to be 10-14 hrs (Spradbery 1973b). Photoperiods longer or shorter do not induce reproductive diapause, and the ovaries in these new queens are able to develop.

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## BOOKS RECEIVED AND BRIEFLY NOTED

**BIOLOGY AND CONSERVATION OF THE MONARCH BUTTERFLY.** S.B. Malcolm and M.P. Zalucki, eds. 1993. No. 38 Science Series, Natural History Museum of Los Angeles County. 219 pp. 139 figs. 100 tables. Cloth. \$90.00.

This volume presents an interdisciplinary approach to understanding how *Danaus plexippus* functions, providing information for an objective approach to conservation of the species. Forty-four papers written by 50 authors present a diverse array of research on biological and conservation topics. These papers embrace four main themes of monarch biology: communication and mating, host plant exploitation and chemical defense, migration, and overwintering.

**THE SCIENCE OF ENTOMOLOGY.** 3rd ed. W.S. Romoser and J.G. Stoffolano. 1994. Wm. C. Brown, Publ. 532 pp. Cloth. \$60.90.

The authors' stated objective for this third edition is to provide a broad, balanced introductory text to the science of entomology, from both basic and applied points of view, for use in a one-quarter or one semester general course.

## SEASONAL FLIGHT ACTIVITY OF *LIPOPTENA MAZAMAE* (DIPTERA: HIPPOBOSCIDAE) IN SOUTH CAROLINA<sup>1</sup>

L. Daniel Cline, James E. Throne<sup>2</sup>

**ABSTRACT:** Flying winged adults (volants) of *Lipoptena mazamae* were collected in sticky traps at two of three grain storage sites in southeastern South Carolina that were being sampled for seasonal occurrence of stored-product insects. Of the 42 volants captured during the 55-week test, at least one was caught in every month from April through November. None were caught from December through March. Most were caught in traps placed near wooded areas or heavy shade where deer were likely to travel or feed. Sticky traps provide an alternative to conventional trapping methods for hippoboscids, but have the disadvantage of not providing positive host information.

*Lipoptena mazamae* Rondani is a parasite of all species and subspecies of deer (*Odocoileus* spp.) and brocket (*Mazama* spp.) wherever the hosts occur in the Neotropical region (Bequaert 1957). It also has been found infrequently and accidentally on domestic cattle. *Lipoptena mazamae* has been found as far south as Argentina and as far north as the states bordering the Gulf of Mexico and up the Atlantic coast into South Carolina (Bequaert 1957). Little is known of its life history and behavior. Because it is essentially a tropical insect, its populations in the United States may fluctuate with the severity of the winter.

Current techniques for the detection and collection of Hippoboscidae can be difficult (Pfadt & Roberts 1978). On live domestic animals, an uncooperative attitude coupled with low numbers of parasites may make them hard to find and the quickness of their movements may make them difficult to catch. Placing newly killed hosts in a bag or screened enclosure may facilitate collections. Collections on large wild animals nearly always requires killing the host and searching a standardized area of its body where the parasites are most likely to occur (Samuel & Trainer 1972). Volants (winged adults) can be collected with sweep nets or by collecting specimens from skin and clothing as the collector walks through a selected area. Both of these methods require a great deal of time and care (Hare 1945).

During a study of the flight activity of stored-product insects around grain bins, we captured *L. mazamae* on sticky traps. Given the scarcity of information on their biology and the complete lack of information on

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volants' seasonal occurrence, we report our findings of this insect at the northern end of its range. In addition, we present a collection method that passively catches the parasites with no trauma to their hosts and minimal effort by the collector.

## MATERIALS AND METHODS

Sticky traps were used to monitor three sites in southeastern South Carolina for flying insects from 18 March 1987 to 6 April 1988 (55 continuous weeks). Traps consisted of clear flat plexiglass (30.5 cm by 30.5 cm) coated on each side with sticky substance (Tangle-Trap™, Tangle-foot Co., Grand Rapids, Michigan)<sup>3</sup> and held in a vertical position on a wooden stake. Details of trap design and preparation are given in Throne and Cline (1989).

The traps were deployed in two nearly concentric rings around grain storage bins. The inner traps were generally about 0.5 m from the bins and the outer traps varied from 5 to 45 m from the bins to accommodate the cooperators' need to use the space. Four inner and four outer traps were deployed at two sites (Bamberg and Hampton Counties) while five inner and five outer traps encircled the larger third site (Barnwell County). A map detailing the placement of the traps and the surrounding area is given in Throne and Cline (1989). In general, the Bamberg and Hampton County sites were surrounded by cultivated fields with wooded areas within 25 m of the grain bins. The Barnwell County site was surrounded by pasture.

Each trap was exposed for one week after which it was replaced and the exposed surfaces returned to the laboratory for examination. The entire sticky surface (both sides) was examined at a magnification of at least 10X. Hippoboscids were removed, recorded, and stored in vials of alcohol. Identification was determined from characters detailed in Peterson & Maa (1970). Voucher specimens were placed in the U.S. National Museum Collection and in the Florida State Collection of Arthropods.

## RESULTS AND DISCUSSION

A total of 42 hippoboscids were collected and all were identified as *L. mazamae*. Most (78.6%) were collected at the Hampton Co. site while 21.4% were collected at the Bamberg Co. site. None were caught at the Barnwell Co. site. At least one volant was caught in every month from

<sup>3</sup> Names of products are included for the benefit of the reader and do not imply endorsement or preferential treatment by USDA.

April through November (Figure 1). None were caught in the four months from December through March. This is similar to the finding of Hare (1945) who found flying adults of a closely related species, *L. depressa* (Say), from late March to early December in California with a peak in July. The deer hosts are present in the area year-round, however, it is unclear whether volants cease to emerge or cease to fly during cold weather.

At the two sites where *L. mazamae* were caught, most were found in the outer traps placed to the south of the grain storage area (44.4% at site 1 and 66.7% at site 2). At both sites, these were the areas either close to woods or near heavy shade. At the Bamberg County site, the south outer trap was placed where deer frequently traveled from a heavily wooded area into a field where either corn or soybeans are usually grown. At the Hampton County site, the south outer trap was placed at the edge of a neglected grove of mature pecan trees where deer presumably come to search for food. The third site was not a very suitable habitat for deer, therefore, it is not surprising that no hippoboscids were caught there. Hare (1945) found that most *L. depressa* (66%) were collected in or near

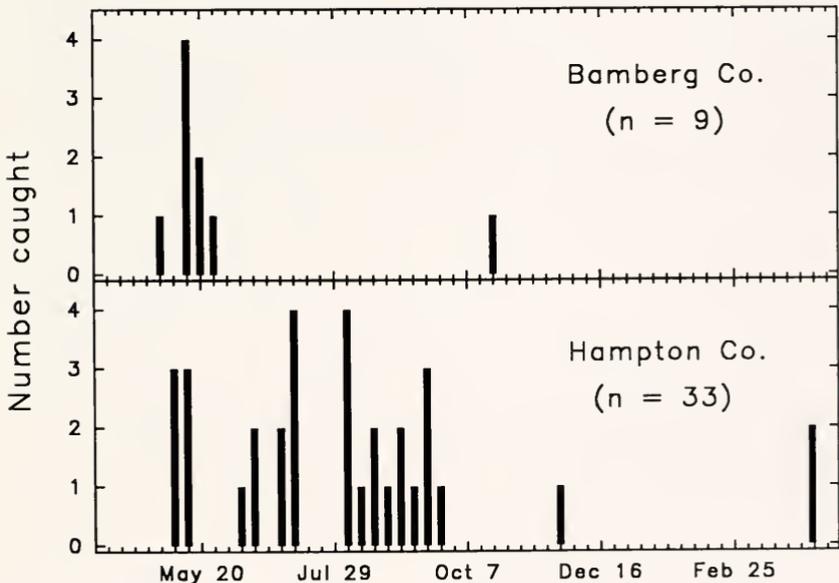


Figure 1. Number of *Lipoptena mazamae* Rondani caught per week on sticky traps at two sites in South Carolina, 1987-88.

the tree shadows bordering wooded areas. A concentrated effort to place traps in areas where hosts are likely to feed and rest would most likely increase the number of volants that are caught. Although sticky traps provide a relatively easy method for collecting hippoboscids, a disadvantage of the method is that they do not provide positive host identification.

#### ACKNOWLEDGMENTS

We thank Mark Culik and Pat Lang for technical assistance; Messrs. Bates, Peeples, and Rentz for allowing us to conduct this study on their farms; and W. W. Wirth and R. V. Peterson (Cooperating Scientist and Scientist, respectively, USDA-ARS, Systematic Entomology Laboratory) for confirming the identifications and reviewing the manuscript.

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## OVERWINTERING AGGREGATIONS OF FEMALE *BRACHYMERIA INTERMEDIA* (HYMENOPTERA: CHALCIDIDAE).<sup>1</sup>

Paul W. Schaefer<sup>2</sup>

ABSTRACT: Discovery of 24 overwintering female *Brachymeria intermedia* in a single aggregation in a window sash in an unheated building; a single female in an attic window 7.4 m above ground; a cluster under felt (tar) paper in a dog house; and in naturally occurring dead stumps or trees—all suggest that any dry, well protected site is suitable for overwintering.

The introduced polyphagous pupal parasite *Brachymeria intermedia* has spread throughout much of the northeastern United States and Canada in close association with its principle host, the gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae). Two, possibly three, generations may occur during a season (Leonard 1981). Adult females of both generations overwinter while males die off before winter (Dowden 1935). Dowden (1935) speculated that overwintering adults "probably hibernate under the bark of dead trees or in similar places". Only decades later are we beginning to fully understand where overwintering occurs.

In Japan, Gytoku (1957) found overwintering *Brachymeria lasus* (Walker) (as *obscurata*) under the bark of a *Chamaechyparis obtusa* Endl. (Cupressaceae) tree with two aggregations totaling ca. 30 wasps on the lower 1.8 m of the south facing side of the trunk.

In laboratory experiments, Simser and Coppel (1980) showed the presence of a chemical that led both *B. lasus* and *B. intermedia* to choose previously used or conditioned overnight resting sites versus new or unconditioned sites. They speculated that this chemically mediated aggregating behavior might extend to overwintering individuals. Produced by adults of both sexes, this aggregation pheromone from *B. intermedia* was later identified as 3-hexanone (Mohamed and Coppel 1987).

Waldvogel and Brown (1978) first reported the discovery of overwintering *Brachymeria intermedia*. Groups of 5 to 15 females were found in tunnels made by wood borers in a dead *Quercus prinus* L. tree in central Pennsylvania. A similar discovery was made 6 January 1983 by Robert Grebeck (USDA, BIIR, Newark, DE) when ca. 15 females were found ca. 60 cm. off the ground in a dead *Pinus rigida* Mill. stump in Belleplain, Cape May Co., New Jersey (B. Grebeck, pers. comm.).

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Overwintering *B. intermedia* also use non-natural sites. I report here on a Dec. 30, 1981 discovery of a single aggregation of 24 female *B. intermedia* found in a window frame/casing in a residence in Wethersfield, Hartford Co., Connecticut. The window was located on an east wall of an unheated shed attached to a family residence. The aggregating females were clustered together in a vertical groove used to receive and hold a cotton sash cord in an old-fashioned counter-balanced window. The groove was in the side of a lower frame in a two-frame window. The cotton cord had worn out and parted, however the end fragment still filled the groove the entire 23 cm length. There was ample space between the cord and the 13 x 13 mm groove in the edge of the window frame so that wasps could move about freely. At the time of discovery, the lower window was raised almost daily but this did not appear to interfere with the overwintering *B. intermedia* as they tended to cluster together against the cotton cord, thereby avoiding being rubbed against the window casing as the sash moved. Wasps were observable only after removing the window jams and removing the sash from the frame. There was no indication of the approach route used to enter this site. The window fit the frame so loosely that it was possible the wasps entered the site simply by passing through the crack between the sash and frame.

In late December 1982, another overwintering female *B. intermedia* was found in a similar location in the same Wethersfield residence. One female was found simply between a loose fitting window sash and its frame. The window was a north facing unheated attic window at a height of 7.4 m above ground level and about 2 m above the roof of the above mentioned shed. This would suggest that overwintering sites are not limited to lower strata.

Others have observed *B. intermedia* overwintering in different artificial situations. Bill Metterhouse (NJ Department of Agriculture, Trenton), in the fall of 1982, found at least 25 female *B. intermedia* overwintering under felt (tar) paper covering a dog house at his residence in Monmouth Co., New Jersey. Furthermore, that spring he found over 50 live *B. intermedia* females on the inside of his cellar windows and many others dead on the basement floor (B. Metterhouse, pers. comm.).

All evidence reconfirms that only *B. intermedia* females overwinter. Overwintering, singly or in aggregations, appears to occur only in concealed, well protected, relatively dry sites, such as in dead trees that have been excavated by other insects, and in man-made objects.

If the pheromone-mediated aggregation behavior of *B. intermedia* females is involved in overwintering, as in over-night site selection, as Simser & Coppel (1980) have speculated, then an artificial aggregation site could be constructed, baited with aggregation pheromone, and

deployed as a survey tool to assess population levels or to measure overwintering survival.

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#### BOOKS RECEIVED AND BRIEFLY NOTED

BUGS OF THE WORLD. G.C. McGavin. 1993. Facts on File. 192 pp.

Another in the "Of the World" series, this is a popular guide to the classification and biology of bugs, by Oxford entomologist, Dr. McGavin.

L'ABDOMEN ET LES GENITALIA DES FEMELLES DE COLEOPTERES ADEPHAGA. T. Deuve. 1993. Tome 155, Memoires du Museum National D'Histoire Naturelle.

With minor differences, this work is reproduced from a doctoral thesis of the University of Paris 6, submitted 25 November 1988 under the title "Morphological and phylogenetic studies on the abdomen and the female ectodermic genitalia of the Coleoptera Adephaga". Present text entirely in French language. Paperback.

## FIRST RECORDS OF PARASITOIDS FOR SLIME MOLD BEETLES OF THE FAMILY SPHINDIDAE (COLEOPTERA: CUCUJOIDEA)<sup>1</sup>

Joseph V. McHugh<sup>2</sup>

**ABSTRACT:** The first three records of parasitoids for the family Sphindidae (Coleoptera: Cucujoidea) are provided: (1) *Sphindus americanus* parasitized by *Pentelicus* sp. (*varicornis* or near) (Hymenoptera: Encyrtidae) in New York, (2) *Carinisphindus* sp. by another *Pentelicus* sp. (probably sp. nov.) in Puerto Rico, and (3) *Eurysphindus comatulus* by *Blacus koenigi* (Hymenoptera: Braconidae) in New York. These observations also represent the first host information for the genus *Pentelicus* and a new host record for *Blacus koenigi*.

Sphindidae is a small family (9 genera and 51 species) of myxomycophagous (slime mold eating) beetles that is represented in every major biogeographical region in the world. Little has been published on the biology of sphindids other than life history notes of one species (Burakowski & Ślipiński, 1987), host food records (see McHugh, 1993 for citations) and a discussion of the possibility of assistance in slime mold spore dispersal (see Blackwell, 1984; McHugh, 1993). During the summer of 1990, simple attempts to rear species of sphindids resulted in the identification of the first parasitoids known for the family.

In June, a few specimens of an undescribed species of *Carinisphindus* were collected from the sporocarp of a myxomycete (*Stemonitis* sp.) in the Caribbean National Forest at El Verde Field Station, elev. 300 M., in Puerto Rico. After the beetles were extracted and the slime mold was examined closely, three *Carinisphindus* pupae were found. Within two weeks, a single parasitoid wasp emerged from each pupa. One specimen was caught and identified as an apparently undescribed species of the encyrtid genus *Pentelicus* Howard (= *Hemaenasius* Ashmead) (J. S. Noyes, pers. comm.).

In late July, a laboratory culture of *Sphindus americanus* LeConte also was found to be parasitized by encyrtid wasps. The beetle culture was started about one month earlier with field-collected sporocarps of *Fuligo septica* (L.) Wiggers from Ithaca, New York. The parasitoid was determined as another species of *Pentelicus*, closely resembling *Pentelicus varicornis* (Girault), but possessing an unusually long first funicle segment. This antennal feature may support recognition as a new species (J. S. Noyes, pers. comm.). Collecting in two subsequent years suggests

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that this *Pentelicus* is most abundant in New York during the latter part of the summer (late July-August), although sporocarps of the slime mold are found colonized by *S. americanus* as early as May.

A culture of *Eurysphindus comatulus* McHugh was established in August from fruiting bodies of *Mucilago crustacea* Wiggers collected in Brooktondale, Tompkins Co., New York. This culture was thought to be free of arthropods other than mites and various life stages of *E. comatulus*, but after two weeks it produced many specimens of the braconid *Blacus koenigi* Fischer. The remains of many parasitized last-instar larvae were found in a characteristic pose. Each larval skin was draped over the top of a white, silky cocoon with the legs wrapped around the cocoon as though holding it.

## DISCUSSION

The *Pentelicus* species parasitizing *Carinisphindus* sp. in Puerto Rico represents the first known parasitoid for a sphindid as well as the first host record for a species of this encyrtid genus. The occurrence of a second *Pentelicus* species parasitizing a species of *Sphindus*, a genus closely related to *Carinisphindus* (see McHugh, 1993), suggests that the association in Puerto Rico was not incidental.

The discovery that *Blacus koenigi* is a parasitoid of *Eurysphindus comatulus* sheds light on the biology of this poorly understood braconid genus. Čapek (1969) states that the tribe Blacini is made up mostly of parasitoids of the larvae of curculionid beetles and related groups, but adds that the taxonomic position of the genus *Blacus* "may be doubted as very little is known about its biology, host relations, etc." later, Čapek (1970) suggests that the biology of *Blacus* involves parasitism of wood boring Coleoptera larvae. Some species of *Blacus* are known to parasitize mycophagous ("true fungus" feeding) beetles (Achterberg, 1975). In a list of label data, Achterberg (1975) also reports that *B. koenigi* was collected from a sporocarp of *Stemonitis fusca* Roth, a myxomycete known to be a host of *E. comatulus* (as well as several other sphindid species). Achterberg adds that this species is "mainly collected in August and first half of October". The parasitized culture of *E. comatulus* was started with slime mold sporocarps collected in August.

All specimens are deposited in the Cornell University Insect Collection with the exception of four specimens of *Pentelicus ?varicornis* which are in the reference collection of J. S. Noyes (The Natural History Museum, London) and 16 specimens of *Blacus koenigi* at the Biosystematics Research Centre (Agriculture Canada, Ottawa).

## ACKNOWLEDGMENTS

I thank P. R. Fraissinet for his help with field work in Puerto Rico and New York. E. R. Hoebeke made original determinations of parasitoids and helped locate additional information. J. S. Noyes provided the final determinations and information about the encyrtids. The determination of specimens of *B. koenigi* was confirmed by M. J. Sharkey. P. R. Fraissinet and E. R. Hoebeke also read and commented on an early version of this note. Funds for the work in Puerto Rico were provided by the Center for International Studies at Cornell University. Other support for this study was provided by NSF Grant No. BSR-87-17401 and Hatch Project No. NY(C)-139426 (both to Q. D. Wheeler).

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## FIRST REPORT OF A TWISTED-WING INSECT (STREPSIPTERA) LARVA IN A CADDISFLY (TRICHOPTERA)<sup>1</sup>

Kenneth L. Manuel,<sup>2</sup> Richard M. Bohart<sup>3</sup>

**ABSTRACT:** A microcaddisfly *Oxyethira janella* (Trichoptera: Hydroptilidae) was observed with a first stage strepsipteran triungulin larva in its abdominal cavity. The triungulinid belongs to the genus *Xenos* or *Pseudoxenos* (Strepsiptera: Stylopidae). This is the first report associating Strepsiptera with Trichoptera.

While identifying adult aquatic insects, the senior author removed a strepsipteran triungulin larva from the abdominal cavity of a female microcaddisfly, *Oxyethira janella*. The *O. janella* specimen was collected by light trap on the South Fork Edisto River, a Coastal Plain sand bottomed blackwater river near Cope, Orangeburg County, South Carolina, on October 22, 1990. Subsequently, the junior author identified the strepsipteran as a first stage larva of either *Xenos*, a *Polistes* wasp parasitoid, or *Pseudoxenos*, a parasitoid of sphecids and eumenid wasps. The mounted triungulin specimen is in the University of California at Davis Insect Museum.

*Polistes* wasp colonies are extremely common in the dense riparian vegetation overhanging the South Fork Edisto River. Roving triungulin larvae released from strepsipteran parasitized wasps may come into contact with caddisflies and other insects seeking daytime shelter in the low light, high humidity environment of the riparian vegetation.

The *O. janella* specimen containing the triungulinid in its abdomen was probably incidentally "parasitized." Due to the relative short life span of most caddisfly adults, a strepsipteran may not be able to complete its life cycle in a caddisfly even if it were physiologically adapted to the host's body. In addition, the small (1 mm long) abdomen of *O. janella* may not allow the complete development of the triungulin larva to an adult.

To our knowledge, no aquatic insect has been reported as a normal or incidental strepsipteran host. Aquatic entomologists, however, may wish to look for additional examples of strepsipteran "parasitism" while they are involved in adult aquatic insect identification.

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## A METHOD FOR SEX DETERMINATION OF THE COLORADO POTATO BEETLE PUPA, *LEPTINOTARSA DECEMLINEATA* (COLEOPTERA: CHRYSOMELIDAE)<sup>1</sup>

Yvan Pelletier<sup>2</sup>

**ABSTRACT:** A method for the determination of the sex of the Colorado potato beetle *Leptinotarsa decemlineata*, at pupal stage is presented. This method is based on sexual differences of the external morphology of pupae. External morphology differences between sexes at adult stage are also depicted.

The sex of the adult Colorado potato beetle can be determined by examining morphological differences of the last abdominal sternite (Rivnay 1928). The available graphic representations (Busvine 1980; Rivnay 1928) do not clearly show the distinctive characters. Rivnay (1928) provided a drawing of the ventral view of the tip of the abdomen of the female only. Busvine (1980) depicted the tip of the abdomen for both male and female but his schematic drawings are difficult to interpret. Pictures (Fig. 1c, d) show more visibly that the distal end of the last sternite is depressed with a somewhat truncated border in the male; whereas the depression is absent and the posterior border rounder in the female.

The determination of the sex of Colorado potato beetle pupae would be useful in situations where sexual dimorphism influenced larval parameters such as larval weight (Pelletier and Smilowitz 1991). This would reduce the time delay before sex determination and, more importantly, would allow sex determination of a larger proportion of beetles, otherwise reduced by mortality during the pupal stage. A method for the determination of the sex of Colorado potato beetle pupae is described for the first time.

I observed that the 7th visible sternite of males is complete and depressed in its center (Fig. 1a) and the posterior margins of the 6th visible sternite is somewhat truncated. In females, the 7th visible sternite is divided in its center by a suture that is usually dark in color (Fig. 1b). The center of the 6th visible segment extends slightly posteriorly. To validate this method, 100 fully grown larvae collected from the field were individually caged in 1 oz cups filled with soil and allowed to pupate. The sex

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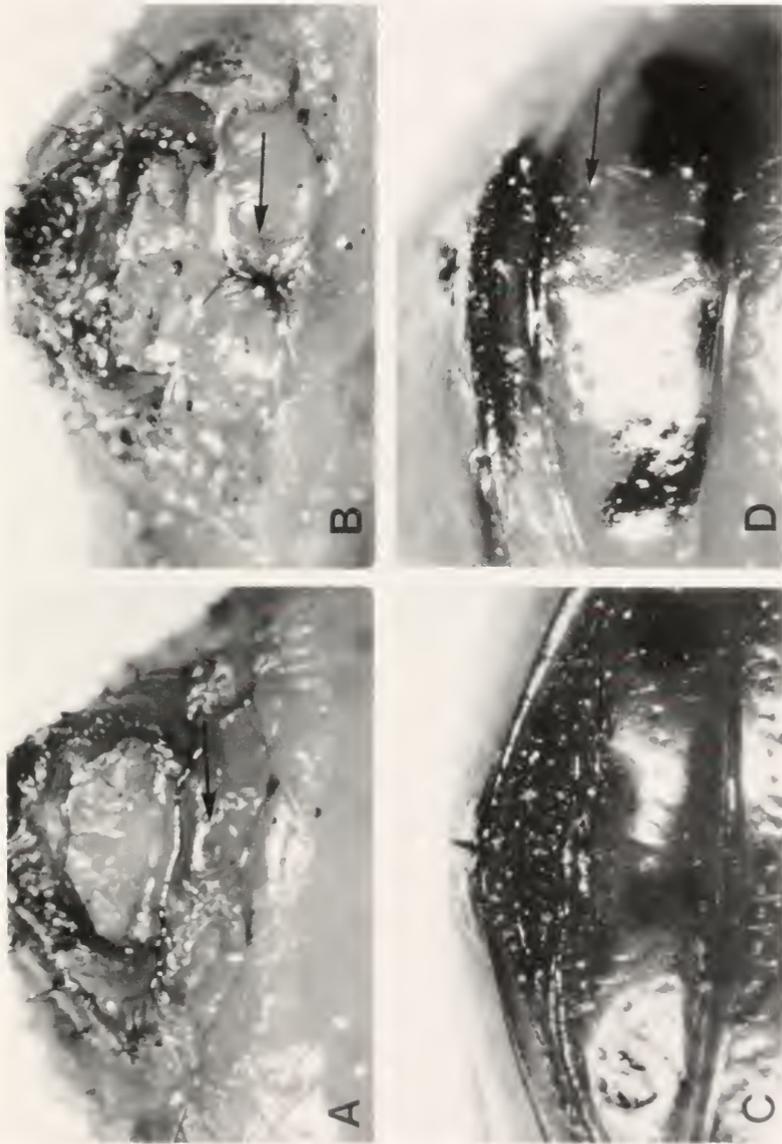


Figure 1. Ventral view of the tip of the abdomen of male (A) and female (B) pupa and male (C) and female (D) adult of the Colorado potato beetle.

was then determined using the characters described above and each pupa put back in its container. After emergence, each adult was sexed again using the descriptions reported by Ravnay (1928) and Busvine (1980). Sex determinations conducted on pupal and adult stages corresponded in all cases.

#### ACKNOWLEDGMENTS

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Figure 1. Ventral view of the tip of the abdomen of male (A) and female (B) pupa and male (C) and female (D) adult of the Colorado potato beetle.

# ESTABLISHMENT OF *UROPHORA QUADRIFASCIATA* (DIPTERA: TEPHRITIDAE) AND *CHRYSOLINA QUADRIGEMINA* (COLEOPTERA: CHRYSOMELIDAE) IN PORTIONS OF EASTERN UNITED STATES<sup>1</sup>

E. Richard Hoebeke<sup>2</sup>

**ABSTRACT:** This paper presents the first recorded distribution in the eastern United States of the introduced weed biocontrol agents *Urophora quadrifasciata* (Diptera: Tephritidae) and *Chrysolina quadrigemina* (Coleoptera: Chrysomelidae). The seed-head fly *U. quadrifasciata*, released in North America in the early 1970's for the control of spotted and diffuse knapweed (*Centaurea* spp.), is recorded from numerous localities in New York, Pennsylvania, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New Jersey. The leaf beetle *C. quadrigemina*, released in the mid-1940's for the control of St. Johnswort (*Hypericum perforatum*), is also documented from the northeastern U.S. with records from New York, Pennsylvania, Ohio, West Virginia, and Maryland. A brief review of the history and background information on the success of these two weed biocontrol agents in North America are presented. Each of the biocontrol agents are also briefly described.

This paper provides a brief review and background information on two classical weed biocontrol projects that continue to attain moderate success in managing two of North America's most dominant and abundant introduced weeds on uncultivated land: spotted knapweed (*Centaurea maculosa* Lamarck) and St. Johnswort (*Hypericum perforatum* L.). The principal focus of this paper emphasizes new distributional data in the eastern United States for the introduced fruit fly *Urophora quadrifasciata* (Meigen) and the leaf beetle *Chrysolina quadrigemina* (Suffrian). Both biocontrol agents were primarily released in western North America for control of spotted knapweed and St. Johnswort, respectively. These distributional records provide the first evidence of establishment of these introduced biocontrol agents in the eastern United States.

## I. The weed: *Centaurea maculosa* (Asteraceae)

Spotted knapweed is a herbaceous composite and short-lived perennial introduced from Europe to the dry rangelands of western North America (Harris, 1980; Harris & Myers, 1984). Because of its allelopathic

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properties, low forage value, and drought adaptations, this knapweed species has been able to displace and outcompete most other herbaceous plants over vast areas of its new homeland (Harris & Myers, 1984). It was first collected in North America at Victoria, British Columbia in 1893 (Groh, 1943). In western Canada, it is distributed in British Columbia and Alberta (Watson & Renney, 1974). The main areas of infestation (> one million ha) are confined to the western United States in Montana, Idaho, Washington, and Oregon (Maddox, 1982). In eastern North America, this weed is common in Ontario, Quebec, and the Maritimes in Canada (Frankton & Mulligan, 1970), and along roadsides and in fields and waste areas in the northeastern and northcentral United States (Cox, 1985).

### The biocontrol agent: *Urophora quadrifasciata*<sup>1</sup> (Tephritidae)

Members of *Urophora* Robineau-Desvoidy (Diptera: Tephritidae) have been widely employed as biocontrol agents of thistles and knapweeds of the composite family Asteraceae (=Compositae). The genus contains almost 100 known species distributed in Europe, temperate Asia, Africa and the New World (White & Elson-Harris, 1992). Two *Urophora* species, both of European origin and collectively referred to as the seed-head flies, have been successfully introduced into western North America for biocontrol of spotted knapweed (*C. maculosa*) and diffuse knapweed (*C. diffusa* Lamarck). *Urophora affinis* (Frauenfeld) and *U. quadrifasciata* (Meigen) oviposit into the developing inflorescences of *Centaurea* species, induce gall formation, and ultimately reduce seed production (Harris, 1980; Harris & Myers, 1984).

The usually univoltine *U. affinis* was originally released in British Columbia (Ned's Creek) in 1970 and 5 western states in 1973 (Harris, 1980; Maddox, 1979; Story & Anderson, 1978; Story, 1985). By 1992, *U. affinis* had been confirmed as established and increasing in abundance in British Columbia, Idaho, Oregon, Montana, Washington and Wyoming (Julien, 1992). Releases of *U. affinis* occurred in the east in 1971 (Ontario), 1979-1980 (Quebec), and 1983 (Maryland and New York) (Harris & Myers, 1984; pers. commun., Stephen D. Hight, USDA-ARS, Insect Biocontrol Laboratory, Beltsville, MD). Eastern establishment had been confirmed as of 1992 in New York, Quebec, and Virginia (Julien, 1992).

<sup>1</sup> In the Palearctic, *Urophora quadrifasciata* may actually represent a species complex (see White & Clement, 1987), with more than one species confused under the name *quadrifasciata*.

The bivoltine *U. quadrifasciata* was first introduced in 1970 at Ned's Creek, British Columbia, but was not released in the western United States (Story, 1985). By May 1981, larvae of *U. quadrifasciata* had been found in spotted knapweed seed heads examined at a site in extreme northwest Montana, ca. 400 km from the Ned's Creek original release site (Story, 1985). By 1982, *U. quadrifasciata* was known to be established in northwest and westcentral Montana (Story, 1985). Specimens of *U. quadrifasciata* had been released and become established in Quebec in 1979 (Julien, 1982) and 1980 (Harris & Myers, 1984). Between 25-31 May 1983, seed heads of field-collected spotted knapweed from British Columbia were released by USDA-ARS personnel at 3 sites in New York (Warren, Essex, and Tompkins counties) and at Beltsville, Maryland. This material contained larval stages of both *U. quadrifasciata* and *U. affinis*. A 1985 follow-up survey recovered only *U. affinis* at the Warren and Essex County release sites located in the Adirondack region of northern New York (pers. commun., S. D. Hight).

In Tompkins Co. (Trumansburg), New York, during July 1990, numerous small tephritid flies were collected from the immature flower heads of tyrol knapweed, *C. dubia* Suter, a common knapweed of the fields and roadsides of southeastern Canada and northeastern U.S. (Gleason & Cronquist, 1991). The flies were identified as *U. quadrifasciata* (by the author and later confirmed), and a survey was initiated to determine the geographic range in the northeast of this introduced seed-head fly. The survey was conducted throughout portions of the northeastern states during June-September 1990-1992. During the survey, no specimens of *U. affinis* were collected from knapweed.

In the following list of distributional data for *U. quadrifasciata*, the abbreviations ERH (for the author) and AGW (for A. G. Wheeler, Jr.) for collectors are used; dates of collection are expressed as "day-month (Roman numeral)-year"; and hosts are abbreviated as follows: *C. maculosa*, spotted knapweed (SK); *C. dubia* (= *C. nigrescens* & *C. vochinensis*), short-fringed knapweed (SFK); and *C. jacea*, brown knapweed (BK). Treatment and usage of scientific and common names of *Centaurea* follow Gleason and Cronquist (1991). The data below are also mapped in Figure 1. All specimens, unless stated otherwise, are deposited in the Cornell University Insect Collection. The author and A. G. Wheeler, Jr. take responsibility for the host plant identifications, with the exception of *C. dubia* (see acknowledgments).

UNITED STATES: CONNECTICUT: Tolland Co., 1-84 West, N. of E. Willington, 11-VIII-90, AGW, SK. MASSACHUSETTS: Plymouth Co., Rte. 58, nr. South Carver, 5-VIII-90, AGW, SK. WORCESTER Co., Gardner, 4-VIII-90, AGW, SK. NEW HAMPSHIRE: Hillsboro Co., Nashua, 5-VIII-90, AGW, SK. NEW JERSEY: Hunterdon Co., Exit 11 on

Rte. 78, 12 mi. E. Phillipsburg, 10-VIII-91, ERH, SK. Sussex Co., High Point St.Pk., 28-VII-90, AGW, SK; Rte. 23, nr. High Point St. Pk., 28-VII-90, AGW, SK. NEW YORK: Allegany Co.: Rte. 17, Exit 33 (to Alfred), 7-VIII-92, ERH, SK; Rte. 17, 0.5 mi. E. Exit 37, 7-VIII-92, ERH, SK; Alfred, 7-VIII-92, ERH, BK. Broome Co.: Binghamton, Junct. Rte. 81 and Rte. 12, 17-VIII-90, ERH, SK. Chemung Co., West Elmira, 30-VI-92, ERH, SK; Pine City, 30-VI-92, ERH, SK; Elmira Heights, 7-IX-92, ERH, SK. Chenango Co., Brisben, 17-VIII-90, ERH, SK; Norwich, 17-VIII-90, ERH, SK. Clinton Co., Rte. 456 @ junct. Rte. 87 E. of Beekmantown, 29-VIII-92, AGW, SK; I-87, Exit 36, S. of Plattsburgh, 2-VIII-92, AGW, SK. Dutchess Co., I-84 West, rest area nr. Stormville, 11-VIII-90, AGW, BK. Greene Co., I-87 North, nr. Catskill, 3-VIII-90, AGW, SK. Jefferson Co., Plesis, 16-VIII-92, AGW, SK; Wellesley Island St.Pk., 16-VIII-92, AGW, SK. Madison Co., DeRuyter, 17-VIII-90, ERH, BK?; New Woodstock, 14-VII-91, ERH, SK. Ontario Co., nr. E. Victor (Farmington), 5-VII-92, ERH, SK. Orange Co., I-84 East, nr. Middletown, 3-VIII-90, AGW, SK. Putnam Co., Rte. 202, nr. Brewster, 11-VIII-90, AGW, BK. Rensselaer Co., Johnsonville, 3-VIII-90,



Figure 1. Northeastern United States. Distribution of *Urophora quadrifasciata* based on examined specimens (dots). Known release sites (NY: Essex, Tompkins, and Warren counties; MD: Beltsville) (stars).

AGW, SK. Saratoga Co., I-87 North, nr. Ushers, 3-VIII-90, AGW, SK. Schuylker Co., Alpine Junction, 6-VIII-92, ERH, SK; Watkins Glen, 31-VIII-90, 15-VIII-92, ERH, SK. Steuben Co., Bath, 31-VIII-90, ERH, SK. Tioga Co., Owego, 17-VIII-90, ERH, SK; Waverly, 17-VIII-90, ERH, SK. Tompkins Co., Ithaca, 14-VI-91, ERH, SK; Trumansburg, 21-VII-91, 27-VI-92, ERH, SK; Town of Ulysses, N. of Jacksonville, 15-VIII-89, 11.13.16-VII-90, 15-VIII-90, 12.15.17.20.27.VI-91, 25-VII-91, 15-VIII-91, 22-VI-92, 10.12.29-VII-92, ERH, SK. Ulster Co., Mohonk Preserve, nr. New Paltz, 3-VIII-90, AGW, SK. Warren Co., Peggy Ann Rd., W. of Glens Falls, 3-VIII-90, AGW, SK. Yates Co., 10 mi. N. of Watkins Glen, @ junct. Rte. 42 and 14, 4-IX-90, ERH, SK. PENNSYLVANIA: Bradford Co., Sayre, 17-VIII-90, ERH, SK; Wysox, 17-VIII-90, ERH, SK. Carbon Co., Rte. 534, 0.3 mi. S. of junct. Rte. 940 nr. East Side, 15-VII-90, AGW, SK. Cumberland Co., Rte. 114 @ junct. I-81, nr. Hogestown, 18-VII-90, AGW, SK. Dauphin Co., Rte. 39, nr. junct. Rte. 322 N. of Harrisburg, 16-VII-90, AGW, SK. Lackawanna Co., I-84 East, Mt. Cobb exit, 25-VII-90, AGW, SK. Lancaster Co., Rte. 272, N. of Buck, 24-VII-090, AGW, SK. Lebanon Co., Rte. 934, Indiantown Natl. Cem., 15-VII-90, AGW, SK. Luzerne Co., Rte. 93 @ I-81, nr. West Hazleton, 15-VII-90, AGW, SK. Lycoming Co., nr. Loyalsock, 28-VII-91, ERH, SK; Muncy, 20-VII-90, K. Valley, SK. Monroe Co., Tobyhanna, 21-VII-90, AGW, SK. Pike Co., Rte. 402, nr. Blooming Grove, 28-VII-90, AGW, SK. Schuylkill Co., Rte. 443, nr. New Ringgold, 23-VII-90, T. Price, SK; Frackville, 15-VII-90, AGW, SK. Sullivan Co., Sonestown, 20-VII-90, K. Valley, SK. Susquehanna Co., Montrose, 17-VIII-90, ERH, SK. Wayne Co., Angels, 21-VII-90, AGW, SK. RHODE ISLAND: Kent Co., West Warwick, 5-VIII-90, AGW, SK. VERMONT: Chittenden Co., Camp Johnson, Colchester, 28-VIII-92, AGW, SK. Franklin Co., Missisquoi Natl. Wildlife Refuge, 28-VIII-92, AGW, SK.

**Comments.** Adults of *U. quadrifasciata* and *U. affinis* are superficially similar. Females of both species can be easily separated using the key in White & Clement (1987:575). Among the chief characters that distinguish *U. quadrifasciata* are the four complete, transverse, black bands and yellow base of the wing, with the first (or basal) and second transverse bands broadly united at the costal margin (see Figure 8 of Plate II in Freidberg & Kugler, 1989). In contrast, adults of *U. affinis* are recognized by having 3 or 4 transverse bands (variable in intensity and completeness), with the first band, when present, less pronounced than the other three and separated from the second transverse band (as in Figures 2-3 of Plate II in Freidberg & Kugler, 1989).

The Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ) of the USDA is initiating a biocontrol program for diffuse and spotted knapweed in the eastern states (states invited to participate in 1992 include Pennsylvania, New York, Michigan, and Virginia). The locality records reported herein represent a "prerelease inventory", establishing important base line data on existing *U. quadrifasciata* populations in eight northeastern states.

## II. The weed: *Hypericum perforatum* (Hypericaceae)

St. Johnswort (also klamath weed or goatweed), *Hypericum perforatum*, a weed native to Europe, northern Africa, and large portions of

Asia to China and Japan, was introduced into Australia and North America. On the latter continent, it has become a serious weed on rangelands in dry areas (Johansson, 1962). The first known introduction of St. Johnswort into the United States was reported in 1793 near Lancaster, Pennsylvania. By 1900 it had spread westward and was reported in California around the Klamath River, which provides the basis for one of the plant's common names (Rosenthal *et al.*, 1984). It is a hardy, deep-rooted, perennial herb occurring in neglected meadows, fields, and pastures and along roadsides from Newfoundland to Manitoba, south to Florida and Texas, and in the far West from British Columbia to central California (Cox, 1985). It remains a noxious rangeland weed only in the western United States (Johansson, 1962).

In heavily infested areas, this weed is especially injurious by displacing valuable and desirable forage plants. It is also toxic to livestock when ingested in considerable quantities, causing a photodermatitis on unpigmented areas of grazing livestock exposed to direct sunlight (Johansson, 1962).

#### The biocontrol agent: *Chrysolina quadrigemina* (Chrysomelidae)

The first use of insects as a means of weed control in North America was initially attempted in the mid-1940's with two European species of leaf beetle (*Chrysolina*) that feed on St. Johnswort, *H. perforatum* (Holloway & Huffaker, 1951). *Chrysolina hyperici* (Förster) and *C. quadrigemina* (Suffrian) [= *gemellata* auct. and *geminata* auct.] have become established in release areas in western and eastern North America, with the latter species exhibiting a greater ability to increase its distributional range, particularly in California (Holloway & Huffaker, 1951).

*Chrysolina hyperici* was introduced into California (via Australia) in 1945 and is now established in many localities in the West, including Oregon, Washington, Idaho, Montana, Colorado, and British Columbia. Similarly, *C. quadrigemina* was introduced into California (via Australia) in 1946, and is also established in the same areas as *C. hyperici*. Another species, *C. varians* (Schaller), was introduced for the biocontrol of *Hypericum* in British Columbia where it remains established and apparently restricted (Johansson, 1962; Brown, 1962).

Populations of *H. perforatum* were dramatically reduced when both *C. hyperici* and *C. quadrigemina* were introduced into Australia (Clark, 1953), the United States (Holloway & Huffaker, 1951; Holloway, 1957), and western (British Columbia) and eastern Canada (Ontario and Nova Scotia) (Smith, 1958; Harris & Maw, 1984). A relatively small number of specimens of *C. hyperici* (252) and *C. quadrigemina* (182) were originally released in eastern Ontario in 1969 and 1970, respectively, for control of

St. Johnswort (Harris & Maw, 1984). Fields *et al.* (1988) demonstrated that 18 years after their initial release both species of leaf beetle had spread nearly 90 km from the original release site near Picton, Ontario. They also concluded that the present distribution of *Chrysolina* spp. in eastern Canada was probably due to natural dispersal, and that both species were capable of finding widely separated stands of the host plant.

No systematic release of either *Chrysolina* species has occurred in the eastern United States. However, *C. quadrigemina* has been collected from several widespread localities in New York, Pennsylvania, Maryland, West Virginia, and Ohio, since 1989. Several states in the east have not been surveyed; therefore, no statement can be made about the presence or absence of this species in these regions. The known distributional records for *C. quadrigemina* document its establishment and range expansion in the eastern United States, apparently resulting from a natural dispersal of populations from eastern Ontario. These data are recorded below and mapped in Figure 2. All specimens were collected from *H. perforatum*, unless stated otherwise. The host plant iden-



Figure 2. Northeastern United States. Distribution of *Chrysolina quadrigemina* based on examined specimens (dots). Known release site (near Picton, Ontario) (star).

tifications, where noted, are provided by the author and other collectors. The leaf beetle determination is the responsibility of the author.

The New York and Pennsylvania specimens are deposited in the Cornell University Insect Collection; Ohio and West Virginia specimens in the collection of the West Virginia Department of Agriculture, Charleston, WV; and Maryland specimens in the collection of the Maryland Department of Agriculture, Annapolis, MD.

UNITED STATES: MARYLAND: Prince Georges Co., Brandywine, 1-V-91, C. L. Staines. NEW YORK: Cattaraugus Co., Allegany St. Pk., 24 July 1985, A. E. Hajek. Chemung Co., no specific locality, 1-VII-90, C. Klass. Erie Co., Tonawanda, 3-VII-92, E. R. Hoebeke. Ontario Co., Geneva, 16-VI-91, ERH; along Rte. 90, W. of Geneva exit, 16-VI-91, ERH. Tompkins Co., Ithaca, 10-VII-89, 12-IX-90, C. Klass; Ithaca, Sept.-Oct. 1990, R. Campbell (student collection); Ithaca, Forest Home Wildflower Garden, 1-X-89, ERH; Town of Ulysses, N. of Jacksonville, 15.17.20-VI-91, ERH; Trumansburg, fairgrounds, 1-VII-90, ERH; Trumansburg, Falls Rd. nr. H. A. Smith Woods, 6-VII-89, ERH; Trumansburg, Taughannock Falls St. Pk., 6-VII-89, ERH. OHIO: Ashland Co., Mohican Mem. St. For., 30-V-87, S. M. Clark. PENNSYLVANIA: Berks Co., Slote Nurseries, nr. Angelica, 25-X-90, AGW. Centre Co., Scotia Barrens, 29-VI-91, A. G. Wheeler, Jr. WEST VIRGINIA: Greenbrier Co., Anthony, 9-VI-92, SMC. Pocahontas Co., Cass, 8-VII-92, SMC, ex. *H. punctatum*. Randolph Co., Cheat Mountain, 1 mi. n. Barton Knob, 3800 ft. elev., 8-VII-92, SMC. Tucker Co., Dolly Sods Scenic Area, 16-IX-92, SMC.

**Comments.** Of the sixteen *Chrysolina* species recorded in North America (Brown, 1962), *C. quadrigemina* can be generally distinguished from its congeners in eastern North America by the following characteristics: its color (blue, blue-green, brassy green, or bronze individuals with venter and legs dark blue or blue-green); its distinctly larger, more robust size (6.0-7.1 mm); and, in the male, by the presence of a saucer-shaped impression on abdominal sternite V, and by the size and details of the aedeagus (Brown, 1962; Wilcox, 1972; Frazer & Emberson, 1987).

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## DESCRIPTIONS OF IMMATURE STAGES OF *NEMATUS DESANTISI* (HYMENOPTERA: TENTHREDINIDAE), A PEST OF SALICACEAE IN ARGENTINA AND CHILE<sup>1</sup>

Sergio M. Ovruski<sup>2</sup>, David R. Smith<sup>3</sup>

**ABSTRACT:** The egg, first- and last-instar larvae, prepupa, and pupa of *Nematus desantisi* Smith are described and illustrated. This species is a serious pest of *Salix* spp. and *Populus* spp. in Argentina and Chile.

Only three species of the tenthredinid subfamily Nematinae are known in South America: *Pristiphora brasiliensis* Malaise, *P. plaumanni* Wong, and *Nematus desantisi* Smith. Host plants of the *Pristiphora* species are unknown. *Nematus desantisi* is a serious pest of *Salix* spp. in much of Argentina and Chile, but it has also been recorded from *Populus* spp. in Argentina (Gianti and Dapoto 1990). Reproduction of *N. desantisi* is by thelytokus parthenogenesis (De Santis and Gallego de Sureda 1984), which facilitates its development as a pest.

The earliest record of *N. desantisi* is from Chubut, Argentina, in 1980 (De Santis 1981), and shortly after it was described by Smith (1983). Later it was collected in Chile (González *et al.* 1986, González 1989) and in the Argentina provinces of Rio Negro, Neuquén, Mendoza, San Juan, San Luis, Buenos Aires (De Santis and Gallego de Sureda 1984), Catamarca (Vattuone 1989), and Tucumán, Salta, and Jujuy (Ovruski 1991, Ovruski and Fidalgo, 1991). De Santis and Gallego de Sureda (1984), Mallea *et al.* (1985), González *et al.* (1986), González (1989), and Gianti and Dapoto (1990) provided some biological data and gave brief descriptions of the egg, late-instar larva, cocoon, pupa, and adults.

This paper, part of the graduation thesis of the senior author (Ovruski 1991) includes a detailed description of the egg, external morphology of the first- and last-instar larvae, prepupa, and pupa of this serious pest. The descriptions are from series of specimens collected on willow in Tafi del Valle, Tucumán Province, Argentina, in January, March, and October of 1990, and reared in the laboratory. Larval terminology is based largely on that of Wong (1963).

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## Description of Immature Stages

**Egg** (Fig. 1). Length, 1.0-1.2 mm. Entirely green; elongated kidney-shaped with one end narrow and slightly curved, averaging from 0.26-0.28 mm in diameter; other end broader, averaging from 0.37-0.39 mm in diameter, with narrowly rounded apex; chorion smooth. Described from numerous series of eggs laid in leaves on first day of oviposition, and from mature ovarian eggs from females reared in laboratory.

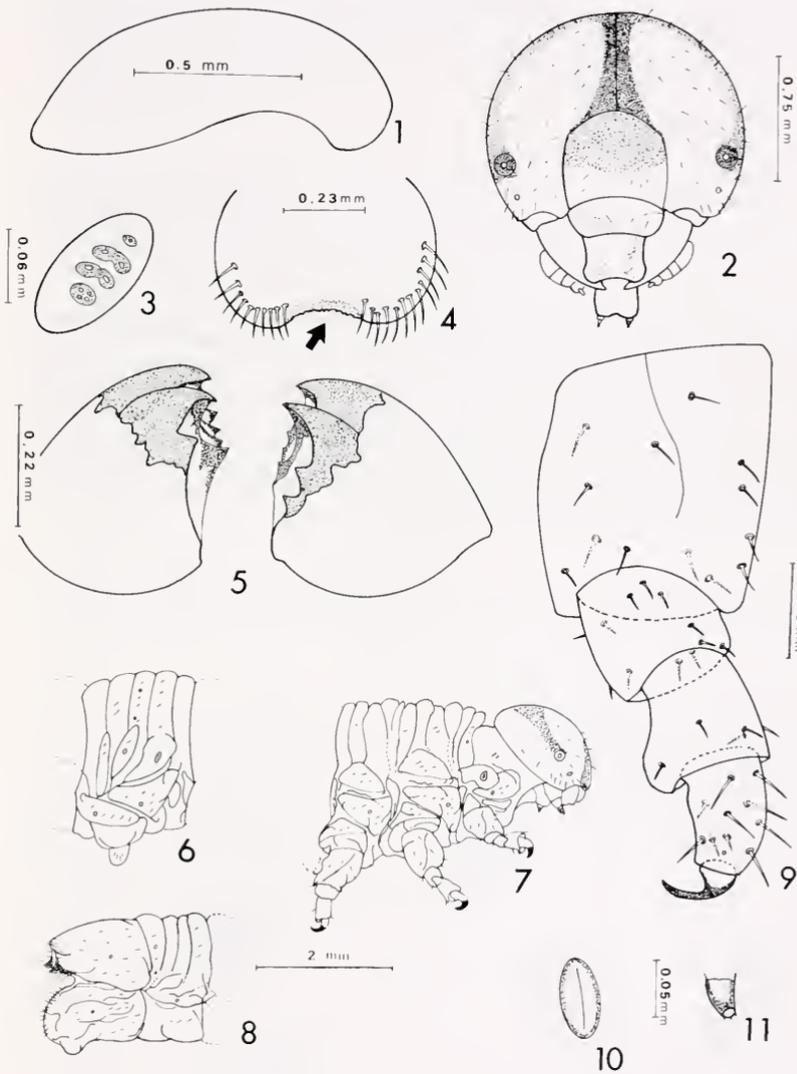
**Last-instar larva** (Figs. 2-11, 18). Length, 17-20 mm. Head capsule pale yellow with black eyespots; longitudinal dark brown to black band present along coronal suture, and a light brown band from vertex laterally to each ocellarium; dorsal half of frons, antenna, clypeus, maxillary palpus, labial palpus, and basal part of mandible light brown; apex of mandible black.

Body entirely green when alive, with two darkened dorsolateral lines; thoracic legs pale yellowish with dark brown tarsal claws; apex of epiproct and caudal protuberances (pseudocerci of Middleton 1921) light brown.

Head capsule (Fig. 2) circular in front view, with few scattered setae that are about 0.09 mm long and slightly longer setae on genae. Antenna (Fig. 3) with 4 segments, each reduced to short sclerotized pieces included in oval antacoria; 1st segment very small and subcircular, its diameter at least half diameter of apical segment and bearing light colored sensory pit; 2nd and 3rd segments crescent-shaped and almost equal in size, each with two light-colored sensory pits; 4th (apical) segment subcircular and bearing four light-colored sensory pits. Clypeus wider than long and bearing 4-6 setae. Inner surface of labrum (Fig. 4) with apical margin emarginate and sinuous at the middle, lateral margins rounded, with 10-12 long setae on each side. Mandibles asymmetrical, strongly sclerotized; each with two large sharp teeth and five smaller lateral teeth (Fig. 5). Maxillary palpus 4-segmented, 2nd segment with 1 seta, longer than 3rd and 4th segments combined; lacinia with 10-12 short spines; palpifer with 4 setae. Labial palpus 3-segmented.

Prothoracic, mesothoracic, and metathoracic terga (Fig. 7) each apparently divided into 4 annulets and with few setae. Prothorax with a large spiracle and a single pore slightly below spiracle. Second prothoracic annulet bearing one pore positioned dorsolaterally. Mesothoracic and metathoracic segments similar to each other; preepipleurite with 5-6 setae and a single pore; postepipleurite with 2 setae. Middle thoracic leg (Fig. 9) with subrectangular coxa, 1.25X longer than wide, with 13-16 scattered setae each about 0.09 mm long; trochanter subquadrate, slightly longer than broad, with 10-12 setae that are 0.05 mm in length; femur subcylindrical, with 6-7 setae similar to the former and 1 seta on femoral process; tibia subcylindrical, 2X longer than wide, with 7-8 scattered setae that are 0.10 mm in length and 3-4 shorter setae and one pore on apical margin; tarsus with a simple claw.

Abdominal segments 2-7 and 10 with prolegs (Fig. 18); segments 1-8 each with 5 dorsal annulets; 9th segment divided into 4 annulets, and 10th without annulets. Third abdominal segment (typical abdominal segment) as follows (Fig. 6): 1st and 5th annulets glabrous; 2nd annulet with vertical row of 4 setae dorsolaterally; 3rd annulet with vertical row of 4 setae and 2 pores on dorsum and pleuron; 4th annulet with 2 setae located subdorsally; with small spiracle; postspiracular area with 1 pore and 1 seta above pore (sometimes absent); preepipleurite nearly always with 5 setae (occasionally 4) and a single pore; postepipleurite usually with longitudinal row of 5 setae and 1 pore; an emarginate lobe bearing 2 setae posterior to postspiracular area; proleg usually with 3 to 4 setae. Ninth segment apparently with 4 dorsal annulets, distribution of setae and pores as in Fig. 8. Epiproct with a pair of caudal protuberances, several short setae and 1 pore. Numerous setae about 0.10 mm in length on subanal and suranal lobes (Fig. 8). Spiracles of abdominal segments 1-7



Figs. 1-11. *Nematus desantisi*. 1, Egg. 2-11, Last-instar larva. 2, Head capsule, front view. 3, Antenna. 4, Inner surface of labrum. 5, Left and right mandibles, dorsal view. 6, Third abdominal segment. 7, Head and thorax. 8, Apical abdominal segments. 9, Middle thoracic leg. 10, Spiracle of third abdominal segment. 11, Pore.

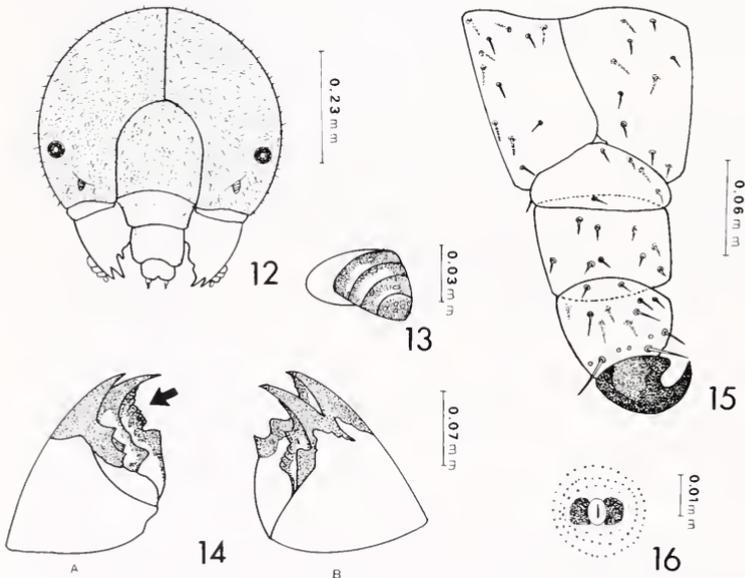
vertical, oval-shaped, and 2.25X longer than wide (Fig. 10), 8th abdominal spiracle longer and very similar to prothoracic spiracle. Pores with 3 dark sharp protuberances on edge of opening (Fig. 11). Eversible ventral glands present on abdominal segments 1-7, situated between and slightly anterior to prolegs (not evident unless fully extended). Integument with very small grayish granules.

Described from a series of 10 larvae, collected from *Salix humboldtiana* Willdn., and *S. babylonica* L. in Tafi del Valle.

**First-instar larva** (Figs. 12-17).— Length, 1.5-2.0 mm at hatching, and reaching to 3.5-4.0 mm at beginning of second instar. First-instar (Fig. 17) similar to last-instar, except for coloration of head capsule, mouthparts, thoracic legs, epiproct and caudal protuberances, morphology of antenna, mandibles, thoracic legs, and abdominal spiracles, and distribution, number, and types of setae on head capsule, thorax, and abdomen.

Head capsule and mouthparts brownish black, same color as thoracic legs, except trochanters which are greenish brown. Body, at hatching, translucent with grayish tone, but pale green after feeding. Apex of epiproct and caudal protuberances dark brown.

Head capsule (Fig. 12) with numerous small setae each about 0.02 mm in length. Antenna (Fig. 13) elongate, cone shaped; basal 3 segments ring-shaped and apical segment subconical; diameter of 1st segment subequal to length of antenna, bearing 2 light-colored sensory pits; 2nd and 3rd segments bearing a single light-colored sensory pit, and 4th segment bearing 4 light-colored sensory pits. Left mandible (Fig. 14A) with 7 sharp teeth, 2 of which are very large and sharp, and a single, large, saw-shaped tooth; right mandible (Fig. 14B) with 6 sharp teeth and 1 large saw-shaped tooth.



Figs. 12-16. *Nematus desantisi*, first instar larva. 12, Head capsule, front view. 13, Antenna. 14A, Dorsal view of left mandible. 14B, Dorsal view of right mandible. 15, Middle thoracic leg. 16, Spiracle of third abdominal segment.

Middle thoracic leg (Fig. 15) with coxa subquadrate, bearing 20-22 scattered short setae each about 0.02 mm in length; trochanters subtriangular, 2X broader than long, with 6 short setae; femur subquadrate, 1.25X broader than long, with 9-10 short setae; tibia subquadrate, with 5 setae each about 0.03 mm in length, and 6-7 setae 0.015 mm in length, 2 large setae each about 0.05 mm in length and 4 pores near apical margin; tarsus with a large, curved tarsal claw.

Third abdominal segment with vertical row of 3 setae on both 1st annulet and 2nd annulets; vertical row of 4 setae on 4th annulet; 3rd and 5th annulets glabrous; spiracle subcircular (Fig. 16), about as long as wide, with brownish spots on anterior and posterior sides, and grayish granules surrounding it on all sides; postspiracular area with 2 setae; preepiplurite with 5-6 setae; postepiplurite with longitudinal row of 6-7 setae; 3 setae on lobe posterior to postspiracular area; proleg with 6, occasionally 7, setae. Pores not found.

Described from 10 larvae reared in the laboratory.

**Prepupa and pupa** (Figs. 19, 20).— Initially (first day), prepupa very similar to last-instar larva. On second day, body curved and reduced in size, averaging 7.5 mm in length (Fig. 19). Head capsule pale green, but with light brown lateral bands, longitudinal blackish band on coronal suture, and light brown spot on frons; thoracic legs greenish brown and body dark green.

Pupa initially somewhat tough, entirely green with light brown eyes, averaging 7.8 mm in length; antenna curved posteriorly, exterior to wings and extended to 4th abdominal segment; prothoracic and mesothoracic legs and wings curved toward ventral surface of thorax; metathoracic legs extend to 5th abdominal segment. Mature pupa (Fig. 20) more sclerotized; head, antenna, thorax, and thoracic legs yellowish brown; mandibles dark brown, eyes black, and abdomen light green.

Fifteen prepupae and pupae, reared in the laboratory from larvae collected in Tafi del Valle, were studied. The prepupa transforms to the pupa and adult stage inside a yellowish brown oval cocoon from 7-8 mm long and from 3-4 mm in diameter.

## DISCUSSION

The first descriptions of the immature stages of *N. desantisi* by De Santis and Gallego de Sureda (1984), Mallea *et al.* (1985), González (1989), and Gianti and Dapoto (1990) were based principally on coloration and measurements. De Santis and Gallego de Sureda (1984) published the first figures of the mature larva, eggs in willow leaves, first-instar larva, and prepupa inside the cocoon. These same authors mentioned that the eggs of *N. desantisi* are initially oval-shaped, flat, and translucent. Conversely, Mallea *et al.* (1985), González *et al.* (1986) and González (1989) described the eggs as kidney-shaped. This latter observation agrees with our studies.

González (1989) stated that the larva of *N. desantisi* has prolegs on abdominal segments 2-8. Our studies show that the larva is typical of the Nematinae and *Nematus*, with prolegs on abdominal segments 2-7 and 10, as defined by Smith and Middlekauff (1987).

Very few sawfly larvae are known from southern South America, but the following combination of characters should aid in the recognition of the larva of *Nematus desantisi*: feeding on *Salix* spp. and *Populus* spp.; pre-



Figs. 17-18. *Nematus desantisi*. 17, First-instar larva. 18, Last-instar larva.



Figs. 19-20. *Nematus desantisi*. 19, Cocoon and prepupa. 20, Mature pupa.

sence of prolegs on abdominal segments 2-7 and 10; flat, 4-segmented antenna; mandibular dentition as described above; 5-annulate abdominal segments (segments 1-8) with setae on annulets 2-4; and presence of a pair of caudal protuberances on the epiproct.

#### ACKNOWLEDGMENTS

We thank Dr. Patricio Fidalgo and Ing. Agr. Arturo L. Terán (CIRPON, S.M. de Tucumán, Argentina) for suggestions and critical reviews of the manuscript, Lic. Nora E. Ovruski (EEAOC, S.M. de Tucumán, Argentina) for helping collect the specimens, and Ing. Hugo Lazaro (CIRPON) for the photographs of the larvae, prepupa, and pupa. We also thank W.W. Middlekauf, University of California, Berkeley; H. Goulet, Agriculture Canada, Ottawa; and R.V. Peterson and D.A. Nickle, Systematic Entomology Laboratory, USDA Washington, D.C., for review of the manuscript.

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**AMBLYCERUS TEUTONIENSIS**  
**(COLEOPTERA: BRUCHIDAE),**  
**A NEW SPECIES OF SEED BEETLE<sup>1,2</sup>**

Cibele S. Ribeiro-Costa,<sup>2</sup> John M. Kingsolver<sup>3</sup>

ABSTRACT: *Amblycerus teutoniensis* is described and illustrated.

To provide a specific name to be used in future species group arrangements, this description is presented.

**Amblycerus teutoniensis**, new species  
(figs. 1-8)

**Dimensions:** Medium body length 5.14 mm; width 3.36 mm. Pronotum length 1.38-1.80 mm (mean = 1.62 mm); width 1.96-2.63 mm (mean = 2.44 mm). Elytra length 2.48-4.20 mm (mean = 3.52 mm); width 2.84-3.80 mm (mean = 3.36 mm).

**Integument:** Black except four basal antennal segments, tarsi and calcaria reddish; entire pygidium and abdomen reddish yellow.

**Vestiture:** Head, pronotum, elytra, venter of thorax and appendages with brown and bluish gray hairs in irregular mottled pattern (fig.1). Pronotum sometimes with four small rounded bluish gray spots (fig.2). Scutellum densely pubescent with light yellow hairs (fig.4). Pygidium (fig.5) and abdomen covered with light yellow and golden yellow hairs in a mottled pattern and with some scattered small brown patches.

**Body:** Subquadrate (fig.1). Vertex micropunctate; frons and clypeus more coarsely punctate than vertex except granulose in narrow apical band; labrum punctate basally. Frons gently flattened, frontal carina evanescent in lower half, sometimes absent; frontoclypeal suture indistinct. Mesal margin of eye with fine carina and umbilicate punctures; eye finely faceted, moderately protruding laterally; ocular sinus (emargination) 1/3 length of eye and ocular index (width across eyes/width between eyes) 2.8:1; postocular lobe long. Antenna subserrate from fifth to tenth segments, eighth to tenth segments slightly wider than long; terminal segment subelliptical (fig.6). Pronotum (fig.2) subconical, lateral margins gently arcuate; disk evenly convex; basal lobe broadly angulate, usually not sulcate; surface densely punctulate, lateral one-third of disk on either side also coarsely punctate, middle also with some punctures smaller than those on lateral areas; basal and apical margins without sulci; lateral carina (fig.3) divided near base and gently divergent toward apex, delimited by fine shallow dorsal and fine deep ventral sulci; cervical boss with two fine setae (fig. 3), posterior angle of pronotum with one seta. Prosternum moderately narrow with sulcate lateral margins and slightly expanded beyond procoxae. Scutellum 1.3

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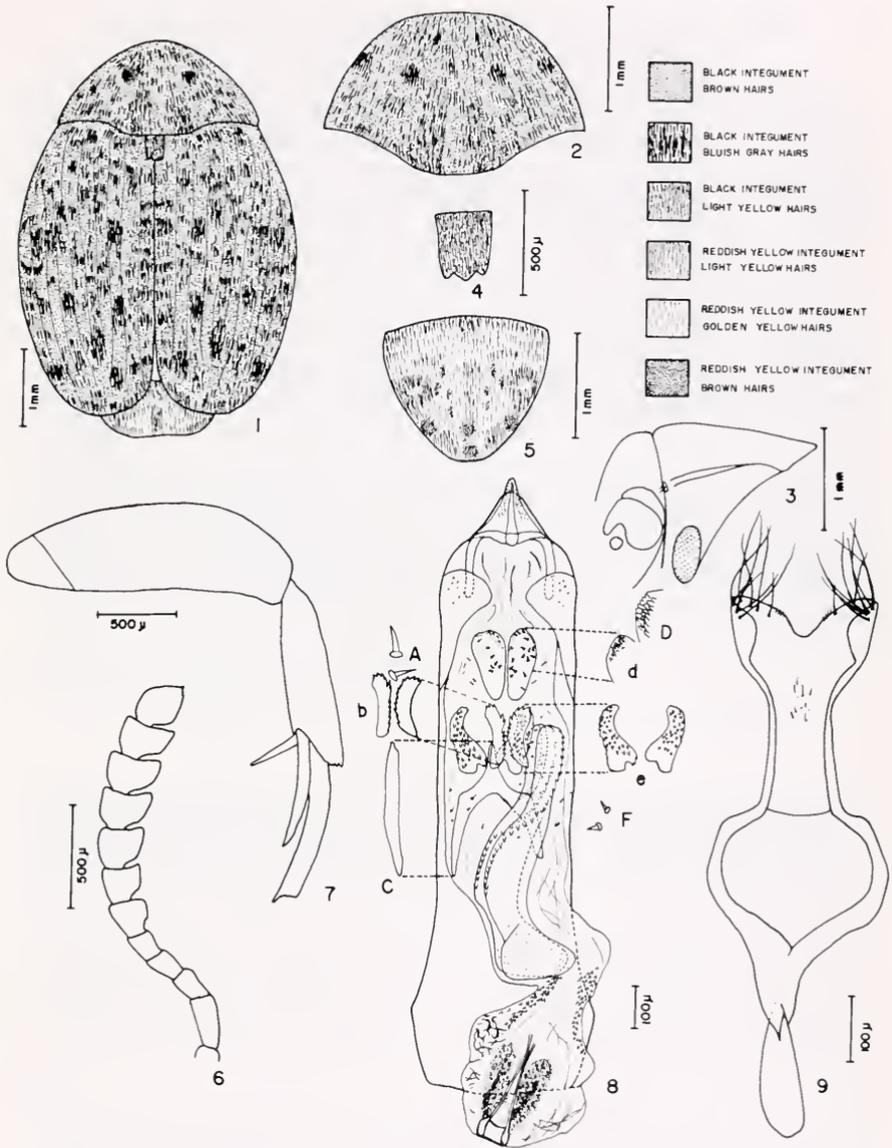
<sup>3</sup> Florida State Collections of Arthropods, Division of Plant Industry, PO Box 147100, Gainesville, Florida 32614-7100, U.S.A.

times as long as wide, apex trilobed (fig.4). Elytra as long as wide, evenly convex except slightly depressed around scutellum; sutural, third, fifth, seventh and ninth intervals gently elevated on middle apical portion; striae strongly impressed, stria punctures fine; elytral apices rounded. Mesosternum elevated, rounded apically. Postmesocoxal sulci meeting mesally at acute angle, then extending laterally and connecting to parasutural sulci, the latter extending beyond middle length of metasternum. Metepisternum punctulate, also with many coarser punctures, lacking striate file; metepisternal sulcus nearly right angled, vertical arm reaching apex and longitudinal arm very short, not reaching middle length of metepisternum. Metasternum between middle coxae not bulging. Face of hind coxa in distal two-thirds and along posterior border of proximal one-third setose and densely punctulate; many scattered larger punctures on distal two-thirds; proximal one-third glabrous in part and punctate except in a reduced area. Metafemur slender, 2.9 times as long as wide (fig.7); ventral face slightly sulcate in distal three-fourths; mesoventral carina complete but lacking blunt, angulate process near apex. Ventral face of hind tibia slightly concave, each margin with row of punctures and short, stiff setae; mesal face lacking tumidity at distal two-thirds; apex with a few, short coronal denticles. Mesal tibial spur one-fifth as long as lateral spur and one-third as long as first metatarsal segment (fig.7). Pygidium (fig.5) vertical, subtruncate apically; surface punctulate and with many coarser punctures. Fifth visible abdominal sternum slightly emarginate in male and rounded in female. Eighth tergite rounded in male.

**Male terminalia** (figs.8,9): Median lobe with ventral valve acute apically, lateral margins incurvate, base broad; dorsal valve subtriangular, lateral margins nearly straight, apex rounded. Internal sac armature (fig.8) consisting of two basal subconcave, slipper-shaped sclerites with short irregular protuberances near apex (figs.8D,8d); two subbasal sclerites, four times as long as wide, subrectangular, slightly sinuate and with serration directed apicad along a margin (fig.8b) near the place of precedent pair and in part overlapping it, two subbasal sclerites, 2.1 times as long as wide at base, subtriangular, very sinuate and armed with denticles directed basad (fig.8e); two long, laminar, median sclerites, slightly angulate toward basal and median portions, with one or two rows of basally directed denticles along middle apical portion; unpaired, median wishbone-shaped sclerite, shorter than the laminars (1.3 as long as the length of laminars), with strongly incurvate lateral margins on middle apical portion, rounded apex in lateral view (fig.8C) and distinctly separate stems; apical sclerite with broad lateral areas and long stems (fig.8). Internal sac membrane with spines on basal and median portions (figs.8A,8F). Lateral lobes with moderately deep rounded cleft between them (fig.9).

**Etymology:** The species name refers to the place where the holotype was collected: Nova Teutônia, Santa Catarina, Brazil.

**Type Material:** Holotype, male: BRAZIL: Sta.Catarina, Nova Teutônia; 14.II.1944; F. Plaumann; deposited in the National Museum of Natural History, Washington (NMNH). Allotype, BRAZIL: Sao Paulo, Ilha da Vitória, 16-27.III.1964, Exp.Dep.Zool. deposited in the Museu de Zoologia de Sao Paulo (MZSP); one male paratype with same label as holotype, deposited in the Museu de Entomologia do Departamento de Zoologia da Universidade Federal do Paraná (DZUP); additional three paratypes.— BRAZIL: Mato Grosso, Chapada dos Guimarães, April, Acc.No.2966, deposited in the Carnegie Museum of Natural History, Pittsburg (CARN); Rio Grande do Sul, São Leopoldo, 15.X.1982, C.J.Becker, 60.602, deposited in the Fundação Zoobotânica do Rio Grande do Sul (FZB.MCN); PARAGUAY: Sao Bernardino, 27.XII, Amaranthaceae, K. Fiebrig (NMNH); Depto. Alto Parana, Centro For. Alto Parana, 25° 30'S, 54° 44'W, 14-16-V-1986, Pogue & Solis (NMNH).



Figs. 1-9. *Amblycerus teutoniensis*, new species. 1, dorsal habitus; 2, pronotum; 3, lateral view of pronotum; 4, scutellum; 5, pygidium; 6, antenna; 7, hind trochanter, femur, tibia and first metatarsal segment; 8, male genitalia, median lobe: A-spines on basal portion enlarged, b-subbasal serrate sclerites, c-lateral view of wishbone-shaped sclerite, d-ventral view of basal sclerite, D-same enlarged, e-subbasal spinous sclerites, F-spines on median portion, enlarged; 9, tegmen.

## DISCUSSION

This species is most closely related to *A. canescens* (Boheman). Both share many characters such as body, except pygidium and abdomen, mottled with brown and bluish gray hairs, postocular lobe long, eyes finely faceted, lateral carina of pronotum divided, scutellum trilobed, longitudinal arm of metepisternal sulcus very short, metepisternum and hind coxa evenly punctured, mesal mesotibial spur about middle length of lateral spur and one-third length of the first hind tarsal segment.

*Amblycerus teutoniensis* can be distinguished from *A. canescens* by the reddish yellow integument of the first four antennal segments, tarsi, pygidium and abdomen; these parts are entirely black in *A. canescens*.

The characters in the internal sac of male genitalia are comparable in these two species. Differences are found in the shape of both pairs of sub-basal sclerites (short in *teutoniensis*, longer in *canescens*; the other sub-triangular with denticles directed basad in *teutoniensis* (fig.8e), sub-rectangular with denticles directed apicad in *canescens*; in the shape of the long laminar sclerites (slightly angulate in *teutoniensis*, strongly angulate in *canescens*; and in the wishbone-shaped sclerite (with incurvate lateral margins and distinctly separate stems in *teutoniensis*, nearly straight and moderately separate stems in *canescens*).

## ACKNOWLEDGMENTS

We would like to thank Renato C. Marinoni for comments on this paper.

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## THE DRAGONFLIES AND DAMSELFLIES (ODONATA) OF BUCK CREEK, PULASKI COUNTY, KENTUCKY<sup>1</sup>

Randall G. Payne<sup>2</sup>, Guenter A. Schuster<sup>3</sup>

**ABSTRACT:** Seven families of Odonata representing 32 species were found to inhabit Buck Creek, a fifth-order tributary of the upper Cumberland River. Of these 32 species, 17 were new records for Pulaski County. Buck Creek was found to be relatively undisturbed and of high water quality as indicated by its diverse community of Odonata.

There have been relatively few published surveys of the Odonata from Kentucky. Resner (1970) compiled a list of all known odonate species occurring in the Commonwealth, adding three species to the list. The last additions to Kentucky's species list were by Crowley and Wilson (1979). The current total number of odonate species known for Kentucky is 138.

Buck Creek, a fifth-order tributary of the upper Cumberland River, had exceptionally good water quality and a diverse aquatic fauna (Harker, *et al.* 1979). Recent studies of fishes (Cicerello and Butler, 1985), freshwater Unionidae (Schuster, *et al.* 1989), and Trichoptera (Floyd and Schuster, 1990) have reported large numbers of species for each of these groups of organisms. Because Buck Creek was relatively undisturbed, as reflected in previous studies, it was thought to potentially support a diverse community of odonates.

### STUDY AREA

Buck Creek is located in southcentral Kentucky (37° 10' N, 84° 30' W). This stream drains approximately 767 km<sup>2</sup> in Lincoln, Pulaski and Rockcastle counties. It flows southward for 107.2 km and discharges into the Cumberland River, near Cumberland River km 859. Buck Creek flows entirely within the Eastern Highland Rim subsection of the Interior Low Plateau Physiographic Province (Quarterman and Powell, 1978). The surface geology is composed primarily of Mississippian Age limestone (Schuster, *et al.* 1989).

The land use in the watershed is primarily agricultural. The upper

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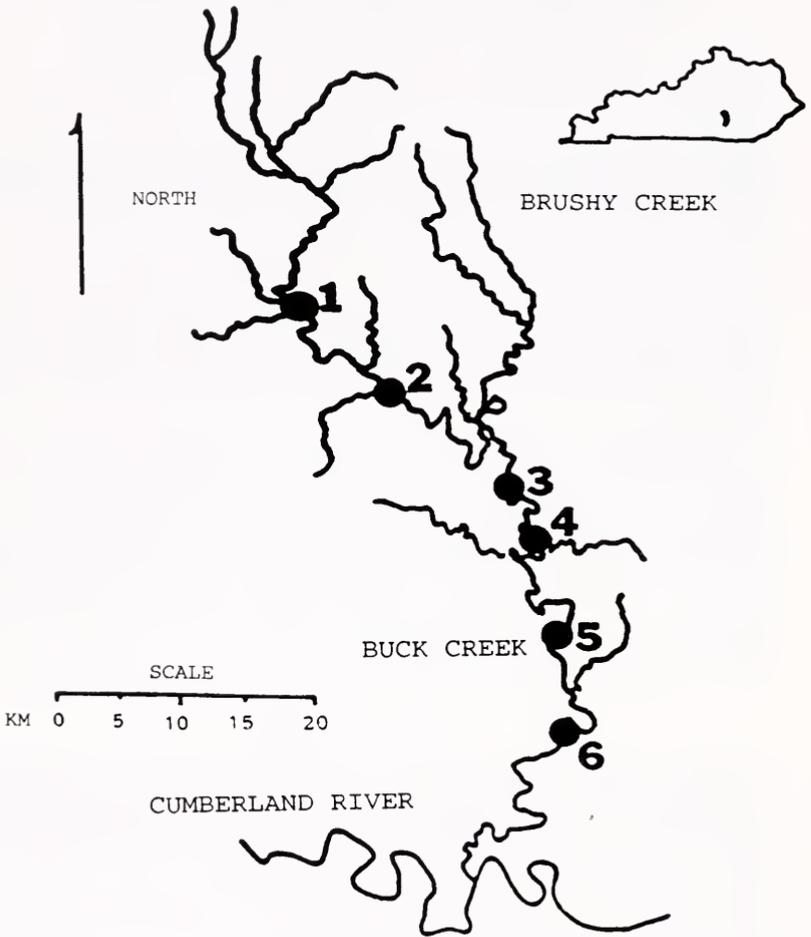


Figure 1. Location of collecting sites along the mainstem of Buck Creek, Pulaski County, Kentucky (after Butler, 1985).

one-half of the watershed is utilized for crop production and the remainder of the watershed lies within the boundary of Daniel Boone National Forest. The stream has numerous braids that become isolated pools during the drier times of the year.

## MATERIALS AND METHODS

Six collecting sites were chosen on the mainstem of Buck Creek (Figure 1). Sites one and two were located on the fourth-order section of the stream, and sites three through six were on the fifth-order segment. Exact localities of each collection site are given in Table 1. Two sites were

Table 1. Location of collecting sites on Buck Creek, Pulaski County, Kentucky.

Site	Location
1	State Route (SR) 70 crossing, approximately 4.9 km WNW of Woodstock and 19.4 km N of Somerset.
2	SR 39 crossing, approximately 3.2 km S of Woodstock and 15.9 km NE of Somerset.
3	SR 1677 crossing, approximately 2.2 km W of Dahl and 13.4 km ENE of Somerset.
4	SR 1675 (old SR 80) crossing at Stab, approximately 14.6 km ENE of Somerset.
5	SR 1003 crossing, approximately 7.2 km S of Stab and 14.6 km E of Somerset.
6	SR 192 crossing, approximately 4.9 km NW of Mt. Victory and 15.8 km ESE of Somerset.

visited per week, and a collecting circuit of all sites was completed every three weeks. Collection of adults began in June and continued through October 1991 and from April to mid-September 1992. Adults were collected using a D-frame net and a .22 caliber rifle loaded with 1/15 oz. number 12 shot shotshell. During the second collecting season a light weight aerial net was used for collection. Representatives of each species collected were placed in the Natural History Museum of Eastern Kentucky University or in the first author's collection.

## RESULTS

Five families of Anisoptera (Aeshnidae, Corduliidae, Gomphidae, Libellulidae and Macromiidae) and two families of Zygoptera (Calopterygidae and Coenagrionidae) were found at Buck Creek (Tables 2 and 3 respectively), including 19 species of Anisoptera (Table 2) and 13 species of Zygoptera (Table 3). This is approximately 25% of the 138 species of Odonata known to occur in Kentucky. Of these 32 species, 17 were new records for Pulaski County, 14 anisopterans (Table 2) and three zygopterans (Table 3).

Table 2. Anisoptera collected at Buck Creek, Pulaski County, Kentucky, (June - November 1991; April - mid-September 1992): \* = new county record; A = adult; N = nymph.

## Aeshnidae

<i>Basiaeschna janata</i> (Say)	*	A
<i>Boyeria vinosa</i> (Say)	*	A

## Corduliidae

<i>Epitheca princeps</i> (Hagen)	*	A
<i>Neurocordulia yamaskanensis</i> Provancher	*	A
<i>Somatochlora linearis</i> (Hagen)	*	N

## Gomphidae

<i>Dromogomphus spinosus</i> Selys		A
<i>Gomphus (Gomphus) lividus</i> Selys	*	A
<i>Gomphus (Gomphurus) lineatifrons</i> Calvert	*	A
<i>Gomphus (Hylogomphus) viridifrons</i> Hine	*	A
<i>Hagenius brevistylus</i> Selys	*	A
<i>Stylogomphus albistylus</i> (Hagen)	*	A

## Libellulidae

<i>Libellula luctosa</i> Burmeister	*	A
<i>Libellula lydia</i> (Drury)		A
<i>Libellula pulchella</i> Drury		A
<i>Erythemis simplicicollis</i> (Say)	*	A
<i>Pachydiplax longipennis</i> (Burmeister)		A
<i>Sympetrum vicinum</i> (Hagen)		A

## Macromiidae

<i>Didymops transversa</i> (Say)	*	A
<i>Macromia alleghaniensis</i> (Williamson)	*	A

Table 3. Zygoptera collected at Buck Creek, Pulaski County, Kentucky, (June - November 1991; April - mid-September 1992): \* = new county record; A = adult.

## Calopterygidae

<i>Calopteryx maculata</i> (Beauvois)		A
<i>Hetaerina americana</i> (Fabricius)		A

## Coenagrionidae

<i>Argia fumipennis violacea</i> (Hagen)		A
<i>Argia moesta</i> (Hagen)		A
<i>Argia sedula</i> (Hagen)		A
<i>Argia tibialis</i> Rambur	*	A

Table 3. (Continued)

<i>Argia translata</i> Hagen	A
<i>Enallagma basidens</i> Calvert	* A
<i>Enallagma civile</i> (Hagen)	A
<i>Enallagma divagans</i> Selys	* A
<i>Enallagma exsulans</i> (Hagen)	A
<i>Ischnura posita</i> (Hagen)	A
<i>Ischnura verticalis</i> (Say)	A

## DISCUSSION

Kentucky is near the northern or southern limits of distribution of many odonates. Montgomery (1967) used Peterson's Resemblance Equation to indicate the degree of similarity or difference of odonates in the North Central States. The similarity of the species of *Enallagma* of Kentucky and southern Indiana was 0.35, while between Kentucky and Tennessee it was 0.79, where a value of 1.0 indicates total similarity.

Buck Creek was found to possess a very diverse odonate community. The assemblage of a diverse community of Gomphidae was indicative of a relatively undisturbed habitat. One gomphid, *Gomphus lineatifrons* Calvert, has been found to inhabit only streams of high water quality (S. W. Dunkle, pers. comm.; Roback and Westfall, 1967). Carle (1979) reported that of the Anisoptera in Virginia, 75% of those that were rare inhabited relatively undisturbed lotic environments. While Buck Creek is relatively undisturbed, certain perturbations such as clear cutting and gravel removal had occurred during the course of this study. Continued monitoring of Buck Creek is encouraged. Water quality assays and periodic surveys of macroinvertebrates should continue in order to detect any deleterious practices in and around this stream.

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## CADDISFLIES (TRICHOPTERA) OF WILDCAT CREEK, PICKENS COUNTY, SOUTH CAROLINA<sup>1</sup>

Michael A. Floyd, John C. Morse<sup>2</sup>

**ABSTRACT:** Sixty-two species of caddisflies (Trichoptera) were identified from collections made from Wildcat Creek over a period of 33 years. A new distributional record for South Carolina was obtained for *Diplectrona metaqui*. Eight species, *Polycentropus carlsoni*, *Wormaldia thyria*, *Neotrichia collata*, *Stactobiella delira*, *Neophylax atlanta*, *Goera fuscula*, *Pseudogoera singularis*, and *Agarodes griseus*, are considered to be threatened in South Carolina. *Psilotreta frontalis* should be removed from the list of threatened species in South Carolina. The diverse caddisfly fauna of Wildcat Creek adds further support to the recommendation by other authors for its use as a biodiversity reference stream.

The aquatic insect fauna of Wildcat Creek has been well documented for mayflies (Ephemeroptera), stoneflies (Plecoptera), and other significant biota (Westfall 1947; McCaskill 1967, unpub. thesis, Clemson Univ., 1973, unpub. dissertation, Clemson Univ.; McCaskill and Prins 1968; Carlson 1971, unpub. thesis, Clemson Univ.; White *et al.* 1979; Stark 1983; Adler 1987; and Daniels and Morse 1992). Because of its potential use as a biodiversity reference stream, as indicated by the high diversity of Ephemeroptera and Plecoptera and the occurrence of several other rare or unique plant and animal species (Daniels and Morse 1992), an additional faunistic study was undertaken to document the caddisfly (Trichoptera) fauna.

Wildcat Creek is a second order tributary of Six Mile Creek in southwestern Pickens County, South Carolina (Fig. 1). It is a clear stream with a gravel and sand substrate and a riparian zone composed of mixed hardwoods. Wildcat Creek lies within the Piedmont Physiographic Region and drains approximately 204 ha (504 ac), 47% (96 ha or 236 ac) of which lies within the Clemson University Experimental Forest (CUEF). The portion of the watershed within the CUEF has been proposed as a Registered Heritage Site as part of the Heritage Trust Program of the South Carolina Wildlife and Marine Resources Department (Fig. 1). This designation would minimize the effects of anthropogenic disturbances such as clearcutting, private development, or sedimentation. A more detailed description of the watershed, including its management

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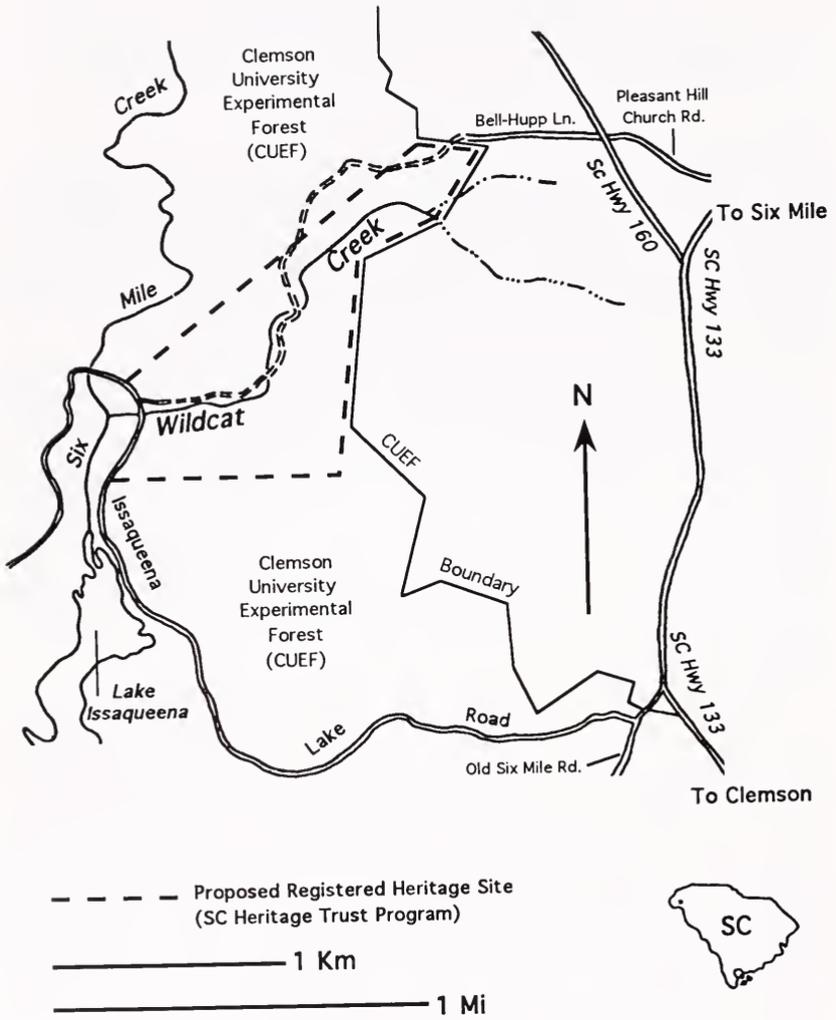


Fig. 1. Map of Wildcat Creek and surrounding area.

by the Clemson University Forestry Department and its biological, educational, and recreational importance, was provided by Sorrells (1984) and Daniels and Morse (1992).

## MATERIALS AND METHODS

The 3980 specimens of Trichoptera examined in this study are housed within the Clemson University Arthropod Collection (CUAC). Many of these specimens have been collected since 1956 by students from the Clemson University Aquatic Insects course (ENT 469/669) or Taxonomy of Immature Insects course (ENT 808). Other collections have been made by Carlson (1971, unpub. thesis, Clemson Univ.), Hoffman and Morse (1990), and by the authors. Collections of larvae have been made by qualitative benthic collecting, while adults have been obtained by a variety of methods. Carlson (1971, unpub. thesis, Clemson Univ.) used a modified emergence trap composed of parachute-netting which was stretched across the stream, touching either the water or ground on all four sides. Malaise traps and ultraviolet light traps were used by Hoffman and Morse (1990) and the authors. The authors performed or verified all identifications.

## RESULTS AND DISCUSSION

Sixty-two species of caddisflies, representing 17 families, were identified from collections obtained from Wildcat Creek (Table 1, Page 176). A new distributional record for South Carolina was obtained for *Diplec-trona metaqui* Ross. Eight species of Wildcat Creek Trichoptera, *Polycentropus carlsoni* Morse, *Wormaldia thria* Denning, *Neotrichia collata* Morton, *Stactobiella delira* (Ross), *Goera fuscula* Banks, *Pseudogoera singularis* Carpenter, *Psilotreta frontalis* Banks, and *Agarodes griseus* Banks, were designated as threatened by the Invertebrate Taxa Review Committee of the South Carolina Heritage Trust Program (Morse *et al.* 1979, and unpublished data). Unless otherwise noted, distributional and habitat information listed below were taken from Morse *et al.* (1979).

*Polycentropus carlsoni* is known from only two states, Alabama and South Carolina. In Alabama it has been reported from two locations in Calhoun County (Harris *et al.* 1991). South Carolina records include two locations in the CUEF (Wildcat Creek, the type locality for this species, and Indian Creek, a first order tributary of Six Mile Creek, Lake Issaqueena [Adler 1992, unpub. dissertation, Clemson Univ.]) and a springbrook 10 km south of Clemson in Pendleton, Anderson County (Hoffman and Morse 1990). Each of these collections is from first order, clear,

cold streams (Hoffman and Morse 1990). The United States Department of Interior (1984) listed *P. carlsoni* as Category 2 (possibly endangered or threatened, but lacking conclusive data). With the exception of two males captured by ultraviolet light traps in Alabama, this species has been captured solely with the use of modified emergence traps or Malaise traps (Hoffman and Morse 1990).

*Wormaldia thyria* has been found at no other locality in South Carolina except Wildcat Creek. It has been reported from four other states, Alabama (Frazer *et al.* 1991), North Carolina (Denning 1950), Tennessee (Etnier and Schuster 1979), and Virginia (Parker and Voshell 1981). It is found in small, clear, cold streams in the Mountains and Upper Piedmont.

*Neotrichia collata* is known from only one other locality in South Carolina, a tributary of Brasstown Creek in Oconee County. It is reported to inhabit small, cold, rocky, rapidly flowing streams and has been found in seven other states: Alabama (Harris *et al.* 1983), Illinois and Kentucky (Ross 1944), Maine (Blickle 1979), New York (Morton 1905), Utah (Baumann and Unzicker 1981), and Vermont (Harris *et al.* 1991).

*Stactobiella delira* has been reported from 26 states and one Canadian Province (a distribution including British Columbia and California extending east to Maine and South Carolina). However, it is known from only two localities in South Carolina, Wildcat Creek and South Fork of the Saluda River, both of which are clear, cold, rocky streams.

*Goera fuscula* is known from only two other South Carolina streams, the Chattooga River and a tributary of Brasstown Creek (both in Oconee County). It requires cold, rocky, upland streams and has been reported from Georgia (Schmid 1983), Massachusetts, New York, Tennessee, and Virginia (Flint 1960), Maine (Mingo and Gibbs 1980), North Carolina (Banks 1905), and Quebec (Roy and Harper 1979).

*Pseudogoera singularis* has been reported in South Carolina from only two other streams, Toxaway Creek and Yellow Branch, both of which lie in Oconee County. The larvae and pupae inhabit moss-covered waterfalls in small, clear, relatively unpolluted streams at elevations of 245 to 825 m (800 to 2700 ft.) (Wallace and Ross 1971). It has been reported from Georgia (Wallace and Ross 1971), North Carolina (Carpenter 1933), and Tennessee (Etnier and Schuster 1979).

*Psilotreta frontalis* should no longer be considered threatened in South Carolina because its distribution in the state now has increased to six counties: Aiken, Greenwood, Lexington, Oconee, Pickens, and Saluda (Floyd, unpub. data). It has been reported from 18 other states in the eastern United States (Parker and Wiggins 1987).

*Argores griseus* has been reported from 20 states in the eastern United States (Harris *et al.* 1983, Harris *et al.* 1991, Parker and Wiggins 1987, Schmid 1983). It is found in depositional areas of small spring seepages and spring streams in three localities in the upper Piedmont of South Carolina. These include Wildcat Creek, Indian Creek (Adler 1992, unpub. dissertation, Clemson Univ.), and a springbrook in Pendleton, Anderson County.

Although not designated by Morse *et al.* (1979) as threatened in South Carolina, one additional species, *Neophylax atlanta* Ross, undoubtedly deserves such a designation. It has been reported from four states, Alabama, Georgia, Virginia, and South Carolina (Ross 1947, Harris *et al.* 1991) but has been found at only two sites, Indian Creek (Adler 1992, unpub. dissertation, Clemson Univ.) and Wildcat Creek, in South Carolina.

Wildcat Creek also is a paratype locality for the subspecies *Cheumatopsyche harwoodi enigma* Ross, Morse, and Gordon (1971). In South Carolina it is known additionally from South Saluda River and Eastatoe Creek in Pickens County, as well as Thompson River, Coley Creek, and Bearcamp Creek in the mountains of Oconee County (Morse *et al.* 1989). Outside South Carolina it has been reported from cold, rocky Piedmont and Mountain streams in Arkansas (Bowles and Mathis 1989), Georgia (Ross, Morse, and Gordon 1971), North Carolina (Gordon 1974), and Virginia (Parker and Voshell).

Because of the high diversity of such orders as mayflies and stoneflies, as well as the presence of other rare and unique aquatic insects, Daniels and Morse (1992) suggested that Wildcat Creek be used as a biodiversity reference stream. The diverse caddisfly fauna detailed in this study serves to reinforce this recommendation. Furthermore, the entire watershed should be protected and managed to maintain its high diversity of plants and animals and thus preserve its potential use for education, recreation, and research.

#### ACKNOWLEDGMENTS

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**Table 1. Caddisflies (Trichoptera) of Wildcat Creek, Pickens County, South Carolina.**

Classification follows that of Weaver and Morse (1986). Stages of development (larva, pupa, and adult) by which species are represented are indicated by L, P, and A, respectively. Stages of development are followed by number of specimens in that particular stage. Dates refer to capture times of adult specimens. New distributional records for South Carolina are indicated by the symbol (#). Threatened species as listed by the invertebrate Taxa Review Committee of the South Carolina Heritage Trust Program (Morse *et al.* 1979) are indicated by an asterisk (\*). An additional species not listed as threatened by Morse *et al.* (1979), but deserving such designation, is indicated by a plus symbol (+).

Suborder Annulipalpia

Infraorder Curvopalpia

Superfamily Hydropsychoidea

Family Hydropsychidae

*Ceratopsyche sparna* (Ross), L (4), A (14 F, 6 M), 10 Apr.-29 June.

*Cheumatopsyche harwoodi enigma* Ross, Morse, & Gordon, A (87 F, 48 M), 8 Apr.-26 Sep.

*Cheumatopsyche pettiti* (Banks), A (17 F, 6 M), 18 Apr.-22 Aug.

*Cheumatopsyche pinaca* Ross, A (39 F, 9 M), 13 Apr.-22 Aug.

#*Diptertrichia metaqui* Ross, L (1).

*Diptertrichia modesta* Banks, L (25), A (22 F, 15 M), 4 Apr.-8 Sep.

*Hydropsyche betteni* Ross, A (17 F, 4 M), 17 Apr.-30 Jul

*Parapsyche cardis* Ross, L (14), A (2), 21 May.

*Potamyia flava* (Hagen), L (2).

Family Polycentropodidae

*Cynellus marginalis* (Banks), A (5 F), 19-21 Jun.

*Nyctiophylax nephophilus* Flint, A (2 M), 21 May.

*Phylocentropus lucidus* (Hagen), A (1 F), 22 Aug.

*Phylocentropus placidus* (Banks), A (1 F), 21 May.

*Polycentropus blicklei* Ross & Yammamoto, A (14 F, 27 M), 14 Apr.-25 Sep.

\* *Polycentropus carlsoni* Morse, A (5 F, 3 M), 15 Apr.-4 Jul.

*Polycentropus cinereus* Hagen, A (22 F, 26 M), 22 Apr.-4 Sep.

*Polycentropus confusus* Hagen, A (3 M), 20 Apr.

*Polycentropus maculatus* Banks, A (3 F), 15 Apr.-12 May.

Family Psychomyiidae

*Lype diversa* (Banks), A (212 F, 1220 M), 10 Apr.-14 Oct.

*Psychomyia flavida* Hagen, A (460 F), 20 Apr.-4 Sep.

Superfamily Philopotamoidea

Family Philopotamidae

*Chimarra aterrima* (Hagen), A (13 F, 10 M), 4 Apr.-20 Jun., 6-13 Oct.

*Chimarra obscura* (Walker), A (1 F), 21 May.

*Dolophilodes distinctus* (Walker), L (9), P (4), A (64 F, 68 M), 10 May-8 Nov.

*Dolophilodes major* (Banks), A (1 F), 21 May.

*Wormaldia moesta* (Banks), A (11 F, 18 M), 20 Apr.-7 Oct.

\* *Wormaldia thyria* Denning, A (1 M), 22 Jul.

Infraorder Spicipalpia

Superfamily Hydroptiloidea

Family Glossosomatidae

*Agapetus iridis* Ross, A (328 F, 144 M), 20 Apr.-13 Aug.

*Glossosoma nigrior* Banks, L (1), A (51 F, 25 M), 19 Mar.-23 Sep.

Family Hydroptilidae

*Hydroptila amoena* Ross, A (17 M), 19 Apr.-18 Sep.

*Hydroptila gunda* Milne, A (27 M), 10 Apr.-21 May.

*Hydroptila quinola* Ross, A (6 M), 19 Apr.-27 Jun.

\* *Neotrichia collata* Morton, A (2 M), 12-20 Jun.

\* *Stactobiella delira* (Ross), A (2 F, 1 M), 10-20 Apr.

### Superfamily Rhyacophiloidea

#### Family Rhyacophilidae

*Rhyacophila carolina* Banks, L (4), P (1), A (74 M), 10 Apr.-19 Sep.

*Rhyacophila fuscula* (Walker), L (5), A (2 F, 5 M), 18 May-21 May, 31 Aug.-18 Sep.

*Rhyacophila glaberrima* Ulmer, L (1), A (35 F, 59 M), 24 Apr.-4 May, 21 Aug.-26 Oct.

*Rhyacophila minor* Banks, P (1), A (1 M), 15-22 May.

*Rhyacophila nigrita* Banks, A (21 M), 23 Apr.-26 May, 6 Oct.

*Rhyacophila teddyi* Ross, A (1 M), 22 May.

*Rhyacophila torva* Hagen, L (6), A (25 M), 4 Apr.-24 Sep.

### Suborder Integripalpia

#### Infraorder Plenitentoria

### Superfamily Limnephiloidea

#### Family Limnephilidae

\* *Goera fuscula* Banks, L (3), A (6 F, 3M), 20 Apr.-27 Jun.

*Pycnopsyche antica* (Walker), L (15), A (5 F, 4 M), 4 Sep.-8 Nov.

*Pycnopsyche gentilis* (MacLachlan), L (45), P (8), A (13 F, 13 M), 12 Sep.-14 Oct.

*Pycnopsyche guttifer* (Walker), L (7).

*Pycnopsyche luculenta* (Betten), L (23), A (8 F, 4 M), 26 Sep.-8 Nov.

#### Family Uenoidea

+*Neophylax atlanta* Ross, A (2 M), 11-14 Oct.

*Neophylax mitchelli* Carpenter, L (4), A (6 M), 11-14 Oct.

*Neophylax oligius* Ross, A (13 M), 1-14 Oct.

#### Family Brachycentridae

*Brachycentrus nigrosoma* (Banks), L (1).

*Micrasema* sp., A (1 F), 8-15 May

#### Family Lepidostomatidae

*Lepidostoma latipenne* (Banks), A (83 F, 61 M), 15 Apr.-8 Nov.

*Lepidostoma ontario* Ross, A (1 F, 1 M), 20 Apr., 17 Jun.

### Infraorder Brevitentoria

#### Superfamily Leptoceroidea

#### Family Odontoceridae

\* *Pseudogoera singularis* Carpenter, P (2), A (2 F, 2 M), 31 Aug.-18 Sep.

\* *Psilotreta frontalis* Banks, L (17), A (57 F, 93 M), 19 Apr.-21 Jun., 8-15 Aug.

#### Family Calamoceratidae

*Anisocentropus pyraloides* (Walker), L (8), P (1), A (12 F, 31 M), 17 May-8 Aug.

*Heteroplectron americanum* (Walker), L (1), A (5 F), 20 Apr.-22 May.

#### Family Leptoceridae

*Ceraclea protonepha* Morse & Ross, A (3 F, 3 M), 20 Apr. 21 May.

*Oecetis inconspicua* (Walker), A (10 F, 4 M), 20 Apr.-27 Jun, 22 Aug.-18 Sep.

*Trianaodes ignitus* (Walker), A (4 F, 7 M), 19 Apr.-22 Aug.

#### Family Molannidae

*Molanna blenda* Sibley, A (11 F, 10 M), 19 Apr.-24 May, 22 Jun.-23 Sep.

### Superfamily Sericostomatoidea

#### Family Helicopsychidae

*Helicopsyche paralimnella*, L (2).

#### Family Sericostomatidae

\* *Agarodes griseus* Banks, A (2 F, 4 M), 5-24 May.

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## ABUNDANCE AND SEASONAL ACTIVITY OF EUCINETOIDEA (COLEOPTERA) IN A RASPBERRY PLANTATION AND ADJACENT SITES IN SOUTHERN QUÉBEC (CANADA)<sup>1</sup>

Claire Levesque, Gilles-Yvon Levesque<sup>2</sup>

**ABSTRACT:** In a raspberry plantation and adjacent sites in southern Québec, we collected adult Eucinetoidae with unbaited pitfall traps and flight interception traps, from early May through late October in 1987, 1988 and 1989. A total of 350 Clambidae (three species), 33 Eucinetidae (four species) and 48 Scirtidae (five species) were collected. The most common species at the soil surface of the raspberry plantation was *Clambus armadillo*. The most abundant species in flight traps were *Clambus howdeni*, *C. armadillo*, *Eucinetus testaceus* and *Cyphon variabilis*. Adults of *C. armadillo*, *C. howdeni* and *C. variabilis* were active mainly in spring and/or early summer and probably overwintered as adults; whereas *Eucinetus testaceus* flew mainly in August and probably overwintered as larvae.

Although world production of raspberries has increased about 5% each year over the past decade (Pritts 1991), little is known on variations in beetle communities associated with raspberry (*Rubus idaeus* L.) plantations, particularly for mycophagous insects. These ecosystems appear as rather stable sites because plants of many raspberry cultivars, with perennial root systems and biennial canes, may be kept over about ten years. Over a three-year period (1987-1989), we collected nearly 60,000 beetles in a raspberry plantation and adjacent sites in southern Québec. We have already presented results for the Nitidulidae and Elateroidea (Levesque and Levesque 1992, 1993). We now present results on the abundance and seasonal activity of adult Clambidae, Eucinetidae and Scirtidae (= Helodidae). These three families of Eucinetoidae are of no known economic importance and little is known of their life history, ecology and behavior. Wheeler and Hoebeke (1984) reviewed published records of hosts and microhabitats of species of Clambidae and Eucinetidae, families considered mainly mycophagous. However, no scirtids are known to be associated with fungi (Wheeler and Hoebeke 1984). All known larvae of Scirtidae are aquatic, phytophagous or detritivorous, and are common in small lentic habitats and shallow areas of peatland pools and marches. Scirtid adults are terrestrial and common along the margins of pools or on emergent plants (Larson 1987).

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## MATERIALS AND METHODS

Beetles were collected from early May through late October on a monocultural raspberry farm at Johnville, near Sherbrooke, in southern Québec. We sampled from the Boyne cultivar in this conventionally cultivated plantation (about 7 ha, on sandy soil).

Ground surface-active beetles were caught with pitfall traps at the following sites: 1) a raspberry row planted in 1978 (**old plants**), 2) a raspberry row planted in 1985 (**young plants**), 3) a woods-field boundary (**boundary**), and 4) an adjacent wooded site dominated by eastern white pine, *Pinus strobus* L. (**pine woods**). Pitfall traps consisted of glass jam jars (450 ml, 6.5 cm diameter at the top) partially filled with 100 ml of 4% formalin. Traps were inserted into the soil beneath the canopy as close to the cane of raspberry plants as possible at the first two sites. At each site, 20 traps were set in a row (5 m apart) and were emptied weekly.

In addition, we studied beetles flying close to the ground with flight interception traps at four sites: 1) an open site near the center of the plantation (**A**), about 20 m from old plants; 2) an open site near a pond (**B**), about 5 m from young raspberry plants; 3) a woods-field boundary (**C**); and 4) a pine woods (**D**). These traps were not located between rows of raspberry plants because of grower's activities and public access during harvest. Flight traps were modified from the large-area "window" trap design promoted by Peck and Davies (1980). Each consisted of a gray 1.5 mm mesh window screen (1.22 m height, 1.52 m width, about 1.85 m<sup>2</sup> of surface) fastened to a wooden frame. The frame itself was suspended by two lateral triangular wooden supports (1.83 m at the base, 1.25 m height), 2-4 cm over a set of two galvanized metal pans (25 by 61 cm at the top, 7.5 cm deep) which were placed directly on the ground. The insects were caught in the pans partially filled with 2% formalin into which a few drops of detergent were added. We installed one flight trap at each site; however, the trap was operated in 1988 and 1989 only in the pine woods (**D**). Samples were collected twice a week and the formalin solution was replaced at each collection; the trap counts from individual sampling periods were combined on a weekly basis.

Levesque and Levesque (1992) presented more detailed information about the sampling methods and study sites, including a sketch-map of the raspberry farm.

## RESULTS AND DISCUSSION

**Abundance of Eucinetoidae Catches.** We collected a total of 350 Clambidae (three species), 33 Eucinetidae (four species) and 48 Scirtidae

(five species). Voucher specimens of some species are deposited in the Canadian National Collection (Ottawa).

Pitfall trapping resulted in the collection of 262 Clambidae (two species), 3 Eucinetidae (two species) and 1 Scirtidae (Table 1). Almost all eucinetoids represented *Clambus armadillo* (DeGeer) (97% of catches). Adults of this species were collected in similar numbers in rows of old and young raspberry plants; the explanation of this result and possible association of these adults with fungi on *R. idaeus* are unknown. *Clambus armadillo* was also caught in large numbers at the ground surface of a wet meadow in southern Québec on clay soil (Levesque and Levesque 1987).

Table 1. Total catches of Eucinetoida species in pitfall traps (1987-1989) at Johnville, Québec.

Family and species	Old plants	Young plants	Boundary	Pine woods	Total
<b>Clambidae</b>					
<i>Clambus armadillo</i> (DeGeer)	131	122	5	—	258
<i>Clambus howdeni</i> Endrödy-Younga	2	—	1	1	4
<b>Eucinetidae</b>					
<i>Eucinetus morio</i> LeC.	—	—	1	—	1
<i>Eucinetus oviformis</i> LeC.	—	—	2	—	2
<b>Scirtidae</b>					
<i>Cyphon variabilis</i> (Thunberg)	—	1	—	—	1

Total catches of eucinetoids in flight traps comprised 88 Clambidae (three species), 30 Eucinetidae (four species) and 47 Scirtidae (five species) (Table 2); all the species monitored at Johnville were collected in flight traps.

Adults of *Clambus howdeni* Endrödy-Younga flew chiefly at the woods-field boundary and in the pine woods, while *Clambus armadillo* was mainly captured in the three flight traps (A, B and C) near the raspberry plants (Table 2). *Eucinetus testaceus* LeC. was the most abundant eucinetid species and flew chiefly in the pine woods (Table 2). In two mixed deciduous-coniferous forest sites in New Hampshire, Chandler (1991) observed the flight activity of *Clambus howdeni* and four species of *Eucinetus* (chiefly *E. morio* LeC.). *Eucinetus morio* was a slime-mold associate, whereas *C. howdeni* and the other three species of *Eucinetus* (*E. oviformis* LeC., *E. punctulatus* LeC., and *E. testaceus*) were associated with Basidiomycete fruiting bodies (Chandler 1991).

Table 2. Total catches of Eucinetoidae species in flight traps (1987-1989) at Johnville, Québec.

Family and species	Open site near center (A)	Open site near pond (B)	Boundary (C)	Pine woods <sup>a</sup> (D)	Total
<b>Clambidae</b>					
<i>Clambus armadillo</i> (DeGeer)	12	10	13	1	36
<i>Clambus gibbulus</i> (LeC.)	—	—	2	—	2
<i>Clambus howdeni</i> Endrödy-Younga	2	5	22	21	50
<b>Eucinetidae</b>					
<i>Eucinetus morio</i> LeC.	—	—	1	3	4
<i>Eucinetus oviformis</i> LeC.	—	—	1	1	2
<i>Eucinetus testaceus</i> LeC.	1	—	3	19	23
<i>Eucinetus</i> sp.	—	1	—	—	1
<b>Scirtidae</b>					
<i>Cyphon obscurus</i> (Guérin)	1	4	3	—	8
<i>Cyphon</i> prob. <i>ruficollis</i> (Say)	1	—	—	—	1
<i>Cyphon pusillus</i> (LeC.)	1	—	—	—	1
<i>Cyphon variabilis</i> (Thunberg)	4	18	8	3	33
<i>Prionocyphon limbaeus</i> LeC.	—	4	—	—	4

<sup>a</sup> not sampled in 1987.

The five species of Scirtidae flew in open sites (A and B) and the boundary site (C). The most abundant species was *Cyphon variabilis* (Thunberg), apparently eurytopic, but mainly collected at the open site B which was near a pond (Table 2). Nilsson (1980) studied the flight activity of nine scirtid species in the vicinity of a river in northern Sweden, and found *Cyphon variabilis* to be one of the three most abundant species.

**Seasonal Abundance of Four Species of Eucinetoidae.** Adults of *Clambus armadillo* were caught by pitfall traps from May through October during the three-year study, mainly in May and the first half of June (Fig. 1). They flew from May until early September, but chiefly in May. In a wet meadow of southern Québec, the soil-surface activity was observed in late spring and summer, mainly in June and July (Levesque and Levesque 1987).

We observed the flight of *Clambus howdeni* only in May, June and July during the three-year study (Fig. 2). In New Hampshire, flight occurred from May through July, but a few adults were also collected in late summer (Chandler 1991).

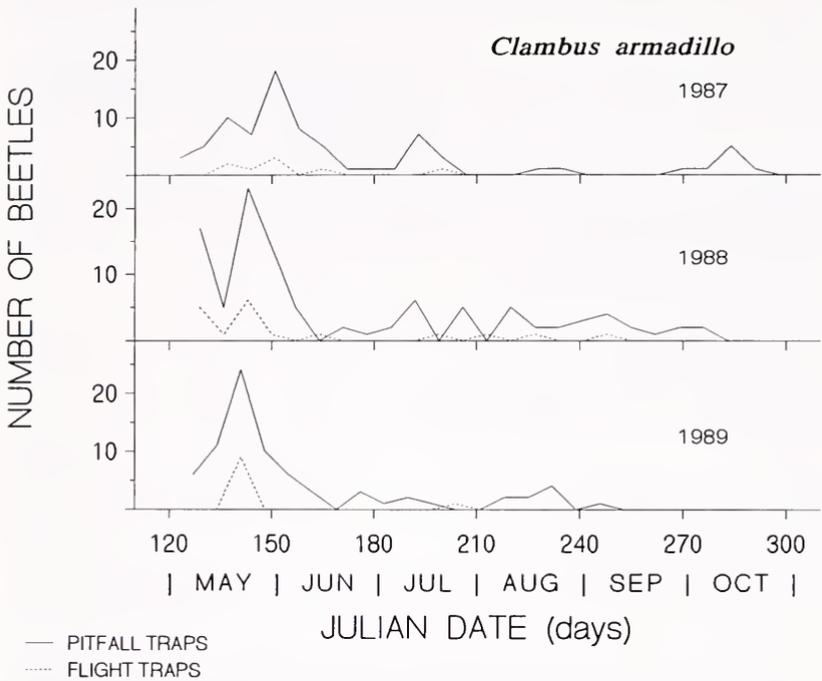


Fig. 1. Seasonal abundance of *Clambus armadillo* in pitfall and flight traps at Johnville, Québec.

Adults of *Cyphon variabilis* flew from May through October, but mainly in May (Fig. 2). In northern Sweden, Nilsson (1980) observed two flight periods, the first from mid-May until early July, the second in late summer and autumn; the peak of captures occurred in June. According to Larson (1987), adults of this species overwinter and reproduce in spring and early summer.

Adults of *Eucinetus testaceus* flew from June through September during the three-year study, and mainly in August (Fig. 2). We caught a teneral adult on June 25, 1989. In New Hampshire, adults of *E. morio* flew mainly in spring and early summer, and one adult was also caught in October (Chandler 1991). In the Finger Lakes region of New York, a breeding population (adults and larvae) of *E. oviformis* was found in late summer, in association with a wood-rotting fungus; in addition, mature larvae and some adults of this species were still present as late as October 18 (Hoebeke *et al.* 1987).

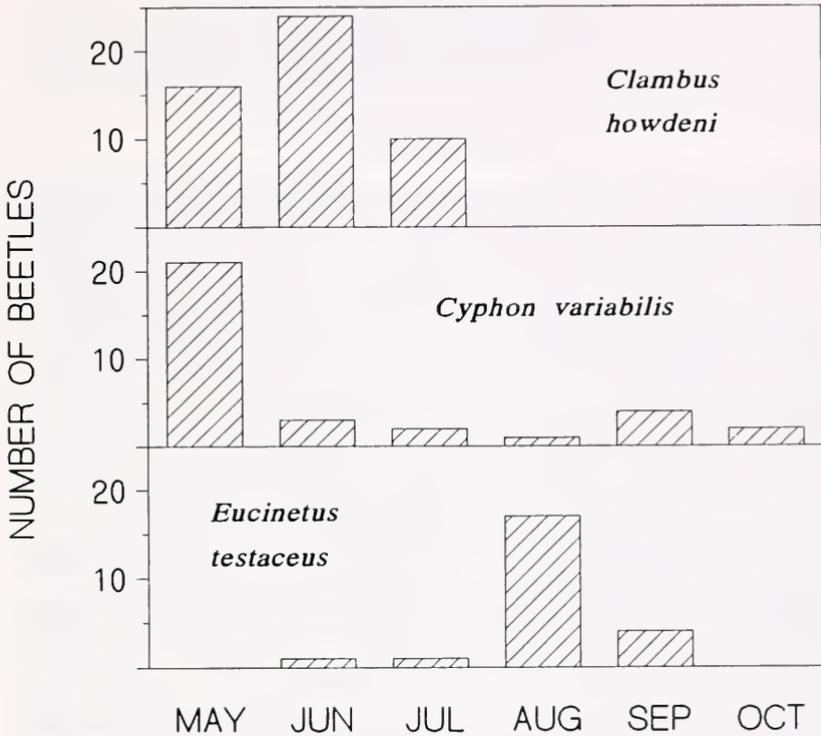


Fig. 2. Seasonal abundance of *Clambus howdeni*, *Cyphon variabilis* and *Eucinetus testaceus*, in flight traps (1987-1989) at Johnville, Québec.

Two life-history patterns are observed among northern European species of Scirtidae: 1) larvae overwinter and reproduction occurs in midsummer, and 2) adults overwinter and reproduce in spring and early summer (Larson 1987). According to Nilsson (1980), the seasonal flight pattern of Scirtidae coincide with these two life-history patterns. If such is the case in other eucinetoids, we suspect that *Clambus armadillo* and *C. howdeni* overwinter as adults, whereas *Eucinetus testaceus* overwinters as larvae.

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## NEW DISTRIBUTION RECORD FOR *ISCHNOPTERA BILUNATA* (DICTYOPTERA: BLATTELLIDAE)<sup>1</sup>

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**ABSTRACT:** Occurrence of *Ischnoptera bilunata* in Alabama is reported for the first time. This record extends the known distribution of the species in the United States outside of Florida. Discovery of *I. bilunata* can be credited, in part, to confusion with the Asian cockroach, *Blattella asahinai*.

*Ischnoptera bilunata* Saussure, was first reported in the United States from Florida in 1990 (Atkinson *et al.* 1990: treated as the Nicaraguan cockroach, *I. bergrothi* [Griffini], due to an error in identification). Previously, the species was known from Brazil, Bolivia, Paraguay and Argentina (Princis 1969). Recent collections of *I. bilunata* in Alabama (Figure 1) extend the known range of this cockroach in the United States outside of Florida.

In July, 1991, five female and five male cockroaches collected in Mobile, Mobile County, Alabama were identified as *I. bilunata*. Individuals were collected in the evening in a residential yard on grass and on a patio around lights. In July, 1992, two females and one male *I. bilunata* were collected in the evening on a house porch around lights in Fair Hope, Baldwin County, Alabama. A third collection was made in the evening of August, 1992, of two female and two male *I. bilunata* in Dothan, Houston County, Alabama near outdoor lights of a supermarket. Specimens from these collections are deposited in the Auburn University Entomological Museum, the Museum of Comparative Zoology at Harvard University, Cambridge, Massachusetts and with the Terminix Insect Collection in Mobile, Alabama.

Before the collections of *I. bilunata*, 21 species of cockroaches were considered established in Alabama (Dakin and Hays 1970, Pratt 1988, Atkinson *et al.* 1991). An additional species, *Blaberus craniifer* Burmeister, has been listed from Lee County as an adventive (Dakin and Hays 1970). The only representative from the genus *Ischnoptera* previously recorded in Alabama is the dark wood cockroach, *I. deropeltiformis* (Brunner). This species is distributed throughout the state, often in wooded areas (Dakin and Hays 1970). All specimens of *I. deropeltiformis*

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Figure 1. Collection sites of adult *Ischnoptera bilunata* Saussure, in Alabama. A: Mobile Co., Mobile, VII-27-1991 (5 males, 5 females); B: Baldwin Co., Fair Hope, VII-27-1992 (1 male, 2 females); C: Houston Co., Dothan, VIII-14-1992 (2 males, 2 females).

in the Auburn University Entomological Museum were collected between the dates of April 24 and August 9. Specimens of *I. bilunata* were collected between July 27 and August 14.

Both sexes of *I. bilunata* are active at night and attracted to light (Atkinson *et al.* 1990). This description agrees with our observations. *Ichnoptera bilunata* also has been recorded as being abundant in open, moist, grassy vegetation on the margins of streams, rivers and ponds (Atkinson *et al.* 1990, 1992). The Alabama collection sites were all adjacent to areas that could be considered open and grassy. Further, these areas had thach and leaf litter that could retain moisture. However, only the Mobile site had a water source nearby. This consisted of a drainage ditch that, depending on rainfall, was intermittently filled with water.

In 1986, the Asian cockroach, *Blattella asahinai* Mizukubo was reported from the Tampa area of Florida (Brenner *et al.* 1986). The Asian cockroach is very similar in appearance to the serious indoor pest, the German cockroach, *Blattella germanica* (L.). The adults of both *Blattella* species are 10 to 13 mm in length, brownish both ventrally and dorsally, with two narrow pronotal spots and wings covering the body (Atkinson *et al.* 1990). Unlike *B. germanica*, *B. asahinai* lives outdoors, often in leaf litter and grassy areas and readily flies to lighted areas at night during warmer months (Brenner *et al.* 1986, 1988). Adult Asian and German cockroaches are similar in appearance to *I. bilunata*. Adult *I. bilunata* are 15 to 18 mm in length, brownish dorsally and black ventrally, with two triangular pronotal spots and wings covering the body (Atkinson *et al.* 1990). Reports of *B. asahinai* and corresponding media coverage apparently heightened the awareness of some pest control operators and homeowners about cockroaches around lighted areas in the summer. In the past few years, the Alabama Cooperative Extension Service has received calls each summer about "Asian cockroaches" around porch lights. These reported cockroaches have turned out to be one of the *Parcoblatta* species and, now, *I. bilunata*. With the similarities to *B. germanica* and *B. asahinai*, we anticipate additional reports of *I. bilunata* in the future.

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## FIRST RECORD OF *SEPEDOPHILUS CORONADENSIS* (STAPHYLINIDAE) FROM MEXICO.<sup>1</sup>

José Luis Navarrete-Heredia<sup>2</sup>

ABSTRACT: The staphylinid beetle, *Sepedophilus coronadensis* is reported from Guerrero, Mexico.

*Sepedophilus* Gistel is a genus of Tachyporinae (Staphylinidae) and is considered to be primarily mycophagous because most of the species are usually found in habitats rich in fungal mycelia (e.g. forest litter, decaying logs, piles of decaying organic matter, etc.) (Hammond 1973; Campbell 1976). A recent summary and discussion on *Sepedophilus*' biology, including information on unidentified Mexican species, is provided by Newton (1984).

*Sepedophilus* is represented in Mexico by three named species from Veracruz: *Sepedophilus bicolor* (Bnhr.), *S. ferrugineus* (Bnhr.) and *S. subpubescens* (Schub.) (Blackwelder 1944: 151, under *Conosomus* genus). This number probably is just a small proportion of the species that exist in Mexico because the genus is widely distributed in temperate and tropical regions and is usually collected in several kinds of habitats (personal observations from Guerrero, Hidalgo, Mexico, Morelos, Puebla, Oaxaca, Veracruz, Yucatan, and from the examination of several specimens deposited in the Field Museum of Natural History, Chicago, IL.

*S. coronadensis* Campbell is a species included in Campbell's revision of species of America north of Mexico in the *bisignatus* group, and is known from the Santa Rita and the Huachuca mountains of southeastern Arizona. One specimen from Ramsey Canyon was collected by sifting deep layers of wet, oak leaf litter (Campbell 1976).

The purpose of this note is to record for the first time *S. coronadensis* from Mexico, and to provide host fungal records for this species.

During several field trips to the mountains of Taxco, Guerrero, Mexico, six specimens (one male and five females) of this species were collected associated with mushrooms of *Amanita rubescens*, *Cortinarius* sp., *Ganoderma applanatum* and *Tylopilus* sp. (FIRST HOST RECORDS). In this area, the specimens were found in cloud forest and in oak-pine

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forest, between 2 180-2 300 m. Adults of the species have been collected from May through August (Campbell 1976), but in Guerrero, one male and one female were collected in October.

**MATERIAL EXAMINED:** MEXICO: Guerrero, Desviación a Pto. Oscuro, Bosque de Pino-Encino, 2 260 m, 3.VII.1986, J.L. Navarrete col., ex *Amanita rubescens* (1♀); same data, except: ex *Cortinarius* sp. (2♀); same data, except: Parque El Huizteco, Bosque Mesófilo de Montaña, 2 300 m, 25.VII.1986, ex *Tylopilus* sp. (1♀); same data, except: km 10 carr. a Tetipac, El Peral, Bosque Mesófilo de Montaña, 2 180 m, 25.X.1986, ex *Ganoderma applanatum* (1♂, 1♀). Specimens are deposited in the Instituto de Biología, UNAM (IBUNAM) and in my collection.

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I would like to thank J.M. Campbell for the specific identification of the species; and A.F. Newton Jr. and M.K. Thayer for their kind help and hospitality during a recent visit to the Field Museum of Natural History.

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## GENERA OF BAETIDAE (EPHEMEROPTERA) FROM CENTRAL AMERICA<sup>1</sup>

C. R. Lugo-Ortiz, W. P. McCafferty<sup>2</sup>

**ABSTRACT:** In addition to eight genera of Baetidae (Ephemeroptera) previously authenticated as occurring in Central America, we report or confirm for the first time the occurrence of *Acerpenna* Waltz and McCafferty and *Baetis* Leach. New records of *Acerpenna* from Belize, Costa Rica, Honduras, Nicaragua, and Panama indicate the genus is well established in the Neotropics. *Baetis magnus* McCafferty and Waltz (*rhodani* group) is newly reported from Costa Rica and Guatemala. The generic placement of *Baetis sinuosus* Navás (probably *fuscatus* group) is provisionally accepted and thereby confirms the presence of a second species of *Baetis* in Central America. Whereas most baetid genera in Central American have Neotropical affinities, the *Baetis* spp. appear to have Nearctic affinities.

Eight genera of the mayfly family Baetidae have been correctly reported from Central America. The biogeography of these genera was treated by McCafferty *et al.* (1992). *Baetodes* Needham and Murphy was first reported from Central America (Honduras) by Packer (1966). Subsequent records include Cohen and Allen (1972) (El Salvador and Guatemala), Cohen and Allen (1978) (Panama), and McCafferty (1985) (Belize and Costa Rica). *Callibaetis* Eaton was first reported from an unspecified Central American country by Eaton (1881). Subsequent records include Eaton (1885) (Guatemala), Packer (1966) (Honduras), and McCafferty and Lugo-Ortiz (1992) (Nicaragua). *Camelobaetidius* Demoulin was reported from Costa Rica, El Salvador, Guatemala, Honduras, and Panama by Traver and Edmunds (1968). *Cloeodes* Traver was reported from Panama by Flowers (1991). *Fallceon* Waltz and McCafferty was reported (as *Baetis* s. lato) from Belize and Costa Rica by McCafferty (1985). *Guajirolus* Flowers was described from Panama by Flowers (1985). *Moribaetis* Waltz and McCafferty was reported from Costa Rica, Guatemala, and Panama by Waltz and McCafferty (1985). *Paracloeodes* Day was reported from Panama by Flowers (1991).

All of the above genera, with the exception of *Guajirolus* and *Moribaetis*, which are strictly Neotropical, are Panamerican (Nearctic plus Neotropical). In addition to the above reported Central American records, we have seen *Cloeodes* from Costa Rica and Honduras; *Fallceon* from Honduras; *Guajirolus* from Costa Rica; and *Paracloeodes* from Costa Rica and Honduras.

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In their analysis of Mesoamerican mayflies, McCafferty *et al.* (1992) showed the Central American baetid fauna generally to have Neotropical affinities, rather than Nearctic. Although McCafferty *et al.* (1992) did not know *Paracloeodes* from Central America at that time, they predicted its presence there, which would corroborate a recent Neotropical center of dispersal for the genus. McCafferty *et al.* (1992) considered the distributional and cladistic data regarding *Callibaetis* to be too inconclusive for deciphering a biogeographic history for the genus. Neotropical elements of this Western Hemisphere genus must be better understood prior to hypothesizing its evolutionary history.

We have discovered one additional genus of Baetidae from Central America and confirm the presence of another genus previously reported on the basis of less restrictive generic concepts. Below, we provide these records and discuss their significance.

### *Acerpenna* Waltz and McCafferty

The *Acerpenna* we report from Central America is represented by larvae of two new species to be described elsewhere.

NEW RECORDS. *Acerpenna* spp. BELIZE. Cayo Prov.: Roaring Creek, VI/20/74, V. Resh, larvae, PERC (Purdue Entomological Research Collection, West Lafayette, Indiana); (?): Sibun River, Gracy, 19/VI/74, V. Resh, larvae, PERC. COSTA RICA: Guanacaste prov.: Río Tenorio at Finca La Pacifica, E of Panamerican Hwy., II/8-11/69, W. P. McCafferty, larvae, PERC; Limón Prov.: Río Banano, 16 km. WSW of Bomba, 9.888°N/83.167°W, 150 m., III/26/87, Holzenthal, Hamilton, and Heyn, larvae, FAMU (Florida A&M University, Tallahassee, Florida); San José Prov.: Río parmita Chiquito, Rt. 12, 6.5 km. SW jct. Rt. 2., 9.703°N/83.970°W, IV/10/87, Holzenthal, Hamilton, and Heyn, larvae, FAMU. HONDURAS. Cortes Prov.: Chamalech, Río Chamel, X/18/64, J. S. Packer, larvae, PERC. NICARAGUA: Presa El Clavo, IX/10/80, larvae, PERC.

REMARKS. The genus *Acerpenna* was erected by Waltz and McCafferty (1987b) to include *A. macdunnoughi* (Ide) and *A. pygmaea* (Hagen). Later, McCafferty and Waltz (1990) added *A. akataleptos* (Traver) and *A. harti* (McDunnough). All of these species occur in North America north of Mexico, the southernmost range of any being that of *A. pygmaea* in the Edwards Plateau in central Texas (McCafferty and Davis 1992; Lugo-Ortiz and McCafferty, 1993).

The discovery of *Acerpenna* in the Neotropics is significant, indicating an additional Panamerican baetid genus. Waltz (pers. comm.) has seen female adults of *Acerpenna* from Panama, and we have also found the genus in South America and the Greater Antilles, and we expect to find it in Mexico. Further analysis of the group may indicate that *Acerpenna* is yet another Panamerican baetid genus of Neotropical origin.

## Baetis Leach

Our Central American record of *Baetis* is based on larvae of *B. magnus* McCafferty and Waltz. This species is a member of the *rhodani* group of species, which in the Nearctic is particularly well represented in the southwestern United States (Moriyama and McCafferty 1979). *Baetis magnus* is known as far north as western Nebraska (McCafferty and Waltz 1986), and we recently have found it throughout Mexico.

NEW RECORDS. *Baetis magnus*. COSTA RICA. Cartago Prov.: Reserva Tapanti, Río Badilla, 9.688°N/83.757°W, 1640 m., III/21/87, Holzenthal and Hamilton, larvae, FAMU; Río Birris, Rt. 8 ca. 2.5 km (air) NE of San Juan de Chicao, 9.960°N/83.844°W, 2850 m., II/4/86, Holzenthal, Morse, and Fasth, larvae, FAMU; Puntarenas Prov.: Río Bellavista, ca. 1.5 km NW of Las Alturas, 8.951°N/82.846°W, 1400 m., VI/15-17/86, Holzenthal, Heyn, and Armitage, larvae, FAMU; Río Sinigri, ca. 2 km (air) S of Finca Helechales, 9.057°N/83.082°W, 720m., II/21/86, Holzenthal, Morse, and Fasth, larvae, FAMU; Río Jaba at rock quarry, 1.4 km (air) W of Las Cruces, 8.79°N/82.97°W, 1150 m., VI/14/86, Holzenthal, Heyn, and Armitage, larvae, FAMU; San José Prov.: Parque Nacional Braulio Castillo, park headquarters, 10.059°N/84.017°W, 1650 m., VII/7/86, Holzenthal, Heyn, and Armitage, larvae, FAMU; 12 mi. N of San Isidro del General, Panamerican Hwy., 5200 ft. VII/20/62, G. G. Musser, larvae, PERC. GUATEMALA. Solalá Prov.: River at Panajachel, I/16/89, B. C. Kondratieff, larvae, PERC.

REMARKS. The genus *Baetis* has been the subject of considerable recent revisionary work that has resulted in many synonymies and recombination of species and the recognition of new genera (Moriyama and McCafferty 1979; Waltz and McCafferty 1985, 1987b, 1987c; McCafferty and Waltz 1990). As pointed out by McCafferty *et al.* (1992), no previous records of *Baetis* s. str. in Central America have been confirmed. Navás (1924) described *Baetis sinuosus* from Costa Rica on the basis of a male adult. We have not been able to secure Navás' material for evaluation. Our examination of Navás' description and figure of the hindwing does, however, indicate a strong probability that it is a true *Baetis*, most likely of the *fuscatus* group. Moreover, it has an apparent similarity to *B. flavistriga* McDunnough, a widespread North American species that we have seen in northern Mexico. We are therefore provisionally confirming the present generic placement of this species.

Although South American species have been described in the genus *Baetis* (see Hubbard and Peters 1981; Hubbard *et al.* 1992), those generic placements are doubtful and have yet to be verified. If the Neotropical element of *Baetis* proves to be limited to a sparse representation in Central America as indicated, then it apparently is one of the few examples of a Panamerican group whose Neotropical representatives are derived from the Nearctic. This has been shown to be the case for a relatively small number of mayfly genera, such as *Isonychia* Eaton (Isonychiidae)

and *Stenonema* Traver, *Rhithrogena* Eaton, and *Iron* Eaton (Heptageniidae) (see McCafferty *et al.* 1992).

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## 1933 CALVERT AWARD PRESENTED FOR STUDY OF STREAM INVERTEBRATES

Justin Schilling grew up near Wissahickon Creek in southeastern Pennsylvania. He noticed that a small tributary flowing near a limestone quarry had a lot of chalky sediment. He hypothesized that the sediment was limestone dust (calcium carbonate) and that mollusks whose shells are made of calcium carbonate would be more abundant on Wissahickon Creek downstream from the tributary. After a thorough study of water quality and an analysis of stream invertebrates at three locations, he refuted his hypothesis. In the process he learned a lot about the identification of local aquatic insects. Among the approximately 25 students who entered insect-related projects at the Delaware Valley Science Fairs, Justin was one of the few who could discuss insect biology and taxonomy. The American Entomological Society awarded Justin Schilling its annual Calvert Award for his project entitled "The Effects of a Limestone Tributary on Invertebrate Life in the Wissahickon Creek." Justin is a sophomore at Abington Friends School in Jenkintown, Pennsylvania.

The Calvert Award recognizes outstanding insect-related work by a young person in the Delaware Valley. It honors Dr. Philip P. Calvert who joined the Society as a teenager, later became its president, and was a member for 74 years until his death in 1961. As a professor of biology at the University of Pennsylvania and as an associate of the Academy of Natural Sciences of Philadelphia. Dr. Calvert stimulated an interest in insects among many young people. The award includes membership in The American Entomological Society and the Young Entomologists' Society and a check for \$50.

The Calvert Award was presented April 28 at the Society's membership meeting at the Academy of Natural Sciences of Philadelphia. Also honored were Benjamin Martin for his runner-up project, "The Extraction and Testing of Natural Pesticides", and Ben Blanchard for his honorable mention project, "A Quantitative Study of Water Quality in Local Streams using Macroinvertebrates."

Harold B. White, Vice President. A.E.S.  
and Chair, Education Committee

## CARPENTER ANT (HYMENOPTERA: FORMICIDAE) TUNNELS VISUALIZED BY COMPUTED TOMOGRAPHY<sup>1</sup>

Rif S. El-Mallakh<sup>2</sup>

**ABSTRACT:** Carpenter ant (*Camponotus* sp.) tunnels within a wooden beam of Douglas fir (*Pseudotsuga menziesii*) were studied by X-ray computed tomography. A pattern characterized by the main, or lead, tunnel within the pith and giving rise to an ever expanding set of tunnels was noted. This innovative method of examination of wood specimens provides accurate information about the interior tunnel systems of the ants without the need for sectioning the wood and destroying the specimen.

Carpenter ants, *Camponotus* sp., are common, economically important animals with a world wide distribution. Within the United States the nine most common species are found primarily in the heavily wooded moist northeast and northwest (Olkowski, Daar, and Olkowski, 1991). Most species seek protection within tunnels excavated in dead or decaying wood, but are capable of chewing through undamaged wood as well. They may be attracted to man made structures, particularly if the wood is weathered or if the structure contains small hollow areas within wooden walls (Olkowski, Daar, and Olkowski, 1991). Since they do not feed on the wood and since a colony may require 3-6 years to grow to its mature size of roughly 2000 individuals, they are often slow to cause extensive damage (Ebling, 1978).

The economic importance of carpenter ants derives primarily from their tunnel excavations, consequently tunnel structure has been extensively studied. It has long been known that they preferentially chew through the softer heart and spring wood to produce a pattern of ever enlarging concentric tunnels (Goetsch, 1953). In the past, making these observations has required the destruction of the wooden structure that holds the nest; this paper presents the results of an alternative method which uses X-ray computed tomography to map the 3-dimensional architecture of *Camponotus* tunnels without destroying the original specimen.

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## MATERIALS AND METHODS

A severely damaged wood beam was obtained from the Field Museum of Natural History in Chicago, Illinois (Figures 1 & 2). The specimen was donated by a sculptor who had bought it for his work. Its origins prior to that are unknown. The wood was identified by vascular anatomy to be Douglas fir, *Pseudotsuga menziesii* (Mirb.) Franco. It measured 9cm X 8.5 cm X 63.5 cm.

The wood was scanned with a 1005 type head EMI computerized axial tomography (C.A.T.) scanner (EMItronics Inc., X-ray Systems Division, Northbrook, Illinois), an early generation computed tomography machine manufactured in the early 1970s. It is designed to obtain cross-sectional X-ray images of the human brain and to reconstruct them digitally. Each cross-sectional plane is scanned several times from a variety of angles over 240° while corresponding X-ray attenuation data are gathered. Since the degree of X-ray attenuation is dependent on the density of the object, the image is a computer reconstruction of the density of the material. In this study, an 8 mm thick x-ray beam was used for each slice, with a energy of 120 kV and 33mA.

## RESULTS

A representative sample of the images is shown in Figures 3a-f. In these photographs white areas are wood of sufficient density that it can be resolved by the computer (usually summer wood). The dark areas are either empty spaces or wood of such low density (usually spring wood) that it cannot be resolved by the machine at the energy settings used. The leading end of the ant tunnels is seen in the pith of the beam in Figure 3a. This section corresponds to the right arrow in Figure 1. As one travels toward the outer end of wood beam (i.e., toward the end pictured in Figure 2), the extent of the tunnels becomes progressively enlarged (Figures 3a-3f). While the density of the spring wood was less than the resolution of the machine at the energy settings used, selective destruction of the spring wood can be ascertained by the clear presence of remnants of summer wood within the major portion of the tunnels (Figures 3c, 3d, and 3e).

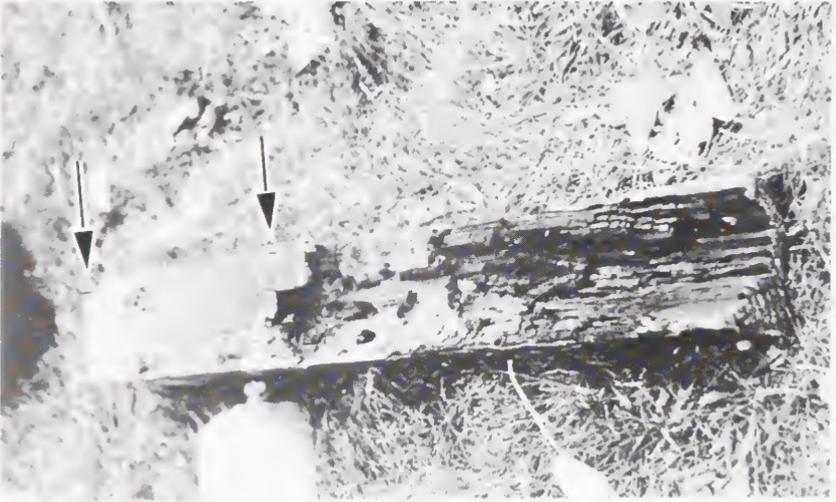


Figure 1. The Douglas fir specimen used in this study. Only the portion between the arrows was scanned. The right arrow corresponds to Figure 3a, while the left arrow corresponds to Figure 3f.



Figure 2. Typical macroscopic pattern of severe *Comptonotus* damage. This photo corresponds to Figure 3f.

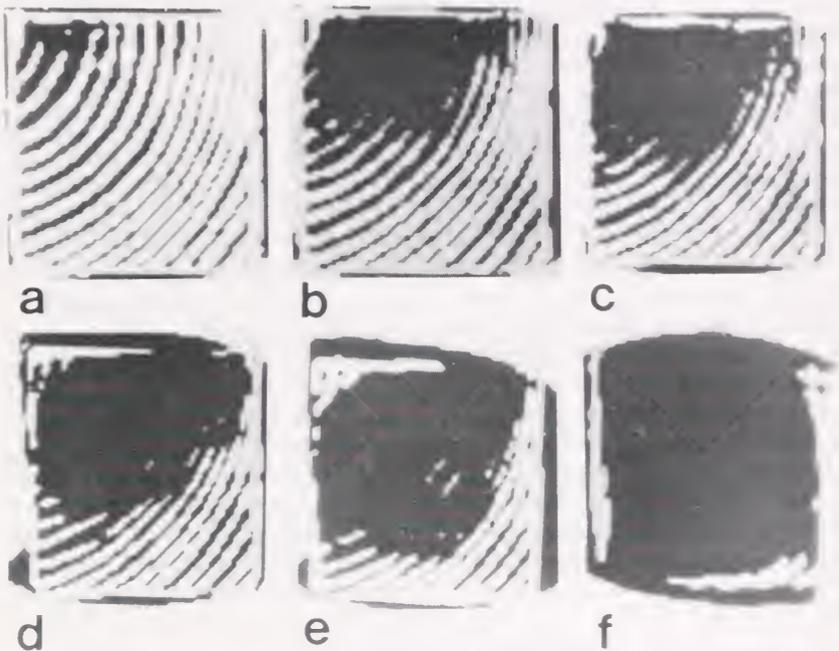


Figure 3. Six representative photographs from a total of 24 taken. Each image is the average density of 8 mm thick slice of wood. (a) The leading end of the tunnel. Note that the ants start at the soft pith. (b-e) A series revealing the progressive widening of the ant excavations. Remnants of denser spring wood can occasionally be seen within the main body of the tunnel. (e) At the outer edge of the tunnel, the entire thickness of the beam is damaged.

## DISCUSSION

Computerized tomography is a medical diagnostic instrument that visualizes the internal soft tissue anatomy of the human body and brain (Huckman, 1975; Weisberg, 1979). Its use in clinical medicine is now quite extensive.

The application of this technique to the study of tunnels created by *Camponotus* is proposed, and our study verifies that the results obtained by this method are similar to previously reported patterns of tunnel architecture. Specifically, the X-ray data is compatible with the primary or leading end of carpenter ant tunnels being through the softer pith and with the ants expanding their tunnels laterally with some sparing of the denser summer wood (Goetsch, 1953).

However, there are various limitations to the technique. First, the great size and intricacy of the machine prevent any level of portability. This reduces the potential application of this technique to relatively small specimens that must be brought to the instrument. Second, at current prices, computerized tomography time is very expensive (human diagnostic charges average \$600.00 per hour, and one hour would be needed for most specimens). Third, while overall tunnel structure can be visualized, small structural details, or the insects themselves are below the level of resolution. The thickness of the X-ray beam, 8 mm in the model used in this study, and software limitations of this and more advanced models, make maximal resolution approximately 5 mm. Finally, in this study full appreciation of the tunnel system was limited due to inability to visualize the less dense spring wood. This problem can be partly alleviated by decreasing the energy of the X-ray beam, and is not a problem when scanning more dense material.

Nonetheless, this technique may be useful for ascertaining the extent of insect damage to valuable wooden specimens (e.g., sculptures, antiques, etc.). More importantly, since 3-dimensional reconstructions can be made from the digitalized data, additional perfection of this technique can lead to the creation of manipulatable perspective images that can be used for teaching or comparing 3-dimensional nest structure of various species.

#### ACKNOWLEDGMENTS

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## AN INEXPENSIVE VACUUM COLLECTOR FOR INSECT SAMPLING<sup>1</sup>

S. W. Wilson<sup>2</sup>, J. L. Smith<sup>2</sup>, A. H. Purcell, III<sup>3</sup>

**ABSTRACT:** An inexpensive suction sampler was constructed by modifying a gasoline powered leaf blower/vacuum (Weed Eater®). Comparison of the sampler with use of an aquatic dip net to collect a planthopper species from emergent aquatic plants showed that the sampler was more efficient in collecting adults and was especially useful for capturing early instars. The Weed Eater® sampler was comparable or superior to a D-Vac for collecting grassland arthropods (Wright and Stewart 1992). The total cost of this light (<6 kg.) sampler, including modifications, is ca. \$130.

The commonly used methods of collecting or sampling insects by sweeping, beating, aspirating, or hand-picking undercollect very small insects and mites disproportionately and miss arthropods at the base of low vegetation (Herms *et al.*, 1990; Perfect and Cook, 1983; Schotzko and O'Keefe, 1989; Southwood, 1978; Summers *et al.*, 1984). Suction collectors such as the D-Vac (Dietrick, 1961) overcome these inadequacies at the costs of large size and weight (18.1 kg), expense (US\$1100+), portability, and reliability. In this paper we describe a relatively small (5.7 kg), inexpensive (\$130) and portable vacuum collector (hereafter referred to as the "bug-vac") easily converted from a gasoline-powered leaf blower.

### MATERIALS AND METHODS

Modifications were made to a Weed Eater® hand held leaf blower (Model 1920, 920, or 960) and Weed Eater® vacuum attachment kit (Model 952-701613 (VA 1905)) purchased at a discount store (the manufacturer's address is: Poulan/Weed Eater, Division White Consolidated Industries, Inc., Shreveport, Louisiana 71139-9329, USA). Materials for modification include duct tape (heavy duty cloth tape), eight 1.2 cm x 0.3 cm machine screws, eight lock washers and nuts, one piece of 0.95 cm metal circular screen, and two U-clamps (to attach the strap to the body of the leaf blower). Detailed instructions for assembly and use as a leaf vacuum are supplied by the manufacturer with the vacuum attachment kit; modifications to these instructions include the following:

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- 1) The strap on the vacuum bag (part of the vacuum attachment kit) was cut off where it connects to the bag, the bag disposed of (the machine can be operated with the vacuum bag attached), and a clamp sewn onto each end of the strap. The clamps on the strap were attached to the ring on the leaf blower handle.
- 2) The basal end of the vacuum tube (from the vacuum attachment kit) was fastened to its fitting sleeve by four bolts and nuts rather than just by the large, circular hose clamp supplied for this purpose. Four holes were drilled through the plastic sleeve on the machine, the base of the plastic vacuum tube, and the hose clamp. The exposed ends of the bolts were wrapped with duct tape around the outside of the vacuum tube ("a" in Fig. 1).
- 3) We used two methods to prevent the insect-collecting bag from being accidentally sucked into the vacuum fan. Either (1) a flat circular piece of wire screen (0.95 cm mesh) can be bolted into the interior of the vacuum tube about 30 cm from the distal end of the tube or (2) the screen can be fashioned into a cup-shaped basket that fits snugly within the tube with the rim of the basket bent flush and taped along the outside 2 cm of the vacuum tube. Loose ends of wire in the screen are soldered. In either method, any protruding bolts or the wire rim of the basket are tightly wrapped with heavy tape to cover these sharp protrusions ("b" in Fig. 1).

Orienting the leaf blower in a reverse (or backward) position facilitates starting.

## RESULTS AND DISCUSSION

The bug vac proved equal or superior to sampling with a D-Vac or net. Wright and Stewart (1992) converted an Atco "Blow-Vac" leaf-blower using our directions and compared its sampling efficiency to a D-Vac in three grassland sites in Great Britain. They found that the "Blow-Vac" collected comparable numbers of Diptera, Hymenoptera, and most Homoptera (Auchenorrhyncha). The D-Vac caught significantly greater numbers of two species of leafhoppers (Cicadellidae) at one of the three sites. However, their "Blow-Vac" proved much more efficient than the D-Vac for capturing Coleoptera and Araneae.

The improved collection of immature planthoppers such as the delphacid *Pissonotus piceus* (Van Duzee) (Homoptera: Fulgoroidea) using the bug-vac was demonstrated in collections from its host, the emergent aquatic plant "mild water pepper" (*Polygonum hydropiperoides* Michx.) Sweeping this plant proved to be an inadequate method of collecting this delphacid. A more efficient method, used once per week

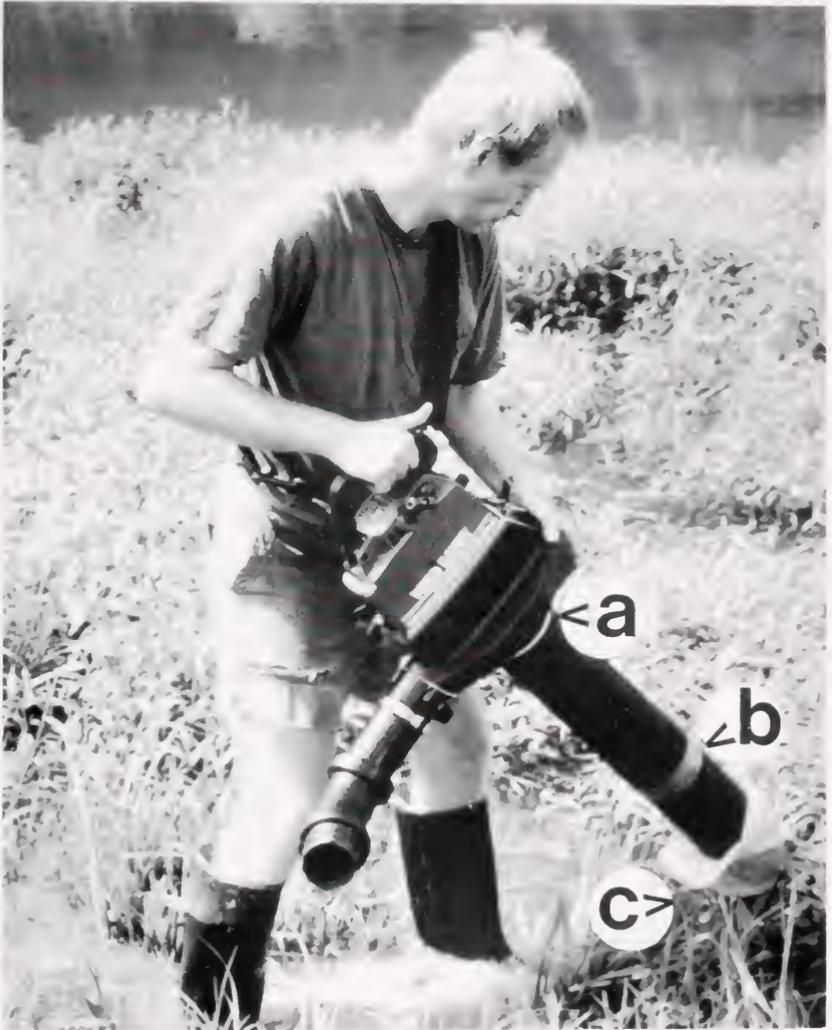


Fig. 1. Using the gasoline-powered leaf blower adapted as an insect vacuum ("bug-vac") to collect insects from an aquatic emergent plant. Four bolts attach the basal end of the vacuum tube to a sleeve on the machine; exposed ends of the bolts are covered with cloth tape (a). A wire screen is bolted to the inside of the collector tube; exposed ends of the bolts are covered with cloth tape (b). A net bag is inserted in the vacuum tube and attached with two large rubber bands (c).

during 1989, was to strike the plants with an aquatic dip net and aspirate the insects from the net. During 1990, the bug-vac was used to sample insects from plants as the collector waded through the vegetation (Fig. 1). The bug-vac reduced average sampling times from 45 to 5 minutes and collected a greater mean number of planthoppers (Fig. 2;  $t = 2.87$ ,  $p < 0.05$ ). It was especially useful for collecting the small (length ca 1.0 mm.) first instar nymphs (Fig. 3;  $t = 3.15$ ;  $p < 0.05$ ), few of which were damaged.

As with other vacuum collectors, the bug-vac develops higher intake velocities with the collecting tube near the ground. Despite this, we collected significantly higher numbers of the leafhopper *Fieberiella florii* Stål (Homoptera: Cicadellidae) from its typical shrub or hedge host plants in Berkeley, California with the bug-vac, than with a standard

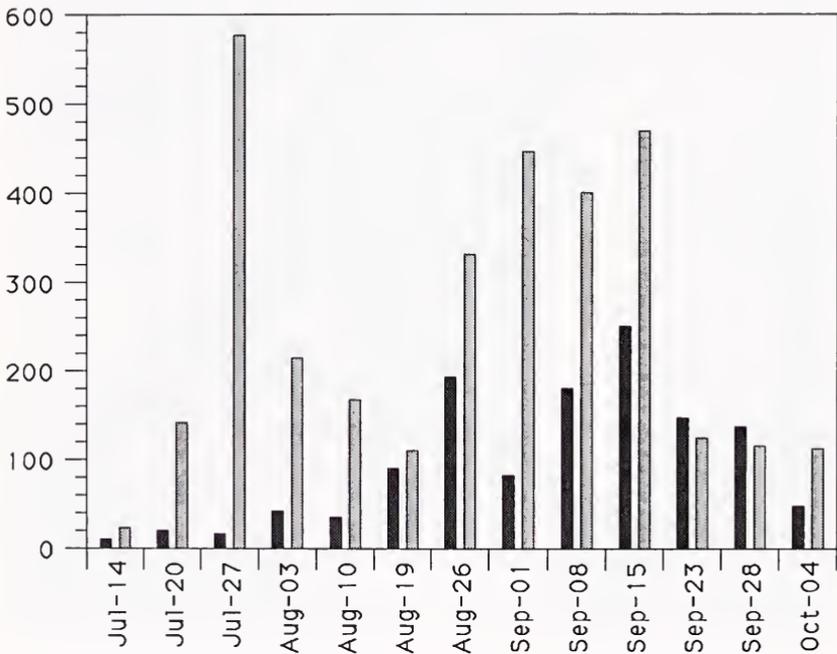


Fig. 2. Number of *Pissonotus piceus* collected per week with a dip net (dark stippling) and bug-vac (light stippling);  $N_{\text{dip net}} = 1587$ ,  $N_{\text{bug vac}} = 3732$ .

sweep net (Purcell, unpubl. data). In these sampling experiments, equal-length halves of boxwood (*Buxus* sp.) or privet (*Ligustrum* sp.) hedges were sampled by thoroughly sweeping or vacuuming horizontally with the net or bug-vac. Typical of other suction collectors, the bug-vac was more efficient than sweeping, especially in collecting early instar nymphs of *F. florii*.

The light weight and size of the bug-vac allow it to be transported, disassembled, in a large suitcase if the exhaust tube and terminal end of the vacuum tube are removed. Also, it can be carried in a carton that fits easily in the luggage compartment of small automobiles. One disadvantage shared with the D-Vac is the high noise level of the bug-vac; ear protection should be worn during operation. The engine has proven to be reliable and durable over four seasons of use.

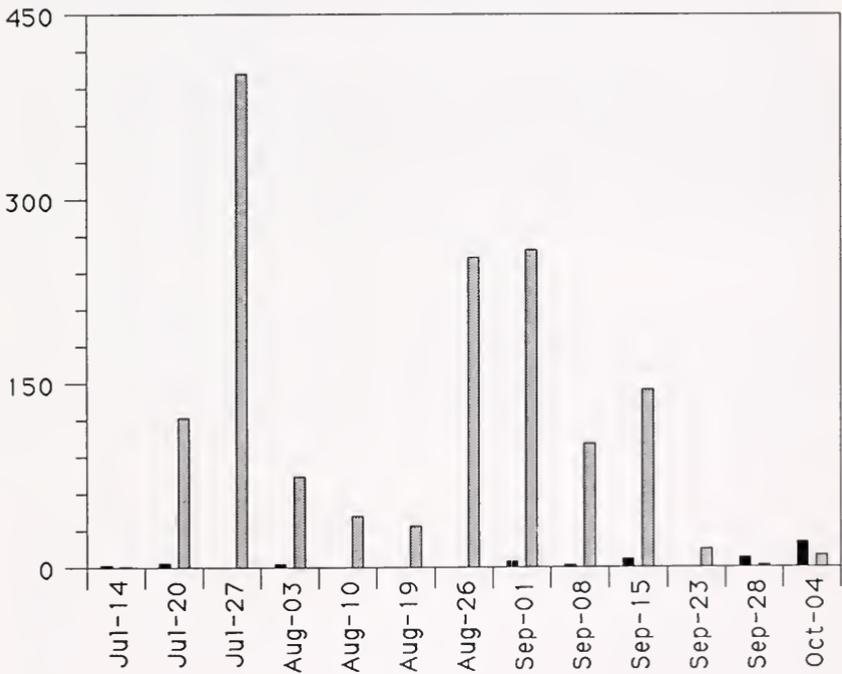


Fig. 3. Number of *Pissonotus piceus* first instars collected per week with a dip net (dark stippling) and bug-vac (light stippling):  $N_{\text{dip net}} = 92$ ,  $N_{\text{bug vac}} = 754$ .

## ACKNOWLEDGMENTS

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## INSECT REMOVAL FROM STICKY TRAPS USING A CITRUS OIL SOLVENT

Richard S. Miller<sup>2</sup>, Steven Passoa<sup>3</sup>, Robert D. Waltz<sup>4</sup>, Victor Mastro<sup>5</sup>

**ABSTRACT:** A new procedure using citrus oil was developed for removing both heavily sclerotized and soft-bodied insect specimens from sticky traps. The scales of adult Lepidoptera are usually left intact. Procedures for using standard techniques such as pinning, slide preparation, and genitalic dissection are also discussed.

Although sticky traps are used extensively for studying and monitoring insect populations (Peterson 1964; Murphy 1985), removal and identification of trapped specimens is difficult (Lindgren *et al.* 1983; Murphy 1985; Knodel and Agnello 1990). The sticky material in the traps, usually polyisobutylene (PIB), often obscures or distorts critical characters needed for accurate determination. Murphy (1985) tested the use of various solvents to remove sclerotized insects, such as Coleoptera and Hymenoptera, from sticky traps. He found that polar solvents are unsuitable and suggested several alternative nonpolar solvents including toluene, heptane, hexane, and xylene. Ethyl acetate, methychloroform, petroleum spirits, gasoline, and kerosene proved less effective. Because all these solvents are, to some extent, toxic to humans and flammable, they must be used under a fume hood in the laboratory away from flames or electric equipment. Besides the laboratory hazards, these solvents are ineffective for extracting adult Lepidoptera and soft-bodied insects (Murphy 1985).

Because some of the targets of the USDA exotic pest detection program are microlepidoptera, we sought alternative solvents and procedures for sticky trap insect identification. One potential alternative solvent is citrus oil, which has the initial advantage that it is on the GRAS (Generally Regarded As Safe) list of the Food and Drug Administration.

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## METHODS

We tested citrus oil marketed by three sources for effectiveness in the extraction of various orders of insects imbedded in PIB. Formulations included Durkee® lemon extract used as a food additive and purchased at a local supermarket; a histological clearing agent marketed as Histo-Clear® by National Diagnostics; and Livos® thinning agent #7222 sold by Livos Plant Chemistry Inc.\* Insect specimens used in the tests were those submitted on delta, Rebell®, and wing traps to the USDA Pest Identification Laboratory in Reynoldsburg, Ohio. The effectiveness of the formulations was observed for most orders of insects.

## RESULTS

All citrus oil formulations examined were viable alternatives to other solvents listed by Murphy (1985), although cost per unit volume varies widely. Our tests of various handling techniques suggest the following procedures for removing and identifying specimens from PIB.

**Screening Samples.** Sticky trap bottoms are most effectively screened with an illuminated magnifying glass mounted on a stable base. It is also advantageous to cover the work area with scraps of cardboard to protect the work surface from being fouled with PIB or scratched with a scalpel blade. If a stereomicroscope is used, protect the objective lens with a neutral density or polarizing filter to prevent contact with PIB.

**Insect Removal.** If the specimen is fresh and heavily sclerotized, for example a beetle, it may be lifted directly from the trap bottom and placed into solvent. A few drops of citrus oil on the trap bottom will loosen the specimen and ease removal. However, if the specimen is dry and brittle or soft bodied, it should be left untouched on the trap. The extraneous portion of the trap (and any excess PIB) surrounding the insect should be cut away with a scalpel before it is placed in the solvent bath. Movement should be minimized, because any distortion of the PIB will probably damage the specimen by pulling it apart. The volume of the solvent bath should be at least sufficient to cover the specimen. After a few hours the insect will float clear of the trap and PIB. Most specimens can be left in the solvent overnight until any residual PIB has dissolved. To prevent saturation of the citrus oil, the cut portion of the trap bottom should be removed after the insect has been freed. The length of time

\*FOOTNOTE. Mention of commercial products in this paper does not constitute a recommendation by the United States Department of Agriculture.

required in the solvent varies with the amount of PIB to be dissolved and the condition of the solvent. Solvent effectiveness will eventually decline when it becomes saturated and, consequently, the time required to remove the PIB will increase. Glassware (e.g., petri dishes) must be used because citrus oil will react with plastic.

One way to speed removal of the PIB is to use an ultrasonic cleaner. The insect is put in a small vial filled with solvent and placed in the ultrasonic cleaner with water. The vial is required for two reasons. It dampens the sound waves protecting fragile insects from excessive movement and potential damage, and it conserves solvent because it is not necessary to fill the whole tank. Most hard-bodied insects will be cleaned in 5-10 seconds. Wings of Lepidoptera can also be descaled in this manner for morphometric and venational studies.

Occasionally, a film of dried PIB will adhere to the specimen when it is removed from spent solvent. This residue can usually be removed by rinsing the insect in xylene and/or absolute ethanol. Leaving material overnight in fresh citrus oil is another option. Although specimens may be left in the citrus oil for extended periods without apparent damage, they do become more brittle after 24 hours.

**Pinning.** After allowing the specimen to air-dry for a few minutes, it may be pinned. If the insect must be relaxed before pinning, it can be immersed in water for a few hours (or in subboiling water for a few minutes).

**Alcoholic Specimens.** Insects which normally are stored in alcohol may be rehydrated by placing them in subboiling water for a few minutes before permanent preservation in 80% alcohol.

**Slide-mounted Specimens.** Very small specimens, e.g., springtails, thrips, mites, scale crawlers, some nematoceran Diptera, and Hymenoptera for which the preparation of slide mounts may be necessary, can be transferred directly from PIB into Euparal. Specimens that need to be cleared before mounting should be handled as in the above section, thus significantly reducing clearing time in KOH. Warming the Euparal prior to mounting is helpful.

**Preparation of Genitalia.** The following procedure can be used to prepare genitalia of moths trapped in PIB. Standard techniques discussed by Holloway *et al.* (1987) have been modified and shortened to save time in screening large samples.

1. Pull the abdomen from the trap substrate.
2. Immerse in citrus oil to clean specimen.
3. If still not free of PIB, return specimen to solvent for another 12 hours.

4. When cleaned of PIB and if time permits, place abdomen in 10% potassium or sodium hydroxide (KOH or NaOH) for 12-24 hours at room temperature. Alternatively, wear safety goggles and boil the abdomen in hot hydroxide until it is soft.

5. Wash abdomen in water, or preferably, a 5% solution of glacial acetic acid and water to neutralize the KOH or NaOH.

6. Place abdomen in 50% alcohol and mechanically brush scales from it.

7. Stain with mercurochrome or chlorazol E black if desired.

8. Either place specimen in vial of 70% alcohol, mount in Hoyer's solution, or clear and dehydrate the specimen for mounting in a resin such as Euparal or Canada balsam.

The time required to prepare lepidopteran genitalia varies extensively. Large moths generally require a longer KOH or NaOH bath than smaller moths. Typically, a large moth may require almost a day at room temperature, whereas smaller moths may need only a few hours. Therefore, we recommend monitoring the progress of maceration. For those unfamiliar with this technique, we suggest making trial runs with moths of various sizes before attempting to use this technique on actual unknowns. Specimens left in citrus oil too long will be brittle, while those left in KOH too long will be over-cleared and difficult to see.

In many cases where quick determination is required, "valve-ripping" may be utilized. In this procedure the genitalic valva is grasped at the base, pulled off the abdomen, placed in citrus oil, and then cleaned in alcohol. Identification of many genera of Tortricidae and Noctuidae can be confirmed by examining only the shape of the valve.

## CONCLUSION

The success of each preparation depends largely on the condition of the specimen when it is removed from the trap bottom. Fresh specimens that are shallowly embedded in the PIB provide the best results, but even those totally immersed can usually be recovered if they have not decomposed. Larger insects usually fare better, because small insects are more likely to become immersed and decay. Extensive struggle by the insect on the trap after capture often results in loss of setae and scales. Additionally, scales, setae, and wings are often dislodged if the specimens are manipulated before removal of the polyisobutylene. Specimens removed with citrus oil using the above procedures have been maintained for more than two years with no adverse effects.

Citrus oil offers distinct advantages over previously used solvents for removing PIB, and most orders of insects have been extracted suc-

cessfully from sticky traps using this procedure. Generally, the technique works well for all taxa tested, but a higher percentage of success occurs in fresh and more sclerotized specimens. Unlike solvents listed by Murphy (1985), citrus oil does not leave specimens unduly brittle, and subsequent laboratory and curatorial techniques can be easily accomplished after removal. Solvent toxicity is reduced or absent, although a fume hood is still recommended to avoid breathing the fumes. Most important, soft-bodied insects and Lepidoptera can be treated without damage, if properly handled. Several problems remain: citrus oil is flammable, the process remains time consuming, all specimens are not recoverable, trap bottoms are often not reusable, and no specimens are perfect "display quality." Other dry-trapping methods with screens to remove unwanted nontargets are recommended if specimen quality is critical.

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## BOOK REVIEWS

LIFE IN AMBER. George O. Poinar, Jr. 1992. Stanford University Press. 350 pp. \$55.00

LES FANTOMES DE L'AMBRE INSECTES FOSSILES DANS L'AMBRE DE LA BALTIQUE. E. Krzeminska, W. Krzeminski, J-P. Haenni and C. Dufour. 1992. Musée d'histoire naturelle de Neuchâtel (14, Rue des Terreaux, CH-2000 Neuchâtel, Switzerland). 142 pp. 38 SFR. (in French)

Amber is a very hot topic these days, with recent articles about it appearing in widely different publications, such as *The Philadelphia Inquirer*, *Newsweek*, *Smithsonian*, and *Nature*. Much of the interest in the general public has been sparked by an interplay of reality and fiction. For example, recent reports on the actual sequencing of DNA from amber-enclosed insect fossils now places the oldest sequenced DNA from a weevil in Lebanese amber (125 million years old) while the fictional idea of cloning dinosaurs from dinosaur DNA in blood fed upon by amber-enclosed mosquitoes is of critical importance to the blockbuster dinosaur book and movie, *Jurassic Park*. In addition, many museums across the country, including the Academy of Natural Sciences, have mounted exhibits looking at the scientific research behind *Jurassic Park*; and these shows have given the public a chance to see actual insect fossils in amber, along with the standard dinosaur bones. Entomologists have surely noted the numerous recent papers by insect systematists on amber insect fossils, most of this resulting from amber mined in the last few decades from the Dominican Republic. The above reviewed books, both written by experts in amber research, are well timed to take advantage of this heightened interest, hopefully allowing the books to reach a broad audience.

George Poinar's work on organisms in amber (primarily Dominican) extends back to 1975 and includes numerous papers on the invertebrates as well as describing the Dominican tree species which is considered the source of the resin, *Hymenaea protera* Poinar. The first 60 pages of his book *Life in Amber* provides a concise and easily readable text dealing with the history of man's activities with amber, the formation of amber and its physical characteristics and a discussion of worldwide amber deposits. Particularly interesting is a section on distinguishing amber from recently deposited resin called copal (up to 4 million years old) and even present day, synthetic resins; Poinar details how "fake" amber inclusions are made and stresses how difficult it is to distinguish some of these from true fossilized amber. One learns that amber is not only found just in the color arising from its name, but may vary from light yellow to deep brown, with oxidized amber becoming reddish. The chapter on the world's amber deposits details all the major areas dating from the Mesozoic and Cenozoic, with maps and tables comparing ages of the deposits. Also of interest was the extensive discussion on the origin of Baltic amber; there is conflicting evidence on the primary species of tree which deposited the resin, either a *Pinus*-like conifer or araucarian, with Poinar supporting an *Agathis*-like araucarian. As a museum curator maintaining amber insect fossils, I found that the brief discussion of amber conservation was inadequate and lacked any references, but this may reflect only a paucity of research on this topic.

Most of *Life in Amber* (nearly 200 pages) consists of a taxon by taxon discussion of the biological inclusions found, starting with bacteria and ending with invertebrates. Insects, by virtue of their diversity and generally small size, make up the vast majority of these inclusions. Each family is treated in a paragraph or two, with a few sentences on general morphology and life history, then a listing of the generic forms found in the deposits, and

pertinent references. Two appendices in the back of the book list all the taxa (generally to family level) known from Mexican and Dominican amber (lists for Baltic amber have appeared elsewhere). This taxon-based section of the book is well illustrated with high quality photographs of the organisms; the eight color plates are particularly striking. Poinar's stated goal is to inform researchers of relevant organisms in amber and to encourage these scientists to incorporate these specimens into their systematic and biogeographic studies, and this book is successful in presenting the information.

The last section (about 30 pages) concerns amber inclusions in discussions of paleosymbiosis, extinction, biogeography and prospects for molecular studies. Of some disappointment to me is the section entitled "Reconstructing Ancient Landscapes," a mere two pages of very general information. This again may reflect upon the lack of information published on the subject, and the difficulties of utilizing any particular deposit of amber as a meaningful sample of the ecology of that time period.

The book *Les fantomes de l'ambre* delves deeply into the largest deposits of amber, those of the Baltic region, and was produced as a companion volume to the exhibit of the same name presently on display at the Musée d'histoire naturelle in Neuchâtel, Switzerland. Although the text is in French, which will, unfortunately, reduce its audience here in the States, this book is visually beautiful, profusely illustrated with magnificent colored photographs interspersed with attractive line illustrations which transcend any language. The first chapter, by Haenni and Dufour, details the history of Baltic amber and man (which one finds out extends at least back to Neolithic times), and also discussed the continuing use of amber in art, industry, and medicine. A well illustrated section shows how the amber is found and mined. The remainder of the book, by the Krzeminskis, details the formation of the Baltic deposits, characteristics of amber, and its inclusions; the taxa are discussed in general ecological groups such as predators, parasites and aquatic insects. As a dipterist myself, one fact jumped out at me: of the Baltic amber inclusions, about 90% are insects, and 70% of these are Diptera! Concluding the book is a small section discussing preparation of amber for scientific study and on conservation.

For anyone interested in amber, or insect fossils in general, I highly recommend both of these very attractive, informative books.

Jon K. Gelhaus, Dept. of  
Entomology, Academy of Natural Sciences

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## SOCIETY MEETING OF FEBRUARY 24, 1993

### SOME OTHER INTERESTING THINGS YOU CAN DO WITH GENITALIA (LEPIDOPTERA: HESPERIIDAE)

John M. Burns  
Smithsonian Institution, Washington, D.C.

The February meeting marked the opening of the 134th year of the Society, and the night's presentation reflected the Society's long history and concentration in evolutionary and systematic research—punctuated with witty and entertaining poems on biological themes. Dr. John M. Burns, well known for his many publications on the systematics of skipper butterflies, is also a published poet. His works have appeared in such journals as *Nature*, *Perspectives in Biology and Medicine*, and *The Bulletin of the Entomological Society of America* and have been collected in a book called *BioGraffiti: A Natural Selection* (published by W. W. Norton).

Although the male genitalia of skippers had been studied and illustrated by some early lepidopterists (most notably Skinner and Williams in the 1920's while at the Academy of Natural Sciences), neither they nor their immediate successors fully grasped the significance of these complex structures for understanding skipper evolution. Dr. Burns's talk centered on North American skippers and showed with numerous examples how a careful study of the genitalia in both sexes can promote a fine scale understanding of geographic variation, speciation mechanisms, and higher level groupings, as well as overall better taxonomy.

Working initially with American species of the genus *Erynnis* (dusky-wing skippers), which are individually narrow in their choice of larval food but collectively diverse, Dr. Burns set out to find evidence of sympatric speciation. However, using various biologic and morphologic characters (especially ones drawn from the remarkably asymmetric male and female genitalia), he arranged these skippers in group after group of closely related, geographically complementary forms reflecting allopatric speciation. In addition Burns found that a striking white fringe on the hindwing evolved eight times independently with the genus, always in those differentiates (species or subspecies) occurring in the American Southwest and/or Mexico.

A 1936 monograph on *Autochton cellus* (the gold-banded skipper) pronounced it "unusually uniform in its characters . . . throughout its range." Because this is a widespread skipper (Pennsylvania to El Salvador) with a large gap in the middle of its range, Burns predicted—and then used male and female genitalic characters to demonstrate—allopatric differentiation, nearly to the point of speciation. Detailed geographic and genitalic analyses of pairs of so-called subspecies showed, in *Atrytonopsis*, that *ovinia* and *edwardsi* are actually separate sister species, closely allopatric and therefore best grouped in a superspecies; and, in *Wallengrenia*, that *otho* and *egeremet* are really very distinct species, differing considerably in range but broadly sympatric in the southeastern United States, where they are also synchronic.

When critically studied and compared, genitalia are every bit as valuable for grouping related species in higher categories like genera and generic groups as they are for distinguishing species. In recent years Burns has been genitally reviewing Nearctic hesperiine skippers, a well-studied fauna whose long-stable genera are gaining what he calls "authority through repetition" in a flood of state, seminational, and national butterfly books and checklists. As it turns out, many of these genera are polyphyletic. Burns explained how and why he has changed generic limits in *hesperia*, *Atalopedes*, *Poanes*, and *Paratrytone*, and noted certain biogeographic results of these changes.

Consistent with the time of year, there were few notes of entomological interest. A discussion centered on the insects living on the pitcher-plant, *Sarracenia purpurea*, and Howard Boyd observed that at least 16 species occur regularly in and around these plants. There were 33 members and guests in attendance.

Jon K. Gelhaus, Corresponding Secretary

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## A NEW SPECIES AND NEW RECORDS OF SYMPHYLA (ARTHROPODA: MYRIAPODA) FROM DELAWARE<sup>1</sup>

Robert T. Allen, D. A. Walther<sup>2</sup>

**ABSTRACT:** Four genera and species of Symphyla were identified among over 300 specimens collected from Berlese samples from the Middle Run Valley Natural Area near Newark, Delaware. *Symphylella delawarensis* was recognized as a new species, providing the first published record of this genus east of the Mississippi River.

During a recent survey of the arthropod fauna of the Middle Run Valley Natural Area near Newark, Delaware (New Castle County), over 300 specimens of Symphyla were collected from forest litter and moss samples. We have identified four different genera and species from these collections.

The very distinct *Scolopendrellopsis subnuda* (Hansen) (Figs. 1-4) has been identified from the Delaware material. This species, originally described from Italy (Hansen, 1903), has additional records from Europe and Michigan (Loring, 1980). A second genus found was *Hanseniella*. All specimens were immature and not identifiable to species. Previously, the genus *Hanseniella* was recorded in North America from California (Hilton, 1931; Michelbacher, 1939b) and Arkansas (Allen, 1992). Only one immature specimen of the genus *Scutigera* has been collected. This specimen was hand collected under a stone near a small stream that flows through the area. By far the most abundant taxon in the samples, 242 specimens, appears to be a new species belonging to the genus *Symphylella*.

Edwards (1990) listed 11 species of *Symphylella* from North America. Nine of these species are known only from California (Michelbacher 1939a, 1939b, 1941, 1942). *Symphylella vulgaris* (Hansen) has a worldwide distribution and has been recorded in North America from California and Michigan. *Symphylella isabellae* (Grassi) is wide spread in Europe and has been reported by Hilton (1931) from southern California and from the Baja peninsula of Mexico. Since the work of Michelbacher (1942) no new species of *Symphylella* have been described from North America, although Scheller and Muchmore (1989) recently described *S. caribica* from St. John in the U. S. Virgin Islands.

<sup>1</sup> Received February 8, 1993. Accepted May 3, 1993

<sup>2</sup> Department of Entomology and Applied Ecology, College of Agricultural Sciences, University of Delaware, Newark, DE 19717-1301

### *Symphylella delawarensis* New Species

Description. Head (Figs. 5-6). 1.2 times wider than long, widest at spiracles or just behind; central rod distinct, interrupted medially, anterior lines extending laterally to near insertion of antennae, lines also extending laterally from the mid-point interruption of the central rod and then diagonally to near insertion of antennae. Tergal surface of head (Fig. 5) with mostly short setae, approximately 1/2 length of the long setae near base of antennal insertion.

Postantennal organ with outer circumference weakly defined, opening distinct, outer circumference approximately 2.6 times larger than opening. Palp of first maxillae straight, conical, pointed. Ventral surface (Fig. 6) with three distinct groups of setae; a lateral group each side composed of two parallel rows of setae; a median group (on mentum) composed, anteriorly, of two rows of setae each side of the midline that merge posteriorly and continue posteriorly to the head midline.

Antennae (Figs. 8-9). Antennae with 17-18 segments, left one with 18. Segment I and II subequal in size. Numbers of setae in apical and secondary whorls (left antenna of holotype) as follows:

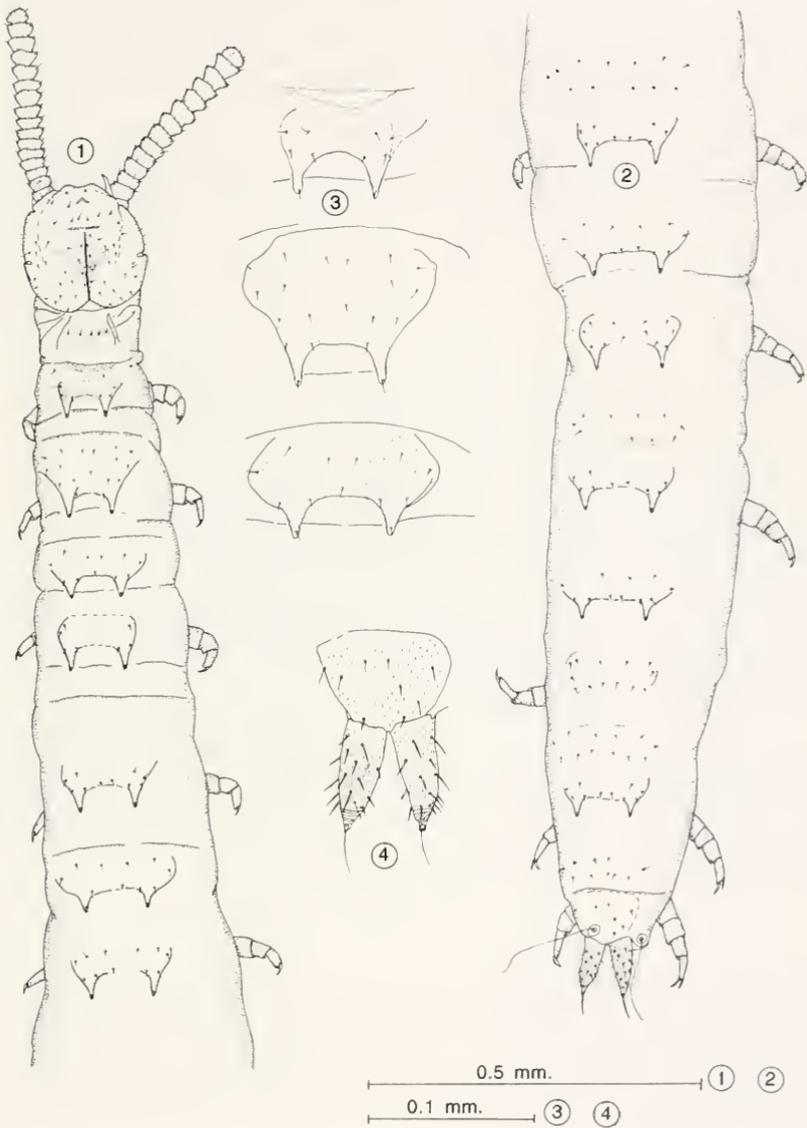
seg	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
api	2	7	8	9	10	10	10	10	9	11	11	12	12	11	9	10	9
sec							2	3	2	2	3	2	2	5	4	4	4

Segment II with 2 setae; segments II-V with 7-10 setae in apical whorl; segment VI-XVIII with 9-12 setae in apical whorl, secondary whorl (usually) beginning on segment VI, only visible ventrally with 2-5 setae on all segments; round, clear sense organ on segments V to penultimate segment; the number of bladder-shaped organs (of Scheller) on the different segments variable, holotype as follows: X2, XI-3, XII-2, XIII-2, XIV-3, XV-7, XVI-7. Segment II, 1.6 times wider than long, lateral inside protruding seta 0.43 width of segment II, lateral outside protruding seta 0.28 width of segment II; III, 2.0 times wider than long, lateral inside protruding seta 0.38 width of segments III, lateral outside protruding seta 0.21 width of segments III; X, 2.0 times wider than long, apical whorl seta, 0.18 width; apical segment oval.

Tergites (Figs. 7, 10-11). I rudimentary with 3-4 setae each side. Thirteen tergites with triangular processes, tergites 2-14. Number of setae on outside lateral margin, inside margin of triangle process and posterior margin between apical processes given in Table 1.

Table 1. Number of setae on the margins of the dorsal tergites

Tergite No.	Outside lateral Margin		Inside Margin		Post.Marg.
	left	right	left	right	
1	3-4	3-4	-	-	-
2	5-7	5-6	3-4	2-4	2
3	8-11	8-10	3-4	3-4	2-4
4	5-7	5-8	2-4	3-4	4-6
5	6-9	7-10	3-4	3-4	2-5
6	10-13	10-12	3-4	3-4	4-7
7	5-8	5-8	3	2-3	6-8
8	8-9	7-9	3-4	3-4	4-6
9	9-11	9-11	3-4	3-4	4-7
10	5-7	4-7	2-3	2-3	5-8
11	6-8	6-9	3-4	2-4	5-7
12	8-11	8-11	3-4	2-4	4-6
13	5-6	4-7	2-3	2-3	5-7
14	-	-	-	-	16-20
15	6-7	6-8	2-3	2-3	2-5



Figures 1-4. *Scolopendrellopsis subnuda*. (1) Habitus, head, antennae, leg segments 1-6; (2) habitus, leg segments 7-12, apex of abdomen.

Ratio of distance between processes to their length, 0.6, 0.5 and 0.3 on tergites 2, 3 and 4 respectively; triangular processes without circular end-swings or knobs; extreme apex of processes sometimes slightly lighter in color. Tergites 3, 6, 9 and 12 longer than preceding ones. Basal outside marginal setae long on segments 2, 3, 4, 6 and 7. Cuticle of tergite granulate, granules forming semicircular or circular spots; cuticle surrounding tergites with distinct granulate circles. Ventral surface (Figs. 12-13) with a reduced number of very short setae.

**Legs.** First pair of legs rudimentary lobes with 1 long and several short apical setae. Last pair of legs (Fig. 14) .26 mm. long. Tarsus narrowed towards apex; 3.8 times as long as wide with 6 dorsal setae; 3 straight and pointing outward, 3 setae angled toward the apex, longest equal to width of tarsus; pubescence covering entire tarsus. Tibia length 1.5 X the width, with 4 distinct dorsal setae; pubescence covering entire tibia. Femur 1.2 wider than long, with 3 distinct dorsal setae; pubescence covering dorsal 1/4 of surface. Trochanter 1.2 times as long as wide with 1 distinct dorsal seta near distal margin; pubescence covering dorsal 1/5 of surface. Anterior claw two times as long as posterior claw.

**Styli** (Figs. 12-13). Base of legs 3-12 short, densely setose with 1 long apical seta. Coxal sacs at base of legs 3-9 with 3 setae on anterior margin of openings and 2 setae on posterior margin of opening. Coxal plates of legs 10, 11 and 12 with 5, 3 and 2 setae respectively.

**Cerci** (Fig. 15). 2.8 times longer than wide, surface equally covered with moderately long setae; pubescence covering entire surface; apex annulate, about 9 rings, with a stout apical seta.

**Immature Forms** (Figs. 16-24). A large number of immature forms of this species were collected. Of the 232 immature forms the following stages and number of specimens were represented: 7 leg pairs, 8; 8 leg pairs (Figs. 23-24), 52; 9 leg pairs (Figs. 21-22), 142; 10 leg pairs (Figs. 16-20), 30. The immatures are always smaller than the adults and with a reduced number of setae.

**Holotype.** USA, Delaware, New Castle Co., Middle Run Valley Natural Area (near Newark), 13 October 1992, D. A. Walther; (RTA-92-20-227). Deposited in the American Museum of Natural History, New York.

**Paratypes.** Eleven slide-mounted, adult specimens: USA Delaware, New Castle Co., Middle Run Valley Natural Area, D. A. Walther, from the following dates: 8 specimens, 29 September 1992; 3 specimens, 13 October 1992. 4 specimens, University of Delaware, 7 specimens, American Museum of Natural History, New York.

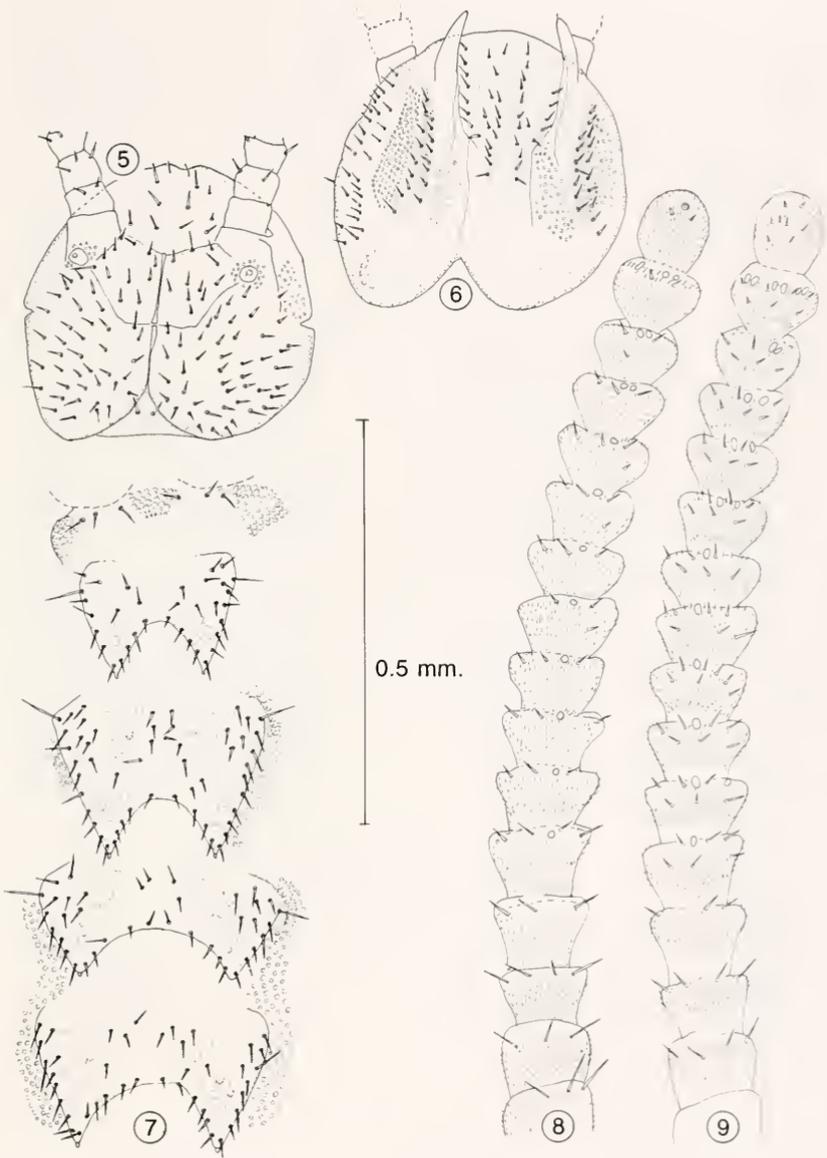
**Etymology.** The specific epithet refers to the state from which the species has been described.

**Diagnosis.** Tergites 3, 6, 9, 11 and 12 bear a larger number of setae along the outside lateral margins than *S. serriae* Michelbacher, which is very similar to this Delaware species. Distinct lateral lines emanate from the disjunct area of the central rod on the head, (a unique feature of *S. delawarensis* and *S. serriae* among the North American *Symphylella*).

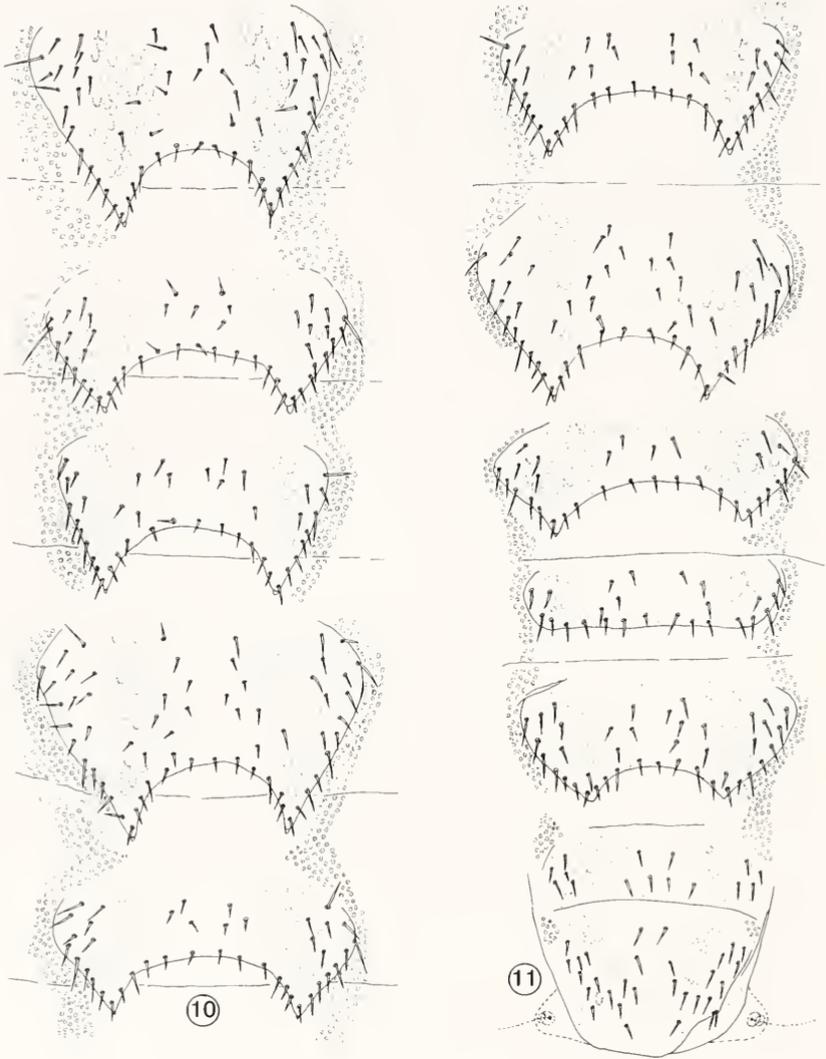
## DISCUSSION

Edwards (1990) has cautioned workers about describing new *Symphylella* taxa because of the addition of setae, body segments and antennal segments during successive molts. Another reason for caution is the apparent world-wide distribution of some species such as *Symphylella vulgaris* (Hansen) and *Scolopendrellopsis subnuda* (Hansen). However when a difference in one or more characters is recognized it is prudent to proceed with a description of the forms involved.

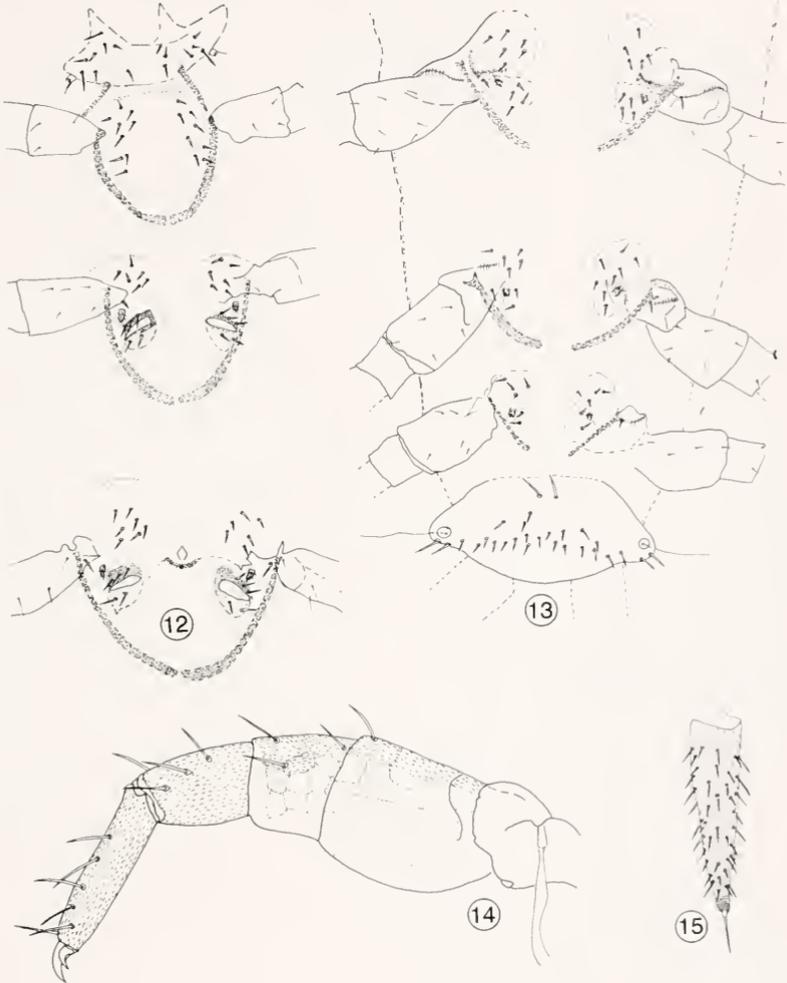
*Symphylella delawarensis* is very similar to *S. serriae* Michelbacher known from California. The most obvious character shared by both species



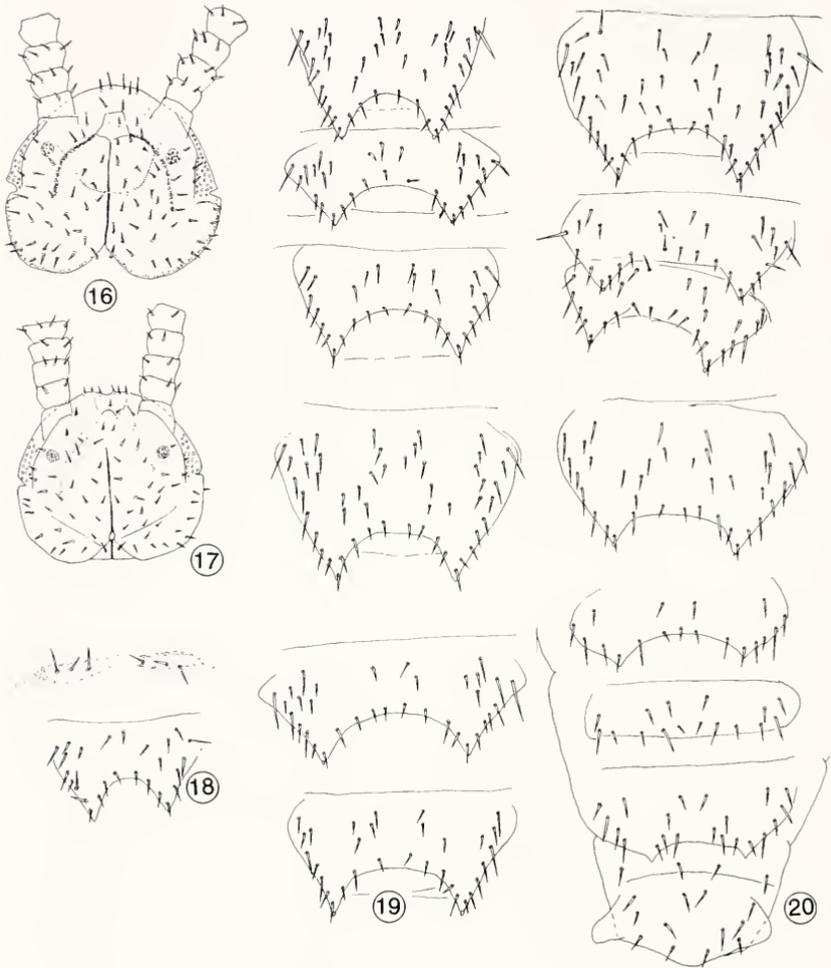
Figures 5-9. *Symphylella delawarensis*. (5) head, dorsal; (6) head, ventral; (7) tergites 1-5; (8) antenna, dorsal; (9) antenna, ventral.



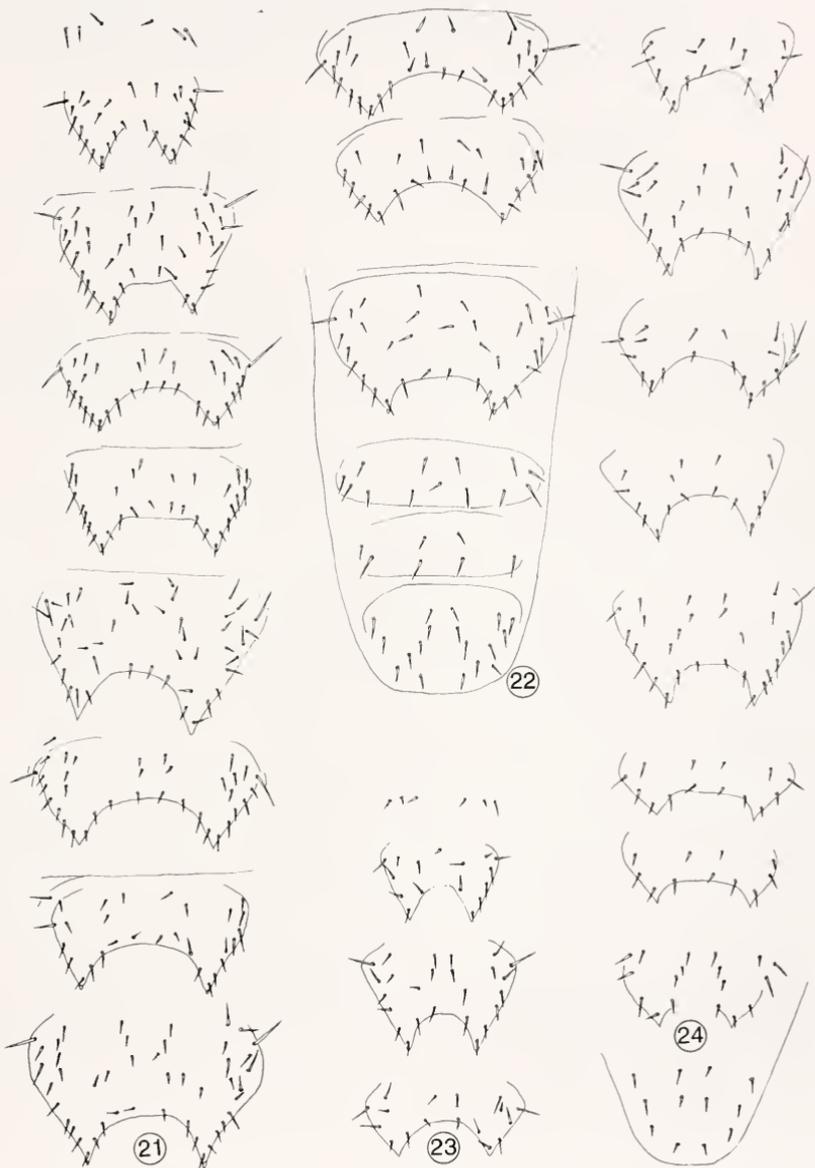
Figures 10-11. *Symphylella delawarensis*. (10) tergites 6-10; (11) tergites 11-15, apex of abdomen.



Figures 12-15. *Symphylella delawarensis*. (12) sterna, leg segments 1-4; (13) sterna, leg segments 10-12, apex of abdomen; (14) 12th leg; (15) cerci, dorsal.



Figures 16-20. *Symphylella delawarensis*. 10 leg form. (16) head, dorsal; (17) head, ventral; (18) tergites 1-2; (19) tergites 3-8; (20) tergites 9-15, apex of abdomen.



Figures 21-23. *Symphylella delawarensis*, 9 leg form. (21) tergites 1-8; (22) tergites 9-13, apex of abdomen. *S. delawarensis*, 8 leg form. (23) tergites 1-4; (24) tergites 5-12, apex of abdomen.

are the lines emanating from the area where the central rod of the head is broken. This shared feature is unique among North American Symphylella. The two species differ in the number of setae present along the outside lateral margins on tergites 3, 6, 9, 11 and 12

Tergite No.	<i>serriae</i>		<i>delawarensis</i>	
	left	right	left	right
3	5	5	8-11	8-10
6	3	4	10-13	10-12
9	3	4	9-11	9-11
11	5	5	6-8	6-9
12	3	3	8-11	8-11

The position and number of circular organs and bladder-shaped organs on the different antennal segments also appears to be different. However these organs are too variable to use with certainty.

#### ACKNOWLEDGMENTS

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## DESCRIPTION OF ADULTS OF *BAETIS MAGNUS*, (EPHEMEROPTERA: BAETIDAE)<sup>1</sup>

Richard Durfee, Boris C. Kondratieff<sup>2</sup>

ABSTRACT: Male and female adults of *Baetis magnus* McCafferty and Waltz are described for the first time, and are distinguished from a common and related sympatric species, *Baetis tricaudatus* Dodds. Variations in hindwing venation are briefly discussed and biological notes for *B. magnus* are given.

In their revision of the known *Baetis* larvae of North America, Morihara and McCafferty (1979) provided descriptions for three species without assigning formal names. One of these species was designated *Baetis* sp. B, with material listed from Arizona and New Mexico. Later, McCafferty and Waltz (1986) proposed the formal name *Baetis magnus* for *Baetis* sp. B, with the holotype larva chosen from Dawes Co., Nebraska. This species is a member of the *Baetis rhodani* group in which the larvae are characterized by having robust setae on the antennal scapes and pedicels and on the paraprocts (Morihara and McCafferty 1979). Other Nearctic species currently placed in the *rhodani* group include: *Baetis adonis* Traver, *B. bicaudatus* Dodds, *B. caelestis* Allen and Murvosh, *B. foemina* McDunnough, *B. moffati* Dodds, *B. palisadi* Mayo, *B. parallelus* Banks, *B. persecutus* McDunnough, *B. piscatoris* Traver, and *B. tricaudatus* Dodds. Three species in this group, *B. bicaudatus*, *B. foemina*, and *B. tricaudatus*, are known from both larvae and adults, and two species, *B. caelestis* and *B. magnus*, are known from larvae only. The remaining species in this group are known only from adult material.

McCafferty *et al.* (1993) suggested the possibility that *B. moffati* and *B. magnus* represent the same species. However, neither the original description of *B. moffati* presented by Dodds (1923) nor Traver's (1935) redescription agree with our reared material of *B. magnus*. We have attempted to collect *B. moffati* from its type locality (South Boulder Creek near Tolland, Colorado), but to date, no *Baetis* species have been collected or reared from this locality that match these descriptions. Additionally, no larvae of *B. magnus* have been collected from South Boulder Creek, however, *B. tricaudatus* and *B. bicaudatus* are abundant in this stream.

In this paper, we do not attempt to distinguish the adults of *B. magnus* from other adults of the *rhodani* group. A comprehensive revision of the genus *Baetis* sensu McCafferty and Waltz (1990) is necessary to establish diagnostic characters for the adults. Our purpose here is to provide regional biologists with a description of a commonly collected mayfly species, and to

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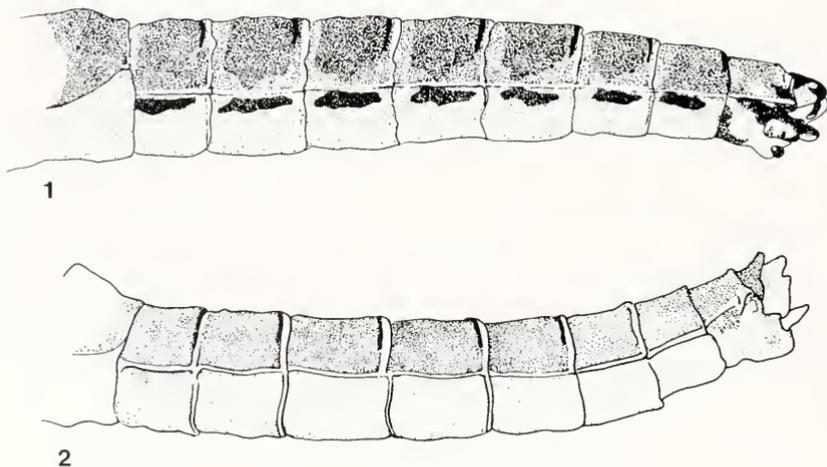
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provide characters to distinguish adults of *B. magnus* from a common and related sympatric species, *B. tricaudatus*.

During this study we noted significant variability in certain hindwing venation characters. Hindwings of *B. magnus* reared from two disjunct localities in Colorado, as well as those of *B. tricaudatus* reared from six localities throughout Colorado, are illustrated to show variations in previously utilized taxonomic characters. Only reared adults with associated larval exuviae were used in the following descriptions.

### *Baetis magnus* McCafferty and Waltz

**Adult male.** Length of body 6.0-8.5 mm, forewings 6.0-7.5 mm, hindwings 1.2-1.5 mm. Head brown; antennae pale to light brown, scapes with red-brown, square shaped mark on ventral surface, pedicels with red-brown, elongate mark on ventral surface (Fig. 3). Turbinate eyes rusty brown basally, white medially, rusty brown dorsally. Thorax generally medium to dark brown. Foretibiae and tarsi medium brown, forefemora light brown; middle and hindlegs pale, second, third, and fourth tarsal segments and apical third of first tarsal segment stained with brown (Fig. 5); all femora with prominent subapical brown mark (Fig. 5). Wings hyaline, longitudinal veins light to medium brown, intercalaries pale, stigmatic area cloudy, anastomosed. Shape of costal projection of hindwings similar to a shark's dorsal fin (Figs. 8-12), a straight, more gradual slope on the leading edge, steeper slope on the hind edge; hindwings with three longitudinal veins. Abdominal tergum 1 dark brown, terga 2-10 usually light red-brown, with dark red-brown shading near lateral margins, posterior margins of terga 2-8 with narrow transverse rusty brown band. Terga 2-8 with pair of submedian light brown oblique marks near anterior margin and smaller pair of light brown dots. Sterna white to pale yellow, sterna 2-8 with red-brown, longitudinal mark below pleural fold (Fig. 1), sterna 2-7 with pair of submedian, light brown, oblique marks near anterior margin and smaller pair of light brown dots. Forceps medium to dark brown,

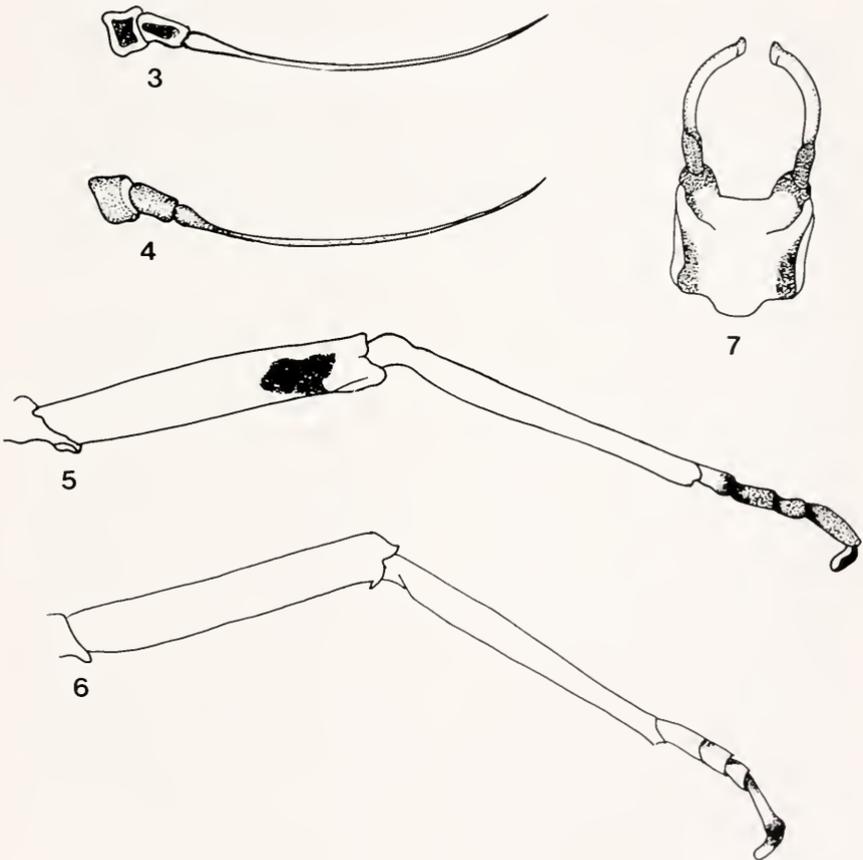


Figs. 1-2. Adult male abdomen, lateral view. 1. *B. magnus*, 2. *B. tricaudatus*.

shaped as in Figure 7. Caudal filaments light to medium brown.

**Adult female.** Length of body 6.5-10.0 mm, forewings 6.5-8.5 mm, hindwings 1.0-1.3 mm. Head pale brown, antennae light brown, markings on scapes and pedicels as in male. Thorax light brown. Fore tibiae and tarsi stained with light brown, middle and hindlegs generally pale, all tarsal segments except basal half of first stained with brown, all femora marked as in male. Wings hyaline with light brown venation, shape of costal projection and hindwing venation as in male. Abdominal terga light brown and sterna pale olive. Abdominal markings as in male. Caudal filaments golden brown.

**Material examined.** *B. magnus*: Chaffee Co., CO, Trout Cr., 16 January 1993, T. Eckberg and R. Durfee, 9 males, 14 females (reared); Larimer Co., CO, Hewlett Gulch, 10 March 1991, B.



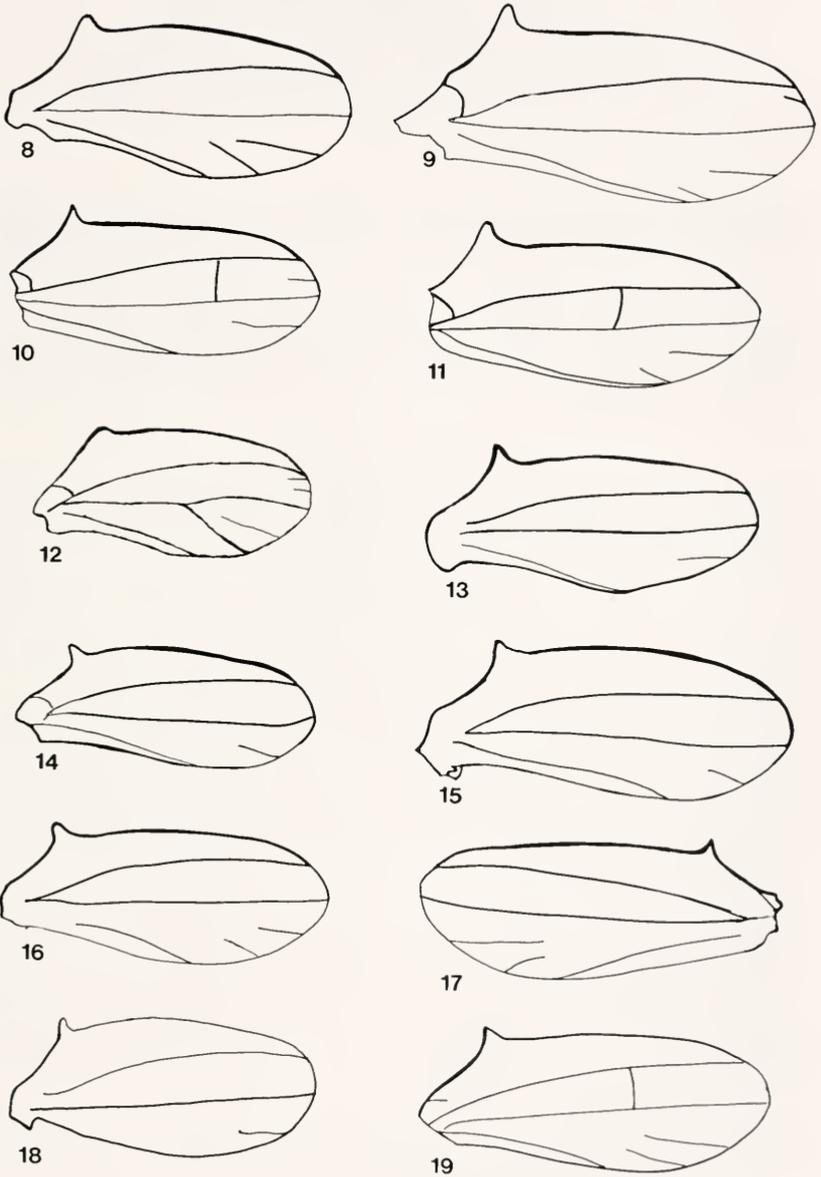
Figs. 3-7. Adult male antennae, ventral view. 3. *B. magnus*, 4. *B. tricaudatus*; Adult male, left hind leg. 5. *B. magnus*, 6. *B. tricaudatus*; 7. *B. magnus*, male genitalia, ventral view.

Kondratieff and R. Durfee, 2 males, 6 females, [1 gynandromorph] (reared); Hewlett Gulch, 23 March 1991, R. Durfee and M. Harris, 9 males, 4 females (reared); Hewlett Gulch, 23 March 1993, R. Durfee, 6 males, 25 females (reared); Skin Gulch, 8 May 1993, R. Durfee and B. Kondratieff, 2 males, 1 female (reared). *B. tricaudatus*: Chaffee Co., CO, Trout Cr., 16 January 1993, T. Eckberg and R. Durfee, 5 males, 9 females (reared); Elbert Co., CO, Kiowa Cr., 26 April 1986, B. Kondratieff, 10 males, 12 females (reared); Garfield Co., CO, Colorado River, 4 May 1991, B. Kondratieff, 1 male (reared); Gunnison Co., CO, Gunnison River, 31 August 1991, B. Kondratieff and R. Durfee, 1 male (reared); Larimer Co., CO, Buckhorn Cr., 28 May 1991, B. Kondratieff and R. Durfee, 1 female (reared); Hewlett Gulch, 23 March 1991, R. Durfee and M. Harris, 3 males (reared); Poudre River, 8 April 1987, B. Kondratieff, 11 males, 10 females (reared); Poudre River, 8 May 1993, B. Kondratieff and R. Durfee, 5 males and 3 females (reared); Young's Gulch, 21 July 1991, B. Kondratieff and R. Durfee, 4 males, 3 females (reared).

## DISCUSSION

Adults of *B. magnus* are similar to *B. tricaudatus* and the available descriptions of *B. moffati*. Both male and female adults of *B. magnus* can be distinguished from these other two species by the red-brown, longitudinal marks below the pleural fold on sterna 2-8 (Fig. 1), and a subapical brown mark on the femora (often faint in the female) (Fig. 5). Additionally, *B. magnus* has a red-brown, square-shaped mark on the ventral surface of the antennal scapes, and a red-brown, elongate mark on the ventral surface of the pedicels (Fig. 3). These conspicuous markings were absent in all specimens of *B. tricaudatus* examined (Figs. 2,4,6), and are not mentioned in the descriptions of *B. moffati* (Dodds 1923, Traver 1935).

Adults of the *rhodani* group are very similar in habitus and are difficult to separate at the species level. The primary characters that have been used in the past have included size, color, hindwing venation, shape of costal projection and shape of forceps (Burks 1953, Day 1956, Edmunds *et al.* 1976, Jensen 1966). During this study it was noted that certain hindwing venation characters previously used to distinguish adults of *Baetis* species can vary when a series of specimens of a single species are examined from various localities. The number of intercalaries between longitudinal veins 1 and 2 can vary from 0-2 and the number of intercalaries between longitudinal veins 2 and 3 can vary from 1-2 (Figs. 8-19). Additionally, 4 reared adults (1 male, 3 females) of *B. magnus* were found to possess a crossvein between longitudinal veins 1 and 2 (Figs. 10-11). The location of this vein varied from just beyond the middle of the wing to about the apical third. This crossvein often occurs in one wing only and was also found in three reared male adults of *B. tricaudatus* (Fig. 19). Another significant hind wing variation noted in *B. magnus* was a symmetrically forked second longitudinal vein (Fig. 12). This unusual variation was found in 2 reared adults (1 male, 1 female), and in both cases appeared on only one wing. This character has been used to distinguish *Dipheter* Waltz and McCafferty (1987) from other adult baetids. These authors, however, noted that the forked second vein of



Figs. 8-19. Hindwings. 8-12. *B. magnus*, 8. Hewlett Gulch, 9. Trout Creek, 10. Hewlett Gulch, 11. Hewlett Gulch, 12. Hewlett Gulch; Figs. 13-19, *B. tricaudatus*, 13. Trout Cr., 14. Gunnison River, 15. Hewlett Gulch, 16. Poudre River, 17. Kiowa Cr., 18. Colorado River, 19. Poudre River.

the hind wing is not unique to the genus *Diphetero*, and has been found in another North American species of *Baetis*.

From present collection records, it appears that *Baetis magnus* is an early season species with adults emerging from January to May. The occurrence of a second generation later in the year is probable in perennial streams. *Baetis magnus* appears to be restricted to smaller, usually spring-fed and often intermittent streams.

A large population of *B. magnus* was discovered in the Trout Creek Spring area of the upper Arkansas River Basin in Chaffee County, Colorado. This unique stream was characterized by Flint and Herrmann (1976). Larvae of *B. magnus* were abundantly associated with water cress (*Rorippa nasturtium-aquaticum* (L.)). Mature larvae and even adults could be collected at this location in January, undoubtedly because of the spring-fed nature of this stream (annual water temperature 13.2-15.9 °C). *Baetis tricaudatus* was also common in this stream.

#### ACKNOWLEDGMENTS

We would like to thank Tom Eckberg for providing valuable specimens of *B. magnus* and *B. tricaudatus* from Trout Creek in Chaffee County, and Howard E. Evans and Richard W. Baumann for reviewing the manuscript.

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**CLOEODES BINOCULARIS**  
**(EPHEMEROPTERA: BAETIDAE),**  
**A NEW COMBINATION FOR A NEOTROPICAL**  
**SPECIES OF *PSEUDOCLOEON* S. AUCTT.<sup>1</sup>**

R.D. Waltz<sup>2</sup>

ABSTRACT: *Pseudocloeon binocularis* Needham and Murphy was reevaluated and compared with known *Cloeodes* species, resulting in its formal transfer and new nomenclatural status as *Cloeodes binocularis*, new combination.

*Pseudocloeon binocularis* Needham and Murphy (1924) was described based on a single male adult specimen from Campamiento, Junin, Peru, July 1, 1920. At the time the description was published, J.G. Needham noted that, "Unfortunately the end of the abdomen is lost...". Although the male genitalia were not illustrated, illustrations were provided of the holotype wing and a wing from a female believed to be conspecific from La Chorrera, Loreto, Peru, as well as an illustration of the highly developed turbinate eyes and head capsule of the male holotype. The proper assignment of this species has been problematic because of the inadequacy of the description and the general state of knowledge surrounding identifications of adult baetids. The assignment of tropical and other Southern Hemisphere species previously placed in the polyphyletic genus construct *Pseudocloeon* s. auctt. (see McCafferty and Waltz, 1990) has been especially problematic.

An attempt to locate and study the type material of *P. binocularis* resulted in the recovery of only the wings illustrated by Needham and Murphy. The entire body of the male holotype (C.U. Type No. 650) including the head capsule could not be located and is presumed lost. The female cited in the description, which is also missing, was apparently not included in the type series and therefore has no formal status.

The striking similarity of this species with other known adults of *Cloeodes* Traver (see Waltz and McCafferty, 1987a,b; Kluge, 1991) led to a more formal comparison of this species with *Cloeodes*. The following characteristics of *Cloeodes* are found in *P. binocularis*: highly-developed turbinate eyes, paired braces of crossveins through the radial sector of the forewings (found also in other baetids), detached vein of MA<sub>2</sub> extending well beyond 0.5x distance between distal crossvein and proximal (=MA<sub>1</sub> to MP<sub>1</sub>) crossvein in the forewings, and tendency for only a single marginal

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intercalary in the MP<sub>2</sub> cell and Cu sector of the forewings although preceding marginal intercalaries are paired (this condition is also notable in *Apobaetis* Day and *Paracloeodes* Day). Interestingly, *P. binocularis* differs from most *Cloeodes* species in that it possesses paired marginal intercalaries in the R<sub>1</sub>-R<sub>2</sub> cell, a condition known among *Cloeodes* species only in the subgenus *Notobaetis* and in a South African species of *Cloeodes* (Waltz and McCafferty MS). It is possible that, as more adult material becomes available, the presence or absence of intercalaries in the R<sub>1</sub>-R<sub>2</sub> cell may be found to be quite variable.

Based on the strong similarities of *P. binocularis* with *Cloeodes* species, and the lack of character states strongly supportive of its placement in either *Apobaetis* or *Paracloeodes*, I conclude that *P. binocularis* is congeneric with *Cloeodes*, and therefore, propose *Cloeodes binocularis* (Needham and Murphy, 1924), new combination.

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## SOCIETY MEETING OF MARCH 24, 1993

### MEDICAL ENTOMOLOGY RESEARCH IN KENYA

Dr. Richard Johnson

Preventive Medicine, U.S. Army, Ft. Lewis, WA.

Kenya is a large country, about the size of Texas, with a tropical coastal area, and increasing elevation and aridity as one moves westward. Kenya is well known for its diverse and showy wildlife, particularly the large mammals, and the human population contain well over fifty ethnic groups. Kenya is also beset with a number of severe arthropod-borne diseases (arboviruses) including malaria, leishmaniasis, filariasis, trypanosomiasis (sleeping sickness) and Rift Valley Fever. Dr. Richard Johnson, a medical entomologist in the

(Continued on page 239)

COMMENTARY ON *DRUNELLA TUBERCULATA* AND  
*PROCLOEON PENNULATUM* (EPHEMEROPTERA:  
EPHEMERELLIDAE; BAETIDAE) IN  
NORTH CAROLINA<sup>1</sup>

W. P. McCafferty<sup>2</sup>

ABSTRACT: A new larval variant of *Drunella tuberculata* (Morgan) (Ephemerellidae) was discovered in streams in North Carolina. It possesses morphological characteristics intermediate between *D. tuberculata* and *D. conestee* (Traver). *Drunella conestee* is shown to be a southern clinal variant of *D. tuberculata*, and thus a synonym: *D. tuberculata* [= *D. conestee*, n. syn.]. All larval variants of *D. tuberculata* are distinguished by a distinct posterior marginal ridge dorsally on the forefemora. Larvae of *Procloeon pennulatum* (Eaton) were also discovered from North Carolina. This Holarctic species previously was known in North America only from central and western Canada, where, for the greater part of this century, it was known only as female adults called *Centropitulum infrequens* McDunnough.

Diligent identification and monitoring of freshwater macroinvertebrates, as part of water resources assessment and conservation programs, will predictably lead to the recognition of taxonomic discoveries and anomalies. For example, aquatic biologists with the Kentucky Nature Preserves Commission, the Missouri Department of Conservation, and the North Carolina Department of Natural Resources, Division of Environmental Management, have all found stream samples of macroinvertebrates that could not be keyed to species and which, upon further investigation by a taxonomic specialist, proved to be new species important to understanding North American faunistics (McCafferty 1981a, 1990). Any synergistic relationship between such field workers and taxonomists can be most productive in this respect and must be encouraged because of the invaluable data potentially rendered and because of the mutual benefit that can be derived.

Certain recent samples of larval Ephemeroptera taken in North Carolina stream surveys by the North Carolina Division of Environmental Management could not be identified to species, not even to family in one case, with the use of presently available North American diagnostic keys. My study of this material has revealed notable new data, reported below, regarding two species, *Drunella tuberculata* (Morgan) and *Procloeon pennulatum* (Eaton).

<sup>1</sup> Received April 3, 1993. Accepted May 3, 1993.

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*Drunella tuberculata* (Ephemerellidae)

This is an essentially Appalachian species ranging in eastern North America from Quebec and Ontario to North Carolina and Tennessee. It was most recently treated (as *Ephemerella* Walsh) by Allen and Edmunds (1962). They provided a key to the larvae and adults of species of North American *Ephemerella* (subgenus *Drunella* Needham) and showed that, on the basis of larval intraspecific variability, *Ephemerella cherokee* Traver (known only from North Carolina) was a junior synonym of *D. tuberculata*.

Certain larvae of *Drunella* taken from streams in North Carolina will not key to any known species when using the Allen and Edmunds key. They tentatively appear to be either *D. tuberculata* or *D. conestee* (Traver) (known only from adjacent areas of North Carolina and Tennessee), having a mixture of characteristics previously applied to one or the other of these species (see Allen and Edmunds 1962) or the former concept of *E. cherokee* (see Traver 1937).

With reference to this new larval material: occipital tubercles of the head are intermediate between the shorter ones shown for *D. conestee* and the highly developed ones described for *D. tuberculata*. The shapes of the clypeus and the lateral frontoclypeal projections are similar to those shown for *D. tuberculata*; however, the genal projections are truncate, as shown for *D. conestee*. Dorsal thoracic tubercles are mainly similar to those described for *D. tuberculata* and *E. cherokee*. There are no anterior submarginal projections on the mesothorax, as is the case in *D. conestee*, and in younger larvae, dorsal thoracic tubercles are not developed or are extremely difficult to detect, similar to the condition described for *D. conestee*. The ventral marginal tubercles of the forefemora match those described for all of these species, but the dorsal femoral warts are intermediate between those shown for *D. conestee* and *D. tuberculata*. The foretibial spine extends only about one-third of the foretarsus length as described for *E. cherokee*. Paired submedian tubercles are present on dorsal abdominal segments 3-7, as described for *D. conestee* and *E. cherokee*, with no sign of small tubercles on segment 2, as described for *D. tuberculata*.

Allen and Edmunds (1962) indicated that *E. cherokee* represented a southern variant of *D. tuberculata* with regard to several characteristics that were clinal in going from north to south within the range of *D. tuberculata*. The newly studied North Carolina material not only matches much of the extreme southern clinal characteristics that have thus been associated with *D. tuberculata*, and particularly *E. cherokee*, but also possesses characteristics that have been associated with *D. conestee*, and some that are intermediate between the two. The lesser tuberculation of *D. conestee*, for example,

appears simply to represent further clinal variation of characteristics associated with southern populations of *D. tuberculata*. Traditional concepts of *D. tuberculata*, *E. cherokee*, and *D. conestee*, as well as the newly studied material, apparently represent variations of one species. Therefore, I am synonymizing *D. conestee* with *D. tuberculata*: *D. tuberculata* (Morgan) [= *D. conestee* (Traver), n. syn.].

At couplet 11 in the Allen and Edmunds (1962) key to the larvae of *Drunella*, one could go either to couplet 12 or 13, depending on the variant of *D. tuberculata* that was being keyed. However, all variants of *D. tuberculata* have a distinctly developed ridge at the posterior margin of the dorsal flat surface of the forefemora. This diagnostic ridge begins submarginally at about one-third the distance from the base of the femora, it then gradually curves to the posterior margin at about one-half the distance from the base of the femora, and it then dissipates at about two-thirds the distance from the base of the femora along the posterior margin [see Figs. 43 and 45 in Allen and Edmunds (1962)]. Traver (1932) indicated that in life some larvae of *D. tuberculata* have a prominent whitish stripe down the back. This is not a true stripe, but there is enough unpigmented area in the medial area, especially of abdominal tergites, that at a distance a pale longitudinal region medially is visible in many individuals, including the newly discovered variant of *D. tuberculata*. This may be a fairly reliable field characteristic, but should not be depended upon for identification of the species. Little can be said about variation or diagnostic features of the adults of *D. tuberculata* because no adults are known of *D. conestee* s. auctt. or the newly discovered variant.

Material Examined (intermediate variant): Two mature larvae, North Carolina, Macon Co., Overflow Creek, 10 July, 1991. Two immature larvae, North Carolina, Stokes Co., Dan River, May, 1982.

### *Procloeon pennulatum* (Baetidae)

This species, which was described by Eaton in 1870, has been known in Europe for over a century as *Centroptilum pennulatum*. Recently, Keffermüller and Sowa (1984) considered it in the genus *Pseudocentroptilum* Bogoescu. In the Palearctic, it is currently known throughout Europe east to the Ural Mountains of Russia. I have recently examined material also from Turkey.

In North America, this species traditionally has been known as *Centroptilum infrequens* McDunnough. Recently, when male and female adults were associated and the larvae were finally reared and described by Lowen and Flannagan (1990a) in Manitoba, it became apparent that *C. infrequens* was a synonym of the European species, and Lowen and Flannagan (1990b) formally considered it as such. McCafferty and Waltz (1990) transferred the species to the genus *Procloeon* Bengtsson, where the majority of species in

North America that were previously placed in *Centroptilum* and *Cloeon* Leach are now included. In the Nearctic, it has been known only from western and central Canada.

Larval specimens of this species were collected in North Carolina, but could not be clearly placed to either the family Siphonuridae or Baetidae when using available keys because of their relatively short antennae (see McCafferty 1981b). Also, this species has double gill lamellae and although this might be confused with the double gill of *Siphonurus* Eaton, gills of the two are actually very different in size and shape and degree of development of the second lamella. No adequate keys to the genera of Baetidae in North America have been published to date. All structural characteristics of the species are found in the North Carolina material, and the dorsal color pattern is similar to that shown in a photograph of a larva from Switzerland [Photo XII in Studemann *et al.* (1992)]. The drawing of the dorsal color pattern of the species shown in Fig. 8 of Lowen and Flannagan (1990a) is overly contrasting, although it does show relative development of the pattern correctly.

The discovery of this species in North Carolina represents a considerable southward extension of its known range in North America. This perhaps is not too surprising when one considers that, in Europe, it is known from Spain and Italy at only slightly more northern latitudes than those of North Carolina. Moreover, now that the larval stage is recognizable in North America, I predict that it eventually will be found to be much more widespread in the conterminous United States. Further discoveries of this species will be facilitated to a large degree once adequate generic keys to the baetid genera are made available by Waltz and McCafferty (in ms). There may also prove to be additional synonyms of *P. pennulatum* in North America. Lowen and Flannagan (1990a) found the larvae to be abundant in cool spring-fed streams in Manitoba, and Macan (1979) indicated that larvae of this species are found in slow sandy bottomed streams in England.

Material Examined: Two mature larvae, North Carolina, Caldwell Co., Wilson Creek at St. Rd. 1358.

#### ACKNOWLEDGMENTS

I appreciate being able to examine unusual specimens of Ephemeroptera from North Carolina sent by Dave Lenat and Dave Penrose of the North Carolina Environmental Services Laboratory, Raleigh. This paper has been assigned Purdue Experiment Station Journal No. 13759.

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(Continued from page 234)

U.S. Army, and a former student at the University of Delaware, spent two years based in Nairobi, Kenya researching leishmaniasis. His informative presentation gave Society members a glimpse in the immense problems fighting arboviruses in an area beset with overpopulation, poverty and regional instability.

Sleeping sickness, an arboviral disease readily associated in entomologists' minds with East Africa, is confined mainly to one valley and considered primarily a veterinarian problem. Dr. Johnson stated that simple tabanid traps are effective in preventing spread of the tsetse fly vector (*Glossina pallidipes* Austen), and recent work has shown that the flies avoid zebras or even "striped" cattle! Malaria, mostly caused by *Plasmodium falciparum*, by contrast, is a severe human health problem, killing worldwide over two million people every year. Control approaches use both high and low technology. Dr. Johnson states that there is no vaccine as yet, and even if available, the prevalence of malaria in Kenya would probably not allow it to be effective. Molecular techniques are being used to sort out the malaria vectors in the *Anopheles gambiae* complex, as some of these cryptic species are better transmitters than others. Impregnating bed nets and rafter screens with pyrethrins is a simple method preventing mosquito transmission.

As mentioned, Dr. Johnson's main research in Kenya dealt with the four species of *Leishmania* causing leishmaniasis and their vectors, the phlebotomine sand flies. Severity ranges from visceral leishmaniasis, which is fatal and destroys the liver and pancreas, to *Leishmania major* which is never fatal. Control techniques run the gamut from vaccine

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**COMPARATIVE NOTES ON  
HYMENOPTERAN PARASITIDS  
IN BUMBLE BEE AND HONEY BEE COLONIES  
(HYMENOPTERA: APIDAE) REARED ADJACENTLY<sup>1</sup>**

James B. Whitfield<sup>2</sup>, Sydney A. Cameron<sup>3</sup>

**ABSTRACT:** Colonies of both honey bees and bumble bees are often infested by parasitoids as well as by wax moths from several genera of the family Pyralidae. The nest associates in turn are parasitized by several groups of hymenopteran parasitoids. Colonies of bumble bees raised in close proximity to honey bee colonies provided an unanticipated opportunity to observe parasitoids that might be able to switch from honey bees or their nest associates, to bumble bees or their nest associates, and *vice versa*. This natural experiment indicated that none of the lepidopteran nest associates were shared between both honey bee and bumble bee colonies. However, most of the hymenopteran parasitoids of *Apis* nest associates were found to parasitize bumble bee nest associates. Diagnostic illustrations of some of the parasitoids from the apid colonies are provided to facilitate future observations on these species.

Bumble bees (*Bombus* and *Psithyrus* spp.) and honey bees (*Apis* spp.) share taxonomic assignment to the same family (Apidae) and the habit of being social. Nevertheless, they exhibit vastly different forms of nest construction, colony cycles (Michener, 1974) and division of labor (Cameron 1989). A number of North American records have been published on the nest associates, parasites, and parasitoids of each of these two groups (e.g. Frison 1926; Holm 1960; Milum 1939; Plath 1922, 1924), although little has been reported on the ability or tendency of their respective nest associates and natural enemies to share hosts. Honey bees are not native to North America and neither are most of their nest associates, largely due to the transport of these bees by humans.

During the summer of 1987, we had the opportunity to make direct observations on nest associates and natural enemies of both bumble bees and honey bees reared in close proximity to each other, and to record which of these bee-associated insects were found in nests of both groups. Below we describe the results of this survey, briefly suggest some possible explanations for the patterns observed, and provide some description of some of the parasitoids as an aid for future identification in field studies.

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## STUDY CONDITIONS

Free-foraging colonies of *Bombus bimaculatus* Cresson, *B. fervidus* (Fabricius), *B. impatiens* Cresson, and *B. vagans* Smith were reared using modifications of standard procedures (Plowright & Jay 1966) at the Ohio State University Honey Bee Laboratory during the summer of 1987 in outdoor observation shelters. Forty colonies were established in wooden and plexiglas nest boxes from single queens collected in the spring within a 125-km radius of Columbus, Ohio. The colonies were situated within 10-50 meters of honey bee colonies under observation at the OSU bee lab. Several old, greater wax-moth (*Galleria melonella* L.) infested honey bee frames were present at the laboratory (approx. 15m away) as a potential source of both wax moth and honey bee parasitoids. Lepidopteran nest associates and hymenopteran parasitoids were allowed to develop naturally in the bumble bee and honey bee colonies to observe which nest associates and parasitoids entered and completed development in both honey bee and bumble bee colonies. Colonies were visually inspected daily for the entire summer; the chance that developing parasitoids went unobserved was small.

## RESULTS

## Parasitoids of Bumble Bees and Honey Bees

The results of the rearing survey are summarized in Table 1. An infestation of the gregarious pupal parasitoid, *Melittobia chalybii* Ashmead (Eulophidae), in old bumble bee nests was not accompanied by any appear-

Table 1. Lepidopteran nest associates and bee and moth parasitoids reared from honey bee and bumble bee colonies established near one another in Columbus, Ohio. Numbers in parentheses after *Melittobia chalybii* indicate number of parasitized hosts.

	Source Bee Colonies				
	<i>A. mellifera</i>	<i>B. bimaculatus</i>	<i>B. fervidus</i>	<i>B. impatiens</i>	<i>B. vagans</i>
<b>Lepidoptera</b>					
<i>Galleria melonella</i>	200+	0	0	0	0
<i>Vitula edmandsae</i>	0	12	10	5	2
<i>Plodia interpunctella</i>	3	0	0	0	0
<i>Nemapogon</i> sp.	0	0	1	0	0
<b>Hymenoptera</b>					
<i>Apanteles galleriae</i>	90	25	0	0	0
<i>Apanteles nephopteris</i>	0	4	9	0	2
<i>Bracon hebetor</i>	36	22	3	2	0
<i>Venturia canescens</i>	10	1(?)	0	0	0
campoplegine sp.	0	0	1	0	0
<i>Melittobia chalybii</i>	0	2000+ (9)	0	400 (2)	0

ance of this species in honey bee colonies or old frames. The larvae and pupae of *M. chalybii* infesting bumble bee pupal cells are shown in Figures 1 and 2. *M. chalybii* has been reported previously from several species of nest-building Hymenoptera, including bumble bees and leafcutter bees (Edwards & Pengelly 1966; Hobbs & Kronic 1971; MacFarlane & Donovan 1989). Although the species of *Melittobia* often have been taxonomically confused and host records have been notoriously suspect, a recent revision of the genus (Dahm, 1984a, b) has clarified many of the host records.

The biology of *M. chalybii* and related species has been well studied (see, e.g., Howard 1891; Buckell 1928; Schmieder 1933; Schmieder & Whiting 1947; Hobbs & Kronic 1971; Dahms 1984b). It is a gregarious eulophid ectoparasitoid, principally attacking prepupal and pupal Hymenoptera (although records from other laboratory studies suggest a broader host range is possible (Gordh 1979)). Hobbs & Kronic (1971) reported that the adult females were easily able to enter apparently closely-fitting containers to parasitize their hosts, and that an average of 175 adults could be reared from a single prepupa leafcutter bee (*Megachile rotundata* [F.]). The ability of the females to enter new nest boxes with ease was observed in our study also. However, the number of parasitoids that emerged from a single bumble bee prepupa or pupa varied greatly (Table 1), depending on the species of the host bee attacked, but nonetheless averaged well above 175 individuals, no doubt due to the large size of the bumble bees. The bumble bee prepupae or pupae were virtually consumed by the *M. chalybii* larvae, leaving only a shrivelled skin.

*Melittobia* did not directly parasitize honey bees during our study.

#### Nest Associates and their Parasitoids

Greater wax moths (*Galleria mellonella* L.) were present in large numbers in old honey bee frames but were not found in any of the bumble bee colonies. A second species of moth, the common stored-products pest *Plodia interpunctella* (Hübner) (Pylalidae), was also present in low numbers only in the old *Apis* frames. Two other species of moth larvae, *Vitula edmandsae* (Packard) (Pylalidae) and *Nemapogon* sp. (Tineidae), were found only in the bumble bee nests, late in the season. *V. edmandsae* commonly has been reported from bumble bee nests (Heinrich, 1956), and was relatively abundant in our study. *G. mellonella*, *P. interpunctella* and *V. edmandsae* all belong to the Pylalidae, but are not especially closely related within that family (Solis & Mitter 1992).

Two species of braconid parasitoids, *Apanteles galleriae* Wilkinson and *Bracon hebetor*. Say, normally reported from honey bee colonies, were found to parasitize both *Galleria* and *Vitula* in honey bee and bumble bee colonies, respectively. *A. galleriae* was originally described from the Old World (Wilkinson, 1932) but was transported to North America along with *Apis*



Figure 1. *B. bimaculatus* pupal cell opened to show gregarious *Melittobia* larvae on *Bombus* pupa. Adult *Melittobia* just visible at left (arrow).

Figure 2. *B. bimaculatus* cell opened to show *Melittobia* pupae.

colonies many years ago. There are no previous reports of *A. galleriae* from bumble bee colonies. *A. galleriae* is a solitary endoparasitoid of early-instar *Galleria* larvae; the larger later instar moth larvae are not commonly attacked. When attacking *V. edmandsae*, *A. galleriae* emerges from later-instar larvae.

*B. hebetor*, on the other hand, is an ectoparasitoid (Fig. 3) capable of parasitizing larvae of many ages. The larger hosts ultimately provide for a larger number of the gregarious parasitoid progeny. *B. hebetor* is one of the most fully-studied parasitoid wasps, and has been the subject of many developmental, physiological, behavioral and genetic investigations (e.g. Hase 1924; Morrill 1942; Martin 1947; Grosch 1948a, b; Beard 1952; Drenth 1974; Steiner 1986).

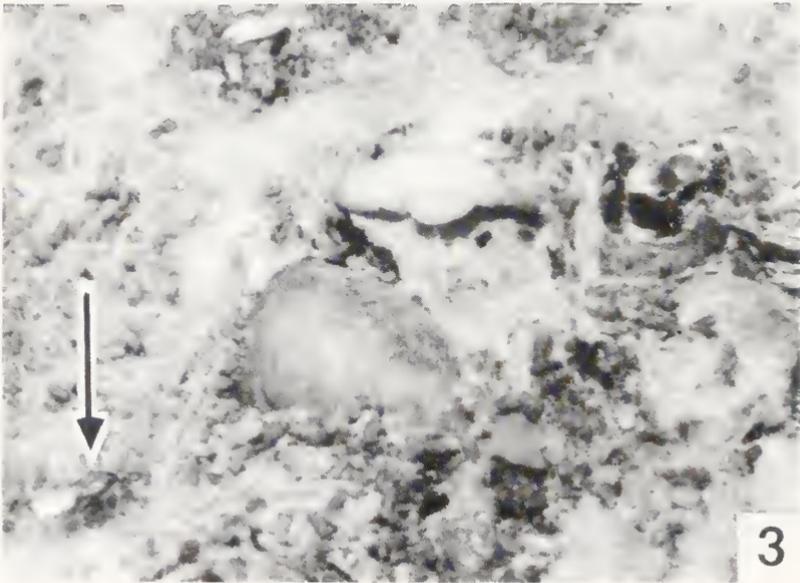


Figure 3. *Bracon hebetor* larva attached to host *Vitula* larva in infested nest of *Bombus bimaculatus*. Adult *Bracon* just visible at lower left (arrow).

A third braconid parasitoid, *Apanteles nephopteris* Ashmead, attacked only *Vitula* larvae in the old bumble bee nests. *A. nephopteris* has been reported previously to attack *Vitula* and other pest Lepidoptera on stored products (Marsh 1979).

An ichneumonid parasitoid, *Venturia canescens* (Gravenhorst), was reared from nest associate Lepidoptera in infested honey bee colonies, but was not reared from bumble bee colonies, although one adult female was discovered flying into an abandoned bumble bee nest and may have been searching for

hosts. Carlson (1979) reports that specimens from undetermined hosts in bumble bee nests are present in the U.S. National Museum. The biology of *V. canescens* is well-studied (Frilli 1965; Carlson in Krombein *et al.* 1979), and it is one of the few Ichneumonidae for which careful studies have been made of host preferences and survivorship in different hosts (Salt 1964, 1975, 1976). As wax consumers in bumble bee colonies. *V. edmandsae* larvae are potentially within the "natural" host range of *V. canescens*.

In Figure 4, we have provided some identification aids for these ichneumonoid parasitoids from bumble bee and honey bee colonies.

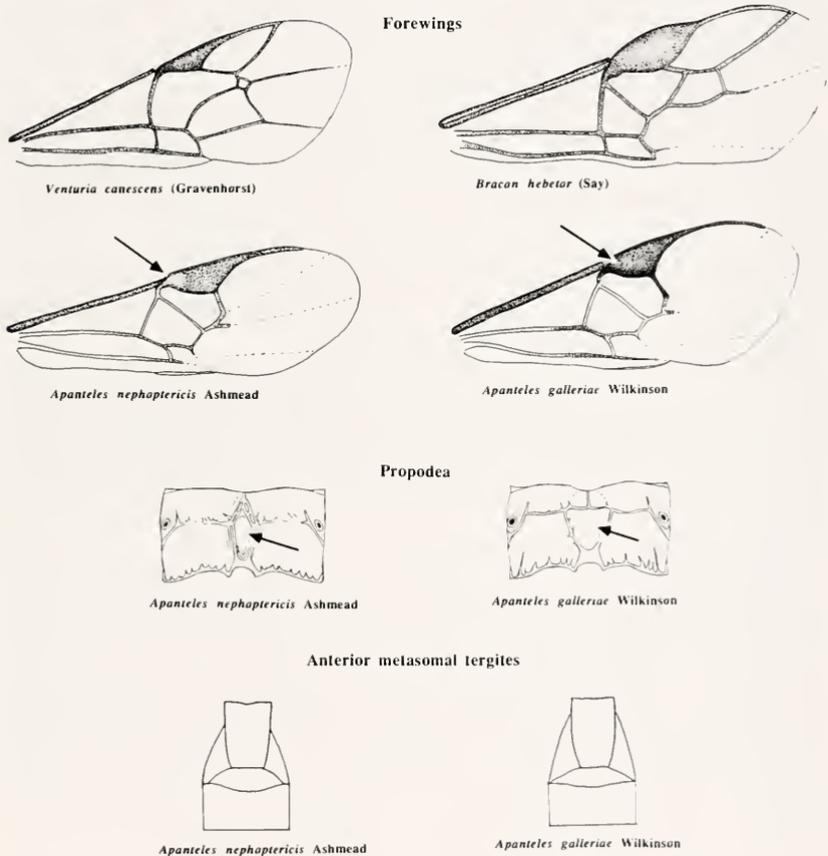


Figure 4. Morphological characteristics of the principal ichneumonoid parasitoids found in North American apid colonies. Arrows indicate differences in pterostigmal pigmentation or differences in the shape of the medial areola on the propodeum (posterior face of functional "thorax"). For additional taxonomic information concerning these species, see (Wilkinson, 1932; Nixon, 1976; Papp, 1980; Quicke, 1987; Wahl, 1987).

## CONCLUSIONS

These observations indicate that none of the lepidopteran nest associates switched between honey bee and bumble bee colonies. The greater wax moth *G. mellonella* was specific to honey bee nests, while *V. edmandsae* was found only in bumble bees nests. On the other hand, some of the hymenopteran parasitoids attacked nest associates within both honey bee and bumble bee colonies. In particular, *A. galleriae* was a parasitoid on *G. mellonella* and *V. edmandsae*, and *B. hebetor* was reared from the nests of several bumble bees as well as from honey bees. In contrast, the parasitoid *M. chalybii* attacked only the prepupal or pupal stages of *B. bimaculatus* and *B. impatiens*. *V. canescens* was reared only from honey bee colonies, although an adult was found searching inside a colony of *B. bimaculatus*.

Differences in the colony hygiene of the bees may be largely responsible for the absence of some of the nest associates and parasitoids, such as *Melittobia*, in honey bee colonies. Honey bees actively remove infected brood from the nest, while bumble bees do not. Furthermore, bumble bees may be especially susceptible to this species (and to the moth *V. edmandsae*) as a result of the gradual abandonment of their nests at the end of each annual colony cycle. Because the nest is eventually abandoned and usually not re-used (at least in temperate regions), it is not imperative to exclude parasitoids and wax moths from the nest late in the season.

The absence of *A. nephopteris* from honey bee colonies may be due in part to a lack of synchrony between the availability of appropriately aged larvae of *Galleria* and the emergence of *A. nephopteris* from *Vitula* larvae, and in part to colony hygiene in honey bee colonies. It is also possible that *A. nephopteris* is unable to survive in *Galleria* larvae due to the internal defense reactions of the host. Laboratory studies to examine this possibility would be useful.

Our results clearly indicate that given the opportunity, some or most of the parasitoids of *Apis* nest associates are able to parasitize bumble bee nest associates. This has rarely been noted in nature, probably because (1) bumble bee nests are usually subterranean, while the introduced *Apis* nests are not; (2) bumble bee nests are abandoned at the end of each year, and are rarely studied after the nest is abandoned, and (3) bumble bee wax moths usually enter at the end of the season, often after the bumble bees have left. Further studies are needed to determine whether the *Apis* colony-associate parasites found in our domesticated bumble bee colonies occur in wild bumble bee nests.

## ACKNOWLEDGMENTS

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**NOTES ON SPECIES OF *EPERIGONE*  
(ARANEAE: LINYPHIIDAE)  
FROM CAPE COD, MASSACHUSETTS<sup>1</sup>**

Robert L. Edwards

ABSTRACT: Six species of *Eperigone*, *E. augustae* Crosby & Bishop, 1933, *E. contorta* (Emerton, 1882), *E. tridentata* (Emerton, 1882), *E. trilobata* (Emerton, 1882), *E. maculata* (Banks, 1892), and *E. tenuipalpis* (Emerton, 1882) [NEW SYNONYMY] occur on Cape Cod. Both sexes of *Eperigone tenuipalpis* are redescribed. Epigynal plugs and abdominal pigment patterns of several species are described. Brief natural history notes are included.

The small spiders of the genus *Eperigone* are troublesome to identify. As is the case with many spiders, immatures of most species are almost impossible to identify with confidence. However, late subadult instars of some species can be recognized by the pattern of chevrons on the abdomen. The females of four species have epigynal plugs, which are characteristic of the species. The chaetotaxy of the epigynal margin is also species specific.

METHODS

Specimens were examined and illustrated with a Bausch & Lomb StereoZoom<sup>®</sup> 7 binocular microscope, equipped with 15X eyepieces. Drawings were made using an ocular grid, transferring the image by eye to gridded paper. Measurements were made with an ocular micrometer, and are accurate to 0.01 mm. For total length, carapace length and carapace width, measurements were made to the nearest 0.05 mm. The cephalic index is determined by dividing carapace length by carapace width. The position of metatarsal trichobothria (TmI, TmII) is measured to the nearest 0.01 mm. The Tm value (%) is determined by dividing the distance from the proximal end of the metatarsus to the trichobothrium by the total length of the metatarsus.

*Eperigone tenuipalpis* (Emerton, 1911)

This species was originally described as *Tmeticus tenuipalpus* by J. H. Emerton (1911); type locality Plum Island, Ipswich, Massachusetts. Crosby and Bishop (1928) revised the genus *Erigone* in 1928, refiguring and redescribing all species. Using type specimens and other material available,

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they included *tenuipalpis* with reservations, considering it an 'aberrant form'. The morphology of the genitalia of both sexes, however, merits placement of *Erigone tenuipalpis* in *Eperigone* [NEW SYNONYMY] as presently understood (cf. Millidge, 1987). In his recent revision of *Eperigone*, Millidge (1987) did not include *Tmeticus tenuipalpis* Emerton. The type specimens were not examined.

**DIAGNOSIS.**—Males have a long, slender palpal tibia with distinctive apophyses, and a large, darkly sclerotized supratégulum (Fig. 3); female epigynum divided longitudinally and with widely spaced lateral arms extending only a short distance beyond the square-ended dorsal plate (Fig. 8).

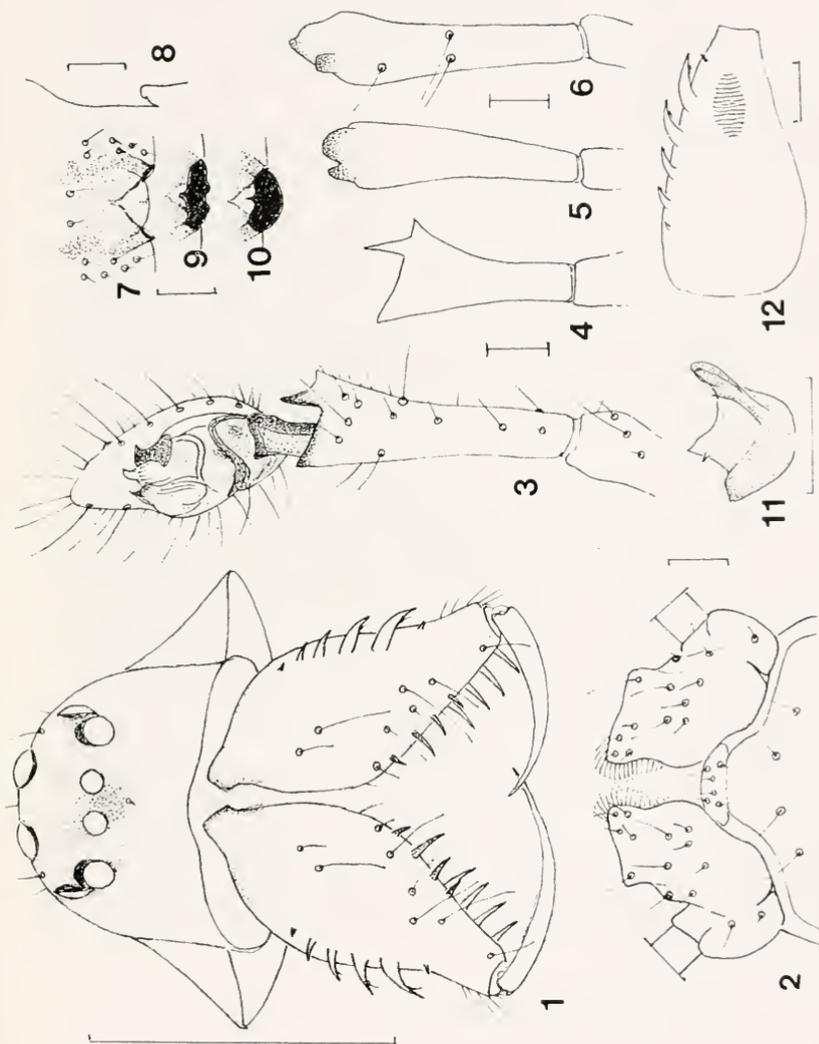
**DESCRIPTION.**—**Male.** Averages and range in mm. Total length 2.41 (2.21-2.70), carapace length 1.16 (1.10-1.30), cephalic index 1.41 (1.29-1.53), TmI 0.65 (0.60-0.70). Chelicerae with four retromarginal and promarginal teeth. Row of six setigerous denticles along antero-lateral margin of chelicera, the first five increasing markedly in size distally with the sixth small (Fig. 1). Distinct file near distal end of chelicera in both sexes (Fig. 12). File with oval outline and circa fourteen regularly spaced ridges. Supratégular apophysis obvious, darkly sclerotized, tongue-like; otherwise projections of the embolic division only lightly sclerotized with none distinctively configured (Fig. 11). Dorsal apophysis of palpal tibia triangular distally, with secondary square-cornered apophysis below dorsal apophysis that projects dorsally (Fig. 6). Ventral apophysis bilobate (Fig. 5). Length of palpal tibia variable, averaging 0.41 mm, occasionally as short (0.28 mm) as shown in Fig. 4. Proximal two-thirds of ventral surface of palpal femur with four to five small setigerous denticles; distal half of prolateral surface with five small denticles also tipped with setae.

Pigmentation of both sexes similar. Cephalic area of carapace light orange-brown with eye area darker orange brown. Thin, dusky marginal line. Cervical groove darkened; thoracic radii broad and dusky. Sternum brown, suffused with dusky, darker markings toward periphery. Legs yellow-brown; proximal segments, especially femora, slightly darker. Abdomen dark gray with a contrasting pattern of six to seven chevrons that are fairly regular in outline (Figs. 25-27). Venter lighter gray, evenly colored, with narrow whitish line laterad. A darker ring around spinnerets, reduced ventrally.

**Female.** Averages and range in mm. Total length 2.60 (2.02-3.30), carapace length 1.22 (0.95-1.50), cephalic index 1.41 (1.22-1.63), TmI 0.67 (0.60-0.71). Chelicera with five teeth in each row; proximal tooth in retromarginal row minute. Denticles and spur of male chelicera replaced by setae. File as described for male (Fig. 12).

Epigynum moderately protuberant (Figs. 7-8, 22), with widely spaced lateral arms; genital openings barely extend beyond dorsal plate. Marginal setae of epigynum somewhat variable in length and position, with two longer setae in central area. Spermatheca usually visible through darkly pigmented cuticle. Epigynal plugs dark reddish in color, extending between but not into genital openings; more or less flat, irregularly oval in shape and usually with small pointed projection on anterior margin (Figs. 9-10, 23-24).

**Immatures.**—Carapace, sternum and appendages light olive-brown and with markings essentially like adults. Abdomen also patterned as adults. TmI, subadult males 0.64 (0.56 to 0.69), subadult females 0.63 (0.55 to 0.69). TmII, subadult males 0.60 (0.53 to 0.64), subadult females 0.59 (0.54 to 0.63). The chevrons of immatures are much like those of adults, but usually more distinct. The relatively high values for both TmI and TmII assist in the identification of older immatures.



Figures 1-12. *Eperigone tenuipalpis* 1. Male chelicerae, anterior. 2. Male chelicerae, ventral. 3. Left palp, ectal. 4. Left palp, ectal, small variant. 5. Left palpal tibia, ventral. 6. Left palpal tibia, dorsal (trichobothria shown). 7. Epigynum, ventral. 8. Epigynum, profile. 9-10. Epigynal plugs. 11. Embolic disk, right palp, mesal. 12. Embolic disk, ectal. Unlabeled scale lines 0.1 mm.

**SPECIMENS EXAMINED:** Five males, 8 females and 39 subadults from West Falmouth, Barnstable County, Massachusetts, collected by the author in wrack (*Zostera detritus*) from a tidal marsh, 4 Feb. 1991; 7 males, 8 females and 35 subadults from same locality and habitat, 22 Nov. 1990; 7 females and 51 subadults from same locality and habitat, 14 Nov. 1990; 9 subadults from same locality and habitat, 30 October, 1990; and 1 female, same locality and habitat, 23 July, 1987. Specimens of both sexes and representative individuals of late subadult instars have been deposited in American Museum of Natural History (New York), Natural History Museum (London), United States National Museum (Washington, D.C.), and Canadian National Collection (Ottawa).

**NATURAL HISTORY.**—The area from which the samples were taken has been collected at regular and frequent intervals for several years. It is a broad Cape Cod tidal marsh bounded on the west by Buzzards Bay, dominated by salt marsh grasses and sedges (*Distichlis* and *Juncus*) and with patches of *Spartina alterniflora* along ditches. Scattered mats of wrack, the remains of eel grass (*Zostera marina* L.), occur near the level of higher tides, often supported above the surface on marsh grasses. Recent collections (fall 1990 and winter 1991) followed periods of unusually high tides and several episodes of onshore winds. These conditions often result in the production of extensive wrack mats. It is suggested here that the aggregations found were primarily the result of strong onshore winds and tidal action, the spiders being carried from an as yet to be identified specific microhabitat in the marsh. These aggregations dissipated after several days of calm weather. This species generally was difficult to find during the warmer months of the year.

The *E. tenuipalpis* population was numbered between from 30 to 75 adult and subadult individuals/m<sup>2</sup> of wrack. Associated with *tenuipalpis*, in the samples listed above and in comparable numbers, were *Grammonota trivittata* Banks and *Erigone aletris* Crosby & Bishop. The population of *G. trivittata* was also maturing during this same period, adults and immatures being represented in roughly equal numbers. *G. trivittata* is usually found on the muddy surface of the marsh or on loose webbing at the base of grass clumps. Equally abundant in these and other collections, *E. aletris* occurs as adults year-round in wrack mats and other types of tidal debris. However, the most common associates, at about twice the number of *E. tenuipalpis*, were adult female *Scolopembolus littoralis* (Emerton). Less abundant was *Satilatlas marxii* Keyserling. This last species is more often found in grass and sedge litter immediately at or above high tide level. *Pardosa littoralis* Banks and *Gnaphosa parvula* Banks commonly occur in and on wrack and other tidal detrital deposits.

*Eperigone augustae* Crosby and Bishop, 1933

Two essentially colorless adult males of *E. augustae* were collected in June in pitfall traps in pine woods. The specimens measured 0.90 and 0.95

mm in total length. These two specimens were the only ones collected in several hundred pitfall and litter collections made in the same area throughout the year.

*Eperigone contorta* (Emerton, 1982)

This species occurs in fresh and slightly brackish water marshes with grasses and sedges. While never found in great abundance, it may be collected with some effort in these preferred habitats. Adults have been collected most frequently in the colder months. It is found in association with other more abundant erigonines, such as *Ceratinopsis laticeps* Emerton, *Grammonota maculata* Banks, and *Scolopembolus littoralis*.

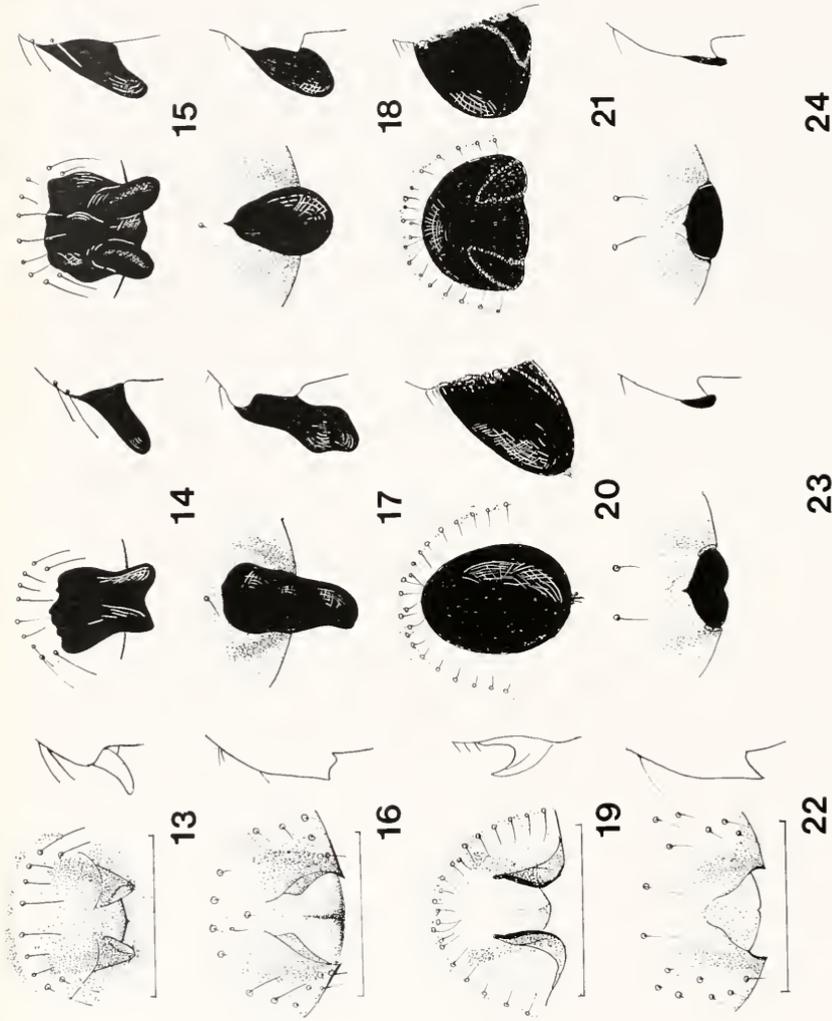
The epigynal plug of *E. contorta* (Figs. 14-15) is unusually structured, reflecting the general configuration of the epigynum (Fig. 13). It completely covers the ventral surface of the epigynum and extends around and well beyond the ends of the extended lateral arms. Dark orange-brown in color and quite hard, it cannot be removed by physical means without damaging the epigynum (cf. Millidge, 1987). It does not block the oviduct. The marginal setae of the epigynum are of moderate length, with the pair of setae at the midline slightly longer.

There is no pattern of chevrons on the abdomen. Immatures of this unpatterned species cannot be identified with confidence.

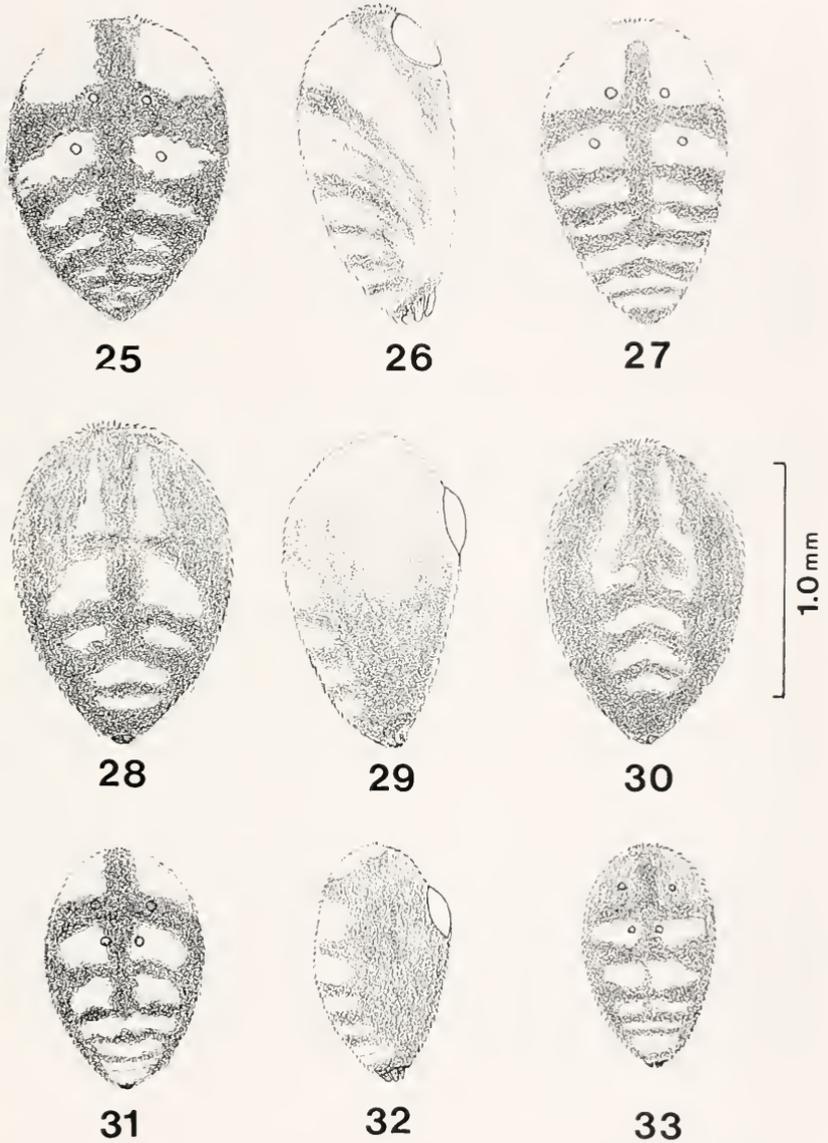
*Eperigone maculata* (Banks, 1892)

This is the most common *Eperigone*. Adults have been collected throughout the year in virtually all habitats. Unlike the other local species, *E. maculata* is found in greatest abundance in both deciduous and coniferous litter. Abundance averaged 31 to 34 individuals/m<sup>2</sup> of litter in the warmer months and 7/m<sup>2</sup> in colder months. This species is associated with other common forest litter inhabitants, such as *Lathys pallidus* (Marx), *Hahnia cinerea* Emerton, *Trabeops aurantiaca* (Emerton), *Phrurotimpus alarius* (Hentz), *Pocadicnemis americanus* Millidge, *Maso sundevalli* (Westring), and *Walckenaeria directa* (O. P.-Cambridge).

Both immatures and adults of *E. maculata* are readily distinguished from their associates by the abdominal pigment pattern (Figs. 31-33). Usually there are six chevrons, with the first varying from obvious to essentially lacking. The sixth chevron appears to be made up of a joining of the sixth and seventh, resulting in a distinct white spot. Over one hundred adult females taken in all seasons have been examined with no evidence of an epigynal plug.



Figures 13-24. Epigyna and two examples of epigynal plugs, ventral and profile views. 13-15, *Eperigone contorta*. 16-18, *E. tridentata*. 19-21, *E. tenuipalpis*. 22-24, *E. tenuipalpis*. Scale lines 0.1 mm.



Figs. 25-33. Abdominal pigment patterns. 25-27, *Eperigone tenuipalpis*. 25. Dorsal, typical. 26. Lateral. 27. Dorsal, variant. 28-30, *E. tridentata*. 28. Dorsal, typical. 29. Lateral. 30. Dorsal, variant. 31-33, *E. maculata*. 31. Dorsal, typical. 32. Lateral. 33. Dorsal, variant. Scale lines 1.0 mm.

*Eperigone tridentata* (Emerton, 1882)

*E. tridentata* is a moderately large species, averaging over 2 mm in total length. Usually it is found in moist leaf litter around the edges of lakes and ponds, and occasionally in great abundance, up to 25 individuals/m<sup>2</sup> of leaf litter. Adults may be found throughout the year but are most often taken in the colder months. Large numbers of *E. tridentata* mature in October and November, with males leading the females by several weeks. This species has a relatively dark, diffusely patterned abdomen (Figs. 28-30). There are usually only five chevrons, with the first being reduced to a narrow, longitudinal stripe. Females tend to be much darker than males and have less clearly defined chevrons. Immatures are patterned much as the adults, although with the chevrons clearer.

The chaetotaxy of the epigynal margin is illustrated in Fig. 16. The centrally located seta on the ventral plate is distinctive. The epigynal plug is a dark brown, rounded plug that covers the genital opening and a portion of the ventral plate (Figs. 17-18). Occasional specimens are found with the plug distorted (Fig. 17), suggesting that its formation had been interrupted. Fresh plugs are white and sticky. The plug is similar to, but is not as large as that of *E. trilobata*.

*Eperigone trilobata* (Emerton, 1882)

Another of the smaller species, *E. trilobata* is without chevrons on the abdomen, much like *E. contorta*. It is uncommon, and there is no specific habitat where one can go with any realistic expectation of collecting specimens. A few specimens have been taken in wetter environments, but also in dry grass fields. Most of my specimens have been taken in lawns, in pitfall traps, and among the broad basal leaves of plantain and dandelion, places where *Grammonota inornata* Emerton, *Grammonota gentilis* Banks, and *Erigone autumnalis* Emerton are consistently taken in greater numbers.

Adult *E. trilobata* have been taken throughout the year. Females with epigynal plugs have been taken in June and July. The plug is relatively large, dark brown, elongate-ovoid, usually with the lateral arms of the epigynum detectable just under the surface (Figs. 20-21). The outer margin of the epigynum is marked by a row of smaller setae (Fig. 19). There are no chevrons on the abdomen and immatures cannot be reliably determined.

## REMARKS

Many of the 68 *Eperigone* species have been described from only one sex, female or male, and often from only a few specimens (cf. Millidge,

1978). Very little is known about the life history of most species, in part because they can be difficult to identify. About half of the species have cheliceral denticles or spurs or both. Also about half have chevrons on the abdomen. Some of the species have chevrons that are similar to those of species of other genera with which they are found, particularly species of *Grammonota* and *Bathyphantes*. Other attributes such as the presence or absence of cheliceral denticles and spurs, the chaetotaxy of the epigynal margin and the form of the epigynal plugs, can be helpful when dealing with the genus, especially in a regional context. Body dimensions and proportions were of limited assistance in separating the species of *Eperigone* dealt with here (Edwards, unpubl.); with the exception, however, of the relative position of the metatarsal trichobothrium of both subadult and adult *E. tenuipalpis*,

#### ACKNOWLEDGMENTS

I am grateful to Herbert Levi (MCZ) and Charles Dondale (CNM), for reviewing an earlier draft of the manuscript and making many useful comments and corrections. Two anonymous reviews made suggestions and corrections that were gratefully received.

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(Continued from page 239)

development, molecular identification, satellite imagery and low technology control. Surprisingly, Dr. Johnson states that important aspects of the basic biology of the vectors and parasites are still mostly unknown, including where sand flies lay their eggs and what the reservoir hosts are. The vectors themselves have specific resting areas in the day; for example, the sand fly vector of visceral leishmaniasis rests in eroded termite hills and that for cutaneous leishmaniasis in rock quarries or caves.

There were several notes of entomological interest. Dr. R. T. Allen mentioned that he has found an undescribed species of symphylan from Delaware, and a new record of a dipluran from Delaware known previously from the Mediterranean. The recent heavy snow-fall prompted discussion of insects on snow, such as the *Chionea* crane fly or collembolan species, and of insects such as the box elderbug overwintering inside houses. There were 20 members and visitors in attendance.

Jon K. Gelhaus,  
Corresponding Secretary

## A DESCRIPTION OF THE MALE *EPERIGONE MODICA* (ARANEAE: LINYPHIIDAE)<sup>1</sup>

Robert L. Edwards<sup>2</sup>

ABSTRACT: The male of *Eperigone modica* Millidge, 1987, previously known only from the female, is described and illustrated. Variation in both sexes is discussed.

The recent revision of *Eperigone* by Millidge (1987) has made it possible to deal more easily with this large, homogeneous group of erigonine spiders. *Eperigone modica* was described by Millidge from a single female. Both sexes and immatures of *E. modica* were collected in litter samples from the edge of a small permanent marsh, on the northern outskirts of Nogales, Arizona. For a detailed description of the genus *Eperigone*, see Millidge op.cit.

### METHODS

Specimens were examined and illustrated with a Bausch & Lomb StereoZoom<sup>®</sup> 7 binocular microscope, equipped with 15X eyepieces. Drawings were made using an ocular grid, transferring the image by eye to gridded paper. Measurements were made with an ocular micrometer, accurate to 0.01 mm. For total length, carapace length, and carapace width, measurements were made to the nearest 0.05 mm. The position of metatarsal trichobothria (TmI and TmII) were measured to the nearest 0.01 mm. Cephalic index is carapace length divided by carapace width. The Tm values (%) are determined by dividing the distance from the proximal end of the metatarsus to the trichobothrium by the total length of the metatarsus.

### *Eperigone modica* Millidge, 1987

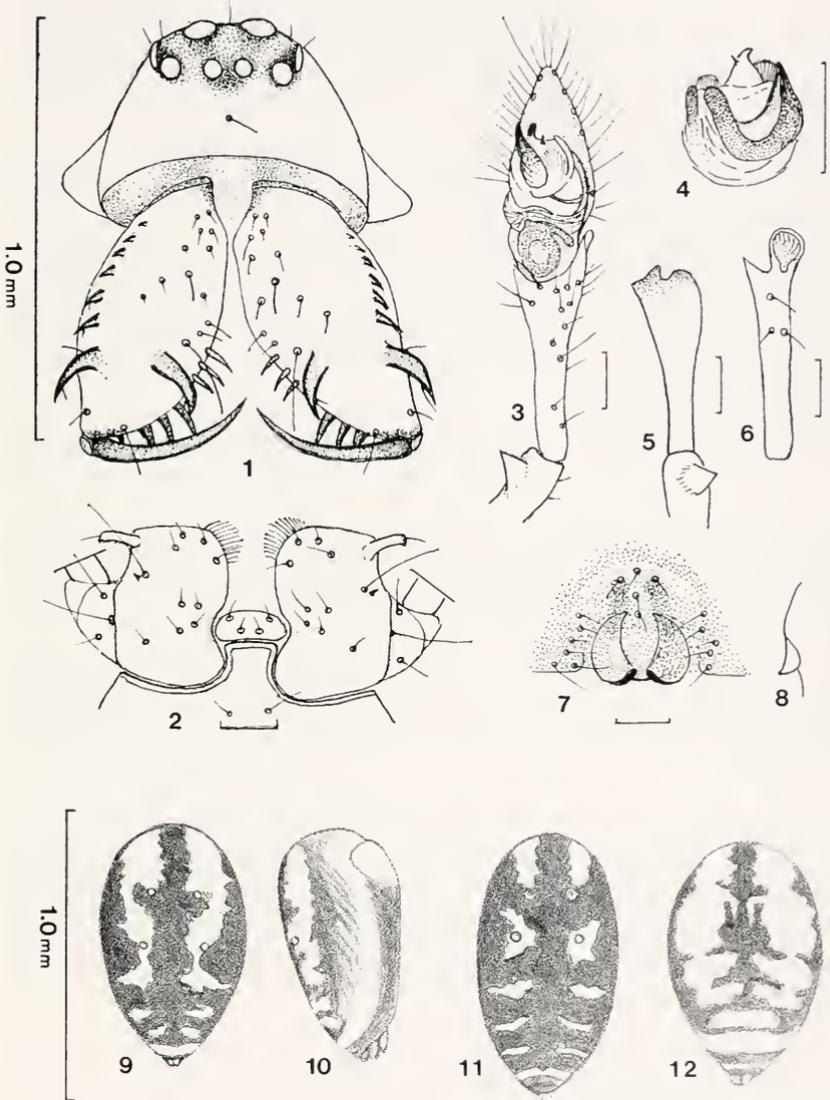
Figures 1-12

*Eperigone modica* Millidge, 1987: 38-40, figs. 139-140. Described from single female.

DIAGNOSIS:—Male with two exceptionally prominent spurs (greatly enlarged denticles) on opposite margins of each chelicera (Fig. 1), and an unusual stalk-like projection on the anterio-lateral margin of the endite (Fig. 2). Ventral projection of embolic division tooth-like, dark and prominent (Fig. 3). Palpal tibia relatively long and slender (Figs. 3, 5, 6). Palpal patella with small, conic spur (Figs. 3, 5). Female epigynum divided longitudinally with distinctly upturned (in ventral view) and incurved tips of lateral arms (Figs. 7, 8). Metatarsus IV with trichobothrium.

<sup>1</sup> Received May 3, 1993. Accepted May 24, 1993.

<sup>2</sup> Research Associate, Department of Entomology, United States National Museum. Present address: Box 505, Woods Hole, MA 02543.



Figures 1-12. *Eperigone modica* Millidge. 1. Male chelicerae, anterior. 2. Male endites, ventral. 3. Palp, ecto-ventral. 4. Embolic division, mesal. 5. Palpal tibia, ventral. 6. Palpal tibia, dorsal. 7. Epigynum, ventral. 8. Epigynum, lateral. 9-12. Abdominal pigment pattern, male. 9. Typical, dorsal. 10. Lateral. 11. Darkest, dorsal. 12. Lightest, dorsal. Unlabeled scales 0.1 mm.

**DESCRIPTION.**—**Male.** 20 specimens measured: total length 2.55 (2.00-2.96), cephalothorax length 1.24 (0.95-1.49), cephalic index 1.37 (1.28-1.63), TmI 0.68 (0.64-0.73), TmII 0.66 (0.58-0.74). Chelicerae with three large promarginal and four retromarginal teeth. PME relatively close, from one half to two thirds diameter apart (Fig. 1). Single large seta on clypeus below AME, about one-half distance from AME to ventral margin of clypeus. Row of six setigerous denticles along antero-lateral margin of chelicera, increasing in size distally, with a very large, curved spur just beyond end of row. A similar, unique, and equally large spur is situated on the antero-medial margin (Fig. 1). Viewed from above these pairs of spurs look very much like the horns of a team of oxen. No discernible file in either sex. Endites with unique stalk-like projection tipped with seta on antero-lateral corner (Fig. 2).

Ventral projection of embolic division large, tooth-like, and darkly sclerotized (Fig. 3, 4). Median projection curved and relatively lightly sclerotized. Dorsal apophysis of palpal tibia rounded and spatulate (Fig. 6). Ventral apophysis bilobate, somewhat irregular in outline, not projecting as far distally as dorsal apophysis (Fig. 5). Patella of tibia with small, conical ventral spur (Fig. 3, 5). Proximal two-thirds of ventral surface of palpal femur with row of six small denticles with setae at tip of denticle. Distal prolateral surface of palpal femur with four small denticles each tipped with setae.

Cephalic portion of carapace orange-brown, slightly darker around eyes, and essentially flat. Posteriorly cephalic portion with 'shield-like' area, thinly delineated with black, then light. Thoracic portion lighter, yellow, with dusky radii and relatively broad, dusky marginal band. Cervical groove darkened with dark line extending halfway to posterior edge of carapace. Chelicerae clear orange-brown. Legs light brown. Sternum dusky brown, slightly darker toward margin. Abdomen gray to nearly black with irregular pattern of six cream-colored chevrons (Figs. 9, 10, 11, 12). Sixth chevron usually not divided and continued laterally to join lighter lateral stripe (Fig. 10). Dorsally anterior two-thirds of abdomen with general appearance of median and lateral dark, irregular, longitudinal stripes, created by the joining of the first three lightly colored chevrons. Venter gray, evenly colored. Spinnerets ringed with darker gray.

The male, using the key provided by Millidge (1987, pp. 58), would belong to those species with an embolic division of trilobate form. It is readily separated from each of these species by the form of the palpal tibial apophyses.

**Female.** 9 specimens measured: total length 2.42 (2.15-2.86), cephalothorax length 1.08 (0.90-1.21), cephalic index 0.74 (0.69-0.85), TmI 0.68 (0.66-0.70). Chelicerae without the denticles and spurs seen in males. Usually four promarginal teeth, second and third largest; four or five retromarginal teeth with proximal two closely paired. No spur on endites as in males. Pigmentation essentially as in male but usually with less contrast in pattern, and with smaller chevrons. Darkened line of cervical groove not further extended posteriorly as in male. Lateral arms of epigynum wide, semi-circular in outline, gray to orange-brown with darker margin around genital opening (Fig. 7). Posteriorly tips of lateral arms upturned (Fig. 8). Spermathecae brown, clearly visible through cuticle.

Specimens of females from this series were compared with the holotype female in the American Museum of Natural History by Dr. Norman Platnick, who stated that the identification as *modica* seems appropriate.

**Immatures.** The immatures collected were antepenultimate and penultimate instars. The base color of the carapace varies from very light gray for

younger instars to a light olive-brown in older instars. The dusky areas (e.g. radii and marginal band) seen in the adults are more clearly visible, standing out against the lighter background color. Distal ends of leg segments were usually with darker bands. The abdominal pattern of chevrons is somewhat less variable in shape and position than in adults, otherwise it is identical.

VARIATION.—Cheliceral denticles and setae of males varied to a minor degree in size, position, and number; such variation was associated in part with overall size. In one specimen the distal denticle on the antero-lateral margin was greatly enlarged, creating a second spur. Larger specimens tended to have larger denticles. A few specimens had paired denticles (usually the third) in the antero-lateral row on the chelicerae. The values for TmI were the least variable statistic for both sexes. TmII was measured to evaluate its usefulness as a substitute for TmI when the first legs were damaged or missing. The pigmentation of the male abdomen varied from very light to darker with most individuals as illustrated in Figs. 9 and 10. Female abdomens had less clearly outlined chevrons that tended to be narrower transversely than those of males.

NATURAL HISTORY.—These specimens were taken in damp leaf litter at the edge of a small permanent pond with a boggy margin. The relatively large number of males (23) to females (10) suggested that this population had only recently begun to mature. Associated with this species were comparable numbers of *Grammonota gentilis* (Banks), dominated by adults of both sexes. The pigmentation pattern of *G. gentilis* is similar to that of *E. modica*. Somewhat less abundant in the litter were adult *Glenognatha emertoni* Simon. *Pardosa concinna* Thorell, both adults and immatures, were common on the litter surface and on nearby drier margins of the bog.

DISTRIBUTION—Southern New Mexico and Arizona.

MATERIAL EXAMINED.—Nogales, Santa Cruz County, Arizona, in damp leaf litter at edge of boggy margin of small lake; 11 January, 1991, 23 males, 10 females and 13 late instar subadults. Voucher specimens of both sexes and immatures have been deposited in the Museum of Comparative Zoology (Cambridge), United States National Museum (Washington, D.C.), Canadian National Collection (Ottawa), American Museum of Natural History (New York), and Natural History Museum (London).

## REMARKS

At first glance the exuberant lateral denticles and spurs on the chelicerae of male *E. modica* (Fig. 1) and the small, conical spur on the palpal patella (Fig. 3), suggest a close relationship with the genus *Erigone*. However, the

structure of the embolic division of the palp (Fig. 4) is characteristic of *Eperigone* as defined by Millidge (1987). Female *modica* have an epigynum with a divided ventral plate, typical of the genus *Eperigone*. *E. modica* has a distinctly patterned abdomen, with chevrons, a feature seen in many species of the genus.

#### ACKNOWLEDGMENTS

I am grateful to Herbert Levi (MCZ), Charles Dondale (CNM) and Jonathan Coddington (USNM), each of whom reviewed the manuscript and provided many useful suggestions. Dr. Norman Platnick (AMNH) kindly compared my specimens of *E. modica* with the holotype. Comments and corrections made by two anonymous reviewers were greatly appreciated.

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## SOCIETY MEETING OF APRIL 28, 1993

### SURVEYING AND CONSERVATION OF LEPIDOPTERA IN OHIO

Dr. Eric H. Metzler

Ohio Department of Natural Resources

Although there are amateur scientists studying most taxonomic groups of insects, those folks interested in Lepidoptera must form the largest and most visible section. How best to harness the vast information and enthusiasm represented by these dedicated researchers? The fifth and final meeting of the 1992-1993 season was highlighted by a fine presentation by Eric Metzler on how the relatively recent organization, the Ohio Lepidopterists' Society, brought together about 300 amateur and professional scientists for the common goal of surveying and conservation of Lepidoptera in Ohio. Mr. Metzler, employed in the Ohio Department of Natural Resources, is himself a long-time lepidopterist, starting his interest as a young boy in Michigan, and co-founding the Ohio Lepidopterists' Society in 1979.

The original intent of the Society was the Lepidoptera Survey, and this clicked immediately with the Ohio Division of Wildlife. Through published records, specimen data in private collections and museums, countless hours of fieldwork in all parts of the state, and financial support from the state for travel and data entry, the survey database now encompasses about 96,000 records for 2600 species of butterflies and moths. Although the survey started with butterflies due to general public interest, published information and the interest of the Society members, it has moved to include leps such as large silk moths, noctuids, and geometrids. The focus now is on the Microlepidoptera, for which Annette Braun's collection, located at the Academy of Natural Sciences, is one of the most important for Ohio. Mr. Metzler reports that even some die-hard butterfly specialists are now

(Continued on page 272)

## RECORDS OF *CHIMARRA HOLZENTHALI* AND *C. PARASOCIA* (TRICHOPTERA: PHILOPOTAMIDAE) FROM EASTERN TEXAS<sup>1</sup>

David E. Bowles<sup>2</sup>, Oliver S. Flint, Jr.<sup>3</sup>, Stephen R. Moulton II<sup>4</sup>

**ABSTRACT:** *Chimarra holzenthali* and *Chimarra parasocia* are reported from Texas for the first time. The former species previously was known only from seven specimens collected at the type locality in northern Louisiana. These new records are proposed to represent the western limit for these two species.

A recent examination of caddisfly (Trichoptera) material in the Texas A&M University (TAMU) and the University of North Texas (UNT) insect collections has revealed some range extensions and new collection records for two species of *Chimarra* (Philopotamidae). Blacklight trap collections from Anderson and Hardin counties, Texas, produced examples of *Chimarra holzenthali* Lago and Harris and *Chimarra parasocia* Lago and Harris.

*Chimarra holzenthali* previously was known only from seven specimens (3♂♂, 4♀♀) collected at the type locality of Schoolhouse Spring, Jackson Parish, Louisiana (Lago and Harris 1987). The type series of *C. holzenthali* is in poor condition, the genitalia of the holotype male is distorted through handling, while those of the male paratypes are either missing or cleared to the point of being transparent (Lago and Harris 1987).

*Chimarra parasocia* previously was known from Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee (Lago and Harris 1987). Lago *et al.* (1989) reported that, due to a misinterpretation of data, the paratype of *C. parasocia* from Montgomery County, Arkansas was actually a specimen of *Chimarra socia* Hagen. However, examples of *C. parasocia* recently were found in material collected from southern Arkansas (Paul Lago, Personal Communication).

**Material Examined:** *Chimarra holzenthali*. Texas, Anderson Co., Salmon, VI-27-1975, H. R. Burke, blacklight trap; 1♂ (TAMU). *Chimarra parasocia*. Same data: 4♂♂, 1♀ (TAMU); Hardin Co., Hickory Creek, off U.S. 287/69, north of Kountze, X-23-1992, S. R. Moulton and K. D. Alexander, UV-light, 1♂ (UNT).

<sup>1</sup> Received May 8, 1993. Accepted May 29, 1993.

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The distributional records presented here for these two species are approximately 300 miles west of previous collections. The collection locality at Anderson County, Texas, lies at western edge of the Austroriparian Biotic Province described by Blair (1950). The Austroriparian Biotic Province forms the western boundary of the main body of the pine and hardwood forests of the Gulf Coastal Plain. However, there is not a distinct physiographic break between the Austroriparian and Texan biotic provinces, and some characteristic faunal elements, including the species of *Chimarra* discussed here, may extend westward into some areas of the latter province. The Texan Biotic Province is primarily a broad ecotone region between the forests of the Austroriparian Biotic Province and the drier grasslands of central Texas (Blair 1950), and, as such, probably marks the western boundary for the ranges of *C. holzenthali* and *C. parasocia*. However, both species may be distributed throughout eastern Texas.

Other species of *Chimarra* known from Texas include *C. angustipennis* (Banks), *C. aterrima* (Hagen), *C. beameri* Denning, *C. elia* Ross, *C. feria* (Ross), *C. obscura* (Walker), *C. ridleyi* (Denning), and *C. texana* (Banks) (Armitage 1991, Edwards 1973).

#### ACKNOWLEDGMENTS

We thank Paul Lago, University of Mississippi, and Chad McHugh, USAF Armstrong Laboratory, for reviewing this manuscript. Horace Burke and Ed Riley, Texas A&M University, graciously loaned the caddisflies for our examination.

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## A NEW SPECIES OF *LARGULARA* (HOMOPTERA: CICADELLIDAE) FROM BRAZIL<sup>1,2</sup>

Paul H. Freytag<sup>3</sup>

ABSTRACT: A new species of leafhopper from Brazil is described in the genus *Largulara*.

A new species of the genus *Largulara* DeLong and Freytag was found in material loaned to me by M. W. Nielson. The two known species of the genus were discussed by DeLong and Freytag (1972) and Freytag (1992). This species is described and compared with the other two species. I wish to thank Dr. Nielson for the loan of the material used in this study.

### *Largulara magnifica* new species (Figures 1-5)

Length of male 7.4-7.8 mm., head width 2.1 mm., female unknown. Similar to *fantasa* and *elegans* but with distinct male genitalia.

External morphology and color nearly identical to *elegans* and *fantasa*.

**Male genitalia:** Genital plates more than two times longer than broad, with two long tufts of setae, one laterally at base and one at apex (Fig. 3). Pygofer without processes, apical margin slightly lobed (Fig. 5). Style broadened near middle, ventral margin thickened, apex pointed and slightly hooked (Fig. 4). Aedeagus with stout shaft, ventrally flattened, with pair of subapical spines; basal processes stout, curving outward, then back toward shaft, with small setal spine on inner margin near middle (Figs. 1-2).

**Holotype male,** Brazil—Rondonia, 7 km E Costa Marques, 03-11 Oct. 1987, malaise trap, T. Klein, in the California Academy of Sciences Collection. Paratype males: one, same data as holotype, in the University of Kentucky Collection; one, Brazil—Rondonia, 8 km + 2 km W of Costa Marques, 11-13 April 1987, malaise trap, T. Klein, in the Oregon State University Collection.

This species can be separated from *fantasa* (DeLong and Freytag) and *elegans* Freytag by the following key:

### Key to Species of *Largulara*

1. Paired basal processes of aedeagus with spine-like processes near middle.....2
- 1'. Paired basal processes of aedeagus with setal-like processes near middle (Fig. 1 and 2)  
Brazil .....*magnifica* n. sp.
2. Aedeagal shaft with lateral subapical spine-like processes Venezuela.....*elegans* Freytag
- 2'. Aedeagal shaft with lateral bifurcate subapical setal-like processes Peru .....*fantasa*  
(DeLong and Freytag)

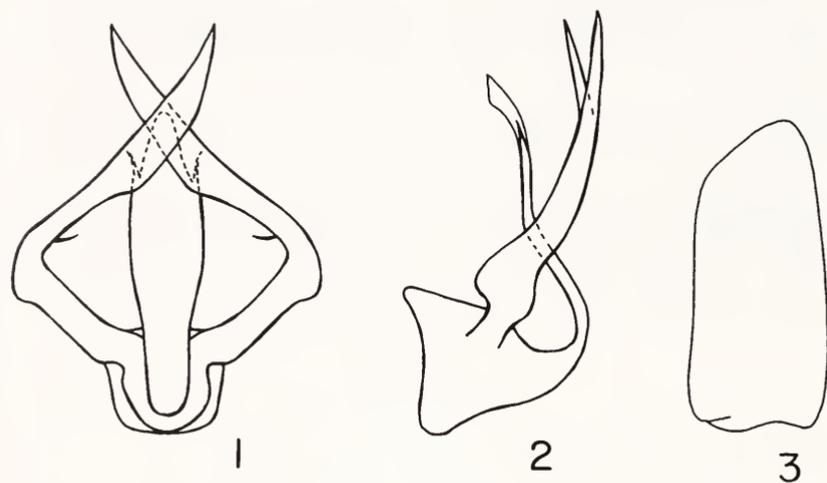
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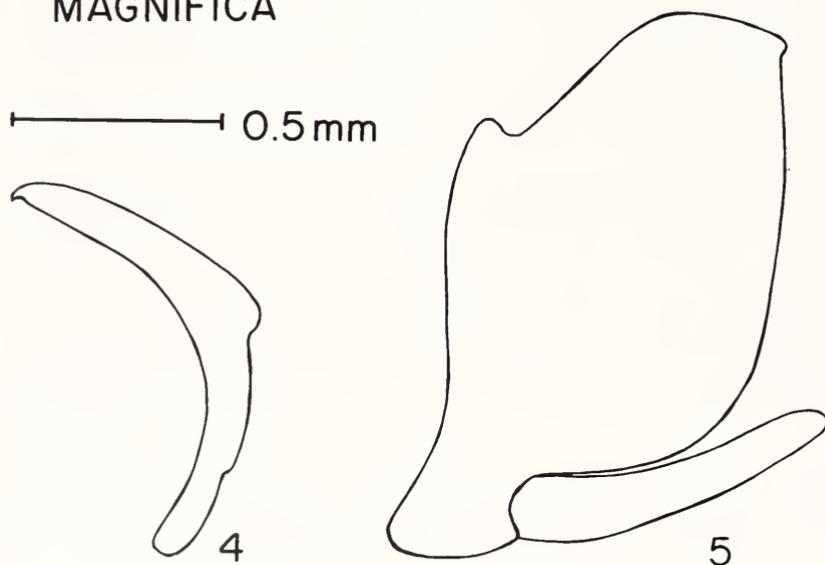
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<sup>2</sup> The investigation reported in this paper (No. 93-7-23) is in connection with a project of the Kentucky Agricultural Experiment Station and is published with approval of the Director.

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**MAGNIFICA**

|-----| 0.5 mm



Figures 1-5 *Largulara magnifica* n. sp., male genitalia 1. aedeagus, ventral view, 2. aedeagus, lateral view, 3. genital plate, ventral view (setae not shown), 4. style, lateroventral view, 5. pygofer and genital plate, lateral view (setae not shown). All drawn to the same scale.

**A NEW *ERYTHMELUS* (HYMENOPTERA:  
MYMARIDAE) FROM CENTRAL ASIA,  
AN EGG PARASITOID OF *CIRCULIFER* SPP.  
(HOMOPTERA: CICADELLIDAE)<sup>1</sup>**

Serguey V. Trjapitzin<sup>2</sup>

**ABSTRACT:** A new species of mymarid wasp from Turkmenistan, *Erythmelus margianus*, is described and illustrated. Adult parasitoids were reared from eggs of several cicadellid species including beet leafhopper, *Circulifer tenellus* (Baker). A key to the *panis* (*Parallelaptera*) species group of *Erythmelus* is given.

Enock (1909) described the genera *Erythmelus* and *Parallelaptera* based on the following distinctions: female funicle 5- and male flagellum 10-segmented in *Parallelaptera*, 6- and 11-segmented in *Erythmelus*; flagellar segment 2 of male antenna very small (Enock overlooked this segment in the original description), and forewing margins almost parallel in species belonging to *Parallelaptera*. In *Erythmelus*, flagellar segment 2 of male antenna is subequal to other flagellomeres in length, and forewing margins are not parallel. Later, the majority of Mymaridae taxonomists, including Annecke and Doutt (1961), followed Enock in recognizing *Parallelaptera* as a valid genus. However, both genera share several important morphological characters such as metanotum projecting over propodeum, several rows of small spines on foretibia, greatly reduced mandibles, females with a well-developed hypopygium (Schauff 1984). Subba Rao (1989) reinstated *Parallelaptera* as a valid genus after Schauff (1984) synonymized it with *Erythmelus*. I am following Schauff's classification and place 6 species which formerly belonged to *Parallelaptera* together with a new species described herein from Turkmenistan into a distinct *panis* species group within *Erythmelus*.

I am following Annecke and Doutt (1961) in using terminology and making measurements to indicate the range (in mm). Specimens of *Erythmelus* (*Parallelaptera*) were borrowed for study from collections indicated by the following acronyms: BMNH, The Natural History Museum, London; CNCI, Canadian National Collection of Insects, Ottawa; UCRC, University of California, Riverside; USNM, National Museum of Natural History, Washington; ZMAS, Zoological Institute, St. Petersburg. Abbreviation used in the description is: F = funicular (flagellar in males) segment.

<sup>1</sup> Received March 22, 1993. Accepted June 14, 1993.

<sup>2</sup> Department of Entomology, University of California, Riverside, CA 92521-0314

### Key to species of the *panis* group, females.

1. Funicular segments progressively longer than preceding ones.....2
- 1' Funicular segments not progressively longer than preceding ones but of different lengths.....5
2. F3 over 1.7 times length of F1 .....3
- 2' F3 less than 1.7 times length of F1 .....4
3. Total length of F1-F4 about 1.75 times length of F5 (Mexico, USA) .....*E. rex* (Girault)
- 3' Total length of F1-F4 about 1.15 times length of F5 (India) .....*E. panchamus* (Subba Rao)
4. General body coloration black. Mesosoma shorter than metasoma. F5 slightly dilated basally (Fig. 1). Club with 5 sensory ridges (Turkmenistan).....*E. margianus*, new species
- 4' General body coloration brown. Mesosoma longer than metasoma. F5 not dilated basally. Club with 3 sensory ridges (Austria, Belgium, Bulgaria, Denmark, England, Iran, Moldavia) .....*E. panis* (Enock)
5. F3 much longer than F4 (South Africa, Uganda).....*E. funiculi* (Annecke and Doutt)
- 5' F3 shorter than F4.....6
6. F3 shortest of funicle (India, Iraq) .....*E. polyphagus* (Livingstone and Yacoub)
- 6' F3 as long as F1 (India).....*E. teleonemiae* (Subba Rao)

### *Erythmelus margianus*, new species

Figs. 1-4

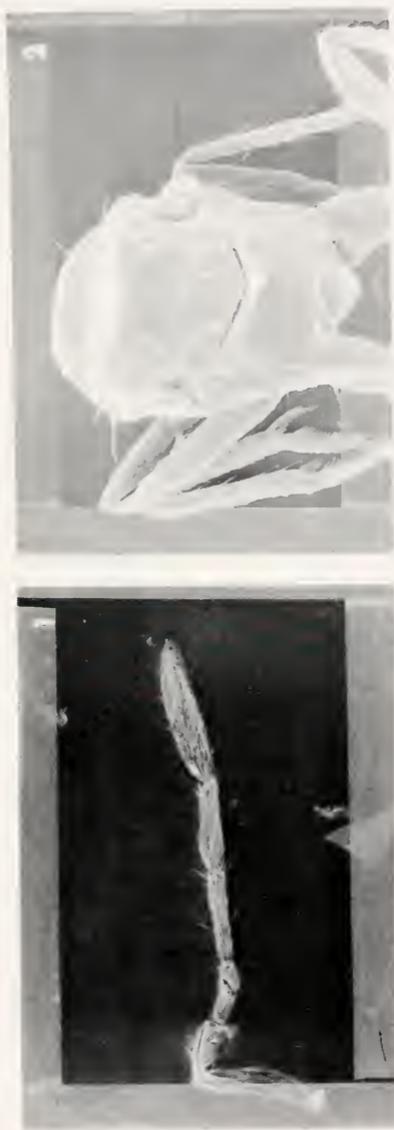
**Female.** General body coloration black; scape, pedicel and F1 light brown, remainder of antenna and eyes dark brown; axillae and tegulae yellowish; legs yellowish brown; femora, middle and hind tibiae dark brown, except middle part of hind femora yellowish; forewing with faint infuscation not extending beyond venation, remainder of forewing and hindwing hyaline; 2 or 3 basal segments of metasoma yellowish golden, hypopygium dark brown.

Head in dorsal view oval, wider than long, slightly wider than mesosoma; trapezoidal in frontal view. Eyes large, broadly separated, sparsely setose. Ocelli in obtuse triangle; POL 3 times OOL. Antenna (Fig. 1) inserted at lower level of eyes; radícula not clearly separated from scape; pedicel longitudinally striate; F1 and F2 with striation finer than pedicel, all mentioned antennal segments sparsely setose, remainder of antenna densely setose; F3 shorter than F4; F5 longest of funicle, slightly dilated basally, bearing 2 sensory ridges; club with 5 sensory ridges.

Mesosoma (Fig. 2) smooth except postscutellum with fine longitudinal sculpturing laterally; pronotum with 2 pairs of small setae; mesoscutum nearly as wide as long, bearing a pair of setae close to notaulices and another pair posteriorly; axillae with a pair of medial setae clearly separated from subcircular scutellum; postscutellum with medial cross shaped carinae, bearing a pair of setae; propodeum divided dorsomedially, smooth; mesophragma projecting slightly into metasoma. Forewing (Fig. 3) of typical shape for *E. panis* species group, with nearly parallel margins, projecting beyond apex of metasoma at about 1/4 of its length; venation short, reaching slightly more than 1/3 of wing's length; hypochoeta close to proximal macrochaeta, reaching posterior margin of forewing; distal macrochaeta about 2 times as long as proximal macrochaeta; blade hairless except for 3 rows of microchaetae, one on anterior margin distad to venation, small setae close and distad to fringe hairs, starting from fifth seta, second row along anterior margin beyond first fringe seta, and third row of 6-10 smaller setae closer to posterior margin. Hindwing narrow, about same length as forewing; blade bare except a row of small chaetae along anterior margin.

Metasoma subsessile, nearly as wide as mesosoma but longer; ovipositor occupying about 3/4 of its length, slightly exerted beyond apex of metasoma.

Measurements (n=2): Body: 0.587-0.658; Head: 0.075-0.076; Mesosoma: 0.240-0.259; Metasoma: 0.270-0.323; Ovipositor: 0.247-0.264.



*Erythmelus marginatus* sp.n.: Figs. 1-2: Scanning electron micrographs. (1) Antenna (female); (2) Mesosoma (female). Figs. 3-4: Photomicrographs. (3) Forewing (female); (4) Head and antennae (male).

Antenna: Scape: 0.090-0.103; Pedicel: 0.037-0.042; F1: 0.019-0.020; F2: 0.023-0.024; F3: 0.032-0.033; F4: 0.039-0.043; F5: 0.065-0.067; Club: 0.106-0.113.

Forewing: Length: 0.465-0.479; Width: 0.052-0.053; Venation: 0.165-0.175; Marginal vein: 0.074-0.075; Hypochaeta: 0.028-0.029; Proximal macrochaeta: 0.037-0.038; Distal macrochaeta: 0.074-0.080; Longest fringe cilia: 0.202-0.213.

Hindwing: Length: 0.464-0.465; Width: 0.022-0.023; Venation: 0.143-0.144; Longest fringe cilia: 0.150-0.160.

Legs:	Femur	Tibia	Tarsus
Fore	0.133-0.164	0.139-0.150	0.154-0.160
Middle	0.103-0.135	0.179-0.180	0.159-0.160
Hind	0.114-0.150	0.171-0.209	0.175-0.203

**Male.** Similar to female except as follows: body lighter, general coloration dark brown; pedicel and legs light brown to yellowish; antenna (Fig. 4) filiform, sparsely setose, F2 very short as typical for *E. panis* species group; basal infuscation of forewing stronger than in female; metasoma shorter and markedly narrower than mesosoma. Genitalia slightly protruding ventrally, similar in structure to male genitalia of *E. panis* (Viggiani 1988).

Measurements (n=2): Body: 0.494-0.525. Antenna: Scape: 0.057-0.067; Pedicel: 0.031-0.034; F1: 0.046-0.048; F2: 0.016-0.020; F3: 0.053-0.059; F4: 0.057-0.068; F5: 0.057-0.063; F6: 0.055-0.061; F7: 0.053-0.063; F8: 0.055-0.063; F9: 0.059-0.061; F10: 0.056-0.060. Forewing: Length: 0.460-0.480; Width: 0.046-0.053.

**Type material:** Described from 2 females and 2 males as follows: TURKMENISTAN. **Holotype.** Female, Old Nisa, on *Atriplex* sp. ex *Circulifer tenellus* eggs, 15.VI.1992, V. Trjapitzin (slide No. 41, deposited in ZMAS). **Allotype.** Male, same data as holotype (slide No. 109, ZMAS). **Paratypes.** 1 female, Old Nisa, sweeping upon *Atriplex* sp., 11.VI.1992, S. Trjapitzin (USNM); 1 male, Ashgabat, near Kurtlinskoye storage lake, on *Salsola* sp. ex *Circulifer* sp. eggs, 10.VI.1992, S. Trjapitzin (USNM).

**Etymology.** The specific name corresponds to the ancient Margiana, a country which is now Turkmenistan.

**Diagnosis.** The new species is close to *E. panis* (Enock) and *E. rex* (Girault). *E. margianus* can be distinguished from *E. panis* by its blackish color (brown in *E. panis*), presence of 5 sensory ridges on the club, mesosoma shorter than metasoma, and postscutellum with medial cross shaped carinae. *E. rex* differs from *E. margianus* in having brownish body coloration and different proportions of antennal segments.

**Other material examined:** *E. panis* (Enock): Holotype female of *Paralleleptera panis* Enock, England, Woking, July 1885, Fred. Enock; allotype male, same data, Richmond (BMNH); 4 females, 3 males, Iran, Karaj, Agricultural College, pantraps, 1-3.IX.1977, J.T. Huber (CNCI). *E. rex* (Girault): Holotype female of *Anthemella rex* Girault, USA, IL, Urbana, greenhouse, 28.XIII.1911 (USNM type No. 14,232); 2 females, USA, IA, Cedar Co., 12 mi. SSE Tipton, 28 VIII.1983, J.D. Pinto, screen sweeping, det. J.T. Huber, 1984 (UCRC). *E. polyphagus* (Livingstone and Yacoub): 1 female, 1 male, Iraq, Mosul, Nenalvali Ag. Stn., ex *Stephanitis pyri* F. (Tingidae), 20.IX.1985 (CIE 17,507 Sp. No. 5, BMNH). *E. panichanus* (Subba Rao): Paratype female of *Paralleleptera panichanus* Subba Rao, India, Tamil Nadu, Coimbatore, 25.IX-1.X.1979, J.S. Noyes (BMNH). *E. teleonemiae* (Subba Rao): 1 female, 1 male, India, Coimbatore, det. B.R. Subba Rao (BMNH). *E. funiculii* (Annecke and Doutt): 1 female, 2 males, Uganda, Kawanda, 3.I.1957, E.D.L. Matega, det. B.R. Subba Rao (BMNH).

## DISCUSSION

The biology and host associations remain poorly known for most of seven species which form *E. panis* group. *E. teleonemiae* (Subba Rao) was reared from eggs of *Dictyla* sp. and *Teleonemia scrupulosa* Stål (Hemiptera: Tingidae) on *Lantana camara* L. in India (Subba Rao 1984). *E. polyphagus* (Livingstone and Yacoob) was recorded as an egg parasitoid of *T. scrupulosa* and 18 other tingid species in southern India (Yacoob and Livingstone 1983). *E. panis* (Enock) was recently reared in Moldavia from eggs of the pear lace-bug, *Stephanitis pyri* F. (Goncharenko and Fursov 1988). *E. rex* (Girault) was reported by Peck (1963) to be an egg parasitoid of the beet leafhopper, *Circulifer tenellus* (Baker) (Homoptera: Cicadellidae), in the USA. Annecke and Doutt (1961) stated that all attempts to breed *E. rex* on *C. tenellus* eggs failed. In the present study attempts to rear the new species, *E. margianus*, which was imported in 1992 into California on *C. tenellus*, have also failed despite the fact that adult wasps were reared in Turkmenistan from eggs of several *Circulifer* species including beet leafhopper.

*Erythmelus* is moderately abundant and shows up frequently in pan traps and Malaise traps (Schauff 1984). I found *E. margianus* to be the most common mymarid wasp in Turkmenistan emerging from samples of foliage from plants which belong to the "saltbush" family (Chenopodiaceae). Specimens examined in the present study were collected on different species of *Atriplex* and *Salsola*, common plant genera in central Asia.

## ACKNOWLEDGMENTS

I am indebted to John D. Pinto and David H. Headrick for reviewing the manuscript; John T. Huber, John LaSalle, Andrew Polaszek and Michael E. Schauff for generous loans of specimens.

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(Continued from page 262)

collecting even these tiny members of the order to document species' occurrences. Published books now available summarize the information on butterflies (144 spp.) and noctuid moths (708) spp.).

What are the applications of all this information? Zoogeographically, many of the species show restricted distributions within the state, possibly due to historical factors such as glaciation, or more recent land-use changes such as destruction of habitat due to development. Although 30 butterfly species are common and found in every county of the state, 44% of the 144 species are somehow restricted in distribution and 22 species of butterflies and moths are considered endangered within the state. The Survey has clearly documented species which require habitat protection or careful monitoring. As an example, the Karner's Blue and some moth species are restricted to the "oak openings" area of north-west Ohio, for which the "openings" and their associated species are disappearing because of the prevention of fires. The Survey data are actively used by the state to support preservation of habitat on government lands, and has been used to convince private industry to modify development plans. For example, Mr. Metzler explained that Honda USA Corporation changed building plans to allow protection of wetland that harbored populations of the Ontario Hairstreak and Duke's Skipper. Even the home gardener is encouraged to plant butterfly gardens and to restrict pesticide use.

There were several notes of entomological interest. Susan Whitney noted that a report of a fire ant mound in Delaware turned out to be that of the Allegheny Mound Ant, *Formica e. exsectoides* Forel. Roger Fuester reported that the first eggs of Gypsy Moth, *Porthetria dispar* (L.), hatched in Cape May Co., N.J. this week. Jane Ruffin was encouraged to talk about her recent bout with malaria, contracted in the northwest corner of Botswana while on a collecting trip with Dan Otte and several others. She came down with a high fever 13 days later, just after arriving back in Pennsylvania. She had a fever of 104° for four days and required hospitalization. She is just finishing up 4 weeks of quinine treatment, which will rid her of the *Plasmodium falciparum* parasite completely.

The meeting at the Academy of Natural Sciences was attended by 45 members and visitors.

Jon K Gelhaus,  
Corresponding Secretary

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Howard P. Boyd, editor.

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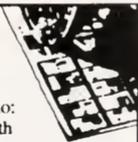
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# ENTOMOLOGICAL NEWS

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## DISTRIBUTIONAL AND CLASSIFICATORY SUPPLEMENT TO THE BURROWING MAYFLIES (EPHEMEROPTERA: EPHEMEROIDEA) OF THE UNITED STATES<sup>1</sup>

W. P. McCafferty<sup>2</sup>

**ABSTRACT:** The extant Ephemeroidea species of the United States are updated with respect to higher classification, species taxonomy, and state records. Distribution maps are provided for all 23 currently recognized species. Forty three new state records for 14 species were published since 1975. An additional 19, mostly expected, new state records are given here for 11 of the species. Species ranges are now apparent from the distributional data. *Ephemera compar* Hagen and *Pentagenia robusta* McDunnough are assumed to be extinct, and the genus *Dolania* is excluded from the Ephemeroidea.

The last review of the Ephemeroidea in North America was given by McCafferty (1975). Since then, the group has been further restricted and its higher classification modified, the family Potamanthidae has been completely revised, certain species have been synonymized, others have been shown to be extinct, and several new geographic records of species have been reported. The purpose of this paper is to update the status of Ephemeroidea since the 1975 work with respect to both classification and distribution in the United States, and to provide additional new state records that allow a more complete representation of specific ranges.

Thirty species were listed for North America north of Mexico by McCafferty (1975). No indication of family classification was given primarily because family limits were undergoing evaluation. Edmunds *et al.* (1976), however, did provide a traditional familial classification of these species. A revised phylogenetic classification of the genera of Ephemeroidea of the world was presented by McCafferty (1991), wherein the former family Euthyplociidae was incorporated into the Polymitarciidae and the former family Palingeniidae was incorporated into the family Ephemeridae. Furthermore, the family Behningiidae (represented in North America only by the genus *Dolania*) was removed from the Ephemeroidea and placed in a separate superfamily. As a result, *Dolania* is not treated in this supplement. The revised higher classification of Ephemeroidea with respect to the North American fauna is given in Table 1. The family and subfamily classification is based on phylogenetic relationships (see McCafferty 1979, 1991)

<sup>1</sup> Received July 21, 1993. Accepted August 20, 1993.

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*Pentagenia robusta* McDunnough and *Ephemera compar* Hagen were treated by McCafferty (1975) and traditionally have been listed with extant species of mayflies (e.g., Edmunds *et al.* 1976). It has become apparent in recent years, however, that these species are in all likelihood extinct. Their status has been discussed by Edmunds and McCafferty (1984) and McCafferty *et al.* (1990). Extensive work on benthos of large rivers in the Midwest by numerous workers in recent years has not yielded *P. robusta*, which is still known only from original material described from the Ohio River by McDunnough (1926). Also, extensive on going work in Colorado (e.g., see McCafferty *et al.* 1993) has not yielded *E. compar*, which is still known only from original material described from Colorado by Hagen (1875). These species therefore are excluded from the present work, which is restricted to extant species.

Opportunities for corroborating and adding to state records of burrowing mayflies have been ample over the past 20 years, a period which has seen a strong emphasis on benthic macroinvertebrate research in the United States. Thus, it is assumed that, based on the data summarized herein, relatively complete pictures of species ranges are now represented. A few states within ranges of certain species still do not indicate a presence of the respective species, but this is generally because these states have yet to be adequately documented with published mayfly records. Below, any recent revisionary or distributional data related to species from Table 1 and supplemental to McCafferty (1975) is discussed. In addition, conterminous United States distribution maps are presented for each of the species, and include all state records. **Circles within states indicate valid records known at the time of the McCafferty (1975) treatment; squares indicate records published between then and the present, and triangles indicate new state records reported herein.** Most specimens on which new records are based are at the Purdue Entomological Research Collection; some are at the National Museum of Natural History. North Carolina specimens are held by the North Carolina Division of Environmental Management (Raleigh) and some Missouri specimens are at the University of Missouri.

No records of Ephemeroidea exist for Alaska (see McCafferty 1985) or Hawaii, although Bae and McCafferty (1991) reported an adult specimen of *Potamanthus formosus* Eaton from Hickam Field that was collected in 1954. It most likely was an adventive transported by military aircraft from Japan or Korea. There is no evidence that the species has become established in Hawaii.

## SPECIES DATA

***Tortopus incertus*** (Traver) (Fig. 1)

Lenat and Penrose (1987) showed this species to occur in North Carolina, thereby extending its known southeastern distribution pattern slightly northward.

***Tortopus primus*** (McDunnough) (Fig. 1)

*Tortopus* is a primarily Neotropical genus, closely related to the also primarily Neotropical genus *Campsurus* (see McCafferty *et al.* 1992). Lugo-Ortiz and McCafferty (1994) found *T. primus* in Texas, and confirmed the presence of *Campsurus decoloratus* and *T. circumfluis* also from that state. McCafferty (1975) indicated questionable records of this species from Missouri and Arkansas. The Texas record would tend to support those records and suggests a general range in the central United States.

***Ephoron album*** (Say) (Fig. 1)

This western and midwestern species overlaps with the distribution of its eastern sister species *E. leukon* in the upper midwestern United States, Missouri (see below), and Manitoba. Lake Erie populations reported on by Britt (1962) probably represent the easternmost range of the species. There is considerable evidence (McCafferty unpublished) that the two species have hybridized in at least one river in Indiana. Ward and Stanford (1990) reported the species from Colorado for the first time. A new state record is as follows: MISSOURI, Crawford Co., Meramac R. nr St. Hwy 8, VII-26-1992, B. Nichols.

***Ephoron leukon*** Williamson (Fig. 1)

Lager *et al.* (1982) reported this eastern and midwestern species from Minnesota, Kondratieff and Harris (1986) reported it from Alabama, and Lugo-Ortiz and McCafferty (1994) reported it from Texas. The listing of this species in Virginia by Kondratieff and Voshell (1983) was not accompanied by substantiating data, but nevertheless it undoubtedly exists there. New state records are as follows: CONNECTICUT, Litchfield Co., Kent, VIII-22-1917 (adults). IOWA, Winneshiek Co., Iowa R. VII-5-1977, K. L. Johnson (larvae). MISSOURI, Newton Co., Shoal Cr. near Neosho, 1974, D. S. Sarai (larvae). PENNSYLVANIA, Center Co., Bald Eagle Cr., VIII-9-1977, G. A. Hoover (larvae and adults); Forrest Co., Allegheny R. at Tionesta, VIII-26-1976; G. A. Hoover (adults). Faulkner and Tarter (1977) reported this species, as a new state record, from West Virginia. It had, however, been known from that state previously.

***Anthopotamus distinctus*** (Traver) (Fig. 2)

All North American species of the Potamanthidae belong to the genus *Anthopotamus* (McCafferty and Bae 1990); they were previously considered in the Old World genus *Potamanthus*. Kondratieff and Harris (1986) reported *A. distinctus* from Alabama; Bae and McCafferty (1991) reported it from Massachusetts, Vermont, and Virginia; and Burian and Gibbs (1991) reported it from Maine. The range map given by Bae and McCafferty (1991) should be extended somewhat southward.

***Anthopotamus myops*** (Walsh) (Fig. 2)

Bae and McCafferty (1991) synonymized *Anthopotamus inequalis* (Needham) and *Anthopotamus rufous* (Argo) with *A. myops*, and thus Maryland and Missouri were automatically added to the distribution of *A. myops*. In addition, Bae and McCafferty (1991) gave records for Alabama, Georgia, Minnesota, Virginia, and West Virginia.

***Anthopotamus neglectus*** (Traver) (Fig. 2)

This species was divided into two geographic subspecies by Bae and McCafferty (1991): *A. n. neglectus*, known only from the Northeast, and *A. n. disjunctus* Bae and McCafferty, from the southeastern and south central United States. Faulkner and Tarter (1977) added West Virginia to the known distribution, McCafferty and Provonsha (1978) reported the species from Arkansas, and this was later confirmed by Bae and McCafferty (1991). A previous report of this species in Arkansas by Koss (1970) remains tentative (see McCafferty 1975), although it may well be correct. Kondratieff and Harris (1986) reported *A. neglectus* from Alabama, and Bae and McCafferty (1991) reported it from Georgia and Oklahoma. Kondratieff and Voshell (1983) listed *A. neglectus* from Virginia. However, it is not known to which subspecies any Virginia or West Virginia populations would be assignable.

***Anthopotamus verticis*** (Say) (Fig. 2)

Bae and McCafferty (1991) synonymized *Anthopotamus diaphanus* (Needham) and *Anthopotamus walkeri* (Ide) with *A. verticis*, and reported new state records for Iowa, Maryland, Minnesota, Pennsylvania, Virginia, and Wisconsin. McCafferty and Bae (1992) established types for this species, designating a lectotype for the junior synonym *Ephemera flaveola* Walsh, and a neotype from Indiana for the senior name, *Baetis verticis* Say. David Lenat (Pers. comm.), using the species keys of Bae and McCafferty (1991), confirmed that this species, along with *A. distinctus*, occurs in North Carolina (both species in the mountains, but only *A. verticis* in the Piedmont). The new state record is

based on numerous collections as follows: NORTH CAROLINA, Ashe, Burke, Caldwell, Henderson, Mitchell, Rutherford, Transylvania, Watauga, Wilkes, and Yancey Counties (where both *A. verticis* and *A. distinctus* occur) and Chatham, Durham, Harnett, Orange, Person, and Randolph Counties (where only *A. verticis* occurs).

***Ephemera blanda*** Traver (Fig. 3)

Kondratieff and Voshell (1983) listed *E. blanda* for Virginia but gave no locale data. The record appears reasonable given this species' southeastern distribution pattern. A new state record is as follows: KENTUCKY, Jackson Co., War Fork of Station Camp Cr. at Turkey Foot Camp, V-4-1982, W. P. McCafferty and A. V. Provonsha (adults); and Pulaski Co., Fishing Cr. .5 mi S of St. Rd. 635 & 70 junction, V-4-1982, W. P. McCafferty and A. V. Provonsha (adults).

***Ephemera guttulata*** Pictet (Fig. 3)

Cather and Harp (1975) reported this species from the Ozarks of Arkansas. This would appear to be the westernmost distribution of this species, which shows an old eastern mountainous distribution pattern, primarily in the Appalachians, but with isolates in the Ozark Plateau. Faulkner and Tarter (1977) predictably found this species in West Virginia, and Kondratieff and Voshell (1983) listed it for Virginia. The Alabama record by Kondratieff and Harris (1986) probably represents the southernmost distribution of *E. guttulata*. I have found it to be the most common burrowing mayfly in small and mid-sized streams in central and eastern Kentucky.

***Ephemera simulans*** Walker (Fig. 3)

Faulkner and Tarter (1977) found this relatively widespread species in West Virginia, Liechti (1981) added it to the Kansas list of mayflies, and Unzicker and Carlson (1982) showed it to occur in North Carolina. Berner and Pescador (1988) indicated that the dubious record of this species in Florida could not be substantiated despite considerable collecting effort in the area where it had supposedly been collected. I have excluded Florida from the range map of this species. New state records are as follows: MISSOURI, Christian Co., James R. & adjacent spring, V-24-1972, W. B. Morton (adults); Greene Co., James R. 4 mi E Springfield, V-30-1972, B. A. Sassmann (adults); Taney Co., Swan Cr. Hwy. AA, V-23-1972, R. W. Baumann (adults). NORTH DAKOTA, Grand Forks Co., Turtle R. at Turtle R. St. Prk. 1.7 mi N Arvilla, V-12-1978 (larvae). OKLAHOMA, Ottawa Co., Five Mile Cr., 5.1 mi N & 1.25 mi E Peoria. VI-12-1984, P. Liechti (adults).



*Campsurus decoloratus*



*Tortopus circumfluus*



*Tortopus incertus*



*Tortopus primus*

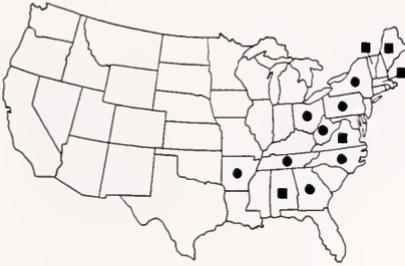


*Ephoron album*



*Ephoron leukon*

Fig. 1. United States distribution of extant species of *Campsurus*, *Tortopus*, and *Ephoron*.



*Anthopotamus distinctus*



*Anthopotamus myops*



*Anthopotamus neglectus*



*Anthopotamus verticis*



*Liobrancha recurvata*



*Pentagenia vittigera*

Fig. 2. United States distribution of extant species of *Anthopotamus*, *Liobrancha* and *Pentagenia*.

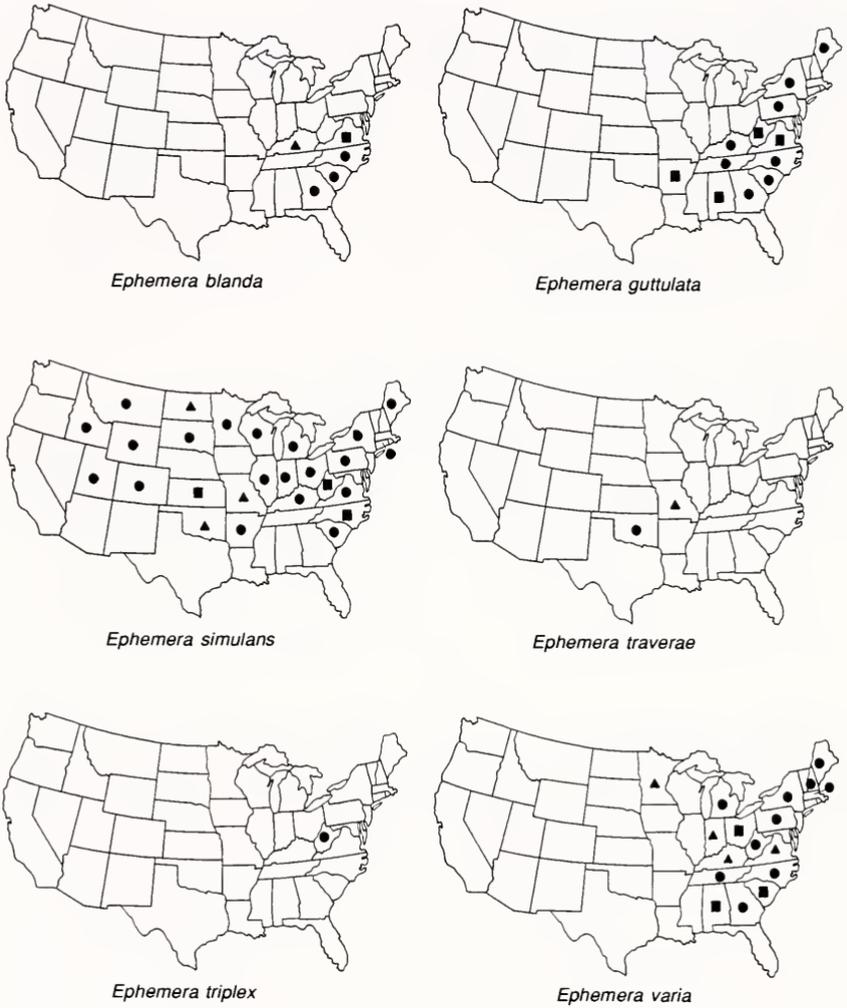


Fig. 3. United States distribution of extant species of *Ephemera*.

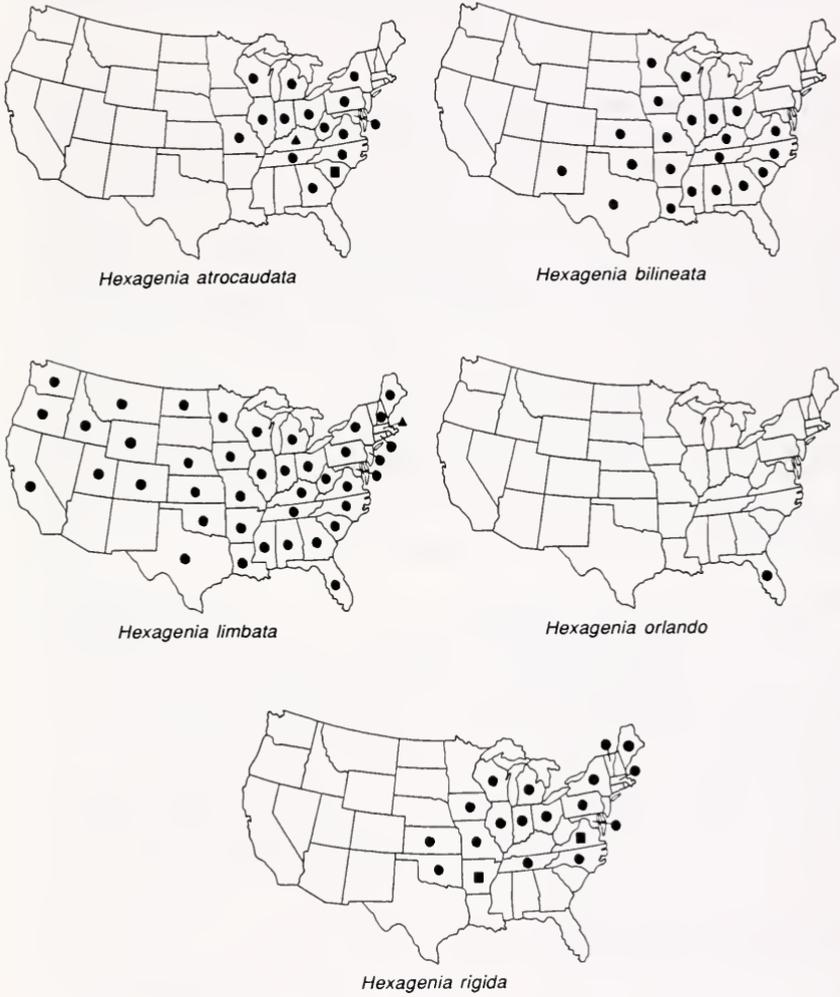


Fig. 4. United States distribution of extant species of *Hexagenia*.

***Ephemera traverae*** Spieth (Fig. 3)

This species was previously known only from Oklahoma. A new state record follows: MISSOURI: Greene Co., Pearson Cr, 3.2 mi E Springfield, V-25-1977, VI-11,15-1977, N. R. Witte.

***Ephemera varia*** Eaton (Fig. 3)

This species was reported from Ohio by Hall (1985), from Alabama by Kondratieff and Harris (1986), and from South Carolina by Unzicker and Carlson (1982). The Virginia record given by Kondratieff and Voshell (1983) is substantiated with new data below. New records are as follows: INDIANA, Owen Co., Rattlesnake Cr., VI-24-1980 (adults). KENTUCKY, Jackson Co., War Fork of Station Camp Cr., VI-7-1973, W. P. McCafferty, A. V. Provonsha, K. Black (larvae). MINNESOTA, Sand Lake, VI-20-1930, J. B. Fisher (adults). VIRGINIA, Prince William Forest Park, VII-4-1973, O. S. Flint, Jr. (adults).

***Hexagenia atrocaudata*** McDunnough (Fig. 4)

Unzicker and Carlson (1982) expectedly reported this species from South Carolina. A new state record is as follows: KENTUCKY, Boyd Co., East Fork of Little Sandy R. off KY 3, 0.9 mi N jct KY 3 and KY 966, VI-1-1978 (larvae); Fleming Co., Fox Cr. at Big Run Road bridge, 0.2 km NW Big Run Road-KY 1013 jct., X-7-1983.

***Hexagenia limbata*** (Serville) (Fig. 4)

McCafferty (1984) synonymized *Hexagenia munda* with this species and thereby expanded the state distribution of *H. limbata* to include Connecticut, Florida, Maryland, New Hampshire, New Jersey, Pennsylvania, and South Carolina. A new state record is as follows: MASSACHUSETTS, Whately, Mill R., X-30-1938 (larvae); Otter R., XI-19-1938 (larvae); N. Amherst, Pulpit Hill, IV-1952, J. R. Traver (larvae); Puffer's Pond, Amherst, R. W. Koss, X-7-1964 (larvae). McCafferty and Pereira (1984) experimentally demonstrated that color and size variants of *H. limbata* (and *H. munda*) sometimes regarded as subspecies were clinal ecophenotypes determined to a large degree by developmental temperature regime. This is the most widespread and variable North American burrowing mayfly species; it is distributed from coast to coast and is well represented in Canada and Mexico.

***Hexagenia orlando*** Traver (Fig. 4)

This species was not treated by McCafferty (1975) because it was considered a synonym of *Hexagenia munda* at that time. Berner and

considered a synonym of *Hexagenia munda* at that time. Berner and Pescador (1988) presented evidence that *H. orlando* is a valid species restricted to sandbottomed lakes of the central Florida highlands.

### ***Hexagenia rigida* McDunnough (Fig. 4)**

Cather and Harp (1975) reported this species from Arkansas. Kondratieff and Voshell (1983) listed this species for Virginia but gave no locale data. Both Arkansas and Virginia are within the expected range of this species.

### ***Litobrancha recurvata* (Morgan) (Fig. 2)**

Lager *et al.* (1982) reported this species from Minnesota, and Hilsenhoff (1981) listed this species in Wisconsin but gave no substantiating data. It probably occurs in Wisconsin since it is known from Minnesota and I have collected it from the Upper Peninsula of Michigan directly north of Wisconsin. New state records are as follows: KENTUCKY, Letcher Co., Bad Branch, from falls to St. Rd. 932, IX-28-1991, G. A. Schuster (larvae). MARYLAND, Beaver pond on Kelley Stream .5 mi from Clayton Lake road, VI-5-1978, S. Strnad (lar-

**Table 1. Classification of the extant Ephemeroidea of North America north of Mexico.**

#### **Family Polymitarcyidae**

##### Subfamily Campsurinae

Genus *Campsurus* Eaton

*Campsurus decoloratus* (Hagen), 1861

Genus *Tortopus* Needham & Murphy

*Tortopus circumfluus* Ulmer, 1942

*Tortopus incertus* (Traver), 1935

*Tortopus primus* (McDunnough), 1924

##### Subfamily Polymitarcyinae

Genus *Ephoron* Williamson

*Ephoron album* (Say), 1824

*Ephoron leukon* Williamson, 1802

#### **Family Potamanthidae**

Genus *Anthopotamus* McCafferty & Bae

*Anthopotamus distinctus* (Traver), 1935

*Anthopotamus myops* (Walsh), 1863

*Anthopotamus neglectus* (Traver), 1935

*Anthopotamus verticis* (Say), 1839

#### **Family Ephemeridae**

##### Subfamily Ephemerinae

Genus *Ephemera* Linnaeus

*Ephemera blanda* Traver, 1932

*Ephemera guttulata* Pictet, 1843

*Ephemera simulans* Walker, 1853

*Ephemera traverae* Spieth, 1938

*Ephemera triplex* Traver, 1935

*Ephemera varia* Eaton, 1883

##### Subfamily Hexageniinae

Genus *Hexagenia* Walsh

*Hexagenia atrocaudata*

McDunnough, 1924

*Hexagenia bilineata* (Say), 1824

*Hexagenia limbata* (Serville), 1829

*Hexagenia orlando* Traver, 1931

*Hexagenia rigida* McDunnough, 1924

Genus *Litobrancha* McCafferty

*Litobrancha recurvata* (Morgan), 1913

##### Subfamily Pentageniinae

Genus *Pentagenia* Walsh

*Pentagenia vittigera* (Walsh), 1862

GINIA, Wythe Co., Barren Springs, VII-8-1978, I. Vance (adults). The Pennsylvania data reported above are incomplete, but there is no doubt that *L. recurvata* is common in Pennsylvania. For example, Caucci and Nastasi (1975), in their popular treatment of mayflies of importance to fly fishers, mentioned its importance on limestone streams of Pennsylvania, and a large sample of larvae evidently was taken from Fishing Creek at La Mar in 1973. Photographs of this material clearly indicate that specimens are *L. recurvata*.

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**PREDATION BY LARVAL SOLDIER BEETLES  
(COLEOPTERA: CANTHARIDAE) ON THE EGGS  
AND LARVAE OF *PSEUDOXYCHEILA TARSALIS*  
(COLEOPTERA: CICINDELIDAE)<sup>1</sup>**

**Tom D. Schultz<sup>2</sup>**

**ABSTRACT:** Predation on the eggs and larvae of *Pseudoxycheila tarsalis* by cantharid larvae at Monteverde, Costa Rica is described. Larvae of the subfamily Chauliognathinae were observed repeatedly to forage on clay banks where tiger beetle adults and larvae were abundant. Eggs and larvae of *P. tarsalis* were excavated from the clay banks and consumed by the soldier beetles.

*Pseudoxycheila tarsalis* Bates, a Neotropical cicindelid, occurs in montane habitats from Costa Rica to Colombia (Palmer 1976). Adults may be found along unpaved roads or on exposed clay banks. Females oviposit by digging a hole 5-7 mm deep on steep or vertical slopes, laying a single egg, and covering it with loose clay. After eclosion, the larvae construct horizontal burrows in the bank, and ambush insects that pass near the burrow opening at the soil surface. Like other tiger beetle species, *P. tarsalis* larvae are parasitized by tephritid wasps and bombyliid flies which attack the larvae within their open burrow (Palmer 1976). Other than parasitoids, few instances of predation on immature stages of tiger beetles have been observed (Mury Meyer 1987, Pearson 1988).

On 4 August 1991 and 10 August 1992, I observed soldier beetle larvae attack and consume eggs and larvae of *P. tarsalis* on a clay slope near the entrance of the Monteverde Cloud Forest Preserve in the state of Puntarenas, Costa Rica. On each day, several cantharid larvae were observed crawling about on the 15 X 20 m slope where the tiger beetles were abundant (Fig. 1 a). The cantharids probed in small crevices or holes they encountered. On one occasion, a cantharid larva located the pile of loose clay that covered a *P. tarsalis* egg laid only 2.5 min before. The cantharid dug out the egg and consumed it. When I moved the same cantharid larvae to within 5 cm of another recent oviposition, it located the second egg and consumed it as well. Two other cantharid larvae repeatedly entered 5 to 6 late instar burrows of *P. tarsalis*. One of the soldier beetles excavated the entrance of a second instar burrow (Fig. 1 b) until its head was inserted to a depth of 25 mm. After 3 min in this position, the cantharid retracted leaving only the macerated head capsule of the cicindelid larva near the burrow entrance.

<sup>1</sup> Received June 25, 1993. Accepted July 24, 1993.

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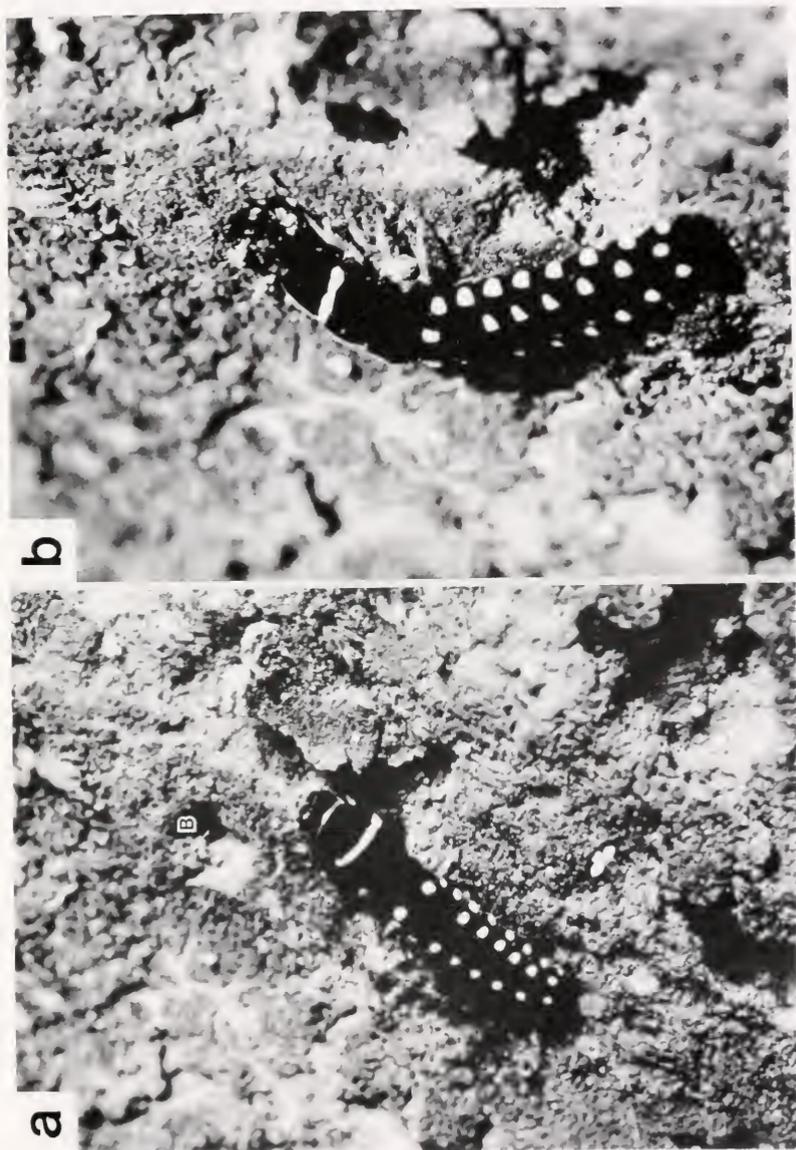


Figure 1. a) Cantharid larva foraging among several larval burrows (B) of *Pseudoxystheila tarsalis*. b) Cantharid larva excavating a larval burrow of *P. tarsalis*. Within the burrow the cantharid consumed the tiger beetle.

The cantharid larvae belonged to an unknown species in the Subfamily Cauliognathinae (L. LeSage, personal communication). The late instar larvae measured 24-34 mm in length and were velvet black with yellow legs. The posterior margin of the pronotum was white and the 1st and 3rd through 8th abdominal tergites bore two pairs of white lateral spots. The 2nd abdominal tergite exhibited only a single spot on each side. Preserved specimens are in possession of the author.

Cauliognathine larvae are known to prey on other insect larvae (Arnett 1985), but cantharids have not been reported previously to prey on cicindelids. It remains uncertain whether predation by this cauliognathine species could have a significant impact on the population of *P. tarsalis* at Monteverde. First and 2nd instars of *P. tarsalis* may be susceptible to cantharids, but the 3rd instar larvae are themselves formidable predators that can subdue small frogs (Palmer 1976). Predation on cicindelid eggs, here reported for the first time, may be an important limiting factor on tiger beetles like *P. tarsalis* that oviposit in clusters within limited microhabitats. The habit of carefully smoothing over the soil filling the egg chamber has been observed in ovipositing *P. tarsalis* (Palmer 1976) and other cicindelids (Pearson 1988), and may have evolved to prevent the detection of eggs by predators such as cantharid larvae

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## NEW RECORDS OF EPHEMEROPTERA FROM MEXICO<sup>1</sup>

C. R. Lugo-Ortiz, W. P. McCafferty<sup>2</sup>

ABSTRACT: Twenty-seven species and six genera of mayflies (Ephemeroptera) are reported from Mexico for the first time. Twenty-four species and the genera *Ephemerella*, *Ironodes*, *Paraleptophlebia*, and *Siphonurus* were previously known from north of Mexico, four species and the genus *Moribaetis* were previously known from Central America, and one species and the genus *Paracloeodes* were previously known from north of Mexico and Central America. *Callibaetis punctilusus* McCafferty and Provonsa, new status, is raised to specific rank. Comments on the distributional significance of each of the new species records are included.

The Ephemeroptera fauna of Mexico has been poorly known. Prior to this report, only 83 species in the following genera were recorded: *Acentrella* Bengtsson, *Acerpenna* Waltz and McCafferty, *Baetis* Leach, *Baetodes* Needham and Murphy, *Callibaetis* Eaton, *Caenis* Stephens, *Camelobaetidius* Traver and Edmunds, *Campsurus* Eaton, *Choroterpes* Eaton, *Cloeodes* Traver, *Drunella* Needham, *Euthyplocia* Eaton, *Fallceon* Waltz and McCafferty, *Hexagenia* Walsh, *Homoeoneuria* Eaton, *Hydrosmilodon* Flowers and Domínguez, *Iron* Eaton, *Isonychia* Eaton, *Lachlania* Hagen, *Leptohyphes* Eaton, *Neochoroterpes* Allen, *Nixe* Flowers, *Rhithrogena* Eaton, *Serratella* Edmunds, *Stenonema* Traver, *Thraulodes* Ulmer, *Traverella* Edmunds, and *Tricorythodes* Ulmer. To these we add 27 species and the following genera: *Ephemerella* Walsh, *Ironodes* Traver, *Moribaetis* Waltz and McCafferty, *Paracloeodes* Day, *Paraleptophlebia* Lestage, and *Siphonurus* Eaton.

McCafferty *et al.* (1992) treated the biogeography of those genera found in Mesoamerica, and their study was applicable to Mexico. They hypothesized that *Baetodes*, *Camelobaetidius*, *Campsurus*, *Cloeodes*, *Euthyplocia*, *Fallceon*, *Homoeoneuria*, *Lachlania*, *Leptohyphes*, *Moribaetis*, *Paracloeodes*, *Thraulodes*, *Traverella*, and *Tricorythodes* have a recent Neotropical center of dispersal, whereas *Hexagenia* s. s., *Iron*, *Isonychia*, *Nixe*, *Rhithrogena*, and *Stenonema* have a Nearctic one. *Caenis* was hypothesized to be comprised of elements from the Nearctic and Neotropics (McCafferty *et al.* 1992). Flowers and Domínguez (1992) showed the Neotropical affinities of *Hydrosmilodon*. Lugo-Ortiz and McCafferty (1993) indicated that *Acerpenna* might have a Neotropical origin. *Acentrella*, *Choroterpes*, *Drunella*, *Ephemerella*, *Ironodes*,

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*Paraleptophlebia*, *Serratella*, and *Siphonurus* have evident Nearctic affinities. *Baetis* thus far appears to be comprised of elements derived from Nearctic lineages (Lugo-Ortiz and McCafferty 1993). Available data regarding *Callibaetis* and *Neochoroterpes* are still too inconclusive to determine affinities. Below, we provide the new distributional records from Mexico and comment on their significance. Except where otherwise noted, the materials upon which these records are based are housed in the Purdue Entomological Research Collection (West Lafayette, IN).

## BAETIDAE

### *Baetis flavistriga* McDunnough

**Records.** CHIHUAHUA.—Río Gavilán, Los Amarillos, VI-23-1987, B. Kondratieff and R. W. Baumann (larvae); Río Gavilán, Gavilán, Ranch, VIII-25-1986, B. C. Kondratieff (male adults).

**Remarks.** *Baetis flavistriga* (*fusatus* group) is a common species in eastern North America (McCafferty and Waltz 1990). Recently, McCafferty and Davis (1992) and McCafferty *et al.* (1993) reported it from Texas and Colorado.

### *Baetis magnus* McCafferty and Waltz

**Records.** CHIAPAS.—Tapachula, VII-20-1966, R. K. Allen (larvae). CHIHUAHUA.—Río Nuevo Casas Grandes, above Casas Grandes, I-18-1987, B. C. Kondratieff (larvae); Arroyo Fresas, 3 mi above Río Piedras Verdes, VI-22-1987 (larvae). DURANGO.—La Michilia, Arroyo Temazcal, IV-15-1987, R. Novelo (larvae, deposited at the Instituto de Ecología, A. C.); La Michilia, Arroyo Temazcal, IX-15-1987, R. Novelo and E. González (larvae, deposited at the Instituto de Ecología, A. C.). MEXICO.—Rd to Cotula, VII-5-1965, A. Ortiz (larva). NUEVO LEON.—Río Ramso, XII-20-1939, L. Berner (larva). MORELOS.—Jojutla, Vicente Aranda, Río Amacúzac, 800 m, IV-16-1987, R. Novelo and E. González (larvae, deposited at the Instituto de Ecología, A. C.). OAXACA.—Portillo del Rayo, Río en Finca El Encanto, bosque de niebla, 1200 m, R. Novelo, IX-27-1988 (larva, deposited at the Instituto de Ecología, A. C.). SAN LUIS POTOSÍ.—Stream, nr 1 mi from Catorce W of Motehuala, V-30-1986, B. C. Henry (larvae, deposited at the Instituto de Ecología, A. C.). VERACRUZ.—Tlapacoyán, Río Tomata, X-10-1984, G. Zapién (larvae); Culinavara, I-1-1948 (larva).

**Remarks.** *Baetis magnus* (*rhodani* group) is the only member of the genus thus far known to be represented in the Nearctic and Neotropical regions. Lugo-Ortiz and McCafferty (1993) recently reported it from Costa Rica and Guatemala. It has a western North American distribution extending as far north as western Nebraska (McCafferty and Waltz 1986, 1990). Its presence throughout most of Mexico was to be expected.

### *Baetis notos* Allen and Murvosh

**Records.** VERACRUZ.—Culinavara, I-1-1948 (larva).

**Remarks.** *Baetis notos* (*rhodani* group) was previously known from Arizona, Colorado, New Mexico, and Texas [Morihara and McCafferty

(1979) as *B. sp. C*; Allen and Murvosh (1987); McCafferty and Davis (1992); McCafferty *et al.* (1993)]. The species should occur in the northern half of Mexico, and it will probably prove to have a distribution similar to that of *B. magnus*.

### *Baetis tricaudatus* Dodds

**Records.** BAJA CALIFORNIA NORTE.—Arroyo Potrero, Rancho Potrero, 1-16-1988, B. C. Kondratieff and R. W. Baumann (larvae); Mike's Sky Rancho, Río San Rafael, 1-15-1988, B. C. Kondratieff and R. W. Baumann (larvae); Río Santo Domingo, V-17-1936, P. R. Needham (larvae).

**Remarks.** Allen and Murvosh (1987) described *B. sonora* from a small series of larvae from Sonora. McCafferty and Waltz (1990) recognized that species as a junior synonym of *B. tricaudatus*; however, R. D. Waltz (pers. comm.), after examining the type material of *B. sonora*, has indicated to us that it is referable to *Fallceon quilleri* (Dodds), and *B. tricaudatus*, therefore, had not been correctly reported from Mexico. Given the widespread distribution and ubiquitous nature of *B. tricaudatus* in North America (McCafferty and Waltz 1990), its presence in Mexico was to be expected.

### *Callibaetis californicus* Banks

**Records.** GUERRERO.—Km 15, Carretera Bejucos, nr Ciudad Altamirano, XI-22-1984 (larvae, deposited at the Universidad Nacional Autónoma de México). MORELOS.—Jojutla, Vicente Aranda, Río Amacúzac, 800 m, II-12-1983, S. Ibáñez (larvae, deposited at the Instituto de Ecología, A. C.). NUEVO LEON.—4 mi S of Monterrey, XII-28-1947, S. Mulaik (larvae); 10 mi N of Monterrey, Sabinas Hidalgo, XII-25-1947, S. Mulaik (larvae).

**Remarks.** Previous to this report, McCafferty and Davis (1992) provided the southeasternmost records of *C. californicus* from Texas. The new records represent a considerable southward extension of its known range into the Neotropical region.

### *Callibaetis floridanus* Banks

**Records.** GUERRERO.—Km 15 carretera Bejucos, nr Ciudad Altamirano, XI-22-1984 (female adults, deposited at the Universidad Nacional Autónoma de México). MORELOS.—Jojutla, Vicente Aranda, Río Amacúzac, 800 m, Arroyo Corralitos, km 15 carretera Suchil-San Juan Michis, IV-16-1987, R. Novelo and E. González (larvae, deposited at the Instituto de Ecología, A.C.). NUEVO LEON.—Anáhuac, Laguna Salinillas, XI-14-1985, H. Rojas, R. Baroa, and S. Tufino (female adults, deposited at the Universidad Nacional Autónoma de México).

**Remarks.** *Callibaetis floridanus* was previously known from southeastern North America west to Texas (McCafferty and Waltz 1990; McCafferty and Davis 1992). The present records considerably extend its known range southward into the Neotropics.

### *Callibaetis punctilulus* McCafferty and Provonsna, NEW STATUS

**Records.** CHIAPAS.—San Cristobal de las Casas, V-5-1979, J. Bueno y Soria (male adult, deposited at the Universidad Nacional Autónoma de México). NUEVO LEON.—

Anahuac, Laguna Salinillas, XI-14-1985, H. Rojas, R. Baroa, and S. Tufiño (male adult, deposited at the Universidad Nacional Autónoma de México).

**Remarks.** McCafferty and Provonsha (1993) described *C. montanus punctilusus* from a small series of male and female adults from south-eastern Texas. The present records represent a significant southward extension of its known range, and indicate that it overlaps with that of *C. montanus montanus* throughout Mexico. We therefore recognize *C. montanus* and *C. punctilusus* as separate species. Given its apparent restricted distribution in southwestern United States and widespread distribution in Mexico, *C. punctilusus* probably has Neotropical affinities.

### *Camelobaetidius trivialis* (Allen and Chao)

**Records.** SONORA.—Río Chico, above El Chico, I-18-1988, B. C. Kondratieff and R. W. Baumann (larvae).

**Remarks.** *Camelobaetidius trivialis* is strikingly similar to *C. warreni*, and it may prove to be equivalent to that species upon further examination. However, we are tentatively assigning the Sonoran larvae to *C. trivialis* since the shape of segments 2 and 3 of the labial palps and the setation on the labrum do not correspond to the descriptions and figures provided by Traver and Edmunds (1968) for *C. warreni*, and the abdominal coloration resembles that described for *C. trivialis*. *Camelobaetidius trivialis* was previously known from Arizona and New Mexico (Allen and Chao 1978a).

### *Camelobaetidius warreni* (Traver and Edmunds)

**Records.** BAJA CALIFORNIA SUR.—Río Calamajue. CHIAPAS.—Ocosingo Valley, tributary of Río Santa Cruz, VII-1-7-1950, Goodnight and Stannard (larva). CHI-HUAHUA.—Río Gavilán, Gavilán Ranch, VIII-26-1986, B. C. Kondratieff (male adult). GUERRERO.—Km 15 carretera Bejucos, nr Ciudad Altamirano, XI-22-1984, Brailovsky *et al.* (larvae, deposited at the Universidad Nacional Autónoma de México). OAXACA.—Dominguillo, III-8-1978, H. Zapién (larvae, deposited at the Universidad Nacional Autónoma de México). SONORA.—Hwy 11, SW of Tezopuco, I-18-1988, B. C. Kondratieff and R. W. Baumann (larvae); Río Yaqui, nr Tonichi, IV-25-1982, D.A. and J. T. Polhemus (larvae).

**Remarks.** *Camelobaetidius warreni* was previously known from west-central California and southern Colorado (Traver and Edmunds 1968; McCafferty *et al.* 1993). The present records represent a considerable southward extension of its known range. The species appears to extend south along the western states via the Sierra Madre Occidental, and may be widespread in Mexico.

### *Cloeodes excogitatus* Waltz and McCafferty

**Records.** UNKNOWN STATE.—R. K. Allen (larvae).

**Remarks.** *Cloeodes excogitatus* was previously known only from the type locality in Arizona (Waltz and McCafferty 1987). Unfortunately, we do not have any data regarding the locality, other than Mexico, where the present specimens were collected. A reconstruction of the col-

lector's itinerary, however, indicates that these were collected from one of the following states: Mexico, Morelos, Oaxaca, or Puebla. If that is in fact the case, then it would represent a considerable southward extension of the range of this species, indicating that it occurs somewhat continuously along the west coast of Mexico, probably via the Sierra Madre Occidental.

### *Cloeodes macrolamellus* Waltz and McCafferty

**Records.** CHIHUAHUA.—Small stream 12 mi W. of Tomóchic, 1-20-1987, B. C. Kondratieff (larva). DURANGO.—La Michilia, Arroyo Taray, IV-14-1987, R. Novelo and E. González (larvae, deposited at the Instituto de Ecología, A. C.).

**Remarks.** *Cloeodes macrolamellus* was previously known only from the type locality in New Mexico (Waltz and McCafferty 1987). The new records significantly extend its known range southward. Apparently, the species occurs somewhat continuously along the Sierra Madre Occidental, but is probably more widespread in Mexico and could also occur in Central America.

### *Moribaetis macaferti* Waltz

**Records.** CHIAPAS.—Stream at Santa Isabel, 12 mi above Arriaga on Hwy 190, 2000 ft, 73°F, X-23-1968, R. K. Allen (larvae); Río Teapa nr Ishuatán, 650 ft, VII-18-1966, R. K. Allen (larvae); Stream 7 mi N of Arriaga on Hwy 190, 1400 ft, VII-20-1966 (larvae). OAXACA.—Portillo del Rayo, Río en Finca El Encanto, Bosque de niebla, 1200 m, R. Novelo, IX-27-1988 (larva, deposited at the Instituto de Ecología, A. C.); La Esperanza, III-23-1984, G. Zapién (larva). VERACRUZ.—Río Tecolapán, nr Santiago Tuxtla on Hwy 80, VII-16-1966, R. K. Allen (larvae); Río San Marcos at Apapantilla, 3 mi SE of Villa A. Camacho, 700 ft, 66°F, XI-12-1968 (larvae); Stream 5 mi S of Ciudad Mendoza, 4500 ft, XII-7-1968, R. K. Allen (larvae); Metlac, XII-26-1940, L. Berner (larvae); XII-25-1940, Berner (larvae); XII-26-1940, L. Berner (larvae).

**Remarks.** Previous to this report, *M. macaferti* was known from Guatemala and Costa Rica (Waltz and McCafferty 1985). The records from Veracruz suggest the probability that *M. macaferti* occurs in the southern reaches of the Nearctic region, since they are near Poza Rica, the northernmost limit of the Neotropical region according to McCafferty *et al.* (1992). Of interest to us was the fact that some of the Mexican larvae lack the procoxal osmobranchia, but their other characters are consistent with the description of Waltz and McCafferty (1985).

### *Paracloeodes minutus* (Daggy)

**Records.** BAJA CALIFORNIA SUR.—Arroyo San Pedro, 19 mi W of Hwy 1, VI-27-1988, B. C. Kondratieff (male adults).

**Remarks.** *Paracloeodes minutus* is a widespread species extending from Minnesota south to Texas and west to California (Daggy 1945; Day 1955; McCafferty and Davis 1992). The species is probably widespread throughout Mexico.

## CAENIDAE

*Caenis anceps* Traver

**Records.** VERACRUZ.—Metlac, XII-26-1940, L. Berner (male adult).

**Remarks.** *Caenis anceps* has a primarily eastern North American distribution, with southwesternmost records from mountainous Arkansas; and southeastern Oklahoma (McCafferty and Provonsha 1978; Provonsha 1990). This considerable range extension suggests that it is a Nearctic element of *Caenis* reaching the Neotropics.

## EPHEMERELLIDAE

*Ephemerella altana* Allen

**Records.** BAJA CALIFORNIA NORTE.—Río San Rafael, Sierra San Pedro Mártir, Mike's Sky Rancho, VI-22-1988, B. C. Kondratieff (larvae).

**Remarks.** Previously, *E. altana* was known from Arizona and New Mexico (Allen 1968). The species may occur in other states of northern Mexico.

## EPHEMERIDAE

*Hexagenia albivitta* (Walker)

**Records.** VERACRUZ.—Mendoza, VI-24-1965, C. S. Martell (male subimagos).

**Remarks.** Prior to this report, McCafferty (1970) provided the northernmost records of *H. albivitta* from Costa Rica. The present record considerably extends its known range and suggests that it is more widespread in Central America. Four species of *Hexagenia* are now known from Mexico: *H. albivitta*, *H. bilineata* (Say), *H. limbata* (Serville), and *H. mexicana* Eaton.

## HEPTAGENIIDAE

*Ironodes nitidus* (Eaton)

**Records.** BAJA CALIFORNIA NORTE.—Sierra San Pedro Mártir, headwaters of Arroyo San Antonio, below entrance to National Park, I-16-1988, B. C. Kondratieff (larvae).

**Remarks.** The larvae of *I. nitidus* have not been formally described. However, the present specimens key out to this species in Traver's (1935) key to the larvae of *Ironodes*. We are therefore assigning them to *I. nitidus*. The species was previously known from California and Oregon (Eaton 1885).

*Rhithrogena morrisoni* (Banks)

**Records.** BAJA CALIFORNIA NORTE.—Río San Rafael, Mike's Sky Rancho, I-15-1988, B. C. Kondratieff (larvae).

**Remarks.** Although the larvae of *R. morrisoni* have not been formally described, Allen and Chao (1978b) included the species in their larval key to the southwestern North American species of *Rhithrogena*. The present record is based on that key. Previous to this report, *R. mor-*

*risoni* was known to occur from Alberta south to Arizona and New Mexico (McDunnough 1934; Allen and Chao 1978b).

#### LEPTOPHLEBIIDAE

##### *Paraleptophlebia memorialis* (Eaton)

**Records.** BAJA CALIFORNIA NORTE.—Río San Rafael, Mike's Sky Rancho, 1-15-1988, B. C. Kondratieff (larvae).

**Remarks.** *Paraleptophlebia memorialis* has been known from Alberta and British Columbia south to Arizona and New Mexico (McDunnough 1926b, 1928; Kilgore and Allen 1972). The species may occur in other states of northern Mexico.

##### *Thraulodes zonalis* Traver and Edmunds

**Records.** CHIAPAS.—Río Lacán-Ha, km 22.5 carretera Agua Azul-Ocotzingo, nr Palenque, VII-22-1978, J. Bueno and J. Padilla (larvae, deposited at the Universidad Nacional Autónoma de México).

**Remarks.** *Thraulodes zonalis* has a widespread distribution in Central America, extending from Panama to Belize (Traver and Edmunds 1967; Allen and Brusca 1978; McCafferty 1985). The present record from Chiapas was expected, and it is probable that the species occurs farther north in Mexico.

#### OLIGONEURIIDAE

##### *Lachlania powelli* Edmunds

**Records.** GUERRERO.—Km 15 carretera Bejucos, nr Ciudad Altamirano, XI-22-1984 (larva, deposited at Universidad Nacional Autónoma de México).

**Remarks.** *Lachlania powelli* was previously known only from Utah (Edmunds 1951). The present record significantly shows that it extends into the Neotropics. Koss and Edmunds (1970) suggested that *L. powelli* might be synonymous with *L. saskatchewanensis* Ide. McCafferty *et al.* (1993) recently found the latter species in Colorado, and suggested the same possibility. If *L. powelli* is indeed a junior synonym of *L. saskatchewanensis*, then it has a wide distribution extending from Saskatchewan south to Guerrero.

#### SIPHLONURIDAE

##### *Siphonurus occidentalis* (Eaton)

**Records.** CHIHUAHUA.—Arroyo Lalo Varela, tributary of Río Gavilán, VI-22-1987, B. C. Kondratieff and R. W. Baumann (male and female adults); Spring at Rancho Salmón, VI-23-1987, B. C. Kondratieff and R. W. Baumann (exuviae). SONORA.—Yécora, at lights, VIII-21-1986, B. C. Kondratieff (exuviae and male and female subimagos).

**Remarks.** *Siphonurus occidentalis* was previously known from Alberta south to Arizona and New Mexico (McDunnough 1928; Traver 1935; Peters and Edmunds 1961; Allen and Chao 1981). Its presence in Chihuahua and Sonora was to be expected.

## TRICORYTHIDAE

*Leptohyphes apache* Allen

**Records.** CHIHUAHUA.—Small stream S of Pacheco, 1-22-1987, B. C. Kondratieff (larva).

**Remarks.** *Leptohyphes apache* was previously known from Arizona, New Mexico, and Utah (Allen 1967). Its presence in northern Mexico was to be expected.

*Leptohyphes castaneus* Allen

**Records.** OAXACA.—Portillo del Rayo, Río en Finca El Encanto, cloud forest, 1200 m, IX-28-1988 (larvae).

**Remarks.** This species was known only from the type locality in Guatemala (Allen 1967). Its presence in southern Mexico was to be expected.

*Leptohyphes michaeli* Allen

**Records.** NUEVO LEON.—Santiago, XII-20-1939, L. Berner (larva).

**Remarks.** Previous to this report, *L. michaeli* was known only from the type locality in Texas (Allen 1978). Its presence in northern Mexico was to be expected.

*Tricorythodes condylus* Allen

**Records.** CHIHUAHUA.—Río Gavilán, Los Amarillos, VI-23-1987, B. C. Kondratieff and R. W. Baumann (larva). SONORA.—Río Chico, above El Chico, B. C. Kondratieff and R. W. Baumann (larva).

**Remarks.** *Tricorythodes condylus* was previously known from Arizona and New Mexico (Allen 1967; Kilgore and Allen 1973). It is possible that *T. condylus* is widespread in the northern half of Mexico.

*Tricorythodes dimorphus* Allen

**Records.** CHIHUAHUA.—7 mi N of Basaseachic, IV-27-1982, D. A. Polhemus (larva)

**Remarks.** This species was previously known from Arizona and New Mexico (Allen 1967; Kilgore and Allen 1973). Its presence in Chihuahua was expected, and the species probably occurs in other states of northern Mexico.

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**DERMESTES RATTUS (COLEOPTERA:  
DERMESTIDAE): TAXONOMIC STATUS AND  
COMPARISON WITH FIVE CLOSELY RELATED  
SPECIES IN THE WESTERN UNITED STATES<sup>1</sup>**

R. S. Beal, Jr.<sup>1</sup>

ABSTRACT: *Dermestes tristis*, ranging from central California into Baja California Norte, Mexico, is determined to be a geographical variant and subspecies (New Status) of *D. rattus* occurring from northern California to British Columbia and east to Wyoming. These two forms are distinguished from five closely related species including the European *D. sardous*. The latter species is apparently established in southern California.

Through the kindness of William H. Clark I have been privileged to study a number of specimens of *Dermestes rattus* LeConte taken in ethylene glycol pitfall traps (Clark and Blom, 1992), particularly a series of 42 specimens collected by him and Thomas A. Bicak over the summer and fall of 1986 in the Almaden Mine area of Washington County, Idaho (Bicak *et al.*, 1987). This series, quite evidently consisting of a single species, clarified a nagging question of what and how many species might be involved in the *D. caninus-rattus* complex. Mr. Clark also provided for my study a number of specimens which he and associates collected in ethylene glycol pitfall traps (Clark and Blom, 1992) over several years in various localities in Baja California Norte. Voucher specimens of the Idaho and Baja California material are deposited in the Orma J. Smith Museum of Natural History (CIDA), Albertson College of Idaho, Caldwell.

*D. rattus* is characterized by (1) the pronotum with intermingled white and golden brown to golden hairs and 3 small patches of all white hairs in a transverse line at the middle and (2) the elytra covered with whitish hairs except for small, irregularly dispersed patches of black hairs. *D. tristis* is the name given by Fall to a form with similar pronotal hairs but with the elytra covered with black hairs except for a few scattered whitish hairs.

The last full revision of the genus *Dermestes* was by P. Lepesme (1946). His revision did not consider *D. tristis*, since specimens of this form were unavailable to him. Hatch (1962) in his study of beetles of the Pacific Northwest recognized *D. rattus* and *D. tristis* as distinct species. He did not distinguish these two species from the closely related *D. caninus*, since it is not known to occur in that area.

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What now seems clear is that *D. tristis* is at best a geographic variant of *D. rattus*, a species quite variable with respect to the type and pattern of setae on the elytra. In the series from Idaho are typical *D. rattus* specimens in which the elytra are covered with whitish setae except for a few small patches of dark hairs. Also included are specimens with variable percentages of whitish hairs, and one specimen with all dark hairs. On some the whitish hairs are fine and on others relatively and noticeably coarser. The dark setae vary from dark brown to black. The all dark and nearly all dark specimens in the series are identical to the forms described as *D. tristis*.

Past difficulty in recognizing the status of these forms no doubt came from the lack of collection of series from any one locality, even though specimens are not uncommon in collections. Out of 62 collections of "tristis" that I have recorded over the past 35 years, most number no more than one or two specimens, the longest series consisting of 7 and one other series of 5 specimens. Of 67 records of "rattus," with one exception, the collections were mostly of single specimens with a few small series, the largest numbering 5 specimens. The exception consists of 36 specimens collected various dates during 1983 in Kemmerer, Lincoln County, Wyoming, by R. R. Parmenter.

The series from Lincoln County, Wyoming, consists entirely of specimens of the "rattus" type. The collections from Baja California Norte are wholly "tristis". "Rattus" type specimens predominate in the series from Washington County, Idaho. I predict that any future long series collected between Idaho and Mexico will include increasing percentages of "tristis" forms southward. "Tristis" forms are much more frequent in collections that have been made in southern California.

In view of the available evidence, I propose that subspecific names be assigned these two forms with a somewhat arbitrary geographic division line as indicated.

#### *Dermestes rattus rattus* Le Conte (1854)

From the level of Mendocino and Colusa counties, California, northward to central British Columbia, Alberta, and Montana, south to Colorado and Utah.

The species does not appear to occur in Arizona, New Mexico, Texas, Kansas, or states farther east. Specimens that I previously determined as *D. rattus* from more eastern localities need to be reexamined. I think they will prove to be varieties of *D. caninus*.

***Dermestes rattus tristis* Fall (1897) subspecies, NEW STATUS**

Synonym: *Dermestes medialis* Casey (Beal and Seeno, 1977)

Sonoma, Napa, and Yolo counties, California, south into Baja California Norte. This would include the San Francisco Bay area population of *tristis* noted by Beal and Seeno.

A Mediterranean species not previously recorded from the United States is apparently established in a small part of the range of *D. rattus tristis* and might be confused with it. *D. sardous* Küster (1846) (see Lepesme, 1946) was collected in California at Santee, San Diego County, (1 specimen, 12-ii-67, J. B. Heppner, blacklight) and at Point Loma, San Diego (3 specimens, 16-iv-79, 1 specimen 29-v-79, R. Baranowski). A voucher specimen of this species is deposited in the California Academy of Sciences.

The following key is provided to distinguish the 2 species above and 4 other closely related species found in North America north of Mexico and west of the Great Plains. The tricolorous hairs on the disc of the pronotum readily separate the 6 species from other species of *Dermestes* found in the same region. The 6 belong to the subgenus *Dermestinus* Zhantiev (1967). In this region there are 2 other species in the same subgenus (*D. maculatus* DeGeer and *D. frischi* Kugelarm). These are further distinguished from *D. rattus* and its congeners by having a tuft of long hairs at the middle of abdominal sternum 4 only, rather than at the middle of both abdominal sterna 3 and 4. (*D. carnivorus* Fabricius with tufts on both sterna 3 and 4 is not known to be established in this part of the U.S.)

1. Elytra with subbasal band of whitish hair; portion of elytra posterior to band with small intermingled patches of golden, whitish, and black hair; dark spots on sides of abdominal sterna consisting of intermingled black and golden brown hairs. Species large, usually longer than 9 mm.....*D. marmoratus* Say
- Elytra with or without subbasal band of whitish hair but if with subbasal band of whitish hair then without small intermingled patches of golden, whitish, and black hair on posterior 1/2; dark spots on sides of abdominal sterna consisting of black hairs only. Smaller species, almost always shorter than 7 mm.
2. Elytra with black hairs and small patches of whitish hair throughout, these usually intermingled with small patches of golden hair, but golden patches may rarely be limited to basal 1/4; pronotum with small, irregular patches of black, golden, and whitish hair; hairs on either side of midline at base of pronotum diverging from midline about 30 degrees.....*D. talpinus* Mannerheim
- Elytra with black hairs and bands or patches of whitish hair or band of golden hair but without small patches of whitish hair throughout (if irregular subbasal band of golden hair present, whitish hairs may be intermingled with black hairs; if whitish patches present, a few golden hairs may be present along basal margin); hairs of pronotum at midline more or less parallel, rarely diverging as much as 10 degrees from midline.....3

3. Elytra with whitish hairs forming broad subbasal band about 2 times length of scutellum, this band separated from base by band of black hair or black hairs intermingled with few golden or whitish hairs; elytra with small intermingled patches of whitish and black hair posterior to subbasal band .....*D. fasciatus* LeConte
- Elytra with black and golden hairs only, or with whitish hairs covering most of elytra, or whitish hairs forming band or patches, but then band or patches of whitish hair extending to base of pronotum.....4
4. Elytron with black hairs and intermingled whitish hairs and golden hairs forming a narrow, irregular triangle at about basal 1/4; pronotum with black hairs, transverse line of patches of golden hair across middle of disc, and other variable patches of golden hair.....*D. sardous* Kuster
- Elytron with all black hairs, all whitish hairs except for few patches of black hair at apex, or band and patches of whitish hair but without golden hairs except at times for very few along basal margin; pronotum with intermingled patches of golden and black hair and 3 patches of white hair set transversely across disc .....5
5. Abdominal sternum 1 with dark lateral area extending not more than 2/3 distance toward posterior margin and separated from margin by region of all white hair; abdominal sterna 2-4 covered with all white hairs except for subcircular area of black hairs at lateral anterior corners of sterna.....*D. caninus* Germar
- Abdominal sternum 1 with dark lateral area extending to posterior margin of segment and consisting of all blackish hairs or with some intermingled golden brown and white hairs; sterna 3-4 covered with intermingled golden brown and whitish hairs except for subcircular area of black hairs at lateral anterior corners of sterna..*D. rattus* subspecies

I submit the following detailed diagnoses of the last 3 species in the key, which are easily confused with each other because of the range of variation in each. The diagnoses depend in large part on setal characters which, unfortunately, are often lost in old or mishandled specimens.

### *Dermestes sardous* Kuster

(1) Pronotum covered with intermingled black and white hairs with pronounced band or patches of golden hair along anterior margin, transverse band of patches of golden hair at middle, and golden patch on each side at basal 1/4 and lateral 1/2. (Lepesme, 1946, describes the primary pubescence as consisting of black and grey-blue hairs, but our specimens have white rather than grey-blue hairs.) (2) Elytron covered with intermingled black and whitish hairs; basal margin with patch of golden hair on humerus and patch of golden hair at about lateral 1/2 of base; basal 1/4 of elytron with somewhat elongate, irregularly triangular, submedian patch of golden hair. (Lepesme does not mention the golden hairs at the basal 1/3 in his description of the species but describes the variety *striatellus* Reitter which has longitudinal lines of yellowish hairs.) (3) Posterior margin of metasternal epimeron transverse (as in *D. rattus*). (4) Dark area on side of abdominal sternum 1 extending about 2/3 distance toward posterior margin and separated from margin by covering of all white hair. (5) Abdominal sterna 1-4 with covering of all white hair except for large lateral dark area on sternum 1 and for subcircular patches of black hair at lateral anterior corners of sterna 2-4; sternum 5 covered with black hair except for 2 small sublateral patches of white hair at anterior margin. (6) Male with dense brush of fine, golden-white hair on underside of front tarsomeres 1-3 and to some extent under tarsomere 4.

### *Dermestis caninus* Germar

(1) Pronotum with patches of golden and black hair and 3 small patches of whitish hair in transverse line across middle of disc (as in *D. rattus*). (2) Elytron with irregular, large patches of whitish hair limited to anterior 1/4, except for some small scattered patches on posterior 3/4, varying to elytron with whitish hairs covering most of anterior 3/4 with irregular patches of whitish and black hair on posterior 1/4; 2 dark areas of variable size always present at or close to basal margin, but whitish band or patches also attaining basal margin. (3) Lateral posterior angle of metasternal epimeron forming acute angle and extending further posteriad than inner angle. (4) Dark area at lateral margin of abdominal sternum 1 extending not more than 2/3 distance from base to posterior margin and separated from margin by covering of all white hair. (5) Abdominal sterna 1-4 with covering of all white hair except as described above for sternum 1 and except for small subcircular patches of all black hair at lateral anterior corners of sterna 2-4; sternum 5 with white hairs along basal margin, these usually forming 2 sublateral patches extending about 2/3 distance toward posterior margin. (6) Male with dense brush of fine, golden-white hair on underside of front tarsomeres 1-3 and to some extent under tarsomere 4.

### *Dermestes rattus* subspecies

(1) Pronotum with patches of black and golden hair and 3 small patches of all-white hair in transverse line across the middle of the disc. (2) Elytron with nearly all white hairs with small, irregular patches of black or dark brown hair (*D. rattus rattus*) to all black or dark brown hairs or all dark hairs except for few intermingled white or golden white hairs (*D. rattus tristis*). (3) Posterior margin of metasternal epimeron transverse, lateral posterior angle not acute, not extending further posteriad than inner angle. (4) Abdominal sternum 1 with lateral dark area extending to posterior margin of segment, this area consisting of all blackish hair or with some intermingled golden brown and white hairs but without being separated from posterior margin by solid band of white hair; (5) Abdominal sterna 1-2, except for lateral dark areas, covered mostly with white hair; sterna 3-5 covered with intermingled golden brown and white hairs. Some small patches of white hair may be present, but 1/3 or more of the hairs are golden brown. (6) Male without a dense brush of fine hair on underside of anterior tarsomeres 1-3; setae of anterior tarsomeres similar to those of middle and hind tarsomeres.

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I am particularly grateful to William H. Clark of the Orma J. Smith Museum of Natural History, Albertson College of Idaho, and to Robert R. Parmenter of the University of New Mexico for providing me with the opportunity of studying some fine series of specimens in the genus. I thank R. Baranowski of the Zoological Institute, University of Lund, Lund, Sweden, and H. V. Weems, Jr., Florida Department of Agriculture and Consumer Services, for the loan of specimens of *D. sardous*. I thank Vladimír Kalík of Pardubice, Czech Republic, for examining a specimen of *D. sardous* and comparing it with other specimens in his collection. Over the years I have had the privilege of examining specimens of *Dermestes* provided by a number of museums and individuals, too numerous to recount here. To each of them I extend my sincere appreciation. For a critical reading of the manuscript and for many helpful suggestions I want to thank William H. Clark, Boris C. Kondratieff, and two anonymous reviewers.

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**FIRST RECORD OF AN HETEROTIC,  
ADULT FEMALE HYBRID  
*LIMENITIS (BASILARCHIA) RUBIDUS*  
(LEPIDOPTERA: NYMPHALIDAE)<sup>1</sup>**

A. P. Platt<sup>2</sup>, S. J. Harrison<sup>3,4</sup>

**ABSTRACT:** The interspecific hybrid cross *Limenitis arthemis astyanax* x *L. archippus* yields the intermediate hybrid morph *L. "rubidus"* (Strecker). Such F<sub>1</sub> hybrids occur in nature but they are quite rare; those reported to date have all been males. Laboratory crosses generally are lethal to females (which are heterogametic), with most dying during development; only a few have eclosed as malformed adults. This paper reports a laboratory cross that produced the first known heterotic female specimen of this remarkable F<sub>1</sub> morph. It is intermediate between two related species of mimetic butterflies which are completely unlike in phenotype.

Interspecific hybridization among the four widely distributed species of Nearctic admiral butterflies *Limenitis (Basilarchia)* has been well-documented (Field, 1904; 1914; Nakahara, 1924; Hovanitz, 1949; Remington, 1958; 1968; Platt, 1975; 1983; 1987; Platt *et al.*, 1978; Ritland, 1990; Kemp, 1991; Platt & Maudsley, in revision). Except for crosses involving the two subspecific forms *L. arthemis arthemis* (Drury), and *L. arthemis astyanax* (Fabr.) (which in this report, as in the earlier papers by Platt and his co-workers, are considered to represent a single polymorphic species), these insects rarely hybridize in the wild (see White, 1990).

Such hybridization occurs among other closely related species within different insect groups as well, *e.g.* Saturniidae (Tuskes & Collins, 1981), Gerridae (Wilcox & Spence, 1986), and Libellulidae (Tennessen, 1981). The viability of such crosses, however, is variable. Bick & Bick (1981) report 93 hybrid pairings among Odonata involving ten families, 24 genera, and 124 species. Only two of these (one of which is questionable, due to the probability of sperm precedence) resulted in hybrid offspring.

In *Limenitis*, the cross involving *L. archippus* (Cr.) and *L. arthemis astyanax* is heterogametically inviable (Platt, 1987), usually producing

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no normal F<sub>1</sub> adult females. The males develop normally and are fertile in backcrosses to parental stock females (Platt, 1975; 1983). All 43 of the known wild-collected hybrid specimens are males. In laboratory crosses using Platt's (1969) hand-pairing method, 43 females (6.4%) among 628 adults occurred (Table 1). All other females died as eggs, larvae, or prepupae (determined to be female by Kean & Platt's, 1973 methods), or else formed hibernacula as third instar larvae, even though they were in long-day photoperiod (16L:8D). Normal *Limnitis* larvae (hybrid and non-hybrid) do not exhibit diapause responses when reared in > 11 hr light (Platt & Harrison, 1988). The few females that did eclose all metamorphosed early, at the end of the fourth larval instar. These, without exception, were stunted, malformed, faded in wing color, unable to fly, and infertile (Fig. 2). The broods in which females occurred generally involved parental strains from geographically distant areas such as northern Vermont and central Maryland (see Platt, 1987; Platt *et al.*, 1978). The stunted females make up only 1.3% of the progeny from crosses involving *L. archippus* and *L. arthemis astyanax* collected in the same geographic area (Table 1). These crosses have been made reciprocally between the sexes of the two species.

Table 1 also shows 441 males and four females were reared among 19 broods involving crosses of the two species obtained from the same regions (type A). Ten broods arising from hybrid crosses made between strains from different localities (type B) produced 187 males and 39 females. A 2 x 2 contingency test for the overall male and female values for stocks originating from A) the same, or B) different geographic regions yields  $\Sigma X^2_1 = 66.82^{**}$ , with  $P < 0.01$ . This highly significant result demonstrates that more adult females develop when stocks of the two species originating from different geographic regions are crossed. However, as the table makes clear, this difference arises from the nearly complete fertility of two hybrid crosses reared in 1973, in which a single male *L. archippus* from Vermont was hybridized to two sibling female *L. arthemis astyanax* from Maryland.

Thirty wild-collected specimens involving crosses between the broadly sympatric *L. archippus* and its congeneric species *L. arthemis arthemis* (n=11), *L. weidemeyerii* Edw. (n=10), and *L. lorquini* Boisd. (n=9) have been recorded by Platt & Maudsley (in revision). (The above allopatric butterflies are more closely related to each other than they are to *L. archippus*—see Platt, 1983). These F<sub>1</sub> hybrids also are all males and exhibit variable intermediate phenotypes.

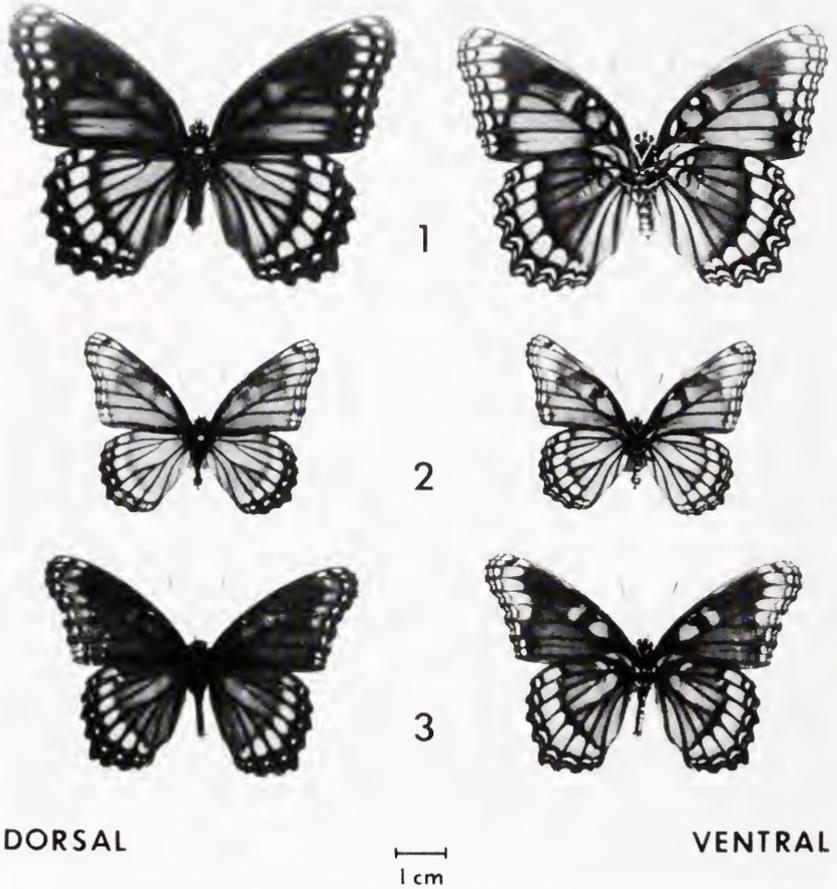
A recently reared brood (*L. archippus* ♀ x *L. a. astyanax* ♂), however, included one heterotic F<sub>1</sub> female, plus 97 males. The lone female

eclosed 14 days after her siblings. Both  $P_1$ 's were of Maryland stock. The fertility of this specimen is unknown, as the age and condition of the remaining males made attempting to breed her impossible. Fig. 1 shows the  $F_1$  heterotic *L. "rubidus"* female; a typical stunted female hybrid is shown in Fig 2, and a typical wild-collected hybrid male in Fig. 3. All laboratory bred *L. "rubidus"* males have been similar in size and coloration to this wild-collected specimen, although they vary somewhat in the amount of dorsally expressed orange.

Heterotic  $F_1$  females similar to the one in Fig. 1 occur when the three allopatric species of Nearctic *Limenitis* (*L. arthemis*, *L. lorquini*, and *L. weidemeyerii*) are crossed. Such individuals are larger, and more robust than those of the pure-bred species. These hybrid females so far have proven to be infertile when crossed to male siblings except in two cases, one involving a New England *L. a. arthemis* ♀ x an *L. lorquini* ♂ from Oregon, and the other involving an *L.a. astyanax* ♀ from Maryland x an *L. weidemeyerii* ♂ from Colorado. In the first cross-type the  $F_2$ 's are phenotypically variable, but many closely resemble *L. lorquini*; in the second cross-type the progeny all are hybrid-like in appearance. Dissections of these heterotic females reveal that many of them possess undeveloped reproductive structures and lack eggs. Similar hybrid-like females result from backcross broods involving the hybrid *L. "rubidus"* males (Platt, 1983; Platt *et al.*, 1978). These females often prove to be infertile when bred to parental stock males. Several such backcrosses, however, have been reared over the years and resulted in large broods.

Interspecific crosses among Lepidoptera, including those involving *Limenitis*, are variable in terms of their viability. Most of our laboratory matings are infertile. However, occasional broods exhibit nearly complete egg hatching, and many male progeny. Such was the case with the brood which produced this unique robust  $F_1$  female, resulting from the union of genetically compatible gametes representing two closely related, but distinct species. Admiral butterflies for the most part conform to Haldane's (1922) Rule among interspecific hybrids, but the survival of this heterotic individual is a clear exception to it. Apparently this female, unlike previously known hybrid specimens, had a compatible genetic makeup allowing for full morphological development. Why her development was so delayed relative to that of her male siblings must have been dependant on the titres of ecdysone and juvenile hormone present in this particularly large individual.

Our results demonstrate the close affinities existing between the *L. archippus* and *L. arthemis-astyanax* species groups of eastern North America. Gene exchange and gene flow between the two complexes takes place only rarely in the natural environment, but it provides a



Figs. 1-3—Laboratory-bred and wild-collected specimens of interspecific hybrid form *L.* "rubicundus" Strecker (*L. a. astyanax* x *L. archippus*): 1) unique heterotic  $F_1$  female reared from first generation Maryland strains; raised on weeping willow, (*Salix babylonica* L.). 2) typical weakened and stunted  $F_1$  female, as rarely obtained in such crosses (see text). This specimen was reared on wild or black cherry (*Prunus serotina* Ehrh.). 3) Typical wild-collected male specimen from near Dover (Kent Co.), Delaware, taken in late Sept. 1943. From an old, local natural history collection, Accession No. 1341, Leg. L. Darr of Middletown, Md. Laboratory-reared males are similar in size and appearance to this latter specimen. All specimens are now in the UMBC collection.

means by which alleles may be passed from the one complex to the other. Indeed, if the rare  $F_1$  hybrids can backcross in nature such introgression could lead to rapid evolutionary modifications which, perhaps, have played an important role in the evolution of the mimetic color patterns of the adult insects.

Table 1—Comparison of hybrid *L. "rubidus"* ♂ vs. ♀ progeny from parental stocks of the two species originating from A) the same, or B) different geographic locations.

Location		No. of Broods	No. of ♂ ♂	No. of ♀ ♀	% ♀ ♀
A) Mid-Atlantic <sup>1</sup> x Mid-Atlantic					
or					
New England <sup>2</sup> x New England:					
P <sub>1</sub> ♀ ♀		P <sub>1</sub> ♂ ♂			
1) <i>L. archippus</i>	<i>L. a. astyanax</i> <sup>3</sup>	4	80	0	0
<i>L. a. astyanax</i>	<i>L. archippus</i> <sup>3</sup>	5	52	0	0
Subtotal:		9	132	0	0
<hr/>					
2) <i>L. archippus</i>	<i>L. a. astyanax</i> <sup>4</sup>	5	204	1*	0.5
<i>L. a. astyanax</i>	<i>L. archippus</i> <sup>4</sup>	5	105	3	2.8
Subtotal:		10	309	4	1.3
<hr/>					
B) New England x Mid-Atlantic:					
3) <i>L. a. astyanax</i>	<i>L. archippus</i> <sup>5</sup>	5	104	39†	27.3
4) <i>L. a. astyanax</i>	<i>L. archippus</i> <sup>6</sup>	4	62	0	0
5) <i>L. archippus</i>	<i>L. a. astyanax</i> <sup>6</sup>	1	21	0	0
Subtotal:		10	187	39	20.9
Total:		29	628	43	6.4

<sup>1</sup> Mid-Atlantic includes strains from Delaware, Maryland, and New Jersey.

<sup>2</sup> New England includes strains from Connecticut, Massachusetts, and Vermont.

<sup>3</sup> Platt (1975), <sup>4</sup> Platt (1987), <sup>5</sup> Platt *et al.* (1978), <sup>6</sup> Platt (Unpubl. data).

\* This is the heterotic ♀ that is the subject of this paper. † Thirty-three of these represent 2 broods with the same P<sub>1</sub> ♂ and sibling P<sub>1</sub> ♀. Sex ratios of both broods were ~1:1.

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## NESTING BIOLOGY OF *DOLICHOVESPULA NORVEGICOIDES* (HYMENOPTERA: VESPIDAE)<sup>1</sup>

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**ABSTRACT:** *Dolichovespula norvegicoides* inhabits very moist areas. Colonies were much larger than those previously collected with nests of 3 to 5 combs, 701 to 1,641 cells, and 137 to 321 workers. Estimates on adult production at normal colony death ranged from 562 to 2,896. The nests were unusual in that reproductive cells were sometimes constructed on all combs. Nest associates *Sphecophaga vesparum burra*, *Vitula edmundsae serratilella*, carwigs, and possibly *Triphleba lugubris* were collected.

*Dolichovespula norvegicoides* (Sladen) is a rarely collected species, with little known about its biology and behavior. Distribution is restricted almost entirely to the Canadian and Hudsonian zones of the Boreal Region (Akre *et al.* 1981, fig. 41).

Previous collections of *D. norvegicoides* nests included one by Bequaert (1931), one by Akre *et al.* (1981), and three by Akre and Bleicher (1985). The three nests described in 1985, all with no more than 31 workers, 3 combs (n=2), and 263 cells (n=2), were found in Alaska, Idaho, and Maine (Akre and Bleicher 1985). Two were supraterrrestrial (half buried in the soil), and one was constructed inside a log.

The purpose of this paper is to report on seven additional colonies/nests collected in the state of Washington.

### MATERIALS AND METHODS

The seven colonies of *D. norvegicoides* were collected in the western half of Cowlitz County, WA between 1986-1992. All colonies were considered mature in that the production of reproductives was underway in the nest. The colonies were located by homeowners who phoned in requests for removal, thus collections were biased towards larger colonies in urban areas.

During collection, flying individuals, typically workers, were vacuumed or netted and transferred to the vacuum, and the nest was placed in a plastic bag. Carbon dioxide was used to quiet the workers if necessary, and the colony was frozen as soon as possible for later analysis. The number of individuals that could not be collected but were left

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behind at the site was estimated and noted.

Colony analyses included counting adults, combs, and cells. Cells were tallied as containing one egg, more than one egg, larvae (3 general sizes; small, medium, large); those having caps, and empty. In addition, cells were examined for parasites. Observations were also made of habitat, nest support, envelope paper, combs, and buttressing.

Estimates were made of the number of adults that had emerged at the time of collection, and the number that would have been produced by the colony before natural demise if it had not been collected. Production at the time of collection was calculated by counting the silk layers left behind in the cells by the pupae that emerged as adults. A minimum and maximum adult production at natural colony demise were calculated to give a range of the estimated total production of the colony. The minimum was calculated by adding the number of capped cells to production at collection, since most pupae emerge even after all the adults die. The maximum was calculated by adding the number of all occupied cells to production at collection.

## RESULTS AND DISCUSSION

Colonies were numbered chronologically as collected. The first nest (#1) was collected on 27 July 1986, when the colony was essentially dead. *Dolichovespula arenaria* (F.) colonies found nearby were approximately one month ahead of their "normal" colony schedule on this date, indicating that this was an unusual year; very warm weather early allowed most yellowjackets to develop colonies much earlier than normal. The other six colonies were collected at or near their peak population levels on 15 July 1989 (# 2), 27 July 1989 (#3), 10 July 1990 (#4), 16 June 1992 (# 5), 18 June 1992 (# 6) and 7 July 1992 (#7).

**Habitat.** Collection areas were moist (ca 100 cm or 40 in. ppt annually) and were located near rivers and streams. Elevations ranged from 30-570 m. Six of the seven colonies had nests located low in shrubs, including rhododendron, salal, azalea, salmonberry, blackberry, and/or huckleberry. Three were 30-34 cm from the ground, one was 133 cm high, the remaining two touched the ground. One of the latter was supraterritorial, as the nest penetrated the leaf litter layer where the workers excavated debris. Soil was probably not excavated. The seventh colony (#1) was collected from the mossy crotch of a bigleaf maple tree 6.7 m above ground. Approximately half of the nest was under the moss layer, and one-third of the envelope was discontinuous where the nest contacted the trunk. The moss layer was probably pulled away from the tree as the nest expanded. All nests had leaves and twigs or moss incorporated into

the envelopes. Leaves, smaller twigs, and moss were chewed away on the inside of the envelope.

Diameters of initial support twigs of the other nests ranged from 2-10 mm, ( $\bar{x}$  =5.8 mm,  $n$ =6: nest #1 support unknown).

**Nest Construction.** The envelope paper was laminar, but the layers were thinner than those of *D. maculata* (L.) or *D. arenaria*. Akre and Bleicher (1985) noted that the paper weave was looser and consisted of smaller fibers. This was also true of the envelope of these nests. The envelope paper color on all nests was grey with subtle variations from lighter to darker grey, with occasional stripes of brown-grey, yellow-grey, red-grey, or green-grey paper. Differences in color variations was much less than that seen in envelope paper of either *D. maculata* or *D. arenaria*.

Nests had an average of 24.5 layers of envelope on the top where the inner layers had not been cut away or modified for nest enlargement [range ( $r$ ) =22-29,  $n$ =6; envelope from nest # 5 was not included as it was smashed]. Layers on the sides of the nests averaged 8.2 ( $r$ =6-14,  $n$ =13). Two counts were made of the envelopes on different sides of each nest except for nest #5, where only one count was made because of envelope damage. These counts on opposite sides differed by an average of 3.3 layers ( $r$ =0-8,  $n$ =6).

Nest #4 had an irregular envelope and possible comb irregularities due to comb separations, but since this colony was the second largest, the damage apparently caused minimal disruption to the colony. Due to the damage, additional envelope was formed between combs 2 and 3, and a layer of previous envelope had folded inward between combs 3 and 4. While other active colonies had from 1-10% empty cells, this colony had 24% of the cells empty, some cells were cut down, and there were areas where envelope was built over the cells (Cells covered with envelope also occur normally in colonies in decline). Combs 1, 4, and 5 were normal, while combs 2 and 3 had 140 and 32 cut down cells, respectively. Comb 3 was unusual as there was one large larva, 2 small larvae, and 62 egg or empty cells from which adults had already emerged among large numbers of cells capped for the first time. Cut down cells were found in small numbers in one other nest (nest # 1), and this was considered normal in the nest sequence.

The queen pedicels of the top combs of all the nests were glazed (secretions from the queen), and the tops of these combs were shinier than the lower combs. The paper of the original queen comb was yellow-grey in two nests (#5 and #2) and grey surrounded by yellow-grey, then becoming normal grey in one nest (#7). The top combs of the remaining nests were uniform grey.

Ribbon buttressing was found on all combs of all nests except for the small bottom combs. Nests had an average of 46.2 cm of ribbon on all combs ( $r=4.8-84.0$  cm). The top comb usually had about a quarter of all buttressing ( $x=24.7\%$ ,  $r=6-48\%$ ), while combs two and three had the greatest amount of buttressing (comb 2:  $x=34.9\%$ ,  $r=12-77\%$ ; comb 3:  $x=36.0\%$ ,  $r=26-56\%$ ,  $n=6$ ). Combs 4-5 had little buttressing as they were constructed just prior to collection. Colony # 1, which was in advanced decline at collection, had fairly even amounts of buttressing on all combs (comb 1: 32%, comb 2: 18%, comb 3: 31%, comb 4: 19%; 84 cm total buttressing). In most cases 1-4 ribbons radiated outward from the central pedicel ( $x=75.6\%$  ribbon on all combs). Some separate ribbons occurred on the sides of the cells ( $x=10.9\%$ , mostly on comb 1; attached to the envelope above), and a few isolated ribbons were neither attached to the center peticel nor on the sides of the cells ( $x=13.6\%$ , usually on middle combs).

Twenty mature (full length) cells were measured on each comb to the nearest 0.1 mm. Cell measurements were not taken from six of the reproductive combs as all the cells were immature, or from nest # 1 which was totally destroyed searching for parasites. Twenty measurements of cells were taken from the queen and the worker sections of the first comb of nest # 6, but queen cells on comb 1 of nest #4 were not included in measurements as there were very few cells. Worker cells averaged 4.8 mm diam ( $r=4.1-6.5$  mm,  $n=120$  cells from 6 combs), and reproductive cells averaged 6.4 mm diam ( $r=5.1-8.0$  mm,  $n=300$  cells from 15 combs).

**Comb Contents:** The nests had 3 to 5 combs, with an average of 4.3 combs ( $n=7$ , Table 1). The top comb (comb 1) consisted of smaller cells producing first workers, then males; while the remaining combs were made of larger reproductive cells producing males and queens. At the time of collection the capped cells of comb 1 in the nests of the 6 living colonies contained both male and worker pupae. *D. norvegicoides* is unusual as queen cells are found on the edge of the worker comb. This has not been reported previously for any member of the genus *Dolichovespula*.

Three of the seven nests had queen cells on their first worker comb. Colony #6 had 88 large cells on the edge of the worker comb, consisting of 58 capped cells and 30 non-capped cells. Fifty five of the capped cells contained queen pupae and three contained male pupae. Comb 1 of nest #4 had three large cells; queens had emerged from two, and one contained a queen pupa. Comb 1 of colony # 1 had 6 empty reproductive cells from which queens had emerged.

Worker combs (comb 1) consisted of an average of 317 cells ( $r=218-405$  cells,  $n=7$ ). An average of 37% of these contained eggs ( $r=18-52\%$ ,  $n=6$  excluding colony #1), 22% larvae ( $r=17-29\%$ ,  $n=6$ ), 36% pupae ( $r=27-50\%$ ,  $n=6$ ), and 5% were empty ( $r=1-9\%$ ,  $n=6$ ). The larvae were evenly divided among small (33.4% of all larvae, 6 colonies), medium (30.5%), and large larvae (36.1%).

The reproductive combs had an average of 968 cells ( $r=331-1,280$  cells,  $n=7$ ). An average of 27% of the cells contained eggs ( $r=19-43\%$ ,  $n=6$  excluding colony #1), 31% larvae ( $r=24-40\%$ ,  $n=6$ ), 32% pupae ( $r=24-39\%$ ,  $n=6$ ), and 10% were empty ( $r=2-30\%$ ,  $n=6$ ). One third of all the larvae in the 6 colonies were small, and there were slightly more medium (37.6%) than large larvae (29.3%).

Cells that contain more than one egg or small larva indicate colony decline as workers begin to lay eggs due to loss of queen control. Five of the six living colonies had multiple eggs and/or small larvae per cell: #4 (42 cells), #6 (9), #5 (8), #7 (38), and #3 (5).

**Adults and Adult Production.** The foundress was collected with five of the six active colonies (Table 2). Only one had age spots (Ross 1984) typical of old foundresses of other species. Some had darker areas on the yellow tergal bands of the gaster, but these were not age spots, and several new queens had similar markings. Foundresses without age spots were distinguished from new queens by the lack of hair and slightly frayed wings. In addition, the wings of foundresses were tinted yellow-brown, while new queens had smoky-grey wings.

The six active colonies contained an average of 213 workers ( $r=137-326$ ), 25 males ( $r=7-71$ ), and 28 new queens ( $r=0-57$ ); only one colony, #7, did not have new queens (Table 2).

The number of adults produced to date of colony collection was based on number of silk pupal layers left in cells by emerging adults (Table 3). The majority of the cells in the six live colonies had not yet produced any adults ( $r=45-75\%$  of cells) while only 12% of the nearly dead colony (#1) cells had never produced adults. Seventeen to 41% of cells from the six living colonies had produced one adult each, while 71% of colony #1 cells had produced one adult. Few cells from the 6 living colonies had produced 2 or more adults per cell ( $r=6-19$ ), and this was also true for colony #1 where 16% of the cells produced 2 adults per cell.

An average of 805 workers, queens, and males (range: 330-1,398) had been produced from the six active colonies at the time of collection (Table 4). Possible errors in this calculation include pupae that died and were removed from the capped cells. The average minimum number of adults that may have been produced at natural colony death was 1,119

( $r=562-1,998$ ). The average maximum number of adults was 1,834 ( $r=1,075-2,896$ ). Possible errors in the estimate of the maximum population include the possibility of colony death before the cell occupants reached maturity. Also, eggs that had not been laid at the time of collection might have developed into adults if the colony had not been collected. However, comparisons of the six active colonies with cell usage in colony #1 indicated that the range was accurate, and that the maximum end of the range was probably more accurate than the minimum. The number produced by colony #1, a smaller colony, by its natural demise was 1,457.

**Parasites and Associates.** *Sphecophaga vesparum burra* Cresson is a parasite that occurs in colonies of *D. arenaria* (Greene *et al.* 1976), *D. maculata* (Akre and Myhre 1991), and *D. saxonica* (F.) (Edwards 1980). It was found in high numbers in colony #1. A total of 22 white and 49 yellow (overwintering) cocoons was found in the combs of this nest. Nine white and 18 yellow cocoons were found in comb 1, 7 yellow in comb 2, 2 white and 10 yellow in comb 3, and 11 white and 14 yellow in comb 4.

*Vitula edmandsae serratilineela* Ragenot, a pyralid scavenger typically found in dead and dying *D. maculata* and *D. arenaria* nests, was found in nest #1. Diptera larvae, tentatively identified as the phorid

Table 1. Cell contents of colonies in chronological order as collected.

Colony No.	Date Collected	Comb Type	No. Combs	No. Cells	No. Eggs	Larvae			Capped Cells	# Empty (% Empty)
						small	medium	large		
1	27/VII/86	Worker	1	261	0	0	0	0	0	261(100)
		Queen	3	1,119	0	0	1	0	0	1,118(100)
		TOTALS:	4	1,380	0	0	1	0	0	1,379(100)
2	15/VII/89	Worker	1	405	78	36	34	47	178	32(8)
		Queen	4	1,082	324	151	127	101	322	57(5)
		TOTALS:	5	1,487	402	187	161	148	500	89(6)
3	27/VII/89	Worker	1	361	160	25	21	14	107	34(9)
		Queen	4	1,280	307	132	122	117	493	109(9)
		TOTALS:	5	1,641	467	157	143	131	600	143(9)
4	10/VII/90	Worker	1	314	154	28	16	25	85	4(1)
		Queen	4	1,203	232	66	136	87	326	356(30)
		TOTALS:	5	1,517	386	94	152	112	413	360(24)
5	16/VI/92	Worker	1	218	86	20	12	11	79	10(5)
		Queen	3	928	262	54	109	68	334	101(11)
		TOTALS:	4	1,146	348	74	121	79	413	111(10)
6	18/VI/92	Worker	1	287	51	19	30	27	144	16(6)
		Queen	3	831	157	142	116	75	288	53(6)
		TOTALS:	4	1,118	208	161	146	102	432	69(6)
7	7/VII/89	Worker	1	370	193	19	21	35	99	3(1)
		Queen	2	331	142	20	31	52	80	6(2)
		TOTALS:	3	701	335	39	52	87	179	9(1)

*Triphleba lugubris* (Meigen), were found in cells with reddish tinted caps in nests #1 (one in each of six cells), #4 (1 in one cell, 2 in a second), and #2 (3 in one cell). The capped cells each contained 1-3 larvae, and the yellowjacket pupae were dead but usually intact. The largest maggot we found had burrowed into the abdomen of a pupa (# 4). Earwigs were found in colonies # 5 and #6.

*D. adulterina* (du Buysson) parasitizes colonies of *D. norvegicoides* (Wagner, cited by Yamane 1975), but none was found in these colonies.

Table 2. Number of old queens (foundresses if not usurped), workers, new queens, and males collected with colony. Colony # 1 was not included in averages as it was essentially dead.

Colony Number	Date Collected	Old Queens	Workers	New Queens	Males
2	15/VII/89	1	288	18	17
3	27/VII/89	0	205	48	71
4	10/VII/90	1	326	14	17
5	16/VI/92	1	137	57	21
6	18/VI/92	1	141	28	15
7	7/VII/89	1	183	0	7
	Ave:	0.8	213.3	27.5	24.7
1	12/VII/86	0	22	0	1

Table 3. Cell usage by emerged adults based on number of silk pupal layers in cells.

Colony Number	No. Cells in Nest	No. cells used: (% of total cells)				
		0 times	1 time	2 times	3 times	4 times
1	1,380	168 (12)	984 (71)	211 (15)	17 (1)	0
2	1,487	1,118 (75)	275 (18)	68 (5)	26 (2)	0
3	1,641	744 (45)	560 (34)	196 (12)	118 (7)	23 (1)
4	1,517	786 (52)	542 (36)	145 (10)	39 (3)	5 (0.3)
5	1,146	553 (48)	474 (41)	86 (8)	33 (3)	0
6	1,118	862 (77)	191 (17)	56 (5)	9 (1)	0
7	701	403 (57)	223 (32)	65(9)	10 (1)	0

Table 4. Total adult production and number of adults produced per cell up to time of collection ("At Collection Date"), and estimated total production and number produced per cell if colony had not been collected ("Natural Death").

Colony Number	At Collection Date		Natural Death	
	Total Production	# Produced per Cell	Total Production Min.-Max.	# Produced/cell Min.-Max.
2	489	0.33	989-1,887	0.67-1.27
3	1,398	0.85	1,998-2,896	1.22-1.76
4	969	0.64	1,382-2,126	0.91-1.40
5	745	0.65	1,158-1,780	1.01 -1.55
6	330	0.30	762-1,379	0.68-1.23
7	383	0.55	562-1,075	0.80-1.53
	Ave:	0.55	1,142-1,857	0.88-1.46
1	1,457	1.06	1,457	1.06

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## A LIST OF BACTERIAL FLORA RESIDING IN THE MID AND HINDGUT REGIONS OF SIX SPECIES OF CARRION BEETLES (COLEOPTERA: SILPHIDAE)

Glenn Berdela,<sup>2</sup> Bonnie Lustigman,<sup>2</sup> Paul P. Shubeck<sup>2,3</sup>

**ABSTRACT:** Forty-eight carrion beetles (Silphidae: *Nicrophorus tomentosus*, *Nicrophorus orbicollis*, *Oiceoptoma noveboracense*, *Oiceoptoma inaequale*, *Necrophila americana*, *Necrodes surinamensis*) were dissected and the midgut, hindgut, and associated hemolymph were cultured for bacteria. Eight specimens of each of the six species above were utilized. Analytical profile index rapid biochemical systems were used for bacterial identifications. Thirty-two bacteria were identified to species and seven to genus level. Six isolations were limited to "group" identifications and eight morphologically distinct bacteria could not be identified using the rapid biochemical test strips because of data base limitations. Many of the species are known opportunistic pathogens.

Most entomologists, and many field naturalists, have been aware of the existence of carrion beetles for many years and, in fact, the last quarter century has seen a fair number of publications on this family in entomological literature. Only recently, however, has a serious effort been made to survey the medically important true bacteria associated with the silphids. In that study (Solter *et al.* 1989) 36 carrion beetles (Silphidae: *Nicrophorus tomentosus* Weber, *Oiceoptoma noveboracense* (Forster), *Necrophila americana* (L.)) were collected in the Great Swamp National Wildlife Refuge (GSNWR), Basking Ridge, N.J. They were dissected and the midgut, hindgut and associated hemolymph were cultured for bacteria. Nineteen bacteria were identified to species and seven to the genus level. Several of the identified coliform and staphylococci bacteria were known opportunistic pathogens.

The primary objective of the current study was to expand on Solter *et al.* (1989), establishing the full spectrum of intestinal bacterial microflora harbored among a greater number of silphid species. In our study we were able to collect six of the eight species of silphids found in GSNWR (Shubeck 1983). In addition to the three species studied by Solter *et al.* (1989) our study included also *Nicrophorus orbicollis* Say, *Oiceoptoma inaequale* (F.), and *Necrodes surinamensis* (F.). Beetle taxonomy follows Anderson (1982). These six species are common at different times throughout the spring and summer months, in a variety of habitats including fields and forests. It was hoped such information

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would help further define an epidemiological role for the carrion beetles.

A secondary objective of this study was to develop and utilize bacteriological techniques suitable for this type of study. Efforts to identify the large numbers and varieties of intestinal bacteria of silphid beetles have proven a formidable task. Colonies representing different species may not always be readily distinguishable when viewed among polymicrobial growth. This approach contrasts with that taken in a clinical microbiology laboratory, where efforts are directed only at identifying or characterizing suspected causative agents of infection. Isolation media commonly employed in clinical applications were used here to assist in the detection of such pathogens as *Salmonella*, *Shigella*, *Yersinia enterocolitica*, *Campylobacter jejuni*, *Staphylococcus aureus*, and pathogenic streptococci and clostridia. These media were also used in conjunction with biochemical tests as a means of grouping isolates.

Identification of pure culture isolates was accomplished using the API 20E, Rapid-STREPT, STAPH-Trac, STAPH-Ident and AN-IDENT identification systems. Such commercially available systems offer advantages over conventional methods including ease of use, standardized selection of biochemical tests, relatively low cost and quick response. Profile numbers are constructed from the results obtained and compared with those in an established data base. It should be understood that data bases supporting each of these systems have been derived primarily from human clinical strains. While systems like API are often used to identify isolates of non-human origin, there is a possibility of obtaining profile numbers either not contained in the data base, or of those yielding incorrect identifications. In spite of this, since bacteria associated with carrion beetles may be expected to represent those of entomological, veterinary or other environmental origins, we considered this study of sufficient importance to be pursued.

## MATERIALS AND METHODS

**Collection.** Six species of carrion beetles (Silphidae) were collected at the Great Swamp National Wildlife Refuge in Basking Ridge, N.J. Collection was accomplished by the use of 5 ground surface type traps described elsewhere (Shubeck 1976). Three of these traps were placed along a straight line at 5 meter intervals within a mixed-oak forest, one in an adjacent field, and the fifth near a swamp. Each trap was baited with a fresh (1-7 days) and a stale (8-14 days) chicken leg, each in a separate styrofoam cup. Seven collections were made during the summer of 1988. Collecting dates were; 06/06, 06/13, 06/20, 06/27, 07/08, 08/02, 08/08.

Collected beetles were stored in a refrigerator and dissected within 72 hours. Only those that were alive at the time of dissection were used. The beetles were killed by crushing their heads with forceps, then rinsed in 2% Amphyl disinfectant and rinsed twice in sterile distilled water. They were then dissected and the midgut, hindgut and associated hemolymph were removed and placed in vials containing 1.0 ml of Trypticase Soy Broth with 15% glycerol. At least 8 specimens of each of the following 6 species were prepared: *Necrophila americana*, *Oiceoptoma inaequale*, *Oiceoptoma noveboracense*, *Nicrophorus orbicollis*, *Nicrodes surinamensis* and *Nicrophorus tomentosus*. The cultures were then stored at or below  $-60^{\circ}\text{C}$ .

**Culture Techniques.** The following protocol is based on the work of Solter *et al.* (1989) but does include some changes which increased the likelihood of identifying additional bacterial species. The contents of each vial were thawed, homogenized and preincubated for 2 hours in lactose broth to facilitate cellular repair. Ten  $\mu\text{L}$  aliquots were then inoculated into Gram Negative (GN) Broth, Selenite Cysteine Medium and 0.1% sterile peptone water. Two drops of the preincubated homogenate were also plated onto Columbia Colistan Naladixic Acid (CNA) Blood Agar Plate (BAP), Mannitol Salt Agar and anaerobic media. The anaerobic media included Anaerobic Phenylethyl Alcohol Blood Agar Plates (ANA PEA BAP), Anaerobic Kanamycin-Vancomycin Blood Agar Plates (ANA KV BAP). These were cultured in a Gas Pak pouch at  $30\text{--}35^{\circ}\text{C}$ . The GN Broth was then plated onto the following agar plates; Salmonella Shigella (SS), Xylose Lysine Deoxycholate (XLD), MacConkey's (MAC), Levine Eosin Methylene Blue (EMB), Bismuth Sulfite (BS), Pseudosel and Cefsulfodin Irgasen Novobiocin Agar Base (*Yersinia* selective agar) (CIN agar). The inoculated tubes of 0.1% peptone water were further serially diluted and plated onto Trypticase Soy Agar (TSA) for total aerobic counts (TAC's). Aerobic plates were incubated at  $35^{\circ}\text{C}$  for 24 hours except for the TAC's which were incubated for 72 hours.

Representative colonial types from the primary isolation plates were then subcultured onto fresh media to obtain pure cultures. All gram negative organisms were streaked onto TSA, gram positive onto Columbia CNA BAP, and anaerobes onto ANA PEA BAP. Stock cultures of the purified isolates were prepared and stored at  $-60^{\circ}\text{C}$ . Each gram negative isolate was streaked onto MAC, XLD, BS, and CIN agars. The plates were incubated and the morphological characteristics of the colonies determined. Tubes of Triple Sugar Iron (TSI), Lysine Iron Agar (LIA), and Urease Broth were inoculated and then incubated.

Gram positive bacteria were characterized and grouped on the basis of colonial morphology observed on Columbia CNA BAP, TSA and coagulase and reactions in Oxidation Fermentation (OF) Glucose Bile Esculin and Trypticase Soy Broth (TSB) with 6.5% NaCl and the results were recorded. Anerobic isolates were tested for oxygen tolerance by incubating PEA BAP under both aerobic and anerobic conditions.

Final identification was performed using the following API identification systems; API 20E for gram negative bacteria, API Staph-Ident and Staph-Trac (catalase positive gram + cocci), API Rapid-Strep (catalase negative gram + cocci) and API An-Ident for anerobes.

## RESULTS

Most of the beetles were collected during the four weeks of June, with the exception of *N. tomentosus* which was common during July and early August. Nineteen of the 48 beetles tested (39.6%) yielded aerobic counts on the order of  $10^7$  cfu's (colonies) per specimen, while 22 beetles (45.8%) yielded  $10^6$  cfu's per specimen, 6 beetles (12.5%) yielded  $10^5$  cfu's per specimen and 1 (2%) yielded  $10^4$  cfu's per specimen. There was no observable correlation between count and carrion beetle species. Overall, 607 isolates consisting of at least 42 different strains of bacteria were recovered. Of these isolates 52.1% were gram negative bacteria (21 strains), 21.1% were coagulase-negative staphylococci (5 strains), 8.1% were obligately anaerobic bacteria (7 strains), 7.6% were streptococci (6 strains), 5.4% were *Bacillus* spp., 4.4% were *Aerococcus* and less than 1% were coryneform bacteria (3 strains) or *Gemella* (formerly *Streptococcus*) *haemolysans*. A variety of colony types were recorded as either *Staphylococcus* spp., *Streptococcus* spp., *Clostridium* spp. or *Bacillus* spp., so that the total number of varying strains recovered was actually more than indicated.

### Facultative and Aerobic Gram Positive Bacteria.

Columbia CNA BAP's supported growth of all recovered gram-positive bacteria, while that of gram-negatives was effectively inhibited. Yeast colonies, although not targeted in this study, also grew on this media. Mannitol Salt Agar was considerably more selective, as only *Staphylococcus sciuri*, *S. xylosus* and *S. warneri* were recovered.

Biochemical testing performed on the gram-positive isolates was able to distinguish between the mannitol positive and mannitol negative non-agglutinating staphylococci, and between *Streptococcus/Aerococcus* spp. and *Streptococcus bovis* (Table 1). These tests were

used in conjunction with colonial morphology, to group the isolates prior to attempts at final identification.

Coagulase-negative staphylococci accounted for 52.9% of the 242 facultative and aerobic gram-positive bacteria recovered. Included were *Staphylococcus xylosus* (19.0%), *S. sciuri* (13.6%), *S. warneri* (9.1%), *S. saprophyticus* (8.3%), and 2.9% identified as *Staphylococcus* spp. (Table 1).

Streptococci accounted for 19.8% of all gram-positive bacteria, 15.7% of which were equally divided between the enterococci and those identified as *Streptococcus* spp. Also recovered were *Streptococcus sanguis* (2.1%), *S. lactis* (1.7%), and one *S. bovis* variant isolate. Two isolates were identified as *Gemella haemolysans*, a species previously assigned to the genus *Streptococcus*.

Another 13.6% of the gram-positive isolates consisted of a number of morphologically distinct catalase-positive, spore-forming rods, all of which were recorded as *Bacillus* spp.. Finally, a small number of coryneform bacteria (1.7%) were recovered.

#### Anaerobic Bacteria

Most of the 49 anaerobic isolates recovered belonged to the genus *Clostridium*, with 44.4% identified as *Clostridium* spp., 18.4% as *C. barati*, 14.3% as *C. bifermentans* and only one isolate each (2%) of *C. cadaveris* and *C. innocuum*. All clostridia failed to grow, or grew only slightly when incubated under aerobic conditions. The two remaining anaerobes recovered were *Peptostreptococcus anaerobius* (16.3%) and *Bacteroides capillosus* (2%) (Table 2).

#### Facultative and Aerobic Gram-Negative Bacteria

There were 23 different strains of gram-negative bacteria recovered, 14 of which belong to the family *Enterobacteriaceae*. The gram-negative bacteria constituted the single largest and most diverse group in this study. There was a total of 638 colonies recorded from among the 7 different gram-negative isolation plates, representing 514 isolates when only one species per plate is considered. The difference may represent either strain variation, or inadvertent recording (as different colony types) of a single strain more than once from the same plate. When counting each species only once per beetle specimen, the number of isolates drops to 316.

There were 23 different taxa and groups of gram-negative bacteria identified by the API 20E system (Table 3). Approximately one half of these constituted almost 90% of the 316 recovered isolates. The single

largest group was the so-called Proteeae tribe, including *Proteus* (26.6%), *Providencia* (16.5%) and *Morganella* (6.6%). Other predominant gram-negatives included *Serratia* (17.1%), *Citrobacter freundii* (9.5%), *Klebsiella* (7%) and *Hafnia alvei* (6.3%).

## DISCUSSION

Bacteria representing most of the major groups, of which approximately 50% are gram-negative rods, were recovered from the beetles studied. These findings are consistent with previous studies of silphids (Solter *et al.* 1989) and other insects (Steinhaus 1941). Eighteen of the 26 bacterial types recovered from the Solter *et al.* study (1989) are included among the 45 different types recovered here. Frank pathogens were not recovered from either study with the exception of 3 possible *Salmonella* isolations in this study. On the other hand, many of these isolates are considered to be opportunistic pathogens, recognizing the often tenuous distinction between "harmless" and "pathogenic" microorganisms.

In the discussion that follows only species **not** mentioned in the Solter *et al.* study (1989) will be covered.

### Gram Positive Bacterial Isolates (Table 1).

In animals, variants of *Staphylococcus* have evolved to be adapted to various hosts. These separate biotypes of ecotypes vary dependent upon the host species. Most of these organisms are coagulase negative and have limited clinical importance (Joklik *et al.* 1988). Included would be *Staphylococcus sciuri* which has been isolated from the skin of rodents, ungulates, carnivora and marsupials. It may be isolated from other mammals and environmental sources such as soil and water. It has only rarely been isolated from humans (Sneath *et al.* 1986).

*Streptococcus faecalis* is primarily located in the gastrointestinal tract of humans, homothermic and poikilothermic animals and in insects and plants. It is common in many non-sterile foods and its presence is often not related to fecal contamination. It is an opportunistic pathogen agent in urinary tract infections (Sneath *et al.* 1986). It also has been frequently associated with biliary tract infections, septicemia, wound infection and intraabdominal abscess complicating appendicitis, especially in the elderly or those who are immunologically compromised (Joklik *et al.* 1988).

*Streptococcus sanguis* is one of a group of streptococci that is associated with the oral cavity. These organisms are consistently isolated as a part of the flora of the mouth and are associated, along with several

other streptococcal species, in the production of dental plaque and dental carries. They have been isolated from the blood and heart valves in some cases of bacterial endocarditis. They are present in low levels in human feces and have been isolated from soil (Sneath *et al.* 1986).

*Streptococcus bovis* is frequently isolated from the alimentary tract of cows, sheep, and other ruminants and the feces of pigs. It is occasionally found in large numbers in human feces. It is one of the acidogenic streptococci found in raw and pasteurized milk, cream and cheese. It has been found occasionally in cases of endocarditis and is considered to be related to *S. faecalis* (Sneath *et al.* 1986).

*Streptococcus lactis* is non-pathogenic and is associated with the production of acid from large numbers of sugars. It is responsible for the souring of milk, and production of yogurt (Sneath *et al.* 1986).

As the name implies, *Streptococcus avium* is characteristically isolated from the feces of chickens and other fowl. These organisms also have been found in the feces of humans, dogs and pigs. They have been associated with appendicitis, otitis and abscesses of the brain (Sneath *et al.* 1986).

*Aerococcus viridans* is frequently found as a common airborne organism. Another variety is a marine organism which causes disease in lobsters. No pathogenic association is known to exist in humans (Sneath *et al.* 1986).

*Gemella haemolysans* is considered to be similar to the neisseria species. It is not known to be a pathogen. This organism has been isolated from bronchial secretions and human gingiva (Sneath *et al.* 1986).

#### Anaerobic Bacterial Isolates (Table 2)

*Bacteroides capillosus* is a gram (-) anaerobic organism forming tan to black pigments. *Bacteroides* are indigenous to various locations throughout the body including the mouth and thoracic region, intraabdominal and pelvic regions. The infections that they may cause are related to their location in the body (Krieg & Holt 1984).

*Bacteroides capillosus* has been isolated from cysts and wounds in humans, as well as the human mouth and feces. This organism has also been isolated from the intestinal tracts of several animals including hogs, mice and termites. It has also been found in sewage sludge (Krieg & Holt 1984).

Clostridia are anaerobic spore forming bacilli that are usually gram (+). Most species are obligate anaerobes. The pathogenic species produce soluble toxins some of which are extremely potent. The clostridia are widely distributed in nature and are present in soil and as inhabitants of the intestinal tract of humans and other animals (Joklik *et al.* 1988).

The histotoxic clostridia cause a severe infection of muscle—commonly called gas gangrene. Because the clostridia are so widely distributed in nature, contamination of wounds by these bacteria is very common. Often more than one clostridial species is present including both saprophytic and histotoxic species. The most commonly isolated histotoxic *Clostridium* is *C. perfringens*. However, several other species are commonly encountered in soft tissue infections, abscesses, wound infections, anaerobic cellulitis and gas gangrene. These organisms may be considered non-pathogenic, but they can be opportunistic pathogens. Included in this group are *C. barati*, *C. bifermentans*, *C. innocuum*, and *C. cadaveris*. While these organisms may not produce toxins, they may play a synergistic role in the development of gas gangrene (Joklik *et al.* 1988).

*Peptostreptococcus anaerobius* is an anaerobic gram (+) coccus. These organisms are a part of the normal flora of the mouth, gastrointestinal tract and genital tract. They are particularly important in pleuropulmonary disease, brain abscesses and obstetric and gynecologic infections (Sneath *et al.* 1986).

#### Gram Negative Bacterial Isolates (Table 3)

The bulk of the species in this category are members of family Enterobacteriaceae. They are glucose fermenting bacilli or coccobacilli and as the name implies they are enteric bacteria;

*Serratia marcescens* is a prominent opportunistic pathogen affecting hospitalized patients. At one time they were thought to be harmless saprophytes and were used to trace air currents in the environment and in hospitals. In nature they are found widely distributed in soil and water and are found associated with a large number of plants and animals, including insects. Almost all *Serratia* infections are associated with underlying disease. They cause nosocomial infections of the urinary tract and wound infections, pneumonia and septicemia. Mastitis in cows and other animal infections are caused by this organism (Joklik *et al.* 1988).

*Serratia liquifacens* has been isolated from clinical specimens. The disease spectrum for this species is similar to *S. marcescens* (Joklik *et al.* 1988).

*Klebsiella pneumoniae* is normally found in the intestinal tract of man and animals, but in lower numbers than *E. coli*. As the name suggests it can cause pneumonia. It can also infect other sites than the respiratory tract. It is the mucoid capsule that determines the pathogenicity. The organism is an opportunistic pathogen and usually causes illness in a patient who is already compromised. It can also cause urinary

tract and wound infections, bacteremia and meningitis (Joklik *et al.* 1988).

*Klebsiella oxytoca* resembles *K. pneumoniae* in disease spectrum and it is also very similar from a clinical viewpoint (Joklik *et al.* 1988).

*Klebsiella ozonae* causes chronic atrophic rhinitis characterized by a fetid odor. Nasal and pharyngeal infections are primarily seen in people from endemic regions in Eastern Europe and South America. It can also be isolated from urinary tract and soft tissue infections and from secondary bacteremia (Joklik *et al.* 1988).

*Enterobacter cloacae* is found less frequently than *Klebsiella* and *E. coli*. It is most frequently associated with urinary tract infections in nosocomial patients having other underlying problems. In the 1970's *Enterobacter agglomerans* and *E. cloacae* were responsible for 150 bacteremias and 9 deaths in a nationwide epidemic caused by contaminated intravenous fluids (Joklik *et al.* 1988).

*Hafnia alvei* is found in feces of man and other animals including birds. It is also found in sewage, soil and water. The infections it produces are similar to those produced by *Enterobacter* (Krieg & Holt 1984).

Some serotypes of *Salmonella* are primarily adapted to one species of host or another. *Salmonella pullorum* is adapted to poultry rather than man and is primarily transmitted between poultry. Humans can, however, develop salmonellosis from contaminated food and water (Krieg & Holt 1984).

*Cedacea* spp. is an enteric genus that has been isolated from a variety of opportunistic infections (over 50% from the respiratory tract). The organisms are infrequent opportunistic pathogens and constitute only a small percentage of isolates. Very little is known about their ecology, epidemiology or role in human disease (Krieg & Holt 1984).

*Mollerella wisconsinensis* is a recently described organism and was formerly considered in Enteric Group 46. It has been isolated from feces. The reported isolates have been found in patients with diarrhea but there is no evidence that it can actually cause diarrhea (Farmer *et al.* 1985).

*Tatumella ptyseos* is similar to other members of the Enterobacteriaceae. It has been isolated from human clinical specimens—86% from the respiratory tract. It may be a rare opportunistic pathogen, whose epidemiology is not known (Krieg & Holt 1984).

The remaining gram negative bacterial isolates are all non-fermenting bacilli:

*Pseudomonas fluorescens* is found in soil and water. It is commonly associated with spoilage of foods, such as eggs, meats and it is often iso-

lated from clinical specimens (Krieg & Holt 1984). Although these organisms are not etiological agents of disease, they may be the cause of opportunistic infections of wounds and the urinary tract (Krieg & Holt 1984).

*Pseudomonas testosteroni* occurs in soil. It is not considered pathogenic, but like *P. fluorescens* it may be opportunistic (Krieg & Holt 1984).

*Pasteurella* are parasitic on the mucous membrane of the upper respiratory and digestive tracts of mammals (rarely man) and birds. Some primary diseases include hemorrhagic septicemia of cattle and fowl cholera in chicken, turkeys, ducks, etc. These organisms also cause secondary pneumonia-like illness in cattle and sheep (Krieg & Holt 1984).

The most significant source of microorganisms colonizing the silphid gut is the carrion on which they feed. The bacteria recovered in this study should, therefore, be reflective of those commonly found on decaying carcasses. Most of the recovered species are, in fact, widely distributed in nature and capable of existing as free-living organisms. The variety of gram-negative and gram-positive, facultative and anaerobic bacteria recovered from all six species indicates conditions which may be favorable to at least transient populations of pathogenic bacteria. Such organisms may be acquired exogenously from infected carrion, in which case the silphids could become vectors of disease transmission.

Table 1. The number of times each identified gram positive bacterial species was isolated from six silphid species. N.a. = *Necrophila americana*, N.o. = *Nicrophorus orbicollis*, O.n. = *Oiceoptoma noveboracense*, O.i. = *Oiceoptoma inaequale*, N.t. = *Nicrophorus tomentosus*, N.s. = *Necrodes surinamensis*. (Silphidae-8 specimens per species were used.)

GRAM POSITIVE BACTERIAL ISOLATE	N.a.	N.o.	O.n.	O.i.	N.t.	N.s.	TOTALS
<i>Staphylococcus xylosus</i> Schleifer and Kloos	6	8	8	8	8	8	46
<i>Staphylococcus sciuri</i> Kloos, Schleifer and Smith	8	6	4	3	7	5	33
<i>Staphylococcus warneri</i> Kloos and Schleifer	5	6	3	0	2	6	22
<i>Staphylococcus saprophyticus</i> (Fairbrother)	3	2	3	0	8	4	20
<i>Staphylococcus</i> spp.	2	1	1	0	3	0	7
<i>Streptococcus faecalis</i> Andrewes and Horder	3	3	3	0	3	6	18
<i>Streptococcus sanguis</i> White and Niven	3	0	1	1	0	0	5
<i>Streptococcus lactis</i> (Lister) Lohnis	0	0	1	3	0	0	4
<i>Streptococcus avium</i> Nowlan and Deibel	0	0	1	0	0	0	1
<i>Streptococcus bovis</i> variant Orla-Jensen	0	1	0	0	0	0	1
<i>Streptococcus</i> spp.	0	2	6	5	3	3	19
<i>Aerococcus viridans</i> Williams, Hirsch and Cowan	1	2	4	5	7	8	27
<i>Bacillus</i> spp.	7	8	8	6	4	0	33
coryneform bacteria	0	0	2	0	1	1	4
<i>Gemella haemolysans</i> (Thjotta and Boe) Berger	1	0	0	0	1	0	2
TOTALS	39	39	45	31	47	41	242

Table 2. The number of times each identified anaerobic bacterial species was isolated from six silphid species. N.a. = *Necrophila americana*, N.o. = *Nicrophorus orbicollis*, O.n. = *Oiceoptoma noveboracense*, O.i. = *Oiceoptoma inaequale*, N.t. = *Nicrophorus tomentosus*, N.s. = *Necrodes surinamensis*. (Silphidae-8 specimens per species were used.)

ANAEROBIC BACTERIAL ISOLATE	N.a.	N.o.	O.n.	O.i.	N.t.	N.s.	TOTALS
<i>Clostridium barati</i> Prevot	5	4	0	0	0	0	9
<i>Clostridium bifementans</i> Weinberg and Seguin	4	1	2	0	0	0	7
<i>Clostridium cadaveris</i> Klein	0	0	1	0	0	0	1
<i>Clostridium innocuum</i> Smith and King	0	0	1	0	0	0	1
<i>Clostridium</i> spp.	2	2	5	4	5	4	22
<i>Peptostreptococcus anaerobius</i> Natvig	0	0	3	5	0	0	8
<i>Bacteroides capillosus</i> (Tissier) Kelly	0	1	0	0	0	0	1
TOTALS	11	8	12	9	5	4	49

Table 3. The number of times each identified gram negative bacterial species was isolated from six silphid species. N.a. = *Necrophila americana*, N.o. = *Nicrophorus orbicollis*, O.n. = *Oiceoptoma noveboracense*, O.i. = *Oiceoptoma inaequale*, N.t. = *Nicrophorus tomentosus*, N.s. = *Necrodes surinamensis*. (Silphidae-8 specimens per species were used.)

GRAM NEGATIVE BACTERIAL ISOLATE	N.a.	N.o.	O.n.	O.i.	N.t.	N.s.	TOTALS
<i>Proteus mirabilis</i> Hauser	8	8	6	5	8	8	43
<i>Proteus vulgaris</i> Hauser	8	7	7	5	6	8	41
<i>Providencia rettgeri</i> (Hadley, Elkins, and Caldwell)	3	3	6	6	8	8	34
<i>Providencia alcalifacens</i> (De Dalles Gomes)	3	0	3	0	4	8	18
<i>Morganella morganii</i> (Winslow, Kligler, and Rothberg)	1	1	6	8	0	5	21
<i>Serratia marcescens</i> Bizio	5	5	1	1	0	0	12
<i>Serratia liquifacens</i> Grimes and Hennerty	3	0	1	1	4	0	9
<i>Serratia</i> spp.	6	2	4	5	8	8	33
<i>Citrobacter freundii</i> (Braak)	5	7	6	6	4	2	30
<i>Klebsiella pneumoniae</i> (Schroeter) Trevisan	3	5	2	0	7	3	20
<i>Klebsiella oxvtoca</i> (Flugge)	1	1	0	0	0	0	2
<i>Hafnia alvei</i> Moller	3	0	6	2	6	3	20
<i>Alcaligenes</i> spp.	0	0	3	4	0	0	7
<i>Alcaligenes</i> or <i>Morganella</i> spp.	0	0	3	0	0	0	3
<i>Pasteurella</i> or <i>Acinetobacter</i> spp.	0	0	1	2	0	0	3
<i>Enterobacter cloacae</i> (Jordan) Hormaeche and Edwards	0	0	1	2	0	0	3
<i>Pasteurella</i> spp.	0	0	0	1	0	0	1
<i>Salmonella pullorum</i> Rettger or <i>Hafnia alvei</i> Moller	0	0	0	0	2	1	3
<i>Cedacea</i> spp. or <i>Klebsiella ozonae</i> (Abel) Bergy	0	0	1	0	0	0	1
<i>Pseudomonas fluorescens</i> Migula	0	0	1	0	0	0	1
<i>Pseudomonas testosteroni</i> Marcus and Talalay or <i>Pasteurella</i> spp.	0	0	0	1	0	0	1
<i>Tautumella ptyseos</i> Hollis, Hickman and Fanning	0	0	1	0	0	0	1
<i>Mollerella wisconsinensis</i> (Farmer <i>et al.</i> )	0	0	1	0	0	0	1
No Match	2	2	0	3	1	0	8
TOTALS	51	41	60	52	58	54	316

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JOE D. PRATT: BIOPHILE

Joe D. Pratt died at 9:30 am, Sunday, June 14, 1992 while attending the Animal Behavior Society meetings in Kingston, Ontario, Canada. He was born September 29, 1945 in Bloomington, Illinois, the son of Robert James and Mary Louise Darnell Pratt.

He lived in Armington, Illinois, attending Armington Grade School and Hittle High School. Joe graduated from Southern Illinois University (Carbondale) in 1968 with a degree in biology. From 1968 to 1970, Joe served in the Army as a biological research specialist at Ford Ord, California. He did graduate work at the University of Wisconsin-Eau Claire from 1970 to 1972.

Joe was park naturalist director of Westmoor Park in West Hartford, Connecticut from 1974 to 1985. Joe returned to Illinois in 1985 and began to work for the Illinois Department of Conservation as a resource planner (August, 1986). He established Biodiversity Unlimited (to integrate sociobiology and biodiversity theory) in 1988. Joe was an ardent admirer of Edward O. Wilson and he was instrumental in attracting Dr. Wilson to the Illinois Academy of Sciences meeting at Loyola University in 1989. It was there that Joe presented Dr. Wilson with the first Benjamin D. Walsh award. This sculpture of the ant, *Daceton armigerrum*, resides in Dr. Wilson's office (Harvard University, Cambridge, Massachusetts). (See photo.)

In the years before his death, Joe developed an interest in ants. Although his publications dealt mostly with plants and natural history, his knowledge was not restricted to these areas. We participated in memorable collecting trips in central Illinois. I found his knowledge of birds, plants, and insects refreshing.

He participated in seminars and symposia (including leading numerous field trips). He was a member of various natural history related societies. Joe was past president of the Hartford Audubon Society and Connecticut Valley Mycological Society and past vice-president of the Connecticut Botanical Society. He served as director at large of the Connecticut Outdoor Education Association and as advisor of the Connecticut Geological and Natural History Survey.

Joe is survived by his wife, Judith and three sons: Landis T. Pratt of Armington, Illinois, Jedediah D. Linden, and Spencer E. Pratt, both at home. One brother, Robert N. Pratt, and one sister, Judy J. Pratt, also live in Armington.

Joe had a keen eye and a questioning mind. His frequent thought provoking questions were his trademark. These queries and zeal will be missed by those who knew him.

This paper could not have been prepared without the help of his wife, Judith. She provided a copy of Joe's resume and improved a draft of this manuscript. Her efforts are appreciated.

Mark B. DuBois, 116 Burton St., Washington, IL.

## BOOK REVIEW

THE BEETLES OF THE WORLD. VOL. 18. CICINDELIDAE 3. THE NEARCTIC REGION. Karl Werner. 1993. Sciences Nat., Venette, France. 163 pp. 24 pl. Text in German, English, and French.

This is another in a series of fine books that attempt to provide species identification almost exclusively by means of beautiful photographs. Included in this volume are the genera *Ctenostoma* (7 sp.), *Amblycheila* (7 sp.), *Omus* (15 sp.), *Tetracha* (7 sp.), *Oxycheila* (1 sp.), *Pseudoxycheila* (1 sp.), *Iresia* (1 sp.), *Odontocheila* (7 sp.), *Pentacomia* (2 sp.), *Oxygenia* (1 sp.), and 35 species of *Cicindela*. Presumably, the balance of the approximately 150 species of Nearctic *Cicindela* will be included in future volumes. In addition to the specimen illustrations, some of the species, or groups of species found in similar habitats, are illustrated with a color habitus photograph. In all, there are 19 color plates illustrating 202 species and 13 habitat photographs.

The specimen photographs are outstanding and well illustrate such obvious characters as shape, relative size, elytral maculation, and color but because there are no species descriptions, and no keys, it is difficult to understand how it is possible to identify very closely related species (ex: *C. longilabris* vs. *C. nebraskana*) and the many subspecies (ex: the 12 listed ssp. of *C. tranquebarica*) without more complete descriptive information. Details of structure simply can not be seen in dorsal habitus photographs. What are provided are complete citations to original descriptions, synonyms, degree of rarity (in collections!), size, type locality, distribution, field notes from cited collectors, and subspecies with citations.

All in all, this is a very beautiful book but perhaps better suited for a coffee table than for a taxonomist's library.

H.P.B.

## IMMIGRANT ARTHROPOD PROJECT

We would like to invite you to participate in a project seeking to gather information on the immigrant arthropods of North America. We would like to obtain documented information, specimens, or published records, on immigrant species of insects or arachnids that you have worked on. In order to best accomplish our task we seek participation of all entomologists.

The goals of this project are: 1) to determine the current status of non-indigenous insects and arachnids in North America; 2) to determine distribution, pathways, and economic/environmental impacts caused by the introduction and spread of non-indigenous arthropods in North America; 3) to compile information on immigrant insects and arachnids and develop a database compatible with the NAIAD.

The development of this database is funded by the National Biological Control Institute (NBCI), USDA/APHIS. The database will be merged with the North American Immigrant Arthropod Database/Western Hemisphere Immigrant Arthropod Database (NAIAD/WHIAD). When completed, it will be available to researchers and the scientific community and will be useful for many applications. We are also planning to have a symposium on immigrant insects and arachnids based on the results of this project in 1995.

If interested in participating in this project or the conference, please contact: K.C. Kim, NBCI Project Manager, or J. Slusark, NBCI Project, The Pennsylvania State University, Dep't. of Entomology, 501 ASI Bldg, University Park, PA 16802, USA.

When submitting papers, all authors are requested to (1) provide the names of two qualified individuals who have critically reviewed the manuscript *before* it is submitted and (2) suggest the names and addresses of two qualified authorities in the subject field to whom the manuscript may be referred by the editor for final review. All papers are submitted to recognized authorities for final review before acceptance.

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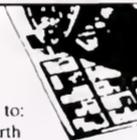
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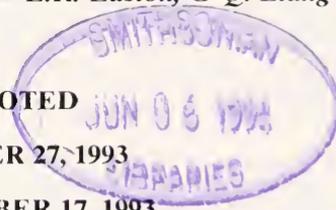
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## COLONY FOUNDING BY QUEENS OF *SOLENOPTIS MOLESTA* (HYMENOPTERA: FORMICIDAE)<sup>1</sup>

Ben R. DuBois<sup>2,3</sup>, Mark B. DuBois<sup>2,3,4</sup>

**ABSTRACT:** Founding queens of *Solenopsis molesta* were collected, isolated, and studied for 100 days. Although the presumed method of colony foundation is haplometrotic, only two queens established colonies with workers during this time. Minimum developmental time was determined to be 49 days from egg to worker at 23 degrees C. Queens began to lay eggs 3 days after mating. Less than 50% of the queens survived the first 100 days. The biology of these founding queens is reviewed and briefly compared with the distantly related *Solenopsis invicta*.

Although the preferred habitat of *Solenopsis molesta* is open fields and meadows (Wilson and Hunt, 1966), this species readily accepts suburban lawns (DuBois and La Berge, 1988). Most colonies have a single queen. In spite of its abundance, many aspects of the biology of this species, including details of nest establishment, are unknown.

Ant colonies may have three stages of growth; a founding stage, an exponential growth stage, and a reproductive stage (Oster and Wilson, 1978). Previous studies of *S. molesta* have concentrated upon the latter two stages of colony growth. McColloch and Hayes (1916) studied the economic importance and life history of *S. molesta*. Development was summarized as follows: egg stage 16-28 days, larvae 21 days, semi-pupa [last instar larvae] 2-11 days, pupae 13-27 days; minimum development time (egg to adult worker), 52 days. Overwintering larvae had significantly longer development times. Their findings were based upon mature colonies collected in the field and observed in the lab. They noted that "queens unattended by workers will rear and care for their young." (McColloch and Hayes, 1916: 31). They inferred newly fertilized queens are able to establish colonies without worker assistance.

Hayes (1920) confirmed that minimum worker development time from egg to adult, in an established colony, is 52 days. He provided detailed descriptions of worker, queen, male, and immature stages and noted that the number of fertile queens ranged from one per colony to one colony containing 26 dealate queens. No queens in laboratory colonies lived through an entire summer nor survived over winter.

<sup>1</sup> Received August 17, 1993. Accepted October 3, 1993.

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<sup>3</sup> Send reprint requests to Washington, Illinois address.

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However, he noted queens were discovered outdoors in May, indicating they could survive the winter under natural conditions.

Macnamara (1945) briefly reported on a nuptial flight of this species. He encountered "two or three small clouds of insects" which were identified as *Solenopsis molesta*. He described the swarms further and noted that some queens were carrying workers. He estimated the swarms might contain tens of thousands of queens with every third queen carrying a worker.

Wilson and Hunt (1966) studied habitat selection by *Solenopsis molesta* queens during and after their nuptial flight. Queens actively selected a preferred macrohabitat ("mowed fields"), but relocated queens would accept alternative habitats. Once queens landed, they exhibited microhabitat selection by locating, a "sheltering leaf, grass stem, or clump of earth." (Wilson and Hunt, 1966: 487).

In July 1991, founding queens of *Solenopsis molesta* were collected and placed together in a suitable nesting chamber. Mortality among queens was high; all but one was dead when the first workers emerged. The resulting colony never achieved significant size, and the remaining queen died within two months of the first worker emergence (M. DuBois, pers. obs.). Due to the limited published studies on colony founding of this species and the above observations, it was decided to determine if reproductives of this species could establish colonies haplometrotically.

## MATERIALS AND METHODS

Queens were collected at dusk (8:30-9:30 pm) on July 26, 1992 [ILLINOIS: Tazewell Co., Washington, 116 Burton Street]. Presumably, they had recently descended from their mating flight, as no nearby colonies were releasing reproductives and there were no workers nearby. Queens were walking on a brick sidewalk and a concrete driveway, and were presumably engaged in the microhabitat selection described by Wilson and Hunt (1966). Most queens had shed their wings; a few were starting to tunnel into the sand between the bricks in the sidewalk. A total of 62 queens were collected from the surface. No workers were found in association with the queens. An area slightly in excess of 30 m<sup>2</sup> was searched. It was apparent that the abundance of queens extended beyond the immediate range; however, the full extent of the area could not be determined (due to lawns and fences in this disturbed, urban setting). Nearby areas searched in a cursory fashion revealed a similar concentration (2 queens per m<sup>2</sup>). Subsequent searching on the following night (July 27) revealed 2 additional isolated queens. No additional queens were located on following nights (July 28 on).

Ants were observed (July 26) when the air was dry with no wind. It had rained heavily the previous day (over 3 cm) with sporadic rainstorms for several days preceding as well. The soil was visibly moist. Air temperature was 19.5 degrees C, relative humidity was 61% and barometric pressure was 737 mm Hg (constant).

Individual queens were isolated in test tubes (1 cm diameter) partly filled with water (separated from the queen by a cotton plug). Each tube was capped with another cotton plug. Queens were observed daily (under red light) and verified they were alive by noting motion of legs or antennae. Records were taken noting ambient air temperature, time, presence and type of brood (including workers). Queens were observed for 100 days. By that time (early November), the outside environment was too cold for ants to function. Queens were then refrigerated for further study the following spring. They were stored between 5 and 6 degrees C for 164 days at 100% humidity.

Voucher specimens (queens) have been deposited in the authors' personal collection and the Illinois Natural History Survey.

## RESULTS

Only 26 of the 62 queens survived two months in the lab (table 2). Initial mortality may have been due to handling during capture; however, subsequent deaths occurred at a steady rate through the remainder of the study (on average 1 queen died every 3 days) (figure 1). Of the 62 queens observed, 5 (8%) established colonies with workers. Of these 5 colonies, only 2 (3%) survived with workers until the end of 100 days. Prime causes of death appeared to be related to various molds which became established in the damp chambers.

All queens began laying eggs within 10 days. Egg laying then decreased through most of the remaining days (figure 1). Those queens which established successful colonies were ones which were able to rear their offspring from these initial eggs. Queens which lost their initial investment in eggs due to mold or cannibalism were only able to rear larvae within the first 100 days. Only 8 queens successfully reared their offspring to the pupal stage (figure 1). By the end of the 100 days, there were no pupae. Similarly, only 5 queens were able to produce workers (figure 1).

Minimum developmental times were observed for all stages. Although some individuals took longer at various stages, the time indicated (table 1) represents the minimum amount of time for a founding queen to establish a colony with at least one worker present. The first worker actually appeared on day 53 (figure 1). Although minimum

developmental time was 49 days, queens did not begin laying eggs until 3 days after mating.

Colony composition was reviewed every 20 days (table 2). After 20 days, August 14, 1992, all queens had both eggs and larvae. Forty days after capture (September 3) some pupae were present in a few nests; however a number of queens (18) had no developing brood at all. Sixty days after capture (September 23) four queens had mature workers. By October 3 (80 days after capture) the number of queens lacking brood had increased to 21. This remained constant through 100 days.

Queens were removed for further study on April 10, 1993 (164 days after being refrigerated). Of the 26 queens refrigerated, 5 died demonstrating that queens can survive low temperatures for extended periods of time.

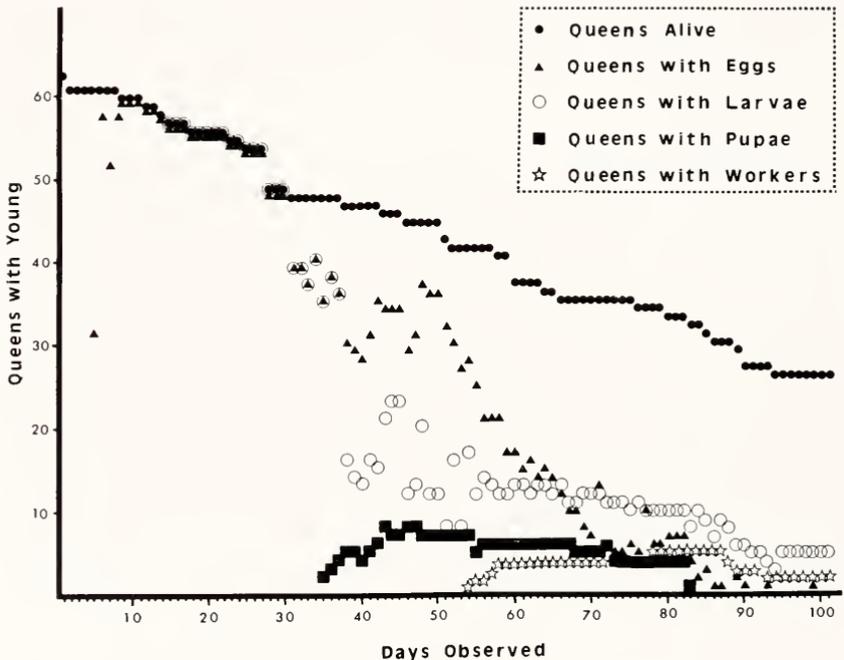


Figure 1. Development of colonies from founding queens (number of queens with young) of *Solenopsis molesta*. Once queens died, unattended offspring died rapidly. The first 101 days of growth are shown. For further discussion, see text.

## DISCUSSION

The ant tribe Solenopsidini contains two dominant genera: *Monomorium* and *Solenopsis*. Over 300 species of *Monomorium* have been described (DuBois, 1986; Bolton, 1987). Of these only *Monomorium pharaonis* has been comprehensively studied (for example, Peacock and Baxter, 1950). *Solenopsis* contains a comparable number of species; only the biology of the "fire ant," *Solenopsis invicta* has been studied in depth (for an early example, Wilson 1966). Thus, only 2 species out of over 500 have been extensively studied.

It is reasonable to expect that young colonies of *S. molesta* will attempt to maximize the number of workers. Ants foraging for food are most susceptible to predation. Therefore, most queens found their colonies in isolation (histolyzing their flight muscles for nourishment and production of trophic eggs to feed their offspring). By rapidly generating workers a colony increases its chance for success (Oster and Wilson, 1978).

Assuming that queens dispersing after their mating flight cover a reasonably large area in a relatively uniform manner (as was observed), initial concentrations of queens appear relatively high (about 2 per m<sup>2</sup> in the area searched). Extrapolated to a hectare, this would yield about 20,500 queens per hectare. Macnamara (1945) observed tens of thousands of queens per mating swarm. Since queens should live at least three years (based upon observations of laboratory colonies), this means a potential concentration of over 6.1 colonies per m<sup>2</sup> within three years. It appears that mating flights populate the same area with founding queens every year (pers. obs.). Previous field observations yielded observed densities of less than 1 colony per m<sup>2</sup>. Mortality must play a significant role in the actual number of colonies.

It appears that colony foundation in *Solenopsis molesta* is haplometrotic. However, some ants have diverse methods of colony foundation. For example, the Australian meat ant, *Iridomyrmex purpureus*, is capable of founding colonies haplometrotically, pleometrotically, or by colony budding (Hölldobler and Carlin, 1985). Furthermore, Tschinkel and Howard (1983) indicated that newly mated queens of *Solenopsis invicta* are able to establish colonies either haplometrotically or by cooperating with other queens (pleometrotically). No workers were found accompanying queens in this study in contrast with Macnamara's (1945) findings. Additionally, MacKay *et al.* (1991) reported that survivorship among queens in monogynous colonies of *S. invicta* was higher than for queens in polygynous colonies. Additional studies of *S. molesta* should compare queens isolated in chambers and grouped

together. Although clusters of dealate queens of *S. invicta* are observed in the field, no such clusters have been noted for *S. molesta*.

Minimum development times in this study agree with those reported by McColloch and Hayes (1916) and Hayes (1920). Development of offspring is slower in *Solenopsis molesta* than the distantly related (and larger) *S. invicta*. Kahn *et al.* (1967) reported that queens of *S. invicta* produced workers in 22-28 days. Markin *et al.* (1972) determined the optimum temperature for development was 29.5 degrees C with workers produced in 22 days. Optimum developmental temperature for *S. molesta* is unknown. Average temperature in the present study was 23 degrees C. Data from Markin *et al.* (1972) for average temperature of 24 degrees C yielded similar developmental times for *S. invicta*.

Queen mortality in the laboratory was high and only a small percentage (3%) of newly mated queens of *Solenopsis molesta* were able to establish colonies after 100 days. This contrasts with the distantly related *Solenopsis invicta*. Stringer *et al.* (1976) reported that 74% (111 out of 150 queens) had produced worker ants within 8 weeks. Given the relatively small size of *Solenopsis molesta* queens, they may be more susceptible to desiccation. O'Neal and Markin (1973) reported that eggs are rapidly attacked by fungus without almost continual care. Additionally, Markin *et al.* (1972) reported that developing larvae of *Solenopsis invicta* are fed trophic eggs. This was also observed in *Solenopsis molesta*. There may be a limit to the number of trophic eggs which each queen can produce by histolyzing her flight muscles. This might prevent queens from having more than one chance at establishing their colonies.

It is hoped this paper stimulates further biological investigations on other species of the ant tribe Solenopsidini. It has been demonstrated that *S. molesta* can establish colonies in the lab (haplometrotically) and that queens can be kept under refrigeration for extended periods of time.

Table 1. Minimum development times for each life stage of *Solenopsis molesta* workers. For further discussion, see text.

Life Stage	Minimum Development Time (Days)
Egg	11
Larva	19
Pupa	19
TOTAL DAYS	49

Table 2. Development details within each colony at selected dates. Dates are shown every 20 days from date founding queens were collected. For further discussion, see text.

Table 2.

Date (Days after Capture)	Queens Alive	Queens with Eggs	Queens with Larvae	Queens with Pupae	Queens with Workers	Queens with No Brood
14-Aug-92 (20 days)	55	55	55	0	0	0
03-Sep-92 (40 days)	46	28	13	4	0	18
23-Sep-92 (60 days)	37	17	13	6	4	20
13-Oct-92 (80 days)	33	7	10	4	5	21
02-Nov-92 (100 days)	26	0	5	0	2	21

#### ACKNOWLEDGMENTS

We wish to thank Jeri DuBois for tolerating numerous ant colonies in the house. Without her support, this work would not have been possible. The following individuals contributed to the quality of the manuscript with their reviews: Wallace LaBerge and Larry Page (Illinois Natural History Survey), Jon Gelhaus (Academy of Natural Sciences), Mark Deyrup (Archbold Biological Station), and Lloyd Davis, Jr. (U.S.D A). We accept responsibility for any errors or omissions which have remained.

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### BOOK RECEIVED AND BRIEFLY NOTED

**THE DANCE LANGUAGE AND ORIENTATION OF BEES.** Karl von Frisch. 1993 Harvard University Press. 566 pp. \$29.95 ppbk.

Now available for the first time in paperback, *The Dance Language and Orientation of Bees*, originally published in 1967, described in non-technical language what Professor Karl von Frisch discovered in a lifetime of studies about honeybees — their methods of orientation, their sensory faculties, and their remarkable ability to communicate with one another. Thomas Seeley's new foreword traces the revolutionary effects of von Frisch's work, not just for the study of bees, but for all subsequent research in animal behavior. A great opportunity at a bargain price.

### ERRATA

In the paper by W.P. McCafferty on "Distributional and classificatory supplement to the burrowing mayflies of the United States" in the Vol. 105, No. 1, January & February, 1994 issue of ENT. NEWS, two last minute printer's errors developed on page 11.

First, the last line on page 10 was repeated as the top line on page 11. This line should be deleted on the top of page 11.

Second, the last line of text on page 11, above Table 1, was dropped out. This line, which needs to be reinserted, should have read:

vae). PENNSYLVANIA, L.M. Bartlett (larvae), no other data. VIR-

ENT. NEWS regrets these errors. Complete new reprints have been furnished to the author and are available from him.

## OCCURRENCE OF *LIMONIA (GERANOMYIA) COMMUNIS* (DIPTERA: TIPULIDAE) IN A MAMMOTH HOT SPRING, WYOMING<sup>1</sup>

Dennis H. Bartow<sup>2</sup>

**ABSTRACT:** *Limonia (Geranomyia) communis* is recorded for the first time from a thermal environment. This represents the first tipulid among 51 dipterous species collected from thermal habitats in the continental United States.

A 1972 survey of the literature concerning insects inhabiting hot springs in the continental United States (Bartow, 1972) and subsequent research (Barnby, 1987; Resh, 1984) has to date identified 50 species of Diptera but includes no records of tipulid species inhabiting thermal waters. While a Seasonal Park Ranger Naturalist at Yellowstone National Park in 1970, I had the opportunity to survey the insects inhabiting hot springs in the Mammoth Hot Springs region of the park. During the survey one tipulid pupa and one pupal case were taken from the face of Orange Mound Spring and were subsequently identified as *Limonia (Geranomyia) communis* (Osten Sacken). G. W. Byers (1977, personal communication) indicated that, although tipulids have been collected from moist runoff areas surrounding hot springs (he collected *L. (G.) ibis* (Alexander) from algae in warm water on a thermal-water fountain at Hot Springs National Park, Arkansas), none have definitely been associated with a hot spring or thermal gradient for breeding. To my knowledge, this collection represents the first published record of association of tipulids with a hot spring habitat in the United States.

The habitat consists of a thin sheet of water slowly flowing over the nearly vertical surface of the hot spring formation (primarily travertine limestone) the surface of which is roughened by the irregular deposition of minerals from the hot spring. The micro-habitat consists of "mini-shelves" of mineral deposition which trap minute pools of water (>1 mm in depth) from which the pupa and pupal case were collected. The collection site is consistent with the habitat of the subgenus described by Pennak (1953) as being "On cliffs or rock faces, in or beneath algal scum with percolating or flowing water..." The temperature of the water at this location was 27.2°C (79°F), whereas it was 60.6°C (141°F) at the source of the spring. As the specimens were collected at a temperature lower than

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30°C., the temperature limit to which accumulated precipitation may be heated naturally by sunlight in desert areas (Brues, 1928) and therefore the lower threshold of the thermal environment, this species may be classified as a sub-thermal form. However, as only two specimens were collected from this location, and the normal habitats of species of *Limonia* (*Geranomyia*) and of this species are in cooler waters, one should refer to the temperature of collection as in its upper range of tolerance rather than the maximum temperature that the species can tolerate (Lutz, 1931). Additional collections may determine that the upper thermal tolerance of *Limonia* (*Geranomyia*) *communis* is within the true thermal habitats hot springs create.

#### ACKNOWLEDGMENTS

I thank George Morrison, former Acting North District Naturalist, Mammoth Hot Springs, Yellowstone National Park, Wyoming, for his assistance and encouragement in my 1970 survey, and George W. Byers and Ernest M. May (Snow Entomological Museum, University of Kansas) for identifying the specimens of *Limonia* (*Geranomyia*) *communis*, and for their critical review of the manuscript and helpful suggestions in its development.

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**FIRST RECORD OF CAMPODEA (S. STR.)  
PEMPTUROCHAETA (DIPLURA: CAMPODEIDAE)  
FROM NORTH AMERICA<sup>1</sup>**

Robert T. Allen<sup>2</sup>

**ABSTRACT:** *Campodea* (s. str.) *pempturochaeta*, previously recorded from Italy, Spain and Algeria, is reported for the first time in North America (Delaware, New Castle Co., Middle Run Nature Area near Newark). A brief description and illustrations of the more pertinent characters are given. Also collected at the same locality was the dipluran *Eumesocampa fragillilis* (Hilton) representing a new state record for this species.

Eighteen species and four subspecies of Diplura in the nominate subgenus *Campodea* have been recorded from North America (Allen, 1993, ms). Only six of these *Campodea* (s. str.) species have been recorded east of the Mississippi River Valley: *C. fragilis* Meinert; *C. lubbocki* Silvestri; *C. ludoviciana* Conde and Geeraert; *C. meinerti* Bagnall; *C. plusiochaeta* (Silvestri); *C. rhopalota* Dennis. The remaining twelve species and four subspecies of *Campodea* are western, with the majority known only from California.

Of the six *Campodea* species recorded from eastern North America *C. fragilis* is the most wide spread being found in Connecticut, Illinois, Kentucky, Massachusetts, New York, New Jersey, Ohio and in a number of western states. *Campodea ludoviciana* has been recorded only from St. Charles Parish in Louisiana. *Campodea lubbocki* and *C. meinerti* have been recorded from single localities in Massachusetts, and *C. rhopalota* from one locality in western New York (Conde, 1973). The latter three species had previously been known only from Europe. To this list of European species now known from North America may be added *Campodea* (s. str.) *pempturochaeta* Silvestri.

Collections made during October and November, 1992 and March, 1993, from Middle Run Nature Area near Newark, Delaware (New Castle Co.) produced a large number of Symphyla (Allen and Walther, 1993) and a much smaller number of Diplura. Only two Diplura species, *C. pempturochaeta* and *Eumesocampa fragillilis* (Hilton), were collected. A total of eight adults and forty immatures of *C. pempturochaeta* were collected from leaf litter samples. Two specimens of *E. fragillilis* were hand collected beneath rocks. This latter species had previously been recorded from Maryland, New York, Ohio and Pennsylvania (Conde,

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1973). In comparison, four species of Symphyla in four different genera (over 250 specimens) have been identified from the leaf litter samples (Allen and Walther, 1993).

## METHODS AND MATERIALS

Forty-eight specimens of *C. pempturochaeta* (8 adults, 40 immatures) were collected from leaf litter samples. All specimens, including the two *E. frigillis* specimens, were initially collected in 70% ethyl alcohol and held until mounted on microscope slides. The mounting medium used for slide preparation was a commercially available Polyvinyl alcohol, phenol and lactic acid mixture. Clearing the specimens before mounting is seldom necessary with Campodeidae.

Illustrations were prepared using a drawing tube attached to a Nikon microscope. Measurements were made using the Jandel Video Analysis Software (JAVA) package and are in millimeters (mm.).

The following is a brief description of *C. pempturochaeta*, accompanied by illustrations, that will assist in the recognition of the species.

### *Campodea pempturochaeta* Silvestri 1912:128

Measurements (in millimeters based on the 8 adult specimens). Total length: adults, males, 3.01 (2.85-3.11); females, 3.62 (3.15-3.92); immatures vary greatly in size depending on the age but are generally much smaller (1.43) than the adults and with fewer setae. Ratios combine male and female data. Head, length to width: .88. The following ratios are the length of the lateral posterior macrochaeta (*lp*) to the distance between *lp*'s: pronotum, .56; mesonotum, .40; metanotum, .43; tergite V, .40; tergite VI, .35.

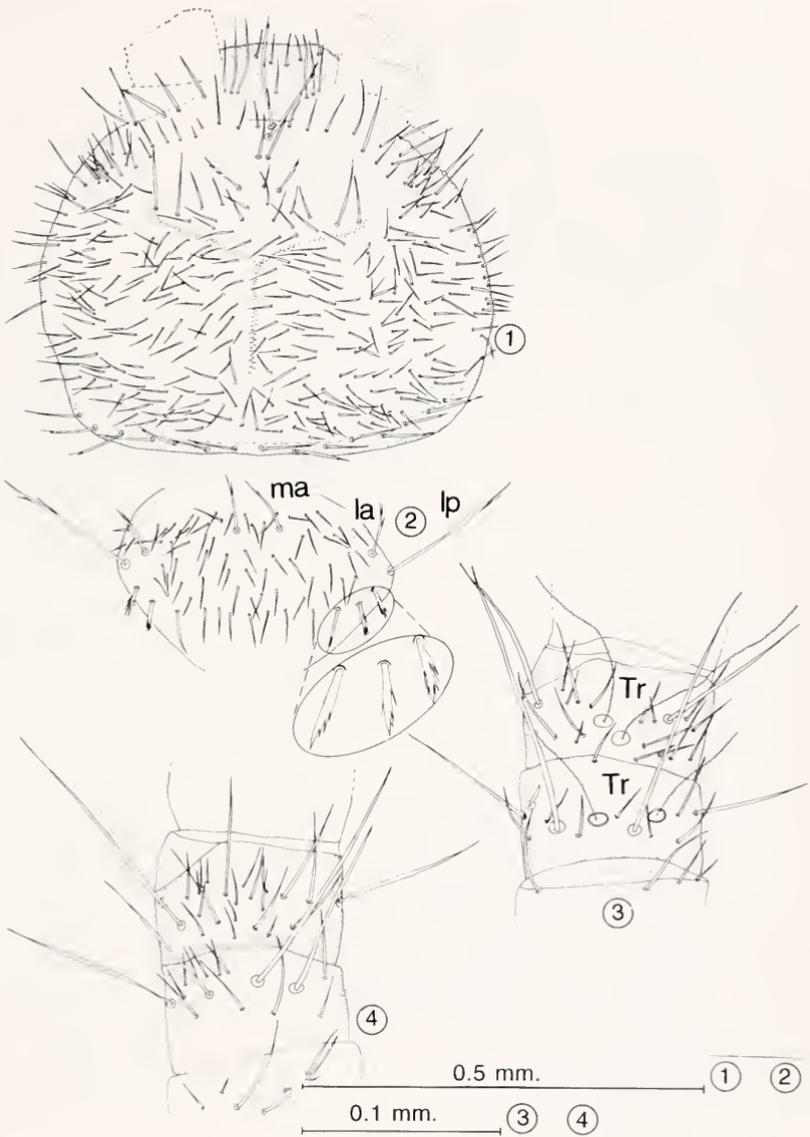
Head, Fig. 1. Moderately setose; cranial sutures distinct; mouth parts and ventral setae normal for the subgenus.

Thorax, Figs 2, 5-7. Pro- (Fig. 2), meso- (Fig.6) and metanota (Fig. 7) with 3 + 3, 3 + 3 and 2 + 2 macrochaetae respectively; surface moderately setose; 3-4 outer setae on posterior margin between *lp*'s short, distinctly barbed (Fig. 2).

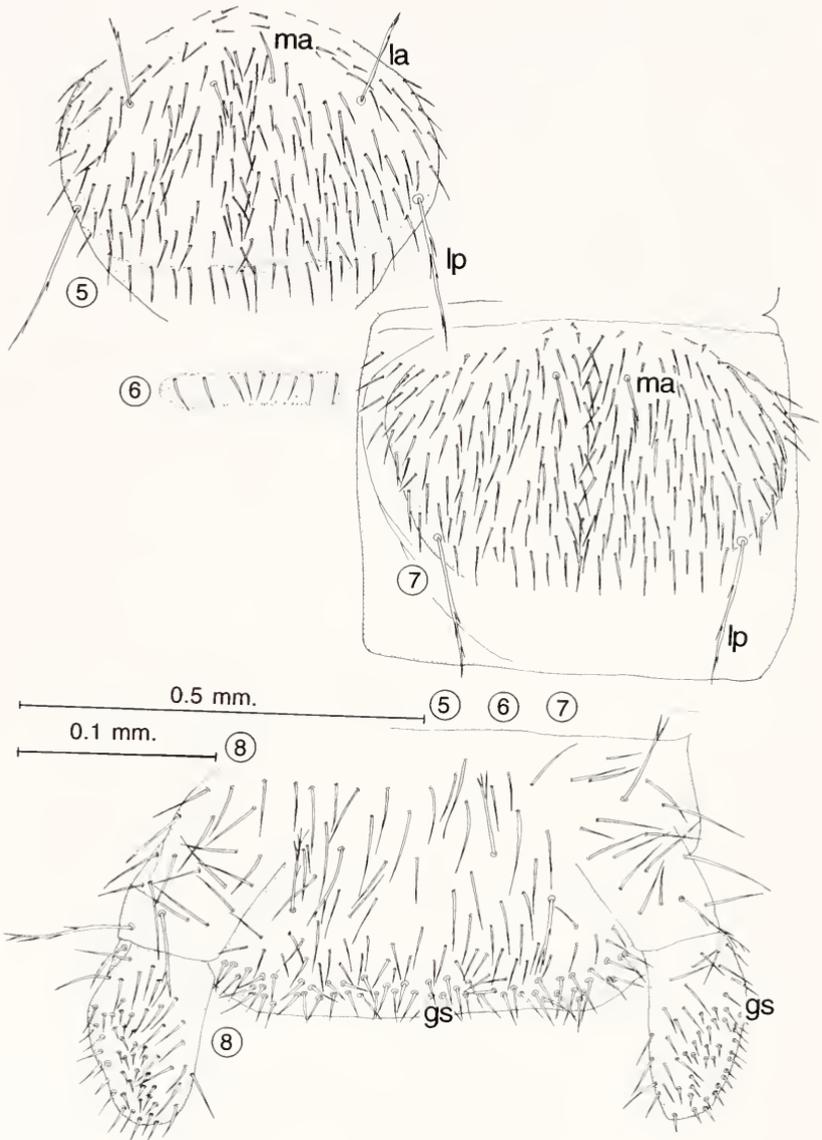
Antennae, Figs 3-4. Number of segments in adults uncertain, 21 segments in one specimen; two trichobothria on dorsum of segments III-VI (Fig. 3); apical segment elongate with pupiliform organ.

Abdomen, Figs. 9-10. All tergites without a pair of median anterior setae (*ma*) (Figs. 9-10); *la* and *lp* beginning on tergite V (Fig. 10). Sternum I: males with distinct glandular setae (Fig. 8) arranged in two irregular rows along the posterior margin, setae numbering about 50-60; lateral subcoxal organs large, with glandular setae and elongate setae (Fig. 8), apical segment distinctly articulated with basal area. Additional sternites normal for the subgenus (Figs. 12-13).

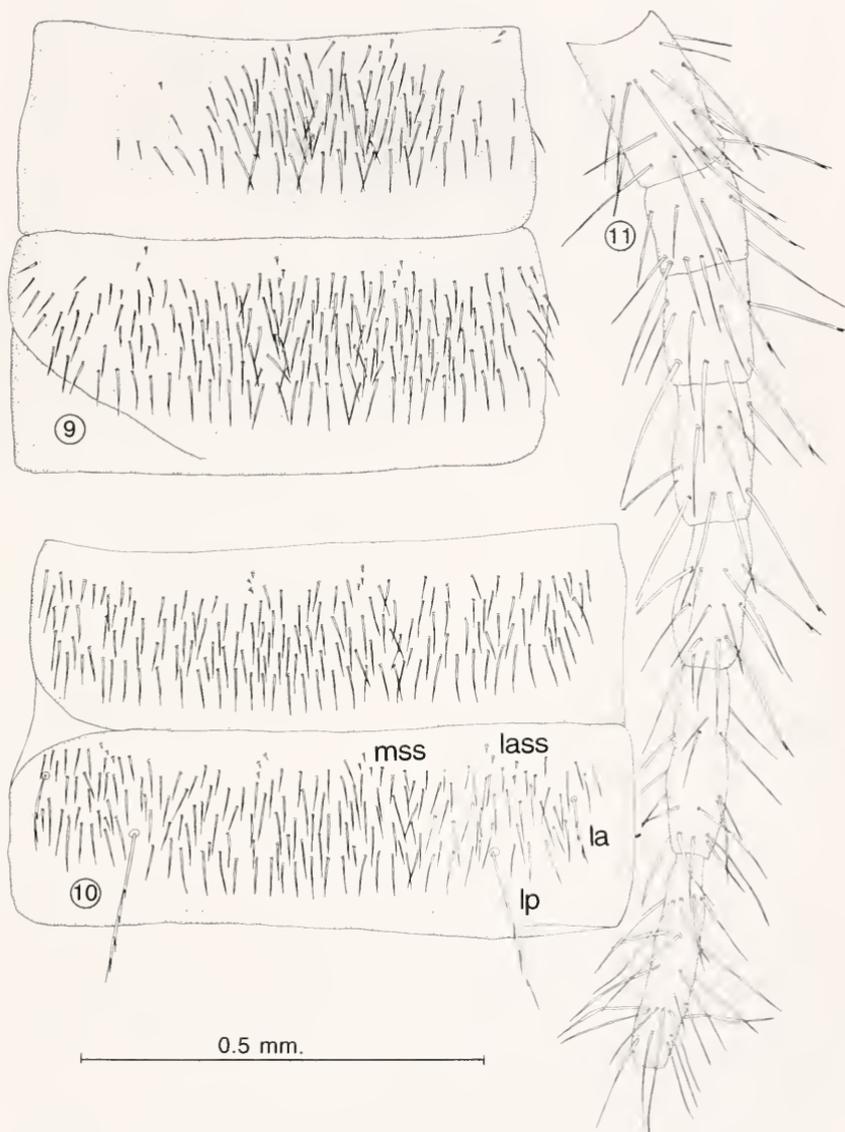
Immatures, Figs. 14-16. Much smaller than the adults and sparsely setose. The *lp*'s on the nota and abdominal tergites present.



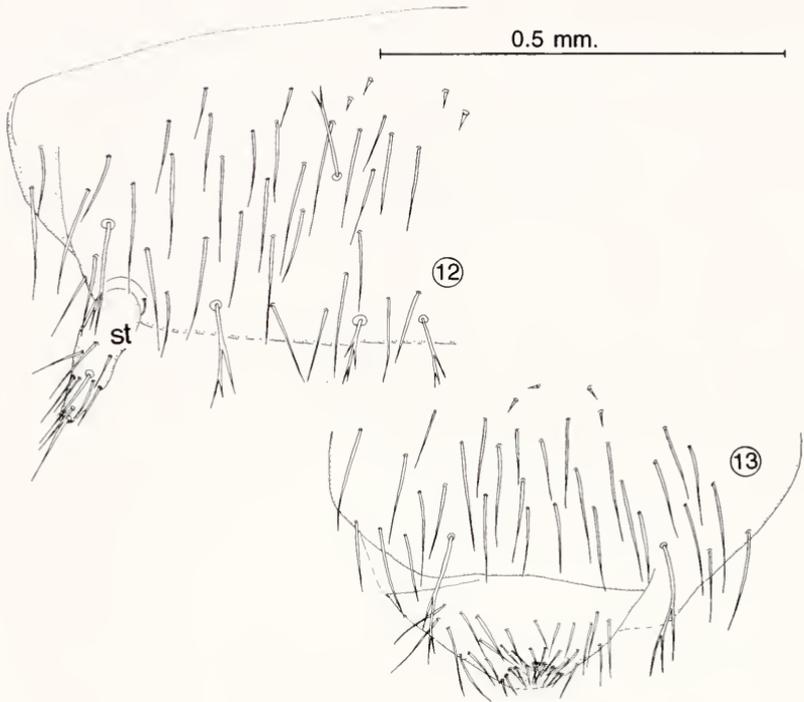
Figures 1-4, *Campodea pempturochaeta*. (1) Head, dorsal. (2) Pronotum. (3-4) Antennal segments III-IV showing insertion of phaneres, trichobothria and basiform sensillum; (3) dorsal; (4) ventral. ma = median anterior macrochaeta, la = lateral anterior macrochaeta, lp = lateral posterior macrochaeta, Tr = trichobothria.



Figures 5-8. *Campodea pempturochaeta*. (5) Mesonotum. (6) Intersclerite between mesonotum and metanotum. (7) Metanotum. (8) Sternum of abdominal segment I. gs = glandular setae.



Figures 9-11. *Campodea pempturochaeta*. (9) Tergites I-II. (10) Tergites IV-V. (11) Cercus. mss = median anterior small setae, lass = lateral anterior small setae.

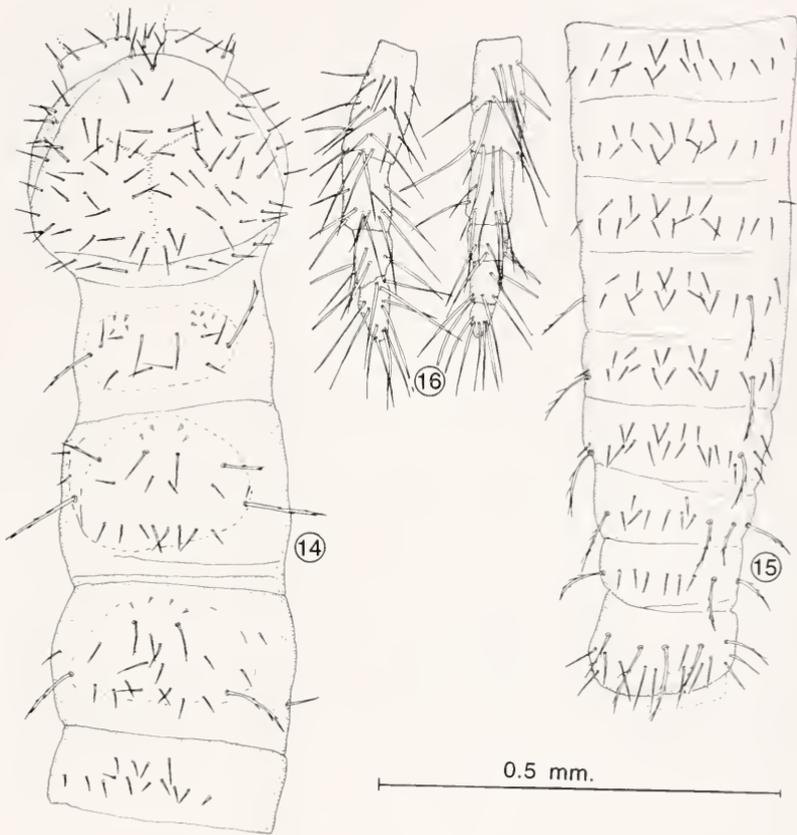


Figures 12-13. *Campodea pempturochaeta*. (12) Sternite IV. (13) Sternite VIII including the male genital area. st = abdominal stylus.

## DISCUSSION

*Campodea pempturochaeta* was first described as a subspecies of *C. fragilis* by Silvestri (1912) from Naples, Italy. Subsequently the taxon was raised to a full species (Wygodzinsky, 1941) and recorded from Spain and Algeria (Conde, 1948; Paclt, 1967). This is the first record of the species from North America. *Campodea pempturochaeta* closely resembles *C. fragilis* but may be easily recognized by the presence of an *lp* and *la* macrochaeta on abdominal tergite V.

The question arises as to whether North American *C. pempturochaeta* are different from European populations. Based on comparison with the literature description, the two populations appear to be the same species (Silvestri, 1912). This was also apparently true for the



Figures 14-16. *Campodea pempturochaeta*, immature form, dorsum. (14) Head, thoracic nota I, II, III and tergite I. (15) Tergites II-X. (16) Cerci.

other three *Campodea* species (*C. lubbocki*, *C. meinerti*, *C. rhopalota*) previously known from Europe but recorded from localities in Massachusetts and New York by Conde (1973). This raises the question of whether or not these species, and perhaps others, are historical introductions from Europe. Lindroth (1967) discussed the possible introduction of 375-417 species of animals into North America from Europe. Some of the introduced insect species were apparently brought over in the ballast of sailing ships during the 19th Century. If the four *Campodea* species are not artificial introductions, then they represent species with very wide geographical distributions. If they originally represented

four wide spread species on the former Euro-America segment of Laurasia prior to the opening of the North Atlantic 65 million years ago, they have changed very little, at least in their external anatomical structure, during the intervening long period of isolation. The paucity of collecting records and knowledge about the Diplura and most of the Apterygota in general, prevents conjecture at this time.

#### ACKNOWLEDGMENTS

I wish to thank Denise Walther for her diligent work collecting, inventorying and preparing the insects from Middle Run Nature Area. T. K. Wood and D. W. Tallamy read the manuscript and offered helpful suggestions.

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**BOOK REVIEW**

WRENSCH, D.L. & M.A. EBBERT. 1991. *EVOLUTION AND DIVERSITY OF SEX RATIO IN INSECTS AND MITES*. Chapman & Hall, NY. 630 pp. \$49.00 (paper), \$97.95 (hard cover).

Workers in several branches of entomology (e.g. biological control, reproductive biology, apiculture, etc.) have long been aware that many insects and mites do not have the one female: one male sex ratio that is common among animals. Some species are 100% female, some can control the sex of their progeny, while the sex of others are regulated by environmental factors such as daylength, temperature, or food quality. Unfortunately, the causes and mechanisms for exceptional sex ratios are unknown for some species, and confusing and complex for others. This book is a valuable reference for entomologists who wish to understand the latest developments on this subject.

There are 28 authors of the 17 chapters in the book. About two thirds of the authors are from the U.S., and the rest are from seven other countries.

To summarize the contents of this large book in the space available here, I've listed the chapter titles and authors: 1) Phylogenetic perspectives on genetic systems and reproductive modes of mites: Norton, Kethley, Johnston, & O'Connor; 2) Patterns of reproduction in insects: Suomalainen & Saura; 3) Evolutionary flexibility through haploid males or how chance favors the prepared genome: Wrensch; 4) Endosymbiotic sex ratio distorters in insects and mites: Ebbert; 5) Evolution of sex determination and sex ratio within the mite cohort Tarsonemina: Kaliszewski & Wrensch; 6) Sex allocation ratio selection in Thysanoptera: Crespi; 7) Ecology and evolution of biased sex ratios in bark and ambrosia beetles: Kirkendall; 8) Evolution of sex ratio variation in aphids: Moran; 9) Sex allocation in social insects: problems in prediction and estimation; Crozier & Pamilo; 10) Male parentage and sexual deception in the social Hymenoptera: Nonacs; 11) Sex ratio and virginity in haplodiploid insects: Godfray & Hardy; 12) Sex ratio manipulation by parasitic wasps: King; 13) Sex determination and sex ratio patterns in parasitic Hymenoptera: Luck, Stouthamer, & Nunney; 14) Sex ratio evolution in parasitic wasps: Orzack; 15) Sex allocation and pseudoarrhenotoky in phytoseiid mites: Sabelis & Nagelkerke; 16) Alteration of sex ratios of parasitoids for use in biological control: Hall; and 17) Quantitative genetics applied to haplodiploid insects and mites: Margolies & Cox.

This is a large book, with advanced terminology and discussions of complex phenomena. Most readers will welcome the 11-page glossary of terms, and the indices to authors cited, taxonomic names, and subjects are also helpful. I recommend this book to libraries used by graduate students and teachers, and to researchers who are working on sex ratios.

W. H. Day.  
USDA-ARS-BIRL, Newark, DE

## NEW RECORDS OF STONEFLIES (PLECOPTERA) FROM PENNSYLVANIA<sup>1</sup>

Jane Earle<sup>2</sup>

**ABSTRACT:** Fourteen species of Plecoptera, *Allocaupnia aurora*, *A. simmonsii*, *Paraleuctra sara*, *Ostrocerca albidipennis*, *O. prolongata*, *Prostoia completa*, *P. similis*, *Bolotoperla rossi*, *Oemopteryx contorta*, *Taenionema atlanticum*, *Taeniopteryx ugola*, *Acroneuria filicis*, *Agnatina flavescens* and *Hansonoperla appalachia* are reported for the first time from Pennsylvania. Two additional species, *Diploperla duplicata* and *Agnatina capitata* are confirmed for the state. *Alloperla neglecta*, *Isogenoides doratus* and *Yugus arinus* are deleted from the state list. With these additions and deletions, the number of species known from Pennsylvania is 113.

Surdick and Kim (1976) published a synopsis of the stoneflies of Pennsylvania, listing 90 species. Stark *et al.* (1986) and Stewart and Stark (1988) listed 95 species as having been recorded from Pennsylvania, adding *Alloperla concolor* Ricker, *A. vostoki* Ricker, *Sweltsa onkos* (Ricker), *Utaperla gaspesiana* Harper and Roy, *Malirekus iroquois* Stark and Szczytko and *Yugus arinus* (Frison); substituting *Agnatina annulipes* (Hagen) for *Agnatina capitata* (Pictet), *Diploperla robusta* Stark and Gaufin for *D. duplicata* (Banks); and deleting *Paragnetina fumosa* (Banks). Other species additions have been *Alloperla chloris* Frison, *A. imbecilla* (Say) and *A. usa* Ricker from Surdick (1985); *Perlesta nitida* Banks from Stark (1989), and *Perlinella drymo* (Newman) from Kondratieff *et al.*, (1987), putting the state total at 100. *Alloperla neglecta* Frison, *Isogenoides doratus* (Frison) and *Yugus arinus* (Frison) have been previously reported in error and should be deleted from the state list.

I have in my collection 14 additional species from Pennsylvania which represent new state records. With these additions, confirmations and deletions, the new state total is 113.

The following is a list of the new species records, counties, streams, dates of collection and the collector. COLLECTORS: Michael D. Bilger (MDB), Jane I. Earle (JIE), Gregory A. Hoover (GAH), Lawrence L. Jackson (LLJ). Identifications were of adult males unless otherwise stated. Listed ranges are from Stark *et al.* (1986).

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### Capniidae

*Allocapnia aurora* Ricker: Adams Co. Carbaugh Run, 17 February 1992 (JIE); Cumberland Co. Mountain Creek, 23 January 1993, (LLJ) and Toms Run, 23 January 1993 (LLJ); York Co. Muddy Creek, 3 February 1993 (MDB).

These records represent a northern range extension for this species, previously known from Maryland south to Alabama.

*Allocapnia simmonsii* Kondratieff and Voshell: Yellow Breeches Creek, Huntsdale, 8 March 1993 (JIE); Dauphin Co. Swatara Creek, Middletown, 24 March, 1993 (JIE).

This rare winter stonefly has previously been known only from two sites in Montgomery County, Virginia and is considered endangered in Virginia (Kondratieff and Kirchner, 1991).

### Leuctridae

*Paraleuctra sara* (Claassen): Cambria Co. Laurel Run, 10 April 1990 (JIE); Columbia Co. Fishing Creek, 30 April 1977 (JIE); Cumberland Co. Cold Spring Run, 19 April 1993 (JIE); Fayette Co. unnamed tributary to Youghiogheny River, 7 May 1978 (JIE); Huntingdon Co. Standing Stone Creek, 7 April 1992 (LLJ); Jefferson Co. Clover Run, 23 April 1986 (JIE); Lawrence Co. unnamed Tributary to Hell Run, 15 April 1980 (JIE); Luzerne Co. Kitchen Creek, 12 April 1977 (JIE); Perry Co. McCabe Run, 11 April 1993 (JIE); Sullivan Co. West Branch Fishing Creek, 17 April 1977 (LLJ); Union Co. Cherry Run, 11 April 1977 (LLJ).

It is surprising that this spring species, known from Quebec to South Carolina, has not been previously reported. Although having a wide-spread distribution in Pennsylvania, nymphs are rarely collected in benthic samples and are likely part of the hyporheos. In Pennsylvania, adults have most commonly been collected from first through third order cool streams, many of which are affected by acid precipitation.

### Nemouridae

*Ostrocerca albidipennis* (Walker): Dauphin Co. Clark Creek, 10 May 1993 (JIE); Franklin Co. unnamed tributary to Conodoguinet Creek, 16 May 1993 (JIE); Potter Co. Black Stump Hollow, 12 May 1993 (LLJ).

This species has previously been reported from Connecticut, Massachusetts, Maine, New Hampshire, New York, Virginia, Nova Scotia, Ontario and Quebec.

*Ostrocerca prolongata* (Claassen): Tioga Co. Babb Creek, 20 May 1992 (JIE).

Babb Creek receives acid mine drainage from abandoned deep mines. A pH of 5.2 was recorded at the time of collection. Stark *et al.* (1986) and Young *et al.* (1989) previously listed this species from Quebec, Ontario, Delaware, Maine, New Hampshire, New York, Virginia and West Virginia. These *Ostrocerca* records confirm the presence of all four eastern *Ostrocerca* species in Pennsylvania.

*Prostoia completa* (Walker): Dauphin Co. Powell Creek, female, 10 May 1993, (JIE) and Susquehanna River, 25 March 1992 (JIE); Lancaster Co. Bowery Run and West Branch Octoraro Creek, 21 March 1992 (LLJ); Potter Co. First Fork Sinnemahoning Creek, 9 May 1992 (LLJ).

This species ranges from Quebec to Minnesota and south to South Carolina.

*Prostoia similis* (Hagen): Cumberland Co. Doubling Gap Run, 18 April 1993 (JIE); Perry Co. McCabe Run, female, 15 May 1993 (JIE) and Tuscarora Creek, female, 18 April 1993 (JIE).

This species of *Prostoia* has a range similar to that of *P. completa*.

### Taeniopterygidae:

*Bolotoperla rossi* (Frison): Dauphin Co. Powell Creek, 10 May 1993 (JIE).

This species is considered to be rare and has been previously reported from Maine, North Carolina, New Hampshire, Virginia, West Virginia and Quebec.

*Oemopteryx contorta* (Needham and Claassen): Cumberland Co. Mountain Creek, 28 February 1992 (LLJ) and Toms Run, 8 March 1992 (JIE).

This species has previously been reported from Connecticut, Kentucky, Massachusetts, Maine, New Hampshire, Tennessee, Virginia and West Virginia.

*Taenionema atlanticum* Ricker and Ross: Luzerne Co. Kitchen Creek, 12 April 1977 (JIE); Perry Co. McCabe Run, (JIE); Potter Co. East Fork Sinnemahoning Creek, 13 May 1992 (LLJ); Union Co. Cherry Run, 11 April 1977 (LLJ); Sullivan Co. West Branch Fishing Creek, 17 April 1977 (JIE).

This species ranges from Quebec to Newfoundland and south to Tennessee.

*Taeniopteryx ugola* Ricker and Ross: Cambria Co. Roaring Run, 7 April 1992 (JIE); Cumberland Co. Cold Spring Run, 5 February 1993 (LLJ), Mountain Creek, 14 February 1992 (JIE) and Toms Run, 22 February 1992 (JIE).

These records represent a northern range extension. Previous records were from Georgia, Kentucky, Tennessee, Virginia and West Virginia.

### Perlidae:

*Acroneuria filicis* Frison: Dauphin Co. at light, Dauphin, PA, 26 June 1992, female (GAH).

This species was previously reported from Illinois through Maryland, south to Arkansas and South Carolina.

*Agnetina capitata* (Pictet): Blair Co. South Poplar Run, 28 June 1978 (LLJ); Cumberland Co. Yellow Breeches Creek, 11 July 1992 (JIE); Dauphin Co. Susquehanna River, 18 June 1992, female (JIE).

Surdick and Kim listed *A. capitata* (as *Phasganophora*) as occurring in Pennsylvania. This, however, was prior to the publication of Stark's (1986) revision and may have been a mixture of all three species. Stewart and Stark (1988) listed *A. annulipes* as occurring in Pennsylvania based on specimens studied during Stark's (1986) revision. These records confirm the presence of *A. capitata* in Pennsylvania.

*Agnetina flavescens* (Walsh): Dauphin Co. Susquehanna River, 12 June 1992 (JIE); Lehigh Co. Ontelaunee Creek, 8 June 1976 (JIE).

These records confirm the presence of all three species of *Agnetina* in Pennsylvania.

*Hansonoperla appalachia* Nelson: Cambria Co. Unnamed Tributary to Laurel Run, 11 April 1990, nymph (JIE); Tioga Co. Babb Creek, 20 May 1992, nymph (JIE).

Both of these streams are acidic. Babb Creek receives acid mine drainage from abandoned coal mines. The pH was 5.2 at the time of collection. The Laurel Run tributary is in a forested watershed affected by chronic acidity from atmospheric deposition; pH's ranged from 4.8 to 5.5 during 1990. This rare species has previously been reported from Alabama, Kentucky, Massachusetts, South Carolina, Tennessee and West Virginia.

### Perlodidae

*Diploperla duplicata* (Banks): Cumberland Co. Mountain Creek, 4 July 1992 (JIE); Dauphin Co. Clark Creek, 26 June 1992 (GAH).

Surdick and Kim (1976) included *D. duplicata* (Banks) as occurring in Pennsylvania; however, their records may have included both *D. duplicata* and *D. robusta*. Stark and Gaufin's (1975) revision of *Diploperla* may not have been completed prior to the preparation of Surdick and Kim's manuscript. Later publications (Masteller, 1983, Stark *et al.*, 1986, and Stewart and Stark, 1988) listed *D. robusta*, not *D. duplicata* from Pennsylvania. My records confirm *D. duplicata* as part of the Pennsylvania fauna.

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## NEW PREY RECORDS FOR *PROCTACANTHUS* (DIPTERA: ASILIDAE) WITH COMMENTS ON PREY CHOICE<sup>1, 2</sup>

R. J. Lavigne<sup>3</sup>, C. R. Nelson<sup>4</sup>, E. T. Schreiber<sup>5</sup>

ABSTRACT: New prey records (n=239) for the following species of *Proctacanthus* in North American collections are listed: *P. coquillettii*, *P. longus*, *P. micans*, *P. nearno*, *P. nigriventris*, *P. occidentalis*, *P. philadelphicus*, and *P. rodecki*. Prey were most often recorded for *P. milbertii* (n=129); these prey represented 7 insect orders and 17 families.

Over the course of several years, miscellaneous records of attacks by asilids of the genus *Proctacanthus* on miscellaneous insects have been observed by the authors and the prey collected. Additionally, in the course of his revision of the genus, Dr. Nelson has made note of insects pinned as prey beneath asilids in the collections he has identified. These records are listed below. Sex of the prey, where noted, follows the scientific name or collecting site; sex of the predator is indicated in parenthesis following the date.

Because of the large number of records encompassed by this accumulation of data, it was felt it would be of little use to list the complete data unless the prey item was identified to genus and/or species. Consequently, data incorporating only Order/Family, State where collected and sex of predator in parenthesis have been included in Table 1. Cumulative data is presented in Tables 2 and 3.

### *Proctacanthus coquillettii* Hine

#### Hymenoptera: Apidae

*Apis mellifera* L., California: Imperial Co., Glamis, 4 mi NW, sand hills; IX-3-81 (♀); E.M. Fisher, coll.; Mexico: Baja California, San Quintin, 20 km S, El Socorro Sand Dunes; V-23-88 (♀); E.M. Fisher, coll.

#### Hymenoptera: Sphecidae

*Ammophila* sp., California: San Bernardino Co., Kelso, 2 mi S; VI-30-78 (♀); J. Powell, coll.

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***Proctacanthus longus* Wiedemann****Hymenoptera: Apidae**

*Bombus* sp., Florida: Palm Beach Co., SR 441, 2mi N Co. line; V-15-31 (♀); (? coll.)

***Proctacanthus micans* Schiner****Coleoptera: Hydrophilidae**

*Sphaeridium scarabaeoides* (L.), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VII-30-81 (2♀ ♀), VIII-2-81 (♀), VIII-6-81 (♂); E. Schreiber, coll.

**Diptera: Asilidae**

*Megaphorus guildianus* (Williston), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VII-26-76 (♀); R. Lavigne, coll.

*Ospriocerus abdominalis* (Say), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VIII-1-81 (♀); E. Schreiber, coll.

*Proctacanthus micans* Schiner, Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VII-31-81 (♂), VIII-2-81 (♂); E. Schreiber, coll.

*Scleropogon picticornis* Loew, Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VIII-2-81 (♂,♀); E. Schreiber, coll. VIII-04-81 (2♀ ♀); E. Schreiber, coll.

**Heteroptera: Lygaeidae**

*Lygaeus reclinatus* (Say), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VIII-2-81 (♀); E. Schreiber, coll.

**Heteroptera: Pentatomidae**

*Codophila remota* (Horvath), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VIII-4-81 (♀); E. Schreiber, coll.

**Hymenoptera: Anthophoridae**

*Synhalonia* sp., Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VII-30-81 (♀); E. Schreiber, coll.

**Hymenoptera: Halictidae**

*Agapostemon virescens* (Fabricius), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VIII-28-68 (♂); R. Lavigne, coll.

**Hymenoptera: Pompilidae**

*Cryptocheilus terminatum* (Say), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VII-30-81 (♀); E. Schreiber, coll.

**Lepidoptera: Lycaenidae**

*Lycaeides melissa melissa* (Edwards), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VIII-2-81 (♂); E. Schreiber, coll.

**Lepidoptera: Nymphalidae**

*Vanessa* sp., New Mexico: Lucy; VII-17-32 (♀); C.W. Sabrosky, coll.

**Neuroptera: Myrmeleontidae**

*Hesperoleon nigrilabris* (Hagen), Colorado: Weld Co., Nunn, 7 mi N, Pawnee Nat'l Grasslands (IBP site); VII-30-81 (♀); E. Schreiber, coll.

**Orthoptera: Acrididae**

- Arphia pseudonietana* (Thomas), Utah: Washington Co., above Zion National Park, Crystal Creek at jct. with Deep Creek; IX-21-82 (♂); C.R. Nelson, coll.
- Melanoplus infantilis* Scudder, Colorado: Weld Co., Nunn, 7 mi N; VIII-6-81 (♂); E. Schreiber, coll.
- Melanoplus sanquinipes* (Fabricius), Colorado: Weld Co., Nunn, 7 mi N; VII-31-81 (♀); E. Schreiber, coll.
- Trachyrachys kiowa* (Thomas), Colorado: Weld Co., Nunn, 7 mi N; VII-31-81 (♀); E. Schreiber, coll.
- Trimerotropis gracilis* (Thomas), Colorado: Alamosa Co., Great Sand Dunes Nat. Mon., T27S R73W Sec. 15; VII-30-77; F.M. Brown, coll.

***Proctacanthus milbertii* Macquart****Coleoptera: Scarabaeidae**

- Aphodius haemorrhoidalis* L., Wyoming: Guernsey, 7 mi W; ♂; Frederick Ranch; VIII-20-76 (♀); GSA 1; VII-25-70; R.E. Pfadt, coll.
- Euphoria inda* (L.), Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts"; VIII-22-91 (♂); R.J. Lavigne, coll.

**Diptera: Asilidae**

- Diogmites angustipennis* Loew, Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts"; VIII-26-91 (♂); R.J. Lavigne, coll.
- Efferia helenae* (Bromley), Wyoming: Guernsey, 7 mi W, Frederick Ranch; VIII-4-60; VIII-16-61 (♂), IX-07-64 (♀); R.J. Lavigne, coll.
- Efferia* sp., Wyoming: Guernsey, 7 mi W, Frederick Ranch; VIII-24-61; R.J. Lavigne, coll.
- Megaphorus guildianus* (Williston), Wyoming: Platte Co., Wheatland, 37 km N; VIII-16-73 (♂); VII-31-74 (♀); D.S. Dennis, coll.
- Guernsey, 7 mi W; VII-29-60 (2♀♀); VIII-4-60 (♂); VIII-12-60 (♀); R.J. Lavigne, coll.
- Wyoming: Wheatland, 37 km N; VIII-24-67 (♀); R.J. Lavigne, coll.
- Ospriocerus latipennis* (Loew), Wyoming: Glendo, 7 mi S; VIII-20-59 (♀); R.J. Lavigne, coll.
- Proctacanthus milbertii* Macquart, Wyoming: Guernsey, 7 mi W, Frederick Ranch; VIII-11-61; R.J. Lavigne, coll. (prey was ♀, sex of predator?); Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts"; VIII-20-91 (♀ took ♂); R.J. Lavigne, coll.
- Canada, Manitoba: Bald Hills, Glenboro, 13 mi N; VIII-18-58, J.G. Chillcott, coll. (♀ took ♀)
- Scleropogon coyote* (Bromley), Wyoming: Glendo, 7 mi S; VIII-12-64 (♂); R.J. Lavigne, coll.
- Scleropogon* sp., Kansas: 2800'; VII-27-11 (♂,♀); F.X. Williams, coll.

**Hemiptera: Alydidae**

- Alydus* sp., nr. *pilosulus* Herrich-Schaeffer, Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts"; VIII-22-91 (♂); R.J. Lavigne, coll.

**Hymenoptera: Anthophoridae**

- Melissodes* sp., Wyoming: Wheatland, T24N R65W Sec 13; VIII-17-74 (♀); R.J. Lavigne, coll.

**Hymenoptera: Apidae**

- Apis mellifera* L., Wyoming: Platte Co., Wheatland, 37 km N; worker; VIII-16-64 (♂); R.J. Lavigne, F. Holland, coll.  
 worker; IX-17-73 (♀); G. Sharafi, coll.  
 worker; VII-27-74 (5 records); R. Lavigne, coll.  
 worker; VII-31-74 (4 records); R. Lavigne, coll.  
 Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts", worker; VIII-26-91 (♀); R.J. Lavigne, coll.
- Bombus* sp., Wyoming: Platte Co., Wheatland, 37 km N; VIII-10-61 (♀, in copula); R.J. Lavigne, coll.  
 VIII-10-61 (♀); in copula); R.J. Lavigne, coll.  
 VIII-17-61 (♀); R.J. Lavigne, coll.  
 VIII-18-61 (♀); R.J. Lavigne, coll.  
 VIII-23-61 (♀); R.J. Lavigne, coll.  
 Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts", 3 workers; VIII-26-91 (3♀♀, one in copula); R. J. Lavigne, coll.
- Canada, Ontario: Simcoe Co., Tiny Twp., Cawaja Beach; VIII-15-68 (♀); J.C.E. Riotte, coll.
- Mellisodes obliqua* (Say), Kansas: Scott Co., 2970'; (? date) (♀); F.X. Williams, coll.

**Hymenoptera: Colletidae**

- Colletes* sp. (3♀♀), Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts"; VIII-26-91 (3♀♀); R.J. Lavigne, coll.

**Hymenoptera: Halictidae**

- Halictus* sp. (♀), Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts"; VIII-26-91 (♀); R.J. Lavigne, coll.

**Hymenoptera: Sphecidae**

- Ammophila* sp., Texas: Brazos Co., College Station; VIII-23-33 (♀); H.J. Reinhard, coll.

**Hymenoptera: Tiphiidae**

- Myzinum quinquecinctum* (F.), Wyoming: Platte Co., Guernsey, 7 mi W; VIII-4-60; R.J. Lavigne, coll.; Wheatland; VII-28-74 (♀); D.S. Dennis, coll. Guernsey, "Oregon Trail Ruts"; VIII-20-91 (2♂♂); R.J. Lavigne, coll.

**Hymenoptera: Vespidae**

- Polistes* sp., Canada, British Columbia, Oliver; VI-22-22 (♀); P.N. Vroom, coll.  
 Ohio: Williams Co, Saint Joseph Tp.; IX-1-32 (♀); H. Price, coll.  
 Washington: Spokane Co., Spokane; VIII-27-31-56 (♀); L.A. Stange, coll.
- Pterocheilus quinquefasciatus* Say, Wyoming: Platte Co., Wheatland; VII-27-74; R. Lavigne, coll.

**Lepidoptera: Noctuidae**

- Drasteria* sp., prob. *howlandi* (Grote), Wyoming: Platte Co., Wheatland, T25N R65W Sec 4; VII-6-74; R.J. Lavigne, coll.

**Lepidoptera: Nymphalidae**

- Junonia coenia* (Hubner), Virginia: Chesterfield, Hoods, Richmond; VIII-28-28 (♀); (? coll.)
- Vanessa cardui* (L.), Kansas: Clark Co., 1950'; VIII-20-11 (?♀); F.X. Williams, coll.

**Lepidoptera: Pieridae**

*Pontia protodice* (Boisduval & LeConte), Colorado: Burlington, S of; VII-27-33; H.G. Rodeck & M.T. James, coll.

**Orthoptera: Acrididae**

*Ageneotettix deorum* (Scudder), Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts";

2♂♂, VIII-26-91 (2♂♂); R.J. Lavigne, coll.

♂; VIII-22-91 (♀); R.J. Lavigne, coll.

♀; VIII-22-91 (♂); R.J. Lavigne, coll.

Wyoming: Platte Co.: Wheatland, T25N R65W Sec 4; VII-6-74; R. Lavigne (coll.)

*Amphitornus coloradus* (Thomas), Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts",

♀; VIII-20-91 (♀); R.J. Lavigne, coll.

♂; VIII-22-91 (♂); R.J. Lavigne, coll.

♂; VIII-26-91 (♂); R.J. Lavigne, coll.

*Aulocara ellioti* (Thomas), Wyoming: Platte Co., Guernsey, 7 mi W, Frederick Ranch;

VIII-11-61; R.J. Lavigne, coll.; Guernsey, "Oregon Trail Ruts",

♂; VIII-20-91 (♂); R.J. Lavigne, coll.

*Melanoplus angustipennis* (Dodge), Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts",

2♂♂; VIII-20-91 (♂, ♀); R.J. Lavigne, coll.

2♂♂; VIII-22-91 (2♀ ♀); R.J. Lavigne, coll.

♀; VIII-22-91 (♀, in copula); R.J. Lavigne, coll.

♂; VIII-22-91 (♀, in copula); R.J. Lavigne, coll.

♂; VIII-26-91 (♀); R.J. Lavigne, coll.

*Melanoplus femurrubrum* (DeGeer), Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts";

2♂♂; VIII-22-91 (2♂♂); R.J. Lavigne, coll.

♂; VIII-22-91 (♀); R.J. Lavigne, coll.

♀; VIII-22-91 (♂); R.J. Lavigne, coll.

*Melanoplus gladstoni* Scudder, Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts",

♂, nymph; VIII-20-91 (♂, ♀); R.J. Lavigne, coll.

♂, ♀; VIII-22-91 (♂, ♀, in copula); R.J. Lavigne, coll.

*Melanoplus occidentalis* (Thomas), Wyoming: Platte Co., Guernsey, 7 mi W, Frederick Ranch;

VIII-20-76; R.J. Lavigne, coll.

Guernsey, "Oregon Trail Ruts", ♂, ♀; VIII-20-91 (2♂♂); R.J. Lavigne, coll.

*Melanoplus sanguinipes* (Fabricius), Wyoming: Platte Co., Guernsey, "Oregon Trail Ruts",

♀; VIII-20-91 (♀); R.J. Lavigne, coll.

2♂♂; VIII-22-91 (2♀ ♀); R.J. Lavigne, coll.

♀; VIII-22-91 (♀); R.J. Lavigne, coll.

Wheatland; VIII-18-64. (♀); R. Lavigne (coll.)

*Hadrotettix trifasciatus* (Say), ♂, Wyoming: Guernsey, "Oregon Trail Ruts"; VIII-22-91

(♀); R.J. Lavigne, coll.

*Spharagemon (Trimerotropis) campestris* (McNeil), ♂, Wyoming: Guernsey, "Oregon Trail Ruts"; VIII-22-91 (♀, in copula); R.J. Lavigne, coll.

***Proctacanthus nearno* Martin****Diptera: Apioceridae**

*Apiocera* sp., Nevada: Clark Co., Mesquite; VIII-30-59 (♂); F.D. Parker, coll.

**Hymenoptera: Apidae**

*Apis mellifera* L., Arizona: Navajo Co., Leroux Wash, Holbrook, 1 mi N, 5075'; VI-25-66 (♀); Davidsons & M. Cazier, coll.

New Mexico: Hidalgo Co., Post office Canyon; VIII-8-65 (♀); Davidsons & M. Cazier, coll.

Utah: Millard Co., Delta; VII-9-47 (♀), VII-30-49 (♀), VIII-13-64 (♀); G.E. Bohart, coll.

Mexico: Coahuila, across from Langtry; V-18-67 (♀); E.E. Remington, coll.

***Proctacanthus nigriventris* Macquart****Hymenoptera: Vespidae**

*Vespula* sp., South Carolina: Horry Co., Myrtle Beach; VI-18-82 (♂); F. Genier, coll.

***Proctacanthus occidentalis* Hine****Diptera: Apioceridae**

*Apiocera* sp., California: Mono Co., Mono Lake, shore, SW corner, 6420'; VIII-18-62 (♀); H.B. Leech, coll.

**Diptera: Asilidae**

*Mallophora faurix*, California: Riverside Co., Riverside; IX-01-35 (♂); Timberlake, coll.

**Heteroptera: Alydidae**

*Alydus* sp., California: Contra Costa Co., Antioch; VIII-05-51 (♂); J.C. Hall, coll.  
Riverside Co., San Jacinto Mts.; VII-9-30 (♂); E.A. Dodge, coll.

**Hymenoptera: Apidae**

*Apis mellifera* L., California: Fresno Co., Kingsburg; VIII-26-52 (♀); (? coll.)

Merced Co., Dos Palos; VII-15-47 (♀); R.E. Beer, coll.

Tuolumne Co., Browns Meadow; VIII-15-60 (♀); A.S. Menke, coll.

Ventura Co., Oxnard; VIII-02-50 (♀); K.G. Whitesell, coll.

Nevada: Humboldt Co., Denio, 1 mi S; VIII-07-72 (♀); D.E. Foster, coll.

Oregon: Jackson Co., Gold Hill; VII-13-30 (♀); H.A. Scullen, coll.

Lake Co., Plush, 15 mi SW; VIII-06-72 (♀); D.E. Foster, coll.

Malheur Co., Adrian, Owyhee River; VII-22-34 (2♀ ♀); D. Martin, coll.

Dixie; VII-08-32 (♂); R.H. Beamer, coll.

*Bombus* sp., California: Contra Costa Co., Antioch; VIII-20-38 (♂), Sept. 1936; M. Cazier, coll.

Tuolumne Co., Strawberry; VIII-04-60 (♀); R.R. Montanucci, coll.

Washington: Garfield Co., Snake River, Lower Granite Dam, 4 mi NW; VII-26-84 (♂); W.J. Turner, coll.

**Hymenoptera: Vespidae**

*Vespula* sp., California: Trinity Co., Mad River, Ruth, 6 mi S (♂); VII-31-60; H.B. Leech, coll.

**Lepidoptera: Pieridae**

*Colias* sp., California: Merced Co., Dos Palos; IX-06-49 (♂); J.E. Gillaspay, coll.

***Proctacanthus philadelphicus* Macquart.****Hymenoptera: Apidae**

*Apis mellifera* L., Massachusetts: Plymouth Co., Carver, sand area near airport; VIII-21-86 (♂); M.A. Valenti, coll.

New Jersey: Burlington Co., Riverton; VIII-24-22 (♀), IX-15-22 (♀); (?), coll

***Proctacanthus rodecki* James****Coleoptera: Cicindelidae**

*Cicindela* sp., Kansas: Reno Co., Medora Sand Dunes; VII-3-? (♂); R.H. Painter, coll.

**Diptera: Asilidae**

*Ospreocerus* sp., Texas: Donley Co.; VI-26-58 (♀); J.W. Monk, coll.

**COMMENTS ON PREY SELECTION**

The greatest number of prey records reported in the literature for any species of *Proctacanthus* have been for *P. milbertii*. "*Proctacanthus milbertii* Macquart is a widely distributed large Asilid occurring from Mexico to British Columbia east to Ontario, Ohio, Virginia, and Florida" (Bromley 1949). In that paper, Bromley recorded 659 prey records for *P. milbertii* from the widely diverse states of Iowa, Michigan, Missouri, Ohio, New Mexico and Texas. Based on a revision of the genus, which one of us (CRN) is currently conducting, some of these records are suspect and are not included in this paper, unless specimens were seen by one of the authors. A few additional prey of *P. milbertii* were reported for Texas (Bromley 1934) and for Florida (Bromley 1950). Additional Orthoptera prey were listed for Wyoming (Lavigne and Pfadt 1966), while Joern and Rudd (1982) recorded the impact of this species on grasshoppers.

It should be noted that all ethological and prey information attributed to *Proctacanthus micans* in Guernsey, Wyoming (Dennis and Lavigne 1975) do, in fact, refer to *Proctacanthus milbertii*. All ethological and prey information attributed to *Proctacanthus micans* in Colorado (Rogers and Lavigne 1972) are correct. The prey (n=50) reported in the latter paper represented 7 orders and 17 families.

As suggested by O'Neil and Kemp (1991) "the contents of prey records are not only a function of local insect abundance, but of variation in visibility and catchability among prey species, as well as evolved preferences of robber flies for nutritionally superior or non-toxic insects (Shelly 1984)". O'Neil and Kemp suggested site-specific prey use for *Stenopogon inguinatus* Loew since that species of asilid was observed to concentrate on winged formicid reproductives when locally

available. Certainly this is the case for *Machimus gilvipes* (Hine) which forages in or near the entrances of mammal burrows and appears to specialize on calliphorid flies (85% of diet) (Schreiber & Lavigne 1986).

This also appears to be true in the case of the population of *Proctacanthus milbertii* briefly studied at Guernsey, Wyoming on August 20, 22, & 26, 1991. The asilids ignored a tremendous number of available insects, and while not tested, color appeared to be a dominant consideration. Large numbers of orange & black cantharid beetles were constantly in flight amongst sunflowers (where many asilids congregated), but were ignored even when they flew directly over the asilids. Additionally, no attempt was made to attack orange & black skippers (Hesperiidae), orange and black wasps, such as *Sphex ichneumoneus* (L.), shiny blue-black wasps (Sphecidae), and dragonflies (both red and orange), even though they were in the same size range as commonly taken prey. On the other hand, this population of robber flies apparently showed a predilection (66%, n=47) for brownish grasshoppers, which also were locally abundant. In the case of grasshoppers, the asilids would have had to show great patience awaiting the occasional flight of a grasshopper, as opposed to taking readily available flying insects. Other prey taken were yellow & black striped wasps, i.e. *Myzinum quinquecinctum* (Fabricius) & *Halictus* sp., black, i.e., an unidentified tachinid and black and yellow bumble bee workers. Based on these limited observations, a case could be made for testing the assumption of color preference by using the technique of lure presentation utilized by Lavigne and Holland (1969). It is of interest to note that the population of *P. milbertii* studied at another location near Guernsey, Wyoming by Dennis and Lavigne (1975) also preyed primarily on Hymenoptera (50.6%) and Orthoptera (24.7%).

Of incidental interest, in 1991 five out of 15 mated females were feeding on prey when the pair was collected. This behavior, while fairly uncommon, has previously been reported for four asilid species (Dennis and Lavigne 1975), including *P. milbertii*.

Does the genus *Proctacanthus* specialize on particular orders of insects? A summary of prey records reported herein, broken down by taxonomic order, is given in Table 2. Eight orders of insects were taken as prey with three orders numerically dominating: Hymenoptera, Orthoptera, and Diptera. While our data cannot be used to indicate true preference for particular prey as information regarding relative availability of potential prey at individual sites is lacking, we can note some trends which indicate potential areas for future research. In *P. milbertii*, the species for which the most prey records were available

(Table 3), three orders predominated: Orthoptera (40.3%), Hymenoptera (35.7%), and Diptera (14.7%). These three orders thus made up 91% of the diet of this species, with nearly equally divided specialization between Orthoptera and Hymenoptera. Specialization for Hymenoptera also may be occurring in *P. nearno* where 56% of the records are Hymenoptera; in *P. occidentalis*, 63%; in *P. philadelphicus*, 88%, and in several other less sampled species (Table 3).

However, *P. micans*, another species for which a reasonable number of prey items have been taken, showed a more generalist strategy as evidenced by a more evenly distributed prey scheme (Tables 2 & 3). *P. brevipennis* also seems to be more generalist in food habit.

Overall, 87% of the prey for *Proctacanthus* was of four orders: 38.5% hymenopteran, 26.4% orthopteran, 14.2% dipteran, and 7.5% coleopteran. By partitioning out the relatively well-studied *P. milbertii*, the overall percentage for the four top orders changed to 78% with 41.8%, 10.0%, 13.6%, and 12.7% for the respective orders. Note that the relative importance of the four orders dropped and that the ranking of the orders changed as well (see totals, Table 3), but that these four orders remained on top.

In summary, a certain amount of prey specialization exists in some species of *Proctacanthus*, while others show more generalist trends. Future food niche studies of *Proctacanthus* should address the questions of availability of prey taxa and explore reasons why these prey orders might be preferentially taken. Particular species of *Proctacanthus* which are abundant enough to be used as models in these studies would certainly include *P. brevipennis*, *P. nearno*, and *P. rodecki*. Feeding behavior studies of *P. rodecki* would be particularly desirable to see if its purported specialization on Orthoptera holds up as larger sample sizes are obtained.

**Table 1. List of prey of *Proctacanthus* that were not identified beyond Order and Family.**

***Proctacanthus brevipennis* Wiedemann**

- Coleoptera: Scarabaeidae; Kansas (♂), New Jersey (♂)
- Heteroptera: Reduviidae; North Carolina (♀)
- Heteroptera: Pentatomidae; Florida (♀)
- Lepidoptera: Hesperiiidae; Florida (♀)
- Odonata: Libellulidae; Florida (♀)
- Orthoptera: Acrididae; Kansas (♀)

***Proctacanthus coquillettii* Hine**

- Diptera: Calliphoridae; California (♂)
- Hymenoptera: Anthophoridae; California (♂)
- Lepidoptera: Noctuidae; California (♀)

***Proctacanthus lonqus* Wiedemann**

Lepidoptera: Hesperiidae; Florida (♀)

***Proctacanthus micans* Schiner**

Coleoptera: Scarabaeidae; Mexico, Durango (2♀♀)

Diptera: Bombyliidae; Arizona (♂)

Heteroptera: Pentatomidae; Arizona (♂)

Hymenoptera: Ichneumonidae; Utah (♀)

Hymenoptera: Sphecidae; Arizona (♂)

Hymenoptera: Tiphidae; Utah (♂)

Lepidoptera: Lycaenidae; Colorado (♂)

***Proctacanthus milbertii* Macquart**

Coleoptera: Cicindelidae; Indiana (♂)

Homoptera: Cicadidae; Kansas (♀)

Hymenoptera: (?); Anthophoridae; Canada, British Columbia (♂)

Hymenoptera: Apidae; Montana (♂)

Hymenoptera: Ichneumonidae; Michigan (♀); Ohio (♀)

Hymenoptera: Sphecidae; Mississippi (♀)

Hymenoptera: Vespidae; Canada, British Columbia (♂);

Ontario (♀); Michigan (♂, ♀); Texas (♀); Wisconsin ((♀)

Lepidoptera: Pieridae; Colorado (♀)

Lepidoptera: (?); Texas (♂)

Orthoptera: Acrididae; Arizona (♀); Canada, Manitoba (♀);

Colorado (♀, ? Xanthippus); Kansas (♂, ♀); Nebraska (♂);

Ohio (♀); Tennessee (♀); Texas (5♂, 3♀♀); Virginia (♂)

***Proctacanthus nearno* Martin**

Coleoptera: Buprestidae; Utah (♀)

Heteroptera: Pentatomidae; New Mexico (♀)

Hymenoptera: Anthophoridae; Utah (♀)

Hymenoptera: Sphecidae; Utah (♀)

Hymenoptera: Sphecidae: Cercerinae; Arizona (♀)

Lepidoptera: (moth); Arizona (♀)

Lepidoptera: Noctuidae; Utah (♀)

Orthoptera: Acrididae; Utah (♀); Mexico: Sonora (♀)

***Proctacanthus nigriventris* Macquart**

Diptera: Tipulidae; New Jersey (♂)

***Proctacanthus occidentalis* Hine**

Coleoptera: Scarabaeidae; California (♂); Idaho (♂)

Coleoptera: Silphidae; California (♂)

Hymenoptera: Apoidea; California (♂)

Hymenoptera: Ichneumonidae; California (♀)

Hymenoptera: Sphecidae; California (♀)

Lepidoptera: Lycaenidae; California (♀)

Odonata: Coenagrionidae; Washington (♂)

***Proctacanthus philadelphicus* Macquart**

Hymenoptera: Vespidae; Massachusetts (♀); Maryland (♀); New York (♂)

Odonata: Libellulidae; Maine (♀)

***Proctacanthus rodecki* James**

Coleoptera: Scarabaeidae; Oklahoma (♂)

Heteroptera: Coreidae; New Mexico (♂)

Orthoptera: Acrididae; Nebraska (♂); New Mexico (2♀♀) Texas (♀)

**Table 2. Records of prey of particular orders pinned with or collected by *Proctacanthus* species in North American insect collections.**

species	Odo- nata	Orth- optera	Heter- optera	Lepi- doptera	Cole- optera	Diptera	Hymen- optera	Neur- optera
brevipennis n=8	1	1	2	1	2	0	1	0
coquillettii n=6	0	0	0	1	0	1	4	0
longus n=2	0	0	0	1	0	0	1	0
micans n=34	1	5	3	3	6	9	6	1
milbertii n=129	0	52	2	6	4	19	46	0
nearno n=16	0	2	1	2	1	1	9	0
nigriventris n=2	0	0	0	0	0	1	1	0
occidentalis n=27	1	0	2	2	3	2	17	0
philadelphicus n=8	1	0	0	0	0	0	7	0
rodecki n=7	0	3	1	0	2	1	0	0
<b>totals</b>	<b>4</b>	<b>63</b>	<b>11</b>	<b>16</b>	<b>18</b>	<b>34</b>	<b>92</b>	<b>1</b>

Grand total: 239 records

**Table 3. Percentage of use of particular orders of prey taken by *Proctacanthus* species.**

species	Odo- nata	Orth- optera	Heter- optera	Lepi- doptera	Cole- optera	Diptera	Hymen- optera	Neur- optera
brevipennis n=8	12.5	12.5	25	12.5	25	0	12.5	0
coquillettii n=6	0	0	0	16.7	0	16.7	66.7	0
longus n=2	0	0	0	50	0	0	50	0
micans n=34	2.9	14.7	8.8	8.8	17.6	26.5	17.6	2.9
milbertii n= 129	0	40.3	1.6	4.7	3.1	14.7	35.7	0
nearno n=16	0	12.5	6.3	12.5	6.3	6.3	56.3	0
nigriventris n=2	0	0	0	0	0	50	50	0
occidentalis n=27	3.7	0	7.4	7.4	11.1	7.4	63	0
philadelphicus n=8	12.5	0	0	0	0	0	87.5	0
rodecki n=7	0	42.9	14.3	0	28.6	14.3	0	0
Genus %, with <i>P. milbertii</i>	<b>1.7</b>	<b>26.4</b>	<b>4.6</b>	<b>6.7</b>	<b>7.5</b>	<b>14.2</b>	<b>38.5</b>	<b>0.4</b>
Order ranking with <i>P. milbertii</i>	7	2	6	5	4	3	1	8
Genus %, without <i>P. milbertii</i>	<b>3.6</b>	<b>10</b>	<b>8.2</b>	<b>9.0</b>	<b>12.7</b>	<b>13.6</b>	<b>41.8</b>	<b>0.9</b>
Order ranking without <i>P. milbertii</i>	7	4	6	5	3	2	1	8

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**AQUATIC WEEVILS (COLEOPTERA:  
CURCULIONIDAE) ASSOCIATED  
WITH NORTHERN WATERMILFOIL  
(*MYRIOPHYLLUM SIBIRICUM*) IN  
ALBERTA, CANADA<sup>1</sup>**

Robert P. Creed Jr., Sallie P. Sheldon<sup>2</sup>

**ABSTRACT:** Eggs, larvae, pupae and adults of two aquatic weevils (*Euhrychiopsis* sp.<sup>3</sup> and *Phytobius leucogaster*) were found associated with northern watermilfoil (*Myriophyllum sibiricum*) in the province of Alberta, Canada. While both weevils had been collected previously in Alberta, this is the first report to document northern watermilfoil as a native host.

The North American weevil *Euhrychiopsis lecontei* (Dietz) may be used for biological control of Eurasian watermilfoil (*Myriophyllum spicatum* L.) (Creed and Sheldon 1991a&b, 1992a&b), an introduced aquatic macrophyte which is a nuisance in lakes and ponds throughout much of North America (Aiken *et al.* 1979, Couch and Nelson 1986, Smith and Barko 1990). *E. lecontei* has been found associated with Eurasian watermilfoil in several lakes located in Vermont, Massachusetts, New York and Connecticut (Creed and Sheldon 1991a&b). Adult *E. lecontei* consume leaf and stem tissue. First instar larvae feed on meristems and older larvae burrow through the stem. Weevils damage the plants and may be responsible for some Eurasian watermilfoil declines in Vermont (Creed and Sheldon 1991a&b, 1992a&b, 1993a&b, Creed *et al.* 1992). Despite the interest in *E. lecontei* as a biological control agent, neither the identity of its native host (or hosts) nor its life history on its native host(s) are known. Blatchley and Leng (1916) report *Potamogeton* sp. and *Myriophyllum spicatum* as hosts. However, Blatchley and Leng incorrectly synonymized this weevil species with the palearctic weevil *Eubrychius velatus* (Beck) (Dr. Charles O'Brien,

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<sup>3</sup> Currently, two species of *Euhrychiopsis*, *E. lecontei* and *E. albertanus* (Brown), are recognized in North America. However, Dr. Charles O'Brien (Florida A&M University) has examined the weevils we collected in Alberta and other specimens in his collection and believes that *E. lecontei* and *E. albertanus* may be a single species based on a lack of differentiation in male genitalia. Due to the present uncertainty in the taxonomic status of these two species we will simply refer to the weevils collected in Alberta as *Euhrychiopsis*. Please note that these two species are not being synonymized in this paper.

Florida A&M, pers. comm.). Since the host use information reported by Blatchley and Leng (1916) may be derived from European records of *E. velatus*, this information is questionable. More recently, Kissinger (1964) reported that one species of *Euhrychiopsis* lived on *M. spicatum*. Kangasniemi (1983) reported collecting *E. lecontei* on *M. spicatum* in British Columbia. The repeated collection of *E. lecontei* on the introduced *M. spicatum* suggests that the native host(s) might be one or more of the native watermilfoils.

We have collected *E. lecontei* from northern watermilfoil (*Myriophyllum sibiricum* Komarov (= *M. exalbescens* Fernald) in three lakes in Vermont. *M. spicatum* was also present in two of the three lakes so it was unclear if the weevils had been present on the northern watermilfoil when Eurasian watermilfoil invaded the lakes or if they had entered the lakes with Eurasian watermilfoil and had then begun to feed on the native watermilfoil which is morphologically similar to Eurasian watermilfoil (Aiken *et al.* 1979). To determine if northern watermilfoil is a native host, we collected weevils in Alberta, Canada, where both northern watermilfoil and the weevil are present but Eurasian watermilfoil is absent. Previous collections of *Euhrychiopsis* had been made in Alberta (Brown 1932, Kissinger 1964, O'Brien and Wibmer 1982) but the native host was not determined.

## MATERIALS AND METHODS

Collections of weevils on northern watermilfoil were made in mid to late July of 1992. Weevils were usually collected from northern watermilfoil while snorkeling. Only lakes where the visibility exceeded 1 m were surveyed intensively by snorkeling. In very shallow water or in very turbid water bodies, collections were made by inspecting northern watermilfoil while wading. Lakes with extensive algal blooms that made visual collection impossible were not examined. Approximately 1 hr was spent examining northern watermilfoil in lakes where collecting was possible. While the primary goal of these collections was to obtain adult specimens, some eggs, larvae, and pupae were collected. The identity of the adult weevils was verified by Dr. Charles O'Brien of Florida A&M University and most of the specimens are now in his collection. The identity of eggs, larvae, and pupae was based on our field and laboratory observations of these life stages of *E. lecontei* and *Phytobius leucogaster* (Marshall) on *M. spicatum* and *M. sibiricum* in eastern North America.

## RESULTS AND DISCUSSION

Adult *Euhrychiopsis* were found on *M. sibiricum* in 10 of the 13 lakes that were sampled (Table 1). *M. sibiricum* was present in all 13 lakes. *Euhrychiopsis* adults were always collected beneath the surface of the water. They were usually located near apical or lateral meristems although they were occasionally found further down the stem. *Euhrychiopsis* eggs, larvae and pupae were always found underwater on *M. sibiricum*. Eggs were found on northern watermilfoil in six of the lakes; larvae and pupae were each collected in two lakes (Table 1). Eggs were found on meristems. Only one egg was found per meristem on northern watermilfoil (n=16). This is unlike what we have observed for *E. lecontei* which may lay several eggs on a Eurasian watermilfoil meristem. No first instar *Euhrychiopsis* larvae were collected in Alberta but the presence of eggs on the meristems suggests that the first instar larvae of western *Euhrychiopsis* feed on northern watermilfoil meristems. Older larvae (n=4) were found burrowing in the stem well below the surface of the water. Pupae (n=2) were found inside the stem below the region burrowed by the larvae. The puparium consisted of a small chamber entirely within the stem with a sealed entrance hole. The location of western *Euhrychiopsis* eggs, larvae and pupae on *M. sibiricum* was the same as that observed for *E. lecontei* on *M. sibiricum* and *M. spicatum* in eastern North America (Creed and Sheldon 1991a, 1992a). It is highly likely that these eggs, larvae and pupae are those of *Euhrychiopsis* as all three life stages were collected in lakes in which *Euhrychiopsis* was the only adult weevil found on *M. sibiricum* (Table 1).

The weevil *Phytobius leucogaster* (Marshall) [= *Litodactylus griseomicans* (Schwarz) and *Litodactylus leucogaster* (Marshall)], a species with a holarctic distribution, was found on *M. sibiricum* in four of these lakes (Table 1). *Phytobius* adults (n=11) were found both above and below the surface of the water. All life stages were collected at Island Lake which was the only lake where large numbers of the *M. sibiricum* plants were flowering. Eggs (n=2) and larvae (n=2) were collected on *M. sibiricum* floral spikes above the water surface. Pupal chambers (n=8) were found on the stem a short distance below the floral spike and were either above or just below the water surface. The puparium consisted of a shallow excavation with a dark, translucent cover and was similar to that described by Buckingham and Bennett (1981). The locations of *Phytobius* eggs, larvae and pupae on northern watermilfoil were similar to the locations reported by Buckingham and Bennett (1981) for *Phytobius* on Eurasian watermilfoil. Hatch (1971) and Buckingham and Bennett (1981) speculated that a native watermilfoil

was the native host of *P. leucogaster*. Our observations confirm that *M. sibiricum* is one host for *P. leucogaster*. While this weevil may use other native macrophyte species as hosts, they have yet to be reported. Our observations and those of Buckingham and Bennett (1981) suggest that *Phytobius*, like *Euhrychiopsis*, may be a watermilfoil specialist.

Table 1. Lakes in which *Euhrychiopsis* and *Phytobius* were collected. E refers to the collection of eggs, L to larvae, P to pupae and A to adults. The numbers in parentheses following a letter refer to the number collected.

Lake	Location <sup>1</sup>	<i>Euhrychiopsis</i>	<i>Phytobius</i>
Winchell	T29,R5,W5	E(3),A(4)	
Pine	T26,R7,W5	E(4),L(1),A(6)	
Hofmann	T30,R5,W5	E(2),L(3),P(1),A(8)	A(2)
Newall	T17,R14,W4	*	
MacGregor	T16,R21,W4		
Narrow	T65,R24,W4	E(4),A(13)	
Long	T64,R25,W4	E(2),P(1),A(5)	
Island	T68,R24,W4	A(5)	E(1),L(2),P(8),A(4)
N. Buck	T66,R17,W4	A(1)	
Chump	T65,R17,W4	A(1)	
Lac la Biche	T68,R16,W4	*	A(4)
Beaver	T66,R13,W4	E(1),A(9)	A(1)
Hasse	T52,R2,W5	A(1) #	

<sup>1</sup> Locations are given with respect to the Townships (T), Ranges (R) and Meridians (e.g., W4) used on the Alberta Transportation Maps (1:250,000 series) which are distributed by Maps Alberta.

\* previously collected at this site by John Carr.

# identified but not collected.

#### ACKNOWLEDGMENTS

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## TECHNIQUES FOR HANDLING MOSQUITO EGG RAFTS AND RAFT SAMPLES (DIPTERA: CULICIDAE)<sup>1</sup>

R. G. Weber, Tracy A. Horner<sup>2</sup>

**ABSTRACT:** We review methods for handling mosquito egg rafts and describe new tools and techniques that permit rapid handling of the large numbers of individual *Culex* spp. egg rafts collected during field studies of oviposition behavior and vector surveillance. We also describe a method of taking egg samples from individual rafts that maintains the species mix and proportional numbers of eggs deposited nightly on an ovisite. The tools and techniques presented greatly decrease the laboratory space required for hatching large numbers of eggs collected for species determination.

Studies of mosquito oviposition behavior and vector surveillance programs commonly utilize data derived from counts of eggs, or egg rafts, collected from ovitraps (Briand 1964, Fay and Eliason 1966, Frank and Lynn 1982, Holck, *et al.* 1988, Jakob and Bevier 1969, Maw and Bracken 1971, Reiter 1986, Smith and Jones 1972, Surgeoner and Helson 1978). Such studies frequently involve thousands of eggs or rafts (e.g., Lowe, *et al.* 1973 [9,956 rafts], Madder, *et al.* 1980 [13,606 rafts], Maw and Bracken 1971 [9,077 rafts], Smith and Jones 1972 [2,332 rafts]). A variety of devices have been used to collect eggs for study: a plastic scoop (Arredondo-Bernal and Reyes-Villaneuva 1989), metal spoon (Beament and Corbet 1981), small sieve (Chadec and Small 1988), small vial (Guptavanij and Barr 1985), spatula made of fine brass screen (Ilitis and Zweig 1962), the corner of a culture plate lid (Reiter 1986), a spoon-type tissue section lifter (Weber and Weber 1985), and a wire loop (Woke 1937). In many cases the collected eggs or rafts must be held in individual containers for hatching so species may be determined using larval characters. Containers used for hatching have been mentioned infrequently: 200 ml plastic cups (Madder, *et al.* 1980), culture dishes (Weber and Weber 1985), and 24-well tissue culture plates (Reiter 1986).

Part of our oviposition research requires that we collect and identify many individual rafts each summer. Only two mosquito species oviposit in our study sites: *Culex pipiens* L. and *C. restuans* Theobald, species distinguishable with certainty using characters of the first instar head capsule (see keys by Dodge 1966 and Reiter 1986). Larval identification

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is easiest when larvae are dead. The time required for eggs of these species to hatch and the larvae to die (55-65 h) means that considerable material is in the laboratory at any particular time. To reduce space requirements we use 96-well tissue culture plates for collecting and holding eggs until they hatch and larvae can be identified. The wells are filled ca. two-thirds with aged tap water. The small diameter of individual wells in these plates (6.7mm) required us to develop a tool ("raft spoon") for rapid, accurate collection of individual rafts in the field that could be used by relatively inexperienced personnel to collect rafts directly from field ovisites into the wells (Fig. 1). When required, removal of rafts from the wells is equally easy.

The raft spoon is made from brass rod, 4 mm (5/32") in diameter and 12 cm (4-3/4") in length. Brass rod is available from hobby shops; brazing rod of similar diameter should serve as well. Steps in making the spoon are shown in Fig. 2. The taper is 4 cm (1-9/16") long and is formed by filing from each side until the thin end is ca. 0.5 mm (1/32") thick. Both sides are then polished with emery paper. At this stage the thin end is bent to an approximate 9.5 mm (3/8") radius and two punch marks are made where holes will be bored. Holes are required so rafts center on the tip as they are lifted from the surface, instead of sliding off the side. Bending hardens the brass, so the tip must be annealed before holes can be drilled. This is done by heating it to a dull red, then allowing it to cool. The 1 mm (0.04") holes are made with a #60 drill bit, using the punch marks as starting guides, and the square end is rounded with a file. After the holes are drilled, upper and lower surfaces should be repolished to remove burrs. Wrapping the handles with bright-colored plastic tape helps avoid loss of spoons on the ground and, by increasing their diameter, makes them easier to hold.

In some field studies of *Culex* spp. oviposition, we need to identify the species that have laid rafts on test ovisites each night, but without removing complete rafts from an ovisite. Removing a daily sample of rafts for species identification from those laid the previous night would greatly alter larval abundance and would not indicate the exact number of rafts deposited by each species. Removal of complete rafts could also alter species ratio of the remaining rafts and thus might affect attractancy of the site to gravid females of one species or the other (e.g., Andreadis 1977, Hudson and McLintock 1967, Nakamura 1978). To avoid this problem we remove a sample of 15-25 eggs from each raft for hatching and identification and return the sampled raft to the ovisite. This practice allows us to maintain larval populations in test containers that are proportional, in larval numbers, to nightly oviposition. It has the added benefits of maintaining original species ratios and any attractancy due to presence of eggs or immature stages.



Figure 1. Using the raft spoon to place a raft into a well of a 96-well tissue culture plate.



Figure 2. The three stages in making a raft spoon. Left to right: the taper has been filed; tip has been bent and punched; holes have been bored at punch marks and tip rounded.



Figure 3. Small spoon for taking samples from egg rafts.



Figure 4. Using the small spoon to obtain a sample of eggs from an egg raft.

To obtain these raft samples, we made a second spoon similar to the one described above, but much smaller and without holes. It consists of a #3 steel insect pin with its tip hammered paper-thin and bent to a radius similar to the first tool. Before bending, the end is rounded with a file and both sides polished with fine emery paper. This tool is set into the end of a wooden handle from an artist's paint brush (Fig. 3).

In practice, a raft is removed from the ovisite surface with the raft spoon, and a sample is removed by slicing off the pointed end of the raft with the edge of the smaller spoon. The smaller spoon is then rotated so it can be slipped under the sample (Fig. 4), and the sample is transferred to a well of a tissue culture plate. The remainder of the raft is placed back on the ovisite, within a floating plastic ring (a fish feeding ring from a pet store) so it will not be sampled again. Eggs hatch within the ring and larvae are free to disperse throughout the ovisite. Both tools are wiped clean after taking a sample to ensure that no loose eggs are carried to the next sample. Data about site and date are written on the culture plate cover with a Sharpie® felt-tip marker (Sanford Permanent Marker Company). Sharpie® markings are easily removed with 95% ethanol when plates are cleaned. We examine each well after returning plates to the laboratory to be sure all samples are upright, which helps ensure hatching (Horner and Weber 1991). It is also necessary to rest one end of the cover on the upper surface of the plate itself, with the other end resting on the table so the two don't seal together from condensation and smother developing embryos (Reiter 1986). For larval identification, the entire culture plate (minus lid) is placed on the stage of a binocular microscope and moved cell-by-cell under the lens.

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**SOCIETY MEETING OF OCTOBER 27, 1993****THE MODE OF ACTION OF THE BIORATIONAL INSECTICIDES  
FROM *BACILLUS THURINGIENSIS*****Dr. Fred Walters**

Ecogen, Inc., Langhorne, PA

During this first talk of the 1993-1994 round of meetings, Dr. Fred Walters, of Ecogen, Inc., Langhorne, PA., focused on the bacterium *Bacillus thuringiensis* (BT), its mode of action and pesticidal properties. Dr. Walters, who received his graduate degrees in entomology from nearby Pennsylvania State University, researches the mode of action of BT for Ecogen, while other teams of researchers bioassay new strains of BT against major pests and develop more effective strains through genetic engineering. All these areas were summarized by Dr. Walters in an informative presentation.

BT is a well-known biological (= biorational) pesticide, with its best qualities being its safety and ease of application, inexpensive cost of overall production due to facilitated registration, and effectiveness on key insect pests. Yet, for all its success, BT and other biorational pesticides still constitute only a minor part (less than 1/2 of 1%) of the entire \$25 billion world-wide pesticide market. Of great importance for the future, though, BT is very amenable to improvement through genetic engineering and it is here that there is great potential to increase its share of the market. As Dr. Walters stressed, Ecogen is focusing its efforts on the genetic engineering of BT, particularly through designing more effective strains or combining strains for wider spectrum effects similar to chemical insecticides. Part of this strategy also relies on a better understanding of how BT actually works once it is ingested by a pest.

The mode of action of BT is through an internal crystalline protein, which, when ingested by a susceptible insect, solubilizes in the gut, causes a swelling and rupturing of the midgut epithelial cells, and the host itself quickly stops feeding and dies of starvation and disrupted hemolymph conditions. The disruption of the midgut epithelium also allows passage of BT spores into the hemolymph which may contribute to toxicity by septicemia. Ecogen has isolated close to 10,000 strains of BT whose internal protein crystals exhibit specificity toward certain orders of insects and over a range of gut physiological conditions.

The internal crystal proteins are encoded on multiple plasmids in the bacterium, not on the chromosomes, and this allows for the excision of plasmids that code for weak proteins, and the introduction of new plasmids that code for more effective proteins or those from strains affecting other insects. Through this, BT strains are developed which are much more effective against a certain pest, or which may possess a diverse combination of crystals affecting a multitude of pests. In this vein, Ecogen has several biological pesticides already on the market and has received an EPA generic approval for small scale field tests of the products it is developing.

The meeting also included several notes of entomological interest. Dr. Harold White, University of Delaware, noted that the reportedly rare gomphid dragonfly, *Gomphus* (= *Stylurus*) *plagiatus*, was found to be the most common dragonfly present on September 5 as he canoed the tidal part of Christina Creek in Delaware. The only previous record of this species for Delaware was a single specimen from Newcastle Co. in October. Dr. Paul Schaeffer, USDA, reported that the introduced beneficial coccinellid *Harmonia axyridis* has the annoying habit of aggregating in homes during the winter. He has had reports from places as widespread as Oregon, Louisiana and Georgia, including the complaint that the beetle's fecal material was staining one house.

About 20 members and their guests attended the meeting.

Jon K. Gelhaus,  
Corresponding Secretary

## KARYOTYPIC DATA ON THIRTEEN SPECIES OF NEARCTIC CARABID BEETLES (COLEOPTERA)<sup>1</sup>

J. Galián, A.S. Ortiz, J. Serrano<sup>2</sup>

**ABSTRACT:** Mitotic and meiotic chromosomes of thirteen Nearctic species of carabid beetles have been studied. The male haploid chromosome number varies between  $n=11+X$  and  $n=21+X$ . The results obtained allow the following conclusions: (1) The  $2n=37$  karyotype has been found in eight species, one of them belongs to the *Limbata Stylifera* group, thus corroborating its widespread occurrence among the main lineages of the family. (2) Data on *Amara (Celia) moerens*,  $2n=37$ , fit the hypothesis about the ancestry of this number for the genus *Amara*. (3) The trend towards low-numbered karyotypes observed in the tribe Lebiini has much progressed in *Cymindis chevrolati*,  $2n=24$ .

The chromosome number is already known for more than 750 species of the family Carabidae. Most cytogenetic studies on the Nearctic fauna have been concerned with the genus *Bembidion* (160 species: Maddison, 1985; Smith, 1953). The chromosome number of other groups of Carabidae from this region were described in 50 species and compiled in Smith and Virkki (1978) and Serrano and Yadav (1984). New results on Nearctic species have been added by Galián *et al.* (1990a, 1992). The aim of this work is to increase the basic knowledge of the cytotaxonomy of North American carabids, by adding the results obtained in 13 Canadian and Mexican species, and discussing briefly their cytotaxonomic significance.

### MATERIALS AND METHODS

The species analyzed were collected in the localities listed in Table 1. Results were obtained from one to four male adults per species. Identifications were made by G.E. Ball and D. Shpeley (Edmonton, Canada) and P. Moret (Paris, France). The beetles are deposited in the Departamento de Biología Animal, Universidad de Murcia (Spain). Specimens of the three unnamed species of *Platynus* are also deposited in the U.S.N.M., Smithsonian Institution, Washington, D.C. Karyological analyses were carried out on testes using a routine orcein-squashing method described elsewhere (Galián *et al.*, 1990). Chromosomes were tentatively arranged in pairs by size and shape (karyogram) in order to show gross features such as symmetry of the karyotype, occurrence of heteromorphic chromosomes, etc.

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## RESULTS

Results are summarized in Table 1.

**Genus *Omophron*.** Spermatogonial metaphases of *Omophron ovale* have  $2n=36$  chromosomes gradually decreasing in size, making a symmetric karyogram (Fig. 1). The X chromosome might be a submetacentric element of intermediate size and the Y is the smallest element of the karyogram. This identification is in agreement with meiotic observations in which there are 18 bivalents one of which is heteromorphic (Fig. 5).

**Genus *Diplous*.** The diploid number of *Diplous californicus* is  $2n=37$ . There is a large submetacentric pair (Fig. 2). The second pair is submetacentric and it is of the same size as an odd metacentric element, probably the X chromosome. The other pairs are mediocentric and gradually decreasing in size. Metaphase I cells have  $18+X$  elements. Metaphase II cells are of two types, with 18 and  $18+X$ .

**Genus *Pterostichus*.** The haploid number of the two species of *Pterostichus* is  $n=18+X$ . Spermatogonial mitosis of *P. melanarius* shows  $2n=37$  chromosomes making a symmetric karyogram (Fig. 3). The X chromosome may be a submetacentric element of intermediate size. In *P. herculeanus* only meiotic observations were available. Metaphase I cells of both species (Figs. 6 and 7) show 18 autosomal bivalents with terminal chiasmata and the X univalent usually situated peripherally. Metaphase II cells are of two types with  $n=18$  and  $n=18+X$ .

**Genus *Agonum*.** The diploid number of spermatogoniae of *Agonum corvus* is  $2n=39$ . The karyogram is made up of meta- and submetacentric chromosomes gradually decreasing in size (Fig. 4). The X chromosome is identified as a mediocentric element about the size of the largest pair.

**Genus *Platynus*.** The diploid number of *Platynus nugax* is  $2n=37$ . The karyogram is made up of 18 autosomal pairs and one element about the size of the largest pair that may be the X chromosome. The haploid number of *Platynus chloreus* is  $n=18+X$ . Metaphase I plates (Fig. 8) show 18 autosomal bivalents and a univalent usually laying at the periphery. Metaphase II cells are of two types with  $n=18$  and  $n=18+X$ . The haploid number of *Platynus* sp. 1 and *Platynus* sp. 3 is  $n=18+X$ . Metaphase I cells of *Platynus* sp. 1 (Fig. 9) show 18 autosomal bivalents and a univalent usually situated at the periphery. Metaphase II cells are of two types with  $n=18$  and  $n=18+X$  (Fig. 10). Meiotic observations indicate that the haploid number of *Platynus* sp. 2 is  $n=21+X$  (Fig. 11). The X univalent is situated peripherally and may be the largest element of the karyotype according to the observations of metaphase II plates. In this stage there are cells with  $n=21$  (Fig. 12) and cells with  $n=22$  (Fig. 13) which have the large X chromosome. The haploid number of *Platynus variabilis* is  $n=21+X$ . At diakinesis (Fig. 14) the two largest pairs form two chiasmata, pairs three and four form one interstitial chiasma and the other

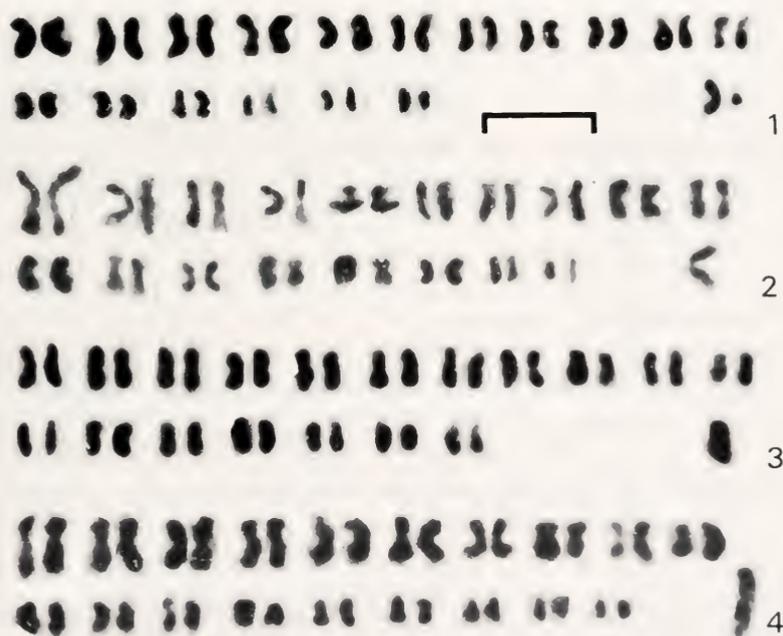
bivalents have only one terminal chiasma. The X chromosome is identified as one element of small size which condenses precociously in the earlier stages and in metaphase I is situated peripherally.

**Genus *Amara*.** *Amara moerens* has a haploid number of  $n = 18 + X$ . At metaphase I (Fig. 15) 18 bivalents were observed with terminal chiasmata and one univalent. Two types of cells either with  $n = 18$  or  $n = 18 + X$  are observed at metaphase II.

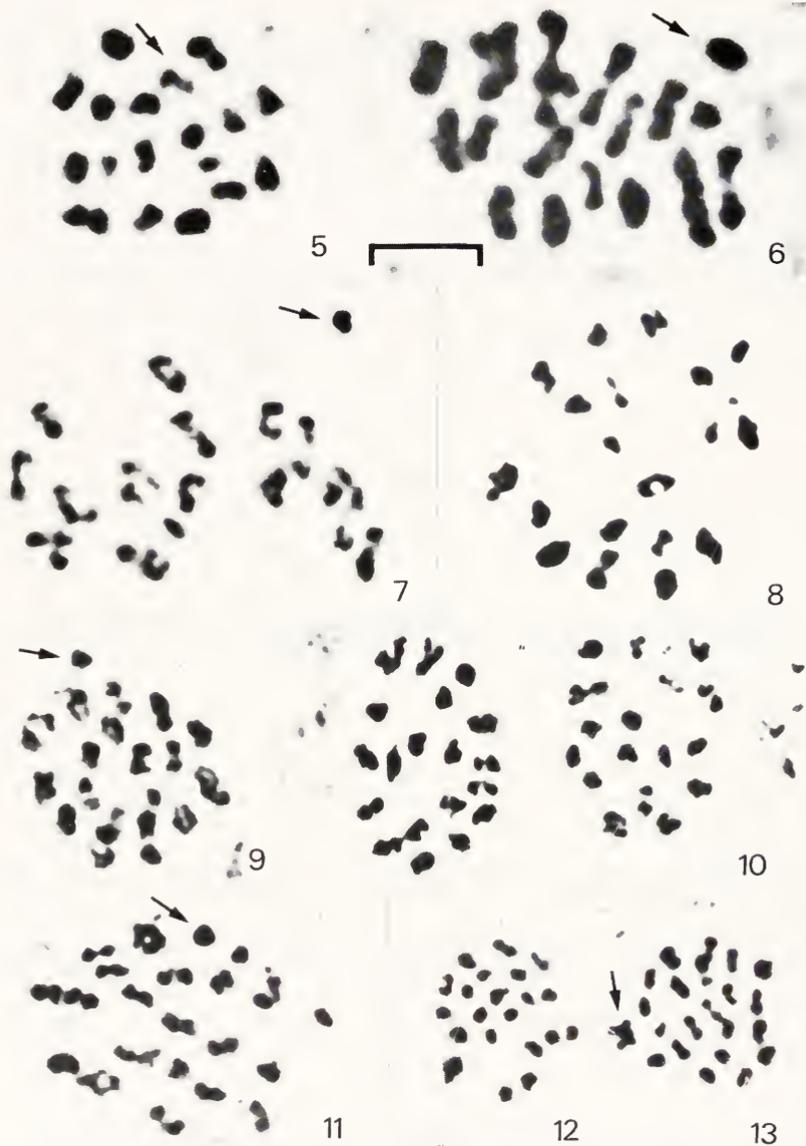
**Genus *Cymindis*.** Meiotic cells of *Cymindis chevrolati* have  $n = 11 + XY$ . At diakinesis (Fig. 16) the three largest bivalents form rings. There is an heteromorphic bivalent that is identified as the XY pair, clearly observed in all the cells studied. Metaphase II plates are of two types with  $n = 11 + X$  (Fig. 17) and with  $n = 11 + Y$  (Fig. 18).

### DISCUSSION

The haploid chromosome number of the species investigated varies between  $n = 21 + X$  and  $n = 11 + XY$  and the commonest number (8 species) is  $n = 18 + X$ . Males of 11 species have XO sex chromosomes and 2 species



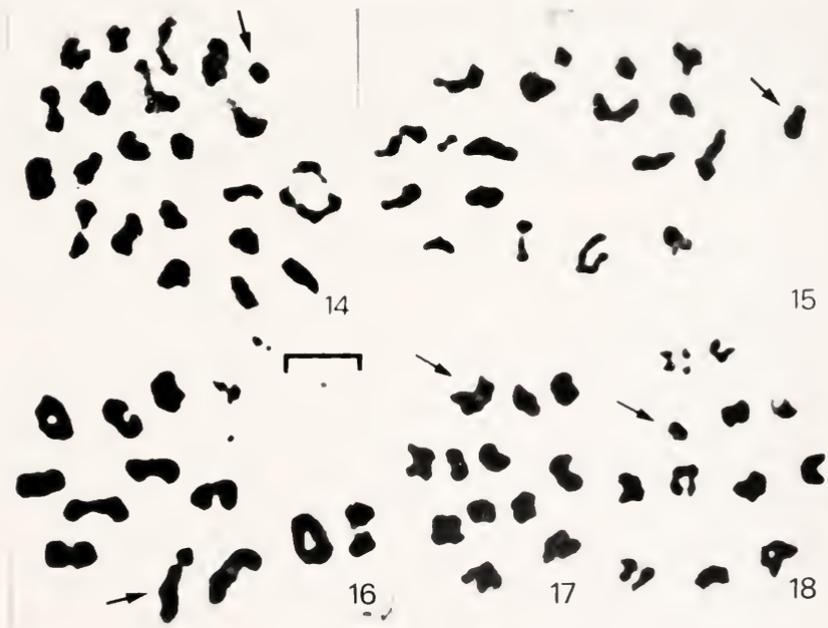
Figs. 1-4. Tentative karyograms of: (1) *Omophron ovale*,  $2n = 36$ ; (2) *Diplous californicus*,  $2n = 37$ . (3) *Pterostichus melanarius*,  $2n = 37$ . (4) *Agonum corvus*,  $2n = 39$ . Sex chromosomes (XY or XO) are figured to the right. The bar equals 5  $\mu\text{m}$ .



Figs. 5-8. Metaphase I or diakinesis of: (5) *Omophron ovale*,  $n = 17 + XY$ . (6) *Pterostichus melanarius*,  $n = 18 + X$ . (7) *Pterostichus herculeanus*,  $n = 18 + X$ . (8) *Platynus chloreus*,  $n = 18 + X$ . Figs. 9, 10. *Platynus* sp 1 (9) metaphase I,  $n = 18 + X$  (10) metaphase II,  $n = 18 + X$ ,  $n = 18$ . Figs 11-13. *Platynus* sp 2 (11) metaphase I,  $n = 21 + X$  (12) metaphase II,  $n = 21$ , (13) metaphase II,  $n = 21 + X$ . Arrows show tentative identification of sex chromosomes. The bar equals  $5 \mu\text{m}$ , except for Fig. 7 which is  $7 \mu\text{m}$ .

have XY sex chromosomes. The course of meiosis is chiasmatic and the recombination index is low because one chiasma per bivalent is the rule. The exception is represented by *Platynus variabilis* in which the four largest pairs form rings at diakinesis and the others have interstitial chiasmata.

The karyotype with  $2n=37$  was previously known of *Limbata Conchifera* and *Scrobifera* of Jeannel (1941), and has been found now in *Diplous californicus* (Tribe Patrobini), a species included in the *Limbata Stylifera*. Numbers close to 37 have also been found in the *Limbata Balteifera* (Galián *et al.*, 1990b) and in the *Limbata Simplicia*. To this last group belongs the Nearctic species *Omophron ovale*, which has  $2n=36$  like *O. limbatum* from Europe (Nettmann, 1986). As more data become available a widespread occurrence of a  $2n=37$  karyotype, or its close derivatives, is corroborated in the main phyletic lineages of Carabidae suggested by Jeannel (1941). The corroboration applies also for Erwin's (1985) system of carabid classification and it supports the hypothesis that



Figs. 14-16. Metaphase I of: (14) *Platynus variabilis*,  $n = 21 + X$ . (15) *Amara moerens*,  $n = 18 + X$ . (16) *Cymindis chevrolati*, metaphase I,  $n = 11 + XY$ . Figs. 17, 18. Metaphase II of *C. chevrolati*, (17)  $n = 11 + X$ , (18)  $n = 11 + Y$ . Arrows show sex chromosomes. The bar equals 5  $\mu$ m.

this number is an autapomorphy for the whole family or appeared early during the first stages of radiation of carabids.

### Particular aspects of the tribes

The chromosomal number  $n=18+X$  of *Pterostichus melanarius* agrees with that reported for Nearctic individuals by Smith (1960) and for Palearctic ones by Wilken (1973), Kowalczyk (1976) and Nettmann (1986); *P. herculaneus* has also this number. Both species follow the same common pattern found in the tribe Pterostichini, in which  $n=18+X$  may be considered the ancestral number of the tribe (Serrano, 1986; Galián, 1989).

The karyotypes of the seven Nearctic species of the tribe Platynini reflect the pattern already known for the tribe based on Palearctic species (Serrano, 1986). The predominant number for the tribe is  $2n=37$ , although there are some species with deviant numbers but keeping in most cases the XO sex system. Incidentally, the species named *Platynus* sp. 1 and sp. 2 were initially separated by the karyotypic results and thereafter by a careful morphological study. This is another case of karyotypic divergence between morphologically related species that is sometimes found among carabid beetles.

The finding of a  $2n=37$  karyotype in *Amara moerens* corroborates its occurrence in species of European and North American groups of the subgenus *Celia*. This same number is found in the subgenera *Amara* and *Camptocelia*, and thus it seems to be a shared state for many subgenera.

Table 1. Male chromosome number of thirteen species of Carabidae.

Species	2n	n	Localities (*)
<i>Omophron ovale</i> Horn	36	17+XY	1
<i>Diplous californicus</i> Motschulsky	37	18+X	1
<i>Pterostichus melanarius</i> Illiger	37	18+X	1
<i>Pterostichus herculaneus</i> Mannerheim	—	18+X	2
<i>Agonum corvus</i> Leconte	39	—	3
<i>Platynus nugax</i> Bates	37	—	4
<i>Platynus chloreus</i> Bates	—	18+X	5
<i>Platynus variabilis</i> Chaudoir	—	21+X	6
<i>Platynus</i> sp. 1	—	18+X	7
<i>Platynus</i> sp. 2	—	21+X	7
<i>Platynus</i> sp. 3	—	18+X	8
<i>Amara moerens</i> Zimmermann	—	18+X	4
<i>Cymindis chevrolati</i> Dejean	—	11+XY	4

\* (1) Nicola River, British Columbia (Canada); (2) UBC Forest, British Columbia (Canada); (3) Thompson River, British Columbia (Canada); (4) La Marquesa, México (México); (5) Piramide de Malinalco, México (México); (6) Bosque de Chapultepec, México D.F. (México); (7) Puerto Lobos, Veracruz. (México); (8) Tenango de Doria, Hidalgo (México).

Serrano (1986) and Galián *et al.* (1991a) have already postulated that this number is ancestral for the genus *Amara*. The data of Smith (1953) for *A. impuncticollis*,  $2n=17+XY$ , indicate that the trend towards decreasing numbers observed in other *Amara* groups is also present in the Nearctic *Celia*.

The number of *Cymindis chevrolati*,  $n=11+XY$ , is lower than those reported for six Palearctic species of the same genus (from  $n=21+X$  to  $n=16+XY$ ; Serrano, 1981; Galián *et al.*, 1991b). This observation in *C. chevrolati* agrees with the predictions of the hypothesis of Galián *et al.* (1991b) of a trend towards numbers lower than  $2n=37$  in the subfamily Lebiinae. This trend is also present in the Australian species of the subfamily Lebiinae (Galián and Moore, in press). According to the hypothesis, *C. chevrolati* is the karyotypically most advanced species of the genus. The study of more Nearctic species is needed before making more accurate comparisons with Palearctic taxa.

#### ACKNOWLEDGMENTS

The authors wish to thank George E. Ball and Danny Shpeley (Edmonton), and Pierre Moret (Paris) for their help in determining the beetles and Pedro Reyes-Castillo (Jalapa) for his help in collecting the Mexican specimens. We are also grateful to D. Mossakowski (Bremen, Germany), E. Petitpierre and C. Juan (Palma de Mallorca, Spain) for their critical review of the manuscript. This work was supported by project number PB90-0357-C02-02 of the DGICYT of the Spanish Government.

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## SOCIETY MEETING OF NOVEMBER 17, 1993

### RAISING SATURNIID MOTHS FOR LABORATORY RESEARCH

**Dr. Willam Telfer**

Department of Biology, University of Pennsylvania

For the past 35 years, a back yard orchard of wild cherry, *Prunus serotina*, normally considered a weed tree, has served as food for hundreds, even thousands of saturniid caterpillars destined for the research laboratory. Housed under netting covering individual trees, cecropia moths and other desired species, including luna moths, have been reared annually to provide specimens used for investigating the intricacies of hormonal control and biochemistry of such physiological processes as molting, pupation, and reproduction. Although these rearing efforts are reminiscent of another time and place where the objective was silk production (i.e. Etienne Leopold Trouvelot in Medford, MA, the site of the release of the gypsy moth in North America [see story in *American Naturalist*, 1:30-38, 85-94, 145-149 and Bull. ESA 35(2): 20-22]), only native moths have been encouraged in these rearings in suburban Philadelphia. Not unlike other outdoor rearing efforts, problems of disease were often encountered in the net cages. Dr. Telfer noted that the cecropia is particularly susceptible to this fate. Nevertheless, over the years, these efforts have led to an annual supply of specimens which were brought into the laboratory and placed in refrigerators until their use in experiments designed to investigate the intricate biochemical processes which occur during pupation, molting, diapause, and reproduction of these magnificent native silk moths.

Once in the laboratory, these moths, usually used as pupae, were subjected to intricate surgical procedures designed to test hypotheses to reveal the complex inner biochemical and physiological workings of transformation processes, hormonal control, and reproduction. Most impressive were illustrated microdissection procedures of bisecting pupae and

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**GRASSHOPPERS (ACRIDOIDEA)  
ASSOCIATED WITH XI QIAO  
MOUNTAIN IN CENTRAL GUANGDONG  
PROVINCE OF SOUTHEASTERN CHINA<sup>1</sup>**

Emmett R. Easton<sup>2</sup>, Ge-Qiu Liang<sup>3</sup>

ABSTRACT: Notes are provided for 31 species of acridoid grasshoppers of the Pyrgomorphidae, Catantopidae, Oedipodidae, Arcepteridae and Acrididae from a mountain area near Nanhai city in the central Guangdong Province of mainland China.

Xi Qiao Hill or mountain is a forested resort area (2-3,000 feet elevation) near Nanhai City approximately 60 miles southeast of the city of Guangzhou in the central Guangdong Province of southeastern mainland China. The climate is wet tropical or sub-tropical, frosts are rare and rainfall averages around 2,000 mm annually. Average temperatures in July range from 28-30C and 13-16C in January. Overstory vegetation in the upper region of the mountain consists largely of secondary growth southern pine, *Pinus mansoniana*. Evidence is lacking for the subtropical broadleaf evergreens reported in nature reserves such as Dinghu Mountain near Zhaoqing City. *Cunninghamia* sp. of conifer was found at lower elevations along with *Eucalyptus* sp. and sweetgum, *Liquidambar formosana*. Bamboo was common along roadsides. Of the 31 species of Acridoidea reported herein, 16 species were collected by sweep net from grassy vegetation near roadsides between July 6-12, 1993. Three species of *Ceracris* inhabited bamboo groves. The others consist largely of museum records collected previously by the second author and deposited in the Zhongshan University Research Institute entomology collection (Guangzhou).

LIST OF SPECIES

ACRIDOIDEA

**Pyrgomorphidae**

*Atractomorpha sinensis* Bolivar, 11-17 June 1987, 6-12 July collected in beans from garden near the Nanhai Middle School. Wei Kai (1992) reports it feeding on willow and bamboo. It is widely distributed in China (Bei Bienko & Michchenko, 1963) and has also been reported

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from the colony of Hong Kong (C. Lau, unpubl. data).

*Atractomorpha psittacina* (deHaan) 17 May 1981.

### Catantopidae

*Tristria pisciformei* (Serville) 17 May 1981, collected in grass. Found in tall grasses on hillsides or slopes of mountains. Adults develop by October and are believed to overwinter until June of the following year. This species is known from Victoria Peak on Hong Kong island at 1400 feet elevation and the species occurs on Hainan island as well as Kwangsi Province of China.

*Spathosternum sinensis* Uvarov, 29 July 1981. Tinkham (1940) found this species in short grass plains in damp areas with nymphs emerging in May and maturing in July. It is believed to occur throughout Guangdong Province as well as Kwangsi and Hainan Island.

*Hieroglyphus tonkinensis* Bolivar, 19 Sept 1984, 6-12 July 1993. Tinkham (1940) reported it as a pest of rice, sugar cane and bamboo. Egg pods, according to him, are bowl-shaped with their ends circularly rounded and the top sunken or concave.

*Gesonula punctifrons* (Stal.) 16 May 1981, 7 July 1993 has been called the Taro locust. We collected this species in a lowland field near a stream on *Colocassia esculenta* leaves. It is believed to inhabit dense shrubs on the edges of streams, and the adults have been observed from November through March in the Guangdong region. Hill (1982) illustrated this species in Hong Kong as a species of *Ceracris*. It is also recorded from the Hunan province of China (Wei Kai, 1992) as well as from Taiwan and the Ryuku islands of Japan.

*Oxya chinensis* (Thunberg) 10 June 1964, 5 July 1993. Hill (1982) in Hong Kong referred to this species as the small rice grasshopper as it is a pest of rice in many areas, including Hawaii, USA.

*Oxya hyla intricata* (Stal) 17 October 1981, 6 July 1993. Tinkham (1940) reported eggs of *O. intricata* hatching in late April through early May and adults developed by July. He reported egg pods as irregularly shaped and cemented to stones with a brown secretion. It is distributed from Japan and Taiwan through central China to India as well as Indonesia. Hollis (1971) reported it from Hong Kong.

*Pseudoxya diminuta* (Walker) 3-6 May, 1983, 5 July 1993 on beans and grasses near middle school. This species is sold for bird food in Hong Kong in Mongkok.

*Chondracis rosea rosea* (DeGeer) 26 Oct. 1992, 5 July 1993. Only immatures were observed during July at this site. Easton (1991) reported an adult feeding on elephant grass in Macau during August and Tinkham (1940) claimed that young nymphs emerge in early May with adults maturing after the first week in July. The female has one more instar than the male and eggs are believed to be laid in September or early October while adults are not able to overwinter. Hill and Cheung (1978) record it from Hong Kong.

*Patanga succincta* (Johannsen) 21 April 1982. This species is known as the Bombay locust in Hong Kong (Hill, 1982). Apparently it is widespread in southeast Asia including India and commonly sold as food for caged birds in the Mongkok bird market in Hong Kong colony.

*Chloroedocus capensis* (Thunberg) 24 Sept 1982, 6 July 1993. It has often been reported from dense grass and brush on hillsides. According to Tinkham (1940), nymphs occur in May with adults developing in July and eggs are laid in September in the Guangdong and Hainan provinces. Willemse (1957) also records it from India and Sri Lanka.

*Stenocatantops splendens* (Thunberg) 6 April 1981, 7 May 1983. Apparently widespread in southern China and India it is a common species sold in the Mongkok bird market of Hong Kong.

*Xenocatantops brachycerus* (Willemse) 28 May 1986, 6 July 1993.

*Eucoptacra praemorsa* (Stal) 5 July 1993 along roadside near the middle school. The type locality is listed as Hong Kong (Willemse, 1957). It is also reported from Taiwan and Burma.

### Oedipodidae

*Aiolopus tamulus* (Fabricius) 14 June 1984. This species has recently been found to be widespread in Macau including the islands of Taipa and Coloane (unpubl. data). It has been recorded in Taiwan and Japan as well as the Guangdong region of China.

*Heteropternis respondens* (Walker) 20 Oct 1990. Occurs also in the Hong Kong colony (C. Lau, unpubl. data).

*Heteropternis rufipes* (Shiraki) 6 April 1981, 20 August 1987. It has been recently collected during September (1993) on the islands of Taipa and Coloane in Macau (unpubl. data).

*Oedaleus abruptus* (Thunberg) 4 April 1981.

*Gastrimargus marmoratus* (Thunberg) 6 April 1981, 5 July 1993. Found near secondary road on sparsely vegetated hillside. It is widespread in China (Ritchie 1982) and believed to occur as far north as Beijing; also found in Japan and South Korea and in Hong Kong it is sold as bird food (Hill and Cheung, 1978).

*Pternoscirta sauteri* (Karny) 6 June 1984.

*Pternoscirta callignosa* (deHaan) 27 May 1986. It is reported as feeding on *Agave* sp. in the colony of Hong Kong.

*Trilophidea annulata* (Thunberg) 11 Sept 1958, 5 July 1993. This was a common species found along roadsides on the ground in arid well drained areas. It also occurs in the Hong Kong colony (C. Lau, unpubl. data.) where it is sold as food in the Mongkok bird market.

### Arcypteridae

*Ceracris nigricornis laeta* (I. Bol.) 8 April 1981, 6 July 1993. Hill (1982) in Hong Kong refers to this species as the Blackhorned grasshopper. It is found on bamboo and roadside grasses.

*Ceracris kiangsu* Tsai, 21 June 1981, 5-8 July 1993. Collected in bamboo thickets along road sides on a hill, it is a major pest of bamboo in the Guangdong province. One of us (LGQ) determined when investigating an outbreak during the spring of 1993 that eggs collected from the soil on March 26th hatched by the middle of April and adults had developed by June. Egg-laying occurs starting in July and lasts through November. Effective control of this pest involves treatment of the soil with pesticides during the period of nymphal emergence (Liang, 1992).

*Ceracris fasciata* (Brunner-Wattenwyl) 8 Oct 1958, 6 July 1993. It was collected from tall grasses. This species is reported as feeding on bam-

boo grass, *Miscanthus* sp. It has also been reported from Hainan island as well as Burma in southeast Asia.

*Ceracris hoffmani* Uvarov. 11 August, 16 Oct 1981, 7 July 1993, collected from tall grasses at foot of mountain near middle school.

*Bidentacris quangdongensis* Zheng, a synonym of *Dnopherula taeniatus* (Bolivar, 1902). This species has recently been collected from Coloane island in Macau during September (1993) (unpubl. data) from short grasses on a hillside.

### Acrididae

*Acrida cinerea* Thunberg. 29 May, 17 July 1981, 5-6 July 1993. Common in grassy fields, this species was abundant near the breast of a dam near the top of the mountain.

*Gelastorhinus chinensis* Willemse. 26 July 1932, 7 July 1993. Collected in tall rank grasses on a lower mountain slope near the middle school.

*Phlaeoba infumata* Brunner-Wattenwyl. 7 July 1993. This species was found in tall rank grasses on the lower slopes near the middle school. Reported in the literature from rice fields and longer grasses along streams. Bei-Bienko and Michchenko (1963) record it from India and Burma as well as the Guangdong and Hainan provinces of China. It also occurs in Hong Kong (C. Lau, unpubl. data).

*Phlaeoba antennata* Brunner-Wattenwyl. 8 July 1986. This species is known to feed upon slender bamboo grass, *Miscanthus* sp. Willemse (1951) has reported it occurring in Singapore, Burma, Borneo and Sumatra in addition to Hong Kong and the Kwangsi and Hainan provinces of China.

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Continued from page 118

then aseptically sealing the severed end to a microscope coverslip to permit both continued development and visual observation of changes in tissues during pupal transformation.

Dr. Telfer's work has contributed to enhanced understanding of the unseen internal biochemical processes that most of us only view as a marvelous eclosion of a magnificent silk moth.

There were several entomological notes of interest, including a first hand account of the urticating properties of a slug caterpillar (Sue Frank), the recent southern movement of pierid butterflies (Joe Sheldon) and Dr. Curtis Sabrosky called our attention to a published account of an African treatment for cobra and viper bites, as well as bee and scorpion stings – the use of electrical shock, as with a cattle prod! Howard Boyd called our attention to an article in *Natural History* (Dec. 1992) showing a 17th Century artist's rendition of various South American caterpillars. On display during the meeting was a collection of insects in amber (Yale Goldman) and another of the Society's historical memorabilia provided by Mildred Morgan. On view were several old block plates used for the Society's logo, letterhead, and, most impressive, an original block plate used to print old certificates of membership. Surrounding the edges of the latter is intricate scroll work in which are embedded the names of some of the famous early members at the time of incorporation (1862, when no other entomological society was in existence): Say, Melsheimer, Haldeman, Leconte, Horn, Scudder, Harris, Fitch, Norton, Uhler, and Cresson.

The meeting at the Academy of Natural Sciences was attended by 23 members and eight guests.

Paul W. Schaefer,  
Recording Secretary

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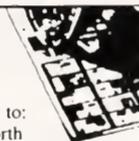
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# ENTOMOLOGICAL NEWS

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## A NEW SPECIES OF *HELIUS* CRANE FLY (DIPTERA: TIPULIDAE) WITH REDUCED ANTENNAE, FROM ARIPO CAVES, TRINIDAD<sup>1</sup>

Nathan Welch,<sup>2</sup> Jon K. Gelhaus<sup>3</sup>

ABSTRACT: A new species of crane fly, *Helius (Helius) darlingtonae*, is described from Aripo Caves, Trinidad. Both sexes possess a single segmented antennal flagellum, a feature unique within the Tipulidae, and of rare occurrence within the Diptera in general. *Helius darlingtonae* n. sp. is apparently an obligate cave dweller, the first noted in this habitat for this genus in the New World and the first species in the genus recorded from Trinidad. Based on characteristics of the male genitalia, *H. darlingtonae* n. sp. appears most similar to *H. distinervis* Alexander from Panama.

The crane fly genus *Helius* consists of approximately 215 described species worldwide, most of these found in tropical regions. In the neotropics alone, 45 species and subspecies have been recorded (Alexander and Alexander 1970, Alexander 1971a, b, 1980). The genus is currently placed in the tribe Limoniini, and is recognized in the adult stage by the distinct and moderately elongate rostrum (about as long as head or longer) and lack of an R2 crossvein (Alexander and Byers 1981). A recent cladistic analysis, based on characters of the immature stages, places *Helius* not in the Limoniini but as a sister taxon to a clade containing the Limoniini, subfamilies Cylindrotominae and Tipulinae and several other genera combined (Oosterbroek and Theowald 1991). Several north temperate species have been reared from aquatic and semi-aquatic habitats, mainly in or around marshy areas (Alexander 1920, Brindle 1967, Byers 1984). In addition, *Helius albitarsis* (Osten Sacken) emerged in a trap set over a small Puerto Rican stream (Livingston and Gelhaus, 1993) and larvae tentatively identified as *Helius* were collected from the water in bamboo internodes in Peru (Louton *et al.*, in press).

Although virtually nothing is known of the adult habitat of the vast majority of species (some exceptions for nearctic species include Rogers 1942, and Zalom 1979), three species in Southeast Asia have been reported from caves, one collected at some distance from the cave entrance (Alexander 1961). We describe in this paper a new species collected from Aripo Caves, Trinidad, which shows a remarkable reduction

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in the antennal flagellum. The adult habitat and entire crane fly fauna from this site is discussed in detail by Darlington and Gelhaus (1993). This is the first species of *Helius* recorded on the island of Trinidad, and the first known cave inhabitant for the genus in the New World.

Terminology follows that of McAlpine (1981) and Young (1987).

### *Helius (Helius) darlingtonae*, NEW SPECIES

**DIAGNOSIS:** Antennal flagellum consisting of a single short segment with 3-4 elongate setae and a single subapical one (Fig. 2); male genitalia with apex of outer dististyle bifid, largest spine with numerous tubercles (Fig. 5), lateral process of vesica broadly flattened, strongly bent beyond base, with rounded apex (Fig. 4).

**DESCRIPTION:** (Figs. 1-9) (Measurements based on N=12 males, 6 critical point dried (CPD), 6 in ethanol; 1 female in ethanol)

**Body length:** 3.7-4.3 mm (CPD specimens); 4.3-5.3 mm (in ethanol). Overall body coloration light yellowish brown in ethanol, slightly darker in CPD specimens, weakly sclerotized throughout.

**Head:** (Fig. 2). Without darker markings; eyes large but not holoptic, clearly separated dorsally and ventrally. Length of rostrum subequal to length of head, orientation perpendicular to longitudinal axis of body. Maxillary palps four-segmented, terminal segment moderately long, equal to or slightly exceeding the lengths of segments 1-3 combined. Antenna strikingly short, 0.2mm long, with three segments. Length of single flagellar segment 2/3 length of scape and pedicel combined, strongly narrowed in apical half with 4-5 elongate setae (3-4 terminal, one near mid-length), length of each exceeding overall length of segments.

**Thorax:** Overall light brown without darker markings. Dorsum slightly polished, distinct dark brown setae on dorsum of cervical region, and arranged in a pair of lines longitudinally on presutural scutum only. Wing (Fig. 1) overall light brown, veins brown, stigma slightly darker. Wing length: male 4.5-5.1 mm; female 4.9; width: male 1.3-1.4 mm; female 1.3mm. Venation as in Fig. 1. Legs mostly brown throughout, but each basitarsus paler in apical half, extreme apex and remainder of tarsi whitish.

**Abdomen:** Evenly light brown, sclerites unmarked.

**Male genitalia:** Figs. 3-5. Eighth tergum narrow, length 1/10th that of preceding; eighth sternum twice as wide, weakly sclerotized. Ninth tergum and sternum fused into continuous ring; posterior margin of tergum weakly concave; sternum strongly produced posteriorly with median apical cleft (Fig. 3). Tenth tergum broadly swollen, mostly membranous, with lightly sclerotized areas dorsolaterally. Basistyles (=gonocoxites) cylindrical, without any basal lobe, not produced past insertion of dististyles; basistyles with scattered long setae but without distinct patches of finer setae. Two dististyles (dorsal and ventral) approximately subequal in length (Fig. 4). Dorsal dististyle (=gonostyle) a darkly sclerotized, nearly straight rod, with unequally bifid apex; at high magnification, apex with numerous tubercles on surface of larger apical point (Fig. 5). Ventral dististyle mostly pale, broad basally, narrowing to slender, rounded apex; distinct setae mostly along dorsal margin, with two subequal setae at apex. Body of vesica small; each lateral process of the vesica (sensu Young 1987, = gonopophysis, Alexander 1961, or lateral tergal arm, Alexander 1940) an evenly broad, flattened, moderately pale blade, strongly bent beyond the base, apex rounded (Fig. 4). Apparent dorsal bridge of vesica with tuberculate surface, extending from base of lateral process medially. Anterior processes of vesica very small, widely separated, not reaching midpoint of ninth segment. Aedeagus of moderate length,

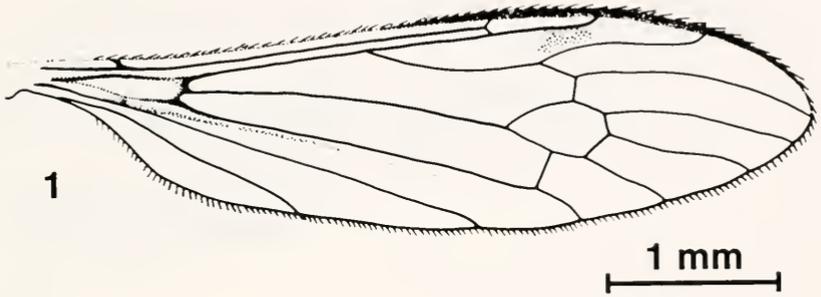


Fig. 1. Wing of *Helius darlingtonae* n. sp.

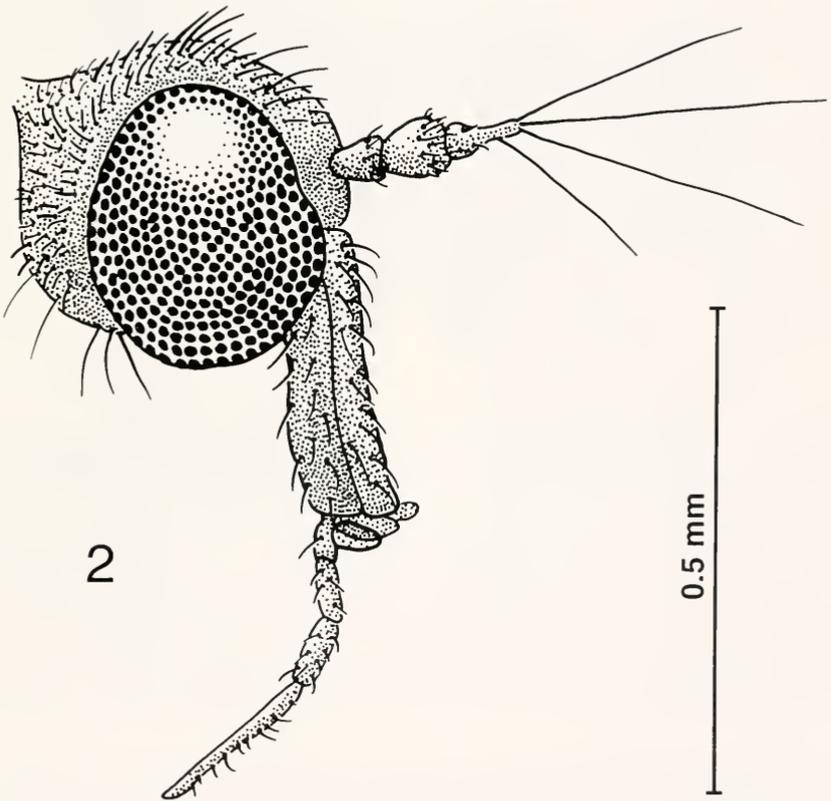
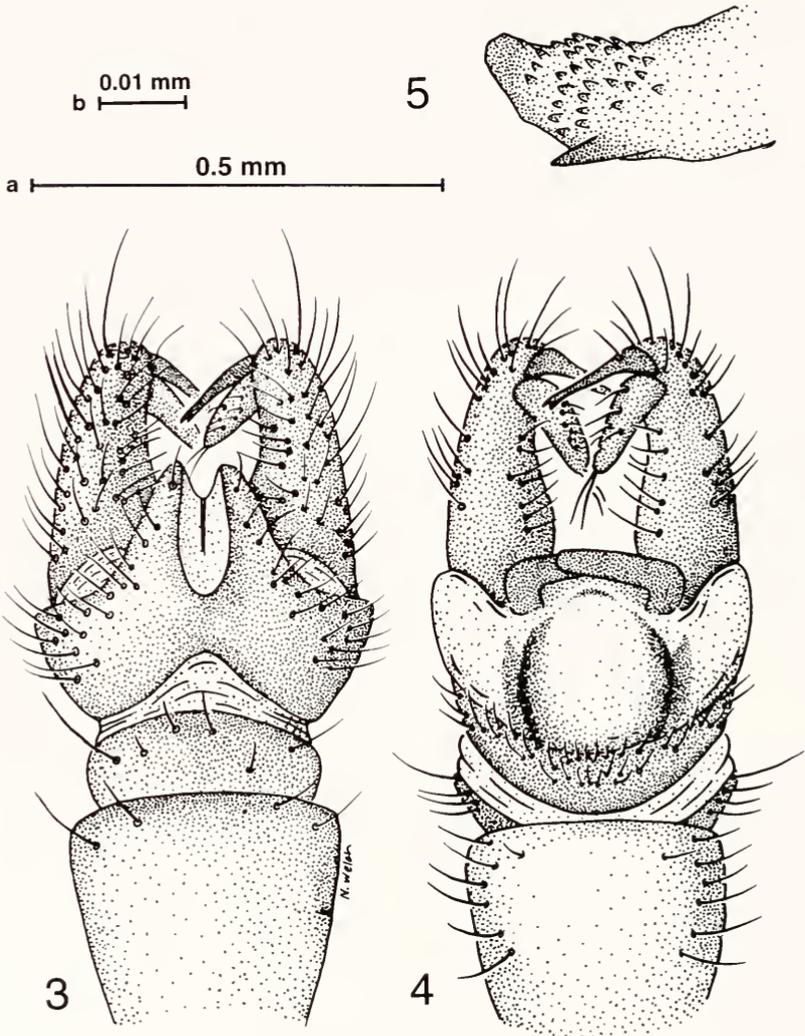
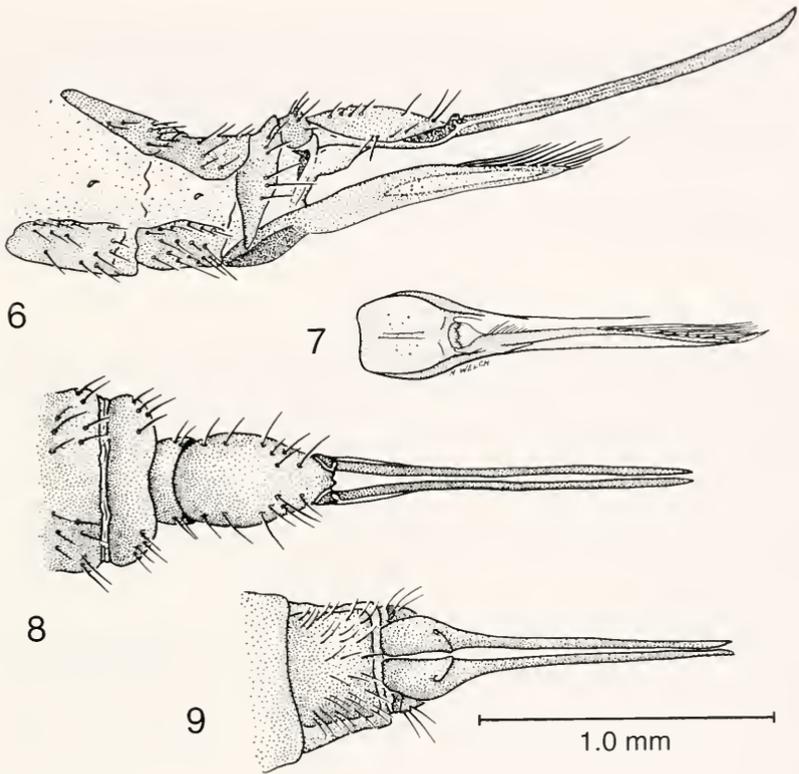


Fig. 2. Head of *Helius darlingtonae* n. sp., lateral view.

straight, lightly sclerotized, about as long as ninth sternal lobe; aedeagal processes as transparent blades, slightly divergent near apex, with medial margin slightly roughened.



Figs. 3-5. Male genitalia of *Helius darlingtonae* n. sp. Fig. 3, ventral view, Fig. 4, dorsal view, terminal abdominal segments (for clarity, aedeagus omitted). Fig. 5, apex of dorsal dististyle. Scale a, Figs. 3,4; scale b, Fig. 5.



Figs. 6-9. Female genitalia of *Helius darlingtonae* n. sp. Fig. 6, lateral view. Fig. 7, inner view of eighth sternum and hypovalves (right valve only shown). Fig. 8, dorsal view. Fig. 9, ventral view.

**Female genitalia:** Figs. 6-9. Eighth and ninth terga narrowed, each approximately half length of preceding terga. Tenth tergum with elongate scattered setae posteriorly, posterior border narrowly emarginate medially, with paired lobes sublaterally appressed to base of cerci (Fig. 8). Cerci slender and elongate, over twice as long as tenth tergum (Fig. 6). Infraanal plate a "U"-shaped sclerite, 13 long setae along posterior margin, finer hairs and microtrichia on remainder of plate. Hypovalves (Figs. 7, 9) as elongate blades, with closely-set setae (or seta-like extensions?) along distal half of dorsal margin, a distinct socketed seta at apex of each blade.

**HOLOTYPE:** Male (recovered from 70% alcohol via CPD), labelled "TRINIDAD:/Aripo Soho Cave/3 March 1991/J.P.E.C. Darlington" "HOLOTYPE/*Helius/darlingtonae*/N. Welch & J. Gelhaus" (red label). The type is in the collection of the Academy of Natural Sciences, Philadelphia.

PARATYPES: All topotypic (Aripo Caves system) and at light: 18-VI-1989 (Main cave), 5 males (dried); 22-IV-1990 (Soho cave), 3 males (fluid, slide of wing); 24-II-1991, (Main cave) 5 males (fluid); 3-III-1991 (Soho cave), 12 males, (CPD), 4 males, 1 female (fluid, slides of male and female genitalia). Paratypes are deposited in the Academy of Natural Sciences, Philadelphia, PA, Carnegie Museum of Natural Sciences, Pittsburgh, PA and the National Museum of Natural History, Washington, D.C.

SPECIFIC ETYMOLOGY: We name this species for Dr. Johanna Darlington, a specialist of Isoptera, in recognition of her great efforts to make the insect fauna of the caves of Trinidad better known.

## DISCUSSION

*Helius darlingtonae* cannot be easily confused with any other known species. As noted, the single-segmented flagellum with several long setae is unique within the Tipulidae. Based on aspects of the male genitalia, *H. darlingtonae* is closely related to *H. distinervis* Alexander from Panama (Chiriqui). Both species share the following two features: the apex of the outer dististyle with numerous tubercles or "spinulae" and the lateral process of vesica broad and flattened with a rounded apex (Alexander 1940). Neither characteristic is described for any other neotropical species of the genus.

Although no other crane fly is known to possess a single segmented flagellum, a somewhat similar reduction is seen in the unrelated genus of flightless crane flies, *Chionea*. In *Chionea*, the first flagellomere is also thick and subconical as seen in *H. darlingtonae*, followed by 1-9 more slender and elongate flagellomeres (Byers 1983). Although this first flagellomere has been thought to be a fusion segment of 5-13 flagellomeres in *Chionea*, this cannot be confirmed by simple examination (Byers 1983: 67), nor is this seen in *H. darlingtonae*. The single flagellomere found in *H. darlingtonae* is a rare condition among Diptera in general as even brachyceran flies usually possess 3-4 flagellomeres and most Nematocera possess far more (Crampton 1942, McAlpine 1981).

Although the reduction of the antennal flagella of *H. darlingtonae* might be related to a cavernicolous way of life, this morphological reduction stands in contrast to the general observation that many cave arthropods have, in relation to their non-cave relatives, lengthened antennae, not shortened ones (Howarth 1983). The overall light sclerotization of the body of *H. darlingtonae* is in agreement with the general trend for thinning cuticle found among many cave-inhabiting arthropods (Howarth 1993).

HABITAT: *Helius darlingtonae* has been found only in the Aripo cave system in Trinidad, both from the mouth of Main cave, and from a darker chamber in the Soho cave (Darlington and Gelhaus 1993).

Adults of three other species of the genus have been collected in caves in southeast Asia and India (Alexander 1961), and an aggregation of adults of two species of *Helius* (both apparently undescribed) was collected in a dark crevice along a dry stream bed in Peru (R. Bouchard, personal communication); none of these five species, though, shows any modification of the antennae.

#### ACKNOWLEDGMENTS

We thank the Pew Foundation for support of N.W. during June - August 1993 as part of the Pew Scholarships in Systematics Program at the Academy of Natural Sciences, Philadelphia. We also thank Margot Livingston for the excellent illustration of the wing, and two anonymous reviewers for their comments.

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## **ARAWANA SCAPULARIS (COLEOPTERA: COCCINELLIDAE) IN THE UNITED STATES AND NEW LOCALITY RECORDS FOR SPECIES OF ARAWANA<sup>1</sup>**

**Robert D. Gordon<sup>2</sup>**

**ABSTRACT:** *Arawana scapularis* is recorded again from southern Arizona. Habitus and genitalia are illustrated, and new locality records are listed for *A. scapularis* and *A. arizonica*.

Leng (1908) described *Arawana* as a subgenus of *Exochomus* and elevated it to generic rank in his 1920 catalog. Korschevsky (1932) placed *Arawana* as a subgenus of *Chilocorus*. Chapin (1965) agreed with Leng that it deserved generic status based on the unique structure of the front tibia of the type species. *S. Arawana* contains three species: *A. cubensis* (Dimmock) from Cuba, *A. arizonica* (Casey) from the mountains of southern Arizona, and *A. scapularis* (Gorham) from Central America, Mexico and southern Arizona. The structure of the front tibia in *A. cubensis* is atypical for *Arawana*, but this species was placed in the genus (Chapin 1965) based on strong genitalic similarities, a decision with which I agree. The first U. S. record of *A. scapularis* was based on specimens collected by H. A. Wenzel in the Huachuca Mountains, Arizona (Leng 1912). This record was overlooked by Gordon (1985), who recorded only *A. arizonica* from the United States. Scott McCleve, Douglas, Arizona, recently collected specimens from the Southern Arizona localities listed below. All specimens examined are in the collections of Scott McCleve (SM), California Department of Agriculture, Sacramento, California (CDA), and the National Museum of Natural History, Washington, D. C. (NMNH).

### **Key to North American Species of *Arawana***

1. Basal red spot on elytron broadly separated from humeral angle of elytron; dorsal habitus as in Fig. 2.....*arizonica* (Casey)
- Basal red spot on elytron reaching humeral angle of elytron; dorsal habitus as in Fig. 1.....*scapularis* (Gorham)

<sup>1</sup> Received December 21, 1993. Accepted January 26, 1994.

<sup>2</sup> Systematic Entomology Laboratory, PSI, Agricultural Research Service, USDA, c/o U.S. National Museum of Natural History, Washington, D.C. 20560.

*Arawana scapularis* (Gorham)

*Exochomus scapularis* Gorham, 1894:178; Leng, 1912:68; Blackwelder, 1945:451.

*Chilocorus scapularis*: Korschefsky, 1932:246 (incorrect generic placement).

*Arawana scapularis*: Chapin, 1965:247.

**Diagnosis:** Length 3.5 to 4.3 mm, width 3.0 to 3.8 mm. Elytron bluish or greenish black with large or small red spot on humeral angle, smaller red or orange spot at apex, pale areas usually narrowly connected along lateral margin (Fig. 1). Male genitalia as in Figs. 3-5.

**Type Locality:** Lectotype not designated, described from Specimens collected in Mexico and Nicaragua.

**Type depository:** Natural History Museum, London. Geographic distribution: Specimens examined, 12. COSTA RICA. 6 km. W. Santa Elena. MEXICO. Guerrero, Amula, Iguala (data from original description); Sinaloa, Eldorado; Sonora, 55 kilometers Southwest of Moctezuma. NICARAGUA. Chontales (data from original description). UNITED STATES. Arizona. Cochise Co., Guadalupe Canyon. Graham Co., Aravaipa Canyon; Graham Co., Turkey Creek. (NMNH) (SM).

**Additional records:** (from Gorham 1894, Specimens not examined) "Mexico, Jalapa, Vera Cruz, Tapachula in Chiapas."

**Comments:** All specimens examined were collected by Scott McCleve except two examples in the CDA collection from Costa Rica, and two specimens in the USNM collection from Eldorado, Mexico.

*Arawana arizonica* (Casey)

*Exochomus arizonicus* Casey, 1899:107

*Exochomus (Arawana) arizonica*: Leng, 1908:38; Casey, 1908:409.

*Arawana arizonica*: Leng, 1920:217; Chapin, 1965:245; Gordon, 1985:620.

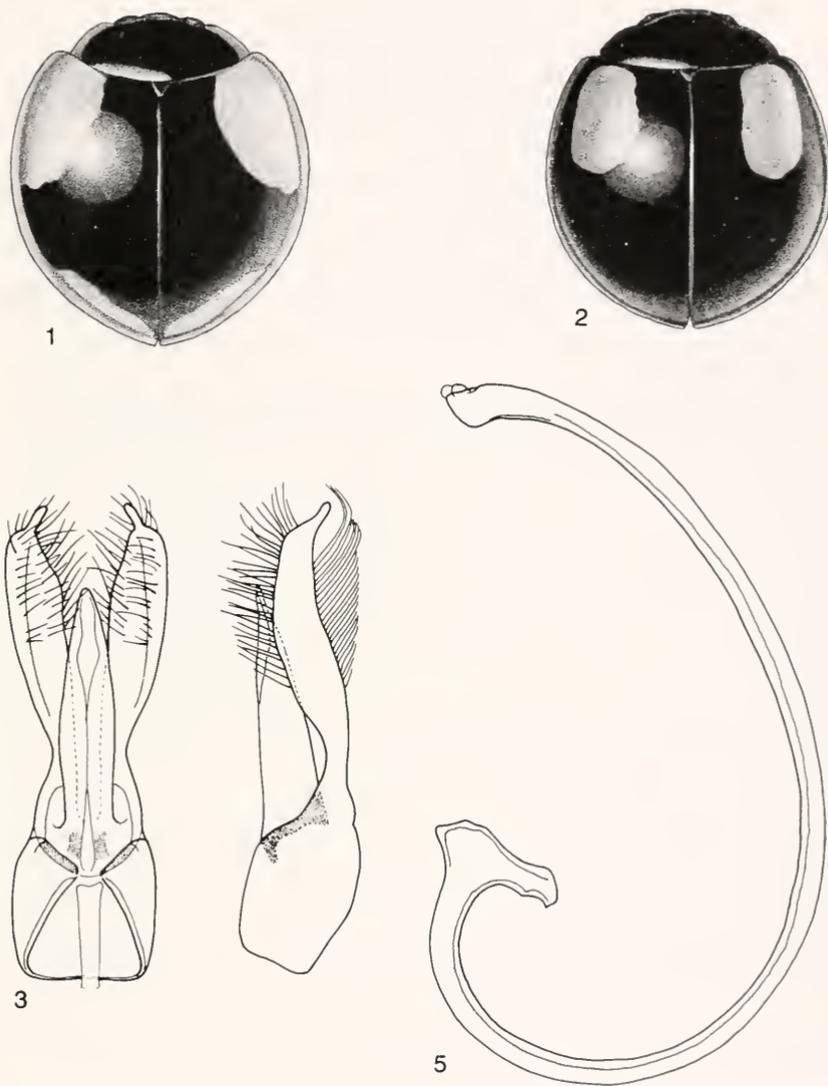
*Chilocorus arizonicus*: Korschefsky, 1932:245 (incorrect generic placement).

Gordon (1985) recorded *A. arizonica* in Arizona only from Catalina Springs and the Santa Rita Mountains. Additional localities are listed below.

**Geographic distribution:** Specimens examined, 6. UNITED STATES. Arizona. Cochise Co., 28 miles east of Douglas; Cochise Co., Guadalupe Canyon; Santa Catalina Mountains, Sabino Canyon. (NMNH) (SM).

## ACKNOWLEDGMENTS

I thank Scott McCleve, Douglas, Arizona, and Fred Andrews, CDA, for the loans of specimens upon which this paper is based. The illustrations were prepared by A. Konstantinov. For manuscript review I thank J. Chapin, Louisiana State University, Baton Rouge; H. Dozier, Pickens, South Carolina; and A. Menke and N. Vandenberg, Systematic Entomology Laboratory, Washington, D.C.



Figures 1-5, *Arawana* species. Fig. 1, habitus, *A. scapularis*; Fig. 2, habitus, *A. arizonica*; Figs. 3-5, male genitalia, *A. scapularis*.

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**A NEW ANAGRUS  
(HYMENOPTERA: MYMARIDAE),  
EGG PARASITOID OF *ERYTHRONEURA* SPP.  
(HOMOPTERA: CICADELLIDAE)<sup>1</sup>**

S.V. Trjapitzin<sup>2</sup>, E. Chiappini<sup>3</sup>

**ABSTRACT:** This paper describes a new species of mymarid, *Anagrus erythroneurae*, a common egg parasitoid of the variegated leafhopper, *Erythroneura variabilis*, in the southwestern United States and northwestern Mexico, and of the grape leafhopper, *E. elegantula*, in California. The new species is compared with the European *A. ustulatus*, to which it is most similar, and with the North American species *A. epos* and *A. spiritus*.

An extensive search for natural enemies of the variegated leafhopper, *Erythroneura variabilis* Beamer, was conducted in 1985 and 1986 in the southwestern United States and northwestern Mexico (González *et al.* 1988) and again from 1987 to 1991 (D. González, pers. comm.). Several species of the genus *Anagrus* Haliday were reared from samples of eggs of *E. variabilis* and the grape leafhopper, *E. elegantula* Osborn, obtained from these collections. The taxonomy of the North American *Anagrus* is poorly known and parasitoids reared from *Erythroneura* spp. eggs could not be identified to species (K. Daane, pers. comm.). From recent studies of the Holarctic *Anagrus* we recognize a new species which is described below.

*A. erythroneurae* n. sp. was the most commonly reared natural enemy of *E. variabilis* in southern California, U.S.A. and Baja California, Mexico. *A. erythroneurae*, a member of the *atomus* species group of the subgenus *Anagrus* s. str. as defined by Chiappini (1989), was the only species of this group among *Anagrus* spp. reared from *Erythroneura* spp. eggs. It is easily distinguished from *A. epos* Girault, which is a member of the *incarnatus* species group and a well-known egg parasitoid of grape-infesting leafhoppers in California and elsewhere in the United States and Canada (McKenzie and Beirne 1972; Jensen and Flaherty 1982), in having only 3 sensory ridges on the antennal club. *A. epos* and other members of the *incarnatus* group possess 5 sensory ridges on the club.

Measurements are given in micrometers, with the mean followed, in

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parentheses, by the range and number of specimens measured, unless otherwise specified. The specimens of *A. erythroneuræ* n. sp. studied are deposited in the collections indicated by the following acronyms: CNCI, Canadian National Collection of Insects, Ottawa; IEFA, Istituto di Entomologia, Facoltà di Agraria, Piacenza; UCRC, University of California, Riverside; USNM, National Museum of Natural History, Washington, D.C. An abbreviation used in the description is: F = funicular (flagellar in males) segment.

### *Anagrus erythroneuræ*, NEW SPECIES

(Figs. 1-2)

**Female.** General color dark brown; head and metasoma darker to black; F2-F6 and club dusky; scape, pedicel, F1, posterior scutellum, propodeum, mesopleura, and legs light brown to brown.

Head slightly wider than mesosoma. Antenna (Fig. 1) sparsely setose; scape slightly curved, F1 almost globular, F2 slightly more than 2 times as long as F1, longer than F3 and usually subequal to F4, F5 slightly shorter or subequal to F6, F6 usually longest of funicle; F3 and F4 without sensory ridges, F5 with 1 sensory ridge, F6 with 2 sensory ridges, club with 3 sensory ridges.

Mesosoma 0.72 (0.69-0.85, n=10) times as long as metasoma. Mesoscutum without a pair of setae near notaulices. Forewing (Fig. 2, a) slightly shorter than body, 9.0 (8.6-9.3, n=10) times longer than wide, with 2 or 3 longitudinal rows of setae at broadest part leaving small oval hairless area subapically. Lengths of distal and proximal macrochaetae in ratio 3.0 (2.4-3.8, n=10). Marginal fringe with longest cilia more than 3 times, but less than 4 times, the wing width. Hindwing (Fig. 2, b) disk asetose, save for 1 complete row of small setae along posterior margin and sometimes 1 incomplete row of 1 to 4 setae along anterior margin on distal third.

Metasoma. Ovipositor slightly exerted beyond apex of metasoma. Ratio of total ovipositor length to length of its exerted part 15 (8-28, n=7). External plates of ovipositor each bearing 1 seta. Ovipositor/foretibia ratio 2.1 (2.0-2.2, n=10).

Measurements (n=10): Body: 571 (543-619); Head: 99 (95-114); Mesosoma: 198 (181-235); Metasoma: 275 (251-289); Ovipositor: 214 (198-230).

Antenna: Scape: 72 (68-80); Pedicel: 35 (32-37); F1: 17 (15-19); F2: 40 (36-45); F3: 35 (32-38); F4: 40 (38-44); F5: 48 (46-51); F6: 51 (48-59); Club: 95 (91-99).

Forewing: Length: 440 (418-456); Width: 49 (46-53); Venation: 144 (133-152); Marginal vein: 29 (27-34); Hypochaeta: 28 (20-34); Proximal macrochaeta: 20 (15-27); Distal macrochaeta: 59 (49-68); Longest marginal cilia: 184 (171-194).

Hindwing: Length: 395 (370-428); Width: 17 (15-18); Venation: 119 (114-129); Longest marginal cilia: 141 (133-158).

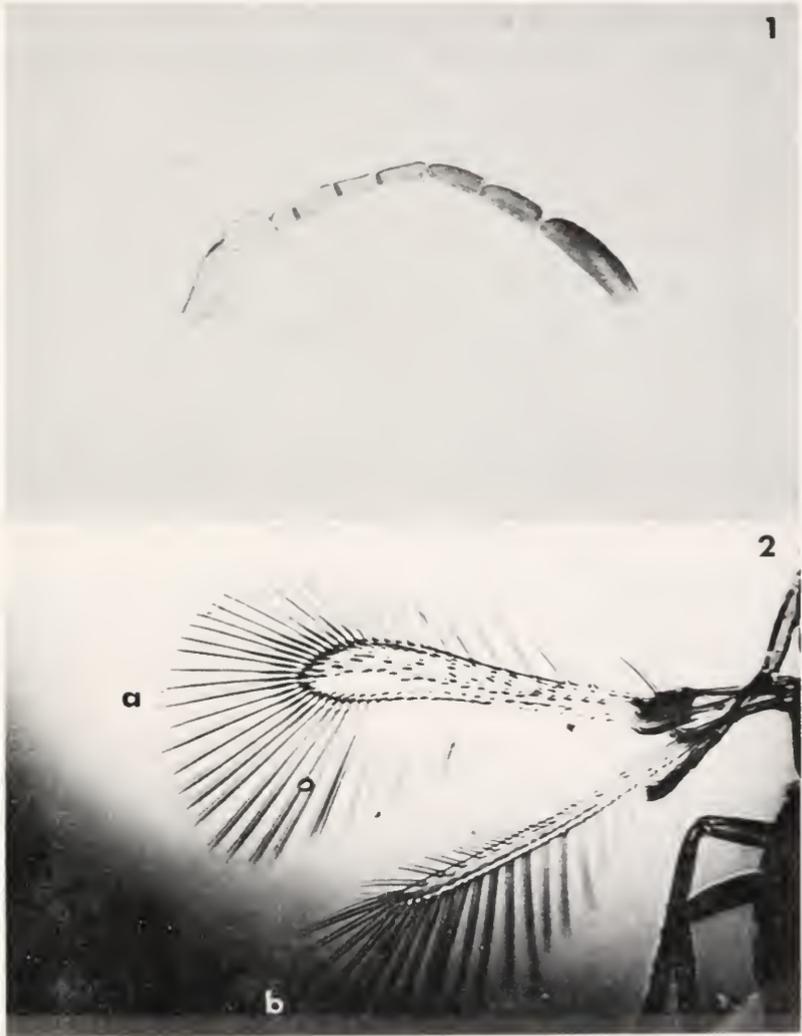
Legs:	Femur	Tibia	Tarsus
Fore	93 (87-99)	100 (95-106)	131 (118-141)
Middle	85 (77-91)	143 (137-150)	129 (122-140)
Hind	86 (82-91)	155 (148-167)	133 (122-141)

**Male.** Similar to female except forewing wider (index 7.7 (7.4-8.0, n=4)), sometimes with 3 or 4 incomplete rows of setae at broadest part of disk leaving no distinct hairless area. Genitalia typical for the *atomus* species group (Chiappini 1989).

Measurements (n=4): Body: 559 (523-570). Antenna: Scape: 60 (53-65); Pedicel: 35 (34-37); F1: 34 (32-36); F2: 43 (40-44); F3: 43 (38-46); F4: 42 (38-44); F5: 44 (39-46); F6: 46 (42-49); F7: 46 (42-48); F8: 46 (42-49); F9: 46 (40-49); F10: 47 (42-50); F11: 48 (43-51).

Forewing: Length: 495 (456-517); Width: 64 (57-68). Genitalia: 79 (72-84).

**Type material:** Described from the type-series of 10 ♀♀ and 4 ♂♂ on slides as follows: **Holotype.** ♀, U.S.A., California, Riverside Co., Coachella, ex. *Erythroneura variabilis* eggs on grape, VII.1988, D. González (deposited in USNM). **Paratypes.** 5 ♀♀, 1 ♂, same data as holotype (UCRC); 2♀♀, 1 ♂, same data (CNCI); 1♂, MEXICO, Estado de Baja California, Mexicali, ex. *Erythroneura variabilis* eggs on grape, 11.V.1988, D. González



Figs. 1-2. *Anagrus erythroneurae*, female. 1. Antenna; 2. Wings: a - forewing, b - hindwing.

(USNM); 1 ♀, 1 ♂, same data as above (IEFA); 1 ♀, MEXICO, Estado de Baja California, Ejido Guerrero, IX.1988, D. González (UCRC).

**Additional material examined:** U.S.A. California. Fresno Co., Parlier, 18.VI.1986, W. White and M. Moratorio, 10 ♀♀, 2 ♂♂, ex. *Erythroneura elegantula* eggs; Riverside Co., Mecca, 1.V.1986, D. González, 3 ♀♀. New Mexico. Las Cruces, 05.VII.1986, D. González, 4 ♀♀. MEXICO. Estado de Baja California. Ejido Veracruz, IX.1988, D. González, 7 ♀♀, 1 ♂; Ejido Guerrero, IX.1988, D. González, 5 ♀♀; Ejido Tehuantepec, IX.1988, D. González, 4 ♀♀, 2 ♂♂; Guadalupe, 9.IX.1988, D. González, 3 ♀♀, 1 ♂ (all UCRC).

Remarks: these specimens were mounted in a water-soluble solution and therefore are not included into the Paratype List.

**Etymology.** *Erythroneurae*, Latin genitif of the host genus.

**Diagnosis.** *A. erythroneurae* n. sp. is most similar to *A. ustulatus* Haliday from Europe but differs from the latter primarily in the darker body coloration and the arrangement of setae on forewing disk. The female of *A. erythroneurae* usually has 2, sometimes 3, rows of setae present anterior to the hairless area, contrasting with 4 or 5 rows in *A. ustulatus*. Other morphological features that distinguish the new species from *A. ustulatus* are as follows: ovipositor/foretibia ratio generally higher than 2.0 in the former but slightly lower than 2.0 in the latter (about 1.8-1.9); female forewing generally narrower in *A. erythroneurae*; club of female antenna is usually longer than F5 and F6 together (or at least equal) in *A. ustulatus* but shorter in the new species; and digiti of male genitalia are proportionally shorter than in *A. ustulatus*.

The new species may be easily distinguished from *A. spiritus* Girault, the only other member of the *atomus* species group so far described from the Nearctic region, by lack of a sensory ridge on F4 of female antenna.

#### ACKNOWLEDGMENTS

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## THE NESTING BIOLOGY AND BEHAVIOR OF THE CALIFORNIA YELLOWJACKET, *VESPULA SULPHUREA* (HYMENOPTERA: VESPIDAE)<sup>1</sup>

Roger D. Akre, Elizabeth A. Myhre<sup>2</sup>

**ABSTRACT:** Additional biological data are provided for *Vespula sulphurea*. Two mature nests from Shasta Co., CA were analyzed and found to consist of 5,633 and 2,250 cells, and were estimated to have produced 17,300 and 3,956 adults, respectively. Both nests were believed to have been *Paravespula vulgaris* nests that were usurped. Aspects of nest morphology atypical for *Vespula* species were cordlike suspensoria and the presence of reproductive cells on worker combs. Observations of foraging workers indicated habitat partitioning with other yellowjacket species. Colony duration was longer than that of previously reported colonies, with the first workers appearing in early May and colony decline in October.

*Vespula sulphurea* (de Saussure) is a subterranean nester restricted almost entirely to the Upper Sonoran fauna of California, with scattered populations in southern Oregon, western New Mexico, southern Arizona, and northern Baja, Mexico (fig. 55; Bohart and Bechtel 1957).

Three colonies were collected by Duncan (1939), one in early October 1930. Data were only available for the October colony which contained 134 workers, 6 new queens, the foundress queen, and a few male pupae. Seven additional colonies were investigated in California by R. E. Wagner (University of California, Riverside), but data were collected on only three nests (Table 1). Each nest had three worker combs; two of them also had a single primary reproductive-cell comb.

The purpose of this paper is to report on two additional nests of *V. sulphurea* and to report new data on behavior and colony cycle of these rare wasps.

### MATERIALS AND METHODS

Two *V. sulphurea* nests ("bottle box nest" and "log nest") from the 1992 season were collected by Carl Weidert in Inwood, Shasta County, CA. The nests were located about 32 km west of Mt. Hassen in the southern end of the Cascade Mountains. This area has a typical Mediterranean climate pattern with a dry summer and most of the 131.8 cm

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of precipitation occurring in the fall, winter, and spring. It is forested with the Sierra Nevada Mixed Conifer Vegetation Type comprised of ponderosa pine, Douglas-Fir, white fir, incense-cedar, sugar pine and Kellogg's oak (California black oak). Observations were made by the collectors on these colonies before they declined and on interactions with foraging workers of other species of yellowjackets.

Cells were counted manually (bottle box nest and combs 1, 5, 6 of log nest) or were estimated by counting the number of cells per unit area with a one inch grid laid on the comb and multiplying by the comb area (combs 2-4 of the log nest). Adult production was estimated by sampling meconia in cells. Twenty cells of each cell type were measured in each comb, unless the comb was too irregular, or there were very few cells.

## RESULTS AND DISCUSSION

**Log Nest.** This nest was constructed inside a decayed incense-cedar log. It was collected at the end of natural decline of the colony in late October, so only approximately 50 workers were collected with the nest.

The nest had five entrances, four had hardened turrets 2-4 cm tall made of decayed wood duff and oral secretions. Late in the season guard workers ringed these entrances. This behavior is very similar to that exhibited by species of *Paravespula*. The duff/oral secretion mixture also lined the tunnels down from the turrets to the nest envelope. However, envelope paper was sparse around the nest, covering only 1 cm at the top. Approximately six layers were formed around the first comb, while only fragments of paper intermixed with duff were formed around the remaining combs. The envelope paper was gray, with the exception of envelope in the central area of the first comb which was tan and fragile. The combs were also largely gray. Comb 1 and the central areas of combs 2-3 consisted of tan carton. Both combs and envelopes had transition gray/tan areas. This construction indicates that the nest had been usurped from *P. vulgaris* (L.) by the *V. sulphurea* queen. This behavior is similar to that of *V. squamosa* (Drury) which has been reported as a facultative parasite of *P. maculifrons* (du Buysson) and *P. flavopilosa* (Jacobson) (MacDonald and Matthews 1984). However, nearly all species of yellowjackets are facultative parasites of several other species (Akre and Reed 1984), the only difference in the case of usurpation of other species by either *V. sulphurea* or *V. squamosa* being that the queen and workers have such distinct colors and patterns that a usurpation is more obvious and noticeable. Wagner (pers. comm.) also investigated a *Paravespula pensylvanica* (de Saussure) nest that was usurped by *V. sulphurea*, but the takeover was not as noticeable as both have gray envelope paper.

Several aspects of the nest morphology were not typical of species of *Vespula*. All suspensoria were cordlike as is typical of *Paravespula* species (Akre *et al.* 1981), with the exception of the central pedicel of the seventh comb which consisted of 3 short side buttresses (0.9, 0.8, and 1.1 mm long). Combs 2-7 were distinctly concave with the inner cells being higher than the outer cells, possibly due to the curving walls of the hollow log. The differences from the horizontal between the top edges of the center cells and the top edges of noncapped rim cells were 0.9, 1.6, 1.8, 1.6, 1.2, and 0.2 cm in combs 2-7, respectively. Mixed combs were present, and consisted of "extensions" of reproductive cells that were begun at several locations around the edges of a central worker or reproductive cell area. These caused unevenness in combs when the extensions either converged, overlapped, or left gaps. Mixed combs as well as worker cells on more than the top comb are characteristic of *Paravespula* species. They have not been reported previously in species of *Vespula*.

The nest consisted of seven combs; three worker, two mixed (small worker and large reproductive cells), and two reproductive (Table 2). The first comb had 12 suspensoria and was very small as it was confined within a groove in the roof of the hollow log. While all cells were interconnected, the tops of some cells were at the level of the bottoms of others. Combs 2-7 were built below the log groove and were larger. Comb 2 had 23 suspensoria, most attached to roof of the hollow log. The central tan area of this comb measured 75 x 45 mm. Comb 3 had 41 suspensoria; 19 were attached to comb 2 and 22 to the log and debris above. In addition, the cell rims on one edge of comb 2 connected with the top of comb 3. The central tan area of comb 3 was 65 x 65 mm. Comb 4 had 33 suspensoria. Comb 5 had 39 suspensoria, and had a partial overlapping of a reproductive comb extension over another. In addition, two small irregular holes were formed where reproductive cell extensions merged. Comb 6 had 29 suspensoria, and one area where merging reproductive cell extensions left a hole in the comb. Two deep indents were formed by extensions that did not quite meet. Comb 7 was small with only 6 suspensoria.

Worker cells were estimated to have produced approximately 17,300 adults, while reproductive cells produced 1,980 adults. Silk cocoon layers could not be used to estimate cell usage as they could in nests of *Dolichovespula* (Akre and Myhre 1992). The layers did not peel into discrete units and were therefore unreliable for cells usage. Thus meconial counts (only discrete, separate packets were considered meconia, connected units were counted as one) were used, and even they showed indistinct generation rings that merged in upper combs as up to 8 genera-

tions were found to have occupied cells. In the cells sampled, combs 1-5 were found to have generated up to 8, 7, 7, 5, and 4 worker cell generations, respectively.

The average width of worker cells was 4.3 mm ( $r$  [range] = 3.8-4.8 mm,  $n$  = 80 cells from combs 2-5). The average width of reproductive cells was 6.3 mm ( $r$  = 5.7-6.7 mm,  $n$  = 60 cells from combs 5-7). Cells on comb 1 were not measured due to comb irregularities.

**Bottle Box Nest.** The second nest was constructed inside a cardboard fruit box which was stored under a lean-to with other paraphernalia. This colony was allowed to die naturally and was collected in February 1993, so no worker count was available. The fruit box had a ventilated lid and sides and was filled with bottles individually wrapped in newspapers. The nest was constructed among the bottles where space was available or could be enlarged by removal of the newspaper.

The nest had six highly irregularly shaped layers of combs; three mixed, three reproductive (Table 2). No comb consisted solely of worker cells. All layers consisted of one comb except for the fifth layer which consisted of four separate pieces of comb (5a-d, fig. 1). Envelope par-

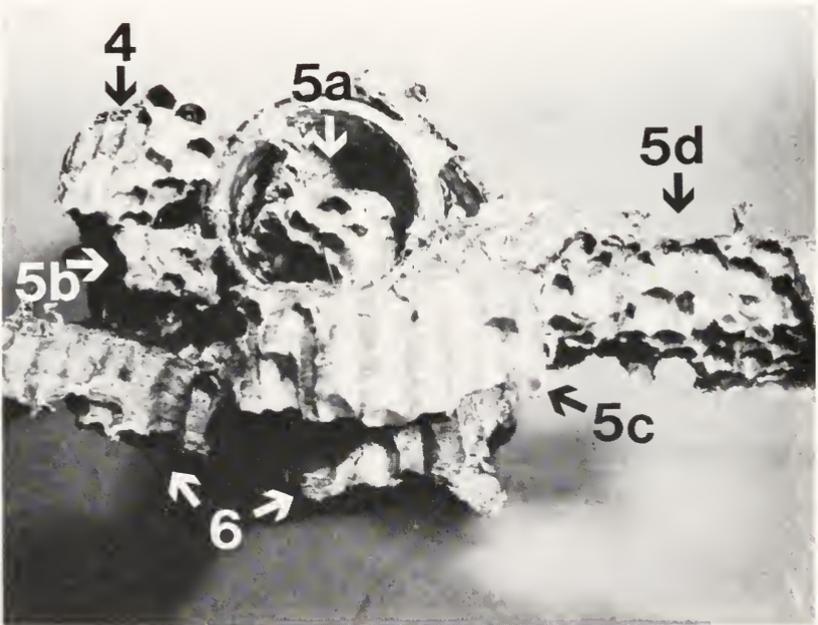


Fig. 1. Bottle box nest showing combs 4, 5a-d, and 6 built around the neck of a bottle.

tially covered the original queen nest area, and a clump of envelope 13 x 8 x 6 cm covered the opposite (reproductive) end of comb 1. Envelope was also intermingled with newspaper, and was used to block the mouths of all bottles that had been exposed by newspaper removal.

The top comb was exposed by removing the lid of the box. The main pedicel was 20 mm long and 14 mm wide. All other suspensoria in the nest were cordlike, including the outer pedicels of comb 1. This comb also may have been initiated by *P. vulgaris*, as the queen nest area (37 mm across) and the envelope above was orange-brown.

Combs 2 and 3 had 9 and 21 suspensoria, respectively. Both of these combs and comb 1 were wrapped around a bottle. Approximately 13 cm of the edge of comb 2 was attached to the bottle neck (fig. 2). Comb 4

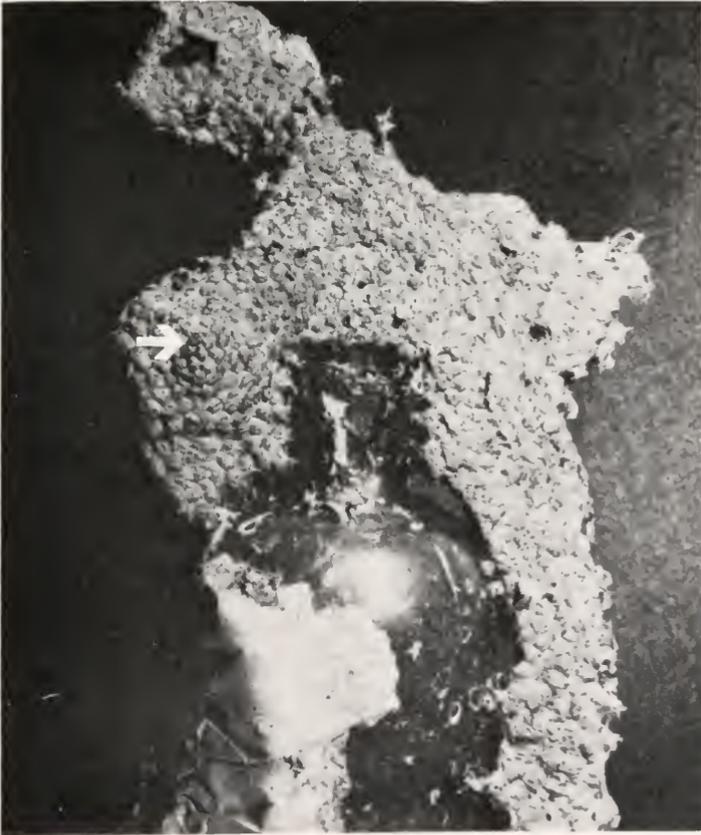


Fig. 2. Bottle box nest showing an irregular comb 2 wrapped around a bottle. The comb levels were necessarily built unevenly and this complicated the nest analysis. The arrow indicates the initiation point of the comb.

was long and narrow, and was attached along one edge to the right side of another bottle neck (fig 1). Comb 5a had one pedicel and was constructed partially within the neck of same bottle as comb 4. Comb 5b was attached to the bottom of comb 4 with 2 suspensoria and was attached along its edge to the right side of the neck of the bottle. Comb 5c was level with the lip of the mouth of the bottle, and was attached to it by 2 long suspensoria and one short edge of the comb. The bottle formed the bottoms for seven cells. Comb 5d was formed to the left of the bottle neck and was attached by 4 suspensoria to the same bottle that combs 1-3 were wrapped around. Comb 6 was under the bottle neck attached to combs 4 and layer 5 (fig 1). It was attached by 12 suspensoria to the combs above and to the bottle.

Worker cells were estimated to have produced approximately 3,956 adults, while reproductive cells produced approximately 1,266 adults. Worker and reproductive cells contained up to 4 meconia.

The average width of worker cells (4.1 mm,  $r = 3.5-4.6$  mm,  $n = 60$  cells from combs 1-3) was narrower than that of the log nest. However, the average width of reproductive cells (6.5 mm,  $r = 5.4-7.1$  mm,  $n = 100$  cells from combs 1, 4, 5c, 5d, and 6) were greater than the log nest cell widths. Reproductive cell width measurements were not taken from combs 2, 3, 5a, and 5b due to low numbers of cells.

**Behavior.** Based on >200 hrs of observations the workers were mostly ground foragers (1 m or less). They were observed foraging only bare soil, dead leaves/needles, and dry grass/brush areas even when lush, green gardens and grass areas were nearby. However, the green areas were foraged by workers of *D. maculata* (L.) and *P. pensylvanica* suggesting habitat partitioning or an avoidance of these areas. Workers of most yellowjacket species were attacked by workers of *D. maculata* when they entered these areas. This observation was supported by observations during August of 1993. Early in the summer *V. sulphurea* workers foraged the green areas, but populations of *D. maculata* and *P. pensylvanica* were extremely low, and few workers were seen anywhere. Later, when foraging worker densities of both the baldfaced hornets and western yellowjackets increased, the *V. sulphurea* workers again tended to avoid the green areas.

The *V. sulphurea* workers did not hover when foraging as has been reported for some yellowjackets such as *V. acadica* (Sladen) (Reed and Akre 1983). Prey consisted mostly of flies, although workers also collected caterpillars and grasshoppers. Workers foraged mostly within 400 m of the nest. One observation was made of a queen of *V. sulphurea* foraging for nectar from raspberry flowers. Also, queens of *V. sulphurea* foraged green areas.

Previously it was reported that this species had a slightly shorter active season than *V. atropilosa* (Sladen) in California (R. E. Wagner, pers. comm., cited in Akre *et al.* 1981). Colonies were from Mill Creek Canyon, San Bernardino County (average 3,500 ft or 1067 m elevation) and from Clear Lake, Lake County, CA (average 1,000 ft or 305 m elevation). The first workers appeared a week or so later, and the last workers disappeared a couple of weeks before those of *V. atropilosa*. However, Duncan (1939) reported workers present in a colony as late as October. In northern California, colonies are initiated in early May, and a few workers were still flying in late October (C. Weidert, pers. comm.). The season for these wasps is therefore as long as that of *P. pensylvanica* in some northern areas. However, in both cases the number of colonies involved has been few so additional data are badly needed on the colony cycle.

Workers of *V. sulphurea* are attracted to heptyl butyrate, and in some areas workers scavenge for protein and are picnic pests (R. E. Wagner, documented by 35 mm color slides of workers scavenging canned pet food). C. Weidert never saw workers scavenging on canned dog or cat food, nor on various meats although these were available. *Vespula squamosa* and *V. sulphurea* were considered to be of uncertain status regarding placement in a genus (Akre *et al.* 1981). Observations of scavenging, of longer colony duration, and of differing internal morphology (ovariole numbers) suggest that perhaps the taxonomic status of these yellowjackets should be re-examined.

Table 1. *Vespula sulphurea* colonies collected in California (after R. E. Wagner).

Colony number	Locally	Date collected	Workers	Queens	New Queens	Males	Worker # cells (# combs)	# Mixed combs	Reprod. # cells (# combs)
1	Clear Lake	9-12-72	1,086	1	31	363	3,258(3)	-	769(5 <sup>1</sup> )
2	Malibu Canyon, Santa Monica Mts.	7-03-75	462	1	0	0	1,641(3)	-	0(0)
3	Mill Creek, San Bernardino Mts.	8-27-75	105	1	0	0	1,080(3)	-	33(1)

<sup>1</sup> One plus 4 partial combs

Table 2. Comb size of two colonies collected.

Comb	Dimensions (mm)	Worker Cells	Reproductive Cells
<u>Log nest</u>			
1	75 x 40	153	0
2	164 x 92	687	0
3	208 x 145	1354	0
4	203 x 183	1540	41
5	196-235 x 170	694	484
6	185-140 x 143	0	532
7	85x76	0	148
<u>Bottle box nest<sup>1</sup></u>			
1	205 x 104	533	127
2	204 x 137	475	30
3	219 x 162	622	81
4	90 x 22	0	46
5a	35 x 22	0	22
5b	46 x 24	0	27
5c	55 x 45	0	46
5d	51 x 86	0	90
6	110x83	0	151

<sup>1</sup> Combs of bottle box nest were highly irregular in shape, and dimensions given reflect only widest points (across "arms"), and do not indicate area.

#### ACKNOWLEDGMENTS

We are indebted to Carl Weidert of Shingletown, California for use of his copious notes on the nests and on colony observations. We also thank him for the personal delivery of the nests so they arrived intact. Previous data on nests of *Vespula sulphurea* were taken from the yellowjacket handbook (Akre *et al.* 1981). We thank P. Landolt, R. E. Wagner, C. Weidert, and R. Zack for suggestions for improving the manuscript.

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## A PRELIMINARY STUDY OF THE NITIDULIDAE (COLEOPTERA) IN SHAWNEE STATE FOREST, OHIO

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**ABSTRACT:** Various collecting techniques were utilized to discover nitidulid diversity in a forest in Scioto Co., Ohio, near the Ohio River. During two collecting periods, 20 species were identified. Four specimens of *Colopterus*, however, were not determined beyond genus, thus a minimum of 21 species were collected. Six of these species were previously recorded from Scioto County, and 14 of the 20 species identified are new county records based on The Ohio State University collection of identified Nitidulidae. The five most abundant species in descending order were: *Stelidota geminata*, *Stelidota octomaculata*, *Glischrochilus obtusus*, *Epuraea helvola*, and *Epuraea peltoides*. All of the *Stelidota octomaculata* and *Epuraea helvola*, and all but five of the *Stelidota geminata* were caught in ground traps during late season. All of the *Glischrochilus obtusus* and all but one of the *Epuraea peltoides* were collected in aerial traps in early season.

In an effort to further our knowledge of the richness and abundance of Nitidulidae in Ohio, a survey was conducted from June 2 to 6 (early season) and from 27 August to 10 September (late season) at Shawnee State Forest in Scioto Co., Ohio in 1991. This site was chosen due to its south-central location within the state and its unglaciated topography. The forest encompasses more than 60,000 acres with several species of oaks, hickories, and shortleaf pines constituting the bulk of the diverse overstory vegetation. Sassafras, ash, elm, walnut, maple, and many other hardwoods are also present. Both surveys (early and late season) were located approximately 16 km southwest of Portsmouth, Ohio in the southcentral part of the forest.

### MATERIALS AND METHODS

#### Early Season (2-6 June)

In the early season we utilized traps (Figure 1) made from plastic 4 l milk jugs which were modified by cutting openings in the upper half to allow insects to enter (R. Androw, pers. comm.). Approximately 0.5 l of bait solution was placed in each jug of four traps. The bait was composed of 0.5 kg of brown sugar, 4 l of water, and a small amount of soil to pro-

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Fig. 1. Gallon jug trap used in early season trapping.

vide wild yeast. Using wires attached to tree branches, the jugs were suspended around 1.5 m above the ground. Traps were in a line spaced about 0.4 km between traps. Collections were made once from traps at the end of the trapping period. These collections were rinsed in fresh water and preserved in 70% alcohol until insect determinations were made.

#### **Late Season** (27 August - 10 September)

The late season survey trapping period was lengthened and replicated at two locations, both within 6.5 to 8.0 km of the Ohio River. The first late season trial was placed in a low ravine about 5 km from State Route 52 just off of State Forest Road 1, while the second was located about 135-150 m higher on a ridge about 5 km NNW of the first trial just off of State Forest Road 2. Each trial consisted of seven treatments replicated four times in a complete randomized block design. Spacing between traps was 9.0 m. The seven treatments used at both test sites were baits proven effective in previous trials (Williams *et al.* 1992). They are as follows: fermenting malt/molasses solution, fermenting brown sugar solution (same as early season), vinegar, cantaloupe, acorns (red oak), whole wheat bread dough, and smoked ham and bacon.

The malt/molasses solution was prepared using liquid Maltsupex® brand malt soup extract (Wallace Laboratories Division of Carter-Wallace Inc., Cranbury, NJ 08512) and livestock feed molasses obtained from a local feed company. The preparation of the malt/molasses solution was as follows: 50 ml of Maltsupex®, 50 ml of molasses, 50 ml of granulated sugar and a pinch of active dry yeast (Fleischmann's Yeast Inc., Oakland, CA 94603) per liter of warm water. One hundred-fifty ml of the above solution of malt/molasses was placed in each trap.

The brown sugar solution was prepared using light brown sugar (Scot Lad Foods Inc., Distributors, Lansing, IL 60438). In our mixture we used approximately 350 g of brown sugar and a pinch of Fleischmann's active dry yeast per liter of warm water. About 150 ml of this mixture was used in each brown sugar trap.

The vinegar traps were baited using pure, uncut, apple cider vinegar (Scot Lad Food Inc., Distributors, Lansing, IL 60438). Approximately 150 ml of vinegar was used in each trap.

The cantaloupe used was usually overripe and was cut into 5 cm squares with the rind intact. one cube was placed in each trap.

Acorns were shown to be an excellent attractant for *Stelidota octomaculata* (Say), as this species is a primary pest of many germinating oaks (Galford *et al.*, 1991). Each portion of our acorn bait was prepared by cutting 4 red oak acorns in half and then partially wrapping them in a moist paper towel to promote germination.

The whole wheat bread dough was made by mixing 0.5 kg of whole wheat flour, 15 ml of sugar, 300 ml of warm water and a 7 g package of Fleischmann's dry active yeast. A "hunk" of dough (about 50 ml) was rolled into a ball and wrapped in a piece of fiberglass screen to prevent the beetles from becoming imbedded in the dough. This screen-covered ball, held together with a twist tie, was then placed in the trap.

Ganglbauer (1899) observed that several of the carrion feeders in the genus *Nitidula* were frequently found in houses on smoked bacon. W. A. Connell (pers. comm.) also noted that the genus *Nitidula* is often collected on smoked hams in Virginia and North Carolina. To entice sap beetles associated with carrion, we used equal weights of sliced smoked bacon and sliced smoked ham. The total weight of these meats placed in each trap was about 150 g.

The late season trap, used only at ground level, was the nitidulid inventory technique (NIT) trap (Figure 2) which is a modification of the trap used by Skalbeck (1976). The NIT trap consists of a 1-liter wide mouth canning jar, with a plastic cone (a tapered drinking cup with bottom removed) inserted in the mouth of the jar and held in place by the canning ring. A 15 cm square of 6.5 mm thick Masonite board was attached about 2 cm above the mouth of the jar as a rain cover. Once the traps were set in the ground, they were covered with a 60 cm square



Fig. 2. NIT trap made of a 1-quart wide mouth canning jar with a funnel, an isolated bait container, and a rain cover. The cover is held in place with duct tape.

piece of "chicken wire", which was anchored to the ground using 25 cm landscaping spikes. This prevented pilfering by raccoons and other hungry mammals. Traps were set out on 27 August, and the contents were collected on 4 September and again on 10 September.

## RESULTS

### Early Season

Table 1 lists the early season species collected as well as their abundance. Species diversity for early season was much greater than expected for a collection period of only four days. Fifteen species were collected, many of which were seldom encountered in our previous collections over many years (Williams and Krueger 1985, Williams *et al.* 1992). Examples include: *Lobiopa undulata* (Say), *Colopterus maculatus* (Erichson), *Cryptarcha strigulata* Parsons, *Cychramus adustus* Erichson, and *Glischrochilus obtusus* (Say). *G. obtusus*, much to our surprise, was the most abundant species in the early season, constituting 43% of the nitidulids collected. In ten previous years, we have only encountered two specimens of this species using similar collection techniques. Here, in

just four days, we collected 137 specimens.

Of the six most abundant nitidulids collected, none are considered pests or nuisance species in Ohio or neighboring states. The only pest species in Table 1 are *Stelidota geminata*, *Glischrochilus fasciatus*, *G. quadrisignatus* and *Carpophilus lugubris*, and these composed only 3% of the total specimens collected.

### Late Season

Surprisingly, only 11 species were encountered in our late season collections (Table 2). Three species, *Stelidota geminata* (Say), *S. octomaculata* (Say), and *Epuraea helvola* Erichson, comprised 95 percent of that total catch.

Of the nitidulids taken in late season, only *Pallodes pallidus* (Beauvois) is considered rare for Ohio, as we have seen very few of these beetles in our collections around the state. Three other species, *Carpophilus hemipterus* (L.), *Epuraea helvola* Erichson, and *Stelidota octomaculata* (Say), although not endangered, could be considered locally rare according to criteria used in a similar study (Williams *et al.*, 1992). All remaining species are generally quite common throughout Ohio. Also of interest is that only 298 beetles were caught at the lower site, whereas 1054 (78%) were caught at the upper site, (135-150 m higher in elevation). The most conspicuous vegetation at the lower site consisted of tulip poplar, sassafras, and several species of oak with poison ivy undergrowth, whereas the upper site was composed of mostly chestnut oak and hickory with a greenbrier (catbrier) and blueberry undergrowth. Whether or not the difference in elevation or vegetation promoted this imbalance is uncertain as, surely, many other factors are involved.

In addition to species richness and abundance (Tables 1 & 2), Table 3 lists the entire season's collections and indicates bait performance. Figure 3 illustrates bait attractiveness to the three most dominant species in the late season.

## DISCUSSION

The time of year each collection was made created a species diversity difference that was not directly comparable as many species primarily emerge in mid to late summer as opposed to spring and early summer.

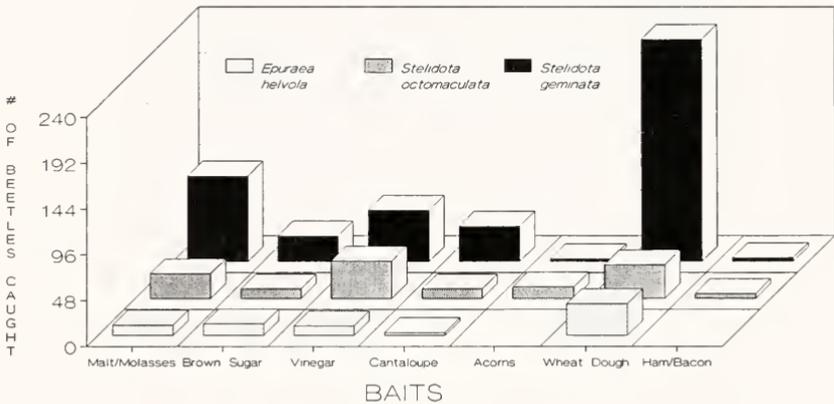


Fig. 3. Mean number of nitidulid beetles caught during late season in Shawnee State Forest, Scioto Co., Ohio 1991.

### Early and Late Season

In early season collecting, gallon jug traps were suspended from tree limbs about 1.5 m above the ground. We know from previous studies (Skalbeck & Kulman 1970, Skalbeck 1976, Williams *et al.* 1992) that aerial traps are preferred by some species, whereas ground traps are preferred by others. Trap placement above the ground may account for the absence of *Stelidota octomaculata* and the scarcity of *S. geminata* captured in the early season survey (Table 1). There is some speculation that *S. octomaculata* is not a good flier. In the late season ground traps (Table 2), there was a many fold increase in the collection of *Stelidota geminata* compared to early season. It was the most abundant species in the ground traps, followed by *S. octomaculata*.

The abundance of *Epuraea helvola* in late season ground traps seemed unusual as we had previously not experienced such a large quantity while using similar traps in northeastern and north central Ohio (Williams *et al.* 1992). Approximately 10% of all nitidulids collected were *E. helvola*. In Minnesota, Skalbeck (1976) reported 16 species of *Epuraea*, of which the two most prevalent species were *E. helvola* and *E. peltoides*.

The most abundant species in the early season traps was *Glischrochilus obtusus*, which is the largest species of this genus in the state. This conspicuous, colorful species was first brought to our attention because it was so abundant in brown sugar traps set out for Cerambycidae in the southern part of the state (Scioto, Vinton, and Ross counties) that it became a nuisance. *G. obtusus* is found in northern Ohio, but is uncommon.

Peng and Williams (1991) found that *G. quadrisignatus* preferred traps about 2 m above the ground in an apple orchard. In an open area, however, more were taken on the ground. In northeastern Ohio this is the most abundant species of *Glischrochilus* followed by *G. fasciatus* (Williams *et al.* 1992). In Shawnee State Forest, we collected only three specimens, one in the aerial traps and two in the ground traps. Only one specimen of *G. fasciatus* was taken and it was in an aerial trap. Apparently in this mostly arboreal setting in Scioto County, this species is not very common. It is known that one of the preferred breeding sites for *G. quadrisignatus* is in the ears of downed corn (Foott & Timmins 1971).

An additional species of nitidulid was found in the forest along State Forest Road 1 just outside the Civilian Conservation Camp (about 6.5 km directly north of the lower site) in the flowers of Convolvulaceae. Several specimens of *Conotelus obscurus* Erichson were collected from the flowers of morning glory, *Ipomoea* sp. This long, narrow beetle resembles a rove beetle, *Stenus* sp. (Staphylinidae); however, unlike rove beetles, nitidulids have clubbed antennae and occupy different ecological niches.

In summary, at least 21 species of nitidulids were collected in the Shawnee State Forest during the 1991 growing season (Table 3). All of these species had been previously collected in the state of Ohio. Comparison of the species record from the current study with the nitidulids in The Ohio State University collection showed that there were new county records. In Table 3, all were new records for Scioto County with the exception of *Carpophilus lugubris*, *Conotelus obscurus*, *Cychramus adustus*, *Epuraea alternata*, *Epuraea helvola*, and *Pallodes silaceus* (= *pallidus*). Three species which had been taken previously in the county but were not taken in our studies are *Epuraea umbrosa* Horn, *Phenolia grossa* (Fabricius), and *Prometopia sexmaculata* (Say). With the addition of these specimens to our study, there are now 24 known species of Nitidulidae from Scioto County, Ohio.

Table 1. Early season inventory of Nitidulidae collected from gallon jug traps in the Shawnee State Forest, Scioto Co., Ohio, 2-6 June, 1991.

Species collected	Number Collected
<i>Glischrochilus obtusus</i> (Say)	137
<i>Epuraea peltoides</i> Horn	78
<i>Glischrochilus sanguinolentus</i> (Olivier)	24
<i>Lobiopa undulata</i> (Say)	21
<i>Cryptarcha ampla</i> Erichson	15
<i>Cryptarcha concinna</i> Melsheimer	15
<i>Colopterus maculatus</i> (Erichson)	8
<i>Cryptarcha strigulata</i> Parsons	5
<i>Stelidota geminata</i> (Say)	5
<i>Carpophilus lugubris</i> Murray	3
<i>Cychramus adustus</i> Erichson	2
<i>Epuraea alternata</i> Parsons	2
<i>Carpophilus corticinus</i> Erichson	1
<i>Glischrochilus fasciatus</i> (Olivier)	1
<i>Glischrochilus quadrisignatus</i> (Say)	1
<b>Total</b>	<b>318</b>

Table 2. Late season inventory of Nitidulidae collected using NIT traps at two sites in the Shawnee State Forest, Scioto, Co., Ohio, 27 August-10 September, 1991 .

Species collected	Number Collected
<i>Stelidota geminata</i> (Say)	892
<i>Stelidota octomaculata</i> (Say)	271
<i>Epuraea helvola</i> Erichson	134
<i>Epuraea alternata</i> Parsons	41
<i>Carpophilus lugubris</i> Murray	11
<i>Colopterus</i> sp.	4
<i>Carpophilus hemipterus</i> (L.)	2
<i>Epuraea peltoides</i> Horn	2
<i>Glischrochilus quadrisignatus</i> (Say)	2
<i>Carpophilus corticinus</i> Erichson	1
<i>Pallodes pallidus</i> (Beauvois)	1
<b>Total</b>	<b>1361</b>

Table 3. Total Nitidulid catches for various baits over the entire season (early and late season combined). Shawnee State Forest, Scioto County, Ohio 1991.

Species	Malt/ Molasses	Brown Sugar	Vinegar	Canta- loupe	Acorns (Red Oak)	Wheat Dough	Smoked Bacon/Ham	Total
<i>Stel. geminata</i>	180	59	106	73	5	466	8	897
<i>Stel. octomaculata</i>	51	20	77	20	24	68	11	271
<i>Glis. obtusus</i>	0	137	0	0	0	0	0	137
<i>Epur. helvola</i>	21	23	19	6	0	65	0	134
<i>Epur. peltoides</i>	0	78	0	0	0	2	0	80
<i>Epur. alternata</i>	11	3	4	2	0	19	4	43
<i>Glis. sanguinolentus</i>	0	24	0	0	0	0	0	24
<i>Lobi. undulata</i>	0	21	0	0	0	0	0	21
<i>Cryp. ampla</i>	0	15	0	0	0	0	0	15
<i>Cryp. concinna</i>	0	15	0	0	0	0	0	15
<i>Carp. lugubris</i>	3	5	0	0	0	6	0	14
<i>Colo. maculatus</i>	0	8	0	0	0	0	0	8
<i>Cono. obscurus</i> <sup>1</sup>	0	0	0	0	0	0	0	7
<i>Cryp. strigulata</i>	0	5	0	0	0	0	0	5
<i>Colo. sp.</i>	0	2	0	0	0	2	0	4
<i>Glis. quadrisignatus</i>	0	1	0	0	0	2	0	3
<i>Carp. hemipterus</i>	1	0	0	0	0	1	0	2
<i>Carp. corticinus</i>	0	1	0	0	0	1	0	2
<i>Cych. adustus</i>	0	2	0	0	0	0	0	2
<i>Glis. fasciatus</i>	0	1	0	0	0	0	0	1
<i>Pall. pallidus</i>	0	0	0	0	0	1	0	1
<b>Total</b>	<b>267</b>	<b>420</b>	<b>206</b>	<b>101</b>	<b>29</b>	<b>633</b>	<b>23</b>	<b>1,686</b>

<sup>1</sup>*Conotelus obscurus* was taken from the flowers of *Ipomoea* sp. (Convolvulaceae).

Table 4. Bait and site comparison of the three most prominent nitidulids in late season, Shawnee State Forest, Scioto Co., Ohio, 1991.

(August 27-September 10)

Species	Malt/ Molasses		Brown Sugar		Vinegar		Canta- loupe		Acorns (Red Oak)		Wheat Dough		Smoked Bacon/Ham	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
<i>Stelidota geminata</i>	35	145	19	34	18	89	19	54	3	2	163	303	6	2
<i>Stelidota octomaculata</i>	1	50	1	19	5	72	2	18	2	22	5	64	4	6
<i>Epuraea helvola</i>	1	20	0	23	1	18	0	6	0	0	3	62	0	0
<b>Totals:</b>	<b>37</b>	<b>215</b>	<b>20</b>	<b>76</b>	<b>24</b>	<b>179</b>	<b>21</b>	<b>78</b>	<b>5</b>	<b>24</b>	<b>171</b>	<b>429</b>	<b>10</b>	<b>8</b>

1 = Lower site (Trial 1)

2 = Upland site (Trial 2)

## ACKNOWLEDGMENTS

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## FIRST RECORDS OF ENICOCEPHALIDAE (HEMIPTERA: HETEROPTERA) FROM WISCONSIN<sup>1</sup>

Steven J. Krauth, Daniel K. Young<sup>2</sup>

**ABSTRACT:** The family Enicocephalidae is recorded from Wisconsin for the first time. *Styelloderes biceps* was collected from pitfall traps at three sites in southeastern Wisconsin during June and July.

In North America Enicocephalidae is a small family of five genera and ten species (Froeschner 1988). Individuals are generally small and frail, and some swarm in mating flights (Kritsky 1977a), thereby giving rise to the name "gnat bugs". Nymphs and adults are predaceous on other small arthropods. Froeschner (1988) reviewed the literature and natural history for species of Enicocephalidae. The infraorder Enicocephalomorpha, to which the Enicocephalidae belong, is distributed across the southern United States, Australia, and Africa.

Specimens of enicocephalids were recovered from pitfall traps at three sites in southeastern Wisconsin, which constitute the first records for this family in the state. One specimen was collected in the Grassy Lake Wildlife Area, Columbia Co., WI, in conjunction with a Wisconsin Department of Natural Resources study of pheasant nesting success (Leonard Huebner, pers. comm.). Two individuals were also collected as part of a survey of macroarthropods associated with the long-term Wisconsin Integrated Cropping Systems Trial. One of the project's primary objectives is to compare, over time, the environmental impacts of six cropping systems that vary considerably in terms of chemical and physical soil disturbances, and thus, sustainability. One specimen from the Arlington Research Station plots in Columbia Co., WI, was taken from a pitfall trap in the corn phase of a drilled soybean-corn rotation. A second specimen was recovered from a pitfall trap in the corn year of a "rapid turnaround alfalfa" rotation (alfalfa-corn-oats/alfalfa) at the Lakeland Agricultural Complex, Walworth Co., WI. Pitfall traps used at the Arlington and Lakeland locations consisted of two nested 8 oz. plastic cups buried in agricultural fields to the lip of the cups. A few ounces of ethylene glycol were poured into the inner cup, and the pitfall trap opening was sheltered from above by a styrofoam plate supported by an offset wooden dowel inserted into the ground near the trap. The cups

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were sampled at two-week intervals throughout the growing season.

Using the available keys to species (Froeschner 1944, Kritsky 1977b, 1978a and b, 1981, Usinger 1945) the Wisconsin material was identified as *Systelloderes biceps* (Say). Distribution: Ariz., D.C., Fla., Ia., Ill., Ind., Ky., La., Md., Mo., N.C., N.Y., Pa., Que., R.I., Tenn., Ut., Va., Cuba, Mexico to Panama (Froeschner 1988).

Specimens from these collections are deposited in the Insect Research Collection of the Department of Entomology, University of Wisconsin-Madison.

MATERIAL EXAMINED: WI: Columbia Co., Grassy Lake State Wildlife Area, Coll: 1 July 1985, pitfall trapped, one male; Columbia Co., Arlington Agricultural Station, 12-17 June 1992, plot 108; T2 corn, pitfall trapped, one male; Walworth Co., Lakeland Ag. Farms, 4-11 June 1992, plot 307; T5 corn, pitfall trapped, one female.

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## TAXONOMIC STATUS OF THREE SPECIES OF *FALLCEON* (EPHEMEROPTERA: BAETIDAE)<sup>1</sup>

W. P. McCafferty, C. R. Lugo-Ortiz<sup>2</sup>

**ABSTRACT:** The taxonomic status of three species of *Fallceon* (Ephemeroptera: Baetidae) is discussed based on the examination of type materials. The syntypes of *Centroptilum poeyi* are identifiable as *Fallceon poeyi* and *Fallceon* sp., but they do not include *F. longifolius*. Recent material from Cuba that was misidentified as *Baetis* (*Fallceon*) *poeyi* is shown to represent a distinct new species, *Fallceon nikitai* McCafferty and Lugo-Ortiz. The Mexican species *Fallceon eatoni*, recently synonymized with *Fallceon quilleri*, is reinstated as a valid species and confirmed in *Fallceon*. The shape of the costal process in the hindwings is shown to be variable among *Fallceon* species.

### *Fallceon poeyi* (Eaton)

Eaton (1885) described *Centroptilum poeyi* from Cuba. Edmunds (1974) recombined this species with the genus *Baetis* Leach based on its possession of hindwings and double marginal intercalaries in the forewings. McCafferty and Waltz (1991) placed it in *Fallceon*, a genus which had been erected by Waltz and McCafferty (1987). Kluge (1992) recognized it in *Fallceon*, but regarded *Fallceon* only as a subgenus of *Baetis*. We continue to recognize *Fallceon* as a distinct genus. It clearly does not belong in *Baetis* based on its lack of a femoral villopore in the larvae. The possession of the villopore is an apomorphic characteristic which defines a distinct phylogenetic lineage containing *Baetis* and other genera related to *Baetis* (Waltz and McCafferty 1987).

Our recent study of the syntypes of *Centroptilum poeyi* (all pinned, alate specimens housed at the Museum of Comparative Zoology, Harvard University, MCZ white tag series No. 4965) indicated that three of the four original syntypes of this species possessed hindwings with an unhooked costal process, and one specimen possessed hindwings with a hooked costal process. The latter condition has been considered typical of the genus. All other characters visible on these poorly preserved specimens, including patterns of crossvenation in the forewings and position and development of the costal process of the hindwings, continue to suggest their placement in *Fallceon*. Two species of *Fallceon*, however, rather than one are represented by Eaton's syntypes.

It cannot be determined from Eaton's (1885:179) written description

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of *Centroptilum poeyi* which of the components of his type material is closest to his intended species concept. With figure 12 of Plate 65 of Eaton's monograph, however, he illustrated the hindwing of his *C. poeyi*. This hindwing clearly matches those specimens with the unhooked, symmetrically produced costal process. We interpret this illustrated hindwing as an indication that these particular specimens typified Eaton's intended concept of the species. In this respect, we are able to recognize the single male adult among these three specimens as the lectotype (Eaton's green tag No. 61) of *F. poeyi*, so designated by Kluge (1992).

The single Eaton syntype with the hooked costal process was identified by Kluge (1992) as *Baetis (Fallceon) longifolius* Kluge, a valid species he described in the same paper, based on larvae and adults he reared in Cuba. On the basis of the poor condition of this specimen, including the lack of genitalia, it is impossible to identify it to species, and given its small size, it is difficult to accept that it is this species since larvae on which the description is based are nearly twice as long as this adult (we have not seen such a size reduction from larva to adult in baetid species). Therefore, we consider that specimen of Eaton's (Eaton's green tag No. 711) as *Fallceon* sp. It is doubtful if it can ever be placed accurately to any particular species of *Fallceon*.

#### *Fallceon nikitai* McCafferty and Lugo-Ortiz, NEW SPECIES

Kluge (1992) described Cuban larvae of what he thought to be *Baetis (Fallceon) poeyi*, based on reared associations with adults that he presumed were that species. From Kluge's description, it is clear that this material is *Fallceon* but definitely not Eaton's *poeyi*. Our conclusion is based primarily on the presence of a hooked costal process in the hindwings of Kluge's material. Nonetheless, because the material represents an adequately described, distinct species, we name it after Nikita Kluge as follows: *Fallceon nikitai* McCafferty and Lugo-Ortiz, new species [= materials previously collected, described and illustrated as *Baetis poeyi* (Eaton) by Kluge (1992:40)]. We designate the holotype of the new species as follows: HOLOTYPE, male adult reared from larva, Cuba, Pinar de Río Province, Soroa, IV-1-1989, N. Kluge, deposited at Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia.

#### *Fallceon eatoni* (Kimmins), REINSTATEMENT

Kimmins (1934) described adults from the state of Sonora in northern Mexico as *Baetis eatoni*. Waltz and McCafferty (1987) recombined

this species with the genus *Fallceon*. McCafferty and Waltz (1991) subsequently synonymized it with *Fallceon quilleri* (Dodds).

Our examination of the type material from the British Museum has revealed that it is not *F. quilleri*. While there are striking similarities in the genitalia of *F. eatoni* and *F. quilleri*, both with respect to the bilobed process of the subgenital plate and the elongate terminal segment of the forceps (see Kimmins 1934), the hindwings of the two species are distinct. In fact, the hindwings of *F. eatoni*, similar to those of *F. poeyi* discussed above, do not possess the hooked costal process associated with other species of the genus. Except for this structural difference, however, it appears that *F. eatoni* and *F. quilleri* are closely related.

We continue to consider this species in *Fallceon* rather than *Baetis* because the general similarities in the genitalia of *F. eatoni* and *F. quilleri* would be too difficult to explain as convergences. The hooked costal process of the hindwing obviously cannot be used as a distinguishing characteristic for *Fallceon*. It will be important to discover and examine the still unknown larvae of both *F. eatoni* and *F. poeyi* because the most critical characters of the genus are apparently found in that stage (Waltz and McCafferty 1987).

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## NEW RECORDS, DISTRIBUTION AND TAXONOMIC STATUS OF SOME NORTHERN ARIZONA CADDISFLIES (TRICHOPTERA)<sup>1</sup>

Stephen R. Moulton II<sup>2,4</sup>, Kenneth W. Stewart<sup>2</sup>, Kirk L. Young<sup>3</sup>

**ABSTRACT:** Forty-nine caddisfly species were collected in northern Arizona during April and June, 1993. These included *Protoptila balmorhea*, previously known from its type locality in west Texas, the presumed rare *Ochrotrichia (Metrichia) volada*, that we determined to be a synonym of the widely distributed *O. (M.) nigritta* and an undescribed species and new Nearctic record of the xiphocentronid genus *Cnodocentron*. New distributional records and taxonomic notes are provided for regional species.

A regional collection of caddisflies was made in north-central Arizona in spring, 1993, in conjunction with a study to determine the population status of the two presumed rare species *Protoptila balmorhea* Ross (Glossosomatidae) and *Ochrotrichia (Metrichia) volada* Blickle and Denning (Hydroptilidae). Both are considered "Category 2" species under the Federal Endangered Species Act of 1973 (USFWS 1991). Collections were made at five sites in Oak Creek from upper to lower Oak Creek Canyon, in the outflows of two major springs, Page Springs and Bubbling Ponds in Yavapai County near the town of Page Springs, and reaches and adjacent springs of the Verde (Yavapai Co.) and East Fork Verde Rivers (Gila Co.). Portable ultra-violet light traps, hand-collecting with an aspirator, sweeping vegetation, and 6 m Malaise traps (Debby Focks Co., Gainesville, FL) were variously employed for collecting adults at these sites. Larvae and pupae were hand-picked from submerged objects and netted from the springs, ponds and streams. Larvae of six species were air-transported to our laboratory in Texas, and reared in a Frigid Units Living Stream™ at simulated habitat temperatures (12 - 14°C) and photoperiod. All material is preserved in 70% ethanol and deposited in the University of North Texas (UNT) Insect Museum Collection. A synoptic collection of species has also been placed in the National Museum of Natural History. Holotypes examined herein are deposited in either the California Academy of Sciences (CAS) or the Illinois Natural History Survey (INHS).

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*Protoptila balmorhea* Ross

*Protoptila balmorhea* Ross 1941:45.

Material Examined.- ARIZONA: YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 4-5-VI-1993, 9 ♂♂; same but, 5-6-VI-1993, 3 ♂♂; spring outfall at Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 7 ♂♂ 11 ♀♀; Oak Cr., below Page Springs Fish Hatchery, 5-6-VI-1993, 4 ♂♂, 5 ♀♀, same but, 17-V-1978, M. W. Sanderson, 2 ♂♂; TEXAS: Reeves Co., Balmorhea, irrigation flume, 19-IV-1939, H. H. & J. A. Ross, Holotype ♂.

**Comments.**- Morse (1988) did not include Arizona in his distributional summary of *P. balmorhea*. This species was previously known only from its type locality at Balmorhea, in the Trans Pecos region of west Texas (Ross 1941). Specimens were reportedly collected from Oak Creek by Milton Sanderson in May, 1978. We located and confirmed some of this material in the INHS collection. Presence of *P. balmorhea* in both west Texas and Arizona suggests that it may have been a widespread southwestern species that now occurs as disjunct, post-glacial relict populations. It is likely to be found in other southwestern states and northern Mexico where its larval habitat requirements are met. These include swift, spring outfalls with sufficient cobble substrate to support the algal grazing habits of the larvae.

*Ochrotrichia (Metrichia) nigritta* (Banks)

*Orthotrichia nigritta* Banks 1907:163.

*Metrichia volada* Blickle & Denning 1977:295. NEW SYNONYM.

Material Examined.- ARIZONA: YAVAPAI CO., Page Springs Fish Hatchery, 3-IV-1968, R.W. Baumann, Holotype ♂, Allotype ♀ (CAS Type No. 16363); same but 23-IV-1993, 18 ♂♂♀♀, pupae, larvae; same but 5-6-VI-1993, 22 ♂♂♀♀; Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 3 ♂♂, same but 5-6-VI-1993, 1 ♂; Bubbling Ponds, 1 km N Page Springs (town), 22-23-IV-1993, 8 ♂♂♀♀; same but 4-6-VI-1993, 332 ♂♂♀♀; OKLAHOMA: MURRAY CO., Buffalo Springs, Travertine Cr., Chickasaw Nat. Rec. Area, 28-IV-1991, Moulton & Kennedy, 66 ♂♂, 22 ♂♂; TEXAS: MENARD CO., San Saba R., at FM 864, Fort McKavitt, 11-IV-1992, 2 ♂♂; VAL VERDE CO., unnamed spring, Dolan Cr., near confluence with Devil's R., 17-III-1993, Stringer, Nelson, & Alexander, 2 ♂♂.

**Comments.** Prior to this study it was thought that *O. (M.) volada* was a rare and threatened species restricted to the spring outfalls near Page Springs, Arizona. The spring outfall above Page Springs Fish Hatchery had been fenced to protect the habitat, and our work was intended to assess the distribution and health of the population. In June 1993 at the

Page Springs and Bubbling Ponds outfalls, aggregations of 20 to 30 males were often found in heavily shaded areas on blades of streamside grasses and at the apex of the large arrowhead-shaped leaves of *Sagittaria*. Larvae and pupae were found only on heavily shaded, moss-covered cobbles in swift water. Some of these were successfully reared in the laboratory, and upon comparison with written descriptions and figures of *O. (M.) volada* and *O. (M.) nigritta*, it appeared that the two species might be synonyms. The ♂ holotype and ♀ allotype of *O. (M.) volada* were borrowed from the CAS and further comparisons confirmed that they were synonymous with confirmed material of *O. (M.) nigritta* in our reference collections from Texas and Oklahoma. In addition, larvae and cases collected from Page Springs were identical to those in our collection from a similar spring habitat in southern Oklahoma and to the written description by Edwards and Arnold (1961). *Ochrotrichia (M.) nigritta* is locally distributed in spring habitats throughout the southwestern United States (Arizona, Oklahoma, Texas), Mexico, and El Salvador (Blickle 1979, Flint 1972).

#### NEW DISTRIBUTION RECORDS

In addition to resolving the status of *P. balmorhea* and *O. nigritta* in the region, we were able to increase substantially the knowledge of forty-seven regional species, some of which were known previously from limited localities. An undescribed species of the xiphocentronid genus *Cnodocentron* was also discovered. Following is an annotated listing of these species. An asterisk denotes a new state record; only Arizona counties are listed.

##### Family Brachycentridae

\**Micrasema bactro* Ross, COCONINO CO., Oak Cr. at Manzanita Rec. Area, along US Hwy 89A 25-IV-1993, 3 larvae; YAVAPAI CO., Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 1 ♀.

This species has been reported previously from Alaska (Vineyard 1982) and the Yukon Territory (Schmid 1983) to California (Schmid 1983), Utah (Baumann and Unzicker 1981), and Colorado (Herrmann *et al.* 1986).

##### Family Calamoceratidae

*Phylloicus aeneus* (Hagen), COCONINO CO., Oak Cr. at Manzanita Rec. Area, along US Hwy 89A, 5-VI-1993, 3 larvae; YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 22-IV-1993, 1 larva.

Wiggins (1977) illustrated the larva of this species from Cochise Co., AZ.

### Family Glossosomatidae

\**Agapetus boulderensis* Milne. COCONINO CO., Oak Cr. along US Hwy 89A, S of Pine Flats Rec. Area, 7-VI-1993, 1 ♂ mmt, many larvae.

This species has been previously reported from Colorado (Milne 1936), Utah (Baumann and Unzicker 1981), and Wyoming (Denning 1948).

*Culoptila kimminsi* Denning. APACHE CO., the location label contained with the holotype reads, "Greer, White Mountains; 8000' Arizona; June 7, 1958; C.P. Alexander", Holotype ♂ (CAS Type No. 16165).

We borrowed the ♂ holotype of this species with the possibility that it might be a synonym of *C. moselyi*, since both species were apparently collected together (see comments below for *C. moselyi*) and subsequently described by Denning (1965). The type is contained in a cork-stoppered, shell vial containing alcohol and it is brittle and in poor condition; the head, right fore- and hind-wings, and right meso- and meta-thoracic legs are missing. The genitalia however, were intact and somewhat flattened. Genitalic characters differed from those of *C. moselyi* in the shape of the tenth tergite and the inferior appendages.

*Culoptila moselyi* Denning. Material Examined: COCONINO CO., West Fork Oak Cr., N Sedona, 15-VI-1978, M. W. Sanderson, 2 ♂♂; Oak Cr. at Manzanita Rec. Area, along US Hwy 89A, 25-IV-1993, 1 larva; Oak Creek Canyon, 13-16-VI-1961, S.G. Jewett. Holotype ♂ (CAS Type No. 16166); same as previous but 16-VI-1961, Allotype ♀ (CAS Type No. 16166).

The type data given by Denning (1965) reads, "Greer, White Mountains (near Springerville), Apache County, Arizona, 8000 feet, 7 June 1958, C.P. Alexander". This is apparently erroneous, as we discovered during our examination of the ♂ holotype that its hand written locality label read, "Oak Creek Canyon, Arizona; June 13-16, 1961; S.G. Jewett". The allotype location label was correctly reported by Denning (1965). Two male paratypes were reported as being deposited in the CAS, but we were unable to locate them despite the presence of a fourth label with the allotype that read, "Paratype ♂; *Culoptila moselyi*; D.G. Denning 1965". Wiggins (1977) illustrated and reported the larva of *C. moselyi* from the Chiricahua Mountains, Arizona. The holotype and allotype are contained in alcohol but are dried and brittle; the specimens are intact except for a few missing legs and antennae. The Sanderson material examined herein and three additional vials (not examined by us) are deposited in the INHS.

*Glossosoma ventrale* Banks. COCONINO CO., Oak Cr. at Manzanita Rec. Area, along US Hwy 89A, 25-VI-1993, 7 larvae; Oak Cr. along US Hwy 89A, S of Pine Flats Rec. Area, 7-VI-1993, 1 ♂ mmt, 3 pupae.

### Family Helicopsychidae

\**Helicopsyche borealis* (Hagen). COCONINO CO., Oak Cr., at Manzanita Rec. Area, along US Hwy 89A, 5-VI-1993, 2 larvae; YAVAPAI CO., Verde R., at US 89A, Cottonwood, AZ, 4-5-VI-1993, 4 ♂♂; Bubbling Ponds, 1 km N Page Springs (town), 46-VI-1993, 2 ♂♂; Oak Cr. below Page Springs Fish Hatchery, 5-6-VI-1993, 5 ♂♂, 3 ♀♀.

This species has been reported previously as "widely distributed on nearly all of the North American continent, from Mexico to Nova Scotia and Alberta" (Schmid 1983).

*Helicopsyche mexicana* Banks. COCONINO CO., Oak Cr. at Manzanita Rec. Area, along US Hwy 89A, 25-IV-1993, 1 larva; Oak Cr., at Sterling Spring Fish Hatchery, along US Hwy 89A, 4-5-VI-1993, 1 ♂.

### Family Hydrobiosidae

*Atopsyche sperryi* Denning. APACHE CO., Greer, White Mts., Government Spring, 7-VI-1993, P. Wagner, 4 pupae, 6 larvae; COCONINO CO., Oak Cr., at Manzanita Rec. Area, along US Hwy 89A, 25-IV-1993, 1 ♂, 1 ♀, 7 larvae; same but 5-6-VI-1993, 1 ♂; Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 4-5-VI-1993, 1 ♂; Oak Cr., along US Hwy 89A, S of Pine flats Rec. Area, 7-VI-1993, 1 ♂, 1 ♀.

Some males and females were reared from pupae in the laboratory. Larval and metamorphic material compare well with the undetermined *Atopsyche* illustrated from Coconino Co. by Wiggins (1977).

### Family Hydropsychidae

*Ceratopsyche oslari* (Banks). COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 4-5-VI-1993, 6 ♂♂.

*Ceratopsyche venada* (Ross). COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 22-IV-1993, 2 ♂♂, 12 larvae; same but, 4-6-VI-1993, 6 ♂♂; Oak Cr., at Manzanita Rec. Area, along US Hwy 89A, 5-VI-1993, 2 pupae, 1 larva; YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 22-IV-1993, 2 larvae; same but 4-6-VI-1993, 4 ♂♂; Bubbling Ponds Fish Hatchery, Page Springs (town), 7 ♂♂, 14 larvae; same but 5-VI-1993, 9 larvae; Oak Cr., below Page Springs Fish Hatchery, 22-IV-1993, 1 ♂, same but 5-6-VI-1993, 2 ♂♂.

*Cheumatopsyche arizonensis* (Ling). COCONINO CO., Oak Cr. at Sterling Spring Fish Hatchery, US Hwy 89A, 4-5-VI-1993, 1 ♂; YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 22-23-IV-1993, 55 ♂♂♀♀; same but 4-6-VI-1993, 11 ♂♂; Bubbling Ponds Fish Hatchery, 23-IV-1993, 31 ♂♂; Oak Cr., below Page Springs Fish Hatchery, 5-6-VI-1993, 12 ♂♂.

*Cheumatopsyche pinula* Denning. YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 22-IV-1993, 3 ♂♂; same but 4-5-VI-1993, 3 ♂♂; Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 4 ♂♂; Page Springs, at Page Springs Fish

Hatchery, Page Springs (town), 23-IV-1993, 4 ♂♂; Page Springs, at Page Springs Fish Hatchery, 22-IV-1993, 5 ♂♂; Verde R., at US Hwy 89A, Cottonwood, AZ, 4-5-VI-1993, 3 ♂♂.

*\*Hydropsyche auricolor* Ulmer. YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 23-IV-1993, 8 ♂♂; same but 4-5-VI-1993, 1 ♂; Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 14 ♂♂; Oak Cr., below Page Springs Fish Hatchery, 5-6-VI-1993, 62 ♂♂; Page Springs, at Page Springs Fish Hatchery, 22-IV-1993, 1 ♂; Verde R., at US Hwy 89A, Cottonwood, AZ, 4-5-VI-1993, 73 ♂♂.

This species was known for a long time in the southwestern United States and northwestern Mexico as *H. solex* Ross (Flint 1967); Buenosoria and Flint (1978) listed the latter as a junior synonym of the former.

*Hydropsyche occidentalis* Banks. YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs, 4-5-VI-1993, 1 ♂; Verde R., at US Hwy 89A, Cottonwood, AZ, 4-5-VI-1993, 104 ♂♂.

*Smicridea arizonensis* Flint. YAVAPAI CO., Oak Cr., below Page Springs Fish Hatchery, 22-IV-1993, 1 ♂; same but 5-6-VI-1993, 1 ♀; Bubbling Ponds, 1 km N Page Springs (town), 4-5-VI-1993, 1 ♂, 1 ♀; Verde R., at US Hwy 89A bridge, Cottonwood, AZ, 4 ♀♀.

### Family Hydroptilidae

*Alisotrichia arizonica* (Blickle & Denning). YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs, 4-5-VI-1993, 1 ♂, 1 ♀.

This rare micro-caddisfly was originally designated as the type species for the new genus *Rioptila* described from Oak Creek (Blickle and Denning 1977). Recently, Harris and Holzenthal (1993) reduced *Rioptila* to the status of a junior synonym of *Alisotrichia* based on characters of adult males and females. To our knowledge, the collection reported here represents the third collection of this rare species in Arizona since the type series in 1949. Blickle (1979), Baumann and Unzicker (1981), and Harris and Holzenthal (1993) recorded this species from Utah.

*Hydroptila arctica* Ross. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 4-6-VI-1993, 52 ♂♂.

*Hydroptila icona* Mosely. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, 4-6-VI-1993, 7 ♂♂; YAVAPAI CO., Oak Cr., below Page Springs Fish Hatchery, 5-6-VI-1993, 6 ♂♂; Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 2 ♂♂; Bubbling Ponds, 1 km N Page Springs (town), 4-5-VI-1993, 54 ♂♂; Verde R., at US Hwy 89A, Cottonwood, AZ, 134 ♂♂.

*Hydroptila rono* Ross. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 4-6-VI-1993, 9 ♂♂.

*\*Ithytrichia clavata* Morton. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 4-5-VI-1993, 2 ♂♂.

This holarctic species has been reported previously from California (Ross 1944), Oklahoma (Ross 1944), Texas (Cloud and Stewart 1974), and Utah (Baumann and Unzicker 1981) as well as 17 other Nearctic states and provinces.

*Leucotrichia limpia* Ross. YAVAPAI CO., Oak Cr., below Page Springs Fish Hatchery, 22-IV-1993, 91 ♂♂; Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 1 ♂; Bubbling Ponds, 1 km N Page Springs, 23-IV-1993, 1 ♂.

Larvae of this species were abundant on rock surfaces.

*\*Mayatrichia ayama* Mosely. YAVAPAI CO., Verde R., at US Hwy 89A, Cottonwood, AZ, 4-5-VI-1993, 1 ♂.

This species has been reported previously from New Brunswick to Alberta (Blickle 1979) to Costa Rica (Bueno-Soria and Flint 1978).

*Ochrotrichia dactylophora* Flint. YAVAPAI CO., Page Springs, at Page Springs Fish Hatchery, 23-IV-1993, 2 ♂♂.

Flint (1965) listed the type locality for this species as "Arizona, Coconino County, West Fork, 16 miles southwest of Flagstaff, 6500 ft. elevation". Denning and Blickle (1972) noted that Oak Creek Canyon may be the northern limit of this species.

*Ochrotrichia ildria* Denning & Blickle. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 22-IV-1993, 1 ♂.

The type locality for this species is Oak Creek Canyon (Denning and Blickle 1972).

*Ochrotrichia quadrispina* Denning & Blickle. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 22-IV-1993, 1 ♂; same but 4-6-VI-1993, 2 ♂♂; YAVAPAI CO., Oak Cr., below Page Springs Fish Hatchery, 22-IV-1993, 1 ♂; same but 5-6-VI-1993, 1 ♂.

This species was described from Portal, Cochise Co., Arizona.

*Ochrotrichia stylata* (Ross). COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, 4-5-VI-1993, 1 ♂; YAVAPAI CO., Oak Cr., below Page Springs Fish Hatchery, 5-6-VI-1993, 80 ♂♂; Page Springs, at Page Springs Fish Hatchery, 23-IV 1993, 2 ♂♂; Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 1 ♂; Bubbling Ponds, 1 km N Page Springs (town), 10 ♂♂; Verde R., at US Hwy 89A, Cottonwood, AZ, 4-5-VI-1993, 30 ♂♂.

*Ochrotrichia tarsalis* (Hagen). YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 5-6-VI-1993, 2 ♂♂.

*Oxyethira aculea* Ross. YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 4-5-VI-1993, 1 ♂.

*Oxyethira dualis* Morton. YAVAPAI CO., Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 2 ♂♂; Bubbling Ponds, 1 km N Page Springs (town), 23 IV-1993, 1 ♂; same but 4-5-VI-1993, 2 ♂♂.

*Oxyethira pallida* (Banks). YAVAPAI CO., LoLo Mai Spring, 1 km N Page Springs (town), 5-6-VI-1993, 1 ♂.

### Family Lepidostomatidae

*Lepidostoma knulli* Ross. APACHE CO., Government Spring, Hwy 377, Greer, White Mts, 7-VI-1993, P. Wagner, many larvae; COCONINO CO., Oak Cr., at Manzanita Rec. Area, 5-VI-1993, 16 larvae.

*Lepidostoma ormeum* Ross. COCONINO CO., Oak Cr., at Manzanita Rec. Area, 25-IV-1993, 1 larva.

Weaver (1988) has previously recorded this species from Oak Creek.

### Family Leptoceridae

*Nectopsyche stigmatica* (Banks). COCONINO CO., Oak Cr., at Manzanita Rec. Area, US Hwy 89A, 5-VI-1993, 10 larvae; YAVAPAI CO., Oak Cr., below Page Springs Fish Hatchery, 5-6-VI-1993, 12 ♂♂♀♀; Bubbling Ponds Fish Hatchery, Page Springs (town), 23-IV-1993, 10 ♂♂♀♀; Bubbling Ponds, 1 km N Page Springs (town), 22-23-IV-1993, 21 ♂♂♀♀; same but 4-5-VI-1993, 6 ♂♂♀♀.

\**Ocetis avara* (Banks). GILA CO., East Fork Verde R., at Control Rd., 24-IV 1993, 1 ♂; YAVAPAI CO., Oak Cr., below Page Springs Fish Hatchery, 23-IV-1993, 1 ♀; same but 5-6-VI-1993, 7 ♂♂♀♀; Bubbling Ponds, 1 km N Page Springs (town), 23 IV-1993, 32 ♂♂♀♀; same but 4-5-VI-1993, 6 ♂♂; Verde R., at US Hwy 89A, Cottonwood, AZ, 4-5-VI-1993, 8 ♂♂.

This species has been reported previously from Canada to Ecuador, Colombia, and Venezuela (Flint 1991),

### Family Limnephilidae

*Apatania arizona* Wiggins. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 4-7-VI-1993, 2 ♂♂, 1 ♀, 1 larva; same but Pumphouse Wash, 28-X-1978, M. W. Sanderson, 1 ♂.

*Hesperophylax magnus* (Banks). COCONINO CO., Oak Cr., at Manzanita Rec. Area, along US Hwy 89A, 5-VI-1993, 3 larvae

### Family Odontoceridae

\**Marilia nobscia* Milne. YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs, 22-IV-1993, 1 ♂, 1 ♀, 1 larva; Page Springs, at Page Springs Fish Hatchery, 22-IV-1993, 2 ♂♂, 1 ♀ .

This species has been reported previously from Texas (Milne 1936) and Baja California in Mexico (Ross 1951).

### Family Philopotamidae

*Chimarra utahensis* Ross. Several hundred males, females, pupae, and larvae were examined from locations throughout the Oak Creek and Verde River drainages in Coconino and Yavapai Counties during April and June, 1993.

This species was the most abundant and frequently encountered species. Adults could be collected throughout the day and at night with all methods described herein.

*Wormaldia arizonensis* (Ling). YAVAPAI CO., Oak Cr., below Page Springs Fish Hatchery, 22-IV-1993, 2 ♂♂; Page Springs, at Page Springs Fish Hatchery, 23-IV-1993, 1 ♂; Bubbling Ponds, 1 km N Page Springs (town), 23-IV-1993, 1 ♂; same but 4-5-VI 1993, 1 ♂.

### Family Polycentropodidae

*Polycentropus arizonensis* Banks. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 4-5-VI-1993, 6 ♂♂.

*Polycentropus halidus* Milne. YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs (town), 23-IV-1993, 1 ♂; Verde R., at US Hwy 89A, Cottonwood, AZ, 4-5-VI-1993, 22 ♂♂.

### Family Rhyacophilidae

*Rhyacophila coloradensis* Banks. COCONINO CO., Oak Cr., at Sterling Spring Fish Hatchery, 5-6-VI-1993, 3 ♂♂.

### Family Sericostomatidae

*Gumaga griseola* Mac Lachlan. YAVAPAI CO., Oak Cr., at Sterling Spring Fish Hatchery, US Hwy 89A, 4-5-VI-1993, 5 ♂♂.

*Gumaga nigricula* Mac Lachlan. COCONINO CO., Oak Cr., at Manzanita Rec. Area, along US Hwy 89A, 5-VI-1993, 2 larvae.

These larvae are identical to the one figured and reported from Coconino Co. by Wiggins (1977) as *G. nigricula*.

### Family Uenoidae

*Oligophlebodes minutus* (Banks). APACHE CO., Greer, White Mts., Government Sprin , Co. Rd . 1120, 6-VI-1993, P. Wagner, many pupae, ♂♂ mmt.

### Family Xiphocentronidae

*Cnodocentron sp.* A YAVAPAI CO., Bubbling Ponds, 1 km N Page Springs, 22-23-IV-1992, 7 ♂♂.

This undescribed species of *Cnodocentron* represents the first record of this genus occurring in the Nearctic region. Despite intense usage of all adult collecting methods at the Bubbling Ponds site, specimens were only collected in the 6 m Malaise trap. Attempts to collect the female and associate the larva from this site are in progress. This species will be described by Moulton and Stewart in a later paper.

#### ACKNOWLEDGMENTS

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## A NEW SUBFAMILY FOR THE FOSSIL CONOPID FLY, *PALAEOMYOPA TERTIARIA* (DIPTERA: CONOPIDAE)<sup>1</sup>

Sidney Camras

ABSTRACT: The fossil fly *Palaeomyopa tertiaria* Meunier is placed in a new subfamily *Palaeomyopinae* of the family Conopidae.

Only one fossil conopid fly is definitely known. I agree with Hennig's (1966) conclusion that *Palaeomyopa tertiaria* Meunier (1889, 1912) and *Palaeosicus loewi* Meunier (1916) are synonymous. *Poliomyia recta* Scudder (1878) from shale from Green River, Wyoming is an incomplete specimen and may or may not be a conopid.

In attempting to place this fly into one of the current subfamilies it became evident that it did not belong to any of them. The most significant character is the presence of the "theca" on the fourth sternite, whereas in modern species it is on the fifth sternite. This is a projection of the sternite of the female that functions as a clasping organ on the male during copulation.

Hennig believed that the original conopid fly had the theca on the fourth sternite, that this receded, and then the projection developed on the fifth sternite. Because of the primitive characters listed below, I believe that *Palaeomyopa* originated from the precursor of the Conopidae, and developed as a separate branch that later became extinct. Perhaps some day a conopid may be found with the theca on the fourth sternite.

The primitive (plesiomorphic) characters that are present in the fossil species are as follows:

1. Abdominal segments of the female of equal length (Fig. 1).
2. First posterior cell ( $R_5$ ) widely open, but somewhat narrowed (Fig. 2).
3. Very short fleshy mouth parts (Fig. 4).
4. Absence of facial grooves (Fig. 3).

The specialized (apomorphic) characters, compared to current species, are as follows:

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<sup>2</sup> c/o Division of Insects, Field Museum of Natural History, Chicago, IL 60605. Office address: 4013 North Milwaukee Ave., #515, Chicago, IL 60641.

1. Theca on fourth sternite (Fig. 1).
2. Angled anal cell (Fig. 2).
3. Very long second segment of an antenna with an arista (Fig. 3).
4. Peculiar arista (Fig. 3).

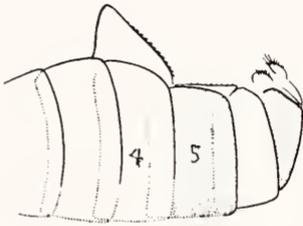


Fig. 1.

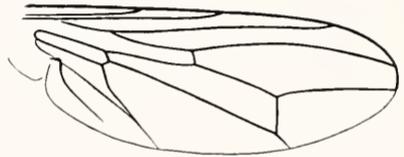


Fig. 2

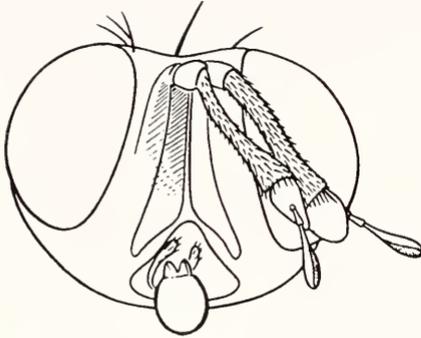


Fig. 3.

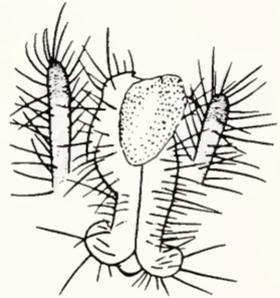


Fig. 4.

Figs. 1-4 *Palaeomyopa tertiaris* Meunier: 1, Abdomen. 2, Wing. 3, Head. 4, Mouth parts (all from Hennig, 1966).

On the basis of the above characters a separate subfamily is justified, which may be called:

*Palaeomyopinae*, SUBFAMILIA NOVA

Type genus: *Palaeomyopa* Meunier (1899).

Meunier designated only the generic name *Palaeomyopa* in 1899 and added the specific name *tertiaria* in his 1912 paper. He apparently did not have the type of *Palaeomyopa terciaria* at hand when he described *Palaeosicus loewi* in 1916.

*Palaeomyopa terciaria* has been known from four specimens, all from Tertiary Baltic amber. The type was from the University of Königsberg and could not be found by Hennig. Hennig studied the type of *Paleosicus loewi*, also from the Königsberg Collection, and the two British Museum specimens. The theca is visible only on the type of *Palaeosicus loewi*.

The type of *Palaeosicus loewi* was received for study from the Institut und Museum für Geologie und Palaontologie der George-August-Universität, Göttingen, Germany, through the courtesy of Dr. S. Ritzkowski. The British Museum specimen #22206 was sent by N.P. Wyatt and S. Morris. The British Museum specimen #22212 could not be found.

The illustrations are from Hennig's paper and were found to be very accurate. They are reproduced with the kind permission of Dr. Wolfgang Seeger. For a more complete and very scholarly study, Hennig's paper should be consulted.

## ACKNOWLEDGMENT

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## A CAGE TO ISOLATE INDIVIDUAL OVIPOSITING *CULEX* SPP. FEMALES (DIPTERA: CULICIDAE) IN THE FIELD<sup>1</sup>

Richard G. Weber, Tracy A. Horner<sup>2</sup>

**ABSTRACT:** We describe and illustrate a small floating cage for isolating individual female *Culex* spp. mosquitoes while they oviposit in the field. The cage allows a female to finish her egg raft without escaping. Her species is determined by first instar larvae hatched from the raft, and she may be dissected or maintained alive for other purposes.

During field studies of oviposition behavior by *Culex pipiens* L. and *C. restuans* Theobald (Weber *et al.* 1991, Weber and Tipping 1990a, Weber and Tipping 1990b), we needed to isolate individual wild females as they oviposited on artificial ovisites containing dyed water. We also wanted to investigate the possible relationships between female age and egg raft size or choice of ovisite. To help us in these studies we developed a small floating, oviposition cage (Fig. 1) that allowed us to associate a particular female with her most recent egg raft and thus identify her to species by characters of the resulting larvae.

The ability to identify individuals to species by characters of their larvae is important because females of these two species can not be separated with certainty by visual characters, especially if they have lost many body scales (Madder *et al.* 1980). They can be identified by electrophoresis (Bartholomew and Munstermann 1984). Our research sometimes requires dissection of captured females to find whether they have retained eggs and to check their gonotrophic age by examining ovarioles (Small and Weber 1992). For this reason electrophoresis is inconvenient and we instead rely on characters of the first instar larval head (Dodge 1966, Reiter 1986) for identification.

Female *Culex pipiens* and *C. restuans* can be approached closely when they are ovipositing (Weber and Tipping 1990a). Females will tolerate considerable manipulation without ceasing oviposition or abandoning the site after they have placed ca. 10-15 eggs in a raft (our personal observations and Mattingly 1970). Because ovipositing females are so tolerant, the floating oviposition cage has proven to be a useful research tool. Females usually continue ovipositing and lay their complete clutch after they have been caged.

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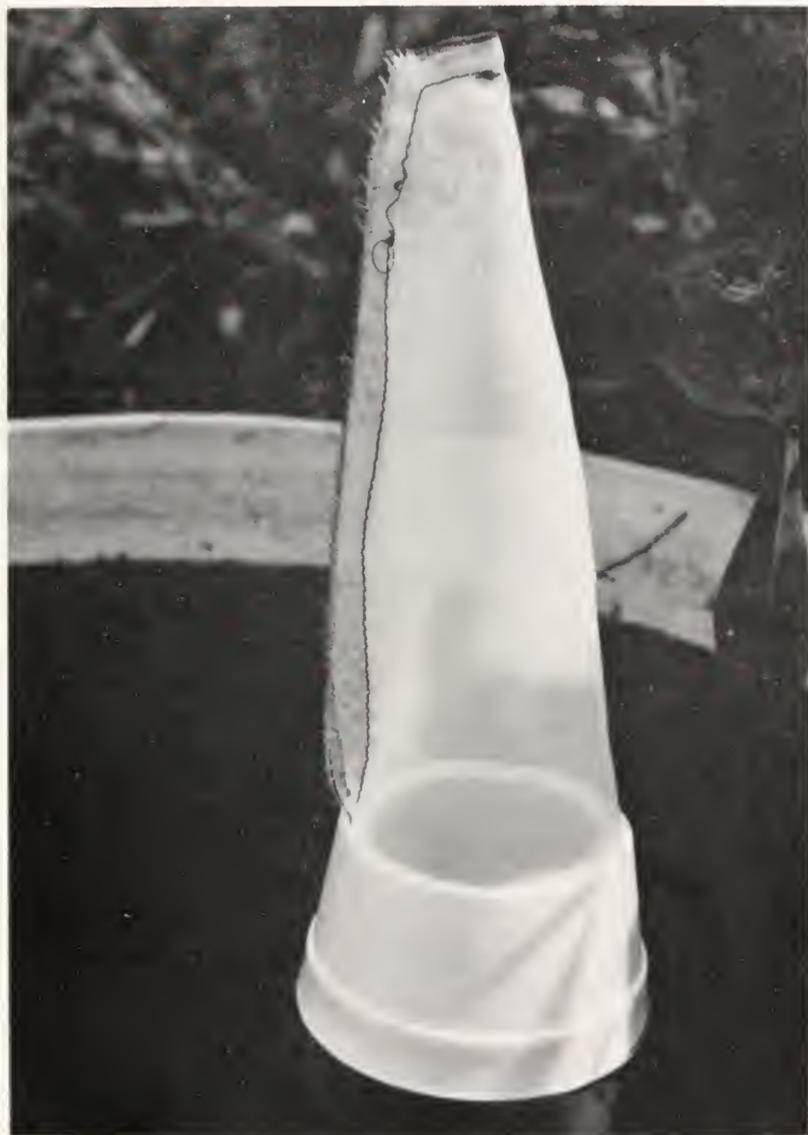


Fig. 1 The oviposition cage floating on the surface of an artificial oviposition site.

The cage is constructed from 261 ml (8.6 oz) styrofoam cups and fine-mesh nylon fabric (Figs. 1 & 2). Cups forming the base were 8 cm (35/32") in diameter at the top. The nylon fabric was cut to shape (Fig. 2a), then folded and sewn along one edge and across the tip to make it cone-shaped. Mesh size of the fabric is not critical, but the fabric should be stiff enough to remain upright. To form the base, we nest three cups and place them opening-downward on a smooth surface (Fig. 2b). The two inner nested cups are cut cleanly below the lip of the outer cup and the entire assembly is cut again 4.6 cm above the first cut, leaving the nested parts of the three cups as a set. The two inner cup sections are cemented together with several dabs of silicon adhesive ("Permatex Flowable Silicone Windshield & Glass Sealer", Loctite Corporation, Cleveland, Ohio 44128), which is waterproof and does not soften styrofoam. When the adhesive has cured for ca. 30 min., this subassembly is ringed with a line of adhesive and the base of the nylon top is pulled down over it. A second line of adhesive is placed around the fabric near the base and the outer cup section is pushed down over the fabric and

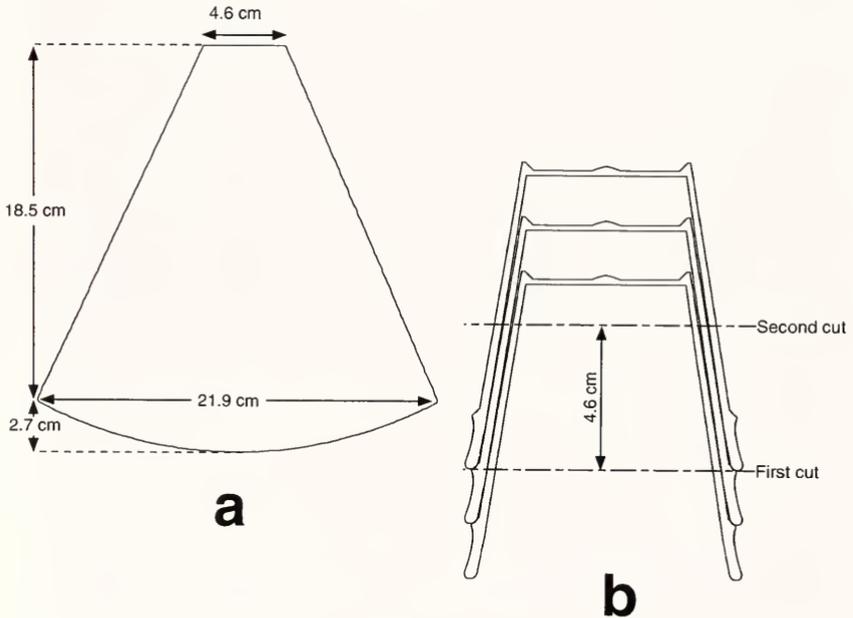


Fig. 2a: Dimensions and shape of the nylon fabric used to make the cage tops.

2b: Floating base of cage made from cut, nested styrofoam cups. (Illustrations not drawn to same scale.)

two inner cups. Silicon adhesive smells mildly of acetic acid as it cures, so we allow several days between cage assembly and use.

In use, we first locate a female with a partially completed raft. Using a flashlight with a red lens decreases chances of disturbing females (Weber and Tipping 1990a). The cage, held by its top, is centered above the female, then lowered gently to the water. Each cage is checked at ca. 5 min intervals to determine when the female has finished her raft and flown into the mesh tip. She is confined there by pinching the mesh together between first and second fingers. The cage is lifted from the surface and the raft is collected for egg counting, hatching and larval identification. The female is removed from a cage by placing a 2.4 cm diameter shell vial into the mesh top to enclose her. After she enters the vial a finger is used to evert the mesh tip into it, thus capturing her. Then the vial and mesh is everted out the bottom of the cage. The vial is plugged using a tuft of cotton which is then moistened with 10% sucrose solution. Storing vials on their sides reduces chances of a female becoming stuck in sucrose solution. In this way we have been able to maintain females alive in shell vials for over 55 hours at normal room temperatures. In time the nylon fabric becomes somewhat limp and the tops droop, interfering with proper operation. We remove limpness by suspending a cage from its tip and spraying the fabric lightly with hair spray ("Rayette Aqua Net", Faberge Incorporated, New York, N.Y. 10019).

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## BOOK REVIEW

**HANDBOOK OF THE FRUIT FLIES (DIPTERA: TEPHRITIDAE) OF AMERICA NORTH OF MEXICO.** Richard H. Foote, F.L. Blanc, and Allen L. Norrbom. Cornell University Press. 1993. 576pp., 535 illus. \$105.00.

This is an impressive, detailed work of one of the most economically important families of Diptera. The authors' long experience with the family is quite apparent. The book has nine sections. After a short Introduction, the Adult Morphology section explains the structures and attributes needed in using the generic and species keys. The relationship of the Tephritidae to other acalyprate Diptera is given a section. The 56 genera and 300 species of the North American assemblage are arrayed in 3 subfamilies and 11 tribes with 10 unplaced genera in the hierarchy, an arrangement based largely on Hering's 1947 (*Siruna Seva* 6) divisions. Each subfamily is discussed, and the Relationships within tribes is treated based upon hypothesized pleisomorphic and apomorphic characteristics. The generic key to U.S. and Canadian members is thoroughly illustrated and makes the key almost foolproof. The genera are arranged alphabetically with synonymy references, a recognition section, and a discussion paragraph. The species within each genus are also listed alphabetically. This is a real boon for every worker who never had enough fingers in using monographs and other handbooks to carry out description comparisons. Like the generic sections, each species has synonym citations, a recognition section, a geographic distribution section which is usually a base map with several species appearing at localities where the species have been taken are given, hosts are cited, and a discussion section pointing out pertinent details concerning the species. In addition to the distribution maps, the distinctive wing markings and patterns that characterize the Tephritidae are illustrated for "nearly every species discussed." These wing illustrations are lettered to designate "key" characters. Only a few wing illustrations are disappointing (e.g. *Eutreta* spp.), but this is just the nature of some of these wing patterns. Other features of taxonomic chaetotaxy generously illustrate all of the keys making them easy to use, even for the novice.

The authors can be proud of this Handbook which is the result of many years of study and experience, particularly the senior author. His successors and other entomologists have a work that points out problems and areas for future work. This work will serve as a model for other comprehensive handbooks of the future. It will be essential for fruit, vegetable and ornamental entomologists and should stimulate many ecology students to undertake studies of members of this important and enthralling family of flies.

Stuart E. Neff,  
Dep't. of Biology, Temple University

**AMPHISBAENIANS (REPTILIA:  
AMPHISBAENIDAE) IN NESTS OF *ATTA SEXDENS*  
(HYMENOPTERA: FORMICIDAE)  
IN EASTERN AMAZONIA, BRAZIL<sup>1</sup>**

Claudia Azevedo-Ramos<sup>2,4</sup>, Paulo R.S. Moutinho<sup>3</sup>

ABSTRACT: Two species of Amphisbaenians (*Amphisbaena alba* and *A. mitchelli*) were discovered in nests of the leaf-cutting ant *Atta sexdens* in Pará, Brazil. This is a new habitat and locality for Amphisbaenians in eastern Amazonia.

There are several reports of reptiles inhabiting ant and termite nests, especially amphisbaenids (Weber, 1972; Brandão and Vanzolini, 1985; Riley *et al.*, 1985). Amphisbaenids are cryptic worm lizards that spend most of their life time burrowed in the ground. Therefore, any information about these animals is useful. In this note, we describe the occurrence of two species of *Amphisbaena* in ant nests, one being a first record in an ant nest and both being new distributional records.

This work was carried out in a secondary forest area in Vitoria Farm (2°55'S, 47° 35'W), Paragominas (see Nepstad *et al.*, 1991 for a detailed description of the area), northeastern Pará, Brazil. In May 1993, the junior author excavated two nests (ca. 0.8 x 1.8 m) of the leaf-cutting ant *Atta sexdens* (L.) to a depth of 3.5 m. During the excavations, two species of *Amphisbaena* (one specimen in each nest) were found: *A. alba* (L.) (length 331 mm; weight 31 g) and *A. mitchelli* Procter (186 mm; 3g). *Amphisbaena alba* was found inside the refuse chamber at a depth of 3.5 m, while *A. mitchelli* was found in the fungus chamber at a depth of 0.5 m. Both specimens are deposited in Museu P. E. Goeldi, Belém, Pará, Brazil (*A. alba* # 16398; *A. mitchelli* # 16399).

*Amphisbaena alba* is known as "mãe de saúva" (mother of leafcutting ants) in Brazil, which reflects its association with ant nests. There is no report of *A. alba* in an *Atta sexdens* nest in the literature, although various authors described the occurrence of *A. alba* in nests of several species of related ants (Weber, 1972; Riley *et al.*, 1985) including the use of the nests by these reptiles to deposit their eggs (Vaz-Ferreira *et al.*, 1970; Weber, 1972; Riley *et al.*, 1985). The fact that its eggs have never been found elsewhere may indicate an obligate association (Riley *et al.*,

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1985), although it does not appear to have a restricted association with this species of ant. Neither *Amphisbaena* species had been recorded before in the Paragominas region. Therefore, this locality is new to their distribution area, even though Paragominas is within their expected area of occurrence (see Gans, 1962, 1964; Hoogmoed and Avila-Pires, 1991). Gans (1964) reported that *A. mitchelli* was found burrowed, but did not mention an association with ant nests. This is the first record for *A. mitchelli* in an ant nest.

#### ACKNOWLEDGMENTS

We would like to thank T. C. Avila-Pires (Museu P. E. Goeldi) and H. G. Fowler (UNESP- Rio Claro) for their suggestions on the manuscript; T. C. Avila-Pires identified the *Amphisbaena* species, and P.R.S. Moutinho the ant species.

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## 1994 CALVERT AWARD

Ben Blanchard, son of Barbara and Wayne Blanchard and an eighth grade student at Indian Valley Middle School, Harleysville, PA, has won the 1994 Calvert Award. This annual award recognizes the best insect-related science project entered in the Delaware Valley Science Fairs which were held this year at the Philadelphia Civic Center on April 20. This award is sponsored by The American Entomological Society, Philadelphia.

Throughout the past year Ben Blanchard monitored water quality at several sites in local streams by measuring the diversity and abundance of aquatic insects and other macro invertebrates. Using his knowledge of insect life cycles, preferred habitats, and pollution tolerance of these organisms, he concluded that pollution had actually decreased since a 1967 study by Lehigh University.

Harold White, University of Delaware, and Jon Gelhaus, Academy of Natural Sciences of Philadelphia, judged the science projects for the American Entomological Society. White said "It is remarkable that an eighth grade student should walk away with the Calvert Award considering that all students through senior high school were eligible. It really shows how outstanding this project was." Gelhaus also was impressed. "Ben's knowledge and interest in his project goes way beyond that of most students. It is not often we see a student who works through the summer and in the middle of winter on a project like this." The judges also noted that Ben was awarded an honorable mention for a related project in last year's competition.

Ben Blanchard received his award and displayed his project at the April 27 membership meeting of the Society held at the Academy of Natural Sciences. Also present were his father and his sponsoring teacher, Mr. Richard Close. The Calvert Award includes memberships in The American Entomological Society and the Young Entomologists' Society as well as a check for \$50.

The Calvert Award honors Philip P. Calvert who joined the American Entomological Society as a teenager, later became its president, and was a member for 74 years until his death in 1961. He played an important role in stimulating interest in insects among young people through the Society, the Academy of Natural Sciences, and the University of Pennsylvania where he was a professor of biology. It is particularly appropriate that Ben Blanchard receive the Calvert Award this year because among the stream insects he studied were dragonflies, the group of insects Calvert most studied.

Harold B. White  
Chair, Education Committee

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**swhitney@brahms.udel.edu**

Susan Whitney  
Extension Specialist—Pesticides  
University of Delaware

**SOCIETY MEETING OF FEBRUARY 23, 1994****APTERYGOTA AND SYMPHYLA****Robert T. Allen**

Department of Entomology and Applied Ecology, University of Delaware

The "Apterygota" orders remain a mystery for most entomologists. These organisms are usually ignored, or only briefly covered in introductory classification courses. They are usually minute and cryptic in the soil, and therefore rarely noticed in the field. In fact, there has been a long-running debate whether some of these groups are truly insects, with major reference works, like *The Insects of Australia* (2nd ed.) coming down firmly on the side of excluding the Protura, Collembola and Diplura from the Class Insecta. So it was with great interest that the Society membership heard more about these enigmatic organisms and the Symphyla from a wonderful, entertaining speaker, Dr. R. Tommy Allen.

How does one embark on a career studying these groups? Like most of us studying a particular group, Dr. Allen's interest was a mixture of chance, curiosity and the realization that these organisms could provide answers to broad questions in biology. In fact, Allen's study of these groups the past few years is a great departure from his previous 25 years studying carabid systematics. Starting with a donated collection of Protura from Dr. T. Copeland, Dr. Allen has augmented it with his own fieldwork in diverse places around the world, including a recent trip to Chile. Although Berlese funnels are best for Collembola and Protura, hand collecting is best for Diplura and involves rolling rocks along stream banks, examining rotten logs, and, in arid areas in Chile, digging in soil up to a meter deep. Specimens can be studied by the usual means from slide mounts, but also by newer methods such as scanning electron microscopy, video imaging and molecular techniques. For example, he illustrated the multitude of morphological characters by SEM photographs, the behavior of a campodeid dipluran by a 30 minute video and mentioned his molecular sequencing collaboration with Ward Wheeler of the American Museum of Natural History.

Although the number of described species in these groups is small, Allen believes that the number of undescribed species is great, with, for example, only one-tenth of the Protura (~400 spp.), and one-half of the Diplura (~1000 spp.) known presently. And although the groups are nearly cosmopolitan, they do exhibit interesting biogeographic patterns which Allen surmises might be a reflection of some of the Earth's early history. In pursuit of these questions, he has derived a phylogeny for the families of Diplura, with some families and subfamilies showing intriguing restricted distributions in places like Tonga. Within the Japygidae, many genera have restricted geographic distributions and absences, while the Campodeidae genera are mostly widely distributed. Questions regarding the historical biogeography of these apparently low-dispersing organisms and the apparent lack of speciation in the face of long isolation (as particularly exemplified in the Symphyla) are important ones that Allen hopes to answer in his future work.

The meeting also included several notes of entomological interest. Paul Schaefer mentioned his research into the "tussocks" or hair groupings of tussock moth caterpillars (Lepidoptera: Lymantriidae) including gypsy moths. He found a gland located under each tussock and suggests that the long hairs may act as a brush to carry the secretion away from the caterpillar. Field Day is set for October 1 this year at Fair Hill, Maryland. Sue Frank displayed a clock incorporating cicada wings which was made by a local artisan. About 22 members and their guests attended the meeting.

Jon K. Gelhaus  
Corresponding Secretary

**SOCIETY MEETING OF MARCH 23, 1994****HOT-HEADED DRAGONS: HEAD TEMPERATURE REGULATION OF DRAGONFLIES****Michael L. May**

Department of Entomology, Rutgers University-Cook College

Dragonflies are active predators on the wing and as such are exposed to a wide range of temperatures. Although the muscles which control their excellent flight abilities are adapted to operate at high temperatures, they still must be able to control their internal thoracic temperatures and indeed show a wide range of behavioral and physiological mechanisms to carry out this regulation. These mechanisms have been investigated over a number of years through the research of Dr. Mike May, Rutgers University, and his most recent results concerning dragonflies "hot heads" were explained and discussed.

Anyone can easily observe the behavioral regulation of temperature by dragonflies at any pond site when adults are present. Different behaviors are used to warm up or dissipate heat. For example, basking on a tree trunk in the sun takes advantage of a warm boundary layer of air and the adult warms up, while raising the body away from the surface, or changing the angle of the body to the sun can reduce unwanted heat. Some species even point the abdomen up and directly at the sun (termed "obelisk" position) to minimize exposure. Dr. May focused his research not on "baskers", however, but on *Anax junius* (Drury) a common pond species that remains almost continually active in flight and generates heat internally (endothermy). In early morning, the adult vibrates the wings with simultaneous contractions until the muscles, which are surrounded by heat-trapping air sacs in the thorax, reach flight temperature (about 35°C).

But what of the excess heat generated once the insect is in flight? Through the use of thermocouples in the thorax, abdomen and head, Dr. May noted that the three areas showed different trends in temperature increase in both lab and field studies: the thorax reached a maximum temperature at take-off regardless of outside temperature (indicating active regulation), the abdomen temperature increased only after take off and was related to outside temperature (indicating no regulation), and the head temperature showed fluctuations after maximum thorax temperature was reached and appeared somewhat independent of outside temperature (indicating some regulation mechanism). That some of this heat is dissipated from the thorax by the flow of haemolymph was clearly demonstrated by May when he clamped off the dorsal vessel flow to the abdomen and head, and noted that as thoracic temperature increased, head and abdominal temperature decreased. Yet the fluctuations of the head temperature, as opposed to the simple increase in abdominal temperature, indicate that the head is not simply a heat dump for the thorax as seen in the abdomen. Other reasons may influence why the head temperature is regulated, perhaps dealing with the dragonflies incredible visual acuity.

Also discussed was Dr. May's interest in the astonishing southward migrations (sometimes in the hundreds of thousands of individuals) of *Anax junius* observed in the fall. Also intriguing are the records of adults of this species in early spring in northern locales, apparently not due to local emergence, indicating a return of some adults from southern areas. Dr. May is interested in any early sightings of this species.

The meeting included a few notes of local entomological observations. Discussion initiated by Howard Boyd centered on the recent activity of insects stimulated by the last few days of over 20°C weather, including the first moths and paper wasps seen. About 25 members and their guests attended the meeting.

Jon K. Gelhaus  
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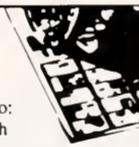
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**DISTRIBUTION AND ABUNDANCE  
OF THE COASTAL TIGER BEETLE,  
*CICINDELA DORSALIS MEDIA*  
(COLEOPTERA: CICINDELIDAE),  
IN SOUTH CAROLINA**

W. Walker Yarbrough, C. Barry Knisley

**ABSTRACT:** We determined the historic distribution of *Cicindela dorsalis media* in South Carolina by examining locality records of university, museum and private collections. Present distribution and abundance were determined by surveys of these and other coastal beach sites. We found *C. d. media* at nine of 14 historic sites and at five of 15 new sites. The greatest numbers, >5000 individuals, occurred on Capers, Dewees, and Bull Islands. Pawleys Island and Litchfield had 300-500 individuals; smaller numbers occurred at nine sites. Large numbers of beetles at a site could be explained by high densities rather than a larger habitat size. We conclude that *Cicindela d. media* is common and widespread along much of the South Carolina shoreline, except for the beaches north of Huntington Beach from which it has apparently been extirpated by high levels of recreational use. Populations at several other sites may have declined, but the lack of any published information on earlier abundance makes this impossible to accurately determine.

*Cicindela dorsalis* Say is widely distributed in sandy beach habitats of the Atlantic and Gulf coasts of the United States. Four subspecies are recognized, with ranges as follows: *C. dorsalis dorsalis* Say from Cape Cod south to central New Jersey and within the Chesapeake Bay of Maryland and Virginia; *C. d. media* LeConte from southern New Jersey to near Miami; *C. d. sauleyi* Guerin from the southern Gulf coast of Florida through Alabama and Mississippi; and *C. d. venusta* LaFerte from Louisiana to south Texas (Boyd and Rust 1982). One of these subspecies, *C. d. dorsalis*, has recently been listed as threatened by the U. S. Fish and Wildlife Service (USFWS 1990). It was extirpated from all but one of the known sites along the northeast Atlantic coast because of destruction and disturbance of natural beach habitats by heavy recreational use and coastal development activities (Knisley *et al.* 1987). It now occurs at only one northeastern site, a Martha's Vineyard beach, and at numerous Chesapeake Bay beaches in Maryland and Virginia. The other subspecies have apparently not yet experienced such rangewide decline, although populations of *C. d. media* at some sites in Florida have been extirpated (P. M. Choate, pers. comm.). On Assateague Island, MD, *C. d. media* is now restricted to only the northern 5 km of the island's shoreline where vehicle and pedestrian use is restricted (Knisley and Hill 1992). It has been extirpated from the other 30 km of the island's Maryland shoreline because of heavy vehicle and pedestrian use (Glaser 1977, Knisley and Hill 1992).

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*Cicindela d. media* has been reported from 12 South Carolina sites (Cartwright 1935, Freitag and Tropea 1969, Choate 1975). Similar to many other Atlantic coastal states, South Carolina's beaches have experienced severe impact from human activities and natural factors (Neal *et al.* 1984), which may have caused the decline or extirpation of some *C. d. media* populations. The objectives of this study are to compare the historic and current distribution and abundance of *C. d. media* in South Carolina and to identify factors which might threaten it.

## MATERIALS AND METHODS

The historic distribution of *C. d. media* in South Carolina was determined from locality records of specimens in 13 university and museum collections (AMNH, CAS, Clemson Univ., Cornell Univ., Fla. Div. Plant Indus., LA State Univ., Mich. State Univ., MCZ [Harvard], Texas A & M Univ., Rutgers Univ., USNM, Univ. Mich. Museum Zool., Peabody Mus. [Yale]), nine private collections (David Brzoska, Gary Dunn, John Glaser, Barry Knisley, Norman Rump, Tom Schultz, Jay Shetterley, John Stamatov, Ron Turnbow) and from the published literature. The present distribution and abundance were determined from visits to 29 coastal beach sites, including the 14 historic sites and 15 other sites. Surveys were conducted on warm sunny days at 1000-1800 hr from mid-June through July when populations were at or near peak abundance. We used a census method which involved walking along the upper intertidal zone and counting the adult beetles which are concentrated in the wet tidal zone during the day. Spot checks of the middle and back beaches were also made at each site and any beetles there counted. At most sites we surveyed a 1500-2000 m length of beach, but at larger sites (with > 5000 m of shoreline), we surveyed three separate 1600 m sections (north end, middle, south end). We determined maximum densities by counting beetles in 5-10 10-meter long sections of beach where beetles were the most abundant. Standard U. S. G. S. topographic maps were used to determine the exact locations of sites surveyed. For each site we determined ownership and obtained information on pedestrian and vehicle use from park officials or local residents, or from our own counts during the surveys. Additional information, including erosion rates, shoreline structures, and storm damage, was obtained from the South Carolina Coastal Council and from Neal *et al.* (1984).

## RESULTS

Our compilation of collection records indicates that *C. d. media* occurred at 14 sites in South Carolina. We found no information about population size at any sites. Our surveys found *C. d. media* at 9 of these 14 historic sites and at 5 of 15 new sites (Table 1). No beetles were found at any of the nine north-

ernmost sites, from Garden City north through Myrtle and North Myrtle Beaches (Fig. 1). The census results from our studies should be considered as minimum population sizes because other studies with *C. d. dorsalis* indicate a census gives a two to three fold underestimate of the numbers actually present (Knisley, unpublished). The largest observed numbers, over 5000 individuals, were at Capers, Dewees, and Bull Islands (Table 1). Pawleys Island and Litchfield Beach had 300-500 individuals and six other sites had 100-300 individuals. Small numbers, of 100 or fewer observed individuals occurred at three sites. The differences in abundance were the result of differences in densities, and not the length of beach at the site because the length of beach surveyed was similar at all sites (Table 1). For example, densities at sites with the greatest beetle abundance were as high as 100 to 200 individuals per 10 m of beach and 10-40 or less at sites with smaller populations. At most sites the beetles tended to be localized within small patches (50-200 m long) of beach habitat, usually at the north or south ends of the island sites and were rare or absent in the middle sections.

Most of the surveyed sites were public beaches, state or county parks, private resorts, or preserves (Table 1). The public beaches and parks generally had the highest use and the lowest beetle populations. Most sites received at least a moderate amount of pedestrian recreational use. Vehicles are now prohibited on most South Carolina beaches. However, numbers at some sites may be low due to impacts of past vehicular use. The northern beaches and Folly Beach and Isle of Palms (northern section) were among the most heavily used beaches. Capers, Dewees, and Bull Islands have the lowest use. Most sites had evidence of recent or active erosion and received beach nourishment in recent years or have shoreline stabilization structures (Table 1).

## DISCUSSION

The results of this survey indicate that *C. d. media* continues to occur over much of coastal South Carolina, except for the northern shoreline (beaches north of Huntington Beach). Because there were no previous systematic surveys of the South Carolina beaches and no published information on population sizes, we cannot fully determine changes in distribution and abundance of *C. d. media* in South Carolina. However, its absence and apparent extirpation from all of the northern South Carolina beaches is probably the result of the intense recreational use at and near Myrtle Beach. The primary impact here is the high density of pedestrian foot traffic on the beaches. Vehicle activity probably has little impact in most South Carolina beaches because it is limited to service or patrol activities. *Cicindela d. media* may also have disappeared from Edisto Island State Park because "large numbers" were found there in 1988 (Tom Schultz, pers. comm.). Human impact is also suggested by

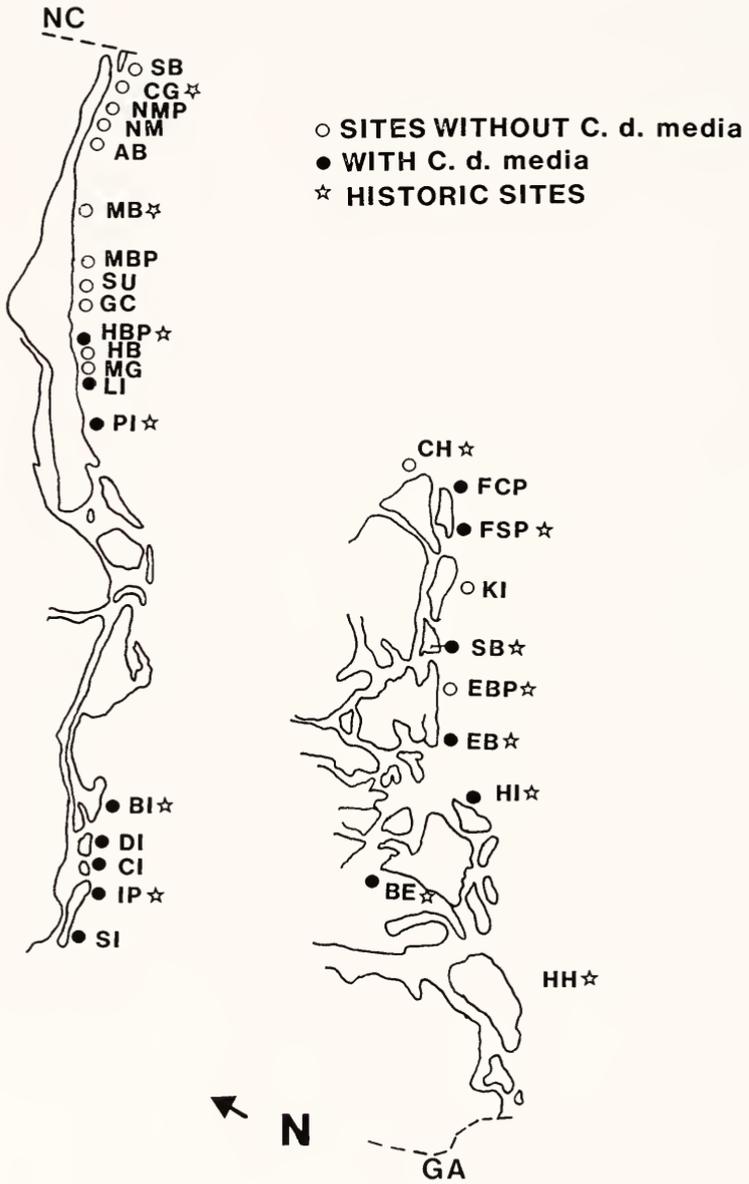


Figure 1. Map of the South Carolina shoreline showing sites surveyed. Site abbreviations are as in Table 1.

Table 1. South Carolina survey sites, beetle densities and total numbers, and relevant site characteristics (\* = historic sites). Densities are the highest of 5-10 10 meter lengths of beach per site or section. Abbreviations for shoreline modifications are I = inlet stabilization, N = nourishment, G = groins, S = seawall or revetment.

Site Abbrev.	Site Name	Shorel. Modific.	Owner-ship	Beetle No. Obser.	Census Estimate	
SB	Sandy Beach	-	Public	0	0	
*CG	Cherry Grove	S	Public	0	0	
NMP	N. Myrtle Beach Pk.	-	Public	0	0	
NM	N. Myrtle Beach	S	Public	0	0	
AB	Atlantic Beach	G	Public	0	0	
*MB	Myrtle Beach	S,G	Public	0	0	
MBP	Myrtle B. S. Pk.	-	State Park	0	0	
SU	Surfside	-	Public	0	0	
GC	Garden City	S	Public	0	0	
*HBP	Huntington B. S.. Pk.	I	State	20	150-200	
HB	Huntington Beach	-	Public	0	0	
MG	Magnolia Beach	-	Public	0	0	
LI	Litchfield	North	N	Public	20	150-200
		Middle	N	Public	0	0
		South	N	Private	10-20	150-200
*PI	Pawleys Is.	North	N,G	Public	25	200-300
		Middle	N,G	Public	0	0
		South	N,G	Public	15-20	100-200
*BI	Cape Romain (Bull Is)	-	U.S Govt.	100-200	>5000	
DI	Deweese Island	-	Private	100-200	>5000	
CI	Capers Island	-	State	100-200	>5000	
*IP	Isle of Palms	North	N,S	Private	30-40	100-200
		Middle	N,S	Public	0	0
		South	-	Public	0	0
SI	Sullivans Is.	North	G	Public	0	0
		Middle	G	Public	0	0
		South	-	Public	10-20	50
*CH	Charleston	-				
FCP	Folly Beach County Pk.	North	N,G,S	County	0	0
		Middle	N,G,S	County	0	0
		South	N,G,S	County	15-20	50-100
*FSP	Folly B. S. P.	North	N,G	State	0	0
		Middle	N,G	State	0	0
		South	N	State	25	100-200
KI	Kiawah	-	Private	0	0	
*SB	Seabrook	N,S	Private	25	200	
*EBP	Edisto Bch. S.P	North	N	State Park	0	0
		Middle	N	State Park	0	0
		South	N	State Park	0	0
*EB	Edisto Beach	North	N,G	Public	0	0
		Middle	N,G	Public	0	0
		South	N	Public	25	100
*HI	Hunting Island S. P.	N	State	25	100-200	
*BE	Beaufort	-				
*HH	Hilton Head Island					
	Sea Pines Tower Beach	N,G	Private	25-35	50-100	

the absence or small numbers at sites with highest amounts of human activity or with beach stabilization structures (seawalls, groins, revetments). Populations of *C. d. dorsalis* on Chesapeake Bay beaches and *C. d. media* on Virginia's isolated barrier islands typically have 2000 or more individuals at sites with little or no human activity or shoreline modifications.

Bull, Dewees and Capers Islands were sites not previously surveyed and had the largest populations of *C. d. media*. These sites have very little pedestrian use, but were all totally submerged by the storm surge from Hurricane Hugo in 1989. Such natural events may actually benefit *C. d. media* by creating new beach habitat as a result of the overwash and sand deposition. Several sites with active accretion of sand (Edisto, Hilton Head, Seabrook, and Sullivans Islands) also supported populations. Many of the sites which had beach nourishment had *C. d. media*, indicating that this may not have a negative impact on the species.

Other barrier islands in South Carolina not surveyed in this study may also support populations. These include Waites, North, South, Cedar, Murphy, Morris, Botany Bay, Pine, Pritchards, Bay Point, and Daufauski Islands.

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# ABUNDANCE AND SEASONAL ACTIVITY OF PILL BEETLES (COLEOPTERA: BYRRHIDAE) IN A RASPBERRY PLANTATION AND ADJACENT SITES IN SOUTHERN QUÉBEC (CANADA)<sup>1</sup>

Claire Levesque, Gilles-Yvon Levesque<sup>2</sup>

**ABSTRACT:** Four hundred and thirty eight adults of three Byrrhidae species were collected with pitfall traps and flight intercept traps, from early May through late October during 1987-1989, in a raspberry plantation and adjacent sites in southern Québec. The two most common species at the soil surface of the raspberry plantation were *Simplocaria semistriata* and *Chaetophora spinosa*, both adventive in North America. *Chaetophora spinosa* flight activity occurred mainly in May and June, in open sites near raspberry plants, and adult overwintering was probable. However, adults of *S. semistriata* were active mainly in October and this species probably overwinters chiefly as larvae.

The taxonomy of the 34 North American species of Byrrhidae has been treated recently by Johnson (1991a). In Canada and Alaska, this family is represented by 26 species, all of which are bryophagous and express microhabitat specificity (Johnson 1991b). The herbivorous larvae live in soil and feed generally on mosses and, incidentally, on liverworts, lichens, on roots of wild grasses, weeds, oats, clovers, and roots of young trees in forest nurseries or plantations (El Moursy 1961; Lindquist and Ingram 1968; Campbell *et al.* 1989).

Recently, Johnson (1990) argued that *Chaetophora spinosa* (Rossi) and *Simplocaria semistriata* (Fab.), both adventive in North America, inhabit cultural steppe, a semi-synanthropic environment containing numerous non-native insects. We collected both species in a raspberry plantation and adjacent sites in southern Québec, during a three-year study (1987-1989). To test Johnson's hypothesis, we present results on the abundance and seasonal activity of these byrrhid species.

## MATERIALS AND METHODS

Beetles were collected from early May through late October in a monocultural raspberry farm at Johnville, near Sherbrooke, in southern Québec, Canada. We sampled from fields of the Boyne cultivar in this conventionally cultivated plantation (about 7 ha on sandy soil).

Ground surface-active beetles were sampled with pitfall traps at the following sites: 1) a raspberry row planted in 1978 (**old plants**), 2) a raspberry row planted in 1985 (**young plants**), 3) a woods-field boundary (**boundary**),

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and 4) an adjacent wooded site dominated by eastern white pine, *Pinus strobus* L. (**pine woods**). Pitfall traps consisted of glass jam jars (450 ml, 6.5 cm diameter at the top) partially filled with 100 ml of 4% formalin. Traps were inserted into the soil beneath the canopy as close to the cane of raspberry plants as possible at the first two sites. At each site, 20 traps were set in a row (5 m apart) and were emptied weekly.

In addition, we studied beetles flying close to the ground with flight intercept traps at four sites: 1) an open site near the center of the plantation (**A**), about 20 m from old plants; 2) an open site near a pond (**B**), about 5 m from young raspberry plants; 3) a woods-field boundary (**C**); and 4) a pine woods (**D**). These traps were not located between rows of raspberry plants because of grower's activities and public access during harvest. Flight traps were modified from the large-area "window" trap design promoted by Peck and Davies (1980). Each consisted of a gray 1.5 mm mesh window screen (1.22 m height, 1.52 m width, about 1.85m<sup>2</sup> of surface) fastened to a wooden frame. The frame itself was suspended by two lateral triangular wooden supports (1.83 m at the base, 1.25 m height), 2-4 cm over a set of two galvanized metal pans (25 by 61 cm at the top, 7.5 cm deep) which were placed directly on the ground. The insects were caught in the pans partially filled with 2% formalin into which a few drops of detergent were added. We installed one flight trap at each site; however, the trap was operated in 1988 and 1989 only in the pine woods (D). Samples were collected twice a week and pooled on a weekly basis.

Levesque and Levesque (1992) presented detailed information about the sampling methods and study sites, including a sketch-map of the raspberry farm.

## RESULTS AND DISCUSSION

We collected 438 adults of three byrrhid species: 131 in pitfall traps and 307 in flight traps. The two adventive species, *S. semistriata* and *C. spinosa*, were common at the ground surface (98% of catches), primarily in raspberry rows (Table 1). However, only *C. spinosa* was abundant in the four flight traps (94% of catches); this species flew mainly in the two open sites (A and B) (Table 1). The third species, *Cytilus alternatus* (Say), a Nearctic byrrhid, showed a minor occurrence at Johnville (Table 1). Voucher specimens of both adventive species are deposited in the Canadian National Collection (Ottawa).

Adults of *Chaetophora spinosa* flew from early May to mid-September (Fig. 1); two flight periods occurred, the main peak between mid-May and mid-June, and a minor second peak in late summer. In addition, adults were active at the ground surface from early May until late October, without a defined capture peak (Fig. 1). This species probably overwinters as adults.

Table 1. Total catches of three Byrrhidae species in pitfall and flight traps at Johnville, Québec (1987-1989).

Traps and sites	<i>Chaetophora spinosa</i> (Rossi)	<i>Cytillus alternatus</i> (Say)	<i>Simpliocaria semistriata</i> (Fab.)	Total
<b>PITFALL TRAPS</b>				
Old plants	39	1	33	73
Young plants	13	–	33	46
Boundary	4	2	5	11
Pine woods	1	–	–	1
<b>Total</b>	<b>57</b>	<b>3</b>	<b>71</b>	<b>131</b>
<b>FLIGHT TRAPS</b>				
Open site near center (A)	178	1	3	182
Open site near pond (B)	68	1	3	72
Boundary (C)	31	3	8	42
Pine woods <sup>a</sup> (D)	11	–	–	11
<b>Total</b>	<b>288</b>	<b>5</b>	<b>14</b>	<b>307</b>

<sup>a</sup> not sampled in 1987

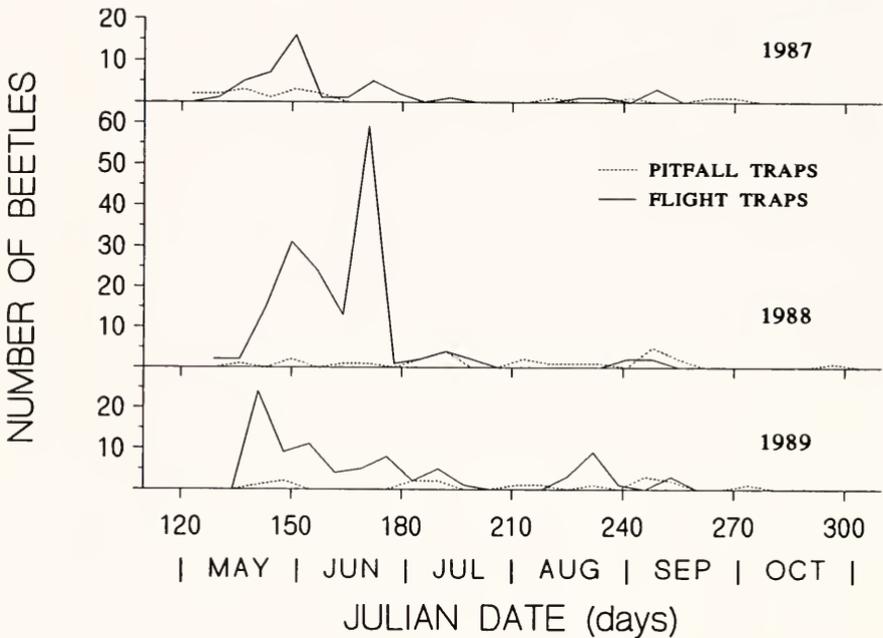


Fig. 1. Seasonal abundance of *Chaetophora spinosa* in pitfall and flight traps at Johnville, Québec.

By pitfall traps, we captured *Simplocaria semistriata* in autumn, mainly in October, and a few overwintered adults were also caught in May (Fig. 2). During the three-year study, we collected adults in flight traps, generally in September (11 of 14 individuals), probably during the dispersal period of the new generation preceding the mating period (Fig. 2). In addition, a teneral beetle was collected in a flight trap in September. According to Johnson (1990), sexually active adults were present in early October in Massachusetts, and overwintering was probably accomplished by the first instar larvae and senescing adults since live adults were not found during late spring and summer. However, at Johnville, the presence of two individuals in the flight trap C on July 10, 1988 suggests that a few adults would emerge early at the boundary. We did not collect byrrhid larvae and we did not examine gut contents.

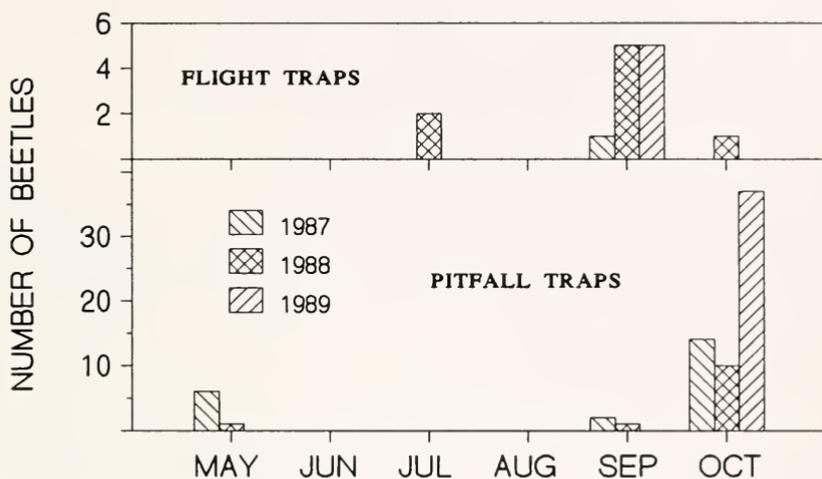


Fig. 2. Seasonal abundance of *Simplocaria semistriata* in pitfall and flight traps at Johnville, Québec.

Like Johnson (1990), we believe that *C. spinosa* and *S. semistriata* may be associated with various agroecosystems in North America, such as cultural steppes containing numerous non-indigenous insects. In addition, the beetle fauna near raspberry plants included many other adventive species, sometimes captured in large numbers, such as *Clambus armadillo* (DeGeer) (Clambidae), *Otiorhynchus ovatus* (L.) and *Sciaphilus asperatus* (Bonsd.) (Curculionidae), and *Pterostichus melanarius* (Ill.) (Carabidae) (Levesque and Levesque 1993, 1994a, 1994b).

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**A NEW HOST FOR *JALYSUS SPINOSUS*  
(HETEROPTERA: BERYTIDAE)  
AND NEW HOST FAMILY (COMMELINACEAE)  
FOR STILT BUGS<sup>1</sup>**

A. G. Wheeler, Jr.<sup>2</sup>

**ABSTRACT:** Nymphs of the stilt bug *Jalysus spinosus* were observed on the densely pubescent *Tradescantia hirsuticaulis* on Glassy Mountain in South Carolina, but they were absent from coexisting colonies of the glabrous *T. ohienensis*. This host association supports the characterization of metacanthine berytids as specialists on glandular-hairy plants. *Tradescantia hirsuticaulis* is the first member of the spiderwort family, Commelinaceae, known to serve as a berytid host.

Four species of the stilt bug genus *Jalysus* Stål occur in North America: *J. caducus* (Distant), known in the United States only from Arizona and Texas; *J. balli* Harris, a Mexican species recorded from Arizona; and the more wide-ranging *J. spinosus* (Say) and *J. wickhami* Van Duzee (Froeschner and Henry 1988, Henry and Froeschner 1992). Following its original description (Van Duzee 1906), *J. wickhami* was reduced to a variety of *J. spinosus* (Van Duzee 1914) but was reinstated as a full species by Harris (1941).

Until recently, *J. spinosus* was assumed to be the most commonly collected and most widely distributed of these berytid species. Because *J. wickhami* was described from Arizona and California, early workers apparently assumed it was a western species. It has been shown, however, that *J. wickhami* occurs in southern Canada and throughout the United States and also extends into Mexico. In contrast, *J. spinosus* is generally restricted to southern Canada and the United States east of the 100th meridian (Wheeler and Henry 1981, Scudder 1991).

It has also been demonstrated that the *Jalysus* species used in nearly all biological studies in North America has been misidentified. *Jalysus wickhami* – not *J. spinosus* – is an occasional pest of tomato. It is also the species whose life history has been studied on onagraceous plants, and is the natural enemy augmentatively released in the southern states to help control aphids and lepidopteran pests of tobacco (Wheeler and Henry 1981 and references therein).

Whereas the polyphagous *J. wickhami* uses diverse hosts, particularly glandular-hairy dicots of the Malvaceae, Onagraceae, Oxalidaceae, Scrophulariaceae, and Solanaceae, *J. spinosus* has a much narrower host range – mostly monocots. Its primary hosts appear to be grasses of the genus *Panicum*, although nymphal development also occurs on a few dicots, namely the ona-

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graceous enchanter's nightshade, *Circaea lutetiana* L. (Wheeler 1986; see also Wheeler and Henry 1981, Wheeler and Schaefer 1982). Here I record another monocot, *Tradescantia hirsuticaulis* Small, as a host plant of *J. spinosus*, the first commelinaceous host for any berytid.

#### STUDY SITE AND HOST PLANTS

Glassy Mountain Heritage Preserve is a natural area northeast of Pickens, South Carolina (Pickens Co.). Managed by the state's Wildlife and Marine Resources Department, Glassy Mountain is a 26-ha, relatively undisturbed monadnock or isolated mountain that has withstood the forces of natural erosion in the piedmont. This granitic dome (elev. 518 m) is similar in appearance to the nearby Table Rock Mountain and structurally similar to Georgia's Stone Mountain, probably the best-known monadnock in the southeastern United States (Nelson 1988).

The berytid host *T. hirsuticaulis*, a rather uncommon member of the spiderwort family Commelinaceae, is found in dry woods and rock outcrops from North Carolina to Florida and in Arkansas and Texas. This spiderwort species is characterized by hirsute stems and generally pubescent leaves (Rickett 1967, Radford *et al.* 1968). On Glassy Mountain, it grows on several rock outcrops near the summit. Observations on *J. spinosus* were made in colonies of *T. hirsuticaulis* that were growing with *T. ohioensis* Raf. southeast of the promontory near the forest tower. Voucher specimens of this berytid have been deposited in the collection of the National Museum of Natural History, Washington, D. C.; host plants have been deposited in the A. C. Moore Herbarium, University of South Carolina, Columbia.

#### HOSTS OF *JALYSUS SPINOSUS*

On 4 May 1991, adults of *J. spinosus*, including mating pairs, were common on *T. hirsuticaulis*, which was in full bloom. This berytid overwinters in the adult stage (Wheeler and Stimmel 1988), and nymphs were not yet present. No *J. spinosus* adults were collected in early May from the essentially glabrous *T. ohioensis*, even though its colonies coexisted with those of *T. hirsuticaulis*.

In 1993, nymphs were abundant on 30 May on *T. hirsuticaulis* that had finished blooming. First through fourth instars and one adult were observed on fruits, pedicels, and other plant parts. As in 1991, no life stages could be found on *T. ohioensis*, including colonies in which stems of the two species were touching. Nymphs and adults were also present on the rock outcrop on the panic-grasses *Panicum sphaerocarpon* Elliott and *P. laxiflorum* Lam.

## DISCUSSION

Metacanthine berytids, including *Jalysus* species, develop mainly on well-glanded, pubescent hosts, feeding preferentially on glandular hairs or on arthropods entrapped by plant secretions. Such use of glandular-hairy plants, although atypical among heteropterans, is also characteristic of many dicyphine mirids (Wheeler and Schaefer 1982 and references therein). The use of *T. hirsuticaulis* as a host of *J. spinosus* on Glassy Mountain, and its apparent absence from the glabrous *T. ohioensis*, is consistent with previous biological studies of this berytid genus. *T. hirsuticaulis* becomes the only non-poaceous monocot known as a host of this stilt bug and the first member of the family Commelinaceae (and order Commelinales) recorded as a berytid host plant.

## ACKNOWLEDGMENTS

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## THE MAYFLIES (EPHEMEROPTERA) OF CONNECTICUT: AN INITIAL FAUNAL SURVEY<sup>1</sup>

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**ABSTRACT:** Mayflies from 80 sites across Connecticut were studied. A list of 109 species, including 34 new State records, was compiled. Two-way Indicator Species Analysis (TSA) was used to investigate block structure in the overall species data matrix. Site classes produced at successive division levels in repeated TSA runs showed no discernible stable geographic trends. Similarities among sites within a class and variation between classes resulted from differences in attributes of aquatic habitat structure that are not constrained within the context of ecoregions/subregions proposed for Connecticut.

Within New England, Connecticut represents a comparatively small area (13,183.1 km<sup>2</sup>), but has the potential for a diverse mayfly fauna. Southernmost of the New England States and located directly east of the Hudson River drainage, Connecticut has a range of climate and habitat types typical of areas much further north and south. Recently, Griffith *et al.* (1993) recognized two broad ecoregions and several subregions in Connecticut (Fig. 1). Throughout these zones aquatic habitats suitable for mayflies are common. Lotic habitats range from large deep rivers to first order streams and spring brooks. Lentic habitats vary from large lakes to small glacially formed ponds and temporary flood plain pools.

Connecticut mayfly populations are routinely sampled by environmental agencies for purposes of monitoring water quality. However, these groups have made little effort to identify species and currently there is no species list available. Further, little is known about the distribution of species with regards to landscape patterns. Some site specific data are available from the Connecticut Department of Environmental Protection, but are biased toward lotic habitats with coarse, poorly sorted substrates. This study is the first attempt to catalog the occurrence of mayfly species in Connecticut and to analyze species assemblages. Species recorded in this study will be entered into a GIS dBase that will be developed into a computerized atlas for mayflies of New England and Atlantic Canada.

### HISTORICAL OVERVIEW

The earliest list of mayflies from Connecticut appears in Britton's (1920)

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checklist of Connecticut insects. The study of his material deposited at the Connecticut Agricultural Experiment Station showed that many of the specimens were female imagos, subimagos, or badly damaged and could not be determined to species. Specimens labeled as *Siphonurus aridus* Say, *S. typicus* Eaton, and *Heptagenia luridipennis* Burmeister were either females or badly damaged male imagos and could only be determined to *Siphonurus* sp. The specimen labeled *Heptagenia terminata* Walsh was damaged and tentatively determined to be *Stenonema* sp. No specimens were located that corresponded to Britton's records for *Hexagenia bilineata* (Say), *Ephemerella cornuta* Morgan and *Siphonurus mirus* Eaton. Two specimens labeled *Ephemera varia* Eaton were tentatively confirmed to be correct. Among the material labeled *Hexagenia limbata* Serville, *Leptophlebia cupida* (Say), and *Callibaetis ferrugineus* (Walsh) were enough intact specimens to verify these determinations.

Traver (1935) only listed records for three species: *Drunella cornuta* (Morgan) [as *Ephemerella cornuta* Morgan], *Siphonurus quebecensis* (Provancher), and *S. typicus* Eaton [as *S. bernice* McDunnough]. Burks (1953) expanded the list to include *Arthroplea bipunctata* McDunnough, *Leucocuta hebe* (McDunnough) [as *Heptagenia hebe* McDunnough], *Stenacron interpunctatum* (Say) [as *Stenonema canadense* (Walker)], *Stenonema modestum* (Banks) [as *Stenonema rubrum* (McDunnough)], *Leptophlebia johnsoni* McDunnough, *Ephemera varia* Eaton, *Ephemerella dorothea* Needham, and *Siphonurus rapidus* McDunnough. The record of *E. varia* is problematic, because Burks (1953) only listed the State with no site location and no other valid records of the species were found.

Studies by Allen and Edmunds (1962) on the genus *Drunella* added the record of *D. walkeri* (Eaton) to the list of Connecticut taxa.

McCafferty (1975) listed spot map records for *Ephemera simulans* Walker and *Hexagenia limbata* Serville [as *H. munda* Eaton]. Bednarik and McCafferty (1979) studied the Nearctic species of *Stenonema* and added *S. mediopunctatum* (McDunnough) and *S. vicarium* (Walker) to the list of Connecticut species. Kondratieff and Voshell (1984) studied the Nearctic *Isonychia* and listed Connecticut records for *I. bicolor* (Walker). Most recently Provonsha (1990) published records for *Caenis amica* Hagen, *C. latipennis* Banks, and *C. punctata* McDunnough.

In addition to these published accounts, there are other sources of records in the "gray literature" that should be mentioned. The first is a masters thesis by Dodds (1978) on the mayfly fauna of the Fenton and Natchaug Rivers in eastern Connecticut. Dodds' thesis contains records for about 47 species. Dodds reared many species and amassed series of nymphs used to study nymphal growth and development. Our study of Dodds' material revealed that specimens determined as *Isonychia sadleri* Traver and *Isonychia thalia* Traver were really *Isonychia bicolor*. Study of series of specimens labeled *Rhithro-*

*gena amica* Traver and *R. anomala* McDunnough showed a third species that was previously not recorded by Dodds: *Rhithrogena jejuna* Eaton. Species listed by Dodds that we could not verify were not included in our taxa list.

The second source of "gray literature" records is a U.S.E.P.A. report by Bilger (1986) on the aquatic macroinvertebrates of New England and New York. Sixty-two taxa of mayflies were listed by Bilger as occurring in Connecticut. These records were based almost entirely on information supplied from the Connecticut Dept. of Environmental Protection (Water Compliance Sec.). Species included in Bilger's list that we could not verify were not included in our species list.

### MATERIALS AND METHODS

Mayfly nymphs and adults from 80 sites distributed across Connecticut were studied. Sites were plotted by latitude/longitude coordinates on a base map of Connecticut formatted to be digitized as a GIS geographic file (Fig. 1). Four control point coordinate pairs are given on the base map for corners of the State and a central location at the intersection of Hartford, Middlesex, and New Haven Counties. Sites for which latitude/longitude coordinates were not previously known were estimated from a 1:250000 scale U.S.G.S. base map of Connecticut. Sites are labeled on the base map (Fig. 1). by county site codes. These codes are listed with site locations, site coordinates, and TWINSPAN code numbers in Appendix 1.

The detection of stable geographic patterns is a primary goal of most studies of species distribution. A method well suited to revealing such patterns or block structures in a divisive polythetic manner is Two-way Indicator Species Analysis (TSA) (Gauch 1982) via the computer program TWINSPAN (Hill 1979). Blocks of sites (i.e., site classes) are defined by TSA by groups of differential species with a similar distribution across all sites in a group. Block structures elucidated by TSA may correspond to a group of uncommon taxa/communities or common widely distributed taxa/communities that have a common distribution among a restricted number of sites (Brown *et al.* 1993). TSA uses no geographic data in finding block structures; thus all such structures result from biological or ecological attributes of species.

Connecticut mayfly species distribution data were compiled into a full format binary matrix (where 1 is a positive occurrence and 0 a negative occurrence) of 80 columns (sites) by 108 rows (species). The species *E. varia* was omitted because of its problematic nature as discussed earlier. Repeated TWINSPAN analyses were completed emphasizing and deemphasizing rare taxa and to look for problems of convergence as described by Furse *et al.* (1984).

Specimens studied to produce the full species matrix were obtained from

the following sources: Amer. Mus. of Nat. Hist. (AMNH), Univ. of Conn. (at Storrs) Insect Col. (UCONN), Conn. Agricul. Exper. Sta. New Haven (CAES), Conn. Depart. of Environ. Protect. (Water Compliance Section) (CDEP), Peabody Museum, Yale Univ. (PMYU), and new material obtained by both authors. Voucher specimens, except where noted, were deposited in the insect collection of the Peabody Museum, Yale University.

## RESULTS AND DISCUSSION

Species of mayflies recorded in this study are presented in Table 1. Arrangement of taxa is according to the classification of McCafferty (1991). New state records are indicated by (:); species recorded in the literature, but not collected or reexamined during this study by (+); and tentative species determinations by (?). Species distributions are given by county site codes defined in Appendix 1. After repeated TWINSPAN analyses no clear stable geographic patterns were observed. Blocks of sites (i.e., classes) overlaid on ecoregions/subregions of Connecticut showed no correlation to broad landscape units. However, site classes (Appendix 1) did more or less correspond to macroecological divisions within aquatic habitats (e.g., shallow riffles, transitional runs, pools, and flood plain pools). Because structurally similar aquatic habitats suitable for mayflies are widely distributed in Connecticut, most species seem to be equally widespread with a high probability of occurring where habitat and climate are within ecological tolerances for a species. Exceptions to this trend seem to be most parsimoniously explained by comparing attributes of species ranges in eastern North America with the occurrences in Connecticut. For example, *Cinygmula subaequalis*, *Leptophlebia bradleyi*, and *Paraleptophlebia assimilis* had restricted occurrences in Connecticut. *Cinygmula subaequalis* has only been recorded from a cool stream in the northwestern corner of the state where hills contiguous with the Appalachians occur. In eastern North America this species is restricted to cool fast flowing streams of the Appalachian Mountains and associated foot hills. The occurrence of this species in northwestern Connecticut is consistent with its known continental distribution and habitat requirements.

In the case of *Leptophlebia bradleyi* and *Paraleptophlebia assimilis*, these species are mostly southeastern components of the Piedmont and Coastal Plain communities. In Connecticut they have only been found in the south-central region, which has the highest annual temperatures and most accumulated heat. Currently, this area represents the northeastern limits of these species ranges. Considering the southeastern nature of these species, their occurrence in this part of Connecticut is consistent with attributes of their distribution in eastern North America.

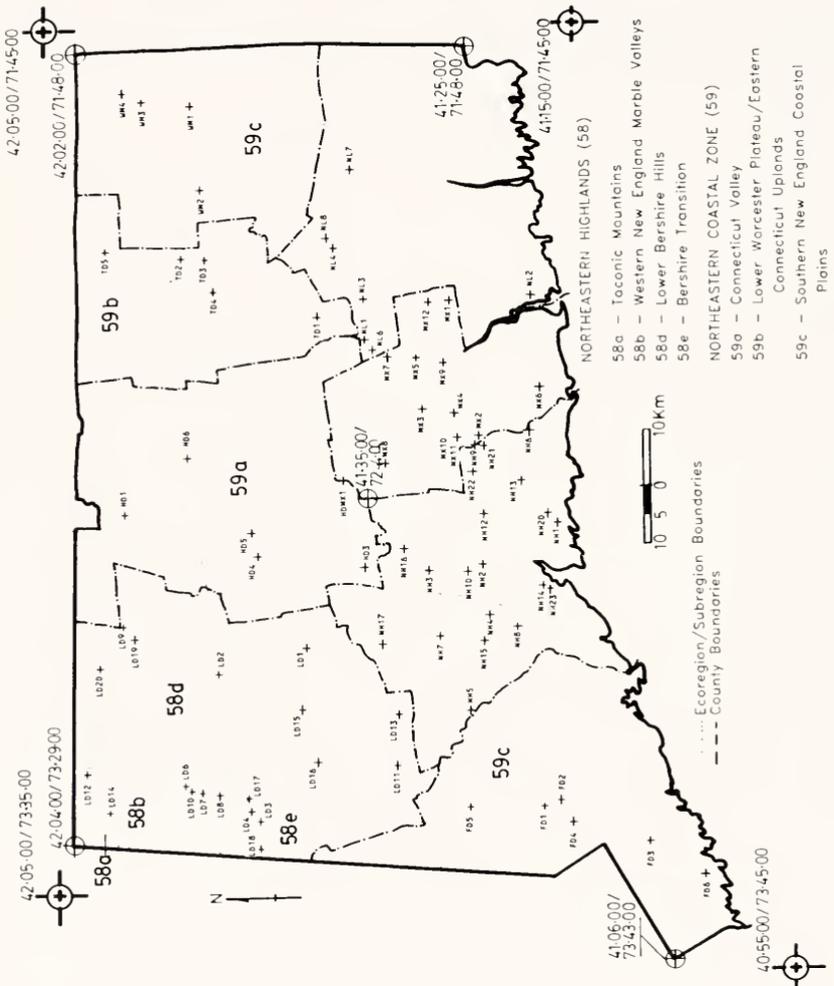


Figure 1. Base map of sites from which mayflies were recorded in this study. Latitude/Longitude control point coordinates are given for the corners of the State and a central point at the intersection of New Haven, Middlesex, and Hartford Counties to facilitate digitizing into a GIS dBase. Coordinates are given in Degrees (dd)- Minutes (mm)- Seconds (ss) in the sequence North dd mm ss/West dd mm ss. Ecoregion/subregion boundaries are from Griffith *et al.* 1993.

Table 1. Species list of Connecticut mayflies. Species distributions are given by county site codes defined in Appendix 1.

Species List	Species Distribution
Suborder Pisciforma	
Infraorder Imprimata	
Family Ameletidae	
<i>Ameletus ludens</i> Needham	LD1
Family Siphonuridae	
<i>Siphonurus alternatus</i> (Say)	TD2
† <i>S. mirus</i> Eaton	MX2
<i>S. quebecensis</i> (Provancher)	MX2, NH2, NH6
<i>S. rapidis</i> McDunnough	FD6, MX2, NH6, NH9
† <i>S. securifer</i> McDunnough	MX2, NH6, NH9
† <i>S. typicus</i> Eaton	LD17‡‡
Family Baetidae	
<i>Acentrella ampla</i> Traver	FD1, LD1, MX4, MX5, NH13, NH22, TD2
<i>A. carolina</i> (Banks)	MX1, NH2, TD4
† <i>Acerpenna macdunnoughi</i> (Ide)	HD6
† <i>A. pygmaea</i> (Hagen)	MX1, MX6
<i>Baetis armillatus</i> McCafferty & Waltz	NH1, NH20
† <i>B. brunneicolor</i> McDunnough	HD3, LD4, LD18, NH2, NH1, NH16, NH17, TD4
<i>B. dubius</i> (Walsh)	LD1, LD5, LD7, NL4, NL8
<i>B. flavistriga</i> McDunnough	LD4, LD8, LD10, LD18, MX2, MX3, NH6, TD2, TD4
<i>B. punctiventris</i> (McDunnough)	FD2, HD3, HD4, LD11, LD14, MX7
Family Baetidae	
<i>B. tricaudatus</i> Dodds	HD3, HD4, HDMX1, NH12
<i>Callibaetis ferrugineus</i> (Walsh)	NH1, NH2, NH4, NH9, NH14, NH15, NH23
† <i>C. fluctuans</i> (Walsh)	NL2
† <i>C. pallidus</i> Banks	NH1, NH2,
<i>C. pretiosus</i> Banks	NH1
† <i>Centroptilum triangulifer</i> (McDunnough)	TD4
<i>C. sp.</i>	TD4
† <i>Cloeon cognatum</i> Stephens	FD1, NH14, NH15, NH23
<i>Heterocloeon curiosum</i> (McDunnough)	LD6, TD2
† <i>Procloeon bellum</i> (McDunnough)	NL3, NL6, TD4
<i>P. sp.</i>	NH2
Infraorder Arenata	
Family Metretopodidae	
<i>Siphloplecton basale</i> (Walker)	MX6, NH1
Suborder Setisura	
Family Isonychiidae	
<i>Isonychia bicolor</i> (Walker)	FD1, LD4, LD10, LD18, MX1, NH1, NH20, TD2
† <i>I. obscura</i> Traver	NH2, NL3, NL6, TD4
<i>I. sp.</i>	TD4
Family Heptageniidae	
<i>Arthroplea bipunctata</i> McDunnough	LD6, MX2, NH6, NH9, TD2
<i>Cinygmula subaequalis</i> (Banks)	LD14***
† <i>Epeorus fragilis</i> (Morgan)	LD8
† <i>E. pleuralis</i> (Banks)	LD3, LD4, MX1, MX2, NH1, TD2
† <i>E. vitreus</i> (Walker)	LD1, LD18, NH1, NL1, NL4, TD2 TD4

Species List	Species Distribution
Family Heptageniidae (continued)	
<sup>1</sup> <i>Heptagenia pulla</i> (Clemens)	LD4, LD18
<i>H. marginalis</i> Banks	TD2 <sup>1+++</sup>
<i>Leucrocota hebe</i> (McDunnough)	NL3, NL6, TD2
<sup>1</sup> <i>L. maculipennis</i> (Walsh)	NL3, NL6, WM1
<sup>1</sup> <i>Nixe lucidipennis</i> (Clemens)	LD1, TD2, TD4
<i>Rhithrogena amica</i> Traver	TD2, WM2
<i>R. anomala</i> McDunnough	WM2
<sup>1</sup> <i>R. jejuna</i> Eaton	TD2, TD4
<i>Stenacron interpunctatum</i> (Say)	LD1, LD8, LD10, MX3, TD2, TD5
<i>Stenonema femoratum</i> (Say)	LDL4
<i>S. ithaca</i> (Clemens & Leonard)	TD2, TD4
<i>S. mediopunctatum</i> (McDunnough)	FD2, FD3, FD4, HD3, LD1, LD12, NH4, NH16
<i>S. mexicanum integrum</i> (McDunnough)	HD4, LD9, LD12, LD13, MX7, MX8, NH5
<i>S. modestum</i> (Banks)	FD1, HD1, LD3, LD10, MX3, MX10 NH1, NH2, NH3, NH9, NL4, NL7, NL8, TD2, TD5
<i>S. pudicum</i> (Hagen)	LD13, LD14, MX1, MX9, MX12
<i>S. vicarium</i> (Walker)	FD1, LD7, MX1, MX9, MX12, NH1, NH2, TD1, TD
Suborder Rectracheata	
Infraorder Lanceolata	
Family Leptophlebiidae	
<sup>1</sup> <i>Choroterpes basalis</i> (Banks)	FD1 <sup>1++++</sup>
<i>Habrophlebia vibrans</i> Needham	NH4, TD2
<sup>1</sup> <i>Habrophlebiodes americana</i> (Banks)	TD2, TD4
<sup>1</sup> <i>Leptophlebia bradleyi</i> Needham	MX10, NH21
<i>L. cupida</i> (Say)	FD1, LD15, MX2, MX10, NH1, NH4, NH6, NH9, NH13, NH22, NH23
<i>L. intermedia</i> (Traver)	FD1, NH6, NH9, NH21, NH23
<i>L. johnsoni</i> McDunnough	MX2, MX11, NH6, NH9, NH23
<i>Paraleptophlebia adoptiva</i> (McDunnough)	LD9, MX1, MX7, MX9, NH4, NL3, TD1, TD2, TD3
<sup>1</sup> <i>P. assimilis</i> (Banks)	MX12
<i>P. debilis</i> (Walker)	LD9, NH16, WM4
<sup>1</sup> <i>P. moerens</i> (McDunnough)	FD1, FD2
<i>P. mollis</i> (Eaton)	LD1, NL1, NL3, TD2, TD4
? <i>P. ontario</i> (McDunnough)	LD14 <sup>1+++</sup>
<i>P. strigula</i> (McDunnough)	NL3, NL6
<sup>1</sup> <i>P. volitans</i> (McDunnough)	TD4
Family Potamanthidae	
<sup>1</sup> <i>Anthopotamus distinctus</i> (Traver)	LD10, NL1, NL3, NL6, TD2, WM2
Family Polymitarcyidae	
<i>Ephoron leukon</i> Williamson	LD10
Family Ephemeridae	
<i>Ephemera guttulata</i> Pictet	WM2
<i>E. simulans</i> Walker	LD9, LD10, LD12, NH1, NH23, WM1
? <i>E. varia</i> Eaton	<sup>1++++</sup>
<i>Hexagenia atrocaudata</i> McDunnough	LD16, NH2
<i>H. limbata</i> Serville	NH2, NH23
<sup>1</sup> <i>Litobrancha recurvata</i> (Morgan)	LD20

Species List	Species Distribution
<b>Infraorder Pannota</b>	
<b>Family Ephemerellidae</b>	
<i>Attenella attenuata</i> (McDunnough)	NH2, NL3, NL6, TD2, TD4
† <i>A. margarita</i> (Needham)	NH5, TD2
<i>Dannella simplex</i> (McDunnough)	FD1, FD2, FD3, HD3, HD4, HD5, LD14, NH1, NH20, TD2, TD4, WD1, WM3, WM4
<i>Drunella cornuta</i> (Morgan)	LD1, LD2, LD3, LD14, NH4, NH8, NL4, NL8, TD2
<i>D. lata</i> (Morgan)	NL3, NL6, TD2, TD4
<i>D. tuberculata</i> (Morgan)	WM2 <sup>††††</sup>
<i>D. walkeri</i> (Eaton)	FD1, HD1, LD1, LD2, MX1, MX12 NL1
<i>Ephemerella dorothea</i> Needham	MX4, NH1, NH4, NH7, NH20, NL1, NL3, TD2, TD4
<i>E. invaria</i> (Walker)	LD3, MX4, NH1, NL1
<i>E. needhami</i> McDunnough	LD10, TD2, WM2
<i>E. rotunda</i> Morgan	HD1, LD1, LD4, LD5, LD18, MX4, MX6, NH1, NH2, NH6, NH12, NH20
<i>E. septentrionalis</i> McDunnough	HD1, LD1, TD2
? <i>E. simila</i> Allen & Edmunds	TD2 <sup>††††</sup>
<i>E. subvaria</i> McDunnough	MX1, MX9, NH1, NH2, NH6
<i>Eurylophella funeralis</i> (McDunnough)	NH3, NH4, NH5
<i>E. lutulenta</i> (Clemens)	FD4, LD9
<i>E. minimella</i> (McDunnough)	FD1, FD4, LD11, LD13, LD19, MX8, TD3
<i>E. prudentialis</i> (McDunnough)	MX2, NH9, TD2
<i>E. temporalis</i> (McDunnough)	FD4, FD5, HD4, LD1, WM1
<i>E. versimilis</i> (McDunnough)	HD1, TD2, TD4
<i>Serratella deficiens</i> (Morgan)	LD6, TD2, TD4
? <i>S. frisoni</i> (McDunnough)	FD2 <sup>††††</sup>
† <i>S. serrata</i> (Morgan)	NH2
† <i>S. serratoides</i> (McDunnough)	LD4, LD11, LN18, NL3, NL6
† <i>S. sordida</i> (McDunnough)	LD4, LD10, LD18
<b>Family Tricorythidae</b>	
<i>Tricorythodes</i> sp.	NH2, TD2, WM2
<b>Family Caenidae</b>	
† <i>Brachycercus nitidus</i> (Traver)	TD2 <sup>††††</sup> , WM2 <sup>††††</sup>
<i>Caenis amica</i> Hagen	LD10, MX2, MX10, NH2, NH10
† <i>C. anceps</i> Traver	LD10
† <i>C. hilaris</i> (Say)	NH2
<i>C. latipennis</i> Banks	NH2, NH10
† <i>C. macafferti</i> Provonsha	LD10
<i>C. punctata</i> McDunnough	NH2, NH10
<b>Family Baetiscidae</b>	
<i>Baetisca laurentina</i> McDunnough	HD1, HD5

†† - Location listed by Traver (1935) for a specimen collected by C.P. Alexander.

††† - Specimens located in the CDEP reference collection.

†††† - Specimens located in the UCONN collection.

††††† - Specimens located in the pinned collection of the AMNH.

†††††† - Specimens located in the pinned collection of the CAES.

Appendix 1. Site locations and codes for Connecticut mayfly data matrix. Latitude/Longitude coordinates are given in Degrees (dd) - Minutes (mm) - Seconds (ss) in the sequence of North dd mm ss / West dd mm ss. Site classes are TSA blocks of sites produced at six division levels.

County	Site Code	Location	Lat./Long. Coordinates	TSA Site Class
Fairfield	FD1	Saugatuck River, North Redding	41 18 00/73 24 00	8
	FD2	Saugatuck River, Redding	41 17 00/73 23 43	5
	FD3	Five Mile River, New Canaan, CDEP site 42	41 08 53/73 29 04	5
	FD4	Norwalk River, Ridgefield at inter. of Rt. 7 & Rt. 102, CDEP site 40	41 16 03/73 26 30	3
	FDS	Still River, Brookfield, CDEP site 02	41 26 19/73 24 05	4
Hartford	FD6	Stamford	41 03 00/73 33 00	8
	HD1	Salmon Brook, Granby	41 57 00/72 46 00	7
	HD3	Eight Mile River, Southington, CDEP site S-9	41 35 16/72 53 52	5
	HD4	Farmington River, Unionville, CDEP site 52	41 45 01/72 52 17	4
	LD5	Farmington River, Avon, CDEP site 53	41 46 18/72 49 18	5
	HD6	Mill Brook, Windsor	41 52 00/72 39 00	1
Hartford/ Middlesex	HDMX1	Mattabessett River, Berlin/Cromwell line	41 37 07/72 42 41	5
Litchfield	LD1	Leadmine Brook, Thomaston	41 41 00/73 05 00	7
	LD2	Naugatuck River, Torrington	41 48 00/73 07 00	7
	LD3	Cranberry Meadow River, Flanders	41 45 00/73 26 00	7
	LD4	Kent Falls Brook, Kent	41 46 00/73 25 00	7
	LD5	Housatonic River, Litchfield (?)	††	7
	LD6	Housatonic River, West Cornwall	41 54 00/73 21 00	7
	LD7	Housatonic River, Cornwall	41 50 00/73 22 00	7
	LD8	Housatonic River, Cornwall Bridge	41 49 00/73 22 00	6
	LD9	Still River, Colebrook (Riverton), CDEP site 54	41 58 02/73 01 59	3
	LD10	Housatonic River, Housatonic Meadows State Park, Sharon	41 51 00/73 22 00	6
	LD11	Shepaug River, Roxbury, CDEP site 25	41 32 55/73 19 51	2
	LC12	Blackberry River, North Canaan (Canaan), CDEP site 37	42 01 24/73 20 28	3
	LD13	Pomperaug River, Woodbury, CDEP site 55	41 32 26/73 12 50	2
	LD14	Salisbury	41 59 00/73 25 00	4
	LD15	Morris	41 41 00/73 12 00	8

County	Site Code	Location	Lat./Long. Coordinates	TSA Site Class
Litchfield (cont.)	LD16	Washington	41 38 00/73 18 00	7
	LD17	Kent Falls, Waren	41 46 00/73 22 00	10
	LD18	Macedonia Brook, Kent	41 45 00/73 29 00	7
	LD19	Still River, Winchester, CDEF site 39	41 57 20/73 02 51	2
	LD20	Loon Brook below Philip's Pond, Colebrook	42 00 00/73 07 00	11
Middlesex	MX1	Eight Mile River, East Haddam	41 26 00/72 20 00	7
	MX2	Hammonasset River, Killingworth	41 24 00/72 37 00	8
	MX3	Seven Falls State Park, Higganum	41 29 00/72 33 00	6
	MX4	Succor Brook, Haddam	41 26 00/72 34 00	7
	MX5	Moodus River, Moodus	41 30 00/72 27 00	8
	MX6	Menunketesuck River, Clinton	41-19 00/72 31 00	7
	MX7	Salmon River, East Hampton, CDEP site 17	41 33 05/72 27 04	7
	MX8	Coginchaug River, Middletown, CEDP site 51	41 33 18/72 40 26	2
	MX9	Strong Brook, East Haddam	41 27 00/72 28 00	7
	MX10	Tetram's Pond, Killingworth	41 26 00/72 37 00	8
	MX11	Grounds Pool, Hammonasset Rod & Gun Club, Killingworth	41 26 00/72 37 00	8
	MX12	Burnham Brook Preserve, East Haddam	41 29 00/72 20 00	7
New Haven	NH1	Branford River, Branford	41 17 00/72 48 00	7
	NH2	Mill River, Hamden	41 24 00/72 53 00	7
	NH3	Cheshire	41 29 00/72 54 00	8
	NH4	Bethany	41 24 00/73 00 00	7
	NH5	Small stream at Kettleton State Park, Southbury	41 25 00/73 12 00	3
	NH6	Hammonasset River, Madison	41 20 00/72 36 00	8
	NH7	Trout Brook, Straitville	41 28 00/73 02 00	6
	NH8	Woodbridge	41 21 00/73 01 00	7
	NH9	Hammonasset Swamp, North Madison	41 25 00/72 38 00	8
	NH10	Community State Farm, Mt. Carmel	41 25 00/72 54 00	9
	NH12	Farm River, Northford	41 24 00/72 47 00	7
	NH13	West River, Guilford (Rt 77 x Rt 80)	41 21 00/72 42 00	8
	NH14	Yale Trout Stream, New Haven	41 19 00/72 56 00	8
	NH15	From side of house on Molsick Road, Seymour	41 24 00/73 03 00	8

County	Site Code	Location	Lat./Long. Coordinates	TSA Site Class
New Haven (cont.)	NH16	Quinnipiac River, Cheshire/Meriden, CDEP site 05	41 31 41/72 51 24	5
	NH17	Steele Brook, Waterbury, CDEP site S-8	41 34 10/73 03 30	6
	NH20	Mill Plain Road, Branford	41 18 00/72 46 00	7
	NH21	Nathan s Pond, Madison	41 24 00/72 37 00	8
	NH22	Bluff Head, North Guilford	41 25 00/72 41 00	8
	NH23	Mill River, New Haven	41 17 00/72 56 00	8
New London	NL1	Salmon River, Westchester	41 35 00/72 25 00	7
	NL2	Old Lyme	41 19 00/72 19 00	11
	NL3	Flat Brook, Colchester	41 35 00/72 20 00	6
	NL4	Pease Brook, Lebanon	41 38 00/72 13 00	7
	NL6	Salmon River, Salmon River State Park	41 34 00/72 26 00	6
	NL7	Shetonket River, Occum	41 36 00/72 03-00	7
	NL8	Susquetonsout River, Lebanon	41 38 00/72 12 00	7
	Tolland	TD1	Jeremy River, Hebron	41 39 00/72 21 00
TD2		Fenton River, Willington	41 52 00/72 15 00	6
TD3		Willimantic River, Coventry/Mansfield	41 49 58/72 18 32	2
TD4		Fenton River, Mansfield	41 50 00/72 14 00	6
TD5		Roaring Brook, Staffordville (Stafford)	41 59 00/72 13 00	7
Windam	WM1	Quinebaug River, Killingly, CDEP site 33	41 50 15/71 54 39	4
	WM2	Natchaug River, Chaplin/Eastford	41 50 00/72 05 00	6
	WM3	Quinebaug River, Putnam, CDEP site 32	41 55 13/71 54 33	5
	WM4	French River, Thompson, CDEP site 31	41 57 45/71 53 04	5

††—Site location label did not indicate where along the Housatonic River the specimens were obtained, thus no coordinates could be listed. This site also does not appear on site base map Figure 1.

most species of mayflies in Connecticut are not constrained by ecoregion/sub-region boundaries. The majority of species seem to have an equal chance of occurring where suitable lotic and lentic habitats occur regardless of geographical position. Overlaid on the template of aquatic habitat variables, climate that affects seasonal water temperatures perhaps has the greatest effect in restricting the distribution of some species. Because no stable geographic trends were observed in this data set does not mean there are no regionally predictable patterns. Much of the information on Connecticut species is centered on relatively few sites. Among the 80 sites analyzed, 13 sites contained from 8.33% to 33.33% of the species in Table 1. The remaining sites had from 0.92% to 7.40% of the species recorded. Site specific environmental and land-use variables, shown to be important in discerning ecologic and geographic patterns (Corkum 1989), were not available for most sites. As more sites are sampled and site specific data accumulated, more refined multivariate analyses will be possible. Data compiled in this study provide a starting point for future studies of mayflies in southern New England.

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## NEW RECORDS OF EPHEMEROPTERA IN UTAH, WITH NOTES ON BIOGEOGRAPHY<sup>1</sup>

W. P. McCafferty, John F. MacDonald<sup>2</sup>

**ABSTRACT:** Two species of mayflies, *Baetis flavistriga* (family Baetidae) and *Choroterpes inornata* (family Leptophlebiidae) are reported from Utah for the first time. Records are from Capitol Reef National Park and represent known range limits for these species. Evidently neither species has penetrated the Great Basin proper. Notes on distribution, aquatic habitat, and life history of both species are provided.

Utah is one of the best known regions in North America with respect to its mayfly fauna. The major reason for this is simple: It is the home state and residence of George F. Edmunds, Jr., one of the world's most noted and productive Ephemeroptera researchers. Edmunds has collected and studied mayflies in the state since the 1940's, and Edmunds' Ph.D. dissertation was in part a faunistic study of the mayflies of Utah (Edmunds 1952). The only faunal list that has appeared for the entire state was provided by Edmunds (1954), wherein 62 nominal species were documented. Other records and synonymies since 1954 bring the current state total to approximately 70.

One of us (JFM) recently collected aquatic insects from the Capitol Reef area in south-central Utah. Ephemeroptera collected from Pleasant Creek, at about 1,900m elevation, within Capitol Reef National Park, consisted of *Acentrella insignificans* (McDunnough), *Baetis flavistriga* McDunnough, *B. tricaudatus* Dodds, *Choroterpes inornata* Eaton, *Hepptagenia solitaria* McDunnough, *Paraleptophlebia debilis* (Walker), *Rhithrogena morrisoni* (Banks), and *Tricorythodes minutus* Traver. *Baetis flavistriga* and *C. inornata* represent new records for the state. The new records are significant because the state's mayfly fauna is relatively well known and because this locale may be near the range limit of both species. The new records and notes on these newly found species follow.

### *Baetis flavistriga* McDunnough

**New Records.** Thirty three larvae, Utah, Wayne Co., Pleasant Creek, Capitol Reef National Park, upstream from Sleeping Rainbow Ranch, VIII-3-1993, J. F. MacDonald, deposited in the Purdue Entomological Research Collection (PERC); 60 larvae and one male adult, Utah, Wayne Co., Capitol Reef National Park, downstream from Sleeping Rainbow Ranch, VIII-4-5-1993, J. F. MacDonald, deposited in PERC.

<sup>1</sup> Received January 29, 1994. Accepted March 10, 1994.

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McCafferty *et al.* (1993) in their inventory of the Colorado mayflies, discussed the distribution of *B. flavistriga*. This species demonstrates an unusual mayfly distribution pattern in that it is transcontinental but mainly distributed in mountain ranges. Except for being generally common in the Great Lakes region in the Midwest (Moriyama and McCafferty 1979), it is known primarily from the Appalachians in the East (Moriyama and McCafferty 1979), the Ozark-Ouachitas (McCafferty and Provonsha 1978), the Black Hills of South Dakota (McCafferty 1990), and the Colorado Rockies (McCafferty *et al.* 1993). The Utah record may prove, however, to be very near its western range limit.

The Capitol Reef area, while considered part of the Great Basin Province in terms of its flora (Gleason and Cronquist 1964), represents an area that differs physiographically from most of the Great Basin (to the west and northwest) in that it has a sea drainage via the Colorado River system. The Great Basin proper drains to the interior, lacking a sea drainage. This may account for the current absence of some western aquatic species in the Great Basin: Dendritic drainage routes connecting the Great Basin proper with exterior drainage systems are essentially lacking [a few minor connections via diversions across divides for irrigation purposes have occurred in the last century (Hubbs and Miller 1948)], and such routes are necessary for dispersal of some lotic aquatic insects (see e.g., Ross 1967, Ross *et al.* 1967, Flannagan and Flannagan 1982) just as they are for freshwater fishes in general (see e.g., Miller 1958, Page 1983, Smith 1983). Western aquatic insects, many of which can be assumed to have been present in the Great Basin during recent Pluvial periods, may not have been able to colonize (or recolonize) the Great Basin since the drying of basin lakes and stream connectors some 7,500 to 2,500 years ago (Blackwelder 1948). Such dispersal via drainages would appear especially pertinent in arid regions of the western United States, where considerable overland distances occur between streams and thus can preclude overland flight dispersal by many aquatic insects. We consider many aquatic insects now present in the Great Basin to be Pluvial relicts, much as the Great Basin fishes (Hubbs and Miller 1948). Given its restricted Colorado drainage distribution in Utah, its continental distribution east of Utah, and its apparent absence from northwestern Pacific drainage systems, we hypothesize that *B. flavistriga* has not colonized the Great Basin either in Pluvial or Postpluvial periods.

Moriyama and McCafferty (1979) indicated that larvae of *B. flavistriga* generally inhabit rocky substrates of streams. Bergman and Hilsenhoff (1978) found populations in Wisconsin to be either univoltine with a prolonged hatching period in the summer, or bivoltine with overlapping

cohorts. Samples from Utah were taken from Pleasant Creek where it is relatively clean and cold, devoid of canopy, and ranging from approximately 1.5 to 3.0m in width and 15.0 to 45.0cm in depth. The current is essentially erosional, and substrate is mixed, being primarily made up of pebble, cobble, and some boulders with moderate periphyton growth. *Baetis flavistriga* larvae were taken on substrates of coarse gravel, pebble, cobble, and boulders. Larval samples consisted of both fully mature individuals, with dark wingpads, and individuals of the same size, but without dark wingpads, and presumably nearly mature. Emergence appeared imminent, and although collecting emphasis with regard to mayflies was on benthic forms, one confirmed adult was taken, and numerous subimagos of *Baetis* that may have been this species were taken in Malaise traps positioned along the stream.

### *Choroterpes inornata* Eaton

**New records.** Three larvae, Utah, Wayne Co., Capitol Reef National Park, downstream from Sleeping Rainbow Ranch, VIII-5-1993, J. F. MacDonald deposited in PERC.

Allen (1974) provided a range map of this southwestern species, which included records from Sonora, Mexico, southeastern Arizona, western and northern New Mexico, and southern Colorado. McCafferty *et al.* (1993) confirmed its existence in much of western and northwestern Colorado. Mesa Co., Colorado, on the Utah border, is the nearest record to the Utah site. Capitol Reef may be near the westernmost distribution north of Arizona. As is the case for *B. flavistriga* (see discussion above), we hypothesize that *C. inornata* has not colonized the Great Basin proper.

McCafferty *et al.* (1993) considered *C. inornata* among species they called the western sand/silt riverine fauna. This faunal group includes western slope/plateau species in Colorado (see McCafferty *et al.* 1993) that range from Mexico, Arizona, or New Mexico usually to southwestern Wyoming, and sometimes as far north as Saskatchewan. Their dispersal evidently has been via sand/silt bottomed rivers of the Colorado River drainage and the Colorado Plateau such as the Green River and its tributaries in Utah and Wyoming. Edmunds (pers. comm.) has unreported sightings of *C. inornata* in other Colorado drainage system areas in northeastern Utah. These sightings would be predictable if the above conclusions regarding the distribution of this species are correct.

## DISCUSSION

Of the other nominal mayfly species taken at Pleasant Creek in

Capitol Reef National Park (see above), *Heptagenia solitaria* was also considered a member of the western sand/silt riverine fauna by McCafferty *et al.* (1993). The identification of *Rhithrogena morrisoni* from Capitol Reef is tentative because it is based on larvae that are very difficult to distinguish from *R. hageni* Eaton and *R. undulata* (Banks) larvae. *Rhithrogena morrisoni* has not been taken commonly from the western slope/plateau area of Colorado, but *R. hageni* and *R. undulata* have been. In any case, the presence of at least two species of the western sand/silt riverine faunal component (*H. solitaria* and *C. inornata*) at Capitol Reef clearly indicates that this area is within the geographic scope of this faunal pattern.

Those mayfly species that occur in both the Great Basin drainage system and the Colorado drainage system can be assumed to be Pluvial relicts in the Great Basin. The drainages were connected as recently as the late Pleistocene when some lakes of the Great Basin evidently overflowed into adjacent basins and did, for example, make contact with large rivers such as the Colorado (Blackwelder 1948).

While several southwestern collections of *C. inornata* have been reported by Kilgore and Allen (1973), no habitat or life history data were made available from these collections. In Colorado, B. C. Kondratieff (pers. comm.) has collected larvae of *C. inornata* only from coarse sand to gravel substrates in a wide variety of stream types (see also McCafferty *et al.* 1993); emergence of this species occurs in September. The few Utah individuals that were collected were taken from a small isolated channel of Pleasant Creek (see general description above) where it undercuts the north bank somewhat. Although the substrate there was mainly pebbles and small cobble, the larvae could have been kicked out of pockets of sandy gravel that were also present; we cannot say for certain. All individuals were middle instar larvae (early August), and suggest a late season (September) emergence, as has been observed for this species in Colorado (Kondratieff, pers. comm.). The collection date of the adults and subimagos of this species described by Eaton (1892) from Mexico and Arizona is not known.

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## NEW ADDITIONS TO THE INVENTORY OF COLORADO MAYFLIES (EPHEMEROPTERA)<sup>1</sup>

Richard S. Durfee, Boris C. Kondratieff<sup>2</sup>

**ABSTRACT:** Four mayfly species, *Baetis dardanus*, *Paracloeodes minutus*, *Homoeoneuria alleni*, and *Rhithrogena pellucida* are reported from Colorado for the first time. *Homoeoneuria* and *Paracloeodes* represent new generic records for the state. The male terminalia of *R. pellucida* from Colorado and a paratype from Minnesota are illustrated and compared, and characters are given to separate this species from the four other *Rhithrogena* species in Colorado. Previous tentative records for two additional species, *Baetis virile*, and *Leptophlebia nebulosa* are confirmed. Biogeographic affinities for several species in the North Platte River system are discussed. A total of 43 genera and 101 species of mayflies are now known from Colorado.

McCafferty *et al.* (1993) listed 41 genera and 97 species of Colorado mayflies. In this paper we report four new species records for the state. The first of these, *Baetis dardanus* McDunnough, was collected from the Green River in Dinosaur National Monument. This species belongs to the *Baetis propinquus* group, and the larvae will key to *Baetis ephippiatus* Traver in Morihara and McCafferty (1979a). However, the larvae of these two closely related species can be separated using the characters given by Soluk (1981). In that paper he described two principal types of dorsal abdominal patterns, and our specimens correspond to the one that is figured. Morihara and McCafferty (1979b) provided a key to separate adult males of the *Baetis propinquus* group. Previously, *B. dardanus* had been reported from Alberta, Manitoba, Idaho, Utah, and Illinois (Soluk 1981), and McCafferty *et al.* (1993) predicted that this species might eventually be found in Colorado.

The second state record, *Homoeoneuria alleni* Pescador and Peters, was discovered in the Yampa River in Dinosaur National Monument. Larvae were collected approximately 0.2 km upstream of the Yampa-Green River confluence in larval fish drift nets that were used during a study on the reproduction and larval abundance of the federally listed endangered Colorado squawfish. Previous distributional records for *H. alleni* include New Mexico, Utah, and Chihuahua, Mexico (Pescador and Peters 1980). This species had been mentioned by McCafferty *et al.* (1993) as possibly occurring in Colorado, therefore, its discovery in the state was expected. The adults of *H. alleni* remain unknown.

The third new record from Colorado, *Paracloeodes minutus* (Daggy), was discovered in a benthic sample taken from the Conejos River near LaSausas. This locality provides the habitat that *P. minutus* seems to prefer (Edmunds *et*

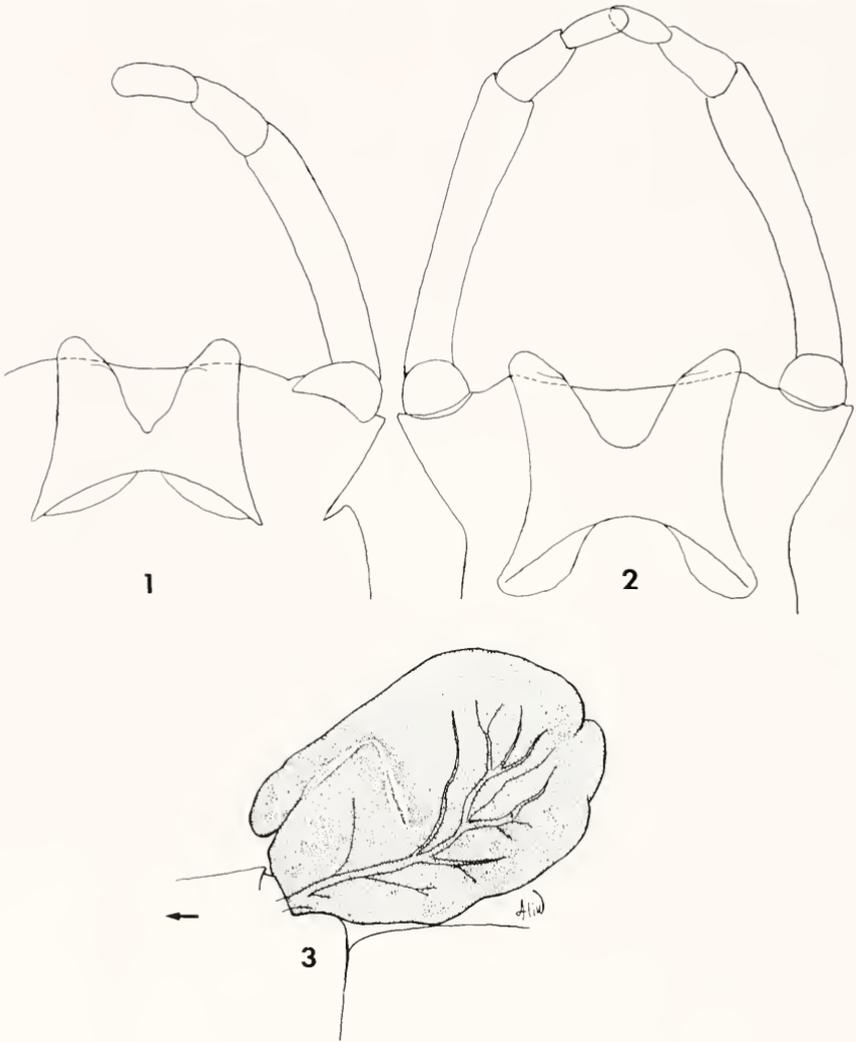
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*al.* 1976). These three-tailed larvae are easily overlooked in benthic samples due to their small size and pale color (Day 1955), and workers need to be careful not to mistake this species for small *Baetis* spp. The distinctive labial palps and the relatively long tarsal claws as illustrated by Edmunds *et al.* (1976) distinguish this genus. *Paracloeodes minutus* is known from Minnesota (Daggy 1945), California (Day 1955, as *P. abditus*, [see McCafferty and Waltz 1990]), Indiana (McCafferty and Waltz 1990), and Illinois and Texas (McCafferty and Davis 1992).

The fourth new species record for the state, *Rhithrogena pellucida* Daggy, was collected from the North Platte River near Walden, Colorado. It was previously suggested that *Rhithrogena* larvae collected here during 1991 and 1992 might be the unknown larvae of *R. flavianula* (McDunnough) (see McCafferty *et al.* 1993). However, in August of 1993, *Rhithrogena* adults collected and reared from this site were determined to be *R. pellucida*. The original description of this species by Daggy (1945), and the redescriptions by Burks (1953), and Leonard and Leonard (1962) adequately match our specimens from Colorado. For comparison purposes we provide illustrations of the male terminalia using a specimen from Colorado (Fig. 1) and a paratype from the original type series (Mississippi River, Minneapolis, Minnesota, 1 July 1939) (Fig. 2). Some differences were noted, particularly in the relative shape of the median notch of the penes. Also, the penes of the Colorado specimens differ slightly from typical midwestern specimens by having a larger dorsal subapical membranous excavation. However, similar variability has been found between populations throughout the Midwest (W. P. McCafferty, pers. comm.). The adults of *R. pellucida* can easily be separated from the other four species of *Rhithrogena* in Colorado by their distinctive genitalia (Fig. 1) and small size. The larvae of *R. pellucida* can be separated from the other species of Colorado *Rhithrogena* by the absence of a dorsal lobe on gills 2-6 (present on *R. hageni* Eaton, and *R. undulata* [Banks]), and the absence of a longitudinal ventral sclerotized setose line on gills 2-6 (present on *Rhithrogena robusta* Dodds) (Jensen 1966). In addition, the larvae of *R. pellucida* have a characteristic V-shaped transparent marking on the ventral gill surface that points out perpendicular to the long axis of the body (Fig. 3). Although the larvae of *R. flavianula* are unknown, the much larger size of the adults (body length 14mm) (McDunnough 1924), should make mature larvae of this species easily separable from the much smaller *R. pellucida* (body length 6-7mm). *Rhithrogena pellucida* has been recorded from Minnesota (Daggy 1945), Michigan (Daggy 1945, Leonard and Leonard 1962), Illinois (Burks 1953), Wisconsin, (Flowers and Hilsenhoff 1975, 1978), Virginia (Kondratieff and Voshell 1983), Alabama (Kondratieff and Harris 1986), Indiana (McShaffery and McCafferty 1988), and Maine (Burian and Gibbs 1991).

Two additional species, *Baetis virile* (McDunnough), and *Leptophlebia*



Figs. 1 and 2. *Rhithrogena pellucida*, male terminalia, dorsal view. 1. North Platte River, Jackson County, Colorado, 19 August 1993. 2. Paratype, Mississippi River, Minneapolis, Minnesota, 1 July 1939.

Fig. 3. *Rhithrogena pellucida*, larval abdominal gill 5, ventral view. North Platte River, Jackson County, Colorado, 19 August 1993. Anterior end indicated by arrow.

*nebulosa* (Walker), tentatively listed as occurring in Colorado by McCafferty *et al.* (1993), have been confirmed for the state. *B. virile* was reared from the North Platte River near Walden, and from Tomichi Creek near Gunnison. We compared these reared specimens with the descriptions by McDunnough (1923) and Traver (1935) and have determined them to be *B. virile*. The previous record from Colorado was based on a single larva taken from Grizzly Creek, a tributary of the North Platte River (McCafferty *et al.* 1993). We have also confirmed *L. nebulosa* from Colorado by rearing a large series of adults from the South Fork of the Republican River in Yuma County in eastern Colorado. This species has been recorded from much of eastern and mid-western North America, so its occurrence in the Great Plains of Colorado is not surprising.

In addition to *R. pellucida*, three other mayflies with primarily eastern/midwestern North American distributions, *Heterocloeon frivolum* (McDunnough), *Barbaetis cestus* (Provonsha and McCafferty), and *Baetis virile* (McDunnough) occur in the North Platte River in Colorado (McCafferty *et al.* 1993). Other aquatic insect species that are considered typical eastern/midwestern North American species and found in this river, include the stonefly *Taeniopteryx parvula* Banks (Kondratieff and Baumann 1988) and the caddisfly *Pycnopsyche guttifer* (Walker) (Ruiter and Lavigne 1985, and Ruiter 1990).

The North Platte River originates as snowmelt streams in the mountains of northern Colorado, flowing northward into central Wyoming, then southeastward into Nebraska. In west-central Nebraska, the river joins the South Platte River to form the Platte River, a major tributary of the Missouri River. The North Platte River flows into the Wyoming Basin, a plateau, which interrupts the continuity of the Rocky Mountain system. Here the North Platte River cuts through two mountain ranges, the Seminoe and the end of the Laramie Mountains before reaching the Great Plains. Most of this region was not glaciated during the last ice age except for high mountain glaciers. The upper North Platte River may have served as effective refugia or population pools for the above species. The Platte River system has been extensively altered by at least 194 reservoirs of capacities greater than 0.6 hm<sup>3</sup> and hundreds of agricultural diversion canals (Kirchner and Karlinger 1983). Therefore, intervening populations of these mayfly, stonefly, and caddisfly species along the North Platte in Wyoming or Nebraska may have been reduced to small local populations or have become extinct.

Material examined. - *B. dardanus*: Moffat Co., CO, Green River, 19 August 93, B. Kondratieff and R. Durfee, 15 larvae, (four slide mounts). *H. alleni*: Moffat Co., CO, Yampa River, 24 July 92, R. T. Muth, 15 larvae. *P. minutus*: Conejos Co., CO, Conejos River, 27 July 92, Colorado Department of Health, 1 larva (slide mount). *R. pellucida*: Jackson Co., CO, North Platte River, 19 August 93, B. Kondratieff and R. Durfee, 3 males, 3 larvae, and 2 males and 1 female (reared).

*B. virile* Jackson Co., CO, North Platte River, 19 August 93, B. Kondratieff and R. Durfee, 2 females (reared); Gunnison Co., CO, Tomichi Cr., 4 September 93, B. Kondratieff and R. Durfee, 8 males, 10 females (reared), and 8 larvae. *L. nebulosa*: Yuma Co., CO, South Fork Republican River, 25 April 93, B. Kondratieff and R. Durfee, 17 males, 7 females (reared).

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## EDITORIAL NOTE

In the following pages of this issue, *Entomological News* presents two papers on the introduction and establishment of non-indigenous species of Coccinellidae (Coleoptera). These papers present some conflicting data and one expresses some controversial and possibly speculative views on the establishment of 'adventive' vs. (purposely) 'introduced' species. *Entomological News* neither supports nor takes issue with either position but leaves consideration of the presented positions to its readers.

H.P.B

**RELEASE AND ESTABLISHMENT OF  
*HARMONIA AXYRIDIS*  
(COLEOPTERA: COCCINELLIDAE)  
IN THE SOUTHEASTERN UNITED STATES<sup>1</sup>**

W. L. Tedders<sup>2</sup>, Paul W. Schaefer<sup>3</sup>

**ABSTRACT:** *Harmonia axyridis* were laboratory reared and 87,810 specimens were released (1978-81) primarily in pecan orchards containing leguminous cover crops at Byron, Georgia. The first major recovery indicating establishment in Georgia was in 1990 at Buchanan, 174 km from the Byron release site. By 1992, the population had spread throughout Georgia to northern Florida and eastern South Carolina. *H. axyridis* is now the dominant coccinellid species (54.4%) in the Byron pecan orchard and appears influenced by the legume cover crop. Numerous pecan growers in Georgia reported control of pecan aphids (*Monellia caryella* and *Monelliopsis pecanis*) during 1993. Adult *H. axyridis* were more attracted to white traps than to similar dark grey, brown, or black traps. During rearing, total development required ca. 36 d. Recorded prey include 36 species of Aphididae, 12 species from 7 other homopteran families, and 3 species from two other insect orders. Aphids appear to be preferred prey but all may be acceptable, indicating polyphagy and suggesting an extended control potential for this generally arboreal coccinellid.

Lady beetles in the genus *Harmonia* occur in Asia and Australia and prey on aphids, psyllids, and scale insects (Gordon 1985). Widely distributed in Asia, *Harmonia axyridis* (Pallas) is recorded from Formosa, China, Korea, Japan, Manchuria, southern Siberia and the Ryukyu and Bonin Islands (Chapin and Brou 1991). This arboreal species occurs in orchard and forest habitats and preys mostly on various aphids, but it will also accept certain scales and two species of chrysomelids. It inhabits various trees, including maple, walnut, willow, and oak (Chapin and Brou 1991). *Harmonia axyridis* is highly polymorphic, very prolific, and may live up to three years (Hodek 1973).

Several attempts have been made to introduce *H. axyridis* into North America. Inclusive dates for recorded releases include: California – 1916, 1964 and 1965; Connecticut, Delaware, Georgia, Louisiana, Maine, Maryland, Mississippi, Nova Scotia, Ohio, Pennsylvania, Washington, and Washington, D.C. – 1978 to 1982; and Connecticut – 1985 (Coulson *et al.* 1981, Gordon 1985, McClure 1987; USDA, Beneficial Introduction Res. Lab., unpubl. records).

Recently, Chapin and Brou (1991) reported the establishment of *H. axyridis* in Louisiana and Mississippi. Releases in that area consisted of a single

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release of 32 specimens in Bossier Parish, Louisiana, in 1979 and eight releases totaling 3781 specimens in Washington County, Mississippi (near Leland), in 1980. The first evidence of establishment was the collection of more than 1000 adults in six light traps near Abita Springs, Louisiana, from July to November 1988. Specimens were collected from August to November 1990 in the Mississippi counties of Calhoun, Harrison, and Panola. In addition, Chapin and Brou reported specimens from crabapple trees infested with *Aphis spiraecola* Patch, crapemyrtle infested with *Tinocallis kahawaluokalani* (Kirkaldy), and from senescent *Erigeron* sp. in an old field habitat. Currently, *H. axyridis* is the most common lady beetle in the Abita Springs area.

This paper records the appearance of *H. axyridis* in Alabama, Georgia, South Carolina, and Florida. We also report on the rearing and release program in Georgia (Gordon and Vandenberg 1991, Tedders 1986, Tedders 1991) and give additional notes and information concerning its biology and behavior in Georgia and its known prey.

## MATERIALS AND METHODS

**Rearing and Production.** An intensive *H. axyridis* rearing and release program was conducted at the USDA-ARS, Southeastern Fruit and Tree Nut Research Laboratory at Byron, Georgia, from 1978 to 1981. The target prey were black pecan aphid, *Melanocallis caryaefoliae* (Davis), blackmargined aphid, *Monellia caryella* (Fitch), and yellow pecan aphid, *Monelliopsis pecanis* Bissell, on pecan, *Carya illinoensis* (Wangenh.) K. Koch. Stock insects were supplied by the USDA-ARS Beneficial Insects Introduction Research Laboratory at Newark, Delaware. At Byron, most *H. axyridis* were reared on *Myzus persicae* (Sulzer) colonies that infested greenhouse-produced Chinese cabbage, *Brassica rapa* L. (*pekinensis* group). Chinese cabbage plants were grown in Jiffy-9<sup>®</sup> peat pellets. Additional fertilizer, fungicides, and insecticides were not used. Two tightly secured greenhouses were used, one to produce aphid-free cabbage plants and the second to produce cabbage plants infested with *M. persicae*. Non-infested plants were transferred to the second greenhouse where they remained for a few days and became infested. Aphid-infested plants were then removed and placed in individual cages containing one or more pairs of *H. axyridis* adults.

Cages for *H. axyridis* were 3.8 ℓ cylindrical cardboard cartons having a thin polyethylene upper cover that allowed for illumination and viewing. Newly infested cabbage plants were added to each cage every second day or as needed as aphids were consumed. Cabbage plants were provided in cages at the rate of one plant per pair of *H. axyridis*. Cabbage plants depleted of aphids were discarded. The inside of the carton cages were lined with brown wrapping paper as an oviposition substrate. Foliage, the paper liner, and the

cover were removed daily to obtain eggs for additional colony production for release, developmental studies, and studies of acceptance of pecan aphids as prey. Specimens of stock lady beetles were maintained in the insect collection at Byron as identification vouchers.

In the greenhouses, temperatures averaged 24.6°C (range 6.7 - 37.7°C) and relative humidity averaged 68.5% (range 30 - 100%). In the rearing facility the temperature averaged 23.6°C (range 20 - 27.7°C) and relative humidity averaged 69.4% (range 40 - 95%). Lighting was held constant by overhead lights 24 hr per day. The production cages often contained 2 or 3 pairs, and supply of food was increased at a comparable rate.

In November 1992, visual traps developed for monitoring the emergence of pecan weevils, *Curculio caryae* (Horn) (Stanley 1992, Tedders and Wood 1993) were used to assess visual color preferences. The traps were interlocking triangular masonite panels, measuring 53.3 cm base x 121.8 cm height, on top of which was positioned a modified boll weevil, *Anthonomus grandis grandis* Boheman, collecting device (Anonymous 1990). The panels were painted either white (84.0% reflectance), gray (18.3% reflectance), brown (4.8% reflectance), or black (1.0% reflectance). Each colored trap was replicated three times and set out across the lawn of the laboratory in a randomized complete block design. Traps were about 3 m apart. Traps were in place from about 3:00 p.m. November 17 until 3:00 p.m. November 20 (3 consecutive 24-hr periods). Beetles were removed and counted after each 24-hr period. Trap data were subjected to analysis of variance.

## RESULTS AND DISCUSSION

**Rearing and Development.** Eggs were laid on the paper lining, cabbage foliage, and the polyethylene cover. A shortage of aphid prey in the cages was always followed by a marked reduction in lady beetle eggs due to cannibalism. Well-fed beetles did not usually cannibalize their own eggs.

Eggs averaged 4 days from oviposition to hatch (range 3-5 d). Average larval development for first through fourth stadia was 2, 2, 2-4, and 6 d, respectively, with larval development overall averaging 12-14 d. The pupal stadium ranged from 5-6 d and averaged 5.5 d. Average time required for development from egg to egg was about 36 d. Cooler temperatures ranging from 15.5 to 21.1°C increased the time required for development from egg to egg by 3-4 d.

Thirty-one newly emerged females were studied for longevity and fecundity. With one copulating pair confined per cage, females lived an average of 32.2 d (sd=25.26), laying an average of 491.3 eggs (sd=375.86); mean 16.7 eggs/female/d (sd=7.64). The shortest life span was 2 d and the longest 101 d. The 101-day old female produced 1543 eggs. Longevity of males was not recorded but was usually shorter than that of the females.

Adults and larval mortality in all colonies was usually the result of natural causes such as individual weakness and old age. Dead beetles were placed in a humidior and observed for suspicious microbial growth. On two occasions fungal pathogens were suspected and identified as *Paecilomyces farinosus* (Holm) Brown and Smith (Deuteromycota) (Richard A. Humber, pers. comm., Boyce Thompson Institute, Ithaca, New York).

All three species, *M. caryaefoliae*, *M. caryella*, and *M. pecanis* represented adequate food when time required for larval development and oviposition on a diet of *M. persicae* were used as baseline data. However, *H. axyridis* appeared to prefer *M. caryella*. The preference may be associated with the copious honeydew excreted by this aphid because both larvae and adults used this alternative food source. Adult *H. axyridis*, fed on *M. pecanis* or *M. caryella*, laid about 20 eggs per day. *Melanocallis caryaefoliae*, which appeared to be least favored as prey, excretes the least amount of honeydew.

**Releases.** Releases of reared *H. axyridis* in Georgia from 1978 to 1981 usually consisted of second and third instar larvae, occasionally 1st instar larvae, and rarely eggs. In total 87,561 immatures and 249 adults were released from 1978 to 1981 (Table 1). Releases were made on the farm at the Byron, Georgia laboratory, mainly into trees or legume cover crops within pecan orchards. Immatures were either transferred to plant foliage with a camel-hair brush, or the supporting substrate of Chinese cabbage leaf, paper liner, or polyethylene cage cover was stapled to pecan or legume foliage. Pecan trees were selected that supported *M. caryella*, *M. pecanis*, or *M. caryaefoliae* aphids or mixtures of two or all three species. The primary release orchard (about 7 ha) was bordered on opposite sides by oak-hickory-gum woods, on a third side by a second pecan orchard, and on the remaining side by a fallow field. No pesticides were applied to the orchard from 1977 through 1983.

Releases during March, April, and May were usually divided evenly between winter cover crop in the orchard and the pecan trees. The winter cover was composed of hairy vetch, *Vicia villosa* Roth, crimson clover, *Trifolium incarnatum* Roth, big flower vetch, *Vicia grandiflora* Scopoli, and rye grass, *Lolium* sp. Vetch and clover ground cover infested with pea aphids, *Acyrtosiphon pisum* (Harris), and occasionally cowpea aphids, *Aphis craccivora*, and *A. medicagenis* Koch was selected. Larvae and adults ( $n = 397$ ) were released in nearby cultivated plums, *Prunus* sp., apple, *Malus* sp., and crapemyrtle, *Lagerstroemia* sp. Plums were infested with black peach aphids, *Brachycaudus persicae* (Passerini), rusty plum aphid, *Hysteroneura setariae* (Thomas), or *A. spiraecola*. Apple was infested with *A. spiraecola* and crapemyrtle with *T. kahawaluokalani*. Also, a total of 2,485 larvae were released in weed covers within pecan orchards where the dominant weeds were horseweed, *Erigeron canadensis* L., infested with *Uroleucon erigeronensis* (Thomas), cocklebur, *Xanthium strumarium* L., infested with *U. ambrosiae* (Thomas), and goldenrod, *Solidago* sp. infested with *U. rudbeckiae* (Fitch) (Table 1).

**Initial Recoveries.** From 1978 to 1981 attempts to recover adults of released *H. axyridis* were conducted weekly, beginning the first week of April and continuing until the end of October or mid-November depending upon the condition of pecan foliage and the weather. From 1982 to the present, collections of beneficial arthropods at Byron, emphasizing Coccinellidae and Chrysopidae, continued on the same schedule in the same 7-ha release orchard or in adjacent orchards not over 8 km distant. Given these efforts, if coccinellid establishment had been successful, beetles should have been detected.

From 1978 to 1981, three sampling methods were employed in the 7-ha orchard. Visual 2-hr searches were conducted weekly in and around the orchard. In addition, weekly sweep net samples of the ground cover (100 sweeps per 7 ha) were taken, and the lower limbs of 25 pecan trees within the orchard were jarred with a club to dislodge beetles onto a 1 m<sup>2</sup> cloth catching frame.

From 1982 to present, visual searches of about 1 hr were conducted monthly. Sweep net collections from cover crops continued but collections from trees were made with the aid of a D-Vac collecting machine as a substitute for the limb-jarring method.

After releases, mature larvae and pupae were easily found on foliage of pecan trees and the ground cover, however adults were scarce. One adult was swept from evening primrose, *Oenothera* sp., May 24, 1978. No adults were collected during 1979. Six adults were swept from vetch from April 28 to May 6, 1980, and fifty-three adults were collected from pecan foliage by jarring and by hand collection from May 5 to June 6, 1980. One adult was swept from rye grass on May 6, 1980. A single adult was recovered September 29, 1981, by jarring pecan foliage. No adults or larvae were collected from 1982 through 1991.

Evidence of colonization in Georgia first became available in fall 1990. John C. Callaway, Jr., County Extension Director for Haralson and Carroll Counties (Buchanan, Georgia) advised the Department of Entomology, University of Georgia, Athens that an unidentified lady beetle had become a nuisance in houses in that area. A visit there on June 18, 1991 revealed a single *H. axyridis* adult on arrow leaf clover, *Trifolium vesiculosum* Savi. No additional lady beetles were found on adjacent trees, shrubs and other vegetation, but suspect pupal exuviae were found on apple. Specimens of that population submitted for identification to the Department of Entomology, University of Georgia, proved to be *H. axyridis* (Cecil L. Smith, per. comm.).

A second trip to Haralson County (elevation 382 m) on November 12, 1991, revealed about 50 *H. axyridis* adults inside the screened porch of a home in Buchanan. Additional searches revealed numerous adults and pupae on apple, *Pinus* spp., and magnolia, *Magnolia macrophylla* Michaux, at this site. During November and December 1991 Mr. Callaway and the Byron Laboratory received numerous reports that *H. axyridis* was an increasing nuisance in

homes throughout northwest Georgia. During early winter of 1991 *H. axyridis* were identified from northeast Alabama and were abundant near Huntsville (Paul Estes, Auburn, Alabama, per. comm.).

**Subsequent Recoveries—Biology and Population Abundance.** At Byron, on February 4, 1992, one adult was collected from loblolly pine, *P. taeda* L. that was heavily infested with *Eulachnus agilis* (Kaltenbach) on which the beetle was feeding. Thereafter and throughout March adults, larvae, and eggs were found regularly on various species of yellow pine infested with *E. agilis*. Foliage samples from April through October 1992 revealed that *H. axyridis* began inhabiting pecan in May and fluctuated in numbers as aphid populations varied. *Harmonia axyridis* comprised 54.4% of all the lady beetles collected from pecan by the end of the growing season (Table 2).

In a separate experiment on October 6, five terminal branches on each of 20 pecan trees were examined for *H. axyridis* by the jarring technique. Adults averaged 0.30/terminal and larvae 0.27/terminal. Aphid control on pecan, which was considered to be very good throughout 1992, was attributed mainly to *H. axyridis*.

By late summer 1992, specimens of *H. axyridis* were found throughout Georgia (W. L. T.), in north Florida (Russ Mizell, University of Florida, pers. comm.) and near McClellanville, South Carolina (Stuart H. Tedders, University of South Carolina, pers. comm.).

Movement by *H. axyridis* to overwintering aggregation sites began about November 1, 1992, when several hundred were found on the southwest sides of several buildings at Byron. On November 17 adults were observed flying around the grounds of the laboratory in such abundance that they were first thought to be the tail end of a swarm of honey bees. Many of these landed on the sides of buildings in large numbers, and four people were able to hand collect about 6,000 beetles in 2½ hrs.

Since beetles appeared to be attracted in greater numbers to light colored buildings than to dark colored ones, it was not surprising that traps captured totals of 208, 143, 61, 23 in the white, gray, black, and brown traps, respectively. Analysis of variance of these data indicated that *H. axyridis* is significantly attracted to white traps ( $\alpha = 0.05$ ) as opposed to darker ones (Table 3). This finding confirms observations by Obata (1986) in Kyoto, Japan, and agrees with those of Hodek (1973) that several coccinellid species were attracted to light-colored rock outcroppings that were used as overwintering sites. Beetles were not observed moving to overwintering sites after November 20, 1992.

Recoveries began in 1993 when several adults were found (February 15) feeding on the floral nectaries of common box, *Buxus sempervirens* L., indicating that emergence from overwintering had begun. About 2,000 hibernating adults were collected on February 26 by three people in 30 minutes from the center of a panelled wall on the south-southwestern side of an abandoned

insecticide building at the laboratory farm center, indicating that most were still overwintering. Also on that date, several active adults were observed on yellow pine, and about 30 active adults were observed on the lighting fixtures in an office of the laboratory building, further indicating that the overwintering period was ending.

At Biloxi, Mississippi (February 28), mature larvae, pupae, and newly emerged adults were found on *Podocarpus* sp. infested with *Neophyllaphis podocarpi* Takahashi at a hotel resort facing the Gulf of Mexico, confirming that *H. axyridis* had been active in that area for several weeks, and had passed through at least one generation (W.L.T.).

On March 9 at Byron, adults were observed feeding on exudates of the floral nectaries of peach, plum, and common box. Aphids or other prey were not observed on these plants, and we can exclude the possibility that aphid eggs were being fed on since aphids are rare on these plants in central Georgia. On March 11, 100 limbs each of peach, plum, and yellow pine were jarred revealing 13, 1, and 3 adults, respectively.

**Impact in Pecan orchard:** Collections of *H. axyridis* from pecan orchards at Byron continued during 1993. In addition to standard sweep net and D-Vac machine samples, a large Malaise trap was placed in a legume ground cover study orchard. Collections from this orchard were compared, with collections from an adjacent control orchard without a legume cover. Yellow aphids on pecan in the legume cover crop orchard were very low, the highest count averaged only 4.7/compound leaf during the week of May 10. Average numbers of aphids for May 1993 was 2.2 aphids per compound leaf. Yellow pecan aphids on pecan during May usually exceed 100/leaf. In the adjacent control orchard the highest counts were 22.3 aphids per compound leaf during the week of May 17, and counts averaged 9.2 aphids per compound leaf for the month. Neither orchard received insecticide but *H. axyridis* were noticeably slower to colonize the non-cover crop orchard. Although a Malaise trap was not used and sweep net samples were not taken from the closely mowed grass of the control orchard, comparative collections of *H. axyridis* suggest the importance of the legume cover crop (Table 4). Numerous pecan growers in Georgia reported excellent control of *M. caryella* and *M. pecanalis* in commercial orchards during 1993 (W.L.T.).

**Conclusions:** *Harmonia axyridis*, first reported to be established in North America by Chapin and Brou (1991) from Louisiana in 1988 with subsequent collections during 1989 and 1990, was not reported in Mississippi until 1990. There was no mention by the authors of the size of that population. Releases possibly leading to the Louisiana-Mississippi establishment were a single release of 32 specimens in Bossier Parish during August 1979 and eight releases of 3781 specimens from July to October 1980 near Leland, Mississippi. The straight-line distance from Bossier City (Bossier Parish) to Abita

Springs, Louisiana is about 418 km (260 mi) and from Leland to Abita Springs is 320 km (199 mi). The distance from Leland and Bossier City to Buchanan, Georgia is about 553 km (344 mi) and 831 km (516 mi) respectively, and from Abita Springs to Buchanan is about 591 km (367 mi) (Figure 1).

The population level first reported in Georgia near Buchanan during the fall of 1990 was very high as judged by numerous calls to county agent John Callaway in Buchanan (personal communication). The straight-line distance from Byron to Buchanan is about 174 km (108 mi). It remains uncertain whether the Buchanan population was the result of migration of beetles across Mississippi and Alabama to Buchanan or the result of migration of releases from Byron to Buchanan. It is clear that many more specimens were released at Byron and the distance from Byron to Buchanan is much shorter. If the Buchanan population originated from Abita Springs, it is unusual that *H. axyridis* were not reported as a nuisance from Alabama before it was found in Georgia in view of its habit of overwintering in homes. The evidence suggests that two separate establishments occurred: one in Abita Springs, LA, and another in Buchanan, GA.

Because *H. axyridis* is highly polymorphic, with a basic red morph and a black morph, as illustrated in Ayala (other variations are also possible), it is important to record that no black morphs were found in Georgia, Alabama, Florida, and South Carolina populations. All beetles found to date are of the red color morphs as described by Chapin and Brou (1991). Live specimens of red morph vary in background color from a pale yellow-orange to a deep orange-red (which may well be age related), and the black spotting varies from none to  $20 \pm$  spots.

As *H. axyridis* spreads from the southeast into other areas and begins to receive increasing attention, a greater understanding of this invading species will result. Toward that end, we present a rapidly growing list of prey species (Table 5). This tentative list will serve as a reference point for addition of new prey species, especially as this lady beetle is redistributed (See Appendix) and spreads naturally into new states.

## APPENDIX

In light of some significant biological information and records of an intentional shipment of *Harmonia axyridis*, we offer the following information for the record.

**Biological Notes:** April 16, 1980, freeze-dried pea aphids and a water supply were found to be acceptable but poor quality food for *H. axyridis*. Thirty-six eggs yielded five pupae but only three adults.

1980—*Uroleucon ambrosiae* on horseweed and cocklebur were unsatisfactory prey and *H. axyridis* did not complete development. *Uroleucon erigeronis* on horseweed were fair prey and produced adults after lengthy feeding.

*Aphis craccivora* on vetch and velvet bean, *Stizolobium Deeringianum* Bert., were poisonous to *H. axyridis* larvae. *Aphis spiraeicola* on Garland cv. crab apple, *Malus coronaria* Mill. were poor prey for larvae.

May 22, 1981—*Phylloxera notabilis* Pergande on pecan were excellent prey for *H. axyridis*; larvae matured in less than 12 d. Field released adult *H. axyridis* were observed feeding on *P. notabilis* emerging from opening galls.

August 25, 1981—*Tinocallis kahawaluokalani* on crapemyrtle were suitable prey. Larvae released on crapemyrtle yielded at least two adult *H. axyridis*. Four *H. axyridis* adults fed *A. pisum* laid a total of 2,016 eggs; average 526.5 eggs/female over a period of 32.3 consecutive days. As prey, *A. pisum* were deemed suitable.

For initial rearing of *H. axyridis* in quarantine at Newark, prey were *A. pisum* produced on faba (fava) beans, *Vicia faba* L. Cages for all life stages were 530 cc unwaxed paper cups (No. 2186 Design, James River Corp.) with tight-fitting clear plastic lids. To prolong the availability of suitable *A. pisum* prey, several lengths of bean stems were stripped of leaves and placed in each cup. By stripping stems of leaves, the containers were kept cleaner, which facilitated detection and removal of eggs, larvae, and adults.

Samples of overwintering *H. axyridis* were weighed on two occasions after collection to gain information about weight loss during hibernation. On December 15, 1992, 315 beetles weighed an average of 35 mg. On January 11, 1993, 224 beetles weighed an average of 33 mg for loss of 2 mg over 27-d period.

May 1993—All stadia of *H. axyridis* were found in very large numbers on six tulip trees, *Liriodendron tulipifera* L., infested with *Macrosiphum liriodendri* (Monell) in Houston County, Georgia.

April 1993—Ornamental rose, *Rosa* spp., infested with *Rhodobium porosum* (Sanderson) were found to have one or more feeding adult or larval *H. axyridis* per plant in Thomasville, Ga. The *H. axyridis* population was very large and effectively controlled aphids during this time.

**Redistribution:** Of the 8,000 *H. axyridis* adults collected during late 1992 and early 1993, 6,000 were sent to California for inspection and subsequent release in California and New Mexico pecan orchards (Ken S. Hagen, Kent Daane, and Steve Sibbett, University of California, pers. comm.). To date 1,500 were released on April 9 and 750 were released on April 30 at Blaine Ranch, Visalia, California. Dr. Hagen inspected and forwarded 2,000 to New Mexico where they were released in pecan orchards at Mesilla (Joe Ellington, New Mexico State University, pers. comm.).

During fall 1993, daily observations were made to detect the onset of *H. axyridis* flight to overwintering quarters. None were observed until November 4 when large numbers congregated on the sides of buildings at Byron (maximum air temperature was 22.2° C). Very few were observed on November 5

(maximum temperature 20.6° C) and fewer yet occurred during the next four days when maximum temperatures were 16.6° C or below.

Maximum flight activity occurred on November 10 when many adults congregated on the sides of buildings. Of particular interest that day was an abandoned silo located on the laboratory farm at Byron. The silo was a light gray concrete shell having no top and containing about 20 cm rain water at the bottom. Insects on the inside were inaccessible but visible through port holes. The silo measured 14.4 m cir. x 9.6 m height. At about 2:00 p.m., congregating *H. axyridis* were estimated at 1550 beetles/m<sup>2</sup> on the outside wall with slightly smaller numbers on the inside wall. Air temperature for November 10 was 20° C maximum and 5° C minimum.

On November 11, entomologists Billy Ree and Allan Knutson of the Texas Agricultural Extension Service, Texas A&M University, arrived at Byron to collect *H. axyridis* during November 11-14. They collected 10,200 adults, mostly from the exterior wall of the silo. Maximum temperature for the period ranged from 19.4-25.0° C. Smaller numbers of adults were observed on the

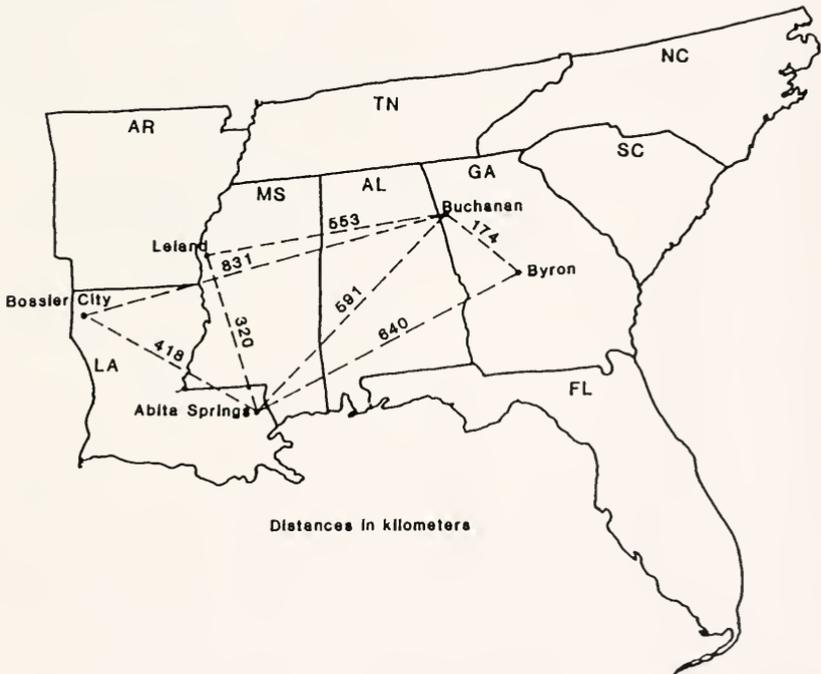


Figure 1. Map of Southeastern United States showing release sites (Byron, GA, Leland MS, and Bossier City, LA) and recovery sites (Buchanan, GA and Abita Springs, LA) of *Harmonia axyridis* and the straight-line distances (KM) between sites.

silo on each successive day, but the change was not measured. On each day, the primary movement of adults to the silo occurred between 1:00 and 4:00 p.m. when air temperature ranged between 17.7-20.6° C. During that period, the sky was bright but large cumulus clouds intermittently blocked full sun. The greatest number of adults was observed flying to the silo during periods when the silo was fully illuminated, and flying decreased with shadows cast by clouds. Most *H. axyridis* that accumulated during the day were gone the following morning; presumably because of a lack of protected sites (cracks and crevices) to inhabit. The *H. axyridis* collection was returned to Texas for study and release in Texas pecan orchards during spring 1994. One Byron technician collected 2795 *H. axyridis* from the silo for our use on November 12 during a 1.5 hr. period. Adult weight averaged 35.4 mg.

Table 1. Release of *Harmonia axyridis* into pecan trees and clover-vetch ground cover, Byron, Georgia.

	1978		1979		1980	1981
	Immatures	Adults	Immatures	Adults	Immatures	Immatures
Mar.					23,401	
Apr.	197	34	1,767	6	6,729	
May	1,195 <sup>1</sup>	162 <sup>2</sup>	723	18	1,052	
Jun	2,496	6				
Jul	482					
Aug	258 <sup>3</sup>		12,164			
Sep	2,780		2,145 <sup>4</sup>			933
Oct	2,846	23	15,244			809
Nov			12,318 <sup>5</sup>		22	
Total	10,254	225	44,361	24	31,204	1,742

<sup>1</sup> 201-plum, 172 apple

<sup>2</sup> 18-apple

<sup>3</sup> 6-crapemyrtle

<sup>4</sup> 540-weed cover

<sup>5</sup> 1,945-weed cover

Table 2. D-Vac collections of important Coccinellidae from pecan trees at Byron, Georgia, 1992.

Species	Month/Number Collected							
	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
<i>Hippodamia convergens</i>	0	4	2	2	0	0	0	8
<i>Coccinella septempunctata</i>	2	16	8	5	1	2	0	34
<i>Olla v-nigrum</i>	1	4	5	4	16	2	1	33
<i>Cycloneda munda</i>	3	6	2	3	3	1	1	19
<i>Coleomegilla maculata</i>	0	0	1	4	0	0	11	16
<i>Harmonia axyridis</i>	0	2	0	9	53	34	34	132
Total	6	32	18	27	73	39	47	242

Table 3. Analysis of variance of means of numbers of *Harmonia axyridis* adults captured in four different colored traps November 17-20, 1992, Byron, Georgia<sup>1</sup>.

Trap Color	24 hr periods <sup>2</sup>			Total of 3 Period <sup>3</sup>
	1	2	3	
White	5.4 a	5.6 a	2.6 a	8.1 a
Gray	4.3 ab	4.2 a	2.1 ab	6.6 ab
Black	2.8 bc	3.0 ab	1.7 ab	4.5 bc
Brown	2.0 c	1.3 b	0.7 b	2.8 c
MSE	0.899	1.767	0.592	2.164

<sup>1</sup> Analysis of variance of means;  $\alpha = 0.05$ ,  $df = 6$ . Means followed by same letter within a column are not significantly different (Duncan's Multiple Range Test).

<sup>2</sup> Means captured in 3 traps per 24 hr period.

<sup>3</sup> Means captured in 3 traps per 72 hr period.

Table 4. *Harmonia axyridis* captured in pecan orchard with ground cover of crimson clover and hairy vetch, sampled by malaise trap, sweep net, and D-Vac methods, compared with adjacent orchard with no cover crop, sampled by D-Vac only, Byron, Georgia 1993.

Sample Period	Legume Cover Crop Orchard			No Cover Crop
	Malaise Trap	Sweep Net <sup>1</sup>	D-Vac <sup>2</sup>	D-Vac <sup>2</sup>
Mar 8-14	—	2	—	—
Mar 15-21	0	1	—	—
Mar 22-28	2	2	—	—
Mar 29-Apr 4	8	10	—	—
Apr 5-11	4	23	—	—
Apr 12-18	8	3	3	0
Apr 19-25	6	5	2	1
Apr 26-May 2	0	3	4	1
May 3-9	1	0	1	1
May 10-16	0	0	2	1
May 17-23	0	1	0	1
May 24-30	0	1	3	0
Total	29	51	15	5

<sup>1</sup> Sweep net samples represent 5 sweeps in each of 10 locations.

<sup>2</sup> D-Vac samples represent 5 terminals/tree from each of 10 trees.

Table 5. Recorded prey of *Harmonia axyridis* Pallas.Taxon and Species [Source(s)]<sup>1</sup>

## Coleoptera:

## Chrysomelidae

*Ambrostoma quadriimpressum* Motschulsky<sup>4</sup>*Chrysomela vigintipunctata* Scopoli

## Homoptera:

## Adelgidae

*Adelges laricis* Vallot<sup>4</sup>

## Aphididae

*Acyrtosiphon pisum* (Harris)<sup>2,3</sup> (Hodek 1973)*Agrioaphis* spp.<sup>4</sup>*Amphorophora oleracea* v.d. Goot<sup>3</sup>*Aphis craccivora* Koch (Hodek 1973)*Aphis pomi* DeGeer (Hodek 1973)*Aphis spiraeicola* Patch<sup>2</sup> (Chapin & Brou 1991)*Chaitophorus* spp.<sup>4</sup>*Cinara kochi* Inouye*Cinara laricicola* (Matsumura)<sup>3</sup>*Cinara todocola* (Inouye)<sup>3</sup>*Cinara pinea* Mordvilko<sup>4</sup>*Cryptosiphum gallarum* Kaltenbach<sup>3</sup>*Eriosoma lanigerum* (Hausmann)<sup>3</sup>*Eulachnus agilis* (Kaltenbach) (Present study)*Hyalopterus pinni* Matsumura*Hyalopterus pruni* (Geoffrey)<sup>3</sup>*Kernaphis pini* (Koch)<sup>3</sup>*Lachnus* sp.<sup>3</sup>*Macrosiphum rosae ibarae* Matsumura<sup>3</sup>*Macrosiphum liriodendri* Monell<sup>2</sup> (Present study)*Megoura viciae japonica* (Matsumura)*Melanocallis caryaefoliae* (Davis)<sup>2</sup> (Present study)*Monellia caryella* (Fitch)<sup>2</sup> (Present study)*Monelliopsis pecanisi* Bissell<sup>2</sup> (Present study)*Myzus malisucta* Matsumura<sup>3</sup>*Myzus persicae* (Sulzer)<sup>3</sup> (Hodek 1973)*Neophyllaphis podocarpi* Takahashi<sup>2,3</sup> (Present study)*Nippolachnus piri* Matsumura<sup>3</sup>*Periphyllus californiensis* (Shinji)<sup>3</sup>*Rhodobium porosum* (Sanderson) (Present study)*Rhopalosiphum pseudobrassiccae* Davis<sup>3</sup>*Rhopalosiphum prunifoliae* Shinji<sup>3</sup>*Schizaphis graninum* (Rondani) (USDA, APHIS, Niles, MI)*Tinocallis kahawaluokalani* (Kirkaldy)<sup>2</sup> (Chapin & Brou 1991)*Toxoptera odinae* (Van der Goot)<sup>4</sup>*Toxoptera piricola* Matsumura<sup>3</sup>

Table 5. Recorded prey of *Harmonia axyridis* Pallas (continued)  
 Taxon and Species [Source(s)] (continued)<sup>1</sup>

Diaspididae

*Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Park and Kim 1990)

*Lepidosaphes salicina* Borchsenius<sup>4</sup>

Eriococcidae

*Rhizococcus transversus* (Green)<sup>3</sup>

Margarodidae

*Icerya purchasi* Maskell<sup>3</sup>

*Matsucoccus resinosae* Bean & Godwin<sup>2</sup> (McClure 1987)

*Matsucoccus matsumurae* (Kuwana) (Kao & Yun 1983)<sup>4</sup>

Phylloxeridae

*Phylloxera notabilis* Pergande<sup>2</sup> (Present study)

Pseudococcidae

*Nesticoccus sinensis* Tang<sup>3</sup>

*Phenacoccus pergandei* Cockerell

Psyllidae

*Anomoneura mori* Schwarz<sup>3</sup>

*Thysanogyne limbata* Enddeyein<sup>4</sup>

Lepidoptera:

Arctiidae

*Hyphantria cunea* (Drury)<sup>5</sup>

<sup>1</sup> Unless indicated otherwise, listed in Yasumatsu and Watanabe (1964) (citing other sources) as prey species in Japan.

<sup>2</sup> Prey species recorded in New World.

<sup>3</sup> listed in Chapin and Brou (1991) and citing other sources. Many other synonymous names are also given but these are not reproduced here.

<sup>4</sup> listed in Yan *et al.* (1989).

<sup>5</sup> Shu and Yu (1985).

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**THE KNOWN DISTRIBUTION OF THE PREDATOR  
*PROPYLEA QUATUORDECIMPUNCTATA* (COLEOPTERA:  
COCCINELLIDAE) IN THE UNITED STATES, AND THOUGHTS  
ON THE ORIGIN OF THIS SPECIES AND FIVE OTHER EXOTIC  
LADY BEETLES IN EASTERN NORTH AMERICA<sup>1</sup>**

W. H. Day<sup>2</sup>, D. R. Prokrym<sup>3</sup>, D. R. Ellis<sup>4</sup>, R. J. Chianese<sup>5</sup>

**ABSTRACT:** We provide 86 new collection records for the exotic *P. quatuordecimpunctata*, increasing its known range from 13 to 99 counties, and from three to nine states. The recovery data indicate that the actual distribution of this coccinellid is likely even larger, because systematic and broad surveys have been done in only a few areas. Evidence provided for *P. 14-punctata* and five other aphidophagous coccinellids [*Coccinella undecimpunctata*, *C. septempunctata*, *Harmonia axyridis*, *H. quadripunctata*, and *Hippodamia variegata*] indicates that all six species were first established accidentally in eastern North America, and that they most likely were introduced through seaports. Inland ports appear to facilitate establishment, compared to urban, coastal ports.

Lady beetles have long been recognized as one of the most important groups that prey on insect pests, especially on aphids and other Homoptera. Following the spectacular success of the *Vedalia* beetle in controlling the cottony-cushion scale in California citrus in the late 1880s (DeBach 1964), numerous attempts to establish foreign aphidophagous coccinellids have been made in the eastern United States, especially during the past 30 years (e.g. Shands *et al.* 1972, Angalet *et al.* 1979). However, nearly all of these intentional releases have failed to persist, and it is an interesting paradox that six aphidophagous coccinellid species have accidentally established themselves during this same period.

*Propylea quatuordecimpunctata* (L.) is one of the six species of exotic aphidophagous coccinellids discovered to be established in eastern North America since 1912. This paper documents its dispersion southward, as demonstrated by new state and new county collection records.

In addition, we discuss the probable means of entry into North America of *P. quatuordecimpunctata* (*P. 14-punctata* hereafter) and five other lady beetles, and briefly reflect on the significance of the apparent displacement of several native coccinellids by some of the exotic lady beetles.

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## MATERIALS AND METHODS

Records for the initial collection of each of the six coccinellid species were obtained from the literature, USDA-APHIS files (Niles, MI; D.R.P. & D.J. Nelson), CAPS (Cooperative Agricultural Pest Survey) data files (Storrs, CT; D.R.E. & R.G. Adams), and from field collections (W.H.D., R.J.C. & staff). We cite the earliest collection date for each species and county because it is most useful for dispersion studies; in a few cases, these precede dates published previously.

Most of the collections of *P. 14-punctata* and other coccinellids were made by sweeping low foliage with an insect net, but several other methods were used, and these are listed with the corresponding records. To prevent escape of any coccinellids, each sweep-net sample by W.H.D. was placed inside a glass-topped sleeve cage before the contents were sorted and counted.

In both Canada and the United States, federal quarantine regulations require issuance of a permit prior to the release of foreign beneficial insects from a quarantine facility. These records were checked to determine if an establishment at each location was preceded by one or more intentional releases in the vicinity.

## RESULTS AND DISCUSSION

**Propylea 14-punctata:** This species was first detected in North America in 1968, near Quebec City, Quebec, by Chantal (1972). Quarantine records in Canada (M. Sarazin, pers. commun.) and the United States (L. R. Ertle, pers. commun.) indicate that no releases of this foreign predator had been made in Canada or the northeastern U.S. prior to this discovery. As Dysart (1988) noted, the evidence clearly indicated that this coccinellid had been present for several years in Quebec before it was first collected. Thus it was not surprising that by 1986, *P. 14-punctata* had been found in 14 counties in Quebec, and had moved southward into three counties in northern Vermont and New York (Dysart 1988).

Table 1 contains the known distribution of this species in the U. S., compiled from our records, data of cooperators, and the literature. Most of these records have not been published – six of the nine state listings are new, as are 86 of the 99 county records. Voucher specimens for records published here for the first time are located at Niles, MI, Newark, DE, and Trenton, NJ.

Based on the dates and locations of many of these first collections on the map (Figure 1), it is obvious that the distribution pattern of *P. 14-punctata* in the U.S. is an extension of the initial establishment in Quebec, and that its dispersion southward is considerable (1,120 km/700 mi.). In addition, if these data are compared to Table 1 using a map with labeled counties, adjacent counties will be found to have different first collection dates. This pattern and the small number of (and widely-spaced) initial positive recovery counties

usually indicate the lack of broad and contemporaneous surveys, rather than absence of the coccinellid, because multi-county surveys later (Table 1) usually detected this species in many additional counties. For example, the 1992 survey results (Table 1: Dutchess, Putnam, & Rensselaer Counties in New York, and Hunterdon, Mercer, & Sussex Counties in New Jersey) suggest that thorough surveys would find *P. 14-punctata* in additional counties west of the Hudson River in New York, and in the eastern border counties of Pennsylvania – and field work in 1993 did detect this beetle in four new counties in western New York (Fig. 1) and in eight counties in eastern Pennsylvania (Table 1).

**Other adventive coccinellids:** Five species of exotic, predaceous coccinellids have become established over large areas of eastern North America since 1912, as has *P. 14-punctata*. These are listed in Table 2, along with pertinent data, and sources of this information.

**Origins of introduced species:** The initial distribution of each of the six adventive species of lady beetles was so limited (Schaeffer 1912, Wheeler & Hoebeke 1981, Vandenberg 1990, Dysart 1988, Angalet *et al.* 1979, Gordon 1987, Chapin & Brou 1991) that we can be reasonably certain that they had been present there for a relatively short time. Each species was first found close to a seaport or a shipping lane (identified in Table 2), and five of these seven cases had never been released in that region (details are in footnotes, Table 2). In each of the other two cases (*H. axyridis* in Louisiana and *C. 7-punctata* in New Jersey), the initial recovery locations were distant from the places where the limited prior releases had been made, and these coccinellids were not detected at their release locations within 10 years (footnotes, Table 2). Thus we agree with Schaefer & Dysart 1988<sup>6</sup> that "... circumstantial evidence ... suggests that accidental arrivals on ships is very probable ..." To this we would add that although aircraft would appear to favor insect introductions by virtue of their short transit times, they are inferior to ships for the following reasons: 1) aircraft are much smaller, and have fewer exterior hiding places that are accessible to large numbers of beetles (chances of successful establishment increase as the number of individual immigrants increases); 2) spaces outside the passenger and cargo compartments are not heated [air temperatures at cruising altitude (10,000 m) are  $-35^{\circ}\text{C}$  (calculations from Finch & Trewartha 1949)]; 3) shipments of plant material in cargo are inspected by quarantine personnel; 4) the usual "in port" time of aircraft (hours) is short compared to ships (days) and limits the time that insects can enter or depart; 5) short transit time is not a critical factor for long-lived coccinellid adults; and 6) the aggregation habit of many lady beetles provides a means for significant numbers to gather on large structures, like a ship in port.

It is interesting that only two exotic aphidophagous coccinellids were found to be established during the first 67 years of this century, but that four

<sup>6</sup> They discussed 5 of the 6 species treated here.

more species (at five locations, one species at two different points) gained footholds in the next 20 years (Table 2). Three of these introductions probably occurred as a result of the increased ship traffic that followed the opening of the St. Lawrence Seaway in 1959 (Anon. 1991) – and the other two introductions could have benefited from the increased foreign trade that has occurred during recent years (King *et al.* 1992).

During its short life the St. Lawrence Seaway system has been the probable means of entry of 60% (3 of the 5 establishments since 1959) of the exotic coccinellids that have established in eastern North America (Table 2; the two widely-separated introduction points for *C. 7-punctata* were counted as two introductions), and this should be commented upon. Using the Seaway, ocean-going ships can travel inland 3,300 km (2,035 mi.) (Anon. 1992) through forests and farmland. This very long waterway offers a much greater opportunity for predaceous or crop-feeding insects to quickly find their hosts, compared to coastal seaports, most of which are now surrounded by urban areas which lack a variety and quantity of prey insects and agricultural food plants. While routine inspections by quarantine officials at Seaway ports may help intercept insect pests in cargo, insects that fly from a ship along the lengthy inland passage will not be excluded by this means. Although much of the St. Lawrence River has always been accessible to transoceanic ships, the opening of the Seaway immediately increased the volume of ship traffic in the river at Montreal by 62% (Matta, pers. commun.), and average ship size also increased (Anon. 1992). The amount of Seaway shipping is significant; for example, in 1991, 445 ships from foreign ports traveled inland as far as Lake Ontario (1,900 km), and 350 (79%) of them continued to westward ports, some to the maximum of 3,300 km (Anon. 1992). Moreover, ship movement is concentrated in the growing season because the Seaway system is closed during the winter (Anon. 1992).

Schaefer *et al.* (1987) suggested that, in addition to the possible introduction of *Coccinella septempunctata* L. by transoceanic ships, this species may have established in Quebec by flying from prior releases in northern Maine (400 km distant) and established in Bergen Co., NJ from earlier releases in Burlington County, NJ (80 km away). While possible, these origins appear much less likely than introduction by ships, because this beetle was never demonstrated to be established at either release site (Angalet & Jacques 1975, Shands *et al.* 1972), nor at intermediate locations, until many years after it was found close to the ports.

It has also been suggested that several of these coccinellids may have become established as a result of intentional releases by man (Gordon 1987, Wheeler 1993). However, quarantine personnel<sup>7</sup> verified that there were no release records for any of the six species listed in Table 2 in the areas where each was first discovered (for examples of the voluminous data maintained by each quarantine laboratory for every shipment, see Coulson 1992). While

<sup>7</sup> Personal communications by L.R. Ertle (U.S.A.) and M. Sarazin (Canada) to W.H.D.

undocumented releases cannot be ruled out, it is unlikely that such unauthorized releases would involve numbers of foreign coccinellids as large as in regular releases – which have had a very low rate of success in eastern North America (Angalet *et al.* 1979, Schaefer & Dysart 1988). For example, although about 150,000 laboratory-reared *C. 7-punctata* were released in 10 states and one province, permanent establishment was not verified at even one location (Schaefer *et al.* 1987).

Large numbers of laboratory-reared *P. 14-punctata* have also been released, in two different regions, with a similar lack of success. The USDA-APHIS Russian wheat aphid biocontrol project disseminated nearly 565,000 *P. 14-punctata* in 16 western states from 1987 to 1992 (Russian Wheat Aphid Biological Control Project, FY 1992 Report, D.R. Prokrym *et al.* 1993, 55 pp., unpubl.). The New Jersey Department of Agriculture released 33,500 *P. 14-punctata* adults and nearly 39,000 eggs in New Jersey, from 1989 through 1992 (R.J. Chianese, unpubl. 2 p. report, 1993). No *P. 14-punctata* has yet been recovered from the 16 western states, but this species has recently been recovered in most of northern New Jersey, as noted in Table 1. The origin of the latter establishments cannot be absolutely determined, but the evidence indicates that the southward movement of *P. 14-punctata* from New England and eastern New York was almost certainly responsible, for the following reasons: 1) the first detection in New Jersey (Warren Co., 1991) was 37 km from the nearest release point; in 1992, this beetle was found in six additional New Jersey counties, several not close to release fields and in one (Sussex) in which no releases had ever been made (but which borders New York state, where *P. 14-punctata* was discovered in six adjacent/nearby counties in 1992 (Table 1); 3) the southward movement of large numbers of *P. 14-punctata* is obvious from the recovery data in Figure 1; and 4) the comparatively small numbers released in New Jersey (33,500 beetles over the whole state vs. 239,000 acres average area per county) could not have produced detectable numbers of this univoltine beetle in 12 counties (Table 1) in such a short period of time (2-4 years and generations).

As noted in Table 2, *Harmonia axyridis* was very likely established in the U.S. via shipping, near New Orleans. It was first found there in 1988 (Chapin & Brou 1991), and was next detected at three widely-separated locations in 1990 [in both southern and northern Mississippi (Chapin & Brou 1991), and in northern Georgia (Teddars & Schaefer 1994)]. Although the latter authors suggest that this coccinellid might have established in central Georgia in 1992 as a result of releases there in 1978-1981, this is very unlikely, because: 1) detection attempts at the release locations were unsuccessful for 10 years (1982-1991); 2) *H. axyridis* was found in northern Alabama in 1991 (Teddars & Schaefer 1994) at a point directly between the northern Mississippi establishment counties and northern Georgia; and 3) the movement of *H. axyridis* had obviously gained great momentum, because this beetle reached Virginia

in early 1993 (P. W. Schaefer, pers. commun.), and by fall 1993 was collected even farther north, in Delaware (D. Paruszewski, pers. commun.), Pennsylvania (K.S. Swan, pers. commun.), and New Jersey (R.J.C., unpubl.).

Exotic coccinellids have traditionally been reared in the laboratory before release, to eliminate parasites that may be present in all four life stages. However, the above results and the summary by Gordon 1985 (Table 1: only one aphidophagous species established in the NE U.S., after attempts with 31 species) indicate that laboratory-reared exotic aphid-feeding coccinellids have not been a practical means of achieving permanent establishment. Interestingly, Gordon's Table 2 also shows that natural (not lab-reared) populations can establish themselves, and subcolonizations by man from these self-established (and preadapted) lady beetle populations have had a much better success rate, as also noted by Schaefer *et al.* 1987.

**Displacement of native aphidophagous coccinellids:** Day (1965) observed that *Coccinella undecimpunctata* L. was by far the most numerous coccinellid on potatoes (55% of individuals, of 14 total spp.), over a three year period, on eastern Long Island, NY. Because this is an introduced species (Table 2), it obviously had previously displaced a native ladybird which had formerly been the dominant species. Angalet *et al.* 1979 stated that the introduced *C. septempunctata* had become the dominant coccinellid on *Phragmites* plants in the Bergen County, NJ meadowlands, and Day (unpubl.) observed that this species had also become the most abundant coccinellid (of 11 spp.) on alfalfa during the 1980s. And, *H. axyridis* is now the dominant lady beetle in a pecan orchard in Georgia (Tedders & Schaefer 1994). These examples indicate that substantial displacement of native lady beetles by exotic species has occurred in the eastern U.S. Although some people are concerned about the intentional or accidental introduction of exotic predators, historical evidence indicates that competitive displacement is likely only when the replacing species is superior in one or more attributes, that a higher degree of prey suppression will result (Huffaker & Messenger 1976), and native predator species do survive.

In any event, accidental introductions cannot be prevented, and we agree with Schaefer & Dysart (1988) that more will occur in the future, if intercontinental commerce continues at the present high levels. And, because all of the six adventive coccinellids were discovered by chance, it is possible that other exotic species may be present – but undetected. As Wheeler 1992 has pointed out, "Prompt detection of immigrants and surveys to document their dispersal" are often neglected, leading to later confusion and uncertainty as to origin and points of introduction – both of which may later be of considerable importance. The CAPS program, a cooperative effort between USDA-APHIS and all the States, provides a means for promptly discovering newly established pest and beneficial insect species, and hopefully this important work can be continued.

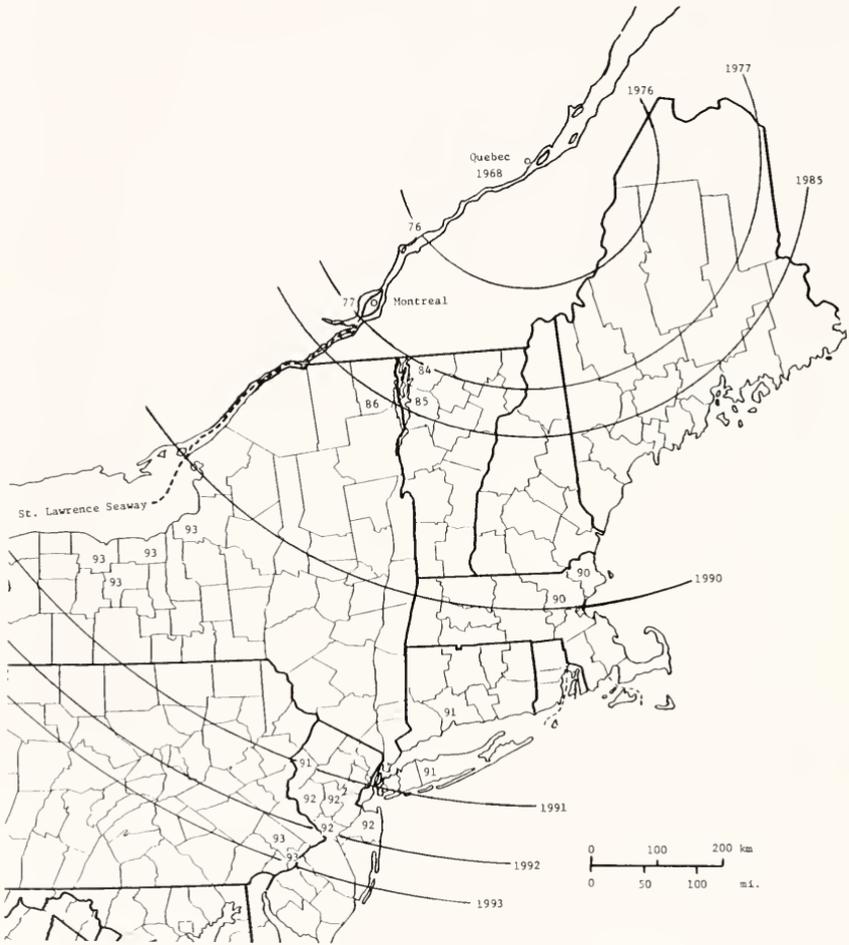


Figure 1. The southward advance of *Propylea 14-punctata* (L.). The number within a county is the year that this species was first detected there. Only "leading edge" county records or new area discoveries are included. The arcs represent maximum dispersion.

Table 1. First recoveries of *Propylea quatuordecimpunctata* (L.) from states and counties in the northeastern United States.

State	County	Date	Collector	Collected on	Sampling method
CT	Fairfield	5/20/92	D. Comboni	roadside	visual
	Hartford	6/17/92	D. Ellis	grasses, weeds	sweep net
	Litchfield	6/14/93	G. Moseley	tomato	pheromone trap
	Middlesex	6/10/93	D. Ellis	alfalfa	sweep net
	New Haven*	8/26/91	D. Ellis	crabapple	Ladd trap
	New London	7/16/92	D. Ellis	alfalfa	sweep net
	Tolland	5/21/92	D. Ellis	alfalfa	sweep net
	Windham	7/16/92	D. Ellis	broccoli	pheromone trap
MA	Berkshire	8/26/93	S. Maisey	alfalfa, weeds	sweep net
	Bristol	6/08/93	D. Fernandez	alfalfa, weeds	sweep net
	Essex	7/30/90	Karen Idoine	sweet corn	visual
	Franklin	9/12/92	A.G. Wheeler <sup>a</sup>	weeds	sweep net
	Hampden	6/25/93	S.A. Maisey	alfalfa	sweep net
	Hampshire	9/18/92	C. Hollingsworth	sweet corn	yellow sticky trap
	Middlesex*	6/19/90	Gary Couch	burdock	visual
	Norfolk	5/22/91	Karen Idoine	<i>Euonymus</i>	visual
	Plymouth	6/08/93	D. Fernandez	alfalfa	sweep net
	Worcester	9/18/92	C. Hollingsworth	sweet corn	yellow sticky trap
ME	Androscoggin	9/13/93	R. Mack	weeds	sweep net
	Aroostook	7/05/89	A.G. Wheeler <sup>a</sup>	speckled alder	branch beating
	Cumberland	7/15/91	D. Barry	sweet corn	sweep net
	Franklin	9/16/93	R. Mack	weeds	sweep net
	Hancock	9/02/93	R. Mack	weeds	sweep net
	Kennebec*	6/07/88	M.P. Tully <sup>b</sup>	raspberry	
	Knox	7/07/92	D. Comboni	weeds	visual
	Lincoln	9/13/93	R. Mack	weeds	sweep net
	Oxford	7/02/93	D. Barry	alfalfa	sweep net
	Penobscot	7/03/89	A.G. Wheeler <sup>b</sup>	hairy vetch	sweep net
	Piscataquis	9/08/93	R. Mack	weeds	sweep net
	Sagadahoc	9/13/93	R. Mack	weeds	sweep net
	Somerset	9/08/93	R. Mack	weeds	sweep net
	Waldo	9/02/93	R. Mack	weeds	sweep net
	Washington	9/07/93	R. Mack	weeds	sweep net
York	7/24/91	D. Barry	sweet corn	sweep net	
NH	Belknap	7/14/93	D. Barry	sweet corn	earworm trap
			N. Smith		
	Carroll	8/11/93	S. Reynolds	alfalfa	sweep net
			J.S. Weaver		
	Cheshire	6/23/93	S. Longsjoe	alfalfa	sweep net
	Coos	8/05/93	L. Wallace	sweet corn	corn earworm trap
	Grafton	9/12/92	A.G. Wheeler <sup>a</sup>	weeds	sweep net
	Hillsborough	6/29/93	S. Reynolds	alfalfa	sweep net
			J.S. Weaver		
Merrimac	6/12/93	A.T. Eaton	weeds	sweep net	
Rockingham	7/10/91	D.S. Chandler	unknown	unknown	

State	County	Date	Collector	Collected on	Sampling method
	Strafford*	6/27/90	J.S. Weaver	alfalfa	sweep net
	Sullivan	7/30/93	D. Barry B. Nelson	sweet corn	corn earworm trap
NJ	Bergen	6/7/93	J. VonderHorst	weeds	sweep net
	Burlington	7/27/93	W. Peaslee	alfalfa	sweep net
	Essex	6/7/93	J. VonderHorst	grass	sweep net
	Hunterdon	6/09/92	H. Crowley	alfalfa	sweep net
	Mercer	5/12/92	R. Chianese	alfalfa	sweep net
	Middlesex	6/09/93	J. VonderHorst	weeds	sweep net
	Monmouth	7/03/92	M. Mayer	weeds	sweep net
	Morris	7/10/92	E. Stern	alfalfa, clover	sweep net
	Passaic	6/03/93	J. VonderHorst	grasses	sweep net
	Somerset	5/29/92	H. Crowley	clover	sweep net
	Sussex	7/16/92	W.H. Day	red & white clov.	sweep net
	Warren*	7/31/91	W.H. Day	alfalfa	sweep net
NY	Albany	9/11/92	A.G. Wheeler <sup>d</sup>	weeds	sweep net
	Clinton*	6/01/86	R.J. Dysart <sup>c</sup>	alfalfa, vetch	sweep net
	Dutchess	7/12/92 <sup>d</sup>	W.H. Day	alfalfa	sweep net
	Essex	6/11/91	Alan Letterman	grass, clover	sweep net
	Franklin	6/07/90	Alan Letterman	vetch	sweep net
	Lewis	8/18/93	J. Knodel	red clover	sweep net
	Monroe	8/05/93	J. Knodel	red clover	sweep net
	Ontario	8/05/93	J. Knodel	red clover	sweep net
	Orange	7/11/92 <sup>d</sup>	W.H. Day	alfalfa	sweep net
	Oswego	8/18/93	J. Knodel	red clover	sweep net
	Putnam	9/19/92	A.G. Wheeler <sup>d</sup>	weeds	sweep net
	Rensselaer	9/11/92	A.G. Wheeler <sup>d</sup>	weeds	sweep net
	Saratoga	9/13/92	A.G. Wheeler <sup>d</sup>	weeds	sweep net
	St. Lawrence	6/13/90	Alan Letterman	clover, vetch	sweep net
	Suffolk	6/26/91	Janet Knodel	sweet corn	visual
	Warren	9/13/92	A.G. Wheeler <sup>d</sup>	weeds	sweep net
	Washington	9/13/92	A.G. Wheeler <sup>d</sup>	weeds	sweep net
	Wayne	7/23/93	J. Knodel	cabbage	pheromone trap
PA	Bucks	7/16/93	R.L. Stewart <sup>c</sup>	alfalfa	sweep net
	Lehigh	8/13/93	R.L. Stewart	alfalfa	sweep net
	Monroe	6/18/93	R.L. Stewart <sup>c</sup>	alfalfa	sweep net
	Montgomery	8/26/93	R.L. Stewart	clover	sweep net
	Northhampton	6/21/93	R.L. Stewart <sup>c</sup>	alfalfa	sweep net
	Philadelphia	6/17/93	Wheeler & Stewart <sup>c</sup>	weeds	sweep net
	Pike*	6/15/93	Wheeler & Stewart <sup>c</sup>	weeds	sweep net
	Wayne	8/31/93	R.L. Stewart	alfalfa	sweep net
RI	Bristol	9/17/92	Lisa Tewksbury	sweet corn	yellow sticky trap
	Newport*	8/14/92	Lisa Tewksbury		pheromone trap
	Providence	9/17/92	Lisa Tewksbury	sweet corn	yellow sticky trap

State	County	Date	Collector	Collected on	Sampling method
VT	Addison	5/20/91 <sup>d</sup>	J. Turmel	alfalfa	sweep net
	Bennington	6/28/93	J. Turmel	alfalfa, clover	sweep net
	Caledonia	7/08/93	J. Turmel	alfalfa, clover	sweep net
	Chittenden	?/?/85 <sup>d</sup>	B.L. Parker <sup>c</sup>	alfalfa	sweep net
	Essex	6/19/93	J. Turmel	alfalfa, clover	sweep net
	Franklin	7/15/93	J. Turmel	alfalfa, clover	sweep net
	Grand Isle*	8/17/84	B.L. Parker <sup>c</sup>	alfalfa	sweep net
	Lamoille	9/20/93	J. Turmel	alfalfa, clover	sweep net
	Orange	5/25/93	J. Turmel	alfalfa, clover	sweep net
	Orleans	7/08/93	J. Turmel	alfalfa, clover	sweep net
	Rutland	9/13/92	A.G. Wheeler <sup>a</sup>	weeds	sweep net
	Washington	9/12/92	A.G. Wheeler <sup>a</sup>	weeds	sweep net
	Windham	9/12/92	A.G. Wheeler <sup>a</sup>	weeds	sweep net
	Windsor	6/28/93	J. Turmel	alfalfa	sweep net

\*First collection in state. This species was first found in the United States in 1984.

<sup>a</sup>Reported in Wheeler, 1993.

<sup>b</sup>Reported in Wheeler, 1990.

<sup>c</sup>Reported in Dysart, 1988.

<sup>d</sup>This is an earlier collection than that cited in Wheeler, 1993.

<sup>e</sup>Personal Communication to W.H.D., from A.G. Wheeler, Jr., 8/93.

Table 2. Foreign aphidophagous Coccinellidae that are now established in eastern North America.

Species	First Collection			Previous	
	Year	State/Prov.	County/Parish	release	Probable entry <sup>m</sup>
<i>Coccinella undecimpunctata</i> L.	1912 <sup>a</sup>	Massachus.	Suffolk	None <sup>h</sup>	Port of Boston
<i>Harmonia quadripunctata</i> (Pontopiddian)	1924 <sup>b</sup>	New Jersey	Passaic	None <sup>h</sup>	New York/New Jersey ports
<i>Propylea quatuordecimpunctata</i> (L.)	1968 <sup>c</sup>	Quebec	Quebec	None <sup>i</sup>	Quebec City port, SLR (St. Lawrence River)
<i>Coccinella septempunctata</i> L.	1973 <sup>d</sup>	New Jersey	Bergen	80km (48mi.) <sup>j</sup>	Ports of Jersey City /Elizabeth, NJ
<i>Hippodamia variegata</i> (Goeze)	1973 <sup>e</sup>	Quebec	L'Assomption	None <sup>k</sup>	SLR, near Montreal
<i>Harmonia axyridis</i> (Pallas)	1984 <sup>f</sup>	Quebec	Shefford	None <sup>i</sup>	Port of Montreal, SLR
	1988 <sup>g</sup>	Louisiana	St. Tammany	360km <sup>l</sup> (215 mi.)	Port of New Orleans

<sup>a</sup>Schaeffer, 1912.<sup>b</sup>Vandenberg, 1990.<sup>c</sup>Chantal, 1972.<sup>d</sup>Angalet and Jacques, 1975.<sup>e</sup>Larochelle, 1979.<sup>f</sup>Gordon, 1987.<sup>g</sup>Chapin and Brou, 1991.<sup>h</sup>No release on record for the U.S.: Clausen *et al.* 1978, Ertle (pers. commun.).<sup>i</sup>No release on record for Canada: Clausen *et al.* 1978, Corbet & Prentice 1971, Sarazin (pers. commun.).<sup>j</sup>112 females released in Hunterdon Co. in 1959 (Ertle, pers. commun.); species not detected here until 1977 (Angalet *et al.* 1979). Also released in Burlington Co. (4,500 females in 1958-59, and 428 females in 1964; this is 117 km/70 mi. from Bergen Co.) but species not detected here until ca. 1978 (estimated from data in Angalet *et al.* 1979).<sup>k</sup>ca. 25 females were released in New Brunswick in 1959-1960, and ca. 65 females in Nova Scotia in 1960 & 1967 (Corbet & Prentice 1971). These locations are far from the 1973 recovery site NE of Montreal (525 km/350 mi. and 750 km/450 mi., respectively), there was no post-release recovery at these locations (Corbet & Prentice 1971), and the very small numbers all make a connection to the 1973 Quebec recoveries (Larochelle 1979) very unlikely.<sup>l</sup>16 females released near Shreveport, LA in 1979 (380 km/230 mi. NW of recovery site) (Ertle, pers. commun.), and ca. 1,900 females near Leland, MS in 1980 (360 km/215 mi. N of recovery site) (Ertle, pers. commun.) *H. axyridis* was not found at either release site through 1990 (Chapin & Brou 1991).<sup>m</sup>Based on absence of nearby (within 167 km/100 mi.) releases for 6 of 7 examples, and data given (j) above for the 7th example.

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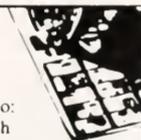
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## THE FEMALE OF *HAYMATUS BLASSUS* (HYMENOPTERA: TENTHREDINIDAE)<sup>1</sup>

David R. Smith<sup>2</sup>

**ABSTRACT:** The female of *Haymatus blassus* is described based on specimens from northern Georgia. The genus and species were described and known from only three males from South Carolina. The female lancet is illustrated.

The genus and species *Haymatus blassus* Smith, were described from three males from Union, South Carolina (Smith, 1979). The female was unknown until recently when specimens were discovered in collections from northern Georgia. The three males on which the original description is based possessed a unique set of characters which set them apart generically from other allantine genera. The females described have the same set of characters but, other than sexual characters, differ from the males in coloration.

*Haymatus* is distinguished from other genera of Allantinae by the following combination of characters:

Forewing with anal crossvein oblique, with 4 cubital cells, and with veins M and Rs+M meeting Sc+R at the same point; hindwing with cell M present, cell Rs absent, petiole of anal cell shorter than cell width or sessile, male without peripheral vein; antenna with 3rd segment subequal in length to 4th, segments beyond 3rd gradually decreasing in length, antennal length more than twice head width; both mandibles bidentate; clypeus truncate; malar space less than half diameter of front ocellus; genal carina absent; propleurae acute on meson; tarsal claw with long inner tooth, without basal lobe; and abdomen black, without paired white spots on dorsum (as in *Empria*).

The genus and species is now known from South Carolina and northern Georgia.

### *Haymatus blassus* Smith

**Female.** – Length, 7.0-7.8 mm. Antenna and head black; clypeus, supraclypeal area, sometimes interantennal area and narrow dorsal margin of antennal sockets, and basal 2/3 mandible pale orange; palpi brownish; apical 1/3 mandible reddish brown. Thorax black with dorsum of pronotum and sometimes upper half of propleuron and mesonotum reddish; metascutellum reddish or black; mesonotal lateral lobe blackish laterally and posterior 1/3 of mesoscutellum slightly blackish. Legs black with outer surface of apical half of forefemur and stripe on outer surface of foretibia pale orange. Abdomen black. Wings darkly and uniformly infuscated; veins and stigma black.

<sup>1</sup> Received April 25, 1994. Accepted May 6, 1994.

<sup>2</sup> Systematic Entomology Laboratory, PSI, Agricultural Research Service, c/o National Museum of Natural History NHB 168, Washington, D.C. 20560.

Antennal length about 2.3X head width; first segment longer than broad; second segment about as broad as long. Lower interocular distance 1.5X eye length; postocellar area 1.5X broader than long. Hindbasitarsus .7X length of following tarsal segments combined. Head and body smooth and shining, covered with white pubescence. Lancet as in Fig. 1. Other characters as for genus.

**Male.** – Length, 5.8 mm. Black with only apex of forefemur and outer surface of foretibia brownish to white. Wings darkly, uniformly infuscated. Genitalia illustrated by Smith (1979, figs. 144, 145).

**Specimens examined.** – GEORGIA: Murray Co., Fort Mountain St. Pk., 27-IV-1985, Scott W. Gross, Scott W. Gross Collection 1990 (1 F); Clarke Co., 200 m, 33°54'N, 83°16'W, 22-29 April 1992, J. Pickering, specimen with scanning label "UGCA 048326" (1 F). Deposited in the National Museum of Natural History, Washington, D.C.

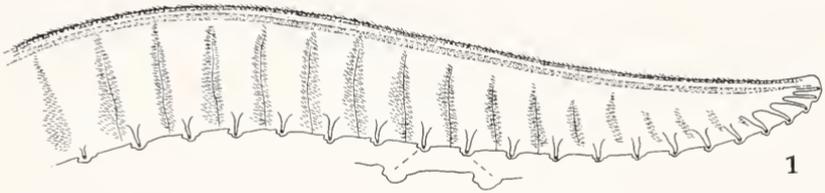


Fig. 1. Lancet of *Haymatus blassus*.

**Discussion.** – The two females differ slightly in coloration as follows: only the supraclypeal area is pale orange or the orange extends to the interantennal area and narrowly on the dorsal margin of the antennal sockets; the propleuron is black or the upper half is reddish and lower half black; and the metascutellum is dark reddish or black.

#### ACKNOWLEDGMENTS

John Pickering, University of Georgia, Athens, kindly allowed study of the specimen from his collections and granted permission to deposit it in the U.S. National Museum of Natural History. I extend thanks to the following for review of the manuscript: Henri Goulet, Biological Resources Division, Agriculture Canada, Ottawa; Nathan Schiff, Bee Research Laboratory, USDA, Beltsville, Maryland; and S. Nakahara and D. A. Nickle, Systematic Entomology Laboratory, USDA, Beltsville, Maryland, and Washington, D.C., respectively.

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**A NEW SPECIES OF *PARALEPTOPHLEBIA*  
FROM TENNESSEE  
(EPHEMEROPTERA: LEPTOPHLEBIIDAE)<sup>1</sup>**

**Boris C. Kondratieff, Richard S. Durfee<sup>2</sup>**

**ABSTRACT:** A distinctive new species of mayfly, *Paraleptophlebia kirchneri*, is described and illustrated from Trousdale County, Tennessee. The adult male of the new species is easily distinguished from all other North American species by the long penis lobes with a ventral-subterminal, forked appendage.

The genus *Paraleptophlebia* in North America presently includes 36 species (Edmunds *et al.* 1976, Harper and Harper 1986, and Robotham and Allen 1988). The taxonomy of the northeastern and southeastern [geographic subdivisions after Edmunds *et al.* (1976)] species are relatively well known because of the excellent taxonomic studies of Berner (1975), Burks (1953), and Traver (1935). Using the combination of abdominal color and genitalic differences, adult males can be readily identified using existing keys (Traver 1935, Burks 1953).

Recently, collecting in northcentral Tennessee revealed the presence of a distinctive new species that is described herein. The terminology follows Traver (1935).

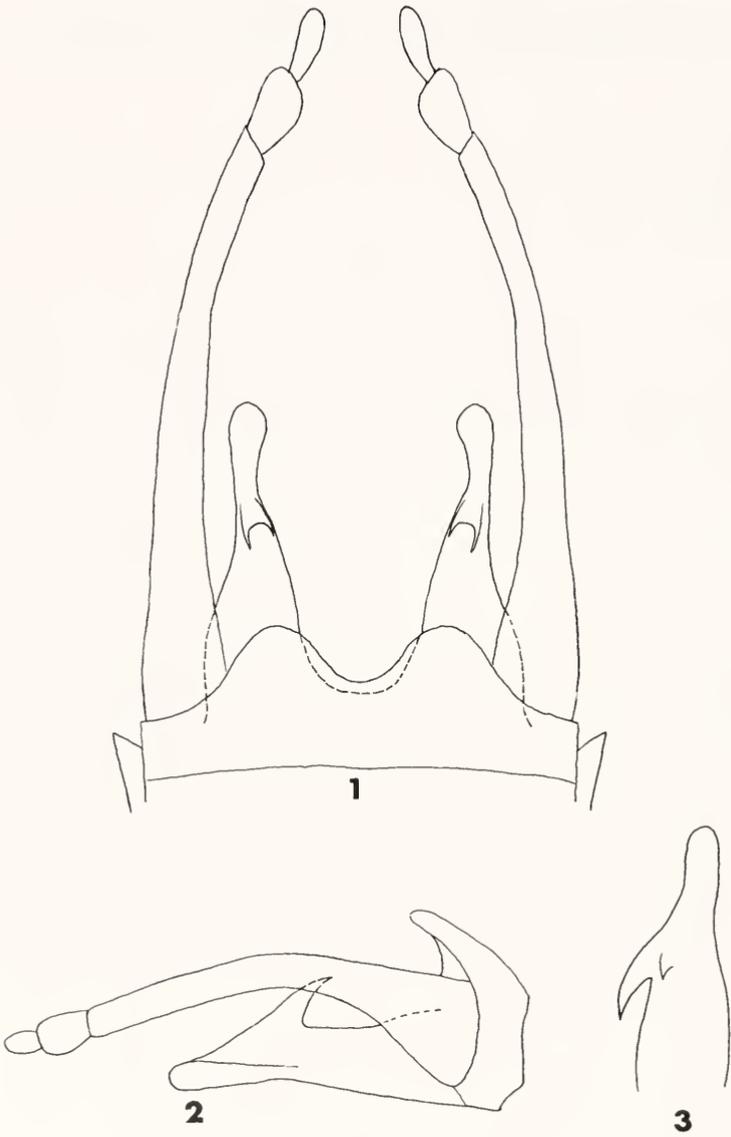
***Paraleptophlebia kirchneri*, NEW SPECIES**

**Male imago** (in alcohol): Length of body and forewing 6 mm. Head and thorax dark red-brown with darker markings on thoracic pleural folds. Legs light brown. Wings hyaline, longitudinal veins light brown, crossveins colorless. Slight milky cloud in stigmatic area. Tergite 1 dark brown, tergites 2-6 white, each with narrow black posterior transverse band and posterolateral mark. Tergites 8-10 brown. Sternites 2-7 hyaline white. Sternites 8-9 stained with brown. Midventral ganglionic marks orange on all sternites. Genital forceps white, penes light brown. Each penis lobe long with a ventral-subterminal, slightly sclerotized, forked appendage, the outer tooth longer (Figs. 1-3). Caudal filaments white.

**Female imago** (in alcohol): Length of body 7 mm, forewing 6.5 mm. Head and thorax dark brown. Legs light brown. Wings hyaline, longitudinal veins and crossveins light brown. Abdominal segments brown with purple-black shading along posterior margin of tergites. Posterior margin of abdominal sternum 9 with a deep broadly rounded excavation.

<sup>1</sup> Received May 6, 1994. Accepted May 31, 1994.

<sup>2</sup> Colorado State University, Department of Entomology, Fort Collins, Colorado 80523.



Figs. 1-3. *Paraleptophlebia kirchneri*, holotype. 1. Ventral view of penes and forceps; 2. Lateral view of penis lobe and forceps; 3. Oblique view of left penis lobe.

**Etymology:** The patronym honors the aquatic biologist and good friend, Ralph Fred Kirchner. The senior author has traveled many thousands of miles with Fred in search of species of mayflies, stoneflies and caddisflies.

**Material Examined:** *Holotype*, male imago, Tennessee: Trousdale County, tributary to Second Creek, Crenshaw Road, 9 April 1994, B. C. Kondratieff and R. F. Kirchner. Paratype female, same data as holotype.

The holotype and paratype will be deposited in the U.S. National Museum of Natural History, Washington, D.C.

**Diagnosis:** The shape and armature of the penes of *P. kirchneri* are not similar to those of any other described North American species. The long penis lobes with a ventral-subterminal, forked appendage, with the outer tooth longer, is unique to the genus (Figs. 1-3).

**Remarks.** Other species of mayflies collected with *P. kirchneri* were *Acentrella carolina* (Banks) and *Stenonema femoratum* (Say). Additionally, *Helopicus rickeri* Stark, a rare species of stonefly (Perlodidae) occurs at the type locality.

#### ACKNOWLEDGMENTS

We thank Howard E. Evans and Howard Rhodes, Colorado State University for prepublication reviews. Charles H. Nelson, University of Tennessee at Chattanooga, guided the senior author to this area of Tennessee.

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## A NEW SYNONYM IN *HYDROPTILA* (TRICHOPTERA: HYDROPTILIDAE)<sup>1</sup>

Steven C. Harris<sup>2</sup>, David E. Etnier<sup>3</sup>

A recent status survey in Tennessee of *Hydroptila decia* Etnier and Way (1973) for possible protection under the Endangered Species Act prompted the examination of a similar species, *H. choco loco* Harris (1985) from northern Alabama (Etnier 1993). *Hydroptila decia* is known from Ten-Mile Creek, the type locality, and Fourth Creek in western Knox County, Tennessee while *H. choco loco* is recorded from Choco loco Creek, Calhoun County, the type locality, and Little Coon Creek, Jackson County, Alabama (Harris 1991). A comparison of paratypes of *H. decia* with those of *H. choco loco* found only minor differences and the species are thus determined to be synonyms, with *H. decia* having priority.

Apparent differences in the ventral view of the inferior appendages and subgenital plate in the original descriptions are attributed to the orientation of the drawings; *H. decia* being turned somewhat caudoventrally. What appear to be differences in the shape of the posterior margin of the tenth tergum presumably resulted from slightly different clearing methodologies. The holotypes of both species are deposited in the National Museum of Natural History, Smithsonian Institution.

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<sup>1</sup> Received March 30, 1994. Accepted May 24, 1994.

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## **FARRODES (EPHEMEROPTERA: LEPTOPHLEBIIDAE) IN THE ANTILLES: NEW SPECIES FROM PUERTO RICO AND REVIEW OF THE GENUS<sup>1</sup>**

C. R. Lugo-Ortiz, W. P. McCafferty<sup>2</sup>

ABSTRACT: *Farrodes taino*, n. sp. (Ephemeroptera: Leptophlebiidae) is described from larvae collected from the central mountainous region of Puerto Rico. The species is compared to *F. grenadae* and *F. hyalinus*, the other Antillean species known from larvae. *Farrodes taino* can be distinguished from these species by the presence of six oblong pale markings on the vertex, the crown-like pattern of the pronotum, the complex abdominal color pattern, and the presence of blackish apical markings on each femur. A key is provided to differentiate the three species.

Peters (1971) erected the genus *Farrodes* (Ephemeroptera: Leptophlebiidae) to include *F. bimaculatus* Peters and Alayo, *F. grenadae* Peters, and *F. hyalinus* Peters. These species are known from Cuba, Grenada, and Jamaica, respectively. *Farrodes grenadae* and *F. hyalinus* are known from the larval and adult stages, whereas *F. bimaculatus* is known from the adult stage only (Peters 1971). Larvae pertaining to the genus can be distinguished by the presence of long, slender gills on abdominal segments 1-7; the distinct denticulation of the tarsal claws, with the apical denticle being much larger than others; the presence of five denticles on the anteromedian emargination of the labrum; and the presence of a V-shaped ridge near the ventral, inner anterolateral margin of the maxillae. Adults of *Farrodes* can be distinguished by the presence of a symmetrically forked MP vein in the forewings; the vein  $ICu_1$  not attaching to veins  $CuA$  or  $CuP$ ; dissimilar tarsal claws (one hooked, the other pad-like); and the styliiger plate of the male adult being deeply cleft apically and extending posteriorly dorsal to the forceps.

Savage (1987) indicated that *Farrodes* is closely related to the South American genera *Homothraulius* Demoulin and *Simothraulopsis* Demoulin, but did not provide detailed phylogenetic data to establish these relationships. Peters (1988) indicated that *Farrodes* evolved in South America and later moved northward, but failed to provide phylogenetic data for his conclusion. In any case, on the basis of the scant information available, the genus appears to have originated in South America (see also McCafferty *et al.* 1992) when the continent became isolated during the Eocene (54-38 mya) and extended northward after North and South America reunited during the Pliocene (5-2 mya). Its radiation in the Antilles is most likely the consequence of continuous dispersal and isolation among the islands during and after the Eocene.

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As part of a continuing effort to document the Ephemeroptera fauna of the Neotropics (Lugo-Ortiz and McCafferty 1993, 1994a, 1994b; McCafferty and Lugo-Ortiz 1992, 1994), we here describe a distinct, new species of *Farrodes* based on larval material collected from the central mountainous region of Puerto Rico. We compare this species to *F. grenadae* and *F. hyalinus*, the other members of the genus known also from the larval stage, and provide a key for their differentiation. The material upon which this study is based is housed in the Purdue Entomological Research Collection (PERC), West Lafayette, Indiana.

***Farrodes taino* Lugo-Ortiz and McCafferty, NEW SPECIES**

**Larva** (Fig. 1). Body length: 4.0-5.8 mm; caudal filaments: 8.0-10.5 mm. Head: Coloration yellow brown, suffused with black markings. Area surrounding antennae and beneath compound eyes suffused with black. Area between ocelli with black band. Area surrounding compound eyes pale yellow-brown. Vertex with six pale brown oblong marks. Antennae pale yellow-brown to pale yellow, 2.0-2.5x length of head capsule. Thorax: Color yellow-brown to medium brown. Pronotum marginally suffused with black spots, with medial V-shaped black mark, and with seven to eight short, simple setae anterolaterally. Mesonotum yellow-brown medially, suffused with black laterally, especially anterolaterally. Metanotum yellow-brown. Sterna pale yellow-brown to yellow-brown. Pleura suffused with black. Legs pale yellow-brown; anterior faces of coxae and trochanters with row of five to six small, simple setae; femora with many long, simple setae dorsally and short, simple setae ventrally, with setae of intermediate length on anterior and posterior faces, and small black markings distally on anterior face; tibiae with row of very fine, long, simple setae dorsally and robust, simple setae of medium length ventrally, and with branched setae on anterior face; tarsi with row of fine, simple setae dorsally and seven to ten short, robust, simple setae ventrally; tarsal claws with 14-17 denticles, becoming progressively larger distally (distal denticle largest). Abdomen: Color yellow-brown with black markings; terga 1-10 with blackish band posteriorly, almost 1/3 length of each tergum; terga 4-6 often with submedian pale triangle; remaining terga variable in color pattern, sometimes with two anterior submedian black spots. Sterna pale yellow brown to yellow-brown, often with sublateral black to brown dash. Caudal filaments yellow-brown; terminal filament longer than cerci.

**Adult.** Unknown.

**Material.** Holotype: Female larva, PUERTO RICO, Maricao, Salto Curet, Sector Orama, VI-2-1992, C. R. Lugo-Ortiz, deposited at PERC. Paratypes: 21 female and five male larvae, same data and deposition as holotype.

**Etymology.** This species is named after the Taino Indians who originally inhabited Puerto Rico.

**Remarks.** *Farrodes taino* was taken in the central mountainous region of Puerto Rico. It was collected from stream riffle areas at water temperatures of 21°-24°C.

The new species differs from *F. hyalinus* and *F. grenadae* by the presence of six distinct oblong markings on the vertex, the crown-like color pattern of the pronotum, the presence of small black markings on the anterior face of each femur, and the complex color pattern of the abdomen (Fig. 1).

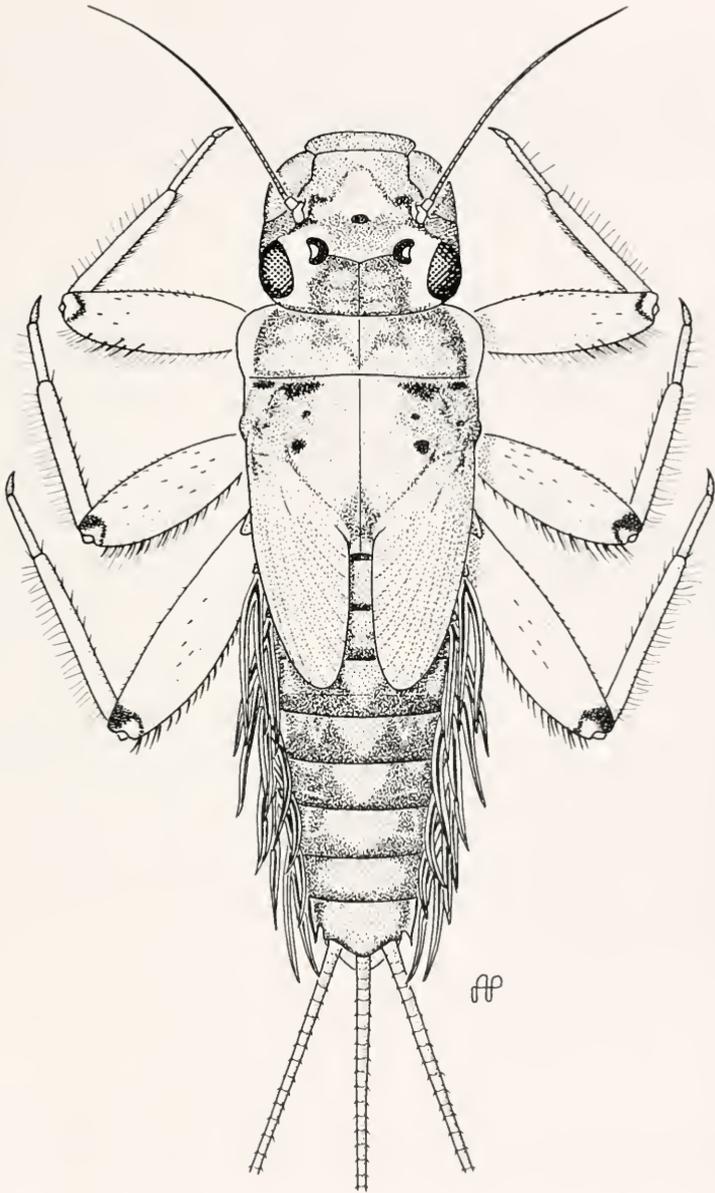


Fig. 1. *Farrodes taino*, new species, female larva, dorsal view.

KEY TO THE KNOWN LARVAE OF *FARRODES* FROM THE ANTILLES

1. Abdominal terga 1-8 uniformly brown; fore- and midfemora entirely pale;  
 Grenada . . . . . *grenadae*  
 – Abdominal terga 1-8 patterned; fore- and midfemora with apical markings . . . . . 2  
 2(1) Abdominal tergum 5 with narrow pale medial marking, tergum 6 with subtriangular  
 medial pale marking, terga 7-8 with narrow anterior and posterior brown margins, tergum  
 9 pale with two submedial brown markings, tergum 10 pale [Figure 211: Peters (1971)];  
 fore- and midfemora with brown apical markings; Jamaica . . . . . *hyalinus*  
 – Abdominal terga as in Figure 1; fore-, mid-, and hindfemora with dark apical markings;  
 Puerto Rico . . . . . *taino*

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## NEW RECORDS OF IMMIGRANT BARK BEETLES (COLEOPTERA: SCOLYTIDAE) IN NEW YORK: ATTRACTION OF CONIFER-FEEDING SPECIES TO ETHANOL-BAITED TRAP LOGS<sup>1</sup>

E. Richard Hoebeke<sup>2</sup>

**ABSTRACT:** A 1993 survey for the recently detected pine shoot beetle, *Tomicus piniperda*, in New York, conducted by Division of Plant Industry field personnel, New York State Department of Agriculture and Markets, has yielded specimens of two other non-indigenous bark beetles (Scolytidae). Trap logs of *Pinus sylvestris* and *P. resinosa*, baited with 95% ethanol, were placed at 100 sites across New York state, particularly in high risk areas. Pine shoot beetle was collected at 12 sites in 5 counties of western New York. *Pityogenes bidentatus*, a Palearctic species first detected in North America in New York in 1989, was trapped at two new localities in western New York. The European *Hylastes opacus*, known previously in North America from a single locality on Long Island, New York, was trapped at 32 sites in 22 counties throughout the state. Localities for all new records are listed and plotted on distribution maps. North American interception records, native distribution, economic importance, and diagnostic features for *H. opacus* are provided, and an existing key to North American *Hylastes* is modified to include this new adventive member of the fauna. Data on relative abundance are provided for other species of conifer-feeding bark beetles that were trapped, which included: *Dendroctonus terebrans*, *Dendroctonus valens*, *Dryocoetes autographus*, *Gnathotrichus materiarius*, *Hylastes porculus*, *Hylurgops rugipennis pinifex*, *Ips grandicollis*, *Ips pini*, *Orthotomicus caelatus*, *Pityophthorus* sp. prob. *puberulus*, and *Polygraphus rufipennis*.

The pine shoot beetle, *Tomicus piniperda* (L.), was first detected in North America in Ohio in 1992, and is now established in at least 106 counties in six states of the U.S. (Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York) and in southern Ontario of Canada (Wheeler 1993; unpublished data). In response to the threat of this imported Old World forest pest, the Division of Plant Industry, New York State Department of Agriculture and Markets, initiated a trapping survey to determine its current distribution.

As a result of *ad hoc* federal and state surveys for pine shoot beetle, various sites in at least 10 counties of western New York are now known to be infested, 8 of which were added in 1993 (see Map 1). Federal regulatory efforts continued in 1993 with delimiting surveys near known infested areas and detection surveys around selected high-risk ports of entry.

### MATERIALS AND METHODS

The 1993 pine shoot beetle survey in New York was conducted during a 10-12 week period – from egg laying (mid-March) to adult pre-emergence

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from galleries (early to mid-June) – using trap logs baited with 95% ethanol. Traditional trap trees (felled) and trap logs have been used successfully in Europe for well over a century for monitoring and, in some instances, controlling populations of economically important bark beetles.

Two hundred logs (3-6" diam., 24" long) cut from Scotch pine (*Pinus sylvestris* L.) and red pine (*P. resinosa* Aiton) were obtained from the New York State Department of Environmental Conservation. One trap log of each pine species was placed in suspect sites at 100 locations throughout the state. These sites were situated primarily along Lake Erie, Lake Ontario, the St. Lawrence Seaway, the Hudson River waterways, Long Island, and also at a few inland sites. The sites that were selected were primarily unmanaged or poorly managed stands of Scotch pine, generally 12-20 feet high, including overgrown Christmas tree areas, reforestation plantings, windbreaks, shelterbelts, or wildlife plantings (Div. Plant Industry Memorandum, dated March 19, 1993). A 35mm plastic film container, containing polyester cotton fill saturated with 95% ethanol, was placed between and touching both trap logs at each site. This bait container, with the top lid securely snapped on, was placed top down on the ground.

Beginning in mid- to late-June 1993 for each of the trap sites, Division of Plant Industry field personnel stripped the bark from the trap logs on site, and extracted and placed all adult beetles in vials with isopropyl alcohol. Each vial was labelled with the appropriate site number (Inspector #-County #-Township #) and date of collection. Vials of specimens were sent to the author, who mounted, labelled, and identified all specimens; these are deposited in the Cornell University Insect Collection.

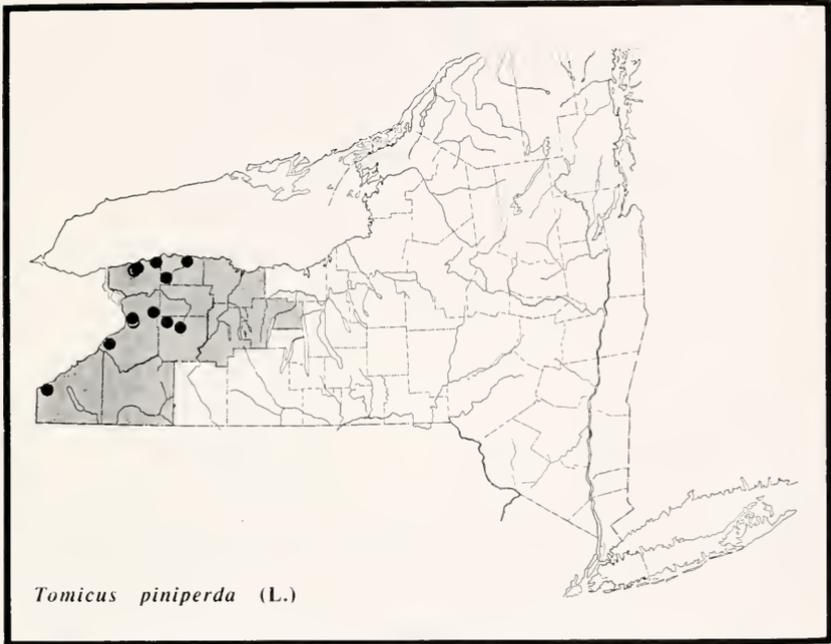
## RESULTS: RECORDS OF IMMIGRANT BARK BEETLES IN NEW YORK

A total of 1,772 adults, predominantly bark beetles (Scolytidae) (96%), were extracted from baited trap logs placed at 80 sites in 33 counties of New York State in early 1993. Although 100 sites were selected, samples were examined from only 80 sites due to loss from vandalism by man and wildlife, and other factors. The significant findings of this trap survey are summarized below. All bark beetles species collected and identified from the survey are listed in Table 1.

### *Tomicus piniperda* (L.)

No new counties were added to the known list of infested counties of western and central New York, but specimens of pine shoot beetle were extracted from baited trap logs at 12 sites in 5 counties (see Map 1) within the infested range of the species in New York.

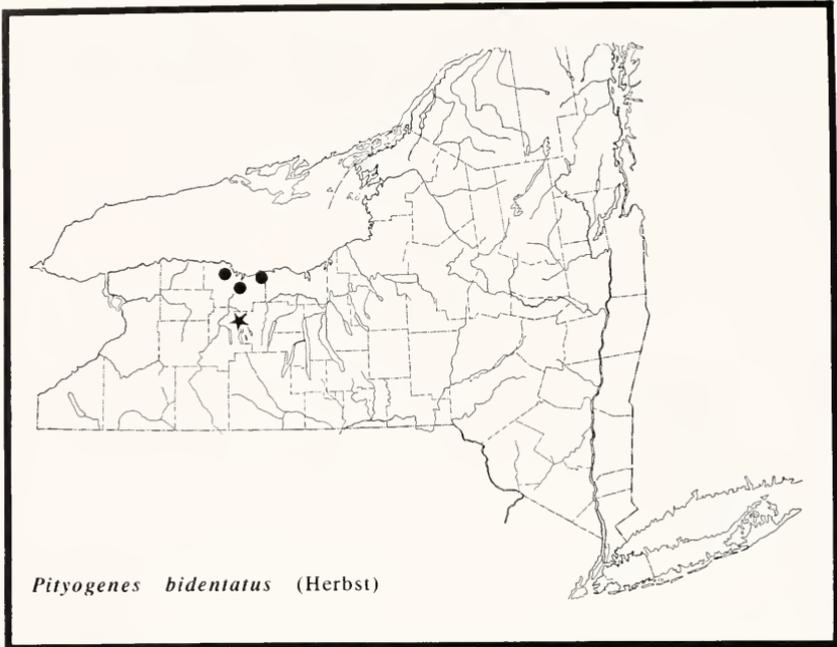
These sites (counties and townships) are: *Chautauqua Co.*, Ripley; *Erie Co.*, Alden, Brant, Orchard Park, West Seneca; *Niagara Co.*, Newfane (2 different sites), Somerset; *Orleans Co.*, Carlton, Shelby; and *Wyoming Co.*, Bennington, Orangeville.



Map 1. Known New York distribution of *Tomicus piniperda* (L.); shaded area  denotes known infested counties and solid circles ( ● ) = new records reported herein.

### *Pityogenes bidentatus* (Herbst)

This adventive scolytid, known in the European literature as the two-toothed bark beetle, was originally recorded in North America from Livingston Co. (Lima), New York, collected under bark of Bosnian pine (*P. leucoderma*) in a nursery (Hoebeke 1989). Another North American record has come to the attention of the author: Brighton (Monroe Co.), New York (a suburb of Rochester), taken from Austrian pine (*P. nigra*) at a private residence in 1992 (E. R. Hoebeke, unpubl. data). Additional specimens of *P. bidentatus* were extracted from trap logs at 2 sites in Monroe County (Parma and Webster) during 1993. These additional records clearly indicate establishment of this Palearctic bark beetle in New York (see Map 2).



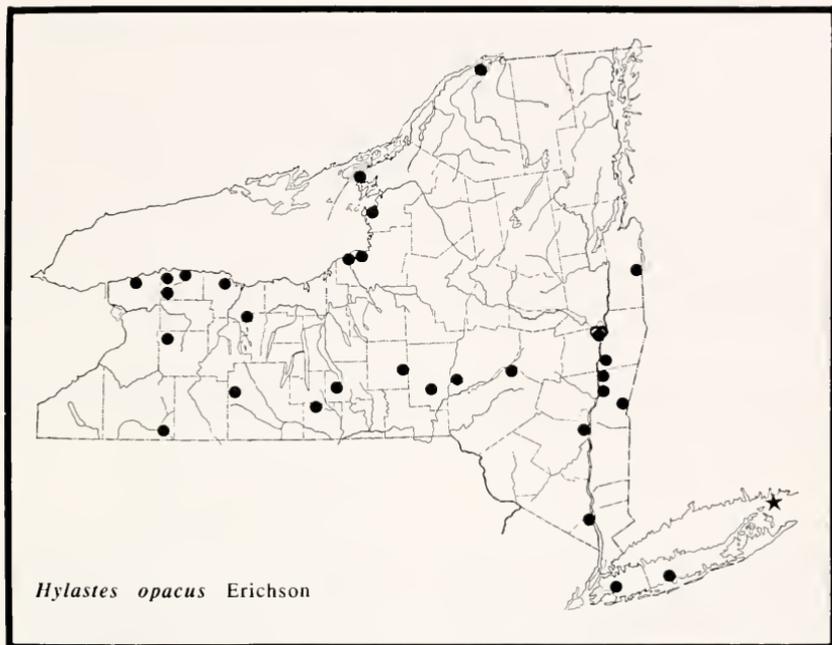
Map 2. Known North American distribution of *Pityogenes bidentatus* (Herbst); Solid star ( ★ ) = original detection record and solid circles ( ● ) = new records reported herein.

### *Hylastes opacus* Erichson

The only North American record of this Palearctic species is based on a series of specimens collected by T. W. Phillips near the eastern tip of Long Island on Fisher's Island, Suffolk Co., New York, 23 May 1989, from an *Ips* pheromone trap (Wood 1992).

The 1993 trapping survey for pine shoot beetle yielded specimens of *H. opacus* from 32 sites in 22 counties across New York State (see map 3).

The new locality records (counties and townships) for this immigrant bark beetle are (in alphabetical order by county): *Albany Co.*, Albany City (two different sites), Colonie; *Cattaraugus Co.*, Olean; *Chemung Co.*, Veteran; *Chenango Co.*, Oxford; *Columbia Co.*, Hillsdale, Kinderhook, Stockport; *Cortland Co.*, Cincinnatus; *Delaware Co.*, Harpersfield; *Jefferson Co.*, Cape Vincent, Henderson; *Montiøe Co.*, Mendon, Parma; *Nassau Co.*, Hempstead; *Niagara Co.*, Newfane; *Orleans Co.*, Carlton, Shelby, Yates; *Oswego Co.*, Oswego, Scriba; *Otsego Co.*, Butternuts; *Rensselaer Co.*, East Greenbush; *Rockland Co.*, Stony Point; *St. Lawrence Co.*, Massena; *Steuben Co.*, Hornellsville; *Suffolk Co.*, Islip; *Tompkins Co.*, Newfield; *Ulster Co.*, Kingston; *Washington Co.*, Salem; and *Wyoming Co.*, Bennington.



Map 3. Known New York distribution of *Hylastes opacus* Erichson. Solid star ( ★ ) = original detection record and solid circles ( ● ) = new records reported herein.

Additional locality records for *H. opacus* in the northeastern United States are reported in a companion paper by Rabaglia and Cavey (1994).

For nearly a 10-year period, 1978-1987, specimens of *H. opacus* were occasionally intercepted at major U.S. ports of entry. At least 5 interception records are documented in the "List of Intercepted Plant Pests," compiled by the U.S. Department of Agriculture. All specimens found during inspection were associated with pine dunnage (*Pinus* spp.) originating in various European countries (Belgium, Germany, and Great Britain), and destined for U.S. entry points (Ohio, Oklahoma, Tennessee, and South Carolina). During 1939-1977, *H. opacus* was not found during inspection at U.S. ports.

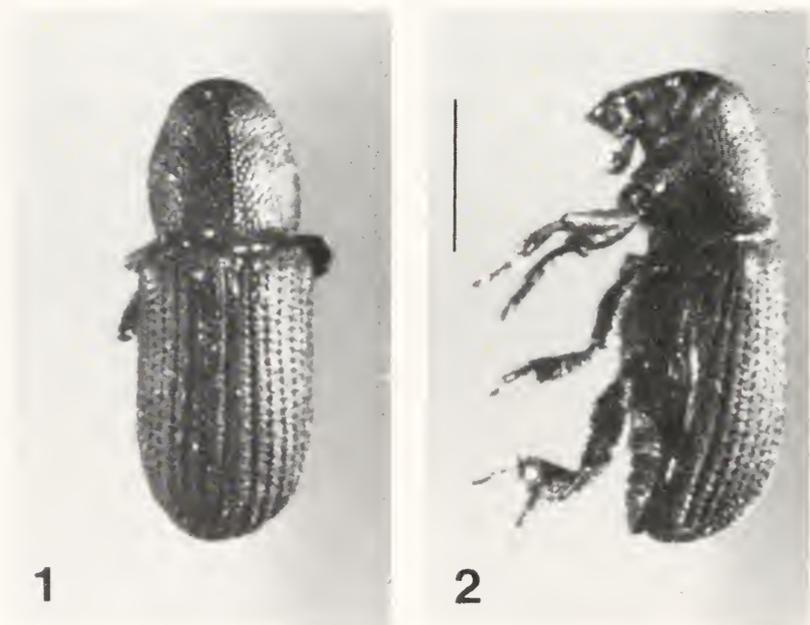
*Hylastes opacus*, widely distributed in the Palearctic region, breeds in the bark of stumps or at the bases of unhealthy *Pinus* spp., chiefly Scotch pine (*P. sylvestris*). It occasionally infests the bark of other conifers (Browne 1968). Because adults will feed on the tender bark near the root collars of seedlings and transplants, often girdling them, the species is frequently considered a noxious pest of nurseries and pine plantations, not only killing small plants but

exposing older trees to infestation by wound parasites such as *Fomes* (Basidiomycetes, Polyporales: Polyporaceae) (Browne 1968).

The genus *Hylastes* Erichson is generally confined to the Holarctic region, with 15 species occurring throughout the coniferous forests of North and Central America south to Honduras. An additional dozen or more species are found in the coniferous forests of north Africa, Europe, and Asia (Wood 1982).

*Hylastes opacus* (Figs. 1-2) can be distinguished from most North American members of the genus (except for *H. exilis* Chapuis and *H. tenuis* Eichhoff, see key below) chiefly on the basis of its small size and certain other structural features. Adults are generally 3.0 mm or smaller (range 2.5-3.0 mm) and are recognized by the following combination of characters:

Frons without longitudinal carina; frons and vertex closely and coarsely punctured; pronotum as long as wide and constricted anteriorly; interstriae flat, wider than striae; elytral declivity with erect setae; and body black, with antennae and legs reddish brown and elytra dull.



Figs. 1-2. *Hylastes opacus*. 1, dorsal habitus. 2, lateral habitus. Scale line = 1.0 mm.

Couplet #3 of Wood's (1982) key to the species of *Hylastes* of North and Central America is modified here to facilitate identification of *H. opacus*.

(Couplets 1-2 unmodified).

3(2). Pronotum quadrate, as long as wide, distinctly constricted anteriorly (Fig. 1); interstriae, at least at base, wider than striae, flattened, each bearing a slightly confused row of fine setiferous granules; adventive in eastern United States (New York); 2.5-3.0 mm . . . . . **opacus** Erichson

– Pronotum slightly elongate, approximately 1.2 times as long as wide, widest on basal half, sides weakly arcuate, broadly rounded anteriorly; interstriae, at least at base, as wide as striae, feebly convex, each bearing a uniseriately or slightly confused row of fine to large, rounded, setiferous granules . . . . . 3a

3a Frons and vertex punctured, interspaces smooth to feebly granulate, median groove feebly indicated or absent; California and Hidalgo to Maryland and Florida; 2.0-2.5 mm . . . . . 2. **tenuis** Eichhoff

Frons and vertex devoid of punctures, coarsely, closely granulate, lower half usually with a conspicuous median sulcus; Texas to North Carolina and Florida; 2.3-2.7 mm . . . . . 3. **exilis** Chapuis

(Couplet 4 and remaining couplets unmodified).

The native *H. porculus* Erichson also occurs commonly in the eastern United States, but it differs from *H. opacus* by its much larger size (3.9-5.3 mm) and the presence of a sharply elevated median carina on the frons.

Aspects of the biology, habits, and life history of *H. opacus* and other *Hylastes* spp. occurring in Europe are reviewed by Munro (1926), Chararas (1962), and Scott and King (1974).

## DISCUSSION

The rate at which exotic bark beetles are being transported by commerce to establish breeding populations in the United States is becoming a matter of increasing concern. In fact, during 1985-1991 alone, at least 13 species of non-indigenous Scolytidae have become established in the United States (Wood and Bright 1992).

The many exotic bark beetles that are apparently slipping through this country's "first line of defense"—port inspection and quarantine—are jeopardizing North American agriculture and forestry. In addition to the pine shoot beetle (*Tomicus piniperda*), there are other economically important bark beetles that have high potential to become established (Marchant and Borden 1976). Examples include such major pest species as the spruce bark beetle, *Ips typographus* (L.); the red-haired pine bark beetle, *Hylurgus ligniperda* (F.); and the Mediterranean pine engraver, *Orthotomicus erosus* (Wollaston).

In January 1993, the Northeast Exotic Pest Survey Committee (NEPSC), concerned with the prospect that other foreign bark beetles might become established without our knowledge, "selected, researched, and recommended exotic bark beetle pests for a 1994 survey ..." (Cavey 1993). Several economically important species, including those mentioned above, were chosen for this survey, based primarily on interception records (most frequently intercepted pests) at U.S. ports of entry for the past 20 years. United States interception lists of bark and ambrosia beetles demonstrate the ease and frequency with which these pests can enter new ranges and habitats. The mainly wood-boring habits of these beetles make them difficult to detect and allow them to be easily introduced (Marchant and Borden 1976).

The New York trapping survey exceeded its primary objective of detecting populations of the pine shoot beetle. It also resulted in extensive additional records for one of the Palearctic black pine beetles, *Hylastus opacus* – demonstrating its long-term establishment in New York and elsewhere in the Northeast (see Rabaglia and Cavey 1994). Additional records for *Pityogenes bidentatus* also were obtained in western New York from the trap log survey.

Although harmful introductions fluctuate, the cumulative number of foreign non-indigenous species in the United States is climbing steadily and swiftly – creating an increasing economic and environmental burden (Anonymous 1993). If the inevitable is true – that foreign pest species *will* find entry

Table 1. Adult conifer-feeding Scolytidae collected during a 1993 trap log survey for pine shoot beetle, *Tomicus piniperda* (L.), in New York<sup>a</sup>.

Species	No. of Specimens	No. of Sites	Endemic	Adventive
<i>Dendroctonus terebrans</i> (Olivier)	1	1	•	
<i>Dendroctonus valens</i> LeConte	1	1	•	
<i>Dryocoetes autographus</i> (Ratzeburg)	49	14	• <sup>1</sup>	
<i>Gnathotrichus materiarius</i> (Fitch)	2	2	•	
<i>Hylastes opacus</i> Erichson	117	32		•
<i>Hylastes porculus</i> Erichson	4	2	•	
<i>Hylurgops rugipennis pinifex</i> (Fitch)	710	53	•	
<i>Ips grandicollis</i> (Eichhoff)	6	6	•	
<i>Ips pini</i> (Say)	28	6	•	
<i>Orthotomicus caelatus</i> (Eichhoff)	699	43	•	
<i>Pityogenes bidentatus</i> (Herbst)	39	2		•
<i>Pityophthorus</i> sp. pb. <i>puberulus</i> (LeC.)	1	1	•	
<i>Polygraphus rufipennis</i> (Kirby)	9	4	•	
<i>Tomicus piniperda</i> (L.)	36	12		•

<sup>a</sup> Trap logs consisted of Scotch and red pine; 80 sites in 33 counties throughout New York were sampled (see Materials and Methods).

<sup>1</sup> Holarctic (North American coniferous forests, and northern Europe and Asia).

into this country – then a logical response is for more extensive and more thorough surveys designed to detect introduced species. One of the superior tools for detecting scolytids, as well as for monitoring their distribution and population density, is the use of baited traps. Various trap designs such as stovepipe, barrier, flight intercept, Lindgren multiple-funnel, and Theysohn baited with conifer monoterpenes, and/or ethanol, or pheromone components, are effective in sampling for populations of conifer-feeding bark beetles. The traditional trap trees and logs are also still used for sampling. The United States is especially prone to foreign introductions because of large volume in international trade in agriculture and forest products. States therefore should take the initiative to support and implement these systematic surveys in areas of high risk.

#### ACKNOWLEDGMENTS

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#### EDITOR'S NOTE

The above paper and the following paper are published 'back to back', but separately, because the three authors, quite independently and nearly at the same time, discovered new North American distributional data for the immigrant bark beetle, *Hylastes opacus*. In each case, data were developed from separate sources: one from a comprehensive trap log survey in New York, the other from *Ips* pheromone-baited Lindgren funnel traps in Maine and Vermont. The authors involved decided it would be more appropriate to publish each paper separately rather than joining them into one manuscript.

H.P.B.

## NOTE ON THE DISTRIBUTION OF THE IMMIGRANT BARK BEETLE, *HYLASTES OPACUS*, IN NORTH AMERICA (COLEOPTERA: SCOLYTIDAE)<sup>1</sup>

Robert J. Rabaglia<sup>2</sup>, J. F. Cavey<sup>3</sup>

**ABSTRACT:** The Palearctic bark beetle, *Hylastes opacus*, was first recorded for North America in 1989 from a single location near Long Island, New York. This paper reports *H. opacus* from Maine, New Hampshire, Vermont, West Virginia, and central New York. This black pine bark beetle was detected in Maine and Vermont in *Ips* pheromone-baited Lindgren funnel traps in 1993, in alpha-pinene baited traps in New Hampshire in 1994, and an ethanol baited trap in West Virginia in 1994. Additional specimens were identified from an earlier collection in New York. These records extend the known range of *H. opacus* in North America from New York to northern New England and south to West Virginia..

The palearctic bark beetle, *Hylstes opacus* Erichson occurs in the "pine belts" of Asia and Europe (China, Japan, Korea, Austria, Belgium, Bulgaria, Denmark, England, Finland, France, Germany, Greece, Norway, Poland, Sweden, Switzerland and USSR) (Wood and Bright 1992). The species has also become established in pine plantations of South Africa (Wood 1992).

Wood (1992) reported the first North American record of *H. opacus*, from a series collected on Fisher's Island, Suffolk County, New York, in May, 1989 by T. W. Phillips. Based on the circumstances of the collection, Wood (1992) concluded that the *H. opacus* was established at this site.

The Fisher's island collection consisted of 12 specimens in a pheromone trap. The island is devoid of native pines, with only one potential host for *H. opacus* – ornamental plantings of Japanese black pine, *Pinus thunbergiana* Franco. (T.W. Phillips, pers. commun., Feb. 1994).

In 1993, we detected specimens of *H. opacus* from Vermont and Maine while screening trap samples from a Cooperative Agricultural Pest Survey (CAPS) for exotic bark beetles in the Northeastern United States. These records extend the known geographic range for *H. opacus* in North America to the northeast from New York to New England (Figure 1). Specific collection data area as follows:

**Maine:** Waldo Co., Lincolnville, 6/V/1993, R. Mack Collector, four specimens and **Vermont:** Washington Co., Plainfield, 5/VI/1993, M. Michaelis Collector and Washington Co., Graniteville, 3/VI/1993, M. Michaelis Collector, single specimens.

<sup>1</sup> Received June 9, 1994. Accepted July 12, 1994.

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All collections were from Lindgren funnel traps baited with Ipslure (ipsdienol, methylbutanol and cis-verbenol). Specimens were identified using Balachowsky (1949) and by comparison to European material in the Eggers Collection at the U.S. National Museum (USNM).

After reviewing the new England specimens, the senior author identified a series of *H. opacus* he collected from a cut stump of *Pinus sylvestris* L. in **New York**: Oneida Co., Woodgate, 27/IV/1987. This Oneida County record is additional to 1993 collections of *H. opacus* reported from 22 New York counties by Hoebeke 1994.

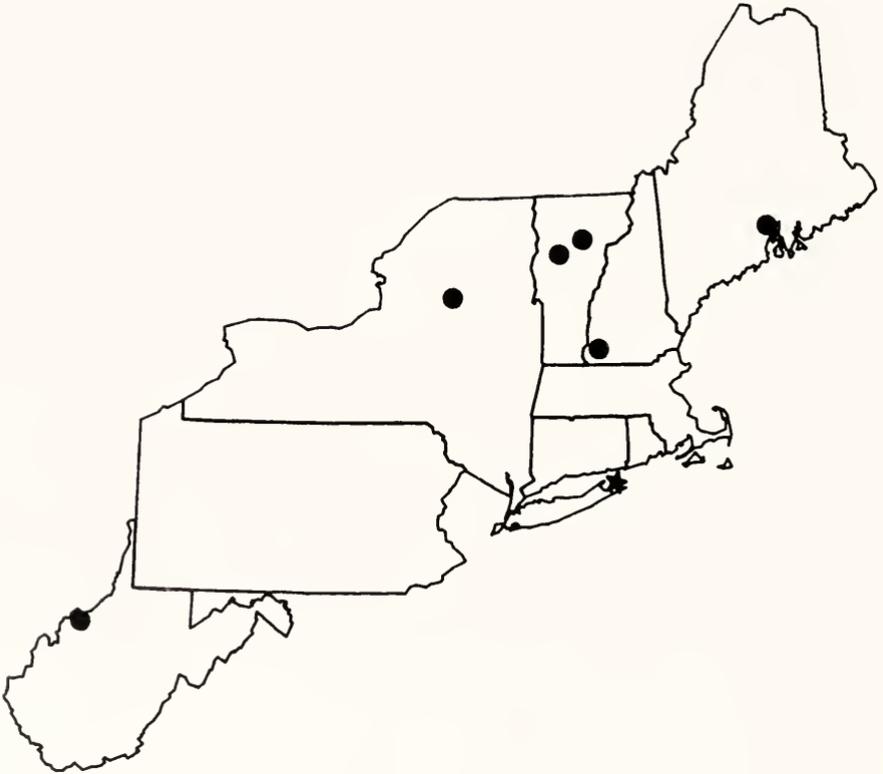


Figure 1. Collection records of *Hylastes opacus*: Star – first collection in North America (Wood 92); Closed circles – new state and county records reported in this paper.

During the review period for the manuscript we learned of the following records of *H. opacus*: from **New Hampshire**: Cheshire Co., Keene, 14-22/IV/1994, J.S. Weaver and S. Longsjoe collectors, in pine shoot beetle trap baited with alpha-pinene (identified by Dr. Donald E. Bright, Agriculture Canada, Ottawa, Canada). **West Virginia**: Wood Co., Parkersburg, 1-8/VI/1994, R. A. Meyers collector, in ethanol-baited Lindgren funnel trap (identified by Dr. Steven L. Wood, Brigham Young University, Provo, UT).

One specimen from Maine and one from New York are deposited in the USNM Insect Collection.

#### ACKNOWLEDGMENTS

We thank Natalia J. Vandenberg, USDA, Agricultural Research Service, Systematic Entomology Laboratory (ARS-SEL), Washington D.C. and Donald M. Anderson, USDA-ARS-SEL (retired) for assistance in using the USNM collections and library; Richard Mack, Maine Pest Survey Coordinator, Maine Cooperative Extension Service, Orono, and Mark Michaelis, USDA-APHIS-PPQ, Berlin, Vermont, for collecting the specimens; John S. Weaver, Department of Entomology, University of New Hampshire, Durham, for contributing the New Hampshire state record; R. A. Meyers, West Virginia Department of Agriculture, for contributing the West Virginia record; and E. Richard Hoebeke, Cornell University, Ithaca, New York and Charles L. Staines, Maryland Department of Agriculture, Annapolis for reviewing an earlier draft of this note.

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## STATUS OF SOME SPECIES NAMES OF EUCERINE BEES (HYMENOPTERA: APOIDEA) PROPOSED BY LEPELETIER IN 1841<sup>1</sup>

Wallace E. LaBerge<sup>2</sup>

**ABSTRACT:** The purpose of this work is to make known the existence of Lepeletier types of American eucerine bees, selection of lectotypes of three species and designate the synonymy of these four names with American species of *Melissodes* and *Florilegus*. *Macrocera philadelphica* Lepeletier and *M. pensylvanica* Lepeletier are synonymized with *Melissodes agilis* Cresson, *Macrocera americana* Lepeletier is synonymized with *Melissodes desponsa* Smith, and *Macrocera cajennensis* Lepeletier is synonymized with *Florilegus festivus* (Smith).

This paper is the result of the discovery of type material of four eucerine bees described by Lepeletier in 1841 in the Latreille-Dejean-Lepeletier material in the Hope Entomological Collection of the University Museum at Oxford, England, by D. B. Baker. These specimens are all in poor or very poor condition and Mr. Baker could not determine them to species using modern references (LaBerge, 1956, 1961; Mitchell, 1962). Mr. Baker kindly loaned the material to the author for study and comparison with fresh material available in the collections of the Illinois Natural History Survey. Lepeletier (1841, pp. 92, 94, 97 and 110) placed these four names in the genus *Macrocera*. LaBerge (1961, p. 654) considered them to be *nomina dubia*, since the types were unknown to him and were not discovered during a visit to Europe in 1957 including a visit to the Hope Collection.

Of the four species named by Lepeletier, one (*Macrocera pensylvanica*) was described from a single male specimen and that specimen was labeled as holotype by Mr. Baker. Three species were described from at least two specimens each and I have chosen the least damaged and most recognizable specimen as the lectotype for each name and so labeled it. Three of the Lepeletier names should be placed in the genus *Melissodes* and the fourth in the genus *Florilegus*. The names *pensylvanica* and *philadelphica* are both synonymous with *Melissodes agilis* Cresson and the name *americana* is synonymous with *Melissodes desponsa* Smith, whereas the name *cajennensis* is synonymous with *Florilegus festivus* (Smith). The resulting synonymies are given below.

<sup>1</sup> Received June 23, 1994. Accepted July 5, 1994.

<sup>2</sup> Center for Biodiversity, Illinois Natural History Survey, Champaign, Illinois.

### 1. *Melissodes pensylvanica* (Lepeletier), 1841, (NEW COMBINATION).

*Macrocera pensylvanica* (sic) Lepeletier, 1841. Hist. Nat. Ins. Hymen., 2:97.

*Macrocera philadelphica* Lepeletier, 1841, *supra cit.*, 2:110 (NEW SYNONYMY).

*Melissodes Agilis* Cresson, 1878, Proc. Acad. Nat. Sci. Philadelphia, 30:204 (NEW SYNONYMY).

The male holotype of *pensylvanica* is in delicate condition. It has been hollowed out by dermestid larvae, the face eaten away and the left antenna missing. The legs and wings are complete and the right antenna partially eaten away. The metasoma and mesosoma appear to be complete.

The lectotype male of *philadelphica* has also been damaged by dermestid larvae which entered through the posterior part of the mesosoma so that most of the propodeum and metanotum and the legs of the right side are missing. Also missing are the antennae and the right compound eye. The remainder of the bee is intact and most key characters are visible. The other syntype available of *philadelphica* is lacking a metasoma, most of the prosoma and most of the appendages.

### 2. *Melissodes americana* (Lepeletier), 1841 (NEW COMBINATION)

*Macrocera americana* Lepeletier, 1841, *supra cit.* 2:92.

*Melissodes desponsa* Smith, 1854, Cat. Hymen. British Mus., Pt. 2, Apidae, p. 310 (NEW SYNONYMY)

The lectotype male of *americana* has had a dermestid larva enter its thorax through the ventral part between the hind coxae. The left leg is missing and the left femur half eaten away but still intact. All legs have lost at least the last two or all of the disitarsi and only the scape remains of the left antenna. The rest of the specimen is in fair shape and there can be no doubt about its identity. The second syntype of *americana* is in much worse condition and cannot be easily recognized.

### 3. *Florilegus cajennensis* (Lepeletier), 1841 (NEW COMBINATION).

*Macrocera cajennensis* Lepeletier, 1841, *supra cit.* 2:94.

*Teralonia festiva* Smith, 1854, Cat. Hymen. British Mus., Part 2, p. 304 (NEW SYNONYMY).

*Florilegus festivus*, Moure and Micheneer, 1955, Dusenica, 6:270.

The male lectotype of *cajennensis* has a complete head, thorax, legs and wings but lacks all but the basal tergum of the metasoma. The second specimen of *cajennensis* referred to me by Mr. Baker is a female specimen and the hind leg (right leg missing) is provided with abundant dark scopal hairs. This specimen is not part of the type series, as Lepeletier did not describe the

Two of the above species, *M. agilis* Cresson and *M. desponsa* Smith, are very common species in eastern North America and these names have been applied many times in the literature for more than 130 years. The Lepeletier names, on the other hand, have not been applied to any species since their description in 1841 with one exception. Dr. G. O. Hendrickson (1930) lists *Melissodes pennsylvanicus* Lep. in his work on the insect fauna of Iowa prairies. The bees involved were probably named for him by Grace Sandhouse of the Division of Insect identification of the U. S. Bureau of Entomology who is mentioned in the acknowledgments of Hendrickson's paper. Considering these circumstances, the author will apply to the International Commission on Zoological Nomenclature to preserve the junior synonyms and to reject and make unavailable the senior synonyms (the Lepeletier names) which apply to the two *Melissodes*. The last species listed above, *Florilegus cajennensis* (Lepeletier), should retain the senior synonymy since the junior synonym *festivus* has been used only a few times in the literature in recent years.

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***EPHACERELLA*, A REPLACEMENT NAME FOR  
*ACERELLA* ALLEN, 1971 (EPHEMEROPTERA),  
NEC BERLESE, 1909 (PROTURA)<sup>1</sup>**

J. Paclt<sup>2</sup>

**ABSTRACT:** *Acerella* Allen is a preoccupied name in zoology and, therefore, is nomenclaturally unavailable. *Ephacerella* nom. nov. is proposed as a replacement name.

Among new ephemerellid taxa described in 1971 from Asia, the late Richard K. Allen established the subgenus *Acerella* as a new division of *Ephemerella*, with the type-species *E. longicaudata* Ueno. In two more recent papers (Allen 1984, 1986) the subgenus *Acerella* was raised to the rank of genus.

A homonymous *Acerella* Berlese exists in the proturan family Acerentomidae. This genus-group taxon was established by Berlese in 1909 as a subgenus of *Acerentulus* Berlese, 1908, with the type-species *Acerentulus tiarneus* Berlese. *Acerella* Berlese is now generally recognized as a distinct genus. A number of authors (Tuxen 1964, Rusek 1974, Nosek 1978) believe *Acerella* belongs in the old family Acerentomidae. Others would split that family into a number of minor families or subfamilies including Acerellidae for *Acerella* (Yin 1987, Dallai *et al.* 1990).

*Acerella* Allen, 1971, being a junior homonym of *Acerella* Berlese, 1909, a replacement name for the ephemerellid mayfly is herein proposed in accordance with ICZN Art. 60.

**Order Ephemeroptera  
Family Ephemerellidae  
Subfamily Ephemerellinae**

***Ephacerella*** nom. nov. pro *Acerella* Allen, 1971 as subgenus of *Ephemerella* Walsh, 1862, preoccupied name.

**Etymology.** Derived from Eph(emeroptera) and *Acerella*. Gender feminine.

**Distribution.** According to Allen 1986, the genus includes only three East Asiatic species from Japan and Vietnam.

<sup>1</sup> Received May 12, 1994. Accepted August 17, 1994.

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## SCIENTIFIC NOTE

**PROPOSED REPLACEMENT NAME FOR *HYDROPTILA SETIGERA*  
(TRICHOPTERA: HYDROPTILIDAE)<sup>1</sup>**

S.C. Harris<sup>2</sup>

In a 1986 paper on microcaddisflies from Alabama (J. Kansas Entomol. Soc. 59:610), I described a new species of *Hydroptila*, as *H. setigera*, unaware that this specific epithet was used by Alice Wells in her description of a new *Hydroptila* from New Guinea (Australian J. Zool. 32:271, 1984). *Hydroptila setigera* Harris, 1986 is thus a homonym and must be renamed. I here propose the name *cottaquilla* as a replacement name for *H. setigera* Harris, 1986. The name is taken from Cottaquilla Mountain which is near the type locality. The type specimen from Calhoun County, Alabama is deposited in the National Museum of Natural History, Smithsonian Institution.

<sup>1</sup> Received March 30, 1994. Accepted May 24, 1994.

<sup>2</sup> Department of Biology, Clarion University, Clarion, PA 16214, U.S.A.

## BITING MIDGES REARED FROM LARVAL HABITATS CONTAINING *CULICOIDES VARIIPPENNIS* (DIPTERA: CERATOPOGONIDAE) IN NEW ENGLAND<sup>1</sup>

Frederick R. Holbrook<sup>2</sup>, William L. Grogan, Jr.<sup>3</sup>

**ABSTRACT:** During a survey conducted in New England for larval *Culicoides variipennis*, the larvae of several other species of Ceratopogonidae were found occupying the same habitats. The collections of *Dasyhela mutabilis*, *C. trivisi* and *Bezzia nobilis* represent first records of association of these species with *C. variipennis*.

*Culicoides variipennis* (Coquillett) has been described as a species complex of from two to five subspecies (Wirth and Jones 1957; Atchley 1967; Downes 1978). While *C. variipennis* s.l. has been implicated as the principal vector of a number of pathogens of vertebrates, most notably the bluetongue (Price and Hardy 1954) and epizootic hemorrhagic disease viruses (Jones *et al.* 1977) of ruminants, and of *Onchocerca cervicalis*, a filarid parasite of horses (Collins and Jones 1978), it is probable that only one or two of the ssp. are important vectors of these pathogens. For instance, the distribution of bluetongue virus transmission in the U.S. (Metcalf *et al.* 1981; Pearson *et al.* 1992) corresponds to the range proposed for only one of the ssp., *C. v. sonorensis* Wirth and Jones (Walton *et al.* 1992; Tabachnick and Holbrook 1993).

As part of a long-term study to elucidate the *C. variipennis* complex, a survey was conducted in the six new England States in 1992 (FRH, unpublished). Larvae (and sometimes pupae) typical of the Ceratopogonidae were identified in mud contaminated with animal feces in waste water sites on dairy farms. Mud samples containing larvae were shipped to the laboratory in Laramie, WY, and the larvae were held in rearing media as previously described (Jones *et al.* 1969). Upon emergence, adults of species other than *C. variipennis* s.l. were preserved in 70% ethanol and subsequently cleared in phenol-alcohol and mounted on microscope slides in phenol-balsam (Wirth and Marston 1968). Identifications of these *Culicoides* were made using the wing atlas of Wirth *et al.* (1985), the keys and illustrations in Blanton and Wirth (1979), and by comparison with specimens in the synoptic collection of WLJG. Voucher specimens are deposited in the collection at the Arthropod-borne Animal Dis-

<sup>1</sup> January 18, 1994. Accepted July 26, 1994.

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eases Research Laboratory (ABADRL), Laramie, Wyoming, with duplicates retained by WLG.

### Subfamily *Dasyheleinae*

#### *Dasyhelea mutabilis* (Coquillett)

NEW HAMPSHIRE: Belknap Co., New Hampton, 20-VII-1992, 1 ♀  
VERMONT: Chittenden Co., Richmond, 5-VIII-1992, Farr, 1 ♀

Comments.— This is a common widespread Nearctic species which has been reared by B. Brookman from Poso Creek and Bakersfield, Kern County, California (Wirth 1952), by R. Jones from the sandy margin of a stream in Rusk County, Wisconsin, and by H. Jamnback and W. Wirth from salt marshes on Long Island, New York (Vaughan and Wirth 1976).

This is apparently the first record of this species being reared in association with *C. variipennis*. Since larvae of *Dasyhelea* do not actively swim like those of *Culicoides*, but crawl slowly on or in their substrate (Mullen and Hribar 1988), they may not have been in direct competition with the larvae of *C. variipennis*. Furthermore, the larvae of *C. variipennis* are often found on the surface of the mud, particularly when feeding at night (Vaughan and Turner, 1989). However, Hribar and Mullen (1991) reported that larvae of *Dasyhelea* sp. collected from algae, rotting vegetation and treeholes and *C. variipennis* collected from soil near horse and cow manure and sewage lagoons in Alabama both contained diatoms, fungal hyphae and oligochaete setae in their guts.

### Subfamily *Ceratopogoninae*

#### Tribe *Culicoidini*

#### *Culicoides crepuscularis* Malloch

CONNECTICUT: Litchfield Co., Sharon, 29-IV-1992, 5 ♂♂. MAINE: Aroostook Co., Island Falls, 15-IX-1992, 5 ♂♂, 1 ♀; Oxford Co., Bethel, 2-IX-1992, 6 ♂♂, 8 ♀♀; South Paris, 2-IX-1992, 16 ♂♂, 14 ♀♀, Penobscot Co., Kenduskeag, 10-IX-1992, 22 ♂♂, 23 ♀♀; Washington Co., Cherryfield, 24-IX-1992, 42 ♂♂, 31 ♀♀. MASSACHUSETTS: Worcester Co., Berlin, 4-VI-1992, 2 ♀♀. NEW HAMPSHIRE: Belknap Co., New Hampton, 20-VII-1992, 7 ♂♂, 2 ♀♀; Cheshire Co., Walpole, 30-VI-1992, 5 ♂♂, 2 ♀♀; Coos Co., Milan, 1-IX-1992, 18 ♂♂, 9 ♀♀. VERMONT: Addison Co., Middlebury, 4-VIII-1992, 1 ♂; Caledonia Co., Groton, 29-VII-1992, 3 ♂♂, 2 ♀♀; Sheffield, 11-VIII-1992, 6 ♂♂, 4 ♀♀; Chittenden Co., Richmond, 5-VIII-1992, 1 ♂; Franklin Co., Sheldon, 17-VIII-1992, Stebbins, 8 ♂♂, 6 ♀♀; Orleans Co., Troy, 8-VIII-1992, Jacobs, 2 ♀♀; Washington Co., Berlin, 12-VII-1992, Burke, 1 ♂, 1 ♀; Windham Co., Rockingham, 16-VI-1992, Stickney, 7 ♂♂, 6 ♀♀.

Comments.— This common and widespread Nearctic species breeds in a variety of wet habitats and was also found in association with *C. variipennis* in Texas in household septic effluent by Jones (1959). Blanton and Wirth

(1979) summarized the known breeding sites from which this species has been reared as follows: pond margins, puddles at stock tank overflows, septic tank overflows, fresh and salt marshes, rainfilled roadside ditches, seepage areas, cattle hoofprints in marshy meadows, lagoon margins, marshy drainage ditches, sewage lagoon effluent, edges of temporary and permanent ponds, edges of hog ponds, and freshwater stream margins.

*Culicoides haematopotus* Malloch

VERMONT: Washington Co., Berlin, 12-VIII-1992, Burke, 1 ♂.

Comments.—This common and widespread Nearctic species breeds in a variety of freshwater habitats summarized in Blanton and Wirth (1979) and Mullen and Hribar (1988). Interestingly, although Wirth and Bottimer (1956) reared this species in association with *C. variipennis* in Texas, they never reared it from sites where pollution was extensive.

*Culicoides trivialis* Vargas

VERMONT: Windham Co., Rockingham, 16-VI-1992, 1 ♀.

Comments.—This moderately common species occurs in the eastern two-thirds of the United States and extreme southern Ontario and Quebec. It emerges in late spring to early summer and is typically reared from stream and pond margins, usually in woody situations (Blanton and Wirth 1979). This is apparently the first record of this species being reared with *C. variipennis*.

**Tribe Palpomyiini**

*Bezzia nobilis* (Winnertz)

MAINE: Aroostook Co., Washburn, 16-IX-1992, 2 ♀♀; Oakfield, 15-IX-1992, 8 ♂♂, 11 ♀♀; Oxford Co., Bethel, 2-IX-1992, 2 ♂♂. NEW HAMPSHIRE: Belknap Co., New Hampton, 20-VII-1992, 1 ♂. RHODE ISLAND: Washington Co., Hope Valley, 28-V-1992, 1 ♂, 1 ♀.

Comments.—This is perhaps the most common and wide ranging species of *Bezzia*, found throughout most of the Nearctic, Neotropical and Palearctic regions (Wirth 1983). The larvae are predaceous and occur in a variety of freshwater habitats, most often in association with filamentous algae. To our knowledge, *B. nobilis* has not previously been reported occurring with *C. variipennis*, and we consider it likely that its larvae prey upon that species.

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## FUNGAL HOST RECORDS FOR SPECIES OF *TRITOMA* (COLEOPTERA: EROTYLIDAE) OF AMERICA NORTH OF MEXICO<sup>1</sup>

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**ABSTRACT:** A summary of the host fungi for the 11 species of North American *Tritoma* is provided. Most species have clear host preferences, with varying degrees of specificity. Life histories are discussed, including a comparison of larval and adult host relationships.

In 1991, we published a comprehensive list of the host preferences of the Erotylidae of America, north of Mexico (Skelley, Goodrich & Leschen 1991). During the past three years, as a result of recent fieldwork in preparation of Part III of our "Illinois Erotylidae", a large amount of additional host data has been collected for the genus *Tritoma*, including additional larval rearings. These data, together with that reported earlier, are presented here. This list reflects the current classification of host fungi.

Members of the genus *Tritoma* Fabricius feed on a variety of macro-Basidiomycetes. Adults are often found in numbers on fresh basidiocarps and sometimes several species of adults are found on one basidiocarp. The duration of the three larval instars is brief in all species which have been reared. Pupation occurs in the ground adjacent to the host. All species reared transformed to adults without an extended quiescent period in either larval or pupal stages. The adult stage appears to be the longest lived.

As noted in our earlier study (Skelley *et al.*, 1991), museum specimens have been of limited value in this research. Thus the majority of the records presented here are based on our recent fieldwork and rearing studies.

### RESULTS

Data from 3,634 specimens are included in this paper; 1,808 of these are from collections made by the authors since 1991. In the following list of host fungi for the genus *Tritoma* north of Mexico, beetles are listed in phylogenetic order according to Boyle (1956) and by their currently accepted names. See Boyle (1956) and Goodrich & Skelley (1991) for lists of *Tritoma* synonyms.

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Host records are reported under each beetle species in the following format:

**Beetle name**

A,B      Fungus name

        Fungus synonymy

Names of host fungi are recorded in the currently accepted combination; synonyms are indented under the currently accepted name. When host records were found in the literature, they are cited in brackets [ ]. Numbers in the code to the left (A,B) represent the number of beetles seen from that host: A = number of collections; B = number of adult beetles and/or larvae taken (ie: a citation of "3,15" means that beetle has been taken on that host 3 times with a total of 15 specimens collected). An asterisk, \*, before a host name indicates that larvae have been collected from that host and/or that the beetle has been reared from the fungus. Larval records are included only where the larvae have been positively identified.

Specimens studied are deposited in the Spooner-Riegel Insect Collection at Eastern Illinois University or in those of the individuals and institutions listed in the acknowledgments.

## DISCUSSION

Our new data substantially increases the number of known hosts for both adults and larvae of *Tritoma* spp., although in many species host preferences are similar to our earlier data (Skelley, *et al.* 1991).

Our earlier conclusions (Skelley, *et al.* 1991) regarding host preferences in species group *sanguinipennis* and species group *humeralis* are confirmed, although some niche overlap is found in both adults and larvae between *T. mimetica* and *T. sanguinipennis*.

Larval hosts continue to be more restricted than adult hosts. This may be due to fewer collections of larvae, because of their relatively short period of development, but we believe it is more likely due to a higher degree of adult ovipositional specificity. On numerous occasions, we have observed adults of several species on a single sporocarp. Yet, when larvae are present in these situations, almost without exception, they prove to be of a single species. This suggests that competitive exclusion is much more a factor among the larvae than the adults.

Some species show unexpected hosts or host overlap in a few records. For example: rearings of *T. biguttata affinis* from a member of the Boletaceae, or rearing of *T. mimetica* from *Boletus* sp. These apparent inconsistencies may be due to the beetles' utilization of an acceptable host in the absence of a preferred one.

## LIST OF SPECIES

*Tritoma* Fabricius 1775Species group *humeralis**Tritoma biguttata affinis* Lacordaire 1842

- 1,18 *Amanita bisporigera*  
 1,4 *Amanita caesarea*  
 2,60 \* *Amanita excelsa*  
 9,89 \* *Amanita rubescens*  
 1,3 *Amanita subsolitaria*  
 1,1 *Amanita vaginata*  
 1,1 *Amanita verna*  
 2,7 *Amanita virosa*  
 12,73 \* *Amanita* sp.  
 2,3 *Armillaria tabescens*  
 1,6 \* *Boletaceae*  
 1,5 *Leptiota* or *Amanita* sp.  
 1,11 *Luecoagaricus naucinus*  
 1,3 *Phylloporus rhodoxanthus*  
 2,3 *Russula* sp.

*Tritoma biguttata biguttata* (Say 1825)

- 1,1 *Agaricus* sp.  
 1,1 *Amanita bisporigera*  
 1,7 *Amanita citrina*  
 1,1 *Amanita flavorubescens*  
*Amanita muscaria* [Weiss & West 1921]  
*Amanita phalloides* [Moennich 1944:1,4]  
 7,453 \* *Amanita rubescens* [Weiss & West 1921]  
*Amanita solitaria* [Moennich 1939:1,1]  
*Amanita strobiliformis* [Chantal 1979; Boyle 1956]  
 1,20 *Amanita vaginata*  
 3,37 *Amanita* sp.  
 1,11 *Armillaria mellea* [Chantal 1979; Boyle 1956]  
 1,1 *Armillaria tabescens*  
*Armillaria* sp. [Weiss & West 1920]  
*Collybia* sp. [Weiss & West 1922]  
*Lactarius piperatus* [Moennich 1939:1,1]  
*Oligoporus tephroleucus*  
*Polyporus lacteus* [Weiss & West 1921]  
*Russula* sp. [Weiss & West 1922]

*Tritoma aulica* (Horn 1871)

No host data available

*Tritoma humeralis* Fabricius 1801

- 1,7 *Amanita bisporigera*  
 2,16 *Amanita vaginata*  
*Amanitopsis vaginata*  
 6,34 *Armillaria mellea*  
 5,43 \* *Armillaria tabescens*  
*Clitocybe maxima* [Weiss & West 1920]  
 1,1 *Collybia dryophila*  
 1,1 *Collybia* sp.  
 1,12 *Mycena galericulata*  
 1,1 *Polyporus alveolaris*  
*Favolus alveolaris*  
 8,53 \* *Polyporus arcularius*  
 2,10 *Polyporus radicans* [Chantal 1979; Boyle 1956]  
 2,114 \* *Polyporus squamosus*  
 1,2 *Polyporus* sp.  
 1,1 *Shizopora paradoxa*  
 1,1 *Xeromphalina* sp.

*Tritoma atriventris* LeConte 1847

- 1,3 *Amanita* sp.  
 2,3 *Armillaria mellea*  
 13,133 \* *Armillaria tabescens*  
*Carduus* sp. [Boyle 1956]  
 1,45 *Clitocybe clavipes*  
 1,8 \* *Lentinus dentosus*  
 2,2 *Meripilus giganteus*  
 1,216 \* *Omphalotus olearius*,  
 2,3 *Oudemansiella radicata*  
 1,1 *Pluteus cervinus* ?  
 1,12 \* *Pluteus* sp.  
 2,5 *Polyporus alveolaris*  
 6,35 \* *Polyporus arcularius*

*Tritoma erythrocephala* Lacordaire 1842

- 1,11 *Amanita vaginata*  
*Amanitopsis vaginata*  
 2,26 \* *Armillaria tabescens*  
 1,22 \* *Lentinus dentosus*  
 1,1 *Marasmius* sp.  
 2,12 \* *Omphalotus olearius*

- Tritoma angulata* Say 1826  
 1,1 *Armillaria tabescens*  
 1,1 *Lactarius arguillaceifolius*  
 1,2 *Lactarius insulus*  
 21,116 \* *Lactarius piperatus* [Moennich  
 1939:1,3]  
 2,15 \* *Lactarius subvellereus*  
 1,1 *Lactarius thejogalus*  
 1,1 *Lactarius volemus* [Moennich  
 1939:1,5]  
 2,69 \* *Lactarius* sp.  
 4,14 *Russula aeruginea*  
 1,2 *Russula albidula*  
 1,3 *Russula compacta*  
 2,3 *Russula crustosus*  
 1,4 *Russula (emetica?)*  
 1,2 *Russula (foetens?)*  
 2,6 *Russula mariae*  
 1,2 *Russula paludosa*  
 1,9 *Russula subalbida*  
 1,3 *Russula xerampelina*  
 22,670 \* *Russula* sp.
- Tritoma unicolor* Say 1826  
*Calvatia craniformis* [Boyle 1956]  
 1,5 *Hypholoma* sp. [Boyle 1956]  
 2,2 *Omphalotus illudens*  
*Clitocybe illudens* [Boyle  
 1956]  
 5,142 \* *Omphalotus olearius*  
 1,2 Tricholomataceae
- Tritoma tenebrosa* Fall 1912  
 No host data available.
- Tritoma mimetica* (Crotch 1873)  
 1,2 *Amanita fulva*  
 1,1 *Amanita vaginata*  
 3,5 *Armillaria mellea*  
 1,37 \* *Boletus* sp.  
 1,1 *Marasmius* sp.  
 1,1 \* *Pluteus cervinus*  
 1,16 \* *Polyporus alveolaris*  
 7,206 \* *Polyporus radicans*  
 4,36 \* *Polyporus squamosus*  
 1,1 *Polyporus* sp.  
 1,1 *Tricholomopsis platyphylla*  
 1,1 *Xerula furfuracea*  
*Oudemensiella furfuracea*  
 [Skelley, et al 1991]
- 14,83 *Xerula radicata*  
*Oudemensiella radicata*  
 [Skelley, et al 1991]  
*Collybia radicata* [Froeschner  
 & Meinert 1953]  
 9,29 *Xerula rugosoceps*
- Species group *sanguinipennis*
- Tritoma sanguinipennis* (Say 1825)  
*Amanita phalloides* [Moennich  
 1944:1,1]  
 19,162 *Polyporus alveolaris*  
*Favolus alveolaris*  
*Favolus canadensis*  
 [Boyle 1956]  
*Hexagenia alveraris* [Boyle 1956]  
 31,193 \* *Polyporus arcularius*  
 3,14 *Polyporus badius*  
 1,4 *Polyporus radicans*  
 2,5 *Polyporus squamosus*  
 3,49 \* *Polyporus* sp.
- Tritoma pulchra* Say 1826  
 1,28 *Ceriporia* sp.  
 1,1 *Ganoderma applanatum*  
*Oligoporus floriformis*  
*Polyporus floriformis* [Chantal  
 1979]  
 1,2 *Oligoporus stipticus*  
*Polyporus immitis*  
 3,17 *Oligoporus tephroleucus*  
*Polyporus tephroleucus* {Judd  
 1957:1,1]  
 1,2 *Oligoporus* sp.  
*Piptoporus betulinus*  
*Polyporus betulinus* [Chantal  
 1979; Boyle 1956]  
 1,1 *Polyporus squamosus*  
*Melanopus squamosus*  
*Russula irrescens* (*R. virescens?*)  
 [Weiss 1924]  
 1,1 *Stemonitis axifers* {Myxomycete}  
 2,5 *Tyromyces chioneus*  
*Polyporus albellus*  
*Polyporus chioneus* {Weiss  
 1920; Weiss & West 1920}

New host data supports our taxonomic conclusions regarding synonymy in the *Tritoma biguttata* complex (Goodrich & Skelley 1991). New data also suggest that further synonymy in this genus may be justified. *Tritoma humeralis*, *T. atriventris*, and *T. aulica*, whose relationships parallel those of the three forms of *T. biguttata*, show no significant difference in host records. This conclusion also applies to *T. erythrocephala*, specimens of which have been regularly collected and reared with *T. atriventris*.

A huge amount of new host data supports our earlier conclusion that fungi of the genera *Russula* and *Lactarius* are the adult and larval hosts of *Tritoma angulata*, whose hosts were virtually unknown prior to our 1991 publication.

*Tritoma mimetica* demonstrates some interesting host relationships. Adults are usually collected in association with *Xerula* spp. (a gill fungus), while larvae have almost exclusively been reared from *Polyporus* spp. (polypores). Changes in the classification of fungi have also complicated the picture. *Xerula radicata* and *X. furfuracea* were, until quite recently, placed in the genus *Oudemansiella*. In addition, *X. radicata* is now known to represent a group of closely related species, some or all of which may be suitable hosts for *Tritoma mimetica*.

It should be noted that host data collected in this research has a significant bias toward midwestern host relationships. When extensive collections are made in other localities, additions and/or apparent shifts in preference may be discovered. For this reason, we would be pleased to examine and identify any Erotylidae collected in association with an identified fungal host.

For further discussion of host relationships in the genus *Tritoma*, see Goodrich & Skelley (1995).

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**EFFECT OF *BACILLUS THURINGIENSIS* VAR. *ISRAELENSIS* UPON THE PREDATORY CAPACITY OF *BUENOA* SP. (HEMIPTERA: NOTONECTIDAE) AGAINST *CULEX PIPIENS QUINQUEFASCIATUS* (DIPTERA: CULICIDAE) LARVAE.<sup>1</sup>**

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**ABSTRACT:** The predatory capacity of *Buenoa* sp. was evaluated with *Culex pipiens quinquefasciatus* larvae. We determined two parameters of predation: searching capacity ( $a'$ ) and the handling time ( $th$ ). Both estimates were calculated when the prey was untreated and when it had been treated with *Bacillus thuringiensis* var. *israelensis*. Also, the mortality exerted by the predator, the predator plus *B.t.i.*, and by *B.t.i.* alone were evaluated. In general, predation was greater when predator and bacteria were present than when each one was used separately.

The mosquito *Culex pipiens quinquefasciatus* Say (Diptera: Culicidae) is an important vector of arboviruses and filarial worms. Commonly, arthropod-borne diseases are controlled by controlling their vectors with chemical insecticides. Use of insecticides presents two complications: insect resistance, and pollution of the environment (Metcalf 1990). With microbial control, these problems can be avoided. The purpose of this work was: 1) to evaluate the predatory capacity of *Buenoa* sp. alone, and of *B.t.i.* together with the predator, and 2) to determine mortality exerted by the predator alone, by *B.t.i.* plus predator, and by *B.t.i.* alone.

#### MATERIALS AND METHODS

Mosquitoes were collected in the Pesquería river, Escobedo, Nuevo Leon, Mexico. Egg rafts were placed in plastic pans until eclosion. The notonectid predator *Buenoa* sp. was collected in an urban area of Monterrey, N. L. Identification of mosquitoes and notonectids was done using keys in Darsie and Ward (1981) and Polhemus (1983). Larvae were placed into 1 L glass containers containing 750 ml of dechlorinated water (pH 6.5). Individual predators of either the third or fourth instar were used to one of 10 densities of prey larvae. These were 1,3,5,7,10,20,30,40,50 and 60 larvae /750 ml of water. Each larval density was exposed to one predator to each larval density, replicated five times. To compare prey consumption by predators against untreated or treated larvae of different body sizes, we selected one group of larvae

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containing first and second instars, and a second group containing third and fourth instars. In the first experiment, we used a single predator in each larval density described above; first to first plus second instar larvae, then to a second group of third plus fourth instar larvae.

For a second experiment, we evaluated the action of the predator, plus Bactimos® (*Bacillus thuringiensis* var. *israelensis* Biochem Products, San Antonio, TX), at the recommended dosage (9.3 gr/m<sup>2</sup>). This experiment was conducted in the same way as the first experiment, first plus second instar larvae and third plus fourth instar larvae.

We recorded the number of prey consumed after 24 h. All treatments were conducted at 14: 10 light- darkness regime, and the average temperature was 24°C. Results were analyzed with linear regression (Zar 1984) and were compared with Holling's functional responses equation type II  $Na = a' TtNo / (1 + a' ThNo)$ . In that equation ( $Na$ ) denotes the number of successful attacks per predator during the time of exposure of prey to the predator ( $Tt$ ); ( $No$ ) denotes the initial density of prey; and ( $a'$ ) and ( $Th$ ) represent the rate of successful attack and the time required to handle the prey, respectively. The ( $a'$ ) and ( $Th$ ) values were determined by means of the linear transformation of Holling's equation:  $Na/No = a' Tt - a' ThNa$  (Holling 1959). An X<sup>2</sup> test for goodness of fit between observed and expected values was performed for both models.

Finally, we conducted a third experiment using the same number of larvae as in the first and second experiments: first plus second instar larvae and third plus fourth instar larvae. In this experiment Bactimos® was used without predators. The numbers of dead larvae were recorded after 24 h.

## RESULTS AND DISCUSSION

For a first experiment the linear regression equation was  $Y = 1.8357 + 0.5320X$ , where  $Y$  is the number of prey consumed after 24 h, and  $X$  is the prey density. This result was obtained for the first plus second instars. For third plus fourth instars it was  $Y = 2.0154 + 0.4214X$ . To determine whether or not the slopes of these lines were significantly different, we used a "t" test, which indicated that both slopes were not different ( $P < 0.05$ ). This indicates that the predation rate exhibited by *Buena* sp. was the same, and was independent of prey body size. Using Holling's equation, a searching capacity of ( $a'$ ) = 0.0342 and a handling time of ( $th$ ) = 0.2399 were determined for the first plus second instars, and ( $a'$ ) = 0.0259, ( $th$ ) = 0.1646 for the third plus fourth instars. Despite apparent differences between the ( $a'$ ) values, we believe that antipredation responses of *C. pipiens quinquefasciatus* to escape this predator were basically the same.

Linear regression for the predator combined with *B.t.i.* gave  $Y = 0.3523 + 0.9837X$  and  $Y = 1.8256 + 0.7546X$  for first plus second, and for third plus fourth instars respectively, In the same way as for the predator alone, we again

performed the "t" test, finding in this case a significant difference between both slopes ( $P < 0.05$ ). These results suggest that the third plus fourth instar larvae were less susceptible to Bactimos<sup>®</sup> than were first plus second instars. Holling's parameters were ( $a'$ ) = 0.0381, (th) = 0.0355 for first and second instars, ( $a'$ ) = 0.0420, and (th) = 0.1222 (Table 1.) for the third and fourth instars.

*B.t.i.* was also tested alone for *C. pipiens quinquefasciatus* larvae to determine the mortality of each treatment. Means were 1) 70.06% for predator alone, 2) 94.5% for *B.t.i.* plus predator, and 3) 99.2% for *B.t.i.* alone upon the first plus second instars. For the third plus fourth instars, mortality was 1) 57.2% for the predator alone, 2) 91.2% for *B.t.i.* plus predator, and 3) 66.2% for *B.t.i.* alone.

The results for Holling's parameters ( $a'$ ) and (th) are similar to the findings of Pérez (1990) who reported a searching capacity value of 0.02954 and the handling time of 1.02159 for the predator *Buenoa* sp. On the other hand, Ortegon and Quiroz (1990) tested the predatory capacity of *Buenoa* sp. adults upon *C. pipiens quinquefasciatus*. In that study, they evaluated both parameters ( $a'$ ) and (th) when the predator was alone, and when the predator was present with a strain of *Bacillus thuringiensis* var. *israelensis*. They found that the ( $a'$ ) value was incremented, and the (th) value was decreased when the bacterium was present. Our results in this study corroborate their findings. Perhaps *B.t.i.* reduced larval strength, thereby diminishing anti-predator response, since moving is the key factor for larvae to avoid being consumed (Sih 1986). Bacterial action might have reduced larval capacity to escape from the predator. This effect was marked in the first and second instars.

Larvae of *Culex pipiens quinquefasciatus* and third and fourth nymphal instars of the predator *Buenoa* sp. have been deposited as voucher specimens in the Nuevo Leon University (accession number: ER- 01- 92 for both species).

TABLE 1. Results of the Holling's equation of the searching capacity ( $a'$ ) and the handling time (th) of *Buenoa* sp. alone, and with the *Bacillus thuringiensis* var. *israelensis*

Larval Stages	Predator alone		Predator with <i>B.t.i.</i>	
	( $a'$ )	(th)	( $a'$ )	(th)
I plus II	0 . 0342	0 . 2399	0 . 0381	0 . 035
III plus IV	0 . 0259	0 . 1646	0 . 0420	0 . 122

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**TWO NEW SYNONYMIES: *ALABAMEUBRIA*, BROWN,  
A JUNIOR SYNONYM OF *DICRANOPSELAPHUS*  
AND *ALABAMEUBRIA STARKI*, A SYNONYM OF  
*DICRANOPSELAPHUS VARIEGATUS*  
(COLEOPTERA: PSEPHENIDAE)<sup>1</sup>,**

**Cheryl B. Barr<sup>2</sup>, Paul J. Spangler<sup>3</sup>**

**ABSTRACT:** Two synonymies are proposed: *Alabameubria* Brown (1980), a junior synonym of *Dicranopselaphus* Guérin-Méneville (1861); and *Alabameubria starki* Brown (1980), a junior synonym of *Dicranopselaphus variegatus* Horn (1880). Lectotype and paralectotype designations are made for Horn's two syntypes of *D. variegatus*.

Several years ago we became aware of a problem in synonymy involving the cubriid names *Dicranopselaphus variegatus* Horn (1880) and *Alabameubria starki* Brown (1980). We planned to propose the synonymies in a revision of *Dicranopselaphus* Guérin-Méneville (1861), which we have in preparation. However, we report the following synonymies now in order to have the correct name, *Dicranopselaphus variegatus* Horn (1880), available for use in the forthcoming edition (3rd) of *An Introduction to the Aquatic Insects of North America* edited by Merritt and Cummins.

**Genus *Dicranopselaphus* Guérin-Méneville**

*Dicranopselaphus* Guérin-Méneville, 1861:531.

*Alabameubria* Brown, 1980:188; type species: *Alabameubria starki* Brown, by original designation. NEW SYNONYMY.

***Dicranopselaphus variegatus* Horn**

*Dicranopselaphus variegatus* Horn, 1880:97; lectotype designated below.

*Alabameubria starki* Brown, 1980:188. NEW SYNONYMY

The following is a brief account of the circumstances that led to our conclusions that *Alabameubria* Brown is a synonym of *Dicranopselaphus* Guérin-Méneville and *Alabameubria starki* Brown is synonymous with *Dicranopselaphus variegatus*.

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One distinctive larval specimen of a false water penny (eubriine) was collected in Alabama by B.P. Stark in 1973 and sent to H.P. Brown. For several years after the discovery of the unique larva, Brown and others periodically sought additional larvae and possible associated adults and a second larva was collected at a different site in Alabama by T. King and C.D. Guthrie in 1978. In 1980, Brown published his descriptions of the genus *Alabameubria* and the type species, *A. starki* based on the two larvae. On May 20 & 21, 1988, we visited the type locality of *A. starki* at the confluence of Mill Creek and the tributary Murphy Creek, which is about 1 km southwest of Blount Springs, Blount County, Alabama. Barr collected five adult specimens of *Dicranopselaphus variegatus* by beating riparian vegetation overhanging the creek, and Spangler found three live, mature, dry, eubriine larvae attached above the water line to the vertical sides of rocks in shallow water at the stream edge. Spangler also found a fourth larva on a rock about 1-1.5 m from the margin of Mill Creek. To this time, no adult specimens that would be those of *A. starki* have been collected.

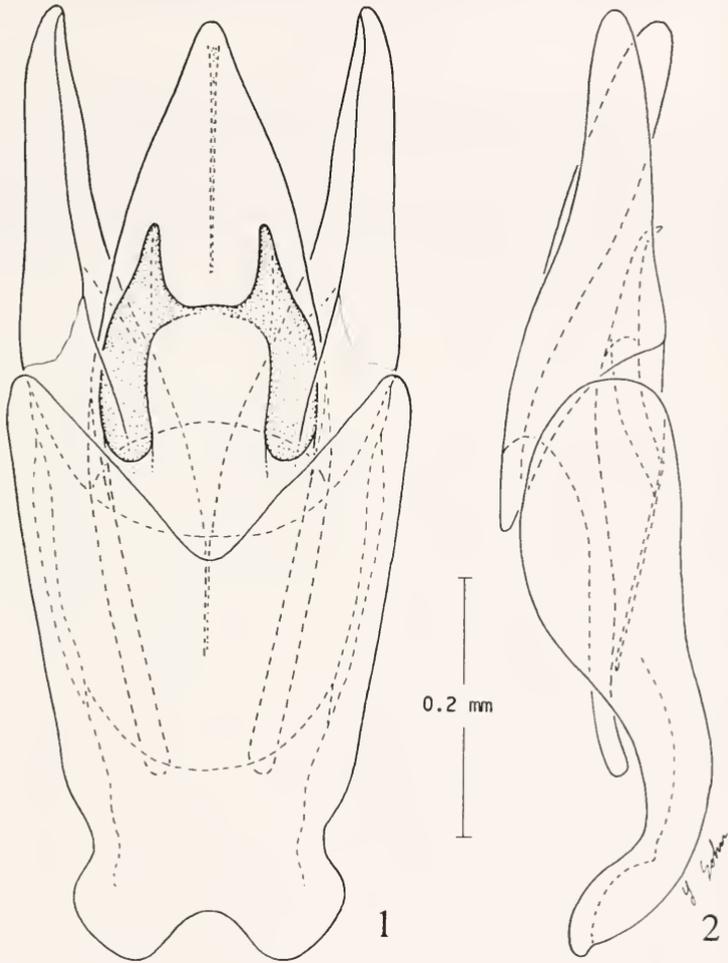
Although we were not successful in our attempt to rear our larvae to the adult stage, we are confident they represent the larva of *Dicranopselaphus variegatus* – by association and elimination of the known larva of *Ectopria*. The larvae we identify as *Dicranopselaphus variegatus* are congeneric and conspecific with the holotype and paratype of *Alabameubria starki*, which becomes a junior synonym of *Dicranopselaphus*.

The larvae we identify as the eubriine *Dicranopselaphus variegatus* are distinct from the larva of *Ectopria*, the only other eubriine genus we collected at the site. For illustrations of the larva of *Ectopria* see Brown, 1991, Fig. 34.413.

In order to verify the identification of our adult specimens as *Dicranopselaphus variegatus* Horn, we borrowed Horn's two male syntypes from the Museum of Comparative Zoology, Harvard University: one specimen is labeled: Md / LectoTYPE 3277 / *Dicranopselaphus variegatus* Horn; the other is labeled: Ill. / Para-Type 3277. We do not find the lectotype and paratype designations validated by publication and believe the labels were added to the specimens, provisionally, by S. Henshaw as was his custom. We here designate the specimen from Maryland as the lectotype (as it was previously labeled) and the one from Illinois as the lectoparatype and have added appropriate labels to each.

The genitalia of the lectotype was damaged slightly before we extracted it; the apex of the right paramere and a small piece of the median lobe are missing. In all other aspects, the genitalia of the lectotype is identical to the genitalia (Figs 1 & 2, by Y.T. Sohn) of one of our specimens from Blount Springs, Alabama. The lectotype is glued to a point and the cleared dissection is in glycerine in a microvial attached to the pin.

Our adult specimens from Blount Springs, Alabama, are virtually identical externally to the type specimens.



Figs. 1 & 2.—*Dicranopselaphus variegatus* Horn, ♂ genitalia: 1, Ventral view; 2, Lateral view.

## ACKNOWLEDGEMENTS

We thank the following individuals for their assistance with this article: Scott Shaw for lending Horn's type material; Harley P. Brown, Richard C. Froeschner, William Shepard, and Phyllis Spangler for their reviews; and Young T. Sohn for the pen and ink illustrations.

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**SOCIETY MEETING OF APRIL 27, 1994****WHEN DESERT, CHAPARRAL AND FOREST COLLIDE:  
INSECT NATURAL HISTORY OF THE DEVILS RIVER OF TEXAS**

C. Riley Nelson

Division of Biology and Brackenridge Field Laboratory  
University of Texas, Austin

The final meeting of The American Entomological Society's 1993-1994 schedule was one of the more exciting of recent years, featuring a joint gathering with the Entomological Society of Pennsylvania, presentation of the annual Calvert Award for the best local student project in entomology and a spectacularly illustrated and presented talk by Dr. C. Riley Nelson, of the University of Texas. Dr. Nelson, well known for his work on the systematics and ecology of two diverse insect groups, stoneflies (Plecoptera) and robber flies (Diptera: Asilidae), combined his wide knowledge of aquatic and terrestrial insects, other animals and plants, and geology in giving the Philadelphia audience an insight into a unique riparian system set in the aridlands of west Texas. At the same time, he clearly conveyed his great enthusiasm for this inventory work which he called a "systematist's dream."

The Devils River is an exceedingly interesting tributary of the Rio Grande river system in North America, lying close to the border of Mexico and flowing through the junction of ecotones of the Edward's Plateau woodland, South Texas Plains chaparral and the Chihuahuan Desert desertscrub. This intersecting of different biotypes explains much of the high diversity of both plants and animals, including many of the rarest plants in Texas. Unlike other systems, like the nearby Pecos River, which have been greatly affected by intensive farming and oil drilling, the low human population surrounding the Devils River and their historical reliance on low impact grazing has allowed this area to serve as a refuge for the native fauna of this part of Texas. To insure that this area remains unimpacted and its beauty unspoiled, the State of Texas and the Nature Conservancy have purchased 40,000 acres surrounding the Devils River. It is from funding by the Nature Conservancy and through cooperation by the State Parks agency that Dr. Nelson has been able to conduct an on-going study of the aquatic insects of the Devils River.

Working with specialists in various groups, Dr. Nelson has enumerated more than 200 species of aquatic insects, and this does not include the chironomids, which might be expected to make up a third of the fauna of any stream! The species of this river are dominated by caddisflies, and, because of the open nature of the riparian region, these are primarily grazers and filter-feeders (hydroptilids, hydropsychids and leptocerids), reaching densities of thousands per square foot. Other groups well represented in the flowing sections of the river include baetid mayflies, aquatic pyralid moths and dobsonflies. Deep pools, including an enormous one below a waterfall (Dolan Falls), are havens for more than 25 species of fish, including gar and the only U.S. species of cichlids and tetras. Interesting aquatic life is not restricted to the river itself, though. Other habitats with their own particular fauna include a short tributary of the river called Dolan's Creek, numerous springs flowing out along the base of high cliffs running along the creek and river, and ephemeral pools forming in the exposed limestone bedrock beside the creek. The springs are apparently where most of the species of crane flies occur, and these interesting sites also include cave dwelling organisms like isopods and amphipods. Ephemeral pools possess characteristic pupfish and fairy shrimp.

There were numerous items of entomological interest presented at this meeting. Jane Ruffin announced the sighting last fall of a tagged Monarch butterfly in Gulf Shores, Alabama, one of a number of individuals she and Mildred Morgan tagged in Cape May Point, New Jersey. This butterfly traveled at least 1000 miles in 26 days, or about 38 miles/day! Harold White noted that fully mature *Anax junius* (Odonata) were seen in flight already this spring, corresponding well to observations made by Dr. Mike May in a talk to the Society last month. Dr. White also noted that *The Scientist* listed a group of papers on tropical aquatic insect emergence, including one by Jon Gelhaus, as receiving an exceptionally high amount of citations. Dr. Gelhaus noted that a follow-up paper to that work has just been published, a joint effort between himself and AES student member Margot Livingston (Margot was the Society's first Calvert Award recipient and a Pew Scholar at the Academy of Natural Sciences for two years). Susan Whitney noted she had received a grant from Dow Elanco for researching termite bait. Dr. Whitney also encouraged everyone to use the new computer entomology discussion group, Entomo-L on the Internet. Approximately 50 members and guests were present.

Jon K. Gelhaus,  
Corresponding Secretary

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### BOOKS RECEIVED AND BRIEFLY NOTED

PARASITIDS. BEHAVIORAL AND EVOLUTIONARY ECOLOGY. H.C.J. Godfrey. 1994. Princeton University Press. 473 pp. \$65 cloth. \$29.95 paper.

Known for a long time to applied biologists for their importance in regulating the population densities of economic pests, parasitoids have recently proven to be valuable tools in testing many aspects of evolutionary theory. This book synthesizes the work of both schools of parasitoid biology and explores how a consideration of evolutionary biology can help us understand the behavior, ecology, and diversity of the approximately one to two million species of parasitoids found on earth.

After a general introduction to parasitoid natural history and taxonomy, the first part of this book treats the different components of the reproductive strategy of parasitoids. Subsequent chapters discuss pathogens and non-Mendelian genetic elements that affect sexual reproduction, evolutionary aspects of the physiological interactions between parasitoid and host, mating strategies, and life history theory and community ecology.

MITES. ECOLOGICAL. AND EVOLUTIONARY ANALYSES OF LIFE-HISTORY PATTERNS. M. A. Houck, ed. 1994. Chapman & Hall. 357 pp. \$67.50 hardback.

Mites rival insects in diversity, abundance, and ubiquity. They also have great potential for answering questions about biological phenomena and for testing biological concepts. Their rapid generation time and ease with which they can be manipulated make them excellent experimental animals and the advent of molecular techniques has overcome the limitation of their small size.

Mites, with their intricate life styles, their unusual genetic and ecological mechanisms, and their hugely diverse adaptations, provide unique opportunities for analyzing and expanding evolutionary and ecological concepts.

This book offers new data synthesized with previous knowledge, in some cases leading to views with broad evolutionary impact, and major implications for the field of the integrated control of animal and plant pests.

**QUATERNARY INSECTS AND THEIR ENVIRONMENTS.** S.A. Elias. 1994. (Smithsonian Institution. 284 pp. \$40.00 cloth.

This book addresses science's long neglect of fossil insects by demonstrating their great potential contribution to our knowledge of the paleoenvironmental record of the past 1.7 million years. In this comprehensive survey of the field the author recounts the development of Quaternary entomology, reviews the fossil record from Quaternary deposits and points to possible areas for future research.

Recent research reveals considerable Pleistocene insect species stability: insects responding to climatic changes by moving rather than evolving. The author argues that fossil insects often are more reliable indicators of past environments and climates than now commonly used pollen data.

The author discusses the methods used to sample and analyze Quaternary insect fossils as well as the principal characters used in their identification. He describes the mutual climatic range method of paleoclimate interpretation and offers data on distributional shifts and the longevity of modern species through the Quaternary.

**EXOTIC ANTS. BIOLOGY, IMPACT, AND CONTROL OF INTRODUCED SPECIES.** D.F. Williams, ed. 1994. Westview Press. 332 pp. \$74.85 hardcover.

Most of the major problems caused by ants are a result of exotic species that have been introduced into areas that lack natural controls on their populations. This book presents the latest research findings on introduced pest ant species. Discussions include the distribution, biology, ecology, and behavior of several exotic ants and also describe current research on basic and applied topics. Brief summaries are offered in Spanish at the end of each chapter.

**THE BEE GENERA OF NORTH AND CENTRAL AMERICA (HYMENOPTERA: APOIDEA).** C.D. Michener, H. J. McKinley, and B.N. Danforth. 1994. Smithsonian Institution. 209 pp., 79 photos, 440 line illus. \$45.00 cloth.

This very nicely produced, 8½ x 11 format, book is essentially an extensive and comprehensive key to the 169 genera of bees throughout the Northern Hemisphere. In addition to its excellent illustrations, the book is produced with side by side texts in both English and Spanish. Along with the comprehensive classification, notes on each genus give its range, number of species, references to revisionary studies, subgenera, if any, and distinguishing features. The book indicates nest sites for those bees that do not nest in the ground and identifies hosts for socially parasitic and cleptoparasitic genera. The authors also list changes in classification and nomenclature and summarize the current classification by genera and subgenera.

**BOOKS RECEIVED AND BRIEFLY NOTED (Continued)**

**IDENTIFICATION GUIDE TO THE ANT GENERA OF THE WORLD.**  
B. Bolton. 1994. Harvard University Press. 222 pp. \$65.00 hardcover.

The principal aim of this very nicely produced, 10 x 12 format, book is to provide a series of dichotomous identification keys to the living ant subfamilies and genera of the world. In addition, it provides synoptic classifications of genera within the various subfamilies and lists of taxonomy works that provide determinations to species rank, where available, for further identification and study.

The family Formicidae is described first and keys are provided to identify the extant subfamilies. Then each extant subfamily is treated separately in alphabetical order. Each subfamily section commences with a newly formulated diagnosis of the group, followed by the keys to the genera, synoptic classification, and list of taxonomy references. A few notes on broad distribution are also provided. A short summary of the extinct subfamilies completes this main part of the work.

A bibliography of faunistic studies is given separately in the back of the book and an extensive glossary of morphological terms is provided. One of the more impressive parts of this book is the series of 522 excellent scanning electron microscope photographs that are presented to illustrate the keys, each chosen to represent the general habitus of a particular genus.

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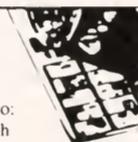
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