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**COVER PHOTOGRAPH**

SEM of a tarsus of a male *Euceros decorus* Walley (Hymenoptera: Ichneumonidae).
Photograph by Maria Theresa Lopez, O. A. R. D. C., Wooster, OH.
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DYTISCIDAE AND NOTERIDAE OF WISCONSIN (COLEOPTERA).

I. INTRODUCTION, KEY TO GENERA OF ADULTS, AND DISTRIBUTION, HABITAT, LIFE CYCLE, AND IDENTIFICATION OF SPECIES OF AGABETINAE, LACCOPHILINAE AND NOTERIDAE

William L. Hilsenhoff

ABSTRACT

Collected from Wisconsin were 83,710 adult and 5,600 larval Dytiscidae representing 148 species, and 95 adult Noteridae representing two species. A key to genera is presented, which includes names of species in genera that are monotypic in Wisconsin. Information on distribution and abundance in Wisconsin, range, habitat, life cycles, and identification are included for species in the dytiscid subfamilies Agabetinae and Laccophilinae, and the family Noteridae. Also included are keys to species of adult and larval Laccophilus found in Wisconsin.

Since 1962 I accumulated a collection of 83,710 adults and 5,600 larvae of 148 species of Dytiscidae from throughout Wisconsin, along with 95 adults of two species of Noteridae. An effort was made to collect from all types of lentic habitats in all counties at different times of the year; lotic habitats were extensively sampled throughout the year in conjunction with other projects. Initially all collections were made with a D-frame aquatic net, but in 1976 I also began to use traps to collect water beetles, especially from McKenna Pond near Madison in Dane County (Hilsenhoff and Tracy 1985). Bryn Tracy continued the study of water beetles in this pond from 1978 to 1981, collecting more than 14,000 adults and larvae of 77 species of Dytiscidae. Beginning in 1984, bottle traps (Hilsenhoff 1987) were used instead of window-screen traps to extensively sample lentic habitats throughout Wisconsin at different seasons of the year. The three most abundant species, Hygrotus sayi, Neoporus undulatus, and Laccophilus maculosus, were collected from all counties and accounted for 41% of all adult Dytiscidae that were collected. More than 1,000 adults of ten additional very common species were collected, while 24 other species were represented by fewer than five specimens. Undoubtedly additional species that are very rare in Wisconsin will be discovered; those most likely to occur are included in the keys and discussion. All specimens are preserved in 70% ethanol and retained in the University of Wisconsin Aquatic Insect Collection.

Life cycles of Dytiscidae vary, but in most lentic species overwintering
adults oviposit in spring, larvae complete development in late spring or early summer, and then crawl from their aquatic habitat to pupate on adjacent land. Adults emerge from the pupal cell after five to 14 days and usually return to the aquatic habitat for at least a few days. In dry summers, adult dytiscids are difficult to find, probably because they aestivate. In wet summers, they are usually plentiful. Most species overwinter as adults in ponds, lakes, or streams, while a few also overwinter as eggs or larvae. Overwintering habitats often differ from breeding habitats. In early spring when dytiscids are actively mating, especially when ponds are still partially covered with ice, large numbers can often be collected with bottle traps (mostly Colymbetinae and Dytiscinae). Adults of some dytiscids overwinter in terrestrial habitats and return to breeding sites in spring. Some species may have at least a partial second generation of larvae in late summer, while others may breed throughout the summer. Lotic species frequently overwinter as larvae as well as adults.

Because Dytiscidae is a very large family and revisions of *Agabus* and *Hydroporus* are in progress, this study will be published in parts. The purpose of the study is to document the distribution and abundance of species of Dytiscidae and Noteridae that occur in Wisconsin and to provide as much information as possible about their habitat, life cycle, and identification. The habitat of each species was determined from collection records, with special emphasis on habitats used by larvae and teneral specimens. Although teneral specimens frequently disperse widely, most probably re-enter their larval breeding site for at least a few days after emerging from the pupal cell. Adult beetles were considered to be teneral if their elytra were still soft in the discal area, a condition that lasts for about a week after eclosion. In species in which larvae cannot be identified, the occurrence of teneral adults was the most important clue to the life cycle and the period when larval development most likely occurred.

Keys to adults are provided as an aid to identification of species in this region. Because fewer species are involved, these keys are less complex than those that encompass the entire North American fauna. While most Dytiscidae can be readily identified by using the keys and notes on identification, differences between many species are slight and a reference collection of identified specimens is advantageous, if not a necessity, for accurate identifications in some genera. Keys to species of larvae will also be provided for some genera. Most of these larval keys must be considered provisional because larvae of all species within a genus have not been positively associated with adults by rearing; larval identification was often based on circumstantial association with adults. Larval keys identify third instar larvae, but usually the second instar also can be identified with these keys. Third instar larvae possess lateral spiracles on the mesothorax and abdominal segments 1–7, which first and second instar larvae lack. Third instar larvae of *Neoporus* and *Heterosternuta* also lack these spiracles (Alarie 1991).

Part I of this study contains a key to genera of adults found or possibly occurring in Wisconsin. Subgenera and species groups of *Hydroporus* s. lat. that were used by Alarie (1991) are given generic status in this key because this will likely result from the impending revision (Robert Roughley, University of Manitoba, personal communication). The *oblitus* group of species, which is distinct from *Sanfilippodytes* (*villis* group), has not yet been assigned a generic name. Lengths reported in the generic key and in species keys are for Wisconsin specimens, which were measured on a line from the anterior of the head to the tip of the elytra. Fifty or more adults from 25 or more sites were measured for each species; all specimens were measured in species with less than 50 adults. Measurements were made with an ocular micrometer in a Leitz dissecting microscope.
Abundance of species in Agabetinae, Laccophilinae, and Noteridae in nine areas of Wisconsin and in McKenna Pond is compared in Table 1; collections from McKenna Pond are listed separately and not included in south-central (SC) totals. An unusually large number of some species in SC Wisconsin is often due to adults obtained from three years of summer bottle trap collections in the Horicon Marsh, Dodge, Co., by Kevin Kenow (see acknowledgments). The range of each species was obtained from the most recent generic revision; other studies were used when no revision was available. The recent publication by Larson and Roughley (1991) on the distribution of dytiscids in Canada and Alaska was especially helpful.

**KEY TO GENERA OF ADULT DYTISCIDAE AND NOTERIDAE IN WISCONSIN**

1. Ventral surface of body in lateral aspect with anterior of prosternum, its postcoxal process (prosternal process), and meso- and metasternum in same plane (Fig. 1); pro- and mesotarsi distinctly 5-segmented, segment 4 as long as segment 3. .......................... 5
2. Ventral surface of body in lateral aspect with anterior of prosternum greatly depressed and much more dorsal than its postcoxal process and meso- and metasternum (Fig. 2); pro- and mesotarsi appear to be 4-segmented because segment 4 is very small, concealed between lobes of segment 3, and much shorter than segments 3 or 5 (except Bidessonotus, which probably occurs only south and east of Wisconsin). .......................... DYTISCIDAE, HYDROPORINAE 19

2(1). Prosternal process spear-shaped, usually pointed apically (Fig. 3); protibia without a large, curved, apical spur; > 4.0 mm long. .......................... DYTISCIDAE (in part) 4
2(2). Prosternal process greatly widened apically and nearly truncate (Fig. 4); protibia with a large, curved spur at apex (Fig. 5); < 5.5 mm long. .......................... NOTERIDAE 3

3(2). Elytra with a transverse pale fascia; small, 2.9-3.3 mm long. .......................... Suphisellus puncticollis Crotch
3(3). Elytra without a transverse fascia; larger, 4.9-5.3 mm long. .......................... Hydrocanthus iricolor Say

4(2). Very large, 23-42 mm long. .......................... DYTISCINAE (in part) 5
4(3). Smaller, 4-18 mm long. .......................... 6

5(4). Large spurs at apex of metatibia subequal in width; beetle widest near middle; 23.0-41.6 mm long. .......................... Dytiscus Linnaeus
5(5). One large spur at apex of metatibia twice as broad as other; beetle widest at posterior third; 27.7-33.4 mm long. .......................... Cybister fimbriolatus (Say)

6(4). Scutellum not visible; metatarsus with a single stout claw; smaller, 3.9-5.5 mm long. .......................... LACCOPHILINAE, Laccophilus Leach
6(5). Scutellum fully visible; metatarsus with 2 claws; larger, except Cope-latus, which has 8-10 impressed striae on each elytron. .......................... 7

7(6). Elytra densely sculptured with short, deep, irregular, longitudinal aciculations; apex of palpi conical (Fig. 6); 6.4-7.4 mm long. .......................... AGABETINAE, Agabetes acuductus Crotch
7(7). Elytra without longitudinal aciculations; if aciculations are present, they are transverse apically and palpi are truncate and notched apically (Fig. 7) .......................... 8
8(7). Anterior margin of eye emarginate above base of antenna (Fig. 8). ................................................. COLYMBETINAЕ 9
Anterior margin of eye not emarginate above base of antenna. ........................................................... DYTISCINAЕ (in part) 16

9(8). Elytra uniformly brown, with 8–10 impressed longitudinal striae on each elytron; mesal margins of metacoxae coming so close together posteriorly as almost to touch median line of metacoxal process (Fig. 9); 4.5–5.5 mm long. .......... Copelatus Erichson
Elytra not having 8–10 impressed longitudinal striae; metacoxal lines not converging so close to median line; > 5.6 mm long .. 10

10(9). Prosternum with a median longitudinal furrow from near front margin to apex of prosternal process; 7.5–9.4 mm long. Matus Aubé
Prosternum without a longitudinal furrow ........................................ 11

11(10). Metatarsal claws subequal in length ........................................ 12
Metatarsal claws distinctly unequal in length. ........................................ 13

12(11). Last segment of palpi distinctly widened and emarginate apically (Fig. 10); elytra patterned with dark blotches and irrorations on a pale background; thoracic sterna pale; 6.8–8.6 mm long. .......... Coptotomus Say
Last segment of maxillary palp not widened apically, only truncate to very slightly emarginate (Fig. 7); elytra usually dark, if pale with stripes, thoracic sterna are black; 5.8–13.4 mm long ...... 14

13(11). Larger, > 13.5 mm long. ........................................ 14
Smaller, < 13.0 mm long. ........................................ 15

14(13). Elytra sculptured with numerous, parallel, transverse grooves; with yellow markings, especially on pronotum; 14.1–18.1 mm long. .......... Colymbetes Clairville
Elytra without parallel, transverse grooves; black, without dorsal pale markings; 13.7–16.7 mm long ........................................ Agabus Leach

15(13). Yellow dorsally, with black markings, or entirely black with basal margin of pronotum deeply sinuate (Fig. 11); 9.5–11.9 mm long. .......... Rhantus Dejean
Black dorsally, usually with subapical and sublateral yellow spots on elytra and 2 posterior rufous spots on head; basal margin of pronotum never sinuate (Fig. 12); 7.5–12.9 mm long. .......... Ilybius Erichson

16(8). Outer margin of metasternal wing straight (Fig. 13); outer spur at apex of metatibia acute; 10.815.2 mm long .......... Hydaticus Leach
Outer margin of metasternal wing arcuate (Fig. 3); outer spur at apex of metatibia blunt, more of less emarginate .......... 17

17(16). Elytra densely punctate throughout, usually fluted and hairy in females; 10.6–16.6 mm long .......... Acilius Leach
Elytra not densely punctate throughout, never fluted in females .... 18

18(17). Posterior margin of mesofemur with stiff setae that are as long as or longer than width of femur (Fig. 14); 9.4–14.4 mm long .......... Thermonectus Dejean
Setae on posterior margin of mesofemur only about half as long as width of femur (Fig. 15); 10.4–16.0 mm long .......... Graphoderus Dejean

19(1). Apices of elytra and last abdominal sternum produced into a sharp point (Fig. 16); scutellum fully visible; 3.8–4.6 mm long .......... Celina hubbelli Young
Apex of abdomen not produced into a sharp point; scutellum covered by elytra .................................................. 20

20(19). Metacoxal process not produced laterally, base of trochanter entirely visible in ventral view (Fig. 17); less than 2.2 mm long .......................................................... 21

Metacoxal process produced laterally, obscuring base of trochanter in ventral view (Fig. 18); more than 2.3 mm long (except Hygrotus farcatus, which has a spine-like tubercle on prosternum) ........... 24

21(20). Metatibia straight, almost uniform in width (Fig. 19); metatarsal claws unequal in length; 1.72.0 mm long .............................................................. Desmopachria convexa (Aubé)

Metatibia arcuate, narrowed at base (Fig. 20); metatarsal claws equal in length .................................................. 22

22(21). Pro- and mesotarsi distinctly 5-segmented, segment 3 linear; metasternum slightly depressed with metacoxal lines converging anteriorly across mid-metasternum to nearly meet at mesocoxae (Fig. 21); 1.9-2.2 mm long (Georgia specimens) ........................................... Bidessonotus inconspicuus (LeConte)

Pro- and mesotarsi apparently 4-segmented, segment 3 bilobed; metasternum not depressed and metacoxal lines not continuing onto mid-metasternum ........................................ 23

23(22). Head with transverse suture between posterior margin of eyes (Fig. 22); 1.6-2.2 mm long .................................. Liodessus Guignot

Head without transverse suture between posterior margin of eyes; 1.6-2.0 mm long .................................. Uvarus Guignot

24(20). A diagonal carina crossing epipleuron near base (Fig. 23) ....... 25

No carina crossing epipleuron .................................................. 26

25(24). Prosternal process spear-shaped (Fig. 3), pointed at apex, and much narrower than procoxae; 2.0-5.5 mm long ... Hygrotus Stephens

Apex of prosternal process fan-shaped, broadly rounded at apex, and as wide as procoxae (Fig. 24); 2.5-2.9 mm long ............... . Hydorvatus pustulatus (Melsheimer)

26(24). Base of metafemur reaching metacoxal lobe (Fig. 25); 4.5-7.2 mm long ........................................ Lacornis des Gozis

Metafemur separated from metacoxal lobe by part of trochanter ...... 27

27(26). Posterior margin of metacoxal process incised at middle, with lateral lobes rounded (Fig. 26) .................................................. 28

Posterior margin of metacoxal process truncate (Fig. 27) or angularly prominent at middle (Fig. 28), sometimes sinuate laterad of middle (Fig. 29) ............................................. 29

28(27). Metacoxal plate densely micropunctate, without larger punctures; pronotum without lateral sulci; 4.3-5.5 mm long .......... Potamonectes Zimmermann

Metacoxal plate micropunctate with scattered larger punctures; pronotum with distinct sulci laterally; 3.3-4.9 mm long .......... Oreodytes Seidlitz

29(27). Apex of metacoxal process truncate, or nearly so (Fig. 27); dorsum rufous to black and without distinct maculae or vittae; lentic; 2.6-6.2 mm long .................................. Hydroporus Clairville

Apex of metacoxal process angulate at middle (Fig. 28), sometimes sinuate laterad of middle (Fig. 29); dorsum often maculate or vitowa; lentic or lotic ........................................... 30

30(29). Apex of metacoxal process angulate at middle, but not distinctly sinuate laterad of middle (Fig. 28) ....... 31
Table 1. Numbers of Dytiscidae and Noteridae from nine areas of Wisconsin (Fig. 1) and from McKenna Pond (McK) collected between 1982 and 1991, and total number of each species. A = adults, L = larvae.

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<th>WC</th>
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Apex of metacoxal process angulate at middle and distinctly sinuate laterad of middle (Fig. 29). .......................... 32

31(30). Elongate, at least twice as long as wide or nearly so, or with black venter; penis bifid; elytra usually distinctly fasciate; lotic; 3.0-4.1 mm long .......................... Heterosternuta Strand Ovate, distinctly less than twice as long as wide; penis not bifid; elytra with dark stripes or pale maculae; lentic or lotic; 2.4-4.5 mm long .......................... Neoporus Guignot

32(30). Elytra widest in basal third, tapering to a pointed apex; each elytron with 2 large, square, pale areas and a pale apex; lotic; 3.5-4.4 mm long .......................... Lioporeus triangularis (Fall) Elytra usually widest at or past middle; elytra without large, square pale areas; lotic or lentic .......................... 33

33(32). Metatrochanter relatively short and stout, length of posterior margin not much greater than half distance from its distal apex to apex of femur; lentic; 2.8-4.0 mm long ................. oblitus group Metatrochanter relatively long, length of posterior margin not much shorter than distance from its distal apex to apex of femur; lotic; 2.7-3.5 mm long .......................... Sanfilippodytes Franciscolo

**Agabetinae**

_Agabetes Crotch, 1873_

A single Nearctic species, _Agabetes acuductus_, has long been placed in the subfamily Colymbetinae, but recent studies by Burmeister (1976, 1990) and Nilsson (1989) show _Agabetes_ to be more closely related to Laccophilinae. I follow Burmeister (1990) by placing it in a separate subfamily. _Agabetes acuductus_ (Harris, 1828)

_Distribution and abundance:_ Uncommon statewide (Table 1). County records (Map 1): 2-3, 22-23, 46, 49, 51-52, 57, 60-61. Range: WI-PQ-FL-AR

_Habitat:_ Adults were collected from small woodland ponds and wooded river sloughs, which often were temporary.

_Life cycles:_ All except two adults were collected between late March and June, mostly with bottle traps. Single adults collected June 24 and July 16
were teneral, which suggests larval development in late spring, with pupation and emergence in early summer. The absence of adults in late summer and autumn collections, except for one collected in early October, suggests that they may aestivate before moving into overwintering sites. No larvae were collected.

**Identification:** The dark color, oval shape, and deep, short, longitudinal aciculations on the elytra permit ready identification of adults of this species. The third-instar larva, which has a lightcolored head and extremely short urogomphi, was described by Spangler and Gordon (1973).
Laccophilus is the only genus of Laccophilinae occurring north of Florida. Zimmerman (1970) revised the genus in North America, recording 27 species and several subspecies. Only four species have been collected in Wisconsin, but a fifth (\textit{L. fasciatus}) may occur in southern counties. Larvae of Wisconsin's three most common species have been reared and described (Wilson 1923, Watts 1970, Barman 1972); a key is provided to larvae of these species and \textit{L. undatus}. Larvae of \textit{L. fasciatus} are unknown.

**Key to Species of Adult Laccophilus in Wisconsin**

1. Elytra markings mostly irrorate ........................................ 2
   Elytra markings solid brown to black, never irrorate .............. 4

2(1). Three or 4 large, boldly outlined maculae along lateral margins of elytra, separated by smaller pale areas; large, 4.8–6.0 mm long ........................................ \textit{maculosus}
   Without boldly outlined lateral maculations; smaller, <5.0 mm long ... 3

3(2). With a black subapical fascia across or partially across elytra; 4.5–4.9 mm long ............................................... \textit{fasciatus}
   Without a subapical black fascia; 4.1–4.6 mm long ........... \textit{proximus}

4(1). Elytra uniformly brownish-yellow or light brown; 3.9–4.6 mm long ............................................... \textit{biguttatus}
   Elytra with a variegated yellow, brown, and black pattern; 3.8–4.3 mm long ............................................... \textit{undatus}

**Key to Species of Larval Laccophilus in Wisconsin**

1. Head with 5–7 temporal spines, usually 6 and rarely 5; head with a prominent W-shaped mark that extends laterally to region of eyes ........................................ \textit{maculosus}
   Head with 4 or fewer temporal spines, rarely 5; head without a prominent W-shaped mark .................................................. 2

2(1). Head with 2 long temporal spines and one very short one; head with a dark arcuate stripe across anterior of frontoclypeus ........... \textit{undatus}
   With 4 similar temporal spines, rarely 3 or 5; head with a diffuse darkened area at base of frontoclypeus ............................ 3

3(2). Longest spine on labium mesad of each palp almost as long as basal palpal segment ........................................ \textit{proximus}
   Longest spine on labium mesad of each palp half as long as basal palpal segment ............................................... \textit{biguttatus}

\textit{Laccophilus biguttatus} Kirby, 1837


\textbf{Habitat}: Adults were collected from a wide variety of ponds, marshes, and swamps. Most larvae were found in woodland and open ponds; a few occurred in marshes.

\textbf{Life Cycle}: Although adults were collected as late as early October, most were collected from late March to mid-July. Larvae were found from June 14 to August 22, suggesting a single generation that develops in mid-summer.

\textbf{Identification}: Adults are the only Wisconsin \textit{Laccophilus} with uniformly colored elytra. Larvae are very similar to those of \textit{L. proximus}, but can be separated by the key. In Wisconsin the range of \textit{L. biguttatus} is north of the ranges of \textit{L. undatus} and \textit{L. fasciatus}. 

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\textit{Laccophilus} Leach, 1817
Laccophilus fasciatus rufus Melsheimer, 1844
Distribution and Abundance: Not yet collected in Wisconsin, but records from northern Illinois, Iowa, and southern Michigan suggest it may occur in southern counties. Range: SD-IA-MI-VT-FL-TX-NB; two other subspecies west and southwest.
Identification: The broad, black fascia across the apical third of the elytra is distinctive.

Laccophilus maculosus maculosus Say, 1823
Distribution and Abundance: Abundant throughout Wisconsin, especially southern third (Table 1). County Records (Map 1): 1-72. Range: MN-PE-SC-Al-TX-ND; two other subspecies west and southwest.
Habitat: Both larvae and adults were found in a wide variety of lentic habitats and along margins of streams.
Life Cycle: Many adults were collected from March to December; they were most numerous from August through October. Between May 19 and October 3, 1,252 third instar larvae were collected. Most (51%) were collected in June, but 32% were collected between July 16 and August 15. The decline in adults after mid-May indicates that overwintering populations had mostly died after mating and oviposition. The bimodal peaks in numbers of larvae, and weekly collections of adults and larvae from McKenna pond, both suggest that this species is largely bivoltine. It is the only species of dytiscid with numerous third instar larvae in spring and again in August.
Identification: Adults resemble those of L. proximus, but are distinctly larger and have black-bordered maculae that separate pale areas along margins of the elytra. In L. proximus, maculae between lateral pale areas are only irrorate. Larvae are readily identified by the bold W-shaped mark and many temporal spines on the head. They also have three or more spines on each side of the gular area, which are never in a row; in L. biguttatus and L. proximus larvae there are usually two spines on each side of the gular area, and if three are present, they are in a row.

Laccophilus proximus Say, 1823
Distribution and abundance: Common southern third, less common east-central and north (Table 1). County records (Map 1): 2-3, 6, 8, 14, 18, 20, 24-29, 31-33, 35-39, 47, 49, 51, 53-68, 70-72. Range: WI-ON-VT-VA-IL
Habitat: Adults were found mostly in open ponds, marshes, and flooded areas; they were uncommon along streams. Larvae occurred only in open ponds and marshes.
Life Cycle: Less than 5% of the adults were found before June; most were collected from August to October. Larvae were collected from June 30 through September 30, suggesting staggered oviposition.
Identification: Adults are near the size of L. fasciatus, but have at most a hint of a fascia in the apical third of the elytra. The “small, stout setae occurring between temporal spines” reported by Barman (1972) for larvae from New York could not be found on Wisconsin larvae at 144X magnification.

Laccophilus undatus Aubé, 1838
Distribution and Abundance: Rare southwest (Table 1). County records (Map 1): 51, 57. Range: WI-ON-VT-VA-IL
Habitat: Adults and one larva were found in wooded river sloughs and ponds created by flooding.
Life Cycle: All adults were collected between mid-April and mid-June; none were teneral. A single third-instar larva was collected along with five
adults on June 14, which suggests that adults of this species overwinter and that larvae develop earlier in spring than those of the other species.

**Identification:** Adults, which have distinctly maculate elytra, lack irruptions found in *L. maculosus, L. proximus,* and *L. fasciatus.* The single larva that was collected is undoubtedly *L. undatus;* it differs in many respects from larvae of the other species collected in Wisconsin, all of which have been described. Dorsally, the center of the head is pale in the area where the other species have dark markings. Instead there is a narrow, brown band with a short posterior extension, which is anterior to the eyes and arches across the frontoclypeus from the margin of the head just anterior to the antennae. In addition, the head has a distinct, narrow stripe that extends from behind each eye almost to the posterior margin; broader, less prominent marks occur behind eyes of other species. There are two long temporal spines and one very small spine immediately posterior to them. The other species normally have at least four strong spines; rarely they have three. As in the other three species, there is a more dorsal spine posterior to the temporal spines. There is only a single spine on each side of the gular area; two or more occur in the other species.

**NOTERIDAE**

*Hydrocanthus iricolor* Say, 1823

**Distribution and Abundance:** Very rare south (Table 1); four adults collected September 17, 1984 from Gibraltar Bog in Columbia Co. (58 on Map 1), two by me and two by students who retained them for their collections. Range: WI-PQ-ME-NC-IN.

**Habitat:** Adults were collected from cattails (*Typha*) and bur-reed (*Sparganium*) surrounding an open leatherleaf (*Chamaedaphne*) bog.

**Life Cycle:** The life cycle is unknown because no larvae or teneral adults were collected.

**Identification:** No other large noterid occurs as far north as Wisconsin. Young (1985) provides a key to American species.

*Suphisellus* Crotch, 1873

*Suphisellus puncticollis* Crotch, 1873

**Distribution and Abundance:** Uncommon southern third, one record northeast (Table 1). County records (Map 1): 21, 56, 58–59, 61, 70, 72. Range: WI-ON-MA-FL-IN.

**Habitat:** Adults were found only in cattail and bur-reed marshes and ponds.

**Life Cycle:** Adults were collected from early June to November. All adults that were collected in June and July were darkly pigmented and had undoubtedly overwintered. Twelve of 14 teneral adults were collected in September; the other two were collected August 6 and November 1. This suggests oviposition in June or July, larval development in summer, and peak emergence of adults in September.

**Identification:** The small size of adults readily separates them from *Hydrocanthus iricolor,* and the pale fascia across the elytra distinguishes them from other *Suphisellus* (Young 1979) or *Pronoterus,* none of which are likely to occur in Wisconsin. This fascia is less prominent in overwintering adults, but still is readily visible.
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LITERATURE CITED


NEW LARVAL DESCRIPTIONS AND COMPARISONS OF NORTH AMERICAN CHOROTERPES (EPHEMEROPTERA: LEPTOPHELEBIIDAE)

W. P. McCafferty

ABSTRACT

Formal descriptions of larvae of the western North American species Choroterpes albiannulata and the eastern North American species Choroterpes fusca (Ephemeroptera: Leptophlebiidae) are given for the first time. Specimens, including reared adult and larval associations, of C. albiannulata were available from Nevada, Oregon, and Idaho, and rearings of C. fusca were made from the Huron Mountains in the Upper Peninsula of Michigan. Six of the nine species of North American Choroterpes (subgenus Choroterpes) are now known as larvae. Larval characteristics are compared, particularly with regard to similarities and differences between C. albiannulata and C. fusca, C. albiannulata and the western C. inornata, and C. fusca and the eastern C. basalis. Choroterpes albiannulata is distinct but shares gill morphology with C. inornata. Choroterpes fusca is quite similar to C. basalis, sharing gill morphology and color patterning, but with some apparent differences that may prove to be consistent. Certain Choroterpes larvae from Arkansas are probably C. oklahomae (known only as adults from Oklahoma) but cannot be associated at this time. Distributions of species of subgenus Choroterpes are updated, and a revision of the entire genus based on cladistic analysis is recommended.

Eaton (1892) described adults of Choroterpes inornata from Mexico, but it was not until 1973 that its larval stage was finally discovered and described (Kilgore and Allen 1973). This situation has typified the chronological gap between our knowledge of adults and larvae for many, if not most, species of Ephemeroptera and has contributed to the current need to re-evaluate the systematics of many genera. At the present, nine valid species of Choroterpes (subgenus Choroterpes) have been recognized in North America north of Mexico. Up to this point, descriptions of the larval stages of four species have been published: C. basalis (Banks) by Needham (1905), C. terratoma Seemann by Seemann (1927), C. hubbelli Berner by Berner (1946), and C. inornata Eaton by Kilgore and Allen (1973). The remaining five species are C. albiannulata McDunnough, C. ferruginea Traver, C. fusca Spieth, C. nanita Traver, and C. oklahomae Traver. In addition, three southwestern species of Choroterpes were described originally as larvae (remaining unknown as adults) but were placed in a separate subgenus Neochoroterpes by Allen (1974) on the basis of their gills having three well-developed terminal processes rather than having only the median process well developed, which distinguishes the subgenus Choroterpes.

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In much of the 1980's, I had the opportunity to extensively study the ecology and behavior of populations of *C. fusca* in the Huron Mountains of the Upper Peninsula of Michigan. As a result of making reared associations of larvae and adults, I present a description of the larvae of this species herein. In addition, I have studied larval and adult specimens of *C. albiannulata* from Nevada, Oregon, and Idaho that are housed in the Purdue Entomological Research Collection (PERC). Actually, G. F. Edmunds, Jr. associated larvae and adults of this latter species by rearing some from the Snake River near Blackfoot, Idaho in 1963; a brief description of those larvae appeared in a 1966 Master's thesis by S. L. Jensen on the mayflies of Idaho. No description of the larvae, however, has been published, and it seems propitious to do so herein. These descriptions should allow further comparative analyses of North American species of *Choroterpes*. However, three species will still remain unknown as larvae and any revision of *Choroterpes* will require more in-depth study in light of world-level generic concepts, as alluded to by Peters (1988).

**Choroterpes albiannulata** McDunnough

*Larva* (in alcohol). Length of mature larvae, excluding caudal filaments: 7.4–7.8 mm (female), 6.3–6.5 mm (male). Caudal filaments subequal, 7.0–9.1 mm.

*Head*: Dorsal head capsule (Fig. 1) light brown with diffuse black markings as follows: one median dark blotch on frons narrowly connecting postero-laterally with a variable, darkened, more-or-less transverse marking extending from anterior of compound eyes and surrounding antennal bases to across vertex at level of ocelli, and in some individuals extending diffusely between and behind lateral ocelli (most distinct in females). Antennae pale, one and one half to twice as long as head. Compound eyes black, with upper portion rust colored in males. Clypeus with distinct transverse row of medium length setae subapically in median third, and much denser row of uniformly shorter setae apically at emargination in same area. Thick setal brush of galealaciniae light to golden brown; maxillary palpi distinctly three-segmented.

*Thorax*: Pronotum light brown with clear lateral flanges, and in some individuals with black, diffuse, longitudinal markings sublaterally and submedially behind lateral ocelli, and with somewhat shaded area medially. Mesonotum light brown, but with some dark penciling at sutures and taking on rufous coloration of adult in last instar. Legs light cream colored and generally lacking any conspicuous patterning, although some individuals with shading basally in femora and tibiae and also apically and medially on femora. Tarsal claws with 9–11 denticles.

*Abdomen*: Tergal pattern variable but generally consisting of dark brown or black granulation on light brown ground color; granulation weaker or less dense in some areas on some individuals, e.g., medially (giving allusion of very faint midlongitudinal stripe), at postero-lateral corners, along anterior margin (especially of tergum 10), submedially at anterior margins, and sublaterally at anterior margins; tergum 10 mostly light except for posterior shading. Sterna cream colored to pale, lacking distinct maculations, although subcutaneous dark circle often evident on sternum 8 or around juncture of sterne 7 and 8. Gills with tracheae faint in median process of dorsal lamellae; median process of dorsal lamellae of gills 3 (Fig. 5) narrow leaf shaped, with acutely pointed apex. Caudal filaments pale except dark rings on basal 5 to 8 segments; basal third of segments with few spines and bristle-like setae at apex of each segment; middle and apical segments with mostly bristle-like setae at apex of every other segment.
Material examined: Twenty-one larvae were studied from the Koss Collection at PERC as follows: Nevada, Elko Co., Humbolt River at Elko, VII-29-1965; Oregon, John Day River, Kimberley, IX-5-1933; and Idaho, Bingham Co., Snake River at Blackfoot, VIII-7-1963.

Choroterpes fusca Spieth, 1938

Larva (in alcohol). Length of mature larvae, excluding caudal filaments: 5.8–6.5 mm (female), 5.8–6.3 mm (male). Caudal filaments subequal, 9.5–11.5 mm.

Head: Dorsal head capsule (Fig. 2) medium brown with light patches as follows: one immediately anterior to median ocellus, variously extended between antennae and tending to narrow anteriorly (appearing triangular in well-marked individuals), pair of somewhat rounded or hemispherical, conspicuous patches on dorsally visible mandibles and anterior to antennae, and pair of lightened areas each continuous from laterad of lateral ocelli, anterior to compound eyes, and posterior to antennae; vertex dark brown or darkest between lateral ocelli and in areas directly posterior to lateral ocelli and extending slightly medially from there; median two-thirds of posterior edge of vertex variously mottled. Antennae light, about twice length of head. Compound eyes black, with upper portion rust-colored in males. Clypeus dorsally colored as dorsal head capsule. with dorsal subapical row of medium length setae in median third and with row of short, thick setae prominent along well-developed anterior emargination. Thick setal brush of galealaciniae dark brown; maxillary palpi three-segmented but with segments 2 and 3 partially fused and often appearing fused under low magnification in some individuals.

Thorax: Pronotum either patterned or diffuse medium brown, always with light to transparent lateral flanges; if patterned, darker or dark brown sublaterally and submedially (submedial marks narrow-elongate anteriorly and broadening posteriorly), and with lighter area anteromedially. Mesonotum lighter brown to yellowish with some dark markings laterally near base of forewingpads (some individuals with penciling transversely at middle third of suture separating pronotum and mesonotum, and longitudinally at lateral notal sutures). Legs light tan to yellow; claws with 10–12 denticles. Forefemora dorsally (Fig. 3) with weak or diffuse maculation medially, not extending from anterior to posterior margins and with shaded area apically in some individuals; ventrally (Fig. 4) similarly placed markings are more distinct, and medial maculation broader, nearly transverse and often divided into two spots. Foretibiae (Fig. 3) diffusely darkened at base and with light brown shading (difficult to see in some individuals) from about midlength to near apex. Foretarsi (Fig. 3) with diffuse brown area beginning subbasally to about midlength, and with small dark maculation ventrally at tarsus-claw articulation. Midlegs and hindlegs with markings generally similar to forelegs, except hindlegs with dorsal maculation extending diffusely from midlength to apex in some individuals.

Abdomen: Tergal pattern quite variable but generally with dark brown granular appearance (darkest at posterior and postero lateral region of each tergum) with variously discernible lighter or less densely granulate markings, including midlongitudinal line and somewhat ill-defined large round areas laterally on most terga, but in some individuals additional more defined, small light spots sublaterally at anterior margin of terga and larger ones at base of gills, and pair of small, light, triangular areas submedially at anterior margins, becoming more elongate in more distal terga. Sterna (Fig. 7) light to medium brown, sometimes with general indistinct mottling, usually with
slightly darker markings sublaterally, more continuous in basal sterna but more separated and defined in distal sterna (sternum 9 often with distinct dark markings sublaterally at anterior margin). Gills with distinct, dark tracheae, with lateral tracheae well developed in median process of at least gills 2-4; median process of dorsal lamellae of gills 3 (Fig. 6) relatively broad and with bluntly pointed apex. Caudal filaments light; basal segments with whorls of spines at apex of each segment; middle segments with whorls of bristle-like setae and spines at apex of every other segment; distal segments with whorls of bristle-like setae at apex of every other segment.

Material examined: Over 50 larvae were studied from Michigan, Marquette Co., Ives Lake, VIII-25, IX-6-1985, VIII-3-1986, PERC.

DISCUSSION

Spieth (1938) indicated that C. albiannulata and C. fusca were most closely related to each other (on the basis of adults) among the species of Choroterpes. Therefore a comparative analysis of their larvae would appear to be of some importance. A direct comparison of the larvae of the two indicates a number of diagnostic characteristics that serve to distinguish them, and at the same time a number of characteristics in common, some of which appear to be uniform throughout the subgenus in North America. The most obvious differences include the dorsal color pattern of the head (including the exposed dorsal surfaces of the mandibles). While all North American species of the subgenus Choroterpes may have a central white or pale patch located directly in front of the median ocellus, the black patch forward on the frons of C. albiannulata (Fig. 1) may be unique. The head patterning of C. fusca (Fig. 2) appears much like that drawn for C. inornata by Kilgore and Allen (1973), particularly with regard to light mandibular patches and the dark brown area between the lateral ocelli described for other species.

The setal brushes on the galealaciniae of C. albiannulata are light relative to the much darker ones found in C. fusca, and whereas the maxillary palpi are distinctly three-segmented in C. albiannulata, the distinction between segments two and three in C. fusca can sometimes be difficult to discern. Leg and ventral abdominal patterning in the two species is quite different, with C. albiannulata lacking the maculations of C. fusca (Figs. 3, 4 and 7). The claws of both species possess approximately the same number of denticles. This character is often difficult to use in species diagnoses of mayflies because of its known variability in species of certain genera (e.g., Bednarik and McCafferty 1979), however it should be noted that Kilgore and Allen (1973) reported 14-18 such spines in C. inornata. Given the variability of dorsal body patterning in both species and evidently in others as well, it is impossible to draw conclusions about the usefulness of such patterning in formulating diagnoses of species. I suspect that the patterning is generally similar throughout the subgenus in North America and may vary somewhat with age and habitat of the larvae [see also plate 7, Fig. 2. in Needham (1905) and Fig. 1 in Kilgore and Allen (1973)].

The median process of the dorsal lamellae of gills is distinctly different in C. albiannulata [lanceolate and sharply pointed] and C. fusca (broad and blunt), as is clearly shown in Figs. 5 and 6. This process in the gills of C. hubbelli [Fig. 3, Berner (1946)] has aspects of both, in that it is broad like that of C. fusca, but with a sharper apex, more similar to that of C. albiannulata. There may also be differences in the caudal filaments in that some dark annulations are found basally in C. albiannulata but not in C. fusca, and segmental spination may be better developed in C. fusca. Also, the caudal filaments
appear to be somewhat longer in proportion to the body in *C. fusca* than they are in *C. albiannulata*, where the tails are not much longer than the body. The latter situation is apparently also found in *C. hubbelli* and *C. inornata*. Finally, there appears to be some difference in body size between the two and in the degree of sexual dimorphism with respect to size in the two species. In *C. fusca*, the mature larvae range from 5.8 to 6.5 mm with little difference in the size of the males and females. However, in *C. albiannulata*, the range is 6.5 to 7.8 mm, but the females are always distinctly larger than the males. I have found this to be true also for species of the subgenus *Neochoroterpes*.

Since Traver (1935), on the basis of adult comparisons, concluded that *C. albiannulata* was most closely related to *C. inornata*, a reiteration of the larval differences in those two appears pertinent. Both of these species are found only in the West, with *C. inornata* known from Arizona and New Mexico (Kilgore and Allen 1973), Colorado (B. C. Kondratieff, pers. comm.), and Mexico (Eaton 1892), and *C. albiannulata* known from Alberta (McDunnough 1924), Saskatchewan (Lehmkuhl 1976), Oregon (Allen and Edmunds 1956), Idaho, and Nevada (herein), and Utah (Edmunds 1954). The only other species of the subgenus known from the far West is *C. terratoma*, from southern California (Seemann 1927, Traver 1935), although *C. oklahomae* and *C. nanita* are known from Oklahoma and Texas, respectively (Traver 1934).

Differences in the head patterning between *C. inornata* and *C. albiannulata* are distinct as mentioned above. The leg markings are apparently very different also, with broad, almost transverse maculae on the femora of *C. inornata* and little, if any, maculation in *C. albiannulata*. If the number of denticles on the tarsal claws proves to be a valid specific character, then differences reported for the two species are significant. It is not clear whether or not the shape of the median process of the dorsal lamellae of the middle gills is different or not in the two species. From the habitus drawing of Kilgore and Allen (1973) of *C. inornata*, the process appears very narrowly leaf shaped and almost lanceolate; this is in general agreement with *C. albiannulata* (Fig. 5), although the latter may be even broader; gills of both species are sharply pointed apically. Also, it is not clear whether or not larvae of *C. inornata* and *C. albiannulata* share the presence of a few dark annulations on the basal segments of the caudal filaments.

Burian and Gibbs (1991) suggested that *C. fusca* and *C. basalis* were probably synonymous. Therefore, I have compared larval collections of *C. basalis* present in the PERC with those of *C. fusca*. The former species apparently is widespread throughout northeastern and midwestern North America, and I have studied larval specimens from Indiana. *Choroterpes fusca*, however, is known only from Ontario (Spieth 1938) and the Upper Peninsula of Michigan (herein). Burian and Gibbs (1991) reported *C. fusca* from Maine, but since they suggested its equivalency to *C. basalis*, it is not clear as to which of these names their populations actually refer. *Choroterpes ferruginea* is known only from New York, but little is known of this species, and it may represent a color morph of *C. basalis*. *Choroterpes hubbelli*, the only other eastern species, is known only from Florida, Alabama, and South Carolina, and possibly North Carolina.

Larvae that I have examined of *C. basalis* and *C. fusca* are quite similar. I can find no consistent differences in the color patterns, although leg and head patterning appears to be extremely variable among *C. basalis*, with legs of a large proportion of individuals lacking medial femoral markings dorsally but not ventrally. Also the white medial patch anterior to the median ocellus is never very well developed in *C. basalis* as it is in some *C. fusca* (Fig. 2). There is usually a small, distinct, dark spot at the tibia-tarsus articulation of *C. basalis* that I did not find in *C. fusca*. The sometimes weak articulation of segments 2 and 3 of the maxillary palpi described above for *C. fusca* is also found in *C.
basalis. Needham (1905) had reported the maxillary palpi of C. basalis to be two-segmented, most probably for this reason.

The shape of the gills is similar in C. basalis and C. fusca (Fig. 6), particularly with regard to the shape of the median process of the dorsal lamellae of the middle gills, however, the median process does not appear to have lateral tracheation as well defined as in C. fusca. Claw denticles numbered 10–12 in C. fusca, but I have found only 8–10 in about 30 specimens of C. basalis that were examined for this character. The length of the antennae relative to the head and the length of the caudal filaments relative to the body are within the same range in both species.

It remains to be seen if the above stated differences are consistent and diagnostic of two discrete species, or if they are due to variability of individuals or populations among one widespread species. This will have to be ascertained within the context of a revisionary study of the genus as intimated above. From the diverse opinions about North American species of the subgenus Choroterpes and their relationships (Traver 1935, Spieth 1938, Burian and Gibbs 1991), it is clear that only a cladistically based revision will resolve questions of species integrity and relationships.

Larval specimens I have seen from Arkansas and that were tentatively identified as C. basalis in the PERC are quite different from what I consider to be typical C. basalis, discussed above, in that they have gills essentially of the C. inornata-C. abianulata type (Fig. 5), discussed above, and have some other characteristics that do not seem to fit any of the presently described species of Choroterpes in North America. They may, in fact, prove to represent a new species, but I rather suspect they are the larvae of C. oklahomae (presently known only as adults from Oklahoma). Since they are not associated with adults by rearing, it is difficult to make a definitive assessment at this time.

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LITERATURE CITED

ABSTRACT

Burrowing mayflies (Hexagenia bilineata) were collected in 1991 in the vicinity of the DePere dam on the Fox River, Brown County, Wisconsin. Because Hexagenia mayflies are indicators of good water quality, their emergence from the Fox River is evidence of improvement in conditions at the sediment-water interface.

Burrowing mayflies (Hexagenia spp.) have become recognized as good indicators of water quality (Fremling 1964a, 1989; Fremling and Johnson 1990). Their relatively long nymphal stage is spent in organically rich sediments, where nymphs may be vulnerable to hypoxia or to the accumulation of toxins (Fremling 1989). In response to anthropogenic declines in water quality, Hexagenia nymphs have been eliminated from many waters, but they have also returned to some areas after pollution abatement measures have been initiated (Fremling and Johnson 1990). In habitats of high quality, Hexagenia adults may reach nuisance levels (Fremling 1960), but both nymphs and adults are important foods for fishes and other animals (Cochran and McConville 1983, Fremling 1989).

In Lake Michigan's Green Bay, the adults of Hexagenia limbata (Serville) formerly reached nuisance levels (Schuette 1928, Arnett 1985), but the population was greatly reduced by as early as 1938 and completely eliminated by 1969 (Harris et al. 1987b and references therein) in response to reductions in water quality caused by input from the lower Fox River. One management objective listed in the development of a remedial action plan for Green Bay was the reestablishment of Hexagenia nymphs in the inner bay at densities of 400–500 per square meter (Harris et al. 1987a). Hexagenia nymphs have been recently reported in the diet of yellow perch (Perca flavescens) from Lake Michigan's Little Bay de Noc (Schneeberger 1991). However, as of the spring of 1991, they were reported "still missing" from Green Bay and other parts of the Great Lakes where they formerly occurred (Anonymous 1991). Thus, the collection in that year of a series of adult Hexagenia near the DePere dam on the Fox River, 12 km upstream from Green Bay, is noteworthy.

I collected 13 adult Hexagenia in June and July 1991. Eleven were collected along the Claude Allouez Bridge, which passes over the Fox River on the downstream side of the DePere dam, or at intersections at either end of the bridge. Two were found on separate days on a building 0.5 km east of the dam. Dates of collection (14, 16, 26, and 27 June; 4 and 15 July) were consistent with the temporal pattern described for Mississippi River populations (Freml-

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ling 1964b, 1973), by which emergences are observed at intervals of 6–11 days. The 13 mayflies included 5 males and 7 females (one individual was not sexed). Three specimens sent to the University of Wisconsin-Madison Insect Collection were identified as *Hexagenia bilineata* (Say) (Hilsenhoff, pers. comm.). *Hexagenia bilineata* tends to be more restricted to large rivers than *H. limbata* (Fremling 1989).

*Hexagenia* apparently have returned to the lower Fox River relatively recently. I have worked in a building near the DePere dam since 1984 and I have lived several blocks from the river since 1986. Since that year I have walked across the Claude Allouez Bridge almost daily, but I observed no *Hexagenia* until 1991. Moreover, bottom sampling by St. Norbert College students in 1986 yielded no *Hexagenia* nymphs, either upstream or downstream from the dam.

It is possible that *Hexagenia bilineata* were artificially reintroduced to the Fox River. Bait shops in the Green Bay area, including a former shop in DePere that ceased operations in 1989, have been known to sell *Hexagenia* nymphs as “wrigglers” to anglers who fish through the ice, and anglers have been known to release excess bait. Substantial numbers of anglers fish through the ice each winter below the DePere dam.

The emergence of *Hexagenia bilineata* from the Fox River is evidence of improvement in conditions at the water-sediment interface sufficient to permit completion of the long nymphal stage in at least some areas of river bottom. This bodes well for the rehabilitation of the river’s biological community. Auer and Auer (1990) implicated chemical suitability of the substrate as a factor limiting natural reproduction by walleye (*Stizostedion vitreum*) in the lower Fox River.

Success of *Hexagenia bilineata* in the Fox River may also be a signal for concern. Ironically, as pollution is reduced in tributaries to the Great Lakes, these tributaries are more likely to be ascended by spawning-phase sea lampreys (*Petromyzon marinus*). Like *Hexagenia*, the sea lamprey undergoes a burrowing larval stage of relatively long duration, and, judging from the frequency with which *Hexagenia* nymphs are reported during applications of chemical lampricides (Gilderhus and Johnson 1980), the two taxa overlap in their habitat requirements. It is perhaps no coincidence that, like *Hexagenia bilineata*, spawning-phase sea lampreys were first reported from the Fox River in 1991 (Cochran and Bougie, ms). It remains to be seen whether either or both taxa increase in abundance.

ACKNOWLEDGMENTS

I thank William Hilsenhoff, Univ. of Wisconsin-Madison, for identifying the *Hexagenia* to species.

LITERATURE CITED


Note added in proof: Additional adult Hexagenia were observed at the Claude Allouez Bridge in 1992, beginning on 24 June.
DISTRIBUTION OF THE WATER SCORPION NEPA APICULATA (HEMIPTERA: NEPIDAE) IN WISCONSIN

P.A. Cochran, A.P. Gripentrog and K.M. Stack

The water scorpion Nepa apiculata Uhler was considered rare in Wisconsin by Hilsenhoff (1984), who collected only 11 individuals during a 25-year period. All of his collections were from overwintering sites, especially debris in streams, during early spring or autumn (Hilsenhoff, pers. comm.). He concluded that the species was restricted to southern Wisconsin. Recent collections indicate that N. apiculata is more widely distributed. These records, summarized below, are documented with specimens in the University of Wisconsin-Madison insect collection.

On 25 September 1986 we collected a N. apiculata during a brief period of sampling in a small artificial pond near De Pere, Brown County, Wisconsin. An additional specimen from Brown County was provided by Doug Hartman, naturalist at the Barkhausen Waterfowl Preserve, who indicated that school children on class trips had collected approximately six individuals in as many years in a small shallow pond that is fed and drained by a small creek. At both Brown County locations, N. apiculata were collected at the water's edge with dipnets. This is consistent with habitat descriptions provided by McPherson and Packauskas (1987). They described the breeding habitat as muddy margins of ponds or marshes where the water barely or only partially covers the insect. A third Brown County specimen, 16 mm long (exclusive of the apical abdominal respiratory appendages), was collected in somewhat different conditions by Andrew Cochran on 29 June 1992. It was found in Duck Creek at Brown County Park beneath a rock approximately 8 cm from shore. The rock was situated over a gravel bottom and the cavity beneath it was 10–13 cm deep.

On 12 July 1991, two N. apiculata were collected from debris in Hackett Branch approximately 0.3 km upstream from its confluence with the Grant River in Grant County. Additional records of N. apiculata in Wisconsin were provided to us by William Hilsenhoff and include specimens from the Black River in Taylor County (October 1987), a marsh in Sheboygan County (March 1986), and Rush Lake in Winnebago County (collected by G. Drecktrah). Together with our records from Brown and Grant counties, these indicate that the distribution of N. apiculata in Wisconsin is much more extensive than previously supposed (Figure 1). Indeed, we expect that this species is even more widely distributed in Wisconsin and perhaps occurs statewide; McPherson and Packauskas (1987) noted that it has been collected in Manitoba. The apparent rarity of N. apiculata in Wisconsin is likely due to inadequate collecting in its shallow, muddy breeding habitat. However, because N. apiculata apparently occurs in low densities in at least some localities (see above), new records may prove difficult to come by. A potentially useful strategy for obtaining new locality data would be to contact nature centers where pond or wetland studies are routinely conducted.

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Figure 1. Distribution of *Nepa apiculata* in Wisconsin. Dots are county records from Hilsenhoff (1984) plotted at the center of each county (more exact localities were not provided). Asterisks (*) mark new county records reported herein.

ACKNOWLEDGMENTS

We thank the various individuals who collected the specimens listed herein, and we thank William Hilsenhoff for comments on an earlier draft on this manuscript.

LITERATURE CITED


SEASONAL DRIFT OF LETHOCERUS AMERICANUS (HEMIPTERA: BELOSTOMATIDAE) IN A LAKE SUPERIOR TRIBUTARY

Robert B. DuBois and Michael L. Rackouski

ABSTRACT

Drifting adult Lethocerus americanus were captured and retained by an inclined-screen smolt trap during two field seasons in the Bois Brule River, Wisconsin. Seasonal peaks of drift occurred in spring for 4 weeks following ice out and in autumn for 7–8 weeks from mid-September through ice formation, and may have continued under ice cover when our gear was not operated. These findings are consistent with the known movement pattern of these insects to fly from lentic habitats to streams to overwinter but also suggest longitudinal movement via drift, perhaps to reach specific overwintering sites. Drift was significantly correlated with declining water temperatures in 1989 but not in 1990. Most drift occurred at water temperatures less than 12°C. There was no correlation between drift and river discharge. Drift rates were consistently low with a maximum by volume of 9 animals per 10,000 m³.

Giant water bugs (Lethocerus americanus [Leidy]) are generally found in lentic habitats of various types and sizes where they breed and sometimes overwinter (Hungerford 1920, Rankin 1935, Hilsenhoff 1984). Occurrence in streams is thought to be infrequent (Menke 1963). They are, however, known to fly to streams to overwinter and are frequently collected in late autumn and early spring along stream banks (Hilsenhoff et al. 1972, Hilsenhoff 1984). Hoffman (1924) found some hibernating adults in December about 15 cm deep in the disintegrated plant material of a Minnesota stream bottom, and others 6 to 8 cm deep among Typha roots near the stream edge. Although this general life history pattern involving riverine overwintering has been fairly well established, little information is available about drifting or other behavioral aspects of this species in lotic systems.

These insects are not often captured in drift nets, probably because they are relatively uncommon in streams. They may also be able to crawl out of many conventional drift nets. A smolt trap used to capture migrating salmonids proved to be effective in capturing and retaining drifting L. americanus. This paper reports on the spring and autumn drifting of these insects in the Bois Brule River, Wisconsin.
STUDY LOCATION AND METHODS

The 79-km Bois Brule River drains a diverse and sparsely developed watershed of about 320 km² and flows north into the western end of Lake Superior. Discharge from this spring-fed, fourth-order river averages about 6 m³/sec, and total alkalinity averages 58 mg/L CaCO₃. A more complete description of the Bois Brule River watershed was given by DuBois (in press).

*L. americanus* was sampled with an inclined-screen smolt trap [see DuBois et al. (1991) for design specifications and operational details] operated at a lamprey barrier about 11 km above the river's mouth. The trap was attached to the downstream face of the barrier dam. Water to be sampled (6 to 10% of the total river flow depending on river level) was shunted down an inclined screen made of parallel aluminum rods spaced 6.4 mm apart and flowed into a floating catch barge covered with a tarpaulin. Because of the covering and the large volume of water entering the trap, escape of giant water bugs from the trap by either crawling or flying out was unlikely. We assume that all *L. americanus* individuals entering the trap were retained until we removed the contents. Contents were removed with a dip net, and woody debris and leaves were examined carefully. Trap contents were removed at intervals ranging from 16 to 72 hours and always included at least one night. Operation of the trap extended throughout the ice-free season, beginning in late March or early April and extending through early to mid-November. In 1989 the trap was operated for 2,406 hours at an average of 78 hours per week. In 1990 operation was more frequent, totaling 4,348 hours and averaging 132 hours per week.

Water temperature and discharge were each examined for correlation with numbers of drifting *L. americanus* retained by the trap per hour by testing the null hypothesis that the Pearson correlation coefficient equaled zero (Snedecor and Cochran 1980). Additionally, we calculated a sampling efficiency of 15% for the trap (assumed to be constant for the duration of both sampling seasons). This was estimated by marking, with a spot of fingernail polish on the wing, 104 individuals caught by the trap at normal flow, releasing them at mid-channel about 125 m upstream of the trap, and recording the number (16) recaptured. This efficiency estimate provided only minimum estimates of total river drift because some of the released insects may have stopped along the bank above the barrier. These minimum estimates are used only to approximate the magnitude of total river drift. Because a partial guide fence was used to direct downstream-moving animals to the mouth of the trap, sampling efficiency was not directly related to the amount of the total river flow sampled.

RESULTS

Over two field seasons, 751 downstream-moving adults were captured and retained by our smolt trap showing spring and autumn peaks of movement (Fig. 1). During spring of each year, the period of substantial movement existed for 4 weeks beginning shortly after ice out (mid-March in 1990, the end of March in 1989). Autumn peaks of movement began in mid or late September and extended 7–8 weeks, which in 1989 included the day prior to permanent winter ice formation. Most of the drift sampled (70–80%) occurred during autumn.

Catch rates per hour of *L. americanus* ranged from 0 to 0.45 (avg. 0.09) in 1989 and 0 to 1.11 (avg. 0.13) in 1990. The highest catch rates we recorded each year, by water volume, were 5 per 10,000 m³ on 16 November 1989 and 9 per 10,000 m³ on 22 October 1990. Drift of these insects was significantly correlated with declining water temperatures in 1989 ($p < 0.0001$), but not in
1990 ($p = 0.259$). Most drift occurred at temperatures less than 12°C (Fig. 1). There was no correlation between drift and river discharge.

Total river drift rates based on the estimated sampling efficiency of our trap of 15%, although inexact for reasons stated in the Methods section, appear to have ranged from 0 to over 7 *L. americanus* per hour. Extending these estimates, total numbers of drifting adults during the ice-free seasons we sampled ranged from approximately 3,000 to 5,000 annually. Mean total length of *L. americanus* in October ($N = 36$) was 52 mm (range 45–59 mm) and mean total body width was 20 mm (range 18–23 mm).
DISCUSSION

Drift of *L. americanus* occurred primarily during late autumn, secondarily during early spring, and may have continued under ice cover when our gear was not operational. These seasonal aspects of drift are consistent with the known behavior pattern of adults flying to streams to overwinter. Several workers have referred to the strong flight ability of these insects (Hungerford 1920, Hoffman 1924, Menke 1963). The autumn peak of drift could represent a searching response for suitable overwintering areas by newly arrived adults. However, numerous observations we have made of this insect in slow-water sections of the upper Bois Brule River during summer and early autumn, as well as reports we have received from anglers, suggests year-round residency of at least some *L. americanus* in the Bois Brule River mainstem. Additionally, adults are frequently observed throughout the winter on raceway screens at the Brule Trout Rearing Station which is located at about the midpoint of the Little Brule River, a major Bois Brule River tributary (S. Plaster, pers. comm.). Because of the frequency of such observations, we speculate that year-round occurrence of this insect in low-gradient stream sections may be more common than previously thought. This idea is further supported by the paucity of significant lentic systems near the study area. The nearest lake is Lake Nebagamon (which is part of the Bois Brule watershed), located approximately 19 km to the south (about 48 km by river). Other lakes to the south and east are yet more distant. A few small ponds and swamps exist within a few miles of the trap, but the total surface area they contain is small (< 25 hectares).

The nearest likely overwintering area having a soft bottom and extensive riparian area resembling that described by Hoffman (1924) is located near the mouth of the Bois Brule River about 11 km downstream of the sampling device. However, the spring drift of *L. americanus* at the lamprey barrier is indicative of suitable overwintering habitat upstream as well, perhaps among roots of vegetation in small areas of reduced flow. Spring drift could thus be attributable to a post-dormant resumption of activity with some individuals subsequently being caught up in the drift.

This study is the first to report on drifting of *L. americanus*, which is not surprising considering that conventional aquatic insect drift studies do not usually sample enough water volume to collect more than a few of these animals. Smolt traps, by virtue of the large volumes of water they strain, can provide hard-to-obtain information on movement patterns of the larger, less-common aquatic insects and crustaceans as well as some reptiles and amphibians. We frequently captured *Pteronarcy s dorsata* (Say) (*Pteronarcidae*) and *Ophiogomphus carolus* Needham (*Gomphidae*) larvae, and adults of *Belostoma flumineum* Say (*Belostomatidae*) and *Ranatra fusca* Palisot Beauvois (*Nepidae*) in addition to *L. americanus*. However, these other insects were more difficult to consistently find amid the leaf litter, woody debris, and other plant material typically retained by the catch barge (they were smaller and usually less active). Hence, we are not able to quantitatively report on the drift of these taxa.

ACKNOWLEDGMENTS

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LITERATURE CITED


ABSTRACT

Native hop vine borer (*Hydraecia immanis*) and introduced potato stem borer (*H. micacea*) populations in Midwest corn have reached noticeable levels near the Great Lakes plant community ecotone between boreal forests and temperate deciduous forests. The hop vine borer is more specialized in its diet and occurs in corn generally south of the plant community ecotone, whereas the potato stem borer is polyphagous and occurs in corn mostly north of the Great Lakes plant transition zone. We analyzed the genetic composition of each species using cellulose acetate electrophoresis and resolved 19 loci of which 6 exhibited fixed or nearly fixed allelic differences. We expect that this will be useful in determining the degree of hybridization where the two species become sympatric due to expected continued range expansions in Michigan, Wisconsin, and New York State.

Two new corn insect pest species have been detected at economically significant levels and appear to be spreading in geographical distribution in the Great Lakes region during the last 15 years. These two moth species are closely related, morphologically similar members of the genus *Hydraecia* (Lepidoptera: Noctuidae) (Forbes 1954, Godfrey 1981). The damage caused to corn plants across several midwestern states by the hop vine borer, *H. immanis* (Gueneé) is also very similar to that caused by the potato stem borer, *Hydraecia micacea* Esper (Giebink et al. 1984, Deedat et al. 1983).

The hop vine borer and potato stem borer arose rather suddenly as Midwest corn pests in the late 1970's and early 1980's. The potato stem borer, *H. micacea*, was introduced from Europe in the early 1900's to North America (New Brunswick, Nova Scotia and Quebec) (Gibson 1908). In Europe, it was a widespread pest of a variety of crops including hops, corn, rhubarb, and potatoes (Deedat and Ellis 1983). The geographic distribution of the potato stem borer appears to have been spreading from localized populations in Wisconsin, Michigan, New York and Canada (Muka 1976, Rings and Metzler 1982, Giebink et al. 1984). Foodplant records (Hawley 1918, Jobin 1963) and recent feeding studies (Deedat et al. 1983, Giebink et al. 1992,) suggest that the potato stem borer is both naturally and potentially more polyphagous than the hop vine borer. The hop vine borer is a native North American insect that has been known primarily from the mid-1800's as a pest of hops in New York and Wisconsin (see review by Hawley 1918). It has been of economic significance in more than 50 counties in Minnesota, Iowa, Illinois and Wisconsin.
Figure 1. Distribution of noticeable levels of damage to corn (reported from 1978-1989) caused by the hop vine borer (*H. immanis*—indicated on map by heavy outlining) and the potato stem borer (*H. micacea*—indicated by cross-hatching) in the Great Lakes region of North America. Locations of our population samples are indicated by arrows for both species. In Michigan, all potato stem borer reports are since 1987.

especially since the increase in reduced tillage/conservation tillage corn (Fig. 1).

The subtle differences between these congener species in their biology (Deedat et al. 1983; Giebink et al. 1984), diapause physiology (Giebink et al. 1985, Levine 1988), and morphology (Godfrey 1981) have been described recently. The recent shift of both species to corn at damaging levels is described in relation to the Great Lakes plant ecotone and insect hybrid zone (Scriber and Hainze 1987). To our knowledge, the genetics of neither species has been reported. We felt it important to investigate the population genetics of these new pest species especially in view of possible genetic introgression of polyphagous genes into the stenophagous hop vine borer populations as the geographic distributions of the two species come into contact and overlap (Fig. 1). Giebink (1988 and unpublished) has observed interspecific matings when the two species are caged together in the laboratory.

Our initial objective was to assess the genetic make-up, identify fixed allele (diagnostic) differences and determine allele frequencies of each *Hydraecia* species. We obtained specimens from the center of the hop vine borer infestation in corn (possibly the result of a major host shift) and from the center of the newly discovered populations of potato stem borer (likely to be the founding populations for the State of Wisconsin). Comparisons of allele
frequencies at polymorphic loci would be particularly useful for monitoring any genetic divergence in the periphery of geographically spreading populations of each species in subsequent years. This would also give us an indication about the degree of hybridization and genetic introgression between the two species where they become sympatric in the Great Lakes region.

METHODS AND MATERIALS

Adult specimens were reared from larvae collected in corn plants from Richland County Wisconsin (hop vine borer) and Manitowoc County, Wisconsin (potato stem borer) and were analyzed using cellulose acetate electrophoresis according to the methods of Hagen and Scriber (1989 and 1991). After eclosion as adults, males and females of both species were frozen at -80°C to preserve tissues. All samples were processed at 5°C in a cold room. Tissue extracts were prepared by grinding 1/4-1/2 of the abdomen of each moth in 250 μl of an extraction buffer (0.1 M tris, pH 7.0, with 40mg EDTA, 10mg NADP, 20mg NAD, and 250 μl B-mercaptoethanol per 100ml). The thorax and remaining abdomen were returned to the freezer and saved for later use, if needed. Extracts were centrifuged for 8 min at 14,000 x g and the supernatant was applied to thin layer cellulose acetate plates ("Titan III", Helena Laboratories, Beaumont, Texas) for electrophoresis. All plates were run at 4°C and specific conditions for each enzyme are listed in Table 1. Running buffers are adapted from those of Richardson et al. (1986): A-10 mM phosphate, 2.5 mM citric acid, pH 6.4; B-20 mM phosphate, pH 7.0; C-50 mM tris, 20 mM maleic acid, pH 7.8; D-15 mM tris, 5 mM EDTA, 10 mM MgCl₂, 5.5 mM boric acid, pH 7.8; E-15 mM tris, 192 mM glycine, pH 8.5.

Enzyme stains followed standard recipes (Harris and Hopkinson 1978, Richardson et al. 1986), scaled to approximately 10 ml total volume, and applied to plates as overlays mixed 1:5 with 1.5% agar. HBDH and LDH stains required extra NAD; activity for these enzymes was only detected in abdomen preparations. Bands for highly active enzymes (Apk, G3pdh, Gpi, Pepla, and Tpi) were most clearly resolved when the sample extract was diluted 1:3 with buffer prior to loading plates.

Interpretation of bands and allozyme nomenclature follows conventional systems (Richardson et al. 1986, Hagen and Scriber 1989). Isoenzyme loci are numbered from cathode to anode (Ac-1, Ac-2). For purposes of this study, alleles at a locus are assigned letters from least to most cathodal according to mobility. Voucher specimens have been retained in the J.M. Scriber research collection at Michigan State University.

RESULTS

Distinct, readily scorable bands were obtained for 19 enzyme-encoding loci (Table 1). Two enzymes were not resolvable on cellulose acetate: Ldh (lactate dehydrogenase) and Sod (superoxide dismutase). Six enzymes showed apparently fixed differences between the species (Table 2): Aat (Aspartate amino transferase), Ac-1 (aconitase-1), Ak (Adenylate kinase), Hbdh (Hydroyzybutyrate dehydrogenase), Mdh (Malate dehydrogenase) and P3gdh (3phosphoglycerate dehydrogenase), and Mpi is nearly fixed. These fixed differences were consistent for both males and females in both species.
Table 1. Allozymic loci resolved for *Hydraecia immanis* and *H. micacea*. Electrophoretic conditions found to give optimal resolution on cellulose acetate plates are indicated for each enzyme. Origin positions (an = anode, ce = center, ca = cathode) are selected to keep migrating enzymes centered on the plate. Running buffers are described in the text.

<table>
<thead>
<tr>
<th>LOCUS</th>
<th>ENZYME NAME (E.C. NUMBER)</th>
<th>ELECTROPHORESIS CONDITIONS</th>
<th>Buffer</th>
<th>Origin</th>
<th>Time</th>
<th>Voltage</th>
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<tr>
<td>Aat-1</td>
<td>Aspartate aminotransferase (2.6.1.1)</td>
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<td>Aconitase (4.2.1.3)</td>
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<td>Ac-2</td>
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<td>Acp</td>
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<tr>
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*Voltage is adjusted to maintain current between 12-15 mA per plate.
#Consistent resolution achieved to date only on starch gel medium using citrate buffer, pH 6.4, from Clayton and Tretiak (1972), Hagen and Scriber (1989).

**DISCUSSION**

While the native hop vine borer is polymorphic at 63% of the loci (12 of 19), the introduced potato stem borer is polymorphic for only 5% of the loci. This may reflect a possible genetic bottleneck or founder effect (Barton 1989). With six allozyme loci exhibiting fixed differences of the 19 enzymes resolved, we now have excellent biochemical diagnostic capabilities for distinguishing the two species. If these apparently fixed differences hold up for different geographic populations, we will have identified an excellent indicator for any natural hybridization that may occur in areas such as central Michigan, central Wisconsin or New York where the populations of the two species are becoming sympatric. Morphology and color types intermediate between *H. immanis* and *H. micacea* have been described by Forbes (1954). We could presumably now identify and classify such intermediates with these biochemical characters as well.

The first potato stem borer populations in Wisconsin were discovered in corn fields of Manitowoc and Kewaunee counties in 1982 (Fig. 1; Giebink et al. 1984). From these northeastern locations, subsequent populations with economically damaging levels were reported moving to the southwest in Brown, Outagamie, Calumet and Sheboygan counties by 1987 (Bruce Giebink, pers.
Table 2. Allele frequencies for hop vine borer and potato stem borer adults at 19 enzyme loci.

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In southwestern Wisconsin, the hop vine borer occupies at least 20 counties at economically significant levels for corn growers (Fig. 1). A similar geographic pattern of distribution of the two species appears to have occurred in Michigan. The first potato stem borer populations were detected in 1987 in the northeast "thumb" region of Michigan (Sanilac Co.) and Arenac Co. (slightly to the north). Subsequent populations (in Newago, Tuscola and Huron counties) have been reported damaging corn in Michigan (D. Landis, pers. comm.). As in Wisconsin, the hop vine borer records of distribution are confined to the south and southwestern part of the State (Berrien, Cass, Oceana, and Lenawee counties; Fig. 1).

The rather narrow Great Lakes plant community ecotone (Curtis 1957) separates the two species of *Hydraecia* in both Michigan and Wisconsin. Hybridization (or any genetic introgression) in the hybrid zone may contribute to wider larval host plant use abilities, altered voltinism patterns, reduced developmental temperature thresholds of the larva and possibly changes in oviposition preferences (Scriber 1988, Scriber and Lederhouse 1992). Such introgression has been shown to affect all of these ecologically important traits for the eastern tiger swallowtail butterfly at the same ecotone locations in Michigan and Wisconsin where the northern species (*P. canadensis*) meets the southern species (*P. glaucus*) (Ritland and Scriber 1985, Rockey et al. 1987, Hagen et al. 1991, Scriber 1990, Scriber et al. 1989, 1991). This plant transition zone is in fact closely aligned with other geographic sutures for insect species distributions (Scriber and Hainze 1987, Scriber and Lederhouse 1992).

For both the southern hop vine borer and the northern potato stem borer, we are currently monitoring the geographic spread of damaging populations and hope to subsequently assess the degree of genetic introgression in sympatric areas directly by use of the six diagnostic allozyme alleles that distinguish the two species at their allopatric locations. If genetic introgression occurs between these species, the economic impact on numerous crop systems in these areas will require careful analysis and perhaps different management programs.

ACKNOWLEDGMENTS

This research was supported by the College of Agriculture and Natural Resources and the College of Natural Sciences at Michigan State University (MAES Projects #1640, #8051 and #8072), Regional Research Projects NC-180 and NC-205, and in part by the "Agroecology" LTER Project at Kellogg Biological Station (NSF-BRS-02332) and the USDACRGO (87-CRCR-1-2581). We are grateful for assistance from Bruce Giebink, Robert Hagen, Doug Landis and Mo Nielsen.

LITERATURE CITED


Scriber, J. M. 1990. Interaction of introgression from *Papilio glaucus canadensis* and diapause
HOLARCTIC INSECTS ADVENTIVE IN MICHIGAN: NEW AND ADDITIONAL RECORDS (HOMOPTERA, HETEROPTERA, COLEOPTERA, NEUROPTERA)

A. G. Wheeler, Jr.

ABSTRACT

Fourteen European insects in the Homoptera (4 species), Heteroptera (5), Coleoptera (4), and Neuroptera (1) are reported from Michigan. Ten are new state records (one new Ohio record is given). The point of entry for most of the species is assumed to be the northeastern United States or Maritime Provinces of Canada. Possibilities of dispersal (natural and human-assisted) from centers of introduction in the Northeast, multiple introductions from Europe, and direct entry into the Great Lakes region are discussed.

The adventive component of the New World fauna has long interested both basic and applied entomologists. Initially, all invading species merit attention, and those that appear to threaten North American agriculture (or be of biocontrol or medical significance) are monitored. Insects that pose little or no economic risk, however, are often forgotten soon after their detection. Spread from apparent points of entry is not tracked. New records accumulate unsystematically and merely tend to reflect the activity of collectors and identifiers.

Records of nonindigenous species are most useful if based on intensive, systematic surveys over a wide area. But even isolated records can be important, for they provide data potentially useful in assessing pathways of entry and dispersal from centers of introduction. If records of subsequent spread are not documented soon after detection, it becomes increasingly difficult to determine whether a particular insect is adventive or naturally Holarctic in the New World. If previously innocuous species common to the Old and New World should assume economic importance, then information on their North American distribution and their biogeographic status (naturally Holarctic or adventive) becomes critical.

Herein, Michigan records (and one from Ohio) of 14 adventive species (4 orders, 10 families) are listed; new state records are indicated by an asterisk. Arrangement of taxa below the ordinal level is alphabetical. All species were collected by the author (except the lygaeid Stygnocoris rusticus) during 14–25 July 1991. Unless otherwise indicated (by numbers in parentheses or noting that a species was common or abundant), only one adult was collected at each locality. Voucher specimens have been deposited in the insect collections of Cornell University, Ithaca, New York (CUIC), and the National Museum of Natural History, Washington, D.C. (USNM).

1Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, PA 17110.
For each species, reference is made to the first North American record, and the current Nearctic distribution is summarized. In most cases, biological studies in North America are mentioned. Literature cited in these papers can be used to obtain information on seasonal history and habits in the Old World.

**Homoptera: Cercopidae**

*Aphrophora alni* (Fallen). Moore's (1956) records from Ontario were the first for this European spittlebug in North America, although one specimen had been collected in 1927. Abundant in southern Ontario, *A. alni* occurs mainly within a 260-km radius of Toronto (Hamilton 1982). The first U.S. record was that of Hanna and Moore (1966) from Monroe County, Michigan, where it occurred along roadsides and edges of woods, especially on goldenrod. Hanna (1970) observed nymphs on various herbaceous plants in Monroe County and suggested that this cecropid had been introduced with European nursery stock.

CHIPPEWA Co.: Rotary Park, Sault Ste. Marie, 21-VII, on *Alnus rugosa*.

*Lepynora coleoptata* (L.). The first verified Nearctic records of this common Old World spittlebug were those of Russell (1962) from New York. It has since been reported from Ontario, Pennsylvania, Quebec, Vermont (Hoebeke and Hamilton 1983), and New Hampshire (Wheeler 1991). In Pennsylvania, this polyphagous immigrant develops mainly on roadside vegetation, particularly naturalized Eurasian composites such as Canada thistle (*Cirsium arvense*) and spotted knapweed (*Centaurea maculosa*), and also crownvetch (*Coronilla varia*) (Wheeler 1991).

BARAGA Co.: junco Rts. 28 and 41 S. of Alberta, 24-VII. GOGEBIC Co.: Rt. 64, 2.4 mi. N. of Rt. 2, 24-VII. HOUGHTON Co.: Rt. 28, 2 mi. W. of Kenton and Rt. 28 E. of Kenton, 24-VII. ONTONAGON Co.: Rt. 64, 2 mi. E. of Silver City, 24-VII. Common along roadsides at all sites.

**Homoptera: Cicadellidae**

*Grypotes puncticollis* (Herrich-Schaeffer). This deltocephaline leafhopper is a pine specialist known from most of continental Europe, England, northern Africa, and Turkey. In the New World, it has been recorded only from western New York (3 counties) and northeastern Pennsylvania (2 counties) (Wheeler 1989a). Collections of this adventive species were made from Scotch pine (*Pinus sylvestris*) and Swiss mountain pine (*P. mugo*) (Wheeler 1989a).

WASHTENAW Co.: University of Michigan, Ann Arbor, 15-VII, common on *Pinus banksiana*, *P. mugo*, and *P. sylvestris*.

OHIO: Lorain Co.: Oberlin College, Oberlin, 14-VII, common on *P. sylvestris*.

**Homoptera: Psyllidae**

*Psyllopsis fraxinicola* ( Förster). Smith (1910) usually is credited with the first North American record (e.g., Tuthill 1943, Hodkinson 1988), but the same locality (Atlantic City, New Jersey) had been published in a previous catalog of New Jersey insects (Smith 1900). An even earlier, overlooked record is that of Heidemann (1892) from Washington, D.C. Because *P. fraxinicola* is known from Washington (McAtee 1918, Tuthill 1943, Hodkinson 1988), including specimens collected during 1884–1890 (USNM), it can be assumed that it was the psyllid Heidemann observed on European ash rather than *P. fraxini*, another North American immigrant but one known only from New York (Tuthill 1943, Hodkinson 1988). Additional records of this European ash specialist are British Columbia, California, Idaho, Nova Scotia, and Utah (Hodkinson 1988).
MECOSTA Co.: Ferris State University, Big Rapids, 18-VII, abundant on Fraxinus excelsior.

Heteroptera: Berytidae

*Berytinus minor* (Herrich-Schaeffer). Walley (1935) gave the first North American record (Ontario) of this European stilt bug. The first U.S. record was Cheboygan County, Michigan (Harris 1941). It is now known from Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Quebec, and West Virginia (Froeschner and Henry 1988), and from New Brunswick, Newfoundland, Nova Scotia, and Prince Edward Island (Scudder 1991). *Berytinus minor* presumably feeds on the roots of legumes such as white clover (*Trifolium repens*) (Wheeler 1970, 1979).

CHIPPEWA Co.: De Tour Village, 19-VII, sweeping weeds.

Heteroptera: Lygaeidae

*Megalonotus sabulicola* (Thomson). This rhyparochromine is one of several immigrant Heteroptera established in eastern and western North America. Reported from California by Van Duzee (1928) (as *Rhyparochromus chira-gra var. californicus*), *M. sabulicola* was discovered in Connecticut by Slater and Sweet (1958). The recent North American catalog also lists it from British Columbia, Idaho, Maryland, Massachusetts, North Dakota, Oregon, Utah, and Washington (Ashlock and Slater 1988). Later records are Delaware, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, and West Virginia (Wheeler 1989b). This ground-dwelling bug feeds on fallen seeds of bachelor's button or cornflower (*Centaurea cyanus*) and spotted knapweed (*C. maculosa*) in temporary habitats (Sweet 1964, Wheeler 1989b).


Stygnocoris rusticus (Fallén). Heidemann's (1908) New York record is the first for the Nearctic Region. A common Palearctic rhyparochromine, it since has been reported from British Columbia, Connecticut, Illinois, Maine, Michigan, New York, Nova Scotia, Prince Edward Island, Quebec, Vermont, Washington, West Virginia, and Wisconsin (Ashlock and Slater 1988, Asquith and Lattin 1991). It feeds on fallen seeds of composites such as tansy (*Tanacetum vulgare*) and yarrow (*Achillea millefolium*) (Sweet 1964, Wheeler 1983). Known in Michigan from Mason and Mecosta counties in the Lower Peninsula (Wheeler 1983), *S. rusticus* is here recorded from the Upper Peninsula.

ONTONAGON Co.: Rt. 64, W. of Ontonagon, 24-VII, sweeping, T. J. Henry coll.

*Stygnocoris sabulosus* (Schilling). Following early records from New York by Barber (1916) and Nova Scotia by Gibson (1917) [both as *S. pedestris* (Fallén)], this European seed predator has been reported from British Columbia, Connecticut, Maine, Massachusetts, Newfoundland, New Hampshire, Oregon, Quebec, and Washington (Slater 1964, Sweet 1964, Ashlock and Slater 1988, Asquith and Lattin 1991). Sweet (1964) studied its habits in New England; nymphs of this univoltine bug feed in the litter layer on seeds of composites and other plants.

HOUGHTON Co.: Osceola, 23-VII, under *Centaurea maculosa*. 
Heteroptera: Rhopalidae


INGHAM Co.: Rt. 36, Fairview Cemetery, Dansville, 15-VII, on *Berteroa incana*.

Coleoptera: Chrysomelidae

*Psyllodes affinis* (Paykull). This European flea beetle was first reported in the Nearctic Region from New York, where it occurred on bitter nightshade (*Solanum dulcamara*) (USDA 1968); Ontario and Pennsylvania have been added to the North American distribution (Wheeler and Hoebeke 1983).


Coleoptera: Coccinellidae

*Scymnus (Pullos) suturalis* Thunberg. Gordon (1976) first reported this European coccinellid (as the indigenous *S. coniferarum* Crotch) from the Western Hemisphere, based on collections from Pennsylvania. He (1982) later referred the Pennsylvania records and one from New York to the Old World *S. suturalis*. This aphid predator has been found primarily on Scotch pine (*P. sylvestris*), and conifer nursery stock from Europe is considered the likely means of introduction (Gordon 1982). Hoebeke (1984) added records from Connecticut and Michigan (Saginaw), noting this scymnine had been intentionally released in Michigan (Clinton and Ottawa counties) in 1961 for the biological control of aphids. He also said it is uncertain if the Saginaw population resulted from the biocontrol releases or westward spread from the East, where populations apparently are adventive. This predator has most recently been reported from Maryland and Virginia (Wheeler 1987).


Coleoptera: Curculionidae

*Sciaphilus asperatus* (Bonsdorff). This brachyderine has long been known from the New World, having been reported from Massachusetts by Henshaw (1888) [as *S. muricatus* (F.)]. Brown (1967) gave the first western records of this European weevil in North America (British Columbia). It is also known from Connecticut, Idaho, Maine, Maryland, New Hampshire, New Jersey, New York, North Carolina, Ontario, Quebec, South Dakota, Vermont, Wisconsin (O’Brien and Wibmer 1982), and Nova Scotia (Campbell et al. 1989).


*Strophosoma melanogrammum* ( Förster). Recorded [as *S. coryli* (F.)] from Massachusetts and New Jersey by Henshaw (1888), this weevil also is


**Neuroptera: Coniopterygidae**

*Aleuropteryx juniperi* Ohm. Henry (1974) reported this European scale predator from Pennsylvania as the first North American record. It is now known from Maryland, New Jersey, New York, Virginia, and West Virginia (Wheeler 1981). Henry (1976) studied its seasonal history and habits in Pennsylvania; larvae and adults attack scale insects (*Carulaspis* spp.) on ornamental juniper (*Juniperus* spp.).

**INGHAM Co.:** Michigan State University, E. Lansing, 16-VII, on *J. chinensis* infested with *Carulaspis juniperi* (Bouch-). **MECOSTA Co.:** Ferris State University, Big Rapids, 18-VII, on *J. chinensis* with *C. juniperi*. Abundant at both sites.

**DISCUSSION**

Most of the adventive insects reported herein were collected on plants not native to North America. Ten of the 14 species are new state records for Michigan. Those for *Lepyronia coleoptrata*, *Grypotes puncticollis*, *Psylloptis fraxinicola*, *Megalonotus sabulicola*, *Rhopalus tigrinus*, *Psylliodes affinis*, and *Aleuropteryx juniperi* represent considerable range extensions. That so many immigrant species new to the state or even the Great Lakes region could be collected in less than two weeks, emphasizes Turnbull's (1979) comment about our ignorance of recent changes in the North American fauna. The paucity of records of nonindigenous species from such an important region can lead to erroneous conclusions regarding their points of introduction.

More European species have been found in Canada's Maritime Provinces than in any other region of the New World (Brown 1940, 1967; Lindroth 1957) and, for many immigrants, the earliest records are from (or near) seaports of the Northeast. The earlier northeastern records for many of the species recorded in this paper suggest that region as the point of introduction, although inferences based on limited collecting obviously are tenuous. Once established in the Northeast, immigrant species may disperse to the Great Lakes and other regions or be further spread through commerce. It is difficult, however, to determine whether isolated records of adventive insects reflect multiple introductions or subsequent dispersal from a single introduction (e.g., Pollock 1991). Michigan populations of some of the species reported here may have resulted from natural dispersal from the Northeast or from the shipment of infested plant material from that region. In some cases Michigan (or nearby areas of the Upper Great Lakes) may have been the original point of entry despite earlier northeastern records.

For most of the species, a northeastern entry, with subsequent natural dispersal and/or spread with plant material and other forms of commerce, seems most likely. Multiple introductions, however (or simply inadequate collecting), may explain the disjunct distributions of several species. The St. Lawrence Seaway, which allowed moderate-sized ocean vessels to enter the
Great Lakes (Mayer 1980), probably has been responsible for the direct introduction of some adventive insects to the Great Lakes region (e.g., Larochelle and Larivière 1980). It apparently also has aided the further spread of established northeastern populations of certain species (e.g., Watson 1979). Prompt detection of immigrants and surveys to document their dispersal are requisite to answering questions about the North American history of adventive species.

ACKNOWLEDGMENTS

I am grateful to T. J. Henry (Systematic Entomology Laboratory, USDA, c/o National Museum of Natural History, Washington, D.C.) for inviting me on the mirid-collecting trip to Michigan and identifying or verifying identifications of Heteroptera and Neuroptera. E. R. Hoebeke (Department of Entomology, Cornell University, Ithaca, NY) identified or confirmed my identifications of Coleoptera and certain Homoptera. I also thank them for critically reviewing the manuscript. G. L. Miller (Systematic Entomology Laboratory, USDA, Beltsville, MD) provided information on Washington, D.C., specimens of *Psyllopsis fraxinicola* in the USNM collection.

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Smith, J. B. 1900. Insects of New Jersey. A list of the species occurring in New Jersey,


FACTORS INFLUENCING LENGTH AND VOLUME OF CELLS PROVISIONED BY TWO PASSALOECUS SPECIES (HYMENOPTERA: SPHECIDAE)

John M. Fricke

ABSTRACT

Length of cells provisioned by Passaloecus areolatus and Passaloecus cuspidatus decreased as bore diameter increased, but volume of provisioned cells increased with increasing bore diameter. Activity of the parasitoid Oma­lus aneus increased length of provisioned cells. Wasp senescence did not result in increased cell length.

Danks (1971) suggested that the availability of nesting sites was one of the factors limiting populations of wood inhabiting aculeate Hymenoptera. If this is true, it should be possible to identify strategies used to optimize available nesting material. One of these strategies could be the decrease of cell length as bore diameter increases. Such a strategy would increase the number of cells possible in a given nest. Fye (1965), Krombein (1967) and Vincent (1978) gave bore diameter and cell length data for cells provisioned by Passaloecus cuspidatus Smith. Krombein (1967) reported 58 provisioned cells from 3.2 mm bore diameter trap-nests (mean length, 16.3 mm; range, 8–52 mm.); four cells from 4.8 mm bore diameter were 7, 8, 13, and 126 mm long; and one 6.4 mm bore diameter trap-nest had four cells 6, 7, 7, and 9 mm long, respectively. Fye (1965) reported a 6.4 mm bore diameter trap-nest of four cells, with a mean cell length of 15 mm. Vincent (1978) reported data from 83 soda straw nests with 4.0 mm bore diameters. One hundred-eleven female cells had a mean length of 10.09 ± 2.19 mm and 110 male cells had a mean length of 8.82 ± 2.16 mm. These data suggest that Passaloecus spp. would optimize nesting material by decreasing cell length as bore diameter increases.

METHODS AND MATERIALS

To test whether Passaloecus spp. optimize their use of bore volume, trap-nests of several bore diameters were made available as nesting sites on the campus of Concordia College from 1984 through 1987. Trap-nest design has been previously described (Fricke 1991). Cell length and volume data were collected from trap-nests provisioned by Passaloecus annulatus (Say), P. areolatus Vincent, P. cuspidatus Smith, and P. monilicornis Dahlbom. Cell length was determined by measuring the distance from the innermost surface of a cell to the exterior surface of the cell closure. Cell volume was determined

1Natural Science and Mathematics Division, Concordia College, Ann Arbor, MI 48105.

<table>
<thead>
<tr>
<th>Bore Diameter (mm)</th>
<th>Passaloecus spp. (Number of Cells)</th>
<th>Cell Length (Median)</th>
<th>Cell Length (Mean)</th>
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<tbody>
<tr>
<td>1.6</td>
<td>49</td>
<td>9-70</td>
<td>16.25</td>
</tr>
<tr>
<td></td>
<td><em>areolatus</em></td>
<td></td>
<td>19.79±12.79</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>73</td>
<td>7.5-41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.33±5.31</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>30</td>
<td>7-36</td>
</tr>
<tr>
<td></td>
<td><em>cuspidatus</em></td>
<td></td>
<td>14.34±5.29</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>40</td>
<td>8-39</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>14.34±5.29</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>210</td>
<td>6-82</td>
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<tr>
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<td></td>
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<td>14.17±8.30</td>
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<td>4.0</td>
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<td>180</td>
<td>5-101</td>
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<td></td>
<td></td>
<td>15.09±17.00</td>
</tr>
<tr>
<td></td>
<td>4.8</td>
<td>95</td>
<td>5-116</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20.58±26.33</td>
</tr>
</tbody>
</table>

by using the formula for a cylinder and the length and bore diameter of each respective cell.

**RESULTS AND DISCUSSION**

Lengths of provisioned cells produced by *P. areolatus* and *P. cuspidatus* were varied and skewed. This should be expected since one tail of the distribution of provisioned cell length is closed (no cell can have a length shorter than 0 mm) and the open end of the distribution is limited by the actual length of the trap-nest bore (120 mm). Data for *P. areolatus* and *P. cuspidatus* are summarized in Table 1. Ranges and medians for these respective species and trap-nest bore diameter classes show median cell lengths much shorter than mid-point cell lengths of respective ranges. In normal distributions equal proportions of measurements above and below the mean would be expected. However, the percentage of cell lengths shorter than respective mean cell lengths for *P. areolatus* were 71.4, 68.5, and 73.3%. For *P. cuspidatus* these values were respectively 72.5, 61.0, 80.8, and 81.5%.

Mean cell lengths are longer than median cell lengths and variances are exceptionally high. This reflects the statistical effect of a small number of provisioned cells of extraordinary length. These cells were usually found to be, but not limited to, the last provisioned cell in a trap nest. Frequently such a trap-nest did not have a vestibular cell, although in a few cases an extraordinarily long cell was followed by a vestibular cell. To eliminate the statistical effects of cells of extraordinary length, a 10% exclusion rule was applied to the analysis of cell length data. For each species, 10% of the cell length values from the open end of the distributions were excluded in subsequent analysis. The results of this analysis are given in Table 2.

With the application of the 10% exclusion rule mean values are clearly more representative of cell length measurements and demonstrate an inverse relationship between bore diameter and cell lengths. One-way ANOVA for differences in cell lengths associated with differences in bore diameter were significant for *P. areolatus* (*F* = 3.30337, df = 134, *p* < .01) and for *P. cuspidatus* (*F* = 19.51697, df = 472, *p* < .001). However, these mean values do not reflect the extreme variation observed in provisioned cell length and we can only speculate on possible causes for such variation. One possible cause could be a declining prey population. As prey numbers decrease, additional time and energy are expended during provisioning. In this case an optimal closure or partition strategy would be reduction of time required to move from the trap-nest bore opening to the partition or closure. A partition or closure placed
Table 2. Cell length data from trap-nests provisioned by *Passaloecus areolatus* and *P. cuspidatus*, 1984–1987 using a 10% exclusion rule.*

<table>
<thead>
<tr>
<th>Bore Number</th>
<th>Med Cell Length</th>
<th>Passaloecus spp.</th>
<th>Mean Cell Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cells</td>
<td>Cell Length</td>
<td>areolatus</td>
<td>cuspidatus</td>
</tr>
<tr>
<td>41</td>
<td>9-25.5</td>
<td>14.17</td>
<td>15.13±3.81</td>
</tr>
<tr>
<td>71</td>
<td>7.5-25</td>
<td>13.06</td>
<td>13.51±3.79</td>
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<tr>
<td>25</td>
<td>7-21</td>
<td>12.81</td>
<td>12.68±3.26</td>
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<tr>
<td>38</td>
<td>8-22</td>
<td>12.89</td>
<td>13.43±3.19</td>
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<tr>
<td>195</td>
<td>6-23</td>
<td>11.93</td>
<td>12.39±3.45</td>
</tr>
<tr>
<td>164</td>
<td>5-23</td>
<td>9.90</td>
<td>10.33±2.38</td>
</tr>
<tr>
<td>79</td>
<td>5-23</td>
<td>9.825</td>
<td>9.47±2.72</td>
</tr>
</tbody>
</table>

*Ten percent of the cell length values from the open end of cell length distributions were excluded in these analyses.*

Closer to the bore opening will produce a cell of disproportionate length and volume.

Previous research on *Passaloecus* has made no reference to cell volume, and no analyses have been done on relationships between number of prey per cell, cell length, cell volume and bore diameter. If *Passaloecus* spp. made maximum use of available bore space, constant volume for cells from trap-nests of different bore diameters should be observed. This hypothesis was evaluated by determining cell volume for provisioned cells of mean cell length from each bore diameter used by *P. areolatus* and *P. cuspidatus* (Table 3). These data show that cell volume increased as bore diameter increased for both species.

A related question is whether or not increased cell volume is associated with a larger number of provisions. Data were available from 3.2 and 4.0 mm bore trap-nests provisioned by *P. cuspidatus* with *Myzus monardae* (Davis) (Aphididae). Cells with extraordinary length and cells in which larval feeding had occurred prior were excluded from this analysis. Such feeding would reduce the number of aphids by an uncertain amount. Ranges and means for number of aphids per cell, cell length, and cell volume were determined for 58 cells of 3.2 mm bore trap-nests and 59 cells from 4.0 mm bore trap-nests (Table 4). There was no significant difference in the number of aphids provisioned in 3.2 and 4.0 mm bore trap-nests. However, differences in cell length and volume were significant. As bore diameter increased, cell length decreased and cell volume increased. While no data were collected on actual volume of aphid provisions, a relative index to utilization of available space is cell volume (mm³)/aphid. The index for 3.2 mm bore trap-nests was 2.885 and for 4.0 mm bore trap-nests, 3.336. If an equal volume per provisioned aphid is assumed,
Table 4. Number of aphids [Myzus mondardae (Aphididae)] provisioned per cell, cell length and cell volume in 3.2 mm bore and 4.0 mm bore trap-nests provisioned by Passaloecus cuspidatus, 1987.

<table>
<thead>
<tr>
<th>Bore</th>
<th>Range</th>
<th>Mean</th>
<th>t(II) statistic</th>
<th>t value</th>
<th>df</th>
<th>prob</th>
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<td>t (II) statistic</td>
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</tr>
<tr>
<td># of</td>
<td></td>
<td></td>
<td>t value</td>
<td>df</td>
<td>prob</td>
<td></td>
</tr>
<tr>
<td>aphids</td>
<td>3.2</td>
<td>22 to 66</td>
<td>35.81±10.25</td>
<td>1.3098</td>
<td>115</td>
<td>p&gt;.05</td>
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<td>per cell</td>
<td>4.0</td>
<td>14 to 74</td>
<td>38.67±13.03</td>
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<td>Cell</td>
<td>3.2</td>
<td>7 to 23</td>
<td>12.89±3.29</td>
<td>4.2796</td>
<td>115</td>
<td>p&lt;.0005</td>
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<tr>
<td>length</td>
<td>4.0</td>
<td>6 to 23</td>
<td>10.27±3.28</td>
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<td>(mm)</td>
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</tr>
<tr>
<td>Cell</td>
<td>3.2</td>
<td>56.30 to 184.98</td>
<td>103.67±26.49</td>
<td>3.9331</td>
<td>115</td>
<td>p&lt;.0005</td>
</tr>
<tr>
<td>volume</td>
<td>4.0</td>
<td>75.40 to 289.03</td>
<td>129.02±41.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mm³)</td>
<td></td>
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</tbody>
</table>

these indices show a more efficient use of the 3.2 mm bore trap-nests. These results agree with the subjective observation that the free space above the aphid provisions was larger in 4.0 mm bores.

Scatter plots of number of aphids provisioned per cell and cell volume for 3.2 and 4.0 mm bore trap-nest are given in Figures 1 and 2. Simple linear regression of cell volume on number of aphids provisioned per cell gave the respective regression equations: \( Y = 54.88 + 1.36X, r = 0.53 \) for 3.2 mm bores and \( Y = 86.75 + 1.09X, r = 0.35 \) for 4.0 mm bores. Cell volume is weakly related to the number of aphids provisioned. In the case of 3.2 mm bores, 25% of the variance of cell volume is accounted for by the variance of the number of aphids provisioned; in 4.0 mm bores only 12.25% of the variance of cell volume is accounted for by the variance of the number of aphids provisioned. Cell volume is not greatly affected by the number of aphids provisioned.

In addition to bore diameter, several other factors could contribute to variations in length of provisioned cells. Wasp behavior, influencing the placement of cell partitions and closures, could be altered by age, prey availability, proximity of prey, weather conditions, competition for nesting sites, and the activity of parasites. To determine whether extraordinary cell lengths were a result of wasp senescence, cell length data for trap-nests with known closure dates were examined from P. cuspidatus trap-nests of 1984 and 1987. If extraordinary cell length is a result of senescence, increased length would be noted in late-season nests. Provisioned cells of extraordinary length (24-116 mm) were found in trap-nests provisioned throughout P. cuspidatus nesting season, and in all but three cases the extraordinary cell was the last cell provisioned (Table 5). Senescence can thus be excluded as a principal factor contributing to increased cell length.

Another possible cause for increased cell length is the activity of parasites. Data from P. cuspidatus nests of 1984 were examined for evidence that activity of Omalus aeneus (Fabricius) (Chrysididae) contributed to increased cell length. Ranges of provisioned cell length from trap-nests of respective bore diameter classes were as follows: 3.2 mm (6 to 31 mm, n = 79); 4.0 mm (6 to 101 mm, n = 29); 4.8 mm (5 to 116 mm, n = 52); and 6.4 mm (5 to 20 mm, n = 10). Cell length data for eight of 170 cells (approximately 5% of all values) were excluded in the analyses of these data because they were characterized as cells with extraordinary length. No cell lengths were excluded from 3.2 mm bore data, 3 cell lengths (56, 94, and 101 mm) were excluded from 4.0 mm bore data, and 5 cell lengths (56, 72, 78, 108, and 116 mm) were excluded from 4.8
Figure 1. Scatter plot of number of aphids provisioned per cell and cell volumes (mm$^3$) for *Passaloecus cuspidatus* 3.2 mm bore trap-nests, 1987.

Figure 2. Scatter plot of number of aphids provisioned per cell and cell volumes (mm$^3$) for *Passaloecus cuspidatus* 4.0 mm bore trap-nests, 1987.
Table 5. Seasonal distribution of *Passaloecus cuspidatus* cells of extraordinary length.

<table>
<thead>
<tr>
<th>Date of closure (mm)</th>
<th>Bore (mm)</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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<td>6-18-84</td>
<td>4.0</td>
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<td>11</td>
<td>94*</td>
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<tr>
<td>6-18-84</td>
<td>4.0</td>
<td>15</td>
<td>101*</td>
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</tr>
<tr>
<td>6-20-84</td>
<td>4.8</td>
<td>116*</td>
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<tr>
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<td>88*</td>
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</tbody>
</table>

*extraordinary cell length

Table 6. Cell length data from 1984 *Passaloecus cuspidatus* nests parasitized by *Omalus aeneus*.

<table>
<thead>
<tr>
<th>Date of closure (mm)</th>
<th>Bore (mm)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
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<td>24</td>
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<td>12*</td>
<td>11</td>
<td>14</td>
<td>12</td>
<td>12</td>
<td>10*</td>
<td>10</td>
<td>11</td>
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</tr>
<tr>
<td>6-18-84</td>
<td>3.2</td>
<td>18*</td>
<td>20*</td>
<td>27*</td>
<td>24*</td>
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*parasitized cell
Table 7. Cell length data for cells from non-parasitized trap-nests and parasitized trap-nests provisioned by *Passaloecus cuspidatus*, 1984.

<table>
<thead>
<tr>
<th>Bore (mm)</th>
<th>All trap-nests in bore class</th>
<th>Trap-nests free of parasites</th>
<th>Trap-nests w/ parasites</th>
<th>Parasitized cells only</th>
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<tr>
<td></td>
<td>( \bar{x} )</td>
<td>( s )</td>
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<td>3.2</td>
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\( \bar{x} = \text{mean}; s = \text{standard deviation}; n = \text{number in class.} \)

mm bore data. No parasitized cells were noted among excluded cells. Eighteen of 53 provisioned trap-nests were parasitized and contained 27 parasitized cells. Parasitized trap-nests contained 32 cells free of parasites. Cell length data for these parasitized trap-nests is given in Table 6. Mean cell length of all bore classes were determined for: all cells, cells from trap-nests free of parasites, cells from parasitized trap-nests, and parasitized cells (Table 7).

Although sample sizes were relatively small these data show that parasitism of *P. cuspidatus* cells by *O. aeneus* results in increased cell length in trap-nests with bore diameters equal to or less than 4.8 mm. The \( t(II) \) test for differences in mean cell lengths between trap-nests without parasites and trap-nests with parasites was significant for 3.2 mm trap-nests (\( t = 2.343, df = 77, p < .025 \)) and for 4.8 mm trap-nests (\( t = 2.5563, df = 45, p < .005 \)). Parasitized cells from 3.2, 4.0, and 4.8 mm bores had cell lengths which were respectively 51%, 26%, and 31% longer than cells from nonparasitized trap-nests. In a single 6.4 mm bore trap-nest, parasitism did not result in increased cell lengths.

*Passaloecus cuspidatus* does not maximally use trap-nest bore volume. Larger bore diameter trap-nests contained cells with decreased length, while cells parasitized by *Omalus aenus* were longer than non-parasitized cells. Volume of provisioned cells increased with increased bore diameter, but number of aphids provisioned did not increase proportionately with increased cell volume. Additionally, wasp senescence did not result in increased length of provisioned cells.

**LITERATURE CITED**


A CHECK LIST OF THE LEPIDOPTERA OF BEAVER CREEK STATE PARK, COLUMBIANA COUNTY, OHIO

Roy W. Rings$^1$ and Eric H. Metzler$^2$

ABSTRACT

Results of a comprehensive survey of Lepidoptera occurring at a 12,334 hectare natural area in Columbiana County, Ohio conducted in 1985 and 1990 is presented. Ten species of skippers, 27 species of butterflies and 597 species and forms of moths were identified and recorded. *Euagrotis forbesi*, and *Spodoptera eridania* had not previously been collected in Ohio; and *Polia nimbosa* and *Idia laurenti* have been designated as special interest since they are considered rare Ohio residents. The gypsy moth, *Lymantria dispar* was taken in bait traps and is the first record for that species in the Park. The presence of the gypsy moth, and the possibility of attempted eradication poses a definite threat to the survival of the species mentioned above with the exception of the southern army worm, *S. eridania* which was undoubtedly a fall migrant.

This is the sixth in a series of papers that document the species and present status of Lepidoptera in Ohio's recreational areas and nature preserves. We previously reported on the Lepidoptera of the Wilderness Center in Stark County, Atwood Lake Park in Carroll and Tuscarawas counties, Mohican State Forest and Mohican State Park in Ashland County, Fowler Woods State Nature Preserve in Richland County, and Goll Woods State Nature Preserve in Fulton County (Rings et al 1987, Rings and Metzler 1988, 1989, 1990, 1991).

The immediate objective of this paper was to publish a check list of the species of butterflies, moths and skippers collected by various means at Beaver Creek State Park. The publication of this information establishes a data base upon which to build a more comprehensive body of knowledge of the non-game wildlife of this recreational area. The threat of chemical spraying to control the gypsy moth, *Lymantria dispar*, if it were eventually found in this area, was a determining factor in the decision to undertake this project.

Subsequent studies may show that the survival and abundance status of some species at these sites has changed as a result of insect control as well as other factors.

DESCRIPTION OF THE STUDY SITE

Beaver Creek State Park is located 13 km northwest of East Liverpool, just off State Route 7, in Columbiana County, Ohio. It is in the foothills of

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$^1$Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, OH 44691.

$^2$Ohio Department of Natural Resources, Fountain Square, Columbus, OH 43224.
the Appalachians and is one of eastern Ohio's most scenic parks. The beautiful Little Beaver Creek was the first to be included in the state wild and scenic rivers system. The exact collecting sites were from the east 40°42'22" to the west 40°43'41" lat. and 80°35'11" long. in St. Clair and Middleton Townships, respectively. A brief description is given of the soils in the valley near the center of visitor activity and in the vicinity of the Park Office. Most of the soils are Chili loam with varying slopes. This moderately steep soil occurs on irregular, hummocky slopes and terrace escarpments. It includes small areas of Chili gravelly loam. Surrounding the Chili loam are Lobdell and Negley soil series. Lobdell soils have a moderately thick root zone, are moderately permeable, and have high available moisture capacity. Negley soils are sloping and occupy kames and terraces. They contain large amounts of gravel and tend to be droughty. Runoff is slow and the erosion hazard is moderate (Lessig et al. 1968).

A plant community survey was conducted at the Beaver Creek Conservation Easement, several km northeast of the park (Pat Jones, pers. comm. 1990) and many of the species listed also are also present in the various areas of the park in which collecting was done. The woodland studied was an oak-maple type. Tree species present, in order of decreasing predominance were: sugar maple, *Acer saccharum*; black oak, *Quercus velutina*; red oak, *Quercus rubra*; American basswood, *Tilia americana*; hornbeam, *Ostrya virginiana*; beech, *Fagus grandifolia*; black cherry, *Prunus serotina*; shagbark hickory, *Carya ovata*; white oak, *Quercus alba*; ash, *Fraxinus* spp.; red maple, *Acer rubrum*; slippery elm, *Ulmus rubra*; tulip tree, *Liriodendron tulipifera*; chestnut oak, *Quercus prinus*; and cucumber magnolia, *Magnolia acuminata*. Sycamores, *Platanus occidentalis*, were common along the banks of Little Beaver Creek. Some reforestation was performed in the 1950's. Park Manager Robert Sheehan estimated that 173 hectares of white pine, were planted at the rate of 1683 trees per hectare in various sections of the park. The Natural Heritage data base lists the following rare plant species in the park: mountainfringe, *Adlumia fungosa*; shale barren pussy-toes, *Antennaria virginica*; lyreleaf rock-cress, *Arabis lyrata*; oak fern, *Gymnocarpium dryopteris*; American water-pennywort, *Hydrocotyle americana*; and Bowman's-root, *Gillenia (Porteranthus) trifoliata*.

**MATERIALS AND METHODS**

Collecting was done when maximum daily temperatures exceeded 16.9°C. In 1985 nine collecting trips were made to collect Lepidoptera at various sections of the park: 27–28 March, 5–6 May, 10–11, 16–18 July, 11–13 and 27 August, 21–22 September and 5 and 9 October. In 1990 16 collecting trips were made on the following dates: 8 February, 12 March, 9 and 22–23 April, 8 May, 1 and 25–26 June, 7–8, and 24–25 July, 9 and 17 August, 9–10 and 26–27 September, 6–7 and 17 October, and 1 November. In addition to these collections made by the senior author The Ohio Lepidopterists scheduled a field day at Beaver Creek on 15 May 1988 and collected 21 species of butterflies and skippers (Metzler 1988). Butterflies and skippers were netted with standard insect nets. Foliage was searched and jarred for lepidopterous larvae, cocoons and galls. Moths were collected from about an hour after sunset to 1:00 or 2:00 AM. These collecting techniques have been described in previous publications by the authors.
The moths that were collected were placed in plastic boxes, lined with moist paper toweling, and taken to the laboratory at OARDC where they were identified, sexed and recorded. Klots (1951), Covell (1984), Rockburne and Lafontaine (1976), Forbes (1923–60) and Holland (1903) were the primary resources for identification. Metzler identified difficult and unusual arctiid, noctuid and notodontid moths. Moths in other families were identified by specialists listed under acknowledgments. Choice and unusual specimens were spread and labeled and deposited in the Ohio Agricultural Research and Developmental Center's Insect Reference Collection at Wooster.

The following areas were regularly sampled in an alternating pattern.

(1) Primitive family camp near Oak Tree Overlook on Leslie Road. This was primarily an upland forested area. The predominant tree species were sugar maple, black oak, red oak, white oak, black cherry, shagbark hickory, ashes, *Fraxinus* spp., dogwoods, *Cornus* spp.; and willows, *Salix* spp. The undergrowth consisted of wild grape, *Vitis* spp.; greenbrier, *Smilax* spp.; poison ivy, *Rhus radicans*; Virginia creeper, *Parthenocissus quinquefolia*; mayapple, *Podophyllum peltatum*; black raspberry, *Rubus occidentalis*; and unidentified mosses, lichens and liverworts.


(3) In a chestnut, *Castanea dentata*, grove 200 m north of Service Building.

(4) In open field across road from (3) in which there were various species of goldenrods; milkweeds; asters; grasses; giant ragweed, *Ambrosia trifida*; teasel, *Dipsacus sylvestris*; common elder, *Sambucus canadensis*; wild carrot, *Daucus carota*; Canada thistle, *Cirsium arvense*; and tall ironweed, *Vernonia altissima*. An adjacent open field contained American elm, *Ulmus americana*, maples and ashes.

(5) In central park, picnic area east of Park Office at south turnabout. Sycamores were predominant along Little Beaver Creek with the typical oak-maple community at a greater distance from the creek. Virginia creeper, poison ivy and Solomon's seal, *Polygonatum* spp., were the principal undergrowth species.

(6) In central park picnic area east of Park Office at north turnabout. Plant species were the same as at site (5).

(7) North of parking lot in Primitive Group Camp area. This was an open area bordered by an oak-maple woodland on the north and east and by sycamores along the creek on the west.

(8) At Primitive Horseman's Camp on top of hill on Sprucevale Road; 3.22 km north of Sprucevale Lookout. The predominant trees here were American elm and quaking aspen, *Populus tremuloides*. The ground cover here was mostly Roman ragweed, *Ambrosia artemisiifolia*.

RESULTS AND DISCUSSION

Species and forms collected during this study are listed in Table 1 according to the most recent regional check list (Hodges et al. 1983) and updated by Brown (1983 and 1986), Ferris (1989), Gall (1990), Kononenko et al (1989), Lafontaine et al (1986), McCabe (1980) and Poole (1989). The numbers preceding the scientific name are the check list numbers from the Hodges check list.
Following the check list number is the genus, species, subspecies, author, and date of collection. When more than one collection date is listed, the first is the earliest seasonal record of collection, and the second is the latest. Following the date of collection is the method of collection abbreviated as indicated at the bottom of Table 1. The number following the method of collection is the number of individuals collected by that method.

A total of 634 species of Lepidoptera, representing 29 families, was collected and identified. This total is composed of 1,972 records and 3,326 specimens. A record may include from 1 to 161 individuals. Of the total number of species 27 were butterflies, 10 were skippers and 597 were moths (Table 1).

In 1990 two species were discovered at Beaver Creek State Park which had not been previously recorded for Ohio: Euagrotis forbesi Franc. and Spodoptera eridania (Cram.). One male E. forbesi was collected on 26 June while a single specimen of S. eridania was collected on 6 October.

The gypsy moth was first discovered in the Park during this study. On 24 Jul 1990 two males were captured in a bait trap 3 m north of the Service Building. That same evening four more gypsy moth males were recorded from an Ellisco black light trap operated 1.5 m north of the Service Building. Four more gypsy moth males were collected in a black light trap on 9 August 1990 in the same area.

The collection of Polia nimbosa is only the second record for Ohio and the species appears to be a rare resident. The first recorded capture for P. nimbosa was in Cuyahoga County. Forbes (1954) described its range from Quebec to the mountains of Virginia and "west." Its host plant(s) are unknown so its residential status cannot be related to its host plant range.

Similarly the occurrence of the single specimen of Idia laurenti represents the second specimen collected in the state. This is believed to indicate that it, too, is a rare resident. The first Ohio specimen was taken in Hocking County. The previously known range of I. laurenti was from central New York State to western Pennsylvania (Forbes, 1954). These two records extend its known range many km to the west. The larval food plants of laurenti have not yet been discovered but it is most probably associated with the fungi occurring on dead leaves as are all other species in this genus.

The collection of a single male Euagrotis forbesi, and the fact that it has never before been collected in Ohio, indicates that it is a rare resident. Its known range substantiates this theory since it was described by Forbes (1954) as "Canada and the northern states." Forbes also adds "the distribution uncertain through confusion with the preceding (Euagrotis illapsa Wlk.), but not reaching that of true (Euagrotis) lubricans." The collection of Spodoptera eridania undoubtedly represents the capture of a species which readily migrates.

Three of the species collected at Beaver Creek State Park, Polia nimbosa, Idia laurenti, and Euagrotis forbesi have been designated as special interest. The special interest category includes local, or very rare, species because Ohio is at the extreme edge of their geographical range. The three species mentioned above are believed to be rare residents of Ohio and in the event that this Park is treated for gypsy moth the chances of survival of all three species in Ohio could be seriously decreased.
Table 1. Check list of Lepidoptera collected at Beaver Creek State Park, Columbiana County, Ohio, 1985 and 1990. Abbreviations for methods of collection are: BL, black light and sheet; BLT, black light trap; BT, sugar-baited trap; E, egg; G, gall; L, larval collection; N, netted; O, observed; S, sugaring.

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<th>Methods of Collection</th>
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<td>Machimia tentoriforella Clem.</td>
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<td>Antaeotricha leuciliana (Zell.) 8 May-1 Jun 1990 BLT 3, MVL 1</td>
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<td>Gretchena bolliana (Slingerland) 8 May 1990 MVL 1</td>
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<td>Ancylis nubeculana (Clem.) 1 Jun 1990 MVL 1</td>
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<td>Ancylis platanana (Clem.) 8 Jun 1990 BLT 1</td>
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<td>Ancylis divisana (Wlk.) 8 May-9 Aug 1990 BLT 3</td>
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<td>Grapholita eclipsana Zell. 8 May 1990 BLT</td>
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<td>Cydia pomonella (L.) 9 Aug 1990 BLT 1</td>
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4700 Sibine stimulea (Clem.) 7 Jul 1990 BLT 1.

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5040 Pyrausta bicoloralis (Gn.) 17 Aug 1990 MVL 2.
5079 Udea rubigalis (Gn.) 8 Jul 1990 S 2.
5156 Desmia fune ralis (Hb.) 8 May – 10 Aug 1985 & 1990 BL 1, BLT 8, S 1.
5182 Blepharomastix ranalis (Gn.) 18 – 26 Jun 1990 BL 1, BLT 6, S 1.
5250 Lygropia rivulalis Hamp. 7 – 8 Jul MVL 1, S 1.
5275 Herpetogramma pertextalis (Led.) 10 Jul 1985 BL 1.
5280 Herpetogramma thestealis (Wlk.) 8 Jul 1990 S 3.
5298 Herpetogramma aeglealis (Wlk.) 7 Jul 1990 S 1.
5315 Crambus saltuellus Zell. 25 Jun 1990 S 1.
5340 Crambus girardellus (Clem.) 27 Jun 1990 S 1.
5365 Crambus laqueatellus (Clem.) 26 Jun 1990 S 1.
5378 Crambus laqueatellus (Clem.) 26 Jun 1990 S 1.
5391 Chrysoteuchia topiaria (Zell.) 7 Jul 1990 MVL 2.
5450 Parapediasia decorella (Zinck.) 9 Aug 1990 MVL 1.
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5464 Urola nivalis (Drury) 7 Jul 1990 MVL 1.
5518 Aglossa cuprina (Zell.) 9 Aug 1990 BLT 2.
5533 Herculia oinalis (Gn.) 7 – 10 Jul 1985 & 1990 BL 1, MVL 1.
5579 Epipaschia zelleri (Grt.) 10 Jul – 9 Aug 1990 BLT 2.
5619 Tetralo pha baptisiella Fern. 17 Aug 1990 BLT 1, MVL 2.
5622 Galleria mellonella (L.) 24 Jul 1990 MVL 1.
5797 Nepheptera virgatella (Clem.) 9 Aug – 10 Sep 1990 MVL 2.
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6299 Itame coortaria (Hulst) 26 Jun 1990 MVL 1, BLT 100, S 1.
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7870  Sphecodina abbottii (Swainson) 1 Jun – 24 Jul 1990 BT 1, MVL 1.
7871  Deidamia inscripta (Harr.) 23 Apr – 8 May 1990 BLT 2.
7873  Amphion floridensis B. P. Clark 24 Jul 1990 BT 1.

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7898  Clostera strigosa (Grt.) 8 May 1990 BLT 1.
7901  Clostera apicalis (Wlk.) 24 Jul 1990 MVL 1.
7917  HyperoAlschro georgica (H.-S.) 8 May 1990 BLT 1.
7924  Odontasia elegans (Stkr.) 12 Aug 1985 BL 1.
7933  Gluphisia avimacula Hudson 8 May 1990 MVL 1.
7937  Furcula cinerea (Wlk.) 8 May 1990 MVL 1.
7952  Symmerista canicosta Franc. 23 Apr 1990 BLT 1.
7957  Dasylophia anguina (J. E. Smith) 25 Jun 1990 BLT 1.
7958  Dasylophia thyatiroides (Wlk.) 5 May 1985 BL 1, S 3.
7990  Heterocampa umbrata Wlk. 25 Jun 1990 MVL 1.
8007  Schizura leptinoides (Grt.) 10 Jul 1985 BL 1.
8010  Schizura concinna 9 Aug 1990 MVL 1.
8012  Oligocentria semirufescens (Wlk.) 11 Jul 1985 BL 1.

8098  Clemensia albata Pack. 27 Aug 1985 BLT 1.
8104  Conocara cadburyi Franc. 8 May – 1 Jun 1990 MVL 3.
8107  Haploa clymene (Brown) 24 Jul 1990 MVL 2, BLT 7.
8111  Haploa lecontei (Guer.-Meneville) 7 – 8 Jul 1990 MVL 3.
8112  Haploa confusa (Lyman) 7 Jul 1990 MVL 1.
8121  Holomelina aurantia (Hbn.) 27 May 1990 BLT 1.
8129  Pyrrhacreta isabella (J. E. Smith) 1 Jun – 9 Sep 1985 & 1990 BL 1, BLT 15, MVL 2.
8131  Estigmene acrea (Drury) 9 Aug 1990 BLT 1.
8133  Spilosoma latipennis Stretch 18 Jun 1985 BLT 1.
8140  Hyphantria cunea (Drury) 10 Jun 1985 BL 3, 23 Apr – 9 Aug 1990 BLT 42,
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8169   Apantesis phalerata (Harr.) 1 Jun–21 Sep 1985 & 1990 BL 1, BLT 1, MVL 6.
8188   Grammia figurata (Drury) 1 Jun 1980 BLT 1, MVL 2.
8196   Grammia parthenice (Kirby) 10 Sep 1990 BLT 1, MVL 1.
8197   Grammia virgo (L.) 10 Jul 1985 BL 1.
8211   Lophocampa caryae Han. 1 Jun 1990 BLT 1, MVL 1.
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8328   Idia diminuendis (B. & McD.) 17 Aug 1990 BLT 1. (State record)
8329   Idia lubricalis (Gey.) 25 Jun–9 Aug 1990 S 18.
8331   Idia iaurenti (Sm.) 10 Jul 1985 BLT 1. (State record)
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8345   Zanclognatha laevigata (Grt.) 25 Jun–9 Aug 1990 BLT 6, MVL 1, S 25.
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8355   Zanclognatha jacchusalis (Wlk.) 24 Jul 1990 S 1.
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8362   Phalaenostola metonalis (Wlk.) 1 Jun–7 Jul 1990 MVL 2, S 1.
8364   Phalaenostola larentioides Grt. 27 Aug 1990 MVL 1.
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8370   Bleptina caradralis (Gn.) 27 Aug 1990 MVL 3, S 3.
8391   Renia discoloralis Gn. 8 Jul–9 Aug 1990 BL 1, MVL 2, S 3.
8397   Renia flavipunctalis (Gey.) 24 Jul 1990 S 1.
8398   Lasoria angulalis (Gn.) 5 May 1985 BL 1.
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8442   Bomolocha baltimoralis (Gn.) 23 Apr–2 Aug 1985 BL 5, BLT 1, MVL 4, S 1.
8443   Bomolocha bejugalis (Sm.) 9 May–1 Jun 1985 & 1990 BL 1, MVL 2.
8447   Bomolocha madefactalis (Gn.) 26 Jun–17 Aug 1985 BL 1, MVL 1, S 2.
8452   Bomolocha edictalis (Wlk.) 7 Jul 1990 BLT 1.
8459   Hypena humuli Harr. 9 Apr 1990 BLT 1.
8479   Spargaloma sexpunctata Grt. 17 Aug 1990 BLT 1, MVL 1.
8499   Metalectra discalis (Grt.) 25 Jun–24 Jul 1990 BL 3, MVL 1, S 8.
8500   Metalectra quadristigma (Wlk.) 7 Jul 1990 S 4.
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Zale minerea (Gn.) 9 Apr-11 Jul 1985 & 1990 BLT 1, MVL 7, S 30.

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Papaipema birds (Dyar) 21 Sep 1985 BLT 1.

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<td>Eupsilia sidus</td>
<td>8 Feb-9 Apr 1990</td>
<td>BLT 2, BT 1, S 1</td>
</tr>
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<td>Eupsilia cirripalae</td>
<td>9 Apr 1990</td>
<td>S 1</td>
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<tr>
<td>Eupsilia tristigmata</td>
<td>27 Mar-23 Apr 1985 &amp; 1990</td>
<td>BL 4, BT 6, S 5</td>
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<tr>
<td>Eupsilia morrisoni</td>
<td>8 Feb-27 Mar 1985 &amp; 1990</td>
<td>BLT 10, BT 72, MVL 1, S 91</td>
</tr>
<tr>
<td>Eupsilia devia</td>
<td>12 Mar-23 Apr 1985 &amp; 1990</td>
<td>BL 9, S 10</td>
</tr>
<tr>
<td>Sericaglaea signata</td>
<td>12 May 1985</td>
<td>BL 2</td>
</tr>
</tbody>
</table>
Metaxaglaea inulta (Grt.) 6–17 Oct 1990 BLT 3, BT 1, MVL 2, S 1.

Epiglaea decliva (Grt.) 26 Sep–1 Nov 1985 & 1990 BL 3, BLT 1, BT 5, S 8.

Chaetoglaea cerata Franc. 6 Oct 1990 BT 2.

Euripoea sericea (Grt.) 6 Oct 1990 BT 2.

Euripoea decipiens (Grt.) 26 Sep–1 Nov 1985 & 1990 BL 3, BLT 1, BT 5, S 8.

Sunira bicolorago (Gn.) 21 Sep–1 Nov 1985 & 1990 BL 1, BLT 59, BT 5, MVL 8.

Anathix ralla (G. & R.) 9–26 Sep 1990 BLT 5, MVL 5.

B. Na comstocki (Grt.) 5–8 May 1985 BL 1, MVL 1.

Eutolype electilis (Morr.) 8 May 1990 BLT 1.

Eutolype grandis (Morr.) 8 May 1990 BLT 2.

Copipanolis styracis (Gn.) 12 Mar–9 Apr 1990 BL 1, BLT 27, MVL 3, S 1.

Lacimpolia renigera (Steph.) 1 Jun–9 Oct 1985 & 1990 BL 1, BLT 27, MVL 3, S 1.


Leucania linita Gn. 26 Jun 1990 S 1.

Leucania phragmitidicola Gn. 1–25 Jun 1990 BLT 1, S 2.

Leucania lapidaria (Grt.) 1 Jun–13 Aug 1985 & 1990 BL 9, S 1.


Leucania ursula (Fbs.) 1 Jun–21 Sep 1985 & 1990 BL 6, MVL 4, S 1.


Orthosia garmani (Grt.) 22 Apr 1990 BLT 1.

Orthosia revicta (Morr.) 22–23 Apr 1990 BLT 2.


Croigrapha normani (Grt.) 23 Apr–1 Jun 1990 BLT 38, MVL 4.

Himella intractata (Morr.) 8 May–1 Jun 1990 MVL 2.


Morrisonia evicta (Grt.) 23 Apr–8 May 1985 & 1990 BL 17, MVL 2.

Morrisonia confusa (Hbn.) 5 May–1 Jun 1985 & 1990 BL 1, BLT 37, MVL 12.


Protorthodes oviduca (Gn.) 14 May–1 Jun 1988 & 1990 BLT 4, MVL 1.

Ulolonche culea (Gn.) 1 Jun 1990 MVL 1.

Pseudorthodes vecors (Gn.) 1 Jun–13 Aug 1985 BL 1, BLT 20, MVL 5, S 1.

Orthodes crenulata (Butler) 27 Aug 1985 BLT 3.


Agrotis iphion (Hufn.) 9 Apr–1 Nov 1985 & 1990 BLT 24, BT 9, MVL 4, S 5.


Feltia tricosa (Lett.) 21 Sep 1985 BLT 2.

Feltia herlis (Grt.) 12 Aug–21 Sep 1985 BLT 5.

(continued)
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LITERATURE CITED


THE SAND-DWELLING PREDATORY MAYFLY *PSEUDIRON CENTRALIS* IN MICHIGAN (EPHEMEROPTERA: PSEUDIRONIDAE)

W. P. McCafferty

An examination of samples of Ephemeroptera larvae taken from 19 sites on the Pere Marquette River, Mason County, Michigan in October, 1990 and May, 1991 by A. G. B. Primack (Indiana University, Bloomington) revealed the presence of *Pseudiron centralis* McDunnough. This species was taken at seven sites between State Highway M37 and Rainbow Rapids, east of Ludington. Voucher specimens are held at the Purdue Entomological Research Collection. Michigan has been surveyed extensively for riverine benthic macroinvertebrates in the past, and mayflies in particular are relatively well documented in Michigan because of their importance to fly fishing (e.g., Leonard and Leonard 1962), bioassessment, etc. Despite these facts, however, this distinctive and somewhat large-sized mayfly has not been previously reported for the state.

The new record is noteworthy because *Pseudiron centralis* is an unusual and fascinating species that may be endangered in parts of its range. Larvae are sand-dwelling midge hunters (Clifford and Soluk 1985, Soluk and Craig 1990) that move along the sand much like crabs (Clifford and Soluk 1984) but are also capable of extremely fast swimming (McCafferty and Provonsha 1986). It is the only recognized species of the Nearctic family Pseudironidae (Pescador 1985, McCafferty 1991a), and its distribution in the southeastern, central, and some northwestern United States and west-central Canada is typical of many unrelated psammophilous mayflies (McCafferty 1991b). Michigan represents the most northeastern record for the species. It is known from nearby states of Indiana, Illinois, and Wisconsin. In Indiana, it has recently been considered an endangered species by that state's Natural Resources Commission (Anonymous 1992).

Besides sand and sand/gravel habitats, a few larvae of *P. centralis* were taken on silt, in *Elodea* beds, on logs, or under cut banks on the Pere Marquette River. This may indicate a broader habitat preference for the species than previously thought, or, more likely, that the larvae are prone to drift and thus can be found in atypical habitats.

Pescador (1985) noted a distinct geographic gradation with regard to degree of body pigmentation found in populations of *P. centralis*, with individuals of northern populations being darker than those of southern populations. The specimens from the Pere Marquette River are typical of northern populations. The frons and vertex of the head of the Michigan specimens are dark brown and therefore, according to Pescador (1985), are not typical of other populations from central continental areas, but instead are typical of populations from Alberta, Saskatchewan, Utah, and Wyoming.

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2Department of Entomology, Purdue University, West Lafayette, IN 47907.
LITERATURE CITED

NEW AND ADDITIONAL DISTRIBUTION RECORDS FOR SEVERAL RARE MAYFLIES (EPHEMEROPTERA) IN WISCONSIN

Richard A. Lillie

ABSTRACT

One nymph and one exuviae of Acanthametropus pecatonica were collected in June 1991 from the Black River and Chippewa River, respectively. These specimens extend the known range of this rare species in Wisconsin to three large Mississippi River tributaries. Homoeoneuria ammophila was recorded in Wisconsin for the first time; nymphs were collected from the Black River and Sugar River. Nymphs of Macdunnoa persimplex, Metretopus borealis, Pentagenia vittigera, Pseudiron centralis, and Cercobrachys sp. were also encountered.

The mayfly fauna of six large rivers in the Upper Mississippi River drainage basin were surveyed between 21 May and 16 July 1991 under a cooperative agreement with the U.S. Fish & Wildlife Service to document the distribution, associated fauna, microhabitat, and population density of Acanthametropus pecatonica (Burks) and Anepeorus simplex (Walsh). Acanthametropus pecatonica and Anepeorus simplex were added to the Wisconsin Endangered and Threatened Species List on August 1, 1989. Both species are currently listed as state endangered, and both species are candidates for possible addition to the federal List of Endangered and Threatened Wildlife (Federal Register 1991). In addition to expanding the known range of A. pecatonica, the surveys resulted in new collection records for several other species of mayflies.

Two specimens of Acanthametropus pecatonica were found in large, sand-bottomed rivers, one on 10 June 1991 in the Black River above the Hwy 35 bridge (T18N:R8W:Sec.28) and another on 11 June 1991 in the Chippewa River near Durand (T25N:R13W:Sec.16). The Black River specimen, a very small nymph (5 mm), was collected from a strong, sand-bottomed eddy in water about 1 m deep, while the Chippewa River specimen, a partial exuviae, was collected as it drifted in moderately fast current above sand and fine gravel in water less than 1 m deep. All previous collections (14 specimens) in Wisconsin were from the lower Wisconsin River (Lillie et al. 1987, author's collection records). Collections of Acanthametropus in other states are summarized elsewhere (Lillie et al. 1987, McCafferty 1991).

Although no nymphs of Anepeorus simplex were encountered, several other collection records are worth noting. Numerous nymphs of Homoeoneuria ammophila (Spieth) were collected on 10 July 1991 from the
Black River above Hwy 35 (T18N:R8W:Sec.28) and on 16 July 1991 from the Sugar River near Avon (T1N:R10E:Sec.27-28). They were collected below a sandbar drop-off by using an air-lift pump in water 2 m deep and in moderately fast current of the main channel with a D-frame net in water 1-1.5 m deep. Nymphs apparently were partially buried in the sand substrate as described by Pescador and Peters (1980). These collections represent the first records of this psammophilous mayfly in Wisconsin. Previously, this species was reported only from Kansas, Indiana, and Illinois (Pescador and Peters 1980).

Other notable records include *Cercobrachys* sp.? Soldan, *Macdunnoa persimplex* (McDunnough), *Metretopus borealis* (Eaton), *Pentagenia vittigera* (Walsh), and *Pseudiron centralis* McDunnough. One nymph of *M. persimplex* was collected on 12 June 1991 from the St. Croix River near Grantsburg (T38N:R19W:Sec.7). This species has also been collected in Wisconsin from the lower Wisconsin River (Lillie and Hilsenhoff 1992). Numerous nymphs of *M. borealis* were collected on 21 May 1991 from the Chippewa River below Durand (T24N:R14W:Sec.23); the only previous record from Wisconsin was also from the Chippewa River (W. Hilsenhoff, pers. comm.). Nymphs of *P. vittigera* were found in the Pecatonica and Sugar rivers, and *Cercobrachys* sp.? and *P. centralis* nymphs were collected from the Sugar, Black, St. Croix, and Chippewa rivers.

A more complete report, listing associated fauna and describing microhabitats, will follow completion of the second year of this study.

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LITERATURE CITED


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