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Pupal cases of Nearctic robber flies (Diptera: Asilidae)

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Abstract

The literature on robber fly pupae published primarily since 1972 is reviewed. Terminology used in morphological descriptions of pupal cases is compared and standardized, and some new terminology is used. A general description of asilid pupal cases is presented. Diagnostically useful characters are identified, and a consistent format for descriptions is presented. Pupal cases of 24 species are described for the first time, those of 13 species are redescribed, and additional comments are made on the pupal cases of 12 other species. Keys to species, genera, and higher categories are presented. *Asilus lecythus* Walker is transferred to the genus *Machimus* (new combination).

Key words: pupal cases, *Nearctic, Andrenosoma, Apachekolos, Asilus, Ceraturgus, Comantella, Cyrtopogon, Dioctria, Diogmites, Efferia, Heteropogon, Lampria, Laphria, Laphystia, Lasiopogon, Leptogaster, Machimus, Mallophora, Megaphorus, Neoitamus, Neomochtherus, Ommatius, Proctacanthella, Proctacanthus, Promachus, Stenopogon, Triorla, Asilus lecythus.*

Introduction

The Asilidae, or robber flies, are a worldwide family of insects known for their predatory habits and mimicry of other insects, especially some bees (Hymenoptera). Adults of many species are large and conspicuous, and they are easily recognized and frequently collected. Many species prey upon honey bees, sometimes causing significant damage to bee colonies (Dennis & Lavigne 2007, Lehr 1964). Some robber flies are regarded as potential biological control agents against scarab larvae (Wei *et al.* 1995).

Bionomic and systematic research on robber flies is hampered by inadequate knowledge of immature stages. We must be able to identify their eggs, larvae, and pupae in order to study their life histories. Furthermore, phylogenetic classifications cannot be considered complete until they incorporate data derived from studies of immature stages. Only about two percent of asilid species are known in any immature stage. Of the 856 described species in North America north of Mexico (Martin & Wilcox 1965), immature stages of about 35 species have been described. Only the more recent studies, such as those by Dennis & Lavigne (1976a) and Scarbrough & Kuhar (1995), are sufficiently detailed to facilitate identification and comparison of immatures. Furthermore, robber fly life history and phylogenetic studies are complicated because all known species have a one- to three-year life cycle, and knowledge of the biology and morphology of immature stages is mostly limited to mature larvae and pupae.

The purposes of this paper are to describe for the first time the pupal cases of 24 species of Asilidae, redescribe the pupal cases of 13 species, and to comment on the pupal cases of 12 other species. Previously described pupal cases have been re-examined because earlier descriptions are not adequate for taxonomic purposes, and it is necessary to describe the pupal cases in a consistent, comparable manner. Keys to genera and species are presented. Nine taxa for which information is available in the literature are included in the keys, and two species descriptions have been rewritten to fit our format to the greatest extent possible.

Supra-generic classification

Various investigators have classified the approximately 7000 species and 537 world genera of Asilidae into 2, 3, 4, 5, 8, 10, 11, 13, or 14 subfamilies (Bybee *et al.* 2004; Dikow 2003, in press; Dikow & Geller-Grimm 2004; Geller-Grimm 2003, 2004; Knutson 1976; Lavigne 2002, 2003; Martin 1957). However, a well supported phylogenetic hypothesis for the subfamilies of Asilidae is lacking, and therefore a stable subfamily classification does not exist. Recent hypotheses have been intuitive and controversial; they have not been rationalized by modern methods. Hull (1962) recognized 5 subfamilies and Papavero (1973) intuitively subdivided the family into 3 major groups with 8 subfamilies as follows: Asilinae-group (Apocleinae+Asilinae+Ommatiinae), Laphriinae-group (Laphriinae+Laphystiinae), and Dasypogoninae-group (Dasypogoninae+Stenopogoninae+Trigonomominae). To this scheme we can add the Leptogastrinae-group, consisting of only the subfamily Leptogastrinae. Papavero (1973) did not treat this group because Martin (1968) had elevated the taxon to family status. Later workers have recognized the subfamily Atomosiinae (Lehr 1977) and the subfamilies Dioctriinae and Stichopogoninae (Artigas & Papavero 1988; Dikow 2003, in press; Geller-Grimm 2003). Dikow (2003) and Geller-Grimm (2003) did not recognize the subfamily Megapodinae. They placed the tribe Megapodini in the Dasypogoninae. The different subfamily classifications are summarized in Table 1.

As indicated above, over the years the subfamily classification of Asilidae has changed considerably with the addition of new subfamilies and with tribes being elevated to subfamily status. It is obvious to many systematists that all available classifications of Asilidae are flawed. The problem is a general lack of rigorous phylogenetic analysis. Many changes will probably be made as a result of future studies. These studies probably will include those at the molecular level.

Bybee *et al.* (2004) presented the first formal analysis of molecular evidence for phylogenetic relationships among the Asilidae, based on 26 species. Their data support the monophyly of Asilidae, with Leptogastrinae as the basal, monophyletic robber fly lineage. The Asilinae-group also is supported as monophyletic. The Laphriinae-group, consisting of the Laphriinae and Laphystiinae, is paraphyletic, although it appears that the subfamily Laphriinae alone may be monophyletic. In their analyses, the Dasypogoninae-group was never monophyletic, but together the Laphriinae-group and Dasypogoninae-group appear to be a monophyletic group, sister to the Asilinae-group plus Trigonomiminae. Bybee *et al.* (2004) indicated that, based on their molecular evidence, current subfamily classification only partially reflects robber fly phylogeny and there is need for further investigation.

Dikow (in press) evaluated 140 genera and proposed a revised phylogenetic classification consisting of 14 subfamilies. He concluded that not all higher-level taxa as previously delineated are monophyletic. The only subfamilies established as monophyletic are Dioctriinae, Laphriinae, Leptogastrinae, Ommatiinae, Stichopogoninae and Trigonomiminae. Apocleinae and Asilinae were considered paraphyletic with respect to each other and Laphystiinae paraphyletic with respect to Laphriinae. The Dasypogoninae and Stenopogoninae were considered not monophyletic. The Bathypogoninae, Brachyrhopalinae, Phellinae, Tillobromatinae and Willistoninae were elevated to new subfamily status based on their morphological distinctness.

In this paper we place genera in the subfamilies Leptogastrinae and Laphriinae, and the Asilinae-group of subfamilies (Apocleinae+Asilinae+Ommatiinae), using the Geller-Grimm (2003) catalog as our guide. All remaining genera, including the megapodines, are placed in the artificial Dasypogoninae-group. This classification scheme is adopted for convenience and for lack of a better system; and it is similar to the five-subfamily classification used by Dennis & Knutson (1988). Although we recognize the importance of the questions associated with the subfamily classification of adult asilids, the subfamily and subfamily-group classification system is currently more useful for pupal characteristics because of the lack of detailed morphological information for a larger number of pupal cases.

TABLE 1. Comparison of some subfamily treatments of Asilidae.

Subfamily	Hull (1962) Wood (1981)	Papavero (1973)	Lehr (1969, 1977, 1996)	Geller-Grimm (2003, 2004) Dikow (2003)	Artigas & Papavero (1988) Bybee *et al.* (2004) Dikow & Geller-Grimm (2004)	Dikow (In press)
Apocleinae	- [1]	X	X	X	X	-
Asilinae	X	X	X	X	X	X
Atomosinae	-	-	X	-	-	-
Bathypogoninae	-	-	-	-	-	X
Brachyrhopalinae	-	-	-	-	-	X
Dasypogoninae	X	X	X	X	X	X
Dioctriinae	-	-	X	X	-	X
Laphriinae	X	X	X	X	X	X
Laphystiinae	-	X	X	X	X	-
Leptogastrinae	X	-	X	X	X	X
Megapodinae	X	-	X	-	-	-
Ommatiinae	-	X	X	X	X	X
Phellinae	-	-	-	-	-	X
Stenopogoninae	-	X	X	X	X	X
Stichopogoninae	-	-	-	X	X	X
Tillobromatinae	-	-	-	-	-	X
Trigonomiminae	-	X	X	X	X	X
Willistoninae	-	-	-	-	-	X

Footnote: [1] X, subfamily recognized by author(s); -, not recognized subfamily.

Literature review

The general life histories of a few species of robber flies are known, but very little in-depth information has been obtained for the immature stages. Three references published over the middle half of the twentieth century examined the literature on asilid immatures. Irwin-Smith (1923) listed papers on the morphology and biology of the immatures of 53 species in 20 genera. Descriptive data on the immature stages of 64 species in 30 genera, some of which were also in Irwin-Smith's publication, were summarized by Hennig (1952). Knutson (1972) referred to papers not mentioned in the previous summaries and listed published descriptions and figures for 46 species in 26 genera.

Since the publication of Knutson's (1972) notes on robber fly feeding habits and review of publications on morphology of immature stages, additional information has appeared in the literature. The following summarizes this information and earlier references not included in Irwin-Smith (1923), Hennig (1952), and Knutson (1972). Data primarily concerning the morphology of the egg stage has been presented by Alcock (1974), Candan *et al.* (2004), Castillo *et al.* (1994), Dennis (1979), Dennis & Lavigne (1975; 1976b, c, d; 1979), Dennis *et al.* (1986), Kurkina (1979), Lawson & Lavigne (1984), Lavigne (1972, 1979, 1984), Lavigne & Bullington (1984), Lavigne & Dennis (1975, 1985), Londt & Harris (1987), Musso (1978, 1981), Scarborough (1978, 1981), Scarborough & Sipes (1973), Shelly (1985), Suludere et al. (2000), Weber & Lavigne (2004), and Wood (1981).

Stubbs and Drake (2001) indicated that shape and color of robber fly eggs is related to where they are laid. Eggs that are dropped onto the ground or in an exposed situation are yellowish or brownish, tend to be oval,

and often have a hard chorion. Eggs deposited in the ground or plants (e.g. grass, seed heads) are white, more elongated, and soft.

Copello (1922) initially described and illustrated the egg, larva and pupa of *Mallophora ruficauda* (Wiedemann) from Argentina. In his Asilidae of France, Séguy (1927) provided descriptions and illustrations of eggs, larvae, and pupae of a number of European species. He also included some details of pupal heads and the eighth and ninth abdominal segments. Barraclough & Londt (1985) illustrated the egg, larva, and pupa of *Microstylum* sp. from southern Africa.

Keilin (1944) discussed larval and pupal respiratory systems and adaptations in Diptera and commented on the larva of *Laphria* sp. Foote & Dennis (1991) gave a general description of asilid larvae, keyed larvae to subfamilies (Leptogastrinae, Asilinae, Laphriinae, and Dasypogoninae) for America north of Mexico, and discussed general biology and ecology.

Hudson (1892) gave brief descriptions and some illustrations of the larva and pupa of *Saropogon viduus* (Walker) from New Zealand. Esipenko (1973) discussed the biology of *Leptogaster cylindrica* (De Geer) and described and illustrated both larva and pupa. Krivosheina (1973, 1974) and Krivosheina & Mamev (1975a, b) described larvae and pupae of species in the genera *Laphystia* Loew, *Ctenota* Loew, *Choerades* Walker, and *Laphria* Meigen and presented keys to some of the immatures. Krivosheina & Mamev (1973) also described the larval characteristics of *Andrenosoma* Rondani and *Pogonosoma* Rondani and provided a key to known species of *Pogonosoma*. Kurkina (1979) described the larva and pupa of *Machimus annulipes* Brullé and presented information on its life history.

Musso (1978, 1981) described in detail the morphological characteristics of larvae and pupae of several species, with emphasis on *Machimus rusticus* (Meigen). For a number of species there is information in the literature on last instar larvae. However, Musso (1978, 1981) presented details on seven stages of development for *M. rusticus*, and compared them with various stages of development of *M. pilipes* (Meigen), *M. fimbriatus* (Meigen), *Dystolmus kiesenwetteri* (Loew) (as *Eutolums kiesenwetteri*), *Andrenosoma atra* (Linnaeus), *A. bayardi* (Séguy), *Antipalus varipes* (Meigen), *Laphria*, and *Choerades*. He also gave keys to several Old World asilid species.

Stubbs and Drake (2001) provided summary information about larvae being predatory on other immature insects and about morphological characteristics of the larvae and pupae.

With respect to only pupae or pupal cases, Hine (1922) gave a brief description of the pupa of *Proctacanthus rufus* Williston from the shore of Lake Michigan in Berrien County, Michigan. Dekhtiarev (1929) provided a small photograph of the pupa of *Satanas gigas* (Eversmann) in the Ukraine. Wilcox (1935) gave a detailed description of a male pupal case of *Willistonina bilineata* (Williston) and compared it with other genera described by Malloch (1917). Parmenter (1952) described and illustrated in detail the pupa of *Leptarthrus brevirostris* (Meigen) (as *Isopogon brevirostris*) found in the soil near Alfriston, Sussex, England. Knutson (1976) described the pupal case of *Pseudorus distendens* (Wiedemann) (as *Doryclus distendens*) and presented a key to 5 commonly recognized subfamilies based on pupal cases. Dennis & Lavigne (1976a) described the pupal cases of 10 species of Wyoming robber flies and presented the first detailed observations on the emergence of adults. Daniels (1983) illustrated and described in detail the male pupal case of *Colepia abludo* (Daniels) (as *Neoaratus abludo*) from Australia using the format established by Knutson (1972, 1976), and Dennis & Lavigne (1976a). Londt (1986) provided a brief description of the pupal case of *Gibbasilus arenaceus* Londt from South Africa. Bullington (1986) illustrated principal pupal case characteristics for male and female *Laphria index* McAtee, male *Laphria sericea* Say, female *Laphria winnemana* McAtee, and the female of a new, unpublished species of *Laphria*. Daniels (1987) described the pupae of *Colepia ingloria* (Macleay), *C. malleola* (Walker), *C. rufiventris* (Macquart), *Neoaratus hercules* (Wiedemann), *Zosteria fulvipubescens* (Macquart), and *Z. sydneensis* (Macquart) from Australia and illustrated lateral and ventral views. Londt & Harris (1987) described the first instar larvae of *Neolophonotus dichaetus* Hull from South Africa. Dennis & Knutson (1988) described pupal cases of four species of robber flies from South America: *Diog-*

mites vulgaris Carrera, *Triorla striola* (Fabricius), *Mallophora sylveirii* Macquart, and *M. ruficauda* (Wiedemann). They also modified Knutson's (1976) subfamily key to asilid pupal cases, compared congeneric species from North and South America, and recorded biological observations on the immatures. Scarbrough & Kuhar (1995) described and illustrated pupal cases of *Machimus snowii* (Hine), *M. paropus* (Walker) and *M. erythocnemius* (Hine), but not in the same format presented here. Weber & Lavigne (2004) described pupal cases of *Blepharotes coriarius* (Wiedemann) collected from soil in Adelaide, South Australia.

Life histories

Musso (1978, 1981), based on field and laboratory data, provided the first details on the life cycle of *Machimus rusticus* form egg through pupa, and commented on other species. At 25°C the egg stage of *M. rusticus* lasted 4–6 days. Eggs of other species usually hatched after 5-8 days, with *Andrenosoma atra* taking 50–56 days. Under laboratory conditions, the larval period for *M. rusticus* can last 10–11 months, and as indicated below, the pupal stage lasts 14–32 days. The developmental period for *M. rusticus* and other species can be extended for one or more years depending on temperature and larval food.

Larval food and habitat affinities for robber flies were summarized by Lavigne *et al.* (1978). Most of the cited studies indicated that asilid larvae are predaceous on the immature stages of other insects. Subsequently, Fisher (1983) observed that *Andrenosoma* larvae live in dead wood of trees, where they feed on larvae of Buprestidae and Cerambycidae; they pupate near the periphery of a log with their anterior ends projecting above the surface. Evidence of larval predation was also provided by Barriga (1990), Dennis & Knutson (1988), Wei *et al.* (1995), and Wood (1981). Species of Megapodini (Dasypogoninae-group, previously in the subfamily Megapodinae) and Laphriinae appear to develop primarily in plant roots and decaying stumps and logs (typically in the galleries of wood boring insects). Larvae of Leptogastrinae and species in the Dasypogoninae-group and Asilinae-group develop in soil, although the eggs of some species are deposited on vegetation.

Label data from the pupae that are described here are presented in Table 2. These data also indicate that larvae and pupae of species of the Dasypogoninae-group and Asilinae-group occur in soil, and those of the subfamily Laphriinae occur in wood. A few of the labels also indicate the predatory nature of robber fly larvae.

When robber fly larvae are ready to pupate, they move to within approximately 1–10 cm of the surface. The larvae can take up to 20 days to pupate (Musso 1981), although 4–7 days may be more typical. During this period the larvae turn a white hue.

Hudson (1892) reported a 4–6 week pupal period for *Saropogon viduus*. Melin (1923) observed pupal periods of 14–50 days for 17 species of Asilidae. According to Skidmore (1966), the pupal stage of asilids lasts 1–2 weeks. Musso (1978) indicated that the length of the pupal period varied with temperature. For *Machimus rusticus*, the pupal period in the laboratory varied from 14–16 days at 25°C and 30–32 days at 20°C. For five other species, the pupal period at 20°C ranged from 19–27 days. Esipenko (1973) found that the pupal stage of *Leptogaster cylindrica* lasts 12–14 days. Wei *et al.* (1995) indicated that the pupal stage of *Promachus yesonicus* Bigot is approximately 23–30 days. The label data from pupae described here indicate that approximately 2–4 weeks pass from the time the larvae pupate until the adults emerge. Melin (1923) attributed the length of the pupal period to environmental conditions. He indicated that moisture accelerates and dryness retards the pupal stage, and pupation can fail if these conditions are not right.

Lehr (1958) indicated that *Stenopogon porcus* Loew adults emerge from their pupae between 10:00 and 11:00 AM, when the temperature of the soil at a depth of 4 cm is a little higher than 20°C. He also observed

TABLE 2. Life history information from labels of described pupal cases.

	Collection Date	Collection Location	Sex	Pupated	Emerged
Subfamily Laphriinae					
Laphria aimatis	?.IV.1914	Tulare County, California, Dinuba, emerged from yellow pine telegraph pole	♂	-	-
L. flavicollis	-[1]	Charter Oak, Pennsylvania; from *Alnus*	♂	-	Reared 19.V.1915
L. flavicollis	-	Chautauqua County, New York, from chestnut stump	♂	-	-
L. index	5.VI.1914	Harrisburg, Pennsylvania, reared from *Hicoria*	2♂	-	Reared 5–14.VI.1914
L. index	20.III.1915	Harrisburg, Pennsylvania, from *Hicoria*	♀	-	-
L .index	-	Hocking County, Ohio, reared from *Salix*	2♂	-	-
L. sackeni	3.IV.1931	Mt. St. Helena, California, from alder	♂	-	-
L. sackeni	-	Placerville, California, from *Pinus sabiniana*	3♀ 1♂	-	-
L. thoracica	11.VI.1931	Stamford, Connecticut, from hollow apple tree	4♂	-	-
L. thoracica	-	Falls Church, Virginia, from *Liriodendron*	2♂	-	Reared 11.V.1914
L. thoracica	-	Falls Church, Virginia, from *Lirodendron tulipifera*	2♂	-	Reared 10.V.1915
L. thoracica	-	Falls Church, Virginia, from *Liriodendron*	♀	-	Reared 26.V.1914
L. thoracica	14.V.1933	Fleetwood, New York, larva collected in decayed stump	♀	-	19.V.1933
L. thoracica	13.VI.1928	Staten Island, New York, Westerleigh, from stump	♀	-	-
L. virginca	-	Falls Church, Virginia, from *Pinus*	♀	-	Reared 17.V.1916
Dasypogoninae-group					
Ceraturgus cruciatus	?.XII.1913	Wolfville, Maryland	-	Prior to 1.VI.1914	18.VI.1914
Comantella fallei	II.X.1972	Nunn, Colorado, Pawnee Grassland Pasture Range.	♀	-	-
Diogmites misellus	9.VIII.1915	Tappahannoch, Virginia, reared from larvae attacking *Lachnosterna*	♀	-	-
D. neoternatus	-	Bryant, Florida, from muck soil heavily infested with *Dyscinetus morator* larvae	♀	-	28.VI.1950
Heteropogon macerinus	21.IV.1912	Rockville, Pennsylvania	♀	25.VI.1912	8.VII.1912
H. wilcoxi	12.V.1960	between Wheatland and Glendo, Wyoming, field of rye (*Secale cereale* L.)	♂	2.VI.1960	17.VI.1960
Asilinae-group					
Asilus sericeus	13.V.1923	Falls Church, Virginia, from soil under rotten manure	♀	16.V.1923	4.VI.1923
Efferia aestuans	12.VII.1945	Lockport, New York, from larva in garden soil	♂	-	-
E. aestuans	18.VII.1969	East Baton Rouge Parish, Louisiana, Hylandia Road	♂	-	28.VII.1969
E. aestuans	24.VII.1945	Lockport, New York, from larva in garden soil	♀	-	-

E. aestuans	7.IV.1965	East Feliciana Parish, Louisiana, Tidwill Idlewild Ex. Farm,	♀	8.VII.1965	6.VIII.1965
Machimus snowii	3.V.1915	Whitesbog, New Jersey, from larva in cranberry turf that endured flooding until 1.V.1916	♀	-	13.VII.1916 (Died 29.VII.1916)
Ommatius gemma	3.IV.1932	Manhattan, Kansas	♀	-	14.IV.1932
Proctacanthus philadelphicus	24.IV.1934	Crown Point., Indiana, reared from *Lachnosterna*?	♂	-	-
Promachus bastardii	21.V.1937	Cass County, Minnesota, Cass Lake, from soil	♀	22.VI.1937	11.VII.1937
P. vertebratus	27.VII.1939 8.VIII.1939	Lafayette, Indiana, reared from *Phyllophaga*?	2♂	-	-
P. vertebratus	27.VII.1935	Dayton, Indiana; reared from *Phyllophaga*?	♂	-	-
P. vertebratus	12.IX.1936	Crown Point, Indiana, reared from *Lachnosterna*?	♀	-	-
P. vertebratus	24.IV.1934	Crown Point, Indiana; reared from *Lachnosterna*	3♀	-	-
P. vertebratus	29.VII.1935	Merrillville, Indiana, reared from *Phyllophaga*?	♀	-	-

Footnote: [1]The symbol "-" indicates "unknown."

that “a small condensation of the soil” and a hard-packed ground did not prevent emergence. Dennis & Lavigne (1976a) observed a male *Machimus occidentalis* (Hine) (as "*Machimus* sp., either *M. callidus* or *M. occidentalis*") emerging from its pupal case at 8:35 AM when the soil temperature just under the surface was 18.4°C. Melin (1923) observed that male robber flies generally appear earlier than females.

When an asilid pupa is mature, it uses its spurs and spines and a rotary movement to work its way to the surface of the ground, plant, or other substrate. Melin (1923) commented that Laphriinae pupae use a gallery to the surface of a tree stump or other part of a plant that was previously made by the larva. Esipenko (1967) observed that the larvae of *Eutolmus rufibarbis* (Meigen) construct a vertical cell with compact walls. Malloch (1917) indicated that pupae can move either forward or backward; however, Melin (1923) observed only forward movement.

According to Melin (1923), the rotary movement of the pupa is brought about by violent contortions of the abdomen; the antennal processes probably serve as a plough and the terminal processes on abdominal segment 9 help the pupa maintain its position and serve as a lever. Melin (1923) also commented that the row of spines on at least abdominal segment 1 are movable in the longitudinal axis of the pupa and also serve as a lever. Esipenko (1967) noted that the pupae of *E. rufibarbis* use their dorsal and ventral spines to work to the surface of the soil.

When the pupa reaches the surface of the substrate, it pushes above the surface up to approximately one-half its length. A "T" or cross-shaped slit then develops on the dorsal surface of the head and thorax. The longitudinal portion of the slit forms along the midline of the head and thorax, typically to abdominal segment 1; the transverse portion of the slit passes over the occipital area of the head behind the anterior antennal processes. The emergence of the adult generally takes place through the slit by wiggling. Once the adult's legs are free they are used to help the adult crawl free of the pupal case. Newly emerged adults are generally pale whitish. They then begin to gain their normal coloration over a period of time up to approximately 1 hour.

Dennis and Lavigne (1976a) observed that adult *Stenopogon inquinatus* Loew freed themselves from pupal cases that were still in the soil by rocking back and forth and then falling to the soil. This resulted in the pupal cases being folded like an accordion. Emerging adults that had pulled their pupal cases out of the soil walked forward and pulled themselves free from the cases (see photograph, *American Entomologist*, 53 (2), p. 95 [2007]).

Identification of pupal cases

The lengths of spurs and spines on pupal cases are variable. According to Melin (1923), the species that live in loose and sandy soil (e.g. *Leptogaster, Dioctria, Lasiopogon, Philonicus,* and *Pamponerus*) have longer and finer spurs and spines that may be more or less in the shape of a feather. The species that live in stumps and other hard vegetation (Laphriinae) often have shorter and more "powerful" spines. We observed that pupae that live in soil (*Asilus, Diogmites, Efferia, Machimus, Proctacanthus,* and *Promachus*) also have longer and fewer spurs and spines (typically less than 25) on abdominal segments 1 to 5 or 6, whereas pupae that live in vegetation (*Laphria*) have shorter and more numerous spines (15 to 52) on abdominal segments 1 to 5 or 6.

The morphological data in the publications listed by Irwin-Smith (1923), Hennig (1952), and Knutson (1972) are, in many instances, cursory, and they deal only with the external features of larvae and pupae. They are often inadequate for use in identifying the immature stages. The more specific publications include those by Brindle (1962, 1968, 1969), Bromley (1946), Copello (1927, 1942), Dennis *et al.* (2008), Dennis & Lavigne (1976a), Dennis & Knutson (1988), Esipenko (1973), Foote & Dennis (1991), Hennig (1952), Kinoshita (1940), Knutson (1972, 1976), Krivosheina (1973, 1974), Krivosheina & Mamev (1975a, b), Kurkina (1979), Malloch (1915, 1916, 1917), Melin (1923), Musso (1967, 1978, 1981), Thorpe (1927), Tsacas *et al.* (1970), Weber & Lavigne (2004), Wood (1981), Esipenko (1967), and Zinov'eva (1959). Of these papers, only those by Bromley (1946), Dennis & Knutson (1988), Foote & Dennis (1991), Hennig (1952), Knutson (1972, 1976), Krivosheina (1973, 1974, 1975a, b), Malloch (1915, 1916, 1917), Melin (1923), and Zinov'eva (1959) give keys to subfamilies, genera, or species of immature robber flies. It should be noted that these keys do not use Papavero's (1973) 8 subfamilies (Apocleinae, Asilinae, Dasypogoninae, Laphriinae, Laphystiinae, Ommatinae, Stenopogoninae, and Trigonomiminae), but recognize only Hull's (1962) and Wood's (1981) five subfamilies (Asilinae, Dasypogoninae, Laphriinae, Leptogastrinae, and Megapodinae) or a combination of these subfamilies.

Pupal case morphology
(Figs 1–7)

The following morphological description is presented to familiarize the reader with the pupal cases of Asilidae. It includes comparison of the terminology used by the more detailed papers of Tsacas *et al.* (1970) and Musso (1978), with that of Knutson (1972, 1976), Dennis & Lavigne (1976a), Dennis & Knutson (1988), and Dennis *et al.* (2008). We also have included comments from Hauser & Irwin (2003) on the pupal cases of Asiloidea, in particular Therevidae.

Pupal case color is not a good characteristic for taxonomic purposes. Asilid pupae are pale white just after pupation, and they turn yellow or brown as they mature (Dennis & Lavigne 1976a). After emergence of the adult, the pupal case fades and becomes pale with increased exposure to light.

The usual 3 tagmata are easily distinguished in asilid pupal cases, although Hauser & Irwin (2003) consider pupae in the superfamily Asiloidea to consist of only 2 major regions, the cephalothorax and abdomen. The head, with ventral mouthpart sheaths and lateral eye sheaths, is separated from the thorax by a cephalothoracic suture (ctst) that passes just above the prothoracic spiracle (pthsr). It bears a pair of terminal horn-like anterior antennal processes (aap; = anterior antennal teeth of Tsacas *et al.* (1970) and Musso (1978)) that are bent ventrally and generally not fused or joined basally. Each eye sheath bears a posterior antennal process consisting of a group of 3–5 basally fused horn-like or hook-like processes (pap; = posterior antennal teeth of Tsacas *et al.* (1970) and Musso (1978); i.e., inner, middle, and outer processes). The known pupal cases of Leptogastrinae have callosities or tubercular structures instead of distinct horn-like or hook-like antennal processes. Knutson (1976) observed that *Pseudorus distendens* and other Megapodinae (now considered by some

to be the tribe Megapodini) have a truncate dorsal antennal process at the base of each anterior antennal process.

Malloch (1917) referred to antennal sheaths with 3–5 lateral cephalic thorns. We found 1 adult robber fly of the genus *Diogmites* to which a portion of the pupal case was still attached. The antennae were spread diagonally downward across each compound eye, their outer sides appressed to the ommatidia. The hollow base of the anterior antennal process was located over the pedicel, and the hollow base of the three conjoined posterior antennal processes was located over the flagellum. These cephalic processes clearly have antennal affinities, but they cannot be interpreted as antennal sheaths.

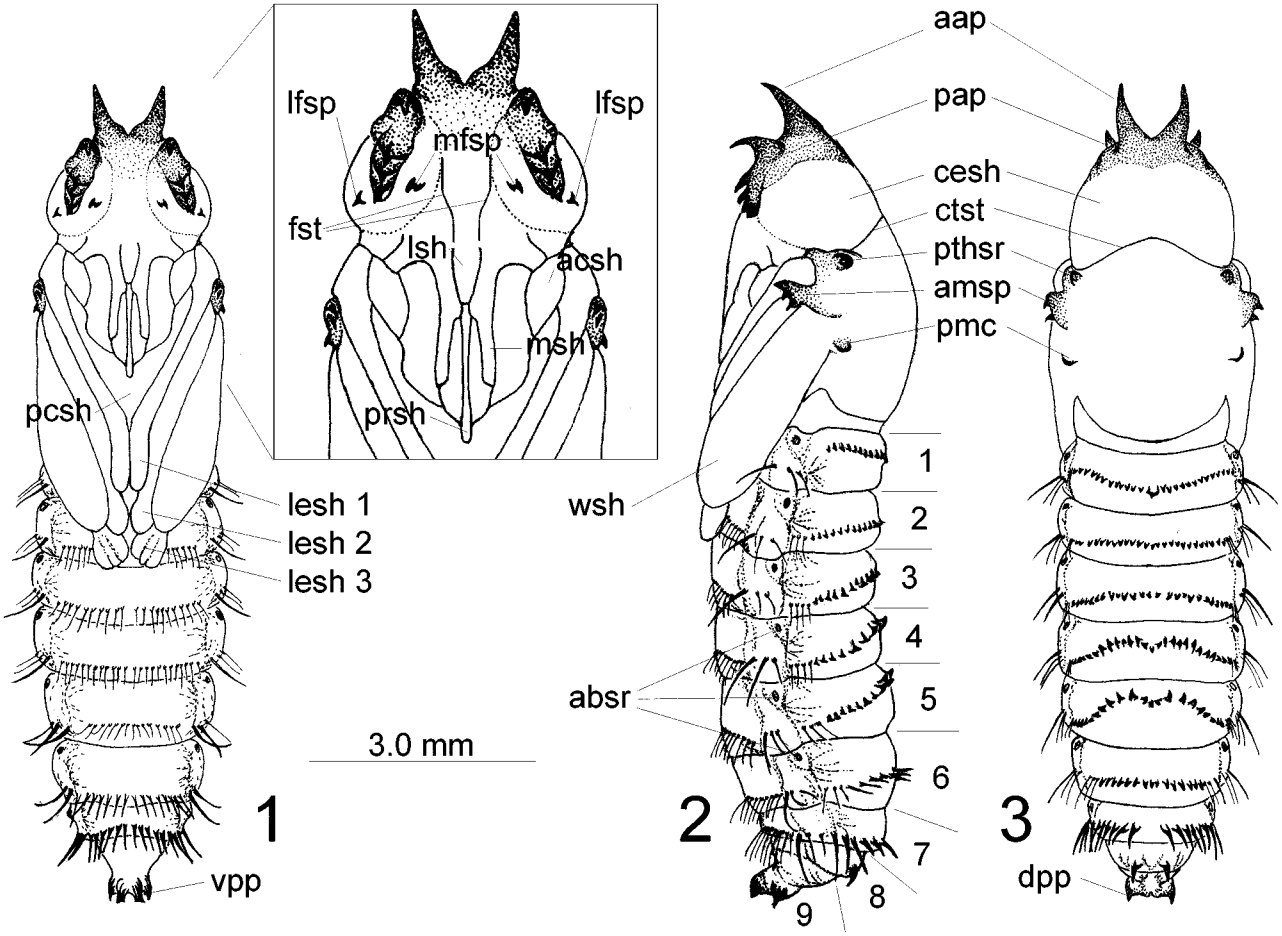
Some investigators have found a small structure, apparently sensory in nature, at the base of the posterior antennal processes in several families of Asiloidea, including Asilidae. This structure has a pore at its apex, and it is apparently located on a membranous area. Hauser & Irwin (2003) surmise that it provides a connection between the antenna and the environment. Because of the difficulty of finding the sensory organ, we did not examine all pupal cases for this structure. However, it was easily observed on *Diogmites misellus* (Wiedemann) and *D. neoternatus* (Bromley).

Frontal sutures (fst) are located between the posterior antennal processes. In the Asilidae, they appear to be the same distance apart in both males and females. In some species, notably the Leptogastrinae, there is a bristle dorsal or lateral to each anterior antennal process. In the Laphriinae, the lower part of the facial area near the most posterior of the posterior antennal processes bears small median or lateral facial spines (mfsp and lfsp, respectively; = internal and external spines of Tsacas *et al.* (1970), and inner and outer facial processes of Oldroyd (1939)). The facial area of a pupal case is on the ventral surface between the anterior antennal processes and the mouthpart sheaths described below, and the occipital or eye sheaths. Knutson (1976) also observed that the Megapodinae (Tribe Megapodini) have suborbital spines below each occipital area or on each side of the pupal case head above the base of the anterior coxal sheath.

On the ventral surface of the pupal case the mouthpart, leg, and wing sheaths are easily distinguished. The labral sheath (lsh) is located medially on the posterior part of the facial area. It can be smooth, grooved, or keeled, and in some species it bears a posterior tubercle. The maxillary sheaths (msh) on each side of the labral sheath sometimes bear posterior and/or median processes or tubercles (maxillary teeth of Tsacas *et al.* (1970), basal teeth of Musso (1978)). In some pupal cases, a pair of small callosities is visible at the apex of the labral sheath. These callosities apparently represent the apices of the palpal sheaths, and the sheaths can sometimes be traced along the seam between the labral and maxillary sheath. The proboscial sheath (prsh) is located immediately posterior to the labral sheath. This sheath also can be smooth, or it might bear posterior and/or median tubercles. This structure was designated the hypopharyngeal sheath by Knutson (1972, 1976), Dennis & Lavigne (1976a), Daniels (1983), Dennis & Knutson (1988), and Scarbrough & Kuhar (1995). We have adopted the term proboscial sheath (Hauser & Irwin 2003) because it probably ensheathes the labium as well as the hypopharynx (Dennis *et al.* 2008).

The paired anterior coxal sheaths (acsh) occur lateral to each maxillary sheath. They are smooth to rugulose, and in some species they bear callosities or tubercles, especially near the proboscial sheath. Each anterior coxal sheath has a median, longitudinal seam, which Melin (1923) concluded separates the coxal and femoral parts of the prothoracic leg. However, Musso (1978) indicated the opposite, with the femoral sheath anterior to the coxal sheath. Hauser & Irwin (2003) believe the anterior coxal sheath encloses the anterior coxa and trochanter. We have chosen to designate the entire sheath as the anterior coxal sheath, as did Tsacas *et al.* (1970). They also indicated that the anterior coxal sheaths have a tubercle-like process in *Hyperechia bomboides* (Loew) (subfamily Laphriinae). At the base of the anterior coxal sheaths is the "heart-shaped" part (Melin 1923, Tsacas *et al.* 1970, Musso 1978) that forms the posterior coxal sheath (pcsh). This part actually covers the coxae of the hind legs. The fore leg sheaths (lesh 1) are located immediately lateral to the anterior coxal sheath. The second or mid (lesh 2) and third or hind (lesh 3) pairs are lateral to the fore leg sheaths. Hauser & Irwin (2003) designated leg sheaths 1 and 2 as tibia I and tibia II. The hind pair is mostly hidden by

the overlying wing sheath (wsh), although the apices of the leg sheaths project posterior to the wing sheath. The wing or alar sheaths are smooth to rugulose, and they sometimes bear tubercles and callosities in various locations.



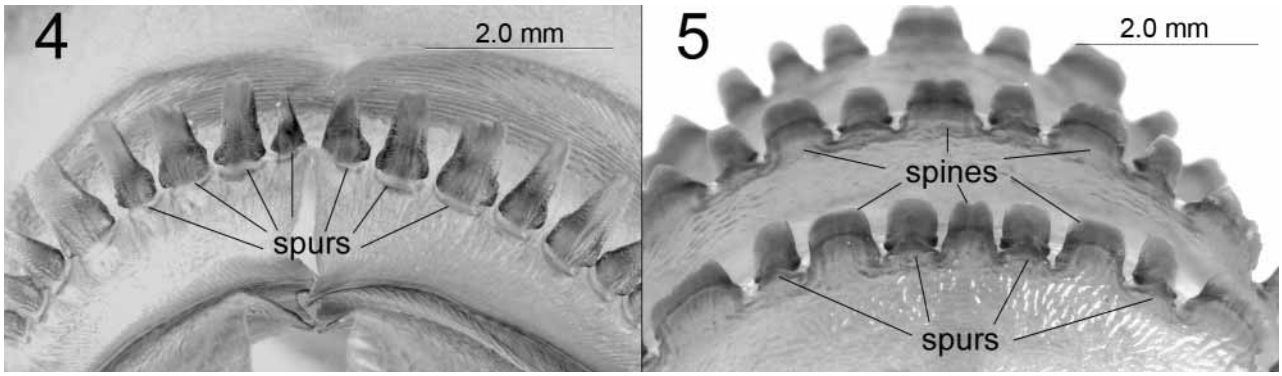
FIGURES 1–3. *Lampria bicolor* (Wiedemann), 1. ventral view, 2. lateral view with abdominal segments numbered, 3. dorsal view. Abbreviations: aap = anterior antennal process, absr = abdominal spiracle, acsh = anterior coxal sheath, amsp = anterior mesothoracic spine, cesh = compound eye sheath, ctst = cephalothoracic suture, dpp = dorsal posterolateral process, fst = frontal suture, lesh 1 = fore leg sheath, lesh 2 = mid leg sheath, lesh 3 = hind leg sheath, lfsp = lateral facial spine, lsh = labral sheath, mfsp = median facial spine, msh = maxillary sheath, pap = posterior antennal process, pcsh = posterior coxal sheath, pmc = posterior mesothoracic callosity, prsh = proboscial sheath, pthsr = prothoracic spiracle, vpp = ventral posterolateral process, wsh = wing sheath.

The thorax sometimes bears bristle-like processes on the dorsal surface. The oval or elongate prothoracic spiracle (pthsr) is located on each side of the thorax at the anterior margin. It can be either flush with the thoracic cuticle or elevated. In some species (e.g. *Megaphorus guildiana* (Williston)), the spiracle is hidden in folded, sclerotized areas of cuticle. A pair of anterior mesothoracic spines (amsp; = mesothoracic teeth of Tsacas *et al.* (1970) and Musso (1978)) of varying shape, size, and length is usually located on each side of the thorax at the base of the mid leg sheaths. A posterior mesothoracic spine (= wing tooth of Tsacas *et al.* (1970) and Musso (1978)), also of varying size and shape, is usually located on a posterior mesothoracic callosity (pmc) or tubercle at the base of each wing sheath.

Some authors have considered pupae of Asiloidea to have only 8 abdominal segments, while others count 9 segments. Knutson (1972, 1976), Dennis & Lavigne (1976a), and Dennis & Knutson (1988) counted 8 segments and described the eighth as being composed of an anterior ring-like part and a posterior tapered part. Wilcox (1935), in his description of a male pupal case of *Willistonina bilineata* from Hamilton, Montana, recognized both eighth and ninth segments. Wood (1981) indicated that Asilidae have 9 abdominal segments,

with the eighth and ninth segments partly fused. Londt (1986) observed that male pupal cases of *Gibbasilus arenaceus* have clearly separate eighth and ninth segments, but female cases have fused terminal segments. In this investigation, we have chosen to designate 9 abdominal segments, but we acknowledge that the line between segments 8 and 9 is often indistinct. The ring-like anterior part is segment 8, and the posterior tapered part is segment 9.

As indicated in Dennis *et al.* (2008), historically only the terms "spine" and "bristle" were used for integumental processes on the abdominal segments. These terms were often used interchangeably. In most cases we have stopped using the term bristle for processes on the abdominal segments, except when historical descriptions could not be confirmed or we were unable to determine the nature of these structures on specimens at hand. A bristle is now strictly defined in modern entomological texts as a unicellular macrotrichium or seta connected with nerves and surrounded at the base by a membranous ring or socket called an alveolus (Daly *et al.* 1998, McAlpine *et al.* 1981).



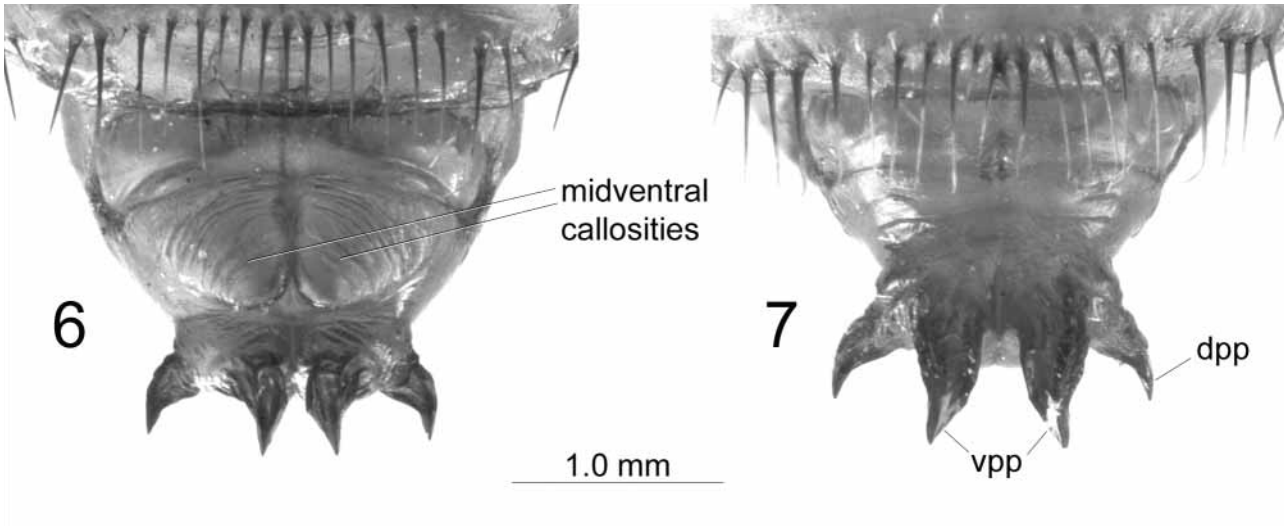
FIGURES 4–5. *Mallophora leschenaulti* Macquart, 4. abdominal segment 1, anterodorsal view, 5. abdominal segments 2–3, anterodorsal view.

While studying the integumental processes of robber fly pupal cases we have observed that some do not have a constricted base or area of integumental weakness. Others are constricted at the base and appear to be articulated by a socket-like area of weakened integument, suggesting that they are movable in life. As previously indicated, Melin (1923) noted that the dorsal integumental processes on at least the abdominal segment 1 are movable in the longitudinal axis of the pupal case and serve as levers that help the organism move through the medium in which the case was formed. To test the ability of "socketed" processes to move, we softened pupal cases of *Proctacanthus micans* Schiner and *Mallophora leschenaulti* Macquart in sodium hydroxide solution. The socketed processes moved easily and deformed the integument far less than the unsocketed processes when pressure was applied. This led us to believe that the processes on the abdominal segments of robber fly pupal cases are actually a combination of spines and spurs, as defined by Comstock (1925) and Daly *et al.* (1998). A spine is a rigid, immovable, thorn-like outgrowth of the cuticle that is not separated from it by a joint. It does not have a socket or area of integumental weakness around its base. A spur is a moveable process of the cuticle that is connected to the body wall by a joint. It has a socket or area of integumental weakness around its base (Figs 4–5).

Typically abdominal segment 1 bears a dorsal transverse row of spurs and abdominal segments 2–7 bear a dorsal transverse row of spines alternating with spurs, sometimes with 2–3 spines between each pair of spurs. However, the species of Laphriinae that we have studied lack discernible spurs. In other subfamilies, spurs are usually longer than spines, but both spurs and spines are of varying size, shape, and arrangement. In some pupal cases the spines are short, stout extensions of the cuticle, and they alternate with longer, thinner spurs that appear to emanate from areas of thin cuticle. The Leptogastrinae may have a row of spines located anterior to a row of long bristle-like or hair-like processes. Usually, segments 1–7 bear lateral rows of bristle-like spines behind the spiracles, near the posterior margin of each segment, and ventral transverse rows of bristle-

like spines. The ventral transverse row of segment 2 is interrupted by the leg sheaths. On segments 3–7 there is sometimes a median space interrupting the row. Each of the first 7 segments has a pair of lateral abdominal spiracles (absr; = ventral spiracles of Tsacas *et al.* (1970) and Musso (1978)) of varying size and shape elevated above the cuticle.

Abdominal segment 8 bears a distinctive arrangement of dorsal, dorsolateral, lateral, and ventral spurs and spines. In some species, one or more of these groups may be absent. Some authors believe that all pupae of Asiloidea have a pair of spiracles on abdominal segment 8 (Malloch 1917, Melin 1923, Hauser & Irwin 2003). We have been able to locate the eighth pair on pupal cases of some species, but not others.



FIGURES 6–7. *Laphria thoracica* Fabricius, abdominal segment 9, ventral view, 6. male, 7. female. Abbreviations: dpp = dorsal posterolateral process, vpp = ventral posterolateral process.

The ninth segment bears a combination of dorsal posterolateral, median, ventral posterolateral, and ventromedian processes and sometimes a distinct arrangement of tubercles or callosities (Figs 6-7). Male pupal cases can often be distinguished from female cases by the presence of a pair of enlarged midventral callosities (= terminal callosities of Musso (1978)). It seems likely that these callosities sheath the genitalia. Melin (1923) also observed that it is generally possible to distinguish male from female pupal cases based on the ventral tubercles. We have observed that within a species, male and female pupal cases have tubercles of different size, shape, and location. However, the sexes are sometimes difficult to distinguish based on this characteristic.

Key to subfamilies and subfamily-groups of Nearctic Asilidae based on pupal cases

The following key is adapted from Dennis & Knutson (1988). Although the Megapodini are confined to the Neotropical Region, they are included here because of their distinctive morphology, in particular the presence of dorsal antennal processes and the absence of anterior and posterior mesothoracic spines.

1 Anterior antennal processes dorsoventrally flattened and joined at base, or tuberculate and poorly developed; posterior antennal processes palmate or represented by only a ridged callosity; dorsum of thorax with 4 bristle-like structures forming corners of a square or rectangle; abdominal segments dorsally with anterior row of short spines and posterior row of hair-like processes longer than length of each segment; abdominal segments laterally and ventrally with hair-like processes longer than length of each segment; last abdominal segment with 1 pair of terminal processes ..... *Leptogastrinae*

- Anterior antennal processes long, acuminate; posterior antennal processes consisting of a group of 3–5 basally fused, horn-like or hook-like processes; dorsum of thorax with 0, 2, or 4 bristle-like structures; abdominal segments dorsally with spines and spurs, lacking long bristle-like or hair-like processes; abdominal segments laterally and ventrally with spines shorter than length of each segment; last abdominal segment with 2–6 pairs of terminal processes 2

2 Suborbital spines, median facial spines, and dorsal antennal processes present; anterior antennal processes almost straight; mesothorax without lateral anterior and posterior spines, but with posterior callosity .... Megapodini

- Suborbital spines absent; lateral facial spines present or absent; dorsal antennal processes absent; anterior antennal processes somewhat curved ventrally; mesothorax with or without lateral anterior and/or posterior spines, but with posterior callosity.....3

3 Abdominal segments 1–7 lacking discernable dorsal spurs; lower facial area with small median or lateral spines; each posterior antennal process consisting of 3–5 confluent hooks; abdominal segment 9 usually with ventral posterolateral processes larger and/or broader than dorsal posterolateral processes..... ..... Laphriinae

- Abdominal segment 1 with dorsal transverse row of spurs; segments 2–7 with dorsal row of spurs alternating with spines; lower facial area without median or lateral spines; each posterior antennal process usually consisting of only 3 confluent hooks (if 4–6, then hooks may be short to very long and narrow); abdominal segment 9 with ventral posterolateral processes smaller than dorsal posterolateral processes ..4

4 Abdominal segment 9 with dorsolateral and ventral posterolateral processes curved dorsally; medioventral callosities not tuberculate; ventral posterolateral processes curved toward dorsal posterolateral processes, or processes straight to curved dorsally..... Dasypogoninae-group

- Abdominal segment 9 with dorsolateral and ventral posterolateral processes and medioventral callosities, if present, usually tuberculate, with dark, sclerotized tip; dorsal posterolateral processes curved or pointed dorsally, ventral posterolateral processes generally pointed ventrally or opposite direction of dorsal posterolateral processes.....Asilinae-group

Subfamily Leptogastrinae

The Leptogastrinae comprise 18 valid genera, 6 of which occur in the Nearctic Region (Geller-Grimm 2003). For the Nearctic Region, pupal cases of only 2 species in 2 genera have been described. The pupal case of *Apachekolos tenuipes* (Loew) is described herein for the first time. *Leptogaster flavipes* Loew was described briefly in Malloch (1917) and Bromley (1946). The following tentative key is based on information presented in the aforementioned publications, as well as Melin (1923), Séguy (1927), and Zinov'eva (1959) concerning *Leptogaster* species not found in the Nearctic Region.

Key to known pupal cases of Nearctic genera of Leptogastrinae

1 Facial area without bristles, median tubercles, or callosities; anterior and posterior antennal processes present, the former without lateral process, the latter palmate; abdominal segment 9 with short dorsomedian processes and long ventral posterolateral processes ..... *Apachekolos*

- Facial area with median callosities or tubercles and bristles; anterior or posterior antennal processes lacking, but head with callosities or tubercles; anterior callosity or tubercle with lateral bristle on each side; posterior callosity or tubercle sometimes ridge-like and pointed posteriorly; abdominal segment 9 with only dorsal posterolateral processes, ventral posterolateral processes absent..... *Leptogaster*

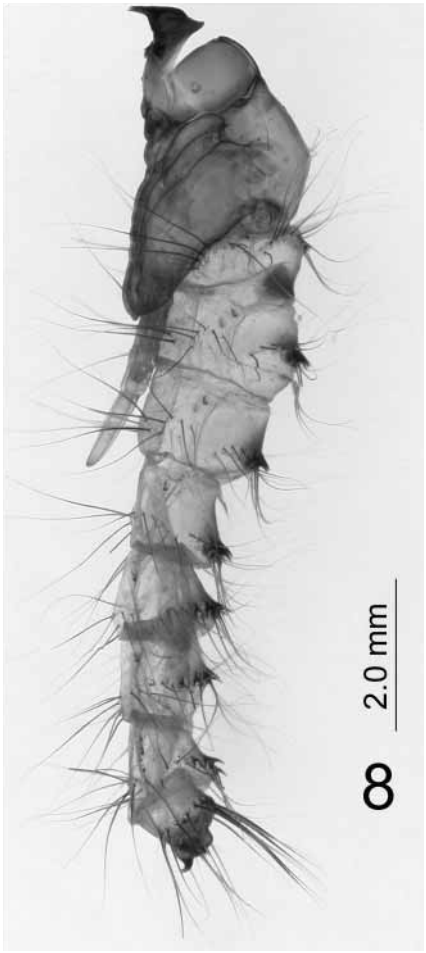


FIGURE 8. *Apachekolos tenuipes* (Loew), lateral view.

Genus *Apachekolos* Martin

***Apachekolos tenuipes* (Loew)**
(Fig. 8)

This description is based on one pupal case associated with an adult female in alcohol, from the United States National Museum of Natural History. It is labeled "Tenn.: Anderson Co.; on rt. 116, 12–24 mi. W. on rt. 25 (Lake City); Aug. 30–31, 1966; F. A. Coyle."

Description: Greatest length, including anterior antennal processes, 11.5 mm; greatest width of thorax 2.5 mm; greatest width of abdomen 2.5 mm, tapering to 1.0 mm at greatest width of abdominal segment 8. Integument subshining golden brown, margins of wing and leg sheaths slightly darker; spines and other processes glistening reddish brown; hair-like processes uniformly reddish brown to lighter apically.

Head with pair of large, dorsoventrally flattened anterior antennal processes joined at base and small posterior antennal processes comprising median spine and 2 terminal, posteriorly pointed to rounded, widely separated tips; posterior antennal processes apparently separate from anterior antennal processes or slightly joined basally by rugulose ridge. Facial area smooth, with small pit centrally on each side of midline. Labral sheath smooth, with slight median ridge. Proboscial and maxillary sheaths smooth; maxillary sheath three-fourths as long as proboscial sheath.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle round, raised on small callosity or flush with surface, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines lacking. Indistinct posterior mesothoracic callosity present, with long, slender, hair-like process

near anterior margin. Dorsal surface of thorax with long, slender, hair-like process on each side of midline. Wing sheath smooth, lacking grooves or tubercles. Thoracic area above wing sheath smooth. Apex of fore leg sheath projecting slightly beyond apex of wing sheath; apex of mid leg sheath reaching between anterior margin and middle of abdominal segment 3; apex of hind leg sheath reaching slightly beyond anterior margin of abdominal segment 4.

Abdominal spiracles small, C-shaped, reddish brown, flush with cuticle, situated along midline laterally on abdominal segments 1-8.

Abdominal segment 1 with dorsal transverse row of 18 long, slender, hair-like processes, longer than length of segment, alternating with 5 short, reclinate spines located slightly anterior to hair-like processes, the middle 4 hair-like processes slightly shorter than others; segment 1 with 6–7 lateral spurs on slight callosity behind spiracle; venter obscured by wing and leg sheaths.

Segments 2–7 similar to segment 1, with dorsal transverse row of 12–15 long, slender, hair-like processes of about equal length alternating with 5 short, reclinate spines about 2–3 times larger than spines on first segment; segments 2–4 also with 1 short spine on each side, lateral to larger spines; segments 2–6 with 4–6 (usually 5 or 6) long, lateral hair-like processes behind each spiracle; segment 7 with 3–4 long, lateral bristle-like spurs behind each spiracle. Segments 2–5 with 2 long, lateral hair-like processes; venter of segments 6–7 with 3 long, lateral hair-like processes.

Segment 8 with dorsal transverse row of 10 long hair-like processes and lateral row of 3 long hair-like processes on each side separated from dorsal spurs by spiracles; venter smooth, lacking hair-like processes.

Segment 9 with pair of short, dorsoventrally-flattened dorsomedian processes and pair of longer, cone-shaped, ventral posterolateral processes separated from each other; all processes curved downward toward the venter.

Genus *Leptogaster* Meigen

Leptogaster flavipes Loew

The following redescription is reworked from Malloch's (1917) and Bromley's (1946) descriptions to conform to our format. It is based mainly on a male specimen studied by Malloch (1917). The larva was found in soil under a rotten log at Cottonwood Grove, Urbana, Illinois on April 23, 1916. It pupated on May 5, and the adult emerged on May 19, indicating an approximate two-week pupal stage for this species. Melin (1923) observed that *L. cylindrica* and *L. guttiventris* Zetterstedt have pupal periods of about 14– 45 and 24 days, respectively.

It should be noted that we have not been able to locate the specimens upon which Malloch (1917) and Bromley (1946) based their descriptions. Thus, we have not been able to determine if their reference to "bristle" is our "spine" or "spur," in particular on the abdominal segments.

Redescription: Length 7 mm. Integument subshining light yellowish; spines and other processes dark brown. Head with poorly developed, tuberculate, ventrally ridged anterior antennal processes, each with a lateral or dorsal bristle; distinct posterior antennal processes absent, but ridged callosity present. Facial area with 3 small, median callosities in vertical row between posterior antennal callosities; center of facial area with small callosity slightly higher than posterior antennal callosities; median bristles present on each side of midline. Prothoracic spiracle small, round, distinctly elevated. Posterior mesothoracic callosity absent, but 2 bristles present. Dorsal surface of thorax with anterior and posterior bristles on each side of midline forming the corners of a square or rectangle. Apex of hind leg sheath reaching slightly beyond posterior margin of abdominal segment 3. Abdominal spiracles minute.

Abdominal segment 1 with dorsal transverse row of 6 median slender spines, with bristles between first and second spine and second and third spine counting from each side and 4–5 bristles on each side lateral to outermost spine.

Segment 2 with 5 long, posteriorly curved, hook-like spines; bristles present between each pair of spines. Segments 3–7 similar to 2, but with 6 spines, which become smaller posteriorly. Abdominal bristles longer than each segment.

Segment 9 with small processes. All abdominal segments with 4 bristles laterally behind each spiracle and 3 long bristles ventrally on each side of midline.

Subfamily Laphriinae

Twelve Nearctic genera of robber flies are placed in the subfamily Laphriinae and four are placed in the Laphystiinae (Geller-Grimm 2003). Information is available on the pupal morphology of *Andrenosoma*, *Lampria*, and *Laphria*. The following key is based on information on *Laphria* and *Andrenosoma* from the literature and on the descriptions of *Lampria bicolor* (Wiedemann) and 7 species of *Laphria* presented in this paper. Martin & Wilcox (1965) cataloged 4 species of *Andrensoma*, 3 of *Lampria*, and 62 of *Laphria* from North America north of Mexico. Poole (1996) listed 8 species of *Andrenosoma*, 3 of *Lampria*, and 63 of *Laphria* for the Nearctic Region. Cursory information on *Andrenosoma* and *Laphria* in Europe is found in Melin (1923), Séguy (1927), Oldroyd (1939), and Musso (1967). Some morphological information on *Andrenosoma* and *Pogonosoma* was provided by Krivosheina (1974), but it is not detailed enough for inclusion in this paper. Musso (1978) presented more detailed information on *Andresoma bayardi* Séguy and *A. atra* (Linneaus). His general characteristics for the genus *Andrenosoma* correspond well to those presented below in the key to genera of Laphriinae. Bullington (1986) illustrated some of the principal characteristics of the pupal cases of *Laphria sericea*, *L. rapax* Osten Sacken, *L. index*, and *L. winnemana*. His illustrations reveal that the cases have 3–4 posterior antennal processes.

Key to known pupal cases of Nearctic genera of the Laphriinae

1 Head with 5 basally fused posterior antennal processes; median facial spines bifurcate or not; face lacking median or anterior bristle between spines; abdominal segment 1 with broad dorsomedian, bifurcate or trifurcate spine; venter of abdominal segment 3 with median space interrupting transverse row of spines; venter of segments 4–7 without median space, but median spines often shorter than surrounding spines..... ..... Lampria

- Head with 3–5 basally fused posterior antennal processes; median facial spines usually not bifurcate; face with or without median or anterior bristle between spines; abdominal segment 1 usually without dorsomedian bifurcate spine, but, if present, spine not broad; venter of segments 3–7 with median space interrupting transverse row of spurs, space becoming smaller posteriorly and/or segments with shorter median spines than surrounding spines 2

2 Head with 3–5 basally fused posterior antennal processes; facial area usually without bristle between or anterior to median spines (present in *Laphria virginica* (Banks)) ..... *Laphria*

- Head with 3–4 basally fused posterior antennal processes, fourth process, when present, small; facial area with bristle between or anterior to median spines ..... *Andrenosoma*

Genus *Lampria* Macquart

***Lampria bicolor* (Wiedemann)**
(Figs 1–3)

The following description is based on two pinned pupal cases in the Charles A. Triplehorn Insect Collection, Ohio State University, Columbus. Both are labeled "Campbell Co., Tenn.; Cedar Creek; August 10, 1950; Robert M. Goslin." Several adults pinned separately bear the same label data.

Description: Greatest length, including anterior antennal processes, 11.1–12.2 mm; greatest width of thorax 2.4–2.9 mm; greatest width of abdomen 2.2–2.5 mm, tapering to 1.2 mm at greatest width of abdominal segment 8. Integument subshining yellowish brown, darker at apex of wing sheath; spurs, spines, and processes reddish brown, often darker apically; some dorsal abdominal spines uniformly colored; bristle-like spines yellowish to light reddish brown.

Head with pair of long, cone-shaped, apically curved anterior antennal processes not joined at base and group of 5 basally fused posterior antennal processes curving and becoming shorter posteriorly, inner or first posterior process barely fused to other posterior processes by area of flattened, heavily sclerotized cuticle, outer or fifth posterior process may be broadly rounded. Facial area with pair of small, basally fused, bifurcate or trifurcate median spines on each side of midline and single, short, outer spine lateral to each outermost posterior antennal process. Labral and proboscial sheaths mostly smooth, with median groove; proboscial sheath terminating with slight keel which has 2 small, anterior tubercles and median groove. Maxillary sheath smooth to slightly rugulose, elongate, extending two-thirds length of proboscial sheath, with minute process on inner margin apically.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle round, located midlaterally on slight callosity. Anterior mesothoracic spines at base of mid leg sheath, consisting of anterior pair of posteriorly curved, fused spines and widely separated, single, posterior, short, straight spine. Posterior mesothoracic callosity small, smooth, at base of wing sheath, with very small, apically rounded posterior mesothoracic spine. Wing sheath smooth to irregularly rugulose, with median, elongate grooves; median and/or basal tubercles absent. Thoracic area above wing sheath mostly smooth except for creases where sheath joins thorax. Apex of hind leg sheath reaching slightly beyond posterior margin of abdominal segment 2.

Abdominal spiracles round, yellowish to light reddish brown, almost flush with cuticle, located along midline laterally on segments 1–8.

Abdominal segment 1 with dorsal transverse row of 23 short, unequal, apically pointed spines and single, short, broad, median bifurcate or trifurcate spine; lacking discernable dorsolateral spines or spurs; 3 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–8 lacking spurs; segments 2–5 with dorsal transverse row of 24–33 short, stout spines; segment 6 with 11 spines of unequal length, some alternately short and long; segment 7 with 8 elongate dorsolateral spines on each side of midline. Segments 2–5 with 3–5 dorsolateral bristle-like spines; segment 6 with 4–6 dorsolateral bristle-like spines; segments 1–6 with 3 lateral bristle-like spines; segment 7 with 4–5 lateral bristle-like spines. Segment 2 with 6–8 ventral bristle-like spines on each side of, or extending under, sheaths of mid legs; segments 3–6 with 19–22 bristle-like spines; ventral spines on segment 3 interrupted medially where presumably mid leg sheaths rubbed venter; segment 7 with 13–17 bristle-like spines, outer 1–2 spines frequently short; venter of all segments with spines of irregular length, some very short, spines becoming longer and often thicker posteriorly.

Segments 8–9 curved downward. Segment 8 with 1 dorsal spine on each side of dorsal midline and round, reddish-brown spiracle at lateral midline; lacking dorsolateral, lateral, and ventral spines.

Segment 9 with pair of stout dorsomedian tubercles, short dorsal posterolateral processes, and pair of short, stout, rugose ventral posterolateral processes.

Genus *Laphria* Meigen

The pupa of the Palaearctic species *Choerades gilva* (Linnaeus) (as *Laphria gilva*) was described by Melin (1923) and Quentin (1948), but the descriptions are not detailed enough to include in the following key. Bullington (1986) provided some information on the pupal cases of *L. sericea*, *L. rapax*, *L. index,* and *L. winnemana*. He provided information primarily on the head, thorax, and abdominal processes and spines, but he did not provide enough information to allow us to include them in the following key. His descriptions and illustrations indicate that female cases have four posterior antennal processes and abdominal segment 9 lacks the ventral, posterior, pointed tubercles observed in male *Laphria* cases. Bullington (1986) showed *L. sericea* and *L. index* with 3 posterior antennal processes. We have observed 4 in *L. index*, based on 4 male pupal cases and 1 female pupal case. Abdominal segment 9 of male *L. index* has pointed posteroventral tubercles. Abdominal segments 8 and 9 of male *L. index* are more bulbous than female cases and they have indistinct or slight tubercles or swellings. Female abdominal segment 9 appears to lack ventral tubercles.

Key to known pupal cases of Nearctic species of *Laphria*

1 Head with 3–5 posterior antennal processes; abdominal segment 1 lacking dorsolateral spines; abdominal segment 2 with 0–8 (usually 0–5) ventral bristle-like spines on each side of hind leg sheath 2

\- Head with 4 posterior antennal processes; abdominal segment 1 with 2–8 dorsolateral bristle-like spines; segment 2 with 2–18 ventral bristle-like spines on each side of hind leg sheath 4

2 Head with 4 posterior antennal processes; abdominal segment 1 with 2–3 bristle-like spines behind each spiracle; abdominal segment 2 with 2 ventral bristle-like spines on each side of hind leg sheath; segment 8 with single dorsal spine and small reddish-brown spiracle on each side of midline and with 2–3 short dorsolateral spines ..... *Laphria aimatis* McAtee

\- Head with 3 or 5 posterior antennal processes; abdominal segment 1 with 3–5 bristle-like spines behind each spiracle; abdominal segment 2 with 0–8 (usually 3–8) ventral bristle-like spines on each side of hind leg sheath; segment 8 with single dorsal spine and small yellowish spiracle on each side of midline, lacking dorsolateral spines 3

3 Head with 3 posterior antennal processes; abdominal segments 2–5 with 21–29 dorsal spines; abdominal segments 3–7 with 9–11 ventral bristle-like spines on each side of median space .. *Laphria index* McAtee

\- Head with 5 posterior antennal processes; abdominal segments 2–4 and 5–6 with 24–33 and 15–21 dorsal spines, respectively; segments 3–7 with 13–18 ventral bristle-like spines on each side of median space..... ..... *Laphria sackeni* (Banks)

4 Abdominal segment 1 with 34–52 stout, dorsal spines, usually 6–8 dorsolateral bristle-like spines (sometimes none), and 6–10 lateral bristle-like spines behind each abdominal spiracle; abdominal segments 2–5 with 5–15 dorsolateral bristle-like spines ..... *Laphria thoracica* Fabricius

\- Abdominal segment 1 with 26–30 stout, dorsal spines, 2–4 dorsolateral bristle-like spines, and 3–7 lateral bristle-like spines behind each abdominal spiracle; abdominal segments 2–5 with 1–6 dorsolateral bristle-like spines 5

5 Abdominal segment 1 with dorsal transverse row of subequal stout spines and 5 alternately long and short bristle-like spines behind each abdominal spiracle; abdominal segments 6–7 with 10–12 stout dorsal spines and 6–8 dorsolateral bristle-like spines; segment 2 with 8 ventral spines on each side of hind leg sheath ..... *Laphria virginica* (Banks)

\- Abdominal segment 1 with dorsal transverse row of stout spines of unequal length and 3–7 bristle-like spines of equal size behind each abdominal spiracle; abdominal segments 6–7 with 6–13 dorsal stout spines and 2–6 dorsolateral bristle-like spines; venter of abdominal segment 2 with 5–8 ventral bristle-like

spines on each side of hind leg sheath 6

6 Abdominal segment 1 with dorsomedian pair of short bifurcate spines and 3 lateral bristle-like spines behind each abdominal spiracle; abdominal segments 6–7 with 13 stout dorsal spines; segment 2 with 7–8 ventral bristle-like spines on each side of hind leg sheaths; abdominal segment 3 with 10–13 ventral bristle-like spines on each side of midline; abdominal segments 4–7 with 19–26 ventral bristle-like spines; abdominal segment 8 with 1 large dorsal spine and 1 small yellowish spiracle on each side of midline .... *Laphria sericea* Say.

- Abdominal segment 1 with dorsomedian pair of long spines and 6–7 lateral bristle-like spines behind each abdominal spiracle; abdominal segments 6–7 with 6–8 stout dorsal spines; abdominal segment 2 with 5–6 ventral bristle-like spines on each side of hind leg sheath, abdominal segments 3–7 with 18–22 ventral bristle-like spines; abdominal segment 8 with 1 large dorsal spine, 1 small spiracle, and 1–2 short dorsolateral spines on each side of midline ..... *Laphria flavicollis* Say

***Laphria aimatis* McAtee**

The following description of *Laphria aimatis* is based on a male pupal case with pinned adult in the collection of the California Academy of Sciences and a female with associated pinned adult from the United States National Museum of Natural History. The male is labeled "Dinuba, Tulare Co., Cal.; IV-1914; emerged from yellow pine telegraph pole." The female is labeled "Cache Crk., Lake Co., Cal.; IV-18-60; F. D. Packer Collector."

Description: Greatest length, including anterior antennal processes, ♂ 16.5 mm, ♀ 18.4 mm; greatest width of thorax ♂ 3.3 mm, ♀ 4.1 mm; greatest width of abdomen ♂ 3.3 mm, ♀ 3.9 mm, tapering to ♂ 1.7 mm and ♀ 1.5 mm at greatest width of abdominal segment 8. Integument subshining light golden brown, becoming darker at margins of wing and leg sheaths, and anterior part of head; spines and other processes glistening reddish brown, darker apically, except for uniformly colored, shorter dorsal abdominal spines; bristle-like spines uniformly reddish brown.

Head with pair of cone-shaped, recurved, anterior antennal processes not joined at base and group of 4 basally fused posterior antennal processes, curving and becoming shorter posteriorly; inner or first posterior process longer than and separated from outer or other processes by flattened area of heavily sclerotized cuticle; outer 3 posterior processes fused and very close together. Facial area with small, basally fused, median spines on each side of midline and single, larger spine lateral to each outer posterior antennal process. Labral sheath elongate, smooth, with median furrow. Proboscial sheath smooth, with median furrow and small, yellowish posterior tubercle. Maxillary sheath smooth, extending one-half length of proboscial sheath.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle round, on slight callosity, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines on side of thorax above base of mid leg sheath consisting of anterior pair of basally broad and fused, posteriorly curved spines and single short, narrow, straight, posterior spine widely separated from anterior pair. Posterior mesothoracic callosity at base of wing sheath small, smooth, with small, apically rounded posterior mesothoracic spine. Wing sheath smooth, with median elongate groove; median and/or basal tubercles absent. Thoracic area above wing sheath smooth to slightly rugulose. Apex of hind leg sheath reaching to middle of abdominal segment 3.

Abdominal spiracles round, light reddish brown, flush or almost flush with cuticle, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 20 short, stout spines of unequal length; dorsolateral bristle-like spines absent; 2 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–5 with dorsal transverse row of 25–30 short, stout spines; outer 4–6 spines and often every group of 1–3 spines shorter than surrounding spines; some spines bifurcate; posterior segments with fewer spines. Segments 6–7 similar to segments 2–5, but with 10 and 14 spines, respectively. Median spines on segments 2–7 always shorter than adjacent spines; segments 2–7 with 1–6 dorsolateral bristle-like spines on each side and 3–6 lateral bristle-like spines behind each abdominal spiracle; some lateral bristle-like spines long, curved, and basally thick, other spines of irregular lengths. Segment 2 with 0–1 ventral bristle-like spines on each side of wing sheath; segments 3–4 with 6–8 bristle-like spines on each side of median space; segment 5 with complete transverse row of 14 bristle-like spines; median and some other bristle-like spines very short; segments 6–7 with complete transverse row of 19–21 bristle-like spines, outer and median 1–2 bristle-like spines short; ventral bristle-like spines become longer on posterior segments, some very thick.

Segments 8–9 curved downward; segment 8 with 1 long, thick, dorsal spine, small spiracle and 2 short dorsolateral spines on each side of midline; lateral and ventral spines absent. Segment 9 with pair of very small dorsomedian tubercles separated by median groove, pair of larger, straight, dorsal posterolateral tubercles, and pair of short, thicker, rugose, recurved, ventral posterolateral processes; segment 9 of male bearing pair of elongate, low ventromedian tubercles forming V-shape, not touching anteriorly.

***Laphria flavicollis* Say**

The following description is based on two male pupal cases from the United States National Museum. One case with pinned adult is labeled " Charter Oak, Pa.; *Alnus*; 12963 Hopk. U.S.; reared May 19/15; C.T. Greene; F.C. Craighead Collector." The other case lacks an associated adult and it is labeled "Chautauqua Co., NY; Jul. 6, 1934; chestnut stump; S.W. Bromley Collection 1955."

Description: Greatest length, including anterior antennal processes, 12.5–13.0 mm; greatest width of thorax 3.0 mm; greatest width of abdomen 3.0 mm, tapering to 2.0 mm at greatest width of abdominal segment 8. Integument subshining golden brown; wing sheath, head, and thoracic area sometimes slightly darker; spines and other processes glistening reddish brown, darker apically; bristle-like spines uniformly yellowish to reddish brown.

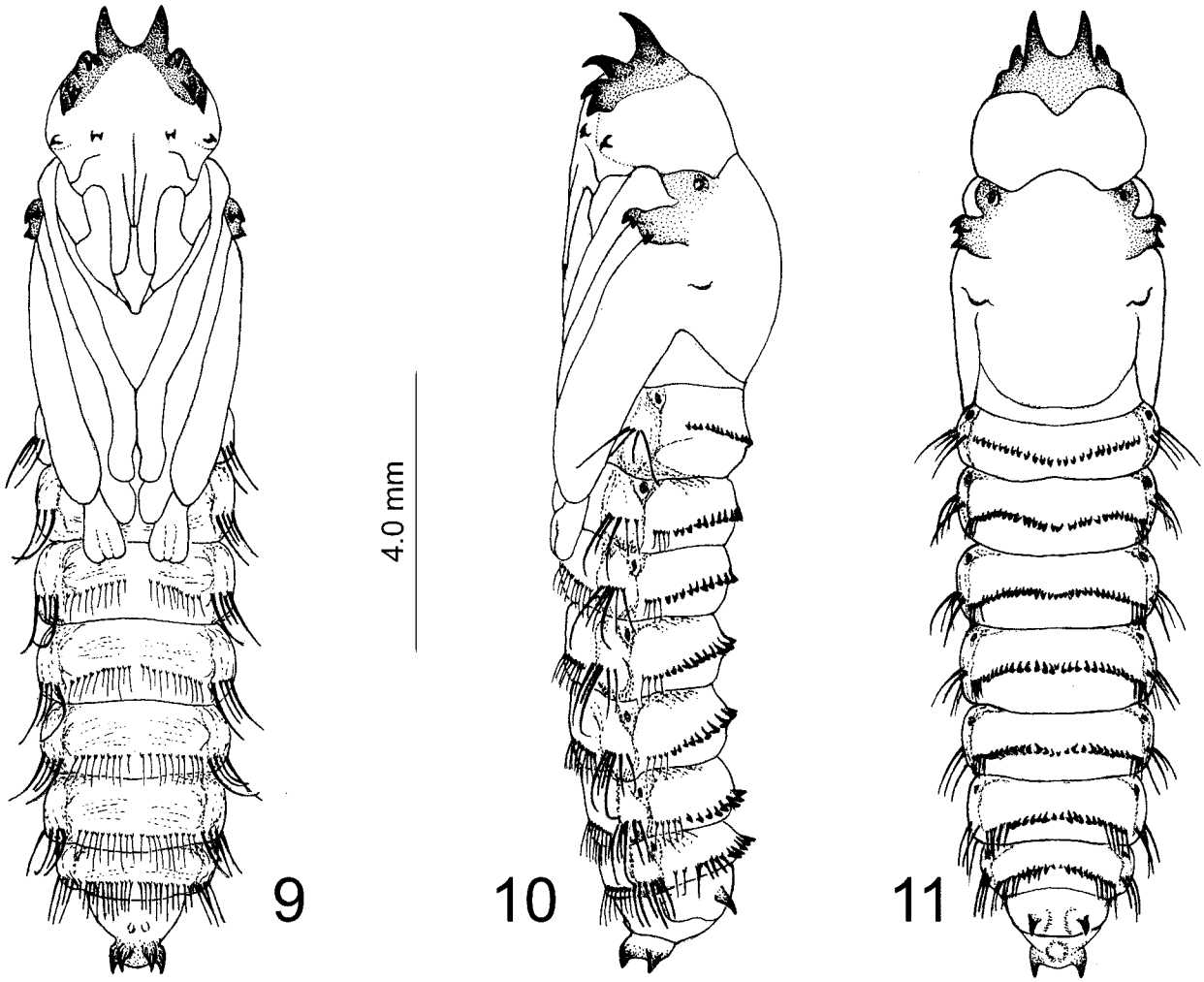
Head with pair of dorsally rounded to flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 4 basally fused posterior antennal processes curving and becoming shorter posteriorly; inner or first posterior process longer than and separated from outer or other posterior processes by flat to slightly swollen area of heavily sclerotized cuticle; outer 2 posterior processes fused for greater distance than other processes. Facial area with 2–3 short, basally fused, median spines and single, longer spine posterolateral to outermost posterior antennal process. Labral, proboscial, and maxillary sheaths smooth and elongate; proboscial sheath with slight median furrow and median posterior swelling; maxillary sheath extending about two-thirds length of proboscial sheath.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle round, situated midlaterally on small, reddish-brown callosity at anterior margin of thorax. Anterior mesothoracic spines on each side of thorax above base of mid leg sheath consisting of anterior pair of basally broad and fused, posteriorly curved spines, and single narrow, straight, posterior spine widely separated from anterior pair. Slight posterior mesothoracic callosity at base of wing sheath with short, broad, apically rounded, sclerotized posterior mesothoracic spine. Wing sheath smooth to irregularly rugulose, sometimes with elongate grooves; median and/or basal tubercles absent. Thoracic area above wing sheath smooth to slightly rugulose. Apex of hind leg sheath reaching between middle and posterior margin of abdominal segment 3.

Abdominal spiracles round, light yellowish to reddish brown, on slight swelling, situated along midline laterally. Abdominal segment 1 with dorsal transverse row of 26–30 short, stout spines; median pair of spines longer, sometimes with 3-4 short spines between longer spines; abdominal segment 1 with 2–4 short to

medium length, dorsolateral, bristle-like spines on each side and 6–7 lateral, bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 4–5 and to lesser extent segments 2–3 with dorsal spines forming row with 2 peaks, 1 peak on each side of midline, 1–3 long spines at peaks pointing anteriorly. Segments 2–7 with dorsal, transverse rows of 25–32, 21–26, 20–23, 17–22, 6–8, and 6–8 spines, respectively; segments 2–5 often with long spines alternating with 1–3 short spines. Segments 6–7 similar or with mostly long spines, often with pair of short median spines farther apart than on other segments. Segments 2–7 with 2–5 (usually 3–4) dorsolateral bristle-like spines on each side and 3–7 lateral bristle-like spines behind each abdominal spiracle; lateral bristle-like spines toward venter longer than other bristle-like spines; more lateral spines generally longer posteriorly. Abdominal segment 2 with 5–6 ventral bristle-like spines on each side of and extending under hind leg sheath; segments 3–7 with median row of 18–22 ventral bristle-like spines that become longer and thicker posteriorly; median pair of ventral bristle-like spines usually very short; segments 3–4 with wider median space than posterior segments.



FIGURES 9–11. *Laphria index* McAtee, 9. ventral view, 10. lateral view, 11. dorsal view.

Segments 8–9 curved downward; segment 8 with 1 large dorsal spine, small spiracle, and 1–2 short dorsolateral spines on each side of midline; lateral and ventral spines and/or spurs absent. Segment 9 with pair of very small dorsomedian tubercles; pair of short, dorsal posterolateral processes curved toward midline; pair of larger, slightly longer, basally rugose, dorsally curved ventral posterolateral processes; and pair of very large, ventral, posteriorly curved, apically acute, basally approximate tubercles almost reaching ventral posterolateral processes.

***Laphria index* McAtee**
(Figs 9–11)

The following description is based on five pupal cases with pinned adults from the United States National Museum and Ohio State University collections. Two male cases are labeled "Harrisburg, Pa.; June 5-14; 10953a Hopk. U.S.; June 5-14; reared, *Hicoria*; W.S. Fisher Collector; Paratype" and "Linglestown, Pa.; May 24 1915; 10964h Hopk. U.S.; W.S. Fisher Colr; paratype." One female case is labeled "Harrisburg, Pa.; Mar. 20-15; 10963c Hopk. U.S.; *Hicoria*; W.S. Fisher Colr." The two male cases in the Charles A. Triplehorn Insect Collection, Ohio State University, Columbus, are labeled “Hocking Co., O.; reared from *Salix*; D.J. & J.N. Knull Collrs.”

Description: Greatest length, including anterior antennal processes, ♂ 13.6–16.7 mm, ♀ 11.7 mm; greatest width of thorax ♂ 2.6–3.2 mm, ♀ 3.0 mm; greatest width of abdomen ♂ 2.6–3.2 mm, ♀ 3.0 mm, tapering to ♂ 1.0–1.2 mm and ♀ 1.0 mm at greatest width of abdominal segment 8. Integument subshining light golden brown; wing sheath slightly darker; spines and other processes glistening reddish brown, darker apically; bristle-like spines uniformly yellowish to reddish brown or light to dark reddish brown.

Head with pair of cone-shaped, recurved, anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes ventrolaterally on each side curving and becoming shorter posteriorly; inner posterior process slightly longer than and separated from outer posterior processes by area of heavily sclerotized cuticle; 2 outer posterior processes fused for greater distance, very close together. Facial area with pair of small, basally fused median spines on each side of midline and single, larger spine lateral to each outermost posterior antennal process. Labral, proboscial, and maxillary sheaths smooth and elongate; labral and proboscial sheaths with shallow, median furrow; proboscial sheath with small, yellowish tubercle posteriorly; maxillary sheath extending about one-half to two-thirds length of proboscial sheath.

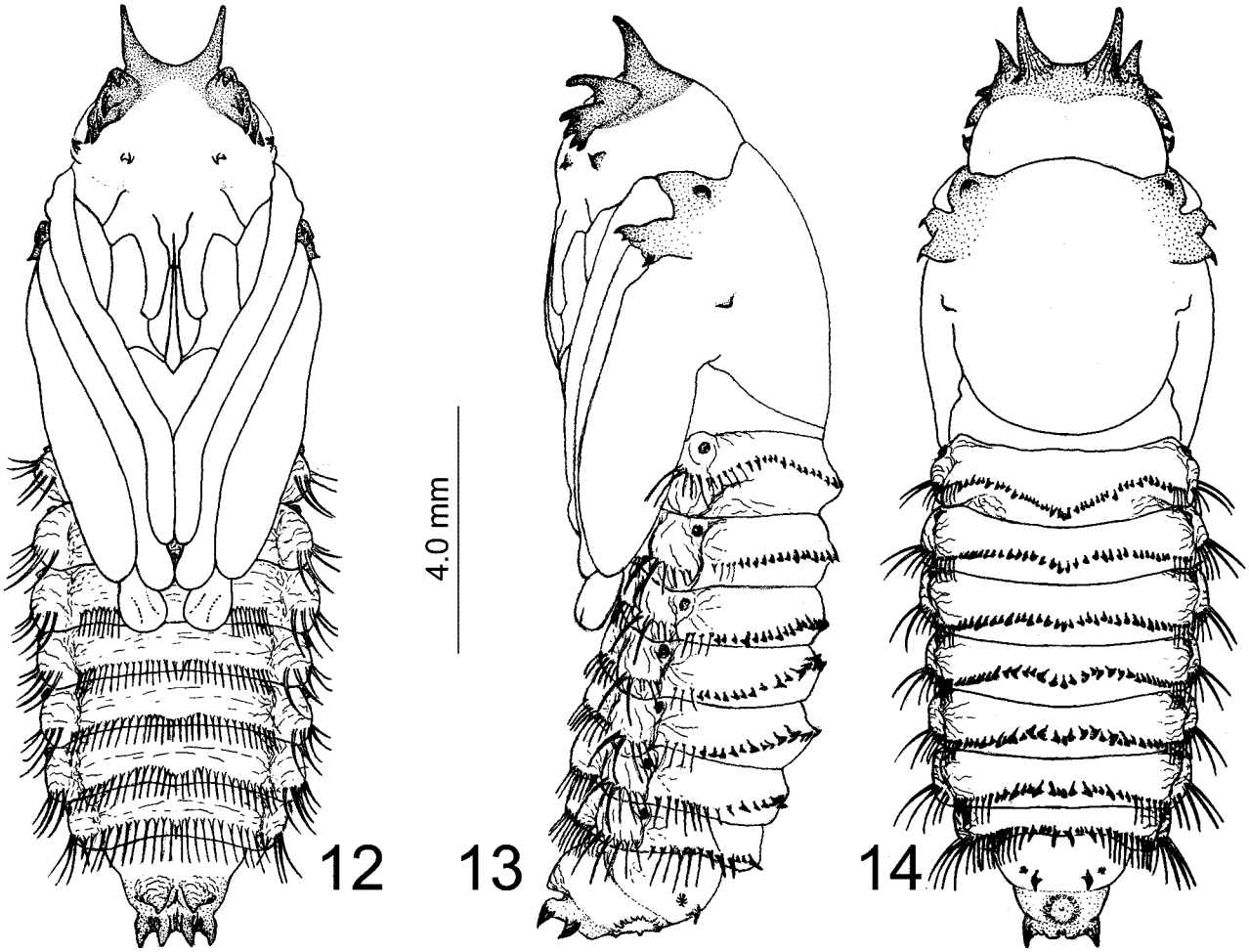
Anterior coxal sheath smooth except for some marginal grooves, with median, anterior, longitudinal split. Prothoracic spiracle round, slightly elevated to almost flush, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines at base of mid leg sheath consisting of anterior pair of basally broad and fused, posteriorly curved spines and short, narrow, straight, posterior spine widely separated from anterior pair. Posterior mesothoracic callosity at base of wing sheath small, bearing short, broadly rounded, apically sclerotized, posterior mesothoracic spine. Wing sheath mostly smooth, with median elongate groove or transverse, shallow groove near base and median elongate groove; median and basal tubercles absent. Thoracic area above wing sheath smooth to irregularly rugulose. Apex of hind leg sheath reaching between middle and posterior margin of abdominal segment 3.

Abdominal spiracles round, light yellowish to reddish brown, flush or almost flush with cuticle, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 20–30 short, stout spines; lateral spines and some other spines shorter, sometimes occurring in pairs; with median bifurcate spine or pair of short spines or 2–3 short, basally fused spines; dorsolateral bristle-like spines absent; 3–5 lateral bristle-like spines present behind each spiracle; venter obscured by wing and leg sheaths. Segments 2–5 with 21–29 short dorsal spines; outer spines and some other spines shorter than most spines, often occurring in pairs or bifurcate; median 3–4 spines short; adjacent 3–4 spines on each side slightly longer and larger, especially on posterior segments. Segments 6–7 similar to segments 2–5, but with 12–20 dorsal spines, including 1–4 median short spines on each side of midline; spines of irregular length or alternately long and short; median pair of short spines sometimes bifurcate and curved toward each other. Segments 2–7 with spines forming line with slight peak on each side of midline; some spines with peaks pointing anteriorly, others pointing posteriorly; peaks more pronounced on segments 2–5; segments 2–7 with 3–7 dorsolateral bristle-like spines, sometimes becoming longer and thicker posteriorly, and 4–9 lateral bristle-like spines of unequal length on each side posterior of spiracle. Segment 2 lacking ventral bristle-like spines or with 2–5 short ventral bristle-like spines on each side of hind leg sheath.

Segments 3–7 with 9–11 ventral bristle-like spines on each side of median space that become smaller posteriorly; bristle-like spines sometimes becoming larger and thicker posteriorly. Segments 6-7 sometimes lacking ventral median space; median 1-2 bristle-like spines smaller than adjacent spines.

Segments 8–9 curved downward; segment 8 with 1 dorsal spine on each side of dorsal midline; dorsolateral, round, yellowish- to reddish-brown spiracle on each side of lateral midline; dorsolateral, lateral, and ventral spines absent. Segment 9 with pair of small dorsomedian tubercles; short, sometimes inwardly curved, dorsal posteroventral processes; pair of large, rugose, dorsally curved, ventral posterolateral processes about same height as dorsal posterolateral processes, but much thicker; and pair of elongate, paired ventromedian tubercles in male in V-configuration, not touching anteriorly.



FIGURES 12–14. *Laphria sackeni* (Banks), 12. ventral view, 13. lateral view, 14. dorsal view.

***Laphria sackeni* (Banks)**
(Figs 12-14)

The following description is based on six pupal cases of *Laphria sackeni* from the United States National Museum and one from the California Academy of Sciences. One male case with pinned adult is labeled "Mt. St. Helena, Cal.; IV-3-31; ex pupa fr alder; collected by E.C. Zimmerman; colln. E.C. Zimmerman 1941," Another male with pinned adult is labeled "Placerville, Cal.; 11715g Hopk. U.S.; *Pinus sabiniana*; Sullivan J.J. Colr." One female pupal case with a pinned adult and two female pupal cases without pinned adults are

labeled the same as the Placerville male case. Another female case with pinned adult from the California Academy of Sciences is labeled "California, Tulare Co., Hot Spgs.; V-17-37; pres. by E.C. VanDyke."

Description: Greatest length, including anterior antennal processes, ♂ 15.3–15.5 mm, ♀ 14.3–19.4 mm; greatest width of thorax ♂ 3.9–4.4 mm, ♀ 3.9–5.3 mm; greatest width of abdomen ♂ 3.4–3.6 mm, ♀ 3.6–4.6 mm, tapering to ♂ 1.9–2.2 mm and ♀ 1.7–2.4 mm at greatest width of abdominal segment 8. Integument subshining golden brown; wing sheath, head, area around thoracic spiracle, posterior antennal processes, and often dorsolateral area of abdominal segments 1–2 darker; spines and other processes glistening reddish brown, darker apically; bristle-like spines yellowish to reddish brown.

Head with pair of cone-shaped, recurved, anterior antennal processes not joined at base and group of 4–5 basally fused, posterior antennal processes that curve and become shorter posteriorly; fifth process sometimes missing or fused with fourth; inner or first posterior process longer than and separated from outer posterior processes by flattened area of heavily sclerotized cuticle; outer 2 posterior processes (fourth and fifth) fused for greater distance than other posterior processes. Facial area with pair of small, basally fused, median spines on each side of midline and single, larger spine posterolateral to outermost posterior antennal process. Labral, proboscial, and maxillary sheaths smooth and elongate; labral and proboscial sheaths with shallow median furrow; proboscial sheath with median posterior swelling; maxillary sheath extending about two-thirds length of proboscial sheath.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle round, situated midlaterally on small callosity at anterior margin of thorax. Anterior mesothoracic spines at base of mid leg sheath consisting of small, basally fused, posteriorly curved, anterior pair of spines and single, short, narrow, straight posterior spine widely separated from anterior pair. Posterior mesothoracic callosity at base of wing sheath small, bearing short, broadly rounded, apically sclerotized posterior mesothoracic spine. Wing sheath mostly smooth, with median elongate grooves; lacking median and/or basal tubercles. Thoracic area above wing sheath smooth. Apex of hind leg sheath reaching beyond middle of abdominal segment 4.

Abdominal spiracles round, light yellowish to reddish brown, flush or almost flush with cuticle, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 23–43 short, stout spines; median spine sometimes bifurcate; outer spines shorter than inner spines; some spines alternately long and short, with 3–5 short spines between 2 long spines; dorsolateral bristle-like spines absent; 3–5 lateral spines present behind each spiracle; venter obscured by wing and leg sheaths.

Abdominal segments 2–4 and 5–6 similar to segment 1, but dorsal transverse row consisting of 24–33 and 15–21 stout spines, respectively; segment 7 with dorsal transverse row of 13–16 spines. Abdominal segments 4–5, and to lesser extent segments 2–3, with stout spines forming a row with 2 peaks, 1 peak on each side of midline; peaks with 1–3 spines pointing anteriorly. Segments 2–7 usually with 5–7 dorsolateral bristle-like spines on each side and 4–6 lateral bristle-like spines behind each spiracle; first and third bristle-like spines on venter and some other bristle-like spines often very long and curved. Segment 2 with 3–5 ventral bristle-like spines on each side of hind leg sheath; segments 3–7 with median space and 13–18 bristle-like spines becoming longer and thicker posteriorly.

Abdominal segments 8–9 curved downward. Segment 8 with 1 large, dorsal spine on each side of midline and sometimes 1–2 short, dorsolateral spines; dorsolateral, round, reddish-brown spiracle at lateral midline; lacking lateral and ventral spines. Segment 9 with pair of dorsomedian tubercles, most prominent in males; short, straight to recurved, dorsal posterolateral processes; larger, slightly longer, rugose, dorsally curved, ventral posterolateral processes; and pair of very large ventral, posteriorly pointed tubercles in male almost touching ventral posterolateral processes.

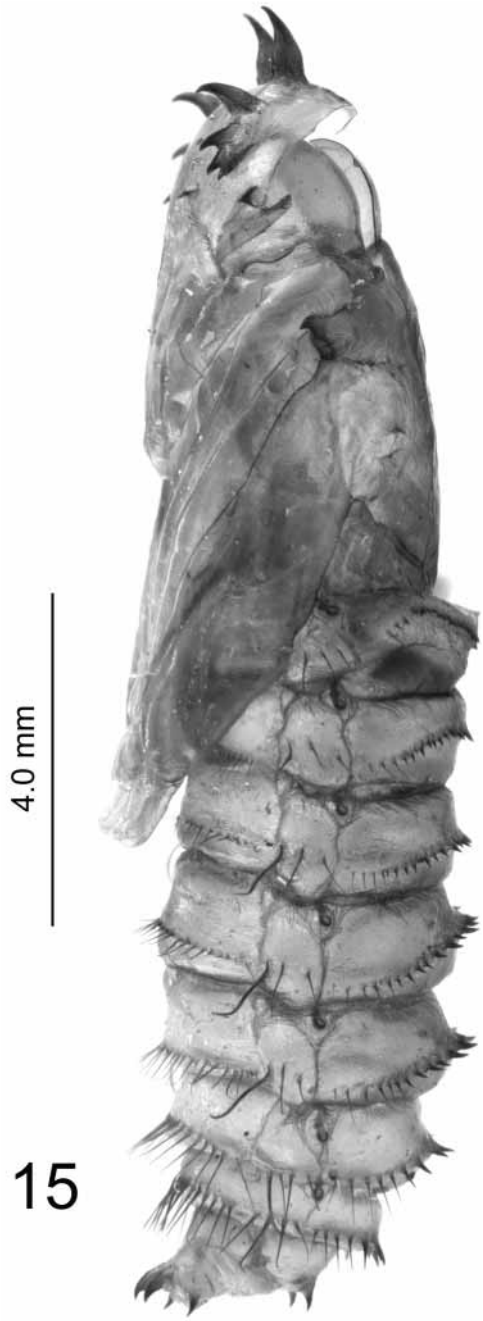


FIGURE 15. *Laphria sericea* Say, lateral view.

***Laphria sericea* Say**
(Fig. 15)

A female pupal case with pinned adult from the United States National Museum was the basis for the following description. It is labeled "Clinton Co., Rose Lake, Michigan; 11 May 1966; J.C. Arnsman; Norman Baker rearing code 66-16."

Description: Greatest length, including anterior antennal processes, 15.0 mm; greatest width of thorax 3.0 mm; greatest width of abdomen 3.0 mm, tapering to 1.0 mm at greatest width of abdominal segment 8. Integument subshining dark golden brown; posterior part of wing sheath and dorsum of thorax darker; spines

and other processes glistening reddish brown, uniformly colored or darker on apical half; bristle-like spines uniformly reddish brown.

Head with pair of dorsally rounded to flattened, ventrally wedge-shaped, basally rugose, anterior antennal processes not joined at base and group of 4 basally fused, posterior antennal processes curving and becoming shorter posteriorly; first or inner posterior process longer than and separated from last or outer posterior processes by slightly swollen, rounded area; outer 2 posterior processes fused for greater distance and straighter than other processes. Facial area with pair of short, basally fused, median spines on each side of midline and single, longer spine posterolateral to outermost posterior antennal process. Labral, proboscial, and maxillary sheaths smooth and elongate. Posterior half of labral sheath with slight median furrow. Proboscial sheath with furrow on each side of median ridge diverging around inconspicuous median posterior swelling with slightly larger posterior swellings on each side. Maxillary sheath extending about two-thirds length of proboscial sheath, with tubercle-like swelling near longitudinally split anterior coxal sheath and overhanging anterior coxal sheath.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle round, on slight callosity, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines on side of thorax above base of mid leg sheath consisting of anterior pair of straight, short, approximate spines and outer longer, wider, straight spine widely separated from anterior pair. Posterior mesothoracic callosity small, with short, broad, apically curved posterior mesothoracic spine at base of wing sheath. Wing sheath smooth, with slight, elongate grooves; lacking median or basal tubercles. Thoracic area above wing sheath smooth to irregularly rugose. Apex of hind leg sheath reaching to posterior margin of abdominal segment 3.

Abdominal spiracles round, reddish brown, on slight swelling, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 29 short spines, some shorter than others, some bifurcate; median pair of spines situated slightly posterior to adjacent spines; 2 short dorsolateral bristle-like spines and 3 long bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsal transverse rows of 26, 26, 22, 20, 13, and 13 spines, respectively; spines on each segment long and short, in no apparent pattern. Rows of spines on abdominal segment 2 and to lesser extent on 3–7 forming gently curved peak on each side of midline; segments 4–6 with long spines of peaks pointing anteriorly.

Segments 5–6 with short median spines; segment 6 with median spines pointing toward each other. Spines become longer on posterior segments; outermost spine on segment 7 very long, thick, bristle-like.

Segments 2–7 with 4–6 dorsolateral bristle-like spines and 3–5 (usually 3–4) lateral bristle-like spines behind each spiracle; lateral bristle-like spines toward venter larger than other bristle-like spines, especially on posterior segments.

Segment 2 with ventral transverse row of 7–8 bristle-like spines on each side of and extending under hind leg sheath; abdominal segment 3 with median row of 10–13 ventral bristle-like spines on each side of midline; segments 4–7 with 24, 26, 19, and 19 ventral bristle-like spines, respectively; spines of unequal length, generally becoming longer posteriorly.

Segments 8–9 curved downward. Segment 8 with 1 dorsal spine on each side of midline; small yellowish-brown spiracle at lateral midline; lacking dorsolateral, lateral, and ventral spines. Segment 9 with pair of short dorsomedian tubercles; pair of short, dorsal posterolateral processes curved toward midline; and pair of larger, rugose, dorsally curved ventral posterolateral processes.

***Laphria thoracica* Fabricius**

(Figs 6–7)

The description of the *Laphria thoracica* pupal case is based on the following specimens from the United States National Museum: four male cases without associated adults labeled "Stamford, Conn.; June 11, 1931;

B.T.R. Lab. Col.; from hollow apple tree; S.W. Bromley Collection 1955"; two male cases without associated adults labeled "Chautauqua Co., N.Y.; June 1934; collector S. Bromley; S.W. Bromley Collection 1955"; one male case with associated adult labeled "9684g Hopk. U.S."; one case with associated adult male labeled "Falls Church, VA.; reared May 11-14; C.T. Greene; *Liriodendron*; 10490a Hopk. U.S.; C.T. Greene Collector"; two male cases with associated adults labeled " Falls Church, VA; May 10-15; *Liriodendron tulipifera*; 12957 Hopk. U.S.; reared C.T. Greene; T.E. Snyder Colr."; one female case with associated adult labeled "Falls Church, Va., reared May 26-14, *Liriodendron*, 10490a Hopk. U. S., C.T. Greene, colr., C. T. Greene"; one female case with pinned adult labeled “Fleetwood, N.Y.; May 14-33; C.L. Ragot; larva taken in decayed stump May 14, emerged on May 19-33; S.W. Bromley Collection 1955"; one female case with pinned adult labeled "Westerleigh, N.Y.; VI-12-1928; N.T. Davis; recently emerged from pupa skin in stump; S.W. Bromley Collection 1955"; and two male cases with pinned adults labeled "Ingham Co. [Michigan]; T2N R1E, S33, Danville State Game Area; on May 13, 1965; Norman Baker." The pupal case of this species was previously described by C.T. Greene (1917).

Description: Greatest length, including anterior antennal processes, ♂ 16.5–22.0 mm, ♀ 19.0–20.5 mm; greatest width of thorax, ♂ 4.0–6.0 mm, ♀ 6.0 mm; greatest width of abdomen, ♂ 4.0–5.0 mm, ♀ 5.0–5.5 mm, tapering to ♂ 2.0–3.0 mm and ♀ 3.0 mm at greatest width of abdominal segment 8. Integument subshining, dark golden brown; posterior part of wing and leg sheaths, head, dorsum of thorax, and anterior part of abdomen sometimes darker; spines and other processes glistening reddish brown, generally darker apically; bristle-like spines mostly uniformly reddish brown.

Head with pair of dorsally rounded, ventrally wedge-shaped, basally rugose, anterior antennal processes not joined at base, and group of 4 basally fused posterior antennal processes curving and becoming shorter posteriorly; inner posterior process longer than and separated from outer posterior processes by rounded to flat, smooth to rugose area; outer 2 posterior processes fused for greater distance than other processes. Facial area often rugose on each side of midline; some cases with 1–3 small spines and longer spine posterolateral to outer posterior antennal process. Labral, proboscial, and maxillary sheaths smooth and elongate. Proboscial sheath with slight median furrow and median posterior callosity or tubercle. Maxillary sheath extending about two-thirds length of proboscial sheath; pair of callosities or tubercles sometimes overhanging anterior coxal sheath lateral to longitudinal split of anterior coxal sheath.

Anterior coxal sheath smooth, with anterior, median, longitudinal split sometimes extending to posterior sheath margin. Prothoracic spiracle oval or round, situated midlaterally on small, reddish-brown, often rugose callosity at anterior margin of thorax. Anterior mesothoracic spines on side of thorax above base of mid leg sheath consisting of inner or anterior pair of short, basally broad, fused, posteriorly curved spines and single outer or posterior broad, straight spine widely separated from anterior pair. Posterior mesothoracic callosity slight, with short, broad, apically rounded and sclerotized posterior mesothoracic spine at base of wing sheath. Wing sheath smooth, with elongate grooves, lacking median or basal tubercles. Thoracic area above wing sheath smooth to slightly rugulose. Apex of hind leg sheath reaching middle or posterior portion of abdominal segment 3.

Abdominal spiracles oval or round, reddish brown, on slight swellings along midline laterally.

Abdominal segment 1 with dorsal transverse row of 34–52 short, stout spines; median pair of spines and some other spines longer than adjacent spines so that 3–8 short spines alternate with 1 longer spine; usually 6–8 indistinct, short dorsolateral bristle-like spines on each side; 6–10 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–5 with dorsal spines forming slight peak with 1–5 long spines at peak pointing anteriorly. Segments 2–7 with 28–52, 27–43, 21–37, 10–31 (usually 23–31), 11–17, and 6–16 (usually 10–16) spines, respectively. Segments 2–5 often with 3–8 short spines between long spines.

Segments 6–7 similar to segments 2–5 or with mostly long spines, often median pair of short spines farther apart than on other segments.

Segments 2–7 with 5–15 dorsolateral bristle-like spines on each side, posterior segments usually with fewer spines; 4–12 lateral bristle-like spines behind each spiracle consisting of 2–3 longer and thicker bristle-like spines, mostly toward venter, alternating with short, thin bristle-like spines and 1–3 short, thin outer bristle-like spines especially toward dorsal surface. Segment 7 with lateral bristle-like spines of about equal length and thickness.

Segment 2 with 6–14 ventral bristle-like spines on each side of and extending under hind leg sheath. Segments 3–7 with ventral transverse row of 14–32 bristle-like spines; spines becoming longer and thicker on posterior segments; some bristle-like spines shorter than others; sometimes 2 bristle-like spines issuing from common base. Segments 3–4 often with wider median space in ventral rows of bristle-like spines than more posterior segments.

Segments 8–9 curved downward. Segment 8 with 1 large, dorsal, sometimes bifurcate spine on each side of midline; small reddish-brown spiracle at lateral midline; lacking dorsolateral, lateral, and ventral spines. Segment 9 with pair of short dorsomedian tubercles, dorsal posterolateral processes curved toward midline, rugose, dorsally curved ventral posterolateral processes, and pair of very large ventral, posteriorly pointed, basally rugose tubercles in male.

Laphria virginica (Banks)

The description of the pupal case of *Laphria virginica* is based on a female case with associated adult from the United States National Museum labeled "Falls Church, Va.; *Pinus*; 12988e Hopk. U.S.; C.T. Greene Collector; reared May 17-16; C.T. Greene" and a male with pinned adult from the United States National Museum labeled " E.F.C. Va.; April 18, 1919; reared by C.T.G.; T.E.S. Cole."

Description: Greatest length, including anterior antennal processes, ♂ 12.6 mm, ♀13.5 mm; greatest width of thorax, ♂ 3.4, ♀3.0 mm; greatest width of abdomen, ♂ 3.5 mm, ♀ 3.0 mm, tapering to ♂ 1.8 mm, ♀ 2.0 mm at greatest width of abdominal segment 8. Integument subshining golden brown; wing sheath, dorsum of head and thoracic area, and area adjacent to dorsal abdominal spines darker; spines and other processes glistening reddish brown, darker apically; bristle-like spines mostly uniformly reddish brown.

Head with pair of dorsally rounded, ventrally wedge-shaped, anterior antennal processes grooved on outer edge and not joined at base, and with group of 4 basally fused, posterior antennal processes curving and becoming shorter posteriorly; inner posterior process longer than and separated from outer posterior processes by slightly swollen area of heavily sclerotized cuticle; outer 2 posterior processes fused for greater distance than other posterior processes; outer or fourth posterior process with small basal spur. Facial area with pair of short, basally fused, median spines on each side of midline and longer spine posterolateral to outermost posterior antennal process. Labral, proboscial, and maxillary sheaths smooth and elongate. Labral sheath with posterior margin indistinct. Proboscial sheath with slight median furrow and minute median swelling posteriorly. Maxillary sheath extending about one-half length of proboscial sheath.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle round, situated midlaterally on reddish-brown callosity at anterior margin of thorax. Anterior mesothoracic spines on each side of thorax above base of mid leg sheath consisting of inner or anterior pair of basally broad, posteriorly curved spines and outer or posterior short, narrow, straight spine widely separated from anterior pair. Posterior mesothoracic callosity slightly swollen, with short, broad, apically rounded, sclerotized posterior mesothoracic spine at base of wing sheath. Wing sheath smooth to slightly rugulose, with slight elongate grooves, lacking median or basal tubercles. Thoracic area above wing sheath mostly smooth. Apex of hind leg sheath reaching between middle and posterior margin of abdominal segment 3.

Abdominal spiracles round, reddish brown, almost flush with surface, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 28 subequal, short, stout, straight spines; 3–4 dorso-

lateral bristle-like spines on each side; 5 alternately long and short bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–3 similar to segment 1, but with 32 and 30 dorsal spines, respectively.

Segments 4–5 with dorsal transverse rows of 27 and 25 spines, respectively, in 2 peaks, 1 on each side of midline; spines becoming longer toward midline, but 2 median spines very short.

Segments 6–7 with dorsal transverse row of 10–12 spines; median 2–4 spines short; some others alternately long and short. Rows of dorsal bristle-like spines with median space becoming wider on posterior segments.

Segments 2–5 and 6–7 with 1–3 and 6–8 dorsolateral bristle-like spines, respectively; most spines long and subequal, some very short. Segments 2–7 with 2–6 lateral bristle-like spines behind each spiracle; some spines alternately short and long; bristle-like spines becoming longer toward venter; long bristle-like spines usually strongly curved.

Segment 2 with ventral rows of 8 bristle-like spines on each side of and extending under hind leg sheath. Segments 3–7 with median transverse rows of 16–26 ventral bristle-like spines; bristle-like spines becoming longer, thicker, fewer, and recurved on posterior segments; most bristle-like spines about same length, but some, including 2–4 median spines, very short.

Segments 8–9 curved ventrally. Segment 8 with 1 long and 0–2 short, dorsal spines on each side of dorsal midline; small reddish-brown spiracle at lateral midline; lacking dorsolateral, lateral, and ventral spines. Segment 9 with pair of minute dorsomedian swellings; pair of short, dorsal, posterolateral processes curved toward midline; and pair of larger, longer, basally slightly rugose, dorsally curved ventral posterolateral processes; venter smooth, lacking tubercles in female, pair of very large, posteriorly pointed, basally rugose tubercles present in males.

Dasypogoninae-group

This group comprises many genera in the Nearctic Region. The following key covers only 9 of the 42 valid genera (Geller-Grimm 2003): *Ceraturgus, Comantella, Cyrtopogon, Dioctria, Diogmites, Heteropogon, Laphystia, Lasiopogon* and *Stenopogon.* Morphological characteristics for *Laphystia* are based on the description of *L. carnea* Hermann presented by Krivosheina (1973). Characteristics for *Cyrtopogon*, *Dioctria,* and *Lasiopogon* are based on descriptons of *C. lateralis* Fallén, *D. hyalipennis* (Fabricius), *D. atricapilla* Meigen, and *L. cinctus* (Fabricius) in Melin (1923). Some information on *Dioctria* is also derived from the descripton of *D. rufipes* (De Geer) in Brindle (1968) and *D. bicincta* Meigen in Musso (1978). Because these are European species and the characteristics are derived from the literature, the key must be considered tentative. It is, in part, an attempt to indicate what we believe are significant characteristics. Information on *Holopogon venustus* (Rossi) was presented by Musso (1978), but it is not adequate to allow us to include *Holopogon* in the generic key. Significant morphological characteristics appear to be the absence of anterior and posterior mesothoracic spines and ventral spines on abdominal segments 2–5.

Key to known pupal cases of Nearctic genera of the Dasypogoninae-group

1 Head with 4–6 apically rounded to acute posterior antennal processes 2
- Head with 3 distinct, apically blunt to acute posterior antennal processes.....3
2 Head with 6 apically rounded to acute posterior antennal processes that become shorter posteriorly; anterior mesothoracic spine single, lacking lateral bristle-like spines; abdominal segments 4–7 with bristle-

like spines ventrally ..... *Ceraturgus*

- Head with 4 elongate, acute posterior antennal processes and 2 shorter processes, 1 between the second and third elongate processes, and 1 between the third and fourth elongate processes; anterior mesothoracic spines elongate, very long posterior spine extending over wing sheath, with bristle-like spines on interior surfaces; abdominal segments 4–6 lacking ventral bristle-like spines; segment 7 with ventral bristle-like spines ..... *Laphystia*

3 Proboscial sheath sharply pointed posteriorly; lower part of facial area, near split of anterior coxal sheath, elongate and protruding over anterior coxal sheath; anterior mesothoracic spines sometimes with microspinules on sides; spines on abdominal segment 1 with anterior sawtooth-like projections; dorsal posterolateral processes of segment 9 sometimes with bristle-like spines on sides ..... *Lasiopogon*

- Proboscial sheath rounded or only slightly pointed; lower part of facial area not elongate or protruding over anterior coxal sheath; anterior mesothoracic spines without microspinules on sides; dorsal transverse spines of abdominal segment 1 without anterior sawtooth-like projections; dorsal posterolateral processes of segment 9 without spines on sides 4

4 Anterior antennal process usually with basal bristle dorsally; thorax with 2 bristles on dorsal surface; anterior mesothoracic spines absent; posterior mesothoracic callosity ridge-like; abdominal segment 1 with 8 long spurs dorsally; segments 2–7 with alternating long spurs and short spines dorsally, becoming subequal on more posterior segments ..... *Dioctria*

- Anterior antennal process with or without basal bristle dorsally; thorax with or without bristles on dorsal surface; anterior mesothoracic spines present; posterior mesothoracic callosity smooth to grooved or rugose; abdominal segment 1 with 4–6 or 12–27 dorsal spurs; segments 2–7 with alternately long spurs and short spines dorsally, not becoming subequal on more posterior segments 5

5 Anterior antennal process with basal bristle dorsally; abdominal segment 1 with 12–14 spurs; ventral abdominal bristle-like spines scattered or absent, but not in transverse rows; abdominal segment 9 with dorsal posterolateral and ventral posterolateral processes curved toward each other ..... *Cyrtopogon*

- Anterior antennal process without basal bristle dorsally; abdominal segment 1 with 4–6 or 12–27 dorsal spurs; ventral abdominal bristle-like spines present in transverse rows or completely absent; abdominal segment 9 with dorsal posterolateral and ventral posterolateral processes not distinctly curved toward each other or only ventral posterolateral processes curved toward dorsal posterolateral processes 6

6 Posterior mesothoracic callosity lacking spine; abdominal segment 1 with 4–6 dorsal spurs; segments 2–6 with 18–32 dorsal spurs and spines; 2–3 bristle-like spines behind each abdominal spiracle; venter of segments 2–7 lacking bristle-like spines; abdominal segment 8 lacking lateral or ventral spines ... *Stenopogon*

- Posterior mesothoracic callosity with spine; abdominal segment 1 with 12–27 dorsal spines; segments 2–6 with 14–15 alternating long spurs and short spines; 0–16 bristle-like spines present behind each abdominal spiracle; venter of segments 2–7 with or without bristle-like spines; abdominal segment 8 with or without lateral or ventral spines.....7

7 Outer or third posterior antennal process truncate or with 1–3 apical teeth; posterior mesothoracic callosity bearing bristle-like spine; ventral and lateral bristle-like spines behind abdominal spiracles absent; abdominal segment 8 with 1–4 dorsal spurs on each side of midline ..... *Heteropogon*

- Outer or third posterior antennal process without teeth, apically rounded to blunt; a single posterior mesothoracic spine present; ventral and lateral bristle-like spines present behind abdominal spiracles; abdominal segment 8 with 4–10 dorsal spurs on each side of midline 8

8 Labral sheath with slight apical keel; posterior or outer anterior mesothoracic spine serrate along posterior margin; posterior mesothoracic callosity bearing posterior spine; abdominal segment 1 with 12–14 long, subequal spurs, 1–4 (usually 3) bristle-like spines behind lateral spiracle; abdominal segments 2–6 lacking ventral bristle-like spines; abdominal segment 7 with ventromedian row of 8–13 bristle-like spines; abdominal segment 8 with 10–18 bristle-like spines ventrally; segment 9 with dorsal posterolateral and

ventral posterolateral processes, sometimes with 1–2 basally fused or separate processes .... *Comantella fallei* Back

- Labral sheath lacking keel, but sometimes with small posterior callosity; posterior or outer anterior mesothoracic spines smooth along posterior margin; posterior mesothoracic callosity at base of wing sheath lacking spine; abdominal segment 1 with 19–27 dorsal spurs, 6–9 bristle-like spines behind lateral spiracle; abdominal segments 2–7 with 10–46 ventral bristle-like spines; abdominal segment 8 lacking ventral bristle-like spines; segment 9 with only dorsal posterolateral and ventral posterolateral processes.. ..... *Diogmites*

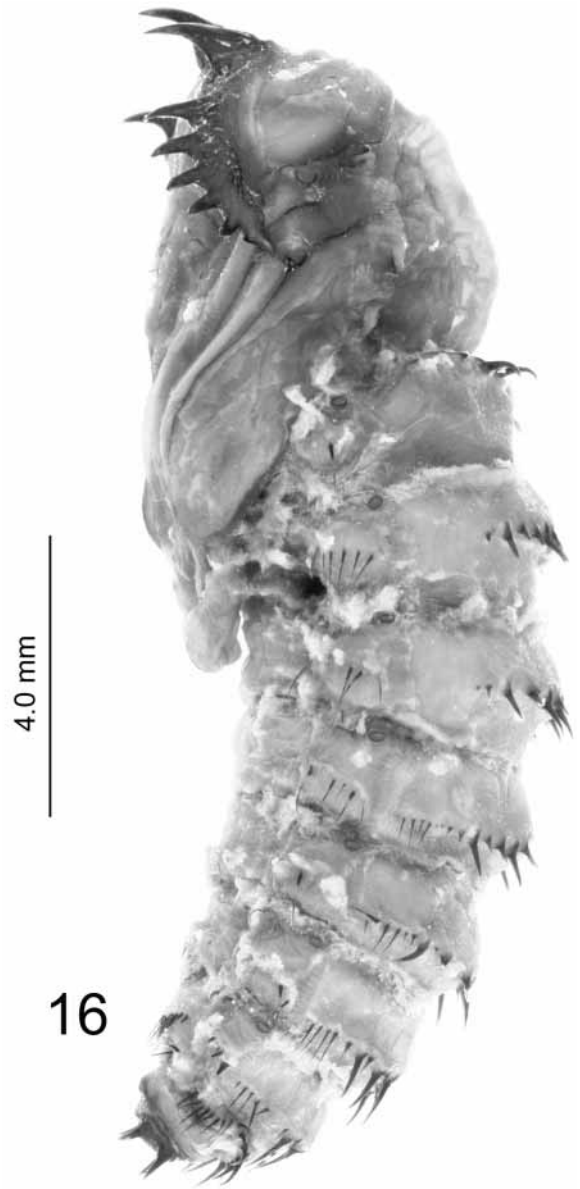


FIGURE 16. *Ceraturgus fasciatus* Walker, lateral view.

Genus *Ceraturgus* Wiedemann

***Ceraturgus fasciatus* Walker**
(Fig. 16)

Malloch (1917) figured and described the pupal case of *Ceraturgus fasciatus* (as *C. cruciatus* (Say)) from specimens collected at Wolfville, Maryland (? = Wolfsville, Frederick County, Maryland). An adult emerged from one of his specimens, allowing for species identification. Bromley (1946) republished Malloch's figure, but he did not describe the pupal case. The following description is based on a single case from the Illinois Natural History Survey that is labeled "Asilid pupa; Wolfville, Md.; My 14, 14; *Ceraturgus cruciatus*." This is apparently one of the pupal cases that Malloch (1917) described. The specimen, which is preserved in alcohol, is severely wrinkled and in generally poor condition. It bears well developed ventral tubercles on abdominal segment 9 and is therefore probably a male.

Osten Sacken (1878) synonymized the eastern *C. fasciatus* with the midwestern *C. cruciatus*, and this synonymy was repeated by all subsequent authors. It is now clear that the 2 species are distinct (Barnes 2008). *Ceraturgus fasciatus* ranges from Ontario and New England south to North Carolina and west to Michigan and Mississippi. It is the most common North American species in a small genus of rare species. *Ceraturgus cruciatus* ranges from Wisconsin south to Arkansas and west to the Dakotas and Oklahoma.

Redescription: Greatest length, including anterior antennal processes, 16.6 mm; greatest width of thorax 5.5 mm; greatest width of abdomen 5.1 mm, tapering to 3.0 mm at greatest width of abdominal segment 8. Integument subshining, pale golden brown; spines and other processes glistening reddish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 6 apically round to acute, basally fused posterior antennal processes shorter than anterior antennal processes, located ventrolaterally on each side, reaching to anterior mesothoracic spines. Labral sheath swollen and smooth, lacking distinct keel. Palpal sheath small, distinct, pointing diagonally inward near apex of labral sheath. Proboscial sheath smooth, with small posterior tubercle. Maxillary sheath smooth to slightly rugulose, extending down half length of proboscial sheath.

Anterior coxal sheath smooth to irregularly rugulose, with anterior, median, longitudinal split. Prothoracic spiracle oval, distinctly raised, dark brown, situated midlaterally at anterior margin of thorax. First anterior mesothoracic spine vestigial, represented by small, rounded tubercle; second anterior mesothoracic spine dark brown, stout, acuminate, situated between mid leg sheath and wing sheath. Posterior mesothoracic callosity rugose, carinate, lacking posterior mesothoracic spine. Wing sheath smooth, lacking distinct tubercles. Apex of hind leg sheath reaching posterior margin of abdominal segment 3.

Abdominal spiracles reniform, distinctly raised above surface of integument, light yellowish brown on outer surface, darker around perimeter.

Abdominal segment 1 with dorsal transverse row of 13 spatulate, sometimes bifurcate, apically recurved spurs and vertical row of 2–3 lateral bristle-like spines behind spiracle; venter obscured by wing and leg sheaths.

Segments 2–3 with dorsal transverse row of 13–15 alternating short, truncate, sometimes bifurcate spines and long, spatulate to acuminate spurs. Segments 4–6 with dorsal transverse row of 12–13 alternating short, acuminate spines and longer, acuminate spurs. Segment 7 with dorsal transverse row of 9 alternating short, acuminate spines and longer, acuminate spurs.

Segments 2–3 lacking dorsolateral bristle-like spines. Segments 4–7 with 4–5 thin, acuminate dorsolateral bristle-like spines lateral to dorsal transverse row.

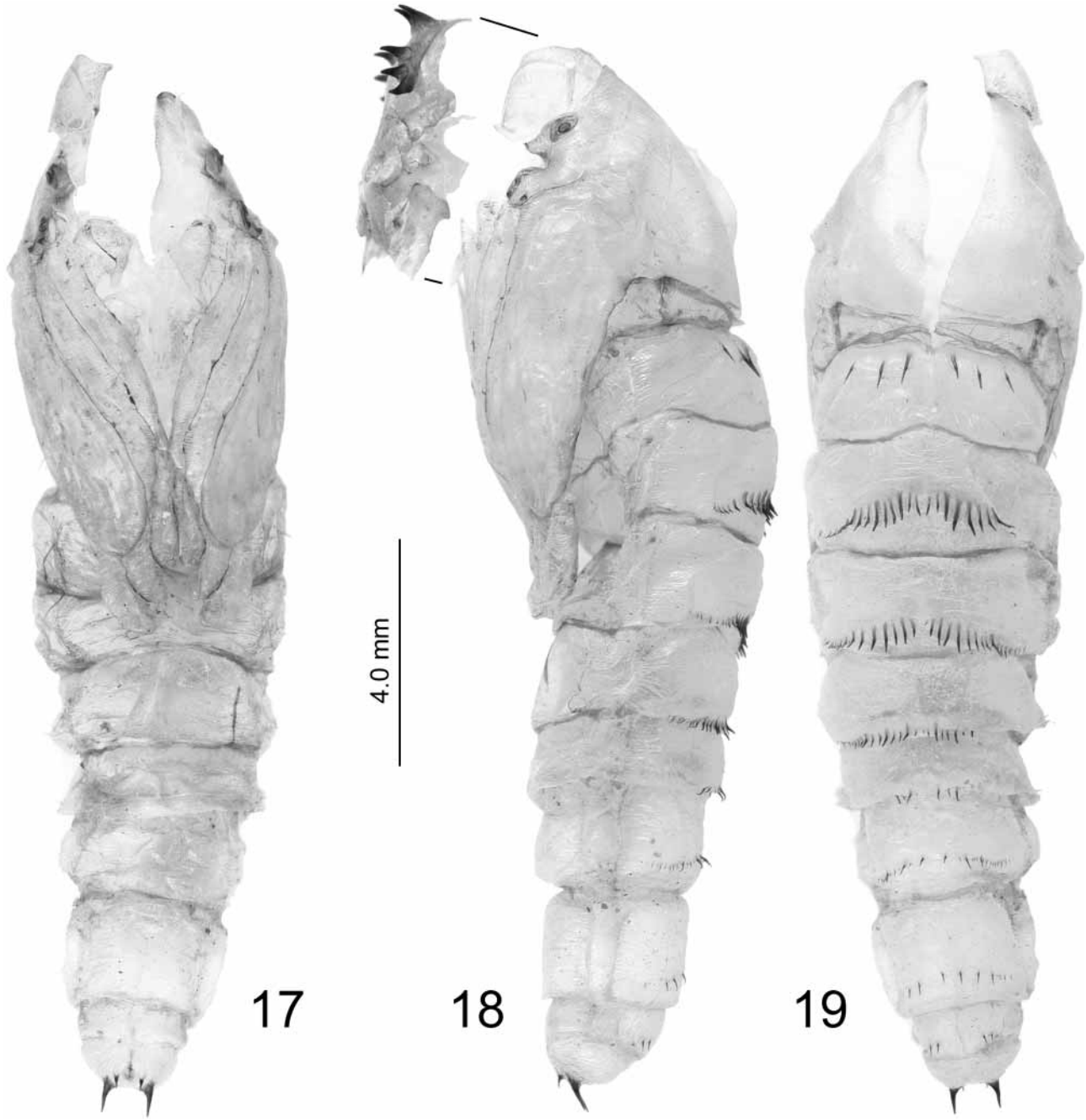
Segments 2–7 with 4–5 acuminate, lateral bristle-like spines behind each spiracle.

Segments 1–4 lacking ventral bristle-like spines; segment 5 with row of 4 short, ventral bristle-like spines; segment 6 with row of 12 longer, ventral bristle-like spines divided by wide median space; segment 7 with

row of 17 still longer ventral bristle-like spines divided by wide median space.

Segment 8 with row of 4 long, dorsal spurs or spines of unequal length on each side of midline, 8–9 long, lateral bristle-like spines, and about 12 ventral bristle-like spines; spiracle not visible.

Segment 9 with pair of long, straight, spine-like dorsal posterolateral processes and pair of shorter, straight, spine-like ventral posterolateral processes; ventromedian tubercles diverging posteriorly.



FIGURES 17–19. *Stenopogon inquinatus* Loew, 17. ventral view, 18. lateral view, 19. dorsal view.

Genus *Stenopogon* Loew

Key to known pupal cases of Nearctic species of *Stenopogon*

1 Middle and outer posterior antennal processes fused, appearing shorter than inner or first process, outer or third process elbowed; distinct labral keel absent; prothoracic spiracle on slight callosity with small anterior tubercle; segments 2–7 with 3 bristle-like spines behind each spiracle..... ..... *Stenopogon rufibarbis* Bromley

- Posterior antennal processes subequal in length, outer or third process not elbowed; labral sheath with slight keel; prothoracic spiracle surrounded by thickened cuticle basally; segments 2–7 with 2 bristle-like spines behind each spiracle..... *Stenopogon inquinatus* Loew

***Stenopogon inquinatus* Loew**
(Figs 17–19)

A description of the pupal case for this species was provided by Dennis & Lavigne (1976a), based on a specimen from the United States National Museum labeled "10 mi. So. Shoshoni, Wyo.; VI-16, 1973; S. Dennis Collector." The description should include the following: prothoracic spiracle slightly upraised and tilted or pointed posteriorly; abdominal spiracles light yellowish brown, elongate-oval to oval, almost flush with surface, sometimes difficult to see along midline laterally; abdominal segment 9 with dorsolateral and median processes curved dorsally.

***Stenopogon rufibarbis* Bromley**

The following description is based on two pupal cases with pinned females from the United States National Museum labeled "Crater Lake, Or.; July 28, 1920; H.G. Dyar coll." and "Azusa, Cal.; May 17, '25; S.W. Bromley Collection 1955."

Description: Greatest length, including anterior antennal processes, 14.6 mm; greatest width of thorax 4.4 mm; greatest width of abdomen 3.1 mm, tapering to 2.7 mm at greatest width of abdominal segment 8. Integument subshining pale whitish to golden brown on wing sheath; spines and other processes glistening reddish brown, darker apically, except for uniformly colored dorsal abdominal spurs and spines.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 apically rounded to acute, basally fused posterior antennal processes about as long as anterior antennal processes, located ventrolaterally on each side; middle and outer posterior processes fused for greater distance, slightly closer together, thus appearing shorter than inner or first posterior process; outer or third posterior process elbowed, sometimes with outer, flattened area with posterior lip. Labral sheath swollen, smooth except for median grooves along entire length of sheath, lacking distinct keel. Proboscial sheath smooth to slightly rugulose, with median furrow running entire length and small posterior tubercle at end of furrow. Maxillary sheath smooth to slightly rugulose, extending down half length of proboscial sheath.

Anterior coxal sheath smooth to irregularly rugulose, with anterior, median, longitudinal split. Prothoracic spiracle oval, on slight callosity with small anterior tubercle, situated midlaterally at anterior margin of thorax. Side of thorax, above base of mid leg sheath, with pair of very short, usually subequal, rugose, apically rounded to blunt and furcate, straight anterior mesothoracic spines on small rugose callosity. Posterior mesothoracic callosity small, smooth, lacking posterior mesothoracic spine. Wing sheath smooth to rugulose, lacking median or basal tubercle. Thoracic area above wing sheath smooth to irregularly rugulose. Apex of hind leg sheath reaching between posterior margin of abdominal segment 2 and middle of abdominal segment 3.

Abdominal spiracles oval, almost flush with surface, light yellowish brown, often difficult to see.

Abdominal segment 1 with 2–3 straight to apically recurved, acuminate dorsal spurs on each side of midline; dorsolateral bristle-like spines absent; 3 yellowish lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–6 with dorsal transverse row of 13–16 alternating long, acuminate spurs and short, acuminate spines continued dorsolaterally with 3–7 short bristle-like spines; transverse row often with 2–3 median spines bifurcate or with other short spines sometimes in pairs.

Segment 7 similar to segments 2–6, but with dorsal transverse row of 12 alternating long spurs and short spines continued dorsolaterally by 0–2 short bristle-like spines.

Segments 2–7 lacking ventral bristle-like spines; 3 lateral bristle-like spines behind each spiracle.

Segments 8–9 somewhat bulbous. Segment 8 with 2–4 (usually 4) dorsal spurs of unequal length on each side of midline; lacking dorsolateral, lateral, or ventral spines or bristle-like spines; spiracle not visible. Segment 9 with pair of long spine-like dorsal posterolateral and shorter spine-like ventral posterolateral processes; processes straight or slightly curved dorsally; female lacking ventromedian tubercles.

Genus *Heteropogon* Loew

Key to known pupal cases of Nearctic species of *Heteropogon*

1 Proboscial sheath without tubercles posteriorly; apex of maxillary sheath with small palpal sheath near juncture with proboscial sheath; posterior mesothoracic spine present; thorax lacking dorsolateral bristle-like spines; abdominal segment 1 with dorsal transverse row of 12–13 recurved spurs, median pair short, outer spurs often shorter than inner spurs; abdominal segment 7 with 6 long spurs alternating with 1–4 short spines; segment 8 with 2 dorsal spurs on each side of midline ..... *Heteropogon macerinus* (Walker)

- Proboscial sheath with minute tubercles posteriorly on each side of median furrow; maxillary sheath without tubercle; posterior mesothoracic tubercle lacking spine, with 2 long, curved bristle-like spines; thorax dorsolaterally with 2 long, curved, median bristles; abdominal segment 1 with dorsal transverse row of 17 apically recurved spurs, dorsolateral and middle spurs shorter; abdominal segment 7 with 6 long spurs, spines absent; abdominal segment 8 with pair of long dorsomedian spurs..... *Heteropogon wilcoxi* James

Heteropogon macerinus (Walker)

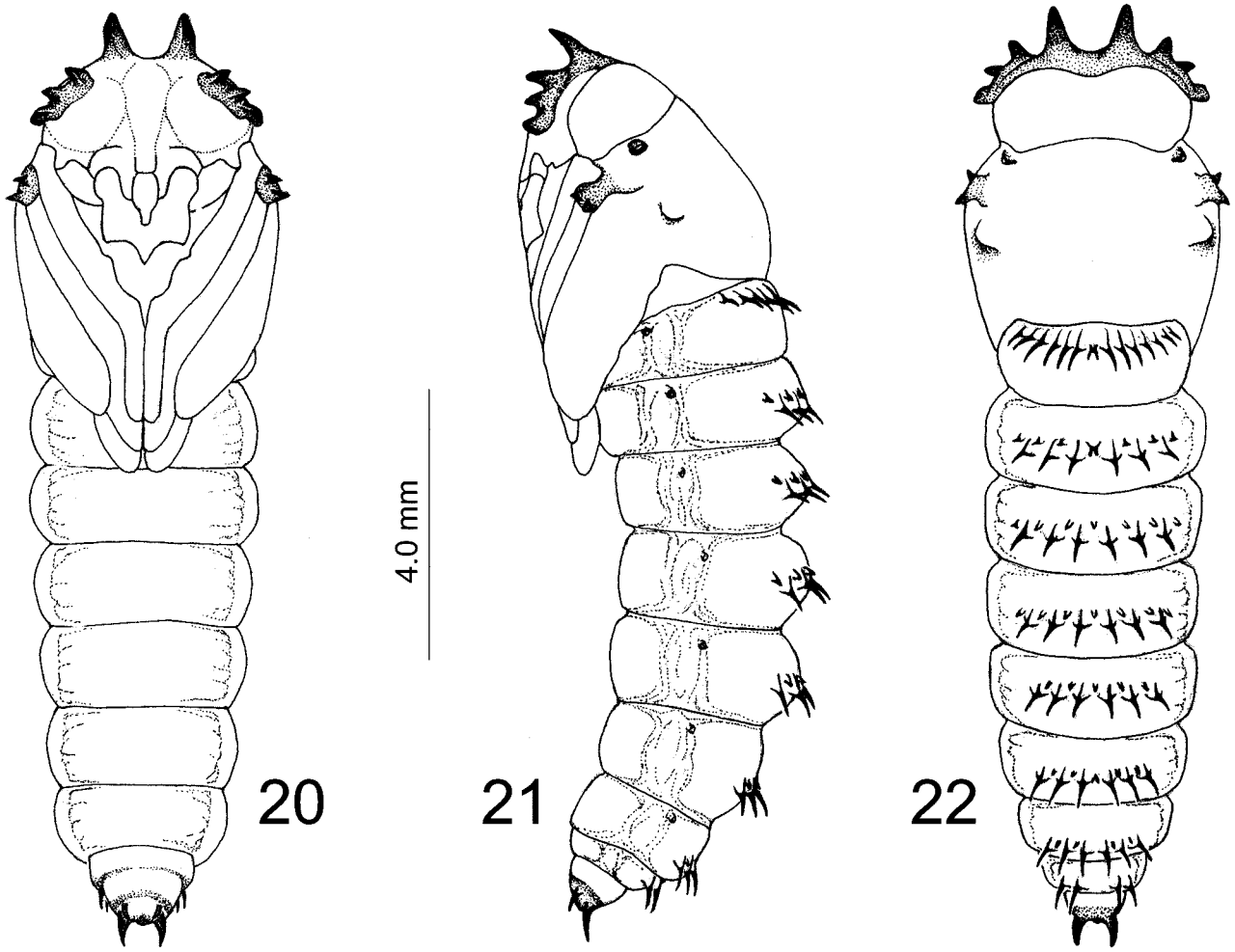
(Figs 20–22)

The following description is based on five female and three male pupal cases with pinned adults from the Charles A. Triplehorn Insect Collection, Ohio State University, Columbus. They are labeled "Rockymount, VA., 6 miles East; Sept. 3, 1956; R.E. Woodruff." Also, one female from the United States National Museum is labeled "Rockville, Pa.; larva coll. IV-21-12, Champlain; pupated VI–25, emerged VII–8–12," which indicates that this species may remain in the pupal stage for approximately two weeks.

Description: Greatest length, including anterior antennal processes, ♂ 13.6–15.5 mm, ♀ 13.6–16.0 mm; greatest width of thorax ♂ 3.7–4.4 mm, ♀ 3.9–4.1 mm; greatest width of abdomen ♂ 3.1–3.6 mm, ♀ 3.5–3.6 mm, tapering to ♂ 1.2–1.9 mm and ♀ 1.2–1.6 mm at greatest width of abdominal segment 8. Integument subshining, faded, yellowish brown; spines and other processes glistening reddish brown, darker apically except for uniformly colored or basally darker dorsal abdominal spines and spurs.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused, subequal posterior antennal processes located ventrolaterally on each side; mid-

dle and outer posterior processes closer together, fused for greater distance; outer or third posterior process at least twice as wide as inner and middle processes, with straight sides, truncate or with 1–3 apical teeth; inner and middle posterior processes with either straight sides or curved outer sides, apically narrow and rounded or more acute. Labral sheath usually smooth, with very slight keel posteriorly. Proboscial sheath smooth; shallow median furrow extending two-thirds to three-fourths length of sheath; posterior tubercle absent. Maxillary sheath smooth, posterior process absent, inner edge extending slightly posterior to labral sheath on each side at juncture with proboscial sheath, forming very small tubercle.



FIGURES 20–22. *Heteropogon macerinus* (Walker), 20. ventral view, 21. lateral view, 22. dorsal view.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle oval, on small, cone-shaped callosity with slight anterior ridge, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines paired, subequal, on each side of thorax, above bases of sheaths of mid legs; anterior spine apically rounded to acute, slightly curved posteriorly; posterior spine more broadly rounded or with median tooth, straight to slightly curved posteriorly. Posterior mesothoracic callosity small, smooth to slightly grooved, with indistinct, broadly rounded, heavily sclerotized posterior margin. Wing sheath smooth to irregularly rugulose with broad anterior-posterior ridge; basal and median tubercles absent. Thoracic area above wing sheath smooth to slightly grooved or rugulose. Apex of hind leg sheath reaching between posterior margin of abdominal segment 2 and middle of abdominal segment 3.

Abdominal spiracles small, almost round, reddish brown, flush with surface, along midline laterally.

Abdominal segment 1 with dorsal transverse row of 12–13 long recurved spurs; median and lateral spurs shorter than others.

Segments 2–6 with dorsal median row of 12–13 alternating short, acuminate spines and long, acuminate spurs.

Segment 7 similar to segments 2–6, but with dorsal row of 9–10 spines and spurs.

All abdominal segments smooth or with numerous shallow grooves; dorsolateral, lateral, and ventral spines absent.

Segment 8 with 2 dorsal spurs on each side of midline; spiracle not visible.

Segment 9 with pair of long, dorsally curved dorsal posterolateral processes and pair of short, dorsally curved ventral posterolateral processes. Male with small, indistinct ventromedial callosities converging anteriorly.

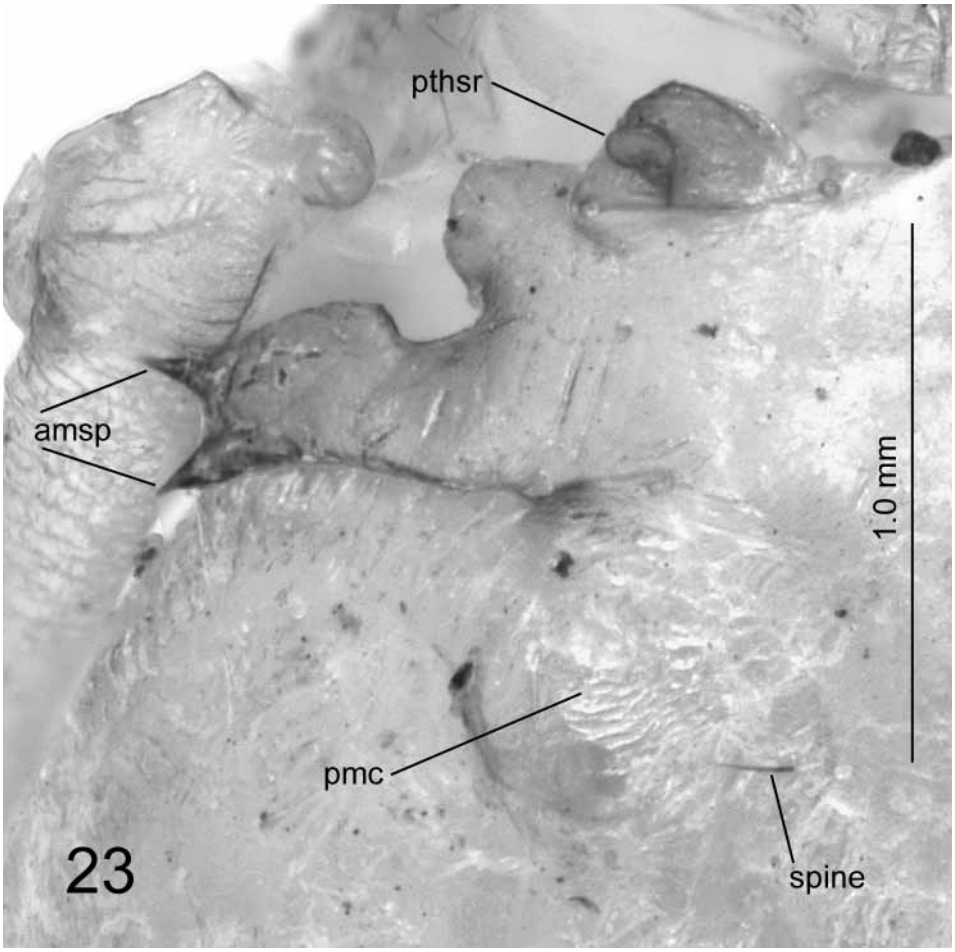


FIGURE 23. *Heteropogon wilcoxi* James, thorax, dorsolateral view. Abbreviations: amsp = anterior mesothoracic spine, pmc = posterior mesothoracic callosity, pthsr = prothoracic spiracle.

***Heteropogon wilcoxi* James**
(Fig. 23)

Dennis & Lavigne (1976a) presented a detailed description of a male pupal case of *H. wilcoxi* James, a specimen of which is from the United States National Museum and is labeled "In field of rye (*Secale cereale* L.) between Wheatland and Glendo, WY.; V-12-1960; pupated VI–2, adult VI–17." The description should include: prothoracic spiracle on cone-shaped callosity, slightly tilted posteriorly; abdominal spiracles round, reddish brown, flush to slightly raised along midline laterally; abdominal segment 8 lacking spiracle; abdominal segment 9 with dorsal posterolateral and ventral posterolateral processes curved dorsally.

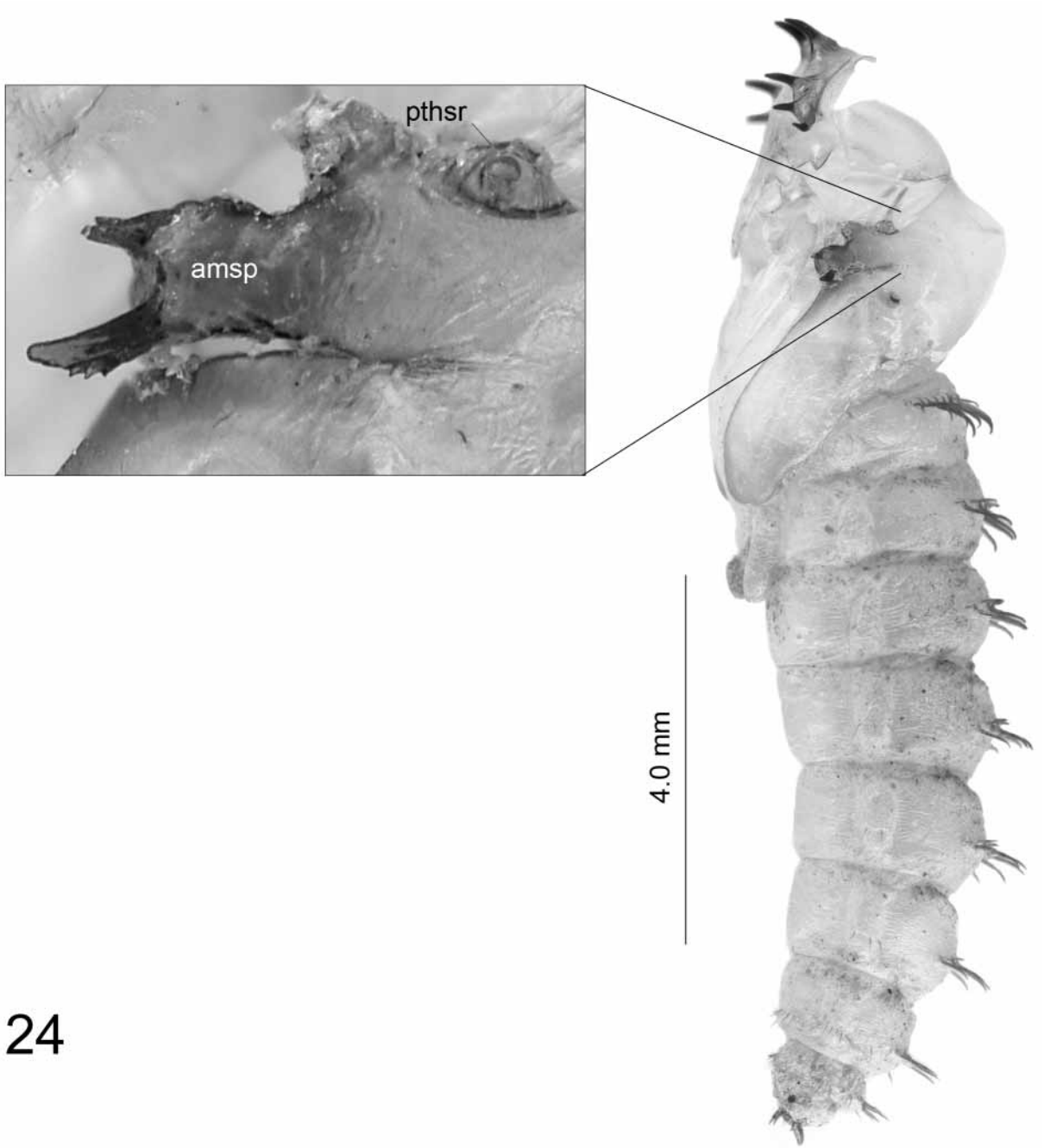


FIGURE 24. *Comantella fallei* (Back), lateral view with enlarged dorsolateral view of anterior mesothoracic spine. Abbreviations: amsp = anterior mesothoracic spine, pthsr = prothoracic spiracle.

Genus *Comantella* Curran

***Comantella fallei* Back**
(Fig. 24)

Dennis & Lavigne (1976a) gave a description of a female pupal case of *C. fallei* Back. That case, which they deposited in the United States National Museum, is labeled "Pawnee Grassland Pasture Range, Nunn, Colorado; X-11, 1972; S. Dennis Collector." This description should include the following: prothoracic spiracle elongate, pointed or tilted posteriorly; abdominal spiracles semi-circular to circular, raised above surface,

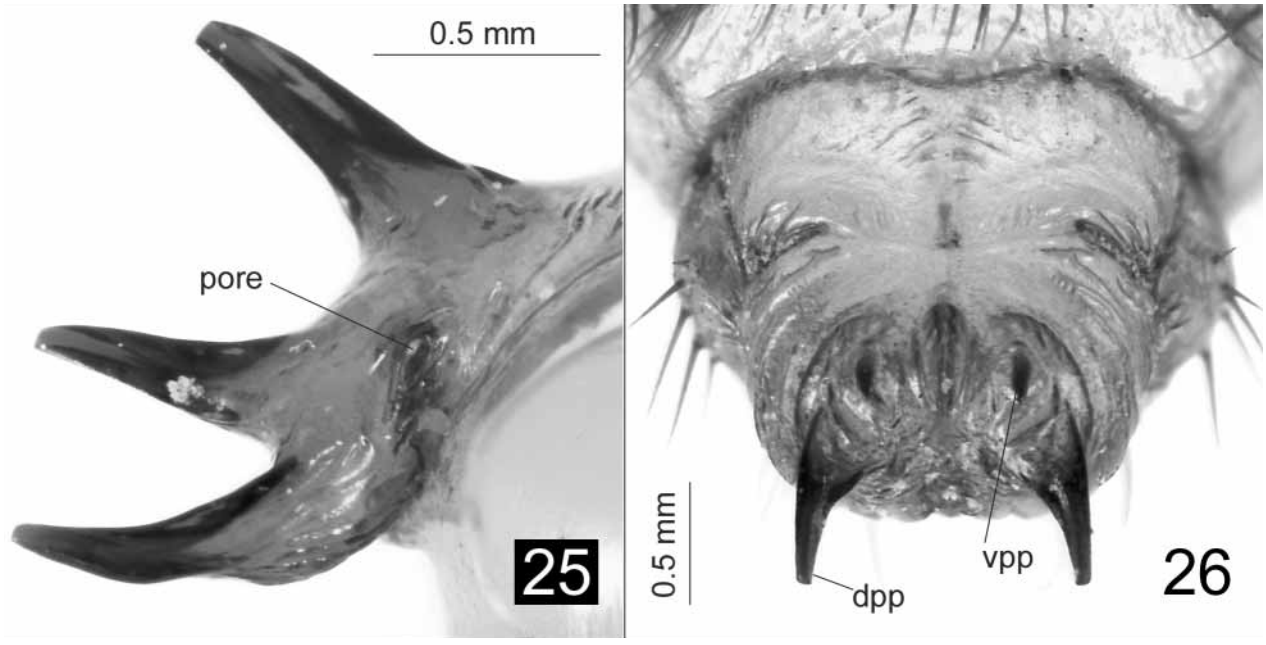
some pointed or tilted posteriorly; abdominal segment 8 lacking spiracle; abdominal segment 9 with pair of obscure midventral tubercles and darkened area of cuticle on posterior edge.

Genus *Diogmites* Loew

The following key includes characters of *Diogmites discolor* Loew based on information in Malloch (1917) and Bromley (1946). Malloch (1915) described the pupal cases of Illinois specimens identified as *Diogmites winthemi* (Wiedemann). That Neotropical species does not occur in the United States. Malloch's (1915) description corresponds with our description of *D. misellus* Loew.

Key to known pupal cases of Nearctic species of *Diogmites*

1 Abdominal segments 3–7 with ventral transverse row of short bristle-like spines interrupted by 2 spaces, thereby forming 3 ventral groups of spines on each segment ..... *Diogmites discolor* Loew
- Abdominal segments 3–7 with uninterrupted ventral transverse row of bristle-like spines.....2
2 Outer posterior antennal process elbowed basally; labral sheath with slight posterior callosity; abdominal segment 1 with dorsal transverse row of 27 spurs, median spurs not spatulate or bifurcate; abdominal segment 8 with 5 lateral bristle-like spines on each side; segment 9 rugose, ventral posterolateral processes not fused basally to dorsal posterolateral processes ..... *Diogmites misellus* (Wiedemann)
- Outer posterior antennal process straight; labral sheath lacking callosity; abdominal segment 1 with dorsal transverse row of 19 spurs, 5–7 spurs on each side of midline spatulate or wider apically, sometimes bifurcate or with short basal spine; abdominal segment 8 with 8–11 lateral bristle-like spines on each side; segment 9 not rugose, with ventral posterolateral processes fused basally to dorsal posterolateral processes ... . *Diogmites neoternatus* (Bromley)



FIGURES 25–26. *Diogmites misellus* Loew, 26. posterior antennal process, dorsolateral view, 27. abdominal segments 8–9, posteroventral view. Abbreviations: dpp = dorsal posterolateral process, vpp = ventral posterolateral process.

***Diogmites misellus* Loew**
(Figs 25–26)

The pupa of *Diogmites misellus* was described by Malloch (1915) under the name *Deromyia winthemi*. The following description is based on one female pupal case with pinned adult from the United States National Museum. It is labeled " Tappahannoch, Va.; B. 46, H. Fox; Aug. 9, 1915; reared from maggot attacking *Lachnosterna*."

Redescription: Greatest length, including anterior antennal processes, 18.0 mm; greatest width of thorax 6.3 mm; greatest width of abdomen 5.1 mm, tapering to 2.0 mm at greatest width of abdominal segment 8. Anterior half of integument subshining golden brown, lower half lighter golden brown to whitish yellow; most spines and other processes glistening reddish brown, darker apically; abdominal spurs and spines uniformly colored.

Head with pair of long, dorsally flattened, ventrally wedge-shaped anterior antennal processes, not joined at base and group of 3 basally fused, apically blunt posterior antennal processes ventrolaterally on each side; middle and outer posterior processes slightly closer together, straight; outer posterior process elbowed basally; middle posterior process with outer basal pore. Labral sheath smooth except for 5 short grooves along midline, and slight posterior callosity. Proboscial sheath smooth, with longitudinal shallow groove on each side of midline, small median ridge posteriorly, and small callosity posterior to ridge. Maxillary sheath smooth, extending one-half to two-thirds length of proboscial sheath, with inner median tubercle at junction of labral and proboscial sheaths.

Anterior coxal sheath smooth with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, on minute callosity with slight anterior ridge. Anterior mesothoracic spines consisting of pair of long, narrow, medially bent, posteriorly curved, pointed spines on either side of thorax above base of mid leg sheath; outer spine slightly longer than inner spine; basal area of cuticle surrounding spines highly rugose. Posterior mesothoracic callosity rugose, with small, straight, apically rounded, highly sclerotized posterior mesothoracic spine. Wing sheath irregularly rugulose, bent directly in front of abdominal segment 1; median and basal tubercles absent. Thoracic area above wing sheath rugulose. Apex of hind leg sheath reaching to posterior margin of abdominal segment 3.

Abdominal spiracles elongate-oval, almost flush with surface, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 27 long, apically recurved spurs; median pair of spines three-fourths length of adjacent spines; dorsolateral bristle-like spines absent; 6 lateral bristle-like spines present behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsal transverse row of 8 long, recurved spurs alternating with 7 short, narrow, straight to apically recurved spines; some median short spines bifurcate or trifurcate and wider than adjacent spines; 6–9 dorsolateral bristle-like spines on each side and 9–11 lateral bristle-like spines behind each spiracle.

Segment 2 with 5 ventral bristle-like spines on each side of hind leg sheaths; segment 3 with incomplete, transverse row of 25 ventral bristle-like spines; segments 4–7 with complete transverse row of 30–37 ventral bristle-like spines; many ventral bristle-like spines of unequal length.

Segment 8 with 4–5 dorsal spurs of subequal length on each side of midline and 5 lateral bristle-like spines on each side; lacking spiracle, dorsolateral bristle-like spines, and ventral bristle-like spines.

Segment 9 rugose, with pair of long dorsal posterolateral processes curved toward each other and pair of short ventral posterolateral processes curved toward but not basally fused to dorsal posterolateral processes; ventral tubercles absent.

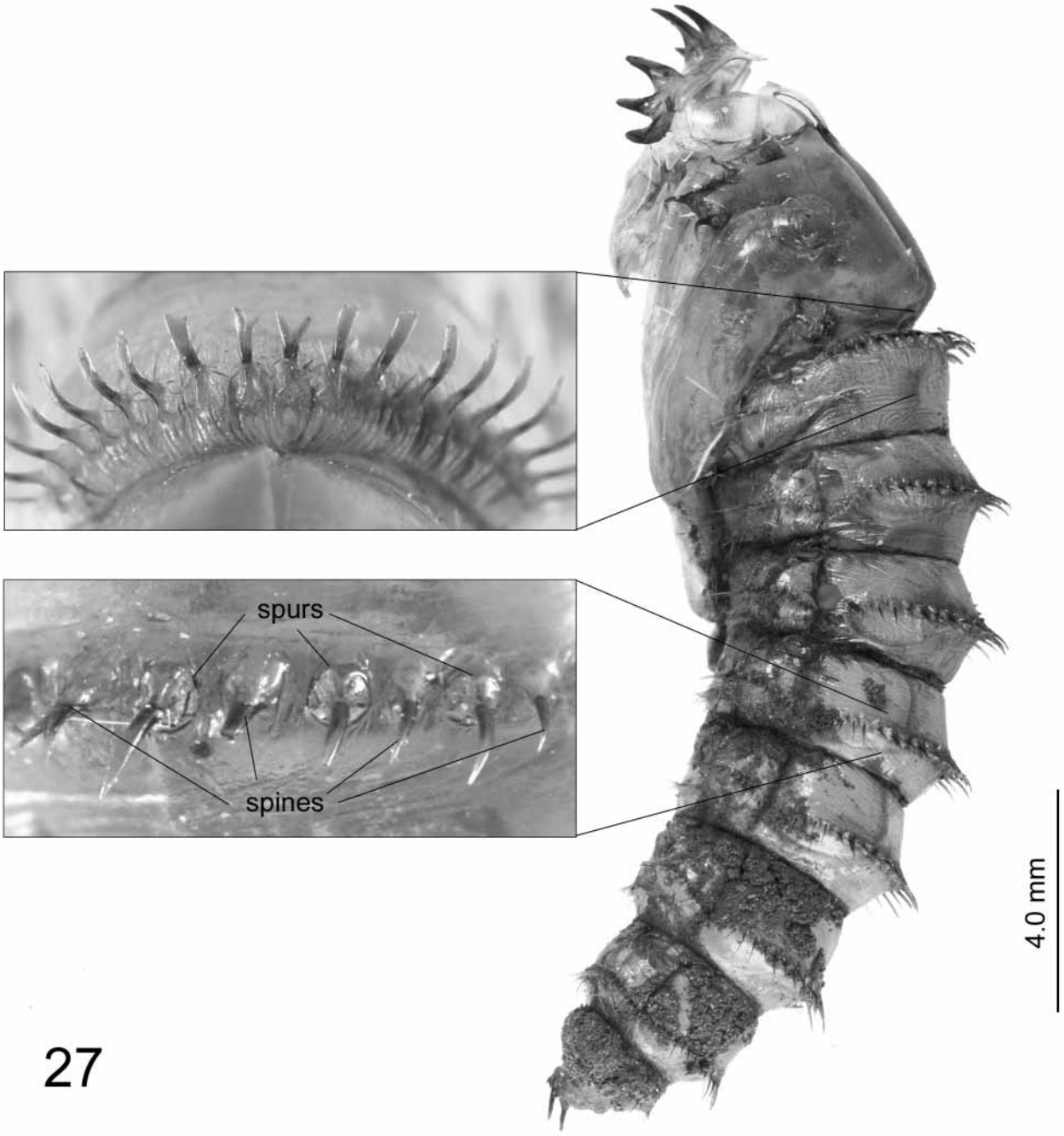


FIGURE 27. *Diogmites neoternatus* (Bromley), lateral view, with enlarged anterodorsal view of row of spurs on abdominal segment 1 and posterodorsal view of row of alternating spurs and spines on abdominal segment 4.

***Diogmites neoternatus* (Bromley)**
(Fig. 27)

The following description is based on four pupal cases. One male case with pinned adult from the United States National Museum is labeled "coll. Bryant, Fla.; pupa obtained from muck soil heavily infested with larvae of *Dyscinetus morator* (F.); emerged June 28, 1950; W.H. Thames, Jr." and one damaged case with a pinned female is labeled "Lakin, Kans.; 27 July 91." A male and female case from the Illinois Natural History Survey, with pinned adults, are labeled "Springfield, Ill.; Aug. 8, '15."

Description: Greatest length, including anterior antennal processes, ♂ 20.4–21.6 mm, ♀ 22.3 mm; greatest width of thorax ♂5.8–6.8 mm, ♀ 7.1 mm; greatest width of abdomen ♂ 4.8–5.3 mm, ♀ 5.1 mm, tapering to ♂ 2.2–2.6 mm, ♀ 2.7 mm at greatest width of abdominal segment 8. Integument subshining dark golden brown; spines and other processes glistening reddish brown, darker apically except for spurs that are uniformly colored; several segments mottled yellowish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped, apically rounded to blunt anterior antennal processes not joined at base and group of 3 subequal, apically rounded to blunt, basally fused posterior antennal processes located ventrolaterally on each side; median process with outer basal pore. Labral sheath smooth except for long, length-wise grooves posteriorly and 4 short grooves along midline; distinct posterior keel or callosity absent. Proboscial sheath smooth, with short median groove posteriorly and small, oval callosity with small tubercle directly posterior to groove. Maxillary sheath smooth, extending two-thirds length of proboscial sheath, minute inner tubercle at juncture of labral and proboscial sheaths.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, situated midlaterally at anterior margin of thorax on small callosity with 2 anterior ridges. Anterior mesothoracic spines above base of mid leg sheath paired, long, narrow, medially bent, posteriorly curved, apically pointed; basal area of cuticle surrounding spines highly rugose. Posterior mesothoracic callosity small, smooth to slightly rugulose, with small, apically rounded and heavily sclerotized posterior mesothoracic spine. Wing sheath mostly smooth, except for longitudinal grooves; median and basal tubercles absent. Thoracic area above wing sheath smooth to rugulose. Apex of hind leg sheath reaching between middle and posterior margin of abdominal segment 3.

Abdominal spiracles elongate-oval, reddish brown, situated along midline laterally on small callosities.

Abdominal segment 1 with dorsal transverse row of 19 long, subequal, apically recurved spurs; 5–7 spurs on each side of midline spatulate, becoming wider apically, sometimes bifurcate, sometimes with short basal spines; dorsolateral bristle-like spines absent; 8–9 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsal transverse row of 8 long, narrow, recurved spurs alternating with 7 shorter, wide, straight, sometimes apically bifurcate or trifurcate spines; spines becoming narrow, long, and more similar to long spurs posteriorly; 5–8 dorsolateral bristle-like spines on each side and 12–16 lateral bristle-like spines behind each spiracle; some bristle-like spines bifurcate or of irregular length.

Segment 2 with 5–8 ventral bristle-like spines on each side of hind leg sheaths; segments 3–7 with complete transverse row of 37–46 ventral bristle-like spines reclining almost flat against integument.

Segment 8 with 3–5 dorsal spurs on each side of midline and 8–11 lateral bristle-like spines on each side; spiracle and ventral spines absent.

Segment 9 with small, dorsomedial callosity on each side of midline, pair of long dorsal posterolateral processes that curve toward each other, and pair of short ventral posterolateral processes fused basally to and curved toward dorsal posterolateral processes.

Asilinae-Group

Fourteen genera of Asilinae, 17 genera of Apocleinae, and a single genus of Ommatiinae comprise the Asilinae-group in the Nearctic Region (Geller-Grimm 2003). The following key covers 12 of these genera (*Mallophora, Ommatius, Promachus, Efferia, Neoitamus, Proctacanthus, Asilus,* and *Machimus* plus *Triorla interrupta* (Macquart), *Proctacanthella cacopiloga* (Hine), *Megaphorus guildiana* (Williston), and *Neomochtherus angustipennis* (Hine)).

Morphological characteristics for the genus *Neoitamus* were taken from the work of Melin (1923), who studied *N. cyanurus* (Loew) and *N. socius* (Loew). Melin (1923) also presented information on *Philonicus*

albiceps (Meigen), but it was not sufficient to include that species in this key**.** The distinctly ventrally curved dorsal posterolateral process of abdominal segment 9 may prove to be a significant characteristic for *Philonicus.* Musso's (1978) general morphological characteristics for the pupa of *Machimus rusticus* correspond well with those indicated in the key for the genus *Machimus*.

Key to known pupal cases of Nearctic genera of the Asilinae-group

1 Anterior mesothoracic spines absent; with or without posterior mesothoracic spine.....2
- Anterior and posterior mesothoracic spines present.....3
2 Posterior mesothoracic spine present or absent; outer or third posterior antennal process with outer basal callosity or knob ..... *Neoitamus*
- Posterior mesothoracic spines absent; outer or third posterior antennal process with outer basal flattened area with small lip..... *Ommatius*
3 Abdominal spiracles mostly flush with cuticle.....4
- Abdominal spiracles distinctly elevated above cuticle.....6
4 Abdominal segment 1 with 6–9 lateral bristle-like spines on each side behind spiracle; segment 8 with 6–11 lateral bristle-like spines ..... *Triorla interrupta* (Macquart)
- Abdominal segment 1 with 2–3 lateral bristle-like spines on each side behind spiracle; segment 8 with 0–5 lateral bristle-like spines.....5
5 Outer or third posterior antennal process distinctly elbowed basally; abdominal segment 8 without dorsolateral bristle-like spines..... *Mallophora*
- Outer or third posterior antennal process straight; abdominal segment 8 with 0–2 dorsolateral bristle-like spines ..... *Promachus*
6 Proboscial sheath with median tubercles, with or without posterior tubercles.....7
- Proboscial sheath without median tubercles, with posterior tubercle or tubercles.....9
7 Abdominal segment 9 with ventral posterolateral and ventromedian processes; outer or third posterior antennal process without apical points, not appearing attached to side of middle process.....8
- Abdominal segment 9 without distinct ventral posterolateral or ventromedian process; outer or third posterior antennal processes with 2 apical points, appearing to be attached to side of middle process ....*Proctacanthella cacopiloga* (Hine)
8 Ventral posterolateral processes long and narrow, resembling dorsal posterolateral process, but not as long as dorsal posterolateral process ..... *Efferia*
Note: In Dennis & Lavigne (1976a) it was indicated that *E. benedicti* (Bromley), *E. frewingi* (Wilcox), and *E. helenae* (Bromley) do not have ventral posterolateral processes. The present work indicates that the median lateral processes described by these authors are actually ventral posterolateral processes.
- Ventral posterolateral processes short and broad, not resembling dorsal posterolateral processes .... *Proctacanthus*
9 Prothoracic spiracle hidden in sclerotized cuticle; abdominal segment 8 with 2 ventromedian tubercles; abdominal segment 9 with dorsal posterolateral and ventral posterolateral processes basally fused .... *Megaphorus guildiana* (Williston)
Note: Hull (1962) suggested that *Mallophorina* is a synonym for *Megaphorus.* Cole & Pritchard (1964) and Wood (1981) used the former designation; however, Geller-Grimm (2003) retained *Megaphorus,* as we have done here.
- Prothoracic spiracle visible on callosity; abdominal segment 8 without ventromedian tubercles; abdominal segment 9 with dorsal posterolateral and ventral posterolateral processes not basally fused 10
10 Venter of abdominal segment 2 with 4–5 bristle-like spines on each side of wing sheath; venter of seg-

ments 4–7 with complete transverse row of 11–13 bristle-like spines ..... *Neomochtherus angustipennis* (Hine)

- Venter of abdominal segment 2 with 5–11 bristle-like spines on each side of wing sheath (usually an unequal number on each side); venter of segments 4–7 with complete transverse row of 15–30 bristle-like spines 11

11 Prothoracic spiracle tilted or pointing posteriorly .....*Machimus*

- Prothoracic spiracle usually not distinctly tilted or pointing posteriorly.....*Asilus*

Genus *Ommatius* Wiedemann

Key to known pupal cases of Nearctic species of *Ommatius*

1 Outer or third posterior antennal process rounded and ridge-like; proboscial sheath smooth, except for slight rugoseness posteriorly; thoracic area above wing sheath with yellowish dorsomedian bristle-like spine behind posterior mesothoracic callosity; segment 1 without dorsolateral bristle-like spine on each side; venter of segment 8 with 15 bristle-like spines..... *Ommatius gemma* Brimley

- Outer or third posterior antennal process apically acute; proboscial sheath smooth with rugose swellings on each side of midline posteriorly and median concave tubercle separated from swellings by narrow ridge of cuticle; thoracic area above wing sheath without dorsomedian bristle-like spine; segment 1 with 1 dorsolateral bristle-like spine on each side; venter of segment 8 with 4 bristle-like spines..... *Ommatius tibialis* Say

***Ommatius gemma* Brimley**
(Fig. 28)

This description is based on a male pupal case from the United States National Museum. It is labeled "Manhattan, KS; 3–VI–32; emerged 14–VI–32; R. H. Painter Collector." According to Martin & Wilcox (1965) this species occurs in Arkansas, Florida, Mississippi, North Carolina, Okalahoma, and Virginia. Wilcox (1936) also reported it from Arkansas, Mississippi, North Carolina, and Oklahoma. The label information for the described specimen indicates a slightly wider distribution than previously reported.

Description: Greatest length, including anterior antennal processes, 9.0 mm; greatest width of thorax 2.0 mm; greatest width of abdomen 1.5 mm; tapering to 0.5 mm at greatest width of abdominal segment 8. Integument subshining golden brown; spines and other processes glistening reddish brown, darker apically, except for abdominal spines, which are uniformly reddish brown.

Head with pair of long, dorsoventrally flattened, medially fused anterior antennal processes and group of 3 basally fused posterior antennal processes located ventrolaterally; middle and third posterior processes closer together and fused for greater distance, appearing shorter than inner or first process; outer or third posterior process apically rounded and ridge-like; first and second posterior processes apically acute. Labral sheath bulbous, composed mostly of large, rugose, apically rounded, dorsoventrally flattened processes. Proboscial sheath smooth, except for slight rugoseness posteriorly. Maxillary sheath mostly smooth with small median tubercle.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, directed posteriorly, on medium to large, smooth to slightly rugose callosity, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines absent. Posterior mesothoracic callosity large, smooth, with sclerotized ridges, especially posteriorly. Wing sheath smooth, except for rugoseness on poste-

rior third to half. Thoracic area above wing sheath smooth, with yellowish dorsomedian bristle behind posterior mesothoracic callosity. Apex of hind leg sheath reaching to about middle of abdominal segment 3.

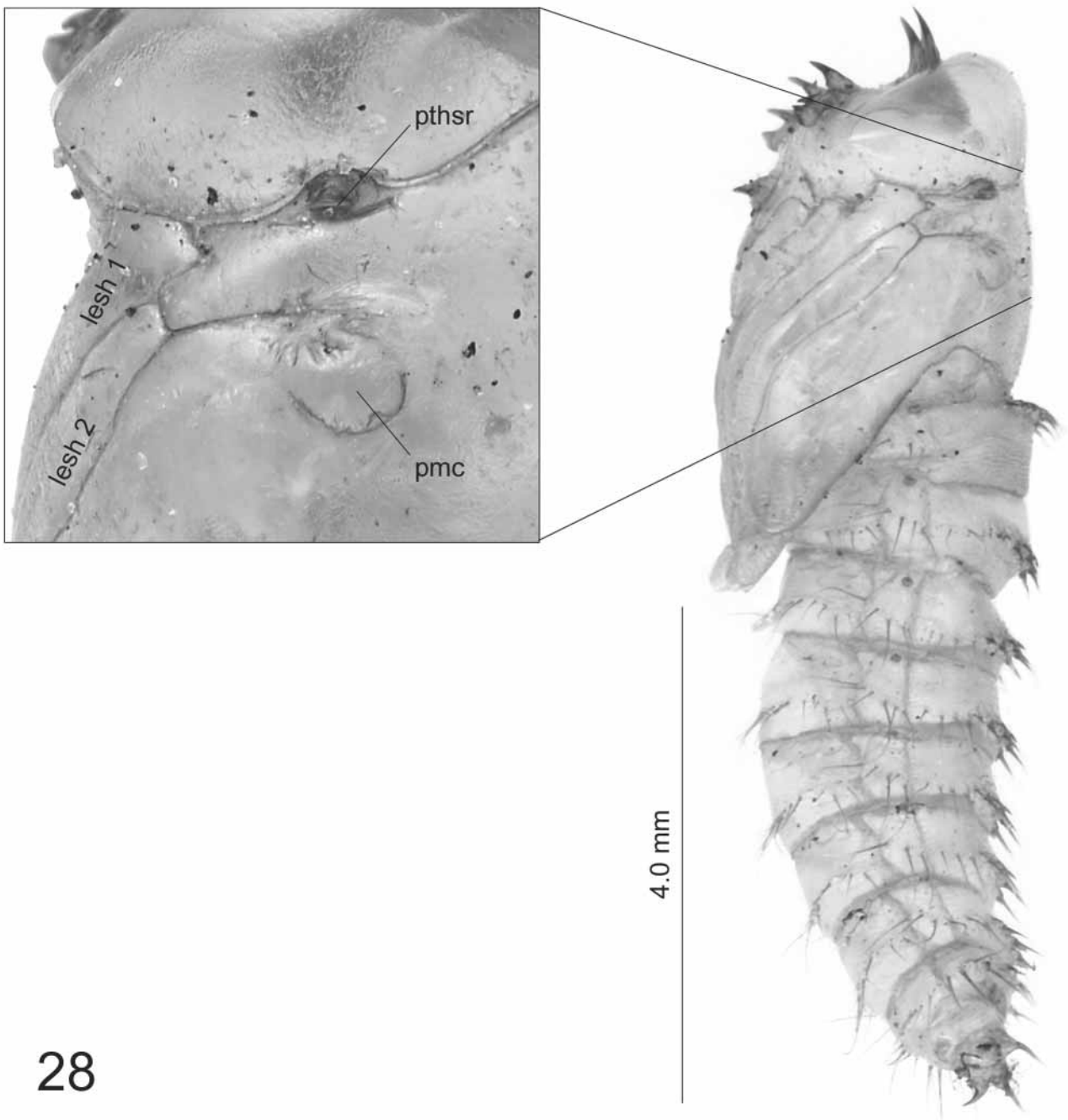


FIGURE 28. *Ommatius gemma* Brimley, lateral view with enlarged dorsolateral view of thoracic region. Abbreviations: lesh 1 = leg sheath 1, lesh 2 = leg sheath 2, pmc = posterior mesothoracic callosity, pthsr = prothoracic spiracle.

Abdominal spiracles upraised and stalk-like, reddish brown, round to elongate-oval, along midline laterally.

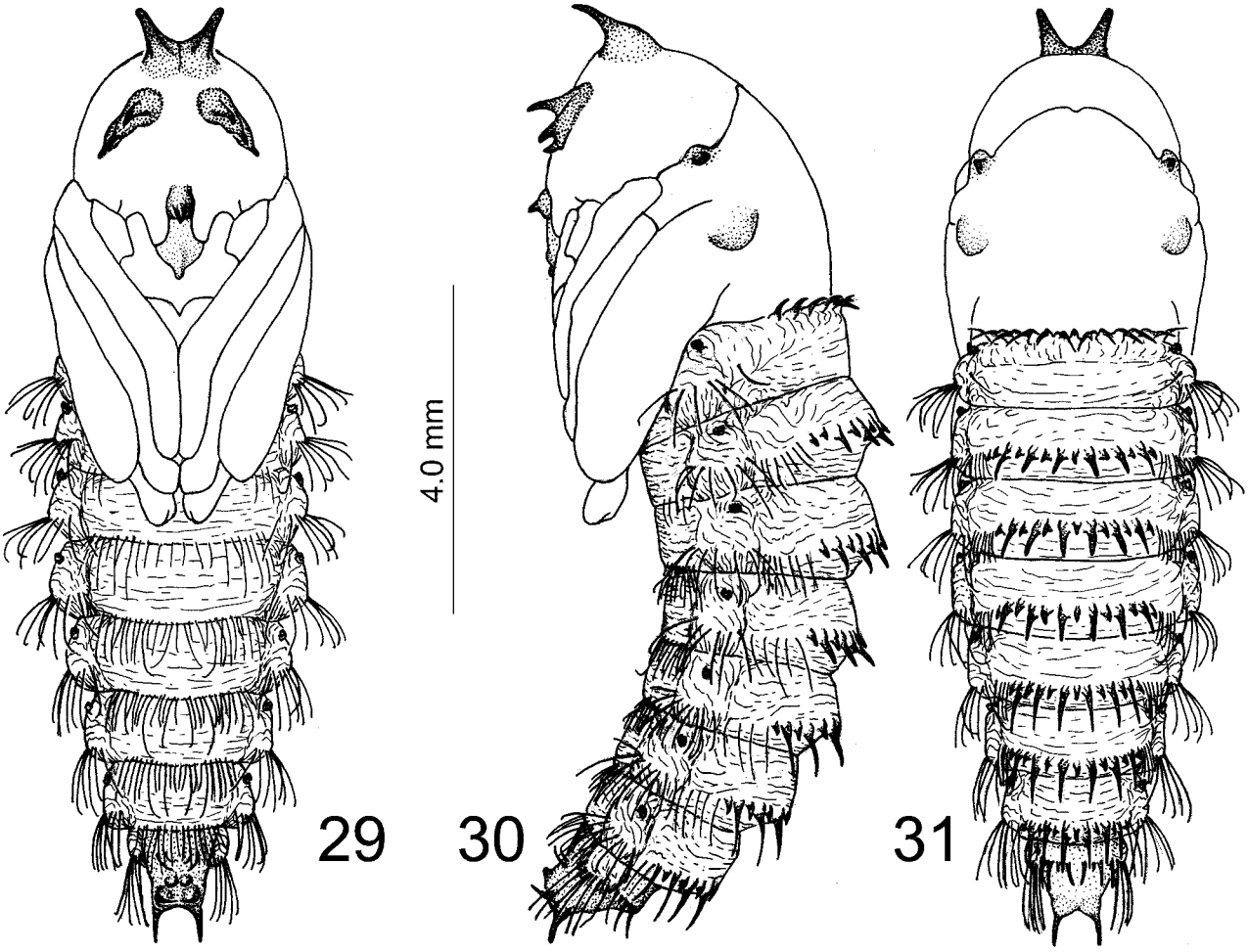
Abdominal segment 1 with dorsal transverse row of 14 mostly long, apically recurved spurs on anterior margin of segment; lacking dorsolateral bristle-like spines; with 3 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsal transverse row of 6 long, straight to slightly apically recurved spurs alternating with 7 short spines; with 2–4 dorsolateral bristle-like spines of unequal size on each side and 3–5 lateral bristle-like spines of unequal size behind each spiracle.

Segment 2 with 4–5 ventral bristle-like spines on each side of hind leg sheaths. Segments 3–7 with complete transverse row of 16–21 bristle-like spines of unequal size; median 2–3 bristle-like spines usually shorter than spines on each side.

Segment 8 with dorsal row of 3 long spurs alternating with 2 short spines on each side of midline, small spiracle along midline laterally, 5–7 lateral bristle-like spines below spiracle, and 15 ventral bristle-like spines of unequal length.

Segment 9 with pair of long, dorsally curved, dorsal posterolateral processes; pair of shorter, dorsally flattened, ventrally curved ventral posterolateral processes; pair of ventral posteromedian acuminate processes; and pair of ventral, posteriorly diverging, elongate swellings.



FIGURES 29–31. *Ommatius tibialis* Say, 29. ventral view, 30. lateral view, 31. dorsal view.

***Ommatius tibialis* Say**
(Figs 29–31)

The following description is based on a female pupal case associated with a pinned adult of *Ommatius tibialis* from the United States National Museum. It is labeled "Haddon Hts., N.J.; 7/5/33; L.J. Bottimer."

Description: Greatest length, including anterior antennal process, 12.8 mm; greatest width of thorax 3.2 mm; greatest width of abdomen 3.2 mm; tapering to 1.3 mm at greatest width of abdominal segment 8. Integument subshining yellowish to golden brown; spines and other processes glistening reddish brown, darker apically, except for uniformly reddish-brown abdominal spurs and spines.

Head with pair of long, dorsoventrally flattened anterior antennal processes fused basally and group of 3 basally fused posterior antennal processes located ventrolaterally; middle and outer posterior processes closer together and fused for greater distance, appearing shorter than inner or first posterior process; outer or third posterior process apically acute, inner and middle posterior processes more rounded, the former with an outer flattened area with small lip. Labral sheath mostly composed of large, apically rounded, rugose process. Proboscial sheath smooth except for rugose swellings on each side of midline posteriorly, medially concave tubercle separated from swellings by narrow ridge of cuticle. Maxillary sheath mostly smooth with small median tubercle on callosity posteriorly.

Anterior coxal sheath smooth, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, facing posteriorly on small, smooth callosity, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines absent. Posterior mesothoracic callosity smooth, with slightly sclerotized margin dorsally; posterior mesothoracic spine absent. Wing sheath smooth except for some shallow basal pits and rugulose posterior third. Thoracic area above wing sheath smooth. Apex of hind leg sheath reaching between middle and posterior margin of abdominal segment 3.

Abdominal spiracles upraised, reddish brown, more round than prothoracic spiracle, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 13 long apically recurved spurs on anterior margin of segment, 1 dorsolateral bristle-like spine on each side, and 5 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsal transverse row of 6 long, straight to slightly apically recurved spurs and 7 short, straight spines, 3–7 (usually 4–5) dorsolateral bristle-like spines of unequal size, and 6–7 lateral bristle-like spines of unequal size behind each spiracle.

Segment 2 with 6–7 ventral bristle-like spines on each side of hind leg sheaths. Segments 3–7 with complete transverse row of 19–26 bristle-like spines of unequal size; median 2–4 bristle-like spines usually short; long bristle-like spines apically curved.

Segment 8 with 2 long dorsal spurs and very short spine between them, small spiracle, and long dorsolateral bristle on each side of midline; with 6–7 lateral bristle-like spines on each side and 2 short ventral bristle-like spines on each side of midline.

Segment 9 with pair of long, dorsally curved dorsal posterolateral processes; pair of slightly shorter, ventrally curved ventral posterolateral processes; and pair of ventral posteromedian acuminate processes one-third as long as ventral posterolateral processes.

Genus *Triorla* Parks

Triorla interrupta (Macquart)

(Fig. 32)

Davis (1919) and Osterberger (1930) observed that *Triorla interrupta* pupae, under the names *Erax maculatus* Macquart and *Erax interruptus*, respectively, occur in the soil. The length of the pupal stage varies between 20 and 34 days. Malloch (1917) described the pupal case of a male under the name *E. maculatus*. The following redescription is based on a female pupal case with a pinned adult from the United States National Museum. It is labeled "8/21 '14; Cage B11."

Redescription: Greatest length, including anterior antennal processes, 18.0 mm; greatest width of thorax 5.5 mm; greatest width of abdomen 5.0 mm, tapering to 2.0 mm at greatest width of abdominal segment 8. Integument subshining golden brown; spines and other processes reddish brown, spurs yellowish brown.

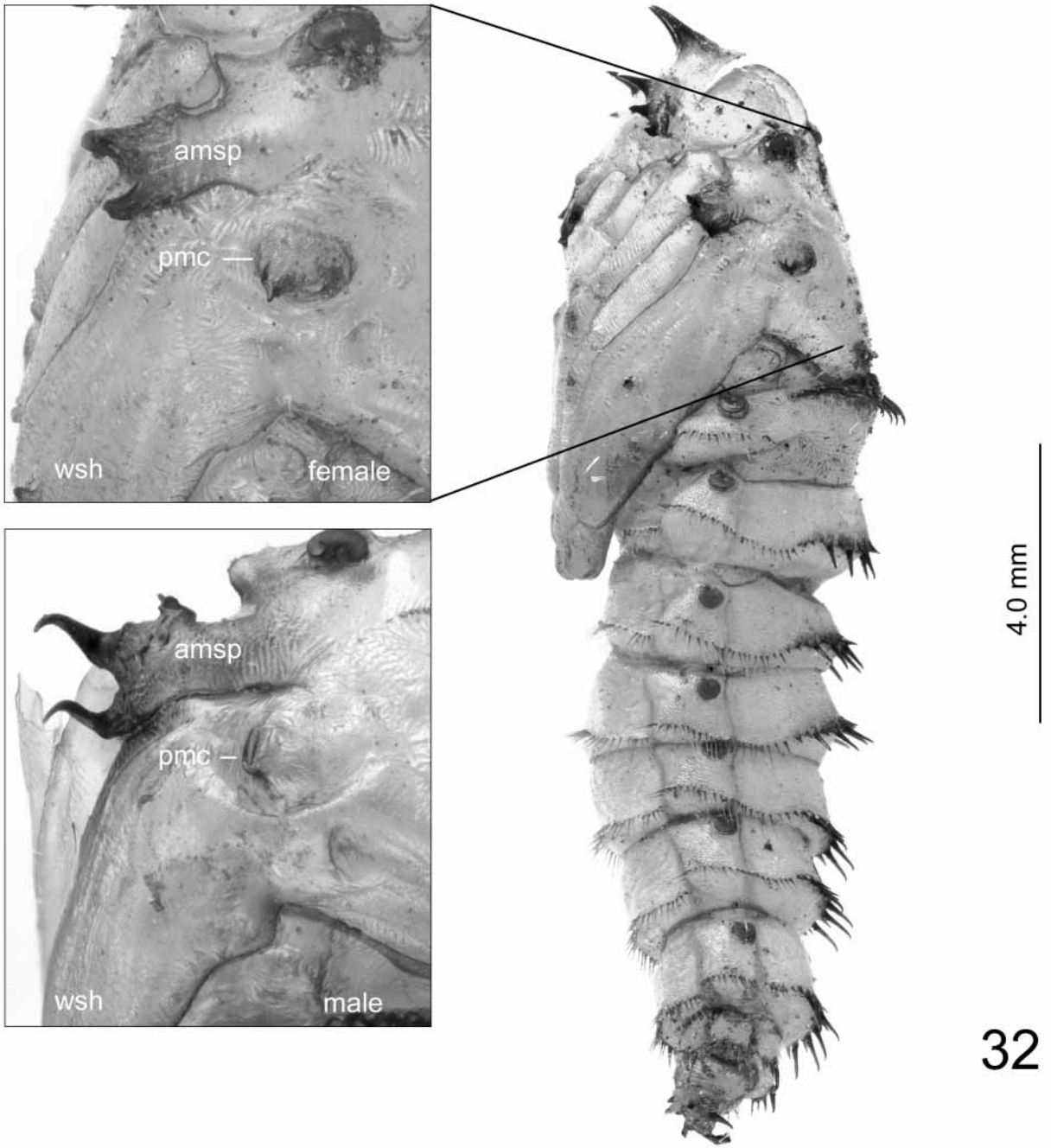


FIGURE 32. *Triorla interrupta* (Macquart), lateral view with enlarged dorsolateral views of thoracic region of female and male. Abbreviations: amsp = anterior mesothoracic spine, pmc = posterior mesothoracic callosity, wsh = wing sheath.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes closer together, fused for greater distance, appearing shorter than inner or first posterior process; inner posterior process slightly more acute than middle and outer posterior processes; outer or third posterior process elbowed basally. Labral sheath with small apical keel posteriorly, slightly rugose. Proboscial sheath slightly rugulose posteriorly on each side of midline, with minute median tubercle on each side and median, apically flattened tubercle posteriorly. Maxillary sheath with terminal, apically rounded process posteriorly. Proboscial sheath with small tubercle on each side, slightly below juncture of labral sheath and proboscial sheath.

Anterior coxal sheath irregularly rugulose along margins with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, situated midlaterally at anterior margin of thorax, projecting above surface of thorax, with ridge-like area anterior to spiracles. Anterior mesothoracic spines on each side of thorax above base of sheath of mid legs; spines short, wide, dorsoventrally flattened and broadly blunt apically with 2–5 furcations. Posterior mesothoracic callosity at base of each wing sheath large, rugose, with basally broad, apically acuminate posterior mesothoracic spine. Wing sheath irregularly rugulose, with small, well developed median tubercle and pair of small, rugose tubercles near posterior margin. Thoracic area above wing sheath smooth to irregularly rugulose. Apex of hind leg sheath reaching to middle of abdominal segment 3.

Abdominal spiracles elongate-oval to crescent shaped, light reddish brown and almost flush with surface, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 21 long, apically recurved spurs and 9 bristle-like spines behind spiracle; dorsolateral bristle-like spines absent; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsomedian transverse row of 6 long spurs alternating with 8–21 short, straight spines; spines slightly in front of long spurs; long spurs with basal upraised anterior part; spine numbers decreasing on more posterior segments. Segments 2–7 with 6–11 dorsolateral bristle-like spines on each side and 11–18 long, apically recurved lateral bristle-like spines behind each spiracle.

Segment 2 with 9 ventral bristle-like spines on each side of hind leg sheaths; segment 3 with complete transverse row of bristle-like spines not interrupted by short, wide, hind leg sheath; segments 4–7 with complete transverse row of 29–41 ventral bristle-like spines, some bristle-like spines shorter than others.

Segment 8 with 4 long dorsal spurs on each side of dorsal midline; small spiracle along midline laterally; 11 lateral bristle-like spines; and 2 bristle-like spines on each side of ventral midline.

Segment 9 with pair of long dorsal posterolateral processes curved toward each other, 2 shorter ventral posterolateral processes apically curved toward dorsal posterolateral processes, and 2 ventromedian processes nearly same size as ventral posterolateral processes.

Genus *Mallophora* Macquart

Key to known pupal cases of Nearctic species of *Mallophora*

1 Maxillary sheath with small median process on each side of labral sheaths; prothoracic spiracle on rugose upraised area; abdominal segment 1 with all or some dorsal spurs expanded, sagittate, broad basally; segments 3–7 usually with median space in transverse row of ventral bristle-like spines (except male *Mallophora bomboides*) 2

- Maxillary sheath without median process on each side of labral sheaths; prothoracic spiracle almost flush with prothoracic area; dorsal spurs on abdominal segment 1 not basally expanded or sagittate; segments 3–7 without median space in ventral row of bristle-like spines 3

2 Anterior coxal sheath with suborbital spine at base; wing sheath with 2 median tubercles; abdominal segments 3–7 with ventral transverse row of 7–14 sometimes bifurcate bristle-like spines; abdominal segment 8 with 10 dorsal spurs ..... *Mallophora leschenaulti* Macquart

- Anterior coxal sheath without suborbital spine at base; wing sheath with 1 median tubercle; abdominal segments 3–7 with ventral transverse row of 20–36 unforked bristle-like spines; abdominal segment 8 with 2–3 dorsal spurs ..... *Mallophora bomboides* (Wiedemann)

3 Posterior mesothoracic callosity with 1 median spine; abdominal segment 1 with 7–8 spurs in transverse row and 2 shorter median spines on anterior margin; segments 2–4 with dorsal transverse row of 16–20 alternating long, narrow spurs and short, wide, unforked bristle-like spines; segments 3–7 with ventral transverse row of 16–29 bristle-like spines; segment 8 with 4 dorsal spurs and lateral spines on each side...

..... *Mallophora fautrix* Osten Sacken

- Posterior mesothoracic callosity with 2 subequal spines; abdominal segment 1 with dorsal transverse row of 16 spurs, outermost spine on each side short, 2 median spines three-fourths as long as adjacent spines; segments 2–4 with dorsal transverse row of 13–14 bifurcate or unforked spurs and spines of equal size; segments 3–7 with ventral transverse row of 10–14 bristle-like spines; segment 8 with 2 dorsal spurs and 3 lateral spines on each side ..... *Mallophora orcina* (Wiedemann)

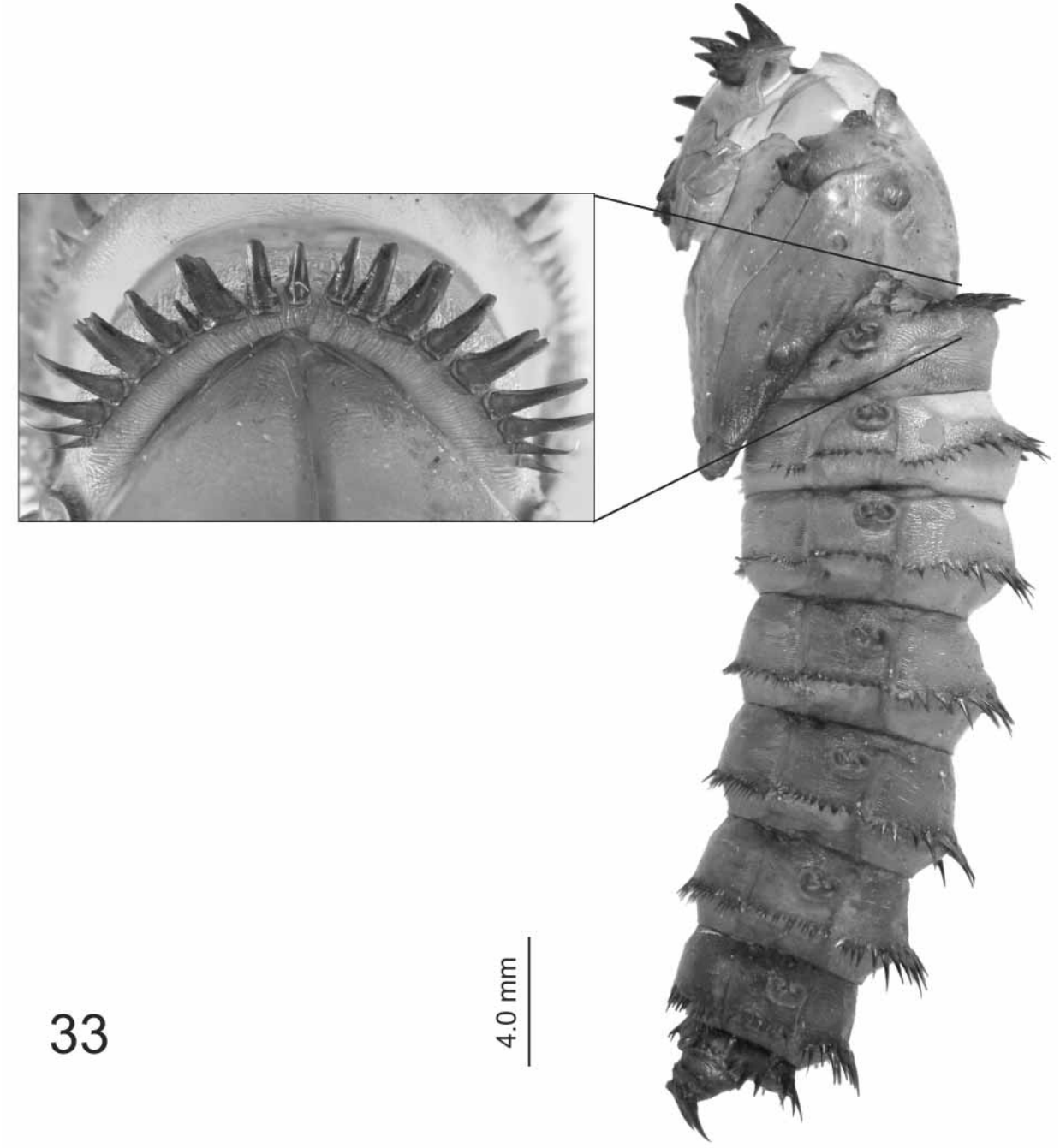


FIGURE 33. *Mallophora bomboides* (Wiedemann), lateral view with enlarged anterodorsal view of row of spurs on abdominal segment 1.

***Mallophora bomboides* (Wiedemann)**
(Fig. 33)

The United States National Museum has four pupal cases of *M. bomboides*. One male case is labeled "Lake Worth, Florida; 1, 21, 24; S.W. Bromley Collection 1955." Two female cases are labeled "McBee, S.C.; 7 Aug. 1926; S.W. Bromley; S.W. Bromley Collection 1955" and "McBee, S.C.; Aug. 29, 1930; S.W. Bromley Collection 1955." One damaged case is labeled "Lake North, Florida; 1, 21, 24; S.W. Bromley Collection 1955."

Description: Greatest length, including anterior antennal processes, ♂ 34.0 mm, ♀ 37.0–39.5 mm; greatest width of thorax ♂ 8.0 mm, ♀ 8.5–9.5 mm; greatest width of abdomen ♂ 7.0 mm, ♀ 7.5–8.0 mm, tapering to ♂ 2.5 mm and ♀ 2.3–2.5 mm at greatest width of abdominal segment 8. Integument subshining brownish yellow to dark golden brown; several abdominal segments mottled yellowish to reddish brown; spines and other processes glistening reddish brown, darker apically.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes fused basally for greater distance, appearing shorter than inner or first posterior process; outer or third posterior process elbowed basally but not as sharply as in *M. leschenaulti;* processes apically rounded. Labral sheath with small posterior concave keel surrounded by 4–5 dark sclerotized rings and with transverse rugose ridges anteriorly. Proboscial sheath slightly rugose on each side of midline, very rugose and tuberculate posteriorly. Maxillary sheath with large rugose, acuminate posterior process; male with small median tubercle on each side of labral sheath.

Anterior coxal sheath rugose especially along margin, with anterior, median, longitudinal split. Prothoracic spiracle on rugose upraised area, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines acuminate, subequal, situated on each side of thorax above bases of of mid leg sheaths. Thoracic area above spines rugose. Posterior mesothoracic callosity large, rugose, situated at base of each wing sheath, usually with small median posterior mesothoracic spine. Wing sheath highly rugose, especially toward apex, with large tubercle near base and smaller tubercle medially. Thoracic area above wing sheath smooth to slightly rugose. Apex of hind leg sheath reaching to posterior margin of abdominal segment 2.

Abdominal spiracles C-shaped, shining reddish brown, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 16–19 apically recurved spurs along anterior margin; outermost 1–3 spurs smaller than other spurs; dorsolateral bristle-like spines absent; with 3 lateral spurs behind and below spiracle; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsomedian transverse row of 13–16 alternating broad, straight, narrow, apically recurved spurs and broad, apically unforked, bifurcate, or trifurcate spines slightly anterior to spurs; with 4–8 dorsolateral bristle-like spines and 6–14 bristle-like spines (usually 9–10) behind each lateral spiracle.

Segment 2 with 5–9 median ventral bristle-like spines on each side of hind leg sheath; segments 3–7 with ventromedian transverse row of 20–36 bristle-like spines (usually 24–34); posterior segments with fewer spines; row complete in male, with median space in female.

Segment 8 with 2–3 dorsal spurs on each side of midline, 2–3 lateral bristle-like spines, and 2–3 ventral bristle-like spines on each side of midline; spiracle absent.

Segment 9 with pair of long dorsal posterolateral processes and pair of short ventral posterolateral processes fused basally to dorsal processes, both pairs curved upward; male with pair of ventromedian tubercles.

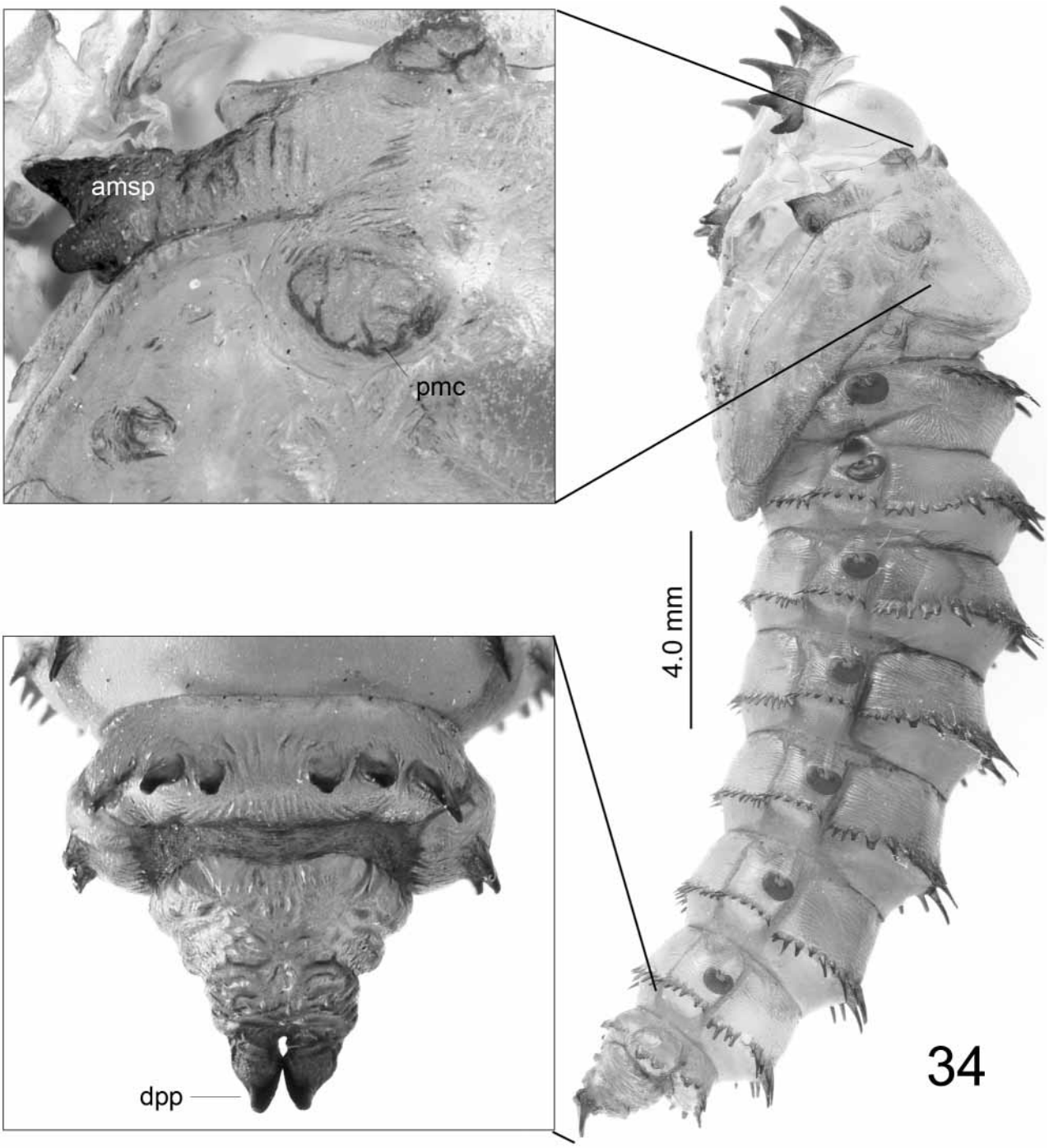


FIGURE 34. *Mallophora fautrix* Osten Sacken, lateral view with enlarged dorsolateral view of thoracic region and ventral view of abdominal segments 8–9. Abbreviations: amsp = anterior mesothoracic spine, dpp = dorsal posterolateral process, pmc = posterior mesothoracic callosity.

***Mallophora fautrix* Osten Sacken**
(Fig. 34)

This description is based on a pupal case with a pinned male from the United States National Museum labeled "Coquillett; Los Angeles, Cal."

Description: Greatest length, including anterior antennal processes, 27.0 mm; greatest width of thorax 6.5

mm; greatest width of abdomen 5.0 mm, tapering to 2.0 mm at greatest width of abdominal segment 8. Integument subshining golden brown, with some orange to tan mottling; spines and other processes glistening reddish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 subequal, basally fused posterior antennal processes; outer or third posterior process elbowed, middle and outer posterior processes round to flat apically, inner or first posterior process rounded. Labral sheath rugulose anteriorly, with apical keel surrounded by 2 dark, concentric rings. Proboscial sheath with 2 indistinct tubercles on each side of midline posteriorly and larger, posteriorly convex posterior tubercle. Maxillary sheath with large, posterior, apically rounded process, base and area on each side of labral sheath highly rugulose.

Anterior coxal sheath mostly smooth with anterior, median, longitudinal split. Prothoracic spiracle elongate, surrounded by ring of cuticle flush with prothoracic area, situated laterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of subequal, apically rounded spines above base of sheath of mid legs; thoracic area above spines rugose. Posterior mesothoracic callosity large, at base of wing sheath, with posterior median spine, rugose and indented near dorsal surface. Wing sheath apically rugulose, rugose and pitted above spiracle of abdominal segment 1; tubercle near base and shorter tubercle medially. Thoracic area above wing sheath and near anterior mesothoracic spines rugulose. Apex of hind leg sheath reaching to middle of abdominal segment 2.

Abdominal spiracles C-shaped, shining brown, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 16 dorsoventrally flattened, straight to apically recurved spurs; median pair and dosolateral spurs short; 3 lateral bristle-like spines behind and below spiracle; venter obscured by wing and leg sheaths; dorsolateral bristle-like spines absent.

Segments 2–7 with dorsomedian transverse row of 13–20 alternating long, narrow spurs and short, straight to slightly recurved spines; short spines slightly anterior to long spurs; with 2–4 dorsolateral bristle-like spines, often basally fused.

Segment 2 with 5 ventral bristle-like spines on each side of hind leg sheath; some spines fused basally. Abdominal segments 3–4 with 21–29 ventral bristle-like spines; segments 5–7 with 16–18 bristle-like spines; some spines bifurcate, apically round to more acute or pointed.

Segments 2–7 with 6–8 bristle-like spines behind spiracles, some spines bifurcate or close together but not fused basally.

Segment 8 with 4 dorsal spurs on each side of midline, 2 dorsolateral spines on each side, 2–3 very broad lateral bristle-like spines, and 6 ventral spines; spiracle absent.

Segment 9 with pair of long dorsal posterolateral processes curved upward; pair of short ventral posterolateral processes fused basally to dorsal posterolateral processes; pair of large, midventral, apically rounded tubercles; and pair of large, rugose, posteroventral tubercles.

***Mallophora leschenaulti* Macquart**

(Figs 4–5, 35–36)

Two pupal cases of *M. leschenaulti* are from the United States National Museum collection. One male case is labeled "Uvalde, Tex.; VII-17-17; D. C. Parman Coll." The other case is a female labeled "Uvalde, Tex.; VII-7-17; D.C. Parman Coll."

Description: Greatest length, including anterior antennal processes, ♂ 33.5 mm, ♀ 35.0; greatest width of thorax ♂ 9.0 mm, ♀ 10.0 mm; greatest width of abdomen ♂ 8.0 mm, ♀ 9.0, tapering to ♂ 2.0 mm and ♀ 2.5 mm at greatest width of abdominal segment 8. Integument subshining dark golden brown, posterior abdominal segments with dark reddish-brown mottling; spines and other processes glistening reddish brown, darker apically.

FIGURE 35. *Mallophora leschenaulti* Macquart, lateral view.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes fused basally for greater distance, appearing shorter than inner or first process; outer or third posterior process elbowed basally; processes apically rounded to acute. Labral sheath rugose; posterior keel surrounded by dark, sclerotized, concentric rings and with slight posterior tubercle. Proboscial sheath rugose on each side of midline and posteriorly; tubercles on each side of midline posteriorly. Maxillary sheath with large, posterior, acuminate process. Labral sheaths very rugose on inner surface toward facial area, small median processes on each side.

Anterior coxal sheath smooth to slightly rugulose, with anterior, median, longitudinal split and long, apically rounded, posterior suborbital spine. Prothoracic spiracle on rugose, upraised area midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of subequal, apically rounded spines on

each side of thorax above base of sheaths of mid legs; first spine flatter and broader than second or outermost spine. Thoracic area above spines slightly rugulose. Posterior mesothoracic callosity large, rugose, at base of wing sheath, often with minute median posterior mesothoracic spine. Wing sheath rugose with large tubercle near base, 2 small median tubercles, and small, upraised, oblong, rugose area on posterior margin below abdominal segment 1. Thoracic area above wing sheath smooth to slightly rugose. Apex of hind leg sheath reaching slightly beyond posterior margin of abdominal segment 2.

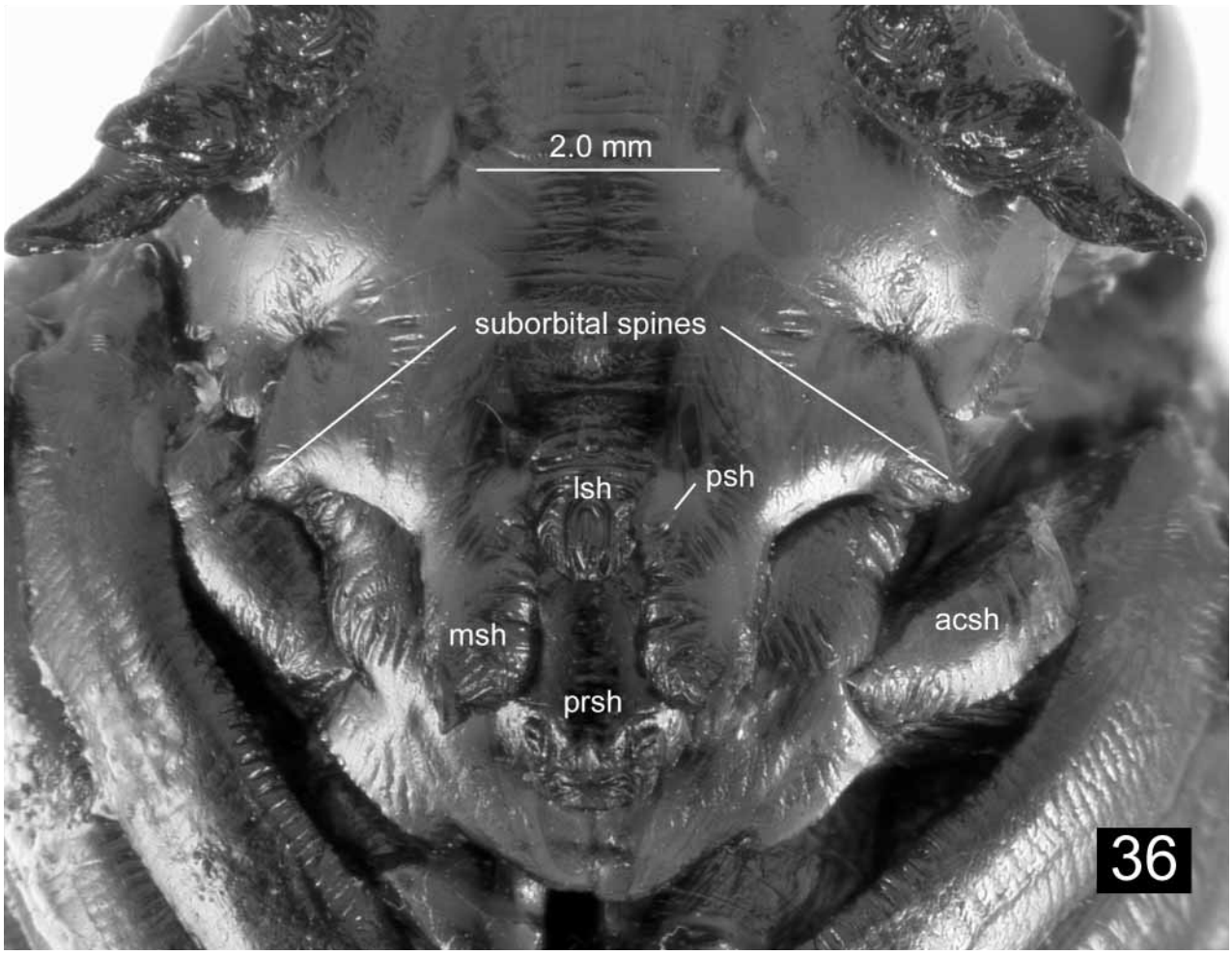


FIGURE 36. *Mallophora leschenaulti* Macquart, facial area. Abbreviations: acsh = anterior coxal sheath, lsh = labral sheath, msh = maxillary sheath, prsh = proboscial sheath, psh = palpal sheath.

Abdominal spiracles C-shaped, shining reddish brown, along midline laterally.

Abdominal segment 1 with dorsal transverse row of 15 apically recurved spurs along anterior margin; outermost spur and 2 median spurs short; some larger spurs bifurcate to quadrifurcate apically; most spurs expanded basally, sagittate; dorsolateral bristle-like spines absent; 3 lateral bristle-like spines behind spiracle, toward venter; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsomedian, transverse row of 12–13 alternating long, basally-expanded, sagittate spurs and shorter, straight spines; most spines slightly anterior to spurs; outermost spines bifurcate or with several furcations, other spines mostly bifurcate or trifurcate; with 3–6 dorsolateral bristle-like spines, outermost 2–3 spines usually basally fused, some spines bifurcate; with 7–9 bristle-like spines behind each spiracle.

Segment 2 with 6–9 ventral bristle-like spines on each side of hind leg sheath; some spines bifurcate or trifurcate; outermost spines sometimes basally fused. Segments 3–6 with row of 9–14 ventral bristle-like spines

on each side of midline divided by median space; segment 7 with 7–10 ventral bristle-like spines on each side of midline; outermost 2–5 spines basally fused; some spines bifurcate.

Segment 8 with 10 dorsal spurs, median pair very short; with 2 lateral spines and 4 ventral spines on each side of midline; spiracle absent.

Segment 9 with pair of long dorsal posterolateral processes and pair of very short ventral posterolateral processes fused basally to dorsal posterolateral processes; pair of median midventral tubercles; pair of lateral, apically blunt tubercles slightly in front of median tubercles; and pair of median, apically blunt tubercles near juncture of segments 8 and 9, larger in male pupal case.

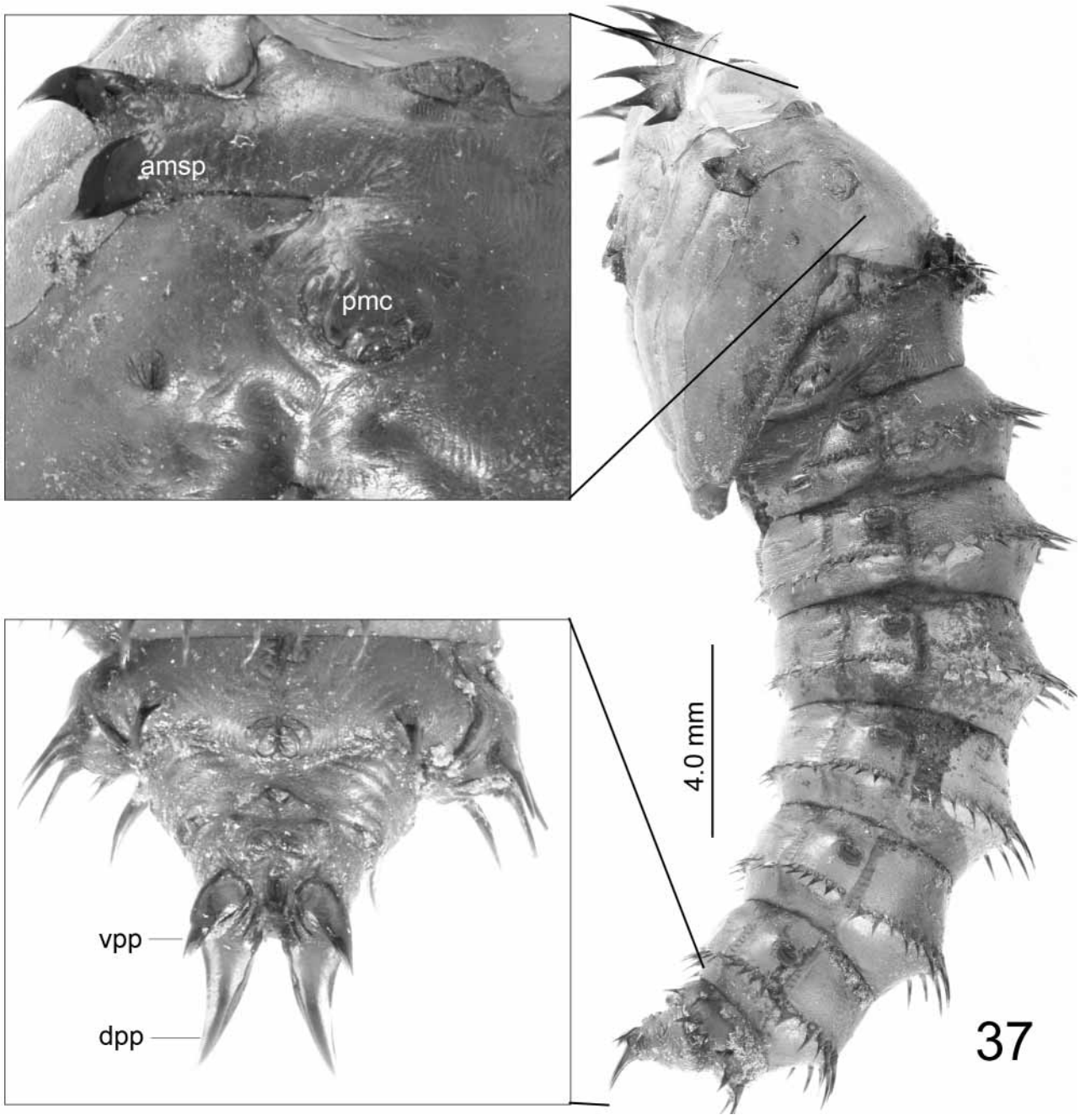


FIGURE 37. *Mallophora orcina* (Wiedemann), lateral view with enlarged dosolateral view of thoracic region and ventral view of abdominal segments 8–9. Abbreviations: amsp = anterior mesothoracic spine, dpp = dorsal posterolateral process, pmc = posterior mesothoracic callosity, vpp = ventral posterolateral process.

***Mallophora orcina* (Wiedemann)**
(Fig. 37)

The following description is based on a pupal case from the United States National Museum that is pinned with an adult female labeled "Lexington, Kentucky; 6/11/39; reared, S.W. Bromley Collection 1955."

Description: Greatest length, including anterior antennal processes, 24.5 mm; greatest width of thorax 5.5 mm; greatest width of abdomen 5.0 mm, tapering to 1.3 mm at greatest width of abdominal segment 8. Head and thorax subshining golden brown, abdominal segments darker; spines and other processes glistening reddish brown, usually darker apically.

Head with pair of dorsally flattened, ventrally slightly wedge-shaped anterior antennal processes not joined at base and group of 3 subequal, basally fused posterior antennal processes; outer or third posterior process slightly curved; all 3 posterior processes acuminate. Labral sheath with apical keel surrounded by 3 dark concentric rings, rugulose anteriorly. Proboscial sheath with minute tubercles on each side of midline posteriorly and larger posterior tubercle on midline. Maxillary sheath with posterior acuminate process and rugulose area at base of process and anteriorly.

Anterior coxal sheath mostly smooth, with median longitudinal split on anterior third. Prothoracic spiracle elongate, surrounded by ring of cuticle, but almost flush with prothoracic area, situated laterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of subequal, acuminate spines on each side of thorax above base of midleg sheath; posterior process broader than anterior, curved process. Thoracic area above spines rugulose. Posterior mesothoracic callosity large, situated at base of wing sheath, with 2 minute posterior mesothoracic spines on posterior margin; shorter spine located toward dorsum; longer spine located toward venter. Wing sheath rugulose on posterior third and above spiracle of abdominal segment 1, short tubercle near base and 2 shorter tubercles medially. Thoracic area above wing sheath slightly rugulose. Apex of hind leg sheaths reaching slightly beyond middle of abdominal segment 2.

Abdominal spiracles C-shaped, shining brown, located along midline laterally.

Abdominal segment 1 with dorsal transverse row of 16 dorsoventrally flattened, apically recurved spurs along anterior margin; outermost spur short, 2 median spines three-fourths as long as adjacent spines; fourth spine from each side apically trifurcate; dorsolateral bristle-like spines absent; 3 lateral bristle-like spines behind and below spiracle; venter obscured by wing and leg sheaths.

Segments 2–6 with dorsomedian transverse row of 13–14 alternating long, straight to apically recurved spurs and slightly shorter spines; median and some lateral spines bifurcate; segment 7 with 10 straight to apically recurved dorsomedian spurs and spines.

Segments 2–7 with 3–4 dorsolateral bristle-like spines often fused basally and 6–8 lateral bristle-like spines behind each spiracle.

Segment 2 with 3–4 short ventral bristle-like spines on each side of hind leg sheath; outer spines sometimes fused basally. Segments 3–7 with complete row of 10–14 short ventral bristle-like spines; outer spines often bifurcate.

Segment 8 with 2 dorsal spurs on each side of midline, 3 lateral spines on each side, 2 ventrolateral spines and 2 median tubercles between and slightly posterior to ventrolateral spines; spiracle absent.

Segment 9 with pair of long dorsal posterolateral processes curved outward and pair of shorter ventral posterolateral processes fused basally to dorsal posterolateral processes; pair of median and lateral tubercles midventrally on posterior part of segment 9 and pair of minute tubercles along midline anteriorly near junction with segment 8.

Genus *Promachus* Loew

Promachus dimidiatus Curran and other species of *Promachus* have been observed to deposit eggs on vegetation (Lavigne & Holland 1969). The larvae drop down to the soil upon hatching, and complete their development in the soil.

Key to known pupal cases of Nearctic species of *Promachus*

1 Labral sheath with slight keel or posterior tubercle; proboscial sheath with 1–2 median tubercles on each side of midline; anterior coxal sheath without callosity on each side of midline near proboscial sheath tubercle; dorsal abdominal spines not sagittate or broad basally; abdominal segment 9 with ventral posterolateral processes not basally fused to dorsal posterolateral processes 2

- Labral sheath with posterior keel; proboscial sheath with 2 median tubercles on each side of midline; anterior coxal sheath with 1–2 callosities on each side of midline near proboscial sheath tubercle; dorsal abdominal spines sagittate or broad basally; abdominal segment 9 with or without ventral posterolateral processes basally fused to dorsal posterolateral processes 3

2 Proboscial sheath usually with 1–2 median tubercles on each side of midline; maxillary sheath often with minute median processes on each side of labral sheaths; venter of abdominal segment 2 with 5–8 bristle-like spines on each side of hind leg sheath; segment 8 with 1 dorsolateral bristle-like spine on each side..... ..... *Promachus bastardii* (Macquart)

- Proboscial sheath with 1 median tubercle on each side of midline; maxillary sheath without median processes on each side of labral sheaths; venter of abdominal segment 2 with 1–2 bristle-like spines on each side of hind leg sheaths; segment 8 without dorsolateral bristle-like spines on each side .... *Promachus rufipes* (Fabricius)

3 Anterior coxal sheath with 1 small callosity on each side of midline near proboscial sheath tubercle; abdominal segments 2–4 with long, sagittate spurs; segment 7 with alternating long, narrow, dorsal spurs and short, dorsal spines; segment 9 with ventral posterolateral processes not basally fused to dorsal posterolateral processes ..... *Promachus fitchii* Osten Sacken

- Anterior coxal sheath with 1–2 small callosities on each side of midline near proboscial sheath tubercle; abdominal segments 2–4 with long, broad spurs; segment 7 with long, dorsal, sagittate spurs, rarely with a small spine between long spurs; segment 9 with ventral posterolateral processes basally fused to dorsal posterolateral processes ..... *Promachus vertebratus* (Say)

***Promachus bastardii* (Macquart)**
(Fig. 38)

The following description is based on six pupal cases with pinned adults from the United States National Museum collection. Four males are labeled "Agawam, Mass.; 8 VII 15; H.E. Smith Coll.; W. Springfield No. 915339; W.R. Walton Coll.," "Agawam, Mass.; 10 VII 15; H.E. Smith Coll.; W. Springfield No. 915297," "Agawam, Mass.; 5 VII 15; H.E. Smith Coll.; W. Springfield No. 91510; W.R. Walton Coll.," and "W. Springfield No. 9159; 5 VI 16; W.R. Walton Coll." Two females are labeled "Agawam, Mass.; 8 VII 15; H.E. Smith Coll.; W. Springfield No. 915293," and "Cass Co., Minn.; Cass Lake, Minn.; from soil; May 21, 1937; pupated June 22, 1937, emerged July 11, 1937; R.H. Nagel." The latter label indicates that under some circumstances the pupal stadium for this species can be 19 days.

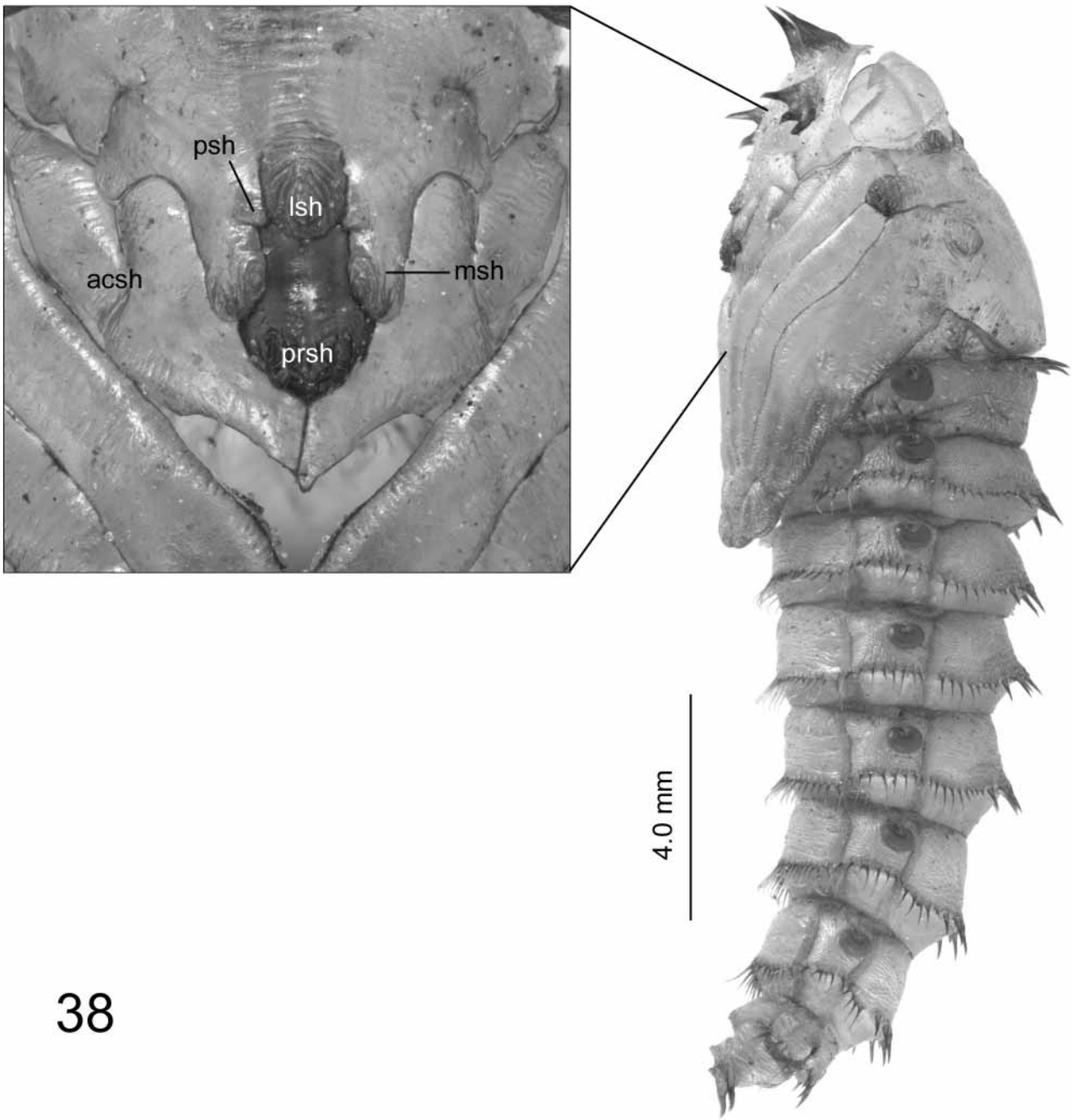


FIGURE 38. *Promachus bastardii* (Macquart), lateral view with enlarged ventral view of facial area. Abbreviations: acsh = anterior coxal sheath, lsh = labral sheath, msh = maxillary sheath, prsh = proboscial sheath, psh = palpal sheath.

Description: Greatest length, including anterior antennal processes, ♂ 18.5–21.0 mm, ♀ 21.0–22.0 mm; greatest width of thorax, ♂ 5.0–5.5 mm, ♀ 5.5 mm; tapering to ♂ 2.0–2.5 mm and ♀ 1.5 mm at greatest width of abdominal segment 8. Integument subshining golden brown; spines and other processes glistening reddish brown, darker apically.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes ventrolaterally on each side; middle and outer posterior processes fused basally for a greater distance and appearing shorter than inner posterior process; middle and outer posterior processes rounded apically, inner and middle posterior processes acute. Labral sheath very rugose, with slight keel to apically rounded tubercle often surrounded by 2–3 dark, sclerotized concentric rings. Proboscial sheath usually with 2 tubercles on each side of midline posteriorly, outer tubercles rounded

or concave apically, inner tubercles more concave apically; with larger posterior tubercle on midline, rugose around tubercles and to each side of midline. Maxillary sheath with posterior, apically rounded, rugose process, often with minute median processes, rugulose on either side of labral sheaths.

Anterior coxal sheath smooth to rugulose along side and posteriorly; anterior third with median, longitudinal split. Prothoracic spiracle difficult to see in rugose ring of thickened cuticle nearly flush with thoracic area, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines subequal, acuminate, on each side of thorax above bases of sheaths of mid legs. Thoracic area above spines rugulose. Posterior mesothoracic callosity large, rugose, located at base of wing sheath, often with minute, median, posterior mesothoracic spine toward dorsum. Wing sheath rugulose posteriorly and along edges, with short tubercle near base and 2 minute tubercles medially, often hidden in rugulose area. Thoracic area above wing sheath smooth to rugulose. Apex of hind leg sheath usually reaching to middle of abdominal segment 3 or slightly beyond.

Abdominal spiracles C-shaped, shining reddish brown, located along midline laterally.

Abdominal segment 1 with dorsal transverse row of 12–14 dorsally flattened, apically recurved spurs along anterior margin; outermost spurs shorter than others; median spur one-fourth to one-third as long as others, some spurs fused basally; with 3 bristle-like spines behind spiracles; venter obscured by wing and leg sheaths.

Segments 2–3 with dorsomedian row of 14–15 alternating straight to slightly apically recurved long spurs and straight, short spines; 2 outer spines sometimes bifurcate; all other spines bifurcate to quadrifurcate, with teeth of unequal size, except for unforked median spine; spurs sometimes bifurcate, with teeth of unequal size.

Segments 4–6 similar to 2–3, but with fewer short spines and more single-toothed spines posteriorly.

Segment 7 usually with 6 long dorsal spurs, but sometimes with alternating short spines. Segments 2–7 with 4–7 dorsolateral bristle-like spines and 5–9 lateral bristle-like spines behind each spiracle; spines sometimes bifurcate.

Segment 2 with 5–8 long ventral bristle-like spines on each side of hind leg sheath. Segments 3–6 with complete transverse row of 22–29 ventral bristle-like spines. Segment 7 with 12–17 ventral bristle-like spines.

Segment 8 with 2 dorsal spurs on each side of dorsal midline, small spiracle at lateral midline, 3–5 lateral bristle-like spines, and 4 ventral spines in males; ventral spines absent in females.

Segment 9 with pair of long dorsal posterolateral processes and pair of very short ventral posterolateral processes fused basally to dorsal posterolateral processes, pair of small median tubercles midventrally on posterior part of segment 9 and pair of midventral median tubercles.

***Promachus fitchii* Osten Sacken**
(Fig. 39)

The pupal case of *Promachus fitchii* was described previously by Malloch (1916, 1917), Davis (1919), and Bromley (1946). A more complete description is presented here based on two cases with pinned adult males from the United States National Museum. These specimens are labeled "W. Springfield No. 915368; 18 VII 16," and "Madison, Wisc.; VI-12-17; Lafayette, Cage No. D252a; J.J. Davis Collector; Collection J.M. Aldrich."

Redescription: Greatest length, including anterior antennal processes, 19.0–24.5 mm; greatest width of thorax 5.0–6.0 mm; greatest width of abdomen 4.5–5.5 mm, tapering to 2.5–3.0 mm at greatest width of abdominal segment 8. Integument subshining light yellow to golden brown; spines and other processes glistening reddish brown, darker apically; spurs uniformly reddish brown.

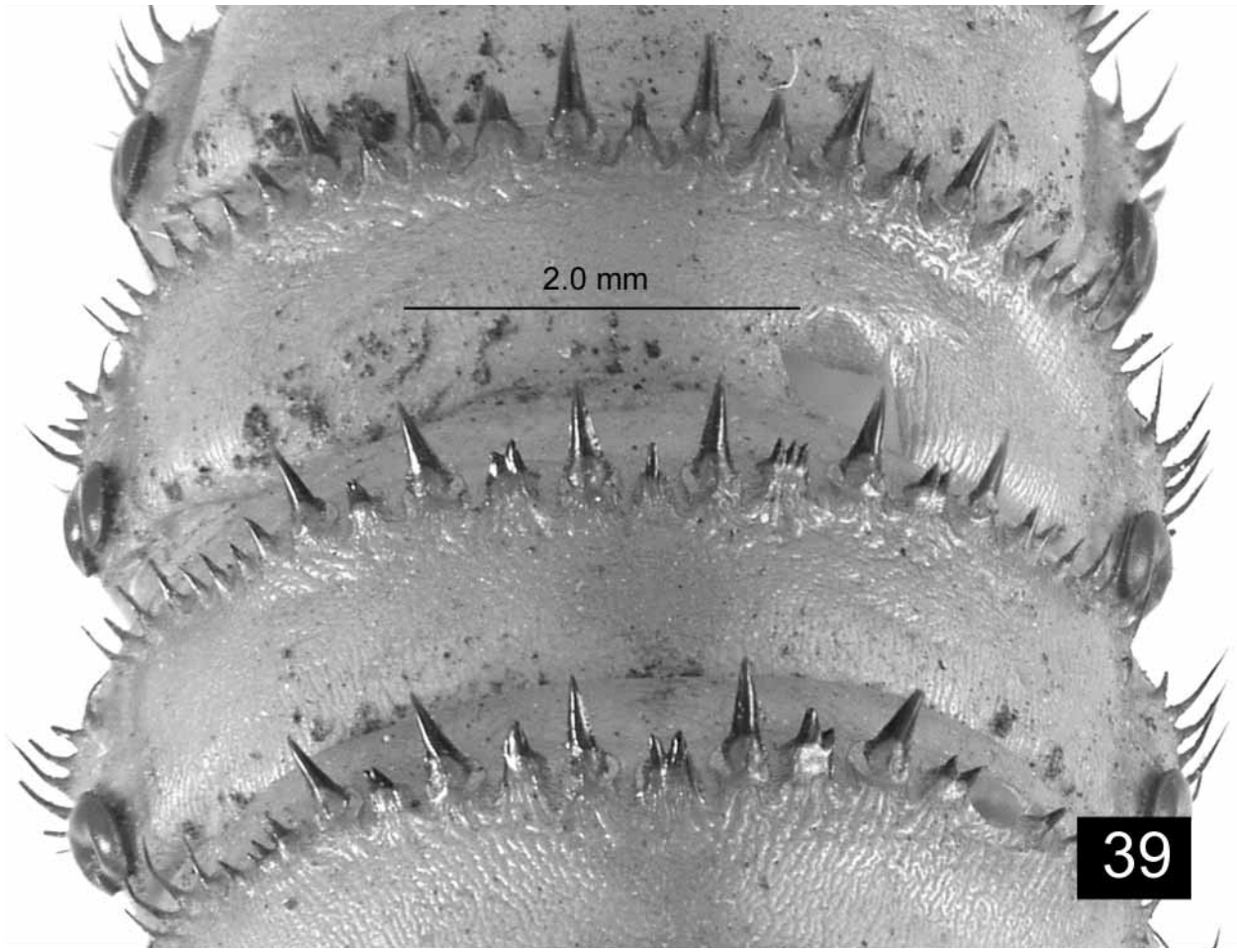


FIGURE 39. *Promachus fitchii* Osten Sacken, abdominal segments 2–4, anterodorsal view.

Head with pair of dorsally flattened, ventrally slightly wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes fused for greater distance, closer together, appearing shorter than inner process; middle and outer posterior processes rounded apically, inner or first posterior process more acute; outer or third posterior process slightly elbowed basally. Labral sheath rugose and with large keel posteriorly; keel with inverted V-shaped sclerotized ridge apically. Proboscial sheath rugose on each side of midline, with 2 subequal tubercles on each side and large, basally concave tubercle posteriorly; innermost tubercle sometimes concave apically. Maxillary sheath mostly smooth, with large, apically rounded, rugose process posteriorly; with small tubercles lateral to labral sheath.

Anterior coxal sheath mostly smooth or with slightly rugulose areas on margins, with anterior median, longitudinal split and small callosity on each side of midline just posterior to large proboscial sheath tubercle. Prothoracic spiracle on flush rugose area, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of dorsoventrally flattened, subequal, apically curved spines on each side of thorax above bases of sheaths of mid legs; anterior spine broader basally and usually curved posteriorly; posterior spine straighter. Posterior mesothoracic callosity large, slightly rugose, with apically rounded posterior mesothoracic spine of variable length located medially on posterior margin. Wing sheath irregularly rugulose, with large, apically rounded tubercle near base and 2 minute median tubercles posteriorly. Thoracic area above wing sheath mostly smooth. Apex of hind leg sheath reaching between posterior margin of abdominal segment 2 and middle of abdominal segment 3.

Abdominal spiracles C-shaped, shining reddish brown, located along midline laterally.

Abdominal segment 1 with dorsal transverse row of 12–14 apically recurved spurs; most spurs subequal, with outermost spine on each side and 2 median spines one-third to one-half as long as others; dorsolateral bristle-like spines absent; with 2–3 (usually 3) bristle-like spines behind spiracle; venter obscured by wing and leg sheaths.

Segments 2–6 with dorsomedian transverse row of 11–14 alternating long, narrow, sagittate, straight to apically recurved spurs and short, broad, straight, bifurcate or multifurcate spines mostly in even row with large spurs; with 3–5 long dorsolateral bristle-like spines.

Segment 7 with dorsomedian transverse row of 10 alternating long, narrow spurs and short spines and 3–4 dorsolateral bristle-like spines.

Segments 2–7 with 5–8 long, straight to curved bristle-like spines behind each spiracle; outermost spine on each side sometimes shorter than other spines; spines rarely bifurcate.

Segment 2 with 4–6 long, median, ventral bristle-like spines on each side of hind leg sheath; some inner spines shorter than others, presumably due to leg sheaths rubbing. Segments 3–6 with 14–20 long, median, ventral bristle-like spines in complete transverse row. Segment 7 with 11–14 ventral bristle-like spines; spines on segments 3–5 curved and bent; spines on segments 6–7 straight to apically recurved; some spines bifurcate or shorter than others.

Segment 8 with 1–2 dorsal spurs on each side of midline; small spiracle at lateral midline; lacking dorsolateral bristle-like spines; with 4–5 lateral bristle-like spines, usually in pairs on callosity, and 4 subequal median ventral bristle-like spines on large callosity.

Segment 9 elongate, with pair of long, basally broad dorsal posterolateral processes and pair of small ventral posterolateral processes not fused basally to dorsal posterolateral processes; with 2 terminal median ventral tubercles just anterior to ventral posterolateral processes, small midventral tubercle, and pair of large tubercles anterior to ventromedian tubercles; venter rugose posteriorly.

***Promachus rufipes* (Fabricius)**

This description is based on one pupal case with a pinned adult female from the United States National Museum. It is labeled "11 mi. S.E. Baton Rouge, on Perkins Rd.; 25 Jun 1965; Mac Tidwell."

Description: Greatest length, including anterior antennal processes, 23.0 mm; greatest width of thorax 6.0 mm; greatest width of abdomen 5.5 mm, tapering to 2.0 mm at greatest width of abdominal segment 8. Integument subshining golden brown; head and thorax darker; spines and other processes glistening reddish brown, darker apically.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes fused for greater distance and closer together, appearing shorter than inner process; all 3 posterior processes dorsoventrally flattened; outer posterior process wide for entire length and broadly rounded apically; inner and middle posterior processes mostly wide basally and more acute apically toward posterior margin. Labral sheath rugose with tubercle-like apical keel posteriorly. Proboscial sheath rugose, especially on each side of midline, with 1 median tubercle on each side of midline and median concave tubercle posteriorly. Maxillary sheath with medium sized, apically rounded process posteriorly, rugose near process and along inner margin.

Anterior coxal sheath mostly smooth except for slight rugoseness along inner margin, with anterior, median, longitudinal split. Prothoracic spiracle on flush rugose area, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of dorsoventrally flattened, subequal, apically pointed spines on each side of thorax above base of sheath of mid legs; anterior spine broader basally than

posterior spine and broadly curved on anterior margin with spine pointing posteriorly; posterior spine straight to slightly curved posteriorly. Posterior mesothoracic callosity large, smooth, located at base of each wing sheath, with sclerotized margin toward dorsum, and apically rounded posterior mesothoracic spine. Wing sheath rugose beyond pair of small, subequal median tubercles; with large, apically rounded tubercle near base and circular, rugose, upraised area in front of abdominal segment 1. Thoracic area above wing sheath irregularly rugulose. Apex of hind leg sheath reaching slightly beyond middle of abdominal segment 3.

Abdominal spiracles C-shaped, shining reddish brown, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 6 apically recurved spurs on each side of median space; outermost spur on each side slightly shorter than other spurs; with 3 bristle-like spines behind spiracle; dorsolateral bristle-like spines absent; venter obscured by wing and leg sheaths.

Segments 2–5 with dorsomedian transverse row of 11 alternating long, straight to slightly apically recurved spurs and short, broad, straight spines; short median spine bifurcate on segments 2, 4, and 5.

Segments 6–7 with dorsomedian row of 6 long, straight to slightly apically recurved spurs. Segments 2–7 with 3–6 straight, dorsolateral, bristle-like spines. Segments 2–5 with 6–7 straight to slightly recurved bristle-like spines behind spiracles; segments 6 and 7 with 5–6 and 3–4 bristle-like spines behind spiracles, respectively; outermost spine toward dorsum on segments 2–6 short; sometimes third bristle-like spine from dorsum also short.

Segment 2 with 1–2 median, ventral bristle-like spines on each side of hind leg sheath; segment 3 with 2 short, median, ventral bristle-like spines and 4–5 long, ventrolateral, bristle-like spines; segments 4–5 and 6-7 with 18–19 and 15–16 ventral bristle-like spines, respectively.

Segment 8 with 1 dorsomedian spur on each side of dorsal midline, small spiracle at lateral midline, 2–3 lateral spines on each side, and median pair of small, closely approximate ventral tubercles; ventral bristle-like spines absent.

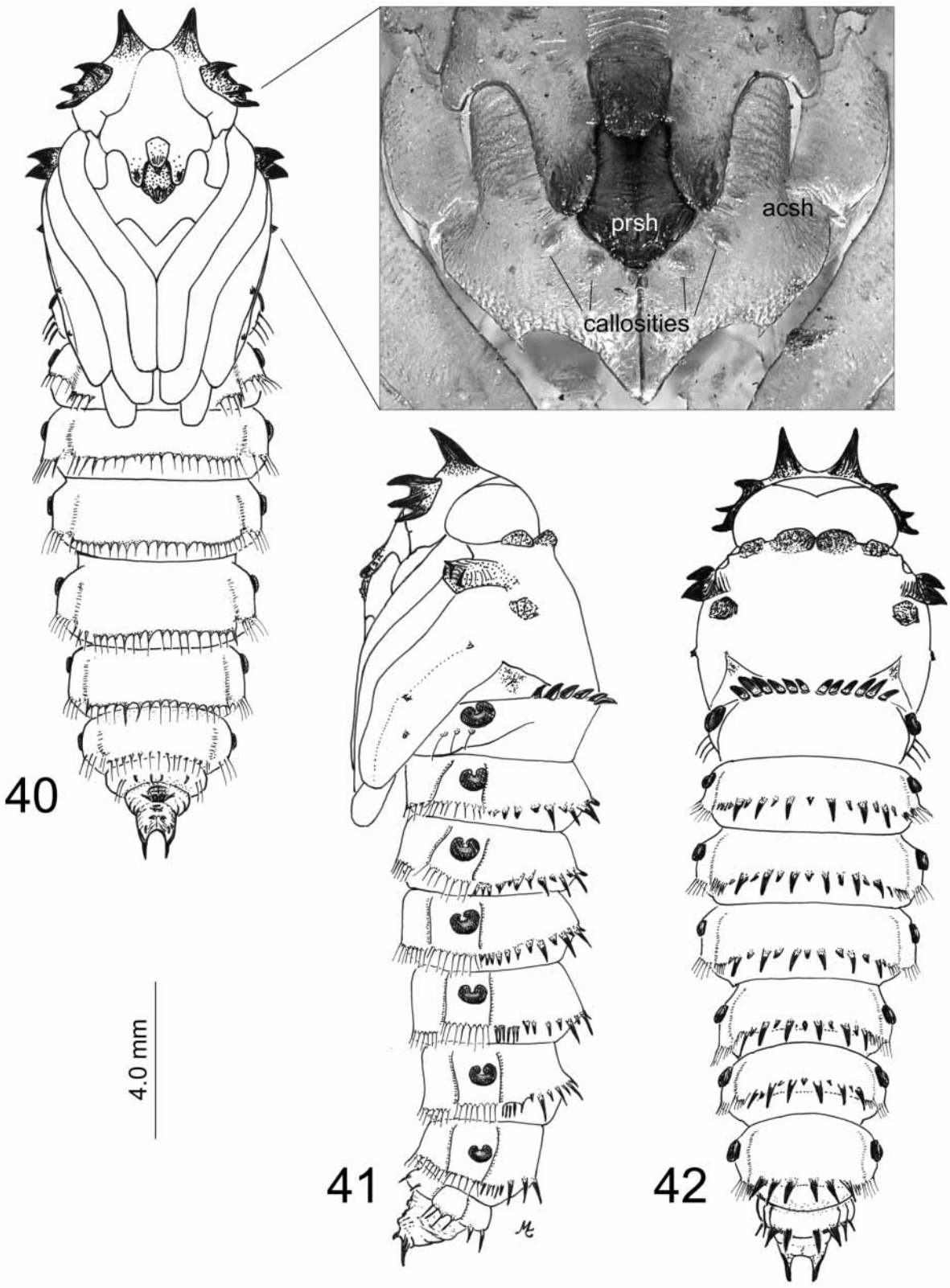
Segment 9 with pair of long, apically recurved dorsal posterolateral processes; pair of short ventral posterolateral processes curved apically toward and fused basally to dorsal posterolateral processes, and pair of terminal, median tubercles on venter.

***Promachus vertebratus* (Say)**
(Figs 40–42)

The following description is based on four male and five female pupal cases from the United States Nation Museum collection. The males are labeled "Crown Point, Ind.; IV-24-34; reared from *Lachnosterna*?; Luginbill & Painter Colls," "Dayton, Ind.; VII-27-35; reared from *Phyllophaga*?; P. Luginbill and H. R. Painter Colls," "Lafayette, Ind.; VIII-8-39; McCoy field; reared from *Phyllophaga*?; P. Luginbill and H. R. Painter Colls," and "Lafayette, Ind., VII-27-39, McCoy field; reared from *Phyllophaga*?; P. Luginbill and H. R. Painter Colls." Three females are labeled "Crown Point, Ind.; IV-24-34; reared from *Lachnosterna*?; Luginbill & Painter Colls," one female is labeled "Crown Point, Ind.; IX-12-36; reared from *Lachnosterna*?; P. Luginbill & H. R. Painter Colls," and one female is labeled "Merrillville, Ind.; VII-29-35; reared from *Phyllophaga*?"

The pupal case of *P. vertebratus* was described by Malloch (1915, 1916, 1917) and Davis (1919). Because these descriptions are incomplete we are redescribing the pupal cases here.

Redescription: Greatest length, including anterior antennal processes, ♂ 21.0–26.0 mm, ♀ 19.0–27.0 mm; greatest width of thorax ♂ 6.0–6.5 mm, ♀ 6.0–6.5 mm; greatest width of abdomen ♂ 4.5–5.5 mm, ♀ 5.0–6.0 mm, tapering to ♂ 1.5–2.0 mm and ♀ 1.5–2.5 mm at greatest width of abdominal segment 8. Integument subshining, light golden brown; spines and other processes glistening reddish brown.



FIGURES 40–42. *Promachus vertebratus* (Say), 40. ventral view with enlarged view of facial area. 41. lateral view, 42. dorsal view. Abbreviations: acsh = anterior coxal sheath, prsh = proboscial sheath.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes closer together and fused basally for greater distance, appearing shorter than inner

process; middle and outer posterior processes rounded apically; inner posterior process more acute apically, especially on posterior margin. Labral sheath rugose, with apical keel. Proboscial sheath rugose, with 2 tubercles on each side and large, basally concave median tubercle posteriorly; innermost tubercle smaller than outer tubercle and somewhat hidden in rugoseness. Maxillary sheath with large, apically rounded posterior process, rugose about process and often along innermost margin, especially on margin next to labral sheath.

Anterior coxal sheath irregularly rugulose, with anterior, median, longitudinal split; with 1–2 small rugulose callosities on each side of proboscial sheath. Prothoracic spiracle on very rugose area, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of dorsoventrally flattened, subequal spines on each side of thorax above mid leg sheaths; anterior spine broader basally than posterior spine, curved posteriorly and acute along posterior margin; posterior spine straight and medially acute, sometimes more wedge-shaped ventrally; thoracic area above spines rugose. Posterior mesothoracic callosity large, slightly rugose, with sclerotized margin, situated at base of each wing sheath; posterior mesothoracic spine short, apically rounded, located medially on posterior margin of callosity. Wing sheath with posterior half rugose; large, apically rounded, spine-like tubercle near base; 2 small median tubercles posteriorly; and small, circular, upraised area posterior to median tubercles and more toward outer edge of wing sheath. Thoracic area above wing sheath irregularly rugose. Apex of hind leg sheath reaching between middle and posterior margin of abdominal segment 3.

Abdominal spiracles C-shaped, shining reddish brown, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 12–13 (usually 12) apically recurved spurs along anterior margin; outermost spur and sometimes second spur on each side of midline shorter than other subequal spurs; dorsolateral bristle-like spurs absent; 3 lateral bristle-like spines behind spiracle; venter obscured by wing and leg sheaths.

Segments 2–6 with dorsomedian transverse row of 11–14 alternating broad, long, straight to apically recurved spurs and narrow, short, straight spines pointing posteriorly; spines slightly in front of long spurs; some short spines bifurcate or irregularly furcate.

Segment 7 with dorsomedian transverse row of 6 long, sagittate, straight to apically recurved spurs; rarely with small spine between large spurs.

Segments 2–7 with 5–9 dorsolateral bristle-like spines of unequal size, often basally fused; segments 2–6 and segment 7 with 8–10 and 6–7 narrow, mostly long bristle-like spines behind each spiracle, respectively; outermost spine on each side and sometimes other spines one-third to three-fourths as long as most spines; rarely with some spines bifurcate.

Segment 2 with 4–7 long, median, ventral bristle-like spines on each side of hind leg sheath. Segments 3–7 with ventral transverse row of 16–21 median bristle-like spines in male, with 20–24 ventral spines in female; some cases with median space on segment 3 or with bristle-like spines missing where hind leg sheath presumably rubbed against venter; median pair of spines on some segments darker and slightly in front of surrounding spines or slightly fused basally and diverging apically; some spines bifurcate and/or smaller than others.

Segments 8–9 frequently bent ventrally at 45–90^0 angle so that ventral bristle-like spines on segment 7 touch venter of segment 8. Segment 8 with 2 dorsal spurs on each side of midline, outermost spur usually shorter than innermost spur; spiracle not visible; with 3–4 lateral bristle-like spines on each side; males with 2 long, median, diverging ventral spines and 2 short ventrolateral spines; females lacking ventral spines.

Segment 9 with pair of long dorsal posterolateral processes pointed dorsally and pair of small ventral posterolateral processes fused basally to dorsal posterolateral processes; with 2 terminal ventromedian tubercles just anterior to ventral posterolateral processes and 2 midventral tubercles shorter and closer together in females.

Genus *Proctacanthella* Bromley

***Proctacanthella cacopiloga* (Hine)**
(Fig. 43)

Dennis & Lavigne (1976a) described the pupal case of *Proctacanthella cacopiloga*. A specimen deposited in the United States National Museum is labeled "Reg. Cliff, Guernsey, Wyo.; VII-22, 1972; S. Dennis Collector." It should be noted that this species has ventrolateral tubercles on abdominal segment 9, but it lacks the ventral posterolateral processes found in other species. As indicated in the key to genera, the abdominal spiracles are elevated or elongate.

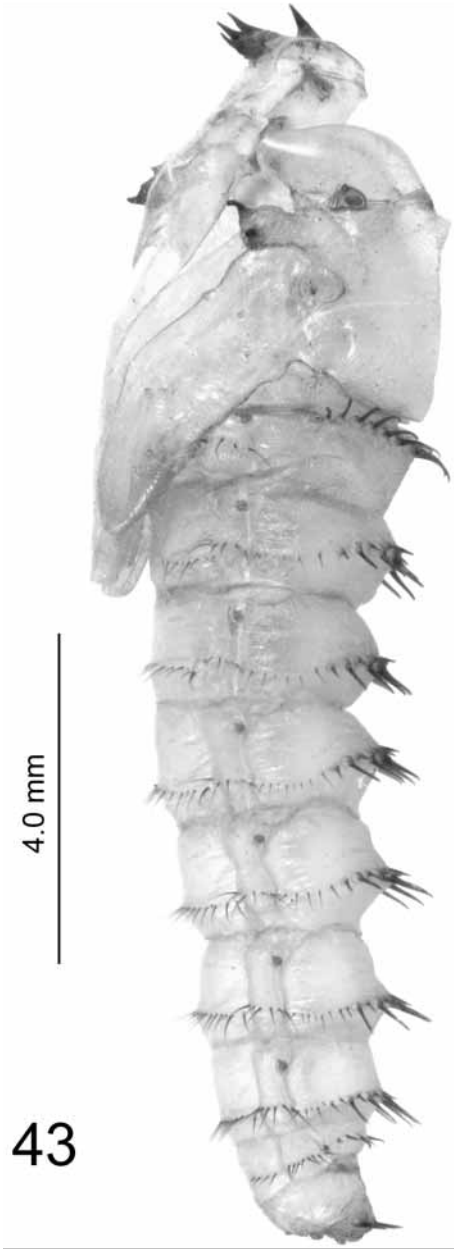


FIGURE 43. *Proctacanthella cacopiloga* (Hine), lateral view.

Genus *Efferia* Coquillett

Key to known pupal cases of Nearctic species of *Efferia*

1 Labral sheath with low apical keel on posterior third or more; proboscial sheath with posterior tubercle .2
- Labral sheath with raised, tubercle-like keel on posterior half; proboscial sheath with spine-like posterior process ..... *Efferia benedicti* (Bromley)
2 Proboscial sheath with single median tubercle on each side of midline; abdominal segment 8 with 2–3 dorsal posterolateral spurs on each side of midline and 5–8 bristle-like spines below and behind each spiracle 3
- Proboscial sheath with 3–8 minute tubercles on each side of midline; abdominal segment 8 with 0-1 dorsal spurs on each side of midline and 2–3 bristle-like spines below and behind each spiracle 4
3 Wing sheath rarely with median tubercle, abdominal segment 1 with 3 bristle-like spines behind each spiracle; abdominal segments 2–4 often with bifurcate dorsal spines; segment 8 with 2 dorsolateral spurs on each side and 6–14 subequal ventral bristle-like spines ..... *Efferia aestuans* (Linnaeus)
- Wing sheath with median tubercle; abdominal segment 1 with 6 bristle-like spines behind each spiracle; abdominal segments 2–4 without bifurcate dorsal spines; segment 8 with 3 dorsal spurs on each side and 16 long and short ventral bristle-like spines ..... *Efferia triton* (Osten Sacken)
4 Anterior mesothoracic spines apically rounded; wing sheath without median tubercle; abdominal segment 1 with 14 dorsal spurs; segment 8 with 14 ventral bristle-like spines ..... *Efferia frewingi* Wilcox
- Anterior mesothoracic spines distinctly acuminate; wing sheath with median tubercle; abdominal segment 1 with 12 dorsal spurs; segment 8 with 2 ventral bristle-like spines ..... *Efferia helenae* (Bromley)

***Efferia aestuans* (Linnaeus)**
(Fig. 44)

Descriptions of the pupae of *Efferia aestuans* were given in Bromley's (1946) key to Connecticut robber fly pupal cases and by Malloch (1917) and Riley (1870). Although Malloch's (1917) description of a male pupal case is fairly complete, it is not presented in a style parallel to ours. We therefore redescribe this species utilizing both male and female material.

This description is based on five pupal cases with associated, pinned adults from the United States National Museum; two male cases are labeled "Lockport, N.Y.; 12 July 1945; L.L. Pechuman; from larva in garden soil; S.W. Bromley Collection 1955," and "E. Baton Rouge Par.; Hylandia Road; 18 July 1969; Mac Tidwell; reared from pupae, emerged 28 July 1969." Three female cases are labeled "Lockport, N.Y.; 24 July 1945; L.L. Pechuman; from larva found in garden soil; S.W. Bromley Collection 1955," "Acc. 15.4; Tidwell; Idlewild Ex. Farm; E. Feliciana Par.; 7 April 1965; reared from larvae, pupated 8 July, emer. 6 Aug," and "Stamford, Conn.; July 15, 1929; B.T.R. Lab.; Col. S.W. Bromley Collection 1955."

Description: Greatest length, including anterior antennal processes, ♂ 14.5–18.5 mm, ♀ 16.5–17.5 mm; greatest width of thorax, ♂ 4.0 mm, ♀ 4.0–4.5 mm; greatest width of abdomen, ♂ 3.0–3.3 mm, ♀ 3.5–4.3 mm, tapering to ♂ 1.3 mm and ♀ 1.0–1.5 mm at greatest width of abdominal segment 8. Integument subshining golden brown, wing sheath darker apically; spines and other processes glistening reddish brown, darker apically, except for uniformly colored dorsal abdominal spines; bristle-like spines yellowish to reddish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes closer together and fused for greater distance, appearing shorter than inner posterior process; outer posterior process usually broad, with outer flattened area basally; inner and middle posterior

processes narrow, acute to slightly rounded apically, with middle posterior process sometimes smaller than inner process. Labral sheath smooth to rugose, usually with a slight apical keel. Proboscial sheath smooth to rugose on each side of midline, with small, rugose, ridge-like tubercle on each side of midline and small, ventrally concave, median tubercle posteriorly. Maxillary sheath rugose on inner margin, with small posterior tubercle; sometimes with minute, yellowish tubercle just above anterior margin of proboscial sheath on each side of labral sheath.

FIGURE 44. *Efferia aestuans* (Linnaeus), lateral view.

Anterior coxal sheath irregularly rugulose, with anterior, median, longitudinal split; sometimes with minute anterior tubercle on each side of midline directly posterior to small lateral tubercles of proboscial sheath. Prothoracic spiracles elongate-oval, slightly upraised, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of long, posteriorly curved, pointed spines above base of

sheath of mid legs; posterior spine wider basally than anterior spine. Posterior mesothoracic callosity medium sized, smooth to slightly rugulose, with small, apically rounded posterior mesothoracic spine. Wing sheath irregularly rugose, lacking basal tubercles. Thoracic area above wing sheath smooth to irregularly rugose. Apex of hind leg sheath reaching to middle of abdominal segment 3.

Abdominal spiracles semi-oval, upraised, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 12–13 long, apically recurved spurs, outermost spur on each side sometime very short; dorsolateral bristle-like spines absent; 3 bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–7 with dorsomedian transverse row of 6 long spurs alternating with 8–14 short spines; spines broad, slightly in front of long spurs, sometimes bifurcate apically; 4–8 long dorsolateral bristle-like spines and 5–8 lateral bristle-like spines behind each spiracle; some dorsolateral spines bifurcate or trifurcate; lateral spine toward dorsum and some other lateral spines about one-half as long as surrounding spines.

Segment 2 with 7–11 long, apically recurved ventral bristle-like spines on each side of and extending under hind leg sheaths; segments 3–7 with complete transverse row of 20–31 long, straight to apically recurved ventral bristle-like spines.

Segment 8 with 2 dorsal spurs on each side of dorsal midline; small dark-brown spiracle at lateral midline; and 5–6 lateral bristle-like spines on each side; venter of female with 3 long bristle-like spines on each side of and curved toward ventral midline; male cases with 4–6 bristle-like spines on each side of midline and 1–2 median bristle-like spines.

Segment 9 with pair of long, straight to slightly apically recurved dorsal posterolateral processes; pair of short ventral posterolateral processes not fused to but curved toward dorsal posterolateral processes; and pair of small posteroventral and posteromedain tubercles; males with pair of large, widely separated, acuminate anteroventral tubercles.

Efferia benedicti (Bromley)

The pupal case of a female *Efferia benedicti* was described by Dennis & Lavigne (1976a) based on a case from which an adult female was observed emerging from the case on July 17, 1969, 16 km south of Shoshoni, Wyoming, by R. J. Lavigne. The case, without the associated adult, is deposited in the United States National Museum. The description should be modified to include: prothoracic spiracle slightly upraised and facing posteriorly; abdominal spiracles circular, reddish brown, upraised along midline laterally; abdominal segment 9 with pair of long, straight to slightly apically recurved dorsal posterolateral processes, pair of short ventral posterolateral processes (previously called median lateral processes) not basally fused to but slightly curved toward dorsal posterolateral processes; pair of short, terminal ventromedian processes.

Efferia frewingi Wilcox

The pupal case of *E. frewingi* was described by Dennis & Lavigne (1976a). A specimen deposited in the United States National Museum is labeled “Laramie, WY; VIII–26–73; S. Dennis Collector.” The description should include the following: prothoracic spiracle slightly upraised; abdominal spiracles elongate-oval to semi-oval, reddish brown, slightly upraised, situated along midline laterally.

***Efferia helenae* (Bromley)**

The male and female pupal cases for this species are described in Dennis & Lavigne (1976a). The pupal cases are in the United States National Museum. They are labeled “Glendo?, WY; VIII–23, 1963." The description should include: prothoracic spiracle upraised; abdominal spiracles oval to circular, reddish brown, upraised, situated along midline laterally.

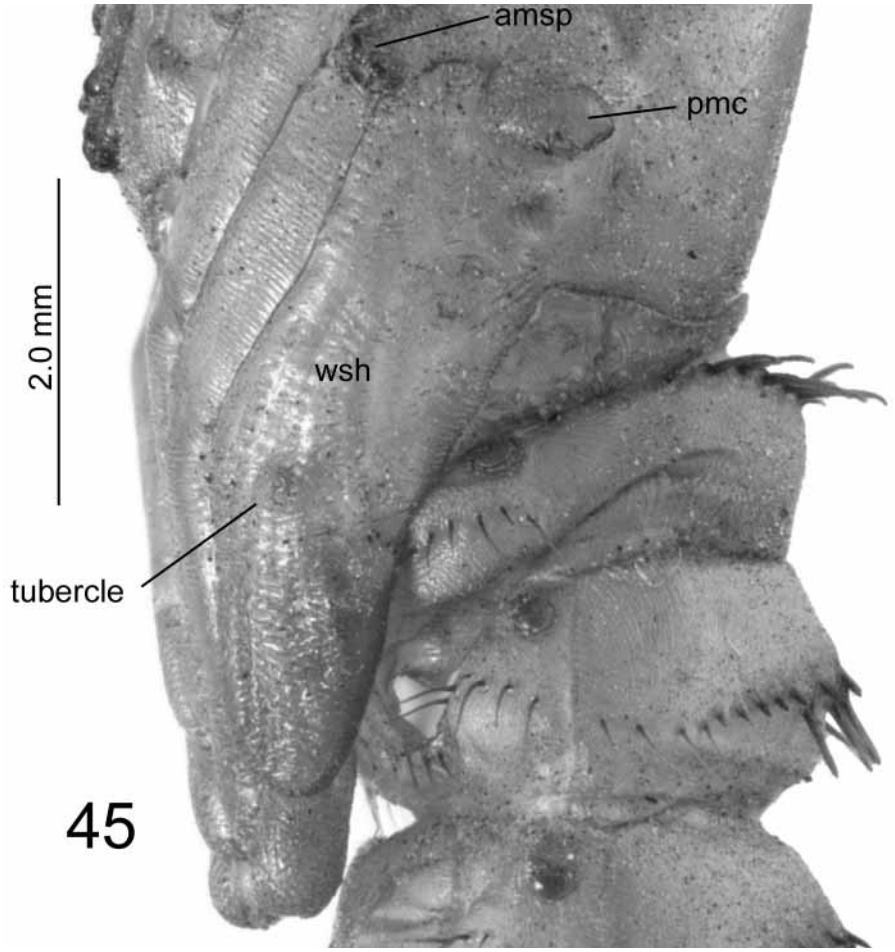


FIGURE 45. *Efferia triton* (Osten Sacken), thorax, ventrolateral view. Abbreviations: amsp = anterior mesothoracic spine, pmc = posterior mesothoracic callosity, wsh = wing sheath.

***Efferia triton* (Osten Sacken)**
(Fig. 45)

In the United States National Museum there is one male *Efferia triton* pupal case with associated pinned adult labeled "S. Rita Mts., Ar.; 30-5; Coll. Hubbard & Schwarz."

Description: Greatest length, including anterior antennal processes, 19.5 mm; greatest width of thorax 4.5 mm; greatest width of abdomen 4.0 mm, tapering to 2.0 mm at greatest width of abdominal segment 8. Integument subshining light golden brown; spines and other processes glistening reddish brown, spines on dorsum of abdomen more glistening reddish; bristle-like spines light reddish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer processes closer together and fused for greater distance, appearing shorter than inner process; outer posterior process wide, apically blunt, slightly curved medially, with flattened underside basally toward dorsum;

inner and middle posterior processes narrow, apically rounded and straight; with small space underneath outer posterior process. Labral sheath slightly rugose, with apical keel. Proboscial sheath rugose on each side of midline and around elongate tubercle on each side of midline posteriorly; with median, basally concave tubercle slightly posterior to lateral tubercles. Maxillary sheath rugose, with apically rounded process.

Anterior coxal sheath irregularly rugulose and rugose on each side of midline, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, slightly elevated, not on callosity, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of short, apically acute, subequal spines at base of sheath of mid legs; posterior spine broad basally, straight; anterior spine narrower, curved posteriorly. Posterior mesothoracic callosity large, mostly smooth, except for rugose anterior margin, with small, apically rounded posterior mesothoracic spine; posterior and dorsal margins sclerotized. Wing sheath mostly rugulose with small basal and median tubercles. Thoracic area above wing sheath smooth to slightly rugulose. Apex of hind leg sheath reaching to middle of abdominal segment 3.

Abdominal spiracles semi-oval, light reddish brown, slightly elevated, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 18 mostly long, straight to apically recurved spurs; dorsolateral bristle-like spines absent; with 6 alternately long and short lateral bristle-like spines behind spiracle on each side; venter obscured by wing and leg sheaths.

Segment 2 with dorsomedian transverse row of 12 alternating long, straight spurs and short spines; pair of short dorsomedian spines; 5 short dorsolateral spines; 4 dorsolateral bristle-like spines; and 6–8 bristle-like spines behind each spiracle.

Segments 3–6 similar to segment 2, but with 1–4 short dorsolateral spines, single short median spine, 3–5 dorsolateral bristle-like spines, and 6 bristle-like spines behind each spiracle.

Segment 7 with dorsal, transverse row of 13 alternating long spurs and short spines, 3 dorsolateral bristle-like spines, and 5 lateral bristle-like spines behind each spiracle.

Segment 2 with 5 ventral bristle-like spines on each side of and slightly extending under sheaths of mid legs; segments 3–7 with 13–22 ventral bristle-like spines of irregular length.

Segment 8 with 3 long dorsal spurs on each side of midline; spiracle not visible; with 6–8 lateral bristle-like spines of irregular length; and ventral transverse row of 16 bristle-like spines on posterior margin.

Segment 9 with pair of short dorsal posterolateral processes; pair of still shorter ventral posterolateral processes; pair of very small posteroventral tubercles; and pair of small ventromedial tubercles; male with pair of larger, widely separated anteroventral tubercles.

Genus *Proctacanthus* Macquart

Key to known pupal cases of Nearctic species of *Proctacanthus*

1 Labral sheath with or without slight posterior keel; prothoracic spiracle on mostly smooth callosity; posterior mesothoracic callosity with 1–3 anterior swellings; abdominal spiracles semi-circular; abdominal segment 8 with 0–2 dorsal spurs; segment 9 lacking ventral posterolateral processes or with only minute processes 2

- Labral sheath with distinct posterior keel; prothoracic spiracle on rugose callosity; posterior mesothoracic callosity without anterior swellings; abdominal spiracles mostly elongate-oval (semi-circular *in P. philadelphicus*); abdominal segment 8 with 8–12 dorsal spurs; segment 9 with small but well-developed ventral posterolateral processes 3

2 Posterior antennal processes longer than anterior antennal processes; labral sheath with inverted V-shaped rugoseness; maxillary sheath without apical process; wing sheath with 4 small, median, tubercle-like swellings; abdominal segment 1 with dorsal transverse row of 20 spurs ..... *Proctacanthus hinei* Bromley

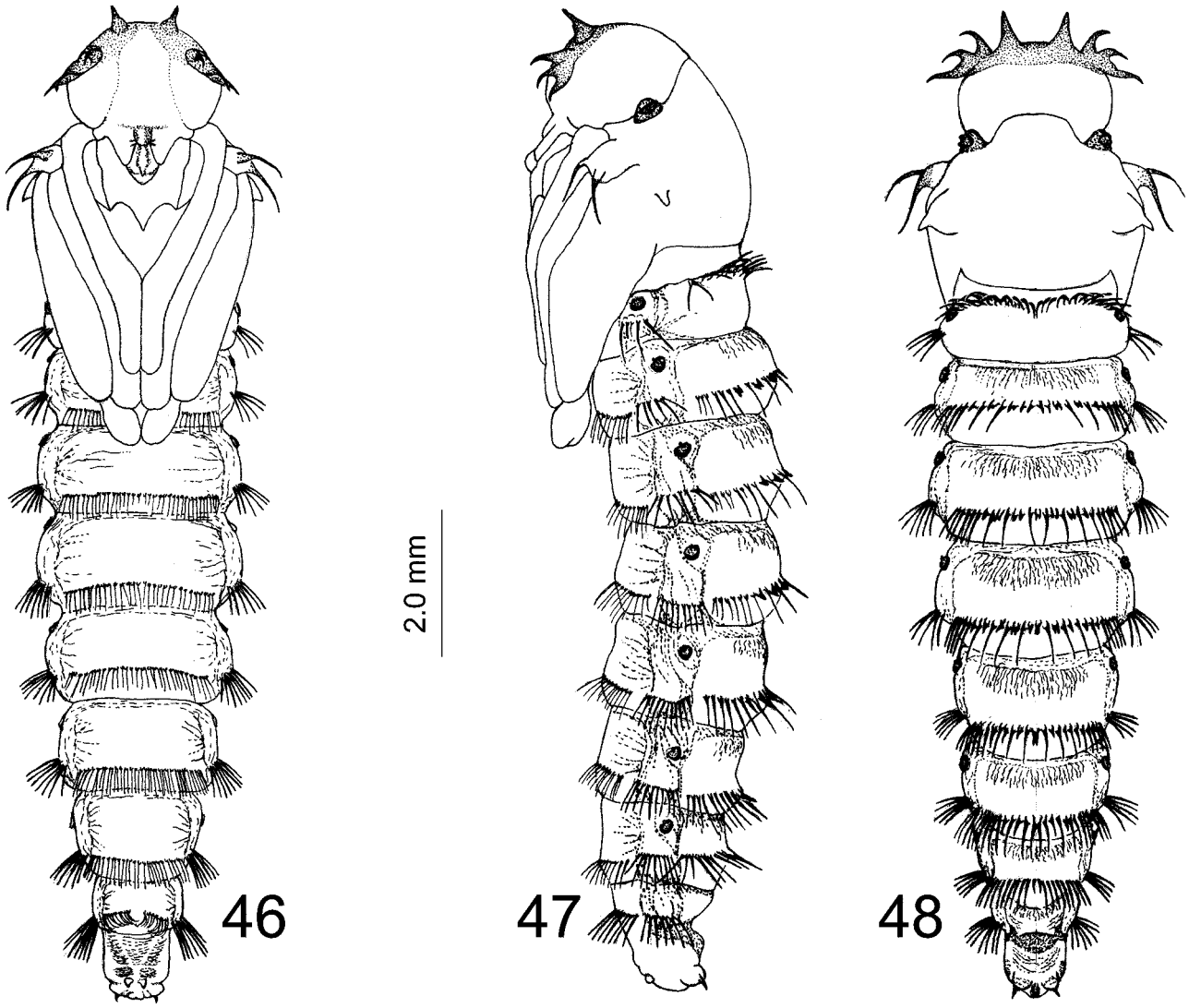
- Posterior antennal processes not longer than anterior antennal processes; labral sheath rugulose, but not inverted V-shaped; maxillary sheath with small, apically rounded process posteriorly; wing sheath with 1–2 small median tubercles; abdominal segment 1 with dorsal transverse row of 14–18 spurs .... *Proctacanthus rufus* Williston

3 Proboscial sheath with slight tubercle-like swelling on each side of midline anterior to median posterior tubercle; maxillary sheath with apically rounded posterior process .....*Proctacanthus milbertii* (Macquart)

- Proboscial sheath without tubercle-like swelling on each side of midline anterior to median posterior tubercle; maxillary sheath without apically rounded posterior process 4

4 Wing sheath with 2–3 basal tubercles, without tubercle-like projections in front of abdominal segment 1 and between basal tubercle and dorsum; abdominal segment 1 with dorsal transverse row of 17–21 spurs; segment 8 with 4–6 ventral bristle-like spines on each side and pair of median tubercles posterior to the spines ..... *Proctacanthus micans* Schiner

- Wing sheath with 1 basal tubercle and 1–3 tubercle-like projections in front of abdominal segment 1 and between basal tubercle and dorsum; abdominal segment 1 with dorsal transverse row of 25 spurs; segment 8 with 7–11 ventral bristle-like spines on each side and without median tubercles posterior to the spines.... ..... *Proctacanthus philadelphicus* Macquart



FIGURES 46–48. *Proctacanthus hinei* Bromley, 47. ventral view, 48. lateral view, 49. dorsal view.

***Proctacanthus hinei* Bromley**
(Figs 46–48)

The following description is based on a male pupal case with associated pinned adult from the Charles A. Triplehorn Insect Collection, Ohio State University. It is labeled "Sandusky, O., Cedar Point; July 13–03."

Description: Greatest length, including anterior antennal processes, 28.0mm; greatest width of thorax 6.0 mm; greatest width of abdomen, 4.5 mm, tapering to 2.0 mm at greatest width of abdominal segment 8. Integument subshining, golden brown; wing sheath slightly darker apically; spines and other processes glistening reddish brown, darker apically except for uniformly colored dorsal abdominal spines; bristle-like spines yellowish to yellowish red.

Head with pair of short, dorsally flattened, ventrally wedge-shaped, anterior antennal processes not joined at base and group of 3 basally fused, apically pointed, posterior antennal processes that are longer than anterior processes, located ventrolaterally on each side; middle and outer posterior processes subequal, longer than inner posterior process, curved posteriorly, fused for greater distance and slightly closer together than inner posterior process; inner posterior process apically curved posteriorly; outer posterior process with small, oval, flattened area on outer side basally toward dorsum. Labral sheath with inverted V-shaped rugoseness, slight apical keel, and median ridge along entire length. Proboscial sheath swollen and bulbous posteriorly, with large, swollen, rugose areas on each side of median shallow groove; with small tubercle at apex and smaller tubercles at base of sheath. Maxillary sheath rugose on inner margin, lacking apical processes, slightly swollen and very rugose just anterior to apex.

Anterior coxal sheath smooth to irregularly rugulose, with shallow pit on each side of midline just posterior to proboscial sheath; with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, on small, rounded, rugulose callosity, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of long, narrow, posteriorly curved, apically pointed spines above base of sheath of mid legs; posterior spine slightly longer and wider than anterior spine. Posterior mesothoracic callosity large, rugose, with apically rounded to acute posterior mesothoracic spine; spine dark reddish brown at margin; callosity with anteromedian swelling and 2 lateral swellings toward dorsum. Wing sheath irregularly rugulose, with basal swelling directly below posterior mesothoracic callosity and 4 median, small tubercle-like swellings. Thoracic area above wing sheath irregularly rugulose. Apex of hind leg sheath reaching between posterior margin of abdominal segment 2 and middle of abdominal segment 3.

Abdominal spiracles semi-circular, light reddish brown, elevated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 20 long, recurved spurs and 2 short median spurs; dorsolateral bristle-like spines absent; with 4 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–5 with 1–2 (usually 1) short, outer, dorsal spines and transverse row of 7 long, recurved spurs alternating with 5–6 short, straight spines; with pair of short, median spines; other short spines often bifurcate or trifurcate; short spines placed slightly anterior to long spurs, becoming longer posteriorly.

Segments 6–7 similar to 2–5, but short spines not furcate, and both spurs and spines more bristle-like. Segments 2–5 and 6–7 with 6–7 and 10–12 dorsolateral bristle-like spines, respectively; spines usually long, straight to slightly recurved; segments 2–7 with 8–13 long, mostly straight, lateral bristle-like spines behind each spiracle.

Segment 2 with 14–16 ventral bristle-like spines on each side of and extending under hind leg sheaths; segments 3–6 and 7 with 40–43 and 28 long, ventral bristle-like spines, respectively.

Segment 8 lacking dorsal spurs, with small spiracle at midline laterally, with 8–10 lateral bristle-like spines on each side and 13–16 ventral bristle-like spines on each side of midline curved toward midline.

Segment 9 with pair of short, narrow, straight, dorsal posterolateral processes on fairly large callosities, shallow lateromedian pit, and small lateral callosity; ventral posterolateral process absent; pair of rugose ven-

tral posterolateral callosities; pair of large, widely separated, reddish-brown, ventral tubercles with small lateral callosity on each side; pair of ventromedian rugose callosities anterior to tubercles; remainder of segment irregularly rugose.

***Proctacanthus micans* Schiner**

Pupal cases for *P. micans* were described by Dennis & Lavigne (1976a). A specimen deposited in the United States National Museum is labeled "Wheatland, Wyo.; VII-28, 1974; S. Dennis Collector." This description should include: abdominal spiracles elongate-oval to circular, light reddish brown and elevated along midline laterally; abdominal segment 9 with 2–4 low tubercles between pair of long, dorsoventrally flattened dorsal posterolateral processes; pair of very short, broad ventral posterolateral processes (previously called median lateral spines), that are not fused basally to the dorsal posterolateral processes, and pair of short ventromedian tubercle-like processes (previously called spine-like processes) that are as long as the ventral posterolateral processes.

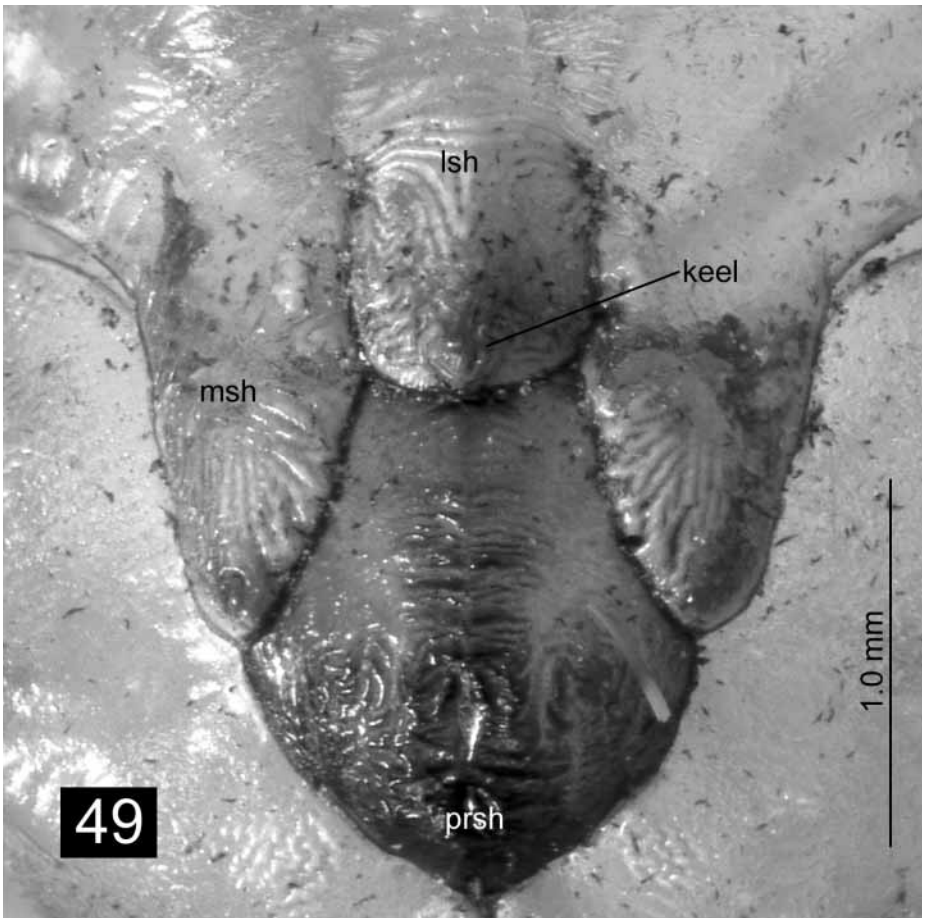


FIGURE 49. *Proctacanthus milbertii* Macquart, mouthpart sheaths. Abbreviations: lsh = labral sheath, msh = maxillary sheath, prsh = proboscial sheath.

***Proctacanthus milbertii* Macquart**
(Fig. 49)

The pupal case of *Proctacanthus milbertii* was described by Malloch (1915, 1917). It is redescribed here based on two male cases in the United States National Museum. These cases are both labeled "E. Lansing,

Mich.; SWB, S.W. Bromley Collection 1955" with the dates Aug. 11, 1939 and Aug. 18, 1939.

Redescription: Greatest length, including anterior antennal processes, 27.3–28.5 mm; greatest width of thorax 7.0–7.3 mm; greatest width of abdomen 5.8–6.0 mm, tapering to 2.8–3.0 mm at greatest width of abdominal segment 8. Integument subshining yellowish brown to golden brown; spines and other processes glistening reddish brown, sometimes darker apically or basally.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side, middle and outer posterior processes fused for greater distance, appearing closer together and slightly shorter than inner posterior process; outer posterior process broad for entire length and broadly rounded apically; inner and middle posterior processes becoming narrow and slightly more acute apically. Labral sheath very rugose, with tubercle-like keel posteriorly. Proboscial sheath rugose on each side of midline, with slight tubercle-like swelling posteriorly on each side of midline and small, ventrally concave tubercle on midline posteriorly. Maxillary sheath rugose, especially around posterior processes and along inner margin; with small, apically rounded process posteriorly and anterior tubercle on each side of labral sheath.

Anterior coxal sheath irregularly rugose, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, on large rugose callosity, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of subequal, straight to slightly posteriorly curved and apically rounded spines on each side of thorax above bases of sheaths of mid legs. Posterior mesothoracic callosity large, rugose, with apically rounded to acute posterior mesothoracic spine; margin of callosity toward dorsum sclerotized. Wing sheath irregularly rugose, with small tubercle at base and two larger median tubercles; tubercle toward venter usually larger than tubercle toward dorsum. Thoracic area above wing sheath irregularly rugulose. Apex of hind leg sheath reaching to posterior margin of abdominal segment 2.

Abdominal spiracles elongate-oval, light to dark reddish brown, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 20 long, apically recurved spurs; dorsolateral bristle-like spines absent; with 8–10 bristle-like spines of irregular size behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–5 with 2–4 short dorsolateral spines. Segments 6–7 with 1–3 short spines Segment 2 with 13–14 alternating dorsomedian long spurs and short spines; spines situated slightly anterior to spurs. Segments 3–7 similar to segment 2, with 11–13 alternating spurs and spines.

Segments 2–6 and 7 with 5–8 and 3–4 dorsolateral bristle-like spines, respectively, and 12–15 bristle-like spines behind each spiracle.

Segment 2 with 7–11 median ventral bristle-like spines on each side of, and sometimes extending under, hind leg sheath; segments 3–6 and 7 with 29–41 and 23–27 ventral bristle-like spines, respectively, several short spines interspersed among long spines.

Segment 8 with 4 dorsomedian spurs on each side of dorsal midline; small, dark brown spiracle at lateral midline; 4–8 lateral bristle-like spines on each side; and 7–9 ventromedian bristle-like spines on each side of ventral midline.

Segment 9 with 2 medium-length dorsal posterolateral processes curved inward toward each other, 2 short ventral posterolateral processes not fused basally to dorsal posterolateral processes, and pair of terminal ventromedian tubercle-like processes slightly anterior to ventral posterolateral processes.

***Proctacanthus philadelphicus* Macquart**

The pupal case of *P. philadelphicus* was briefly described by Packard (1870), Malloch (1917), and Bromley (1946). The following description is based on a male pupal case with associated pinned adult in the United States National Museum labeled "Crown Point, Ind.; IV-24-34; reared from *Lachnosterna*?; Luginbill &

Painter Col1s., 106" and two males with associated pinned adults from the Illinois Natural History Survey, both labeled simply "46349."

Redescription: Greatest length, including anterior antennal processes, 23.1–30.3 mm; greatest width of thorax 8.0–8.7 mm, greatest width of abdomen 6.5–6.8 mm, tapering to 2.7–3.1 mm at greatest width of abdominal segment 8. Integument subshining golden brown; wing sheath darker apically; spines and other processes glistening reddish brown, darker apically except for basally darker spurs; dorsal abdominal spines uniformly reddish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused, apically acute posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes closer together and fused for greater distance, appearing shorter than inner posterior process; outer posterior process wider for entire length than tapered inner and middle posterior processes; middle posterior process narrower than inner process. Labral sheath rugose, with rugose, tubercle-like keel posteriorly. Proboscial sheath rugose, especially on each side of midline, slightly bulbous and with ridge on each side of midline posteriorly; with small, median tubercle just posterior to ridges. Maxillary sheath rugose, with small, posterior tubercle on each side of proboscial sheath.

Anterior coxal sheath irregularly rugulose with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, facing posteriorly, situated on rugose callosity midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of wide spines above base of sheath of mid legs; posterior spine straight; anterior spine slightly curved posteriorly. Posterior mesothoracic callosity medium sized, rugose, with sclerotized ridges toward dorsum and small, apically rounded to acute posterior mesothoracic spine at base of each wing sheath. Wing sheath irregularly rugose, with small basal tubercle and pair of small, unequal median tubercles; with 1–3 tubercle-like projections in front of abdominal segment 1 and between basal tubercle and dorsum. Thoracic area above wing sheath irregularly rugulose. Apex of hind leg sheath reaching to about middle of abdominal segment 4.

Abdominal spiracles elongate-oval to semi-circular, raised slightly above surface, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 25 apically recurved spurs, some very short; outer spurs slightly shorter than others; dorsolateral bristle-like spines absent; with 8–9 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–4 with 3–4 short outer spines on each side and dorsal transverse row of 6 long, apically acute spurs alternating with 8 shorter, broad or acute spines; 9–10 dorsolateral bristle-like spines on each side; and 13–14 lateral bristle-like spines behind each spiracle.

Segment 5 similar to 2–4, but with 1–3 short outer spines, 11–12 dorsolateral bristle-like spines on each side, and 15–16 lateral bristle-like spines behind each spiracle.

Segments 6–7 with 1–2 short outer spines on each side and dorsal transverse row of 6 long spurs alternating with 5 shorter spines; segment 6 with 8 dorsolateral bristle-like spines on each side and 14 lateral bristle-like spines behind each spiracle; segment 7 with 3–4 dorsolateral bristle-like spines on each side and 12 lateral bristle-like spines behind each spiracle.

Segment 2 with 12–16 mostly long ventral bristle-like spines on each side of and extending under hind leg sheaths; segments 3–7 with complete transverse row of 32–45 mostly long ventral bristle-like spines, some spines crossing over each other; more posterior segments with fewer bristle-like spines.

Segment 8 with 4–5 dorsal spines on each side of dorsal midline, small spiracle at lateral midline, 5–6 lateral bristle-like spines on each side, and 7–11 bristle-like spines on each side of ventral midline.

Segment 9 with pair of long dorsal posterolateral processes curved toward each other; pair of short, straight ventral posterolateral processes not fused basally to dorsal posterolateral processes; pair of widely separated terminal ventromedian tubercles; pair of approximate ventromedian tubercles anterior to terminal tubercles; and pair of anterior ventromedian callosities touching basally and terminating in sclerotized, rug-

ose, tubercle-like area. Area bounded by dorsal and ventral posterolateral processes with pair of outer, dorsally tubercle-like ridges and 2–3 inner ridges on either side of midline.

Proctacanthus rufus Williston

The pupal case of *Proctacanthus rufus* was briefly described by Hine (1922). The following, more detailed description is based on four pupal cases from the United States National Museum. One male case with associated pinned adult is labeled " Ocean Grove, N.J.; issued July 11, '93; S.N. Dunning through C.V. Riley." Another male case is labeled "Clemson College, S.C.; VII, 17, '26; S.W. Bromley Collection 1955." One female case is labeled the same as the latter male case and another female case is labeled "Hampden, Conn.; VII, 8, '21; in sandy (soil); S.W. Bromley Collection 1955."

Redescription: Greatest length, including anterior antennal processes, ♂ 27.0–29.5 mm, ♀ 27.5–28.0 mm; greatest width of thorax, ♂ 5.5–6.5 mm, ♀ 6.5–7.0 mm; greatest width of abdomen, ♂ 5.0–5.5 mm, ♀ 5.0–6.5 mm, tapering to ♂ 2.5–3.0 mm and ♀ 2.5–3.0 mm at greatest width of abdominal segment 8. Integument subshining light to dark golden brown; processes light reddish brown, spines and spurs darker; processes, spurs, and spines darker apically; bristle-like spines uniformly light or dark reddish brown.

Head with pair of narrow, dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes ventrolaterally on each side; middle and outer posterior processes closer together and fused for greater distance, appearing shorter than inner posterior process; inner and outer posterior processes about same diameter; middle posterior process usually smaller; middle and inner posterior processes usually apically recurved more than outer posterior process. Labral sheath small, rugulose, with small keel posteriorly. Proboscial sheath slightly rugulose to rugose, with 2 bulbous, tubercle-like projections and small median tubercle posteriorly. Maxillary sheath with very small, apically rounded process posteriorly, posterior half rugose; rarely with rugulose area on each side of labral sheath.

Anterior coxal sheath irregularly rugose with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, on large, rugulose callosity midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of long, narrow, posteriorly curved and apically pointed spines above base of sheath of mid legs; posterior spine usually longer than anterior spine. Posterior mesothoracic callosity large, rugulose to almost smooth, with apically rounded to acute posterior mesothoracic spine and usually small anterior reddish-brown tubercle. Wing sheath irregularly rugose on anterior half, mostly rugose posteriorly, with or without small basal tubercle and with 1–2 small median tubercles. Thoracic area above wing sheath irregularly rugose. Apex of hind leg sheath reaching between posterior margin of abdominal segment 2 and middle of abdominal segment 3.

Abdominal spiracles semi-circular, light reddish brown, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 14–15 long, straight to apically recurved spurs in male, 17–18 spurs in females; dorsolateral bristle-like spines absent; with 3–4 bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–6 usually with dorsal transverse row of 11–15 alternating long, narrow, straight to apically recurved, acute spurs and short, broad, straight, bifurcate to quadrifurcate spines; with median pair of short spines sometimes fused basally; short spines becoming longer on more posterior segments.

Segment 7 with 9–10 alternating long spurs and shorter, narrow spines and 1–2 short median spines.

Segments 2–6 with 6–9 long dorsolateral bristle-like spines and 11–13 long lateral bristle-like spines of irregular size, but mostly long, behind each spiracle. Segment 7 with 5–6 dorsolateral bristle-like spines on each side and 8–10 bristle-like spines of uniform size behind each spiracle.

Segment 2 with 12–15 long and short ventral bristle-like spines on each side of and sometimes extending

under hind leg sheath; segments 3–6 and 7 with 31–41 and 24–34 long, straight to apically curved or recurved ventral bristle-like spines, respectively; 2–3 ventral bristle-like spines often very close together basally and crossing over each other apically, especially on posterior segments.

Segment 8 with 1 very small, dorsomedian spur on each side of midline on male cases; dorsal spurs absent on female; cases of both sexes with bulbous posterior area on each side of midline; with small spiracle at lateral midline; 10–12 lateral bristle-like spines on each side; 7–12 and 3–5 ventrolateral bristle-like spines on male and female cases, respectively; female cases with pair of large, median, rugose tubercles very close together between ventrolateral bristle-like spines; tubercles absent from male cases.

Segment 9 often with small dorsomedian tubercle on each side of midline, pair of long, straight dorsal posterolateral processes and usually pair of minute, rugose ventral posterolateral callosities; male with pair of large ventromedian tubercles; female with pair of very small ventromedian tubercles.

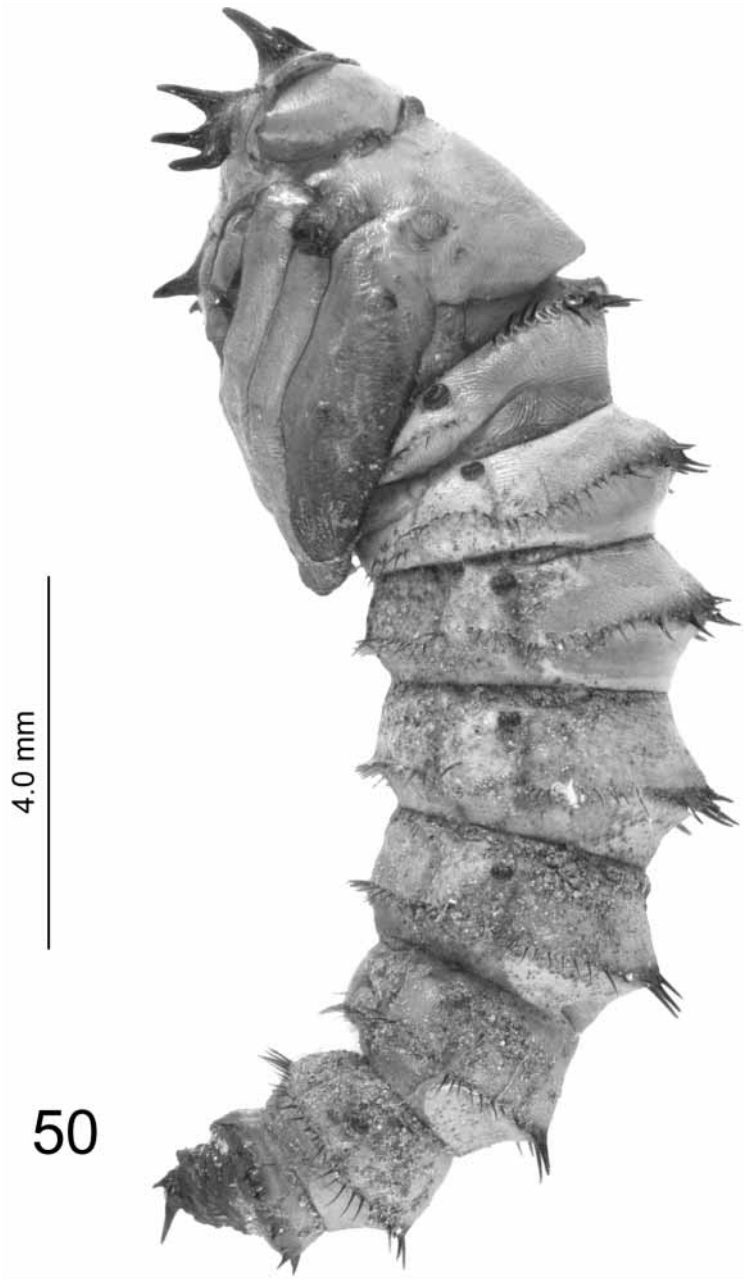


FIGURE 50. *Megaphorus guildiana* (Williston), lateral view.

Genus *Megaphorus* Bigot
***Megaphorus guildiana* (Williston)**
(Fig. 50)

A description of a male pupal case was given by Dennis & Lavigne (1976a) (as *Mallophorina guildiana* (Williston)). A specimen deposited in the United States National Museum is labeled "Jack Jones Pl., Wheatland, Wyo.; VII–29–1973; S. Dennis Collector." The description should include the following: abdominal spiracles reddish brown, elongate-oval, situated along midline laterally.

Genus *Neomochtherus* Osten Sacken

***Neomochtherus angustipennis* (Hine)**

Knutson (1972) described the pupal case of a male of this species. The description should include: abdominal spiracles elongate-oval to circular, reddish brown, elevated along midline laterally.

Genus *Machimus* Loew

Key to known pupal cases of Nearctic species of *Machimus*

1 Maxillary sheath sometimes with tubercle-like swelling on inner margin halfway between sheath tip and posterior margin of labral sheath; abdominal segment 8 with 1–4 dorsolateral spines 2
- Maxillary sheath without tubercle-like swelling; abdominal segment 8 without dorsolateral spines 4
2 Maxillary sheath with tubercle-like swelling; abdominal segment 8 with 2–8 dorsal spines 3
- Maxillary sheath with or without tubercle-like swelling; abdominal segment 8 without dorsal spines .... *Machimus lecythus* (Walker), new combination
3 Abdominal segments 2–6 with 6 long dorsal spurs alternating with 7 short, unforked spines; segment 8 with 2 dorsal spurs and 1–2 dorsolateral bristle-like spines; male with 16 ventral bristle-like spines .... *Machimus notatus* (Wiedemann)
- Abdominal segments 2–6 with 1–2 short outer spines on dorsum of each side and 6 long spurs alternating with 5–7 short spines which may be bifurcate; segment 8 with 4–8 (usually 6–8) dorsal spurs, 0–2 dorsolateral bristle-like spines; male with 1–9 ventral bristle-like spines ..... *Machimus paropus* (Walker)
4 Proboscial sheath with posterior groove, area of flattened cuticle, and small tubercle; abdominal segment 1 with 3–5 bristle-like spines behind each spiracle; segments 2–6 with 1–6 short, outer, dorsal spines on each side and 6 long spurs alternating with 5–9 short spines, which may be bifurcate; segment 7 with 0–1 short outer spine on each side and 4–6 long spurs alternating with 3–5 short spines; segment 8 with 4 dorsal spurs, 3–4 bristle-like spines behind each spiracle; male with 1–8 ventral bristle-like spines .... *Machimus snowii* (Hine)
- Proboscial sheath without distinct posterior groove, with indistinct or minute tubercle; abdominal segment 1 with 9–11 bristle-like spines behind each spiracle; segment 2 dorsally with 6 long spurs alternating with 7 short, non-bifurcate spines; segments 3–7 similar to 2 but with 1–2 outer short spines in addition to alternating long spurs and short spines; segment 8 with 2 dorsal spurs, 5–6 bristle-like spines behind each spiracle; male with 18 ventral bristle-like spines ..... *Machimus occidentalis* (Hine)

Because Scarbrough & Kuhar (1995) did not comment on the presence or absence of a tubercle-like swelling on the maxillary sheath of *M. erythocnemius* we were not able to include this species in the key. The pupal

cases appear to have 2–3 dorsolateral bristle-like spines on the eighth abdominal segment.

Machimus erythocnemius (Hine)

The pupal case of female *M. erythocnemius* was described by Scarbrough & Kuhar (1995) based on specimens from the United States National Museum. They indicated that the pupal cases are similar to *M. paropus*, but have wider spacing between the second and third posterior antennal processes. Abdominal segment 1 has 11 or 12 spurs. Segments 2–7 have alternating long spurs and short spines, and segment 8 has 6 "setae." *M. paropus* pupal cases have spaces between the posterior antennal processes that are equal or subequal. Abdominal segment 1 has 10 dorsal spurs. Long dorsal spurs alternate with pairs of short spines on segments 2–7, and segment 8 has only 2 dorsomedian bristle-like processes.

Machimus lecythus (Walker), new combination
(Fig. 51)

The following description is based on one male and two female pupal cases of *M. lecythus* with associated pinned adults from the United States National Museum. All three specimens are labeled "Agawam, Mass.; on 15 VI 15; H.E. Smith collector." The male is also labeled "W. Springfield No. 915342;" the two females bear similar labels, but with the numbers 915276 and 915332.

Martin & Wilcox (1965) listed this species among a total of 38 cataloged in the genus *Asilus* in North American north of Mexico. Martin (1975) transferred the species to *Eutolmus* (misspelled as *Eutolmerus*), and it thus became the only Nearctic representative of an otherwise Palaearctic genus. In their updated catalog of Nearctic robber flies, Fisher and Wilson (in litt.) have transferred 14 North American *Asilus* species to *Machimus*, including *A. lecythus*. They transferred the other species to *Dicropaltum*, *Negasilus*, *Neomochtherus*, *Polacantha*, *Prolatiforceps*, and *Wyliea*, leaving only *Asilus sericeus* Say in an otherwise widespread genus.

Description: Greatest length, including anterior antennal processes, ♂ 16.0 mm, ♀ 16.5–18.0 mm; greatest width of thorax ♂ 3.5 mm, ♀ 4.0 mm; greatest width of abdomen ♂ 3.3 mm, ♀ 3.5 mm, tapering to ♂ 1.0 mm and ♀ 1.0 mm at greatest width of abdominal segment 8. Integument subshining golden brown; spines and other processes glistening reddish brown, darker apically except for uniformly colored dorsal abdominal spurs and spines; bristle-like spines yellowish to yellowish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 subequal, basally fused posterior antennal processes located ventrolaterally on each side, middle and outer posterior processes closer together and fused for greater distance, appearing shorter than inner posterior process; outer posterior process wide entire length, apically blunt to more acute and with oval flat area, with an outer lip basally toward dorsum; inner and middle posterior processes tapering and rounded to more acute apically. Labral sheath rugose with posterior tubercle-like keel. Proboscial sheath smooth to rugulose posteriorly and on each side of midline; with shallow median groove posteriorly separated from small tubercle by area of flattened cuticle. Maxillary sheath rugulose on inner margin, otherwise smooth to irregularly rugulose; posterior processes absent, but sometimes with small tubercle-like swelling on inner margin near middle of proboscial sheath.

Anterior coxal sheath smooth to irregularly rugulose, especially on margins, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, directed somewhat posteriorly, on small callosity with small anterior ridge, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines apically acute, situated above bases of sheaths of mid legs; posterior spine straight, about 2 times as wide as and 1.5–2.0 times as long as posteriorly curved anterior spine. Posterior mesothoracic callosity smooth except for rugose

margin, with apically rounded to acute posterior mesothoracic spine. Wing sheath rugose on posterior third, irregularly rugose on anterior two-thirds; basal and median tubercles absent. Thoracic area above wing sheath irregularly rugulose. Apex of hind leg sheath reaching to middle of abdominal segment 3 in female, between middle and posterior margin of segment 3 in male.

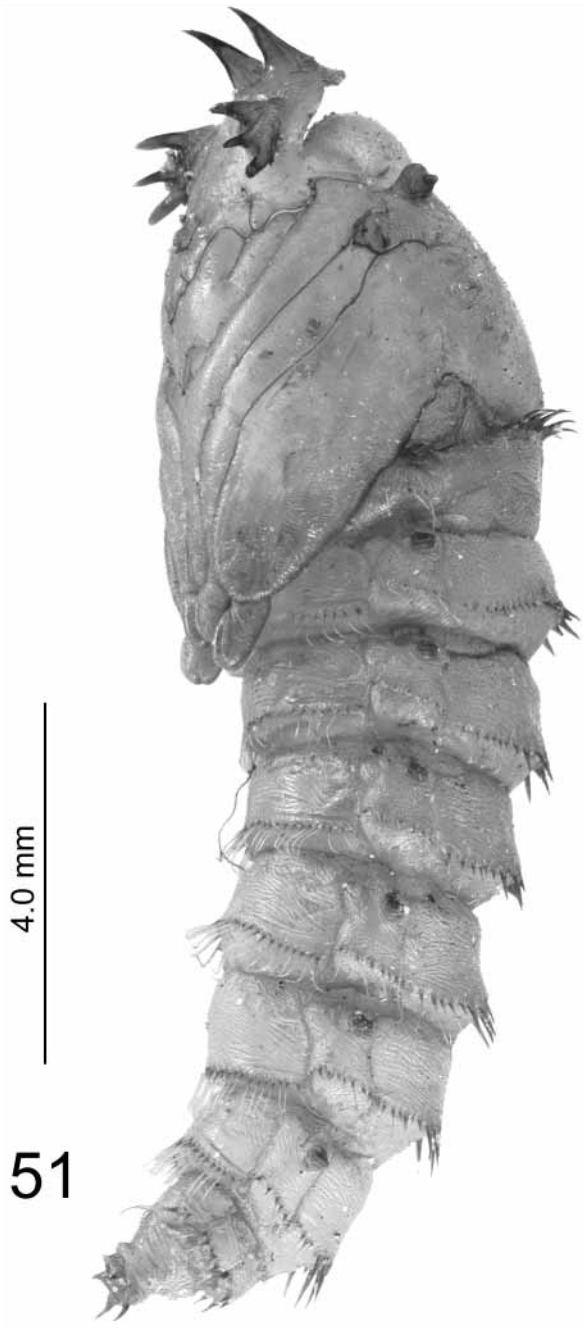


FIGURE 51. *Machimus lecythus* (Walker), lateral view.

Abdominal spiracles elongate-oval, reddish brown, elevated slightly along midline laterally.

Abdominal segment 1 with dorsal transverse row of 10–11 long, apically recurved spurs, sometimes with short outer spines; dorsolateral bristle-like spines absent; with 3 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–6 with 1–3 small, short dorsolateral spines on each side and dorsomedian row of 6 long, straight to slightly recurved, apically acute spurs alternating with 5 short, straight spines; spines apically blunt

on anterior segments and more acute on posterior segments; segment 7 similar to 2–6, but outermost short spine sometimes absent on 1 or both sides.

Segments 2–7 with 8–12 dorsolateral and 4–7 lateral, straight to apically recurved, unequal bristle-like spines on each side; with fewer bristle-like spines on progressively posterior segments.

Segment 2 with 7–9 recurved ventral bristle-like spines on each side of and extending under hind leg sheaths; segments 3–6 and 7 with complete ventral transverse row of 25–31 and 21–24 straight to apically recurved bristle-like spines, respectively.

Segment 8 of male with 1 long and 1 shorter dorsolateral reddish-brown spur on each side of dorsal midline; segment 8 of female with 1–2 subequal dorsolateral spurs on each side of dorsal midline; both male and female with small, reddish-brown spiracle at lateral midline; with 4–7 lateral bristle-like spines on each side; venter of male with transverse row of 17 bristle-like spines, with outer spines curved toward midline; venter of female with 1–2 ventrolateral bristle-like spines curved toward midline, outermost spines sometimes straight.

Segment 9 with pair of long, recurved dorsal posterolateral processes and pair of short, apically recurved ventral posterolateral processes. Female with pair of fairly long, approximate, terminal posteroventral tubercles; pair of low, basally fused ventromedian tubercles; and pair of low, basally fused tubercles at the junction of abdominal segments 8 and 9. Male with pair of widely separated terminal posteroventral processes, pair of widely separated ventromedian processes, and rugose area at junction of segments 8 and 9.

***Machimus notatus* (Wiedemann)**
(Fig. 52)

The pupal case of *Machimus notatus* was briefly described by Malloch (1915, 1917) and Bromley (1946) under the name *Asilus notatus* Wiedemann. The redescription presented here is based on a male pupal case with associated pinned adult from the United States National Museum. It is labeled "Staten Isl., N.Y.; VI, 17, '28; S.W. Bromley Collection 1955."

Redescription: Greatest length, including anterior antennal processes, 16.0 mm; greatest width of thorax 3.8 mm; greatest width of abdomen 3.5 mm, tapering to 1.0 mm at greatest width of abdominal segment 8. Integument subshining light yellow tan, head and thorax slightly darker; bristle-like spines pale yellowish; head processes light reddish brown; anterior antennal processes darker apically, posterior processes more uniformly colored; spines and other processes of abdominal segment 8–9 darker reddish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes; middle and outer posterior processes fused for greater distance, appearing slightly shorter than inner posterior process; outer posterior process apically pointed on inner margin, with flattened, basal, oval area toward dorsum projecting slightly posteriorly beyond process; inner and middle posterior processes apically rounded. Labral sheath small, slightly rugose, especially near posteromedian tubercle. Proboscial sheath laterally rugulose, with median groove posteriorly, slightly ridged on each side, with flattened area of cuticle between groove and small, round, terminal tubercle. Maxillary sheath rugose anteriorly, slightly rugulose posteriorly, with minute tubercle-like swelling on inside margin halfway between sheath tip and posterior margin of labral sheath.

Anterior coxal sheath mostly smooth, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, tilted posteriorly on small, smooth, anteriorly ridged callosity, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines subequal, short, apically acute, situated above base of sheath of mid legs; both spines directed posteriorly; anterior spine more curved on inner margin than posterior spine; posterior spine straight sided, at sharp angle to thoracic surface. Posterior mesothoracic callosity smooth, with apically rounded to acute posterior mesothoracic spine at base of each wing sheath. Wing sheath rugose on

posterior half. Thoracic area above wing sheath mostly smooth, except for rugoseness near posterior mesothoracic callosity. Apex of hind leg sheath reaching to middle of abdominal segment 3.

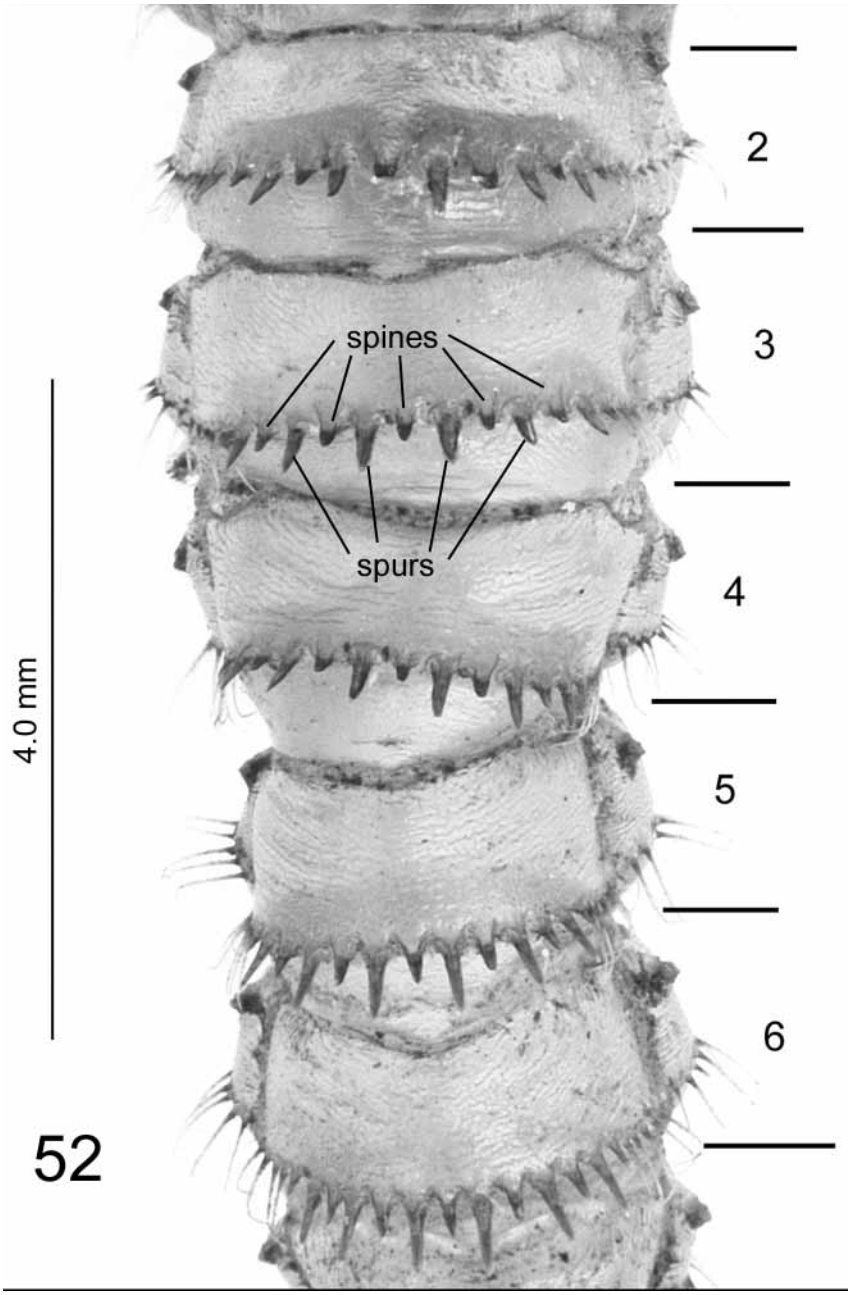


FIGURE 52. *Machimus notatus* (Wiedemann), abdominal segments 2–6, dorsal view.

Abdominal spiracles elongate-oval, reddish brown, similar to thoracic spiracles.

Abdominal segment 1 with dorsal transverse row of 10 long, apically recurved spurs, 2 median spines pointing laterally; dorsolateral bristle-like spines absent; with 5 bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–6 with dorsomedian transverse row of 6 long, straight spurs alternating with 7 short spines; segment 2 with short, apically blunt spines; segments 3–7 with spines apically rounded, similar to long spurs.

Segments 2–7 with 4–7 (usually 6–7) dorsolateral bristle-like spines and 5–9 (usually 7–9) lateral bristle-like spines behind each spiracle; dorsolateral and lateral bristle-like spines frequently bent at right angle apically.

Segment 2 with 8–11 straight to apically recurved bristle-like spines on each side of, and extending under, hind leg sheath; segments 3–5 with complete transverse row of 27–30 straight to apically recurved ventral bristle-like spines; segments 6 and 7 with 23 and 21 bristle-like spines, respectively.

Segment 8 with 1 dorsal spur on each side of midline, 1–2 dorsolateral spines, small reddish-brown spiracle at lateral midline, 5–6 lateral bristle-like spines on each side, and complete transverse row of 16 overlapping ventral bristle-like spines.

Segment 9 with pair of long dorsal posterolateral processes curved toward each other for entire length; pair of ventral posterolateral processes apically bent at a right angle toward each other, not fused basally to dorsal posterolateral processes; pair of approximate terminal posteroventral tubercles slightly anterior to ventral posterolateral processes, and pair of widely separated midventral tubercles.

Machimus occidentalis (Hine)

A male pupal case of this species was described by Dennis & Lavigne (1976a) under the heading "*M.* sp. either *callidus* (Williston) or *occidentalis* (Hine)." The specimen was subsequently deposited in the United States National Museum. It is labeled "Sherman Hill Estates, Laramie, WY; VII–10–72; S. Dennis Collector." We believe the pupal case is now correctly identified as *M. occidentalis.*

The description should be modified to include the following: outer posterior antennal processes with flattened, basal, oval area toward dorsum; posterior labral keel apically tubercle-like; prothoracic spiracle tilted posteriorly; segment 9 with pair of long dorsal posterolateral processes, pair of slightly shorter ventral posterolateral processes (previously described as mediolateral processes), and pair of short ventromedian tubercle-like processes.

Machimus paropus (Walker)

Scarbrough & Kuhar (1995) described the pupal case of *Machimus paropus* based on one case with pinned female labeled "Agawan [*sic*], Mass.; 20.VI.15; W. Springfield; H. E. Smith Coll., No 915348." The following, more detailed description is based on 16 pupal cases from the United States National Museum. Two male cases are labeled "Sioux City, Ia.; C.N. Ainslie Collector; A.E. Pritchard collection 1962" and "Lincoln Co., Me.; 18-VII-39; D. J. Borror; S. W. Bromley Collection 1955." Three male cases from Agawam, Massachusetts, collected by H. E. Smith, are further labeled "21 VI 15; W. Springfield No. 915274," "29 VI 15; W. Springfield No. 915262," and "15 VII 15; W. Springfield No. 915337." One female case is labeled "Beach, ND; Aug. 10, 1924; C.N. Ainslie Collector; A.E. Pritchard Collection 1962." Ten female cases from Agawam, Massachusetts, collected by H.E. Smith, are further labeled "15 VI 15; W. Springfield No. 915341," "21 VI 15; W. Springfield No. 915266," "21 VI 15; W. Springfield No. 915273," "21 VI 15; W. Springfield No. 915294," "21 VI 15; W. Springfield No. 915299," "21 VI 15; W. Springfield No. 915322," "24 VI 15; W. Springfield No. 915344," "2 VII 15; W. Springfield No. 915283," "5 VII 15; W. Springfield No. 915264, and "5 VII 15; W. Springfield No.915329."

Redescription: Greatest length, including anterior antennal processes, ♂ 12.0–14.5 mm, ♀ 13.0–16.5 mm; greatest width of thorax ♂ 3.0 mm, ♀ 2.8–3.3 mm; greatest width of abdomen ♂ 2.5 mm, ♀ 2.5–3.0 mm, tapering to ♂ 1.0–1.3 mm and ♀ 0.8–1.3 mm at greatest width of abdominal segment 8. Integument subshining, light yellow tan; head and thorax darker than abdomen; wing sheath often darker apically; spines and other processes glistening reddish brown, darker apically except for uniformly colored dorsal abdominal spurs and spines; bristle-like spines faded yellowish to light reddish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base

and group of 3 basally fused, subequal posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes fused for greater distance than inner posterior process; outer posterior process usually wider than other processes, straight, apically rounded, with small, oval, flattened outer area basally toward dorsum; inner and middle posterior processes sometimes slightly curved posteriorly, apically rounded to acute. Labral sheath small, mostly smooth or slightly rugulose near small tubercle-like keel and posterior margin. Proboscial sheath smooth or slightly rugulose medially on each side of midline, with shallow median groove posteriorly and small tubercle separated from groove by flattened area of cuticle. Maxillary sheath smooth or slightly rugulose on inner margins; posterior tubercles absent; sometimes with swellings below junction of labral and proboscial sheaths.

Anterior coxal sheath smooth or slightly rugulose, especially on margins, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, directed posteriorly on small callosity with small anterior ridge, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of long, subequal, apically acute, posteriorly curved spines above bases of mid leg sheaths; spines usually of same shape, but posterior spine sometimes broader and straighter than anterior spine. Posterior mesothoracic callosity small, smooth to slightly rugulose on margin, with small apically rounded posterior mesothoracic spine, situated at base of each wing sheath. Wing sheath mostly smooth to rugulose on apical third, otherwise irregularly rugulose; median and basal tubercles absent. Apex of hind leg sheath reaching between posterior margin of abdominal segment 2 and middle of abdominal segment 3.

Abdominal spiracles elevated, reddish brown, elongate, similar to thoracic spiracles, situated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 10–11 long, apically recurved spurs, each with anterobasal ridge; sometimes 2–3 spurs bifurcate; often with short spur on 1 or both sides or between long spurs; dorsolateral bristle-like spines absent; with 3–5 (usually 4–5) lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–6 with 1–2 short outer spines and dorsal transverse row of 6 long, straight to apically recurved spurs alternating with 5–7 short, straight spines; some short spines bifurcate or in pairs, especially on segments 2–3; with 4–9 (usually 4–7) dorsolateral, curved bristle-like spines on each side and 6–8 lateral, curved bristle-like spines behind each spiracle.

Segment 7 similar to 2–3, with row of alternating long spurs and short spines; with 3–5 dorsolateral bristle-like spines and 4–6 lateral bristle-like spines.

Segment 2 with 5–9 ventral bristle-like spines on each side of and often extending under hind leg sheaths; segments 3–6 and 7 with 21–26 and 15–20 ventral bristle-like spines, respectively; spines straight to apically recurved, sometimes bifurcate apically or shorter than surrounding bristle-like spines, appearing to be about equidistant from one another.

Segment 8 with 2–4 (usually 3–4) dorsal spurs on each side of dorsal midline, minute yellowish-brown spiracle at lateral midline, and 3–6 (usually 3–4) lateral bristle-like spines on each side; some spurs and spines apically recurved and sometimes bifurcate apically; female with 1 long, strongly recurved dorsolateral bristle-like spine and often 1–3 (usually 1–2) short outer dorsolateral bristle-like spines on each side; male venter highly variable, with 1 median spine or row of 5–9 spines.

Segment 9 of male and female cases similar to *M. snowii*, but female cases with slight swelling anterior to terminal posteroventral tubercles.

***Machimus snowii* (Hine)**
(Fig. 53)

Scarbrough & Kuhar (1995) described two male pupal cases of *Machimus snowii* from the University of Delaware Collection. The following, more detailed account is based on six pupal cases of *M. snowii* with pinned adults from the United States National Museum. Two males are labeled "Spencerville, Ont.; 23-VII-1938; J.M. Smith" and "Newcastle, Del.; 7/23/35; Donald MacGreary Collector; L-32; S.W. Bromley Collection." Four females are labeled "33, S.W. Bromley Collection," "Wellington, Kans.; E.G. Kelly Collector; Webster No. 5445; Cage No. 1867," " Whitesbog, N.J.; 5-3-15; bred specimen; 7-3-15; Quaintance No. 12625; H.K. Plank Collector," and "Reared from a larva maggot found in cranberry turf, maggot endured winter flooding in cranberry bog turf to May 1, 1916, emerged July 13, 1916, died naturally and was pinned July 29, 1916; S.W. Bromley Collection 1955."

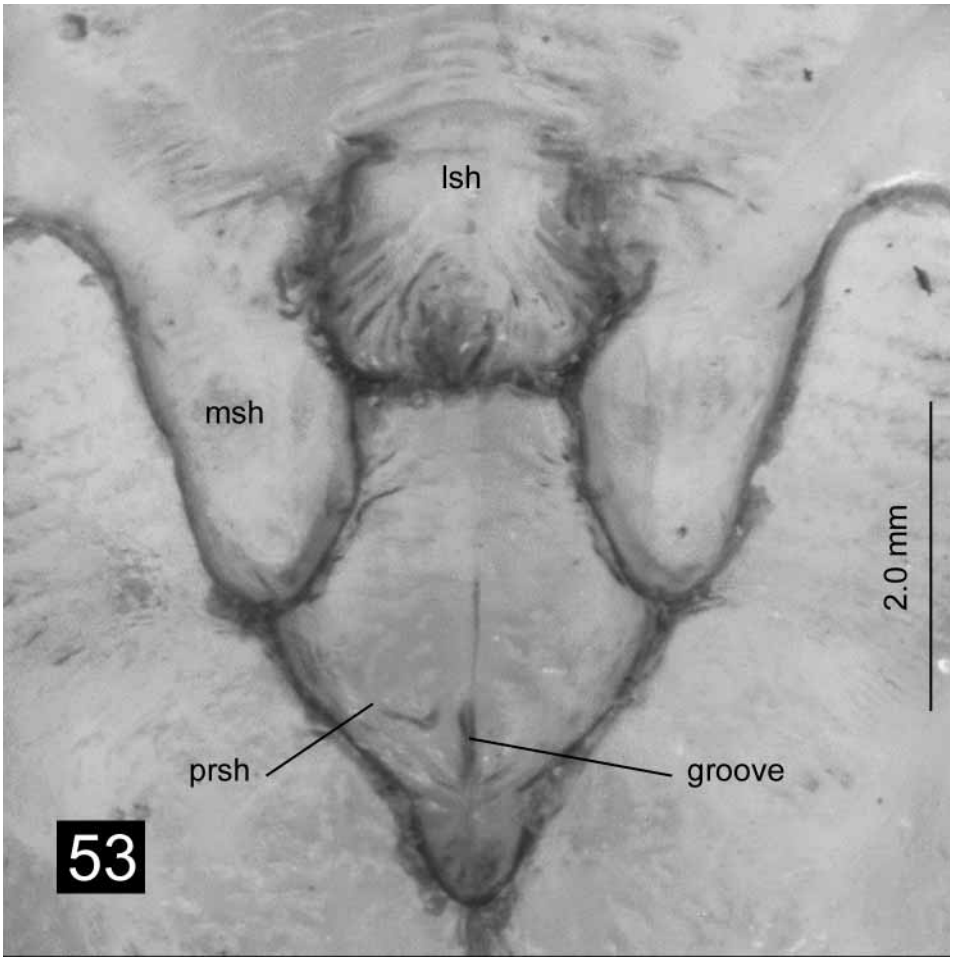


FIGURE 53. *Machimus snowii* (Hine), mouthpart sheaths. Abbreviations: lsh = labral sheath, msh = maxillary sheath, prsh = proboscial sheath.

Scarbrough & Kuhar (1995) note the following additional features for *M. paropus, M. snowii,* and *M. erythocnemius:* basal half or more of anterior antennal process and posterior antennal process rugose; paired thoracic spiracles and first abdominal spiracle reniform.

Redescription: Greatest length, including anterior antennal processes, ♂ 12.0–13.0 mm, ♀ 14.0–16.5 mm; greatest width of thorax ♂ 3.5 m, ♀ 3.0–3.5 mm; greatest width of abdomen ♂ 3.0 mm, ♀ 3.0–3.5 mm, tapering to ♂ 1.0–1.2 mm and ♀ 1.0–1.3 mm at greatest width of abdominal segment 8. Integument subshining yellow tan; wing sheath sometimes darker apically; spines and other processes glistening reddish brown, darker

apically, except for uniformly colored dorsal abdominal spurs and spines; bristle-like spines yellowish to yellowish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes closer together and fused for greater distance, appearing shorter than inner posterior process; inner and middle posterior processes apically rounded to more acute; outer posterior process often wider than inner and middle posterior processes and becoming more acute toward anterior margin, with oval flattened area basally toward dorsum. Labral sheath mostly smooth to slightly rugulose anteriorly and around tubercle-like posterior keel. Proboscial sheath smooth or minutely rugulose, with very shallow median groove posteriorly and small tubercle usually separated from groove by flattened area of cuticle. Maxillary sheath smooth to slightly rugulose along inner margin; posterior processes absent.

Anterior coxal sheath smooth or slight rugulose along inner margin and anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, on small, smooth callosity with small anterior ridge, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines consisting of pair of subequal, medium length, apically narrow, acute spines above bases of sheaths of mid legs; posterior spine basally wide and straight to slightly curved posteriorly; anterior spine not as basally wide as posterior process and usually strongly curved posteriorly. Posterior mesothoracic callosity smooth to slightly rugulose anteriorly and on margin toward dorsum; with apically rounded mesothoracic spine and often slight swelling toward dorsolateral margin. Wing sheath rugose on apical third, otherwise mostly smooth to irregularly rugulose. Thoracic area above wing sheath smooth to slightly rugulose. Apex of hind leg sheath usually reaching between posterior margin of abdominal segment 2 and middle of abdominal segment 3.

Abdominal spiracles reddish brown, elongate-oval similar to thoracic spiracles, along midline laterally.

Abdominal segment 1 with dorsal transverse row of 10–13 long, apically recurved spurs; some cases with 1 short outer spur on each side; dorsolateral bristle-like spines absent; with 3–5 recurved lateral bristle-like spines on each side; venter obscured by wing and leg sheaths.

Segments 2–6 with 1–6 (usually 1–3) short outer spines on each side and dorsal transverse row of 6 long, narrow, recurved spurs alternating with 5–9 short, wide, straight spines; short spines sometimes bifurcate or occurring in pairs, especially on segment 2, becoming narrower on more posterior segments; with 4–10 (usually 4–6) straight to apically recurved dorsolateral bristle-like spines on each side and 6–8 straight to recurved lateral bristle-like spines behind each spiracle.

Segment 7 without outer spines or with only 1 short outer spine on each side, with row of 4–6 long spurs alternating with 3–5 short, narrow spines; with 3–4 dorsolateral bristle-like spines and 5–7 lateral bristle-like spines.

Segment 2 with 7–11 long, recurved ventral bristle-like spines on each side of and sometimes slightly extending under hind leg sheath; segments 3–7 with complete transverse row of 23–29 straight to apically recurved bristle-like spines of irregular length.

Segment 8 usually with 1 long inner dorsal spur and 1 short outer dorsal spur on each side of dorsal midline, minute brown spiracle at lateral midline, and 3–4 lateral bristle-like spines; male with transverse row of 2–8 ventral bristle-like spines; female with 1 long, inner, recurved spine and 1 short outer spine on each side.

Segment 9 with pair of long, apically recurved dorsal posterolateral processes, pair of small ventral posterolateral processes about half length of dorsal posterolateral processes, and pair of apically reddish-brown, terminal posteroventral tubercles three-fourths length of ventral posterolateral processes; male with pair of small, widely separated ventromedian tubercles; female with pair of minute, approximate ventromedian swellings.

Genus *Asilus* Linnaeus

***Asilus sericeus* Say**
(Figs 54–56)

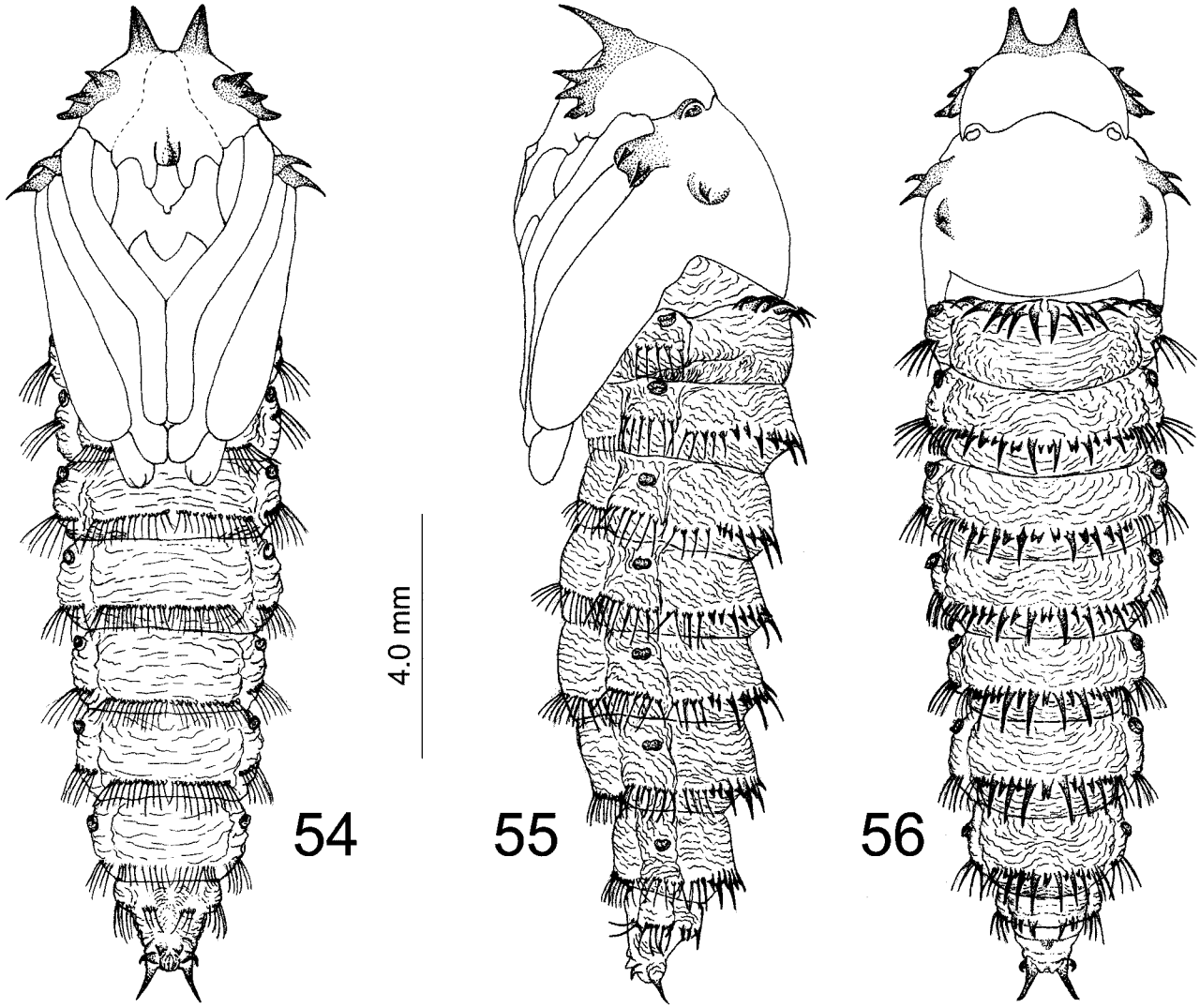


FIGURE 54–56. *Asilus sericeus* Say, 54. ventral view, 55. lateral view, 56. dorsal view.

A good description of an *Asilus sericeus* female pupal case was given by Malloch (1917). This species was also included in a key to the pupal cases of Connecticut robber flies by Bromley (1946). The following description is based on 3 male and 3 female pupal cases from the United States National Museum and 2 females from the Charles A. Triplehorn Insect Collection, Ohio State University. A male preserved in alcohol without an associated adult is labeled "*Asilus sericeus* Say; Stoughton, Mass.; May 1924; D. H. Blake coll." The other 2 male pupal cases and 2 females from the National Museum are pinned with adults and labeled "Stoughton, Mass.; June 1924; D. H. Blake coll." Among the Stoughton material collected in June 1924, one female case is pinned with an adult male and two male cases are pinned with adult females. The last National Museum female is labeled "Falls Church, Va.; May 13, 23; in earth under rotten manure; pupated May 16, 1923, emerged June 4, 1923." The 2 females from the Ohio collection are pinned with associated adults and labeled "Columbus, O.; issued 6.10.03."

Redescription: Greatest length, including anterior antennal processes, ♂ 14.5–15.5 mm, ♀ 14.5–20.00 mm; greatest width of thorax ♂ 3.5–4.0 mm; ♀ 3.5–5.0 mm; greatest width of abdomen ♂ 2.8–3.3 mm, ♀ 3.0–

4.3 mm, tapering to ♂ 1.0–1.5 mm and ♀ 1.0–2.0 mm at greatest width of abdominal segment 8. Integument subshining golden brown, wing and leg sheaths darker apically; spines and other processes glistening reddish brown, darker apically except for uniformly colored dorsal abdominal spines; bristle-like spines yellowish to yellowish brown.

Head with pair of dorsally flattened, ventrally wedge-shaped anterior antennal processes not joined at base and group of 3 basally fused posterior antennal processes located ventrolaterally on each side; middle and outer posterior processes closer together and fused for greater distance, appearing shorter than inner posterior process; inner posterior process usually somewhat thicker than middle and outer posterior processes; outer posterior process with posteriorly lipped, outer, oval flattened area toward dorsum; all 3 posterior processes apically rounded to acute, outer posterior process often more so anteriorly; 1 male with very small middle posterior process almost completely lying against outer posterior process and with small spine-like process between middle and inner posterior process. Labral sheath slightly rugulose, especially along midline, and with elongate, tubercle-like posterior keel. Proboscial sheath smooth to slightly rugulose on each side of midline, with very shallow median groove posteriorly and small tubercle separated from groove by area of flattened cuticle. Maxillary sheath smooth to rugose on inner margin, especially on each side of labral sheath; posterior and median processes or tubercles absent.

Anterior coxal sheath smooth to irregularly minutely rugulose, with anterior, median, longitudinal split. Prothoracic spiracle elongate-oval, directed posteriorly on small callosity with slight anterior ridge, situated midlaterally at anterior margin of thorax. Anterior mesothoracic spines long, subequal, posteriorly curved, situated above base of sheath of mid legs; posterior spine apically rounded, 2–3 times as wide as apically acute anterior spine. Posterior mesothoracic callosity smooth to irregularly rugulose near apically rounded posterior spine, usually irregularly rugulose to rugose on margin, at base of each wing sheath. Wing sheath rugose on posterior third, smooth to irregularly rugulose anteriorly; basal and median tubercles absent. Thoracic area above wing sheath smooth to irregularly rugulose. Apex of hind leg sheath reaching between middle and posterior margin of abdominal segment 3.

Abdominal spiracles reddish brown, elongate-oval, elevated along midline laterally.

Abdominal segment 1 with dorsal transverse row of 12–15 (usually 12) long, apically recurved spurs; sometimes with smaller spur between larger spurs, outer spurs sometimes slightly shorter than others; dorsolateral bristle-like spines absent; with 5–7 lateral bristle-like spines behind each spiracle; venter obscured by wing and leg sheaths.

Segments 2–5 with 1–4 short outer spines on each side and dorsomedian row of 6 long, straight to apically recurved spurs alternating with 4–6 short, straight spines; spines slightly anterior to spurs; median short spine sometimes bifurcate; segments 6–7 with row of 6 long spurs alternating with 7 short spines, with or without short, median, bifurcate spine.

Segments 2–6 with 4–7 (usually 4–5) dorsolateral bristle-like spines and 7–9 lateral bristle-like spines on each side; segment 7 with 2–7 dorsolateral bristle-like spines and 6–8 lateral bristle-like spines on each side; dorsolateral bristle-like spines usually subequal, straight to strongly recurved; lateral bristle-like spines of unequal size, straight to apically recurved.

Segment 2 with 6–8 bristle-like spines on each side of and extending slightly under hind leg sheath; segments 3–7 with complete transverse row of 22–30 ventral bristle-like spines; spines usually long, sometimes short, straight to apically recurved.

Segment 8 with 2 long dorsal spurs and rarely 1–2 dorsolateral bristle-like spines on each side of dorsal midline; small brown spiracle at lateral midline; with 3–5 lateral bristle-like spines on each side; male with median row of 12–16 ventral bristle-like spines; female with 1–2 ventral bristle-like spines on each side of midline.

Abdominal segment 9 with pair of long, recurved dorsal posterolateral processes; pair of short, apically recurved ventral posterolateral processes not fused to dorsal posterolateral processes; and pair of long, widely

separated terminal posteroventral processes not joined basally; male with pair of large, widely separated ventromedian tubercles; female lacking ventromedian tubercles.

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References

Alcock, J. (1974) Observations on the behavior of *Mallophara fautrix* Osten Sacken (Diptera: Asilidae). *Pan-Pacific Entomologist*, 50, 68–72.

Artigas, J.N. & Papavero, N. (1988) The American genera of Asilidae (Diptera): Keys for identification with an atlas of female spermathecae and other morphological details. II. Key to the genera of Dasypogoninae Macquart, with description of new genera and species and new synonymies. *Gayana Zoología*, 52, 199–260.

Barnes, J.K. (2008) Review of the genus *Ceraturgus* Wiedemann (Diptera: Asilidae) in North America north of Mexico. *Zootaxa*, 1766, 1–45.

Barraclough, D.A. & Londt, J.G.H. (1985) Order Diptera (Flies). *In*: Scholtz, C.H. & Holm, E. (Eds.), *Insects of Southern Africa*, Butterworth, Durban, pp. 283–381.

Barriga, T.J.E. (1990) Parasites and larval predators of Cerambycidae and Buprestidae (Coleoptera) of Chile. *Revista Chilena de Entomología*, 18, 57–60.

Brindle, A. (1962) Taxonomic notes on the larvae of British Diptera, 10 - The Asilidae. *Entomologist*, 95, 241–247.

Brindle, A. (1968) Taxonomic notes on the larvae of British Diptera. No. 25, The larva and pupa of *Dioctria rufipes* (De Geer) (Asilidae). *Entomologist*, 101, 213–216.

Brindle, A. (1969) Taxonomic notes on the larvae of British Diptera. No. 26, The presumed larva of *Dioctria oelandica* (Linnaeus) (Asilidae). *Entomologist*, 102, 3–6.

Bromley, S.W. (1946*)* Guide to the insects of Connecticut. Part VI. The Diptera or true flies of Connecticut. Third Fascicle. Asilidae. *Bulletin of the Connecticut State Geological and Natural History Survey Bulletin*, 69, 1–48.

Bullington, S.W. (1986) Two New Genera Related to *Laphria Meigen* (Diptera: Asilidae), With Revisions of the Included Species in North America North of Mexico. Doctoral dissertation, University of Wyoming, Laramie, Wyoming, 275 pp.

Bybee, S.M., Taylor, S.D., Nelson, C.R. & Whiting, M.F. (2004) A phylogeny of robber flies (Diptera: Asilidae) at the subfamilial level: molecular evidence. *Molecular Phylogenetics and Evolution*, 30, 789–797.

Candan, S., Suludere, Z., Hasbenli, A. Cagiran, N., Lavigne, R. & Scarbrough, A. (2004) Ultrastructure of the chorion of *Dioctria flavipennis* Meigen, 1820 (Diptera: Asilidae; Stenopogoninae) compared with those of fourteen asilid species from the mid-Atlantic region of North America. *Proceedings of the Entomological Society of Washington*, 106, 811–825.

Castillo, E.E., Jerez, V. & Artigas, J.N. (1994) Egg chorionic microsculpture in robber flies (Diptera Asilinae, Dasypogoninae, Laphriinae and Stenopogoninae). *Boletín de la Sociedad de Biología de Concepción*, 65, 107–116.

Cole, F.R. & Pritchard, A.E. (1964) The genus *Mallophora* and related asilid genera in North America (Diptera: Asil-

idae). *University of California Publications in Entomology*, 36, 43–100.
Comstock, J.H. (1925) *An Introduction to Entomology*, second edition. Comstock Publishing Co, Ithaca, New York, 1044 pp.
Copello, A. (1922) Biologia de "*Mallophora ruficauda*" (Wied.). *Physis*, 6, 30–42.
Copello, A. (1927) Biología de Moscardón cazador de abejas (*Mallophora ruficauda*, Wied.). *Argentina Ministry of Agriculture (Buenos Aires) Circular*, 699, 1–19.
Copello, A. (1942) Moscardón cazador de abejas "*Mallophora ruficauda*." *Revista de Apicultura, Argentina*, 19 (218), 4–5; (219), 10–11; (220), 13–14; (221), 14; (222), 12–13.
Daly, H.V., Doyen, J.T., & Purdell, A.H. (1998) *Introduction to Insect Biology and Diversity*, second edition. Oxford University Press, Oxford and New York, 680 pp.
Daniels, G. (1983) A new species of *Neoaratus* Ricardo (Diptera: Asilidae). *Journal of the Australian Entomological Society*, 22, 233–236.
Daniels, G. (1987) A revision of *Neoaratus* Ricardo, with the description of six allied new genera from the Australian Region (Diptera: Asilidae: Asilini). *Invertebrate Taxonomy*, 1, 473–592.
Dekhtiarev, N.S. (1929) Notes on the scarabaeid beetles attacking vines in Ukraine. *Bulletin of Entomological Research*, 20, 95–98.
Davis, J.J. (1919) Contributions to a knowledge of the natural enemies of *Phyllophaga*. *Illinois Natural History Survey Bulletin*, 13, 53–133.
Dennis, D.S. (1979) Ethology of *Holcocephala fusca* in Virginia (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 81, 366–378.
Dennis, D.S., Barnes, J.K. & Knutson, L. (2008) Description of the pupal case of *Mallophora atra* (Diptera: Asilidae) Macquart from South America. *Proceedings of the Entomological Society of Washington*, 110, 234–241.
Dennis, D.S. & Knutson, L. (1988) Descriptions of pupae of South American robber flies (Diptera: Asilidae). *Annals of the Entomological Society of America*, 81, 851–864.
Dennis, D.S. & Lavigne, R.J. (1975) Comparative behavior of Wyoming robber flies II (Diptera: Asilidae). *University of Wyoming Agriculture Experiment Station Science Monograph*, 30, 1–68.
Dennis, D.S. & Lavigne, R.J. (1976a) Descriptions and notes on the pupae and pupal cases of ten species of Wyoming robber flies (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 78, 277–303.
Dennis, D.S. & Lavigne, R.J. (1976b) Ethology of *Efferia varipes* with comments on species coexistence (Diptera: Asilidae). *Journal of the Kansas Entomological Society*, 49, 48–62.
Dennis, D.S. & Lavigne, R.J.(1976c) Ethology of *Leptogaster parvoclava* in Wyoming (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 78, 208–222.
Dennis, D.S. & Lavigne, R.J. (1976d) Oviposition of *Cyrtopogon inversus* (Diptera: Asilidae). *Pan-Pacific Entomologist*, 52, 288–290.
Dennis, D.S. & Lavigne, R.J. (1979) Ethology of *Machimus callidus* with incidental observations on *M. occidentalis* in Wyoming (Diptera: Asilidae). *Pan-Pacific Entomologist*, 55, 208–221.
Dennis, D.S. & Lavigne, R.J. (2007) Hymenoptera as prey of robber flies (Diptera: Asilidae) with new prey records. *Journal of the Entomological Research Society*, 9, 23–42.
Dennis, D.S., Lavigne, R.J. & Bullington, S.W. (1986) Ethology of *Efferia cressoni* with a review of the comparative ethology of the genus (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 88, 42–55.
Dikow, T. (2003). Family-group names in the Asilidae (Diptera). *Studia Dipterologica*, 10, 459–471.
Dikow, T. (in press) Phylogeny of Asilidae inferred from morphological characters of imagines (Insecta: Diptera: Brachycera: Asiloidea). *Bulletin of the American Museum of Natural History.*
Dikow, T. & Geller-Grimm, F. (2004) Information on robber fly phylogeny: introduction with a brief history of former studies. Available at: http://www.geller-grimm.de/genera19.htm (accessed 22 June 2007).
Esipenko, P.A. (1967) Biology of the robber fly *Eutolmus rufibarbis* Mg. (Diptera, Asilidae) in Khabarovsk Territory. *Entomological Review*, 46, 61–62.
Esipenko, P.A. (1973) The biology of *Leptogaster cylindrica* DeG. (Diptera, Asilidae) in the Khabarovsk Territory. *In*: Ivliev, L.A. (Ed.), Entomological Researches in the Far East. Issue 2. Diptera of the Far East. *Trudy-Biologo-pochvennogo-Instituta, Dal'nevostochnyl-Nauchnyl-Tsentr, Akademiya-Nauk,-SSSR*, 5, 130–134 (in Russian).
Fisher, E.M. (1983) *Pilica formidolosa* (Mosca Asesina, Robber Fly). *In*: Janzen, D.H. (Ed.), *Costa Rican Natural History.* University of Chicago Press, Chicago, pp. 755–758.
Foote, B.A. & Dennis, S. (1991) Asilidae (Asiloidea). *In*: Stehr, F.W. (Ed.), *Immature Insects, Volume 2*. Kendall/Hunt Publishing Company, Dubuque, Iowa, pp. 778–780.
Geller-Grimm, F. (2003) A world catalogue of the genera of the family Asilidae (Diptera). *Studia Dipterologica*, 10, 473–526.
Geller-Grimm, F. (2004) Key to the subfamilies of Asilidae (Diptera) after Artigas and Papavero, 1988. Available from http://www.geller-grimm.de/subfam.htm (accessed 22 June 2007).
Greene, C.T. (1917) A contribution to the biology of North American Diptera. *Proceedings of the Entomological Society*

of Washington, 19, 146–161.
Hauser, M. & Irwin, M.E. (2003) The Nearctic genus *Ammonaios* Irwin and Lyneborg 1981. *Annals of the Entomological Society of America*, 96, 738–748.
Hennig, W. (1952) *Die Larvenformen der Dipteren. 3. Teil.* Akademie-Verlag, Berlin, 628 pp.
Hine, J. S. (1922) Some robberflies in the University of Michigan Museum of Zoology, and the description of a new species. *Occasional Papers of the Museum of Zoology (University of Michigan, Ann Arbor)*, 121, 1–7.
Hudson, G.V. (1892) *An elementary manual of New Zealand entomology. Being an introduction of our native insects.* West, Newman, & Co., London, 128 pp.
Hull, F.M. (1962) Robber flies of the world: the genera of the family Asilidae. *United States National Museum Bulletin*, 224, 1–907.
Irwin-Smith, V. (1923) Studies in life histories of Australian Diptera Brachycera. Part II. Asilidae. No. 1. Catalogue of the species of Asilidae of which the earlier stages have been recorded, with literary index, and bibliography of biological literature. *Proceedings of the Linnean Society of New South Wales*, 48, 368–374.
Keilin, D. (1944) Respiratory systems and respiratory adaptations in larvae and pupae of Diptera. *Parasitology*, 36, 1–66.
Kinoshita, E. (1940) Untersuchungen über die Yesoraubfliege *Promachus yesonicus* Bigot unter Berücksichtigung des Forstschutzes. *Journal of Faculty of Agriculture, Hokkaido University*, 40, 171–270.
Knutson, L. (1972) Pupa of *Neomochtherus angustipennis* (Hine), with notes on feeding habits of robber flies and a review of publications on morphology of immature stages (Diptera: Asilidae). *Proceedings of the Biological Society of Washington*, 85, 163–178.
Knutson, L. (1976) Key to subfamilies of robber flies based on pupal cases, with a description of the pupal case of *Doryclus distendens* (Asilidae: Megapodinae). *Proceedings of the Biological Society of Washington*, 88, 509–514.
Krivosheina, N. P. (1973) Larvae and pupae of robber flies from the genus *Laphystia* Lw. (Diptera, Asilidae). *Zoologicheskii Zhurnal*, 52, 457–459 (in Russian).
Krivosheina, N.P. (1974) Larvae of robber flies (Asilidae, Ctenotini) - root inhabitants of desert plants. *Biologicheski Nauki* (Moscow), 17, 16–21 (in Russian).
Krivosheina, N.P. & Mamev, B.M. (1973) Larvae of assassin flies of the tribe Andrenosomini (Diptera, Asilidae) as xylophilous forms. *Biologicheski Nauki* (Moscow), 16, 20–23. (In Russian.)
Krivosheina, N. P. & Mamev, B.M. (1975a.) Revision of materials on morphology and ecology of xylophilic larvae of assassin flies of the Laphriini tribe (Diptera, Asilidae). *Vestnik Zoologii*, 2, 66–72 (in Russian).
Krivosheina, N.P. & Mamev, B.M. (1975b) Revision of materials on morphology and ecology of xylophilic assassin fly larvae of the tribe, Laphriini (Diptera, Asilidae). Communication II. Genus *Laphria* Mg. *Vestnik Zoologii*, 6, 46–50 (in Russian).
Kurkina, L.A. (1979) The biology of *Machimus annulipes* (Diptera, Asilidae). *Entomological Review*, 58, 26–30.
Lavigne, R.J. (1972) Ethology of *Ablautus rufotibialis* on the Pawnee Grasslands IBP site. *Journal of the Kansas Entomological Society*, 45, 271–274.
Lavigne, R.J. (1979) Notes on the ethology of *Efferia argyrogaster* (Diptera: Asilidae) in Mexico. *Proceedings of the Entomological Society of Washington*, 81, 544–551.
Lavigne, R.J. (1984) Ethology of *Neocerdistus acutangulatus* (Diptera: Asilidae) in South Australia. *Proceedings of the Entomological Society of Washington*, 86, 422–431.
Lavigne, R.J. (2002) Evolution of courtship behaviour among the Asilidae (Diptera), with a review of courtship and mating. *Studia dipterologica*, 9, 703–742.
Lavigne, R.J. (2003) Provisional checklist of the Asilidae (Insecta: Diptera) of South Australia, utilising an updated subfamily classification. *Records of the South Australian Museum*, 36, 189–194.
Lavigne, R.J. & Bullington, S.W. (1984) Ethology of *Laphria fernaldi* (Back) (Diptera: Asilidae) in southeast Wyoming. *Proceedings of the Entomological Society of Washington*, 86, 326–336.
Lavigne, R.J. & Dennis, D.S. (1975) Ethology of *Efferia frewingi* (Diptera: Asilidae). *Annals of the Entomological Society of America*, 68, 992–996.
Lavigne, R.J. & Dennis, D.S. (1985) Ethology of three coexisting species of *Efferia* in Mexico (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 87, 146–160.
Lavigne, R.J., Dennis, D.S. & Gowen, J.A. (1978) Asilid literature update 1956–1976. *University of Wyoming Agriculture Experiment Station Science Monograph*, 36, 1–134 .
Lavigne, R.J. & Holland. F.R. (1969) Comparative behavior of eleven species of Wyoming robber flies (Diptera: Asilidae). *University of Wyoming Agriculture Experiment Station Science Monograph*, 18, 1–61.
Lawson, F.A. & Lavigne, R.J. (1984) Oviposition and eggs of an Australian robber fly, *Neoaratus abludo* Daniels (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 86, 773–776.
Lehr, P.A. (1958) The biology of a robber fly feeding on acridids. *Doklady Kazakhstan Akademi selskokhoz Nauk (Alma-Ata)*, 3, 16–23. (In Russian).
Lehr, P.A. (1964) On the nutrition and significance of robber flies. *Trudy Kazackskogonauchno-issledovatel'skogo Instituta Zashchita Rastenii (Kasakhstan Academy Sel Nauk, Alma-Ata)*, 8, 213–244 (in Russian).

Lehr, P.A. (1969) An ecological and morphological analysis of the robber flies (Dipt., Asilidae), Communication II. *Entomological Review*, 48: 341–357.
Lehr, P.A. (1977) Robber flies from the subfamilies Atomosiinae and Laphriinae (Diptera, Asilidae) from Central Asia and Kazakhstan. *Entomological Review*, 56, 123–131.
Lehr, P.A. (1996) Robber flies of subfamily Asilinae (Diptera, Asilidae) of Palearctic: Ecological and mophological analysis, taxonomy and evolution. Dalnauka, Vladivostok. 184 pp. (In Russian.)
Londt, J.G.H. (1986) *Gibbasilus arenaceus*, a new genus and species from western Cape Province of South Africa (Diptera: Asilidae: Asilinae). *Journal of the Entomological Society of Southern Africa*, 49, 1–6.
Londt, J.G.H. & Harris, M. S. (1987) Notes on the biology and immature stages of *Neolophonotus dichaetus* Hull in South Africa. *Journal of the Entomological Society of Southern Africa*, 50, 427–434.
Malloch, J.R. **(**1915) Some additional records of Chironomidae for Illinois and notes on other Illinois Diptera. *Bulletin of the Illinois State Laboratory of Natural History*, 11, 305–363.
Malloch, J.R. (1916) A comparison of the pupae of *Promachus vertebratus* and *Promachus fitchi*. *Bulletin of the Brooklyn Entomological Society*, 11, 66–68.
Malloch, J.R. (1917) A preliminary classification of Diptera, exclusive of Pupipara, based upon larval and pupal characters, with keys to imagines in certain families. Part 1. *Bulletin of the Illinois State Laboratory of Natural History*, 12, 161–409.
Martin, C.H. (1957) A revision of the Leptogastrinae in the United States (Diptera, Asilidae). *Bulletin of the American Museum of Natural History*, 111, 347–385.
Martin, C.H. (1968) The new family Leptogastridae (The Grass Flies) compared with the Asilidae (robber flies) (Diptera). *Journal of the Kansas Entomological Society*, 41, 70–100.
Martin, C.H. (1975) The generic and specific characters of four old and six new Asilini genera in the western United States, Mexico, and Central America (Diptera: Asilidae). *Occasional Papers of the California Academy of Sciences*, 119, 1–107.
Martin, C.H. &. Wilcox, J. (1965) Family Asilidae. *In*: Stone, A., Sabrosky, C.W., Wirth, W.W., Foote, R.H., & Coulson, J.R. (Eds.), *A Catalog of Diptera of North America. United States Department of Agriculture Handbook*, 276, 360–401.
McAlpine, J.F. (1981) Morphology and terminology – Adults. *In*: McAlpine, J.F., Peterson, B.V., Shewell, G.E., Teskey, H.J., Vockeroth, J.R., & Wood, D.M. (Coordinators), *Manual of Nearctic Diptera*, volume 1. Research Branch, Agriculture Canada, Monograph 27, pp. 9–63.
Melin, D. (1923) Contributions to the knowledge of the biology, metamorphosis and distribution of the Swedish asilids in relation to the whole family of asilids. *Zoologiska Bidrag från Uppsala*, 8, 1–317.
Musso, J.J. (1967) Étude de la nymphe *d'Andrenosoma bayardi* Séguy, 1952 (Dipt. Asilidae). *Bulletin de la Société entomologique de France*, 72, 75–80.
Musso, J.J. (1978) Recherches sur le développement, la nutrition et 1'ecologia des Asilidae (Diptera-Brachycera). Doctoral Dissertation, Universite de Droit, d'Economie et des Sciences d'Aix-Marseille. 312 pp.
Musso, J.J. (1981) Morphology and development of the immature stages of some robber flies. (Diptera: Brachycera: Asilidae). *Entomologia Generalis*, 7, 89–104.
Oldroyd, H. (1939) A note on the pupa of *Andrenosoma albopilosum* Villn. (Diptera: Asilidae). *Proceedings of the Royal Entomological Society of London (A)*, 14, 7–8.
Osten Sacken, C.R. (1878) Catalogue of the described Diptera of North America, second edition. *Smithsonian Miscellaneous Collections*, 270, 1–276.
Osterberger, B.A. (1930) *Erax interruptus* Macq. as a predator. *Journal of Economic Entomology*, 23, 709–711.
Packard, A.S. (1870) Injurious insects, new and little known. Note: Habits of an *Asilus* fly; pupae of *Proctacanthus philadelphicus*. *Annual Report of the Massachusetts Board of Agriculture*, 1870, 1–31.
Papavero, N. (1973) Studies of Asilidae (Diptera) systematics and evolution. I. A preliminary classification in subfamilies. *Arquivos de Zoologia* (São Paulo), 23, 217–274.
Parmenter, L. (1952) The pupa of *Isopogon brevirostris* Meigen (Diptera, Asilidae). *Proceedings of the Royal Entomological Society of London*, 27, 43-44.
Poole, R. W. (1996) Diptera, pp. 15-604. *In*: Poole, R. W. & Gentili, P (Eds). *Nomina Insecta Nearctica: A Check List of the Insects of North Americ*a. *Volume 3. Diptera, Lepidoptera, Siphonaptera.* Entomological Information Services, Rockville, Maryland. 1143 pp.
Quentin, R. M. (1948) Sur la nymphe de *Laphria gilva* L. (Dipt. Asilidae). *L'Entomologiste*, 4, 9–10.
Riley, C.V. (1870) *Second Annual Report on the Noxious, Beneficial and Other Insects of the State of Missouri*. Missouri State Board of Agriculture, Jefferson City, Missouri, 135 pp.
Scarbrough, A.G. (1978) Ethology of *Cerotainia albipilosa* Curran (Diptera: Asilidae) in Maryland: courtship, mating and oviposition. *Proceedings of the Entomological Society of Washington*, 80, 179–190.
Scarbrough, A.G. (1981) Ethology of *Eudioctria tibialis* Banks (Diptera: Asilidae) in Maryland: reproductive behavior. *Proceedings of the Entomological Society of Washington*, 83, 432–443.

Scarbrough, A.G. & Kuhar, T.P. (1995) Pupal cases of *Machimus* Loew in Maryland (Diptera: Asilidae). *Maryland Entomologist*, 4, 15–22.
Scarbrough, A.G. & Sipes, G. (1973) The biology of *Leptogaster flavipes* Loew in Maryland (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 75, 441–448.
Séguy, E. (1927) Faune *de France. 17. Diptères (Brachycères) (Asilidae)*. Fédération Française des Sociétés de Sciences Naturelles, Office Central de Faunistique, Paris, 190 pp.
Shelly, T.E. (1985) Observations on the reproductive behavior of two neotropical robber fly species (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 87, 253–254.
Skidmore, P. (1966) Asilidae (Diptera) of northern England. *Entomological Record and Journal of Variation*, 78, 230–235, 257–266.
Stubbs, A.E. & Drake, M. (2001) *British soldierflies and their allies. An illustrated guide to their identification and ecology, covering all flies (Diptera) in the families Acroceridae, Asilidae, Athericidae, Bombyliidae, Rhagionidae, Scenopinidae, Stratiomyidae, Tabanidae, Therevidae, Xylomyidae and Xylophagidae*. British Entomological and Natural History Society, Reading, 512 pp.
Suludere, Z., Candan, S., Kalender, Y., & Hasbenli, A. (2000) Ultrastructure of the chorion of *Machimus rusticus* (Meigen, 1820) (Diptera, Asilidae). *Journal of the Entomological Research Society*, 2, 63–71.
Thorpe, W.H. (1927) The larvae and pupae of the genus *Hyperechia* (Diptera, Asilidae). *Transactions of the Entomological Society of London*, 75, 177–185.
Tsacas, L., Desmier de Chenon, R. & Coutin, R. (1970) Observations sur le parasitisme larvaire d'*Hyperechia bomboides* (Dipt. Asilidae). *Annales de la Société entomologique de France*, 6, 493–572.
Weber, G.S. & Lavigne, R. (2004) Notes on the behaviour of *Blepharotes coriarius* (Wiedemann, 1830) (Diptera: Asilidae) with a description of the pupal case. *Studia dipterologica*, 11, 13–21.
Wei, X., Xu, X., & DeLoach, C.J. (1995) Biological control of the white grubs (Coleoptera: Scarabaeidae) by larvae of *Promachus yesonicus* (Diptera: Asilidae) in China. *Biological Control*, 5, 290–296.
Wilcox, J. (1935) Description of the male of *Willistonina bilineata* (Williston) together with a new form (Diptera-Asilidae). *Pan-Pacific Entomologist*, 11, 31–34.
Wilcox, J. (1936) New *Ommatius* with a key to the species (Diptera: Asilidae). *Bulletin of the Brooklyn Entomological Society*, 31, 172–177.
Wood, G.C. (1981) Asilidae. *In*: McAlpine, J.F., Peterson, B.V., Shewell, G.E., Vockeroth, J.R. & Wood, D.M. (Coordinators), *Manual of Nearctic Diptera*, Volume 1, Research Branch, Agriculture Canada, Monograph 27, 549–573.
Zinov'eva, L.A. (1959) Biology and ecology of robber flies (Diptera, Asilidae) in the Naryn Sands. *Entomological Review*, 38, 499–511.