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The Pupal Case of a Nearctic and Neotropical Robber Fly, *Andrenosoma cruentum* (McAtee, 1919) (Diptera: Asilidae)

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ABSTRACT

The pupal case of the Nearctic and Neotropical robber fly, *Andrenosoma cruentum* (McAtee, 1919), is described, illustrated, and compared with the pupal cases of three Palearctic species of *Andrenosoma.*

Key words: Andrenosomatini, Asiloidea, Brachycera, Immature Diptera, Insecta, Laphriinae.

INTRODUCTION

Andrenosoma is the largest genus of the tribe Andrenosomatini in subfamily Laphriinae. Species occur in all zoogeographic regions of the world. The genus is most speciose in the Neotropical, Palearctic and Nearctic regions with 38, 14, and 6 species, respectively (Geller-Grimm, 2012). Hull (1962) pointed out that *Andrenosoma* has a wide, scattered distribution, without a regional concentration. However, Fisher (2009) stated that "… the concepts traditionally used to define the genus (e.g. Hull, 1962) render it to be paraphyletic, and eventually *Andrenosoma* will probably have to be restricted to a small core of Palearctic species closely related to the type of the genus, *A. atrum* (Linnaeus, 1758)…"

Andrenosoma cruentum (McAtee, 1919) is a species that has limited distribution in the Nearctic [extreme southern Florida (Miami, southwest through Florida Keys), United States of America (U.S.A.)] and Neotropical (Cuba, Camaguey) regions (Bromley, 1934; Fisher, 1986). According to Fisher (1986), the adults of this species appear to be restricted to areas with both red mangrove (*Rhizophora mangle* Linnaeus) and black mangrove (*Avicennia germinans* (Linnaeus)) trees. They are usually found resting on dead branches and stems. The only previous morphological information on *A. cruentum* immature stages pertains to the egg. Fisher (1986, as *Dasyllis cruenta*) shows a scanning electron microscope image of the egg and indicates that it is relatively small compared to other species.

There also is limited information on the pupae of *Andrenosoma.* Musso (1967, 1978) described and illustrated the cephalic and terminal processes of the Paleartic *A. atrum* (Linnaeus, 1758) pupae, and compared them with those of *A. bayardi* Séguy,

1952. Musso (1978) also included *A. atrum* and *A. bayardi* in a key to the pupae of 13 species of robber flies and the subfamilies Asilinae, Dasypogoninae, and Laphriinae. Dennis *et al.* (2008a) provided a key to the known pupal cases in the subfamily Laphriinae for the Nearctic genera *Andrenosoma* and *Laphria*. The most detailed description of a pupal case is for *A. atrum* (Dennis and Barnes, 2012).

The immatures of some robber flies in the subfamily Laphriinae are known to occur in dead wood, particularly in tree stumps and typically in the galleries of wood boring insects. Fisher (1983) observed that *Andrenosoma* larvae live in dead wood of trees, where they feed on larvae of Buprestidae and Cerambycidae. Lehr (1977) indicated that they feed on the larvae and pupae of xylophagous insects. They pupate near the periphery of a log with their anterior ends projecting above the surface. Dufour (1850) said that *A. atrum* pupae occur in decaying pine trunks. Musso (1967) provided a photograph of the anterior end of an *A. atrum* pupa projecting from a wooden stump. Brauer (1883) commented that *A. atrum* larvae are parasitic on larvae of the cerambycids *Spondylis buprestoides* (Linnaeus, 1758) and *Arhopalus rusticus* (Linnaeus, 1758) (as *Criocephalus rusticus*). The larvae of *S. buprestoides* occur mainly in tree stumps, but can also occur in trees weakened by fire, wind or defoliators, or in wooden materials in contact with the soil (e.g., poles, fencing). The larvae of *A. rusticus* develop in the heartwood of conifers, particularly Scotch pine (*Pinus sylvestris* Linnaeus, 1758) (University of Georgia, Center for Invasive Species and Ecosystem Health, 2010).

In his studies on the phylogeny of Asilidae based on analysis of both morphological and DNA sequence data, Dikow (2009) placed the Laphystiinae in the subfamily Laphriinae as the tribe Laphystiini. Within the Laphystiini, only a single species is known in the larval and pupal stages. Krivosheina (1973) described the immatures of *Laphystia carnea* Hermann, 1906 and indicated that they develop in sandy loam soils.

Here we describe a pupal case of *Andrenosoma cruentum*, and compare it with the pupal cases of *A. atrum, A. bayardi* and *A. albopilosum* Villeneuve, 1911.

MATERIALS AND METHODS

The following description is based on a single pupal case with an associated, separately pinned female adult. The pupal case and female are labeled, “14997 Hopk US, USNMENT00876520” and “14997 Hopk US, May 10-17 Reared, Red mangrove, Miami Beach Fla, T E Snyder Collector, USNMENT00876520”, respectively. It is believed that the label information indicates the pupal case was associated with red mangrove trees.

Our description follows the format found in Dennis *et al*. (2008a and b), and Dennis and Barnes (2012), recognizing nine abdominal segments and abdominal processes consisting 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 does not have a socket area of integumental weakness around its base. A spur is a moveable process that has a socket around its base. Some spines also might be bristlelike, but a bristle is defined as an 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).

Source images were captured with a JVC KY-F75U 3CCD digital camera (Victor Company of Japan, Ltd.) mounted on a Leica MZ7.5 dissecting microscope (Leica Microsystems GmbH, Wetzlar, Germany) with a Leica motor focus drive mounted to a Leica z-step microscope stand. Final images were generated using Auto-Montage™ software (Syncroscopy, Cambridge, UK).

RESULTS

Pupal case slightly curving starting with abdominal segment 3; greatest length, including anterior antennal processes, 21.5 mm; greatest width of thorax 4.8 mm; greatest width of abdomen 5.0 mm tapering to 2.6 mm at segment 8; subshining light golden brown, anterior area of head and wing sheaths apically darker, leg sheaths slightly darker apically. Spines uniformly glistening reddish brown, anterior and posterior anternnal processes, and dorsal and ventral posterolateral processes uniformly reddish brown to only apical 3/4 (Figs. 1-3).

Head with pair of recurved, basally rugose, dorsally rounded, ventrally wedge-shaped anterior antennal processes not joined at base; with group of 4 fused, dorsally rounded to flattened, ventrally wedge-shaped, basally rugose posterior antennal processes becoming shorter posteriorly; with 4th process very small, about 1/4 length of other processes; inner or first posterior process separated from other processes by curved area; outer three processes much closer together; sensory pore present on posterior side of 4th process. Facial area with 2 pairs of short, stout, dark, reclinate spines posterior to antennal processes; median facial spines large, bifurcate, bearing long, thin bristlelike spines posteriorly; lateral facial spines unbranched, dorsoventrally compressed. Labral sheath short, with median furrow and apically split; proboscidal (proboscial, formerly, incorrect spelling) sheath much longer than labral sheath, with deep median furrow, posteriorly bulbous or bell-shaped, not extending over anterior coxal sheaths; maxillary sheaths extending 3/4 length of proboscidal sheath; palpal sheaths large, basally rugose, tubercle-like, with reddish brown, pointed tips, extending posteriorly beyond labral sheath over proboscidal sheath; sheaths with horizontal grooves, most obvious on proboscidal sheath (Fig. 4). Compound eye sheaths on inside with irregular, elongate oval areas containing impression of large number of adult eye facets (Figs. 1-2).

Anterior coxal sheath anteriorly rugose, especially towards maxillary sheath, with anterior median longitudinal split. Posterior coxal sheath folded inward, not visible. Prothoracic spiracle oval, light to dark reddish brown, situated midlaterally at anterior margin of thorax on large, slightly rugose, raised area. Paired anterior mesothoracic spines present on each side of thorax above bases of mid leg sheaths, basally joined by curved area of cuticle, widely separated, dorsally broadly flattened to rounded, ventrally flattened to wedge-shaped, apically pointed and directed towards posterior mesothoracic spine; anterior spine much smaller than posterior spine and about 1/2 the length, lacking median spine. Posterior mesothoracic callosity at base of wing

sheath large, slightly bulbous, smooth, bearing, large, basally rugose, tubercle-like, apically pointed, posterior mesothoracic spine on posterior edge. Wing sheath smooth, with median furrow on posterior 2/3, lacking tubercles and callosities. Thoracic area above wing sheath with striations. Apex of hind leg sheath reaching to just beyond posterior margin of abdominal segment 3. Leg sheaths smooth, apically bilobed with median projection, in particular hind leg sheath (Fig. 3).

Abdominal segments 1-6 (Figs. 1-2) each with dorsomedian row of stout, long and short, reclinate spines, with long spines generally curved towards midline and short spines straight; abdominal segment 7 with dorsomedian row of long, erect bristlelike spines almost reaching lateral postspiracular spines. Dorsolateral spines of segments 2-6 becoming more bristlelike on posterior segments. Postspiracular bristlelike spines increasing in number from anterior to posterior segments. Number of ventral bristlelike spines increasing from segment 1-4 and then segments 4-7 with almost same number of spines.

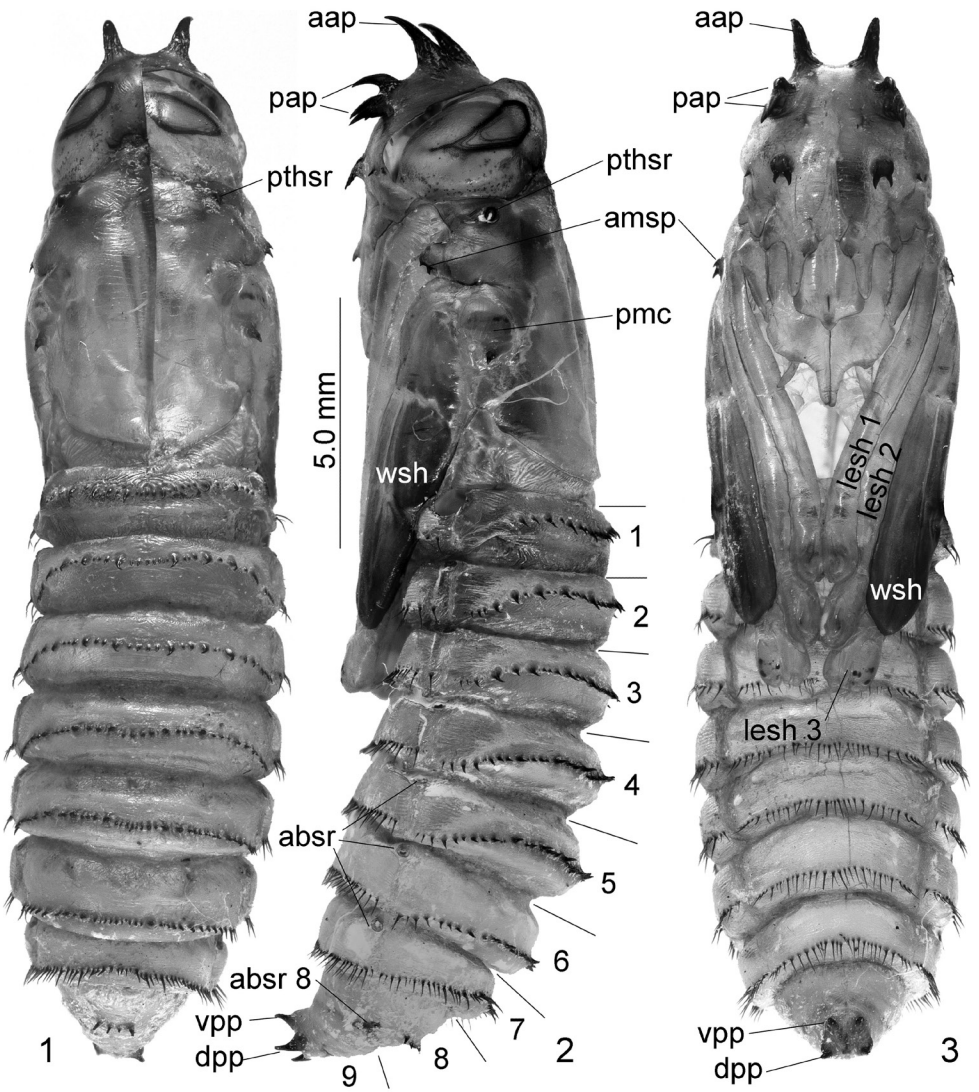
Spiracles of abdominal segments 1-7 (Fig. 2) situated along midline laterally, spherical, slightly raised, shining reddish brown. Postspiracular spines straight, reclinate.

Abdominal segment 1 dorsomedially with 4 straight to apically recurved median spines, 2 on right long and equal in size, 2 on left short and equal in size, flanked on each side with 4 long, large, equal length spines, curved towards midline, and between which are 1-5 short, small, equal length, straight spines, some vestigial or apically bifurcate; then 2-3 outer short spines becoming shorter laterally; dorsolateral bristlelike spines absent; with 3 subequal postspiracular bristlelike spines; venter obscured by wing and leg sheaths.

Abdominal segment 2 dorsomedially with 7 short, unequal, straight to apically recurved spines, becoming shorter laterally, flanked on each side by 4-5 large, long, equal length spines curved towards midline, between which are 0-3 unequal length short, straight, spines; large spine on one side apically bifurcate; with 4-5 dorsolateral short spines, outer ones more bristlelike; with 6 unequal bristlelike postspiracular spines; with 6-7 unequal ventral bristlelike spines on either side of, and slightly extending under, wing sheath.

Abdominal segment 3 dorsomedially with 4 subequal short, straight to apically recurved, spines flanked on each side by 3 equal long, spines curved towards midline, between which are 1-3 short straight, unequal spines, some vestigial; with 7-8 short dorsolateral spines becoming shorter laterally, some vestigial, outer ones more bristlelike; with 8 unequal postspiracular bristlelike spines; with 15 unequal ventral bristlelike spines on each side of midline and extending under, wing and leg sheaths.

Abdominal segment 4 dorsomedially with 4 short, equal, straight spines flanked on each side by 3 long, equal spines curved towards midline, between which are 2-4 short subequal, straight spines, and 8 variable length dorsolateral spines, with outer 2-3 thinner and more bristlelike; with 12 unequal postspiracular bristlelike spines, some very short or bifurcate; with ventral transverse row of 32 long, unequal bristlelike spines, median 2 apically bifurcate.



Figs. 1-3. *Andrenosoma cruentum* pupal case. 1, dorsal view. 2, lateral view showing abdominal segments 1-9. 3, ventral view. aap = anterior antennal process, absr = abdominal spiracles, absr 8 = abdominal spiracle 8, amsp = anterior mesothoracic spine, dpp = dorsal posterolateral process, lesh 1 = fore leg sheath, lesh 2 = mid leg sheath, lesh 3 = hind leg sheath, pap = posterior antennal processes, pmc = posterior mesothoracic callosity, pthsr = prothoracic spiracle, vpp = ventral posterolateral process, wsh = wing sheath.

Abdominal segment 5 dorsomedially with 8 short, equal, straight flanked on each side by 5-7 long, subequal spines curved towards midline, between which are 0-7 (usually 1-3) short, straight spines; with 3-4 short, unequal dorsolateral bristlelike

spines; with 10-12 unequal postspiracular bristlelike spines; with ventral transverse row of 32 long, unequal bristlelike spines, median spine trifurcate, some spines very short.

Abdominal segment 6 dorsomedially with 10 short, unequal, mostly straight spines flanked on each side by 3 long, unequal spines curved towards midline, between which are 1-3 short, mostly straight, spines (some vestigial), then 4 short, outer spines sometimes curved towards midline and very short; with 4 dorsolateral bristlelike spines; with 9-13 unequal postspiracular bristlelike spines; with ventral transverse row of 31 mostly long, unequal, bristlelike spines, some very short and median 2 apically bifurcate.

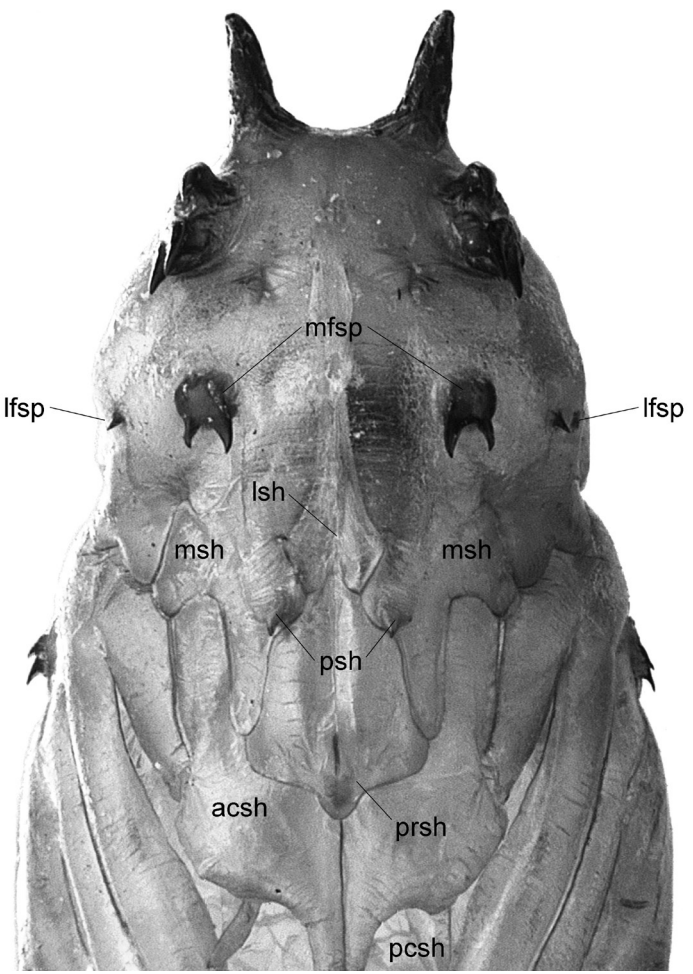


Fig. 4. *Andrenosoma cruentum* pupal case, facial sheath and adjacent structures. acsh = anterior coxal sheath, lfsp = lateral facial spines, lsh = labral sheath, mfsp = median facial spines, msh = maxillary sheath, pcsh = area of posterior coxal sheath (with sheath folded inward), prsh = proboscidal sheath, psh = palpal sheath.

Abdominal segment 7 dorsomedially with 6 unequal, short bristlelike spines, flanked on each side by 21 long, unequal bristlelike spines that almost reach to postspiracular bristlelike spines; with 14-16 mostly long, unequal postspiracular bristlelike spines; with ventral transverse row of 32 long, unequal bristlelike spines.

Abdominal segment 8 with 4 stout, subequal dorsal spines, dorsolateral, lateral, and ventral bristlelike spines absent. Spiracles (Fig. 2) spherical, slightly raised to recessed in integument, yellowish to dark reddish brown, located dorsolaterally, slightly posterior to dorsal spines

Segment 9 (Figs. 1-3) with elongate dorsal calluses on each side of midline; ventral callosities or tubercles absent; with pairs of basally slightly rugose, dorsally rounded, ventrally wedge-shaped dorsal and ventral posterolateral processes, curved towards each other, with dorsolateral processes slightly longer and larger.

DISCUSSION

The following comparison of what we believe to be some major characteristics of *Andrenosoma* pupal cases is based on material given here and the descriptions and figures of Dennis and Barnes (2012) and Musso (1967, 1978) for *A. atrum* and *A. bayardi*, and Oldroyd (1939) for *A. albopilosum*. Dennis and Barnes (2012) indicate that the pupal cases of *Andrenosoma* spp. and other members of the the subfamily Laphriinae, which are found in plant materials, are generally straighter than robber fly pupal cases found in other substrates, such as soil. This might be due to the density of the plant roots, decaying tree stumps and logs, and wooden telegraph poles that they are found in. On the head there are 3 (*A. atrum*) or 4 (*A. bayardi* and *A. cruentum*) well-developed posterior antennal processes. The pupal case of *A. albopilosum* has 3 processes with a rudimentary fourth. The facial area has 2 subequal, median facial spines on either side of the midline and a small, median, bristlelike spine between the subequal spines. The pupal cases of *A. atrum, A. bayardi*, *A. cruentum,* and *A. albopilosum* have a single facial spine on each side, lateral to the median facial spines. The labral sheath is apically split or bifurcate on at least *A. atrum*, *A. cruentum*, and *A. albopilosum*. There are distinct, tubercle-like palpal sheaths on each side of the labral sheath. The proboscidal sheath is bell-shaped or bulbous posteriorly.

Melin (1923) indicated, based on the pupae of six species of *Laphria*, that the hypopharyngeal sheath (now designated the proboscidal sheath) on pupae of the subfamily Laphriinae extends to the heart-shaped piece or posterior coxal sheath. Dennis et al. (2008a) also showed this for seven species of *Laphria* and *Lampria bicolor* (Wiedemann, 1828). However, this is not true for *A. atrum, A. bayardi, A. cruentum* or *A. albopilosum*.

Andrenosoma bayardi, A. cruentum, and *A. albopilosum* each have a distinct and relatively long posterior mesothoracic spine on a callosity at the base of the wing sheath. The posterior mesothoracic spine on *A. atrum* is shorter and not as distinct. It may be a light yellowish color without a dark tip, and it occurs in a heavily sclerotized, rounded area.

The majority of described robber fly pupal cases have a distinct pattern of dorsal abdominal spines and spurs. Abdominal segment 1 typically has a transverse row of spurs, and abdominal segments 2-7 have a transverse row of spines alternating with spurs, sometimes with 2-3 spines between each pair of spurs. On some pupal cases the spines are short, stout extensions of the cuticle and the longer thinner spurs emanate from areas of thin cuticle. However, Dennis *et al.* (2008a) indicate that the pupal cases of known species in the subfamily Laphriinae (which includes *Andrenosoma cruentum*) lack discernible spurs. Dennis and Barnes (2012) also found this to be true for *A. atrum*.

The dorsal abdominal spines on *A. bayardi* pupal cases are often bifurcate or multi-furcate. *Andrenosoma atrum* and *A. cruentum* cases have one to a few bifurcate spines. The abdominal spines of *A. albopilosum* were not described by Oldroyd (1939). The abdominal spines may not exhibit an obvious pattern of long and short spines; abdominal segments 1-6 on the pupal case of *A. cruentum* has 4-10 short median spines flanked on each side by 3-7 long spines that are curved towards the midline, between which are 0-7 (mostly 0-3) short spines. The dorsolateral abdominal spines become more distinct and longer posteriorly and the lateral spines behind the spiracles generally increase in number from segment 1-7.

The transverse rows of ventral abdominal spines are not interrupted by a median space, as is often seen on pupal cases of other robber fly species, including many *Laphria* spp.

On abdominal segment 8, the paired dorsal spines on each side of the midline appear to be equal in length on *A. bayardi* and *A. cruentum*; they are of unequal length on *A. atrum* and *A. albopilosum*. There are no dorsolateral or ventral bristlelike spines.

Segment 9 has dorsal and ventral posterolateral processes of equal length. The dorsolateral processes are basally larger on *A. bayardi* and *A. cruentum*; on *A. atrum* and *A. albopilosum*, the ventrolateral processes are basally larger or thicker.

Dennis *et al.* (2008a) and Melin (1923) found that male pupal cases could be distinguished from female cases by the presence of midventral callosities on the ninth abdominal segment. These callosities are present on the male pupal case of *A. atrum*. Oldroyd (1939) did not comment on sexual differences of the ninth segment of *A. albopilosum* pupal cases, but his illustration in lateral view of a pupal case clearly shows well-developed callosities. Musso (1967) also described and illustrated similar callosities on the male pupal cases of *A. bayardi* and *A. atrum*. Female pupal cases, including *A. cruentum*, lack the callosities. We believe that these callosities sheath the male genitalia (Dennis *et al.,* 2008a).

As indicated above, Dikow (2009) placed the subfamily Laphystiinae in the Laphriinae as the tribe Laphystiini. Based on this classification, there are 16 Nearctic genera in the Laphriinae (Geller-Grimm, 2003). Dennis *et al.* (2008a) provided a key to three of these genera: *Andrenosoma*, *Lampria*, and *Laphria*. This key is revised below to reflect the pupal cases of the Nearctic and Neotropical *A. cruentum*, the Palearctic *A. atrum* (Linnaeus, 1758) (Dennis and Barnes, 2012), and the Nearctic *Laphria* discussed in Dennis *et al.,* (2008a).

Revised Key to Known Pupal Cases of Genera in the Subfamily Laphriinae

1 Head with 5 basally fused posterior antennal processes; median facial spines bifurcate or trifurcate, face lacking median or anterior bristle between spines; abdominal segment 1 with broad dorsal, bifurcate or trifurcate spine; venter of abdominal segment 3 with median space interrupting transverse row of spurs, 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 (if 3-4, 4th process small); median facial spines usually not bifurcate or trifurcate, face with or without median, anterior or posterior bristle between spines; abdominal segment 1 usually without dorsal median bifurcate or trifurcate spine, but, if present, spine not broad; venter of segments 3-7 with or without median space interrupting transverse row of bristlelike spines, if with space it may become smaller posteriorly and/or have shorter median bristlelike spines than surrounding spines…….2

2 Head with 3-5 basally fused posterior antennal processes; facial area with or without bristle between or posterior to median spines; posterior mesothoracic spine very small to broadly rounded with sclerotized edge; abdominal segment 1 with or without dorsal median bifurcate spine, other dorsal spines maybe bifurcate; venter of abdominal segments 3-7 or 4-6 with median space interrupting transverse row of bristlelike spines……*Laphria*

- Head with 3-4 basally fused posterior antennal processes, 4th process small; facial area with bristle between or anterior to median spines; posterior mesothoracic spine more distinct, small to large and maybe tubercle-like; abdominal segment 1 without dorsal median bifurcate or trifurcate spines, although other spines maybe bifurcate; venter of segments 4-7 without median space interrupting transverse row of bristlelike spines… ……*Andrenosoma*

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