



LARVAE OF THE WINTER STONEFLY GENUS *ALLOCAPNIA* (PLECOPTERA: CAPNIIDAE) IN MISSISSIPPI, USA

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ABSTRACT

Larval associations were made for four common *Allocapnia* species in Mississippi (USA) and a comparative study of pharate and adult males was completed with scanning electron microscopy. Descriptions are provided for pre-emergent larvae of *A. aurora* Ricker, *A. mystica* Frison, *A. starki* Kondratieff & Kirchner and *A. virginiana* Frison, and a provisional key is presented for larval Capniidae known to occur in Mississippi.

Keywords: Plecoptera, Capniidae, *Allocapnia*, larval descriptions

INTRODUCTION

Stewart & Stark (1988, 2002) emphasized the need for species level descriptions of stonefly larvae and suggest the need is no greater for any group than for the Capniidae. The lack of knowledge for larvae of this group may be attributed to their small size and absence of distinctive pigment patterns. Harper & Hynes (1971) referred to these larvae as "disappointingly homogenous" with "few distinctive features" yet their careful study led to a taxonomic key for 15 species found in eastern Canada.

In eastern North America, the most widely distributed and speciose capniid genus is *Allocapnia*. More than 40 species are currently recognized (Ross & Ricker 1971; Kondratieff & Kirchner 2000) but partial descriptions are available for larvae of only 11 of these; most of these are from Harper & Hynes (1971) study which includes descriptions and a key to nine *Allocapnia* found in eastern Canada. Others are from earlier works of Frison (1929) and Claassen (1931) who provided descriptions and provisional keys for larvae of a few species [*A. vivipara* (Claassen), *A. pygmaea* (Burmeister), *A. recta* (Claassen), *A. granulata* (Claassen), *A. mystica* Frison]. A variety of characters were utilized in these studies

but setal patterns on various body surfaces were found to have the greatest value for separating these species (Harper & Hynes 1971). Since the latter study the only complete description of a mature *Allocapnia* larva is for *A. granulata* (Stewart & Stark 1988, 2002), a species also described by Harper & Hynes (1971), Frison (1929) and Claassen (1931).

Stark (1979) reported six *Allocapnia* species from Mississippi and two were subsequently added by Stark et al. (2000) and Kondratieff & Kirchner (2000). In the latter study, *A. starki* was proposed as a new species for southwest Mississippi populations previously identified as *A. recta*. It now seems probable that all Mississippi *A. recta* records should be considered *A. starki* and *A. recta* should be deleted from the state list. Thus the current list of seven Mississippi *Allocapnia* species includes three species whose larvae are at least partially described (*A. granulata*, *A. mystica* and *A. rickeri* Frison) and four (*A. aurora* Ricker, *A. polemistis* Ross & Ricker, *A. starki* and *A. virginiana* Frison) whose larvae are unknown (Stewart & Stark 1988, 2002). In this study larvae of the four common *Allocapnia* species found in Mississippi streams were targeted for association and description to determine if sufficient differences exist in this life stage to permit their identification.

MATERIALS AND METHODS

Records in the literature (Alford 1998; Kondratieff & Kirchner 2000; Stark et al. 2000) and in the Stark collection at Mississippi College indicate two or more species of *Allocapnia* occur at many Mississippi sites, however, several streams were identified where frequent efforts have resulted in the collection of a single *Allocapnia* species. These sites, Ragsdale Creek, Claiborne Co. (*A. starki* site), Mill Creek, Simpson Co., (*A. virginiana* site), Little Okatuppa Creek, Clarke Co. (*A. aurora* site) and Line Creek, Webster Co. (*A. mystica* site) were selected as potential sources of unambiguous larval samples.

Each stream was visited in December and January and pre-emergent larval *Allocapnia* specimens were collected from leaf packs and adults were taken from nearby riparian vegetation, snags and bridge railings. Adult samples were examined to confirm their identity and several pharate male larvae and adult males were selected from each sample for study with scanning electron microscopy. Samples were also taken from streams near those targeted in order to more fully test the "single *Allocapnia* hypothesis".

Samples studied with SEM were dehydrated to 100% ethanol, placed in an ultrasonic cleaner for 15-20 seconds to remove debris, transferred through two, 30 minute washes in hexamethyldisilazane, then mounted on specimen stubs and coated with gold-palladium before study with an AMRAY 1810D scanning electron microscope. Setal patterns on head, pronotum, mesonotum, abdominal terga 7-10, foreleg, antennae, cerci and mouthparts were carefully examined for a minimum of 10 specimens. In the descriptions which follow only those characters which appear to be useful for separation are emphasized. SEM specimens and unmounted voucher material in alcohol are archived in the Stark collection.

RESULTS

Allocapnia aurora Ricker

Allocapnia aurora Ricker (1952). Holotype ♂, Pigeon River, Woodrow, North Carolina

Distribution. AL, DC, GA, MD, MS, NC, PA, SC, TN, VA (Stark 2001). Mississippi populations have

been reported from Amite, Franklin, Lauderdale and Tishomingo counties (Alford 1998; Stark 1979). A new record is given for Clarke County.

Material examined. Mississippi: Clarke Co., Little Okatuppa Creek, Hwy. 18, 7 December 2002, 2 ♂, 22 larvae, B. Stark. Same location, 18 December 2002, 19 larvae, B. Stark, J. Lacey. Same location, 29 December 1999, 1 ♀, B. Stark. Same location, 18 January 2003, 1 ♂, 4 larvae, B. Stark, W. Hawkins, S. Cope. Same location, 8 January 2005, 1 ♂, B. Stark.

Male genitalia. Previously described from scanning electron micrographs by Alford (1998). Dorsal arm of epiproct bent near midlength, apical shape similar to a spear point; apex of dorsal limb engraved with a pattern of smooth, scalloped ridges (Figs. 1-2). Dorsal process of tergum 8 deeply divided by a wide U-shaped notch; tergum 7 with an obscure mound shaped process near anterior margin.

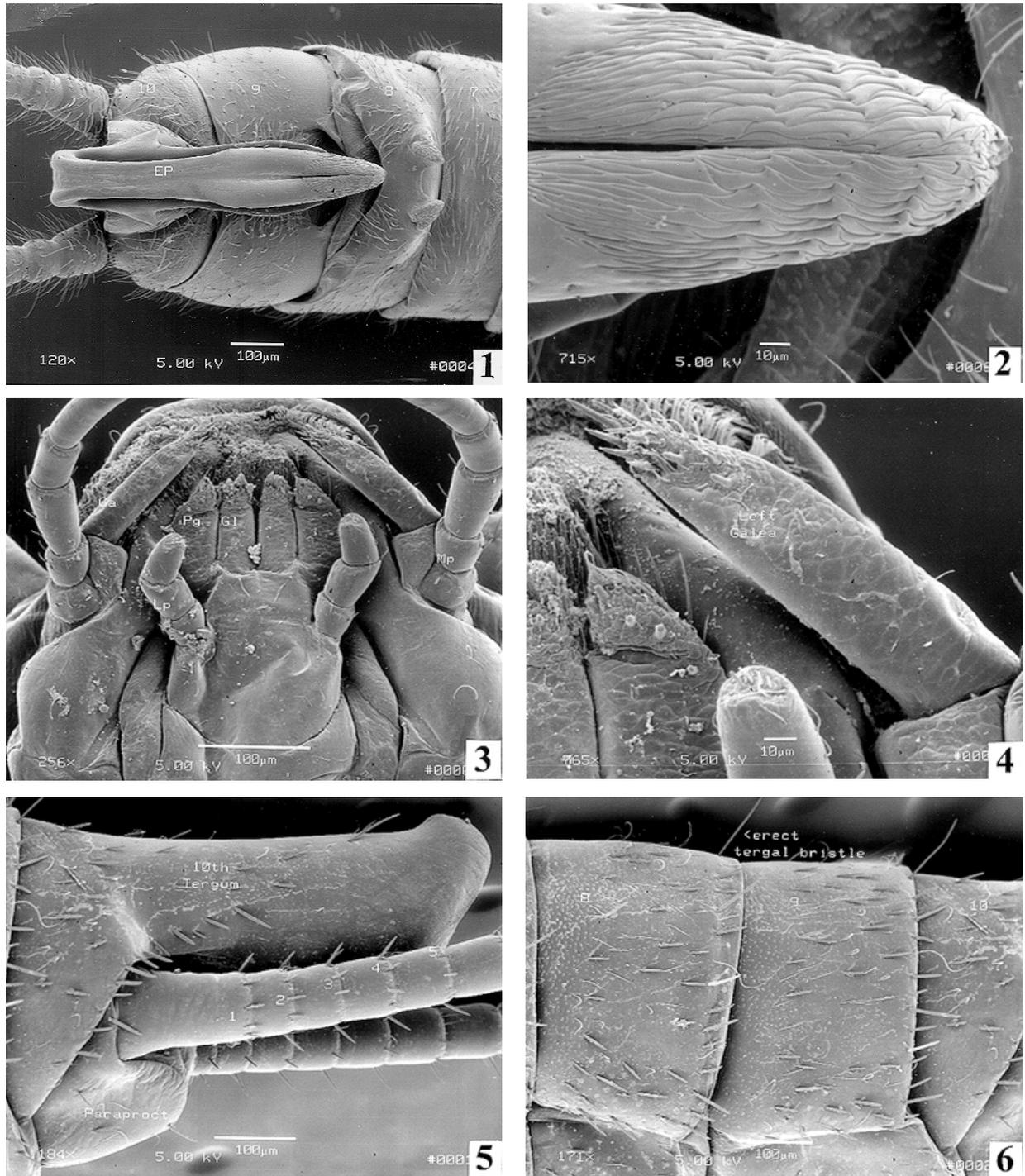
Pre-emergent larva. Body length 6.0-7.5 mm. General body color pale brown to tan, without distinctive pattern. Mandibles, laciniae and labium (Fig. 3) typical of genus; galea armed on apex with a few acute spines; outer margin of galea without fringe of long setae (Fig. 4). Developing lobe of male tergum 10 distal to cercal bases more than twice as long as tergum length proximal to cercal bases (Fig. 5); dorsal margin of developing male lobe straight but with slight subapical elevation; posterior margin slanted in lateral aspect. Abdominal terga sparsely covered with clothing hairs and decumbent bristles; erect bristles restricted to posterior tergal margins (Fig. 6); longest erect bristles about 0.4 times as long as tergum.

Diagnosis. The presence of erect bristles only on the posterior margins of abdominal terga (Fig. 6) will distinguish nymphs of this species from all those occurring in Mississippi except *A. mystica*. In that species the posterior margin of the developing male 10th tergal lobe is truncate in lateral aspect rather than slanted (Fig. 5).

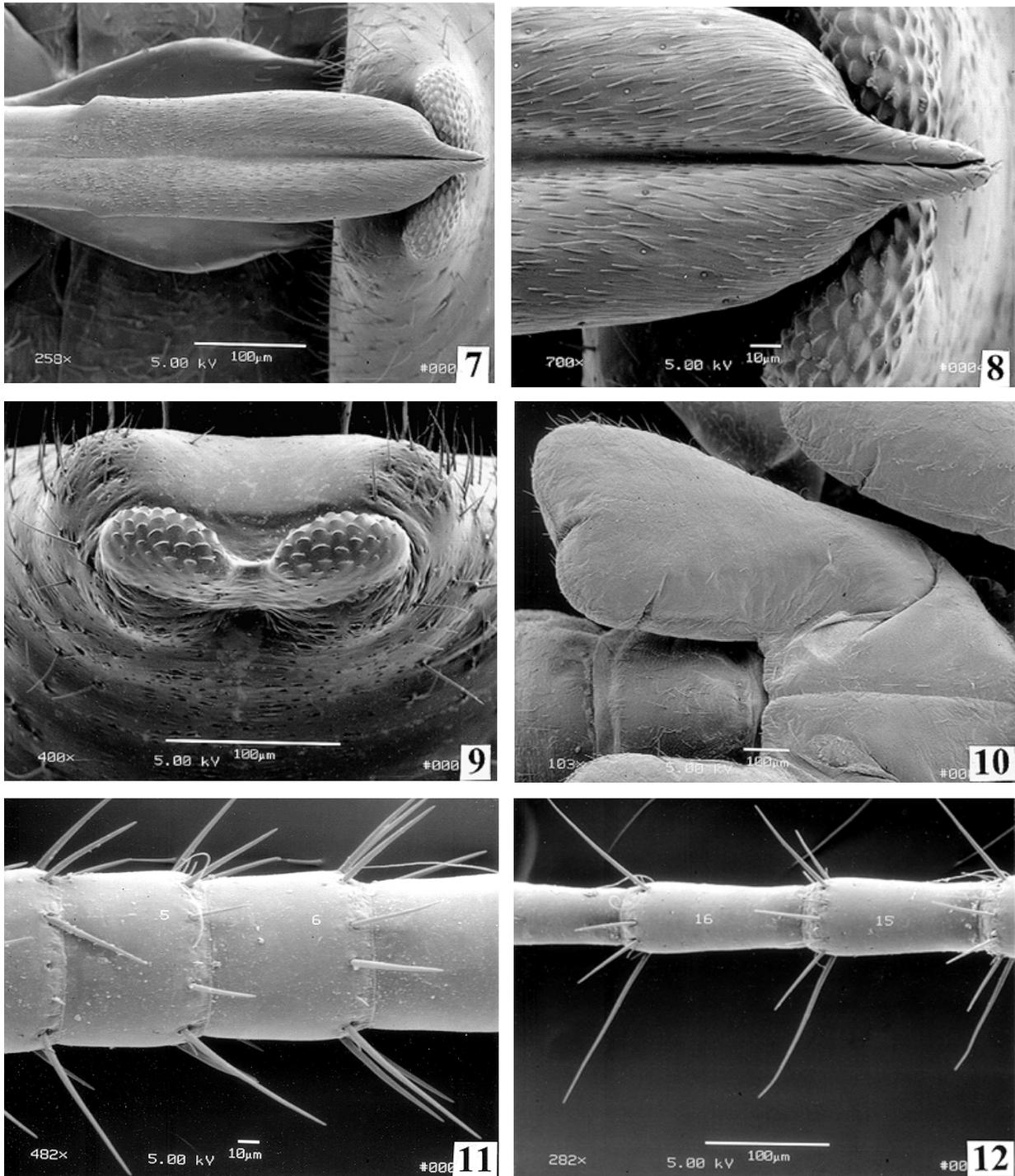
Allocapnia mystica Frison

Allocapnia mystica Frison (1929). Holotype ♂, Salt Fork River, Oakwood, Illinois

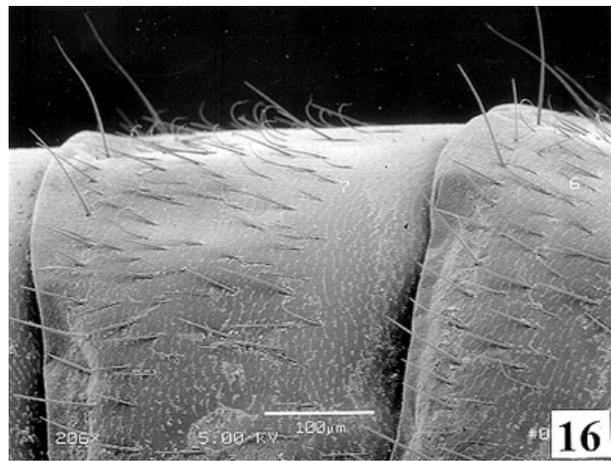
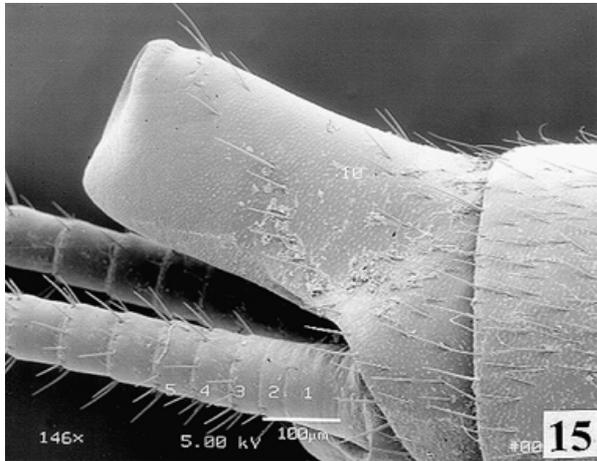
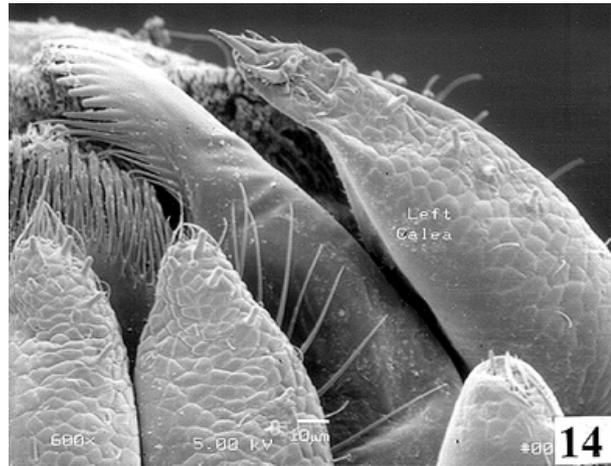
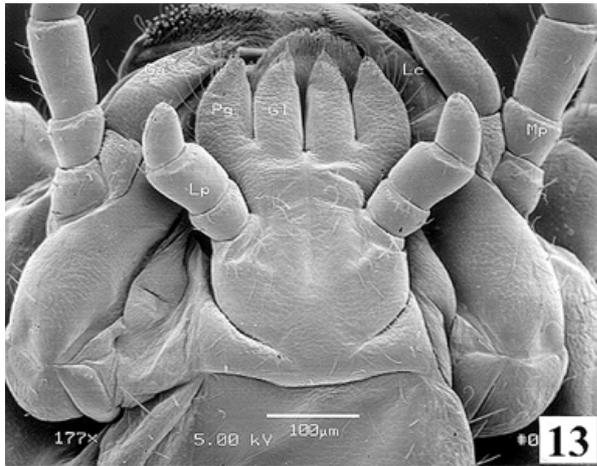
Allocapnia mystica: Frison (1929) and Claassen (1931), larval description



Figs. 1-6. *Allocapnia aurora*. 1. Male terminalia. 2. Apex of epiproct. 3. Ventral aspect of larval head. 4. Ventral aspect of left galea. 5. Lateral aspect of larval male 10th tergum and basal cercal segments. 6. Lateral aspect of abdominal terga 8-9. (Ep = epiproct, Ga = galea, Gl = glossa, Lp = labial palp, Mp = maxillary palp, Pg = paraglossa)



Figs. 7-12. *Allocapnia mystica*. 7. Male epiproct. 8. Apex of epiproct. 9. Male 8th tergal process. 10. Larval left metanotal wingpad. 11. Basolateral aspect of larval cercal segments. 12. Apicolateral aspect of larval cercal segments.



Figs. 13-16. *Allocapnia mystica*. 13. Ventral aspect of larval head. 14. Ventral aspect of left galea. 15. Lateral aspect of larval male 10th tergum and basal cercal segments. 16. Lateral aspect of abdominal terga 6-7. (Ga = galea, Gl = glossa, Lc = lacinia, Lp = labial palp, Mp = maxillary palp, Pg = paraglossa)

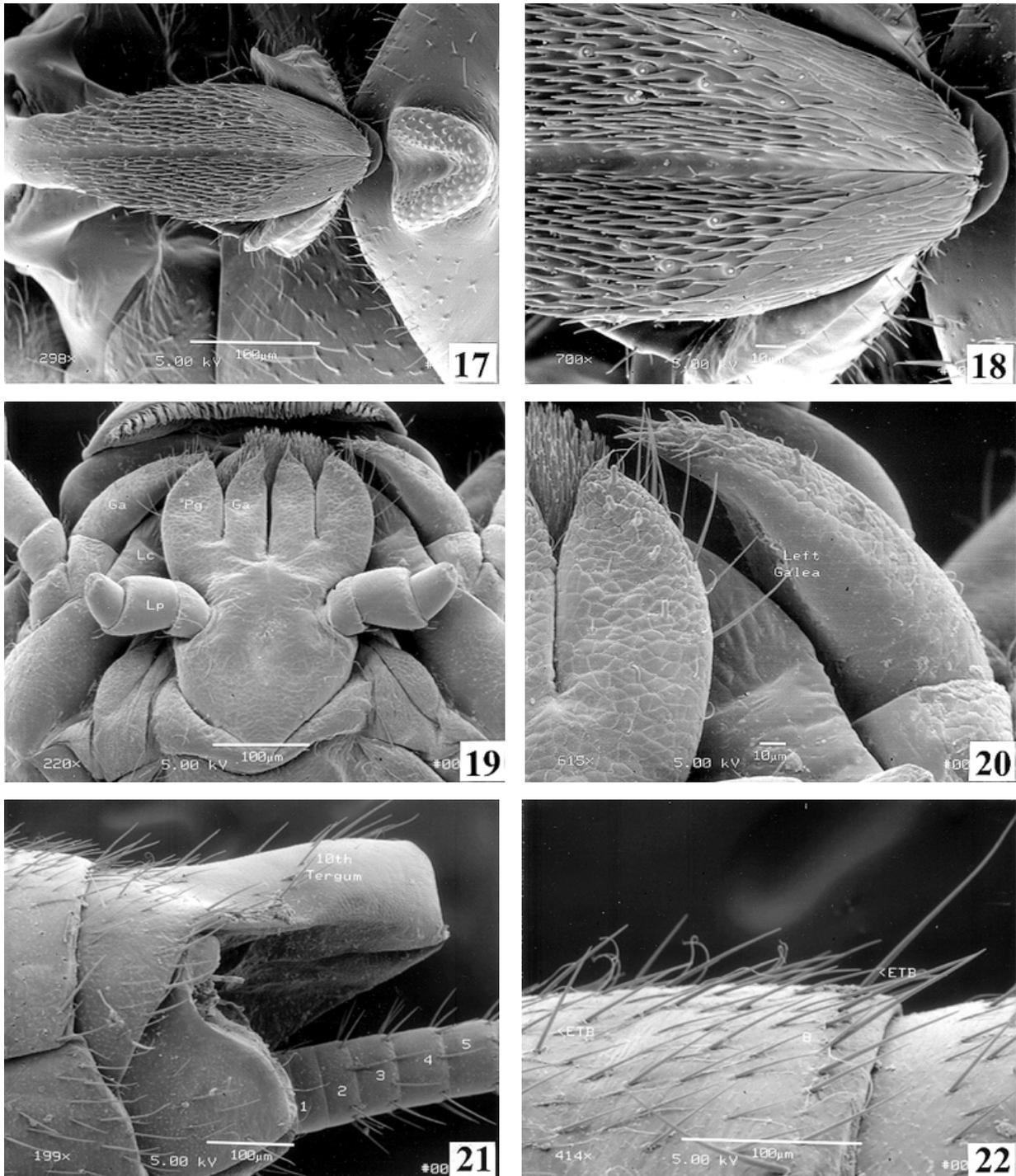
Distribution. AL, AR, GA, IL, IN, KY, MO, MS, OH, TN, VA, WV (Stark 2001). Mississippi, populations have been reported in Lauderdale, Pontotoc, Union, and Webster counties (Stark 1979). New records are given for Clarke, Lowndes and Tishomingo counties.

Material examined. Mississippi: Clarke Co., Rock Creek, Hwy. 18, 18 December 2002, 3 ♂, B. Stark, J. Lacey. Lowndes Co., Mayhew Creek, Hwy. 12, 29 December 1998, 7 ♂, B. Stark. Tishomingo Co., Little Cripple Deer Creek, Hwy. 957, 4 January 2000, 12 ♂, B. Stark, M. Alford. Webster Co., Line Creek, Hwy. 15, 3 January 2000, 22 ♂, 8 ♀, B. Stark, M. Alford. Same location, 27 December 2002, 15 ♂, 6 ♀, 30 larvae, B. Stark.

Male genitalia. Dorsal arm of epiproct bent near midlength; apical half slightly wider than base and

swollen before the attenuated apex; surface sparsely armed with posteriorly directed spines (Figs. 7-8). Dorsal process of tergum 8 narrowly notched on thin anterior ridge and developed into a large flat posterior plateau behind ridge (Fig. 9).

Pre-emergent larva. Body length 6.5-8.0 mm. General body color pale brown to tan, without distinctive pattern. Metanotal (Fig. 10), cercal (Figs. 11-12), mandibular, lacinial and labral setation (Fig. 13) typical of genus; galea armed on apex with a few acute spines; outer margin of galea without fringe of long setae (Fig. 14). Developing lobe of male tergum 10 distal to cercal bases about twice as long as tergum length proximal to cercal bases (Fig. 15); dorsal margin of developing male long and straight; posterior margin truncate in lateral aspect.



Figs. 17-22. *Allocapnia starki*. 17. Male terminalia. 18. Apex of epiproct. 19. Ventral aspect of larval head. 20. Ventral aspect of left galea. 21. Lateral aspect of larval male 10th tergum and basal cercal segments. 22. Lateral aspect of abdominal tergum 8. (ETB = erect tergal bristle, Ga = galea, Gl = glossa, Lc = lacinia, Lp = labial palp)

Abdominal terga sparsely covered with clothing hairs and decumbent bristles; erect bristles restricted to posterior tergal margins (Fig. 16); longest erect bristles about 0.4 times as long as tergum.

Diagnosis. The absence of erect tergal bristles at midlength (Fig. 16) will distinguish larvae of this species from all but those of *A. aurora* among Mississippi species. The truncate posterior margin of the developing male 10th tergal lobe (Fig. 15) will distinguish these species.

***Allocapnia starki* Kondratieff & Kirchner**

Allocapnia starki Kondratieff & Kirchner (2000). Holotype ♂, Kennison Creek, Claiborne Co., Mississippi

Allocapnia recta: Stark (1979), not Claassen (1924)

Mississippi distribution

Allocapnia recta: Alford (1998), male genitalia

Distribution. Known from Mississippi (Kondratieff & Kirchner 2000) and the Florida Parishes of Louisiana (Alford 1998. as *A. recta*). Mississippi, populations have been reported from Amite, Claiborne, Copiah, Franklin, Hinds, Lowndes, Marshall, Newton, Simpson, Tishomingo, Warren and Wilkinson counties mostly as *A. recta* (Alford 1998; Kondratieff & Kirchner 2000; Stark 1979; Stark et al. 2000). New records are given for Jefferson, Lincoln, Scott and Smith counties.

Material examined. Mississippi: Claiborne Co., Ragsdale Creek, 23 November 2002, 13 ♂, 27 larvae, B. Stark, J. Lacey. Hinds Co., Jones Creek, Tom Cain Road, 28 December 2002, 4 ♂, 4 ♀, 35 larvae. Jefferson Co., Clarks Creek, Hwy. 552, 1 January 2005, 5 ♂, 1 ♀, B. Stark. Jefferson Co., North Fork Coles Creek, Redlick Road, 1 January 2005, 13 ♂, 1 ♀, B. Stark. Lincoln Co., Fair River, Hwy. 84, 5 January 2005, 1 ♂, B. Stark. Lowndes Co., Mayhew Creek, Hwy. 12, 20 January 1996, 7 ♂, B. Stark. S. Tucker. Newton Co., Tallahatta Creek, Dean Road, 18 December 2002, 5 ♂, B. Stark, J. Lacey. Scott Co., Leaf River, Hwy. 501, 1 February 2003, 1 ♂, B. Stark. Scott Co., Leaf River, Sherman-Hill Road, 1 February 2003, 2 ♂, B. Stark. Smith Co., Ichusa Creek, Boyte Road, 1 February 2003, 2 ♂, B. Stark. Smith Co., Turkey Creek, Hwy. 501, 1 February 2003, 5 ♂, B. Stark.

Male genitalia. Previously described from scanning

electron micrographs by Alford (1998) as *A. recta*, and by Kondratieff & Kirchner (2000). Dorsal arm of epiproct bent near midlength and paddle shaped in apical half; surface densely armed with posteriorly directed spines (Figs. 17-18). Dorsal process of tergum 8 shaped somewhat like a horseshoe.

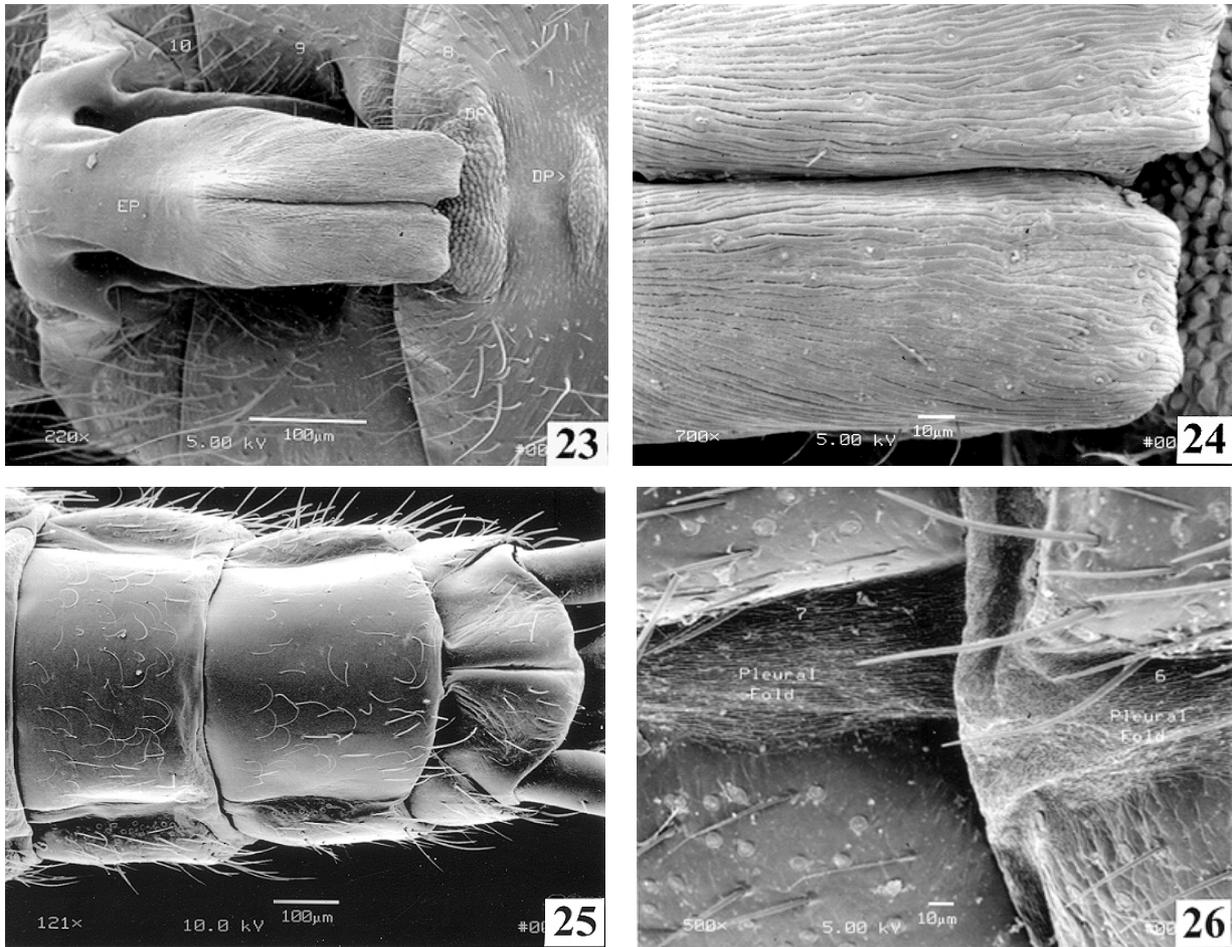
Pre-emergent larva. Body length 5.5-6.5 mm. General body color pale brown to tan, without distinctive pattern. Mandibles, laciniae and labium (Fig. 19) typical of genus; galea armed on apex with a few acute spines; outer margin of galea without fringe of long setae (Fig. 20). Developing lobe of male tergum 10 distal to cercal bases less than 1.5 times as long as tergum proximal to cercal bases (Fig. 21); dorsal margin of developing male lobe straight; posterior margin slightly rounded to truncate in lateral aspect. Abdominal terga sparsely covered with thin, curled, clothing hairs and semi-erect bristles; erect bristles located at posterior tergal margins and at midlength (Fig. 22); longest erect bristles about 0.4 times as long as tergum.

Diagnosis. Larvae of this species share with several species the presence of erect or semi-erect bristles at midlength of most terga. Among this group, *A. starki* larvae are similar to those of *A. granulata* by virtue of the truncate developing male tergal lobe but can usually be separated on the basis of multiple erect and semi-erect bristles visible in lateral aspect along the length of the abdominal terga of *A. granulata* (Harper & Hynes 1971), whereas in *A. starki* these occur at midlength and at the posterior tergal margins (Fig. 22). The only Mississippi record of *A. granulata* is a single female collected at Potts Camp (Marshall Co.) by T.H. Frison in 1941, and no unambiguous larval samples of *A. granulata* were available for our study.

***Allocapnia virginiana* Frison**

Allocapnia virginiana Frison (1942). Holotype ♂, Rapidan River, Shelby, Virginia

Distribution. AL, DE, GA, LA, MS, NC, SC, VA (Stark 2001). Mississippi, populations have been reported from Amite, Franklin, Lauderdale, Simpson and Wilkinson Counties (Alford 1998; Stark 1979). New records are given for Lowndes, Newton and Tishomingo Counties.



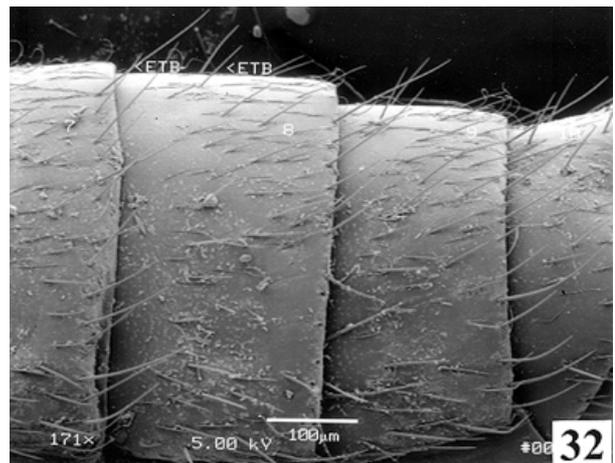
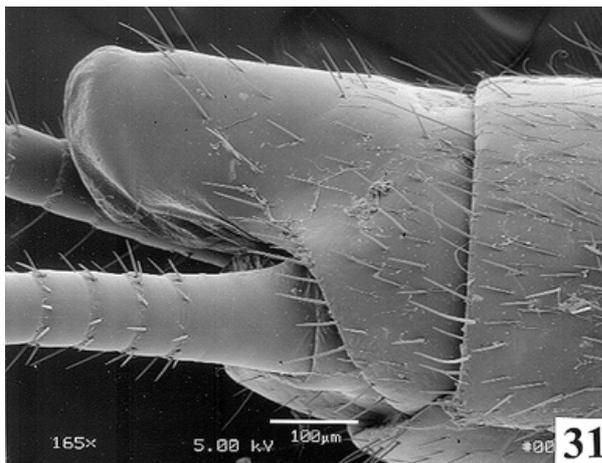
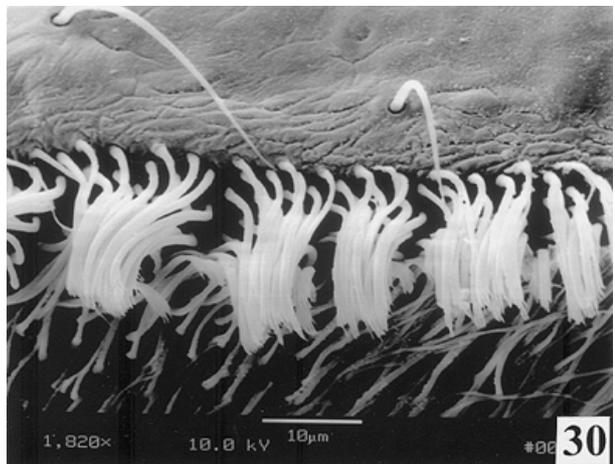
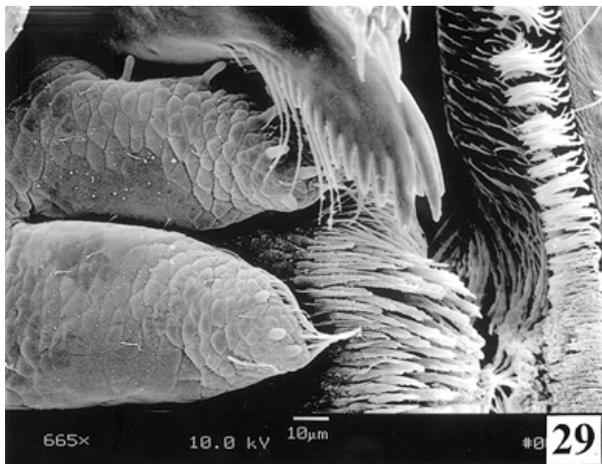
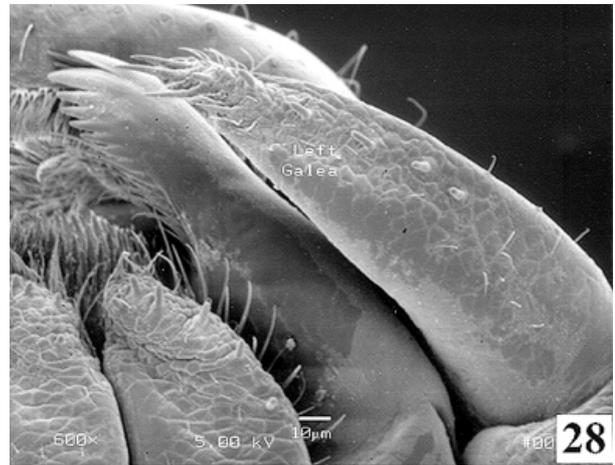
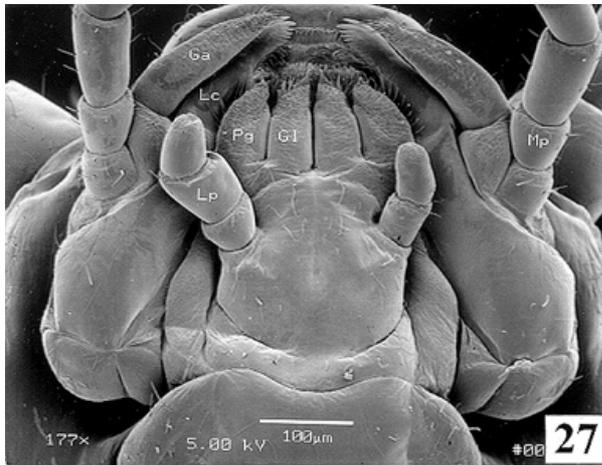
Figs. 23-26. *Allocapnia virginiana*. 23. Male terminalia. 24. Apex of epiproct. 25. Larval abdominal sterna 8-10. 26. Larval pleural folds on sterna 6-7. (DP = dorsal process, EP = epiproct)

Material examined. Mississippi: Lowndes Co., Mayhew Creek, Hwy. 12, 29 December 1998, 3 ♂, B. Stark. Newton Co., Tallahatta Creek, Dean Road, 9 December 2000, 8 ♂, B. Stark. Same location, 18 December 2002, 26 ♂, B. Stark, J. Lacey. Simpson Co., Mill Creek, Hwy. 472, 11 December 2002, 5 ♂, 14 larvae, B. Stark, J. Lacey. Same location, 10 January 2002, 3 ♂, B. Stark. Same location, 3 December 2002, 4 ♂, 15 larvae, B. Stark. Simpson Co., Westville Creek, Hwy. 43, 2 December 2000, 14 ♂, B. Stark. Tishomingo Co., Little Cripple Deer Creek, Hwy 957, 4 January 2000, 39 ♂, B. Stark, M. Alford. Tishomingo Co., Jourdan Creek, Hwy. 4, 3 January 2000, 2 ♂, B. Stark, M. Alford. Tishomingo Co., Pennywinkle Creek, Hwy. 191, 3 January 2000, 1 ♂, B. Stark, M.

Alford.

Male genitalia. Described from scanning electron micrographs by Alford (1998). Dorsal arm of epiproct without conspicuous bend at midlength; apical half broad, flat and surface covered with pattern of fine, longitudinal grooves (Figs. 23-24). Dorsal process of tergum 8 consisting of a small erect ridge near anterior margin and a larger cushion shaped structure near posterior margin.

Pre-emergent larva. Body length 6.0-7.5 mm. Body color pale brown to tan, without distinctive pattern. Abdominal sternal folds (Figs. 25-26), mandibles, laciniae and labium (Fig. 27) typical of genus; galea armed on apex with a few acute spines; outer margin of galea without fringe of long setae (Fig. 28).



Figs. 27-32. *Allocapnia virginiana*. 27. Ventral aspect of larval head. 28. Ventral aspect of left galea. 29. Ventral aspect of larval mouthparts showing labral setal tufts. 30. Labral setal tufts. 31. Lateral aspect of larval male 10th tergum and basal cercal segments. 32. Lateral aspect of abdominal terga 7-9. (ETB = erect tergal bristle, Ga = galea, G1 = glossa, Lc = lacinia, Lp = labial palp, Mp = maxillary palp, Pg = paraglossa)

Ventral aspect of labium with tufts of long setae at intervals along the margin (Figs. 29-30). Developing lobe of male tergum 10 distal to cercal bases about 1.3 times as long as tergum length proximal to cercal bases (Fig. 31); dorsal margin of developing male lobe straight with slight pre-apical dip; posterior margin rounded with dorsal apex extending well beyond ventral apex. Abdominal terga sparsely covered with clothing hairs and decumbent bristles; erect bristles present at posterior tergal margins and at midlength (Fig. 32); longest erect bristles about half as long as tergum.

Diagnosis. Among the other species whose larvae display erect or semi-erect bristles at midlength of most abdominal terga (*A. granulata*, *A. rickeri*, *A. starki*) the larvae of *A. virginiana* are distinguished from *A. rickeri* by virtue of a straight dorsal margin of developing male tergum 10 (Fig. 31), and from the others in having the posterolateral aspect of this structure slanted rather than truncate.

DISCUSSION

Stewart & Stark (2002) note, "...*Allocapnia* nymphs are difficult to separate from those of genera *Capnia*, *Mesocapnia* and *Utacapnia*..." but this can be accomplished among the macropterous and most brachypterous species of these genera on the basis of the developing wing fold manifested as an inner marginal notch in these related genera but not in *Allocapnia*. *Allocapnia* larvae with developing wingpads have this notch entirely absent, or shifted to an apical (posterior) marginal position on the structure as indicated in Fig. 10. Apterous and micropterous larvae of *Allocapnia* are distinguished from these related genera on the basis of serrations on the ventral tooth of the right mandible (Stewart & Stark 2002).

Allocapnia larvae also share the membranous pleural folds on abdominal sterna 1-9 with other capniid larvae. These folds, although sometimes difficult to see with light microscopy, are conspicuous with SEM due to the presence of fine irregular ridges in the membrane of the fold (Figs. 25-26). Also conspicuous are clusters of long whisk-like setae on the ventral labral margin. These structures, shown in Figs. 29-30, require investigation in other capniid and leuctrid genera to determine their value as a taxonomic tool in these families.

Harper & Hynes (1971) included shape and setation of the galea as a major character for species distinction among *Allocapnia* larvae found in eastern Canada. Unfortunately, the four species examined in this study all have the galea similar to that shown by Harper & Hynes (1971) for *A. nivicola* (Fitch), with the apex bearing a few sharp spines and with the outer margins lacking a setal fringe (Figs. 4, 14, 20, 28), consequently, this character is not useful in the separation of Mississippi *Allocapnia*. These authors also found the lateral aspect of abdominal terga to show significant differences in setal patterns among their species. This character is useful among Mississippi *Allocapnia*, with two species (*A. aurora* and *A. mystica*) lacking erect bristles at midlength of abdominal terga, and others (*A. starki*, *A. virginiana*, *A. granulata* and *A. rickeri*) having erect tergal bristles at the posterior margin and at midlength. The other major character which seems to have value for separation of these larvae is the length and lateral shape of the developing male tergum 10. These characters were used to develop the following provisional key for Mississippi capniid larvae. Characters for *Nemocapnia carolina* Banks, *Allocapnia granulata* and *A. rickeri* were extracted from Stewart & Stark (2002) and Harper & Hynes (1971).

Provisional Key for Larval Mississippi Capniidae (*A. polemistis* unknown)

1. Apical cercal segments with vertical fringe of bristles along dorsal and ventral margins of each segment.....*Nemocapnia carolina*
 Apical cercal segment with terminal bristle whorls on each segment, vertical fringe absent (Figs. 11-12).....*Allocapnia*, 2
2. Erect bristles, seen in lateral aspect, restricted to posterior margins of most abdominal terga (Fig. 6)3
 Lateral aspect of most abdominal terga with an additional erect or semi-erect bristle, or bristles, near midlength (Fig. 32)4
3. Posterolateral aspect of developing male 10th tergal margin truncate, dorsal margin straight (Fig. 15)*A. mystica*
 Posterolateral aspect of developing male 10th tergal margin slanted, dorsal margin with pre-apical elevation (Fig. 5)*A. aurora*

4. Posterolateral aspect of developing male 10th tergum bent upward in apical third; lobe portion of tergum 10 distal to cercal bases about twice as long as tergum proximal to cercal bases; longest erect tergal bristles about half as long as tergum*A. rickeri*

Lateral aspect of developing male 10th tergum straight on dorsum; lobe portion of tergum 10 distal to cercal bases no more than 1.5 times as long as tergum proximal to cercal bases; longest erect tergal bristles about 1/3 as long as tergum5

5. Lateral aspect of developing male 10th tergum slanted along posterior margin (Fig. 31); longest tergal bristles almost half as long as tergum (Fig. 32)*A. virginiana*

Lateral aspect of developing male 10th tergum almost truncate apically (Fig. 21); longest tergal bristles about 1/3 as long as tergum (Fig. 22)6

6. Erect and semi-erect tergal bristles irregularly distributed along tergal length*A. granulata*

Erect and semi-erect tergal bristles restricted to apical and midlength positions (Fig. 22) .*A. starki*

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