



## EPIPROCT AND DORSAL PROCESS STRUCTURE IN THE *ALLOCAPNIA FORBESI* FRISON, *A. PYGMAEA* (BURMEISTER), AND *A. RICKERI* FRISON SPECIES GROUPS (PLECOPTERA: CAPNIIDAE), AND INCLUSION OF *A. MINIMA* (NEWPORT) IN A NEW SPECIES GROUP

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### ABSTRACT

Epiprocts and tergal processes for males of twenty *Allocapnia* species assigned to the *A. forbesi* Frison, *A. pygmaea* (Burmeister), and *A. rickeri* Frison groups were examined with scanning electron microscopy. Results suggest these groups are closely related and that *A. minima* (Newport) should be excluded from the *A. forbesi* group and assigned to its own group.

**Keywords:** *Allocapnia*, Male Genitalic Structures, Scanning Electron Microscopy, Plecoptera

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### INTRODUCTION

The snowfly (Stark et al. 2012) genus *Allocapnia* Claassen, 1928, is an eastern Nearctic endemic, and , currently includes 47 species (DeWalt et al. 2012). In the comprehensive study of the group, Ross & Ricker (1971) provide diagnostic characters and a phylogenetic framework for the 38 species recognized at that time. In the phylogenetic aspect of their study, 10 species groups, based primarily on the adult genitalic features illustrated in the monograph, were recognized. Subsequently, 10 additional *Allocapnia* species have been proposed, often with support of scanning electron microscopy images for the critical male genitalic structures (e.g. Kondratieff & Kirchner 2000; Grubbs 2006; 2008; Grubbs & Sheldon 2008).

Although scanning electron microscopy (SEM) has been widely used in study of various stonefly structures, it was not used in the study of male

capniid genitalia until Nelson & Baumann (1987) demonstrated the advantages of SEM for this purpose. Alford (1998) followed with the first study of *Allocapnia* males. Presently, SEM data are available for 19 species (Table 1), and six of the recognized species groups (Alford 1998; Grubbs 2006; 2008; Grubbs & Sheldon 2008; Kondratieff & Kirchner 2000; Kirchner et al. 2002; Nations et al. 2007; Stark & Lacey 2005; Stark & Nelson 2000; Stark et al. 2000; Ray et al. 2012). However, no SEM studies are available for members of the *A. forbesi* group, only one member, *A. aurora* Ricker (Alford 1998; Stark & Lacey 2005; Nations et al. 2007), of the *A. pygmaea* group, and two members, *A. rickeri* Frison (Nations et al. 2007) and *A. perplexa* Ross & Ricker (Kirchner et al. 2002), of the *A. rickeri* group. In this study we provide comparative SEM data for males of 20 species, and more fully diagnose these three species groups within *Allocapnia*.

**Table 1.** List of *Allocapnia* species studied with scanning electron microscopy.

SPECIES	SEM STUDIES
<i>Allocapnia aurora</i> Ricker 1952	Alford, 1998; Stark & Lacey, 2005; Nations et al., 2007
<i>A. granulata</i> (Claassen 1924)	Nations et al., 2007; Grubbs & Sheldon, 2008
<i>A. loshada</i> Ricker 1952	Kondratieff & Kirchner, 2000
<i>A. malverna</i> Ross 1964	Grubbs, 2008
<i>A. menawa</i> Grubbs & Sheldon 2008	Grubbs & Sheldon, 2008
<i>A. mohri</i> Ross & Ricker 1964	Stark & Nelson, 2000; Grubbs, 2008
<i>A. muskogee</i> Grubbs & Sheldon 2008	Grubbs & Sheldon, 2008
<i>A. mystica</i> Frison 1929	Stark & Lacey, 2005; Nations et al., 2007; Grubbs & Sheldon, 2008
<i>A. perplexa</i> Ross & Ricker 1971	Kirchner et al., 2002
<i>A. polemistic</i> Ross & Ricker 1971	Stark et al., 2000
<i>A. recta</i> (Claassen 1924)	Kondratieff & Kirchner, 2000; Stark et al., 2000; Grubbs, 2008
<i>A. rickeri</i> Frison 1929	Nations et al., 2007
<i>A. sano</i> Grubbs 2006	Grubbs, 2006
<i>A. sequatchie</i> Kondratieff & Kirchner 2000	Kondratieff & Kirchner, 2000
<i>A. starki</i> Kondratieff & Kirchner 2000	Alford, 1998 (as <i>A. recta</i> ); Kondratieff & Kirchner, 2000; Stark et al., 2000 (as <i>A. recta</i> ); Nations et al. 2007; Ray et al., 2012
<i>A. tsalagi</i> Grubbs 2008	Grubbs, 2008
<i>A. unzickeri</i> Ross & Yamamoto 1966	Grubbs & Sheldon, 2008
<i>A. virginiana</i> Frison 1942	Alford, 1998; Stark & Lacey, 2005; Nations et al., 2007
<i>A. wrayi</i> Ross 1964	Grubbs & Sheldon, 2008

## MATERIALS AND METHODS

Most *Allocapnia* specimens were provided by the Stark Collection, Mississippi College, Clinton, Mississippi (BPS) and the C.P. Gillette Museum, Colorado State University, Fort Collins, Colorado (CSUC). Comparative material of four recently described species was provided by Dr. Scott Grubbs, and additional specimens were obtained from Mr. Fred Kirchner, Mr. Robert Boyle, Dr. Mac Alford, Mr. Matthew Hicks and Dr. Brian Armitage. Specimens examined with SEM were prepared by the methods outlined by Harrison & Stark (2010).

## RESULTS AND DISCUSSION

### ALLOCAPNIA FORBESI GROUP

Ross & Ricker (1971) recognized six species (*A.*

*curiosa* Frison 1942; *A. forbesi* Frison 1929; *A. maria* Hanson 1942; *A. minima* (Newport 1851); *A. ozarkana* Ross 1964; *A. pechumani* Ross & Ricker 1964); *A. minima* was included, perhaps tentatively, and *A. frumi* Kirchner 1982 was subsequently added. All species in this group, except *A. minima*, share a short, ornately sculpted apical segment of the upper epiproct (e.g. Figs. 2-3, 32-33), and also have similar dorsal processes on abdominal terga 7 and 8 (e.g. Figs. 5-6, 17-18). We have not studied details of the female genitalia, but the figures in Ross & Ricker (1971) indicate *A. minima* and *A. maria* have similar subgenital plates which differ from the other species placed in the group. On the basis of the lack of shared male characters, we are removing *A. minima* from this group and placing it in the *Allocapnia minima* group. Ross & Ricker (1971) also suggest *A. illinoensis* Frison 1935, is descended from a common

ancestor (#11) with members of the *A. forbesi* group. Presently, we have no supporting data for this hypothesis.

Ross & Ricker's (1971) phylogenetic analysis of the *A. forbesi* group places it close to the *A. rickeri* group. This hypothesis is supported by the shared apomorphic feature of a short apical segment of the upper epiproct limb (Figs. 2, 98). The *A. pygmaea* group species have a longer apical segment (Figs. 43-44), but all three groups share the same wave-like spiked armature on the apical segment (Figs. 2, 44, 98). Within the *A. forbesi* group, Ross & Ricker suggested *A. forbesi* and *A. ozarkana* form a sister group, and *A. pechumani* and *A. maria* form another sister group closely related to *A. curiosa*. Our data show *A. curiosa*, *A. frumi*, *A. maria* and *A. pechumani* share the presence of ear-like expansions on the base of the apical segment of the epiproct upper limb (Figs. 2, 14, 20, 32), whereas the apical segment of this structure in *A. forbesi* and *A. ozarkana* is slender and not modified with ear-like basal lobes (Figs. 9, 26). The latter two species share a deeply notched 8<sup>th</sup> tergal process not found among other species in this group (Figs. 11, 28). These characters support the Ross & Ricker (1971) hypothesis of a sister group relationship between *A. forbesi* and *A. ozarkana*. Furthermore, we are able to place *A. frumi* as the probable sister species of *A. curiosa*, as suggested by Kirchner (1982). The basis for this assignment is the shared, thin lateral aspect of the elevated portion of the 8<sup>th</sup> tergal process (Figs. 4, 15).

***Allocapnia curiosa* Frison**  
(Figs. 1-6)

*Allocapnia curiosa* Frison 1942:268. Holotype ♂ (Illinois Natural History Survey), Kanetown [Preston Co.], West Virginia

*Allocapnia curiosa*: Ross & Ricker, 1971:39.

**Material examined. Kentucky:** Jackson Co., Peter Branch Middle Fork Rockcastle River, below Robinson Creek, 10 February 1998, B.C. Kondratieff, R.K. Kirchner, 9♂, 1♀ (CSUC). **Virginia:** Tazewell Co., East Fork Cove Creek, Rt. 662, 15 February 1982, B.C. Kondratieff, 2♂ (CSUC). **West Virginia:** Mercer Co., Camp Creek, I-77, 26 February 1999, B.C.

Kondratieff, R.F. Kirchner, 5♂, 1♀ (CSUC). Pocahontas Co., Hills Creek Falls, Hills Creek Scenic Area, Hwy 39, 16 March 1980, R.F. Kirchner, R.M. Meyer, 3♂ (BPS).

**Male epiproct.** Apical segment of upper limb ca. 210-215 µm long, bearing a pair of basolateral ear-like projections and a dense median patch of wave-like spikes (Figs. 1-3). Median spike patch ca. 187-194 µm long and narrowly divided along entire length by groove, ear-like projections without spikes; apical segment ca. 138-146 µm wide across ear-like projections and narrowed to ca. 60 µm at apex. Basal segment of upper limb ca. 283 µm long and ca. 85-94 µm wide for most of length. Lateral areas of basal segment bearing irregular row of setae and a median groove but otherwise unadorned. Lower limb ca. 167-175 µm wide proximal to apical spoon.

**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 1, 4-6). Process of tergum 7 conical, apex covered with scale-like structures; process of tergum 8 thin, narrowly notched, lobes bent slightly forward in lateral aspect and covered dorsally with scale-like structures; width of tergum 8 process ca. 177 µm. Anterior face of tergum 8 process bearing a low, rounded, median knob.

***Allocapnia forbesi* Frison**  
(Figs. 7-12)

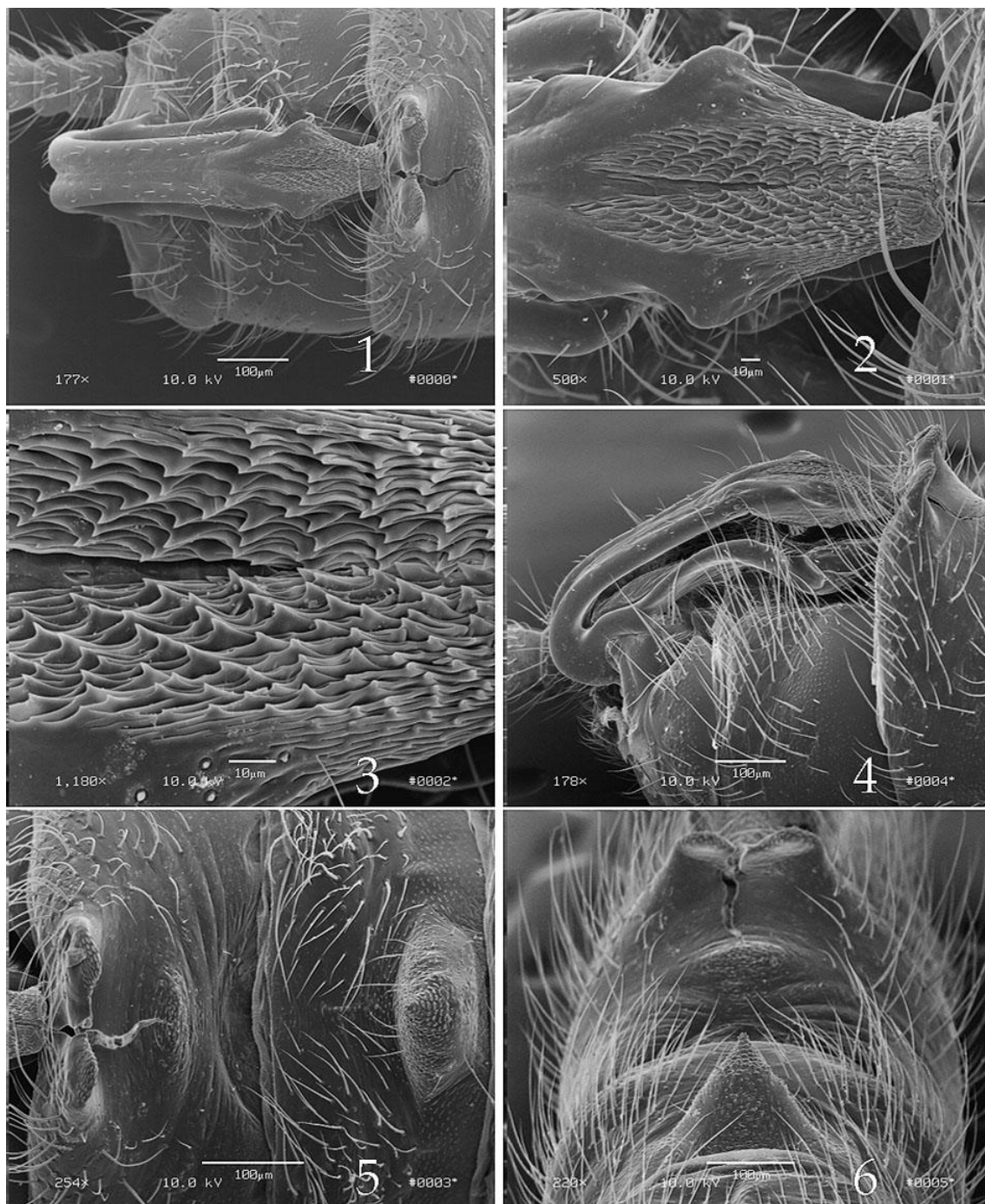
*Allocapnia forbesi* Frison 1929:397. Holotype ♂ (Illinois Natural History Survey), tributary North Hicks Branch, Herod [Pope Co.], Illinois

*Allocapnia forbesi cornuta* Frison 1935:363. Holotype ♂ (Illinois Natural History Survey), Hills Branch Creek, Dixon Springs [Pope Co.], Illinois, syn. Illies, 1966:123.

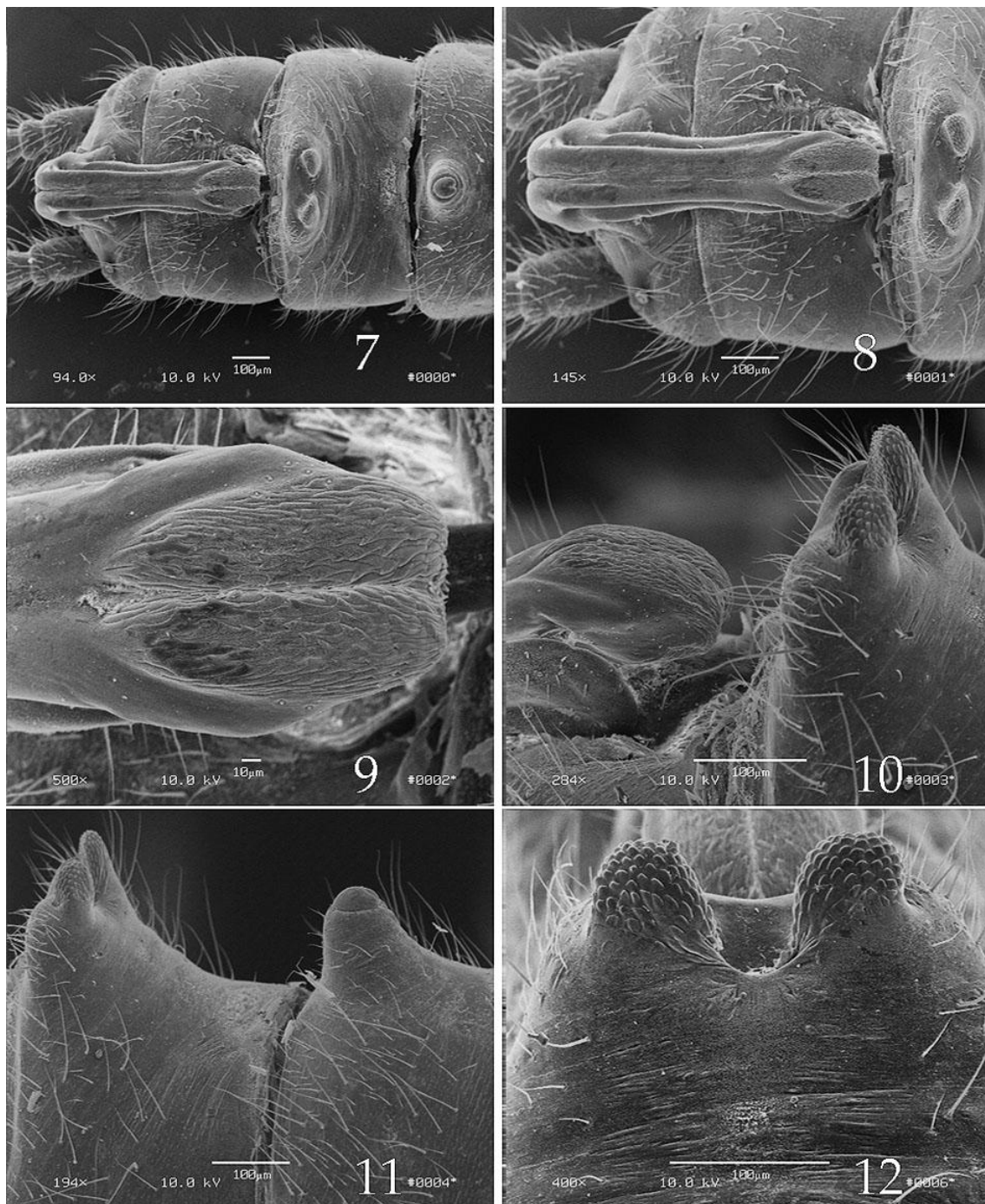
*Allocapnia forbesi*: Ross & Ricker, 1971:35.

**Material examined. Kentucky:** Adair Co., tributary Big Creek, Hwy 268, west of Milltown, 3 March 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 7♂ (CSUC). Marion Co., Conley Creek, Hwy 49, 3 March 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 2♂ (CSUC). **Ohio:** Hamilton Co., Cincinnati, French Park, 31 January 1953, A.R. Gaufin, 1♂ (BPS).

**Male epiproct.** Apical segment of upper limb ca. 180 µm long, swollen at midlength but not bearing ear-like lobes; median field of apical segment bearing a



Figs. 1-6. *Allocapnia curiosa*, Hills Creek Falls, Pocahontas Co., West Virginia. 1. Male terminalia, dorsal. 2. Apical segment upper limb of epiproct tip, dorsal. 3. Surface detail apical segment upper limb of epiproct, dorsal. 4. Male terminalia, lateral. 5. Abdominal tergal lobes, dorsal. 6. Abdominal tergal lobes, anterodorsal.



Figs. 7-12. *Allocapnia forbesi*, tributary Big Creek, Adair Co., Kentucky. 7. Male terminalia, dorsal. 8. Epiproct and 8<sup>th</sup> tergal process, dorsal. 9. Apical segment upper limb of epiproct tip, dorsal. 10. Apical segment upper limb of epiproct and 8<sup>th</sup> tergal process, lateral. 11. Abdominal tergal lobes, lateral. 12. 8<sup>th</sup> tergal process, anterodorsal.

patch of wave-like spikes ca. 178  $\mu\text{m}$  long and narrowly divided along entire length by groove (Figs. 7-10); greatest width of apical segment ca. 162  $\mu\text{m}$ , narrowed to apical width of ca. 87  $\mu\text{m}$  (Fig. 9). Basal segment of upper limb ca. 437  $\mu\text{m}$  long and ca. 89  $\mu\text{m}$  wide at narrowest point near midlength (Fig. 8). Lateral areas of basal segment appearing bare; median area with longitudinal groove. Lower limb ca. 139  $\mu\text{m}$  wide proximal to apical spoon.

**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 7, 10-12). Process of tergum 7 somewhat conical, but broadly rounded on dorsum (Fig. 11); apex without scale-like structures. Process of tergum 8 broadly and deeply notched with lobes resting on a narrow, plateau-like structure (Figs. 8, 10, 12); dorsal outline of lobes subtriangular and covered over most of surface with scale-like structures; basal width of notch ca. 42  $\mu\text{m}$ , dorsal width across lobes ca. 211  $\mu\text{m}$ .

*Allocapnia frumi* **Kirchner**  
(Figs. 13-18)

*Allocapnia frumi* Kirchner 1982:786. Holotype ♂ (United States National Museum of Natural History), Coats Run of North Fork Cherry River, Greenbrier Co., West Virginia

**Material examined. West Virginia:** Pocahontas Co., Sugar Creek at Williams River, 28 March 1982, R.F. Kirchner, V.J. Marchese, 2♂ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 287  $\mu\text{m}$  long, bearing a pair of dorsolateral ear-like projections and a dense median patch of wave-like spikes (Figs. 13-16). Median spike patch ca. 230  $\mu\text{m}$  long and divided along entire length by narrow groove, spikes absent on ear-like projections and basal dorsolateral bulges (Fig. 14). Apical segment ca. 147  $\mu\text{m}$  wide across ear-like projections, and narrowed to ca. 29  $\mu\text{m}$  at apex (Fig. 14). Basal segment of upper limb ca. 280  $\mu\text{m}$  long and ca. 100  $\mu\text{m}$  wide for most of length; setation and dorsal longitudinal groove absent from basal segment. Lower limb ca. 200  $\mu\text{m}$  wide proximal to apical spoon.

**Male tergal process.** Prominent raised structures on

abdominal terga 7 and 8 (Figs. 15, 17-18). Process of tergum 7 thin in lateral aspect, forming a triangular projection in anterodorsal aspect, covered over much of surface with scale-like structures (Figs. 17-18). Process of tergum 8 thin in lateral aspect (Fig. 15) and tapered to a slightly concave dorsal surface in anterodorsal aspect; dorsum of process covered with a narrow strip of scale-like structures; width of process ca. 176  $\mu\text{m}$ .

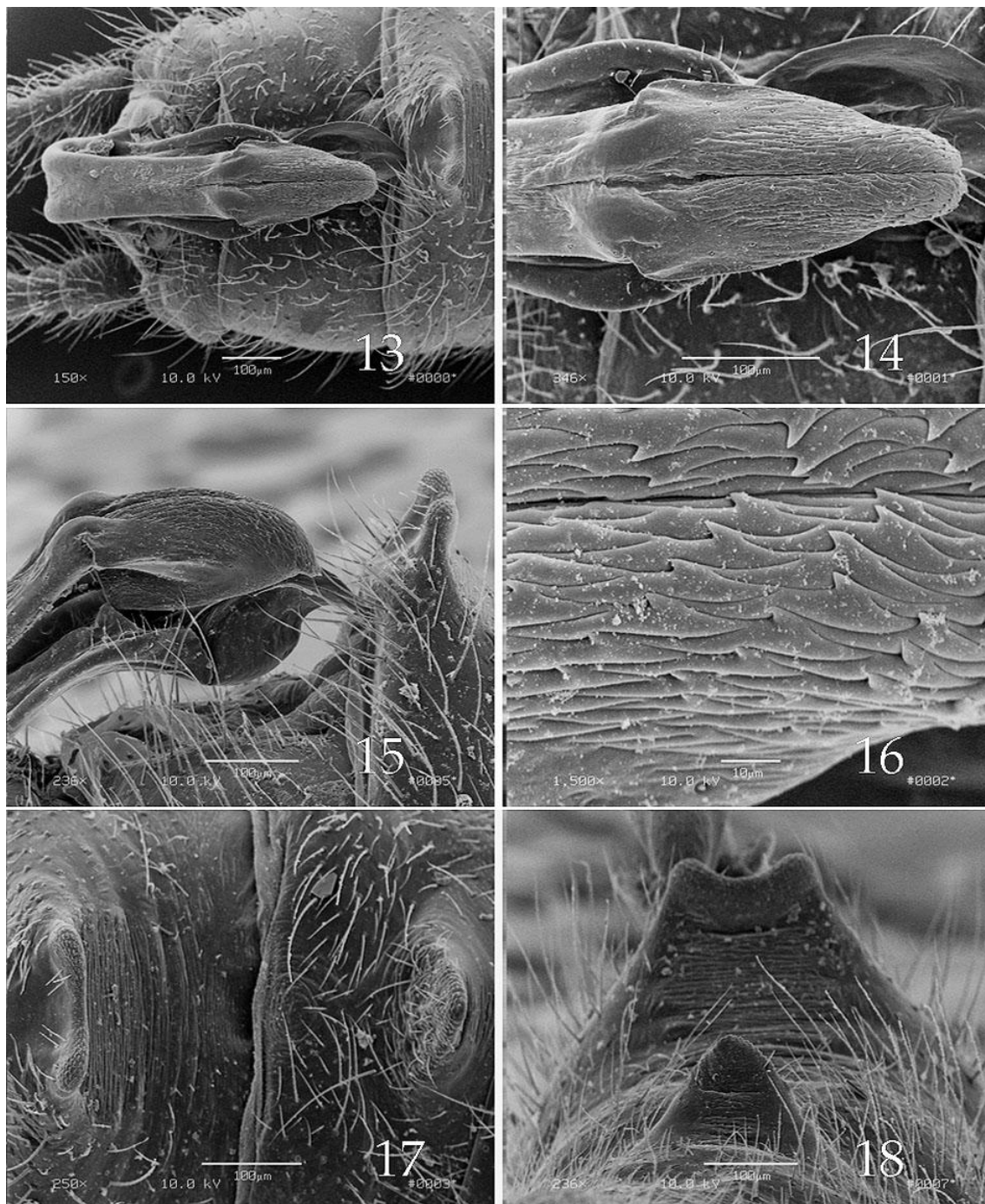
*Allocapnia maria* **Hanson**  
(Figs. 19-24)

*Allocapnia maria* Hanson 1942:81. Holotype ♂ (United States National Museum of Natural History), East Amherst [Hampshire Co.], Massachusetts  
*Allocapnia maria*: Ross & Ricker, 1971:37.

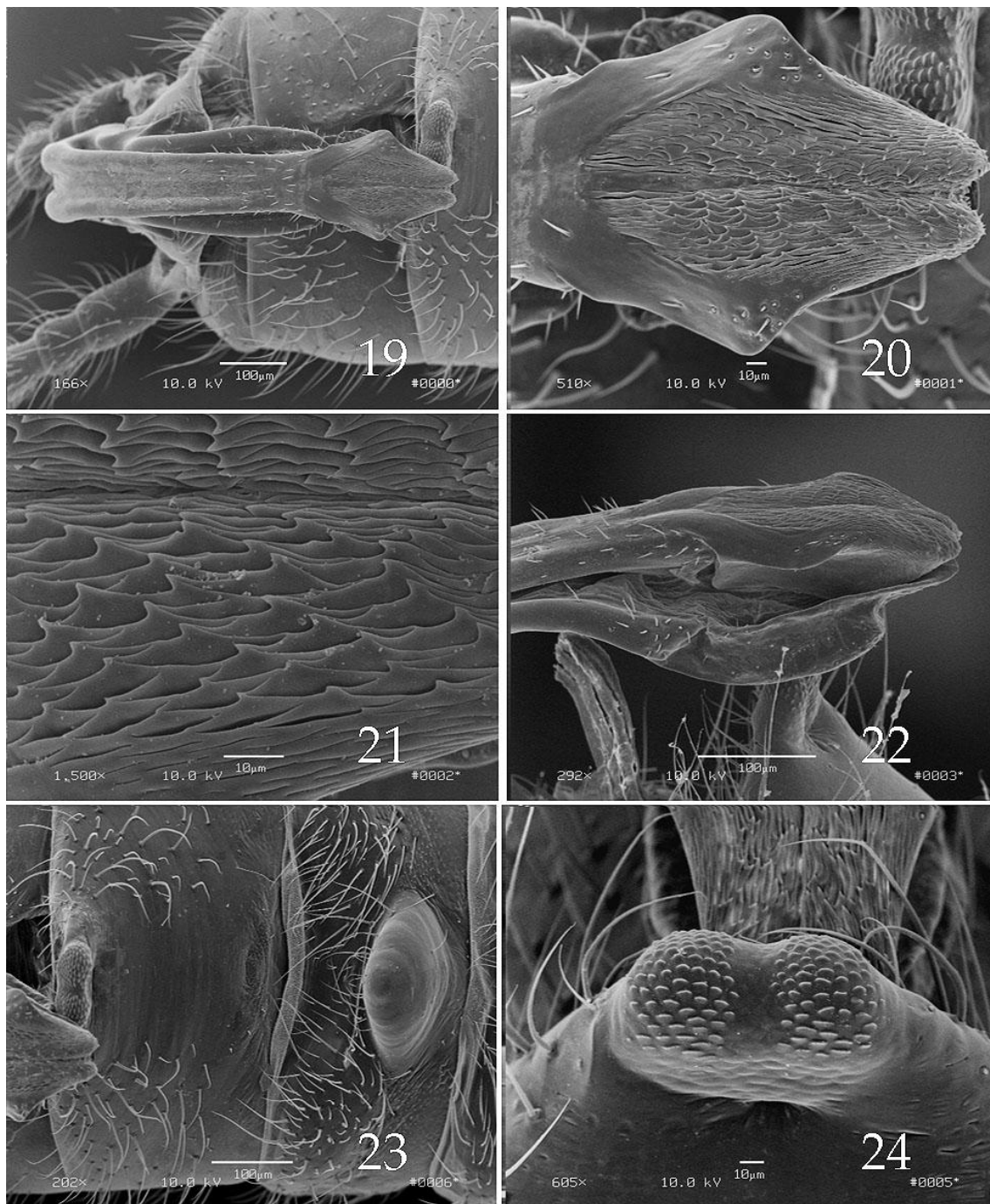
**Material examined. Virginia:** Giles Co., Stony Creek, CR 635, north of Goldband, 25 February 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 13♂, 1♀ (CSUC). Smyth Co., Lick Creek, Rt 621, 14 February 1982, B.C. Kondratieff, 5♂ (CSUC). Wythe Co., Stoney Fork Reed Creek, Dark Horse Hollow, Hwy 52, 26 February 1999, B.C. Kondratieff, R.F. Kirchner, 23♂, 4♀ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 210  $\mu\text{m}$  long, bearing a pair of basolateral ear-like projections and a dense median patch of wave-like spikes (Figs. 19-22). Median spike patch ca. 200  $\mu\text{m}$  long and separated along entire length by narrow groove (Fig. 20), ear-like projections without spikes. Apical segment ca. 161  $\mu\text{m}$  wide across ear-like projections and narrowed to ca. 47  $\mu\text{m}$  at apex. Basal segment of upper limb ca. 344  $\mu\text{m}$  long and ca. 78  $\mu\text{m}$  wide at midlength; apical third of basal segment bearing a sparse patch of setae; median field of basal half with wide groove (Fig. 19). Lower limb ca. 172  $\mu\text{m}$  wide proximal to apical spoon.

**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 22-24). Process of tergum 7 conical, apex without scale-like structures (Fig. 23); process of tergum 8 thin in lateral aspect (Fig. 22), dorsal surface truncate, or slightly concave, and bearing a pair of dorsolateral patches of scale-like structures (Fig. 24). Width of tergum 8 process ca. 100  $\mu\text{m}$ .



Figs. 13-18. *Allocapnia frumi*, Sugar Creek, Pocahontas Co., West Virginia. 13. Male terminalia, dorsal. 14. Apical segment upper limb of epiproct, dorsal. 15. Apical segment upper limb of epiproct and 8<sup>th</sup> tergal process, lateral. 16. Surface detail apical segment upper limb of epiproct, dorsal. 17. Abdominal tergal lobes, dorsal. 18. Abdominal tergal lobes, anterodorsal.



Figs. 19-24. *Allocapnia maria*, Dark Horse Hollow, Wythe Co., Virginia. 19. Male terminalia, dorsal. 20. Apical segment upper limb of epiproct, dorsal. 21. Surface detail apical segment upper limb of epiproct, dorsal. 22. Epiproct apex and 8<sup>th</sup> tergal process, lateral. 23. Abdominal tergal lobes, dorsal. 24. 8<sup>th</sup> abdominal tergal lobe, anterodorsal.



### *Allocapnia ozarkana* Ross

(Figs. 25-30)

*Allocapnia ozarkana* Ross 1964:172. Holotype ♂ (Illinois Natural History Survey), Cannon Creek, Madison Co., Arkansas

*Allocapnia ozarkana*: Ross & Ricker, 1971:34.

**Material examined.** Arkansas: Johnson Co., East Fork Horsehead Creek, Hwy 103, 16 January 1999, B. Stark, 1♂ (BPS).

**Male epiproct.** Apical segment of upper limb ca. 183 µm long, swollen basolaterally but not bearing ear-like lobes; median field of apical segment bearing a patch of wave-like spikes ca. 150 µm long and divided along entire length by groove (Figs. 25-28); greatest width of apical segment ca. 175 µm, narrowed to 58 µm at apex (Fig. 26). Basal segment of upper limb ca. 343 µm long and ca. 97 µm wide at midlength; margins of basal segment lacking setae, median groove present, at least in basal half. Lower limb ca. 110 µm wide proximal to apical spoon.

**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 25, 28-30). Process of tergum 7 ca. 72 µm wide and separated to base into a pair of small mounds (Figs. 29-30); apices of lobes appear smooth. Process of tergum 8 ca. 188 µm wide and divided to base by gap ca. 50 µm wide (Fig. 30); dorsal surface of lobes covered with scale-like structures.

### *Allocapnia pechumani* Ross & Ricker

(Figs. 31-36)

*Allocapnia pechumani* Ross & Ricker 1964:88. Holotype ♂ (Illinois Natural History Survey), Otsquago Creek, Starkville, Herkimer Co., New York

*Allocapnia pechumani*: Ross & Ricker, 1971:36.

**Material examined.** New York: Montgomery Co., tributary to Canajoharie Creek, Rt 10 near Smith Lane, 10 March 2012, B.C. Kondratieff, L. Myers, 15♂, 2♀ (CSUC). Schenectady Co., Normans Kill, Cole Rd, Duanesburg, 8 March 2009, L. Myers, 3♂ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 251 µm long, hastate in dorsal aspect; width across posterolateral projections ca. 208 µm; apical ca. 243 µm armed with patch of wave-like spikes (Figs. 31-33). Basal segment of upper limb ca. 511 µm long and

ca. 200 µm wide at midlength; marginal areas of basal segment bearing sparse setal patch in apical half.

**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 34-36). Process of tergum 7 ca. 79 µm wide and emarginate on dorsal margin; process of tergum 8 ca. 181 µm wide and bearing a shallow dorsal notch ca. 29 µm wide. Surfaces of both tergal processes covered with scale-like structures.

### ALLOCAPNIA MINIMA GROUP

Our decision to remove *A. minima* from the *A. forbesi* group and place it as the solitary member of this group is discussed above. Ross & Ricker (1971) indicated the tenuous nature of their assignment by linking the species to *A. maria* by a dashed line in their phylogenetic chart (Ross & Ricker 1971, Fig. 86). Ross & Ricker's (1971) inclusion of *A. minima* in the *A. forbesi* clade was based entirely on the similarity of the female terminalia, a character state that can vary in other species groups of the genus (e.g. *A. rickeri* group). *Allocapnia minima* is similar in epiproct armature to members of the *A. vivipara* (Claassen) group, including *A. brooksi* Ross 1964, and *A. tennesse* Ross & Ricker 1964 (Stark & Kondratieff, unpublished), and may be more closely related to that group than to members of the *A. forbesi* group.

### *Allocapnia minima* (Newport)

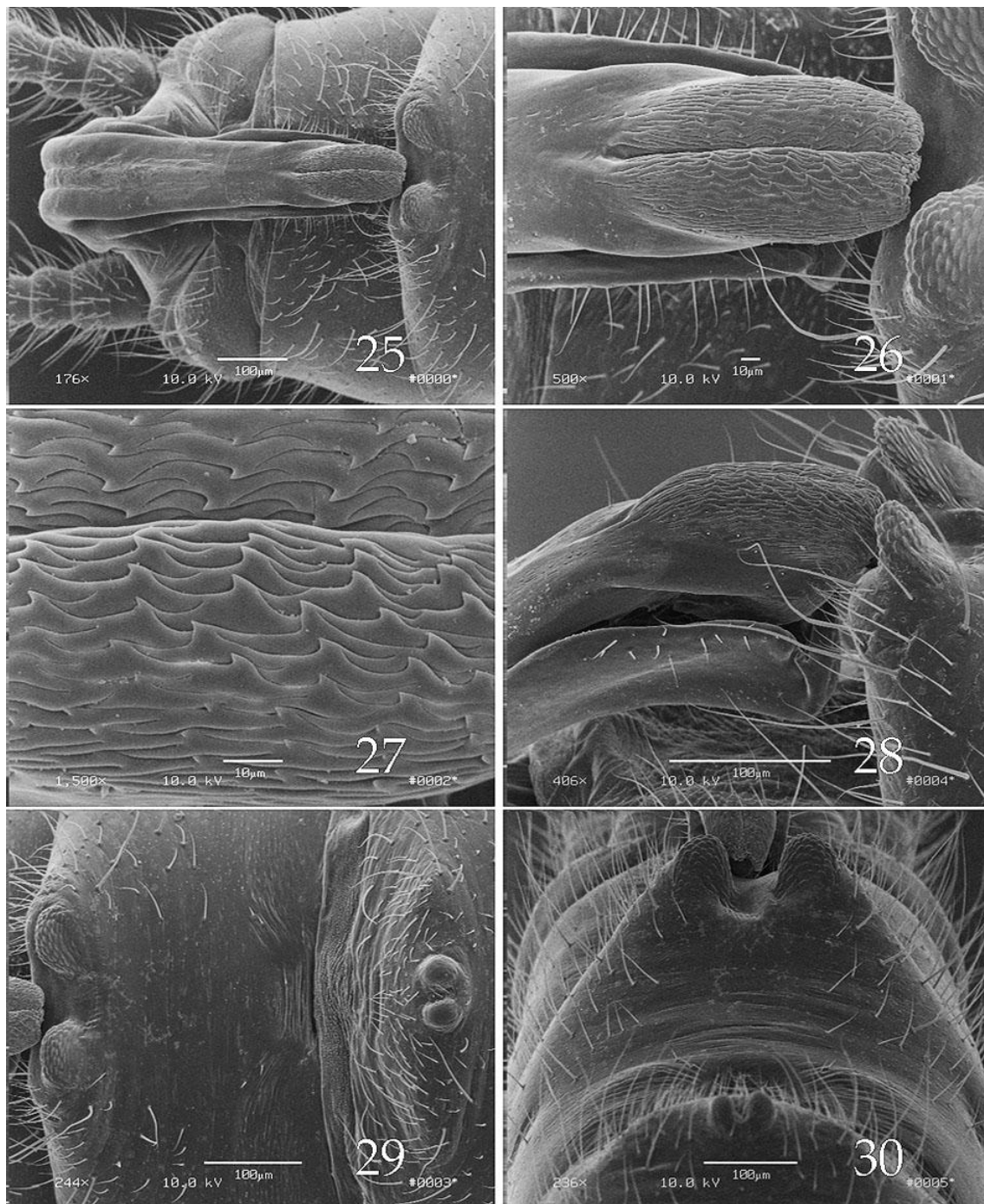
(Figs. 37-42)

*Perla minima* Newport 1851:450. Lectotype ♂ (British Museum of Natural History), St. Martins Falls, Albany River, Ontario, designation by Kimmins 1970

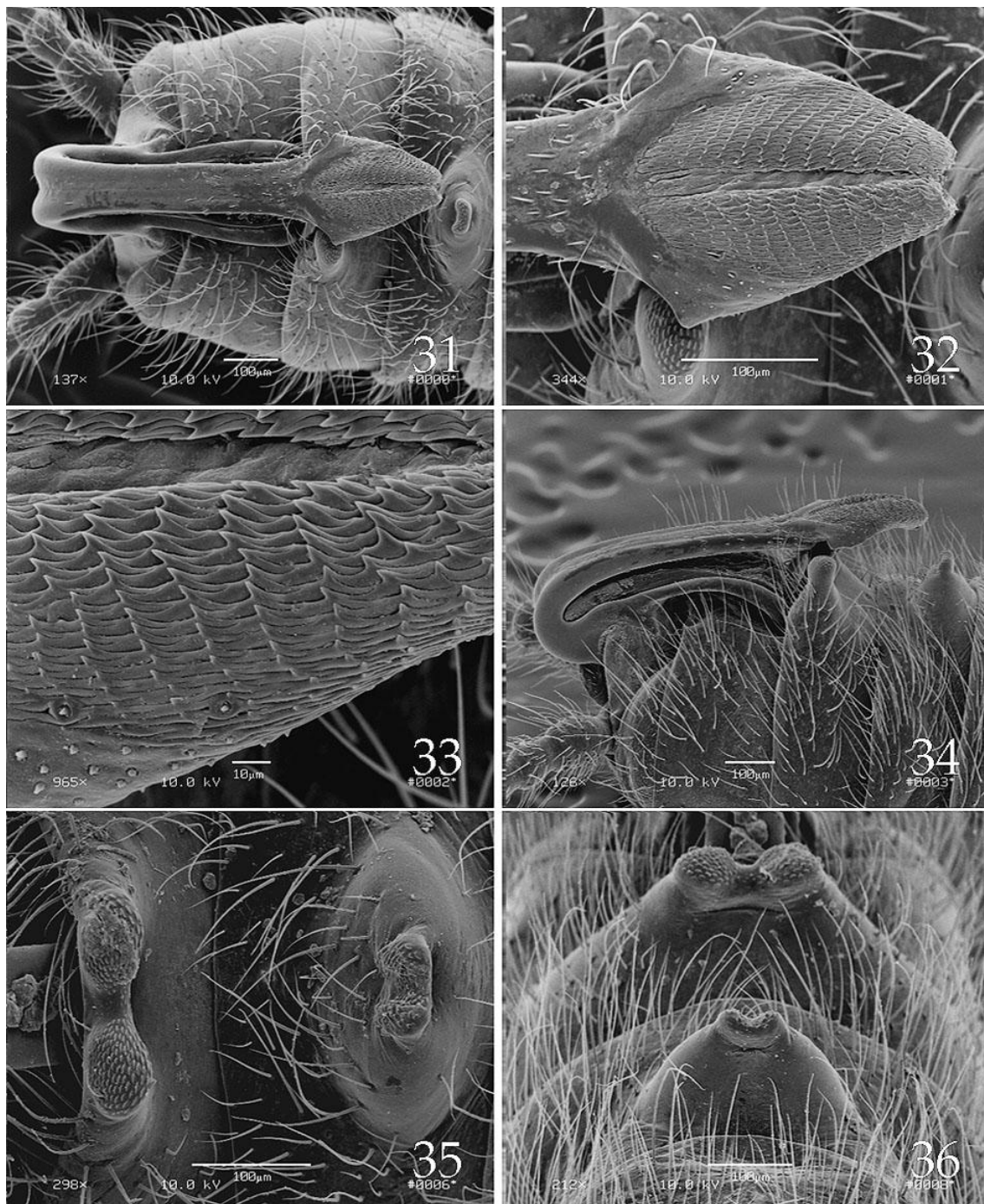
*Capnella incisura* Claassen 1924:45. Holotype ♂ (Cornell University), Ithaca [Tompkins Co.], New York. syn. Ricker, 1938:136.

**Material examined.** New York: Clinton Co., Saranac River, Clayburg, Silver Lake Rd, 25 March 2005, L. Myers, 24♂, 2♀ (CSUC). Hamilton Co., Sacandaga River, Wells, jct. Rt 8-Rt 30, 43.4453°N, 74.2524°W, 12 March 2012, B.C. Kondratieff, L. Myers, 16♂, 3♀ (CSUC). St. Lawrence Co., St. Regis River, Rt 11, 14 March 2009, T. Mihuc, 8♂, 5♀ (CSUC).

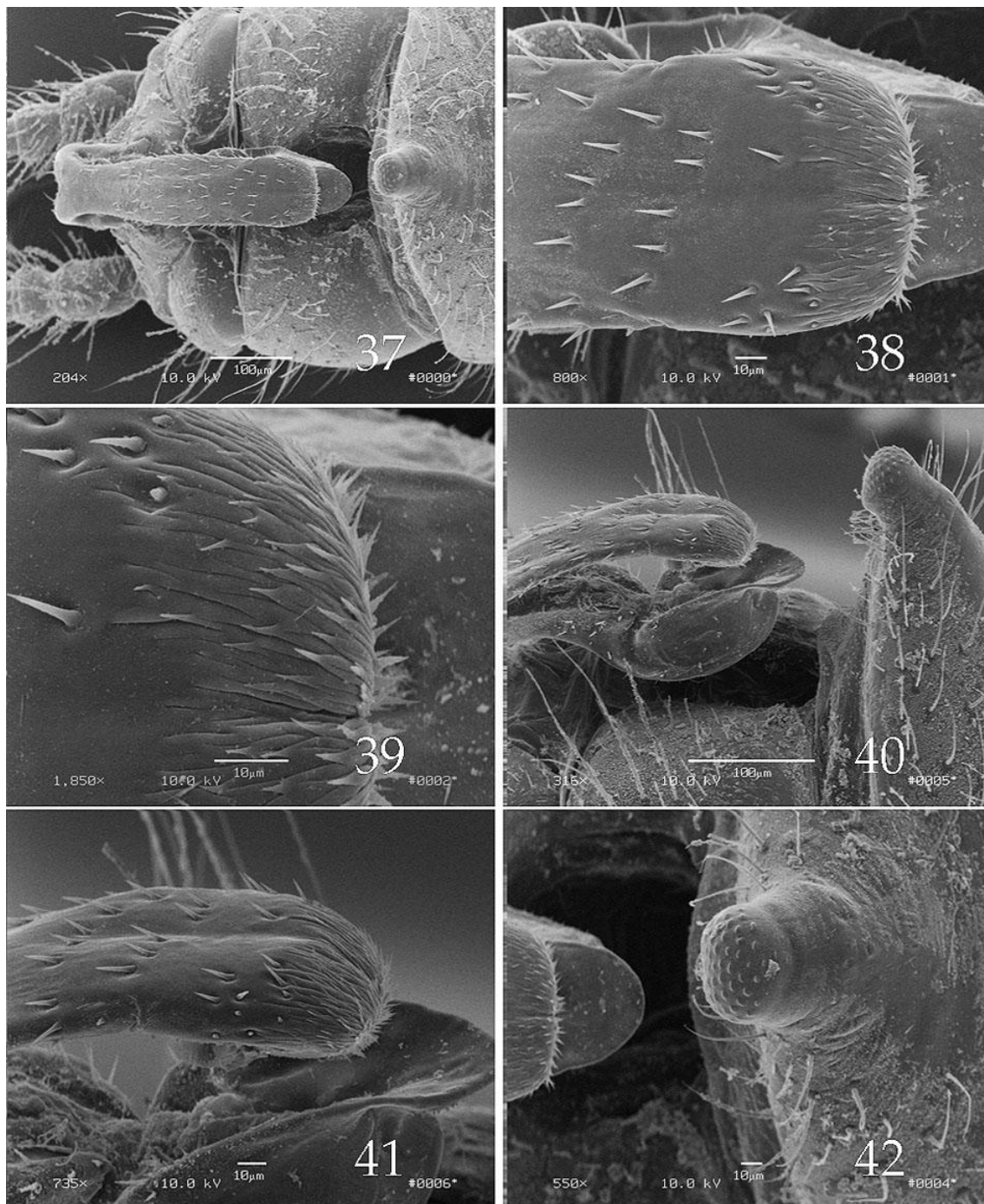
**Male epiproct.** Apical segment of upper limb



Figs. 25-30. *Allocapnia ozarkana*, East Fork Horsehead Creek, Johnson Co., Arkansas. 25. Male terminalia, dorsal. 26. Apical segment upper limb of epiproct, dorsal. 27. Surface detail apical segment upper limb of epiproct, dorsal. 28. Epiproct apex and 8<sup>th</sup> tergal process, lateral. 29. Abdominal tergal lobes, dorsal. 30. Abdominal tergal lobes, anterodorsal.



Figs. 31-36. *Allocapnia pechumani*, tributary Canajoharie Creek, Montgomery Co., New York. 31. Male terminalia, dorsal. 32. Apical segment upper limb of epiproct, dorsal. 33. Surface detail apical segment upper limb of epiproct, dorsal. 34. Epiproct and tergal processes, lateral. 35. Abdominal tergal processes, dorsal. 36. Abdominal tergal processes, anterodorsal.



Figs. 37-42. *Allocapnia minima*, Saranac River, Clinton Co., New York. 37. Male terminalia, dorsal. 38. Apical segment upper limb of epiproct tip, dorsal. 39. Surface detail apical segment upper limb of epiproct, dorsal. 40. Epiproct apex and 8<sup>th</sup> tergal process, lateral. 41. Epiproct apex, lateral. 42. 8<sup>th</sup> abdominal tergal process, dorsal.

flattened in lateral aspect and ca. 198  $\mu\text{m}$  long; apical ca. 31  $\mu\text{m}$  armed with a series of appressed processes separated by narrow grooves and terminating in elongate, flattened spines (Figs. 37-41), remainder of apical segment armed with widely separated long, thick setae; apical segment ca. 83-86  $\mu\text{m}$  wide throughout length and bluntly rounded at tip. Basal segment of upper limb ca. 62  $\mu\text{m}$  wide, without mesal longitudinal groove. Lower limb ca. 96  $\mu\text{m}$  wide near apical spoon.

**Male tergal process.** Prominent thimble-shaped, undivided structure on tergum 8 slanted caudad and ca. 54  $\mu\text{m}$  wide at tip; apex covered with scale-like structures (Fig. 40-42).

#### ALLOCAPNIA PYGMAEA GROUP

Ross & Ricker (1971) recognized six species (*A. aurora* Ricker 1952; *A. indianae* Ricker 1952; *A. nivicola* (Fitch 1847); *A. ohioensis* Ross & Ricker 1964; *A. pygmaea* (Burmeister 1839); *A. smithi* Ross & Ricker 1971) in the *A. pygmaea* group. There have been no subsequent changes to this species list. In this group the apical and basal segments of the male epiproct are usually subequal in length, and at least the distal half of the apical segment is armed with a patch of wave-like spikes. On the epiproct lower limb the notch delineating the apical spoon is absent or much reduced. Abdominal terga 7-8 typically bear dorsal processes, although the 7<sup>th</sup> tergal process may be obscure or absent (e.g. *A. aurora*, *A. pygmaea*). The 8<sup>th</sup> tergal process is notched and may bear a mesal tooth giving the process a trilobed appearance. Ross & Ricker placed the *A. pygmaea* group as the sister group to the *A. rickeri* group. *Allocapnia pygmaea* is considered the most primitive member of the complex and *A. smithi* and *A. nivicola* are considered the most derived members of the group.

The sister group hypotheses proposed by Ross & Ricker (1971) for this group were based primarily on variations of the tergal processes, and we find no suitable characters on the epiproct to suggest modifications be made to these hypotheses. Males of four species in the group (*A. indianae*, *A. nivicola*, *A. ohioensis*, *A. smithi*) share trilobed processes on tergum 8 (Figs. 53, 59, 66, 77), whereas *A. aurora* and *A. pygmaea* share bilobed processes (Figs. 47-48, 71-

72). Two of the species, *A. indianae* and *A. ohioensis* also share trilobed processes on tergum 7; this latter condition is considered by Ross & Ricker as the primitive one for tergum 7 structure "...because this [trilobed process] could have arisen as a single homeotic mutant..." and later become modified to a simpler arcuate structure in the ancestral form giving rise to *A. nivicola* (Fig. 58) and *A. smithi*.

#### *Allocapnia aurora* Ricker

(Figs. 43-48)

*Allocapnia aurora* Ricker 1952:159. Holotype ♂ (Illinois Natural History Survey), Pigeon River, Woodrow [Haywood Co.], North Carolina

*Allocapnia aurora*: Ross & Ricker, 1971:46.

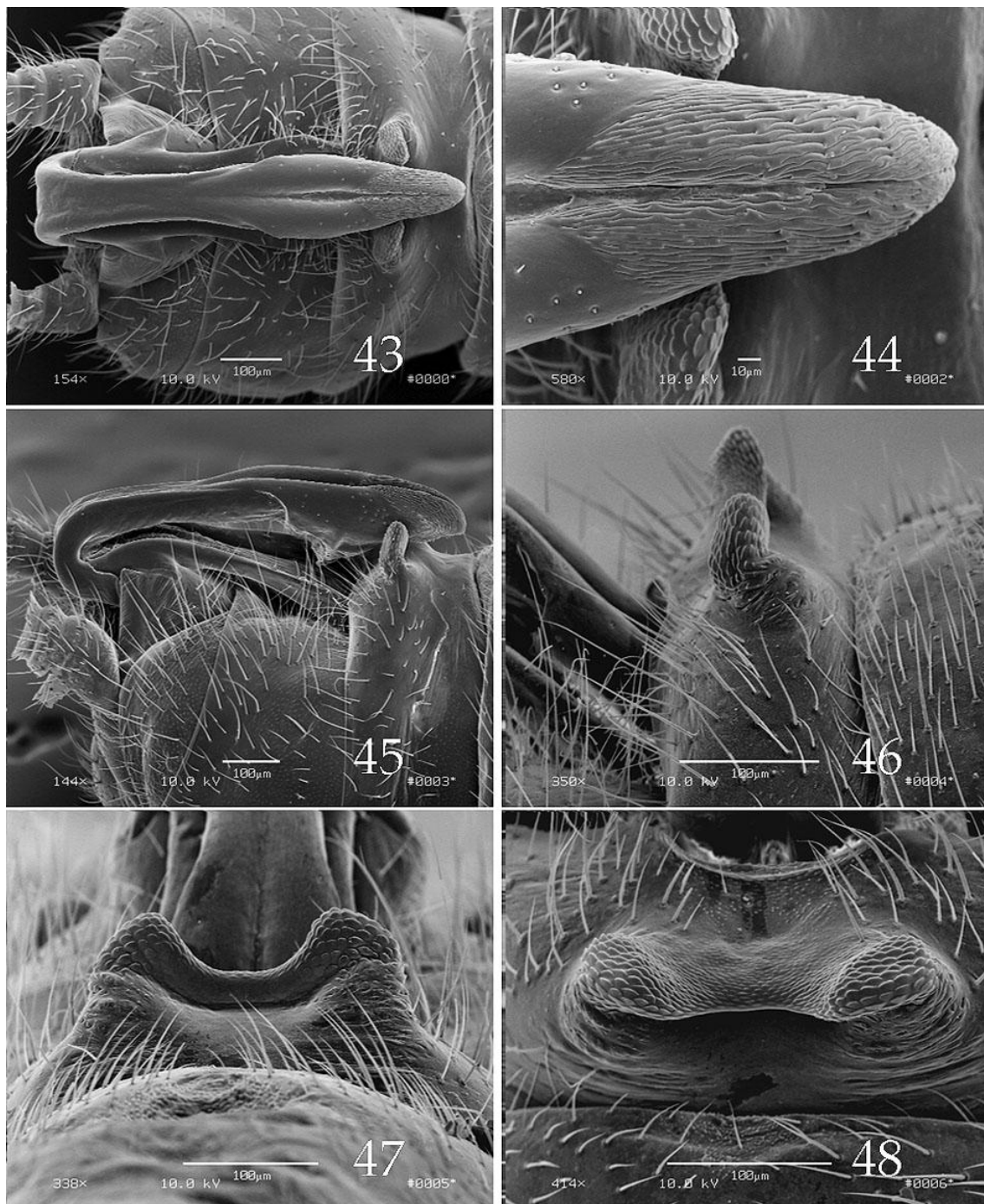
*Allocapnia aurora*: Stark & Lacey, 2005:11.

*Allocapnia aurora*: Nations et al., 2007:73.

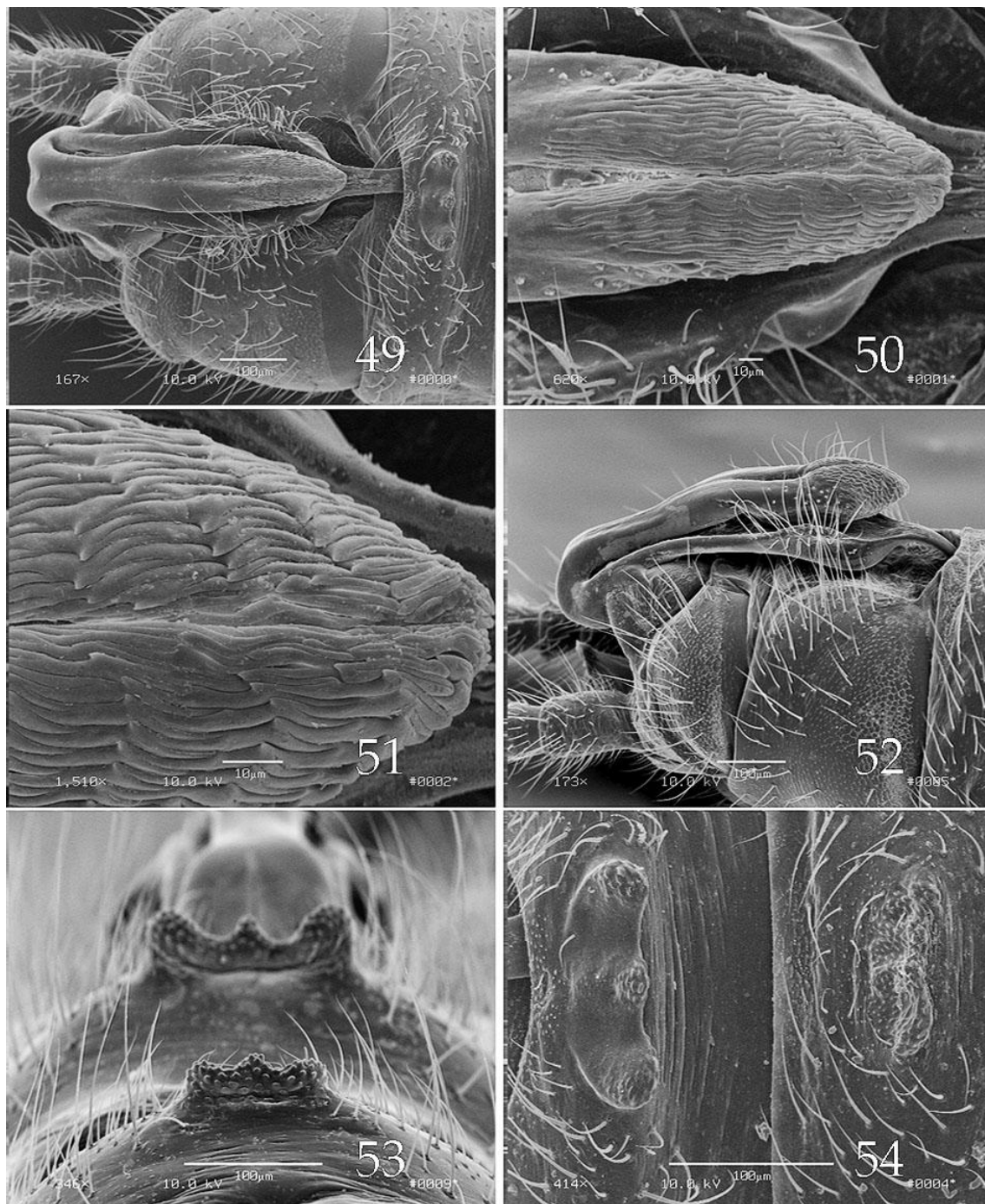
**Material examined. Mississippi:** Franklin Co., Cane Mill Branch, 29 December 1996, M.H. Alford, 1♂ (BPS). Tishomingo Co., Rock Creek, CR 1, 8 January 2007, B. Stark, 5♂, 1♀ (BPS). Tishomingo Co., Rock Quarry Creek, Tishomingo State Park, 23 December 2006, B. Stark, 3♂ (BPS). **North Carolina:** Haywood Co., Cove Creek, Hwy 1395, 27 December 1986, B.C. Kondratieff, R.F. Kirchner, 7♂, 1♀ (CSUC). Macon Co., Wayah Creek, LBJ Center, 5 January 1993, B. Stark, 6♂, 1♀ (BPS). Surry Co., North Fork Mitchell River, CR 1332, 29 January 1996, B.C. Kondratieff, R.F. Kirchner, 20♂, 1♀ (CSUC). **Tennessee:** Blount Co., Middle Prong Little River, Hwy 321, 27 February 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 9♂, 1♀ (CSUC). Cooke Co., Cosby Creek, Hwy 301, 1 January 1999, M.H. Alford, 25♂, 10♀ (BPS). Greene Co., Horse Creek, Horse Creek Recreation Area, 25 December 1986, B.C. Kondratieff, 12♂ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 334-370  $\mu\text{m}$  long, armed over apical ca. 175-200  $\mu\text{m}$  with dense patch of wave-like spikes (Figs. 43-45); apical segment ca. 131-134  $\mu\text{m}$  wide at base, tapered to a narrow rounded tip. Basal segment of upper limb ca. 340-380  $\mu\text{m}$  long and ca. 75-88  $\mu\text{m}$  wide at midlength; basal segment with a broad, shallow groove extending from base to base of apical segment. Lower limb ca. 181-187  $\mu\text{m}$  wide at point of greatest width, and bearing a sparse, irregular, setal row along apical third of lateral margins.

**Male tergal process.** Prominent raised structure on



Figs. 43-48. *Allocapnia aurora*, Horse Creek, Greene Co., Tennessee. 43. Male terminalia, dorsal. 44. Apical segment upper limb of epiproct tip, dorsal. 45. Male terminalia, lateral. 46. 8<sup>th</sup> tergal process, lateral. 47. 8<sup>th</sup> tergal process, anterodorsal. 48. 8<sup>th</sup> tergal process, dorsal.



Figs. 49-54. *Allocapnia indiana*, Kinniconick Creek, Lewis Co., Kentucky (49-51, 54) and Grassy Creek, Carter Co., Kentucky (52-53). 49. Male terminalia, dorsal. 50. Apical segment upper limb of epiproct tip, dorsal. 51. Surface detail apical segment upper limb of epiproct, dorsal. 52. Male terminalia, lateral. 53. Abdominal tergal lobes, anterodorsal. 54. Abdominal tergal lobes, dorsal.

abdominal tergum 8 (Figs. 46-48). Bilobed process ca. 213-230  $\mu\text{m}$  wide, bearing a U-shaped notch ca. 84  $\mu\text{m}$  wide. Lobes of process and posterior face of notch bearing scale-like surface structures; anterior face of process bearing a deep transverse groove (Fig. 47). In lateral aspect, lobes extend vertically at an approximate 90° angle from swollen base (Fig. 46).

***Allocapnia indianae* Ricker**  
(Figs. 49-54)

*Allocapnia indianae* Ricker 1952:162. Holotype ♀ (Illinois Natural History Survey), creek northwest of Medora, [Jackson Co.], Indiana

*Allocapnia indianae*: Ross & Ricker, 1971:47.

**Material examined. Kentucky:** Carter Co., Grassy Creek, Hwy AA9, 3 March 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 152♂, 19♀ (CSUC). Lewis Co., Kinniconick Creek, SE Vanceburg, 3 March 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 11♂ (CSUC). Lincoln Co., Green River, Hwy 698, Jumbo, 3 March 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 3♂ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 265-277  $\mu\text{m}$  long, armed on apical ca. 152-172  $\mu\text{m}$  with dense patch of wave-like spikes (Figs. 49-52); apical segment ca. 100-106  $\mu\text{m}$  wide at base, tapered to a narrow rounded tip. Basal segment of upper limb ca. 257  $\mu\text{m}$  long and ca. 65-67  $\mu\text{m}$  wide at midlength; basal segment with a broad, shallow, median groove. Greatest width of lower limb ca. 176-187  $\mu\text{m}$ ; lower limb bears a sparse, marginal row of long setae in apical third (Fig. 49).

**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 53-54). Trilobed process of tergum 8 ca. 140-146  $\mu\text{m}$  wide and bearing a broad, shallow median notch, interrupted by median projection. Lobes of process covered with scale-like structures; anterior face of process bears a deep transverse groove (Fig. 53). In lateral aspect, lobes extend vertically as thin discs set on narrow bases. Process of tergum 7 ca. 100  $\mu\text{m}$  wide; similar in structure to 8<sup>th</sup> tergal process.

***Allocapnia nivicola* (Fitch)**  
(Figs. 55-60)

*Perla nivicola* Fitch 1847:278. Lectotype ♂ (Museum of Comparative Zoology), unspecified location, designation by Frison, 1942:266.

*Allocapnia nivicola*: Hanson, 1942:83.

*Allocapnia nivicola*: Ross & Ricker, 1971:49.

**Material examined. Kentucky:** Jackson Co., Rock Lick Creek, Hwy 89, 10 February 1996, B.C. Kondratieff, R.F. Kirchner, 15♂ (CSUC). **Tennessee:** Lawrence Co., Factory Creek, Hwy 242, 28 February 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 15♂, 4♀ (CSUC). Perry Co., Buffalo River, Old Hwy 13, 28 February 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 49♂, 30♀ (CSUC). **Virginia:** Montgomery Co., Tom's Creek, Rt 655, 18 February 1981, B.C. Kondratieff, 2♂ (BPS). Wythe Co., East Fork Stony Fork Creek, Hwy 52, 28 December 1978-29 January 1979, R.F. Kirchner, 18♂ (BPS).

**Male epiproct.** Apical segment of upper limb ca. 340-400  $\mu\text{m}$  long, armed on apical ca. 140-165  $\mu\text{m}$  with dense patch of wave-like spikes (Figs. 55-57); apical segment ca. 110-150  $\mu\text{m}$  wide at base, tapered to a broadly rounded tip. Basal segment of upper limb ca. 290-320  $\mu\text{m}$  long and ca. 80-120  $\mu\text{m}$  wide at midlength; basal segment with a moderately broad, shallow groove extending from base to apical segment base. Greatest width of lower limb ca. 173-200  $\mu\text{m}$ , and bearing a sparse, irregular row of marginal setae in apical half of limb (Fig. 57).

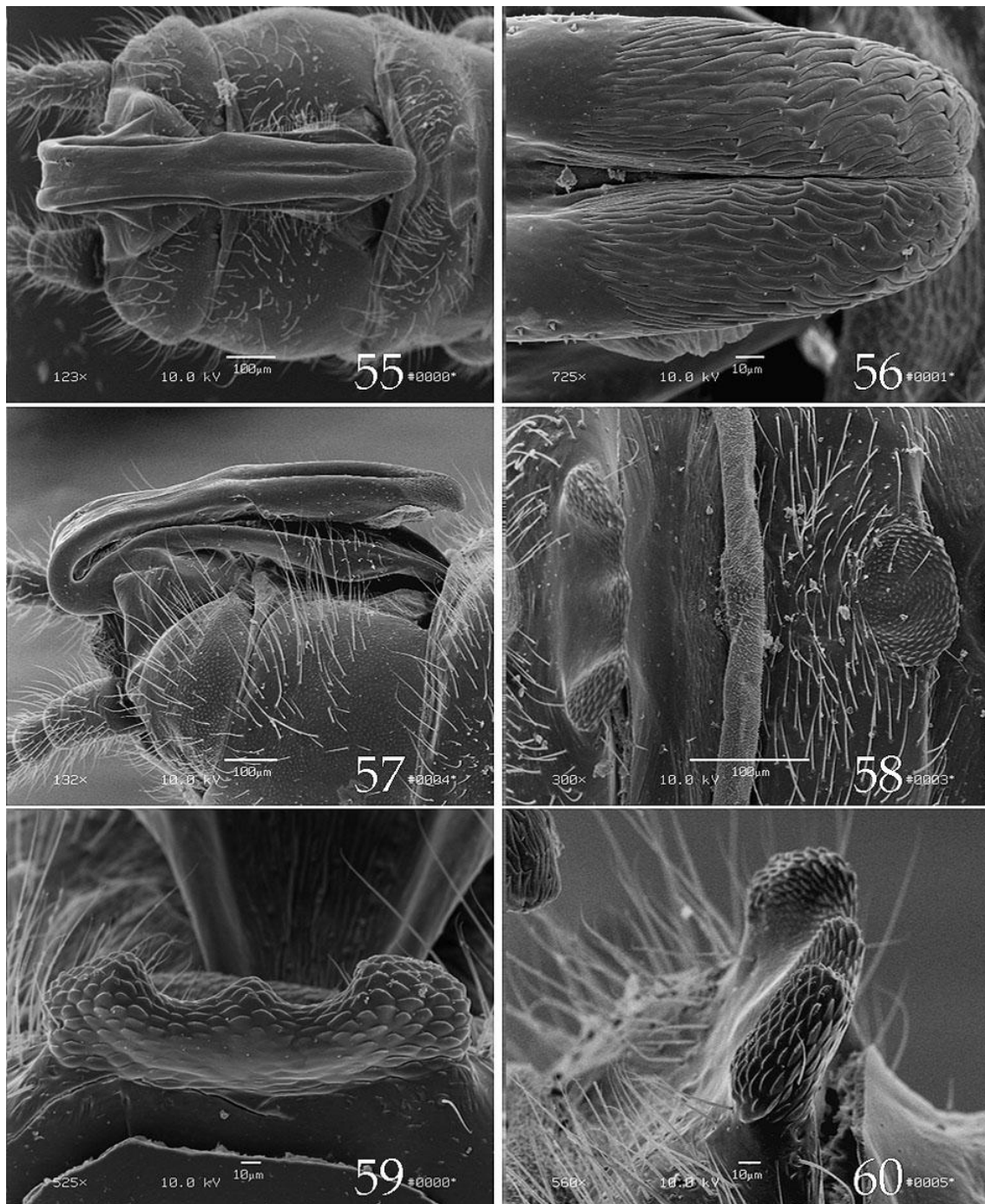
**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 58-60). Trilobed process on tergum 8 ca. 190-220  $\mu\text{m}$  wide, and bearing a broad, shallow median notch interrupted by a median projection. Tergum 7 process much lower and not distinctly trilobed; both tergal processes covered on dorsum with scale-like structures; tergum 8 process with a deep, transverse groove on anterior face. In lateral aspect, lobes of 8<sup>th</sup> tergal process appear thin and bent forward (Fig. 60).

***Allocapnia ohioensis* Ross & Ricker**  
(Figs. 61-66)

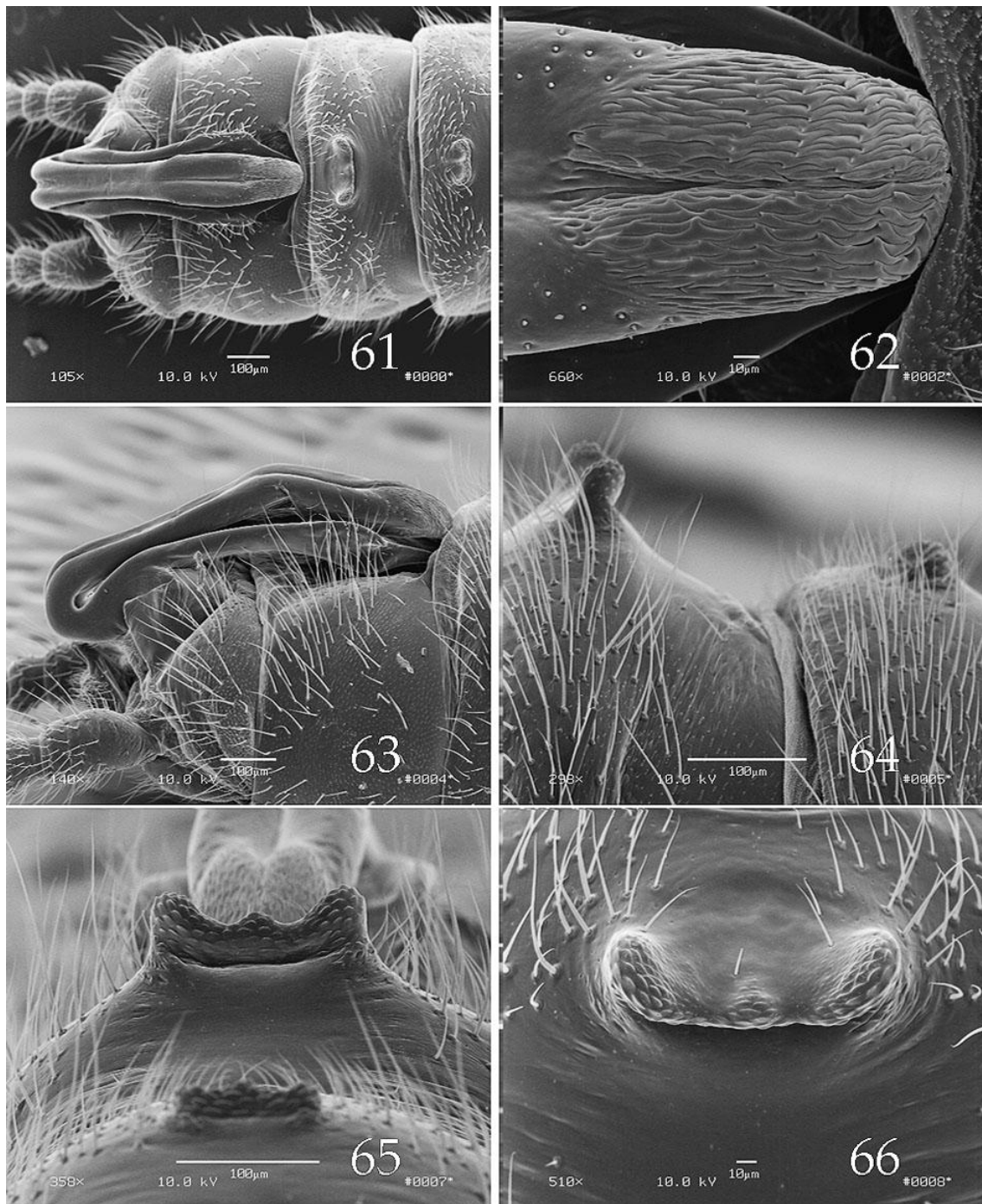
*Allocapnia ohioensis* Ross & Ricker 1964:92. Holotype ♂ (Illinois Natural History Survey), tributary Hocking River, Coalville, [Summit Co.], Ohio

*Allocapnia ohioensis*: Ross & Ricker, 1971:46.





Figs. 55-60. *Allocapnia nivicola*, Tom's Creek, Montgomery Co., Virginia. 55. Male terminalia, dorsal. 56. Apical segment upper limb of epiproct tip, dorsal. 57. Male terminalia, lateral. 58. Abdominal tergal processes, dorsal. 59. 8<sup>th</sup> tergal process, anterodorsal. 60. 8<sup>th</sup> tergal process, lateral.



Figs. 61-66. *Allocapnia ohioensis*, Long Branch Creek, Wayne Co., West Virginia. 61. Male terminalia, dorsal. 62. Apical segment upper limb of epiproct tip, dorsal. 63. Male terminalia, lateral. 64. Abdominal tergal processes, lateral. 65. Abdominal tergal processes, anterodorsal. 66. 8<sup>th</sup> tergal process, dorsal.

**Material examined. Kentucky:** Fleming Co., Crane Creek, Hwy 32, 22 February 1998, R.F. Kirchner, 5♂ (BPS). **West Virginia:** Wayne Co., Long Branch Beech Fork, Beech Fork State Park, 20 January 1993, R.F. Kirchner, 3♂ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 316-322 µm long, armed on apical ca. 155-172 µm with dense patch of wave-like spikes (Figs. 61-63); apical segment ca. 120-148 µm wide at base, tapered to a bluntly rounded tip. Basal segment of upper limb ca. 421 µm long, and ca. 81-85 µm wide at midlength; basal segment with a shallow, median groove. Greatest width of lower limb ca. 222-233 µm; lower limb bearing sparse, marginal row of long setae in apical third.

**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 64-66). Trilobed process of tergum 8 ca. 153-200 µm wide, and bearing a broad, shallow notch, interrupted by a low median projection. Lobes of process appear slender and angled slightly forward in lateral aspect; surfaces covered with scale-like structures; anterior face bearing a transverse groove. Process of tergum 7 weakly trilobed, ca. 103-160 µm wide, and covered with scale-like structures.

*Allocapnia pygmaea* (Burmeister)  
(Figs. 67-72)

*Semblis pygmaea* Burmeister 1839:874. Lectotype ♂ (Zoological Museum Berlin), Pennsylvania [no specific site], designation by Needham & Claassen, 1925:278.

*Capnella pygmaea*: Needham & Claassen, 1925:277.

*Allocapnia torontoensis* Ricker 1935:257. Holotype ♂ (Canadian National Collection), Credit River, Cooksville, Peel Co., Ontario, synonymy proposed by Frison, 1942:265.

*Allocapnia pygmaea*: Ross & Ricker, 1971:45.

**Material examined. Kentucky:** Leslie Co., Middle Fork Kentucky River, Daniel Boone Parkway, 8 February 1998, B. C. Kondratieff, R.F. Kirchner, 30♂, 8♀ (CSUC). Powell Co., Middle Fork Red River, Hwy N, 10 February 1998, B.C. Kondratieff, R.F. Kirchner, 21♂, 6♀ (CSUC). **New York:** Tompkins Co., Salmon Creek, Myers, 26 February 2000, M.H. Alford, 23♂, 12♀ (BPS). Tompkins Co., Ithaca, Cascadilla Creek, Cornell University, 26 February 2000, M.H. Alford,

8♂, 3♀ (BPS). Tompkins Co., Owasco Inlet, Stevens Rd, near Groton, 26 February 2000, M.H. Alford, 6♂, 2♀ (BPS). **West Virginia:** Mason Co., Ohio River, Apple Grove, 3 March 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 5♂, 4♀ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 340-400 µm long, armed on apical ca. 176-220 µm with dense patch of wave-like spikes (Figs. 67-69); apical segment ca. 125-135 µm wide at base, tapered to a narrow, rounded tip. Basal segment of upper limb ca. 303-309 µm long and ca. 79-103 µm wide at midlength; basal segment with median groove narrowed toward base of apical segment (Fig. 67). Greatest width of lower limb ca. 148-194 µm; lower limb bearing a sparse, marginal row of long setae in apical third (Fig. 69).

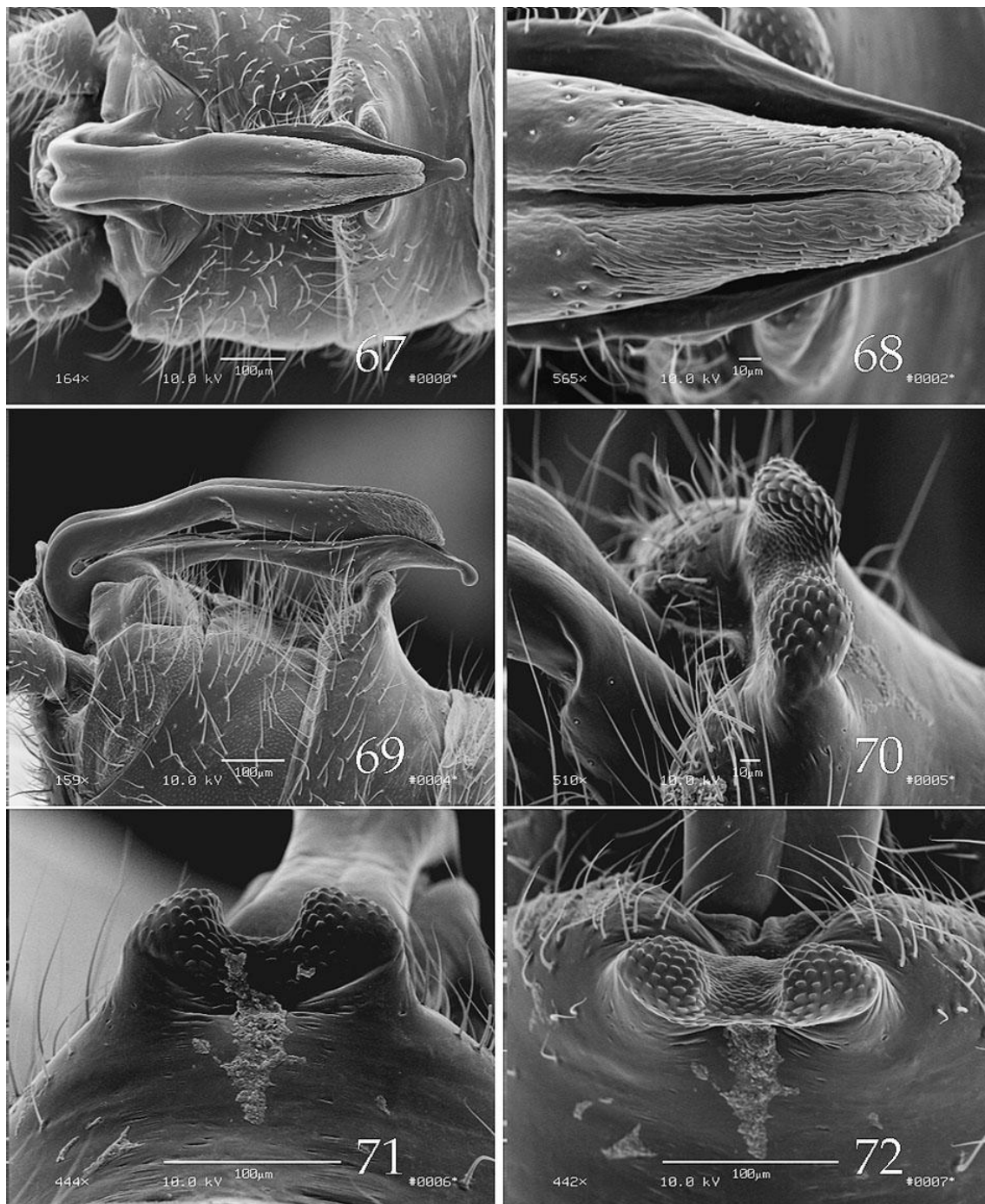
**Male tergal process.** Prominent raised structure on abdominal tergum 8 (Figs. 70-72). Bilobed process on tergum 8 ca. 162-174 µm wide and bearing a deep U-shaped mesal notch; notch width ca. 44-56 µm. Lobes of process diverge in dorsal aspect, but appear straight and slightly swollen in lateral aspect; lobes covered with scale-like structures; anterior face bearing a shallow, transverse groove.

*Allocapnia smithi* Ross & Ricker  
(Figs. 73-78)

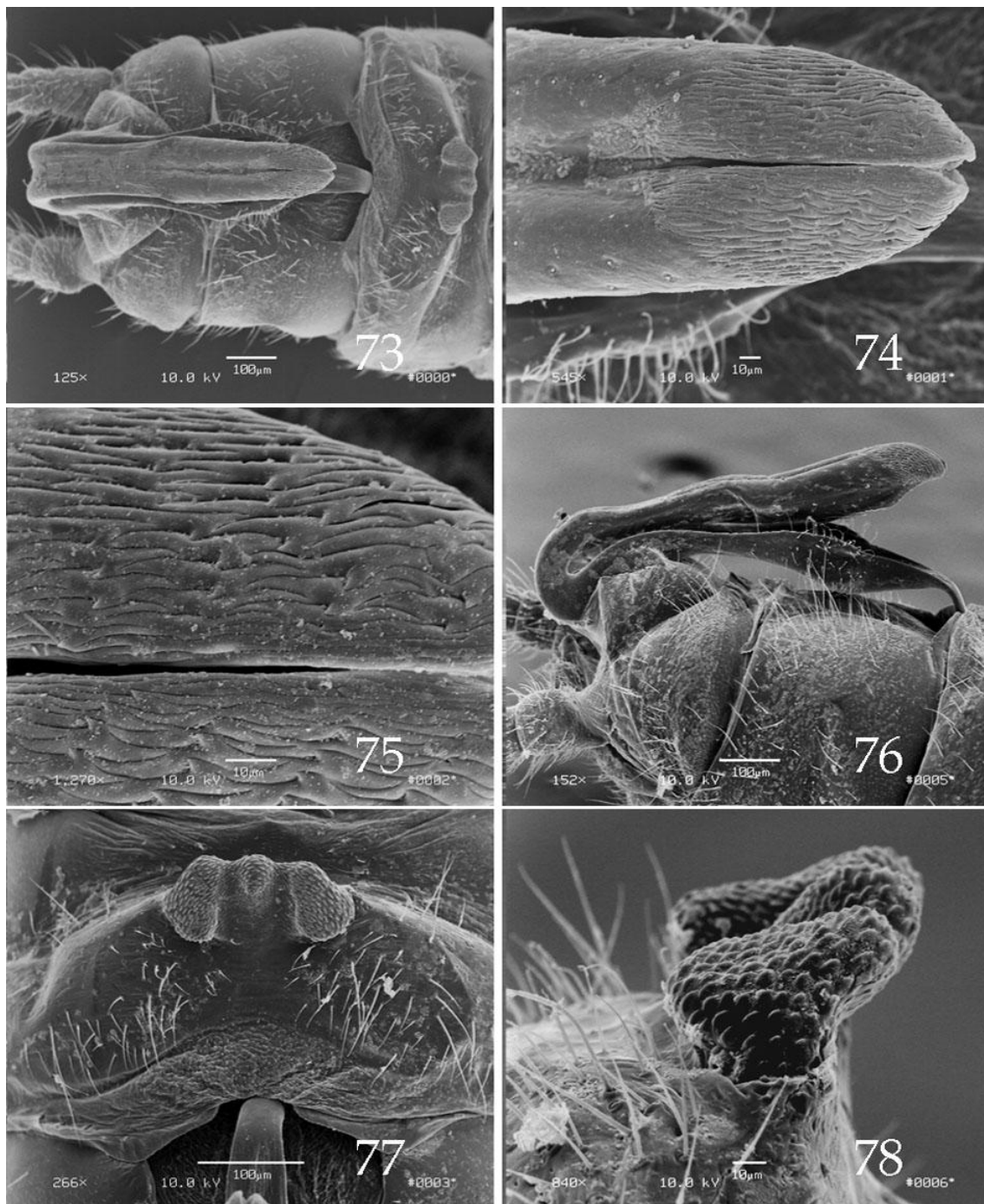
*Allocapnia smithi* Ross & Ricker 1971:48. Holotype ♂ (Illinois Natural History Survey), 2.5 miles W South Hill, Butler Co., Kentucky

**Material examined. Alabama:** Tuscaloosa Co., Wallace Branch, 5 mi SE Berry, 21 January 1982, S.C. Harris, P. O'Neil, 4♂ (BPS). Tuscaloosa Co., Blue Creek, CR 38, 15 January 2011, B. Stark, K. Gaynor, 7♂ (BPS). **Kentucky:** Edmondson Co., Cub Creek, Roundhill Rd, 22 February 1999, B.C. Kondratieff, R.F. Kirchner 22♂, 2♀ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 345 µm long, armed on apical ca. 154 µm with dense patch of wave-like spikes (Figs. 73-76); apical segment ca. 135 µm wide at base, tapered to a rounded tip. Basal segment of upper limb ca. 355 µm long and ca. 102 µm wide at midlength; basal segment with median groove. Greatest width of lower limb ca. 200 µm; lower limb bearing a sparse,



Figs. 67-72. *Allocapnia pygmaea*, Ohio River, Mason Co., West Virginia. 67. Male terminalia, dorsal. 68. Apical segment upper limb of epiproct tip, dorsal. 69. Male terminalia, lateral. 70. 8<sup>th</sup> tergal process, oblique lateral. 71. 8<sup>th</sup> tergal process, anterodorsal. 72. 8<sup>th</sup> tergal process, dorsal.



Figs. 73-78. *Allocapnia smithi*, Wallace Branch, Tuscaloosa Co., Alabama. 73. Male terminalia, dorsal. 74. Apical segment upper limb of epiproct tip, dorsal. 75. Surface detail apical segment upper limb of epiproct, dorsal. 76. Male terminalia, lateral. 77. 8<sup>th</sup> tergite process, dorsal. 78. 8<sup>th</sup> tergite process, lateral.

marginal row of long setae in apical third.

**Male tergal process.** Prominent raised structures on abdominal terga 7 and 8 (Figs. 77-78). Process of tergum 8 trilobed with mesal lobe about as high as lateral lobes; tergum 8 process ca. 176  $\mu\text{m}$  wide; lateral lobes expanded on dorsum in lateral and dorsal aspect, appearing somewhat boot shaped in side view; anterior face of process with a transverse groove. Process of tergum 7 only slightly elevated, ca. 75  $\mu\text{m}$  wide, and without mesal lobe.

### ALLOCAPNIA RICKERI GROUP

Ross & Ricker (1971) placed six species (*A. cunninghami* Ross & Ricker 1971; *A. perplexa* Ross & Ricker 1971; *A. rickeri* Frison 1942; *A. sandersoni* Ricker 1952; *A. stannardi* Ross 1964; *A. zola* Ricker 1952) in this group and suggested, primarily on the basis of female characters, these form two “well-marked complexes of three species each”. The line of fusion between abdominal sterna 7-8 includes a sclerotized ridge in females of *A. cunninghami*, *A. perplexa* and *A. zola*, whereas females of *A. rickeri*, *A. sandersoni* and most *A. stannardi* lack such a structure. Subsequently, *A. harperi* Kirchner 1980, was added to the second complex.

The epiproct upper limb for species in this group, is typified by a long basal segment and a relatively short, somewhat bulbous apical segment (Figs. 79, 85, 91, 97), a feature shared with members of the *A. forbesi* group. The apical segment bears a distal patch of densely packed, wave-like spikes (Figs. 81, 87) and the basal segment has a relatively broad, shallow longitudinal groove. The lower limb bears a distinct notch offsetting the apical spoon (Fig. 100). Abdominal tergum 8, or 7 and 8, bear dorsal processes (Figs. 90, 95, 112); those on tergum 8 are typically bilobed but in one species, *A. zola*, this structure is trilobed and a second process, also present on segment 8, is displaced toward the anterior segmental margin (Fig. 115). In Ross & Ricker’s analysis, *A. stannardi* and *A. rickeri* were considered sister species with *A. sandersoni* more distantly related, and the other complex was presented as an unresolved trichotomy. The *A. rickeri* group shares “ancestor number 15” with *A. jeanae* Ross 1964, in this analysis (Ross & Ricker 1971).

We are unable to provide a definitive hypothesis for relationships within the *A. rickeri* group, but based primarily on tergal lobe variations, we could propose one subgroup in which the 8<sup>th</sup> tergal lobe notch is at least 75  $\mu\text{m}$  wide (*A. harperi*, *A. perplexa*, *A. rickeri*, *A. stannardi*; Figs. 90, 96, 101, 114) and another in which the 8<sup>th</sup> tergal lobe notch is no more than 45  $\mu\text{m}$  wide (*A. cunninghami*, *A. sandersoni*, *A. zola*; Figs. 83, 108, 120). Within the first group, *A. harperi*, *A. stannardi*, and *A. rickeri* share ear-like lobes on the 8<sup>th</sup> tergal process, whereas those of *A. perplexa* are not ear shaped, however we offer no resolution for the former trichotomy. In the *A. cunninghami*, *A. zola*, *A. sandersoni* subgroup, the former two species each share a small lobe on tergum 7 and also a small median projection on the 8<sup>th</sup> tergal process which supports a sister group relationship between these two species. Unfortunately, we have no probable apomorphy which unites this latter subgroup.

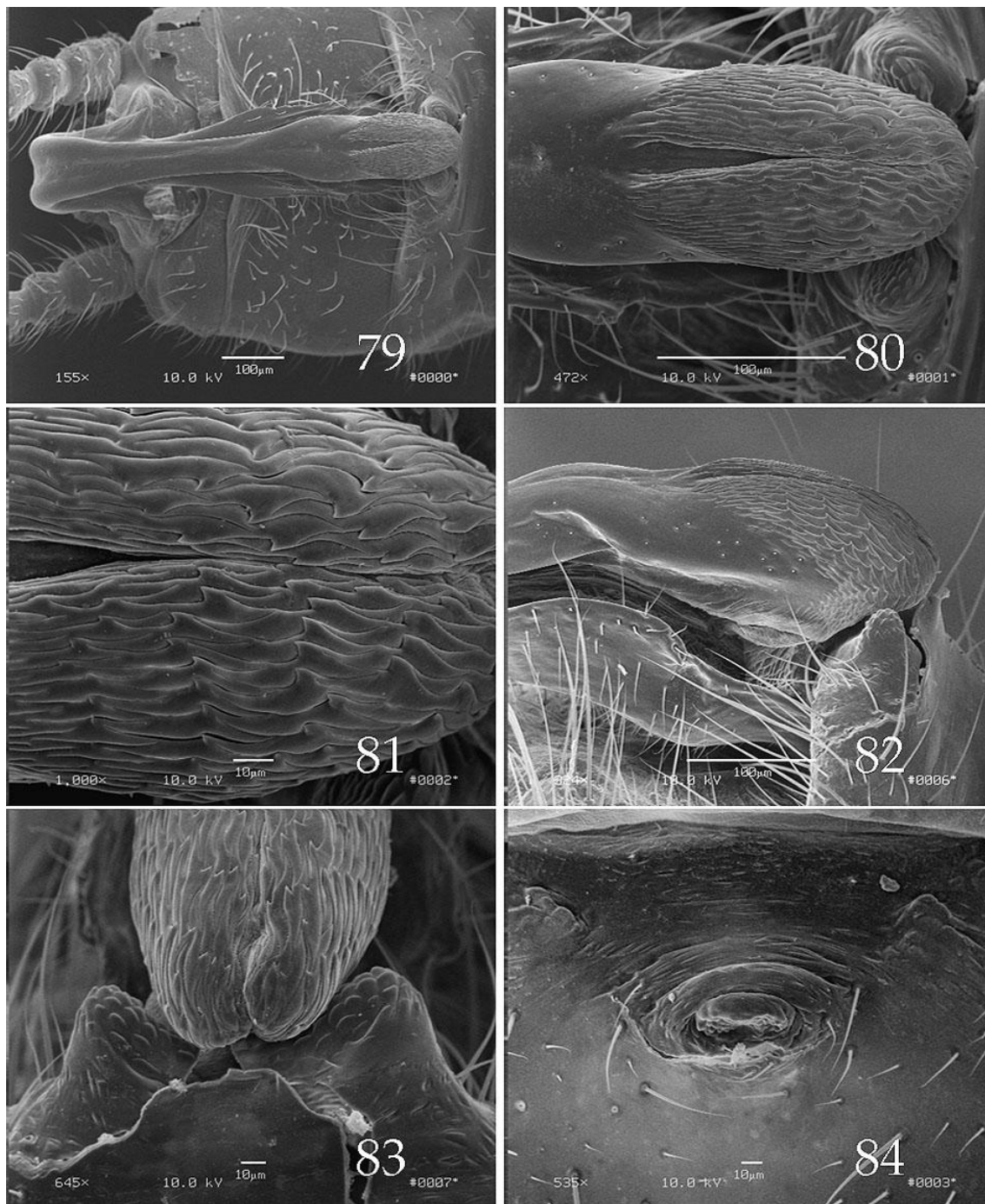
#### *Allocapnia cunninghami* Ross & Ricker (Figs. 79-84)

*Allocapnia cunninghami* Ross & Ricker 1971:42. Holotype ♂ (Illinois Natural History Survey), [tributary Little Trammel Creek], Turners [Station], Sumner Co., Tennessee

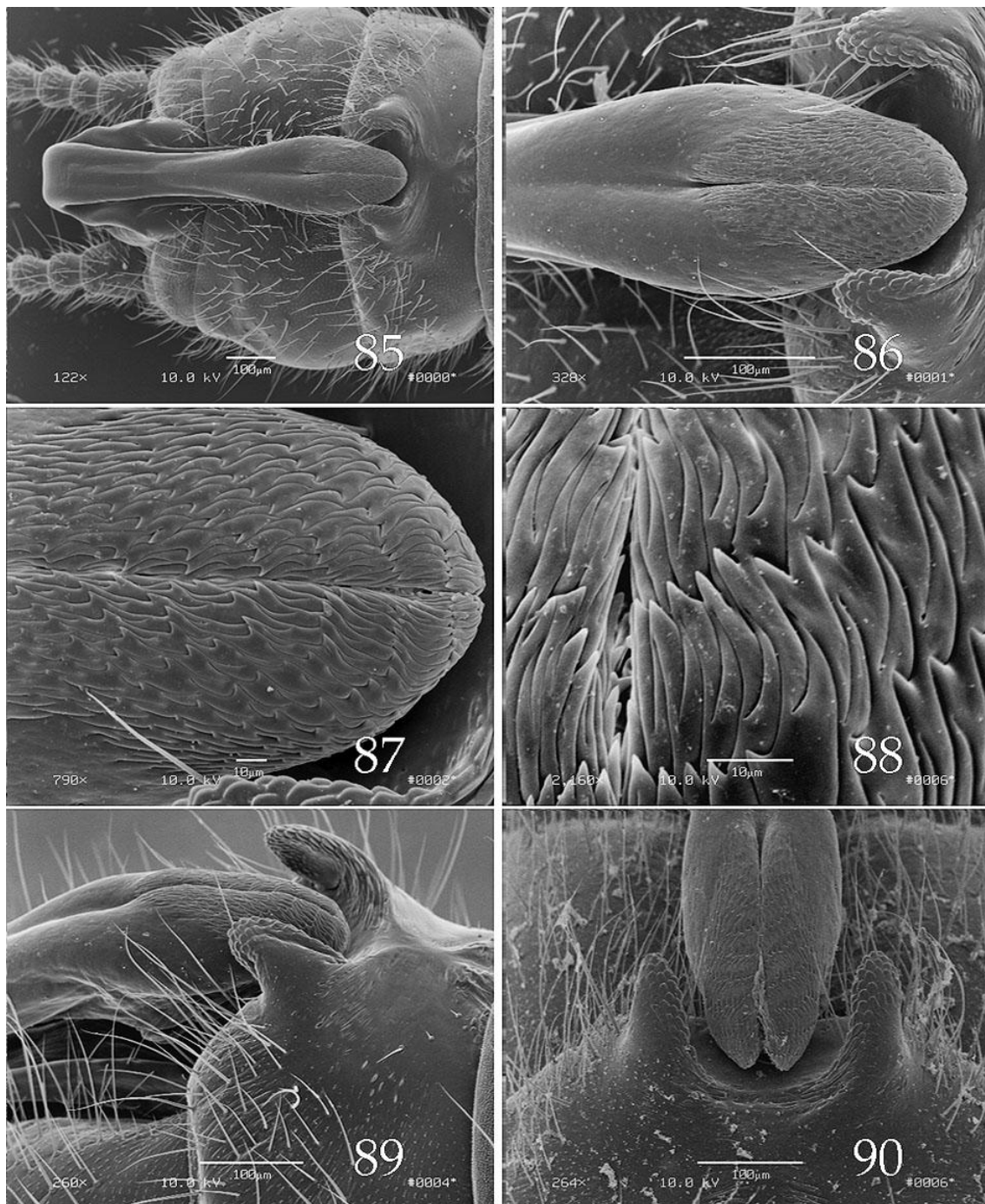
**Material examined. Tennessee:** Sumner Co., tributary Little Trammel Creek, Sugar Grove, Hwy 174, 22 February 1999, B.C. Kondratieff, R.F. Kirchner, 5♂, 1♀ (CSUC). Sumner Co., Little Trammel Creek, Fairfield Rd, 10 March 2012, B. Stark, 3♂ (BPS).

**Male epiproct.** Apical segment of upper limb ca. 281  $\mu\text{m}$  long, and armed on the apical ca. 188  $\mu\text{m}$  with dense patch of wave-like spikes (Figs. 79-82); apical segment ca. 106  $\mu\text{m}$  wide at base, slightly constricted near midlength, and expanded to a bluntly rounded tip. Basal segment of upper limb ca. 471  $\mu\text{m}$  long and ca. 56  $\mu\text{m}$  wide at midlength; basal segment bears a wide, shallow, longitudinal groove from base to near midlength. Greatest width of lower limb ca. 163  $\mu\text{m}$ ; lateral margins of lower limb bearing a sparse row of long setae near apical spoon.

**Male tergal process.** Prominent raised bilobed structure on abdominal tergum 8 and a smaller, slightly raised process on tergum 7 (Figs. 82-84). Process on tergum 8 ca. 142  $\mu\text{m}$  wide, covered with



Figs. 79-84. *Allocapnia cunninghami*, tributary Little Trammel Creek, Sumner Co., Tennessee. 79. Male terminalia, dorsal. 80. Apical segment upper limb of epiproct tip, dorsal. 81. Surface detail apical segment upper limb of epiproct, dorsal. 82. 8<sup>th</sup> tergal process and epiproct tip, lateral. 83. 8<sup>th</sup> tergal process and epiproct tip, anterodorsal. 84. 7<sup>th</sup> tergal process, dorsal.



Figs. 85-90. *Allocapnia harperi*, Station Spring Creek, Tazewell Co., Virginia. 85. Male terminalia, dorsal. 86. Apical segment upper limb of epiproct, dorsal. 87. Apical segment upper limb of epiproct tip, dorsal. 88. Surface detail apical segment upper limb of epiproct, dorsal. 89. 8<sup>th</sup> tergal process and epiproct tip, lateral. 90. 8<sup>th</sup> tergal process and epiproct tip, anterodorsal.



scale-like structures, and bearing a shallow, V-shaped notch (Fig. 83); process on tergum 7 ca. 40  $\mu\text{m}$  wide, without scales or notch (Fig. 84).

***Allocapnia harperi* Kirchner**

(Figs. 85-90)

*Allocapnia harperi* Kirchner 1980:19. Holotype ♂ (United States National Museum), East Fork Stony Fork Reed Creek, Wythe Co., Virginia

**Material examined. Virginia:** Tazewell Co., Station Spring Creek, 15 February 1982, B. C. Kondratieff, 10♂, 1♀ (CSUC). Wythe Co., East Fork Stony Fork, Hwy 11, 26 January 1980, R.F. Kirchner, 2♂, 4♀ (BPS). Wythe Co., East Fork Stony Fork, Rt 717, 26 February 1999, B.C. Kondratieff, R.F. Kirchner, 20♂, 5♀ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 303  $\mu\text{m}$  long, and armed on the apical ca. 186  $\mu\text{m}$  with dense patch of wave-like spikes (Figs. 85-88); apical segment ca. 145  $\mu\text{m}$  wide at base, gradually narrowed to a bluntly rounded tip. Basal segment of upper limb ca. 541  $\mu\text{m}$  long and ca. 85  $\mu\text{m}$  wide near midlength; basal segment bears a shallow, longitudinal groove in basal half. Greatest width of lower limb about as wide as apical segment of upper limb, but not clearly projecting beyond margins of apical segment.

**Male tergal process.** Prominent raised bilobed structure on abdominal tergum 8 (Figs. 89-90); process on tergum 8 ca. 256  $\mu\text{m}$  wide and covered with scale-like structures. Lobes of tergum 8 process small, ear-like, directed caudally and obliquely oriented on segment; notch ca. 140  $\mu\text{m}$ .

***Allocapnia perplexa* Ross & Ricker**

(Figs. 91-96)

*Allocapnia perplexa* Ross & Ricker 1971:44. Holotype ♂ (Illinois Natural History Survey), Five miles S Bransford, [East Fork Bledsoe Creek, Hwy 231], Trousdale Co., Tennessee

*Allocapnia perplexa*: Kirchner et al., 2002:332. SEM ♂ epiproct

**Material examined. Tennessee:** Sumner Co., East Fork Bledsoe Creek, Old Hopewell Rd, 1 March 2001, B.C. Kondratieff, R.F. Kirchner, 2♂ (BPS).

**Male epiproct.** Apical segment upper limb of epiproct ca. 219  $\mu\text{m}$  long and armed over the apical ca. 236  $\mu\text{m}$  with wave-like spikes; apical segment ca. 203  $\mu\text{m}$  wide across basal ear-like projections, and tapered to 89  $\mu\text{m}$  wide at the tip (Figs. 91-93). Basal segment ca. 294  $\mu\text{m}$  long and ca. 157  $\mu\text{m}$  wide at midlength; basal section with a few grooves on dorsal surface and a few obscure, ventrolateral spines (Fig. 94). Lower limb not visible from dorsal aspect.

**Male tergal process.** Prominent raised, bilobed structure on abdominal tergum 8 (Figs. 94-96); process ca. 224  $\mu\text{m}$  wide and deeply notched; notch width ca. 92  $\mu\text{m}$ . Process covered with scale-like structures.

***Allocapnia rickeri* Frison**

(Figs. 97-102)

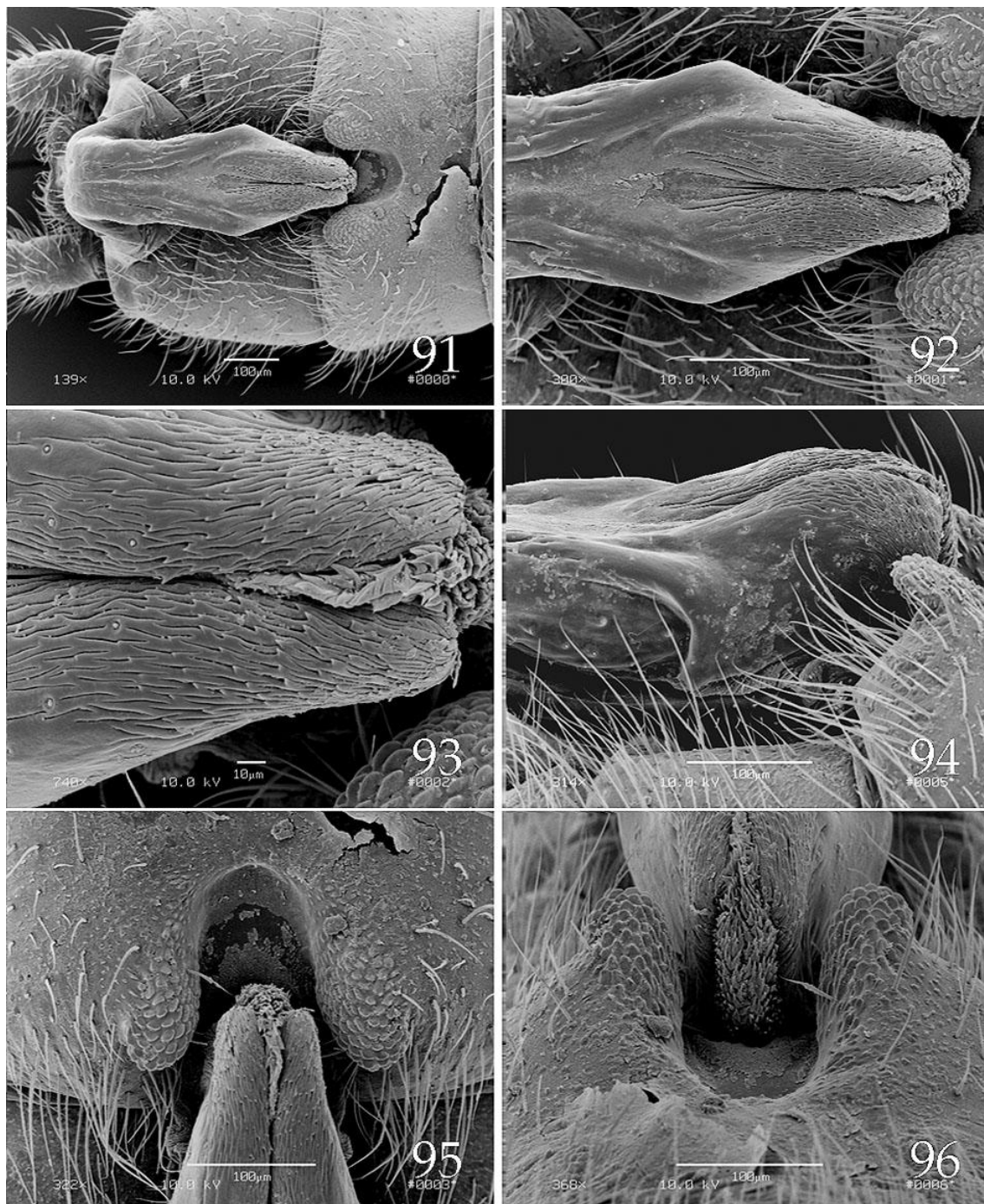
*Allocapnia rickeri* Frison 1942:269. Holotype ♂ (Illinois Natural History Survey), Big Grand Pierre River, Golconda [Pope Co.], Illinois

*Allocapnia rickeri*: Ross & Ricker, 1971:41.

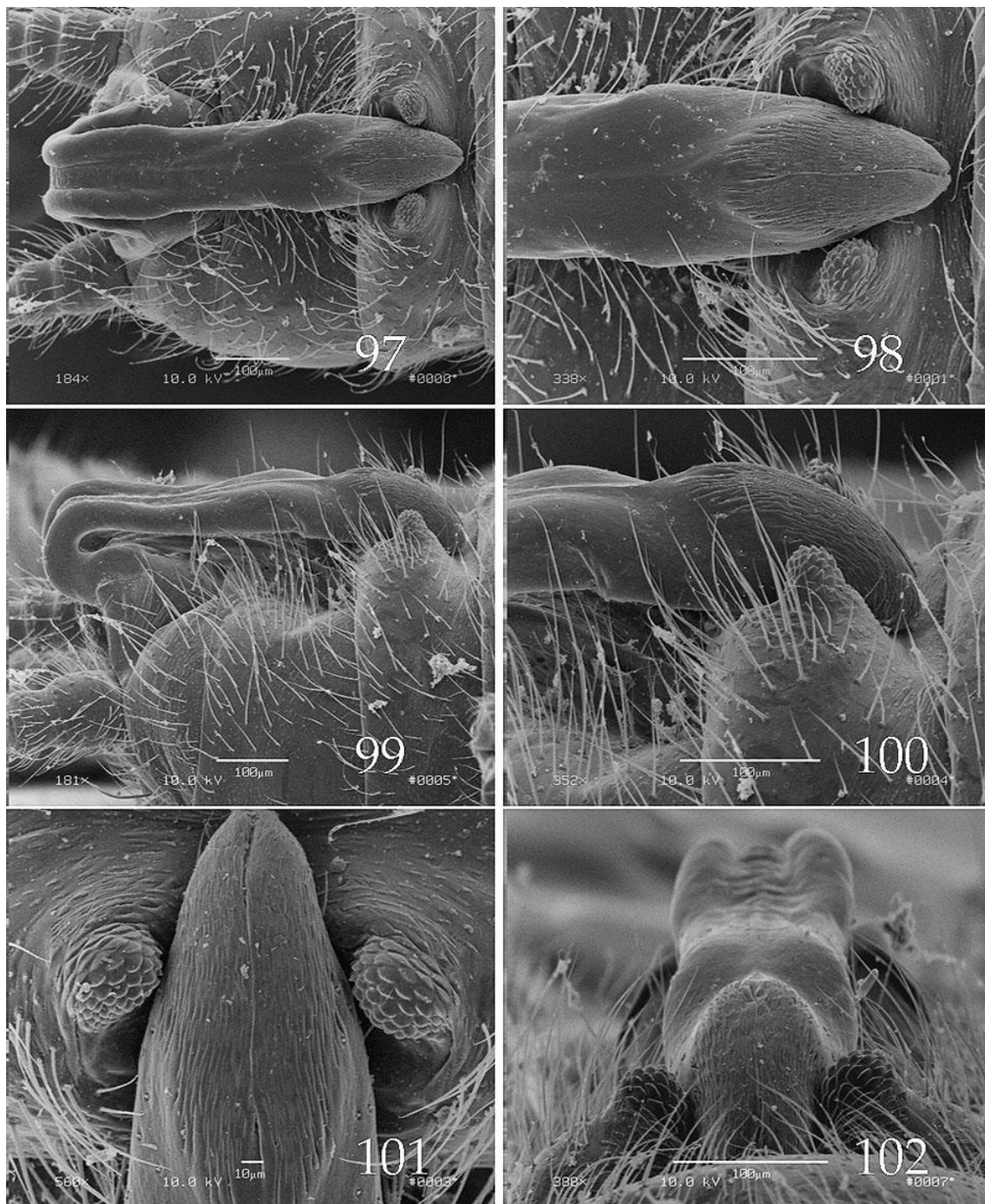
*Allocapnia rickeri*: Nations et al., 2007:82.

**Material examined. Alabama:** Limestone Co., East Fork Anderson Creek, Anderson, 5 January 2001, B. Stark, C.G. Simpson, I. Nazir, 7♂ (BPS). **Arkansas:** Montgomery Co., 2 miles E Hurricane Grove, Hwy 270, 28 December 2010, B. Stark, 2♂ (BPS). Van Buren Co., Choctaw Crk, Hwy 65, 4 January 1997, B. Stark, S. Tucker, 42♂, 3♀ (BPS). Van Buren Co., Archey Creek, Rt 166, 3 January 1997, B. Stark, S. Tucker, 23♂, 4♀ (BPS). **Mississippi:** Tishomingo Co., Clear Creek, Hwy 172, 10 February 2007, B. Stark, 40♂, 3♀ (BPS). **North Carolina:** Cabarras Co., East Concord, Barringer Creek, Hwy 49, 4 January 1998, M.H. Alford, 8♂ (BPS). Orange Co., Eno River, Pleasant Green Road, 18 January 1998, M.H. Alford, 2♂, (BPS).

**Ohio:** Scioto Co., Turkey Creek, Hwy 52, 26 February 2005, M.H. Alford, 2♂(BPS). **Oklahoma:** Latimer Co., tributary Brazil Creek, 1 mile N Cedar Cemetery, 28 December 2006, B. Stark, J. Stark, 23♂, 2♀ (BPS). **Tennessee:** Bedford Co., Ashland Branch Sugar Creek, Bluestock Road, 23 February 1999, B.C. Kondratieff, R.F. Kirchner, 8♂ (CSUC). Wayne Co., Eagle Creek, Hwy 114, 14 March 2010, B. Stark, 5♂ (BPS).



Figs. 91-96. *Allocapnia perplexa*, East Fork Bledsoe Creek, Sumner Co., Tennessee. 91. Male terminalia, dorsal. 92. Apical segment upper limb of epiproct tip, dorsal. 93. Surface detail apical segment upper limb of epiproct, dorsal. 94. 8<sup>th</sup> tergal process and epiproct tip, lateral. 95. 8<sup>th</sup> tergal process and epiproct tip, dorsal. 96. 8<sup>th</sup> tergal process, anterodorsal.



Figs. 97-102. *Allocapnia rickeri*, Turkey Creek, Scioto Co., Ohio. 97. Male terminalia, dorsal. 98. Apical segment upper limb of epiproct tip, dorsal. 99. Male terminalia, lateral. 100. 8<sup>th</sup> tergal process and epiproct tip, lateral. 101. 8<sup>th</sup> tergal process and epiproct tip, dorsal. 102. 8<sup>th</sup> tergal process and epiproct tip, anterodorsal.

**Male epiproct.** Apical segment of upper limb ca. 226  $\mu\text{m}$  long, and armed on the apical ca. 173  $\mu\text{m}$  with dense patch of wave-like spikes (Figs. 97-101); apical segment ca. 132  $\mu\text{m}$  wide at base and gradually narrowed to bluntly rounded tip. Basal segment of upper limb ca. 350  $\mu\text{m}$  long and ca. 111  $\mu\text{m}$  wide near midlength; basal segment bears a wide, shallow, longitudinal groove which extends to base of apical segment. Lower limb hidden beneath apical segment of upper limb.

**Male tergal process.** Prominent raised structures on abdominal tergum 8 (Figs. 100-102). Process of tergum 8 bilobed, ca. 175  $\mu\text{m}$  wide, and the lobes separated by a ca. 85  $\mu\text{m}$  notch. Lobes deeply divided and covered with scale-like structures.

*Allocapnia sandersoni* Ricker  
(Figs. 103-108)

*Allocapnia sandersoni* Ricker 1952:165. Holotype ♂ (Illinois Natural History Survey), Clear Creek, 2.5 miles N Fayetteville, Washington Co., Arkansas

*Allocapnia sandersoni*: Ross & Ricker, 1971:40.

**Material examined. Arkansas:** Searcy Co., Little Red River, Hwy 65, 4 January 1997, B. Stark, S. Tucker, 1♂, 2♀ (BPS).

**Male epiproct.** Apical segment of upper limb ca. 286  $\mu\text{m}$  long and armed on the apical ca. 202  $\mu\text{m}$  with dense patch of wave-like spikes (Figs. 103-106); apical segment ca. 142  $\mu\text{m}$  wide at base and slightly swollen to ca. 164  $\mu\text{m}$  near base of armature; armed area gradually narrowed to a rounded tip. Basal segment of upper limb ca. 572  $\mu\text{m}$  long and ca. 111  $\mu\text{m}$  wide near midlength; basal segment bears a shallow, longitudinal groove extending to near base of apical segment. Greatest width of lower limb ca. 198  $\mu\text{m}$ ; marginal area near spoon lined with sparse row of long setae.

**Male tergal process.** Prominent raised, narrowly divided process on abdominal tergum 8 (Figs. 106-108). Process on tergum 8 ca. 214  $\mu\text{m}$  wide and covered with scale-like structures; median notch of process ca. 36  $\mu\text{m}$  wide.

*Allocapnia stannardi* Ross  
(Figs. 109-114)

*Allocapnia stannardi* Ross 1964:174. Holotype ♂ (Illinois Natural History Survey), 1 mile east Walker Prong Branch, Sevier Co., Great Smoky Mountain National Park, Tennessee

*Allocapnia stannardi*: Ross & Ricker, 1971:42.

*Allocapnia stannardi*: Kondratieff & Kirchner, 1982:243.

**Material examined. Tennessee:** Sevier Co., 1 mile W New Found Gap, 14 March 2006, B. Stark, 2♂, 1♀ (BPS). Sevier Co., tributary Walkers Camp Fork, Hwy 441, Great Smoky Mountain National Park, 26 February 2001, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 12♂, 14♀ (CSUC).

**Male epiproct.** Apical segment of upper limb ca. 257  $\mu\text{m}$  long and armed on the apical ca. 195  $\mu\text{m}$  with dense patch of wave-like spikes (Figs. 109-112); apical segment ca. 179  $\mu\text{m}$  wide at base, gradually constricted to a narrowly rounded tip. Basal segment of upper limb ca. 297  $\mu\text{m}$  long and ca. 105  $\mu\text{m}$  wide near midlength; basal segment bears a shallow, longitudinal groove, extending from base to beyond midlength. Greatest width of lower limb ca. 155  $\mu\text{m}$ ; margins of lower limb adjacent to notch lined with sparse row of long setae.

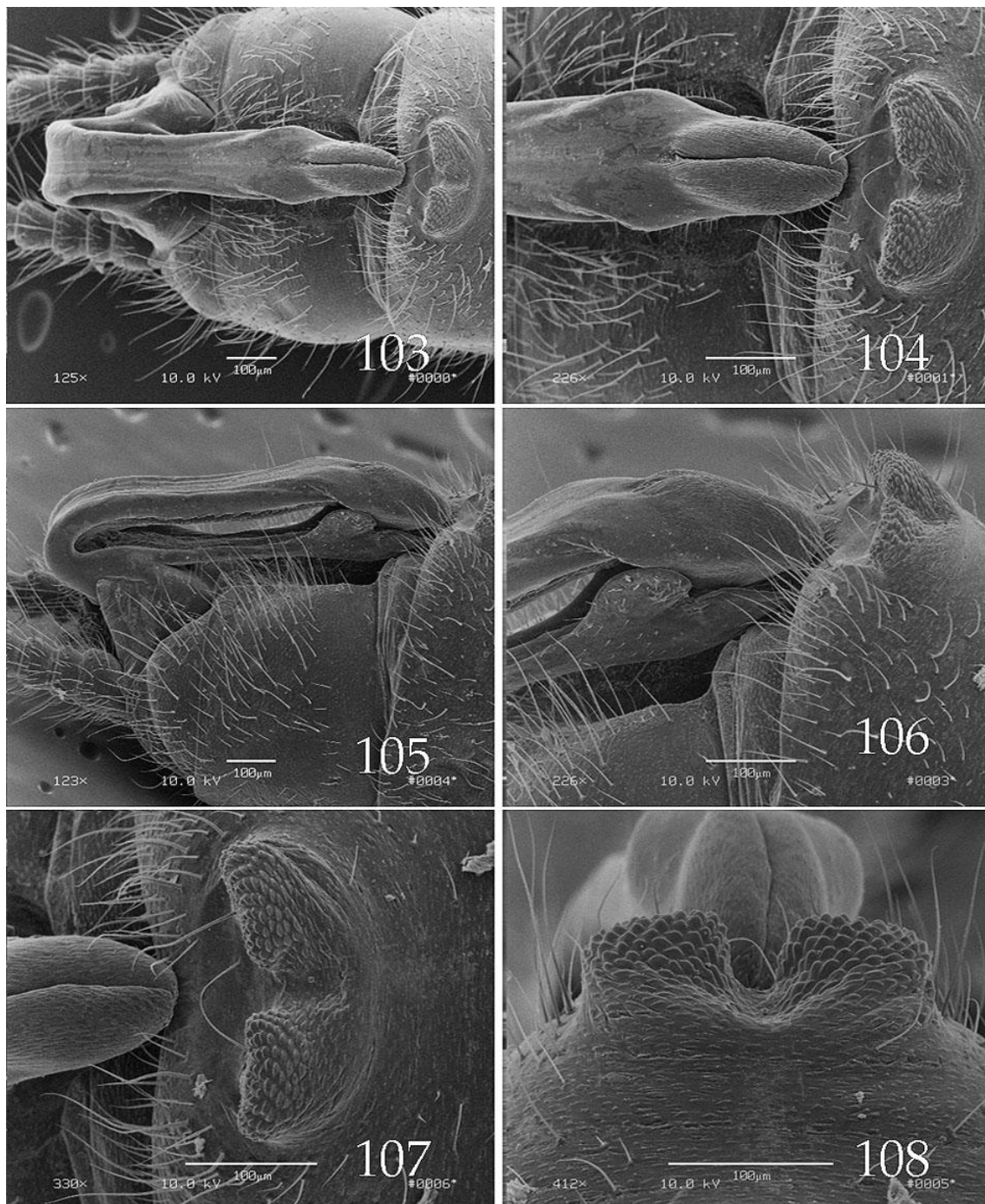
**Male tergal process.** Prominent raised structures on abdominal terga 7-8 (Figs. 113-114); process on tergum 8 deeply bilobed, ca. 168  $\mu\text{m}$  wide, and covered with scale-like structures; notch of process ca. 76  $\mu\text{m}$  wide. Process of tergum 7 upright, slender, slightly notched on dorsal margin and not bearing scale-like structures; tergum 7 process ca. 68  $\mu\text{m}$  wide.

*Allocapnia zola* Ricker  
(Figs. 115-120)

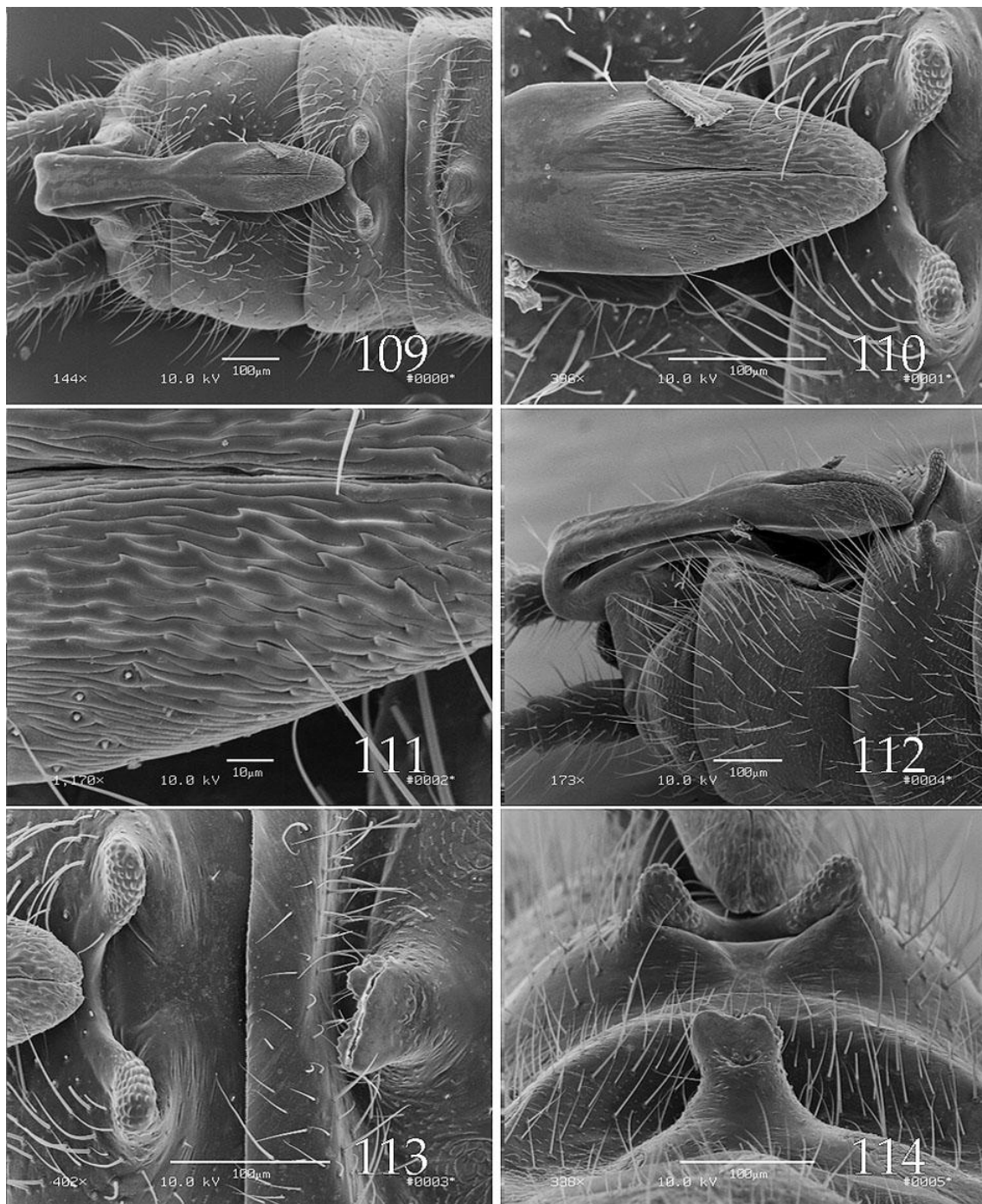
*Allocapnia zola* Ricker 1952:166. Holotype ♂ (Illinois Natural History Survey), Ash Cave, [Hocking Co.], Ohio

*Allocapnia zola*: Ross & Ricker, 1971:43.

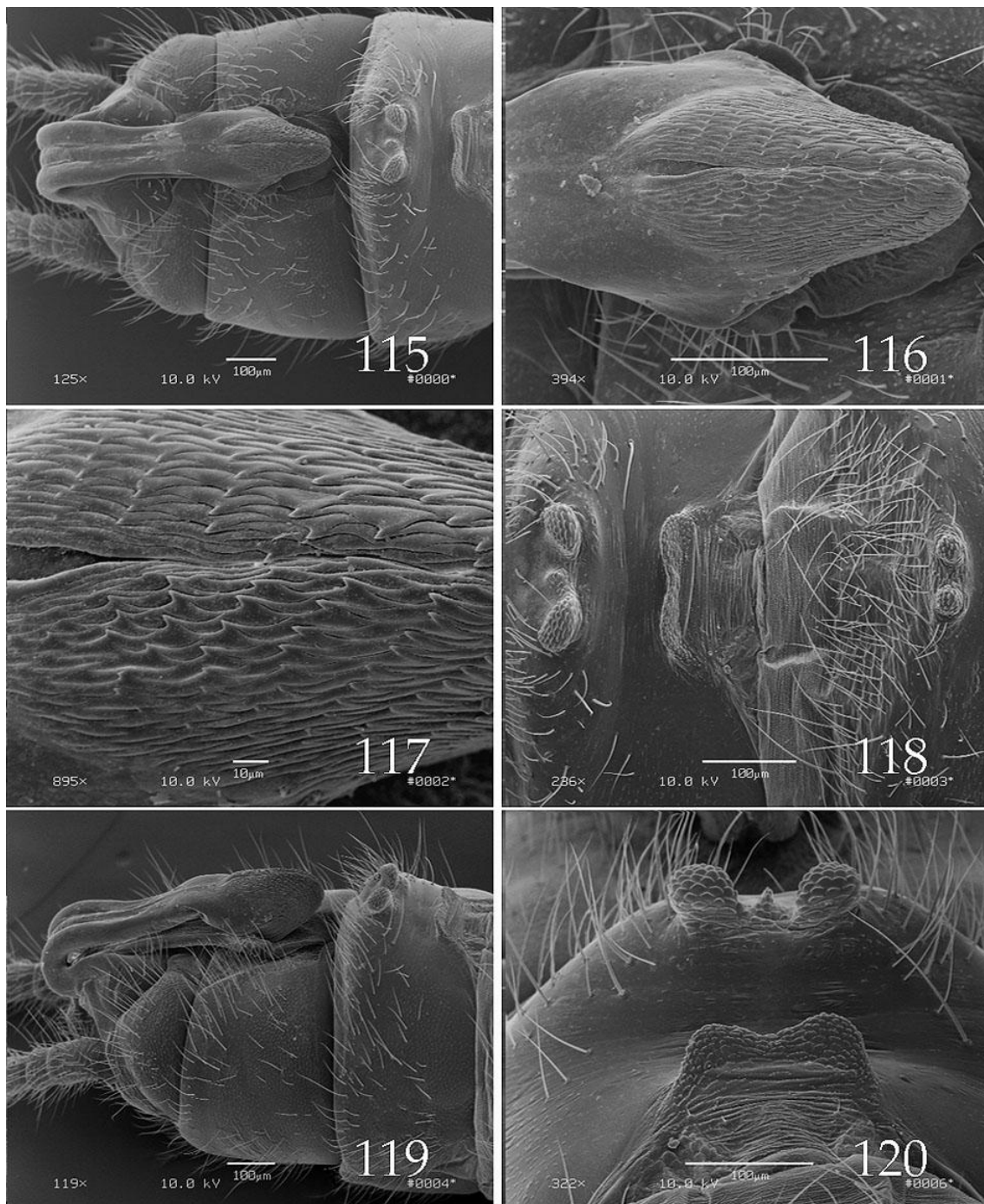
**Material examined. Tennessee:** Morgan Co., Green Branch White Creek, Barnett Bridge Road, 9 February 1998, B.C. Kondratieff, R.F. Kirchner, 9♂, 5♀ (CSUC). Morgan Co., Mud Lick Creek, Hwy 299, Oakdale City Park, 9 February 1998, B.C. Kondratieff, R.F. Kirchner, 5♂, 4♀ (CSUC). **Virginia:** Wythe Co., Stony



Figs. 103-108. *Allocapnia sandersoni*, Little Red River, Searcy Co., Arkansas. 103. Male terminalia, dorsal. 104. Apical segment upper limb of epiproct tip, dorsal. 105. Male terminalia, lateral. 106. 8<sup>th</sup> tergal process and epiproct tip, lateral. 107. 8<sup>th</sup> tergal process and epiproct tip, dorsal. 108. 8<sup>th</sup> tergal process, anterodorsal.



Figs. 109-114. *Allocapnia stannardi*, 1 mile W Newfound Gap, Sevier Co., Tennessee. 109. Male terminalia, dorsal. 110. Apical segment upper limb of epiproct tip, dorsal. 111. Surface detail apical segment upper limb of epiproct, dorsal. 112. Male terminalia, lateral. 113. Abdominal tergal processes, dorsal. 114. Abdominal tergal processes, anterodorsal.



Figs. 115-120. *Allocapnia zola*, Stoney Fork Reed Creek, Wythe Co., Virginia. 115. Male terminalia, dorsal. 116. Apical segment upper limb of epiproct tip, dorsal. 117. Surface detail apical segment upper limb of epiproct, dorsal. 118. Abdominal tergal processes, dorsal. 119. Male terminalia, lateral. 120. Abdominal tergal processes, anterodorsal.

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Fork Reed Creek, Hwy 52, 26 February 1999, B.C. Kondratieff, R.F. Kirchner, 4♂, 3♀ (CSUC). **West Virginia:** Nicholas Co., Panther Creek, Rt 39, 21 February 1981, R.F. Kirchner, V.J. Marchese, 7♂, 3♀ (BPS).

**Male epiproct.** Apical segment of upper limb ca. 283 µm long, and armed on the apical ca. 225 µm with dense patch of wave-like spikes (Figs. 115-117, 119); apical segment ca. 126 µm wide at base, swollen to ca. 165 µm at midlength and tapered to a narrowly rounded tip. Basal segment of upper limb ca. 350 µm long and ca. 94 µm wide near midlength; basal segment bears a median groove which extends to apical segment base. Greatest width of lower limb ca. 190 µm; lateral margins of lower limb bearing a sparse row of long setae near apical spoon.

**Male tergal process.** Prominent raised structures on abdominal terga 7-8 (Figs. 118-120); posterior process on tergum 8 trilobed and ca. 152 µm wide; median lobe much smaller than lateral lobes, but all covered with scale-like structures; notch ca. 45 µm wide. Anterior process of tergum 8 slightly notched on dorsal margin, covered with scale-like structures, and ca. 132 µm wide. Process on tergum 7 bilobed, ca. 25 µm wide and covered with scale-like structures.

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