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A SCANNING ELECTRON MICROSCOPY STUDY OF THE EPIPROCTS OF WESTERN NORTH AMERICAN *SWELTSA* (PLECOPTERA: CHLOROPERLIDAE)

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ABSTRACT

Three *Sweltsa* species with generally similar, wide epiprocts, known to occur in California and the Pacific Northwest are redescribed based on scanning electron microscopy data. The epiproct tips for *Sweltsa oregonensis* (Frison), *S. pacifica* (Banks) and *S. resima* Surdick are redescribed and compared with that of *S. townesi* (Ricker).

Keywords: *Sweltsa*, Plecoptera, Epiproct morphology, Scanning electron microscopy, Western Nearctic

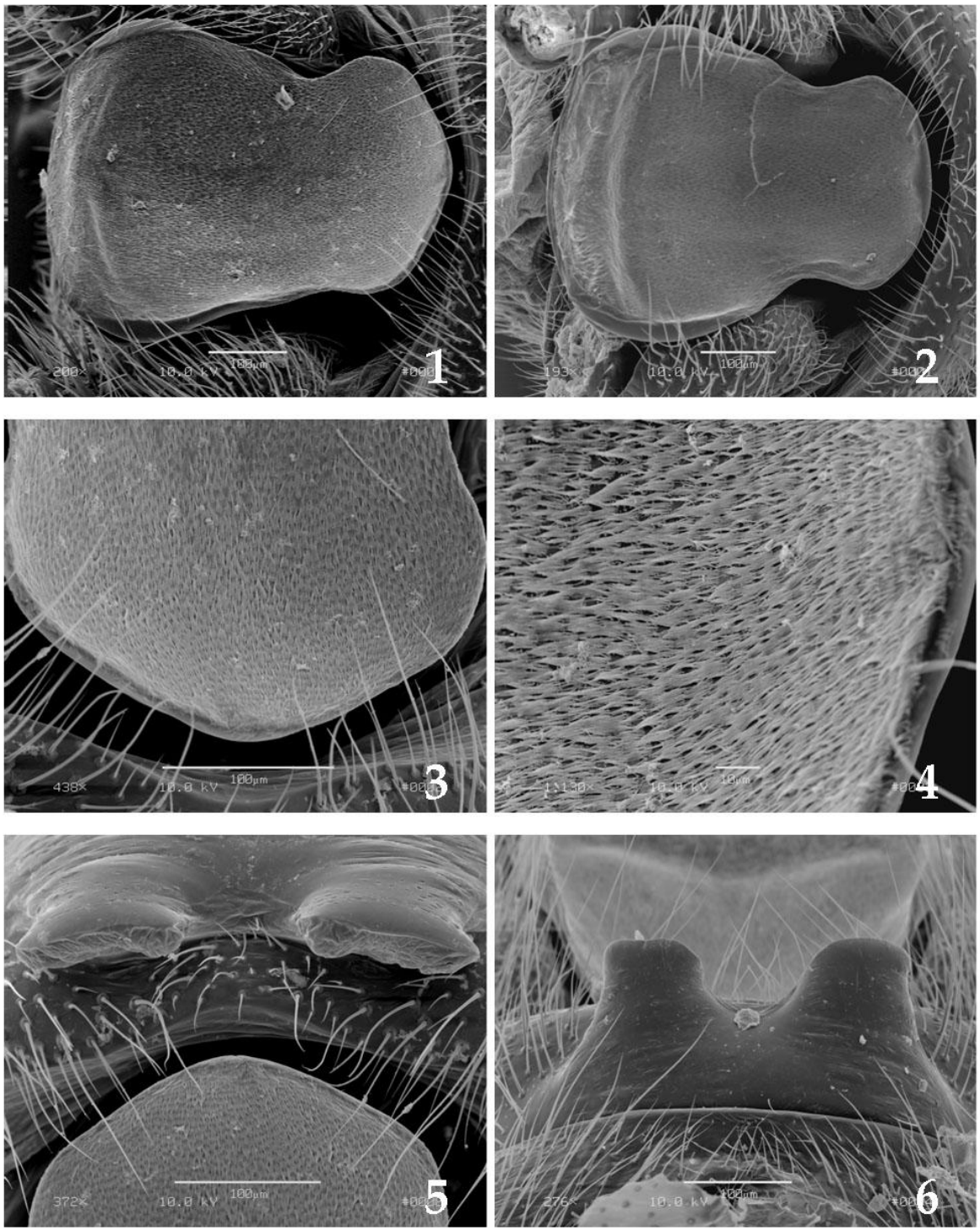
INTRODUCTION

Genus *Sweltsa* Ricker, the second most speciose genus among Chloroperlidae, currently includes 48 Nearctic and eastern Palearctic species with 24 known from western North America (DeWalt et al. 2009; Lee & Baumann 2010); eighteen of these species occur in the Coast, Cascades or Sierra Nevada Mountains of California, Oregon and Washington (Stark et al. 2009; Lee & Baumann 2010). Male *Sweltsa* have a well developed epiproct composed of a basal bar and anchor and a generally hirsute epiproct tip; in most species a transverse, often bilobed process occurs on tergum nine (Surdick 1985). Recently the surface detail and general epiproct morphology for several *Sweltsa* species have been examined with scanning electron microscopy (Delk et al. 1998; Kondratieff & Baumann 2009; Lee & Baumann 2010; Stark & Baumann 2007; Stark & Sivec 2009), and some of these studies have aided in recognition of cryptic species or they have been helpful in the establishment of species groups within the genus.

In this study we examined the epiproct tips of *Sweltsa oregonensis* (Frison), *S. pacifica* (Banks), *S. resima* Surdick, and *S. townesi* (Ricker) with scanning electron microscopy. These species were selected because they occur in the same region, have a generally similar epiproct morphology, and might belong to the same species group within the genus.

MATERIALS AND METHODS

Sweltsa specimens were collected by the authors in June 2009 or obtained from the Monte L. Bean Life Sciences Museum, Brigham Young University, Provo, Utah (MLBM), the K.W. Stewart Collection, University of North Texas, Denton, Texas (KWS), the Richard Bottorff Collection, South Lake Tahoe, California (RB), or the Stark Collection, Mississippi College, Clinton, Mississippi (BPS). Wings were clipped for specimens selected for SEM study and the bodies were placed in 80% ethanol and sonicated for 10-15 seconds to remove debris. Cleaned specimens were dehydrated through a series of 90%, 95% and 100% ethanol for 10 minutes each and then placed in Hexamethyldisilizane for 30 minutes. Dried specimens were mounted on aluminum stubs with double stick copper tape, sputter coated with gold-



Figs. 1-6. *Sweltsa oregonensis*. 1. Epiproct, dorsal aspect. 2. Epiproct, dorsal aspect. 3. Epiproct apex, dorsal aspect. 4. Epiproct surface detail. 5. Process of tergum 9, dorsal aspect. 6. Process of tergum 9, anterior aspect. (Figs. 1, 3, 4, 5 = Oregon, Deschutes Co., Deschutes River; Figs. 2, 6 = Oregon, Lincoln Co., Siletz River).

palladium, and examined with an Amray 1810 scanning electron microscope. Digital images were captured using an Orion system.

RESULTS AND DISCUSSION

Sweltsa oregonensis (Frison)
(Figs. 1-6)

Alloperla oregonensis Frison, 1935:332. Holotype ♂ (Illinois Natural History Survey), Oregon, [Clackamas Co.], Salmon River, near Welches, Mt. Hood National Forest

Material examined. OREGON: **Deschutes Co.:** Deschutes River, Deschutes Bridge Campground, 11 June 2004, B. Stark, R.W. Baumann, 6♂, 8♀ (BPS). **Lincoln Co.:** Siletz River, Moonshine Park, 1 June 2000, B. Stark, I. Sivec, M. Zúñiga, 6♂ (BPS). **Marion Co.:** North Santiam River, Hwy 22, 3 miles above Idanhas, 3 June 2000, B. Stark, I. Sivec, M. Zúñiga, 2♂ (BPS). **Tillamook Co.:** Three Rivers, Castle Rock, Hwy 22, 1 June 2000, B. Stark, I. Sivec, M. Zúñiga, 1♂ (BPS). **WASHINGTON**: **Clallam Co.:** Soleduck River, Hwy 101, 18 June 1967, R.W. Baumann, 1♂, 3♀ (MLBM). **Skamania Co.:** Wind River, Paradise Creek Campground, Hwy 30, 14 June 2004, B. Stark, R.W. Baumann, 4♂, 4♀ (BPS).

Male epiproct. Dorsal length ca. 505-510 µm, basal width ca. 395-409 µm, width at subapical constriction point ca. 256-263 µm. Somewhat spatulate in shape, broad at base (Figs. 1-2), dorsoventrally flattened, with slightly depressed concavity on dorsal surface, constricted beyond midlength, and usually broadly rounded or upturned at tip. Dorsal surface, except for narrow rim, bearing dense pile of short, setae (Figs. 3-4); setae appear comb-like with several filaments arising in a common grouping; ventral surface glabrous, at least near tip.

Dorsal process. Located on tergum 9. Total width ca. 300-341 µm, median notch ca. 88-93 µm wide. Process bilobed, lateral lobes truncate to slightly rounded, each ca. 105-124 µm wide, extending above a median U-shaped notch. Dorsal surface smooth on anterior margin but eroded posteriorly (Figs. 5-6).

Comments. Frison (1935) mentioned the spatulate shape of the epiproct and the mesal cleft of the dorsal process and both Ricker (1943) and Jewett (1959) used the dorsal concavity on the epiproct as an important key character for this species. In their key to *Sweltsa* species, Stewart & Oswood (2006) note the epiproct shape is broadest basally and upturned and broadly rounded at the tip. The only previous original figures for the epiproct of this species are those in Frison (1935) and Stewart & Oswood (2006); those in Frison (1935) were reproduced in Jewett (1959). Additional comments given below compare this species with *S. pacifica.*

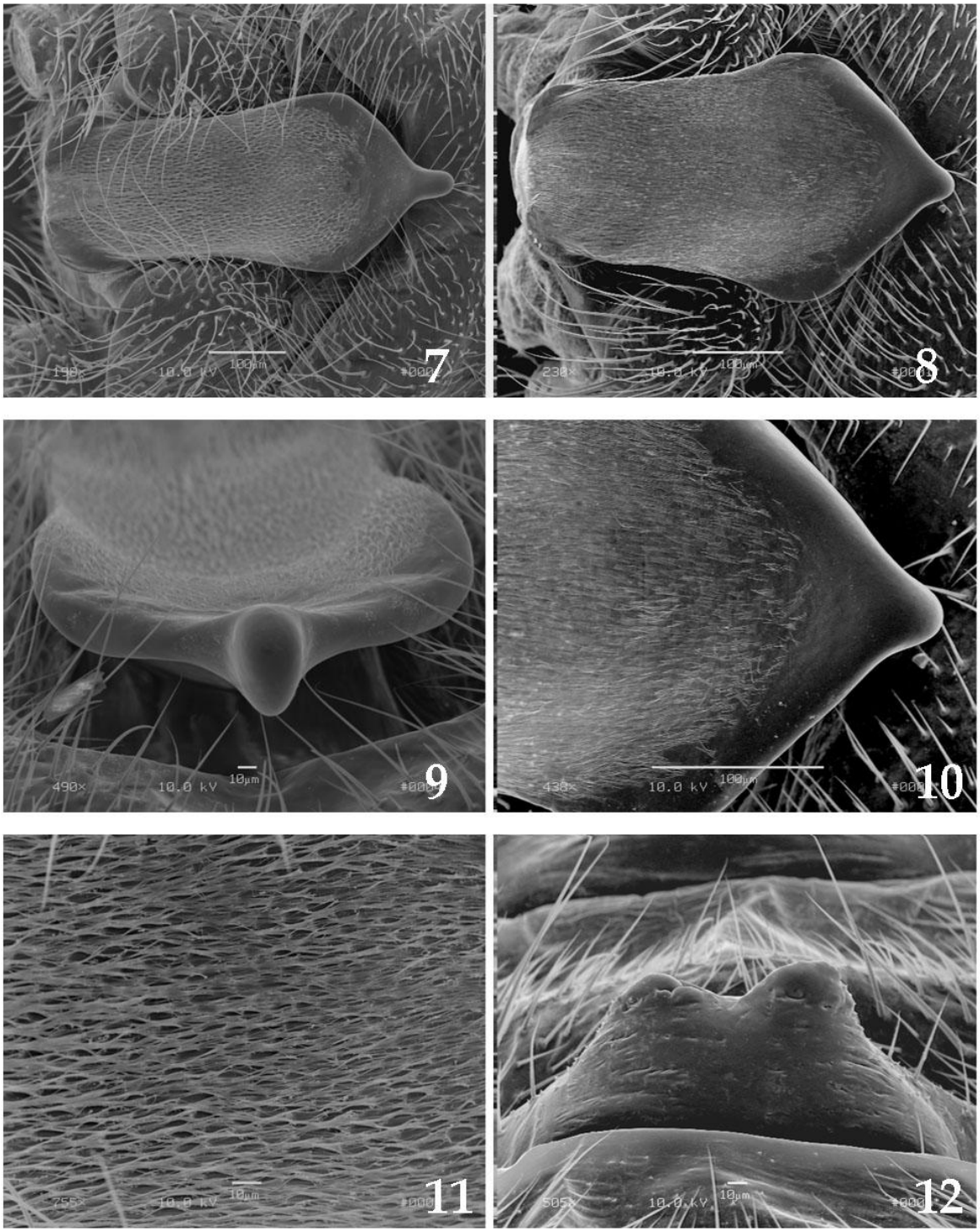
Sweltsa pacifica (Banks)
(Figs. 7-12)

Chloroperla pacifica Banks, 1895:313. Holotype ♀ (Museum of Comparative Zoology), Washington, Skokomish River

Alloperla spatulata Needham & Claassen, 1925:120. Holotype ♂ (Cornell University), California, San Antonio Canyon near Claremont, Synonymy by Ricker, 1952:182

Material examined. CALIFORNIA: **Calaveras Co.**, Jesus Maria Creek, near North Calaveras River, Mokelumne Hill, 7 May 1987, R. Bottorff, A. Knight, 1♂, 1♀ (RB). **Nevada Co.**, Prosser Creek, Hwy 89, 24 June 2009, B. Stark, C.R. Nelson, K. Nye, A. Harrison, 2♂, 3♀ (BPS). **Placer Co.:** Truckee River, Hwy 89, 1 mile south of Truckee, 19 June 1985, R.W. Baumann, C.R. Nelson, M. Whiting, 15♂, 15♀ (MLBM). Truckee River, Hwy 89, Goose Meadow Campground, 22 June 2009, B. Stark, K. Nye, A. Harrison, 14♂, 7♀ (BPS). **Plumas Co.:** Little Last Chance Creek, above Chilcoot Campground, 7 June 2004, B. Stark, R.W. Baumann, 2♂, 4♀ (BPS). **Riverside Co.:** Stone Creek, below Pine Cove, San Jacinto Mountains, 21 June 1977, R.W. Baumann, C. Hogue, 1♂, 3♀ (MLBM). **Sierra Co.**: Little Truckee River, Hwy 89, 14 mi north of Truckee, 21 June 2009, B. Stark, K. Nye, A. Harrison, 1♂ (BPS). **OREGON**: **Lincoln Co.:** Siletz River, Moonshine Park, 1 June 2000, B. Stark, I. Sivec, M. Zúñiga, 1♂ (BPS). **WASHINGTON**: **Chelan Co.:** seep at Nason Creek, above White Pine Campground, 16 June 2004, B. Stark, R.W. Baumann, 2♂, 2♀ (BPS).

Male epiproct. Dorsal length ca. 490-530 µm, basal width ca. 137-157 µm, greatest width ca. 235-265 µm. Epiproct dorsoventrally flattened, broad basally becoming gradually wider, then abruptly widened



Figs. 7-12. *Sweltsa pacifica*. 7. Epiproct, dorsal aspect. 8. Epiproct, dorsal aspect. 9. Epiproct apex, anterior aspect. 10. Epiproct apex, dorsal aspect. 11. Epiproct surface detail. 12. Process of tergum 8, anterior aspect. (Figs. 7, 9, 11 = California, Sierra Co., Little Truckee River; Figs. 8, 10, 12 = California, Placer Co., Truckee River).

into subtriangular apex terminating in small nipple-like point (Figs. 7-10); dorsum concave, apex slightly upturned. Dorsal surface bearing dense pile of short, multifilament setae except for glabrous margin around subapical triangular region (Figs. 10-11); ventral surface glabrous.

Dorsal process. Located on tergum 8, some specimens bear slightly elevated ridge on tergum 9. Total width ca. 90-120 µm, median notch shallow, V-shaped. Process broad basally, lateral margins angled sharply to apex of projections (Fig. 12).

Comments. Banks (1895) original description of this species is based primarily on pigment pattern and wing venation, no figures are given. Needham & Claassen (1925) include the first figures of the male (Plate 22, Fig. 2) and provide a figure of the male *Alloperla spatulata* (Plate 21, Fig. 14), now considered a synonym of *S. pacifica*. The latter figure shows the dorsal aspect of the epiproct much more accurately than does the former, but other authors (e.g. Jewett 1959) have selected the less accurate figures for reproduction. Stewart & Oswood (2006) study prepared new figures which show the two dorsal processes, however the epiproct shape in their Fig. 7.94 shows a constriction not found in our specimens. One reviewer checked additional *S. pacifica* specimens from California, Oregon and Washington and noted an apparent constriction for specimens in which the epiproct is closely appressed to the cowl, however, on closer inspection, no actual constriction occurred in these specimens. Specimens from the Stewart & Oswood (2006) should be re-examined for the presence of this epiproct feature.

The broad and dorsoventrally flattened epiproct of this species is more similar to that of *S. oregonensis* than to *S. resima* or *S. townesi.* However, significant differences including the presence of an apical nipple-like structure, an extensive apical glabrous area, and the absence of a mesal constriction in our *S. pacifica* specimens, suggest *S. oregonensis* and *S. pacifica* are not so closely related as to be placed together in a single species group.

Sweltsa resima Surdick
(Figs. 13-18)

Sweltsa resima Surdick, 1995:161. Holotype ♂ (United States National Museum), California, Inyo Co., Whitney Portal

Material examined. CALIFORNIA: **Inyo Co.:** Division Creek, north of Independence, 7 June 1986, D. Giuliani, 2♂, 2♀ (MLBM). Lone Pine Creek, Whitney Portal, 36.34° N, 118.14° W, 28 July 2005, E. Drake, 8♂, 2♀ (KWS).

Male epiproct. Total length ca. 600-654 µm, basal width ca. 230-260 µm, greatest width ca. 400-430 µm. Epiproct somewhat saggitate in outline with upturned tip and broad apically expanded mesal groove (Figs. 13-16). Dorsal surface bearing dense pile of short, multifilament setae (Fig. 17); ventral surface glabrous.

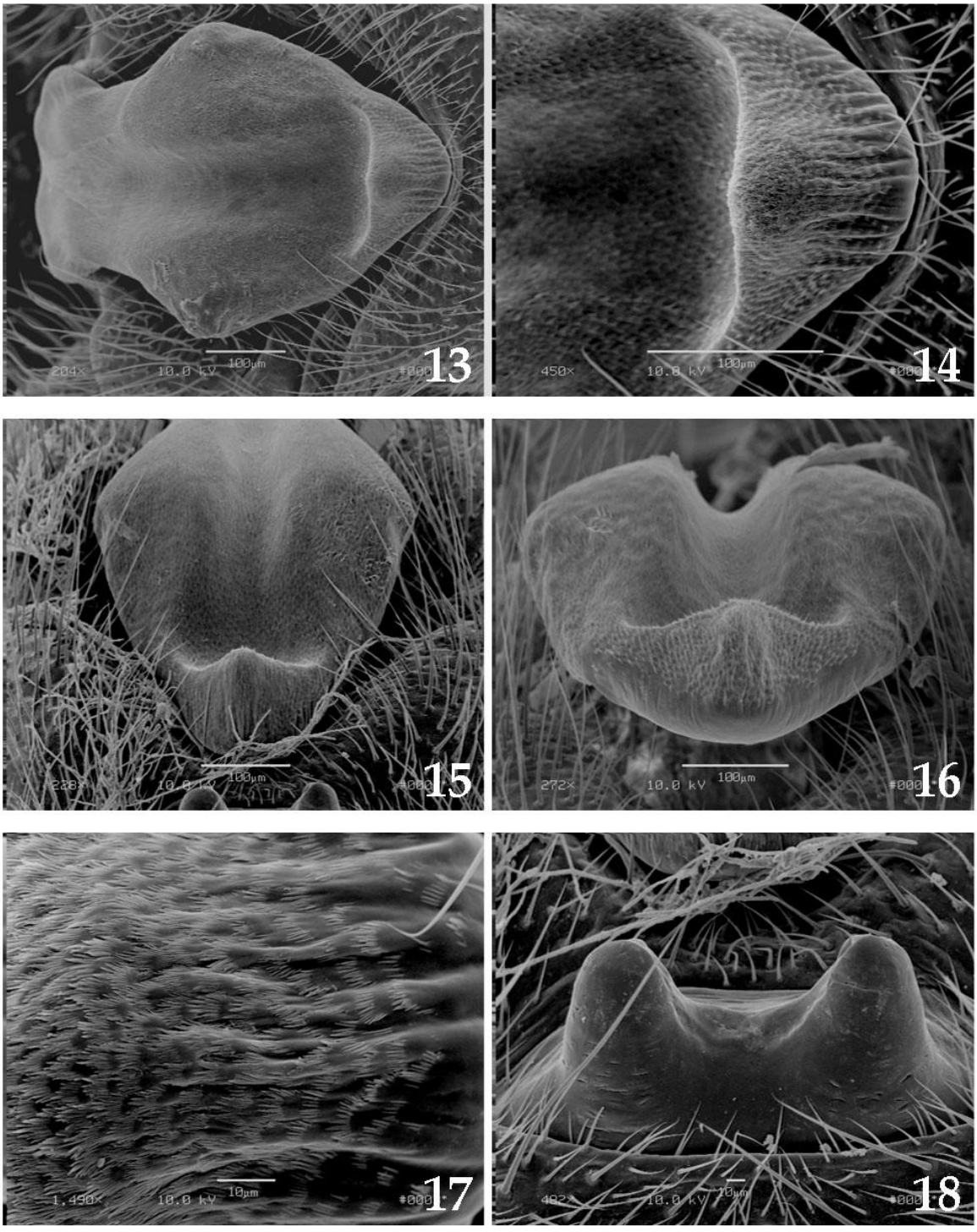
Dorsal process. Located on tergum 9. Total width ca. 180-190 µm, median notch shallow, ca. 100-140 µm wide. Process broadly bilobed (Fig. 18).

Comments. Surdick (1995) provides excellent illustrations of the epiproct of this species. Additional comments are given below.

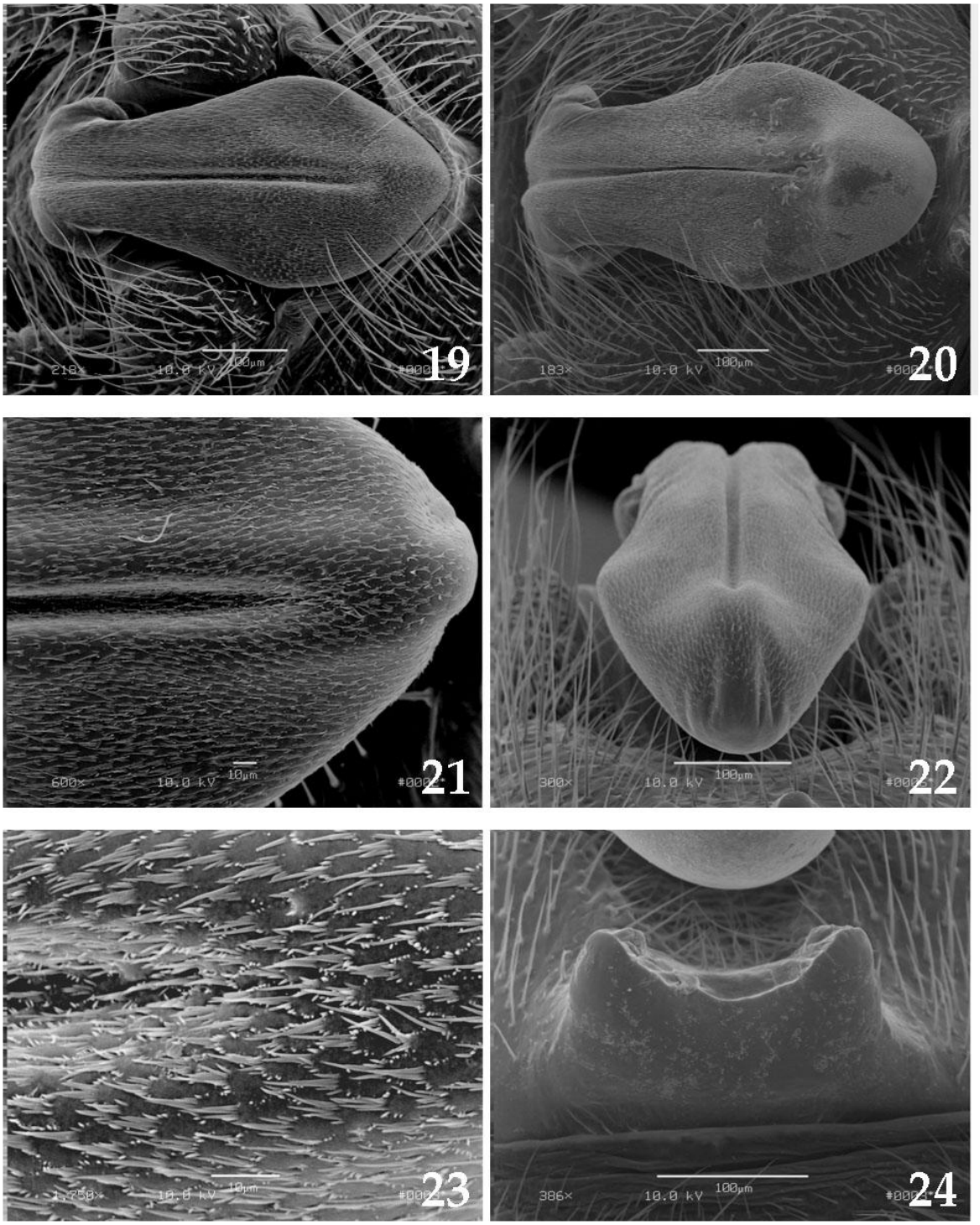
Sweltsa townesi (Ricker)

Alloperla (*Sweltsa*) *townesi* Ricker, 1952:184. Holotype ♂ (Illinois Natural History Survey), California, [Tuolumne Co.], Dardanelle
Sweltsa townesi: Lee & Baumann, 2010:35. Redescription with SEM

Material examined. CALIFORNIA: **Alpine Co.:** West Carson River, 12 July 1995, R. Bottorff, 1♂ (BPS). **El Dorado Co.:** Truckee River, Hwy 50, 13 July 1995, R. Bottorff, 2♂ (BPS). **Nevada Co.:** Sagehen Creek, Sagehen Biological Station, 19 June 1985, B. Stark, 16♂, 9♀ (BPS). **Placer Co.:** Truckee River, Hwy 89, Goose Meadow Campground, 22 June 2009, B. Stark, K. Nye, A. Harrison, 1♂, 1♀ (BPS). **Plumas Co.:** Graeagle Creek, Graeagle, 5 July 1979, B. Stark, K.W. Stewart, 1♂, 3♀ (BPS). **Sierra Co.:** Big Spring, Hwy 49, near Bassetts, 21 June 2009, B. Stark, K. Nye, A. Harrison, 1♂, 3♀ (BPS). Dark Canyon Creek, Lemon Canyon Road, 21 June 2009, B. Stark, K. Nye, A. Harrison, 2♂, 3♀ (BPS). Cold Creek, 1 mile south Cold Creek Campground, 5 July 1979, B. Stark, K.W. Stewart, 2♂ (BPS). **NEVADA**: **Washoe Co.:** small stream from Marletta Lake, Hwy 28, 24 June 2009, B. Stark, C.R. Nelson, K. Nye, A. Harrison, 9♂, 7♀ (BPS). Galena Creek, Galena Creek Park, 24 June 2009, B. Stark, C.R. Nelson, K. Nye, A. Harrison, 3♂, 16♀ (BPS).



Figs. 13-18. *Sweltsa resima*. 13. Epiproct, dorsal aspect. 14. Epiproct apex, dorsal aspect. 15. Epiproct, anterior aspect. 16. Epiproct, anterior aspect. 17. Epiproct surface detail. 18. Process of tergum 9, anterior aspect. (California, Inyo Co., Division Creek).



Figs. 19-24. *Sweltsa townesi*. 19. Epiproct, dorsal aspect. 20. Epiproct, dorsal aspect. 21. Epiproct apex, dorsal aspect. 22. Epiproct apex, anterior aspect. 23. Epiproct surface detail. 24. Process of tergum 9, anterior aspect. (Figs. 19, 21, 22, 23 = California, Nevada Co., Sagehen Creek; Figs. 20, 24 = Nevada, Washoe Co., stream from Marletta Lake).

Male epiproct. Total length ca. 500-530 µm, basal width ca. 125-150 µm, greatest width ca. 245-250 µm. Epiproct saggitate in dorsal aspect with thick tip slightly upturned and bearing narrow groove which extends from base to ca. 90-110 µm from apex (Figs. 19-22). Dorsal surface bearing short, multifilament setae (Fig. 23); ventral surface glabrous.

Dorsal process. Located on tergum 9. Total width ca. 160-180 µm, median notch shallow with truncate floor, notch width ca. 80-90 µm. Lobes of process triangular in outline (Fig. 24).

Comments. The epiproct and dorsal process were illustrated by Ricker (1952). Surdick (1995) presented dorsal, dorsolateral and fully lateral outlines of this structure. More recently Lee & Baumann (2010) included five SEM images of the *S. townesi* epiproct in their redescription of that species. Surdick (1995) considered *S. townesi* and *S. resima* as sister species but data from the description and placement of *S. salix* in this group suggest *S. townesi* and *S. salix* are the more closely related pair (Lee & Baumann 2010). Unfortunately, no support for either of these hypotheses is available from our limited study.

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