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LEUCTRA SCHUSTERI, A NEW STONEFLY SPECIES (PLECOPTERA: LEUCTRIDAE) OF THE *L. TENUIS* (PICTET) GROUP FROM THE SOUTHEASTERN USA

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ABSTRACT

Leuctra schusteri sp. n. is described from spring runs located in the Interior Plateau Region in central Kentucky, USA. *Leuctra schusteri* sp. n. is differentiated from the other members of the *L. tenuis* (Pictet) species group, particularly *L. tenuis*, by characteristics of the paraprocts. Scanning electron micrographs and descriptions of diagnostic morphological characteristics are provided for males of all species of the *L. tenuis* group. A taxonomic key to the male adult stage is included.

Keywords: Plecoptera, Leuctridae, *Leuctra*, Nearctic, Kentucky, new species

INTRODUCTION

The Holarctic stonefly genus *Leuctra* Stephens (Plecoptera: Leuctridae) is represented within the eastern and central Nearctic region by 30 species (DeWalt et al. 2015). By contrast, >170 species total are known from Europe and to a lesser degree, central Asia, western Asia, and northern Africa. Harper & Harper (1997) assigned most of the Nearctic species into one of five groups based on external morphology of the adult male. They emphasized characteristics of the paraprocts instead of relying solely on the dorsal processes on the 7th and 8th abdominal terga. Tergal process characteristics had been used exclusively in the most recent key to the Nearctic species (Hitchcock 1974).

Harper & Harper (1997) placed five species in the *L. tenuis* (Pictet 1841) group: *L. carolinensis*

(Claassen 1923), *L. tenella* (Provancher 1878), *L. tenuis*, *L. triloba* (Claassen 1923) and *L. variabilis* (Hanson 1941). The *L. tenuis* group was defined according to the presence of a large process on the 7th abdominal tergum, a vesicle on the 9th abdominal sternum that is triangular in shape and reduced in size, and paraprocts with smooth outer margins. *Leuctra usdi* has subsequently been assigned to this group (Grubbs 2010).

An undescribed species belonging to the *L. tenuis* group was found in several spring runs in the Interior Plateau Region in central Kentucky, U.S.A. The undescribed species closely resembled *L. tenuis*. Examination of material determined as *L. tenuis* from throughout the eastern Nearctic region confirmed that the new species was morphologically distinct. The holotype is deposited at the United States National Museum of Natural

History, Washington, DC (USNM).

MATERIALS AND METHODS

Leuctra specimens examined in this study were obtained from the R.W. Baumann collection, Monte L. Bean Museum, Brigham Young University, Provo, Utah (BYUC), Donald C. Tarter collection, Marshall, West Virginia (DCTC), and Western Kentucky University, Bowling Green (WKUC). Other codens used were Cornell University Insect Collection, Ithaca, New York (CUIC), Illinois Natural History Survey, Champaign, Illinois (INHS), and Museum für Naturkunde, Berlin (ZMHB).

Fresh adult material was typically collected with a beating sheet although some specimens were obtained by hand-searching rocks and emergent leaf packs. Location data (in decimal degrees) for each specimen record were recorded either directly with a portable GPS unit or georeferenced from vial label data (if possible). Specimens for SEM analyses were dehydrated through a series of 75%, 95%, and 100% ethanol for 10 minutes each and placed in hexamethyldisilazane for 30 minutes. Dehydrated specimens were attached to aluminum stubs with double-stick tape and coated with gold-palladium using an Emscope SC500. Coated specimens were examined using a Jeol JSM-5400LV scanning electron microscope and digital images were captured with an IXRF system.

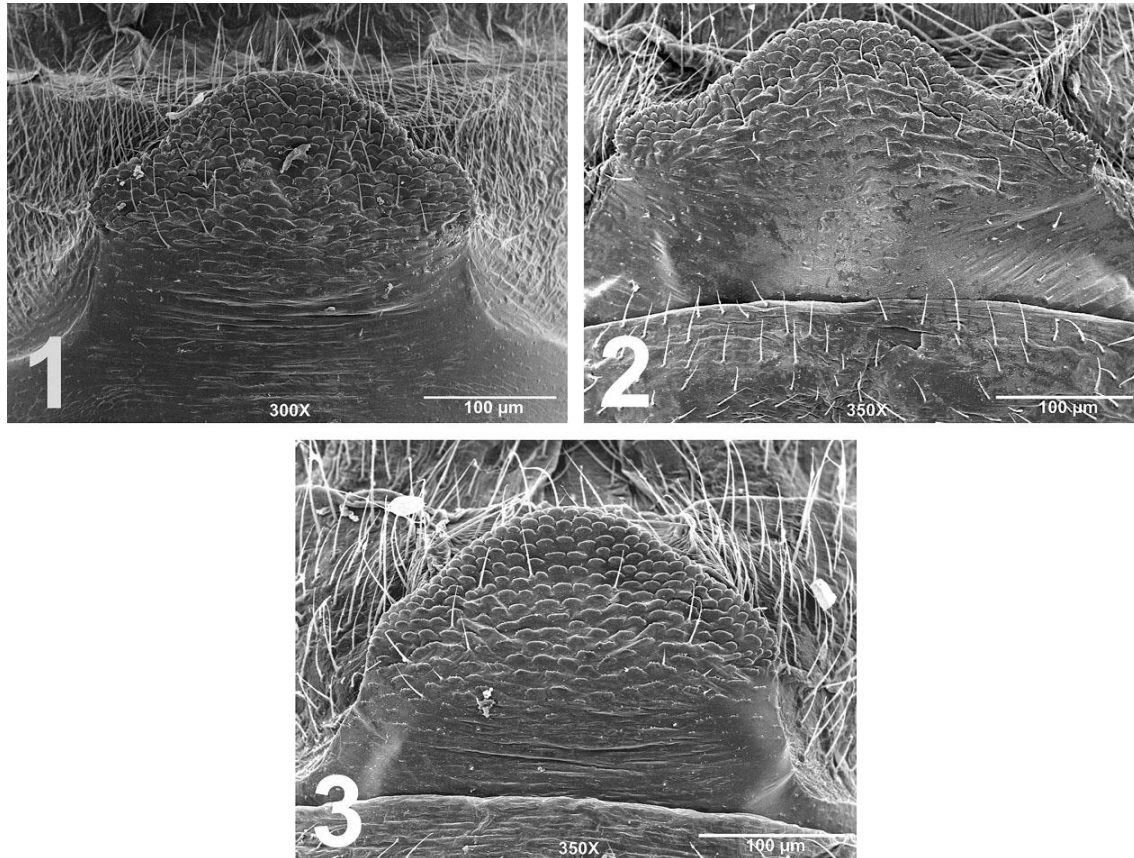
Several terms have been used in taxonomic treatments of *Leuctra* both prior to, and after, Brinck's (1956) review of the reproductive morphology of the common European species *L. hippopus* Kempny. For example, Harper & Harper (1997) used subanal lobe to refer to both the inner and outer members. Harper & Harper (2003) subsequently used paraproct but referred to the specillum and lateral style for the inner and outer members, respectively. Prior treatments (e.g. Hanson 1941) have used subanal lobe for the inner member and titillator for the outer lobe. Reproductive terminology for this treatment followed Brinck (1956), who partitioned the male paraproct into the outer subanal lobe and the inner specillum.

RESULTS AND DISCUSSION

Key to males of the *L. tenuis* species group

- 1 Dorsal process on 7th abdominal tergum tapering to a single, narrowly-rounded posterior lobe, overall shape triangular (Figs. 10–11, 23–25) 2
- 1' Dorsal process on 7th abdominal tergum narrowing little posteriorly, overall shape variable (Figs. 1–3, 19, 34–36, 43, 48) 3
- 2 Subanal lobe ca. $\frac{3}{4}$ length of the specillum (Figs. 28–30, 32); specillum simple, lacking spurs or tubercles distally (Figs. 27, 31, 33) *L. tenuis* (Pictet)
- 2' Subanal lobe ca. equal length to specillum (Figs. 14–15); specillum with a prominent, laterally-directed spur (Figs. 12–13) *L. schusteri* sp. n. Grubbs
- 3 Posterior margin of 7th abdominal dorsal process terminating along the same plane, overall shape symmetrically-trapezoidal (Figs. 43, 48) 4
- 3' Dorsal process on 7th abdominal tergum variable, overall shape variable (Figs. 1–3, 19, 34–36) 5
- 4 7th abdominal dorsal process bearing three subtruncate lobes, lateral lobes small, medial lobe ca. 4X wider than lateral lobes (Fig. 43); specillum bearing tubercles distally and along the outer distal margin (Figs. 44–47); late winter and spring-emergent species *L. usdi* Grubbs
- 4' 7th abdominal dorsal process lacking distinct lateral lobes, essentially straight along posterior margin (Fig. 48); specillum lacking tubercles along distal outer margin and at the tips (Figs. 49–52); autumn-emergent species *L. variabilis* Hanson
- 5 7th abdominal dorsal process bearing three rounded lobes, medial lobe narrowly-rounded posteriorly and nipple-like (Figs. 34–36); autumn- and winter-emergent species *L. triloba* Claassen
- 5' 7th abdominal dorsal process lacking distinct lobes, medial posterior portion either broadly-rounded or subtriangular (Figs. 1–3, 19); late spring- and summer-emergent species 6

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| <p>6 7th abdominal dorsal lobe broadly rounded posteriorly (Figs. 1–3); specillum subtriangular distally (Figs. 4, 7, 9), subanal lobes recurved anteriorly, but not at tip (Figs. 4, 6, 9) <i>L. carolinensis</i> Claassen</p> | <p>6' 7th abdominal dorsal process broadly subtriangular posteriorly (Fig. 19); specillum truncate distally (Fig. 22), subanal lobes sharply recurved anteriorly at tips (Figs. 21–22) <i>L. tenella</i> Claassen</p> |
|--|--|



Figs. 1–3. *Leuctra carolinensis*. 1, 7th abdominal process, dorsal view, 300X, Connecticut, tributary to Beaver Brook; 2, 7th abdominal process, dorsal view, 350X, Maryland, spring into Little Laurel Run; 3, 7th abdominal process, dorsal view, 350X, Alabama, tributary to Ross Branch.

Taxonomy

Leuctra tenuis (Pictet) group

<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:462469>

Leuctra carolinensis Claassen 1923

Carolina Needlefly

<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:462471>

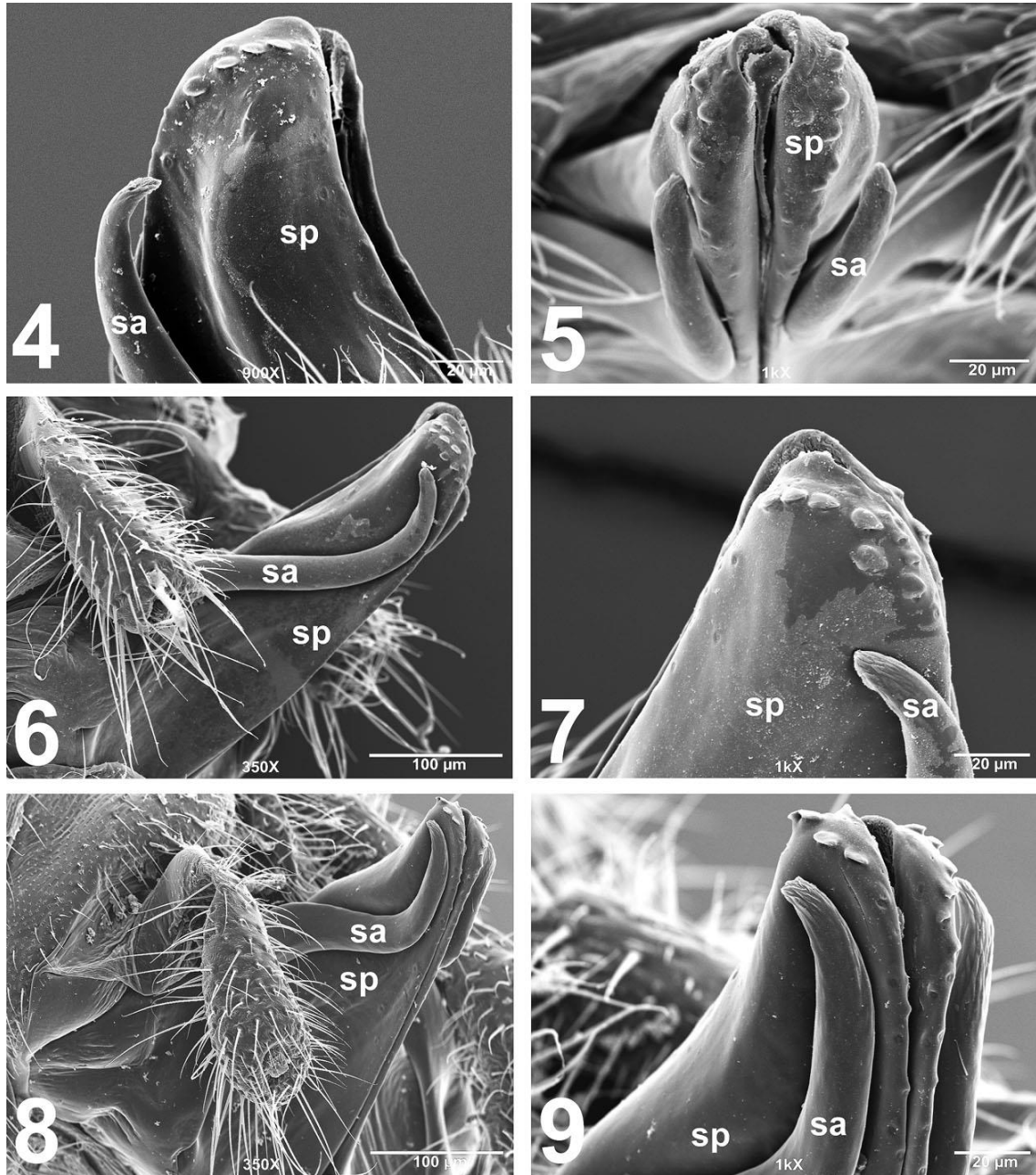
(Figs. 1–9)

Leuctra carolinensis Claassen 1923:258. Holotype ♂ (CUIC), Black Mountains, North Carolina.

Leuctra carolinensis: Needham and Claassen 1925:226

Leuctra carolinensis: Illies 1966:84

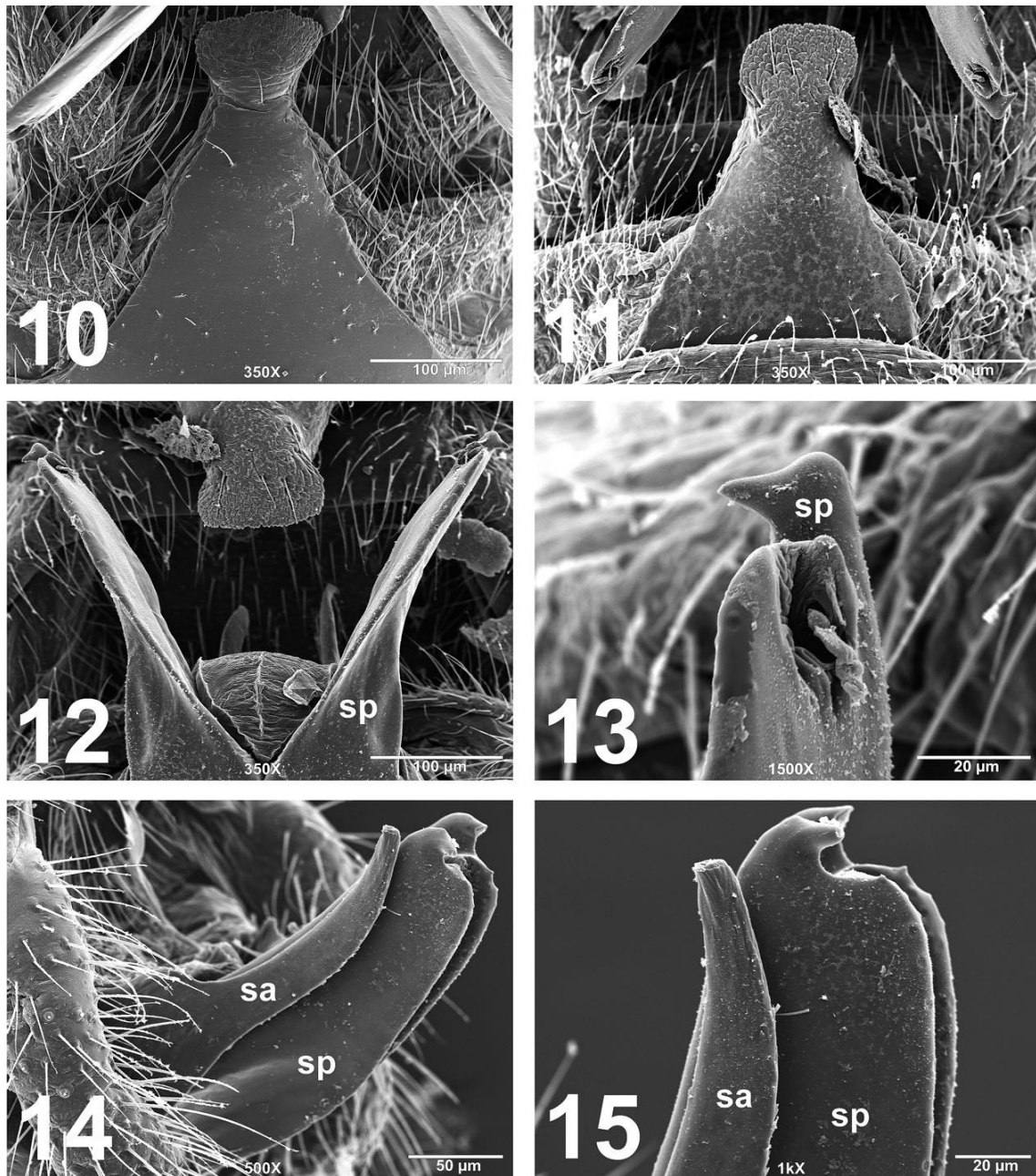
Male. The 7th abdominal dorsal process is large and broadly rounded posteriorly; subtle lateral lobes are evident on central Appalachian populations and further north into New England (Figs. 1–2) but essentially absent from



Figs 4–9. *Leuctra carolinensis*. 4, paraprocts, lateral view, 900X, Connecticut, tributary to Beaver Brook; 5, paraprocts, dorsal view, 1000X, Alabama, tributary to Ross Branch; 6, paraprocts, lateral view, 350X, Maryland, Bull Glade Run; 7, paraprocts, lateral view, 1000X, Maryland, Bull Glade Run; 8, paraprocts, lateral view, 350X, Alabama, tributary to Ross Branch; 9, paraprocts, lateral view, 1000X, Alabama, tributary to Ross Branch. sp = specillum, sa = subanal lobe.

northwestern Alabama near the southwestern edge of this species range (Fig. 3). The specilla varies from triangular with a broad base (Fig. 8) to ca. parallel-sided (Fig. 6); distally the specillum is

subtriangular with tubercles present and also along the distal outer margin (Figs. 4–9). The subanal lobes extend nearly to tip of the specilla, recurved anteriorly in posterior half (Figs. 4, 6–9).



Figs. 10–15. *Leuctra schusteri* sp. n., Kentucky, spring into Smyrna Creek. 10–11, 7th abdominal process, dorsal view, 350X; 12, paraprocts, caudal view, 350X; 13, paraprocts, caudal view, 1500X; 14, paraprocts, lateral view, 500X; 15, paraprocts, lateral view, 1000X. sp = specillum, sa = subanal lobe.

Material examined. USA, Alabama, Colbert Co., tributary to Ross Branch, 6 km SE Waterloo, 34.8781, -88.0102, 4 May 2008, S.A. Grubbs, 17♂ (WKUC); Lauderdale Co., South Fork Panther Creek, 7.5 km NW Waterloo, Lauderdale Wildlife

Management Area, 34.9633, -88.1241, 4 May 2008, S.A. Grubbs, 1♂ (WKUC); Second Creek, 9 km NE Waterloo, 34.9745, -87.9942, 4 May 2008, S.A. Grubbs, 1♂ (WKUC). Connecticut, New London Co., tributary to Beaver Brook, 4 km W

Chesterfield, Nehantic State Forest, 41.4244, -72.2685, 16 June 2007, S.A. Grubbs, 10♂ (WKUC); tributary to Green Fall River, 7.5 km SE Voluntown, Pachaug State Forest, 41.5228, -71.8091, 17 June 2007, S.A. Grubbs, 1♂ (WKUC). **Maryland**, Garrett Co., spring into Little Laurel Run, Savage River State Forest, 39.6314, -79.1484, 21 June 1996, S.A. Grubbs, 9♂, 8♀ (WKUC); Bull Glade Run, Garrett State Forest, 39.4912, -79.4584, 25 May 1996, S.A. Grubbs, 4♂ (WKUC); Alexander Run, 39.6597, -79.2254, 12 July 1996, S.A. Grubbs, 6♂, 5♀ (WKUC); **Pennsylvania**, Westmoreland Co., spring into Linn Camp Creek, 40.1675, -79.2307, 1 August 1991, S.A. Grubbs, 1♂ (WKUC).

Distribution. USA: MD, MS, NC, NJ, TN, VA (DeWalt et al. 2015), AL (Grubbs 2010), CT (new state record), PA (Masteller 1996).

Remarks. *Leuctra carolinensis* and *L. tenella* appear to be sister species based on overall similarity in structure of the paraproct and the 7th abdominal dorsal process. The abdominal process resembles only *L. tenella*, a species with a similar distribution and spring–summer emergence in the southern and central Appalachian Mountains. The two records of *L. carolinensis* from low elevation streams in southeastern Connecticut represent a northeastern range extension and suggest that the distribution of this species is still poorly understood. The dorsal process of *L. carolinensis* is broadly-rounded posteriorly (Figs. 1–3) whereas the process of *L. tenella* is subtriangular (Fig. 19). Although the specilla of *L. carolinensis* vary slightly in overall shape (Figs. 6, 8), the location of tubercles and the shape of the distal portion are similar among the material examined (Figs. 4–9) and distinct from *L. tenella* (Figs. 21–22).

Leuctra schusteri sp. n.

<http://lsid.speciesfile.org/urn:lsid:Plecoptera:speciesfile.org:TaxonName:472643>

(Figs. 10–18)

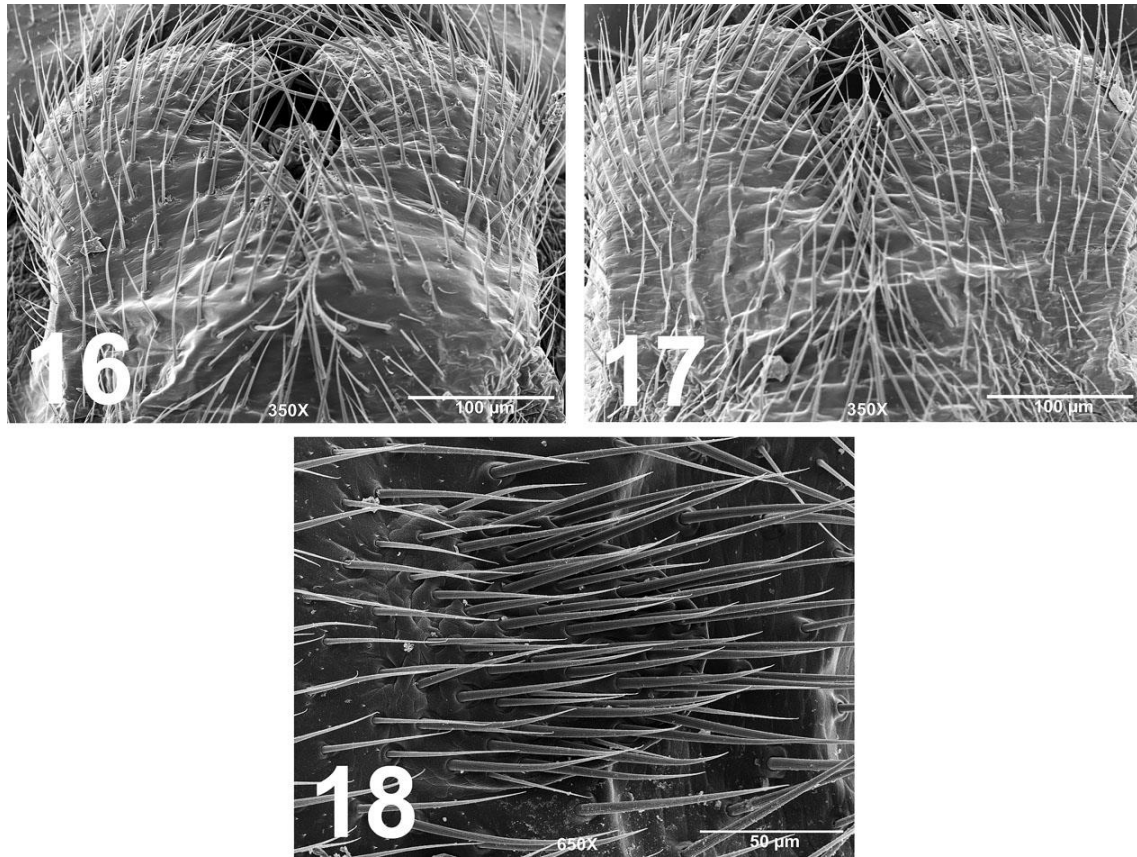
Male. Forewing length 4.5–5.5 mm, body length 4.5–6.0 mm (n=15). General body color and wings brown. Cerci tubular and unmodified. Abdominal terga 1–6 unmodified. Dorsal process on abdominal tergum 7 emanating from anterior

margin of segment, tapering markedly to the posterior tip that is slightly bulbous and expanded medially, overall shape of process triangular (Figs. 10–11). Abdominal tergum 8 unmodified except for a quadrate-shaped lightly-pigmented medial sclerite. Epiproct sclerite unmodified and narrow throughout length, tapering slightly posteriorly. Specilla broadest basally, tapering little throughout length (Figs. 14–15), generally lacking tubercles along distal outer margins (Figs. 12–15), tip bears a conspicuous, laterally-directed spur (Figs. 12–13). Subanal lobes flat, slightly recurved anteriorly, and subequal in length to specilla (Figs. 14–15). Vesicle small and subtriangular, length ca. equal to width at base (Fig. 18).

Female. Forewing length 5.5–7.0 mm, body length 5.5–7.5 mm (n=21). General body color similar to male. Abdominal sternum 7 with a pentagonal-shaped medial sclerite. Abdominal sternum 8 sclerotized medially in anterior ½; subgenital plate lobes rounded posterolaterally and angular along the mediolateral corners; lobes separated by a membranous diamond-shaped medial notch, extending maximally over the anterior ¼ of abdominal sternum 9 (Figs. 16–17).

Larva. Undescribed.

Material examined. Holotype ♂, USA, Kentucky, Hart Co., Cooper Spring, 37.1974, -86.0476, Mammoth Cave National Park, 15 September 2015, S.A. Grubbs (USNM). Paratypes: **Kentucky**, Allen Co., spring into Smyrna Creek, 6.5 km SE Gold City, 36.6777, -86.3913, 8 October 2013, S.A. Grubbs, 17♂, 43♀ (INHS, USNM, WKUC). Adair Co., Spout Spring Branch, 24 km SE Campbellsville, 37.2020, -85.1480, 3 October 2013, S.A. Grubbs, 1♂, 3♀ (WKUC); tributary to Sulphur Creek, 10 km NE Columbia, 37.1346, -85.1946, 3 October 2013, S.A. Grubbs, 1♂, 13♀ (WKUC). Edmonson Co., springhead in Fish Trap Hollow, Sal Hollow Trail, 37.1983, -86.1443, Mammoth Cave National Park, 15 September 2015, S.A. Grubbs, 1♂, 9♀ (WKUC); spring run into Ugly Creek, 37.2393, -86.1476, Mammoth Cave National Park, 15 September 2015, S.A. Grubbs, 5♂, 10♀ (WKUC); spring run into Ugly Creek, 37.2374, -86.1092, Mammoth Cave National Park, 15 September 2015, S.A. Grubbs, 8♂, 9♀ (WKUC); Good Church



Figs. 16–18. *Leuctra schusteri* sp. n., Kentucky, spring into Smyrna Creek. 16–17, subgenital plate, ventral view, 350X; 18, vesicle, ventral view, 650X.

Spring, 37.2096, -86.1476, Mammoth Cave National Park, 17 September 2015, S.A. Grubbs, 2♂, 5♀ (WKUC); spring out of Silent Grove Springhouse Cave, 37.1716, -86.1836, Mammoth Cave National Park, 24 September 2015, S.A. Grubbs, 1♂, 2♀ (WKUC); Blue Spring, Mammoth Cave National Park, 37.2424, -86.1797, 5 October 2015, S.A. Grubbs, 3♂, 3♀ (WKUC); Sand Spring, Mammoth Cave National Park, 37.2340, -86.1547, 11 October 2015, S.A. Grubbs, 1♂ (WKUC); tributary to Wet Prong Buffalo Creek, Mammoth Cave National Park, 37.2404, -86.1738, 11 October 2015, S.A. Grubbs, 1♂, 1♀ (WKUC). Green Co., spring into Big Brush Creek, nr. Rte. 569, 9 km WNW Summersville, 37.3441, -85.6236, 1 October 2013, S.A. Grubbs, 2♂, 3♀ (WKUC); Hart Co., spring into Roundstone Creek, 7.5 km NW Bonnieville, 37.4105, -85.9823, 17 July 2001, S.A. Grubbs and J.M.

Taylor, 1♂, 3 nymphs (WKUC); same but 7–28 September 2002, S.A. Grubbs, 5♂, 6♀ (WKUC); same but 26 September 2003, S.A. Grubbs, 7♂, 6♀ (WKUC); spring into Lynn Camp Creek, nr. Rte. 569, 14 km NW Summersville, 37.3545, -85.7128, 1 October 2013, S.A. Grubbs, 1♂, 13♀ (WKUC); same as holotype, 4♂, 10♀ (WKUC); Collins Spring, 37.2061, -86.0489, Mammoth Cave National Park, 15 September 2015, S.A. Grubbs, 1♂, 4♀ (WKUC); Warren Co., tributary to Shanty Hollow Lake, 8.5 km NE Richardsville, 37.1390, -86.3849, 4 October 2013, S.A. Grubbs, 1♂, 4♀ (WKUC).

Etymology. This species is named in honor of Dr. Guenter Schuster, Foundation Professor of Biological Sciences, Eastern Kentucky University. Dr. Schuster and his students have spent many years studying the aquatic fauna of Kentucky.

Diagnosis. The combination of the well-defined

dorsal process on the 7th abdominal tergum and a small triangular vesicle places *L. schusteri* sp. n. in the *L. tenuis* species group (Harper & Harper 1997). The posteriorly tapering process on the 7th abdominal tergum of *L. schusteri* sp. n. (Figs. 10–11) is similar only to *L. tenuis* (Figs. 23–25), and very distinct from *L. carolinensis* (Figs. 1–3), *L. tenella* (Fig. 19), *L. triloba* (Figs. 34–36), *L. usdi* (Fig. 43), and *L. variabilis* (Fig. 48).

Leuctra schusteri sp. n. can be distinguished from *L. tenuis* by paraproct characteristics. The subanal lobes of *L. schusteri* sp. n. are approximately the same length as the specilla (Figs. 14–15) whereas with *L. tenuis* the subanal lobes extend ca. $\frac{3}{4}$ the length of the specilla (Figs. 28–30, 32). The specilla of *L. schusteri* sp. n. possess a prominent, laterally-directed spur (Figs. 12–12). In contrast, the specilla of *L. tenuis* is rounded distally and lack a spur (Figs. 27, 31, 33). The dorsal process on the 7th abdominal tergum of *L. schusteri* sp. n. (Figs. 10–11) and *L. tenuis* (Figs. 23–25) are too similar in overall appearance, namely shape and size, to provide reliable diagnostic value.

As is the case for most Nearctic *Leuctra*, possessing females definitively associated with males is the easiest means of differentiating between species. Females of *L. schusteri* sp. n. and *L. tenuis* are very similar morphologically, particularly in the shape of the subgenital plate lobes and pigmentation patterns in darker individuals. Both species have lateral indentations that essentially demarcate the anterior plane of the lobes.

Remarks. The type locality is a small spring run that emanates from a limestone bluff in south-central Kentucky (Figs. 53–54). Most adults were collected proximal to the spring source. All paratype localities are also springheads or small spring runs. No other species of stoneflies were collected in the adult stage.

The type and all paratype localities (Fig. 53) are located within the Interior Plateau Level III Ecoregion, a region characterized by Mississippian-age limestone, extensive karst development, and emergent spring systems (Woods et al. 2002). The range of this species likely extends southward into Tennessee since one paratype locality (Allen Co.,

spring into Smyrna Creek) is only ca. 3 km north of the state border. Northward into unglaciated southern Indiana and southern Ohio, *L. tenuis* has been the only autumn-emergent *Leuctra* collected. Similarly, only *L. tenuis* has been collected eastward into the Appalachian Plateau region of eastern Kentucky and West Virginia.

Grubbs et al. (2006) showed that *L. schusteri* sp. n. (as *L. cf. tenuis*) exhibited a univoltine-slow life cycle. Nymphs were present by early January and appear to require continuous flow in the spring run during the dry summer months. *Leuctra* nymphs present through summer were presumably only *L. schusteri* sp. n. since this was the only adult species collected from July through early October. The common name, Karst Needlefly, is proposed for this species (Stark et al. 2012).

Leuctra tenella Provancher 1878

Broad-lobed Needlefly

<http://lsid.speciesfile.org/urn:lsid:Plecoptera:speciefile.org:TaxonName:460049>

(Figs. 19–22)

Leuctra tenella Provancher 1878:126. No type designation, vicinity of Quebec City

Leuctra tenuis Provancher 1876:218. Not *L. tenuis* Pictet

Leuctra hamula Claassen 1923:261. Syn. Ricker 1952

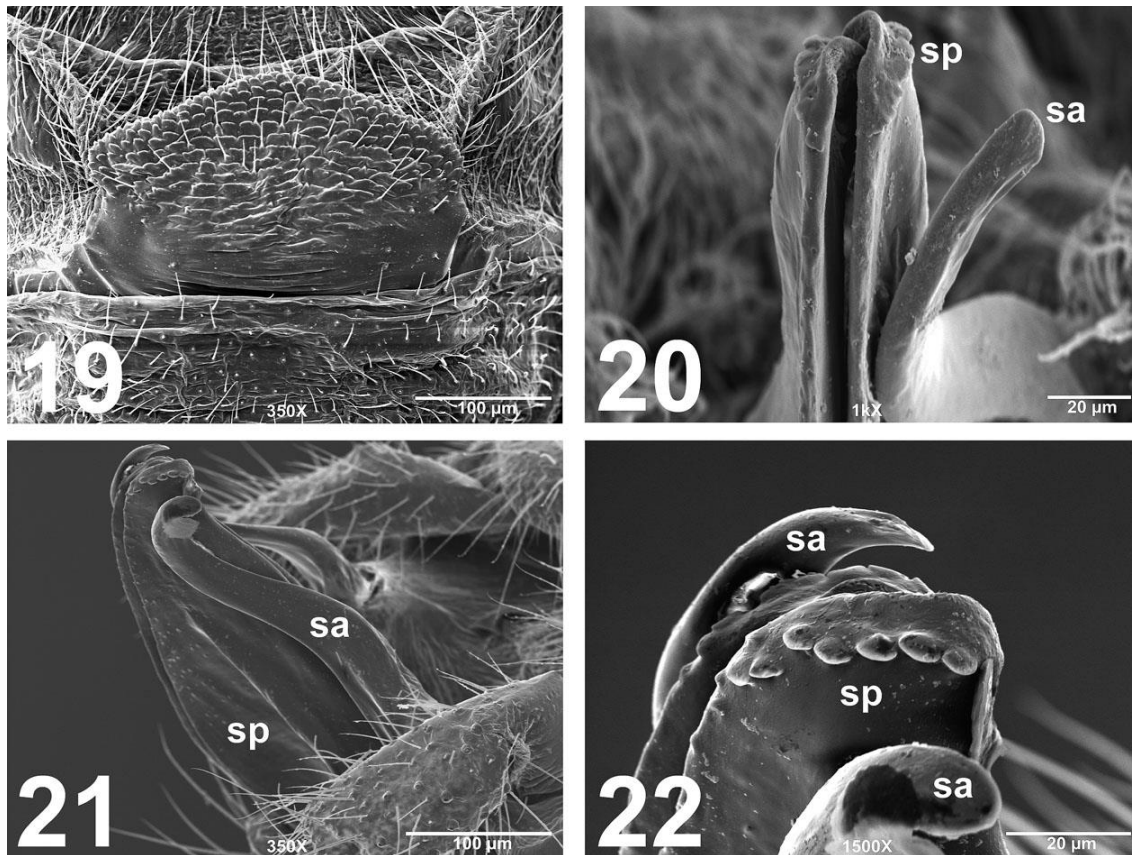
Leuctra hamula: Needham and Claassen 1925:229

Leuctra (Leuctra) tenella: Ricker 1952:171. Lectotype ♂ designated.

Leuctra tenella: Illies 1966:109

Male. The 7th abdominal dorsal process bears a simple, broadly-subtriangular lobe (Fig. 19); subtle anterolateral lobes present on some specimens. The specilla are broad basally, overall shape subtriangular and bearing prominent, laterally-directed tubercles distally (Figs. 20–22). The subanal lobes are subequal in length to the specilla; near uniformly-narrow through length, tapering little but recurved anteriorly in the distal half, especially at tips (Figs. 21–22).

Material examined. Canada, New Brunswick, Carleton Co., Gibson Creek, Hwy 105, Northampton, 15 June 1993, R.W. Baumann & B.C.



Figs. 19–22. *Leuctra tenella*, Pennsylvania, spring into Powdermill Run. 19, 7th abdominal process, dorsal view, 350X; 20, paraprocts, caudal view, 1000X; 21, *L. tenella*, paraprocts, lateral view, 350X; 22, *L. tenella*, paraprocts, lateral view, 1500X. sp = specillum, sa = subanal lobe.

Kondratieff, 1♂ (BYUC); Kent Co., South Fork, Coal Branch River, Hwy 126, Coal Branch, 12 June 1998, R.W. Baumann & B.C. Kondratieff, 1♂ (BYUC). **USA, Maryland**, Frederick Co., tributary to Tuscarora Creek, 39.5601, -77.4827, 3 June 1997, S.A. Grubbs, 7♂, 2♀ (WKUC); Garrett Co., Black Lick Run, Savage River State Forest, 39.6098, -79.0827, 17 May 1995, S.A. Grubbs, 1♂ (WKUC); Poplar Lick Run, Poplar Lick ORV Trail, Savage River State Forest, 39.6124, -79.1494, 24 May 1996, S.A. Grubbs, 4♂ (WKUC). **New Hampshire**, Grafton Co., headwaters, Hubbard Brook, at road, 25 June 1974, S.B. Fiance, 17♂ (BYUC). **New York**, Oswego Co., Little Sandy Creek, Hwy. 13, east of Lacona, 17 June 1997, R.W. Baumann & B.C. Kondratieff, 12♂, 8♀ (BYUC). **North Carolina**, Haywood Co., tributary to Flat Laurel Creek, Little

Sam Trail, Pisgah National Forest, 35.3167, -82.8918, 22 July 2015, A.L. Sheldon, 2♂ (WKUC); tributary to Flat Laurel Creek, Pisgah National Forest, 35.3230, -82.8982, 22 July 2015, A.L. Sheldon, 1♂ (WKUC); Flat Laurel Creek, Pisgah National Forest, 35.3244, -82.8960, 22 July 2015, A.L. Sheldon, 1♂ (WKUC); Macon Co., Wine Spring Creek, Nantahala National Forest, 35.8791, -83.5979, 28 May 2014, A.L. Sheldon, 1♂ (WKUC). **Ohio**, Hocking Co., tributary to Pine Creek, Hocking State Forest, 39.4468, -82.5850, 26 May 2010, S.A. Grubbs, 2♂ (WKUC). **Pennsylvania**, Bedford Co., Bear Gap Run, 7 km ESE Centerville, Buchanan State Forest, 39.8111, -78.5669, 14 May 1999, S.A. Grubbs, 1♂ (WKUC); Westmoreland Co., spring into Powdermill Run, Powdermill Nature Reserve, 3 June 1993, S.A. Grubbs, 24♂, 24♀

(WKUC). **Vermont**, Lamoille Co., Big Spring, Hwy 108, south of Smugglers Notch, 15 July 1998, R.W. Baumann, 3♂ (BYUC). **Virginia**, Giles Co., Big Stony Creek, Hwy 635, 24 May 1990, S.W. Szczytko, 1♂, 1♀ (BYUC). **West Virginia**, Tucker Co., seep below Watershed 3, Fernow Experimental Forest, 2 June 1991, S.A. Grubbs, 2♂ (WKUC).

Distribution. Canada: LB, NB, NS, ON, PQ. USA: CT, MA, MD, ME, MN, NJ, NY, OH, PA, WI, WV (DeWalt et al. 2015), NC, NH, VA, VT (new state records).

Remarks. The dorsal abdominal process of this species is most similar to *L. carolinensis*. The specilla of *L. tenella* are distally truncate (Figs. 21–22) compared to the distally-subtriangular tips of *L. carolinensis* (Figs. 4, 7, 9). The subanal lobes of *L. tenella* are sharply-recurved at the tips (Figs. 21–22), contrasting with the gradually-recurved lobes in the distal half on *L. carolinensis* (Figs. 4, 6–9).

***Leuctra tenuis* (Pictet 1841)**

Narrow-lobed Needlefly

<http://lsid.speciesfile.org/urn:lsid:Plecoptera:speciefile.org:TaxonName:460989>

(Figs. 23–33)

Nemoura tenuis Pictet 1841:375. Type (ZMHB), Philadelphia, (Philadelphia Co.), Pennsylvania

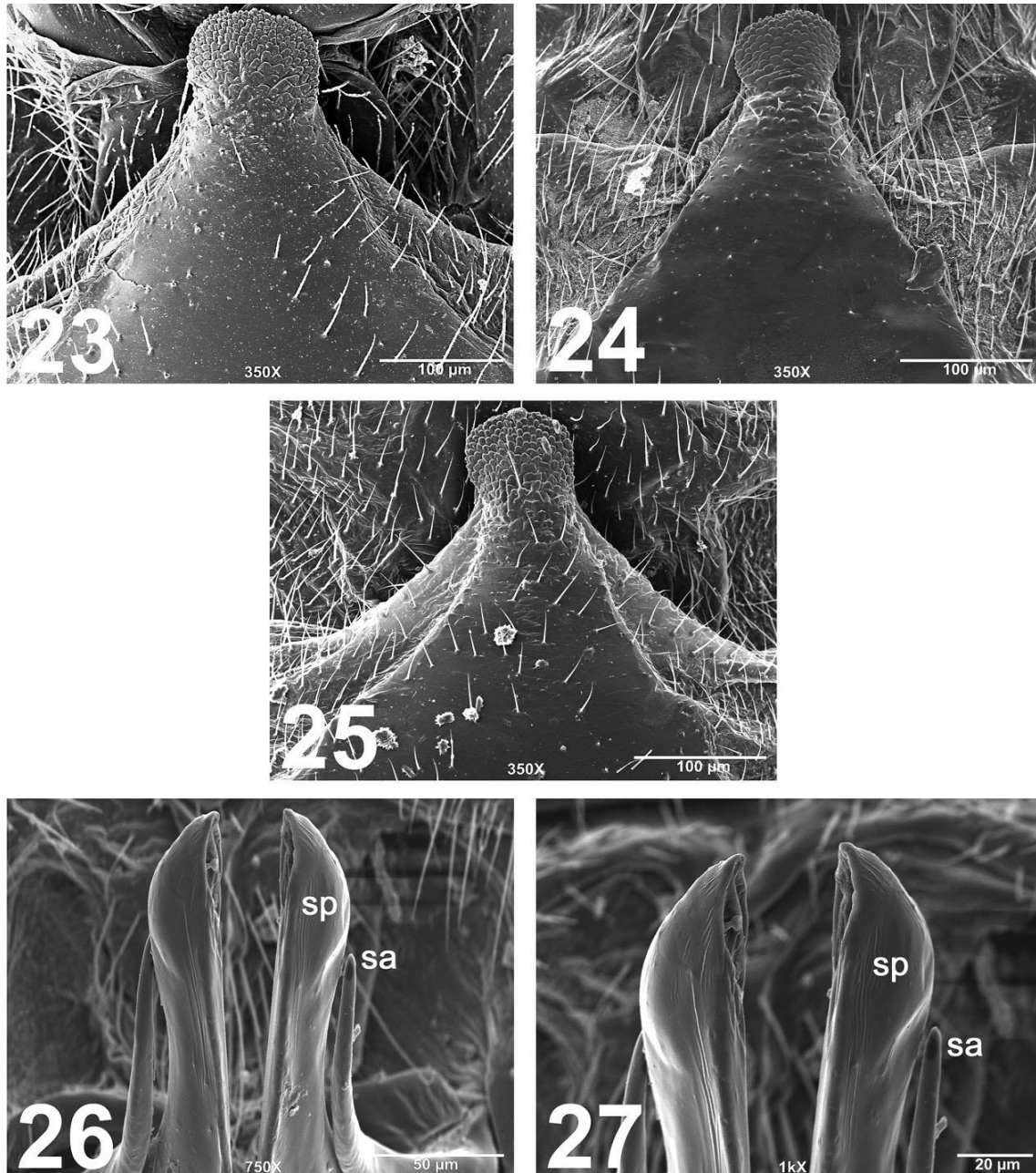
Leuctra tenuis: Illies 1966:109

Leuctra tenuis: Zwick 1973:407

Male. The 7th abdominal dorsal process is narrowly-triangular in shape, tapering to a tip that is bulbous and rounded posteriorly (Figs. 23–25). The specilla are ca. parallel-sided throughout length, except at the tip; specilla gently recurved anteriorly and mostly smooth distally (Figs. 28–30, 32); lacking a terminal spur or raised tubercles; bearing few pits distally (Figs. 31, 33). The subanal lobes are narrow basally, tapering and gently recurved distally, ca. $\frac{3}{4}$ the length of the specilla (Figs. 28–30, 32).

Material examined. USA, **Alabama**, Cleburne Co., Hillabee Creek, 33.4855, -85.7934, 16 October 2005, A.L. Sheldon, 3♂ (WKUC). **Connecticut**, Tolland Co., Roaring Brook, Rte. 32, 6 km S Stafford

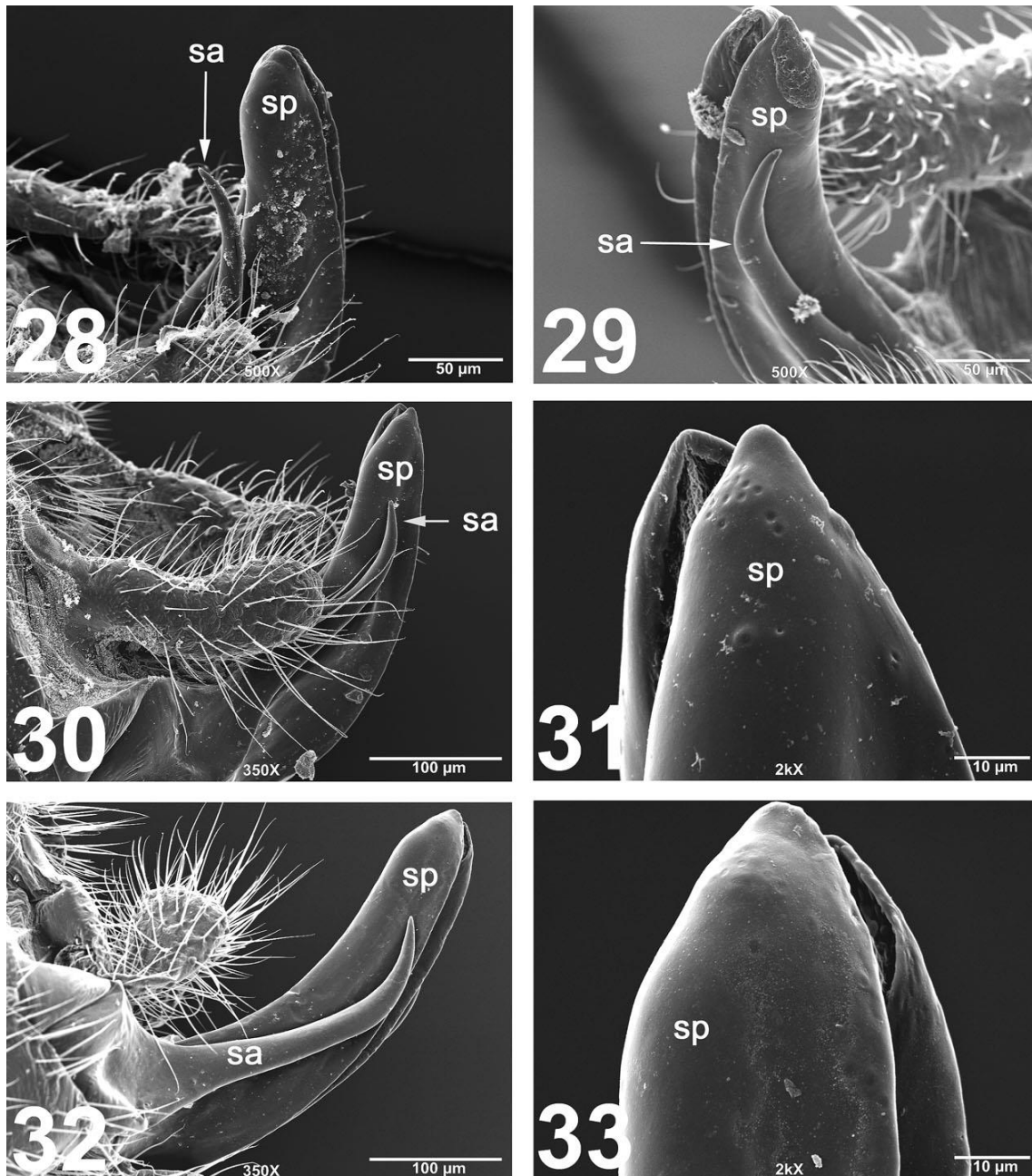
Springs, 41.9035, -72.2878, 29 June 2006, S.A. Grubbs, 1♂, 2♀ (WKUC); Windham Co., Bungee Brook, 3.5 km S Eastford, 41.8713, -72.0878, 29 June 2006, S.A. Grubbs, 1♂, 1♀ (WKUC). **Indiana**, Harrison Co., tributary to West Fork Mosquito Creek, 4 km E Laconia, 38.0245, -86.0393, 20 October 2002, S.A. Grubbs, 3♂, 4♀ (WKUC). **Kentucky**, Harlan Co., Watts Creek, Blanton Forest State Nature Preserve, 36.8619, -83.3753, 11 July–3 September 2009, M.A. Floyd, 6♂ (DCTC); same locality but 9 September–4 November 2009, M.A. Floyd, 6♂ (DCTC). **Maryland**, Allegany Co., Deep Run, Green Ridge State Forest, 39.6531, -78.4523, 4 July 1996, S.A. Grubbs, 2♂, 7♀ (WKUC); same locality but 7 August 1998, S.A. Grubbs, 6♂, 2♀ (WKUC); Garrett Co., Middle Fork, Savage River State Forest, 39.5130, -79.1548, 3 July 1996, S.A. Grubbs, 15♂, 7♀ (WKUC); Youghiogheny River, 39.5659, -79.4293, 13 July 1996, S.A. Grubbs, 4♂, 1♀ (WKUC). **Massachusetts**, Worcester Co., Stillwater River, Rte. 140, 5 km E Princeton, 42.4463, -71.8168, 28 June 2006, S.A. Grubbs, 4♂, 4♀ (WKUC); Burnshirt River, Rte. 62, 5 km ENE Barre, 42.4363, -72.0528, 28 June 2006, S.A. Grubbs, 1♂ (WKUC). **North Carolina**, Haywood Co., tributary to Mount Sterling Creek, FR 289, Pisgah National Forest, 35.7452, -83.0700, 11 July 1997, S.A. Grubbs, 1♂, 4♀ (WKUC); Right Hand Prong, FS 97, Pisgah National Forest, 35.3711, -82.9405, 22 July 2015, A.L. Sheldon, 1♂ (WKUC); Yancey Co., South Toe River, Pisgah National Forest, 35.7517, -82.2205, 17 July 2015, A.L. Sheldon, 2♂ (WKUC). **Ohio**, Adams Co., Waggoner Run, Abner Hollow, 12 km SE West Union, 38.7179, -83.4343, 19 September 2015, S.A. Grubbs, 1♂, 11♀ (WKUC). **Pennsylvania**, Mercer Co., Little Shenango River, 10 km E Greenville, 41.4185, -80.2683, 23 June 1998, S.A. Grubbs, 1♂ (WKUC); Westmoreland Co., Powdermill Run, Powdermill Nature Reserve, 40.1517, -79.2703, 18 August 1993, S.A. Grubbs, 1♂ (WKUC). **Rhode Island**, Kent Co., Bucks Horn Brook, 14 km NW Exeter, Nicholas Farm Wildlife Management Area, 41.6952, -71.7566, 18 June 2007, S.A. Grubbs, 3♂, 2♀ (WKUC). **Tennessee**, Cocke Co., Cosby Creek, Rte. 32, 35.7839, -83.2191, 11 July 1997, S.A. Grubbs, 5♂, 3♀ (WKUC). **Virginia**, Wythe Co., Reed Creek, FR 221/CR 625, 16 km NW Wytheville, Jefferson



Figs. 23–27. *Leuctra tenuis*. 23, 7th abdominal process, dorsal view, 350X, Maryland, Middle Fork; 24, 7th abdominal process, dorsal view, 350X, Maryland, Youghiogheny River; 25, 7th abdominal process, dorsal view, 350X, Massachusetts, Stillwater River; 26, paraprocts, caudal view, 500X, Indiana, tributary to West Fork Mosquito Creek; 27, paraprocts, caudal view, 1000X, Indiana, tributary to West Fork Mosquito Creek. sp = specillum, sa = subanal lobe.

National Forest, 36.9809, -81.2801, 24 July 2008, S.A. Grubbs, 1♂, 4♀ (WKUC); Stony Fork, Reed Creek, U.S. 52, 10 km NW Wytheville, Jefferson National

Forest, 36.9774, -81.1864, 24 July 2008, S.A. Grubbs, 2♂, 1♀ (WKUC). **West Virginia**, Greenbrier Co., Rt. 14, 3 mi E Neola, 6 September 2008, L.T. Miller, 1♂,



Figs. 28–33. *Leuctra tenuis*. 28, paraprocts, lateral view, 500X, Alabama, Hillabee Creek; 29, paraprocts, lateral view, 500X, Massachusetts, Stillwater River; 30, paraprocts, lateral view, 500X, Maryland, Middle Fork; 31, paraprocts, lateral view, 2000X, Maryland, Middle Fork; 32, paraprocts, lateral view, 350X, Tennessee, Cosby Creek; 33, paraprocts, lateral view, 2000X, Tennessee, Cosby Creek. sp = specillum, sa = subanal lobe.

1♀ (DCTC); Mercer Co., Camp Creek State Forest, 18 September 2008, L.T. Miller, 1♂ (DCTC);

Randolph Co., nr. Laneville, Dolly Sods, 25 September 2008, L.T. Miller, 1♂ (DCTC); Tucker

Co., Red Creek, Laneville, 20 August 2011, no collector information, 2♂, 3♀ (DTC).

Distribution. Canada: NB, NS, ON, PQ. USA: AL, AR, CT, DE, IA, IL, IN, KY, MA, MD, ME, MI, MN, MO, NJ, NY, OH, OK, PA, VA, WI, WV (DeWalt et al. 2015), NC, RI (new state records).

Remarks. Examination of material from throughout the eastern Nearctic region revealed consistency with the shapes of the paraprocts and the dorsal process on the 7th abdominal tergum. *Leuctra tenuis* is a broadly-distributed species known from Quebec and the Canadian Maritime provinces of New Brunswick and Nova Scotia southwest to Alabama and westward to Minnesota and Oklahoma (DeWalt et al. 2015).

Leuctra triloba Claassen 1923

Three-lobed Needlefly

<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:462470>

(Figs. 34–42)

Leuctra triloba Claassen 1923:258. Holotype ♂ (CUIC), McLean, New York

Leuctra triloba: Needham and Claassen 1925:233

Leuctra crosbyi: Claassen 1937:45. Syn. Illies 1966

Leuctra triloba: Illies 1966:110

Leuctra triloba: Zwick 1973:408

Male. The 7th abdominal dorsal process bears three lobes, with the medial lobe terminating more posteriorly than the paired lateral lobes (Figs. 34–36). The specilla are very broad basally, scarcely recurved anteriorly (Figs. 39, 41), and bear raised tubercles distally along outer margins (Figs. 37–38, 40, 42). The subanal lobes are narrow throughout length, tapering and recurved anteriorly, and ca. 80% the length of the specilla (Figs. 39, 41).

Material examined. USA, Alabama, Clay Co., tributary to West Fork Hatchet Creek, Talladega National Forest, 33.2912, -86.0723, 25 January 2006, A.L. Sheldon, 3♂, 2♀ (WKUC); Mill Shoals Creek, Talladega National Forest, 33.4201, -85.8070, 6 November 2011, A.L. Sheldon, 1♂ (WKUC); Cleburne Co., Dry Creek, 33.8725, -85.5811, 7 November 2011, A.L. Sheldon, 1♂, 5♀ (WKUC). **North Carolina**, Burke Co., Linville River, above

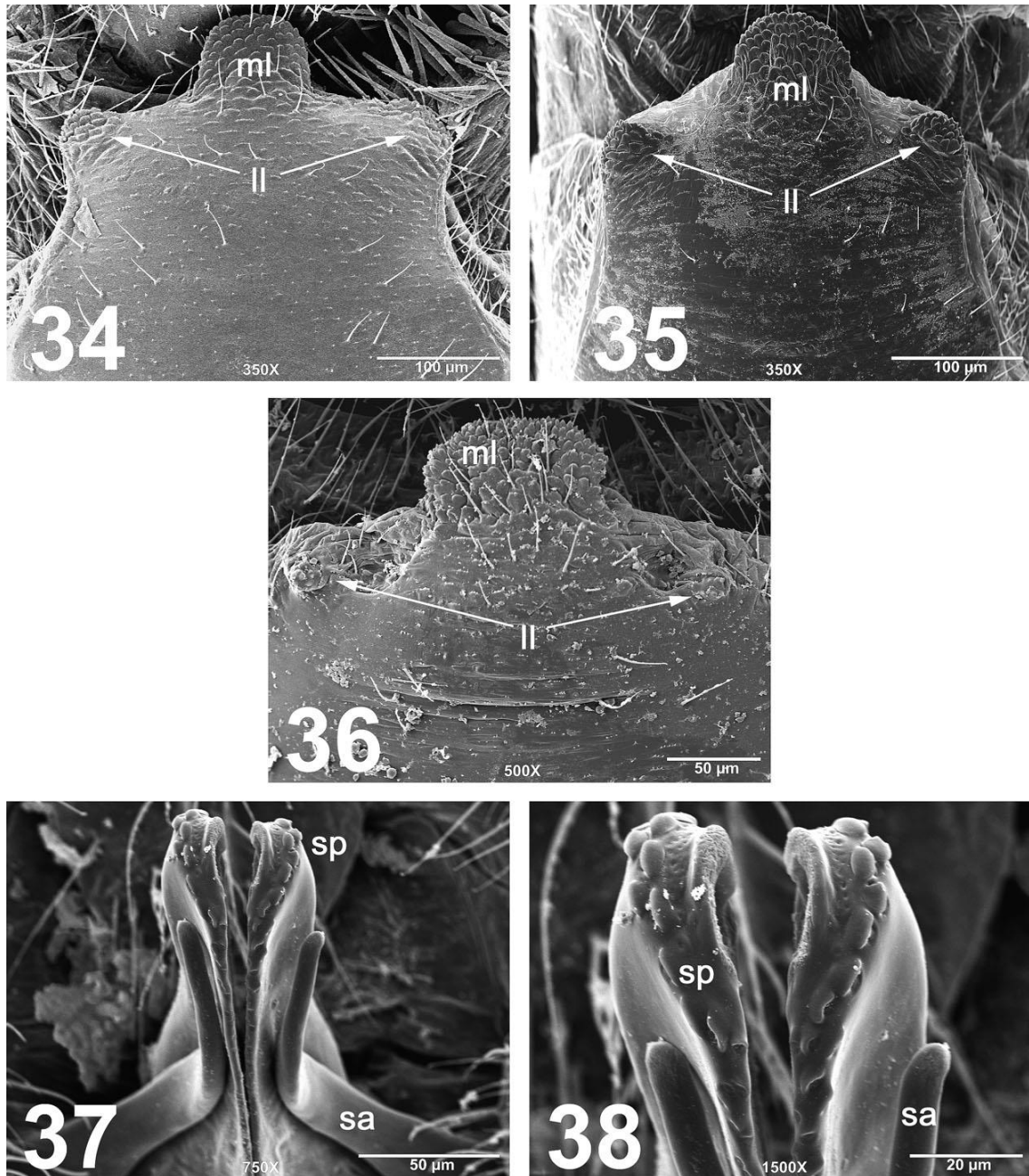
Linville Falls, 27 November 2002, 35.9541, -81.9279, S.A. Grubbs, 1♂, 3♀ (WKUC); Haywood Co., Cold Springs Creek, Pisgah National Forest, 35.7785, -82.9559, 2 March 2008, S.A. Grubbs, 1♂, 1♀ (WKUC); tributary to Yellowstone Prong, 35.3219, -82.8518, 24 October 2014, A.L. Sheldon, 3♂, 3♀ (WKUC); Macon Co., Wine Spring Creek, Nantahala National Forest, 35.1761, -83.5897, 1 October 2013, A.L. Sheldon, 6♂, 10♀ (WKUC); Sassafras Branch, Nantahala National Forest, 35.1895, -83.5939, 20 November 2013, A.L. Sheldon, 3♂, 7♀ (WKUC). **Tennessee**, Marion Co., tributary to South Suck Creek, Prentice Cooper State Forest, 35.1597, -85.4065, 12 February 2007, S.A. Grubbs, 1♂, 2♀ (WKUC); same locality but 31 January 2015, S.A. Grubbs, 1♂ (WKUC); tributary to South Suck Creek, Prentice Cooper State Forest, 35.1474, -85.3926, 12 February 2007, S.A. Grubbs, 1♂, 1♀ (WKUC).

Distribution. Canada: PQ. USA: AL, FL, NC, NY, SC, VA, WV (DeWalt et al. 2015), TN (new state record).

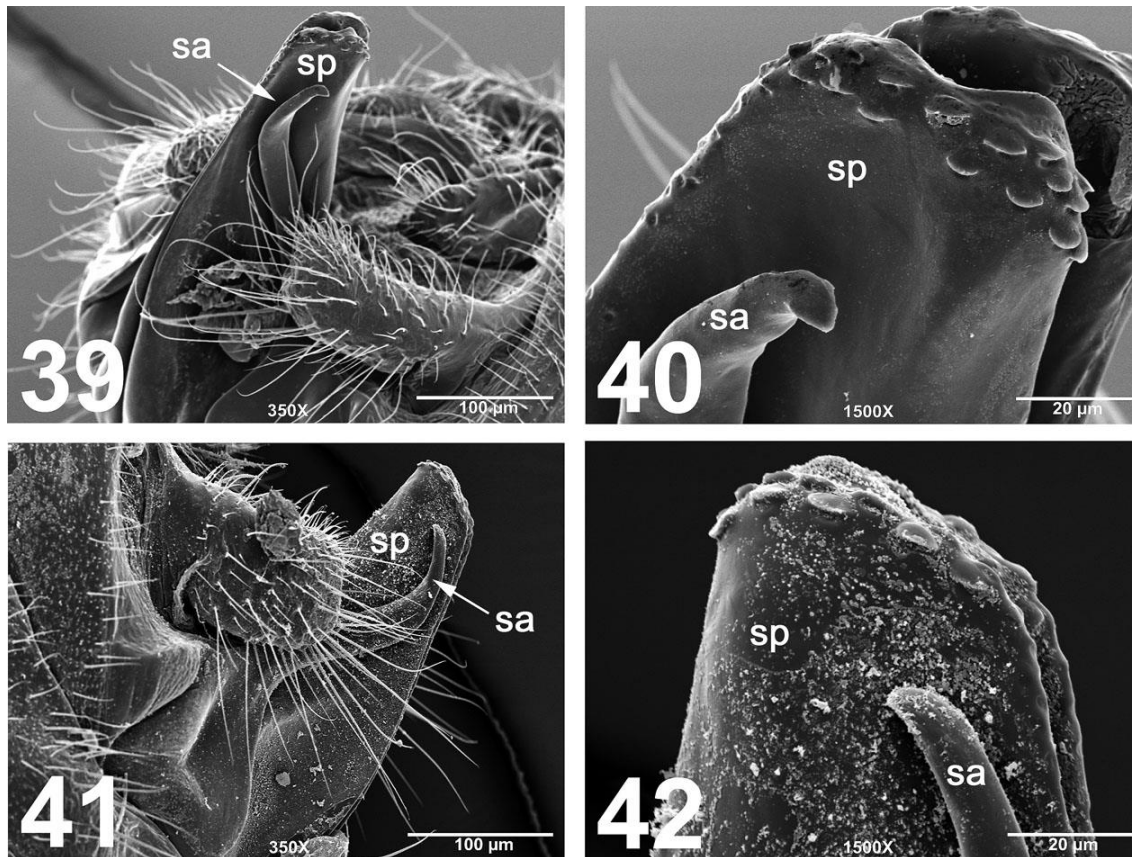
Remarks. This species exhibits variability in the dorsal abdominal process, namely the size of the lateral lobes compared to the medial lobe (Hitchcock 1974, fig. 86). The dorsal processes depicted herein from Alabama (Fig. 34) and North Carolina (Fig. 35) are very similar to one form shown in Hitchcock (1974, fig. 86c). The Alabama and North Carolina populations are also very similar to the dorsal process in Claassen (1923, fig. 19) of the holotype male from New York. The males from Tennessee, however, bear a dorsal process that is different (Fig. 36) from specimens from Alabama and North Carolina, and similar to Hitchcock (1974, fig. 86b). The lateral lobes are smaller and can appear near-absent even under a dissecting microscope. Paraproct characteristics from the Alabama and North Carolina material were identical to the Tennessee males.

This species has a narrow and long north-south distribution from Quebec to Florida (DeWalt et al. 2015). The sporadic nature of its known distribution is likely due to an adult emergence pattern that is mainly autumnal, a period with very low adult stonefly diversity and less frequented collecting efforts. This is the only species in the *L*

tenuis group with an emergence period that extends through winter.



Figs. 34–38. *Leuctra triloba*. 34, 7th abdominal process, dorsal view, 350X, Alabama, tributary to West Fork Hatchett Creek; 35, 7th abdominal process, dorsal view, 350X, North Carolina, Wine Spring Creek; 36, *L. triloba*, 7th abdominal process, dorsal view, 500X, Tennessee, tributary to South Suck Creek; 37, paraprocts, caudal view, 750X, North Carolina, Wine Spring Creek; 38, *L. triloba*, paraprocts, caudal view, 1500X, North Carolina, Wine Spring Creek. sp = specillum, sa = subanal lobe, ll = lateral lobe, ml = medial lobe.



Figs. 39–42. *Leuctra triloba*. 39, paraprocts, lateral view, 350X, Alabama, tributary to West Fork Hatchett Creek; 40, paraprocts, lateral view, 1500X, Alabama, tributary to West Fork Hatchett Creek; 41, paraprocts, lateral view, 350X, North Carolina, Wine Spring Creek; 42, paraprocts, lateral view, 1500X, North Carolina, Wine Spring Creek. sp = specillum, sa = subanal lobe.

***Leuctra usdi* Grubbs 2010**
Leipers Fork Needlefly

<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:4322>

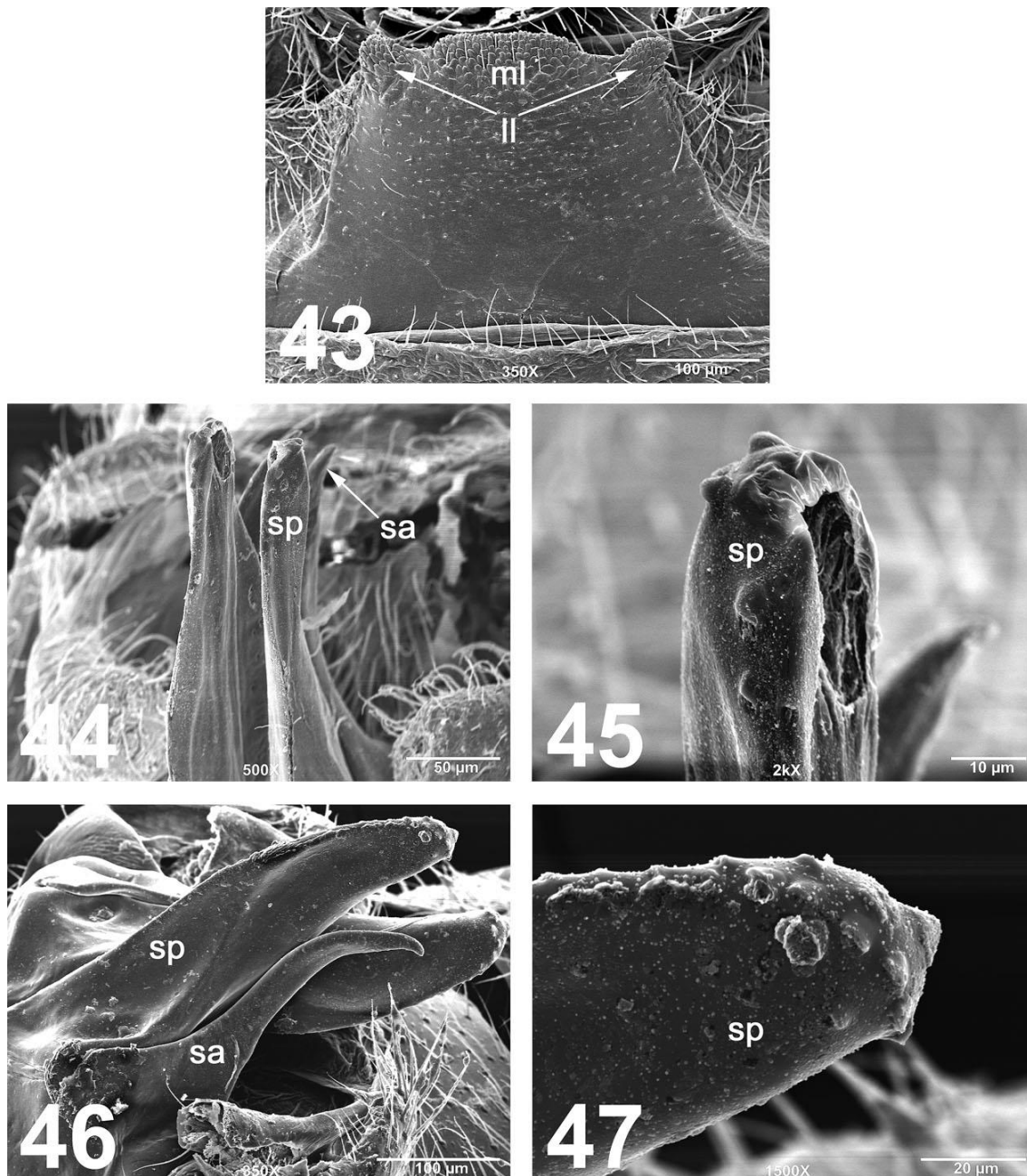
(Figs. 43–47)

Leuctra usdi Grubbs 2010:59. Holotype ♂ (INHS), spring into Pinewood Branch, Leipers Fork of West Fork Harpeth River, 4 km W Leipers Fork, Williamson County, Tennessee

Male. The 7th abdominal dorsal process bears three lobes that terminate at the same plane; lateral lobes are small and directly somewhat diagonally;

the medial lobe is subtruncate and ca. 4X the width of the lateral lobes (Fig. 43). The specilla are broadest basally, scarcely recurved and slightly tapered anteriorly, and bear raised tubercles distally along the inner and outer margins (Figs. 44–47). The subanal lobes are recurved anteriorly, tapered distally, and ca. 80% the length of the specilla (Fig. 46).

Material examined. USA, Alabama, Limestone Co., spring into unnamed tributary to Scarce Grease Branch, 2 km SE Lester, 34.9806, -87.1309, 18 February 2008, S.A. Grubbs, 2♂ (Paratypes, WKU). Tennessee, Williamson Co., spring into Pinewood Branch, Leipers Fork, West Fork Harpeth River, 4 km W Leipers Fork, 35.8944, -87.0388, 5 March 2007, S.A. Grubbs, 3♂, 2♀ (Paratypes, WKU); same

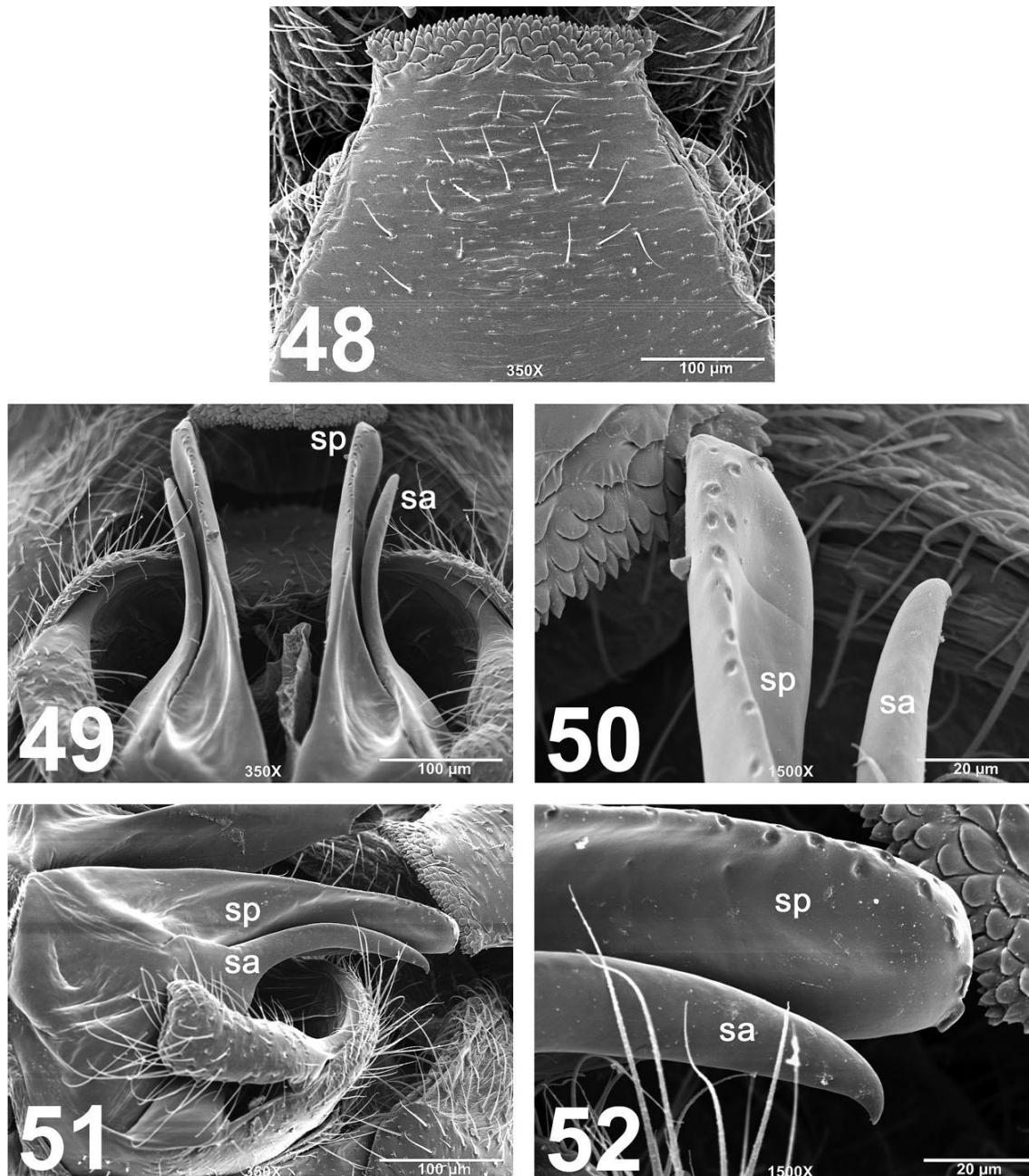


Figs. 43–47. *Leuctra usdi*, Tennessee, spring into Pinewood Branch. 43, 7th abdominal process, dorsal view, 350X; 44, paraprocts, caudal view, 500X; 45, paraprocts, caudal view, 2000X; 46, paraprocts, lateral view, 350X; 47, *L. usdi*, paraprocts, lateral view, 1500X. sp = specillum, sa = subanal lobe, ll = lateral lobe, ml = medial lobe.

locality but 12 March 2015, S.A. Grubbs, 1♂ (WKUC).

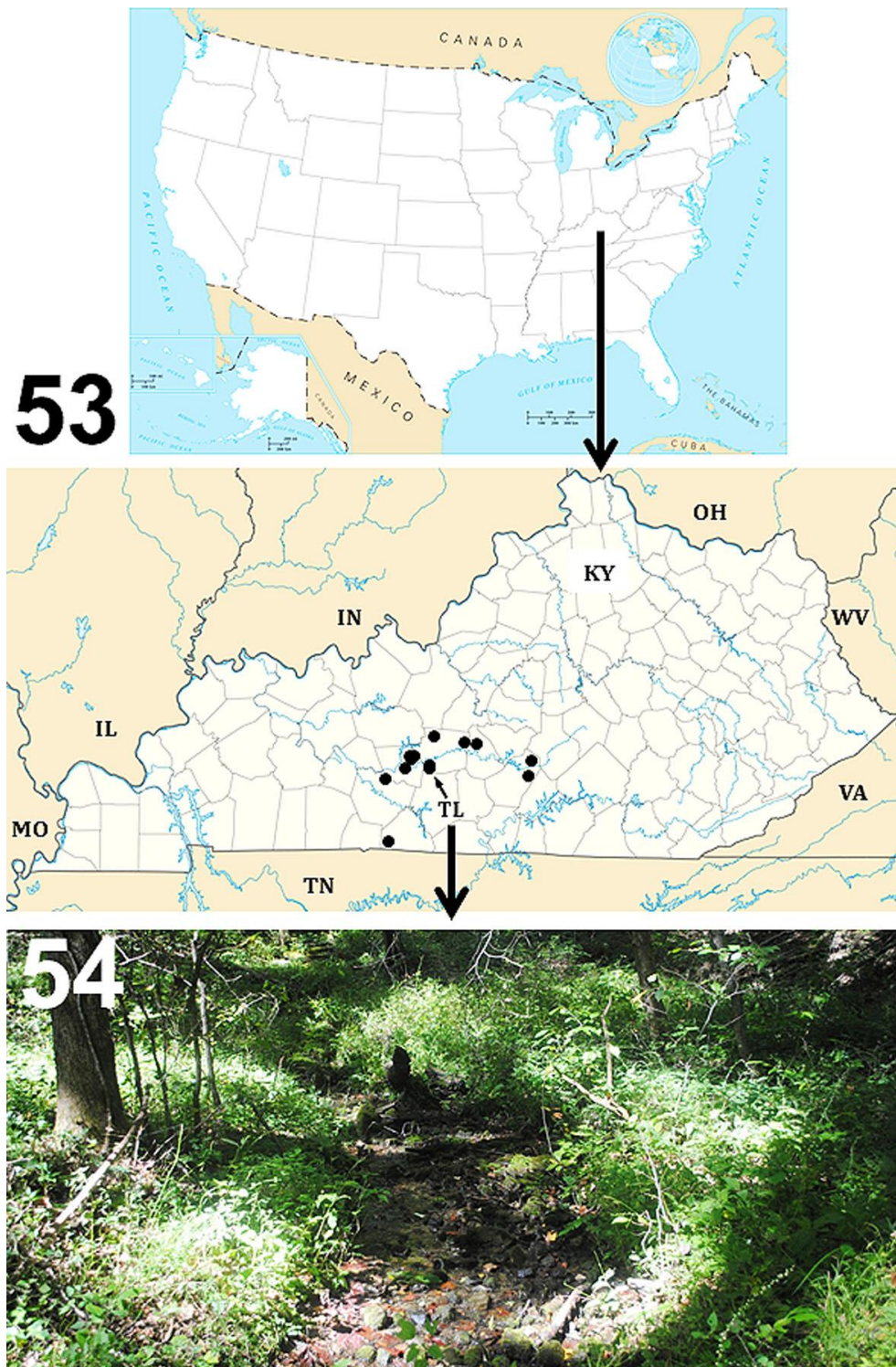
Distribution. USA: AL, TN (DeWalt et al. 2015).

Remarks. This species is still known only from three small spring runs, two in middle Tennessee and one in northern Alabama (Grubbs 2010).



Figs. 48–52. *Leuctra variabilis*, Tennessee, Twin Springs. 48, 7th abdominal process, dorsal view, 350X; 49, paraprocts, caudal view, 350X; 50, paraprocts, caudal view, 1500X; 51, paraprocts, lateral view, 350X; 52, *L. variabilis*, paraprocts, lateral view, 1500X. sp = specillum, sa = subanal lobe.

Grubbs, Scott A. 2015. *Leuctra schusteri*, a new stonefly species (Plecoptera: Leuctridae) of the *L. tenuis* (Pictet) group from the southeastern USA. *Illiesia*, 11(12):147-166. Available online: <http://illiesia.speciesfile.org/papers/Illiesia11-12.pdf>



Figs. 53-54. 53, Location of the *Leuctra schusteri* sp. n. collection sites. IL = Illinois, IN = Indiana, KY = Kentucky, MO = Missouri, OH = Ohio, TN = Tennessee, VA = Virginia, WV = West Virginia. TL = type locality; 54, *Leuctra schusteri* sp. n. type locality (Cooper Spring, Mammoth Cave National Park, Kentucky, USA) facing downstream.

***Leuctra variabilis* Hanson 1941**
Variable Needlefly

<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:460700>

(Figs. 48–52)

Leuctra variabilis Hanson 1941:62. Holotype ♂ (USNM), Paradise Trail, Sunderland, Massachusetts
Leuctra variabilis: Illies 1966:111

Male. The 7th abdominal dorsal process shown herein from eastern Tennessee is symmetrically-trapezoidal with no appearance of lateral lobes (Fig. 48). The specimens examined from eastern Kentucky have small, laterally-directed spurs, yet still lack the appearance of lateral lobes. The specilla are broad basally, tapering slightly and not recurved; specilla mostly smooth in appearance, bearing shallow pits along the distal outer margin and very few raised tubercles (Figs. 49–52). The subanal lobes are narrow throughout length, gently recurved anteriorly, and ca. 90% the length of the inner lobes (Figs. 49, 51–52).

Material examined. USA, Kentucky, Harlan Co., Watts Creek, Blanton Forest State Nature Preserve, 36.8619, -83.3753, 9 September–4 November 2009, M.A. Floyd, 4♂ (DCTC). North Carolina, Mitchell Co., tributary to Holder Creek, FS 130, 36.1018, -82.1266, 23 October 2014, A.L. Sheldon, 1♂, 1♀ (WKU). Tennessee, Carter Co., Twin Springs, 26 km N Spruce Pine (NC), Cherokee National Forest, 36.1213, -82.0865, 29 November 2002, S.A. Grubbs, 3♂ (WKU).

Distribution. USA: MA, MD, ME, NH, NJ, NY, PA, VA, VT (DeWalt et al. 2015), NC, TN (new state records).

Remarks. The abdominal dorsal process of *L. variabilis* is similar only to *L. usdi*. Hanson (1941, fig. 7) depicted three forms of the dorsal process, namely with the absence or presence of small lateral lobes that appear superficially-similar to *L. usdi* (Fig. 43). These two species can more readily be separated by characteristics of the specilla. The distal outer margin of the specilla of *L. usdi* bears numerous raised tubercles (Figs. 45, 47) whereas on *L. variabilis* the tubercles are lacking along the distal outer margin and at the tips (Figs. 49–52).

The shallow pits present along the outer margin on *L. variabilis* are lacking on *L. usdi*. Additionally, *L. usdi* is a spring-emergent species whereas *L. variabilis* emerges during late summer and autumn.

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