Grubbs, Scott A. and Summer Wei. 2017. Morphological systematics of *Leuctra duplicata* Claassen, 1923 species group (Plecoptera: Leuctridae). *Illiesia*, 13(05):59-69. https://doi.org/10.25031/2017/13.05

http://zoobank.org/ urn:lsid:zoobank.org:pub:9669ECAD-2449-477B-B190-828DB33F49E0

# MORPHOLOGICAL SYSTEMATICS OF *LEUCTRA DUPLICATA* CLAASSEN, 1923 SPECIES GROUP (PLECOPTERA: LEUCTRIDAE)

**Scott A. Grubbs[1] and Summer Wei[2]**

[1] Department of Biology and Center for Biodiversity Studies, Western Kentucky University, Bowling Green, KY 42101, U.S.A.
E-mail: scott.grubbs@wku.edu

[2] Gatton Academy of Mathematics and Science, Western Kentucky University, Bowling Green, KY 42101, U.S.A.
E-mail: summer.wei625@topper.wku.edu

## ABSTRACT

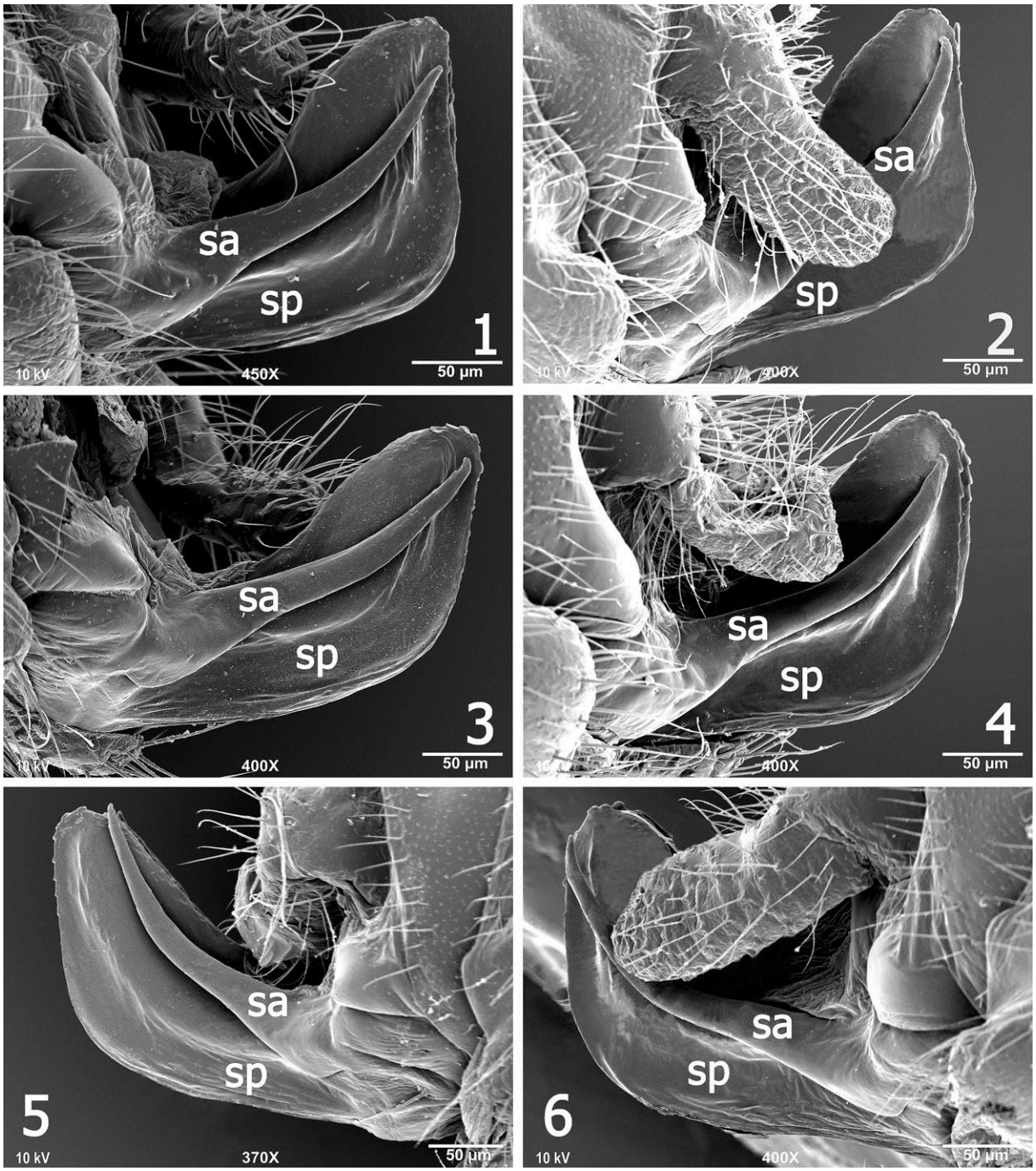
Adult males and females of *Leuctra duplicata* Claassen, 1923 and *L. maria* Hanson, 1941, the two proposed members of the *L. duplicata* group, were compared using standard light microscopy and scanning electron microscopy. Characteristics of the male paraprocts and female subgenital plate of *L. duplicata* are consistent across the broad range of this common species and allow for easy differentiation from *L. maria*. Distribution maps based on material examined are provided for both species.

**Keywords:** Plecoptera, Leuctridae, *Leuctra duplicata* Claassen, 1923, Nearctic, scanning electron microscopy

## INTRODUCTION

The Holarctic stonefly genus *Leuctra* Stephens, 1836 (Plecoptera: Leuctridae) is represented in the eastern and central Nearctic region by 31 species (DeWalt et al. 2017). With the exception of *L. crossi* James, 1976 and *L. moha* Ricker, 1952, Harper & Harper (1997) assigned the Nearctic species known at that time into five groups: *L. biloba* Claassen, 1923 group, *L. duplicata* Claassen, 1923 group, *L. ferruginea* (Walker, 1852) group, *L. grandis* Banks, 1906 group, and *L. tenuis* (Pictet, 1841) group. All five species (Grubbs & Sheldon 2009; Grubbs 2010; Harrison & Stark 2010; Grubbs 2015) described since Harper & Harper (1997) have likewise been assigned.

*Leuctra duplicata* and *L. maria* Hanson, 1941, the two proposed members of the *L. duplicata* group (Harper & Harper 1997), are endemic to the eastern Nearctic region extending from the southern Appalachian Mountains northward to Ontario, Quebec, and Atlantic Canada (DeWalt et al. 2017). Unlike the four other Nearctic species groups, however, *L. duplicata* and *L. maria* were not placed together by external male genitalic characteristics




**Figs. 1–6.** *Leuctra duplicata*, paraprocts, lateral view. 1, West Virginia, Gandy Creek, 450X; 2, Virginia, spring near Lewis Fork bridge, 400X; 3, Maryland, tributary to Toliver Run, 400X; 4, North Carolina, Flat Laurel Creek, 400X; 5, Rhode Island, small stream into Wilbur Pond, 370X; 6, Nova Scotia, Silvey Brook, 400X. sa = subanal lobe, sp = specillum.

but by similarities of the female subgenital plate. Harper & Harper (1997) did not provide a comparative assessment of the males of these two species.

The intent of this study was to assess the *L. duplicata* group through an external morphological comparison of adult males and females of *L. duplicata* and *L. maria* using standard light microscopy and scanning electron microscopy (SEM). Reproductive terminology followed Brinck (1956).

## METHODS

Specimens needed for this project were obtained from the Bill P. Stark Collection, Mississippi College, Clinton (BPSC), Monte L. Bean Museum, Brigham Young University, Provo, Utah (BYU), Canadian National Collection of Insects, Ottawa (CNC), C.P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins (CSUIC), University of Guelph Insect Collection, Guelph (DEBU), Illinois Natural History Survey, Champaign-Urbana (INHS), Royal Ontario Museum, Toronto (ROM), and Western Kentucky University, Bowling Green (WKUC). Other codens used were Cornell University Insect Collection, Ithaca, New York (CUIC) and United States National Museum, Washington, DC (USNM).

Locality data for all specimen records, in decimal degrees, were obtained either directly on site with GPS units or georeferenced from museum label data (if possible) using Acme Mapper 2.1 (http://mapper.acme.com). Collection and locality data for all specimens examined in this study are available as a comma separated values file. Specimens for SEM analyses were serially dehydrated in 75%, 95%, and 100% ethanol for 10 minutes each and placed in hexamethyldisilizane for 30 minutes. Dehydrated specimens were attached to aluminum stubs with double-stick tape and coated with gold-palladium in an Emscope SC500. Coated specimens were examined using a Jeol JSM-6510LV scanning electron microscope and digital images were captured with an IXRF system. Digital images of females were also obtained using Auto-Montage software with a Leica MZ16 stereomicroscope equipped with a JVC KY-F75U digital camera.

## RESULTS

### *Leuctra duplicata* Claassen, 1923

Atlantic Needlefly

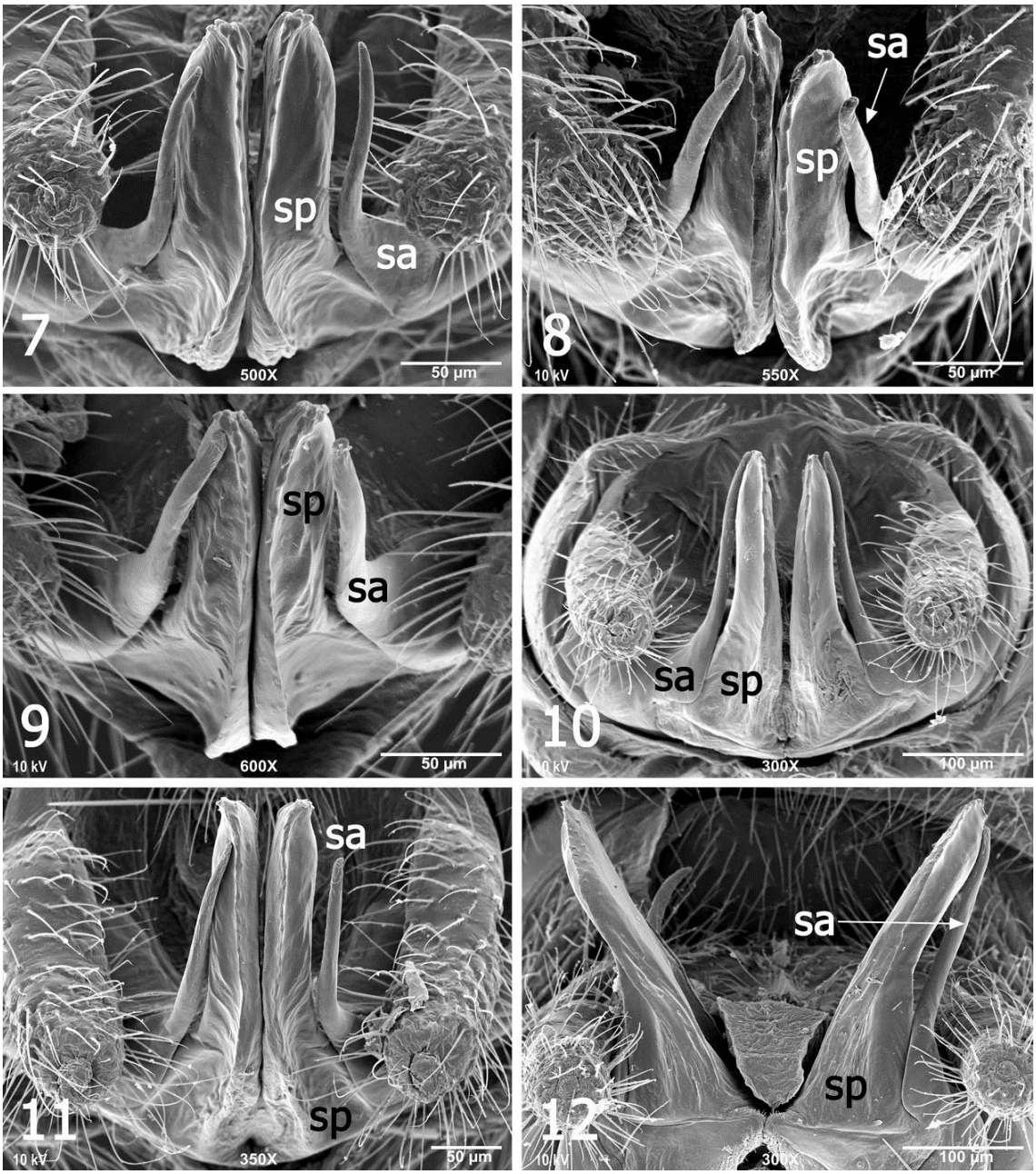
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:460988

(Figs. 1–26, 33)

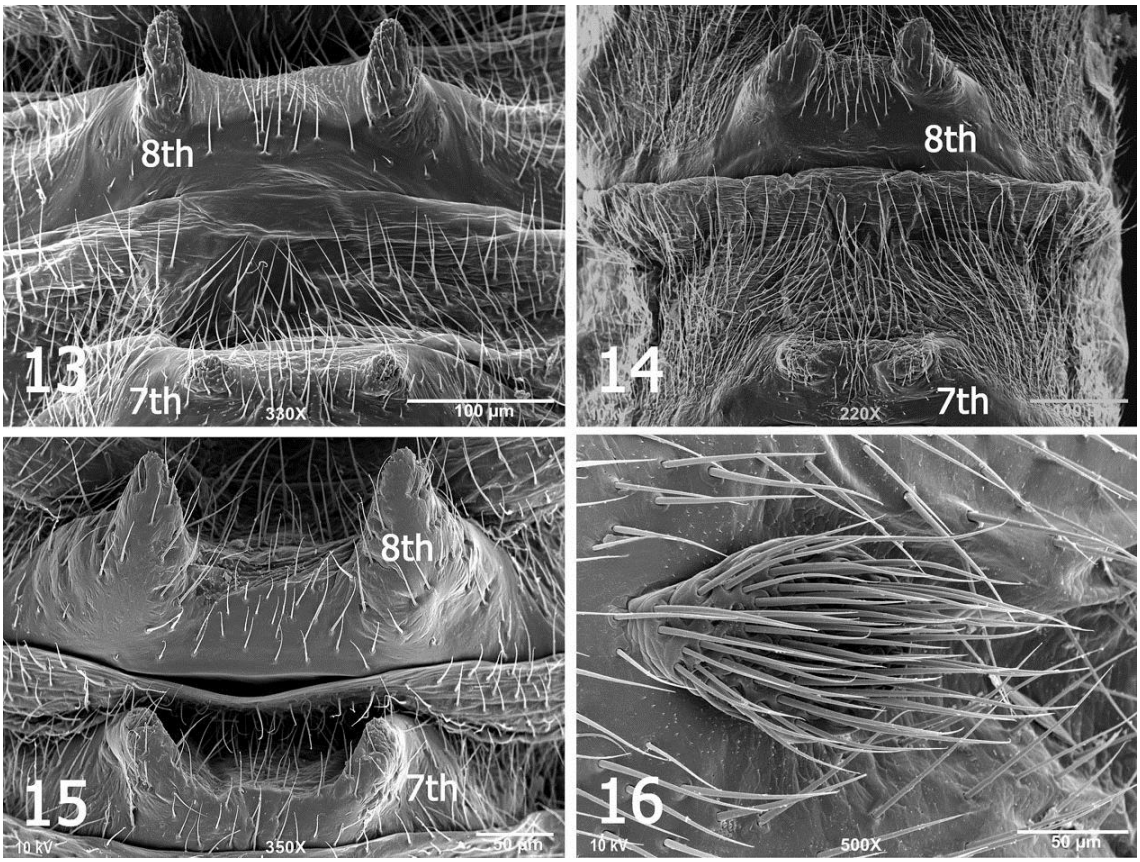
*Leuctra duplicata* Claassen 1923:260. Holotype ♂ (CUIC), Labrador Lake (Cortland or Onondaga Co.), New York
*Leuctra duplicata* Needham & Claassen, 1925:227.
*Leuctra duplicata* Illies, 1966:88.
*Leuctra duplicata* Zwick, 1973:399.
*Leuctra duplicata* Hitchcock, 1974:75.

**Male.** The dorsal abdominal process of the 8th abdominal tergum emanates anteriorly, extending ca. ½ length of the segment and terminates on the posterior margin as a raised, bilobed process with small, distally rounded or subtriangular lobes (Figs. 13–15). The dorsal abdominal process of the 7th abdominal tergum is nearer the anterior margin of the segment and raised as a bar with smaller, distally rounded lobes (Figs. 13–15). The paired dorsal processes exhibit variation, namely in the distance between lobes and "scaly" nature of the lobes that can be seen only with SEM (Figs. 13–15). The specilla are broadest medially in lateral view due to an expanded keel, noticeably thickened in dorsal ½, and taper very little distally (Figs. 1–6); the outer margin has low, tooth-like tubercles present along the outer distal ⅓ (Figs. 7–12); in caudal view the basal ⅓ is concave (Figs. 7–9, 11). The subanal lobes are widest basally, narrow and tapering slightly along entire length, slightly recurved anteriorly in distal ½, and extend nearly to the distal tip of the specilla (Figs. 1–6). The vesicle base is short, body expanded medially and ovoid in shape, and entire surface covered in long, socketed bristles (Fig. 16).

**Female.** The 8th abdominal sternum bears a prominent, broadly-rounded medial tubercle on the anterior ½ that occupies the medial ca. ½ of the segment (Figs. 17–26). The subgenital plate terminates in large, broadly rounded or subtriangular lobes separated by a v-shaped notch (Figs. 17–26).




**Figs. 7–12.** *Leuctra duplicata*, paraprocts, caudal view. 7, West Virginia, Gandy Creek, 500X; 8, Virginia, spring near Lewis Fork bridge, 550X; 9, Maryland, tributary to Toliver Run, 600X; 10, Rhode Island, small stream into Wilbur Pond, 300X; 11, Quebec, tributary to Lac Cromwell, 350X; 12, Nova Scotia, Silvey Brook, 300X. sa = subanal lobe, sp = specillum.




**Figs. 13–16.** *Leuctra duplicata*. 13-15, abdominal processes, dorsal view; 16, vesicle, ventral view. 13, West Virginia, Gandy Creek, 330X; 14, Virginia, spring near Lewis Fork bridge, 220X; 15, Quebec, tributary to Lac Cromwell, 350X; 16, Nova Scotia, Silvey Brook, 500X.

**Distribution.** Canada: NB, NS, ON, PE, PQ. USA: CT, MD, ME, NJ, NY, OH, PA, VA, WV (DeWalt et al. 2017), MA (Needham & Claassen 1925, p. 228), NC, RI, VT (new state records).

### *Leuctra maria* Hanson, 1941

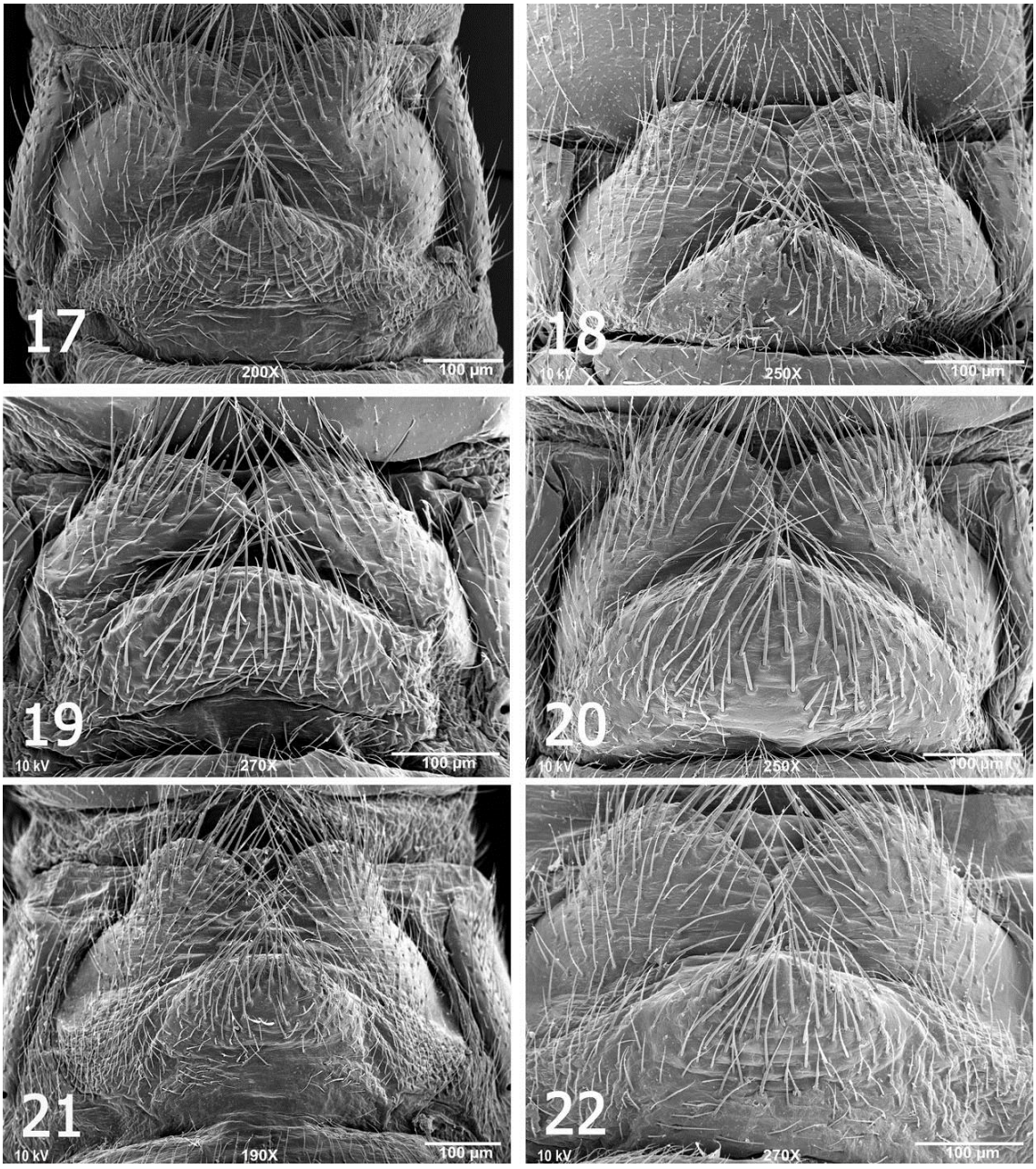
Northeastern Needlefly

http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:462458

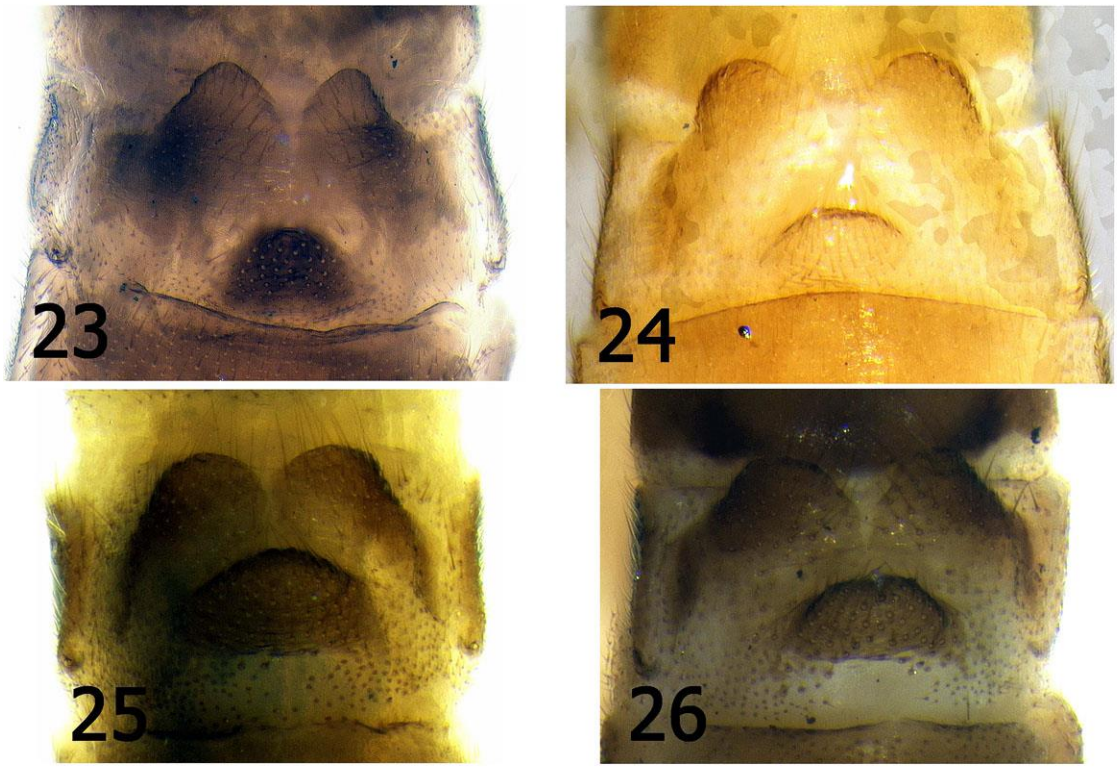
(Figs. 27–32, 34)

*Leuctra maria* Hanson 1941:175. Holotype ♂ (USNM), Barrington (Stratford Co.), New Hampshire
*Leuctra maria* Ricker, 1952:169. (correct description of female)
*Leuctra maria* Illies, 1966:98.
*Leuctra maria* Zwick, 1973:403.
*Leuctra maria* Hitchcock, 1974:77.

**Male.** The dorsal abdominal process of the 8th abdominal tergum emanates anteriorly, extending ca. ½ length of the segment and terminates on the posterior margin as a raised, bilobed process with small, distally rounded lobes (Fig. 30); the distance between the lobes is consistently ca. equal to lobe width (Fig. 30). The 7th abdominal tergum lacks dorsal processes, bearing only a thin, unraised sclerotized band anteriorly. The specilla are very broad basally and medially in lateral view, tapering distally to an acute apex (Fig. 27); the dorsal margin is essentially straight (Fig. 27); in caudal view the specilla bear prominent troughs from near the base




**Figs. 17–22.** *Leuctra duplicata*, subgenital plate, ventral view. 17, Virginia, spring near Lewis Fork bridge, 200X; 18, Maryland, tributary to Toliver Run, 250X; 19, Rhode Island, small stream into Wilbur Pond, 270X; 20, Quebec, tributary to Lac Cromwell, 250X; 21, Nova Scotia, Silvey Brook, 190X; 22, Maine, Little Simsquish Brook, 270X.




**Figs. 23–26.** *Leuctra duplicata*, subgenital plate, ventral view. 23, West Virginia, Gandy Creek; 24, Virginia, spring near Lewis Fork bridge; 25, Maryland, tributary to Toliver Run; 26, Rhode Island, small stream into Wilbur Pond.

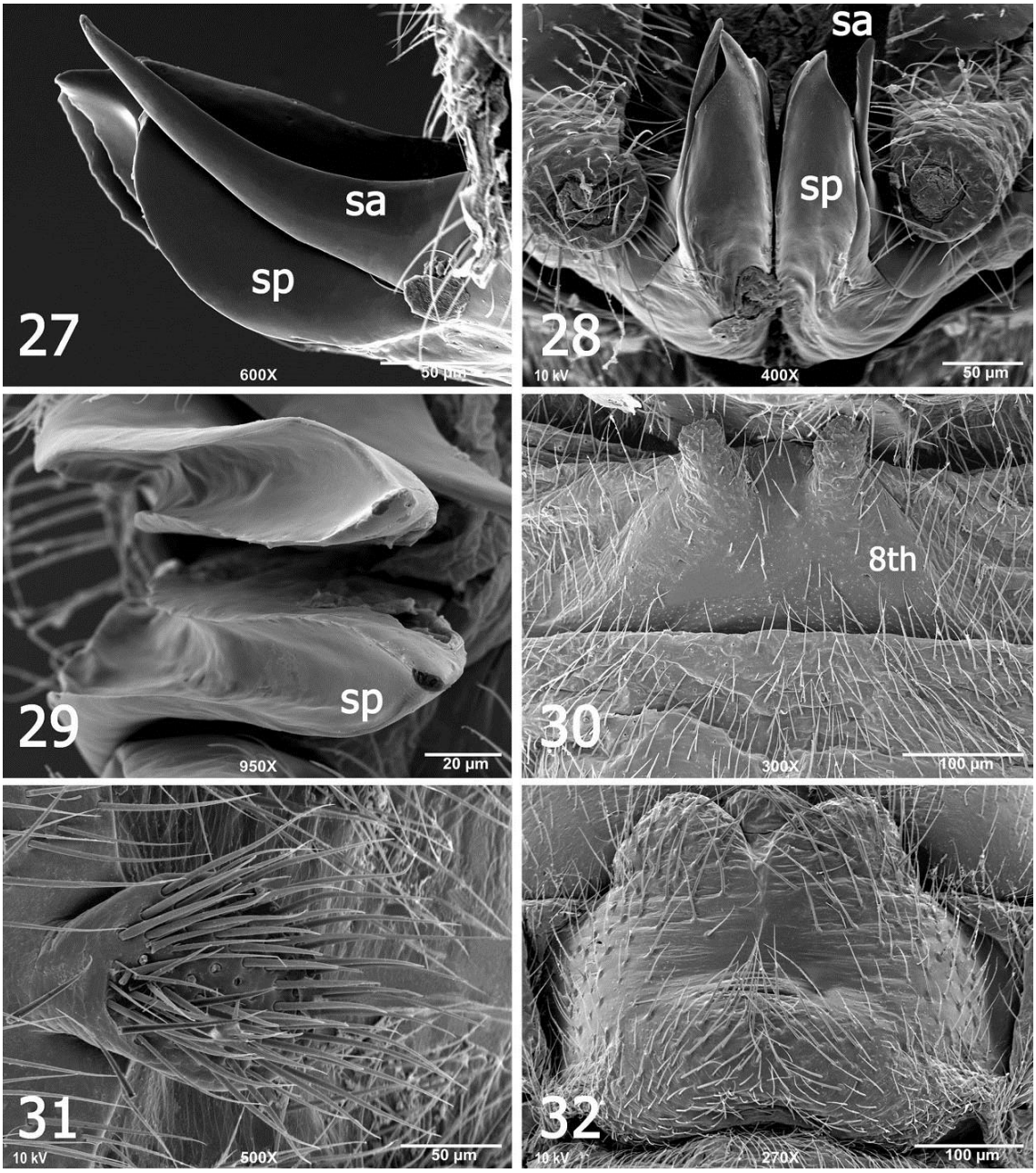
to the tips, giving a distinct concave appearance (Figs. 28–29); the medial margin of the trough has low, tooth-like tubercles present along the distal ⅓ (Figs. 28–29). The subanal lobes are broadest basally, slightly recurved anteriorly in distal ½, and subequal in length to the specilla (Figs. 27–28). The vesicle base is short, body expanded medially and ovoid in shape, and entire surface covered in long, socketed bristles (Fig. 31).

**Female.** The 8th abdominal sternum bears a broadly-rounded medial tubercle on the anterior ½ that occupies the medial ca. ½ of the segment (Fig. 32). The subgenital plate terminates in large, broadly rounded or subtriangular lobes separated by a v-shaped notch (Fig. 32).

**Distribution.** Canada: ON, PQ. USA: CT, ME, NH, NY, PA, VT, WV (DeWalt et al. 2017).

## DISCUSSION

Adult males and females of *L. duplicata* and *L. maria* share several similar features that support the morphological concept of these two taxa as a species group (Harper & Harper 1997). First, females of both species possess a prominent, broadly rounded medial tubercle on the anterior portion of the subgenital plate. This is a diagnostic characteristic of the *L. duplicata* group and distinct from females of all other eastern Nearctic *Leuctra* species. The tubercle is consistently larger for *L. duplicata* (Figs. 17–26) and easily contrasted from *L. maria* (Fig. 32). The subgenital plate is distinctly bilobed for both




**Figs. 27–32.** *Leuctra maria*, 27-28, 30-32, West Virginia, Big Run Swamp; 29, Quebec, tributary to Lac Cromwell. 27, paraprocts, lateral view, 600X; 28, paraprocts, caudal view, 400X; 29, paraprocts, caudal view, 950X; 30, abdominal processes, dorsal view, 300X; 31, vesicle, ventral view, 500X; 32, subgenital plate, ventral view, 270X. sa = subanal lobe, sp = specillum.

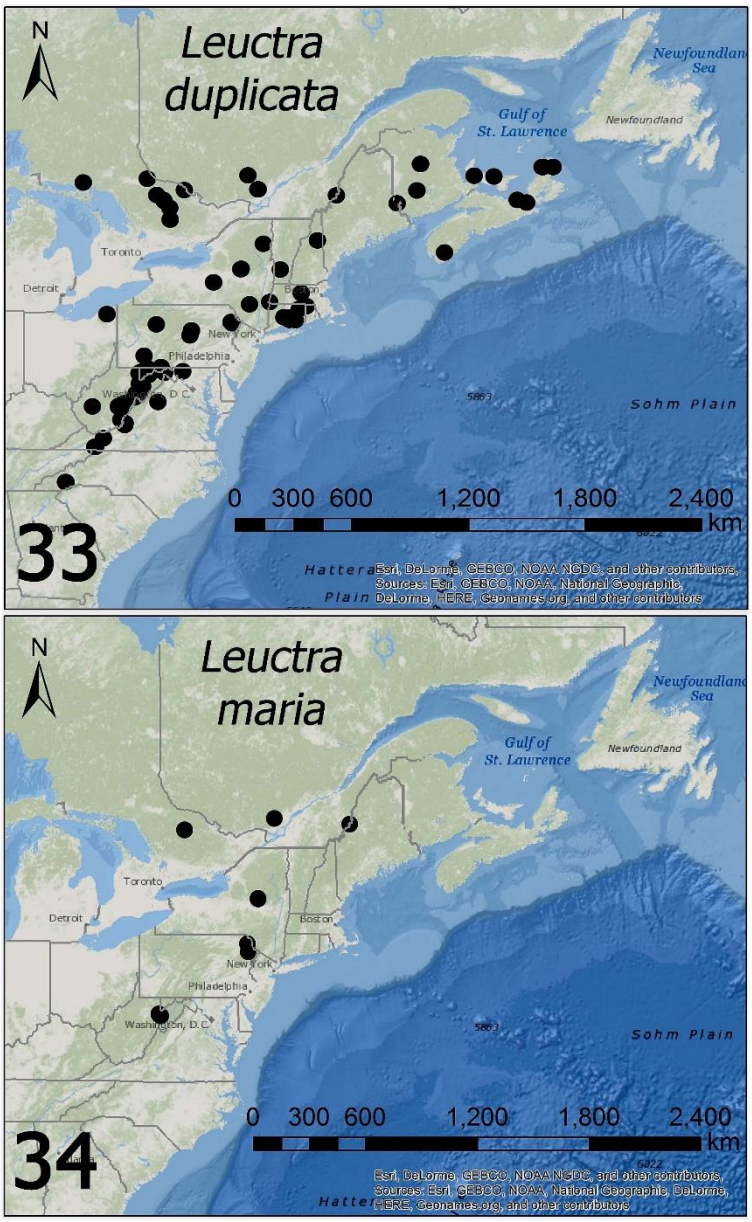



**Fig. 33.** Distribution map of *Leuctra duplicata* specimens examined in this study.
**Fig. 34.** Distribution map of *Leuctra maria* specimens examined in this study.

species, with lobes varying in shape from subtriangular to distally rounded (Figs. 17–26, 32). Ricker (1952) was the first to illustrate and describe the female of *L. maria* (his Fig. 124). He pointed out that the female described and illustrated by Hanson (1941, his Fig. 1C) was not of *L. maria*.

Second, the subanal lobes of males of both species are broadest basally, only slightly recurved in distal ½, and tapered distally (Figs. 1–6, 27). The subanal lobes of *L. maria* (Fig. 27) are broader basally compared to *L. duplicata* (Figs. 1–6). The shape and length of the *L. duplicata* subanal lobes (Figs. 1–6) are essentially identical across its broad range. Third, the vesicles of both species are ovoid in shape with only a short stalk (Figs. 16, 31) and indistinguishable from each other.

*Leuctra duplicata* and *L. maria* can be easily differentiated, however, by characteristics of the dorsal abdominal processes and specilla. First, males of *Leuctra duplicata* possess bilobed dorsal processes on both the 7th and 8th abdominal terga (Figs. 13–16). *Leuctra maria* lacks a bilobed process on the 7th abdominal tergite (Fig. 30); all that is present is a thin, unraised sclerotized band anteriorly. Second, the specilla of *L. duplicata* are recurved anteriorly and rounded distally and are noticeably thickened anteriorly (Figs. 1–6). Similar to the subanal lobes, the shape and length of the specilla are consistent across its range. In contrast, the specilla of *L. maria* are acute distally but not recurved anteriorly (Fig. 27) with a distinct trough from near the base to the apex (Figs. 28–29).

*Leuctra duplicata* appears to be the more common species, at least as represented by the total number of vials (*L. duplicata*, n = 146; *L. maria*, n = 14) and adult specimens (*L. duplicata*, n = 848 males, 932 females; *L. maria*, n = 30 males, 13 females) present in the collections examined in this study. *Leuctra maria* is a mainly a northeastern Nearctic species, with a few relictual populations known from northern West Virginia (Fig. 34), and is essentially sympatric within the range of *L. duplicata* (Fig. 33). Extensive collecting in western Maryland by SAG during the 1990s failed to locate populations of *L. maria* (unpublished data). *Leuctra duplicata* is mainly a broadly distributed Appalachian species (Fig. 33). Compared to the known range of *L. maria*, *L. duplicata* extends further southward through Virginia to western North Carolina as well as northeastward to the Atlantic Canadian provinces of New Brunswick, Nova Scotia, and Prince Edward Island (Fig. 33; Kondratieff & Baumann 1994, DeWalt et al. 2017). The distribution of both species also extends northward through the Adirondack Mountains of New York (Myers et al. 2011) to southeastern Ontario and southern Quebec (Harper & Hynes 1971). The conspicuous absence of records of *L. duplicata* from Delaware (i.e. Lake 1980) is likely due to the paucity of collecting efforts in that state.

## CONCLUSIONS

Similar to the comparative analysis of the *L. tenuis* (Pictet, 1841) group (Grubbs 2015), this morphological assessment of the *L. duplicata* group using SEM supports and extends the framework established by Harper & Harper (1997), namely that characteristics of the male paraprocts provide more useful diagnostic information compared to the dorsal abdominal processes.

## ACKNOWLEDGEMENTS

Dr. John Andersland (Western Kentucky University) assisted with scanning electron microscopy and Auto-Montage imaging. Dr. Boris Kondratieff (Colorado State University, Fort Collins, Colorado), Dr. Richard Baumann (Brigham Young University, Provo, Utah), Dr. Bill Stark (Mississippi College, Clinton, Mississippi), and Dr. R. Edward DeWalt (Illinois Natural History Survey, Champaign-Urbana, Illinois) made material and collection data of *L. duplicata* and *L. maria* available for this study. Funding to support this work has been provided by a Western Kentucky University Faculty Summer Fellowship awarded to SAG and a Gatton Academy of Mathematics and Science Research Internship Grant to SW. Dr. Andrew Sheldon (Crawfordsville, Florida) collected the *L. duplicata* material in North Carolina and Dr. Richard Jacobsen (Fort White, Florida) kindly provided housing to SAG for numerous collecting trips to Maryland during the mid-1990s.

## REFERENCES

Brinck, P. 1956. Reproductive system and mating in Plecoptera. Opuscula Entomologica, 21:57–127.

Claassen, P.W. 1923. New species of North American Plecoptera. Canadian Entomologist, 55:257–263, 281-292. http://www.biodiversitylibrary.org/item/88627#page/565/mode/1up

DeWalt, R.E., M.D. Maehr, U. Neu-Becker & G. Stueber. 2017. Plecoptera Species File Online. Version 5.0/5.0. Accessed 20 August 2017. http://Plecoptera.SpeciesFile.org

Grubbs, S.A. 2010. *Leuctra usdi* n. sp., a new stonefly (Plecoptera: Leuctridae) of the *L. tenuis* (Pictet) species group from the southeastern U.S.A. plus three new Alabama state records. Zootaxa, 2498:59–64. http://www.mapress.com/zootaxa/2010/f/z02498

p064f.pdf

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

Grubbs, S.A. & A.L. Sheldon. 2009. *Leuctra pinhoti*, a new species of stonefly (Plecoptera: Leuctridae) from Alabama, U.S.A. Illiesia, 5:195–198. http://illiesia/papers/Illiesia05-19.pdf

Harper, P.P. & F. Harper. 1997. The genus *Leuctra* Stephens in North America: a preliminary report. Pages 467–472. *In* Landolt, P and M. Sartori, editors. Ephemeroptera & Plecoptera: Biology-Ecology-Systematics. Fribourg, MTL.

Harper, P.P. & H.B.N. Hynes. 1971. The Leuctridae of eastern Canada (Insects; Plecoptera). Canadian Journal of Zoology, 49:915–920.

Harrison, A.B. & B.P. Stark. 2010. Two new species of stoneflies in the *Leuctra ferruginea* group (Plecoptera: Leuctridae), with notes on the *Leuctra* species known from Mississippi and Alabama. Illiesia, 6:16–33. http://illiesia.speciesfile.org/papers/Illiesia06-03.pdf

Hitchcock, S.W. 1974. Guide to the insects of Connecticut. Part VII. The Plecoptera or stoneflies of Connecticut. Bulletin of the State Geological and Natural History Survey of Connecticut, 107:1–262.

Illies, J. 1966. Katalog der rezenten Plecoptera. Das Tierreich No. 82. Walter de Gruyter and Company, Berlin.

Kondratieff, B.C. & R.W. Baumann. 1994. Assault on Atlantic Canada: a stonefly collecting foray to the Canadian Maritime Provinces. Perla, 12:16–18. http://plecoptera.speciesfile.org/HomePage/Plecoptera/LitArchive/PerlaNo12_1994.pdf

Lake, R.W. 1980. Distribution of the stoneflies (Plecoptera) of Delaware. Entomological News, 91:43–48. http://biostor.org/reference/77246

Myers, L.W., B.C. Kondratieff, T.B. Mihuc & D.E. Ruiter. 2011. The mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) of the Adirondack Park (New York State). Transactions of the American Entomological Society, 137:63–140. https://doi.org/10.3157/061.137.0118

Needham, J.G. & P.W. Claassen. 1925. Monograph of the Plecoptera or stoneflies of America, north of Mexico. Thomas Say Foundation, Entomological Society of America, 2:1–397. https://archive.org/details/monographofpleco00need

Ricker, W.E. 1952. Systematic studies in Plecoptera. Indiana University Publications, Science Series, 18:1–200. http://www.nativefishlab.net/library/textpdf/16861.pdf

Zwick, P. 1973. Insecta: Plecoptera, Phylogenetisches System und Katalog. Das Tierreich No. 94. Walter de Gruyter and Company, Berlin.

Submitted 7 September 2017, Accepted 25 September 2017, Published 11 October 2017

Hosted and published at the University of Illinois, Illinois Natural History Survey, Champaign, Illinois, U.S.A.