



A NEW SPECIES OF *ZEALUUCTRA* RICKER, 1952 (PLECOPTERA: LEUCTRIDAE) FROM NORTH CAROLINA, U.S.A.

Chris J. Verdone¹, Steven R. Beaty¹, Victor B. Holland¹ & Boris C. Kondratieff²

¹North Carolina Department of Environmental Quality, Division of Water Resources,
Water Sciences Section, Raleigh, NC, 27607, U.S.A.
E-mail: chris.verdone@ncdenr.gov, steven.beaty@ncdenr.gov, victor.holland@ncdenr.gov

²Department of Bioagricultural Sciences and Pest Management, Colorado State University,
Fort Collins, Colorado, 80523, U.S.A.
E-mail: boris.kondratieff@colostate.edu

ABSTRACT

The stonefly genus *Zealeuctra* Ricker, 1952 (Plecoptera: Leuctridae) is reported from North Carolina, U.S.A. for the first time by the new species, *Z. uwharrie* sp. n. described from the Carolina Slate Belt. The new species is proposed based on details of the male 9th abdominal tergum, epiproct, abdominal sclerotization, and the female 7th sternite. Supporting data includes scanning electron micrographs and color images of all life stages including the adult male and female, larva, and ovum. A distribution map, biological notes and an amended key are also presented.

Keywords: Plecoptera, Leuctridae, *Zealeuctra*, new species, Carolina Slate Belt, North Carolina

INTRODUCTION

Recently, Grubbs et al. (2013) reviewed the North American leuctrid genus *Zealeuctra* Ricker, 1952. This study recognized 11 species distributed in central and eastern North America. Only four of these 11 species have been reported from the southeastern United States (Stark 2017): *Z. claasseni* (Frison, 1929) from Kentucky and Tennessee; *Z. fraxina* Ricker & Ross, 1969 from Alabama, Georgia, Kentucky, Tennessee, and Virginia; *Z. talladega* Grubbs, 2005 from Alabama; and *Z. ukayodi* Grubbs, 2013 from Alabama and Tennessee (Grubbs 2005, Grubbs et al. 2013, Verdone et al. 2017, Kondratieff et al. 2017, DeWalt et al. 2019). No records of this genus are available for North Carolina (Kondratieff et al.

1995, DeWalt et al. 2019).

In January 2019, we conducted a winter stonefly expedition into the North Carolina Piedmont region including Uwharrie National Forest and Morrow Mountain State Park in the south-central portion of the Carolina Slate Belt. Within these areas are the hilly peaks of the Uwharrie Mountains and surrounding foothills. The original objective of this collecting trip was to elucidate the distribution of *Allocapnia* Claassen, 1928 within the North Carolina Piedmont. However, just as Ricker & Ross (1969) fortuitously turned up undescribed species of *Zealeuctra* during their *Allocapnia* research, we discovered an unknown species of *Zealeuctra* (Figs. 1–2) among our catch of *Allocapnia*. Herein,



Figs. 1–2. *Zealeuctra uwaharrie* sp. n., unnamed spring tributary to Little River, Montgomery Co., NC. 1. Adult, female. 2. Larva, female.

we provide a description of this new species supported by scanning electron micrographs (SEM) and color images.

MATERIAL AND METHODS

Adult stoneflies were collected using a beating sheet and aerial nets from bankside vegetation, while larvae were collected from benthic substrates using a sweep or kick net. Adults and larvae were preserved in 80% ethanol. Larvae were difficult to obtain; however, one female was associated using the laboratory rearing methods described in Beaty et al. (2017). Coordinate data for new material were recorded directly using Topo Maps version 1.16 for iPhone. Additional material were examined from the C.P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins, Colorado (CSUIC), the Illinois Natural History Survey, Champaign, Illinois (INHS), and the Western Kentucky University Insect Collection, Bowling Green, Kentucky (WKUC). A distribution map of the

new species was created using ArcMap, ArcGIS 10.4.1 (ESRI 2016). Level III–IV ecoregion data were obtained from the US Environmental Protection Agency (USEPA 2018). Coordinate data for archived records were gathered using GEOLocate v. 3.22 (Rios & Bart 2010) and are indicated by “[]”.

Specimens were prepared for SEM following the methods of Verdone & Kondratieff (2018). Scanning electron micrographs were taken using a JEOL JSM-6500F Field Emission Scanning Electron Microscope at the Central Instrument Facility, Imaging Laboratory, Colorado State University (<http://cif.colostate.edu/imaging-laboratory/>). Specimens were photographed using a Nikon D2700 in the field or mounted on a Wild M5-A. Final images are a compilation of serial photomicrographs taken at progressively deeper focal planes. Composite images were assembled using Zerene Stacker version 1.04. Image adjustments including background color correction, color levels and sharpening functions

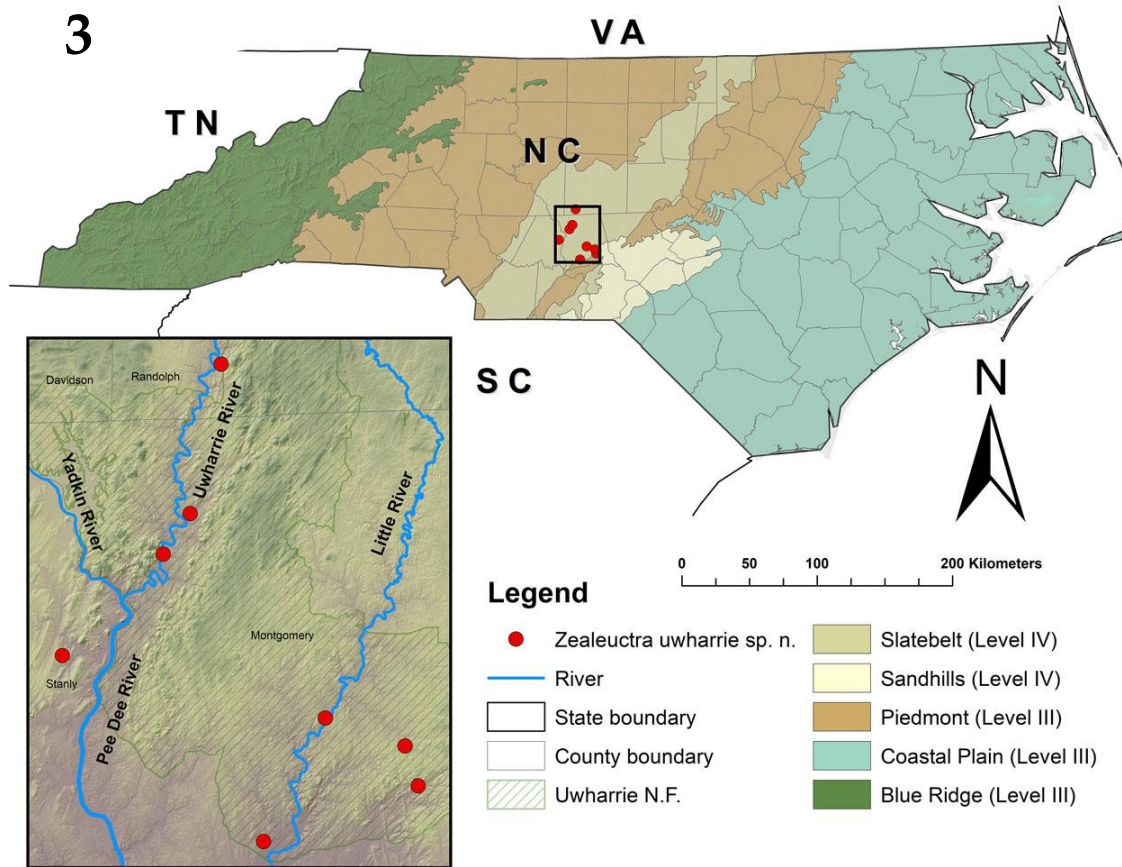


Fig. 3. Distribution of *Zealeuctra uwharrie* sp. n.

were achieved using Adobe Photoshop CC.

The holotype and paratypes of *Z. uwharrie* sp. n. are deposited in the National Museum of Natural History, Washington, DC (NMNH). Additional paratypes are deposited at CSUIC, INHS, WKUC, and the North Carolina Division of Water Resources Biological Assessment Branch collections (NCDWR), Raleigh, North Carolina. Morphology and terminology follow that of Ricker & Ross (1969) and Grubbs et al. (2013).

RESULTS

Zealeuctra uwharrie sp. n. Verdone, Beaty, Holland & Kondratieff

[http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:](http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:506050)

[TaxonName:506050](http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:506050)

(Figs. 1–2, 4–19)

Material examined. *Holotype* ♂ U.S.A. —**North Carolina: Montgomery Co.,** unnamed spring tributary to Little River, SR 1005, Troy Boat Access, N 35.29628, W 79.88583, 16 January 2019, C. Verdone, S. Beaty, V. Holland, B. Kondratieff (NMNH). *Paratypes:* **Montgomery Co.,** Gold Mine Branch, FS Rd. 555, N 35.41232, W 80.02314, 23 January 2019, C. Verdone, S. Beaty, V. Holland, 6♂, 6♀ (INHS); Little Creek, SR 1516, N 35.27616, W 79.81779, 16 January 2019, C. Verdone, S. Beaty, V. Holland, B. Kondratieff, 10♂, 6♀ (CSUIC); Little Rocky Creek, SR 1543, N 35.21038, W 79.93981, 26 January 2019, C. Verdone, D. Fuller 3♂, 1♀ (INHS); unnamed tributary to Barnes Creek, SR 1303, N 35.44052, W 79.99970, 23 January 2019, C. Verdone, S. Beaty, V. Holland, 17♂, 15♀ (NCDWR); same location, 2 February 2019, C. Verdone, S. Beaty, V. Holland, 4♂, 6♀



Figs. 4–6. *Zealeuctra uwharrie* sp. n., adult. 4. Head and pronotum, dorsal, Little Creek, Montgomery, Co., NC. 5. Abdomen, male and female, dorsal, unnamed tributary to Barnes Creek, Montgomery Co., NC. 6. Male sterna 7–10, ventral, Little Creek, Montgomery, Co., NC.

(WKUC); same location, 12 March 2019, C. Verdone, S. Beaty, V. Holland, 1♀ (NCDWR); unnamed tributary to Cheek Creek, SR 1563, N 35.24810, W 79.80711, 16 January 2019, C. Verdone, S. Beaty, V. Holland, B. Kondratieff, 2♂ (CSUIC); unnamed spring tributary to Little River, SR 1005, Troy Boat Access, N 35.29628, W 79.88583, C. Verdone, S. Beaty, V. Holland, B. Kondratieff, 15♂, 9♀, 2 larvae, 1 exuvium

(NCDWR); same location, 23 January 2019, C. Verdone, S. Beaty, V. Holland, 4♂, 5♀, 2 larvae, 1 exuvium (CSUIC); same data, 1♀, 1 exuvium (reared) emerged 13 February 2019 (NCDWR). **Randolph Co.**, unnamed tributary to Uwharrie River, N 35.54490, W 79.97184, 2 February 2019, C. Verdone, S. Beaty, V. Holland, 3♂, 3♀, (NMNH). **Stanly Co.**, unnamed tributary to Mountain Creek, Morrow Mountain State Park,

SR 1730, N 35.34196, W 80.11049, 16 January 2019. C. Verdone, S. Beaty, V. Holland, B. Kondratieff, 2♂, 1♀ (NCDWR).

Additional material examined

Zealeuctra fraxina (Figs. 20–22): **Alabama: Jackson Co.**, tributary to Larkin Fork, Paint Rock River Opossum Hollow, Rte. 65, 1 km SE Francisco, 18 February 2006, S.A. Grubbs, 4♂, 12♀ (WKUC). **Georgia: Floyd Co.**, Johns Creek, Everett Spring Rd., N 34.56416, W 85.10104, 8 February 2017, C. Verdone, B. Kondratieff, 4♂, 1♀ (CSUIC). **Illinois, Pope Co.**, Burden Branch, 10.9 km SSE Stonefort, Shawnee N.F., N 37.56330, W 88.64240, 22 February 2019, R.E. DeWalt, E.A. Newman, 5♂, 5♀ (INHS: Insect Collection 660751). **Tennessee: Sumner Co.**, tributary to Little Trammel Creek, TN 174, [N 36.62366, W 86.26806], 22 February 1999, B. Kondratieff, R.F. Kirchner, 13♂, 8♀, 1 exuvium (CSUIC). **Virginia: Bedford Co.**, Peaks of Otter Lake, N 37.44539, W 79.60286, 12 March 2013, E.M. Malloy 1♂ (WKUC). **Fauquier Co.**, Arlington Outdoor Laboratory, malaise trap, [N 38.80720, W 77.72170], 8–23 March 2016, D. Smith, O. Flint, 1♂, 1♀ (CSUIC).

Zealeuctra talladega: **Alabama: Clay Co.**, tributary to Tallaseehatchie Creek, FR 616, Talladega National Forest, N 33.20530, W 86.08000, 5 March 2012, S.A. Grubbs 1♂, 2♀ (WKUC). **Talladega Co.**, Smelley Creek, CR 234, N 33.30104, W 86.09445, 21 December 2007, A.L. Sheldon, 1♂ (WKUC).

Zealeuctra ukayodi: **Alabama: Jackson Co.**, Poplar Spring, 6 km SW Hytop, N 34.87790, W 86.12830, 16 March 2008, S.A. Grubbs 5♂, 25♀ (WKUC; paratypes). **Tennessee: Marion Co.**, Cave Spring Creek, Franklin State Forest, N 35.07644, W 85.84269, 25 February 2007, A.L. Sheldon, 1♂, 1♀ (WKUC: paratypes); tributary to Sweeten Creek, 15 km NW S. Pittsburg Franklin-Marion State Forest, N 35.09420, W 85.86000, February 2013, S.A. Grubbs 3♂, 18♀ (WKUC: paratypes).

Distribution. U.S.A. – NC (Fig. 3).

Etymology. The new species is named after the region where the majority of specimens were collected, the Uwharrie National Forest of south-central North Carolina. The proposed common name is the “Uwharrie Needlefly” (Stark et al.

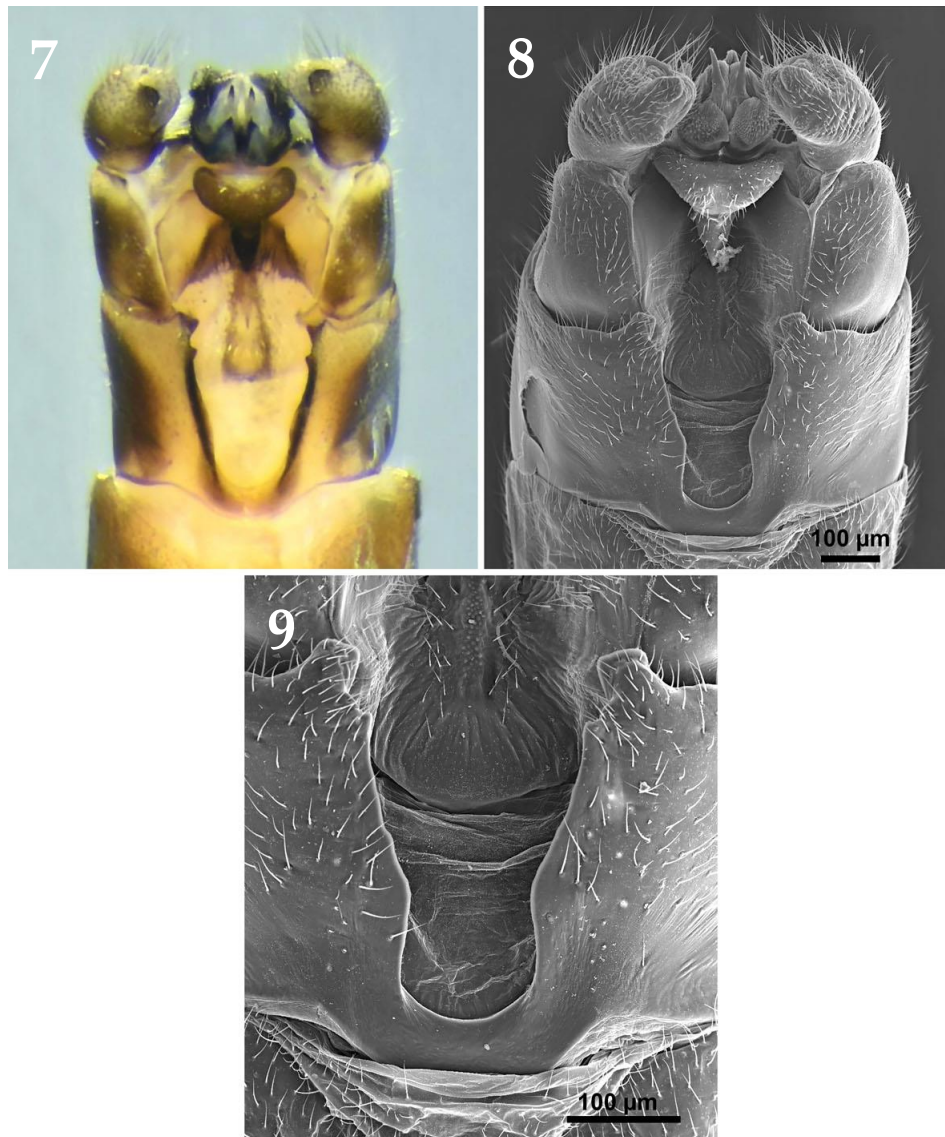
2012).

Male. Macropterous. Length of forewings 6.4–7.2 mm (n = 10). Length of body 5.9–6.7 mm (n = 10). General body color dark-brown to black (Fig. 1).

Head: (Fig. 4). Dorsum of head mostly dark-brown to black; lateral ocelli pale brown; interocellar area often with a slight depression; a piceous, glabrous oval area between lateral ocelli and antennal scape near eye; a pair of small raised humps anterolateral to median ocellus, often slightly darker than surrounding ground color. Antennae uniformly dark-brown; at least 44 segments. Occiput with small, irregular, dark rugosities. Entire head capsule adorned with short, clear clothing hairs, shorter posteriorly.

Thorax: Pronotum (Fig. 4) subquadrate, slightly longer than wide with anterior pronotal corners rounded; brown overall with darker rugosities; anterior and posterior pronotal furrows darkened lines; median ecdysial line raised and rugose, discal rugosities coalesced in semicircular fashion, resembling a mushroom overall; pronotal sclerotization extending medially beyond posterior margin of the pronotal disc, extensions medially divided by a pale line. Meso- and metathorax heavily sclerotized dorsally and ventrally, with dark brown to black stripe lateral to ecdysial suture. Legs uniformly brown, sometimes slightly darker at the femoral-tibial joint; apex of tibiae with 2 stout apical spines. Wings slate grey; venation brown; brown spot present at base of costa (Fig. 1).

Abdomen: (Fig. 5). Brown, with a darker brown longitudinal medial sclerotized stripe dorsally, variously developed, and four dark transverse spots on terga 1–8; terga 1–2 mostly pale and membranous; each tergum with a dark brown lateral sclerite, giving the appearance of a lateral abdominal stripe; a dark, thin, linear sclerite in the pleural folds, variously developed on posterior segments; abdominal sterna 1–7 each with two dark spots. In lateral view abdominal sterna heavily setose compared to terga. Vesicle (Fig. 6) present on posterior margin of sternum 8; length 1.5X width, evenly rounded, entire surface densely clothed in golden setae. Sternum 9 darker than preceding segments, area occluded

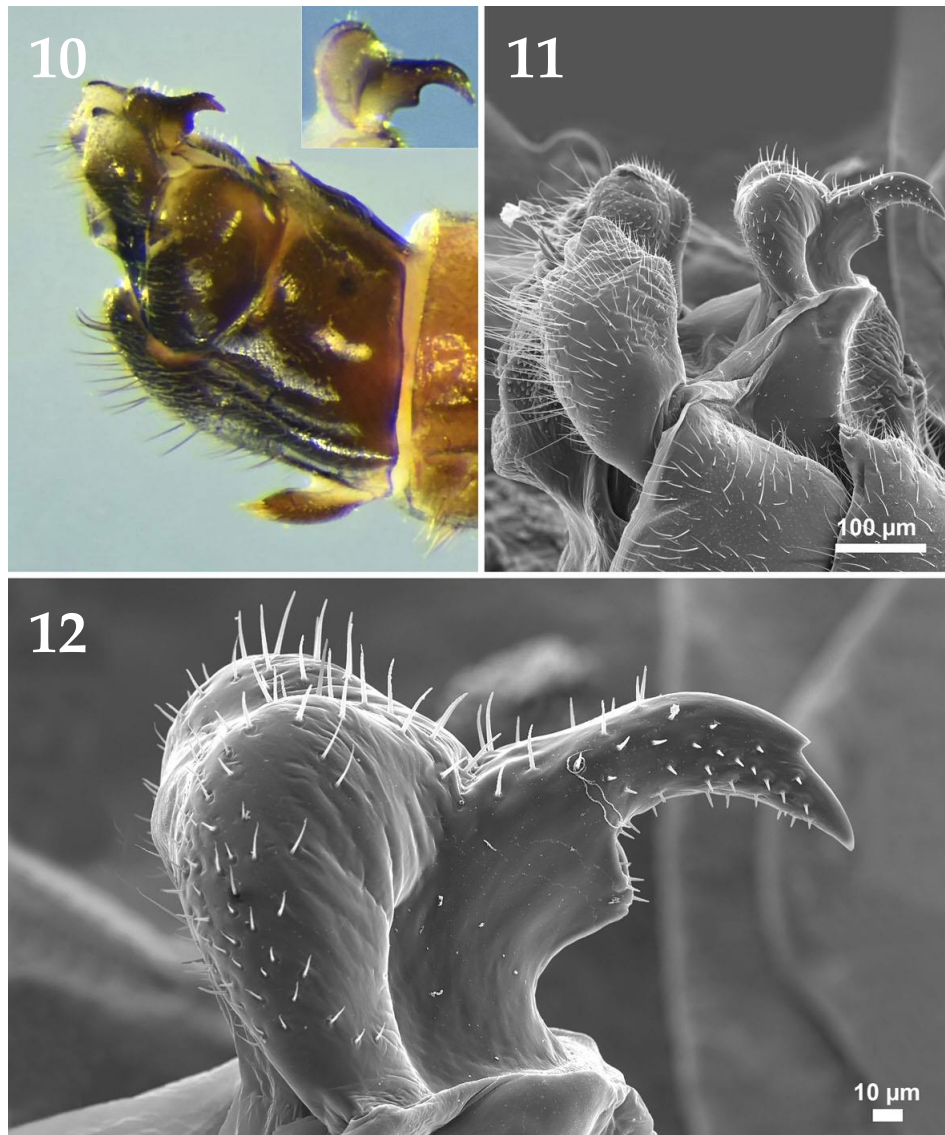


Figs. 7–9. *Zealeuctra uwharrie* sp. n., adult, unnamed spring tributary to Little River, Montgomery Co., NC. 7–8. Male terminalia, dorsal. 9. Male tergum 9, dorsal.

by vesicle pale and unsclerotized.

Terminalia: (Figs. 7–13). Tergum 9 deeply cleft, narrowly U-shaped anteriorly, inner margins sinuous, divergent posteriorly (Figs. 7–9); inner posterolateral margins with small sub-terminal, medially directed points; posterior apices with larger truncated or rounded posteromedially directed projections (Figs. 8–9). Medial area of tergum nine membranous with a triangular sclerite. Epiproct recurved over tergum 10; base

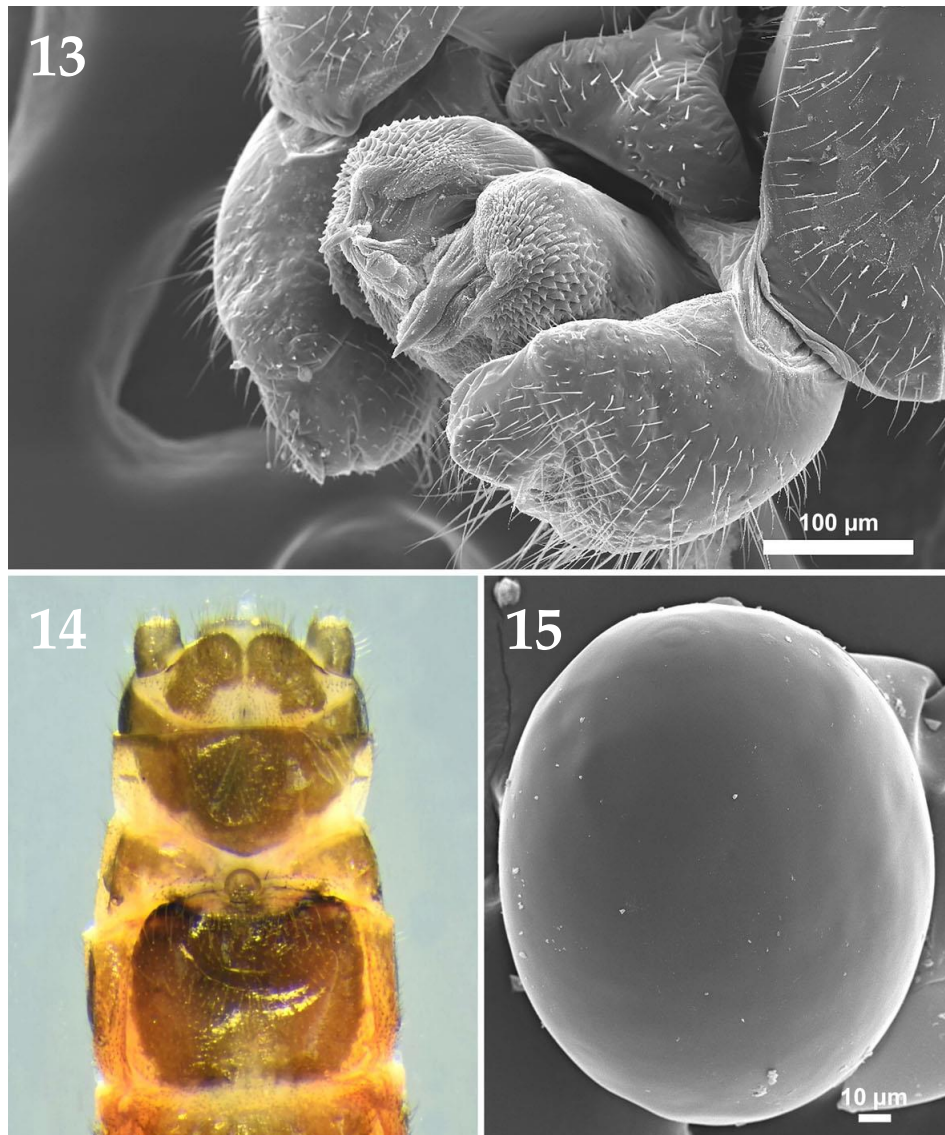
in lateral view expanded, sharply quadrate to broadly rounded (Figs. 10–12); in lateral view, anterior hooked portion of epiproct, dark brown to black, tapered and strongly curved ventrad with a relatively large dorsal subterminal spine; posterior portion of epiproct adjacent to quadrate base with broad hemispherical lobes that extend caudally (Figs. 10–12) and laterally in dorsal aspect (Fig. 13); epiproct with regularly spaced sensilla over much of its surface; dorsoapical



Figs. 10–12. *Zealeuctra uwharrie* sp. n., adult male epiproct, lateral. 10. Unnamed spring tributary to Little River, Montgomery Co., NC (inset: Little Creek, Montgomery, Co., NC). 11–12. Little Creek, Montgomery, Co., NC.

areas of the epiproct and subterminal spine, in addition to the lateral areas of the expanded base are glabrous (Fig. 12). Subanal probe (Fig. 13) open apically; deeply divided longitudinally for most its length; each side joined together both basally and posteriorly by a membranous sheath bearing dark triangular spinulae apically and posteriorly; dark lateral sclerites envelop the probe laterally and anteriorly; widely separated

apically and narrowly basoposteriorly; a pair of long, thin anteromedial sclerites are held internally, becoming membranous subapically, then narrowing to acute well sclerotized points which extend slightly beyond the probe apex (Figs. 7–8). Cercus one segmented with a small subapical dorsal projection and a darkly sclerotized fingernail-like process on posterodorsal margin; setose ventrally (Figs. 7–8).

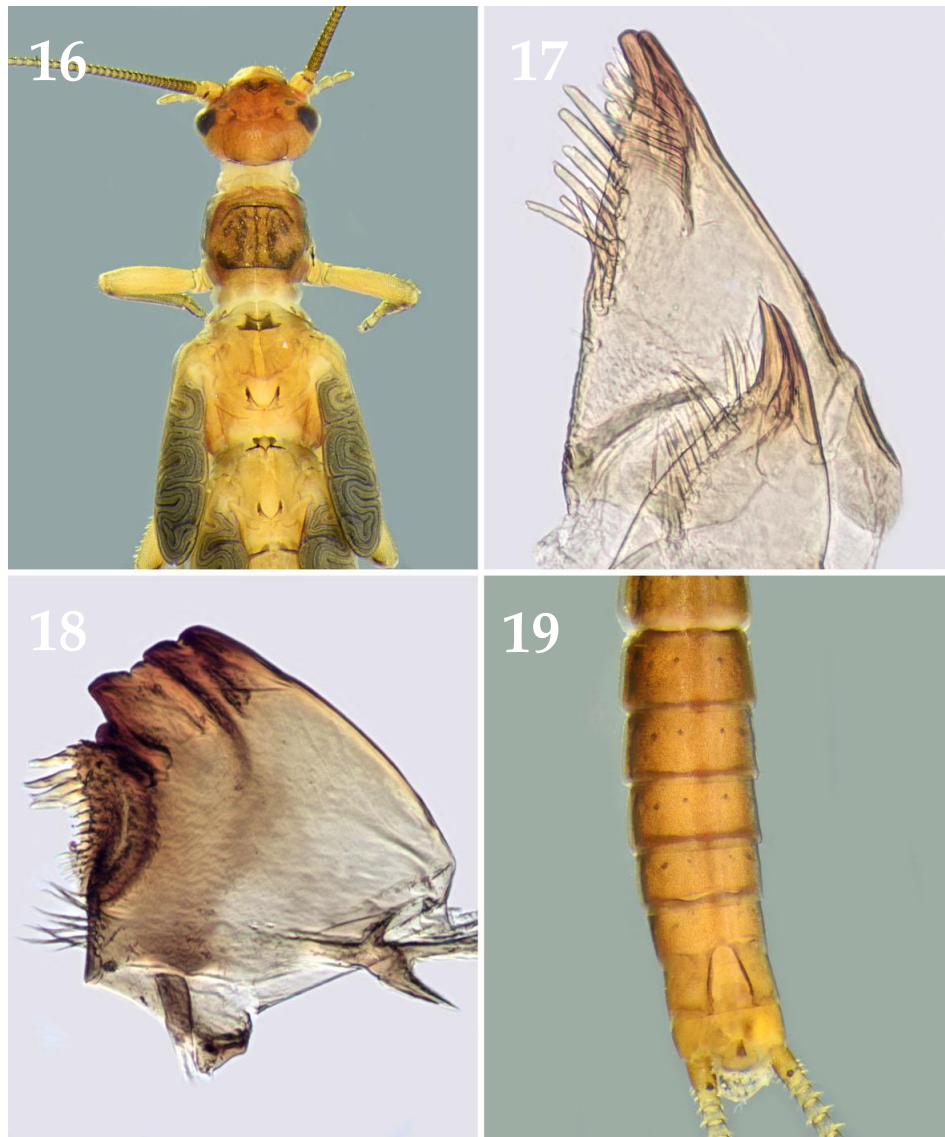


Figs. 13–15. *Zealeuctra uwharrie* sp. n., adult, unnamed spring tributary to Little River, Montgomery Co. NC. Fig. 13. Male sub-anal probe, dorsolateral. 14. Female terga 7–10, ventral. 15. Ovum.

Female. Macropterous. Length of forewings 7.6–7.9 mm (n = 10). Length of body 6.4–8.8 mm (n = 10). General habitus coloration similar to male. Dorsum of abdomen mostly membranous and with a medial sclerotized brown stripe on terga 1–8 (Fig. 5).

Terminalia: (Fig. 14). Sternum 7 strongly produced and heavily sclerotized on posterolateral margins; posteromedial margin

lightly sclerotized with a shallow posterior notch and bearing a moderately sclerotized ovoid lobe; sternal lobe length 1.25X width, projecting beyond the posterior margin of tergum 7 recessed in notch for no more than $\frac{1}{2}$ its length; lobe is often in-folded perpendicular to tergum eight. Membranous intersegmental fold posterior to sternal lobe with dark socketed sensillae, often obscured by the in-folding of the posterior margin



Figs. 16–19. *Zealeuctra uwharrie* sp. n., larva, unnamed spring tributary to Little River, Montgomery Co. NC. 16. Head, pronotum and thorax, dorsal. 17. Left lacinia, ventral. 18. Left mandible, ventral. 19. Male abdomen, dorsal.

of sternum eight.

Ovum. (Fig. 15). Length 164 μm ($n = 2$); width 137–144 μm ($n = 2$). General shape oblong; cross section circular; chorionic surface completely smooth; lightly to moderately sclerotized. Despite the ovum's apparent lack of specialized structures, individual ova readily adhered to the sides of glass vials even when in alcohol.

Mature larva. (Fig. 2) Length of σ body 6.4–7.5

mm ($n = 3$), ♀ body 9.1 mm ($n = 1$). General color yellow-brown. Integument covered in fine scales.

Head: (Fig. 16). Dorsum of head yellow-brown, purplish-brown dorsal reticulations variously developed but delineating ocelli somewhat, markings present lateral to median ocellus; lateral edges of labrum darkly sclerotized. Antennae uniformly yellow-brown, with at least 49 segments.

Maxilla: Lacinia (Fig. 17) bidentate with two subequal apical teeth; teeth short, truncate and peg-like on pre-emergent specimens; lacinia triangular, evenly receding from base to apical teeth; 11–12 stout marginal setae receding from dorsal apical tooth to the apical $\frac{1}{2}$; marginal setae adjacent to apical tooth short, subsequent seta becoming longer, then shorter; nine stout setae on ventral face below ventral apical tooth; 1–2 prominent hair-like, sub-marginal seta positioned on the basal $\frac{1}{2}$. Galea 1.5X lacinia length or less, broad approximately $\frac{2}{3}$ the width of the lacinia; apex bearing 2–3 stout setae. Palpi robust; segments 1–2 subequal, segments 3–5 approximately 2X the length of segments 1–2, segment 5 about 1.3X as long as segment 3 or 4; segments 2–4 bearing 3–6 spines on palpal body.

Mandible: Left mandible (Fig. 18) with 4 apical teeth; proximal margin with a pectinate comb consisting of 14 long scraping blades (10X as long as wide); basal $\frac{1}{3}$ with a tuft of hair-like setae. Right mandible similar to left except pectinate comb consists of 11 teeth, which are 5X as long as wide. Mouthparts of only one specimen were slide mounted, as such the biometrics of other individuals may vary.

Thorax: (Fig. 16). Pronotum glabrous, margin smoothly contoured laterally; sclerotization extending medially beyond posterior margin of the pronotal disc, medially divided by a pale line. Length of forewing pads 3.75X width; length of hindwing pads 3X width; posterior $\frac{2}{5}$ narrowed. Meso- and metabasisterna light brown, glabrous; furcal sternites slightly darker. Legs pale yellow; dorsum of femur with approximately 20 stout setae, mostly in the distal half. Ventral edge of tibia and tarsi with a line of stout setae, ending with 2 stout apical spines dorsal edge of tibia with a sparse fringe of hair-like setae, mostly concentrated on distal half; tarsal segment 3 with 5–6 hair-like setae.

Abdomen: (Fig. 19). Glabrous, yellow-brown; abdominal segments 1–7 divided by a ventrolateral membrane. Paraprocts fused basally; male paraprocts strongly divergent apically, tapered to triangular points, cleft 9th tergum visible through integument in pre-

emergent males; female paraprocts mostly parallel, subquadrate apically. Cercus with at least 22 segments; each cercal segment with an apical circlet of 12–15 stiff setae, the longest approximately $\frac{3}{4}$ the length of the respective segment.

Diagnosis. *Zealeuctra uwaharrie* is defined in the males by having an epiproct consisting of a large, quadrate base and a prominent subapical tooth, in addition to the abdomen being marked with a sclerotized dorsal stripe. Females are characterized by having a dorsal abdominal stripe and a moderately sclerotized median lobe that is recessed half its length within the notched posterior margin of the subgenital plate.

Emended key to *Zealeuctra* males.

The following couplets from the key to *Zealeuctra* males are from Grubbs et al. (2013). New couplets are proposed to include the new species.

- 9 Epiproct comprised of two prominent spines, a large posterior spine plus an accessory anterior spine (fig. 10B, Grubbs et al. 2013) *Z. warreni* Ricker & Ross
- 9' Epiproct bearing only a small, subterminal cusp posterior to the main spine (Figs. 10–12 & 20, figs. 1B, 4C, Grubbs et al. 2013) 10
- 10 Cleft narrowly U-shaped anteriorly and divergent posteriorly with the inner margins sinuate (Figs. 7–9); currently known only from North Carolina *Z. uwaharrie* Verdone, Beaty, Holland & Kondratieff
- 10' Cleft broadly U-shaped (Fig. 21, figs. 1A, 4A, Grubbs et al. 2013); known only from Texas or widely distributed 11
- 11 Epiproct base bearing a conspicuous, slightly concave cusp anteriorly (figs. 1B–C, Grubbs et al. 2013); known only from Texas (fig. 12, Grubbs et al. 2013) *Z. arnoldi* Ricker & Ross
- 11' Epiproct base simple (Fig. 20) and lacking a prominent cusp, at most, only a very small rounded projection anteriorly (Fig. 20, fig. 4C, Grubbs et al. 2013); sporadically distributed across the central and eastern USA (fig. 11, Grubbs et al. 2013) *Z. fraxina* Ricker & Ross



Figs. 20–22. *Zealeuctra fraxina*, adult, Burden Branch, Pope Co., IL. 20. Male terga 8–10, dorsal. 21. Male terminalia, lateral. 22. Female sterna 7–10.

Remarks. Adults of *Z. uwharrie* are superficially similar to *Z. fraxina*, *Z. talladega*, and *Z. ukayodi*. Males of the new species can be distinguished by the details of the epiproct, the cleft of tergum nine, and abdominal sclerotization. The epiproct of the new species tapers to an acute tip with a sub-terminal dorsal spine (Figs. 10–12). Of the three similar species, only *Z. fraxina* has a well-developed sub-terminal spine. However, the epiproct of the new species has an expanded base

which varies from sharply quadrate to broadly rounded in lateral aspect and the anterior portion of epiproct is strongly curved relative to the base (Figs. 10–12). Whereas, in *Z. fraxina*, the epiproct base is generally triangular in lateral aspect and the anterior portion is not as strongly curved (Fig. 20).

The male of the new species is readily distinguished from *Z. fraxina* by the shape of the cleft, which is narrowly U-shaped anteriorly,



Fig. 23. Type locality, unnamed spring tributary to Little River, Montgomery Co., NC, N 35.29628, W 79.88583, 16 January 2019.

divergent posteriorly with the inner margins sinuate, and the posterior apices are truncated or rounded (Figs. 7–9). In males of *Z. fraxina*, the cleft is broadly U-shaped, the inner margins are concave, and the posteromedially directed projections on the posterior apices are sharply pointed (Fig. 21, fig. 4A, Grubbs et al. 2013). Finally, it appears that *Z. uwharrie* males are the only species of the genus that have a medial sclerotized stripe on the dorsum of the abdomen (Fig. 5).

Females of the new species are easily separated from *Z. fraxina* and *Z. talladega* by the details of sternum seven and abdominal coloration. In the new species, the notch on the posterior margin of sternum seven is shallow and the lobe projects beyond the posterior margin for over half its length (Fig. 14). Additionally, the lobe on *Z. uwharrie* is moderately sclerotized. In

females of *Z. fraxina* (Fig. 22) and *Z. talladega*, the notch on sternum seven is deep, the lobe is very lightly sclerotized and scarcely projects beyond the posterior margin of sternum seven.

Females of the new species differ from *Z. ukayodi* in the following: in *Z. ukayodi*, the lobe on sternum seven is recessed slightly, if at all. Additionally, in *Z. ukayodi*, sternum seven has a triangular pale area medially that begins near the anterior $\frac{1}{4}$ and widens posteriorly. In *Z. uwharrie*, the pale area on sternum seven is restricted to the posterior margin and the lobe is recessed up to $\frac{1}{2}$ its length (Fig. 14). Finally, the new species has a conspicuous dorsal abdominal stripe (Fig. 5), which the other species lack.

The larva of *Z. uwharrie* is only the second species of this genus to be formally described, the other being *Z. claasseni* (Frison 1929, Stewart & Stark 2002). Therefore, separation of *Z. uwharrie*

from its congeners is not recommended at this time.

Type locality. (Fig. 23). The unnamed tributary to the Little River in Montgomery County, North Carolina is a 1st order stream with a drainage area of 0.22 km². The watershed is primarily forest, but the small stream is bordered by several roads, including a gravel landing for a state-maintained boat access on the adjacent Little River. During the initial and subsequent collections in January 2019, we observed one spring source within the stream channel. The water temperature at the spring source was 9.1°C. In-stream habitat consisted of stepped pools containing a mix of boulder, cobble, gravel and silt. Riparian vegetation included American holly (*Ilex opaca* Aiton), American beech (*Fagus grandifolia* Ehrh.) and Christmas fern (*Polystichum acrostichoides* (Michx.) Schott).

Biological notes. *Zealeuctra uwaharrie* is currently known from eight locations in the vicinity of Uwharrie National Forest in the Carolina Slate Belt of North Carolina. The Slate Belt consists predominantly of low water-yielding rocks (Daniel 1989); consequently, streams in this area are prone to reduced flows and may dry up in the summer months (Griffith et al. 2002, Beaty et al. 2017). The new species has been documented from 1st–2nd order streams with drainage areas ranging from 0.22–6.81 km². The elevation range of occurrence localities is approximately 74–147m. Water temperature taken at four locations at the time of collection ranged from 7.0°–9.4° C. In 2019, adults were active from mid-January to at least mid-March. Larvae were difficult to collect, and an inordinate amount of time was spent looking for the few larvae that were obtained. Like other *Zealeuctra* (Snellen & Stewart 1979), *Z. uwaharrie* may inhabit the hyporheic zone until just prior to emergence. Additional stonefly species often collected in association with *Z. uwaharrie* were *Allocaupnia wrayi* Ross, 1964 and *A. rickeri* Frison, 1942, two species commonly collected in the region.

Although records of *Zealeuctra* east of the Appalachians are few, the range extension presented by this new species is perhaps unsurprising considering *Zealeuctra* are typically

found in spring-fed streams that traverse hilly terrain and exhibit seasonally low flows or drying (Ricker 1952, Snellen & Stewart 1979). Two other recently described *Zealeuctra*, *Z. talladega*, and *Z. ukayodi* also occur in low-elevation southern Appalachian landscapes.

ACKNOWLEDGEMENTS

We thank Eric Fleek, taxonomist in the North Carolina's Biological Assessment Branch, for his support and assistance in the field. We also thank Dr. S.A. Grubbs, Western Kentucky University, Bowling Green, Kentucky, and Dr. R.E. DeWalt, Illinois Natural History Survey, Champaign, Illinois, for making comparative material available, and Dr. Patrick McCurdy, Colorado State University, Fort Collins, Colorado, for his guidance with scanning electron microscopy.

REFERENCES

- Beaty, S.R., V.B. Holland & D.R. Lenat. 2017. *Isoperla arcana* and *Isoperla borisi* (Plecoptera: Perlodidae), two new stonefly species from North Carolina, U.S.A. with notes on the distribution of *Isoperla powhatan*. *Illiesia*, 13(14):140–166. <http://illiesia.speciesfile.org/papers/Illiesia13-14.pdf>
- Daniel, C.C. 1989. Statistical analysis relating well yield to construction practices and siting of wells in the Piedmont and Blue Ridge provinces of North Carolina. US Geological Survey, Water-Supply Paper, 2341-a, 27 pp.
- DeWalt, R.E., M.D. Maehr, U. Neu-Becker, & G. Stueber. 2019. Plecoptera Species File Online. Version 5.0/5.0. Accessed 5 February 2019. <http://Plecoptera.SpeciesFile.org/>
- Environmental Systems Research Institute (ESRI). 2016. ArcGIS Release 10.4.1. Redlands, California.
- Frison, T.H. 1929. Fall and winter stoneflies, or Plecoptera, of Illinois. Illinois Natural History Survey Bulletin, 18(02):345–409.
- Griffith, G., J. Omernik, & J. Comstock. 2002. Ecoregions of North Carolina regional descriptions. US Environmental Protection Agency, Corvallis, Oregon, USA.
- Grubbs, S.A. 2005. *Zealeuctra talladega*, a new

- species of Leuctridae (Plecoptera) from Alabama, U.S.A. *Illiesia*, 1:40–42.
<http://illiesia.speciesfile.org/papers/Illiesia01-06.pdf>
- Grubbs, S.A., B.C. Kondratieff, B.P. Stark, & R.E. DeWalt. 2013. A review of the Nearctic genus *Zealeuctra* Ricker (Plecoptera, Leuctridae), with the description of a new species from Cumberland Plateau region of eastern North America. *ZooKeys*, 344:17–47.
- Kondratieff, B.C., R.F. Kirchner, & D.L. Lenat. 1995. A review of stonefly records (Plecoptera: Hexapoda) of North Carolina and South Carolina. *Brimleyana*, 23:25–40.
- Kondratieff, B.C., C.J. Verdone, & S. Roble. 2017. New records of stoneflies (Plecoptera) from Virginia, U.S.A. Pp. 22–27. *In*: Perla. Kondratieff B.C. (ed.) *Perla*, 35. Fort Collins, Colorado, U.S.A. 47 pp.
- Ricker, W.E. 1952. Systematic studies in Plecoptera. Indiana University Publications, Science Series No. 18. Indiana University Press, Bloomington, Indiana. 200 pp.
- Ricker, W.E. & H.H. Ross. 1969. The genus *Zealeuctra* and its position in the family Leuctridae (Plecoptera, Insecta). *Canadian Journal of Zoology* 47:1113–1127.
- Rios, N.E. & H.L. Bart. 2010. GEOLocate (Version 3.22) [Computer software]. Belle Chasse, LA: Tulane University Museum of Natural History.
- Snellen, R.K. & K.W. Stewart. 1979. The life cycle and drumming behavior of *Zealeuctra claasseni* (Frison) and *Zealeuctra hitei* Ricker and Ross (Plecoptera: Leuctridae) in Texas, USA. *Aquatic Insects*, 1(2):65–89.
- Stark, B.P. 2017. Chapter 3, Plecoptera. Pp. 161–247. *In*: Larvae of the southeastern USA mayfly, stonefly, and caddisfly species (Ephemeroptera, Plecoptera, and Trichoptera). Morse, J. C., W. P. McCafferty, B.P. Stark and L.M. Jacobus (eds.) *Biota of South Carolina*. Vol. 9. Clemson University Public Publishing, Clemson University, Clemson, South Carolina, USA. 482 pp.
- Stewart, K.W. & B.P. Stark. 2002. Nymphs of North American stonefly genera, 2nd ed. The Caddis Press. Columbus, Ohio. xii + 510 pp.
- Stark, B.P., K.W. Stewart, S.W. Szczytko, R.W. Baumann, & B.C. Kondratieff, B.C. 2012. Scientific and common names of stoneflies of Nearctic stoneflies (Plecoptera), with corrections and additions to the list. *Caddis Press, Miscellaneous Contributions 1*, 1–20."
- US Environmental Protection Agency (USEPA). 2019. Level III and IV ecoregions of the continental United States. US Environmental Protection Agency. <https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states>
- Verdone, C.J. & B.C. Kondratieff. 2018. Holomorphology and systematics of the eastern Nearctic stonefly genus *Remenus* Ricker (Plecoptera: Perlodidae). *Illiesia*, 14(05):81–125.
<http://illiesia.speciesfile.org/papers/Illiesia14-5.pdf>
- Verdone, C.J., B.C. Kondratieff, R.E. DeWalt, & E.J. South. 2017. Studies on the stoneflies of Georgia with the description of a new species of *Soyedina* Ricker, new state records and an annotated checklist. *Illiesia*, 13(3):30–49.
<http://illiesia.speciesfile.org/papers/Illiesia13-03.pdf>

Submitted 29 March 2019, Accepted 13 May 2019, Published 17 June 2019

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