A review of the Nearctic genus Zealeuctra Ricker (Plecoptera, Leuctridae), with the description of a new species from the Cumberland Plateau region of eastern North America

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Abstract

The stonefly genus Zealeuctra (Plecoptera: Leuctridae) is endemic to the central and eastern Nearctic regions and is presently comprised of 10 species. Scanning electron microscopy (SEM) was used to examine and redescribe two important diagnostic features typically used to identify and define the adult male stage: the large, anteriorly-recurved epiproct and the medial cleft of the ninth abdominal tergite. SEM was also employed to depict the posteromedial portion of female 7\(^{th}\) sternum. A new species, *Z. ukayodi* sp. n., is described from the Cumberland Plateau region of northeastern Alabama and Tennessee. The new species appears superficially similar to *Z. talladega* Grubbs, but is easily differentiated by characteristics of the male medial cleft. An updated taxonomic key to the males of *Zealeuctra* is provided.
Keywords
Plecoptera, Leuctridae, Zealeuctra, new species, North America

Introduction


Zealeuctra is endemic to the central and eastern Nearctic regions, and is typically associated with intermittent or temporary upland streams (Snellen and Stewart 1979; Stewart and Stark 2002). Zealeuctra claasseni and Z. fraxina are the only species distributed broadly. In contrast, three species are found mainly in the Texas Hill Country region (Z. arnoldi, Z. hitei, and Z. stewarti), three species are regional endemics within the Interior Plateau region (Z. cherokee, Z. wachita, and Z. warreni), Z. narfi is distributed from Arkansas and Missouri north to Wisconsin, and Z. talladega is known only from the Talladega Mountains region in eastern Alabama.

Zealeuctra exhibits several unique characteristics in the adult stage, namely the swollen male cerci with accessory humps and/or spines, the male ninth tergite bearing a conspicuous medial depression (i.e. “cleft”), and the female seventh sternite having a posteromedial lobe (although secondarily lost in two species; Ricker and Ross 1969). The two diagnostic features typically used to identify and distinguish between males are the (1) large, anteriorly-recurved epiproct and the (2) shape and sclerotization patterns of the cleft. The shape and arrangement of cercal lobes/spines can also aid with identifications (e.g. Poulton and Stewart 1991). In addition, the fused subanal plate-anal probe structure appears to offer diagnostic information yet this has not been fully studied. Identifying females to species is markedly easier if associated males are present. Females are identified by the hind margin of the seventh abdominal sternite, notably the (a) presence or absence of a central notch and lobe and (b) shape of the “shoulders” if a notch is present. Zealeuctra nymphs are uncommon in collections and only one species has been described in detail (Z. claasseni; Stewart and Stark 2002).

In this study scanning electron microscopy (SEM) was employed to examine two diagnostic features of Zealeuctra males, focusing on the epiproct and the abdominal cleft. The posteromedial portion of the female seventh abdominal segment is also depicted with SEM micrographs. A new species is described herein and an updated taxonomic key to the males of Zealeuctra is provided.
Materials and methods

Most of the Zealeuctra specimens examined in this study were obtained from the Monte L. Bean Museum, Brigham Young University, Provo, Utah, USA (BYUC), C.P. Gillette Museum, Colorado State University, Fort Collins, Colorado, USA (CSUC), S.A. Grubbs collection, Western Kentucky University, Bowling Green, Kentucky, USA (WKUC), B.P. Stark Collection, Mississippi College, Clinton, Mississippi, USA (BPSC), and the Illinois Natural History Survey, Champaign-Urbana, Illinois, USA (INHS). Other codens used were TAMU (Texas A&M University Insect Collection, College Station, Texas, USA), and USNM (National Museum of Natural History, Smithsonian Institute, Washington D.C., USA). Location data (in decimal degrees) for each specimen record were recorded either directly with portable GPS units or georeferenced from vial label data (if possible).

Specimens for SEM analyses were dehydrated through a series of 75%, 90%, 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 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.

Results and discussion

Ricker and Ross (1969, their figure 29) placed Zealeuctra in a polytomy with Paraleuctra Hanson, 1941, Rhopalopsole Klapálek, 1912, and Leuctra divisa Hitchcock, 1958 (the latter is now included in Paraleuctra (Stark & Kyzar, 2001)). They postulated that these taxa were grouped by two synapomorphies: females with an incomplete 10th abdominal sternite and the presence of membranous pleural folds on larval abdominal segments 1–6 (shared also by Moselia Ricker, 1943, (Stewart and Stark 2002)). Ricker and Ross (1969, their figure 28) proposed that the seven species of Zealeuctra recognized at that time were derived from a series of three basal ancestors, and that Z. narfi was the most ancestral species.

Testing Ricker and Ross’s (1969) hypotheses, however, and assessing how those species described since 1970 fit within an evolutionary framework is mostly beyond the scope of this paper. This would require a comparative morphological assessment of the fused subanal plates-anal probe structure, and arguably more importantly, a modern and robust phylogenetic analysis using molecular techniques (e.g. mitochondrial cytochrome c oxidase I gene sequencing).

An updated taxonomic key to the males of Zealeuctra is provided, and a new Zealeuctra species is described herein from the Cumberland Plateau region of southern Tennessee and northeastern Alabama.
Key to Zealeuctra males, modified in part from Ricker and Ross (1969) and Poulton and Stewart (1991)

1  Cleft (=medial depression) tapering and V-shaped, especially in anterior half (Figs 3A–D, 5A) ................................................................. 2
   – Cleft distinctly U-shaped in anterior half (Figs 1A, 4A, 9A).......................... 3

2  Epiproct with a broad triangular base (Figs 3E–H); inner margins of cleft bearing several medial crenulations (Figs 3A–D); widespread distribution across the eastern and central USA (Fig. 12) .................. Z. claasseni (Frison)
   – Epiproct base narrowly triangular and with a minor shelf-like anterior projection (Figure 5B); inner margins of cleft lacking crenulations and with only a single tooth-like medial projection in posterior half (Fig. 5A); known mainly from central Texas (Fig. 11) ................................. Z. hitei Ricker & Ross

3  Distal portion of epiproct with only one spine (Figs 2B, 8D, 9C) ................. 4
   – Distal portion of epiproct comprised of two distinct spines (Fig. 4B) or one prominent spine plus a prominent, accessory posterior cusp (Figs 1C, 10B)....... 9

4  Epiproct spine very long and slender (Kondratieff and Zuellig 2004, their fig. 2); endemic to south-central Texas (Fig. 13) ........................................ Z. stewarti Kondratieff & Zuellig
   – Epiproct spine markedly shorter, either lacking (Figs 2B, 6C, 9C) or bearing a prominent anterior shelf-like projection at base (Fig. 7E–F, 8C–E)............ 5

5  Epiproct bearing a prominent shelf-like projection at base, either rounded and subquadrate (Figs 6F, 8C–8D) or angular and squarish (Figs 7D–D, 8E)..... 6
   – Epiproct base not as above (Figs 2B, 6C, 9C) ............................................. 7

6  Inner margins of cleft sinuous, without crenulations along inner margins (Figs 7A–7C); anterior, recurved portion of epiproct possessing a minute, medially-positioned hump (Figs 7D–F); known only from the southern Talladega Mountains region of eastern Alabama (Fig. 13) ....... Z. talladega Grubbs
   – Inner margins of cleft V-shaped to almost sinuous, bearing several large crenulations along inner margins on posterior half (Figs 8A–B); anterior, recurved portion of epiproct possessing a medial hump (Figs 8C–E); distributed across the southern Cumberland Plateau region from central Tennessee south to northeastern Alabama (Fig. 13) ...................... Z. ukayodi Grubbs, sp. n.

7  Anterior portion of cleft with a secondary U-shaped extension, with inner margins set apart from remainder of cleft, medial subtruncate thumb-like projections present at terminus of cleft (Fig. 9A); epiproct anteriorly recurved gradually from base to tip (Fig. 9C) .................. Z. wachita Ricker & Ross
   – Cleft U-shaped, with margins concave and contiguous throughout entire length, two medially-projected terminal processes present at terminus of cleft (Figs 2A, 6A); epiproct recurved abruptly, ca. 90° degree angle anteriorly (Figs 2B, 6C)................ 8

8  Epiproct with a small, thickened, shelf-like structure posteriorly (Fig. 2B) ..... Z. cherokee Stark & Stewart
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Zealeuctra arnoldi Ricker & Ross
http://species-id.net/wiki/Zealeuctra_arnoldi
Figs 1, 12

Zealeuctra arnoldi Ricker & Ross, 1969: 1114. Holotype ♂ (INHS), Sorrell Creek, 1 mi S of Hancock, Comal Co., Texas

**Description. Male - abdominal tergal cleft.** Simple in outline. Anterior portion wide and broadly U-shaped, with a nearly straight terminal margin (Fig. 1A). Posterior portion narrowing slightly with no medial projections and only scarcely visible crenulations along inner margins.

**Male - epiproct.** Base short and robust, narrowing slightly to a short, recurved, subtriangular spine (Figs 1B–C). A short, slightly concave projection extends anteriorly from the base to approximately the same plane as the spine. Base with bulbous posterior swelling, spine with small accessory posterior cusp that is low and nub-like.

**Female - 7th sternum.** Seventh sternum with a large, subquadrate lobe nested in a distinct, central notch. The notch is bordered laterally by large, convex “shoulders” (Fig. 1D).


**Distribution.** USA: TX (DeWalt et al. 2012)
Remarks. This species is somewhat superficially similar to *Z. fraxina*. Males are easily identified by the combination of the simple, U-shaped cleft and the presence of the anterior, concave cusp present at the base of the short, compact epiproct spine. The depiction of the posterior cusp as pointed and acute in Ricker and Ross (1969, their Fig. 2) is not accurate and typically not visible. The cusp tends to be low and nub-like. This species is known mainly from the Edwards Plateau of west-central Texas (Fig. 12).

*Zealeuctra cherokee* Stark & Stewart  
http://species-id.net/wiki/Zealeuctra_cherokee  
Figs 2, 14

*Zealeuctra cherokee* Stark & Stewart, 1973: 192. Holotype ♂ (USNM), 2 mi W Vian, Sequoyah Co., Oklahoma

**Description.** Male - abdominal tergal cleft. Anterior portion U-shaped and very broadly rounded, posterior portion narrowing distally to a pair of medial projections,
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the terminal projection larger, subtruncate, and thumb-like, the subterminal projection smaller and subtriangular (Fig. 2A). Crenulations absent from inner margins of cleft.

**Male - epiproct.** Broad at base, extending posteriorly along one plane then extended abruptly and dorsally at a ca. 90 degree angle (Fig. 2B), spine tip slightly recurved anteriorly. No accessory spine or cusp present.

**Female - 7th sternum.** Seventh sternum with a small, subtriangular lobe nested in a distinct central notch (Fig. 2C).


**Distribution.** USA: AR, OK (DeWalt et al. 2012)

**Remarks.** The cleft and epiproct spine of the male of this species are very similar to that of *Z. narfi*. The major difference for *Z. cherokee* is the presence of the posterior thickening along the recurved portion of the epiproct spine, and additionally, the subtruncate terminal medial processes at the posterior end of the cleft. The ranges of these two species broadly overlap in Arkansas and eastern Oklahoma (Fig. 14; Poulton and Stewart 1991).

**Zealeuctra claasseni** (Frison)

http://species-id.net/wiki/Zealeuctra_claasseni

Figs 3, 12


*Zealeuctra claasseni* Illies, 1966: 120.


**Description. Male - abdominal tergal cleft.** Anterior portion V-shaped with slight inward medial swelling but lacking crenulations along inner margins, anterior terminus very narrowly rounded (Figs 3A–D). Posterior portion slightly more U-shaped with several irregularly-sized and rounded teeth projecting medially.

**Male - epiproct.** Triangular base narrowing to anteriorly-recurved and tapering terminal spine, no accessory spine or swelling present (Figs 3E–H). Conspicuous tubercles located on the anterior margins of the triangular base. No accessory spine or cusp present.

**Female - 7th sternum.** Seventh sternum with a small, variably-shaped lobe nested in a small central notch (Figs 3I–3L). The lobe ranges in shape from somewhat quadrate to broadly convex. The notch is likewise variably shaped, from essentially straight and scarcely perceptible (Figs 3I, 3K) to slightly concave (Figs 3J, 3L). Posterior margin essentially straight.

**Material examined. USA, Arkansas:** Baxter Co., High Tower Creek, Hwy 126 S of Monkey Run, 36.3369, -92.4743, 16.III.2002, B.C. Kondratieff and R.E. Zuellig, 31♂, 24♀ (CSUC); Logan Co., West Fork Hegwood Creek, Hwy 22, 3 mi E Paris, 35.2950, -93.6782, 21.III.1984, B.C. Poulton, 2♂, 3♀ (BYUC); Newton Co., Buffalo River, Hwy 21 bridge S of Boxley, 35.9610, -93.4042, 10.III.2002, B.C. Kondratieff and R.E. Zuellig, 8♂, 3♀ (CSUC). **Illinois:** Alexander Co., tributary to Sandy Creek, 4.8 km WNW Tamms, 37.2450, -89.3210, 25.IV.2001, D.W. Webb, ♂, ♀ (INHS); Hardin Co., Threemile Creek, 6.5 km WNW Elizabethtown, 5.IV.2000, R. E. DeWalt, ♂, ♀ (INHS); Jackson Co., tributary to Big Muddy River, Clear Springs Picnic Area, 3.5 km ESE Howardton, 37.6234, -89.4255, 7.IV.1992, M.A. Harris and M.J. Wetzel, ♂, ♀ (INHS); Pope Co., Burden Branch, Burden Falls, Shawnee National Forest, 37.5633, -88.6424, 20.IV.1992, D.W. Webb and M.A. Harris, ♂, 3♀ (INHS); Dog Creek, 9 km NW Hamletsburg at CR 1, Shawnee National Forest, 37.2041, -88.4914, 10.III.2011, R.E. DeWalt and M.R. Jeffords, 17♂, 9♀ (INHS); Gibbons Creek, 0.8 km N Herod, 37.5842, -88.4422, 5.IV.2000, R.E. DeWalt, ♂ (INHS); tributary to Lusk Creek, 0.8 km N Rising Sun, 37.4156, -88.5797, 28.III.2006, R.E. DeWalt, 3♂, 6♀ (INHS); Lusk Creek, SE of Eddyville, 37.4729, -88.5472, 28.III.2006, R.E. DeWalt, ♂, 3♀ (INHS). **Indiana:** Brown Co., Jackson Creek, 8 km W
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-86.5109, 22.II.1999, B.C. Kondratieff and R.F. Kirchner, ♂, ♀ (CSUC); Hancock Co., tributary to North Branch South Fork Panther Creek, Rte. 1700, 10 km N Fordsville, 37.7246, -86.6737, 16.III.2002, S.A. Grubbs, ♂, 4♀ (WKUC); Marion Co., Sulfur Lick Creek, 6 km SE New Hope at Sulfur Lick Rd., 37.5876, -85.4993, 11.IV.2009, R.E. DeWalt and E.T. Chabot, ♂, 5♀ (INHS); Metcalfe Co., East Fork Little Barren River, Delk Branch Road, 12 km N Marrowbone, 36.9387, -85.5075, 27.III.2013, S.A. Grubbs and J.M. Yates, 2♂, ♀ (WKUC); tributary to East Fork Little Barren River, Reese Hurt Road, 12.5 km N Marrowbone, 36.9457, -85.5188,

Figures 3. Continued.
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Distribution. USA: AL, AR, IL, IN, KS, KY, MO, OK, OH, TN, TX, WV (DeWalt et al. 2012)

Remarks. Despite the broad distribution (Fig. 12), there appears to the little variation in the general features of the cleft. Only a minor degree of variation is evident in the epiproct, particular in the size and shape of the triangular base. Ricker and Ross (1969, their fig. 20) and Poulton and Stewart (1991, their fig. 112) depicted an epiproct base that is markedly broader than what is shown here with SEM micrographs.

**Zealeuctra fraxina** Ricker & Ross

http://species-id.net/wiki/Zealeuctra_fraxina
Figs 4, 11

**Zealeuctra fraxina** Ricker & Ross, 1969: 1117. Holotype ♂ (INHS), 5 mi S Hardinsburg, Breckinridge Co., Kentucky

Description. Male - abdominal tergal cleft. Anterior portion wide and very broadly U-shaped, posterior portion also broadly rounded and bearing a slightly-concave serrated medial projection (Fig. 4A). Crenulations absent from inner margins of cleft.

Male - epiproct. Triangular base narrowing somewhat to an anteriorly-recurved and tapering terminal spine; a small accessory posterior spine is present but manifested only as a cusp-like projection on some specimens (Fig. 4B).

Female - 7th sternum. Seventh sternum with a large, convex lobe nested in a distinct, central notch. The notch is bordered laterally by large, convex “shoulders” (Fig. 4C).

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A review of the Nearctic genus Zealeuctra Ricker (Plecoptera, Leuctridae)...


Tennessee: Sumner Co., tributary to Bledsoe Creek, Leaths Hollow Church Rd., 36.5153, -86.2437, 23.II.1998, B.C. Kondratieff and R.F. Kirchner, ♂ (CSUC); tributary to Little Trammel Creek, Sugar Grove, 36.6239, -86.2679, 22.II.1999, B.C. Kondratieff and R.F. Kirchner, 8♂, 8♀ (BPSC, BYUC); Little Trammel Creek, Rte. 174, nr. Sugar Grove, 36.6239, -86.2679, 18.I.2010, S.A. Grubbs, 2♂ (WKUC).


Distribution. USA: AL (Grubbs 2006), IL, IN, KY, NJ, OH, PA, TN, WV (DeWalt et al. 2012), VA (new state record)

Remarks. Only Z. claasseni is distributed more broadly across the central and eastern US than Z. fraxina (Fig. 11; DeWalt et al. 2012). Additionally, this is one of only two species, Z. talladega being the other, that occur in the Appalachian Mountains. The Virginia record noted above was collected along the margins of Peaks of Otter Lake, but surprisingly several hundred meters from the nearest inlet or the only outlet (Little Stony Creek). Zealeuctra fraxina and Z. arnoldi are the only two species that bear a small subterminal cusp posterior to the tapering epiproct spine. Ricker and Ross (1969, their fig. 28) speculated that these two species, plus Z. wachita, share a common ancestor.

Zealeuctra hitei Ricker & Ross

http://species-id.net/wiki/Zealeuctra_hitei

Figs 5, 11

Zealeuctra hitei Ricker & Ross, 1969: 1118. Holotype ♂ (INHS), 3 mi S Johnson City, Blanco Co., Texas

Description. Male - abdominal tergal cleft. Anterior portion nearly identical to Z. claasseni, with slight inward medial swelling but no apparent crenulations along inner margins (Fig. 5A). Posterior portion slightly more U-shaped with paired medially-projected processes, the terminal projection larger, convex, and thumb-like, the sub-terminal projection smaller and subtriangular.
Male - epiproct. Base slender and triangular, narrowing to anteriorly-recurved and tapering terminal spine, no accessory spine present (Fig. 5B). A small “step” (sensu Ricker and Ross 1969) demarks the base from the tapering spine. No accessory spine or cusp present.

Female - 7th sternum. Seventh sternum with a small, subtriangular lobe nested in a scarcely-concave central notch (Fig. 5C). Posterior margin essentially straight.


Distribution. USA: TX (DeWalt et al. 2012)
Remarks. The form of the cleft of this species is nearly identical to *Z. claasseni*, and the epiproct is essentially a narrower form of that exhibited by *Z. claasseni*. Ricker and Ross (1969, their fig. 28) speculated that these two species share a common ancestor.

Zealeuctra narfi Ricker & Ross
http://species-id.net/wiki/Zealeuctra_narfi
Fig. 6, 14

*Zealeuctra narfi* Ricker & Ross, 1969: 1118. Holotype ♂ (INHS), Otter Creek, Sauk Co., Wisconsin

**Description. Male - abdominal tergal cleft.** Anterior portion U-shaped and tapering slightly to a broadly-rounded anterior terminus (Fig. 6A). Posterior portion markedly narrower than anterior portion, with a pair of medially-projected processes (Figs 6A–B), the terminal projection larger, subtruncate, and thumb-like, the subterminal projection smaller and subtriangular.

**Male - epiproct.** Base broad and slightly-directed posterodorsally, tip of spine directed abruptly and anteriorly at ca. 90° angle from base, tapering and gently recurved anteriorly (Figs 6B–C). No accessory spine or cusp present.

**Female - 7th sternum.** Seventh sternum with a broadly-subquadrate lobe nested in a scarcely-convex central notch (Fig. 6D). Posterior margins essentially straight.


**Distribution.** USA: AR, IL, MO, OK, WI (DeWalt et al. 2012)

**Remarks.** Although the type locality for *Z. narfi* is in southern Wisconsin, this species is common and widespread only in the southern portion of its range, and par-
particularly in southern Missouri (Fig. 14). There are only three known locations for *Z. narfi* in Wisconsin (DeWalt unpublished data) and is likewise uncommon in Illinois, with only three collected localities between 1976 and 2000 (Webb 2002). There have also been several failed attempts by the senior author to locate this species in western and southern Indiana.

**Zealeuctra stewarti** Kondratieff & Zuellig
http://species-id.net/wiki/Zealeuctra_stewarti
Fig. 13

*Zealeuctra stewarti* Kondratieff & Zuellig, 2004: 840. Holotype ♂ (TAMU), 5.2 mi E Leakey, Real Co., Texas

**Description. Male - abdominal tergal cleft.** Anterior portion broadly U-shaped and parallel-sided. Posterior portion V-shaped, with small crenulations evident along inner...
margins, terminating posteriorly with paired, subtriangular, medially-projected extensions (Kondratieff and Zuellig 2004, their Fig. 1)

**Male - epiproct.** Epiproct spine long, slender, and gently-recurved anteriorly (Kondratieff and Zuellig 2004; their fig. 2). No accessory spine or cusp present.

**Female - 7th sternum.** Seventh sternum lacking medial lobe, with posteromedial portion overlapping as a slightly-notched, subtruncate flap onto anteromedial margin of the eighth sternum Kondratieff and Zuellig 2004; their fig. 3).


**Distribution.** USA: TX (DeWalt et al. 2012)

**Remarks.** This is easily the rarest of the *Zealeuctra* species, currently known only from two streams within a very small geographic area in the Texas Hill Country region (Fig. 13; Kondratieff and Zuellig 2004), overlapping in range and adult flight periods only with *Z. arnoldi*. The long and very slender epiproct spine exhibited by *Z. stewarti* is unique and easily distinguished from all members of this genus. In addition, the females of *Z. stewarti* and *Z. warreni* are the only two *Zealeuctra* species lacking a posterior lobe nested in central notch and where the posteromedial portion of the 7th sternum is flap-like and extending over the anteromedial margin of the 8th sternum.

**Zealeuctra talladega** Grubbs

http://species-id.net/wiki/Zealeuctra_talladega

Figs 7, 13

*Zealeuctra talladega* Grubbs, 2005: 40. Holotype ♂ (INHS), tributary to Barbaree Creek, 22 km E Talladega, Clay Co., Alabama

**Description.** **Male - abdominal tergal cleft.** Anterior portion is near parallel-sided, U-shaped, and broadly rounded along anterior margin (Figs 7A–C). Posterior portion is somewhat V-shaped and sinuous along inner margins, posterior terminus marked by either a single (Fig. 7C) or paired (Figs 7A–8B) medially-directed subtriangular projections. Crenulations absent from inner margins of cleft.

**Male - epiproct.** Base very broad and subquadrate in shape, narrowing to anteriorly-recurved and broadly tapering terminal spine, no accessory spine present although a small subterminal posterior nub may be present (Figs 7D–F). Subquadrate base varies from rounded broadly to right angular in shape. No accessory spine or cusp present, but a minute, very low, medially-positioned hump is present along the anterior, recurved portion of epiproct (Figs 7D–F).

**Female - 7th sternum.** Seventh sternum with a small, lobe nested in a scarcely-convex central notch. Lobe ranges in shape from subtriangular (Fig. 7G) to convex (Fig. 7H). Posterior margin moderately convex.

Material examined. USA, Alabama: Clay Co., tributary to Barbaree Creek, 22 km E Talladega, Talladega National Forest, 33.4187, -85.8706, 16.II.2003, S.A. Grubbs and D.K. King, 2♂, 2♀ (WKUC – paratypes); same but 5.III.2012, S.A. Grubbs, 1♂, 4♀ (WKUC); Swept Creek, Talladega National Forest, 33.2602, -86.1006, 23.I.2006, A.L. Sheldon, 1♀ (WKUC); tributary to Swept Creek, Talladega National Forest, 33.2595, -86.1031, 23.I.2006, A.L. Sheldon, 3♂, 6♀ (WKUC);
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Distribution. USA: AL (DeWalt et al. 2012)

Remarks. This species is known only from the southern Talladega Mountains region of eastern Alabama (Fig. 13), the southern terminus of the Appalachian Moun-

Figures 7. Continued
tains. Extensive collecting efforts by both the author and Dr. Andrew Sheldon since 2005 have yet to produce localities north from the two counties (Clay and Talladega) where this species has been obtained.

**Zealeuctra ukayodi** Grubbs, sp. n.
http://zoobank.org/7D5A6F56-AA11-458D-868B-CB7654BFD8C8
http://species-id.net/wiki/Zealeuctra_ukayodi
Figs 8, 13

**Description. Male.** Forewing length 6.5–7.0 mm; body length 5.0–5.5 mm. General body color brown.

Anterior portion of male abdominal tergal cleft is narrowly U-shaped, and rounded along the anterior terminus. The posterior portion is widest anteriorly with crenulations present along inner margins. Overall shape of cleft ranges from either V-shaped to somewhat sinuous (Figs 8A–B, I). Epiproct base very broad and subquadrate in shape, narrowing to anteriorly-recurved and broadly tapering terminal spine, no accessory spine present (Figs 8C–E). Subquadrate base varies in from rounded broadly to right angular in shape. No accessory spine or cusp present. Cerci sclerotized mainly along outer margin and bearing a small dorsomedial hump and a subapical, triangular sclerotized tooth (Figs 8G–I). Length of vesicle ca. 1.5× width.

**Female.** Forewing length 7.5–8.0 mm; body length 6.0–8.0 mm. General body color brown. Seventh sternum with a quadrate sclerotized region, convex posteriorly, and scarcely projecting over the anterior portion of the eighth sternum (Fig. 8I); posteromedial portion unpigmented and very slightly notched, bearing a lightly-pigmented lobe that is convex posteriorly (Figs 8F, I).

**Nymph.** Unknown.

**Material examined.** Holotype ♂, in 95% ethyl alcohol, USA, Alabama, Jackson Co., Poplar Spring, 6 km SW Hytop, 34.8779, -86.1283, 19.II.2007, S.A. Grubbs (INHS). Paratypes: same as Holotype, 19.II.2007, S.A. Grubbs, 4♂, 7♀ (WKUC); same as Holotype but 16.III.2008, S.A. Grubbs, 13♂, 30♀ (INHS, WKUC). Tennessee: Cumberland Co., North Fork Elmore Creek, TN Rte. 298, 36.1037, -84.9414, 9.II.1998, B.C. Kondratieff and R.F. Kirchner, 2♂, 4♀ (CSUC); Grundy Co., tributary to Elk River, Rte. 50, 14 km N Monteagle, 35.3578, -85.8363, 12.II.2007, S.A. Grubbs, 2♂, 2♀ (WKUC); Marion Co., tributary to Cross Creek, 17 km NW South Pittsburg, Franklin-Marion State Forest, 35.0847, -85.8673, 12.II.2007, S.A. Grubbs, 2♂ (WKUC); tributary to Sweeten Creek, 15 km NW South Pittsburg, Franklin-Marion State Forest, 35.0827, -85.8391, 12.II.2007, S.A. Grubbs, 2♀ (WKUC); tributary to Sweeten Creek, 15 km NW South Pittsburg, Franklin-Marion State Forest, 35.0942, -85.8600, 8.II.2013, S.A. Grubbs, 3♂, 17♀ (WKUC); Cave Springs Creek, Franklin-Marion State Forest, 35.0764, -85.8427, 25.II.2007, A.L. Sheldon, ♂, ♀ (WKUC).

**Etymology.** The specific epithet is a Cherokee word for “dry”, a figurative reference to the temporary stream habitat characteristic of this species. Cherokee Native Americans formerly inhabited the southern Cumberland Plateau region.

**Diagnosis.** The species is similar only to the cognate *Z. talladega*, and these two species can be separated mainly by characteristics of the male cleft. In *Z. talladega*, the
cleft is highly sinuous or hourglass in shape and lacks the large crenulations along the inner margins. In *Z. ukayodi*, the cleft ranges from broadly V-shaped to somewhat sinuous, with large, conspicuous crenulations present along the inner margins of the posterior portion. Variation in the shape of the epiproct, namely the anterior quadrate or subquadrate shelf, overlaps between the two species. There is also a minute, medially-positioned hump present along the anterior, recurved portion of epiproct in *Z. talladega* (Figs 7D–F) that is lacking entirely in *Z. ukayodi* (Figs 8C–E). The fused subanal plates-anal probe of *Z. talladega* and *Z. ukayodi* appears to be highly similar in structure.

**Remarks.** *Zealeuctra ukayodi* appears to be restricted to the southern portion of the Cumberland Plateau, known at present from central Tennessee south to the type locality in northeastern Alabama (Fig. 13). The range of only one other *Zealeuctra* species, *Z. fraxina*, extends south and eastward into the Cumberland Plateau region in northeastern Alabama (Grubbs 2006). No other stonefly species have been collected at the type locality. *Allocapnia unzickeri* Ross & Yamamoto, *Oemopteryx contorta* (Needham & Claassen), and *Taeniopteryx ugola* Ricker & Ross have been obtained with *Z. ukayodi* at some of the paratype localities in Tennessee. The common name, Cumberland Needlefly, is proposed for this species (Stark et al. 2012).
Zealeuctra wachita Ricker & Ross
http://species-id.net/wiki/Zealeuctra_wachita
Figs 9, 11

Zealeuctra wachita Ricker & Ross, 1969: 1119. Holotype ♂ (INHS), Ouachita River, Polk Co., Arkansas

Description. Male - abdominal tergal cleft. Anterior portion broadly rounded, with a secondary U-shaped extension, inner margins set apart from remainder of cleft (Fig. 9A). Posterior portion markedly wider than anterior portion, interior margins rounded and lacking crenulations, terminating posteriorly as paired, large subtruncate medially-projected extensions.

Male - epiproct. Base narrow and extending laterally (Fig. 9A), spine directed at ca. 90° angle from base, tapering gradually, and recurved somewhat anteriorly (Figs 9B–C). No accessory spine or cusp present.
Female - 7th sternum. Seventh sternum with a small, subtriangular lobe nested in a slightly-concave central notch (Fig. 9D).


Distribution. USA: AR (DeWalt et al. 2012), OK (new state record).

Remarks. This is the only Zealeuctra species that has a cleft bearing a secondary anterior extension. Zealeuctra wachita appears to be easily the least common of the three Zealeuctra species endemic to the Interior Plateau region. Poulton and Stewart (1991), in their study of the stoneflies of the Ozark and Ouachita Mountains, included only two Arkansas localities for this species. In contrast, the other two regional species, Z. cherokee and Z. warreni, plus Z. claasseni and Z. narfi, are markedly more common. The Oklahoma records noted above (Fig. 11) represent new state records.

Zealeuctra warreni Ricker & Ross
http://species-id.net/wiki/Zealeuctra_warreni
Figs 10, 13

Zealeuctra warreni Ricker & Ross, 1969: 1120. Holotype ♂ (INHS), Sugar Creek, 5 mi E Hardy, Sharp Co., Arkansas

Description. Male - abdominal tergal cleft. Anterior portion broadly-rounded and U-shaped. Posterior portion V-shaped, with small crenulations evident along inner margins, terminating posteriorly with paired, subtriangular, medially-projected extensions (Fig. 10A).

Male - epiproct. Base broad and flanged laterally (Fig. 10A), with paired spines both originating from base, posterior spine ca. 2× length of anterior spine, moderately recurved anteriorly (Fig. 10B), anterior spine straight and bifurcated slightly at tip, with the paired terminal ends bearing four thick spines at tip (Fig. 10C).

Female - 7th sternum. Seventh sternum lacking medial lobe, with posteromedial portion overlapping as a broadly-triangular flap onto anteromedial margin of the eighth sternum (Fig. 10D).

Material examined. USA, Arkansas: Polk Co., Rock Creek, Hwy 71, 2 mi SW Mena, 34.5601, -94.2902, 26.X.1983, B.C. Poulton, 4♂ (CSUC); tributary to Cossatot (sic Cossatot) River, 1.5 mi S Shady off AR 375, 34.4373,-94.1281, 11.XI.1990, S.R. Moulton & K.W. Stewart, 22♂, 19♀ (BYUC); Scott Co., Johnson Creek, Hwy
A review of the Nearctic genus Zealeuctra Ricker (Plecoptera, Leuctridae)...

Distribution. USA: AR, MO, OK (DeWalt et al. 2012)

Remarks. Zealeuctra warreni males are easily distinguished from all Zealeuctra species by presence of the two prominent epiproct spines. The common name for this species, Early Needlefly (Stark et al. 2012), is apt since its November–February emergence period is earlier compared to each of the four other regional congeners (Z. cherokee, Z. claasseni, Z. narfi, and Z. wachita) in the Interior Highlands. Poulton and Stewart (1991) noted the emergence period for Z. warreni starts in November.
Figure 11. Distribution map for *Z. fraxina*, *Z. hitei*, and *Z. wachita*.

Figure 12. Distribution map for *Z. arnoldi* and *Z. claaseni*.
Figure 13. Distribution map for *Z. stewarti*, *Z. talladega*, *Z. ukayodi* sp. n., and *Z. warreni*.

Figure 14. Distribution map for *Z. cherokee* and *Z. narfi*. 
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References


Snellen RK, Stewart KW (1979) The life cycle and drumming behavior of *Zealeuctra claasseni* (Frison) and *Z. hites* Ricker and Ross (Plecoptera: Leuctridae) in Texas, USA. Aquatic Insects 2: 65–89. doi: 10.1080/01650427909360980


