Grubbs, Scott A. 2006. *Soyedina alexandria* and *S. calcarea* (Plecoptera: Nemouridae), new stonefly species from the eastern Nearctic region and notes on the life cycle of *S. calcarea*.
Illiesia, 2(6):39-49. Available online: http://www2.pms-lj.si/illiesia/Illiesia02-06.pdf

SOYEDINA ALEXANDRIA AND *S. CALCAREA* (PLECOPTERA: NEMOURIDAE), NEW STONEFLY SPECIES FROM THE EASTERN NEARCTIC REGION AND NOTES ON THE LIFE CYCLE OF *S. CALCAREA*.

Scott A. Grubbs

Department of Biology and Center for Biodiversity Studies, Western Kentucky University,
1906 College Heights Boulevard 11080, Bowling Green, KY 42101-1080, U.S.A.
E-mail: scott.grubbs@wku.edu

ABSTRACT

Two new species of eastern Nearctic Nemouridae, *Soyedina alexandria* and *S. calcarea*, are described from the karst regions of Tennessee and Kentucky, U.S.A. Illustrations and scanning electron micrographs of the male and female stages are provided and diagnostic characters separating these two species from closely-related *S. vallicularia* are presented. *Soyedina vallicularia* was studied across its broad range to address potential morphological variation, which may impede the ability to differentiate *S. alexandria* and *S. calcarea* from *S. vallicularia*. A diagnostic key is provided for the males of *S. vallicularia*, *S. alexandria*, and *S. calcarea*. Nymphs of *S. calcarea* were collected monthly over a two-year period from the Kentucky type locality and size frequency histograms of head capsule width revealed a univoltine-slow cycle. Adults emerged between February and April, and early-instar nymphs were present by May suggesting a direct hatch of eggs. The life history pattern displayed by *S. calcarea* is similar to that demonstrated by *S. vallicularia* in Quebec and Ontario.

Keywords: Plecoptera, Nemouridae, *Soyedina*, Kentucky, Tennessee, life history, univoltine

INTRODUCTION

The North American nemourid genus *Soyedina* was erected by Ricker (1952), then as a subgenus, to include six taxa belonging to four species within the once-broadly defined genus *Nemoura*. Needham & Claassen (1925), however, had recognized all six taxa as distinct species. Ricker (1952) established subspecies designation for (a) *N. (S.) carolinensis washingtoni* (Claassen) and *N. (S.) carolinensis carolinensis* (Claassen) and (b) *N. (S.) interrupta nevadensis* (Claassen) and *N. (S.) interrupta interrupta* (Claassen) due to variability in the shape of the paraproct. At that time only *N. (S.) vallicularia* (Wu) and *N. (S.) producta* (Claassen) were afforded full specific status. Baumann & Gaufin (1971) described *N. (S.) potteri* and Illies (1966) elevated all subspecies to species and *Soyedina* to genus status. Two species have since been described: *S. kondratieffi* and *S. merritti* (Baumann & Grubbs 1996).

A new species of *Soyedina* was discovered while studying comparative life cycles of stoneflies inhabiting an intermittent stream–perennial spring continuum in the karst region of central Kentucky (Grubbs et al. 2005, 2006). The new species appeared closely related only to *S. vallicularia*, prompting the need for examination of potential morphological variation of *S. vallicularia* both across its broad range and within the immediate region where the new species was collected. In addition, recent collection of *Soyedina* in Tennessee revealed a second new species. Morphological terms follow Baumann (1975) and Baumann & Grubbs (1996). The type material is deposited in the Illinois Natural History Society (INHS), Western Kentucky University (WKU), and Brigham Young University (BYU). Additional material studied is deposited in the R.F. Kirchner collection (RFK) and at the University of Iowa Hygienic Laboratory (UI).

MATERIAL AND METHODS

Scanning electron microscopy

Males were prepared for scanning electronic microscopy by transferring abdominal terminalia to 95% ETOH for 30 minutes and then through a double wash of 100% ETOH for 30 minutes each. Specimens were then transferred either (a) to a 100% ETOH-immersed basket in a Tousimis Samdri-790 Critical Point Dryer or (b) placed in two 30-minute washes of hexamethlydisilizane. The dehydrated terminalia were attached to aluminum stubs and sputter-coated with gold with an Emscope SC500. Specimens were examined with a Jeol JSM-5400LV Scanning Electron Microscope.

Life cycle study

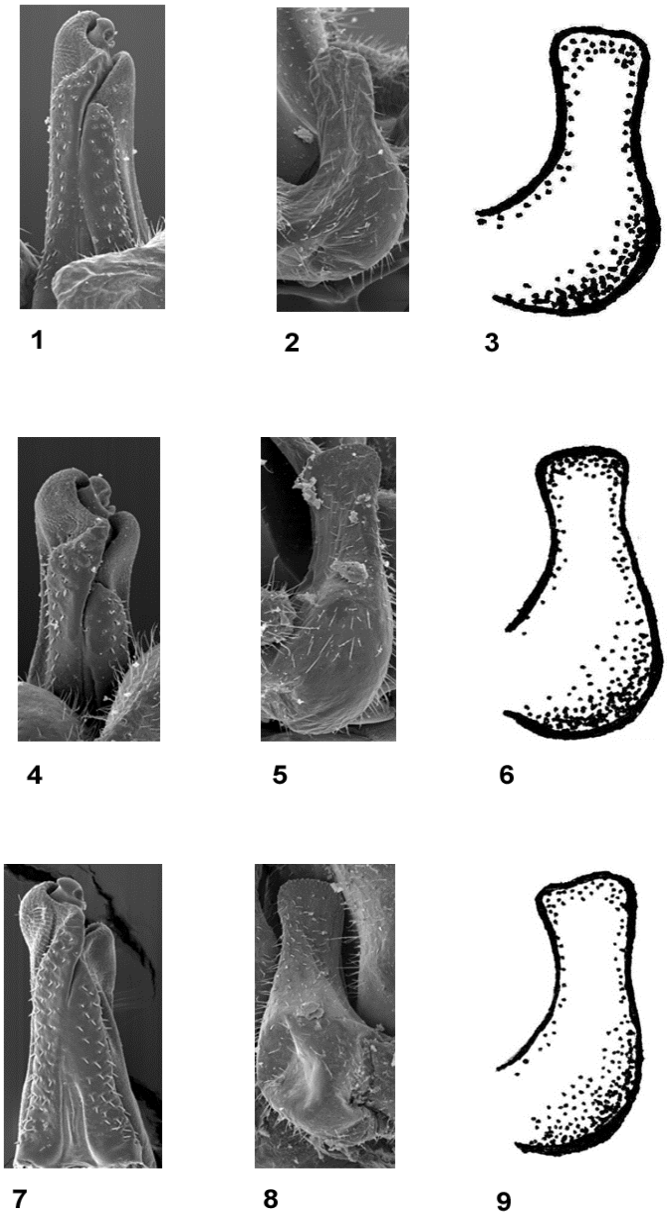
Nymphal growth patterns and adult flight activity at the type locality in Kentucky were monitored between May 2002 and April 2004. The study stream was partitioned longitudinally into transects 0.5 m apart. Three transects were selected randomly on a monthly basis and sampling occurred in the channel midpoint. Sampling from May 2002–December 2003 was based on brushing cobble substrates into a bucket and scooping finer substrates with a 250-µm sieve. An Ekman dredge (0.023m^2 sampling area) was used from January–April 2004. The three replicate samples were composited in the field, rinsed through a 250-µm sieve, and preserved with 95% ethanol. Each composite sample was re-rinsed through the 250-µm sieve in the laboratory and full-sorted under a dissecting microscope. Head capsule widths were measured for all individuals and used to construct size frequency histograms. Adults were collected weekly during the emergence period and flight records were superimposed onto each histogram.

Soyedina vallicularia (Wu)

(Figs. 1–27)

Nemoura vallicularia Wu, 1923:58. Type locality: Ithaca, NY. Holotype (Cornell University).
Nemoura vallicularia: Needham & Claassen, 1925:215.
Nemoura (Soyedina) vallicularia: Ricker, 1952:53.
Soyedina vallicularia: Illies, 1966:248.
Soyedina vallicularia: Zwick, 1973:357.

Material examined. Paratype ♂ and ♀, U.S.A., New York: Tompkins Co., Ithaca, April 1922, no collector indicated (INHS); Canada, Ontario: Grey Co., spring, Inglish Falls, Owen Sound, 4 May 1986, B. J. Sinclair and S. A. Marshall, 1♂, 1♀ (BYU); Wentworth Co., spring, Webster Falls, Dundas, 12 April 1986, B. J. Sinclair, 2♂, 2♀ (BYU); Quebec: tributary of Riviere Jean Larose, Mont Sainte Anne Park, 9 June 1997, C. R. Nelson, R. W. Baumann and B. C. Kondratieff, 2♂ (BYU). USA, Illinois: Vermillion Co., seep, Forest Glen County Forest Preserve, 15 April 1996, B. C. Kondratieff, B. O. Huntsman and R. W. Baumann, 2♂, 7♀ (BYU); Forest Glen County Forest Preserve, 21–27 April 1977, D.W. Webb, 3♂, 5♀ (INHS); same but 3 March 2001, R.E. DeWalt, 6♂, 1♀, 7 nymphs (INHS); Indiana: Crawford Co., tributary to Otter Creek, Yellow Birches Ravine Nature Preserve, 25 March 2003, S.A. Grubbs, 1♂, 3♀ (WKU); Montgomery Co., Shades State Park, 16 March 1958, H.H. Ross and C.O. Mohr, 3♂, 5♀ (INHS); Orange Co., spring into Youngs Creek, 20 February 2006, S.A. Grubbs, 2♂, (WKU); Parke Co., seep, Turkey Run State Park, 23 March 1975, R. W. Baumann and O. S. Flint, 11♂, 11♀ (BYU); Vermillion Co., seep into unnamed tributary to Little Vermillion River, 12 March 2005, S.A. Grubbs and R.E. DeWalt, 2♂ (WKU); Iowa: Dubuque Co., seep into Middle Fork Maquoketa River, 4 April 2004 (reared), D.P. Heimdal, 1♂ (UI); Kentucky: Adair Co., spring into unnamed tributary to Sulphur Creek, 10 March 2001, S.A. Grubbs and D.E. King, 4♂, 7♀ (WKU); Spout Spring Branch, Green River, 10 March 2001, S.A. Grubbs and D.E. King, 7♂, 10♀ (WKU); Allen Co., tributary to Garrett Creek, 3 March 2001, S.A. Grubbs and D.E. King, 5♂, 3♀ (WKU); Barren Co., spring into Skaggs Creek, Brigadoon State Nature Preserve, 17 February 2001, S.A. Grubbs, 8♂, 8♀ (WKU); Breathitt Co., Upper Clemons Fork, 21 February 2004, S.A. Grubbs, 3♂, 5♀ (WKU); Green Co., spring into Little Brush Creek, 13–24 March 2001, S.A. Grubbs and C. Boswell, 2♂, 5♀ (reared) (WKU); Harlan Co., tributary to Brownies Creek, 21 March 2002, Shillalah Creek Wildlife Management Area, S.A. Grubbs, 1♂, 1♀ (WKU); Hart Co., spring into Lynn Camp Creek, 23 March 2004, S.A. Grubbs, 1♂, 5♀ (WKU); McCreary Co., spring into South Fork Cumberland River, Big South Fork Recreation Area, 18 March 2001, S.A. Grubbs and D.E. King, 1♂, 1♀ (WKU); Rockcastle Co., (sic), Disputanta (sic), 21–27 March 1964, J.M. Campbell, 2♂ (INHS); Maryland: Allegany Co., tributary to Sideling Hill Creek,



Figs. 1–9. *Soyedina vallicularia*. 1–3. PA: Beaver Co., spring into Traverse Creek. 1. Male, SEM micrograph, dorsal view of epiproct (350x). 2. Male, SEM micrograph, lateral view of left paraproct (200x). 3. Male, lateral view of left paraproct. 4–6. MI: Mason Co., Big South Branch Pere Marquette River. 4. Male, SEM micrograph, dorsal view of epiproct (350x). 5. Male, SEM micrograph, lateral view of left paraproct (200x). 6. Male, lateral view of left paraproct. 7–9. MD: Allegany Co., tributary to Black Sulphur Run. 7. Male, SEM micrograph, dorsal view of epiproct (350x). 8. Male, SEM micrograph, lateral view of right paraproct (200x). 9. Male, lateral view of left paraproct.

Sideling Hill Creek, Green Ridge State Forest, 17 March 1996, S.A. Grubbs, 2♂ (WKU); tributaries to Fifteenmile Creek, Green Ridge State Forest, 17 March 1996, S.A. Grubbs, 5♂, 3♀ (WKU); tributaries to Black Sulphur Run, Green Ridge State Forest, 7 March 1997, S.A. Grubbs, 8♂, 6♀ (WKU); tributary to Maple Run, Green Ridge State Forest, 7 March 1997, S.A. Grubbs, 1♂, (WKU); tributary to Purslane Run, Green Ridge State Forest, 7 March 1997, S.A. Grubbs, 1♂, (WKU); tributary to Trading Run, Green Ridge State Forest, 7 March 1997, S.A. Grubbs, 4♂, 2♀ (WKU); Massachusetts: Berkshire Co., brooklet, October Mountain State Forest, 27 April 1991, R.W. Baumann and M. F. Whiting, 1♂, 1♀ (BYU); Franklin Co., Sunderland Reservoir, Sunderland, 9 May 1964, C. H. Nelson, 1♂, 3♀ (BYU); Worcester Co., Shaw Brook, Leicester, 22 April 1969, L. M. Potter, 1♂,3♀ (BYU); Michigan: Benzie Co., Platte River, 10 May 1940, T.H. Frison and H.H.Ross, 1♂ (INHS); Mason Co., Big South Branch Pere Marquette River, Manistee National Forest, 26 May 1998, S.A. Grubbs and D.E. King, 2♂ (WKU); Montmorency Co., Hunt Creek, 14 April 1939, J.W. Leonard, 1♂ (INHS); New Hampshire: Grafton Co., Lebanon, 22 April 1973, R. Grey, 1♂, 1♀ (BYU); New York: Cortland Co., Kenney Brook, north of Truxton, 6 May 1991, R. W. Baumann and S. A. Wells, 5♂, 11♀ (BYU); Hamilton Co., Alder Brook, east of Hoffmeister, 4 June 1997, R. W. Baumann and B. C. Kondratieff, 1♂ (BYU); Tompkins Co., Ithaca, April (no year indicated), no collector indicated, 1♂ (INHS); Ohio: Ashland Co., seep to Hog Hollow Clear Fork Mohican River, 12 March 1990, R.F. Kirchner and R.W. Baumann, 2♂ (RFK); seep joining Hog Hollow Creek, Mohican State Park, 13 March 1990, R. W. Baumann and R. F. Kirchner, 2♂, 2♀ (BYU); Pennsylvania: Beaver Co., spring into Traverse Creek, Raccoon Creek State Park, 9–24 April 1999, S.A. Grubbs, 3♂, 5♀ (WKU); spring joining Traverse Creek, Raccoon Creek State Park, 20 March 1975, R. W. Baumann and O. S. Flint Jr., 10♂,10♀ (BYU); stream below Frankfort Mineral Springs, Hwy 18, 20 March 1975, R. W. Baumann and O. S. Flint Jr., 1♂ (BYU); Blair Co., Brush Mountain, 14 March 1987, S. Bonta, 1♂, 3♀ (BYU); Erie Co., tributary of Conneaut Creek, 13 April 1980, B. Travis, 1♂, 1♀ (BYU); Butler Co., spring into unnamed tributary to Connoquenessing Creek, 20 April 1999, S.A. Grubbs, 1♂, 5♀ (WKU); Venango Co., seep, Drake Well State Park, Titusville, 21 April 1979, R. W. Baumann and E. C. Masteller, 1♂, 2♀ (BYU); Warren Co., Hemlock Creek, 22 April 1979, R. W. Baumann and O. S. Flint Jr., 1♂ (BYU); seep, Kinzua Dam, 22 April 1979, R. W. Baumann and O. S. Flint, 9♂, 10♀ (BYU); Tennessee: Cannon Co., spring into East Fork Stones River, 7 March 2004, S.A. Grubbs, 2♂, 3♀ (WKU); Virginia: Wythe Co., East Fork of Stony Fork Reed Creek, 24 February 1976, R.F. Kirchner, 2♂ (RFK); West Virginia: Logan Co., Frogtown Hollow of Copperas Mine Fork, 11 March 1975, R.F. Kirchner, 2♂ (RFK).

Male. Forewing length 7.0–7.5 mm; body length 6.0–6.5 mm. General body color dark brown; legs dark brown. Wings fumose with darker area near cord; venation typical for genus with veins A1 and A2 united near margin. Gills absent. Seventh abdominal tergum distinctly upturned distally into a slightly, but broadly, incised bilobed process. Eighth abdominal tergum also distally upturned, but as a low convex ridge lower in profile than the seventh tergum. Cerci small, membranous, single-segmented. Hypoproct well-developed, with broad base covering most of ninth abdominal sternum and apex narrowing to a pointed, lightly-sclerotized tip. Epiproct moderately short; apex width subequal to basal width, typical bilateral asymmetry with right half noticeably longer; ventral sclerites long and narrow, covered with spines on outer margins throughout length (Figs. 1, 4, 7, 10, 13, 16, 19, 22, 25); dorsal sclerite lightly sclerotized and densely covered by tooth-like scales throughout length, ending in broadly-rounded, separated tips, open throughout apical half, revealing darkly-sclerotized inner structure which terminates as blunt hook-like structures with subterminal bolt-like knobs; lateral sclerite long and thin, extending near epiproct base for approximately 4/5 of dorsal sclerite length; basal sclerite broadly triangular in shape. Paraproct with two lobes; inner lobes small, narrow, and lightly sclerotized; outer lobes enlarged, darkly sclerotized, broadest at base, narrowed markedly at midlength to slightly concave or convex apical portion, inner and outer shoulders rounded, with outer shoulder raised slightly above inner shoulder (Figs. 2–3, 5–6, 8–9, 11–12, 14–15, 17–18, 20–21, 23–24, 26–27).

Female. Forewing length 7.5–9.0 mm; body length 6.0–8.0 mm. Body, leg, and wing coloration similar to

male. Subgenital plate well-developed; base broad, extending from posterior of seventh sternum entirely over eighth sternum and approximately ¼ over ninth sternum; apical portion darker than basal portion and ending in broadly-round tip.

Remarks. Morphological features of *S. vallicularia* have been provided by numerous authors, namely Wu (1923), Needham & Claassen (1925), and Hitchcock (1974). The apical portion of the outer paraproct lobe of *S. vallicularia* narrows markedly beyond the bulbous base to yield the "flask" shape (i.e. Hitchcock 1974). The flask-like shape of the paraproct was illustrated both by Needham & Claassen (1925, Fig. 3) and Hitchcock (1974, Fig. 137) somewhat differently, yet little variation exists in either the shape or size of this structure across the broad range of this species. Slightly different rotational aspects accounted for variability of the appearance of the paraprocts both within and between populations.

Soyedina alexandria sp. n.
(Figs. 28–31)

Material examined. Holotype ♂ and paratype ♀, U.S.A., Williamson Co., spring into Pinewood Branch, Leipers Fork, West Fork Harpeth River, 4 km W Leipers Fork, 15 March 2003, S. A. Grubbs and D. E. King (INHS); Paratypes, Tennessee: Cheatham Co., spring into unnamed tributary to Harpeth River, 6 km W Ashland City, 1 March 2003, S. A. Grubbs and D. E. King, 2♂, 5♀ (WKU); Sumner Co., spring into Liggett Branch, Station Camp Creek, 6 km SE White House, 1 March 2003, S. A. Grubbs and D. E. King, 6♂, 8♀ (WKU, BYU, INHS); Williamson Co., same as holotype, 1♂, 4♀ (WKU).

Male. Forewing length 7.0–7.5 mm; body length 5.0–5.5 mm. Body color, wings, absence of gills, cerci, hypoproct, and epiproct (Fig. 28) as in *S. vallicularia*. Paraproct with two lobes; inner lobes small, narrow, and lightly sclerotized; outer lobes noticeably robust and enlarged, darkly sclerotized, broadest at base, narrowed very slightly at distal fourth, apical portion with slightly convex tip, inner and outer shoulders rounded, with outer shoulder raised slightly above inner shoulder (Figs. 29–30).

Female. Forewing length 7.5–9.0 mm; body length 5.0–7.0 mm. Body, leg, and wing coloration similar to male. Subgenital plate well-developed; base broad, extending from posterior of seventh sternum entirely over eighth sternum and approximately ¼ over ninth sternum; apical portion darker than basal portion and ending in broadly-rounded to moderately-pointed tip (Fig. 31).

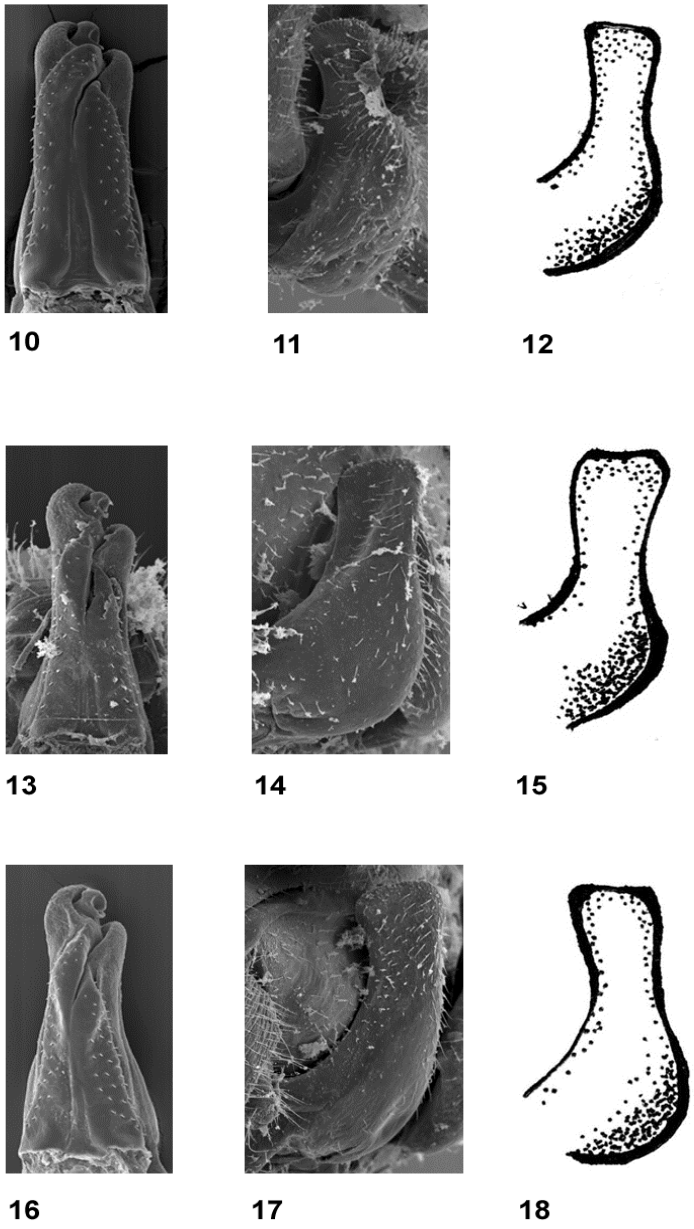
Diagnosis. *Soyedina alexandria* is distinguished from *S. vallicularia* by the outline of the outer lobe of the paraproct. Although moderately variable in shape, the outer paraproct lobe of *S. vallicularia* is much narrower in lateral profile than the robust shape exhibited by *S. alexandria*. The apical portion of the epiproct of *S. alexandria* is much broader than *S. vallicularia*. Both the epiprocts and the female subgenital plates of *S. alexandria* and *S. vallicularia* are inseparable. The SEM micrograph of the subgenital plate of *S. alexandria* shows that while this structure may appear more pointed in some specimens, this is simply a manifestation of the outer margins sometimes folding under the plate.

Etymology. *Soyedina alexandria* is named in honor of my daughter Alexandria Arlene.

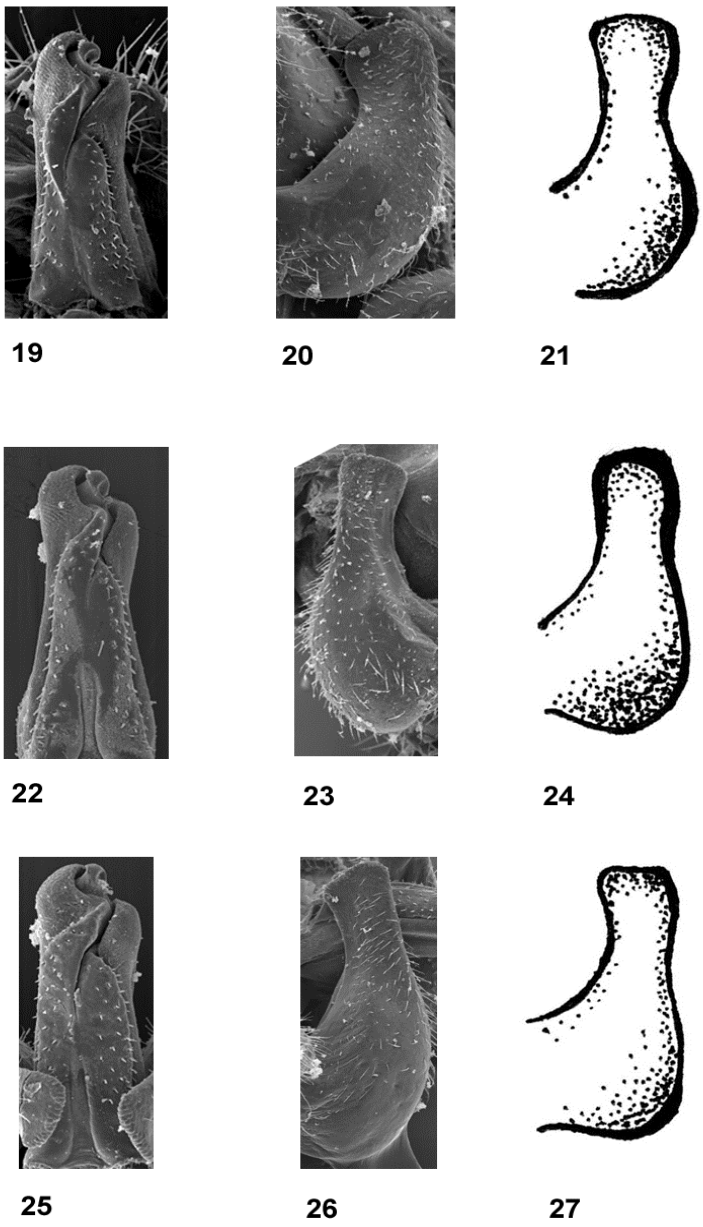
Soyedina calcarea sp. n
(Figs. 32–36)

Material examined. Holotype ♂ and paratype ♀, U.S.A., Kentucky: Hart Co., small spring-fed stream, 7.5 km NW Bonnieville, 2–6 March 2000, S. A. Grubbs and J.M. Ferguson (reared) (INHS); Paratypes, same as holotype but 9 March 2000, S. A. Grubbs and J.M. Ferguson, 1♂, 7♀ (reared) (WKU); 2 April 2000, S. A. Grubbs and J.M. Ferguson, 1♂, (reared) (WKU); same but 4-19 March 2001, S. A. Grubbs and J.M. Ferguson, 11♂, 12♀ (reared) (WKU, BYU); same but 15 February 2003, S. A. Grubbs and J.M. Ferguson, 1♂ (WKU); same but 27 February 2003, S. A. Grubbs, 1♂ (WKU); same but 20 February 2004, J.M. Butler, 1♂ (WKU);

Male. Forewing length 7.0–7.5 mm; body length 6.0–6.5 mm. Body color, wings, absence of gills, cerci, hypoproct, and epiproct (Fig. 32) as in *S. vallicularia*. Paraproct with two lobes; inner lobes small, narrow, and lightly sclerotized; outer lobes enlarged, darkly sclerotized and robust, broadest at base, narrowed noticeably at distal third, both inner and outer portions concave; apical portion constricted toward



Figs. 10–18. *Soyedina vallicularia*. 10–12. MD: Allegany Co., tributary to Trading Run. 10. Male, SEM micrograph, dorsal view of epiproct (350x). 11. Male, SEM micrograph, lateral view of left paraproct (200x). 12. Male, lateral view of left paraproct. 13–15. WV: Logan Co., Frogtown Hollow of Copperas Mine Fork. 13. Male, SEM micrograph, dorsal view of epiproct (350x). 14. Male, SEM micrograph, lateral view of left paraproct (200x). 15. Male, lateral view of left paraproct. 16–18. KY: Green Co., spring into Little Brush Creek. 16. Male, SEM micrograph, dorsal view of epiproct (350x). 17. Male, SEM micrograph, lateral view of left paraproct (200x). 18. Male, lateral view of left paraproct.



Figs. 19–27. *Soyedina vallicularia*. 19–21. KY: Adair Co., Spout Spring Branch, Green River. 19. Male, SEM micrograph, dorsal view of epiproct (350x). 20. Male, SEM micrograph, lateral view of left paraproct (200x). 21. Male, lateral view of left paraproct. 22–24. OH: Ashland Co., seep into Clear Fork Mohican River. 22. Male, SEM micrograph, dorsal view of epiproct (350x). 23. Male, SEM micrograph, lateral view of right paraproct (200x). 24. Male, lateral view of left paraproct. 25–27. VA: Wythe Co., East Fork, Stony River. 25. Male, SEM micrograph, dorsal view of epiproct (350x). 26. Male, SEM micrograph, lateral view of left paraproct (200x). 27. Male, lateral view of left paraproct.

concave tip, inner and outer shoulders rounded, with outer shoulder raised slightly above inner shoulder (Figs. 33–35).

Female. Forewing length 7.5–9.0 mm; body length 6.0–8.0 mm. Body, leg, and wing coloration similar to male. Subgenital plate well-developed; base broad, extending from posterior of seventh sternum entirely over eighth sternum and approximately ¼ over ninth sternum; apical portion darker than basal portion and ending in broadly-round tip (Fig. 36).

Diagnosis. *Soyedina calcarea* is differentiated from both *S. alexandria* and *S. vallicularia* by the shape of the outer paraproctal lobe. The compact, robust paraproct with the concave tip of *S. calcarea* is easily distinguished from the narrow, flask-like paraproct of *S. vallicularia*. The combination of the concave tip and the noticeably concave inner and outer margins of the paraproct of *S. calcarea* are also readily distinguished from *S. alexandria*. With *S. alexandria* the paraproct lobe is only faintly concave along both the inner and outer margins and the tip is straight or slightly convex. In addition, the epiproct and female subgenital plate of *S. calcarea* cannot be distinguished from *S. alexandria* and *S. vallicularia*.

Remarks. The highly asymmetrical and scaly epiproct, with the distinctive inner structure, is shared only by *S. alexandria*, *S. calcarea*, and *S. vallicularia*, and easily separates these three species from the remaining eastern Nearctic *Soyedina* species (*S. carolinensis*, *S. kondratieffi*, *S. merritti* and *S. washingtoni*). The latter four species are distributed mainly in the Appalachian Mountains. *Soyedina vallicularia* is distributed broadly, as (1) throughout the northern Great Lakes region east to Maine and Nova Scotia, (2) at lower elevations in the Appalachian Mountains, and (3) within the lower Ohio River Basin and one location in the lower Cumberland River Basin in Tennessee (Grubbs 1997; Stark & Baumann 2005), and (4) Heimdal et al. (2004) provided the first record west of the Mississippi River in eastern Iowa. The type and sole known locality of *S. calcarea* occurs within the southwestern portion of the distribution of *S. vallicularia*, while the known localities of *S. alexandria* overlap with *S. vallicularia* only in central Tennessee.

Etymology. The specific epithet is in reference to the well-developed calcareous limestone bedrock in the central Kentucky karst region.

Biology. The Kentucky type locality (195 m A.S.L.) emanates on a sandstone ridge and flows 35 m as an intermittent reach before dropping over a hollowed cliff. The stream continues intermittently before two small springs provide perennial surface flow for approximately 20 m. Downstream of the spring reach the stream sinks through fractured limestone into a subterranean fluvial network. *Soyedina calcarea* adults have been collected only from the spring reach. Other stonefly species collected with *S. calcarea* from the type locality were *Allocapnia recta* (Claassen), *Amphinemura varshava* (Ricker), *Clioperla clio* (Newman), *Diploperla robusta* Stark and Gaufin, *Leuctra alta* James, *L. sibleyi* Claassen, *L.* cf. *tenuis* (Pictet), and *Ostrocerca truncata* (Claassen).

The adult flight period of *S. calcarea* at the Kentucky type locality occurred between mid-February and early April. Early-instar nymphs appeared by May after no apparent egg diapause and grew continuously through summer and autumn (Fig. 37). Nymphal growth increased through winter prior to emergence. The growth pattern displayed was similar to the univoltine-slow cycles (Hynes 1961) displayed by *S. vallicularia* in Ontario (Harper 1973) and Quebec (Mackay 1969). Both studies revealed that early-instar nymphs appeared shortly after adult emergence, suggesting a direct development of eggs similar to *S. calcarea*. The similar growth patterns displayed by the two species, despite the disparate latitudinal settings, are not surprising because the two taxa are likely sibling species.

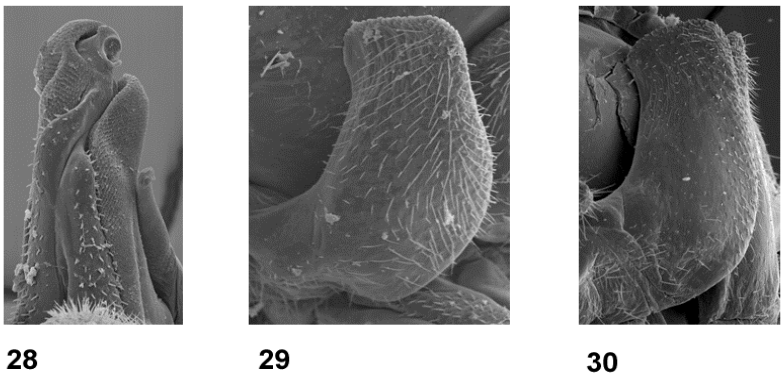
Key to males of *Soyedina vallicularia*, *S. alexandria*, and *S. calcarea*

1. Outer paraproct lobe markedly narrowed dorsal to the bulbous base (e.g. Figs. 5-6)…… *S. vallicularia*

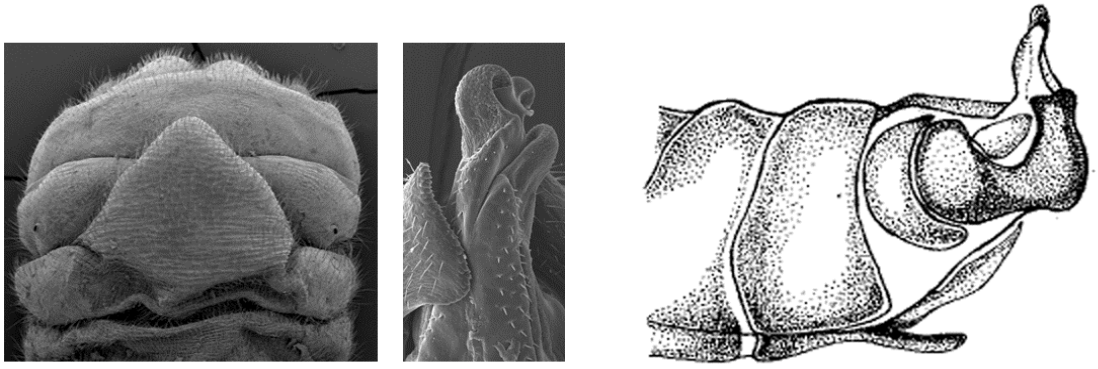
Outer paraproct lobe robust in shape and narrowed minimally dorsal to the bulbous base (Figs. 29-30, 34-35)……..…2

2. Outer paraproct lobe minimally concave along both anterior and posterior margins; tip nearly parallel-sided and straight or slightly concave (Figs. 29-30)……..……...…....*S. alexandria*

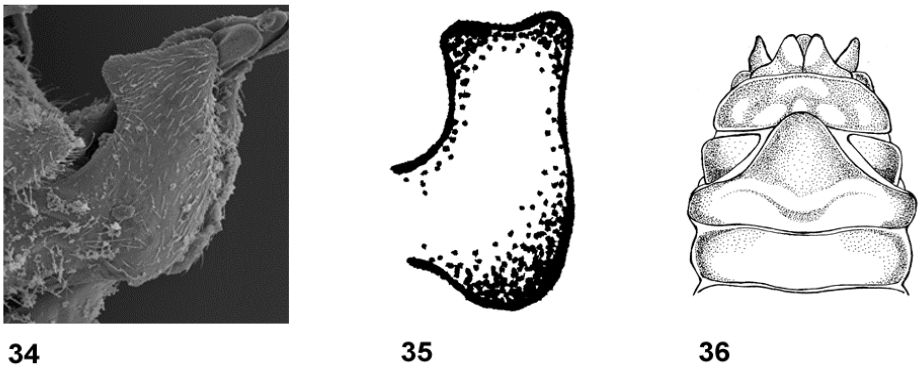
Outer paraproct lobe noticeably concave along both anterior and posterior margins; tip flared both anteriorly and posteriorly and concave (Figs. 29-30)……..…...*S. calcarea*



28 29 30



31 32 33



34 35 36

Figs. 28–31. *Soyedina alexandria*, TN: Sumner Co., spring into Liggett Branch, Station Camp Creek. 28. Male, SEM micrograph, dorsal view of epiproct (350x). 29–30. Male, SEM micrographs, lateral view of left paraprocts (200x). 31. Female, ventral view.
Figs. 32–36. *Soyedina calcarea*, KY: Hart Co., small spring-fed stream. 32. Male, SEM micrograph, dorsal view of epiproct (350x). 33. Male, lateral view of abdominal terminalia. 34. Male, SEM micrograph, lateral view of left paraproct (200x). 35. Male, lateral view of left paraproct. 36. Female, ventral view.

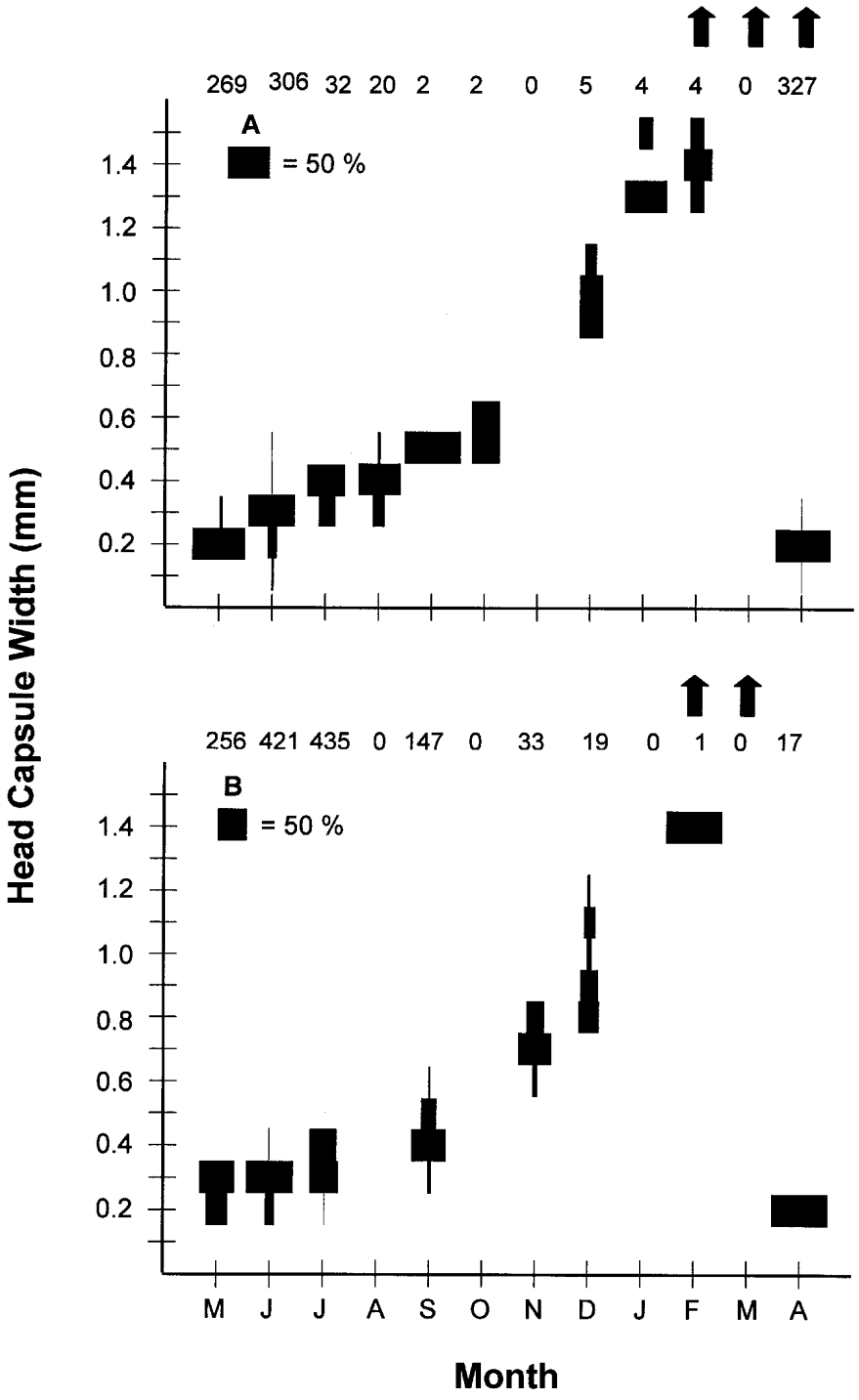


Fig. 37. Size frequency histograms of head capsule width for *Soyedina calcarea* from the Kentucky type locality. A: May 2002 – April 2003; B: May 2003 – April 2004. Numbers on top give number of specimens per month; n = 2300 nymphs total across the two-year sampling period. Vertical arrows refer to adult flight period.

ACKNOWLEDGMENTS

I thank Fred Kirchner (Department of the Army, Huntingdon District Corps of Engineers), Dennis Heimdal (University of Iowa Hygienic Laboratory), and Colin Favret (Illinois Natural History Survey) for loan of material, and Dr. Richard Baumann (Brigham Young University) for constructive advice. Cloyce Hedge and Roger Hedge, Indiana Department of Natural Resources, provided collecting permits for Indiana State Nature Preserves. Assistance in the field and laboratory for the life cycle study was provided by Charles Boswell, Jason Butler, Jon Cambron, Joseph Ferguson, Benjamin Hutchins, Michael Romans, Jered Studinski, and Christopher Thomas. Dan Givens kindly allowed access to his property during the entire life cycle study period.

REFERENCES

Baumann, R.W. 1975. Revision of the stonefly family Nemouridae (Plecoptera): A study of the world fauna at the generic level. Smithsonian Contributions to Zoology, 211:1–74.

Baumann, R.W. & A.R. Gaufin. 1971. New species of *Nemoura* from western North America (Plecoptera: Nemouridae). Pan-Pacific Entomologist, 47:270–278.

Baumann, R.W. & S.A. Grubbs. 1996. Two new species of *Soyedina* (Plecoptera: Nemouridae) from the Appalachian Mountains. Entomological News, 107:220–224.

Claassen, P.W. 1923. New species of North American Plecoptera. Canadian Entomologist, 55:281–292.

Grubbs S.A., C.M. Thomas, B.T. Hutchins, & J.M. Taylor. 2006. Life cycles of *Leuctra* spp. and *Allocapnia recta* (Plecoptera: Leuctridae and Capniidae) across a flow gradient in a headwater karst valley. Southeastern Naturalist, 5:321-332.

Grubbs S.A., C.M. Thomas, B.T. Hutchins, & J.M. Taylor. 2005. Comparative life history study of two species of Nemouridae (Plecoptera) from an intermittent-perennial stream continuum from the central Kentucky karst region, U.S.A. Verhandlungen Internationale Vereinigung für theoretische und angewandte Limnologie, 29:912–916.

Grubbs, S.A. 1997. New records, zoogeographic notes, and a revised checklist of stoneflies (Plecoptera) from Maryland. Transactions of the American Entomological Society, 123:71–84.

Harper, P.P. 1973. Life histories of Nemouridae and Leuctridae in southern Ontario (Plecoptera). Hydrobiologia, 41:309–356.

Heimdal, D.P., R.E. DeWalt, & T.F. Wilton. 2004. Annotated checklist of the stoneflies (Plecoptera) of Iowa. Proceedings of the Entomological Society of Washington,. 106:761–778.

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

Hynes, H.B.N. 1961. The invertebrate fauna of a Welsh mountain stream. Archiv für Hydrobiologie, 57:344–388.

Illies, J. 1966. Katalog der rezenten Plecoptera. Das Tierreich, Berlin, 82: i-xxx, 1-632.

Mackay, R.J. 1969. Aquatic insect communities of a small stream on Mont. St. Hillaire, Quebec. Journal of the Fisheries Research Board of Canada, 26:1157–1183.

Needham, J.G. & P.W. Claassen. 1925. A monograph of the Plecoptera or stoneflies of America north of Mexico. Entomological Society of America, Thomas Say Foundation 2.

Ricker, W.E. 1952. Systematic studies in Plecoptera. Indiana University Publicaton Science Series 18.

Stark, B.P. & R.W. Baumann. 2005. North American stonefly (Plecoptera) complete list. Updated as of March 30, 2005. URL address http://mlbean.byu.edu/plecoptera/list.asp.

Wu, C.F. 1923. Morphology, anatomy and ethology of *Nemoura*. Bulletin of the Lloyd Library Entomological Series, 3:1–81.

Zwick, P. 1973. Insecta: Plecoptera. Phylogenetisches System und Katalog. Das Tierreich, Berlin, 94: i-xxxii, 1-465.

Received 14 April 2006, Accepted 1 June 2006, Published 16 December 2006