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A REVIEW OF THE EASTERN NEARCTIC ISOPERLINAE (PLECOPTERA: PERLODIDAE) WITH THE DESCRIPTION OF TWENTY-TWO NEW SPECIES

S.W. Szczytko[1] and B.C. Kondratieff[2]

[1] Professor Emeritus, College of Natural Resources,
University of Wisconsin/Stevens Point, Stevens Point, WI 54481 USA
E-mail: sszczytk@uwsp.edu

[2] Department of Bioagricultural Sciences and Pest Management,
Colorado State University, Fort Collins, CO 80523 USA
E-mail: Boris.kondratieff@colostate.edu

ABSTRACT

The Isoperlinae of eastern North America is represented by two genera, *Clioperla* Needham & Claassen and *Isoperla* Banks. *Clioperla* is monotypic, represented by *C. clio* (Newman), but *Isoperla* includes 53 eastern North American species assigned to twelve species groups and seven additional species which are not assigned. Twenty-two species are described as new and three species are synonymized, *I. coushatta* Szczytko & Stewart, n. syn. of *I. davisi* James; *I. mohri* Frison, n. syn. of *I. irregularis* (Klapálek); and *I. extensa* Claassen, n. syn. of *I. quinquepunctata* (Banks). A total of sixty-one species of Isoperlinae are now reported from eastern North America. Keys to the males, females, and eggs and supporting original illustrations and scanning electron micrographs are provided.

Keywords: Plecoptera, Isoperlinae, *Clioperla*, *Isoperla*, eastern North America, adult species keys

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Fig. 1.1. *Clioperla clio* female – WI: Lincoln Co., Ripley Creek, Hwy 107, 20/IV/1992, J.B. Sandberg – Photo by Stan Szczytko.

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Fig. 1.2. *Isoperla bilineata* female – WI: Eau Claire Co., Chippewa River, 12/VI/1992, J.M. Cahow – Photo by Stan Szczytko.

INTRODUCTION

Two genera of Isoperlinae Frison are recognized in eastern North America, *Clioperla* Needham and Claassen 1925 and *Isoperla* Banks 1906. *Clioperla* is monotypic and presently includes *C. clio* Newman. Szczytko and Stewart (1981) provided a recent review of the genus. The Holarctic genus *Isoperla* currently includes more than 152 species (Szczytko and Stewart 1979a, Stark et al. 2009, Murányi 2011, Sandberg and Kondratieff 2013, DeWalt et al. 2013), with 64 species of *Isoperla* reported from North America (DeWalt et al. 2013). To this date, 40 species of *Isoperla* are recorded from eastern North American species (DeWalt et al. 2013). The more recently described species have been by Harper (1971), Stark and Stewart (1973b), James (1974), Nelson (1976), Szczytko and Stewart (1976), Nelson and Kondratieff (1983), Poulton and Stewart (1987), and Grubbs and Szczytko (2010). No comprehensive treatment of the eastern North American species is currently available other than Hitchcock's (1974) treatment of the Connecticut stoneflies which included a key to adults of "northeastern species" of that time. Hitchcock (1974) generally accepted Frison's (1942) species concepts. Szczytko and Stewart (1978) designated a neotype and redescribed *I. bilineata* (Say) and more recently, Poulton and Stewart (1991) treated the ten *Isoperla* known from the Ozark and Ouachita mountains.

At least three species considered primarily western Nearctic in distribution (Szczytko and Stewart 1979a) have penetrated into the Midwest via the Platte and Missouri River drainages, including *I. quinquepunctata* (Banks), *I. longiseta* (Banks), and *I. phalerata* (Needham). Conversely, two eastern species, *I. marlynia* (Needham and Claassen) and *I. transmarina* (Newman), have colonized the post-glacial West via the Missouri River (Huntsman et al. 1999, Zuellig et al. 2006).

In this review, 53 eastern North American *Isoperla* species are assigned to twelve species groups (Table 1) based primarily on aedeagal characters, and seven species are unassigned. Two of these, the *I. longiseta* group and the *I. phalerata* group were previously proposed (Szczytko and Stewart 1979a, Sandberg 2011, Sandberg and Kondratieff 2013). Among the unassigned species, three possess unique characters, *I. chickamauga* sp. n., *I. poffi* sp. n., and *I. jamesae* Szczytko and Grubbs, are left unassigned. Three additional species are known only from females without ova, *I. citronella* Newport, *I. conspicua* Frison, and *I. emarginata* Harden and Mickle, and *I. maxana* Harden and Mickle is known from a single male of uncertain taxonomic status. The relationships of these four species are also unknown. Future studies of the unknown stages, particularly the nymphs of the eastern North American *Isoperla* species may allow a more complete resolution of the phylogenetic relationships.

MATERIALS AND METHODS

Specimens including type material were examined from the following institutions and collections.

British Museum of Natural History (BMNH)
Bill P. Stark Collection, Clinton, Mississippi (BPSC)
Canadian National Collection of Insects, Ottawa, Ontario (CNIC)
Charles H. Nelson Collection, Chattanooga, Tennessee (CHNC)
C.P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins, Colorado (CSUC)
Cornell University Insect Collection, Ithaca, New York (CUIC)
David H. Funk Collection, Avondale, Pennsylvania (DFIC)
Florida A & M University; W.L. Peters Aquatic Entomology Research Collections, Tallahassee, Florida (FAMU)
Jane Earle Insect Collection, Mechanicsburg, Pennsylvania (JEIC)
Illinois Natural History Survey, Champaign, Illinois (INHS)
Lyman Entomological Museum, Ste. Anne de Bellevue, Quebec (LEMQ)
Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZC)
Naturhistorisches Museum Wien, Austria (NHMW)
New York State Museum, Albany, New York

(NYSM)
Purdue University, West Lafayette, Indiana (PURC)
Monte L. Bean Life Science Museum, Brigham Young University, Provo, Utah (BYUC)
Royal Ontario Museum, Toronto, Ontario, Canada (ROM)
Scott A. Grubbs Collection, Western Kentucky University, Bowling Green, Kentucky (SAGC)
United States National Museum of Natural History, Washington, D.C. (USNM)
University of Minnesota Insect Collection, St. Paul, Minnesota (UMSP)
University of North Texas, Denton, Texas (UNTC)

Locality records of the eastern *Isoperla* species that have been previously published and are accepted are included in the "Distribution" section under each species. In those species where identification is possible only with males that have fully everted aedeagi, or with species that have been historically misidentified (i.e. *I. namata* Frison and *I. kirchneri* sp. n.; *I. similis* (Hagen), and *I. pseudosimilis* sp. n.), records are included in the "Distribution" section. State distribution records are not included where published lists of species were given with no locality information.

The aedeagus of male specimens was everted from live specimens using a stereo dissecting microscope to ensure that complete eversion was achieved. Outlines of male and female genitalia were made using a Leica MZ 12-5 stereo dissecting microscope equipped with a camera lucida at both institutions. Detailed color images were made using the Leica microscope equipped with a JVC TK-107OU color video camera and a Sony Mavigraph UP-2300 thermal color video printer. Habitus drawings were completed using the computer program Adobe Illustrator CS4® from the outline drawings made with the camera lucida and referencing the digital images, color prints and specimens. The methods of Stark and Lacey (2005) were used to prepare the male aedeagus for scanning electron microscopy. Ova were dissected from preserved gravid females and were prepared for scanning electron microscopy as described by Szczytko and Stewart (1979a). Scanning electron micrographs of aedeagus and ova were made with a Hitachi S-3400 Environmental scanning electron microscope at University of Wisconsin, Stevens-Point.

Fig. 1.3. *Isoperla cotta* male – WI: Bayfield Co., Sioux River, Big Rock Rd., 2/VI/1996, S.W. Szczytko – Photo by Stan Szczytko.

Table 1. The Isoperlinae of Eastern North America. See following discussion for species group assignment.

Species Group and Species

Clioperla clio (Newman 1839)

Isoperla bilineata Group

1. *Isoperla bilineata* (Say 1823)
2. *Isoperla dicala* Frison 1942
3. *Isoperla fauschi* sp. n.
4. *Isoperla frisoni* Illies 1966
5. *Isoperla gibbsae* Harper 1971
6. *Isoperla myersi* sp. n.
7. *Isoperla powhatan* sp. n.
8. *Isoperla richardsoni* Frison 1935
9. *Isoperla sagittata* Szczytko & Stewart 1976
10. *Isoperla tutelo* sp. n.
11. *Isoperla zuelligi* sp. n.

Isoperla burksi Group

12. *Isoperla burksi* Frison 1942
13. *Isoperla cotta* Ricker 1952
14. *Isoperla orata* Frison 1942

Isoperla decolorata Group

15. *Isoperla davisi* James 1974
    Isoperla coushatta Szczytko & Stewart 1976, n. syn.
16. *Isoperla decolorata* (Walker 1852)
17. *Isoperla transmarina* (Newman 1838)

Isoperla irregularis Group

18. *Isoperla decepta* Frison 1935
19. *Isoperla irregularis* (Klapálek 1923)
    Isoperla mohri Frison 1935, n. syn.
20. *Isoperla ouachita* Stark & Stewart 1973b
21. *Isoperla szczytkoi* Poulton & Stewart 1987

Isoperla lata Group

22. *Isoperla lata* Frison 1942
23. *Isoperla marlynia* Needham & Claassen 1925
24. *Isoperla pseudolata* sp. n.

Isoperla longiseta Group

25. *Isoperla jewetti* Frison 1942
26. *Isopela longiseta* Banks 1906a
27. *Isoperla quinquepunctata* (Banks 1902)
    Isoperla extensa Claassen 1937, n. syn.

Isoperla montana Group

28. *Isoperla montana* Banks (1898)
29. *Isoperla nelsoni* sp. n.
30. *Isoperla smithi* sp. n.

Isoperla nana Group

31. *Isoperla catawba* sp. n.
32. *Isoperla lenati* sp. n.
33. *Isoperla nana* (Walsh 1862)

Isoperla phalerata Group

34. *Isoperla phalerata* (Needham 1917)
35. *Isoperla slossonae* (Banks 1911)

Isoperla signata Group

36. *Isoperla francesca* Harper 1971
37. *Isoperla holochlora* (Klapálek 1923)
38. *Isoperla kirchneri* sp. n.
39. *Isoperla namata* Frison 1942
40. *Isoperla signata* (Banks 1902)
41. *Isoperla siouan* sp. n.

Isoperla similis Group

42. *Isoperla bellona* Banks 1911
43. *Isoperla cherokee* sp. n.
44. *Isoperla distincta* Nelson 1976
45. *Isoperla major* Nelson & Kondratieff 1983
46. *Isoperla sandbergi* sp. n.
47. *Isoperla similis* (Hagen 1861)
48. *Isoperla starki* sp. n.

Isoperla pseudosimilis Group

49. *Isoperla pauli* sp. n.
50. *Isoperla pseudosimilis* sp. n.
51. *Isoperla reesi* sp. n.
52. *Isoperla stewarti* sp. n.
53. *Isoperla yuchi* sp. n.

Unassigned Species

54. *Isoperla chickamauga* sp. n.
55. *Isoperla citronella* (Newport 1851)
56. *Isoperla conspicua* Frison 1935
57. *Isoperla emarginata* Harden & Mickel 1952
58. *Isoperla jamesae* Grubbs & Szczytko 2010
59. *Isoperla maxana* Harden & Mickel 1952
60. *Isoperla poffi* sp. n.

Fig. 1.4. *Isoperla dicala* female – WI: Price Co., North Fork Flambeau River, off Hwy 70, 2/VI/2001, S.W. Szczytko – Photo by Stan Szczytko.
Fig. 1.5. *Isoperla frisoni* female – WI: Iron Co., Laymans Creek, Schomberg Park, Hwy 39, 9 mi. S. of Hurley, 26/V/2006, S.W. Szczytko – Photo by Stan Szczytko.

Fig 1.6. *Isoperla lata* female – WI: Lincoln Co., Ripley Creek, upstream of Hwy 107 bridge, 17/IV/1989, J.B. Sandberg, S.W. Szczytko – Photo by Stan Szczytko.
Fig. 1.7. *Isoperla lata* male - WI: Lincoln Co., Ripley Creek, upstream of Hwy 107 bridge, 17/IV/1989, J.B. Sandberg, S.W. Szczytko – Photo by Stan Szczytko.

Fig. 1.8. *Isoperla marlynia* female – WI: Florence Co., Pine Rd. at end of W. Elwood Lake Rd. and Hwy 141, 14/IV/1992, S.W. Szczytko, J.J. Dimick – Photo by Stan Szczytko.
Fig. 1.9. *Isoperla nana* male – WI: Green Lake Co., Bell Fountain Creek, 24/IV/1991, S.W. Szczytko, J.B. Sandberg – Photo by Stan Szczytko.

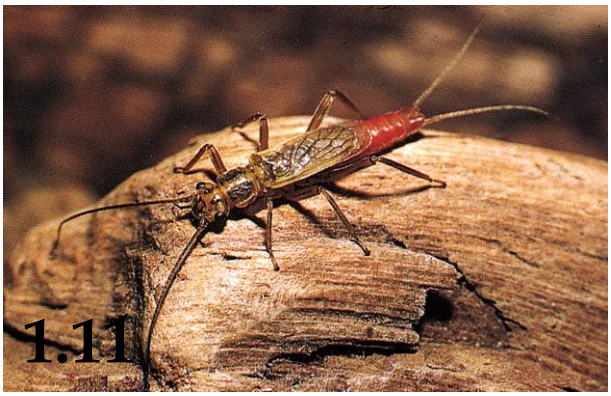


Fig. 1.10. *Isoperla phalerata* male – NM: Taos Co., Rio Fernando de Taos River, Hwy 64 ca. 7 mi. NE of Taos, 20/V/1991, S.W. Szczytko, B.P. Stark, R. Nelson – Photo by Stan Szczytko.
Fig. 1.11. *Isoperla quinquepunctata* male – CO: Larimer Co., Cache la Poudre River, 7/VII/1995, B.C. Kondratieff – Photo by Bill P. Stark.

Fig. 1.12. *Isoperla richardsoni* female – WI: Iron Co., Manitowish River, Hwy 39 wayside, 4 mi. S. of Manitowish, 26/V/2005, S.W. Szczytko – Photo by Stan Szczytko.
Fig. 1.13. *Isoperla signata* male – WI: Clark Co., Black River, Hwy H, 6 mi. N. of Neillsville, 22/V/2001, S.W. Szczytko – Photo by Stan Szczytko.

Fig. 1.14. *Isoperla slossonae* male – WI: Portage Co., Little Plover River, Kennedy Ave. 4 mi. E. of Whiting, 15/IV/1999, S.W. Szczytko - Photo by Stan Szczytko.
Fig. 1.15. *Isoperla transmarina* female – WI: Waushara Co., Bird Creek, 6/V/1989, S.W. Szczytko – Photo by Stan Szczytko.

SYSTEMATICS (*CLIOPERLA* AND *ISOPERLA* SPECIES GROUP DESCRIPTIONS)

Clioperla clio (Newman)

Clioperla clio is unique among eastern Nearctic Isoperlinae in having a shallow posteromedian cleft and bipartite posteromedian upturned ridges with row of short stout spinulae on the male tergum ten (Fig. 2.3). The male paraprocts are flat, unsclerotized, triangular and not elevated above the posterior margin of tergum 10 (Fig. 2.5), and a membranous, rounded, bulbous posteromedian structure occurs on tergum ten (Fig. 2.3). The genus is most closely related to the *I. similis* group as discussed below. *Clioperla clio* is a common species that occurs from Ontario to Florida, throughout the midwestern and southeastern U.S., and into Oklahoma and Arkansas.

Isoperla bilineata Species Group

The *I. bilineata* group includes *I. bilineata*, *I. dicala* Frison, *I. fauschi* sp. n., *I. frisoni* Illies, *I. gibbsae* Harper, *I. myersi* sp. n., *I. powhatan* sp. n., *I. richardsoni* Frison, *I. sagittata* Szczytko and Stewart, *I. tutelo* sp. n., and *I zuelligi* sp. n. (Table 1). The phylogenetic cohesiveness among these species is not completely resolved and further subdivision may be warranted after all stages are known and studied. The present grouping is primarily based on medium to small body size, pale yellow habitus, and presence of an inverted dark V-band connecting the ocelli (occasionally absent, *I. dicala*). The aedeagus is usually membranous with or without sclerotized structures or patches of stout or long spinulae (Figs. 4.6, 17.6, 19.6, 47.6, 48.5, 61.6), but sclerotized structures or distinct heavy spinule patches are present on the aedeagus of several species included in the group (Figs. 14.6c., 20.5).

The aedeagus of *I. dicala* is distinctive among eastern species in having a long, stout, sclerotized, posteromedian spine enclosed within a sheath of striated overlapping plates (Figs. 14.6c, 14.7). The male vesicle is approximately 3X as long as wide and set in a distinctive U- shaped depression (Fig. 14.2). The male paraprocts are lightly sclerotized, bluntly pointed apically and extend slightly over the level of tergum ten (Figs. 14.3, 14.4). The female subgenital plate is broadly triangular, produced posteriorly over ca. ½ length of sternum nine and usually has a small posteromedian nipple (Fig. 14.5). The ovum of *I. dicala* is oblong with a circular cross section and the collar, eclosion line and follicle cell impressions are well-developed (Fig. 14.13). *Isoperla dicala* has a widespread distribution through eastern and midwestern North America.

The aedeagus of *I. gibbsae* has a conspicuous posteromedian band of large, stout, reddish brown, closely packed spines that become progressively longer apically. The basal spines are short, flat and plate-like, and are armed with numerous fine, apical finger-like spines which become shorter and are interspersed with short, stout, sharp spines (Fig. 20.5). The male paraprocts are lightly sclerotized, long, thin and not recurved over tergum 10. These structures are broad basally and their apices are deflected downward anteriorly and taper to sharp points (Figs. 20.2, 20.4). The female subgenital plate is broad, elongate and semi-ovate in shape, and usually extends to near the posterior margin of sternum ten; the apex is not deflected ventrally but scoop-shaped (Figs. 20.6, 20.7). At the present time no specimens with ova are known. *Isoperla gibbsae* is relatively poorly known, but is presently known from northeastern North America.

The aedeagus of *I. myersi* sp. n. has a tubular stalk and a wide mesal band of dense, stout golden-brown spinulae (Fig. 32.7d) and a distinctive posteromesal paddle-shaped patch of minute dark brown spinulae (Fig. 32.6b). The male paraprocts are lightly sclerotized, wide, short, flat, wrinkled basally, broadly rounded at the apex, paddle-shaped dorsally and extending slightly over tergum ten (Figs. 32.2, 32.3, 32.5). The female and ovum are unknown.

The aedeagus of *I. powhatan* sp. n. has a broad posterodorsal patch of sharp, golden- brown spinulae (Figs. 42.7, 42.8) and the distinctive paraprocts (Figs 42.3, 42.4) are broadly rounded apically, paddle-shaped and similar to those of *I. holochlora* (Klapálek) and *I. myersi* sp. n. The elongate female subgenital plate is narrowly triangular, produced posteriorly over

approximately ⅓ the length of sternum ten and is distinctively deflected ventrad (Fig. 42.5). The ovum is nearly round but with cross section triangular and collar well-developed; follicle cell impressions and eclosion line are absent (Fig. 42.9). Currently, *I. powhatan* sp. n. is known only from Pennsylvania and Virginia.

The aedeagus of *I. tutelo* sp. n. has a distinct posteroventral indented patch of broadly- pointed spinulae; edges of patch are indicated by overlapping spinulae and medially the spinulae become shorter dorsally (Fig. 59.7a). The male paraprocts are short, stout, lightly-sclerotized with blunt tips, extending barely to the level of tergum ten (Figs. 59.3, 59.4). The female subgenital plate is produced ⅓ the length, or less, of sternum nine, and is broadly-rounded, with a slight medial emargination (Fig. 59.5). The ovum is unknown. *Isoperla tutelo* sp. n. is known only from North Carolina.

Generally the male paraprocts of this group are lightly, or moderately- sclerotized, are only slightly recurved over tergum ten, and are sharply-pointed or blunt apically (Figs. 14.3, 14.4, 19.3, 19.4, 47.3, 47.5, 59.3, 59.4, 61.3, 61.4). The paraprocts of *I. bilineata* (Fig. 4.5) and *I. fauschi* sp. n. (Figs. 17.3, 17.4) are nearly erect, and they are broadly-rounded and paddle-shaped in *I. myersi* sp. n. (Figs. 32.2, 32.3, 32.5) and *I. powhatan* sp. n. (Figs. 42.3, 42.4).

The female subgenital plate is broadly-triangular in *I. bilineata, I. dicala*, *I. fauschi* sp. n., and *I. sagittata* (Figs. 4.4, 14.5, 17.5, 48.4) and narrowly-triangular and distinctly deflected ventrad. The base extends anteriorly for approximately 0.3 the length of sternum eight, and is produced posteriorly over approximately ⅓ the length of sternum ten in *I. powhatan* sp. n. (Figs. 42.5, 42.6). The plate is broadly rounded in *I. richardsoni*, *I. tutelo* sp. n., and *I. zuelligi* sp. n. (Figs. 47.4, 59.5, 61.5), broadly semi-ovate in *I. gibbsae* (Figs. 20.6, 20.7) and broadly truncate with median, posterior variable-length nipple and plate produced posteriorly over ca. ½ length of sternum nine with distal end usually deflected ventrad in *I. frisoni* (Fig. 19.5). The female of *I. myersi* sp. n. is unnassociated.

The known ova of this group vary considerably from nearly square with a triangular cross section in *I. bilineata* and *I. fauschi* sp. n. (Figs. 4.17, 17.13, 17.14); oblong with circular cross section in *I. dicala* (Fig. 14.13); oblong with concave cross section in *I. frisoni* (Figs. 19.11, 19.14); nearly round with cross section triangular in *I. powhatan* sp.n. (Fig. 42.9); oblong with cross-shaped ridges and triangular cross section in *I. richardsoni* and *I. zuelligi* sp. n. (Figs. 47.12, 47.14, 61.11, 61.12). The collar of the known ova is developed in all species; however the collar is low and set in an apical depression in *I. fauschi* sp. n. (Fig. 17.14). The eclosion line is absent in *I. fauschi* sp. n., *I frisoni, I. powhatan* sp. n., *I. richardsoni*, and *I. zuelligi* sp. n., but is present in the other species of the group. The follicle cell impressions are well developed and ridges elevated in all known ova except for *I. powhatan* sp. n. (Fig. 42.9). The ova of *I. gibbsae, I. myersi* sp. n., *I. sagittata,* and *I. tutelo* sp. n. are unknown.

Isoperla burksi Species Group

The *I. burksi* group includes *I. burksi* Frison, *I. cotta* Ricker, and *I. orata* Frison (Table 1). These species all share the inverted dark V-bands connecting the ocelli but open posteriorly (Figs. 5.1, 10.1, 37.1), a membranous aedeagus (Figs. 5.3, 5.7, 10.7. 37.7), apically blunt, lightly-sclerotized male paraprocts, which are recurved only to the level of tergum ten (Figs. 5.5. 10.3, 10.5, 37.3, 37.4), a truncate female subgenital plate extending over sternum nine with the apical ¼ deflected ventrad (Figs. 5.4, 5.6, 10.4, 10.6, 37.5, 37.6), and an oblong ova (ova of *I. burksi* unknown) with concave cross section and well-developed collar; follicle impressions, elevated ridges and eclosion line are absent (Figs. 10.14, 37.9). *Isoperla burksi* occurs in the Midwest, the Ozarks and southeastern US; *I. cotta* is distributed in the northeastern and upper midwestern North America and nymphs of *I. orata* usually occur in pristine medium to larger streams of the Appalachians of Pennsylvania to North Carolina, and Tennessee.

Isoperla decolorata Species Group

The *I. decolorata* group includes *I. davisi, I. decolorata,* and *I. transmarina* (Table 1). These species share a dark body coloration, heavily-sclerotized and apically pointed male paraprocts which extend over tergum ten (Figs. 11.3, 11.4, 13.3, 13.4, 58.5, 58.6) and a membranous aedeagus (Figs. 11.6, 13.6, 58.3). The female subgenital plate varies from broadly triangular with a posterior nipple in *I. decolorata* (Fig. 13.5), to triangular with distinct bipartite medium-brown triangular patches posteriorly in *I. davisi* (Fig. 11.5) to a truncate apex with a shallow or deep emargination (Fig. 58.40). The male vesicle of *I. decolorata* and *I. transmarina* is expanded posteriorly (Figs. 13.2, 58.2), whereas in *I. davisi* it is evenly rounded (Fig. 11.2). The ovum of *I. davisi* is oblong with cross-shaped ridges and triangular cross section, follicle impressions are absent, the collar is well-developed and the eclosion line is absent (Fig. 11.13); the ovum of *I. decolorata* is oval, the cross section circular, collar well-developed, follicle impressions faintly visible, eclosion line absent and micropyles with sperm guides (Fig. 13.7), and the ovum of *I. transmarina* is oval, cross section circular, collar well-developed, follicle cell impressions slightly visible, and eclosion line absent (Fig. 58.14). *Isoperla transmarina* is unique to this group in having a posterior band of short stout spinulae on tergum 10 (Fig. 58.6). *Isoperla davisi* is known from the Coastal Plain and Gulf Coastal streams from Delaware to Florida, Alabama, and Texas; *I. decolorata* is distributed in eastern and midwestern Canada and Alaska. *Isoperla transmarina* is geographically widespread occurring from northeastern North America and the upper midwestern states to northeastern Wyoming.

Isoperla irregularis Species Group

The *I. irregularis* group includes *I. decepta* Frison, *I. irregularis* (Klapálek), *I. ouachita* Stark and Stewart, and *I. szczytkoi* Poulton and Stewart (Table 1), species that are primarily distributed in the lower midwestern states and especially in the Ozark highlands (Poulton and Stewart 1991). These species share unusual sclerotized aedeagal structures that are variable among species (Figs. 12.6, 12.9, 22.6, 22.7, 38.6k, 38.14, 57.6, 57.10), an ovum without a collar (Figs. 12.18, 22.13, 38.21, 57.15) and nymphal lacinia with reduced or absent subapical tooth. marginal lacinial setae continuing to near the base, and a deeply-cleft right mandible with two or three apical teeth.

Isoperla decepta is the only Nearctic *Isoperla* species with the combination in the male of a completely pale yellow head without dark markings (Fig. 12.1) and a sclerotized elongate posteromedian blade-like aedeagal structure with sharp stout spinulae (Figs. 12.6d, 12.10). The aedeagus of *I. irregularis* is unique in having a large stout, upturned posteromedial sclerotized spine with horizontal sclerotized bars and posteromedial area surrounding spine with a large vertical indented sclerotized structure consisting of eight horizontal bars above the spine and eight larger horizontal bars below the spine, the lateral bars are connected by vertical median sclerotized rods and there is a dorsal membranous "tongue" shaped lobe extending over the apical end of the sclerotized structure partially covering the first three lateral bars (Figs. 22.6b, 22.8). The aedeagus of *I. ouachita* has an elevated golden brown sclerotized cover supported by basal tangs covering a posteromedian depressed area (Figs. 38.8k, 38.14) and the aedeagus of *I. szczytkoi* has a wide "V" shaped horizontal row of 6-8 elongate stout, golden brown sclerotized teeth with more slender teeth beneath outer teeth (Figs. 57.6e, 57.10). The ovum cross section of *I. decepta* is round (Fig. 12.18), concave in *I. ouachita* and *I. szczytkoi* (Figs. 38.21, 57.15) and triangular in *I. irregularis* (Fig. 22.13). *Isoperla decepta* and *I. ouachita* are pale yellow species whereas *I. irregularis* is darkly pigmented. *Isoperla decepta* occurs from the Interior Plains to the Cumberland Plateau of Kentucky, Tennessee, and Alabama; *I. irregularis* is known from the Ozark/Ouachita Mountains including Arkansas, Illinois, Indiana, Missouri, Oklahoma, but also Ohio; *I. ouachita* is distributed in the Ozarks/Ouachita Mountains of Arkansas, Missouri, Oklahoma, and *I. szczytkoi* is known only from Mount Magazine in western Arkansas.

Isoperla lata Species Group

The *I. lata* group includes *I. lata* Frison, *I.*

marlynia, and *I. pseudolata* sp. n. (Table 1). These species share a large body size, dark color pattern, membranous aedeagus, sharp heavily sclerotized male paraprocts which extend over ⅓ the length of tergum ten (Figs. 26.3, 26.4, 30.3, 30.4, 43.3, 43.4), tergum nine with posterior spinule patches (Figs. 26.4, 30.3, 43.4), oblong ova with circular cross section, and collar and eclosion line well developed (Figs. 26.11, 30.13, (*I. pseudolata* sp.n. ovum is unknown)). The aedeagus of *I. lata* and *I. pseudolata* sp. n. has a dorsal posterior directed beak-like lobe (Figs. 26.5, 43.6), whereas the aedeagus of *I. marlynia* has a large rounded dorsal lobe (Fig. 30.5). The three species of this group generally emerge early in the spring. *Isoperla lata* is distributed in northeastern North America and the upper Midwestern US; *I. marlynia* is geographically widespread, known from Atlantic Canada to Virginia and west to eastern Colorado and *I. pseudolata* sp. n. is known only from pristine Applachian streams of North Carolina, Virginia, and West Virginia.

***Isoperla longiseta* Species Group**

The *I. longiseta* group (Szczytko and Stewart 1979a) includes *I. jewetti* Frison, *I. longiseta*, and *I. quinquepunctata* (Table 1). These three species share a membranous tubular aedeagus (Figs. 24.6, 28.7, 45.7), male tergum ten with mesal bipartie medium brown triangular patches with fine spinulae, posterior ½ or ¾ of male tergum nine elevated with posterior median bipartie crescent shaped patches with short stout spinulae (Figs. 24.2, 28.3, 45.3), recurved sclerotized male paraprocts (Figs. 24.2, 24.4, 28.3, 28.5, 45.3, 45.4), and oblong ova with faint follicle cell impressions, developed collar and eclosion line absent (Figs. 24.7, 28.14, 45.17). *Isoperla longiseta* has paired posterodorsal tubular lobes (Fig. 28.7), *I. jewetti* has a single posterodorsal tubular lobe (Fig. 24.6) and *I. quinquepunctata* lacks a posterodorsal lobe (Fig. 45.7). The ova of *I. jewetti* and *I. longiseta* are round in cross section (Figs. 24.7, 28.14) whereas *I. quinquepunctata* is triangular in the anterior ½ and round in the posterior ½ (Fig. 45.17). *Isoperla jewetti* is known only from southwestern Texas and a high elevation site in Colorado, and may be extinct, whereas *I. longiseta*, is a relatively common species of large silty western North American rivers ranging into Midwest prairie streams primarily via the Missouri River system. However, apparently this species has been extirpated in large areas of its former Midwestern range (Heimdal et al. 2004 and DeWalt et al. 2005). Another common western species that has dispersed into western fringes of the Great Plains is *I. quinquepunctata.*

***Isoperla montana* Species Group**

The *I. montana* group includes *I. montana* Banks, *I. nelsoni* sp. n., and *I. smithi* sp. n. (Table 1). These species all share a single posterior sclerotized arrowhead shaped aedeagal spine plate with upturned distal stout spine (Figs. 33.5i, 33.8b, 33.10, 36.7c, 36.8d, 54.4d) and dark brown bars connecting the ocelli. *Isoperla nelsoni* sp. n. and *I. montana* have a posteroventral membranous aedeagal tube and it is unknown whether it is present in *I. smithi* sp.n. due to the lack of available fully everted material. The male paraprocts are moderately to heavily sclerotized and produced slightly over tergum ten (Figs. 33.3, 33.6, 36.3, 36.4, 54.2, 54.5). The female subgenital plate varies from triangular in *I. montana* and *I. smithi* sp. n. (Figs. 33.7, 54.6) to broadly rounded in *I. nelsoni* sp. n. (Fig. 36.6). The known ova (*I. montana, I. nelsoni* sp. n.) are triangular in cross section, have distinct cross shaped ridges dividing anterior and posterior poles and the hexagonal follicle cell impressions have elevated ridges (Figs. 33.25, 36.9). The collar is well developed and elevated in *I. montana* (Fig. 33.26) and low and poorly developed in *I. nelsoni* sp. n. (Fig. 36.10). *Isoperla montana* is widely distributed in eastern North America from Nova Scotia to South Carolina. *Isoperla smithi* sp. n. is known only from Virginia and West Virginia and *I. nelsoni* sp. n. appears to be more widespread in the southern Appalachians.

***Isoperla nana* Species Group**

The *I. nana* group includes *I. catawba* sp. n., *I. lenati* sp. n., and *I. nana* (Walsh) (Table 1). These species share small body size (forewing length < 8.5

mm), a membranous aedeagus with an elongate tubular base and expanded dorsal area (Figs. 6.6, 27.6, 35.6). The head pattern of *I. catawba* sp. n. and *I. lenati* sp. n. is pale yellow (Figs. 6.1, 27.1) whereas *I. nana* is medium brown with a dark brown posterior band with reticulate markings (Fig. 35.1), also the forewings do not exceed the tip of the abdomen and the costal area and tip of the wings are white in fresh specimens. The male paraprocts of *I. catawba* sp. n. and *I. nana* are heavily sclerotized and recurved over tergum ten and are sharply pointed (Figs. 6.3, 6.4, 35.3, 35.4), however the paraprocts of *I. lenati* sp. n. are moderately sclerotized, blunt apically and barely extend over tergum ten (Figs. 27.3, 27.4). The subgenital plates of *I. catawba* sp. n. and *I. lenati* sp. n. are low and evenly rounded posteriorly and barely extend over sternum eight (Figs. 6.5, 27.5), whereas the subgenital plate of *I. nana* is narrow and elongate extending for ca. ¾ length of sternum eight and posteriorly for ½ the length of sternum nine and has a posteromedian notch (Fig. 35.5). The ovum of *I. lenati* sp. n. is oblong with the anterior ½ triangular and the posterior ½ quadrangular with distinct horizontal ridges dividing the anterior and posterior poles with the longitudinal ridge divided at the horizontal ridge into two distinct posterior ridges; the bottom is flat and the eclosion line and follicle cell impressions are absent (Fig. 27.13). The ovum of *I. nana* is oblong, the cross section concave, collar and eclosion line are absent and the chorion is covered with reticulate raised ridges some not connected (Fig. 35.13). The ovum of *I. catawba* sp. n. is unknown. This group of species is the smallest sized species of *Isoperla* in eastern North America. *Isoperla catawba* sp. n. is known only from a single stream on the Coastal Plain of South Carolina and *I. lenati* sp. n. is more widespread, a Coastal Plain species ranging from North Carolina to Florida, whereas *I. nana* is widely distributed in northeastern North America and the Upper Midwest.

Isoperla phalerata Species Group

The *I. phalerata* group (Szczytko and Stewart 1979a) includes *I. phalerata, I. pinta* Frison and *I. slossonae* (Banks) (Table 1). Both *I. phalerata* and *I. pinta* are considered western North American species (Szczytko and Stewart 1979a, Sandberg and Kondratieff 2013). The three species share a membranous aedeagus (Figs. 40.6, 53.4), brightly pigmented head and pronotum (Figs. 40.1, 53.1), low wide male vesicle 3-4X times as wide as long (Figs. 40.2, 53.2), brown vertical band on femora, membranous abdominal plura on segments one to eight, spinule patches on tergum nine (Figs. 40.3, 53.3), oblong ova with circular cross section and well developed collar (Figs. 40.10, 53.11) and a diaphasic male drumming call (Szczytko and Stewart 1979b). *Isoperla pinta* is a western species extending as far east as Colorado. *Isoperla phalerata* reaches its eastern most distribution in the Black Hills of South Dakota. *Isoperla slossonae* is widespread in eastern North America and the Upper Midwest and is not sympatric with either *I. phalerata* or *I. pinta.*

Isoperla signata Species Group

The *I. signata* group includes the eastern Nearctic species *I. francesca* Harper, *I. holochlora, I. kirchneri* sp. n., *I. namata, I. signata* (Banks) and *I. siouan* sp. n. (Table 1). These species all share paired posterior aedegal sclerotized spine plates which taper to a stout ventral spine (Figs. 18.6c, 21.7b, 25.7, 34.6b, 50.7b, 52.7a). *Isoperla kirchneri* sp. n. and *I. namata*. have a posterobasal membranous aedeagal tube (Figs. 25.6b, 34.7a), however it is absent in the other members of the group. The ova of *I. kirchneri* sp. n., *I. namata* and *I. signata* are triangular in cross section, have distinct cross shaped ridges dividing the anterior and posterior poles and the ridges of the hexagonal follicle cell impressions and collars are elevated and well-developed (Figs. 25.19, 34.17, 50.20). The ovum of *I. holochlora* lacks the distinct cross shaped ridges and the follicle cell impressions are not visible (Fig. 21.20). The ovum of *I. francesca* is concave but the follicle cell impressions are well developed and the ridges elevated (Fig. 18.17). The female subgenital plate varies in this group from a large truncated plate with posteromesal emargination and ventrally deflected apex in *I. francesca* (Fig. 18.4), to triangular and elongate in *I. holochlora* (Figs. 21.4, 21.8), to broadly triangular in *I. kirchneri* sp. n., and

I. namata (Figs. 25.5, 34.4), to broadly rounded in *I. signata* and *I. siouan* sp. n. (Figs. 50.5, 52.5). Paraprocts are either lightly sclerotized and short, not usually recurved over tergum ten, blunt apically in *I. francesca* (Figs. 18.3, 18.5); heavily sclerotized, broadly rounded apically, recurved slightly over 10 tergum in *I. holochlora* (Figs. 21.3, 21.5, 21.6), moderately sclerotized, bluntly pointed apically recurved over tergum ten in *I. kirchneri* sp. n. (Figs. 25.3, 25.4); heavily sclerotized, sharply pointed, with a slight ventral spine in *I. namata* and *I. signata* (Figs. 34.3, 34.5, 50.3, 50.4) or short stout rounded apically lightly sclerotized and not recurved over tergum ten in *I. siouan* sp. n. (Figs. 52.3, 52.4). *Isoperla namata* is endemic to the Ozarks of the Lower Midwest where it is sympatric with *I. signata. Isoperla signata* is widely distributed in the Midwest and eastern North America extending from Nova Scotia to Virginia. *Isoperla kirchneri* sp. n. has an Appalachian distribution and extends from New York to North Carolina. *Isoperla. francesca* is a species of the northern Appalachian/Acadian ecoregion and *I. siouan* sp. n. may be restricted to North Carolina. *Isoperla holochlora* has a widespread distribution in North America. The head pattern of *I. namata* and *I. signata* is dark whereas *I. kirchneri* sp. n., *I. francesca*, and *I. siouan* sp. n. are light with only dark brown bars connecting the ocelli. The head pattern of *Isoperla holochlora* is unique within this group with the interocellar area dark brown/black and the frons dark brown (Fig. 21.1). The female subgenital plate is broadly triangular to round.

***Isoperla similis* Group**

The *I. similis* group includes *I. bellona* Banks, *I. cherokee* sp. n., *I. distincta* Nelson, *I. major* Nelson and Kondratieff, *I. sandbergi* sp. n., *I. similis*, and *I. starki* sp. n. (Table 1). All species share large stout golden brown or reddish brown aedeagal spines in various concentrations and sizes usually along the posterior margin (Figs. 3.7, 7.7e, 7.10g, 29.6e, 49.7f, 51.6e, 55.7c) and have sclerotized dorsal spine patches on the aedeagal stalk (Figs. 3.7, 3.8, 7.9, 29.6h, 49.7k, 49.8, 51.6k, 55.10). In addition, *Isoperla bellona, I. distincta, I. major*, and *I. similis* have sclerotized posteromesal spine plates (Figs. 29.6d, 49.9a, 51.6d, f). The male tergum nine is elevated in *I. bellona, I. cherokee* sp. n., and *I. distincta* (Figs. 3.6, 7.5, 15.2). The male paraprocts are sclerotized, nearly black and erect in *I. bellona, I. distincta, I. major*, and *I. starki* sp. n. and are barely recurved over tergum 10 (Figs. 3.3, 3.4, 3.6, 7.2, 7.6, 15.3, 15.4, 29.3, 29.4, 55.2, 55.4, 55.5), however the paraprocts of *I. similis* are only moderately sclerotized (Figs. 51.3, 51.4). The shape of the female subgenital plate varies among species in the group from broadly triangular in *I. bellona* and *I. distincta* (Figs. 3.5, 15.6), narrowly triangular in *I. cherokee* sp. n. (Fig. 7.4), low and broadly rounded in *I. major* and *I. similis* (Figs. 29.5, 51.5), to unusually truncated shape with an apical nipple in *I. starki* sp. n. (Fig. 55.6). The ova of *I. major, I. similis,* and *I. starki* sp. n. are oblong and round in cross section (Figs. 29.7, 51.15, 55.19, 55.20), however the ovum of *I. cherokee* sp. n. is nearly round and concave in cross section (Figs. 7.23, 7.24). The collar and eclosion line are well developed in *I. major, I. similis*, and *I. starki* sp. n. (Figs. 29.7, 29.8, 51.15, 51.16, 55.19, 55.20), however the collar is low and button-like and the eclosion line is absent in *I. cherokee* sp.n. (Figs. 7.23, 7.25). *Clioperla clio* is closely related to this group sharing large stout reddish brown aedeagal spines (Figs. 2.6, 2.8) and sclerotized dorsal spine patches on the aedeagal stalk (Fig. 2.7), oblong ova with concave cross section, and well developed collar, follicle cell impressions and eclosion line (Fig. 2.25). It differs from this group in having a shallow posteromedian cleft and bipartite posteromedian upturned ridges with row of short stout spinulae on male tergum 10 (Fig. 2.3), flat, unsclerotized triangular male paraprocts not elevated (Fig. 2.5) and a membranous rounded bulbous posteromedian structure on the tenth tergum (Fig. 2.3).

Perhaps other than *I. similis*, these species are endemic to rheocrene or low order spring-fed streams of the higher southern Appalachians. *Isoperla similis* is apparently restricted to remnant pristine low order streams of the Atlantic Coastal Plain and Piedmont Plateau from New England south to Virginia. Adults are rarely collected and probably the rarest and most unusual species of this group is *I. distincta*, known only from several

localities in the Unaka Mountains of southeastern Tennessee. The elevated posterolateral lobes bearing stout spinulae on male terga five and six and the strongly incurved male cerci are unique among Nearctic *Isoperla.*

***Isoperla pseudosimilis* Group**

The *I. pseudosimilis* sp. n. group includes *I. pauli* sp. n., *I. pseudosimilis* sp. n., *I. reesi* sp. n., *I. stewarti* sp. n., and *I. yuchi* sp. n. (Table 1). Species of this group are similar to the *I. similis* group sharing the large stout golden brown or reddish brown aedeagal spines (Figs. 39.6e, 39.7b, 44.6g, 44.7e, 46.6b, 46.8e, 56.7c, 56.8b,m, 60.6d, 60.7c, 60.8c) but lack sclerotized dorsal spine patches on the aedeagal stalk. Species in this group share heavily sclerotized male paraprocts, apically pointed and recurved over or slightly over tergum ten (Figs. 39.3, 39.4, 44.3, 44.4, 46.3, 46.4, 56.3, 56.4, 60.3. 60.4). Tergum nine of of the male of *I. stewarti* sp. n. is unique within the group having a low median ridge on the anterior ¼ with long stout setae (Fig. 56.6). The female subgenital plate varies from broad basally narrowing to a blunt narrow apex with a ribbed pattern subapically and produced posteriorly to or over the posterior margin of tergum nine in *I. pauli* sp. n. (Fig. 39.5), to low and broadly rounded in *I. pseudosimilis* sp. n. (Fig. 44.5) to broadly triangular in *I. reesi* sp. n. (Fig. 46.5), to narrowly triangular in *I. stewarti* sp. n. (Fig. 56.5) and *I. yuchi* sp. n. (Fig. 60.5). The ovum of *I. pseudosimilis* sp. n. is oblong and the cross section circular, the follicle cell impressions are well-developed with walls elevated and thickened and the eclosion line is elevated and striated (Fig. 44.19). Ova of the other species in this group are unknown. In this group, *I. pseudosimilis* sp. n. is relatively widespread and common from Atlantic Canada to Tennessee, whereas the other species are apparently restricted to rheocrene or low order spring-fed streams of the higher southern Appalachians.

Unassigned species

Seven species could not be assigned into the above groups. *Isoperla citronella*, *I. conspicua*, and *I. emarginata* are currently known with certainty from single female specimens and available characters preclude placement. *Isoperla chickamauga* sp. n. is the only eastern Nearctic *Isoperla* with a prominent sclerotized aedeagal rod (Fig. 8.6) which is similar to several western Nearctic *Isoperla* species (see Szczytko and Stewart 1979a, Sandberg and Kondratieff 2013) and presently is known only from Georgia. *Isoperla jamesae* is distinctive from other eastern *Isoperla* by having diffuse wide medium brown bands connecting ocelli and extending to posterior margin of head, terminating in two darker brown spots (Fig. 23.1) and by the unique shape, spinule patterns and unusual finger-like lobes of the entirely membranous aedeagus (Fig. 23.6). *Isoperla jamesae* is known only from Alabama. *Isoperla poffi* sp. n., a southeastern Atlantic Coastal Plain species, is the only eastern Nearctic *Isoperla* to have an ovum with a pentagonal cross section with five distinct elevated ridges (Figs. 41.13, 41.14) and it also has the earliest known emergence date of eastern *Isoperla* species. *Isoperla poffi* sp. n. occurs along the Atlantic Coastal Plains of North Carolina, South Carolina to Florida, generally associated with larger shifting sand streams with woody snag and debris nymphal habitats.

Morphology

Body Coloration. *Isoperla bilineata, I. burksi, I. cotta, I. decepta, I. dicala, I. emarginata, I. francesca, I. frisoni, I. gibbsae, I. jewetti, I. kirchneri* sp. n., *I. longiseta, I. maxana, I. myersi* sp. n., *I. montana, I. orata, I. powhatan* sp. n., *I. richardsoni, I. sagittata, I. siouan* sp. n., *I. tutelo* sp. n. and *I. zuelligi* sp. n. are medium/small in size, pale yellow *Isoperla* with a pale head pattern except for dark brown bands connecting the median and lateral ocelli (typical inverted dark V-band pattern). *Isoperla decepta* usually has an almost entirely pale yellow head and occasional individuals of *I. dicala* will also have an entirely pale yellow head. The darkest species include *C. clio, I. decolorata, I. irregularis, I. lata, I. major, I. marlynia, I. namata, I. pauli* sp. n., *I. pseudolata* sp. n., *I. pseudosimilis* sp. n., *I. signata, I. slossonae, I. similis*, and *I. transmarina.* The abdomen of male *I. lenati* sp. n., *I. jamesae, I. longiseta*, and *I.*

quinquepunctata are bright red in life but fade quickly in alcohol. Males of *I. montana* occasionally have reddish abdomens in life.

Size. Most species of eastern Nearctic *Isoperla* are medium to small size. The largest species include *C. clio, I. major, I. pseudosimilis* sp. n., and *I. similis* and the smallest species are *I. lenati* sp. n., *I. nana* and *I. powhatan* sp. n. Male forewing length varies from 15.0-17.0 mm (*C. clio*) to 5.1-6.0 mm (*I. nana*) and 2.8 mm (*I. jewetti* brachypterous) and female forewing length varies from 19-21 mm (*C. clio*) to 5.5-6.5 mm (*I. nana*).

Male Vesicle. The male vesicle is developed, sclerotized to some degree and extends to at least the anterior margin of sternum nine in most species. It varies in shape and degree of sclerotization but in most species it is nearly as long as wide. However, *I. dicala* has a long narrow vesicle approximately 3X as long as wide, set in a distinctive deep U-shaped depression (Fig. 14.2). The male vesicle of *I. phalerata* and *I. slossonae* is low and wide, usually 3-4X times as wide as long (Figs. 40.2, 53.2). The enigmatic *I. maxana* has an additional small posteromesal lobe on sternum seven (Fig. 31.2).

Male Abdominal Terga. Many species have a faint indication of two lateral and a median longitudinal stripe on the first 7 abdominal terga as well as 6 faint longitudinal rows of spots (three each laterally and 2 medially). The presence of these stripes and dots depends on the age of the specimen and preservation techniques and may not be apparent in older preserved material. This is certainly the case in *I. orata*. In most species the male terga nine and ten are unmodified except for scattered spinulae. In the *I. similis and I. pseudosimilis* sp.n. groups and *I. longiseta* and *I. jewetti,* terga nine and ten have distinct mesal bipartite, triangular, medium- brown patches with small spinulae. The ninth tergum of some species (*I. bellona, I. cherokee* sp. n., *I. distincta,* and *I. stewarti* sp. n.) is elevated and bears sharp spinulae (Figs. 3.6, 7.5, 15.2, 56.6). Tergum ten of *C. clio* has a shallow posteromedian cleft and bipartite posteromedian upturned ridges with rows of short stout spinulae (Fig. 2.3). In *I. distincta*, abdominal segment five has elongate rounded spinulose posterolateral protuberances deflected posterolaterally; segment six has smaller (⅓) rounded spinululose posterolateral protuberances with the apical end concave and the posterior ¾ of tergum nine distinctively elevated and tergum 10 depressed with bipartite mesal longitudinal medium-brown bands (Figs. 15.2, 15.5).

Male Paraprocts. In most species the paraprocts are sclerotized and upturned to the level of, or recurved over, tergum ten. The size, shape and degree of sclerotization vary highly among species. Generally they are pointed or blunt apically, however the paraprocts of *I. holochlora, I. myersi* sp. n., *I. orata,* and *I. powhatan* sp. n. are paddle-shaped and broadly-rounded apically (Figs. 21.3, 21.5, 32.5, 37.4, 42.3, 42.4). The paraprocts of *C. clio* are unsclerotized, tab-like, flat, triangular- shaped, and are not elevated to the level of tergum 10 (Fig. 2.5) The species in the *I. similis and I. pseudosimilis* sp. n. groups usually have erect long paraprocts that are heavily or moderately sclerotized, acutely pointed apically and recurved to, or over tergum ten (Figs. 3.3, 3.4, 7.2, 7.6, 15.3, 15.4, 29.3, 29.4, 39.3, 55.2, 55.4, 55.5). The paraprocts of *I. davisi* are heavily sclerotized and strongly curved outward near the apical ⅓ which is one of the more distinctive characters of this species (Figs. 11.3, 11.4). The paraprocts of *I. dicala, I. burksi, I. bilineata, I. richardsoni, I. decepta, I. cotta, I. francesca, I. gibbsae, I. sagittata,* and *I. orata* are either lightly sclerotized or unsclerotized and do not extend beyond the level of tergum ten. The paraprocts of *I. namata, I. signata* and *I. slossonae* have a distinctive ventral spur apically (Figs. 34.3, 50.4, 53.6).

Male Aedeagal Shape. Generally the aedeagus of eastern Nearctic *Isoperla* is hemispherical with bilateral symmetry. Aedeagal shape is highly variable among species but there are usually multiple membranous lobes. *Isoperla dicala, I. catawba* sp. n., *I. holochlora, I. lenati* sp. n., *I. longiseta, I. myersi* sp. n., *I. nana, I. orata, I. poffi* sp. n., *I. quinquepunctata* and *I. zuelligi* sp. n. have an elongate tubular basal stalk and expanded dorsal area (Figs. 6.6, 14.6, 21.9, 27.6, 28.7, 32.7, 35.6, 37.7, 41.6, 45.7, 61.6).

Male Sclerotized Aedeagal Structures. Most of the sclerotized aedeagal structures are located

posteriorly or mesally.

Paired Dorsobasal Sclerotized Spine Plates. In the *I. similis* group and *C. clio* there are unique paired dorsobasal sclerotized spine plates with stout, sharp usually golden-brown spinulae Examples of these plates include *C. clio* (Fig. 2.7), *I. bellona* (Figs. 3.7, 3.8), *I. cherokee* sp. n. (Fig. 7.9), *I. major* (Fig. 29.6h), *I. sandbergi* sp. n. (Figs. 49.7k, 49.8), *I. similis* (Fig. 51.6k) and *I. starki* sp. n. (Fig. 55.10). This location of sclerotized structures appears to be unique to *C. clio* and to the *I. similis* group.

Paired Sclerotized Posteromesal Spine Plates. Species in the *I. signata* group (*I. francesca, I. holochlora, I. kirchneri* sp. n., *I. namata, I. signata*, and *I. siouan* sp. n.) have paired posteromesal spine plates consisting of tightly packed stout spines which become progressively longer apically and terminate with a large spine. Plates near the base are elongated and truncate apically with several apical finger-like projections. These plates grade into much shorter, scallop- shaped plates with numerous fine finger-like apical projections at the plate base. The spine plates are upturned apically and when viewed under a dissecting microscope they appear to be large, wide single spines. Examples of this type of armature can be found in *I. holochlora* (Figs. 21.7b, 21.14), *I. namata* (Figs. 34.6b, 34.8, 34.9), *I. signata* (Figs. 50.7b, 50.8, 50.9) and *I. siouan* sp. n. (Fig. 52.7a).

Paired Posterolateral Sclerotized Plates with Apical Stout Spines. *Isoperla bellona* (Fig. 3.7*), I. distincta, I. major* (Fig. 29.6d) and *I. similis* (Fig. 51.6d) have paired posterolateral reddish-brown sclerotized plates with stout reddish-brown spines variously placed. *Isoperla similis* also has paired mesal tear-shaped sclerites with large stout reddish-brown spines (Fig. 51.6f).

Posteromedian Sclerotized Plate with row of 6-8 Stout Golden Brown Sclerotized Teeth

The wide V-row of six-eight elongate stout golden-brown sclerotized ventrally projecting aedeagal teeth with numerous small more slender teeth beneath outer teeth of *I. szczytkoi* is unique among eastern *Isoperla* (Figs. 57.6, 57.10, 57.12).

Posteromedian Sclerotized Structure with Large Upturned Spine and Horizontal Bars. *Isoperla irregularis* has a large unique posteromedian sclerotized structure with a large stout upturned spine with horizontal sclerotized bars (Figs. 22.6b, 22.7, 22.8, 22.9). The posteromedial area surrounding the spine has a large vertical indented sclerotized structure consisting of eight horizontal bars above the spine and eight larger horizontal bars below the spine. The lateral bars are connected by a vertical median sclerotized rod and there is a dorsal membranous "tongue" shaped lobe extending over the apical end of the sclerotized structure partially covering the first three lateral bars (Figs. 22.7, 22.8). This structure is unique among Nearctic *Isoperla*.

Posteromedian Elongate Sclerotized Blade-Like Structure. *Isoperla decepta* is unique in having a posteromedian sclerotized blade-like structure with apical tip deflected ventrad, with scattered short stout spines (Figs. 12.6d, 12.10).

Sclerotized Bone-shaped Rod. *Isoperla chickamauga* sp. n. is the only eastern Nearctic *Isoperla* to have a single bone-shaped sclerotized rod (Fig. 8.6).

Sclerotized Convex Shaped Posteroventral Plate. *Isoperla sandbergi* sp. n. is the only eastern *Isoperla* to have a sclerotized convex shaped posteroventral plate with a heavily sclerotized ventral margin (Figs. 49.7a, 49.9a).

Single Sclerotized Arrowhead Shaped Posteromesal Sclerotized Spine Plate. Species in the *I. montana* group (*I. montana, I. nelsoni* sp. n., and *I. smithi* sp. n.) have a single sclerotized posteromesal spine plate. This spine plate has the general appearance of a ventrally projecting "arrowhead" and consists of tightly packed (8-9) large stout reddish-brown apical spines which grade into large flat hand-shaped plates with blunt apical fingers, plates at the base are shorter and wider and have numerous fine apical extensions. The spine plate is upturned apically and when viewed under a dissecting microscope it appears as a wide single spine. Examples of this type of armature are found in *I. montana* (Figs. 33.5i, 33.9, 33.10), *I. nelsoni* sp. n. (Figs. 36.7c, 36.8d), and *I. smithi* sp.n. (Fig. 54.4d).

Single Sclerotized Posteromesal Large Spine. *Isoperla dicala* has a unique, large posteromesal

unicorn-shaped ventrally projecting sharp stout spine. This spine is sheathed with flat sclerotized ridged plates for approximately the basal ½. Some plates near the base have fine apical finger-like projections (Figs. 14.6, 14.7, 14.8, 14.9).

Aedeagal Lobes

Dorsal Tubular Lobes. *Isoperla bilineata* has a single dorsal tubular lobe (Figs. 4.6i, 4.7), and *I. jewetti* (Fig. 24.6), and *I. longiseta* have paired dorsal tubular lobes (Figs. 28.7, 28.8, 28.9).

Posterobasal Tubular Lobes. Some species in the *I. signata* and *I. montana* groups have an elongate basal, posterior tubular lobe that is curved upward. Examples of this type of posterobasal tube occur in *I. kirchneri* sp. n. (Fig. 25.6b), *I. montana* (Fig. 33.8a), and *I. namata* (Fig. 34.7a).

Paired Anteromedian Lobes with Finger-like Sub Lobes. The aedeagus of *I. jamesae* has paired anteromedian lobes with six-seven distinct inwardly deflected finger-like sub lobes (Figs. 23.13, 23.18).

Paired Posterodorsal Pointed Lobes. *Isoperla ouachita* has paired posterodorsal apically-pointed aedeagal lobes which are deflected medially at the tips (Figs. 38.6m, 38.18, 38.19).

Aedeagal Armature

Clumps of Dense Hair-Like Spinulae. The aedeagus of *I. montana* has dense clumps of long hair-like spinulae (Fig. 33.14).

Dense Stout, Blunt Peg-Like Spinulae. An example of this type of spinulae is found in *I. szczytkoi* (Figs. 57.6g, 57.13).

Dense Elongate Hair-Like Spinulae. *Isoperla bilineata* (Fig. 14.11), *I. fauschi* sp. n. (Fig. 17.12), and *I. quinquepunctata* (Fig. 45.10) have densely packed patches of elongate hair-like spinulae often twisted together at the tips.

Dense Rows of thick Hair-like Spinulae. The aedeagus of *I. kirchneri* sp. n. has dense rows of thick dark brown hair-like spinulae (Fig. 25.15).

Elongate Sharp Spinulae. Elongate sharp spinulae are common in many species. Some examples of this type of armature are found in *I. signata* (Fig. 50.17), *I. montana* (Figs. 33.5b, c, 33.17, 33.18, 33.20) and *I. signata* (Fig. 50.17).

Elongate Sharp Spinulae with Apical Filament. The aedeagus of *I. signata* has a dense band of elongate sharp spinulae with a single apical filament (Fig. 50.14).

Flat Sclerotized Plates. The aedeagus of *I. pseudosimilis* sp. n. has rows of shallow flat sclerotized plates without apical projections (Fig. 44.17).

Long and Short Stout Curved Spinulae. The aedeagus of *I. francesca* has long (Fig. 18.12), and short (Figs. 18.13, 18.14) distinctively curved spinulae.

Long Truncated Sclerotized Plates with Numerous Fine, or Stout Finger-like Projections. Species in the *I. signata* and *I. montana* groups have elongate, truncate plates with apical finger-like projections above the paired curved posterior spine plates as in *I. francesca*, *I. holochlora, I. kirchneri* sp. n., *I. namata, I. signata*, and *I. siouan* sp. n. Some examples of this type of armature are found in *C. clio* (Fig. 2.23), *I. kirchneri* sp. n. (Fig. 25.13), *I. montana* (Fig. 34.10) and *I. signata* (Fig. 50.10).

Raised Posterodorsal Longitudinal Sclerotized Ridges. The aedeagus of *C. clio* is distinctive in having packed and raised longitudinal posterodorsal sclerotized ridges which become progressively longer posteriorly (Figs. 2.21, 2.22).

Rows of Fine Hair-Like Spinulae. Many species have rows of fine hair-like spinulae, especially common on the basal aedeagal stalk. The concentration may be dense or sparse. Examples of this type of armature occur in *I. bilineata* (Fig. 4.8), *I. burksi* (Fig. 5.11), *I. cherokee* sp. n. (Fig. 7.14), *I. dicala* (Fig. 14.10), *I. decepta* (Fig. 12.9), *I. frisoni* (Fig. 19.7), *I. jamesae* (Fig. 23.11), *I. marlynia* (Fig. 30.9), *I. montana* (Fig. 33.23), *I. namata* (Fig. 34.13), *I. pauli* sp. n. (Fig. 39.10), *I. pseudosimilis* sp. n. (Fig. 44.10), *I. signata* (Fig. 50.18), *I. starki* sp. n. (Fig. 55.17) and *I. zuelligi* sp. n. (Fig. 61.9).

Scallop-Shaped Sclerotized Plates with Numerous Fine, or Stout Finger-Like Apical Projections. Several species have scallop-like plates with fine finger-like apical projections positioned variously on the aedeagus. The finger-like

projections can be short or elongate. Some examples of this type of armature include; **short** *C. clio* (Fig. 2.24), *I. francesca* (Figs. 18.8, 18.9), *I. frisoni* (Fig. 19.7), *I. namata* (Fig. 34.11), *I. nana* (Fig. 35.10) and *I. signata* (Figs. 50.11, 50.12); **elongate** *I. holochlora* (Fig. 21.16) and *I. montana* (Fig. 33.11).

Sensilla Basiconica. These sensory aedeagal structures are common in many eastern *Isoperla* species and vary in size and shape from small bumps to elongate pegs. They are usually associated with membranous non-spinulated areas of the aedeagus and are generally located in a medial or dorsal plane. Some examples of these sensory structures include **short sharp** in *C. clio* (Fig. 2.20) and *I. namata* (Fig. 34.15); **elongate and sharp** in *I. pseudosimilis* sp. n. (Fig. 44.15), *I. signata* (Fig. 50.16), and *I. starki* sp. n. (Fig. 55.16); **short stout peg-like** in *I. bilineata* (Fig. 4.14), *I. cotta* (Fig. 10.12), and *I. nana* (Fig. 35.12); and **elongate peg-like** in *I. fauschi* sp. n. (Figs. 17.10, 17.11).

Short Flat Scales. *Isoperla ouachita* has a dense patch of large blunt, stout, sclerotized scales lateral to a posteromedian depressed area (Fig. 38.15).

Short Stout Dense Blunt Spinulae. Examples of this type of armature include *I. lata* (Fig. 26.8), *I. longiseta* (Fig. 28.11), *I. pauli* sp. n. (Fig. 39.14), and *I. poffi* sp. n. (Fig. 41.12).

Small Raised Knobs with Apical Filament. *Isoperla slossonae* has small raised knobs with single apical setae above mesal section of the aedeagus (Figs. 53.4e, 53.10).

Short Stout Dense Sharp Spinulae. Some examples of this type of armature include *I. bilineata* (Fig. 4.11), *I. cherokee* sp. n. (Fig. 7.22), *I. cotta* (Fig. 10.9), *I. montana* (Fig. 33.24), *I. quinquepunctata* (Fig. 45.12), *I. transmarina* (Fig. 58.9), and *I. zuelligi* sp. n. (Fig. 61.8).

Short Stout Sharp Spinulae with Fine Apical Filament. *I. cotta* (Fig. 10.13), *I. davisi* (Fig. 11.11), *I. dicala* (Fig. 4.12), *I. ouachita* (Fig. 38.9), *I. phalerata* (Fig. 40.8), *I. richardsoni* (Fig. 47.9), and *I. signata* (Fig. 50.14) have patches of short, stout sharp spinulae with a single apical filament.

Small Rounded Knobs with Apical Filaments. *Clioperla clio* (Fig. 2.17) and *I. slossonae* (Fig. 53.10) have small rounded knobs with apical filaments.

Stout Rounded Knobs. The aedeagus of *I. fauschi* sp. n. (Fig. 17.9) and *I. marlynia* (Fig. 30.7) have concentrated patches of stout rounded knobs.

Stout Elongate Reddish Brown/Golden Brown Spines. There are stout reddish-brown or golden-brown posterior spines that usually have a socketed base in *C. clio* and the *I. similis* and *I. pseudosimilis* sp.n. groups. The size and locations of these spines vary considerably among species. Examples of this type of armature are found in *C. clio* (Figs. 2.6a, 2.8f, 2.8k, 2.9, 2.12, 2.16), *I. bellona* (Fig. 3.7), *I. cherokee* sp. n. (Figs. 7.7c, 7.10g, 7.16, 7.17), *I. major* (Fig. 29.6e), *I. pauli* sp. n. (Figs. 39.6e, 39.7e, 39.8, 39.11, 39.12), *I. pseudosimilis* sp. n. (Figs. 44.6f, 44.7e, 44.8c, 44.12), *I. reesi* sp. n. (Figs. 46.7, 46.8a, e), *I. sandbergi* sp. n. (Figs. 49.7f, 49.9f), *I. similis* (Figs. 51.6e, 51.11), *I. starki* sp. n. (Figs. 55.7c, 55.8d, 55.9h, 55.15) and *I. yuchi* sp. n. (Figs. 60.6d, 60.7c, 60.8c).

Stout Medium Length Reddish-Brown/Golden-Brown Spines. *Isoperla similis* has 7-8 medium length stout reddish-brown spines on the rounded posterior ends of the paired posterolateral sclerites (Figs. 51.10, 51.12).

Stout Elongate Reddish-Brown/Golden-Brown Spines with Curled Apical Tips. The aedeagus of *I. cherokee* sp. n. has long stout reddish-brown spines with distinct apical hooks above the conical lobes (Figs. 7.7e, 7.17, 7.16),

Female Subgenital Plate. The female subgenital plate of many species of eastern Nearctic Isoperlinae is variable among populations and between individuals of the same population. Identification of species, in most instances should not be based solely on subgenital plate characteristics given this variability. Generally the female subgenital plate of most eastern Nearctic *Isoperla* extends over at least ¼ the length of sternum nine; however, the subgenital plate of *I. catawba* sp. n. (Fig. 6.5), *I. lenati* sp. n. (Fig. 27.5), *I. pseudosimilis* sp. n. (Fig. 44.5), *I. reesi* sp. n. (Fig. 46.5), *I. zuelligi* sp. n. (Fig. 61.5) extends to, or only slightly over, sternum nine. The shape varies from broadly triangular (many species) to very long and broadly triangular (*I. frisoni*, Fig. 19.5; *I. pauli* sp. n. Fig. 39.5) to narrowly triangular (*I. powhatan* sp. n.,

Fig. 42.5) to low and evenly rounded (*I. decepta*, Fig. 12.4; *I. lenati* sp. n., Fig. 27.5; *I. reesi*, Fig. 46.5; *I. zuelligi* sp.n., Fig. 61.5). Many species have a mesal emargination or notch, although this character may be variable within a population (*I. bilineata*, Fig. 4.4; *I. marlynia*, Fig. 30.6; *I. montana*, Fig. 33.7; *I. richardsoni*, Fig. 47.4; *I. signata*, Fig. 50.5). In some species the subgenital plate is elongate and truncate (*I. frisoni*, Fig. 19.5; *I. transmarina*, Fig. 58.4). *Isoperla burksi* (Figs. 5.4, 5.6), *I. cotta* (Figs. 10.4, 10.6), *I. francesca* (Fig. 18.4), and *I. sagittata* (Figs. 48.4, 48.6), have a subgenital plate which is semi-truncate and deflected ventrally near the apical ⅓, appearing scoop-shaped in lateral view.

Eggs. Mature eggs of eastern Nearctic *Isoperla* are not frequently found in collected material. Many females have abdomens packed with mermithid parasites and no mature eggs are present regardless of time or location of collection. The largest known eggs are *I. bilineata* (length 425 µm, width 395 µm) and *I. similis* (length 425 µm, width 395 µm) and the smallest egg is *I. cherokee* sp. n. (length 200 µm, width 180 µm).

Most known eastern Nearctic *Isoperla* eggs are generally oblong, although some are more nearly square (*I. fauschi* sp. n., Fig. 17.13; *I. nelsoni* sp. n., Fig. 36.9), nearly round (*I. cherokee* sp. n., Fig. 7.23; *I. jamesae*, Fig. 23.20) or pear shaped (*I. ouachita*, Fig. 38.20). The ovum cross section can be circular (*I. decepta*, Fig. 12.18; *I. decolorata*, Fig. 13.7; *I. dicala*, Fig. 14.13; *I. jewetti*, Fig. 24.7; *I. lata* (Figs. 26.11, 26.14), *I. longiseta*, Fig. 28.14; *I. major*, Fig. 29.7; *I. marlynia*, Fig. 30.13; *I. pseudosimilis* sp. n. (Figs. 44.19, 44.21), *I. similis*, Fig. 51.15; *I. slossonae*, Fig. 53.11; *I. transmarina*, Fig. 58.14), triangular (*I. fauschi* sp. n., Fig.17.13; *I. holochlora*, Fig. 21.20; *I. irregularis*, Fig. 22.13), triangular with cross-shaped longitudinal and horizontal ridges (*I. davisi*, Fig. 11.13; *I. montana*, Fig. 33.25; *I. namata*; Fig. 34.17; *I. nelsoni* sp. n., Fig. 36.9; *I. quinquepunctata*, Fig. 45.17; *I. richardsoni*, Fig. 47.12; *I. zuelligi* sp. n., Fig. 61.11), concave (*C. clio*, Fig. 2.28; *I. cherokee* sp. n., Fig. 7.24; *I. cotta*, Fig. 10.15; *I. francesca*, Fig. 18.17; *I. frisoni*, Fig. 19.14; *I. jamesae*, Fig. 23.21; *I. nana*, Fig. 35.13; *I. orata*, Fig. 37.10; *I. ouachita*, Fig. 38.21; *I. starki* sp. n., Fig. 55.20; *I. szczytkoi*, Fig. 57.15) or multi-shape (*I. poffi* sp. n. [oblong, 5 sided, flat bottom, Figs. 41.13, 41.14] and *I. lenati* sp. n. [posterior ½ near collar, triangular, anterior ½ quadrangular, Figs. 27.13, 27.14]).

The egg collar is attached on the posterior end of the egg body and is well-developed in *C. clio* (Fig. 2.26), *I. bilineata* (Fig. 4.18), *I. cotta* (Fig. 10.16), *I. davisi* (Fig. 11.14), *I. decolorata* (Fig. 13.9), *I. dicala* (Fig. 14.13), *I. francesca* (Fig. 18.16), *I. frisoni* (Fig. 19.12), *I. holochlora* (Fig. 21.21), *I. lata* (Fig. 26.13), *I. longiseta* (Fig. 28.15), *I. marlynia* (Fig. 30.12), *I. montana* (Fig. 33.26), *I. orata* (Fig. 37.9), *I. phalerata* (Fig. 40.12), *I. poffi* sp. n. (Fig. 41.15), *I. powhatan* sp. n. (Fig. 42.10), *I. pseudosimilis* sp. n. (Fig. 44.20), *I. quinquepunctata* (Fig. 45.18), *I. similis* (Fig. 51.16), *I. slossonae* (Fig. 53.12), *I. starki* sp. n. (Fig. 55.21) and *I. transmarina* (Fig. 58.15). The collar is low in *I. cherokee* sp. n. (Fig. 7.25), *I. fauschi* sp. n. (Fig. 17.14), *I. jewetti* (Fig. 24.9), *I. lenati* sp. n. (Fig. 27.15), *I. namata*, (Fig. 34.19), *I. nelsoni* sp. n. (Fig. 36.10), *I. richardsoni* (Fig. 47.13), *I. zuelligi* sp. n. (Fig. 61.11) and absent in *I. decepta* (Fig. 12.18), *I. irregularis* (Fig. 22.13), *I. jamesae* (Fig. 23.20), *I. nana* (Fig. 35.13), *I. ouachita* (Fig. 38.20), and *I. szczytkoi* (Fig. 57.14).

The follicle cell impressions (FCI) are well-developed with thickened walls in *C. clio* (Fig. 2.27), *I. bilineata*, (Fig. 4.19), *I. cotta* (Fig. 10.14), *I. decepta* (Fig. 12.18), *I. dicala* (Fig. 14.13), *I. fauschi* sp. n. (Fig. 17.13), *I. francesca* (Fig. 18.6), *I. frisoni* (Fig. 19.11), *I. irregularis* (Fig. 22.13), *I. kirchneri* sp. n., (Fig. 25.19), *I. lata* (Fig. 26.11), *I. montana* (Fig. 33.25), *I. namata*, (Fig. 34.17), *I. nana* (Fig. 35.13 [chorion covered with thickened raised reticulate ridges], *I. nelsoni* sp. n. (Fig. 36.9) [ridges thin], *I. orata* (Fig. 37.9), *I. phalerata* (Fig. 40.10), *I. poffi* sp. n., (Fig. 41.13) [ridges wide, slightly elevated], *I. richardsoni* (Fig. 47.12), *I. signata* (Fig. 50.20), *I. starki* sp. n. (Fig. 55.19), *I. szczytkoi* (Fig. 57.14), *I. zuelligi* sp. n. (Figs. 61.11, 61.13). The FCI's are faintly visible in *I. decolorata* (Fig. 13.8), *I. jewetti* (Fig. 24.8), *I. longiseta* (Fig. 28.14), *I. major* (Fig. 29.7), *I. marlynia* (Fig. 30.13), *I. namata* (Fig. 34.17), *I. ouachita* (Fig. 38.20), *I. quinquepunctata* (Fig. 45.17), *I. similis* (Fig. 51.15), *I. slossonae* (Fig. 53.13), *I. transmarina* (Fig. 58.14), and are absent in *I. cherokee* sp. n. (Fig. 7.23), *I. davisi* (Fig. 11.13), *I. holochlora* (Fig. 21.20), *I. jamesae* (Fig. 23.20), and *I. lenati* sp. n. (Fig. 27.13).

The eclosion line, when present, is located near the anterior end of the egg and is well-developed in *C. clio* (Fig. 2.27) and *I. major* (Fig. 29.9) as sinuous ridges; *I. bilineata* (Fig. 4.20), *I. dicala* (Fig. 14.1), *I. marlynia* (Fig. 30.14) as wide and flat; *I. francesca* (Fig. 18.21) as thin; *I. frisoni* (Fig. 19.13), and *I. irregularis* (Figs. 21.13, 21.15) as wide and elevated; *I. lata* (Figs. 26.11, 26.14) as raised, thickened, and wide; *I. poffi* sp. n. (Fig. 41.13) as raised and wide; *I. pseudosimilis* sp. n. (Fig. 44.19) as raised, thickened, and striated; *I. similis* (Fig. 51.17), as wide, smooth with sinuous ridges; *I. starki* sp. n. (Figs. 55.22, 55.23) and *I. szczytkoi* (Fig. 57.16) as low sinuous ridges. The eclosion line is absent in *I. cherokee* sp. n. (Fig. 7.23), *I. cotta* (Fig. 10.14), *I. davisi* (Fig. 11.13), *I. decepta* (Fig. 12.18), *I. decolorata* (Fig. 13.8), *I. fauschi* sp. n. (Fig. 17.13), *I. holochlora* (Fig. 21.20), *I. jamesae* (Fig. 23.22), *I. jewetti* (Fig. 24.8), *I. kirchneri* sp. n. (Fig. 25.19), *I. lenati* sp. n. (Fig. 27.13), *I. longiseta* (Fig. 28.14), *I. montana* (Fig. 33.25), *I. namata* (Fig. 34.17), *I. nana* (Fig. 35.13); *I. nelsoni* sp. n. (Fig. 36.11), *I. orata* (Fig. 37.9), *I. ouachita* (Fig. 38.23), *I. phalerata* (Fig. 40.10); *I. poffi* sp. n. (Fig. 41.13), *I. powhatan* sp. n. (Fig. 42.9), *I. quinquepunctata* (Fig. 45.20), *I. richardsoni,* (Fig. 47.12), *I. signata* (Fig. 50.22), *I. slossonae* (Fig. 53.11), *I. transmarina* (Fig. 58.14), and *I. zuelligi* sp. n. (Fig. 61.13).

Micropyles are generally located near the anterior ⅓ of the egg body, often near, or on the eclosion line in a linear configuration. However in *I. lenati* sp. n. they are scattered (Fig. 27.16) and in *I. frisoni* (Fig. 19.13) and *I. cotta* (Fig. 10.18) they are positioned along a sinuous row. The micropyle orifices are generally positioned on FCI ridges. The orifices are flush with the ridge for example, in *C. clio* (Fig. 2.27), *I. bilineata* (Fig. 4.20), *I. cotta* (Fig. 10.18), *I. davisi* (Fig. 11.16), *I. decepta* (Fig. 12.19), *I. fauschi* sp. n. (Fig. 17.15), *I. frisoni* (Fig. 19.13), *I. lata* (Fig. 26.14), and *I. irregularis* (Fig. 21.5). In other species, the orifices have a donut-shaped lip, for example *I. cherokee* sp. n. (Fig. 7.26), *I. jamesae* (Fig. 23.23), *I. nana* (Fig. 35.15), *I. nelsoni* sp. n. (Fig. 36.11), *I. ouachita* (Fig. 38.23), and *I. similis* (Fig. 51.17). In other species the orifices have slit like openings (*I. marlynia,* Fig. 30.14, *I. orata,* Fig. 37.12; *I. phalerata*, Fig. 40.11; *I. slossonae,* Fig. 53.13). Some species have sperm guides associated with the orifices for example *I. decolorata* (Fig. 13.8) and *I. longiseta* (Fig. 28.16) have have elongate and thick guides. In *I. major* (Fig. 29.9) and *I. powhatan* sp. n. (Fig. 42.12) the guides are short. In *I. transmarina* the orifices (Fig. 58.16) are set in a depression.

KEY TO THE EASTERN NORTH AMERICAN ISOPERLINAE

Males
(males of *I. citronella, I. conspicua,* and *I. emarginata* unknown)

1 Tenth tergum with shallow posteromedian cleft and bipartite posteromedian upturned ridges (Fig. 2.3); distribution–Ontario to Florida through the midwestern US ……..***Clioperla clio***

1′ Tenth tergum entire (Figs. 4.3, 14.3, 22.3) ..…….. ***Isoperla* 2**

2 Small body size, body length < 7.0mm; forewing < 8.0 mm; in fresh specimens abdominal color red to orange or brown to dark brown ……..… **3**

2′ Larger body size, body length > 7.0mm; forewing length > 8.0 mm; abdominal color variable …….. **4**

3 Dorsum of head with wide posterior transverse dark band with reticulate markings; paraprocts heavily sclerotized, pointed apically; abdomen not red or orange after alcohol preservation but brown to dark brown; costal area of forewings greyish white, forewings extending over abdomen ¼ length of forewings (Figs. 35.1, 35.3-35.2); distribution–northeastern North America–upper Midwest ……..… ***I. nana***

3′ Dorsum of head mostly pale without a wide posterior transverse dark band with reticulate markings; paraprocts moderately sclerotized, rounded apically; abdomen with distinct red or orange coloration after recent alcohol preservation, costal area of forewings hyaline; forewings barely extending over abdomen (Figs. 27.1, 27.2–27.4); distribution–Atlantic Coastal Plain streams–North Carolina, South Carolina to Florida …….. ***I. lenati* sp.n.**

4 Small posteromedian lobe on sternum 7; paraprocts flat and unsclerotized (Figs. 31.2–

31.4); distribution–rare (extinct?) – Minnesota …….. ***I. maxana***

4′ Sternum 7 without a lobe; paraprocts not flat and unsclerotized (Figs. 6.3, 6.4, 10.3, 40.3) ….. **5**

5 Macropterous or brachypterous; forewings < 4.0 mm in brachypterous specimens; distribution–west of Mississippi River, or Texas ……... **6**

5′ Macropterous; forewings > 6.0 mm; distribution otherwise …….. **7**

6 Brachypterous forewings < 3.0 mm; medium brown bands connecting ocelli; mesonotum without large V-shaped anterior pale area; aedeagus with dorsal elongate finger-like membranous tube (Figs. 24.1, 24.6); distribution–rare (extinct?)–Texas ….. ***I. jewetti***

6′ Macropterous or brachypterous forewings > 3.0 mm; ocelli not connected by medium brown bands; mesonotum with large V-shaped anterior pale area; aedeagus without elongate finger-like membranous tube (Figs. 45.1, 45.7); distribution–common–midwestern US–west of the Mississippi River …..….. ***I. quinquepunctata***

7 Vesicle of 8th sternum expanded apically, wider than base, truncate posteriorly (Figs. 13.2, 58.2) ……..…. **8**

7′ Vesicle of 8th sternum evenly rounded posteriorly, not expanded apically (Figs. 8.2, 28.2) ……. **9**

8 Vesicle of 8th sternum darker than remainder of segment; 8th tergum with posterior band of short spinulae; 10th tergum with bipartite median patch of short stout spinulae (Figs. 58.2, 58.6); distribution–northeastern North America and upper midwestern US to northeastern Wyoming …… ***I. transmarina***

8′ Vesicle of 8th sternum paler than rest of segment; 8th and 9th tergum without band or patch of short stout spinulae (Figs. 13.2, 13.3); distribution–eastern and midwestern Canada ..... ***I. decolorata***

9 Vesicle of 8th sternum short, 3X–4X wide as long, not reaching anterior margin of 9th sternum (Figs. 40.2, 53.2) …….. **10**

9′ Vesicle of 8th sternum elongated posteriorly, < 3X as wide as long, usually reaching or extending past anterior margin of 9th sternum (Figs. 42.2, 44.2) …….. **11**

10 Vesicle of 8th sternum 3X as wide as long (Fig. 53.2); dorsal head pattern dark with extensive areas of dark brown/black markings, pronotum with checkerboard pattern of pale and dark markings, lateral margins mostly dark brown/black (Fig. 53.1); aedeagus with posterior dumbbell-shaped membranous lobe (Fig. 53.4); distribution–widespread, eastern North America–upper midwestern US ….. ***I. slossonae***

10′ Vesicle of 8th sternum 4X as wide as long (Fig. 40.2); dorsal head pattern pale yellow with contrasting dark brown/black bands; pronotum mostly pale yellow with dark brown/black splotches, lateral margins pale (Fig. 40.1); aedeagus without dumbbell-shaped posterior membranous lobe (Fig. 40.6); distribution–midwestern US, west of the Mississippi River, especially Black Hills, South Dakota …….. …….. ***I. phalerata***

11 Dorsal head pattern pale, usually without dark brown bands or brown markings connecting ocelli (Figs. 14.1, 12.1) ……. **12**

11′ Dorsal head pattern with dark brown bands connecting ocelli (Figs. 17.1, 20.1, 33.1) …….. **13**

12 Vesicle 3X as long as wide, set in a deep U-shaped depression ¾ as long as length of vesicle (Fig. 14.2); paraprocts lightly sclerotized, bluntly pointed apically, not deflected ventrad apically (Fig. 14.4), aedeagus with erect posteromesal sclerotized unicorn-shaped rod (Figs. 14.6, 14.7); head pattern occasionaly with thin dark brown bands connecting ocelli distribution–widespread–eastern and midwestern North America ……..……..... ***I. dicala***

12′ Vesicle 1¼X as long as wide, not set in a deep depression (Fig. 12.2); paraprocts lightly sclerotized, sharply pointed apically, deflected ventrad apically (Fig. 12.5); aedeagus with posteromesal lightly sclerotized elongate blade-like structure with apically deflected tip (Fig. 12.6); head pattern without thin dark brown bands connecting ocelli; distribution–small streams of Midwest Interior Plains to Kentucky, Tennessee, Alabama ……..……. ***I. decepta***

13 Interocellar area pale (Figs.18.1, 28.1) …….. **14**

13′ Interocellar area mostly diffuse medium to dark brown (Figs. 15.1, 21.1, 56.1) ……. **44**

14 Aedeagus with a single flat, posteroproximal horizontal bone-shaped sclerotized rod with expanded tip (Figs. 8.6, 8.7); distribution–southeastern US–Georgia ……. ……..…. ***I. chickamauga* sp.n.**

14′ Aedeagus without flat posteroproximal horizontal bone-shaped sclerotized rod …….. **15**

15 Paraprocts weakly or moderately sclerotized not darkly pigmented (Figs. 10.3, 10.5) ……... **16**

15′ Paraprocts heavily sclerotized nearly black (Figs. 26.3, 26.4) ……... **34**

16 Paraprocts nearly erect, not recurved over 10th tergum (Figs. 4.3, 4.5, 17.3) …… **17**

16′ Paraprocts not nearly erect, may or may not be recurved over 10th tergum (Figs. 28.3, 28.5) … **19**

17 Fully extruded aedeagus with single elongate anterodorsal finger-like membranous tube in lateral view (Figs. 4.6i, 4.7), with distinct posteroventral lobe (Figs. 4.6b, 4.7), and paired anterodorsal lobes (Figs. 4.6j, 4.7); distribution–larger streams of the Interior Plains of midwestern US …… ***I. bilineata***

17′ Fully extruded aedeagus without single elongate finger-like membranous tube, aedeagus with lobes otherwise (Figs. 41.6) … **18**

18 Paraprocts distinctly deflected ventrad at tips (Fig. 20.2); aedeagus with posteromedian band of large stout reddish brown spines (Fig. 20.5); distribution–northeastern North America–Quebec, Connecticut ……. ***I. gibbsae***

18′ Paraprocts not distinctly curved ventrad at tips (Fig. 17.4); aedeagus without posteromedian band of large stout reddish brown spines (Fig. 17.6); distribution–Atlantic Coastal Plains of Virginia, North Carolina ……. ***I. fauschi* sp.n.**

19 Paraprocts lightly sclerotized, bluntly pointed or rounded apically (Figs. 10.5, 18.5, 19.4) …. **26**

19′ Paraprocts variously sclerotized, sharply pointed apically (Figs. 28.3, 28.5, 41.2, 61.4) …... ……**20**

20 Anterior ½ of tergum 9 elevated with crescent shaped bipartite patch of stout spinulae, 10th tergum with bipartite sclerotized medium brown patches with small fine spinulae; paraprocts long, extending over ⅓ length of 10th tergum (Figs. 28.3, 28.6); aedeagus with two posterodorsal tubes (Fig. 28.7); distribution – uncommon–Interior Great Plains of the Mississippi River drainage …… ***I. longiseta***

20′ Anterior ½ of tergum 9 not elevated; paraprocts not extending over ⅓, length of 10th tergum (Figs. 41.4, 61.3); aedeagus without two posterodorsal tubes (Figs. 41.6, 61.6); distribution– east of the Mississippi River …. **21**

21 Tergum 9 depressed with pale brown median area bearing short, stout spicules (Fig. 41.4); paraprocts short, tab-like barely extending to level of 10th tergum (Figs. 41.2, 41.4); distribution–larger streams of Atlantic Coastal Plains–North Carolina, South Carolina to Florida ……. ***I. poffi* sp.n.**

21′ Tergum 9 not depressed and lacking pale brown median area with short, stout spicules (Fig. 61.3); paraprocts variously modified but not tab-like (Fig. 61.4) ……. **22**

22 Aedeagus with large tubular ventral section (Fig. 61.6a); distribution–eastern US–Piedmont Sand Hill streams–North Carolina ……. ……. ***I. zuelligi* sp.n.**

22′ Aedeagus without large tubular ventral section (Figs. 57.7) …… **23**

23 Aedeagus with posteromedian broad V-shaped horizontal row of 6-8 elongate stout golden brown sclerotized teeth (Figs. 57.6, 57.10); distribution–Ozarks of western Arkansas (Mt. Magazine) …….. ***I. szczytkoi***

23′ Aedeagus without posteromedian broad V-shaped horizontal row of 6-8 elongate stout golden brown sclerotized teeth (Figs. 23.6, 5.7) …… **24**

24 Dorsum of head with diffuse wide medium brown bands connecting ocelli and extending to posterior margin of head terminating in two dark brown spots; paraprocts weakly sclerotized, bluntly pointed, not recurved over 10th tergum, (Figs. 23.1, 23.4, 23.5); distribution–southeastern US–Alabama, Mississippi ……. ……..……. ***I. jamesae***

24′ Dorsum of head without ocellar bands extending to posterior margin of head and terminating in two dark brown spots (Figs. 5.1, 32.1) ……... **25**

25 Aedeagus with large posteroventral rounded lobe with large ovate patch of long stout

spinulae (Figs. 5.7, 5.8); vesicle 2X as wide as long (Figs. 5.2, 5.7, 5.8); distribution–Midwest including the Ozarks, southeastern US …….. ……. ***I. burksi***

25′ Aedeagus without large posteroventral rounded lobe with large ovate patch of long stout spinulae (Figs. 32.6, 32.7); vesicle < 2X as wide as long (Fig. 32.4) …….. **26**

26 Paraprocts paddle-shaped and broadly rounded dorsally (Figs. 32.3, 32.5, 42.4, 42.3) ……. **27**

26′ Paraprocts not paddle-shaped or broadly rounded dorsally (Figs. 10.3, 10.5, 19.3, 19.4) . **28**

27 Aedeagus with posteromesal paddle-shaped patch of minute dark brown spinulae (Fig. 32.6, 32.7) and large dorsal lobe (Fig. 32.7b); paraprocts deflected laterad at tips (Figs. 32.3, 32.5); distribution–northeastern North America–New York …….. ***I. myersi*** **sp.n.**

27′ Aedeagus with broad band of dense posterodorsal stout sharp golden brown spinulae (Figs. 42.7b, 42.8b) and paired dorsal lobes (Figs. 42.7c, 42.8a); paraprocts not deflected laterad apically (Fig. 42.3); distribution–Pennsylvania and Virginia …… ……..… ***I. powhatan*** **sp.n.**

28 Aedeagus with ventral heart-shaped lobe (Fig. 48.7); distribution–eastern Texas ….. ***I. sagittata***

28′ Aedeagus without ventral heart-shaped lobe (Fig. 10.7); distribution–not eastern Texas ….. **29**

29 Clypeus and frons with a broad inverted, dark brown triangular patch; aedeagus with paired anterodorsal lobes (Fig. 10.1); fresh specimens with a greenish cast; distribution–northeastern and upper midwestern North America. ……. ……... ***I. cotta***

29′ Clypeus and frons without a broad inverted, dark brown triangular patch (Fig. 19.1); aedeagus without paired anterodorsal lobes; body coloration without greenish cast …… **30**

30 Aedeagus membranous with stout posterobasal tube-like lobe (Fig. 19.6); distribution–eastern and upper midwesternern North America ……... ***I. frisoni***

30′ Aedeagus membranous without stout posterobasal tube-like lobe (Fig. 6.6) ……... **31**

31 Aedeagus with paired median sclerotized spine patches with long stout spines (Figs. 18.6c, 52.7a) **… 32**

31′ Aedeagus without paired median sclerotized spine patches with long stout spines (Figs. 37.7, 37.8, 59.6, 59.7) ……. **33**

32 Aedeagus with paired posterodorsal horseshoe-shaped lobes with scallop-shaped plates, paired median sclerotized patches of long stout spinulae (Figs. 18.6, 18.9, 18.11); distribution–northeastern North America ……. ***I. francesca***

32′ Aedeagus with median posterodorsal ridge-like row of large heavy reddish brown spines; paired sclerotized posteroventral spine patches with heavy reddish brown spines, patches tooth-shaped with longest spines apically (Fig. 52.7); distribution–Atlantic Coastal Plain/Piedmont Sandhill streams–North Carolina ……... ***I. siouan*** **sp.n.**

33 Aedeagus with posteroventral indented patch of broadly pointed spinulae, edges of patch indicated by overlapping spinulae (Fig. 59.7); distribution–southern Appalachians–North Carolina …… ***I. tutelo*** **sp.n.**

33′ Aedeagus membranous without posteroventral indented patch of broadly pointed spinulae (Figs. 37.7, 37.8); distribution–southern Appalachians of North Carolina, Tennessee, Virginia ……..…….. ***I. orata***

34 Paraprocts pointed apically, moderately or lightly sclerotized not almost black (Figs. 33.3, 33.6, 25.3, 25.4) ……. **35**

34′ Paraprocts pointed apically, heavily sclerotized, almost black (Figs. 11.3, 11.4, 6.3, 6.4) …….. **37**

35 Paraprocts acutely pointed apically, deflected slightly laterad apically (Fig. 33.3) ……... **36**

35′ Paraprocts bluntly pointed apically, deflected slightly inward (Fig. 25.4); aedeagus with long tapered posterobasal tube and paired sclerotized posteromedian spine plates with stout reddish brown spines (Figs. 25.6, 25.7, 25.11); distribution–Appalachians of eastern US –New York to North Carolina ….. ***I. kirchneri*** **sp.n.**

36 Paraprocts slightly deflected ventrad apically (Fig. 33.6); dorsum of head with dark brown bands connecting ocelli and extending anteriorly to frons (Fig. 33.1); aedeagus with posterior sclerotized arrowhead-shaped spine plate with reddish brown spines and large posterobasal elongate membranous tube (Figs.

33.5, 33.8); distribution–common–widely distributed–eastern North America . ***I. montana***

36′ Paraprocts not deflected ventrad apically (Fig. 47.5); dorsum of head without dark brown bands connecting ocelli and extending anteriorly to frons (Fig. 47.1); aedeagus entirely membranous without posterior sclerotized arrowhead-shaped spine plate with reddish brown spines and large posterobasal elongate membranous tube (Fig. 47.6); distribution–uncommon –Interior Plains of midwestern US–Iowa, Illinois, Indiana, Minnesota, Wisconsin .....***I. richardsoni***

37 Paraprocts, acutely pointed apically, strongly curved outward near apical ½, recurved over 10th tergum (Fig. 11.3); aedeagus with large cone-shaped dorsal lobe with concentrated short, stout spinulae with hair-like tips (Figs. 11.6, 11.7, 11.10); distribution–Gulf and Atlantic Coastal Plain streams–Delaware to Florida, Alabama, Missouri and Texas …… ***I. davisi***

37′ Paraprocts pointed apically but not strongly curved outward near apical ½ (Figs. 6.3, 22.3, 22.4); aedeagus without large cone-shaped dorsal lobe (Figs. 6.6, 22.6) ……. **38**

38 General body coloration pale, paraprocts deflected slightly ventrad apically (Fig. 6.4); aedeagus tubular with large rounded dorsal lobe (Fig. 6.6); distribution–southeastern US–South Carolina …… ***I. catawba* sp.n.**

38′ General body coloration dark; aedeagus not tubular (Fig. 22.6) …… **39**

39 Paraprocts short, stout extending only slightly over tergum 10 (Figs. 22.3, 34.5) ……... **40**

39′ Paraprocts elongate, acutely pointed apically, extending well over tergum 10 (Figs. 26.4, 30.3) …… **42**

40 Paraprocts without an apical ventral spur (Fig. 22.4); aedeagus with large stout, upturned posteromedial sclerotized spine with vertical lateral ridges (Figs. 22.6b, 22.7, 22.9), posteromedial area surrounding spine with large vertical indented sclerotized structure consisting of eight horizontal bars above spine and eight larger horizontal bars below spine, lateral bars connected by vertical median sclerotized rod, dorsal membranous tongue-shaped lobe extending over apex of sclerotized structure partially covering the first three lateral bars (Figs. 22.7, 22.8); distribution–midwestern US and Ozarks/Ouachita Mountains–Arkansas, Illinois, Indiana, Missouri, Ohio, Oklahoma …. ……..…… ***I. irregularis***

40′ Paraprocts with an apical ventral spur (Figs. 34.3, 50.4); aedeagus without large stout, upturned posteromedial sclerotized spine and horizontal bars but with paired posteromesal sclerotized spine plates bearing stout apical spine (Fig. 50.4) ……... **41**

41 Fully extruded aedeagus with long posterobasal elongate membranous tube near base (Fig. 34.7a); vesicle stalked (Fig. 34.2); distribution–Midwest and Ozarks/Ouachita Mountains–Arkansas, Illinois, Indiana, Missouri, Ohio, Oklahoma ……... ***I. namata***

41′ Fully extruded aedeagus without long posterobasal elongate membranous tube near base (Fig. 50.6); vesicle not stalked (Fig. 50.2); distribution–widespread–northeastern North America and midwestern US ……... ***I. signata***

42 Aedeagus without constricted tubular apical section (Fig. 30.5); paraprocts occasionally twisted together at tips; distribution–eastern US west to larger streams of Nebraska and eastern Colorado …….. ***I. marlynia***

42′ Aedeagus with constricted tubular apical section (Figs. 26.5, 43.6, 43.7) …… **43**

43 Dorsal head pattern with pale irregular shaped patch anterior to median ocellus (Fig. 26.1); paraprocts extending to ½ of tergum 10 (Fig. 26.4); aedeagus with a posterior directed beak-like lobe with short, stout flat plates (Fig. 26.5); distribution–northeastern North America and upper midwestern US ……..…… ***I. lata***

43′ Dorsal head pattern with a thin light M-shaped band (Fig. 43.1), paraprocts recurved slightly over tergum 10 (Fig. 43.4); aedeagus with a bulbous basal area, apical finger-like lobe encircled by dense dark brown or golden brown spinulae, constricted at base, apex of lobe enlarged and tapering to a small nipple without spinulae (Figs. 43.6, 43.7); distribution–Appalachians of southeastern US–North Carolina, Virginia, West Virginia ……

…….. ***I. pseudolata* sp.n.**

44 Dorsum of head with dark brown to black patch extending to frons, U-shaped medium brown patch anterior to median ocellus (Fig. 21.1); paraprocts sclerotized, short, stout broadly rounded paddle-like and deflected inward apically (Figs. 21.3, 21.5, 21.6); aedeagus with paired posterodorsal sclerotized spine plate with stout spines (Figs. 21.7, 21.14); distribution–widespread–eastern North America …….. ***I. holochlora***

44′ Dorsum of head without large dark brown patch on frons (Figs. 38.1, 56.1); paraprocts variously modified but not broadly rounded or paddle-like apically (Figs. 56.3, 38.3, 38.5) …. **45**

45 Aedeagus without reddish or golden brown stout spines (Fig. 38.7), with posteromedian depressed area with an elevated golden brown sclerotized cover supported by basal rods (Fig. 38.6k) and paired finger-like lateral posteromedian lobes (Figs. 36.6m, 38.18); distribution–midwestern US–Ozarks/Ouachita Mountains of Arkansas, Missouri, Oklahoma … …… ***I. ouachita***

45′ Aedeagus with reddish or golden brown stout spines (Figs. 7.7, 7.10, 56.7), without posteromedian depressed area with an elevated golden brown sclerotized cover supported by basal rods …… **46**

46 Abdominal terga 5-6 with rounded elongate spinulose posterolateral protuberances deflected posterolaterally (Figs. 15.5, 15.7); cercal segments 1-5 distinctly deflected mesally (Figs. 15.3, 15.5); distribution–rare–southeastern US–Smoky Mountains–Tennessee … ***I. distincta***

46′ Abdominal terga 5-6 without rounded elongate spinulose posterolateral protuberances deflected posterolaterally; cercal segments 1-5 not distinctly deflected mesally (Figs. 7.6, 56.4) …….. **47**

47 Tergum 9 elevated (Figs. 56.6, 7.5) …….. **48**

47′ Tergum 9 not elevated (Figs. 49.5, 55.5) ……. **50**

48 Aedeagus with dorsobasal spine plates (Figs. 7.9, 3.8) …… **49**

48′ Aedeagus without dorsobasal spine plates (Fig. 56.7); dorsum of head with pale brown patch extending from ocellar triangle to posterior margin of head and an undulating dark brown band anterior to median ocellus (Fig. 56.1); distribution–higher rheocrenes of southern Appalachians–North Carolina, Virginia …… …….. ***I. stewarti* sp.n.**

49 Aedeagus with posterior sclerotized plates (Fig. 3.7); paraprocts nearly erect (Fig. 3.4); distribution–rare–higher rheocrenes of southern Appalachians–North Carolina, South Carolina ……. ***I. bellona***

49′ Aedeagus without posterior sclerotized plates (Fig. 7.10); paraprocts recurved forward (Fig. 7.2), deflected ventrad apically (Fig.7.2); distribution–higher rheocrenes of southern Appalachians–North Carolina, South Carolina ……. ***I. cherokee* sp.n.**

50 Aedeagus with posterior sclerotized structures; (Fig. 29.6) …….. **51**

51′ Aedeagus without posterior sclerotized structures (Figs. 55.7, 55.9, 60.7) ……... **55**

51 Area posterior to lateral ocelli with dark brown/black patches (Figs. 29.1, 51.1); general body coloration dark brown; body size large, forewing length 9.0-17mm …… **52**

51′ Area posterior to lateral ocelli pale yellow (Figs. 49.1, 54.1); general body coloration pale yellow, body size medium, forewing length 8-13mm …… **53**

52 Dorsum of head with thin pale M-shaped band anterior to median ocellus (Fig. 29.1); aedeagus without paired posterolateral tear-shaped sclerites (Fig. 29.6), sclerotized dorsobasal aedeagal spine plates semi-rectangular (Fig. 29.6h); paraprocts acutely pointed apically (Fig. 29.4); distribution–higher rheocrenes of southwestern Virginia ……. ***I. major***

52′ Dorsum of head with area anterior to median ocellus dark brown (Fig. 51.1); aedeagus with paired posterolateral tear-shaped sclerites with enlarged rounded posterior ends and reduced anterior hook shaped ends (Fig. 51.6f); sclerotized dorsobasal aedeagal spine plates eyebrow-shaped (Fig. 51.6k); paraprocts bluntly pointed apically (Fig. 51.4); distribution–New England Maritimes of northeastern US and Piedmont and Atlantic Coastal Plain to Virginia ……. ***I. similis***

53 Aedeagus with a sclerotized posteroventral plate with heavily sclerotized ventral margin (Figs. 49.7, 49.9), paired posteroventral lobes with row of 11-15 stout dark reddish brown spines (Figs. 49.7, 49.9), dorsobasal sclerotized spine patches present (Figs. 49.7, 49.8); distribution –southeastern US–Alabama …… ……..…… ***I. sandbergi* sp.n.**

53′ Aedeagus without a posteroventral sclerotized plate but with a posterior arrowhead-shaped sclerotized spine plate (Figs. 54.4, 36.7, 36.8), dorsobasal sclerotized spine patches absent (Fig. 36.7) …….. **54**

54 Aedeagus with singular proximal posterior lobe with concentrated patch of golden brown stout spinulae and an elongate mesal row of golden brown setal spines (Fig. 54.4); vesicle of 8th sternum moderately sclerotized, not obscured by long hairs (Fig. 54.3); distribution–eastern US–West Virginia ……... ***I. smithi* sp.n.**

54′ Aedeagus with paired small proximal posterior lobes without concentrated patch of golden brown stout spinulae and elongate row of golden brown setal spines (Fig. 36.7); vesicle of 8th sternum lightly sclerotized nearly obscured by long hairs (Fig. 36.2); distribution–southeastern US–Alabama, Georgia, North Carolina, Tennessee, Virginia …. ***I. nelsoni* sp.n.**

55 Aedeagus with dorsobasal sclerotized spine patches which widen medially with mesal hooked sclerotized spines (Fig. 55.10); small triangular patch of minute stout setae anterior to lateral ocelli; distribution–rheocrenes of high southern Appalachian streams–North Carolina ……..…….. ***I. starki* sp.n.**

55′ Aedeagus without dorsobasal sclerotized spine patches (Figs. 39.6, 46.6, 60.6); small triangular patch of minute stout setae anterior to lateral ocelli absent …….. **56**

56 Paraprocts nearly erect projecting to the level of, or slightly over, tergum 10, distinctly deflected ventrad apically (Figs. 39.3, 39.4); distribution–rare, high rheocrenes of southern Appalachians-North Carolina ……. ***I. pauli* sp.n.**

56′ Paraprocts recurved forward over 10th tergum (Figs. 44.4, 46.4, 60.4) …….. **57**

57 Paraprocts distinctively deflected ventrad apically, recurved slightly forward (Figs. 44.3, 44.4); aedeagus with elongate posterobasal lobe with dense patch of short stout spinulae (Figs. 44.6b, 44.11); distribution–common–Appalachians of Maine to North Carolina ……...***I. pseudosimilis* sp.n.**

57′ Paraprocts not distinctively deflected ventrad apically, recurved forward to approximately ⅓ length of 10th tergum (Figs. 46.3, 46.4, 60.3, 60.4) ……..…….. **58**

58 Paraprocts sharply pointed apically, with elongate anteriorly projecting arm, deflected slightly outward apically (Figs. 46.3, 46.4); aedeagus with paired posteromesal lobes with short, stout spinulae (Figs. 46.6c, 46.8b); distribution–Atlantic Coastal Plain to Appalachians–North Carolina, Virginia ….. ……..…… ***reesi* sp.n.**

58′ Paraprocts stout, blunt apically, extending approximately over 10th tergum, not deflected outward apically (Figs. 60.3, 60.4); aedeagus with large posteromesal conical-shaped lobe with large golden brown stout spines (Figs. 60.6d, 60.7c, 60.7e); distribution–southern Appalachians–Virginia ……... ***I. yuchi* sp.n.**

Females

(Females of *I. maxana,* and *I. myersi* sp.n., unknown; *I. citronella* not included)

The following key to the females of eastern Nearctic Isoperlinae is tentative and should be used with caution due to the high variability in color patterns and the shape of the subgenital plate between and among populations. It is our hope that this key will facilitate narrowing species identifications to several morphologically similar species. In some instances, it may be possible to separate similar species by the known distributions provided in the key. We were not able to examine specimens of ***I. citronella*** and therefore did not include this species in our key.

1 Head without a dark pigment pattern, usually without dark brown bands or brown markings connecting ocelli (Figs. 12.1, 14.1) …….. **2**

1′ Dorsal head pattern with discernible dark brown bands connecting ocelli (Figs. 42.1, 6.1) ……..…… **3**

2 Subgenital plate broadly triangular, extending ½ length of 9th sternum; usually with posteromedian nipple (Fig. 14.5); distribution–widespread, eastern North America through midwestern US ……. ***I. dicala***

2′ Subgenital plate evenly rounded extending over ⅓ length of 9th sternum (Fig. 12.4); distribution–small streams of Interior Plains of the midwestern US ……..…… ***I. decepta***

3 Interocellar area pale (Figs. 6.1, 42.1) …… **4**

3′ Interocellar area mostly diffuse medium to dark brown or black (Figs. 29.1, 51.1, 55.1) ……. **49**

4 Subgenital plate long, acutely triangular, extending posteriorly to anterior margin of 10th sternum, base extending anteriorly ¾ length of sternum 8 (Fig. 42.5); distribution–Pennsylvania and Virginia ...……..…… ***I. powhatan*** **sp.n.**

4′ Subgenital plate shorter, variously shaped (Figs. 6.5, 27.5, 61.5) …….. **5**

5 Subgenital plate rounded posteriorly (Figs. 6.5, 27.5, 61.5) …… **6**

5′ Subgenital plate shape triangular, ovate or truncate (Figs. 13.5, 11.5, 20.6, 10.4) …… **22**

6 Subgenital plate without a posteromedian notch or emargination (Figs. 6.5, 27.5, 61.5) …… **7**

6′ Subgenital plate with a posteromedian notch or deep or slight emargination (Figs. 9.2, 30.6, 40.5, 53.5) ……..… **15**

7 Subgenital plate short, barely extending over anterior margin of 9th sternum (Figs. 6.5, 27.5) …….. **8**

7′ Subgenital plate of variable length, extending posteriorly over >20% length of 9th sternum (Figs. 26.6, 52.5) ……... **10**

8 Base of subgenital plate narrow < 60 % width of posterior margin of sternum 8 (Fig. 6.5); distribution–southeastern US .. ***I. catawba*** **sp.n.**

8′ Base of subgenital plate wider >80% width of posterior margin of sternum 8 (Figs. 27.5, 61.5) ……..…… **9**

9 Pale area anterior to median ocellus elongate (Fig. 27.1); distribution–Atlantic Coastal Plain streams of North Carolina, South Carolina to Florida ……..…… ***I. lenati*** **sp.n.**

9′ Pale area anterior to median ocellus short, broadly U-shaped (Fig. 61.1); distribution – eastern US–Piedmont Sandhill streams of North Carolina …… ***I. zuelligi*** **sp.n.**

10 General body coloration dark brown to almost black …….. **11**

10′ General body coloration pale brown to pale yellow with dark brown markings …… **12**

11 Subgenital plate broad, base of plate extending anteriorly > 50% length of 8th sternum plate with broad posteromedian medium brown patch (Fig. 26.6); pale interocellar area enclosed posteriorly by medium brown band extending from lateral ocelli (Fig. 26.1); distribution–eastern Canada and US and midwestern US …… ***I. lata***

11′ Subgenital plate narrow, base of plate < 40% of posterior width of posterior margin of sternum 8, produced posteriorly ca. 20% length of 9th sternum (Fig. 43.5); pale interocellar area not enclosed posteriorly by medium brown bands extending from lateral ocelli (Fig. 43.1); distribution–Appalachians of southeastern US – North Carolina, Virginia, West Virginia …….. ***I. pseudolata*** **sp.n.**

12 Base of subgenital plate > 80% width of posterior margin of sternum 8 (Figs. 8.5, 57.4) ……..…. **13**

12′ Base of subgenital plate < 80% width of posterior margin of sternum 8, posterior margin occasionally with a shallow emargination (Fig. 25.5); distribution–Appalachians of eastern US, New York to North Carolina ... ***I. kirchneri*** **sp.n.**

13 Subgenital plate produced posteriorly over ½ length of 9th sternum (Figs. 8.5, 57.4); ..……... **14**

13′ Subgenital plate produced posteriorly < ½ length of 9th sternum (Fig. 52.5); distribution–Atlantic Coastal Plain/Piedmont Sandhill streams of North Carolina …… ***I. siouan*** **sp.n.**

14 Subgenital plate produced posteriorly over length of sternum 9 (Fig. 8.5); pronotal disk pale brown (Fig. 8.1); distribution–southeastern US-Georgia …… ***I. chickamauga*** **sp.n.**

14′ Subgenital plate produced posteriorly < ⅔ length of sternum 9 (Fig. 57.4); pronotal disk medium/dark brown (Fig. 57.1); distribution–Ozarks-Arkansas …… ***I. szczytkoi***

15 Subgenital plate with a deep posteromedian notch (Figs. 9.2, 40.5) …….. **16**

15′ Subgenital plate with a shallow posteromedian notch (Figs. 41.5, 50.5, 47.4)) …… **19**

16 Interocellar area open, not enclosed posteriorly and with medium brown bands connecting lateral ocelli (Fig. 40.1) …….. **17**

16′ Interocellar area mostly enclosed posteriorly and with medium brown bands connecting lateral ocelli (Figs. 30.1, 53.1) …… **18**

17 Dorsal head pattern with a sinuous dark brown band on frons; pronotum with dark brown/black splotches (Fig. 40.1); posteromedian notch of subgenital plate shallow < 20% length of plate (Fig. 40.5); distribution–western Great Plains .. ***I. phalerata***

17′ Dorsal head pattern without a sinuous dark brown band on frons; pronotum without dark brown to black splotches, posteromedian notch of subgenital plate deep ca. 30% length of plate (Fig. 9.2); distribution–Extinct - USA – Illinois …….. ***I. conspicua***

18 Dorsal head pattern dark with extensive areas of dark brown to black markings, posterior margin of head with large area of dark brown to black markings and medial paired pale spots; pronotum with checkerboard pattern of pale and dark markings (Fig. 53.1); lateral margins of abdominal sterna 1-8 with longitudinal pale bands (Figs. 53.2, 53.5); basal width of subgenital plate ca. 90% width of posterior margin of sternum 8, depth of posteromedian notch ca. 20% length of plate (Fig. 53.5); distribution–widespread, northeastern North America and upper midwestern US ……..…….. ……...…… ***I. slossonae***

18′ Dorsal head pattern paler, posterior margin of head without large area of dark brown to black markings and medial paired pale spots; pronotum without checkerboard pattern of pale and dark markings (Fig. 30.1); lateral margins of abdominal sterna 1-8 without pale longitudinal bands; basal width of subgenital plate ca. 70% width of posterior margin of sternum 8, depth of posteromedian notch ca. 10% length of plate (Fig. 30.6); distribution–eastern North America to larger streams of eastern Nebraska and Colorado …….. ***I. marlynia***

19 Dorsal head pattern with interocellar area completely enclosed posteriorly with dark brown bands connecting lateral ocelli, paired median brown bands extending from lateral ocelli to posterior margin of head; pronotum mostly medium brown (Fig. 50.1); subgenital plate shallow, posteromedian notch occasionally absent (Fig. 50.5); distribution–widespread - eastern North America and midwestern US …….. ***I. signata***

19′ Dorsal head pattern with interocellar area not completely enclosed posteriorly with dark brown bands connecting lateral ocelli; pronotum pale (Figs. 41.1, 59.1) …… **20**

20 Dorsal head pattern with interocellar area partially enclosed posteriorly with dark brown bands extending from lateral ocelli, medium brown bands extending from anterior ocellus to antennal bases (Fig. 41.1); general body coloration medium to pale brown, base of subgenital plate extending to anterior margin of 8th sternum (Fig. 41.5); distribution–larger streams of Atlantic Coastal Plains of Florida, North Carolina, South Carolina …. ***I. poffi*** **sp.n.**

20′ Dorsal head pattern with interocellar area open posteriorly; medium brown bands extending from anterior ocellus to antennal bases (Figs. 47.1, 59.1); general body color pale yellow; base of subgenital plate short not extending to anterior margin of 8th sternum (Fig. 47.4) ….. **21**

21 Dorsal head pattern with dark brown spot on frons (Fig. 47.1); posteromedian notch of subgenital plate occasionally absent (Fig. 47.4); distribution–uncommon, Interior Plains of midwestern US - Iowa, Illinois, Minnesota, Wisconsin ……. ***I. richardsoni***

21′ Dorsal head pattern without dark brown spot on frons (Fig. 59.1); distribution-southern Appalachians-North Carolina ….. ***I. tutelo*** **sp.n.**

22 Subgenital plate triangular (Figs. 11.5, 13.5) ... **23**

22′ Subgenital plate truncate, to semi ovate (Figs. 10.4, 20.6, 58.4) …… **32**

23 Dorsal head pattern with interocellar area completely enclosed posteriorly with dark brown bands connecting lateral ocelli, medial brown bands extending from lateral ocelli to

posterior margin of head (Fig. 13.1); subgenital plate usually with a posteromedian nipple (Fig. 13.5); distribution-northeastern Canada ……. ……. ***I. decolorata***

23′ Dorsal head pattern with interocellar open posteriorly, medial brown bands extending from lateral ocelli to posterior margin of head absent (Figs. 5.1, 11.1); subgenital plate without a posteromedian nipple (Figs. 5.4,11.5) …….. **24**

24 Subgenital plate with distinctive paired sclerotized medium brown triangular patches (Fig. 11.5); distribution–Gulf and Atlantic Coastal Plain, streams from Delaware to Florida, Alabama, and west to Texas … ***I. davisi***

24′ Subgenital plate without distinctive paired sclerotized medium brown triangular patches (Figs. 5.4, 16.2) ……. **25**

25 Subgenital plate usually with a posteromedian notch (Figs. 5.4, 16.2, 45.5, 45.6) …… **26**

25′ Subgenital plate usually without a posteromedian notch (Figs. 17.5, 50.5, 48.4) ... **30**

26 Subgenital plate produced over ¼ length of 10th sternum, plate deflected ventrally near apical ½ (Figs. 5.4, 5.6); distribution-southeastern and midwestern US ……. ***I. burksi***

26′ Subgenital plate not produced over 10th sternum (Figs. 16.2, 45.5) ……... **27**

27 Depth of posteromedian notch of subgenital plate deep ca. 30% length of plate (Fig. 16.2); distribution – North midwestern US – Minnesota …… ***I. emarginata***

27′ Depth of posteromedian notch of subgenital plate shallow < 30% length of plate (Figs. 4.4, 33.7, 45.5) …….. **28**

28 Dorsal head pattern variable, usually without dark brown bands connecting ocelli, two small crescent shaped pale brown spots posterior to lateral ocelli (Fig. 45.1); mesonotum with a broad anterior V-shaped pale yellow patch extending across notum; posteromedian notch of subgenital plate variable (occasionally ¼ length of plate) (Figs. 45.5, 45.6); distribution–common-western Great Plains …..……..…….. ***I. quinquepunctata***

28′ Dorsal head pattern with dark brown bands connecting ocelli, without two small crescent shaped pale brown spots posterior to lateral ocelli (Figs. 4.1, 33.1; mesonotum without a broad anterior V-shaped pale yellow patch extending across notum ……. **29**

29 Dorsal head pattern with distinct dark brown bands extending anteriorly from median ocellus to near frons, medial area anterior to median ocellus and anterior margin of head pale yellow without dark coloration (Fig. 33.1); subgenital plate broadly triangular extending posteriorly ca. ½ length of 9th sternum, base of plate near level with posterior margin, depth of posteromedian notch of subgenital plate shallow (occasionally absent) (Fig. 33.7); distribution-common-widely distributed-eastern North America ……... ***I. montana***

29′ Dorsal head pattern without distinct dark brown bands extending anteriorly from median ocellus to near frons, anteromedian margin of head usually with a median brown patch (Fig. 4.1); subgenital plate more narrowly triangular extending posteriorly ca. 70% length of 9th sternum, depth of posteromedian notch of subgenital plate shallow (commonly absent) (Fig. 4.4); distribution-large streams of the Interior Plains of midwestern US …. ***I. bilineata***

30 Dorsal head pattern with median wide dark brown band extending from median ocellus to anterior margin of head (pale brown band between median ocellus and wide dark band) (Fig. 17.1); subgenital plate ovate to triangular (Fig. 17.1); distribution – Atlantic Coastal Plain of North Carolina and Virginia .. ***I. fauschi* sp.n.**

30′ Dorsal head pattern variable without median wide dark brown band extending from median ocellus to anterior margin of head (pale brown band between median ocellus and dark bands extending to antennal bases) (Figs. 34.1, 48.1); subgenital plate broadly triangular (Figs. 34.4, 48.4) ……... **31**

31 Dorsal head pattern with interocellar area nearly enclosed posteriorly by medium brown bands connecting lateral ocelli, distinct dark brown bands extending from anterior ocellus to antennal bases, medium brown lateral bands below compound eyes, frons with a large rectangular shaped transverse dark band widest anteriorly (Fig. 34.1); subgenital plate not deflected ventrally near posterior ½ (Fig. 34.4);

distribution–Midwestern and Ozarks/Ouachita Mountains – Arkansas, Indiana, Missouri, Ohio, Oklahoma …….. ***I. namata***

31′ Dorsal head pattern with interocellar open posteriorly, distinct dark brown bands extending from anterior ocellus to antennal bases absent, area below compound eyes pale yellow, frons with diffuse, irregular shaped brown large markings (Fig. 48.1); subgenital plate deflected ventrally near posterior ½ (Fig. 48.6); distribution–eastern Texas ….. ***I. sagittata***

32 Subgenital plate narrow, width of base ca. 35% width of posterior margin of 8th sternum; plate, tapering to a narrow truncate apex with a shallow posteromedian notch, medial area of sternum 8 dark brown, (Fig. 58.4); distribution–eastern North America into the upper midwestern US to northeastern Wyoming …….…… ***I. transmarina***

32′ Subgenital plate wider, width of base ca. >50% width of posterior margin of 8th sternum, not tapering to a narrow truncate apex; plate, medial area of sternum 8 pale (Figs. 10.4, 20.6, 37.6) …….. **33**

33 Subgenital plate semi ovate (Figs. 10.4, 18.4, 20.6, 22.5, 24.6, 35.5, 37.6, 51.6) or broad with apical truncate nipple (Fig. 55.6) …….. **34**

33′ Subgenital plate truncate either short, broad (Figs. 24.3, 28.4) or elongate, triangular (Fig. 19.5) …….. **40**

34 Subgenital plate broad elongate, semi ovate extending posteriorly to near anterior margin of 10th sternum (Fig. 20.6), scoop-shaped in lateral view (Fig. 20.7); distribution–northeastern North America–Quebec, Connecticut ……..…… ***I. gibbsae***

34′ Subgenital plate shorter, not extending posteriorly over 75% of sternum 9 (Figs. 10.4, 29.5, 37.6, 51.5), not scoop-shaped in lateral view (Figs. 10.6, 37.5) ……. **35**

35 Subgenital plate with a posteromedian notch or shallow median emargination (Figs. 10.4, 29.5, 37.6) …….. **36**

35′ Subgenital plate without a posteromedian notch or shallow median emargination (Fig. 51.5) ... **42**

36 Subgenital plate deflected ventrally near posterior ½ (Figs. 10.6, 37.5) …….. **37**

36′ Subgenital plate not deflected ventrally near posterior ½ (Figs. 18.4, 35.5) …….. **38**

37 Subgenital plate produced posteriorly slightly over 10th sternum, in lateral view plate without a ventral notch near apical ½ (Figs. 10.4, 10.6); dorsal head pattern with a dark triangular patch on anterior margin of head, widest anteriorly, interocellar area occasionally dark brown/black, bands connecting ocelli dark brown to black (Fig. 10.1); body color of fresh specimens with a greenish cast; distribution-northeastern North America and upper Midwest …….. ***I. cotta***

37′ Subgenital plate produced posteriorly ca. ¾ length of 9th sternum, plate in lateral view with a ventral notch near apical ½ (Figs. 37.3, 37.5); anterior margin of head pale with diffuse pale brown markings, medium to pale brown bands connecting ocelli (Fig. 37.1); general body color pale yellow; distribution - southern Appalachians-North Carolina, Tennessee, and Virginia …….. ***I. orata***

38 General body color pale yellow with dark brown markings, posterior margin of head pale yellow, arms of medium brown bands connecting ocelli extending anteriorly slightly beyond median ocellus (Fig. 18.1); base of subgenital plate produced anteriorly ca. 30% length of 8th sternum, lateral margins of plate pale yellow (Fig. 18.4); distribution–eastern Canada to New York ……. ***I. francesca***

38′ General body color dark/medium brown …... **39**

39 Dorsal head pattern with wide, posterior transverse dark band with reticulate markings, thin dark brown M-shaped band anterior to median ocellus (Fig. 35.1); subgenital plate narrow, produced posteriorly > 40% length of 9th sternum, base extending anteriorly > 70% length of 8th sternum (Fig. 35.5); distribution – eastern Canada and US and upper Midwest ……..……. ***I. nana***

39′ Dorsal head pattern without wide, posterior transverse dark band with reticulate markings (Fig. 22.1); subgenital plate low, broad, produced posteriorly < 20% length of 9th sternum, base extending anteriorly < 40% length of 8th sternum (Fig. 22.5); distribution–

midwestern US and Ozarks/Ouachita Mountains-Arkansas, Indiana, Missouri, Ohio, Oklahoma ……..…… ***I. irregularis***

40 Subgenital plate short, produced posteriorly ca. ¼ length of 9th sternum (Figs. 24.3, 28.4), posterior margin of plate broadly truncate, darker than rest of sternum; anterior margin of head with a broad pale brown or medium brown triangular patch widest anteriorly (Figs. 24.1, 28.1) …….. **41**

40′ Subgenital plate elongate, produced posteriorly ca. ¾ length of 9th sternum; general shape truncate/triangular, width of base ca. 70% width of posterior margin of 8th sternum (Fig. 19.5); anterior margin of head pale or diffuse pale brown (Fig. 19.1); distribution-eastern and upper midwestern US ……. ***I. frisoni***

41 Width of subgenital plate base narrow < 50% width of posterior margin of 8th sternum darker than rest of sternum, base of plate extending anteriorly ca. 15% length of 8th sternum (Fig. 24.3); distribution–rare-Texas ……... ***I. jewetti***

41′ Width of subgenital plate base ca. 70% width of posterior margin of 8th sternum darker than rest of sternum, base of plate extending anteriorly ca. 40% length of 8th sternum (Fig. 28.4); distribution–uncommon-Interior Great Plains of the Mississippi River …….. ***I. longiseta***

42 Subgenital plate truncate with at most a slight shallow median emargination (Figs. 29.5, 51.5, 55.6) ……... **43**

42′ Subgenital plate variously shaped, not truncate (Figs. 2.4, 36.6, 44.5) …… **45**

43 Subgenital plate with a narrow truncate apex, produced posteriorly over ½ length of 9th sternum (Fig. 55.6); distribution–rheocrenes of southern high Appalachians–North Carolina …… ***I. starki* sp.n.**

43′ Subgenital plate broadly truncate, produced posteriorly slightly over 9th sternum (Figs. 51.5, 29.5) …… **44**

44 Dorsal head pattern completely dark brown to black anterior of median ocellus to near anterior margin of head, pronotal disk nearly completely dark brown to black (Fig. 51.1); subgenital plate squarely truncate posteriorly, plate mostly medium brown with medial pale area (Fig. 51.5); distribution–New England Maritimes of northeastern US and Piedmont and Atlantic Coastal Plain to Virginia …… ***I. similis***

44′ Dorsal head pattern with a pale M-shaped band anterior to median ocellus, pronotal disk pale brown with dark brown rugosities (Fig. 29.1); subgenital plate with posterior margin medium brown, paler basally, posterior margin with a shallow median emargination (Fig. 29.5); distribution–higher rheocrenes of southwestern Virginia …….. ***I. major***

45 Subgenital plate, low evenly rounded posteriorly (Figs. 2.4, 44.5, 46.5) or broadly elongate (Fig. 36.6), evenly rounded posteriorly …… **46**

45′ Subgenital plate elongated posteriorly, posterior margin variously shaped not evenly rounded (Figs. 7.4, 49.6, 39.5, 56.5) ……... **53**

46 General body coloration and head pattern dark brown (Figs. 2.1, 44.1) ……... **47**

46′ General body coloration pale yellow with medium brown markings, head pattern paler (Figs. 36.1, 46.1) ……... **48**

47 Dorsal head pattern with distinct dark brown to black bands extending laterally from posterior ocelli, posterior margin of head pale except for small dark posterolateral bands below compound eyes, anterior margin of head with transverse dark brown band, pale area anterior to median ocellus bowl-shaped (Fig. 2.1); pronotal disk mostly dark brown to black; distribution–widely distributed from Ontario along the Atlantic Coast to Florida and through the midwestern US ……..… ***Clioperla clio***

47′ Dorsal head pattern without distinct dark brown to black bands extending laterally from posterior ocelli, posterior margin of head with median splotch of diffuse medium brown pigmentation, posterolateral margins of head pale yellow below compound eyes, anterior margin of head pale brown, pale area anterior to median ocellus with a pale thin, broadly U-shaped band (Fig. 44.1); pronotal disk mostly pale brown with dark brown/black rugosities; distribution–common Appalachians of Maine to North Carolina ……..…… ***I. pseudosimilis* sp.n.**

48 Subgenital plate long extending posteriorly to

posterior margin of 9th sternum, broadly ovate, scooped-shaped in lateral view, base extending 75% length of 8th sternum (Figs. 36.5. 36.6); frons with a dark brown medial patch (Fig. 36.1); distribution–Southeastern US–Alabama, Georgia, North Carolina, Tennessee, Virginia … ……. ***I. nelsoni* sp.n.**

48′ Subgenital plate low extending posteriorly only slightly over 9th sternum, not scoop-shaped in lateral view, base shallow extending only 15% length of 8th sternum (Fig. 46.5); frons pale yellow medially (Fig. 46.1); distribution-Atlantic Coastal Plain to Appalachians of North Carolina and Virginia ……... ***I. reesi* sp.n.**

49 Dorsal head pattern with interocellar area dark brown to black (Figs. 15.1, 21.1, 60.1) ……... **50**

49′ Dorsal head pattern with interocellar area diffuse medium brown (Figs. 7.1, 39.1, 49.1) .. **52**

50 Dorsal head pattern with dark brown medial patch extending from anterior margin of head to near median ocellus (Figs. 15.1, 21.1) …….. **51**

50′ Dorsal head pattern with anterior margin of head pale yellow, small medium brown medial patch anterior to median ocellus (Fig. 60.1); subgenital plate extending ¾ length of 9th sternum, bluntly pointed apically, anterolateral margins of plate with medium brown bands, base of plate extending anteriorly ½ length of sternum 8 (Fig. 60.5); distribution–southern Appalachians, Virginia ……... ***I. yuchi* sp.n.**

51 Dorsal head pattern with dark brown bands extending anterolaterally from median ocellus (Fig. 15.1); subgenital plate broadly triangular, plate extending to near posterior margin of 8th sternum, base of plate ca. <70% width of posterior margin of 8th sternum (Fig. 15.6); distribution–rare–Smoky Mountains of Tennessee ……. ***I. distincta***

51′ Dorsal head pattern without dark brown bands extending anterolaterally from median ocellus (Fig. 21.1); subgenital plate elongate triangular (shape of plate highly variable) pointed or bluntly rounded apically, plate extending posteriorly to near posterior margin of 8th sternum, base of plate ca. >80% width of posterior margin of 8th sternum (Figs. 21.4, 21.8); distribution–widespread - eastern North America ……. ***I. holochlora***

52 Subgenital plate broadly triangular at base tapering acutely to a narrow tip, extending posteriorly to posterior margin of 9th sternum (Fig. 39.5); anterior margin of head pale yellow, interocellar area medium brown, diffuse, medium brown coloration lateral to median and posterior ocelli (Fig. 39.1); distribution–rare, high rheocrenes of southern Appalachians of North Carolina ……. ***I. pauli* sp.n.**

52′ Subgenital plate triangular not tapering acutely to a narrow tip (Figs. 7.4, 49.6, 56.5) ……. **53**

53 Subgenital plate triangular, truncate apically, extending posteriorly < 15% length of 9th sternum (Figs. 7.4, 49.6) ……. ……. ***I. cherokee* sp.n.**, ***I. sandbergi* sp.n.**

53′ Subgenital plate triangular, pointed/rounded apically, extending posteriorly > 25% length of 9th sternum (Figs. 23.2, 38.4, 54.6) ……. **54**

54 Subgenital plate triangular to ovate, extending posteriorly ca. 25% length of 9th sternum, plate evenly rounded apically (Fig. 56.5); posterior margin of head with wide medial brown band extending to lateral ocelli (Fig. 56.1); distribution–higher rheocrenes of southern Appalachians of North Carolina, Virginia ……. ……..…. ***I. stewarti* sp.n.**

54′ Subgenital plate broadly triangular, extending posteriorly > 50% length of 9th sternum, plate pointed apically; posterior margin of head without wide medial brown band extending to lateral ocelli (Figs. 23.2, 38.4, 56.5) ……. **55**

55 Dorsal head pattern with oblique medium brown bands extending from lateral ocelli to posterior margin of head with small dark brown posterior spots (Fig. 23.1); subgenital plate extending to posterior margin of 9th sternum, (Fig. 23.2); distribution–southeastern US–Alabama, Mississippi ……..…….. ***I. jamesae***

55′ Dorsal head pattern with posterior margin pale yellow without oblique medium brown bands (Figs. 3.1, 38.1, 54.1) ……. **56**

56 Dorsal head pattern with a large pale patch anterior to median ocellus, medium brown bands extending from median ocellus to anterior margin of head; pronotal disks pale brown (Fig. 38.1); distribution–midwestern US–

Ozarks/Ouachita Mountains of Arkansas, Missouri, Oklahoma ……... ***I. ouachita***

56′ Dorsal head pattern without a large pale patch anterior to median ocellus, medium brown bands extending from median ocellus to anterior margin of head absent; pronotal disks pale yellow with medium brown rugosities (Figs. 3.1, 54.1) ……. **57**

57 Anterior margin of head pale yellow, pronotal rugosities pale (Fig. 54.1); distribution–eastern US–West Virginia ……... ***I. smithi* sp.n.**

57′ Anterior margin of head diffuse medium brown; pronotal rugosities medium brown (Fig. 3.1); distribution–rare-higher rheocrenes of southern Appalachians of North and South Carolina ……..……. ***I. bellona***

Eggs

Eggs of *I. bellona, I. burksi, I. catawba* sp.n., *I. chickamauga* sp.n., *I. citronella, I. conspicua, I. distincta, I. emarginata, I. gibbsae, I. maxana, I. myersi* sp.n., *I. pauli* sp.n., *I. pseudolata* sp.n., *I. reesi* sp.n., *I. sagittata, I. sandbergi* sp.n., *I. siouan* sp. n., *I. smithi* sp.n, *I. stewarti* sp.n., *I. tutelo* sp.n., and *I. yuchi* sp.n. are unknown.

1 Collar absent (Figs. 12.18, 22.13, 35.13) …….. **2**

1′ Collar present (Figs. 28.14, 36.9, 41.13, 58.15) ... **6**

2 Chorion covered with raised reticulate thickened ridges, some not connected, eclosion line absent (Figs. 35.13, 35.14) ……..…… ***I. nana***

2′ Chorion without raised reticulate thickened ridges, eclosion line present or absent (Figs. 12.18, 22.13, 22.14) ……. **3**

3 Cross section triangular, eclosion line wide, smooth (Figs. 22.13, 22,15) …...…… ***I. irregularis***

3′ Cross section not triangular, either round or concave, eclosion line absent (Figs. 12.18, 23.21, 57.15) ……... **4**

4 Cross section round, follicle cell impressions faintly visible (Fig. 12.18) ..……...……. ***I. decepta***

4′ Cross section concave (Figs. 23.21, 57.15) ……. **5**

5 Follicle cell impressions absent, micropyle orifices with thickened flared openings, surface of chorion with shallow pits (Figs. 23.21, 23.23, 38.20, 38.23) …….. ***I. jamesae, I. ouachita***

5′ Follicle cell impressions faintly visible, micropyles not visible, surface of chorion with deep pits (Figs. 57.14, 57.16) ……. ***I. szczytkoi***

6 Egg cross section pentagonal, chorion with five longitudinal raised ridges (Fig. 41.14) …… ……..…… ***I. poffi* sp.n.**

6′ Egg cross section not pentagonal, chorion without five longitudinal raised ridges (Figs. 25.20, 33.25) …… **7**

7 Egg shape nearly square, collar poorly developed (Figs.36.9, 36.10) …… ***I. nelsoni* sp.n.**

7′ Egg shape variable, collar variously shaped and developed, (Figs. 11.13, 21.20, 33.25) ……. **8**

8 Egg cross section triangular (Figs. 33.25, 33.28, 34.17, 34.18, 47.14) …… **9**

8′ Egg cross section not triangular (Figs. 37.9, 51.15, 53.11) …… **14**

9 Chorion with cross-shaped ridges (Figs. 33.25, 34.17, 47.12) …….. **10**

9′ Chorion without cross-shaped ridges (Figs. 4.17, 21.20, 42.9) …… **11**

10 Follicle cell impressions well-developed (Figs. 25.19, 25.22, 33.25, 33.27, 47.12, 47.14, 50.20, 50.22, 61.11, 61.14) ……. ***I. kirchneri* sp.n., *I. montana, I. richardsoni, I. signata, I. zuelligi* sp.n.**

10′ Follicle cell impressions faint or absent (Figs. 11.13, 11.16, 21.20, 21.22, 27.13, 27.15, 4.17, 34.19) …… ***I. davisi, I. holochlora, I. lenati* sp.n., *I. namata***

11 Eclosion line, raised slightly, wide, smooth (Figs. 4.17, 4.20) ……..……. ***I. bilineata***

11′ Eclosion line absent (Figs. 17.13, 42.9) ……. **12**

12 Follicle cell impressions absent (Figs. 21.20, 21.22, 42.9, 42.11) …… …… ***I. holochlora, I. powhatan* sp.n.**

12′ Follicle cell impressions variously developed (Figs. 17.15, 45.18) …….. **13**

13 Egg shape nearly square, collar low, button shaped, set in apical depression, follicle cell impressions well developed, walls elevated thickened, anterior pole flat (Figs. 17.13, 17.14, 17.15) …….. ***I. fauschi* sp.n.**

13′ Egg shape oblong, collar elevated, flared apically, follicle cell impressions faintly visible, walls low, anterior pole round (Figs. 45.17, 45.18) …….. ***I. quinquepunctata***

14 Egg cross section round (Figs. 30.13, 26.11, 51.15) ……. **15**
14' Egg cross section concave (Figs. 10.15, 37.10) . **21**
15 Eclosion line present (Figs. 14.13, 26.14, 44.21, 44.22, 51.17) …….. **16**
15' Eclosion line absent (Figs. 10.14, 40.10) …….. **19**
16 Eclosion line slightly developed (Figs. 29.7, 29.9, 51.15, 51.17) ……..…… ***I. similis, I. major***
16' Eclosion line well developed …… **17**
17 Eclosion line narrow, striated and elevated …… ***I. pseudosimilis***
17' Eclosion line wide, low, smooth and not striated ……..…….. **18**
18 Follicle impressions well-developed, raised, thickened, floors deep ……..…. ***I. dicala, I. lata***
18' Follicle cell impressions faintly visible, floors shallow ……. ***I. marlynia***
19 Follicle cell impressions well-developed, walls elevated (Fig. 40.10) …..……. ***I. phalerata***
19' Follicle cell impressions faintly visible or absent, walls not elevated, (Figs. 13.7, 28.14) …...…… **20**
20 Micropyles with elongate sperm guides (Figs. 13.8, 28.16) ……... ***I. decolorata, I. longiseta***
20' Micropyles without elongate sperm guides (Figs. 24.8, 53.11, 53.13, 58.16) ……. ……..… ***I. jewetti, I. slossonae, I. transmarina***
21 Eclosion line present (Figs. 30.13, 30.14, 29.7, 29.9) ……... **22**
21' Eclosion line absent (Figs. 10.14, 10.18, 37.9, 37.12) …… ***I. cotta, I. orata***
22 Follicle cell impressions not visible, eclosion line faintly visible with low sinuous ridges, collar low and button shaped, micropyles with thickened openings (Figs. 7.23, 7.25, 7.26) ……..…….. ***I. cherokee* sp.n.**
22' Follicle cell impressions developed, ridges elevated, eclosion line well developed, collar not button shaped, micropyles without thickened openings (Figs. 2.25, 2.26, 2.27, 18.19, 18.21) …… **23**
23 Eclosion line with striated ridges, micropyles positioned adjacent to eclosion line (Figs. 2.25, 2.26, 2.27) ……..…… ***C. clio***
23' Eclosion line a narrow ridge without striated ridges, micropyles positioned on eclosion line (Figs. 18.16, 18.21, 19.11, 19.13) …… ……. ***I. francesca, I. frisoni***

SPECIES TREATMENTS

(Species are treated in alphabetical order)

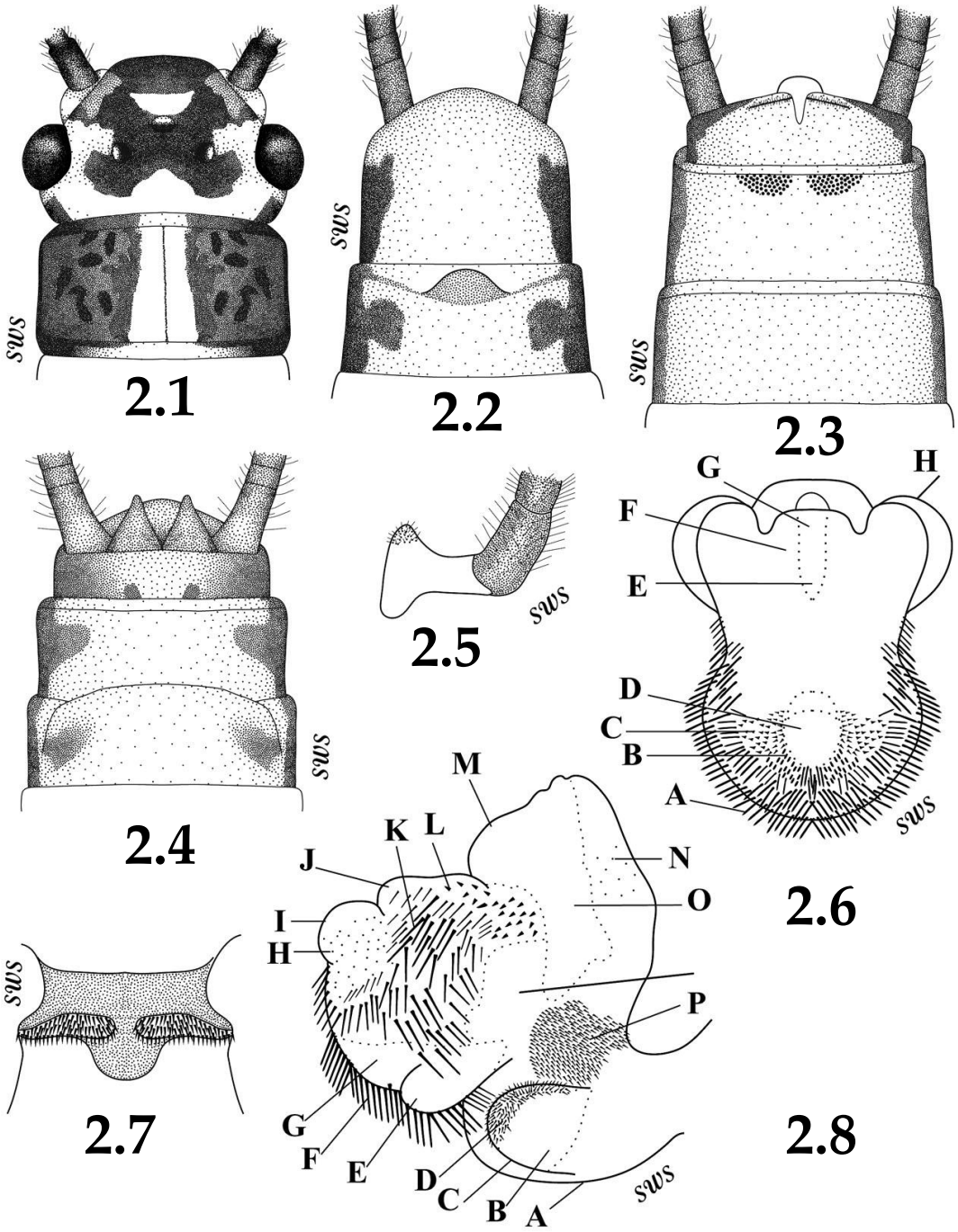
Clioperla clio (Newman)

Clio Stripetail

(Figs. 1.1, 2.1-2.28)

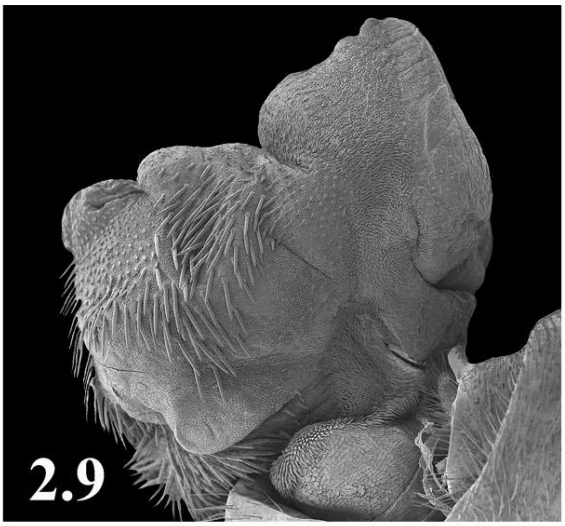
Isogenus clio Newman 1839, 3:86. No type designation, Georgia.
Perla clio: Hagen 1861:19.
Clioperla clio: Needham and Claassen, 1925, 2:137.
Isoperla confusa Frison 1935, 20:441. Holotype ♂ allotype ♀ (INHS) Illinois. Syn. Ricker 1952:143.
Clioperla clio: Claassen, 1940, 232:196.
Isoperla clio: Ricker, 1952, 18:143. Syn. indicated.
Isoperla clio: Illies, 1966:398.
Isoperla clio: Kimmins, 1970, 24:339. Lectotype ♂ designated (BMNH) Georgia.
Clioperla clio: Szczytko and Stewart, 1981, 74:563.

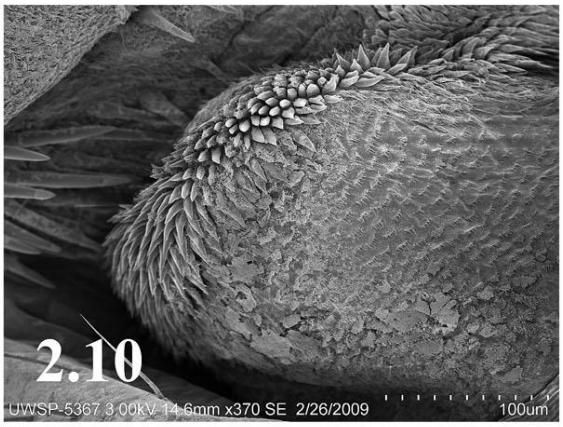
Distribution: **CANADA – ON** (Harper and Ricker 1994), **USA – AL** (James 1974), **AR** (Szczytko and Stewart 1981, Poulton and Stewart 1991, Ricker 1952), **CT** (Hitchcock 1974), **DE** (Szczytko and Stewart 1981, Lake 1980), **FL** (Ricker 1952, Pescador et al. 2000), **IA** (Heimdal et al. 2004), **IN** (Needham and Claassen 1925, Ricker 1952, Grubbs 2004, DeWalt and Grubbs 2011), **IL** (Frison 1935, Ricker 1952, Szczytko and Stewart 1981, DeWalt and Grubbs 2011), **GA** (Hagen 1861, Szczytko and Stewart 1981), **KY** (Szczytko and Stewart 1981, Tarter and Chaffee 2004, Tarter et al. 2006), **MA** (Neves 1978), **MD** (Szczytko and Stewart 1981, Grubbs 1997, Ricker 1952), **MI** (Ricker 1952, Szczytko and Stewart 1981, Grubbs and Bright 2001), **MO** (Szczytko and Stewart 1981, Poulton and Stewart 1991), **MS** (Stark 1979, Szczytko and Stewart 1981), **NC** (Needham and Claassen 1925, Kondratieff et al. 1995), **OH** (Ricker 1952, Gaufin 1956, Szczytko and Stewart 1981, DeWalt et al. 2012), **OK** (Szczytko and Stewart 1981, Poulton and Stewart 1991, Stark and Stewart 1973a), **PA** (Surdick and Kim 1976, Grubbs 1996, Masteller 1996b, Szczytko and Stewart 1981), **SC (**Szczytko and Stewart 1981, Kondratieff et al. 1995), **VA** (Ricker 1952, Kondratieff and Kirchner 1987), **TN (**Szczytko and Stewart 1981), **WI** Hilsenhoff and Billmyer 1973, Szczytko and Stewart 1981), **WV**

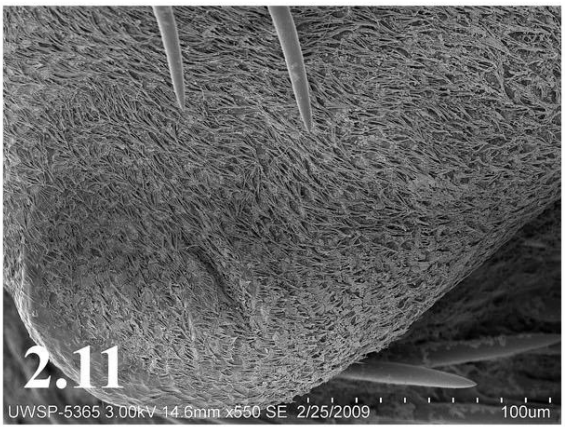


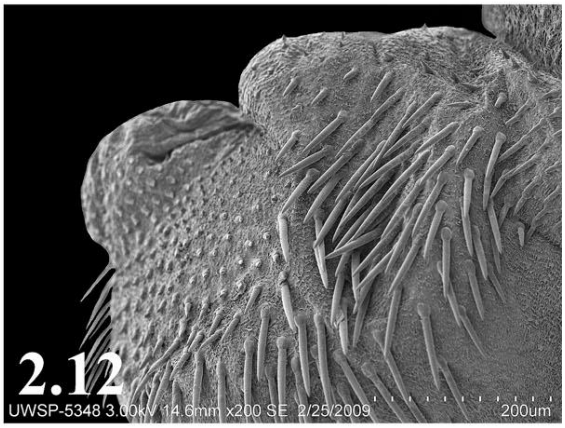
Figs. 2.1-2.8. *Clioperla clio*. 2.1. Dorsal head and pronotal pattern. 2.2. Male posterior abdominal sterna. 2.3. Male posterior abdominal terga. 2.4. Female subgenital plate. 2.5. Male paraproct lateral view. 2.6. Male aedeagus posterior view; a. posteromesal stout reddish brown spines, b. basal short stout, blunt spinulae on posteromesal lobe, c. short sharp spinulae near posteromesal lobe, d. posteromesal lobe, e. patch of long flat stout spines with numerous fine apical fingers, f. patch of shallow scallop shaped plates and scattered sensillae basiconica, g. light brown mesal spear shaped area with anterior long, flat stout spines, h. paired posterodorsal lobes g. concentrated fine hair like spinulae of posteromesal area. 2.7. Dorsobasal sclerotized aedeagal plates. 2.8. Male aedeagus lateral view; a. posterobasal lobe, b. mesal spine patch on

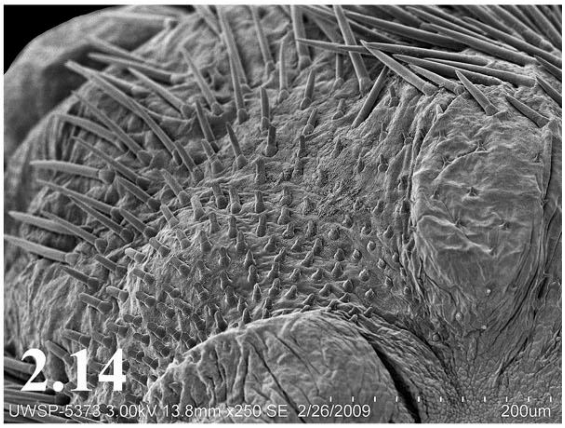
laterobasal lobe, c. laterobasal paired lobes, d. stout apical spines on laterobasal paired lobes, e. conical posteroventral lobe, f. posteromesal stout reddish brown spines , g. posteromesal patch of fine hair-like spinulae, h. short stout blunt spinule patch on posteromesal lobe, i. posteromesal membranous lobe, j. small fine spinulae above posteromesal lobe, k. large reddish brown spines mesal to posteromesal lobe, l. small stout sharp spinulae above posteromesal lobe, m. paired posterodorsal lobes, n. sparse fine spinulae and scattered sensillae basiconica, o. mesal patch of small knobs with apical filaments and scattered sensillae basiconica, p. dorsobasal sclerotized spine plate.



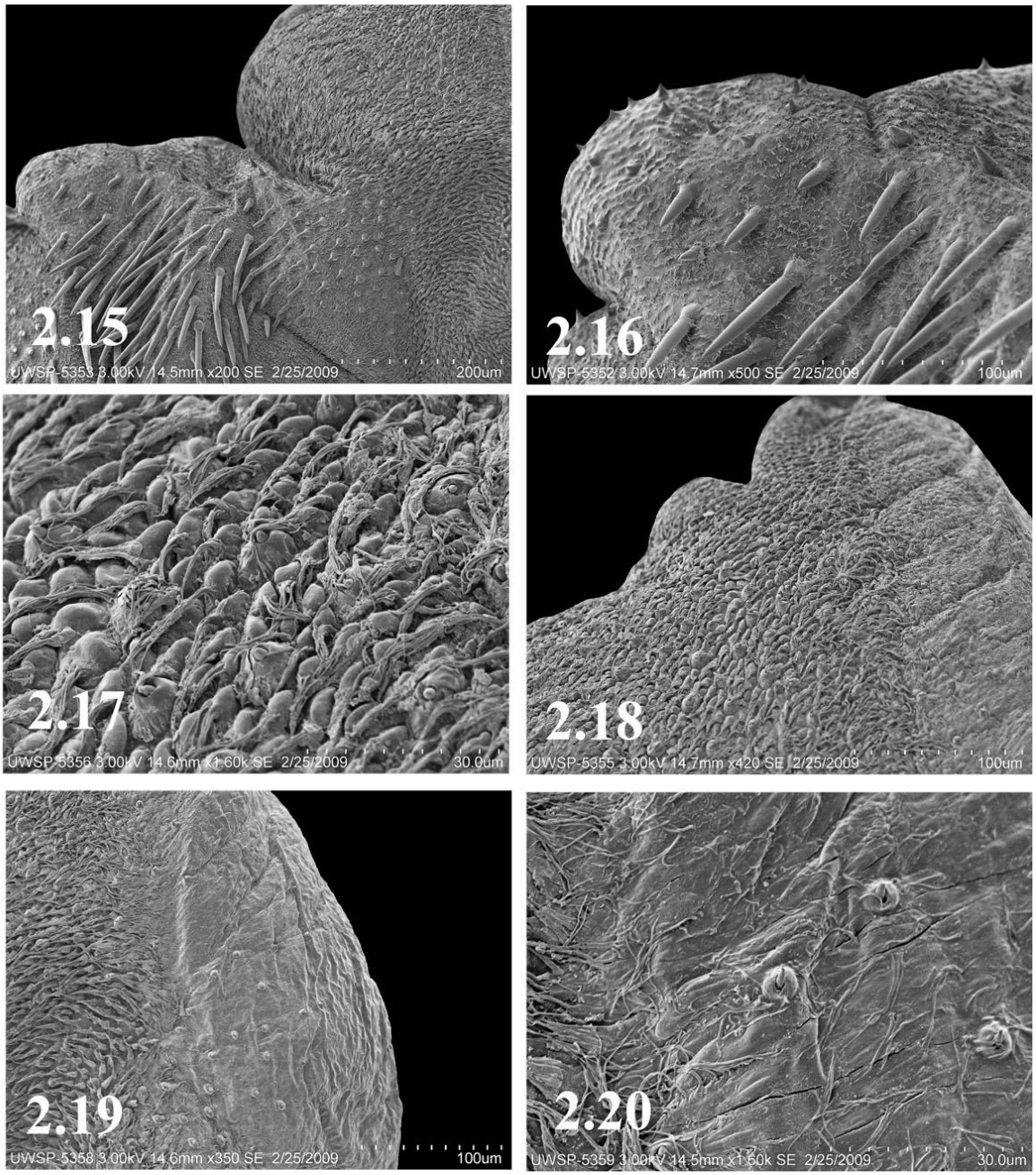








Figs. 2.9-2.14. *Clioperla clio*. 2.9. Male aedeagus lateral view. 2.10. Posterobsal aedeagal lobe. 2.11. Conical posteroventral aedeagal lobe. 2.12. Posteromesal aedeagal lobe. 2.13. Aedeagus posterodorsal oblique view. 2.14. Detailed spinule armature of base of posteromesal aedeagal lobe.



Figs. 2.15-2.20. *Clioperla clio*. 2.15. Detail of spinule of mesal area near posteromesal lobe. 2.16. Detailed area mesal stout spines near posteromesal lobe. 2.17. Small knobs and sensillae basiconica below stout spines. 2.18. Spinulae of mesal area near posterodorsal lobes. 2.19. Fine setae and sensillae basiconica near anterior margin of aedeagus. 2.20. Detail of sensillae basiconica.


2.21
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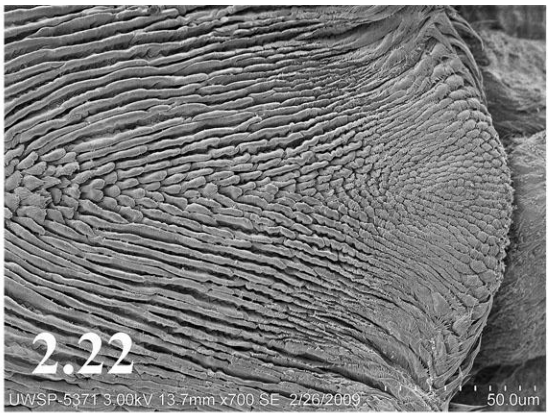
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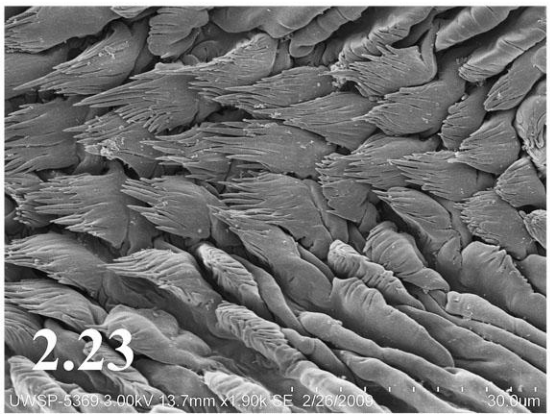
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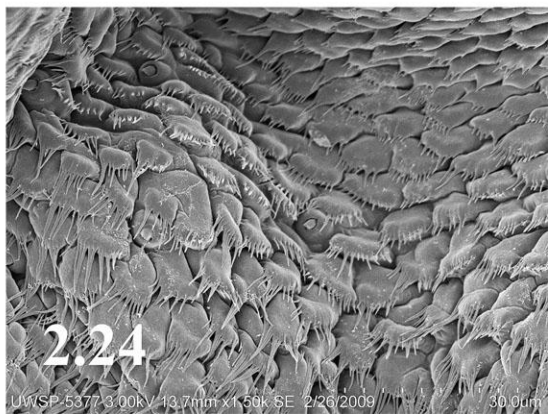
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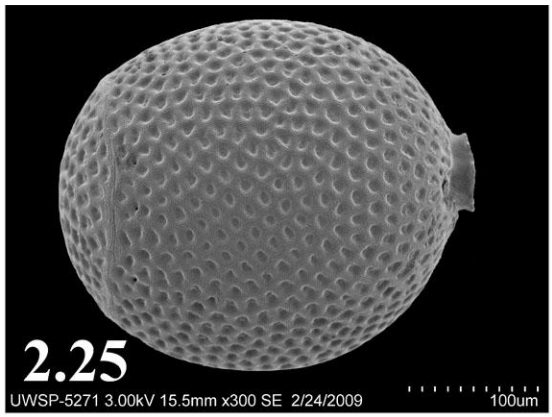
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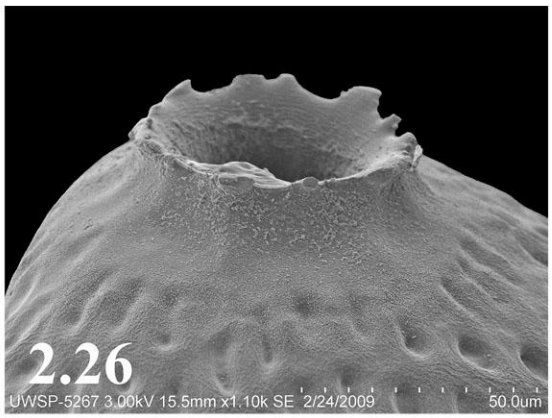
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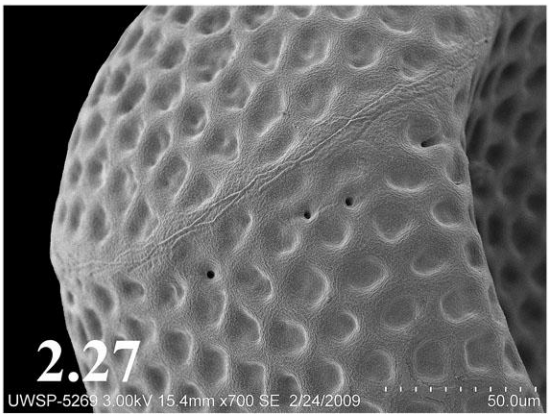
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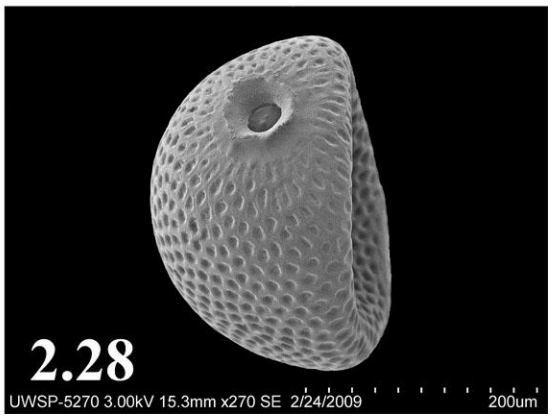
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200um

Figs. 2.21-2.24. *Clioperla clio*. 2.21. Spear shaped mesal area of dorsoposterior region of aedeagus. 2.22. Detail of ridges of mesal area of dorsoposterior region of aedeagus. 2.23. Detail of long flat stout spines of mesal area of dorsoposterior region of aedeagus. 21.24. Detail of scallop shaped plates of mesal area of dorsoposterior region of aedeagus.
Figs. 2.25-2.28. *Clioperla clio* egg. 2.26. Detail of egg collar. 2.27. Detail of eclosion line and micropyles of egg. 2.28. Oblique lateral view of egg showing concave profile.

(Tarter and Kirchner 1980, Grubbs 1997, Tarter and Nelson 2006, Szczytko and Stewart 1981).

Male. Macropterous. Forewing length 15.0-17.0 mm. General body bright yellow with dark brown to black markings. Dorsal background of head bright yellow with large dark brown patch covering mesal area including interocellar area, medium to dark brown patch extending anterolaterally to antennal bases (paler near bases), broad bowl-shaped pale patch anterior to median ocellus, frons with dark brown rectangular patch, dark brown bands extending posteriorly from posterior ocelli to near posterior margin of head, posterior ends of bands with short lateral arms projecting anteriorly (Fig. 2.1). Submentum without a mesal round dark brown patch. Antennal scape, pedicel, and flagellum dark brown to black. Pronotum with a median pale stripe (widest posteriorly), middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown to black, pronotal disks dark brown, anterior and posterior margins with broad bipartite dark brown bands (Fig. 2.1). Meso- and metasterna bright yellow with medium brown lateral bands, rounded dark brown anterior spots and flask-shaped median pale band. Wings pale brown, veins dark brown. Femora, tibia and tarsi medium brown, femora with a mesal pale band on proximal ⅔ of outer surface, tibia with a dark horizontal band on proximal ¼ of outer surface. Sterna bright yellow with lateral dark bands, sternum 8 with a low broad amber vesicle, ca. 2X as wide as long, posterior margin evenly rounded, extending posteriorly to anterior margin of sternum 9 (Fig. 2.2). Ninth sternum bright yellow with dark lateral bands. Terga 1-10 bright yellow, occasionally with 3 lateral and 2 median rows of faint brown spots on segments 1-8, tergum 9 with bipartite median patch of short stout spinulae, tergum 10 with shallow posteromedian cleft and bipartite posteromedian upturned ridges with row of short stout spinulae (Fig. 2.3). Paraprocts not sclerotized, flat, triangular shaped, not elevated, tip fringed with fine setae (Fig. 2.5). Cerci dark brown to black. Aedeagus with large posterobasal lobe (Fig. 2.8a), paired laterobasal lobes with stout short apical spines and mesal concentration of rows of small, fine hair-like spinulae (Figs. 2.8b, c, d, 2.9, 2.10); 2 conical posteroventral lobes with concentrated fine hair-like spinulae (Figs. 2.8e, 2.9, 2.11); posteromesal/ventral margin of aedeagus fringed with long, stout reddish-brown spines (Figs. 2.6a, 2.8f, 2.9); posteromesal area with concentrated fine hair-like spinulae (Figs. 2.8g, 2.9); posteromesal lobe with membranous apical section and basal area with short stout, blunt spinulae (Figs. 2.6b, d, 2.8h, i, 2.12); base of lobe with short blunt spinulae grading into short sharp spinulae (Figs. 2.6b, c, 2.8i, 2.12, 2.13, 2.14); mesal area near posteromesal lobe with concentrated long, stout reddish-brown spines which grade into smaller short, stout sharp spinulae dorsomesally (Figs. 2.8j, k, l, 2.15); small posterior lobe above posteromesal lobe with scattered short stout reddish- brown spines which grade into longer stout reddish-brown spines, surface covered with rows of fine hair like spinulae (Figs. 2.8j, 2.16); area mesal to small posterior lobe with concentration of long, stout reddish-brown spines which transition into small stout spines dorsally (Figs. 2.8k, l, 2.9, 2.12); mesal area below long stout spines with small knobs with numerous apical filaments and scattered sensillae basiconica (Figs. 2.8o, 2.9, 2.17), paired posterodorsal lobes and mesal area covered with concentrated short sharp spinulae (Figs. 2.6h, 2.8m, 2.18), anterior margin of aedeagus with scattered sensilla basiconica and sparse fine setae (Figs. 2.8n, 2.9, 2.19, 2.20); pale brown mesal spear-shaped area on

dorsoposterior region comprised of posterior sclerotized pale brown longitudinal ridges which become progressively longer anteriorly, anterior end with concentration of long flat stout spines with numerous fine apical fingers (Figs. 2.6g, 2.21, 2.22, 2.23); lateral anterior and basal areas to the spear shaped patch covered with shallow scallop-shaped plates with numerous apical fine fingers and scattered sensilla basiconica (Figs. 2.6f, 2.24); dorsobasal area of aedeagus with a large sclerotized plate covered with small fine spinulae and anteromedian tongue-like protrusion; posterior bipartite eyebrow-shaped sclerotized patches with concentrated short, stout reddish-brown spines (Figs. 2.7, 2.8p).

Female. Forewing length 19.0-21.0 mm. General body color and morphology similar to male described above. Eighth sternum with low, wide evenly rounded subgenital plate slightly extending over sternum 9, posterolateral margins of plate with dark brown patches (Fig. 2.5). Ninth sternum with dark brown posterolateral patches, sternum 10 yellow with dark brown lateral bands, occasionally with a pale brown median band and paired posteromedian dark brown spots (Fig. 2.5).

Ovum. General shape oblong, cross section concave (Figs. 2.25, 2.28). Color pale brown. Length 338 μm; width 270 μm. Collar well developed, flared apically (Figs. 2.25, 2.26, 2.28). Hexagonal follicle cell impressions well developed with thickened ridges, floors with numerous small shallow pits, eclosion line narrow with low sinuous ridges, micropyles arranged singularly, openings small, positioned adjacent to eclosion line near anterior ⅓ of egg (Figs. 2.25, 2.27).

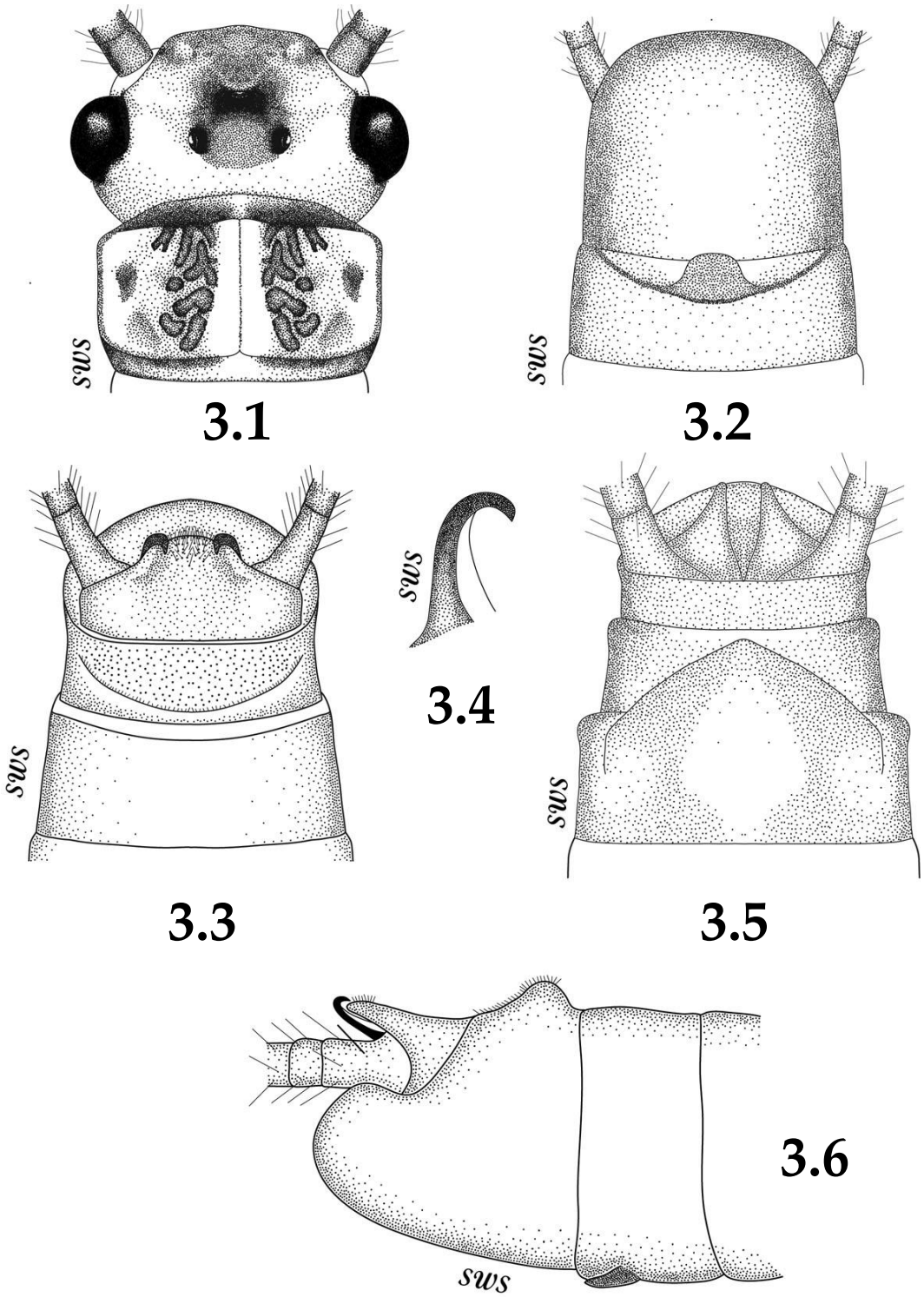
Nymph. Frison (1935) described the nymph as *I. confusa* and provided habitus and mouthpart illustrations. Szczytko and Stewart (1981) and Stewart and Stark (2002) also described the nymph and provided habitus illustrations. Hilsenhoff and Billmyer (1973) illustrated the lacinia. Feminella and Stewart (1986) illustrated the mouthparts and Unzicker and McCaskill (1982) reproduced Frison's (1935) original habitus illustration.

Diagnosis. *Clioperla* is a monotypic eastern Nearctic genus of Isoperlinae which is most closely related to *Isoperla* and the western genus *Cascadoperla* Szczytko and Stewart (1979a). It shares the absence of gills with *Isoperla* and partial cleft of the male tergum 10 and upturned ridges and broad, flat mostly unsclerotized paraprocts with *Cascadoperla*. *Clioperla clio* is the largest eastern North American Isoperlinae.

Clioperla clio is a yellow species with a mostly dark brown to black head pattern including the interocellar area. The male differs from all *Isoperla* by possessing a partial posteromesal cleft, and upturned spinulated ridges, and terminal bulbous structure on tergum 10. In general habitus, it resembles *I. pseudosimilis* sp. n., *I. major*, and *I. similis* in size and coloration, but is most similar to *I. major*. *Clioperla clio* differs by the generic characters mentioned above and by having a broad pale bowl-shaped patch anterior to the median ocellus instead of a pale thin M-shaped band, and the submentum lacks a brown mesal submental patch. The eggs of these two species are similar, however, the ridges of the follicle cell impressions are lower and thinner in *I. major* compared to *C. clio* and the micropyle openings of *I. major* are not elevated slightly as in *C. clio*. There was also early confusion in the literature of *C. clio* with *I. marlynia* (Claassen 1931, Frison 1935). The adults and nymphs of these two species are quite distinctive and easily separated.

Clioperla clio has an Eastern North American distribution and extends in the east from Ontario, Canada south to Florida, and west to Wisconsin, Iowa and south to the Ozarks and Ouachitas of Arkansas and Oklahoma. Nymphs of *C. clio* appear to be more common in lower elevation small to large streams.

Biological Notes. The adult emergence period of *C. clio* is long, extending from mid-February in Mississippi to late June in Kentucky (Minshall and Minshall 1966). The nymphs are carnivorous, the life cycle is univoltine and adults are diurnal (Minshall and Minshall 1966, Frison 1935). Minshall and Minshall (1966) found eggs hatched in August through September with the greatest nymphal growth occurring in January and April. Harper (1973) stated that the emergence period lasted a maximum of 20 days in southern Ontario and laboratory females in his study did not attempt

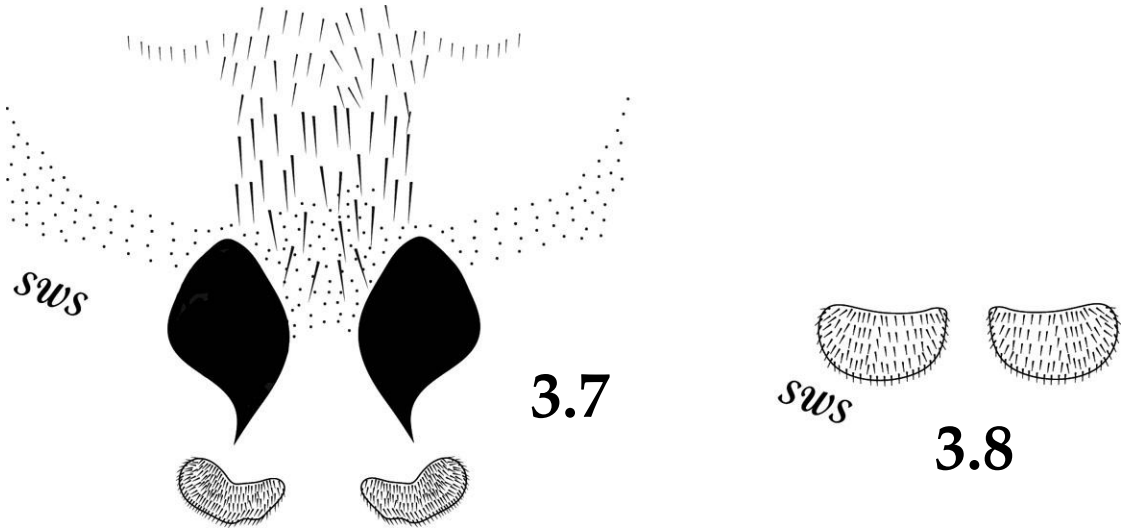


Figs. 3.1-3.6. *Isoperla bellona*. 3.1. Dorsal head and pronotal pattern. 3.2. Male posterior abdominal sternites. 3.3. Male posterior abdominal tergites. 3.4. Male paraproct lateral view. 3.5. Female subgenital plate. 3.6. Male posterior abdominal segments lateral view.

to mate before 3-5 days. Eggs were deposited on the 7th or 8th day after emergence and one or two egg batches were laid. Oviposition occurred in late afternoon and the number of eggs/batch ranged from 113-118 eggs.

Poulton and Stewart (1991) stated that *C. clio* was collected in a wide variety of stream types in the Ozark and Ouachita Mountains, and was the most widespread stonefly in their study. They found that the adults were secretive and not often collected. Poulton et al. (1989) reported that the nymphs appear to be tolerant to organic pollution from agriculture and toxicity due to chromium.

Graham (1982) studied the drumming behavior of *C. clio* and stated that the male call was monophasic with a mean beat number of 9.10 ± 4.23 (range 3-15), and a mean interbeat frequency of 357.02 ± 198.97 ms. She found that the female answer signal was also monophasic and consisted of one or two beats with an interbeat frequency of 275.50 ms (n=1).



Figs. 3.7-3.8. *Isoperla bellona*. *3.7.* Posterior aedeagal sclerites and spines. 3.8. Dorsobasal aedeagal spine plates.

Isoperla bellona Banks
Smokies Stripetail
(Figs. 3.1-3.8)

Isoperla bellona Banks 1911, 37:335. Holotype ♀ (MCZC) Black Mountains (Yancey Co.), North Carolina. Examined.
Isoperla bellona: Claassen, 1940:198.
Megahelus bellona: Banks, 1947: 54:282.
Isoperla bellona: Needham and Claassen, 1925:151.

Distribution: **USA** – **NC** (Banks 1911, Kondratieff et al. 1995), **SC** (McCaskill and Prins 1968).
Additional Records: **USA** – **NC:** Yancey Co., Mt. Mitchell Camp Alice rd., 1/IX/1959, G.B. Wiggins, 1♂ (ROM); Black Mts., late May/1910, F. Sherman, 1♂ (USNM). **SC:** Oconee Co., small spring @ Tamassee rd., ½ mi. E. Hwy 107, 12/V/1981, B.P. Stark, J.S. Weaver, 1♀ (INHS); Upper Wash Branch, Tamassee rd., 20/V/1983, B.P. Stark, 1♂ (INHS). Pickens Co., Wildcat Creek, 9 km NW Clemson, 1/IV/1976, P.H. Carlson, 2♂ (INHS); Same locality, 5/IV/1976, P.H. Carlson, 1♀ (INHS); Same locality, 12/IV/1968, P.H. Carlson, 2♂ (INHS); Same locality, 22/IV/1976, P.H. Carlson, 1♀ (INHS); Same locality, 3/V/1976, P.H. Carlson, 1♀ (INHS); Same locality, 12/IV/1976, P.H. Carlson, 2♂ (INHS); Same locality, 18/IV/1976, P.H. Carlson, 5♀ (INHS); Same locality, 8/IV/1976, P.H. Carlson, 2♂, 1♀ (INHS); Same

locality, 9/V/1976, P.H. Carlson, 2♂, 1♀ (INHS).

Male. Macropterous. Forewing length 7.5-8.9 mm. General body coloration pale yellow with medium brown markings. Head with wide medium brown bands connecting ocelli extending anterolaterally, truncate anteriorly, darkest near anterior ocelli; interocellar area diffuse pale brown; thin pale U-shaped thin band extending anteriorly from median ocellus; frontoclypeus area diffuse pale brown (Fig. 3.1). Antennal scape pale yellow, pedicel and flagella medium brown. Pronotum with a median pale slightly hourglass-shaped stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, medium brown, pronotal disks pale yellow, anterior margin with bipartite medium brown bands, lateral and posterior margins with thin medium brown margins (Fig. 3.1). Meso- and metasterna pale yellow with narrow lateral pale brown bands. Meso- and metanota mostly pale yellow with paired anteromesal rounded medium brown spots. Femora pale yellow with a small dorsal proximal medium brown band, tarsi pale/medium brown. Sterna pale yellow, sternum 8 with a vesicle ca. as wide as long, darker than rest of segment, posterior margin evenly rounded, extending slightly over anterior margin of sternum 9, posterior margin of sternum 8 with a thin medium brown band (Fig. 3.2). Terga pale yellow, tergum 9 elevated near anterior margin; broad patch of short stout setae posteriorly below elevated ridge; tergum 10 with a posteromedian patch of long stout setae (Figs. 3.3, 3.6). Paraprocts sclerotized, long, thin, recurved slightly over tergum 10, deflected ventrad anteriorly and tapering to sharp points (Figs. 3.3, 3.4). Cercal segments 1-5 pale yellow, posterior segments pale brown.

Unfortunately, no male with a fully everted aedeagus was available for study to provide a detailed description of the shape and spinule patterns of the aedeagus. From study of cleared terminalia of males, it is evident that this species has paired posteromedian sclerotized plates with median posteriorly directed strong spines with bands of short stout spinulae lateral to sclerotized plates, paired posteroventral sclerotized bands with dense stout spinulae below sclerotized plates and posteromedian band of long stout reddish-brown spines above the sclerotized plates (Fig. 3.7). Paired dorsobasal rectangular patches of dense short, stout reddish brown spinulae occur near aedeagal stalk (Fig. 3.8).

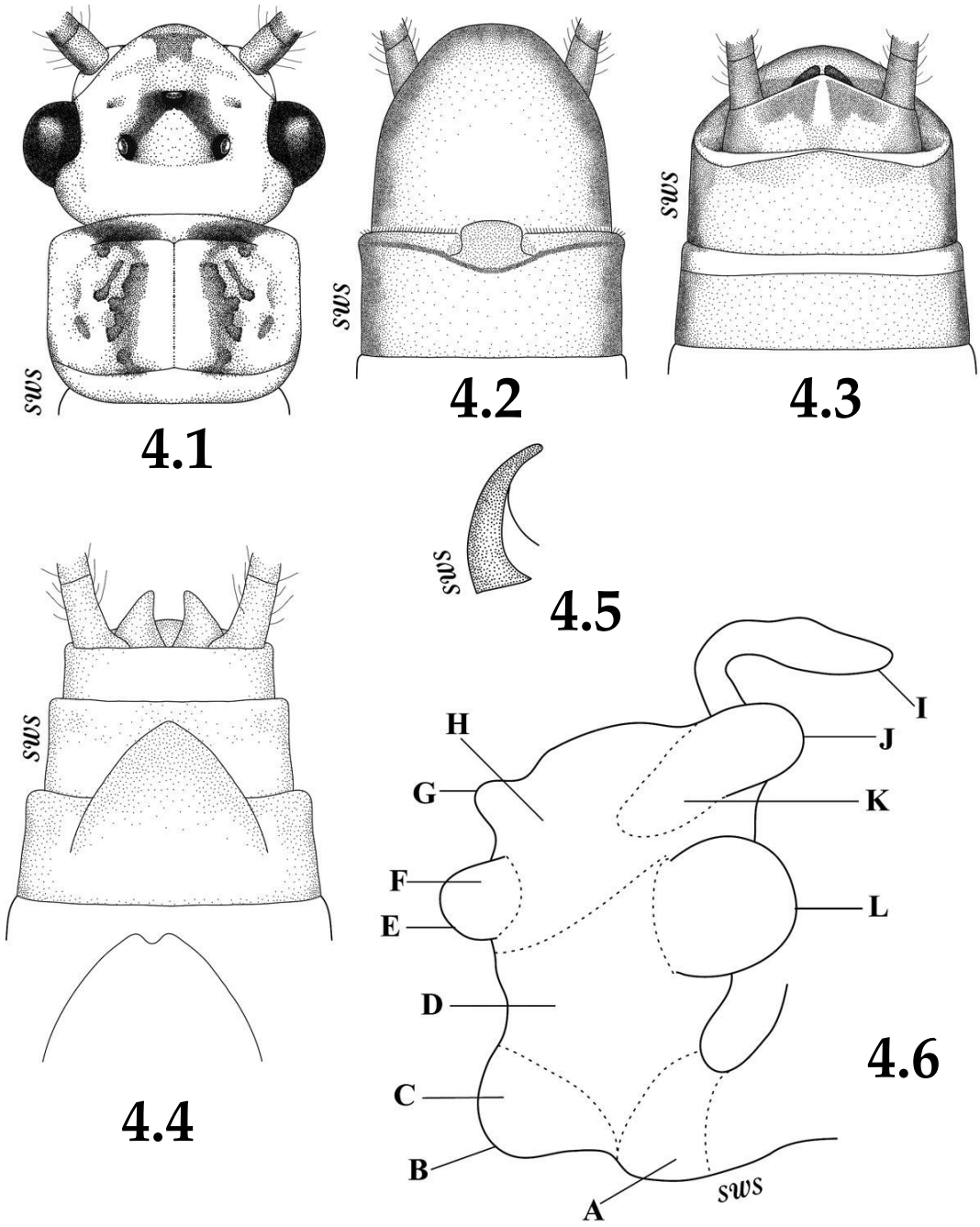
Female. Forewing length 8.4-9.5 mm. General body color and morphology similar to male described above. Eighth sternum with a broad triangular-shaped subgenital plate extending to near posterior margin of sternum 9 (Fig. 3.5).

Ovum. Unknown.

Nymph. Unknown.

Diagnosis. *Isoperla bellona*, a small pale yellow species with medium brown markings is a member of the *I. similis* species group which also includes *I. distincta*, *I. cherokee* sp. n., *I. major*, *I. sandbergi* sp. n., *I. similis*, and *I. starki* sp. n. (Table 1). The aedeagus of these species possess both long spines and plates bearing spines. Little information is available for this species since its original description in 1911. The holotype female from Black Mountains, North Carolina (originally pinned) is in poor condition. Needham and Claassen (1925) illustrated the subgenital plate of *I. bellona* as being relatively short, narrow and broadly rounded which does not agree with the original illustration provided by Banks (1911) who illustrated it as broadly triangular, as is the case for material examined during this study. Therefore, we follow the concept as presented by Banks (1911). Unfortunately, no eggs were available for study. The male paraprocts and vesicle as illustrated by Needham and Claassen (1925) apparently from the Georgia specimens, does appear similar to the South Carolina material examined during this study. The shape of the sclerotized plates of the aedeagus is apparently distinctive for this species of the *I. similis* group. The Georgia material was not available for study and Georgia was not included in the distribution list. The general vicinity of the type locality was visited on several occasions with no success in securing additional material.

Biological Notes. The emergence period occurs from early April to late May. This species apparently occurs in small spring-fed rheocrene streams.



Figs. 4.1-4.6. *Isoperla bilineata*. 4.1. Dorsal head and pronotal pattern. 4.2. Male posterior abdominal sterna. 4.3. Male posterior abdominal terga. 4.4. Female subgenital plate. 4.5. Male paraproct lateral view. 4.6. Male aedeagus lateral view; a. hair-like spinulae on basal stalk, b. posteroventral lobe, c. long stout spinulae on posteroventral lobe, d. mesal band of short stout spinulae, e. posteromesal lobe, f. sparse rows of small, fine hair-like spinulae on posteroventral lobe, g. .paired posterodorsal lobes, h. scattered sensillae basiconica, i. dorsal membranous tube, j. paired anterodorsal lobes, k. elongated multi strand hair-like spinulae, l. anteromesal lobe.

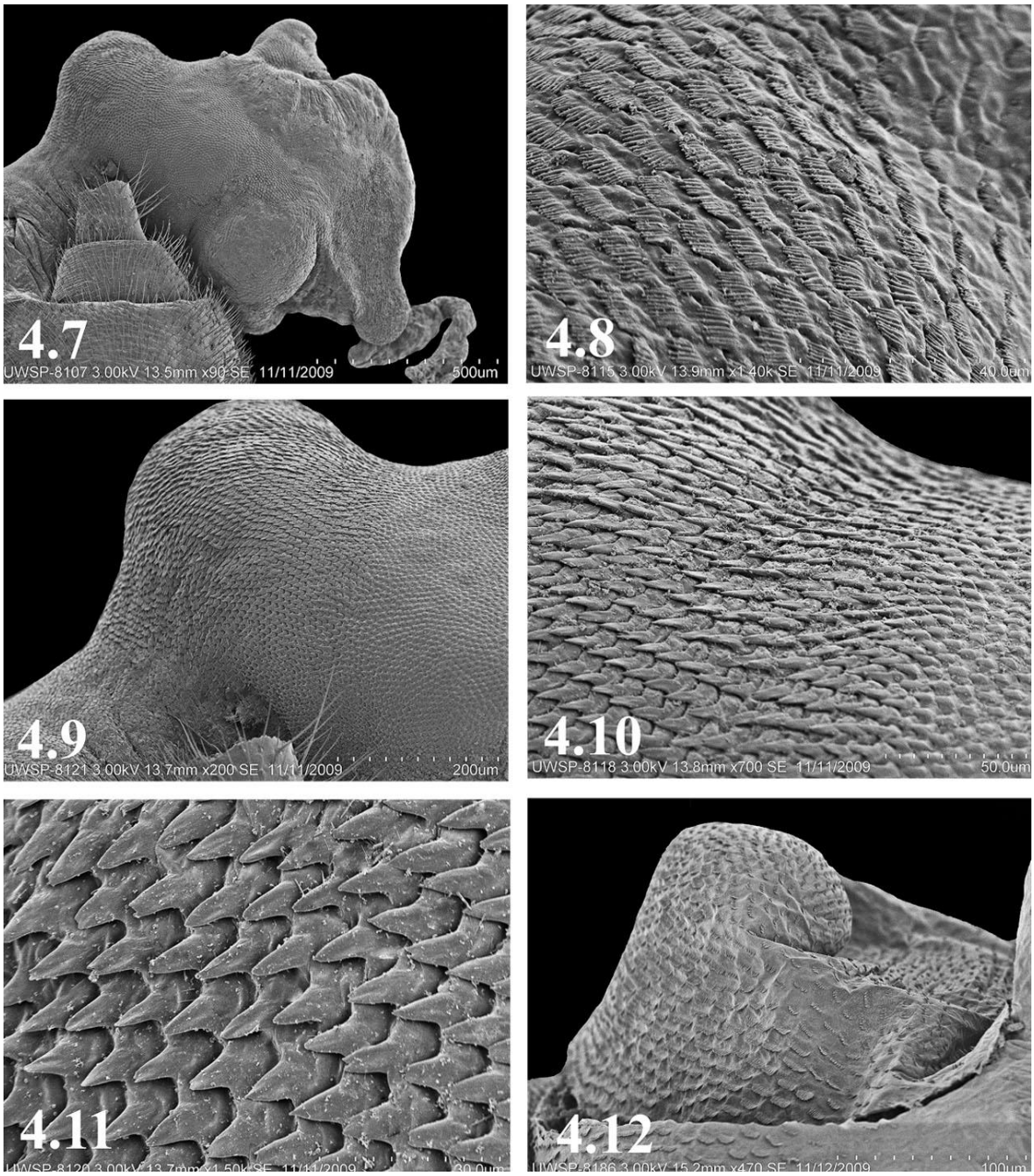
Isoperla bilineata (Say)
Two-lined Stripetail
(Figs. 1.2, 4.1-4.20)

Sialis bilineata Say 1823, 2, 165. Neotype ♂ (USNM) designated, Szczytko and Stewart 1978:212, Montgomery Co., Ohio. Examined.
Perla picta: Walker, 1852, 161.
Perla bilineata: Hagen, 1861, 20:30.
Chloroperla bilineata: Walsh, 1862, 19, 342.
Isoperla bilineata: Banks, 1906, 17:175.
Isoperla bilineata: Needham and Claassen, 1925:154.
Isoperla bilineata: Frison, 1935, 20:437.
Isoperla bilineata: Harden and Mickel, 1952, 201:39.
Isoperla bilineata: Ricker, 1964, 34:54.
Isoperla bilineata: Hitchcock, 1974, 107:193.
Isoperla bilineata: Szczytko and Stewart, 1978:212.
Isoperla bilineata: Poulton and Stewart, 1991, 38:47.

Distribution: **CANADA – MB** (Burton 1984), **SK** (Dosdall and Lehmkuhl 1979); **USA – IA** (Heimdal et al. 2004), **IL** (Frison 1935, Poulton and Stewart 1991, DeWalt and Grubbs 2011), **IN** (Ricker 1945, Grubbs 2004, DeWalt and Grubbs 2011), **KS** (Stewart and Huggins 1977), **MI** (Grubbs and Bright 2001), **MN** (Harden and Mickel 1952), **MO** (Poulton and Stewart 1991), **MS** (Stark 1979; Stark et al. 2009), **ND** (Kondratieff and Baumann 1999), **OH** (Gaufin 1956, Szczytko and Stewart 1978, DeWalt et al. 2012), **WI** (Hilsenhoff and Billmyer 1973).

Additional Records: **CANADA – SK:** North Saskatchewan River @ Junct. Hwy 5, Borden Bridge, 29/V/1974, L. Dosdall, 4♂, 3♀ (CNIC). **USA – IN:** Monroe Co., Bloomington, Eriffy Reserve, 15/V/1957, D.L. Weaver 1♀ (INHS). **MO:** Daviess Co., Grand River Near Gallatin, Hwy 6, 23/V/1986, R.W. Baumann, C.R. Nelson, 1♂(BYUC). Madison Co., St Francis River, rd. E, 21/V/2006 B.C. Kondratieff, R.W. Baumann, 1♀ (CSUC). St. Louis Co., St. Anthony's Medical Center at lights, 9 mi. NE Meramac River, Hwy 21, 22/V/2009, R.E. Zuellig, 52♂, 67♀ (CSUC). **NE:** Howard Co., North Loup River, Hwy 282, 7/VI/2002, B.C. Kondratieff, R.W. Baumann, 1♂, 2♀ (CSUC). Knox Co., Missouri River, 524 Ave., Niobrara, 27/VI/2003, B.C. Kondratieff, R.E. Zuellig, 5♂, 2♀ (CSUC); Mormon Canal, Hwy 12, W Niobrara, 28/VI/2003, B.C. Kondratieff, R.E. Zuellig, 3♂, 1♀ (CSUC). Nace Co., Cedar River, St. Route. 14 N Fullerton, 26/VI/1998, B.C. Kondratieff, H. Rhodes, 2♂, 6♀ (CSUC). **MS:** Hinds Co., Clinton, Mississippi College Campus, 6/V/1980, J. Scott, D. Dickerson, 9♂, 7♀ (INHS); Same locality, 1/V/1980, B.P. Stark, 10♂, 5♀ (INHS). **WI:** Bayfield Co., Apostle Islands National Lakeshore, Rocky Island, 47° 2'36.3"N, 90°40'1.9"W, 22/VI/2001, S.W. Szczytko, 2♂, 1♀ (INHS); Michigan Island, near light house, 12/VII/2002, S.W. Szczytko, 1♀ (INHS). Eau Claire Co., Chippewa River, Line rd., W Eau Claire, 16/VI/1990, J. Cahow, 5♂, 12♀ (INHS); Same locality, 12/VI/1992, J. Cahow, 16♀(INHS).

Male. Macropterous. Forewing length 12.7-14.8 mm. General body color pale yellow with dark brown markings. Dorsum of head mostly faint yellow with thin dark brown bands connecting ocelli, slightly truncate at anterior ocellus, interocellar area pale, not enclosed posteriorly, two pale brown spots lateral to anterior ocellus (occasionally faint), frons occasionally with a small pale brown patch (sometimes faint or absent in preserved material) (Fig. 4.1). Antennal scape pale yellow, pedicel medium brown, flagellum pale brown. Pronotum with wide median pale stripe, middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, medium to dark brown, pronotal disks pale yellow, anterior margin with broad bipartite median brown band (Fig. 4.1). Meso- and metasterna pale yellow with medium brown lateral bands and wide pale yellow median band. Mesonotum with large anteromedian pale patch and small medium brown posteromedian spot. Metanotum with large mesal heart shaped medium brown patch, anterior margin with transverse pale band. Wings cloudy, veins pale brown. Legs pale brown, dorsal margin of femur with a longitudinal medium brown band, tibia with a wide horizontal medium brown band on proximal ¼ of outer surface. Sterna pale yellow, sternum 8 with a thin posterior pale brown band, row of short stout posterior setae and a low, pale brown vesicle, ca. as wide as long, posterior margin evenly rounded, extending slightly over anterior margin of sternum 9 (Fig. 4.2). Terga pale yellow with medial and lateral medium brown bands (occasionally faint) on segments 1-9, and 3

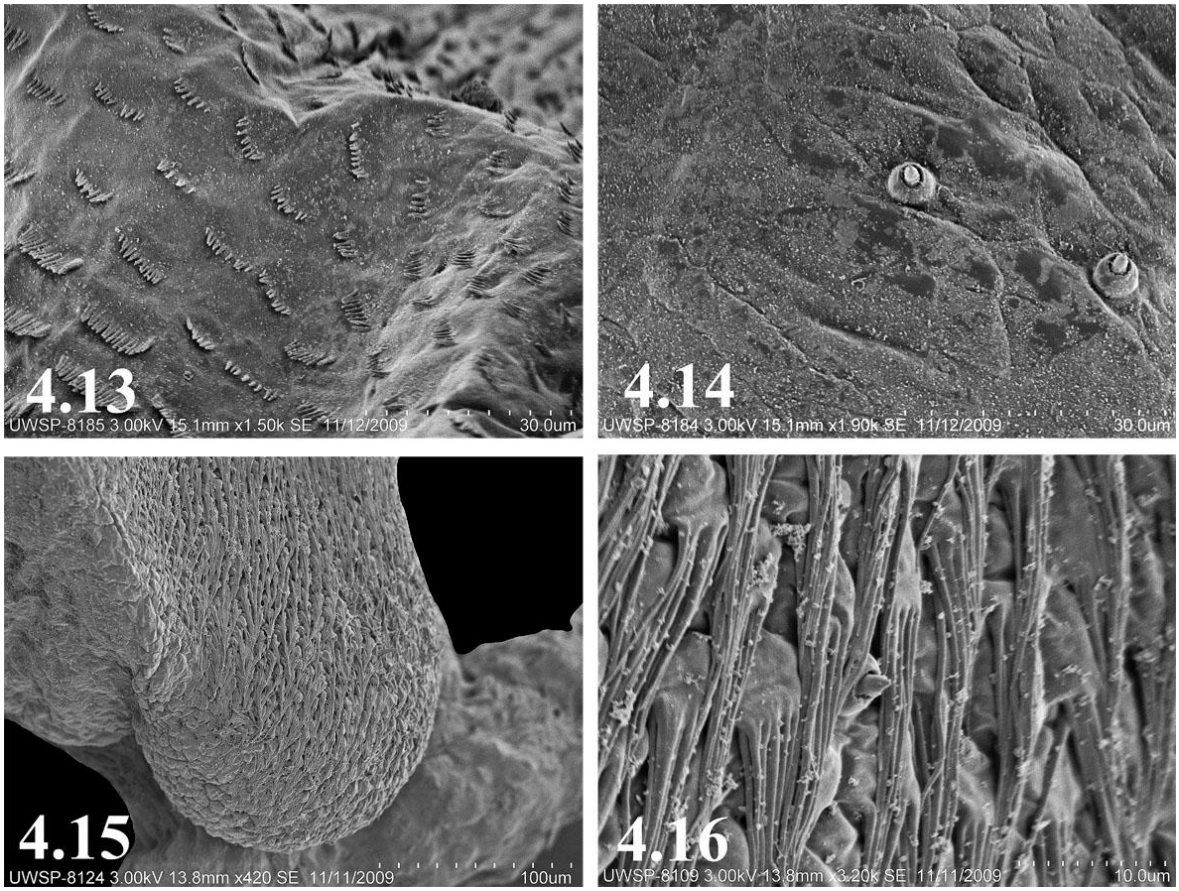


Figs. 4.7-4.12. *Isoperla bilineata*. 4.7. Male aedeagus lateral view. 4.8. Detail of spinulae on basal aedeagal stalk. 4.9. Posteroventral aedeagal lobe. 4.10. Detail of spinulae on posteroventral aedeagal lobe. 4.11. Detail of spinulae on mesal section of aedeagus. 4.12. Posteromesal aedeagal lobe.

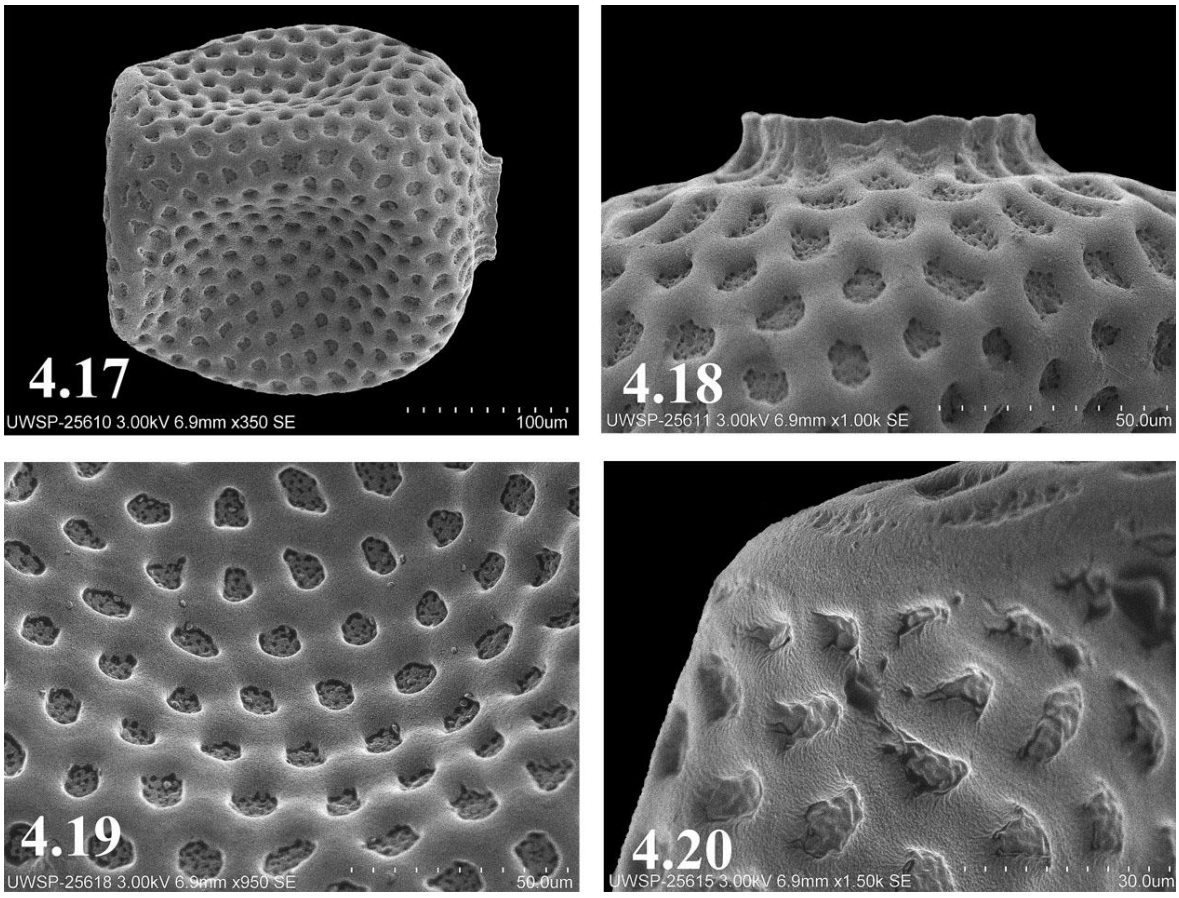
lateral and 2 median medium brown spots on terga 1-9 (sometimes faint in preserved material), tergum 10 paler than preceding segments with faint brown posterior triangular shaped patches, median area paler and slightly depressed (Fig. 4.3). Paraprocts moderately sclerotized, extending only to level of

tergum 10, nearly erect, sharply pointed apically, broad basally (Fig. 4.5). Cercal segments pale yellow. Aedeagus (Fig. 4.6) with posteroventral lobe (Figs. 4.6b, 4.9), posteromesal lobe (Figs. 4.6e, 4.12), paired posterodorsal lobes (Fig. 4.6g), dorsal finger-like membranous tube (Fig. 4.6i), paired anterodorsal lobes (Figs. 4.6j, 4.15) and large anteromesal lobe (Figs. 4.6l, 4.7). Basal stalk covered with concentrated rows of fine hair-like spinulae (Figs. 4.6a, 4.7, 4.8), posteroventral lobe covered with concentrated patch of long stout spinulae (Figs. 4.6b, c, 4.9, 4.10), mesal section covered with concentrated band of shorter stout spinulae (Figs. 4.6d, 4.11), posteromesal lobe covered with sparse rows of small, fine hair-like spinulae (Figs. 4.6e, f, 4.12, 4.13), paired posterodorsal lobes devoid of spinulae (Figs. 4.6g, 4.7), dorsal mesal section with scattered sensilla basiconica (Figs. 4.6h, 4.14), dorsal elongate membranous tube expanded slightly apically (Figs. 4.6i, 4.7), paired anterodorsal lobes with elongate multi-strand hair-like spinulae interspersed with an occasional sensilla basiconica (Figs. 4.6j, k, 4.15, 4.16), anteromesal lobe devoid of spinulae (Fig. 4.6l).

Female. Forewing length 9.0-9.5 mm. General body color and morphology similar to male described above. Eighth sternum with broadly triangular subgenital plate extending ca. ½ distance over sternum 9 (occasionally with a shallow median posterior emargination) (Fig. 4.4).



Figs. 4.13-4.16. *Isoperla bilineata*. 4.13. Small fine hair-like spinulae on posteromesal aedeagal lobe. 4.14. Sensillae basiconica on mesal section of aedeagus. 4.15. Anterodorsal aedeagal lobe. 4.16. Hair-like spinulae on anterodorsal aedeagal lobe.



Figs. 4.17-4.20. *Isoperla bilineata*. 4.17. Egg. 4.18. Detail of egg collar. 4.19. Detail of egg chorion. 4.20. Detail of eclosion line and micropyle.

Ovum. General shape oblong, cross section triangular (Fig. 4.17). Color pale yellow. Length 425 µm; width 395 µm. Collar low, elevated with thickened longitudinal ridges (Figs. 4.17, 4.18). Hexagonal follicle cell impressions well developed, ridges thickened, floors with small shallow punctations (Fig. 4.19), eclosion line wide, smooth and slightly raised, micropyles arranged singularly on follicle cell ridges near eclosion line on anterior ⅓ of egg (Fig. 4.20).

Nymph. Frison (1935) described the nymph and illustrated the habitus of the female nymph and details of the mouthparts. Harden and Mickel (1952) and Hilsenhoff and Billmyer (1973) provided keys for separating *I. bilineata* adults and nymphs from *I. richardsoni* and other *Isoperla* species in Minnesota and Wisconsin respectively. Szczytko and Stewart (1978) illustrated the mouthparts. Stark et al. (1998) and Stewart and Stark (2002) provide a color photograph of the habitus.

Diagnosis. *Isoperla bilineata* is a medium size pale yellow species that has the typical dark inverted V-band pattern connecting the ocelli. This pattern occurs among a number of eastern *Isoperla* species including *I. burksi, I. dicala* (dark form), *I. francesca, I. frisoni, I. gibbsae, I. kirchneri* sp. n., *I. montana, I. orata, I. richardsoni*, and others. *Isoperla bilineata* is placed in the *I. bilineata* group (Table 1), that also includes *I. dicala, I. fauschi* sp. n., *I. frisoni, I. gibbsae, I. myersi* sp. n., *I. powhatan* sp. n., *I. richardsoni, I. sagittata, I. tutelo* sp. n., and *I zuelligi* sp. n. Among

those above taxa, I. *bilineata* is most similar to *I. richardsoni* in general appearance and size (Frison 1935, Harden and Mickel 1952). This close habitus similarity and direct sympatry with *I. richardsoni* has caused considerable confusion in the literature and misidentification regarding these two and other species. *Isoperla bilineata* females are most easily confused with *I. montana*, *I. kirchneri* sp. n., and *I. gibbsae* because they all have a triangular subgenital plate and the inverted dark V-band pattern on the head.

Frison (1935) stated that he could not reliably separate the males of *I. bilineata* and *I. richardsoni* and designated a female holotype for *I. richardsoni* "…because the subgenital plate of the female offers better recognition characters than does the male." Harden and Mickel (1952), after study of reared material, determined that the two species could be separated by the color pattern of the terga and the shape of the female subgenital plate. The female subgenital plate of *I. richardsoni* is a low evenly rounded sometimes with a posterior mesal emargination whereas the subgenital plate of *I. bilineata* is generally broadly triangular. Additionally, the male paraprocts of *I. bilineata* are shorter, stouter and more erect than *I. richardsoni*. Szczytko and Stewart (1978) reported that males of *I. bilineata* could be separated from *I. richardsoni* by the large spinulated aedeagal dorsal sac and long coiled membranous tube and that females could be separated by the size and shape of the subgenital plate. The ova of this species is generally similar to many species in this group having a triangular cross section, developed collar, and defined follicle cell impressions with raised thickened ridges and flat floors with numerous shallow punctations. *Isoperla bilineata* ova differ from *I. richardsoni* by having a well-developed eclosion line and not having cross-shaped ridges.

Isoperla bilineata has been previously reported from Alabama north to Newfoundland and west to Saskatchewan and south to Mississippi. The above distribution records are only those that were confirmed by studying material that included males with fully everted aedeagi. Records of this species from other locations must be reconfirmed with males with fully everted aedeagi. Since the general color pattern and secondary sex characteristics of this species are similar to other eastern *Isoperla* species as discussed above, the difficulty in determination is not surprising.

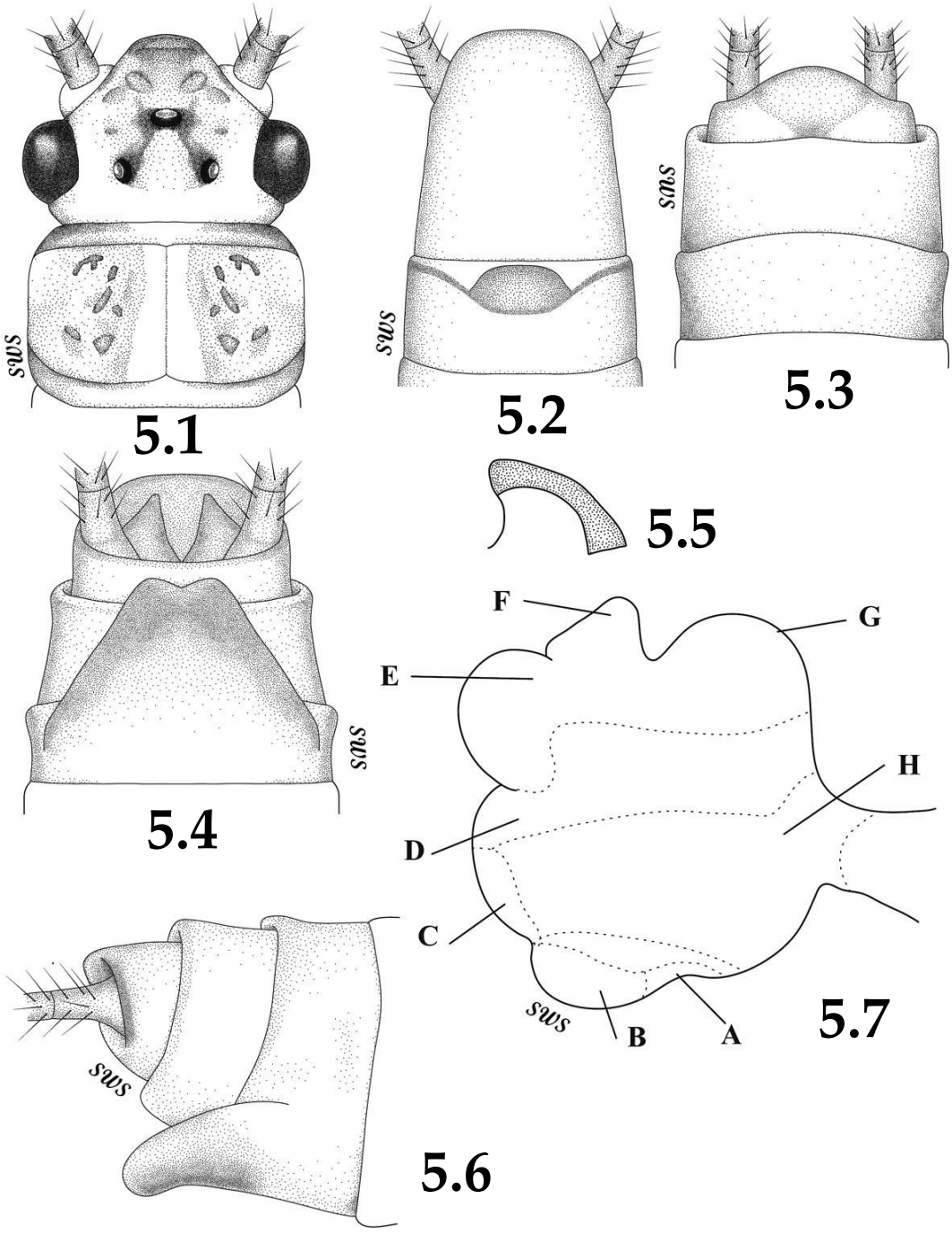
Biological Notes. *Isoperla bilineata* can be relatively common in large and medium size rivers within its range, especially the Midwest. Frison (1935) and Poulton and Stewart (1991) indicate that *I. bilineata* is a species that is confined to larger streams and rivers. Frison (1935) mentioned that this species begins emerging in southern Illinois by the end of March, but maximum abundance in most of the state is not reached until the middle of May. Frison (1935) also indicated nymphs rapidly grow from January to April and are univoltine. He concluded that nymphs are "essentially" herbivores. In the northern portion of the Ozarks, adults emerge from May to June (Poulton and Stewart 1991). Stark et al. (1998) reported adult emergence from April to July. Frison (1935) and Harden and Mickel (1952) found that *I. bilineata* was commonly associated with *I. richardsoni* in medium and large rivers in Illinois and Minnesota.

Graham (1982) reported that male calls recorded by Bill P. Stark from a Mississippi population were a monophasic paired signal consisting of 9-10 beats with an interbeat frequency of 170.4 ± 69.1 ms. Ziminske (1989) studied the drumming behavior of *I. bilineata* from the Rock River, Illinois and found that the male call comprised five bi-beats and a triple beat at the end of the signal. He stated that the intergroup interval was 184.4 ± 22.8 ms and the bi-beat and tri-beat intervals were 94.5 and 125.9 ms respectively and reported that the male call was most similar to the far western North American species *Calliperla luctuosa* (Banks). Males drummed infrequently and no signals were obtained from females.

Isoperla burksi Frison
Banded Stripetail
(Figs. 5.1-5.13)

Isoperla burksi Frison 1942, 22:332. Holotype ♂ (INHS), Lusk Creek, Eddyville (Pope Co.), Illinois. Examined.

Isoperla burksi: Poulton and Stewart, 1991, 38:47.



Figs. 5.1-5.7. *Isoperla burksi*. 5.1. Dorsal head and pronotal pattern. 5.2. Male posterior abdominal sterna. 5.3. Male posterior abdominal terga. 5.4. Female subgenital plate. 5.5. Male paraproct lateral view. 5.6. Female subgenital plate lateral view. 5.7. Male aedeagus lateral view; a. basal patch of short stout spinulae, b. posteroventral lobe, c. patch of concentrated horizontal rows of sclerotized plates, d. upper mesal section void of spinulae, e. posterodorsal lobe, f. dorsal triangular lobe, g. anterodorsal lobe, h. large lower mesal patch of small fine, sharp spinulae.

Distribution: USA – **AR** (Poulton and Stewart 1991), **IL** (Frison 1942, Poulton and Stewart 1991, DeWalt and Grubbs 2011), **IN** (Ricker 1945, Grubbs 2004, DeWalt and Grubbs 2011), **KY** (Tarter and Chaffee 2004, Tarter et al. 2006, **MD** (Duffield and Nelson 1990, Grubbs 1997), **MO (**Poulton and Stewart 1991), **NC** (Kondratieff et al. 1995), **OH** (Gaufin 1956, DeWalt et al. 2013), **OK** (Poulton and Stewart 1991), **SC** (Kondratieff et al. 1995), **VA** (Kondratieff and Kirchner 1987), **WV** (Tarter and Nelson 2006).

New Records: USA – AL: DeKalb Co., Straight Creek, Rte. 35 Bridge nr. Powell Crossing, 14/V/1988, B.C. Kondratieff, R.F. Kirchner, 11♂, 15♀ (CSUC).

Additional Records: USA – IN: Knox Co., White River, at Cunninghams Ferry, 15/IV/1977, A.V. Provonsha, D. Morihara, A.A. Alabi, 11♂, 15♀ (PURC). **KY:** Rowan Co., Triplett Creek, Rte. 32, 3 mi. SW of Morehead, 1/V/1987, B.C. Kondratieff, R.F. Kirchner, 2♂, 1♀, 2N (CSUC). **NC**: Chatham Co., Terrell Creek, @ NC 87, 30/III/2012, S. Beaty, V. Holland, M. Walters, 2♂, 2 exuviae (CSUC).

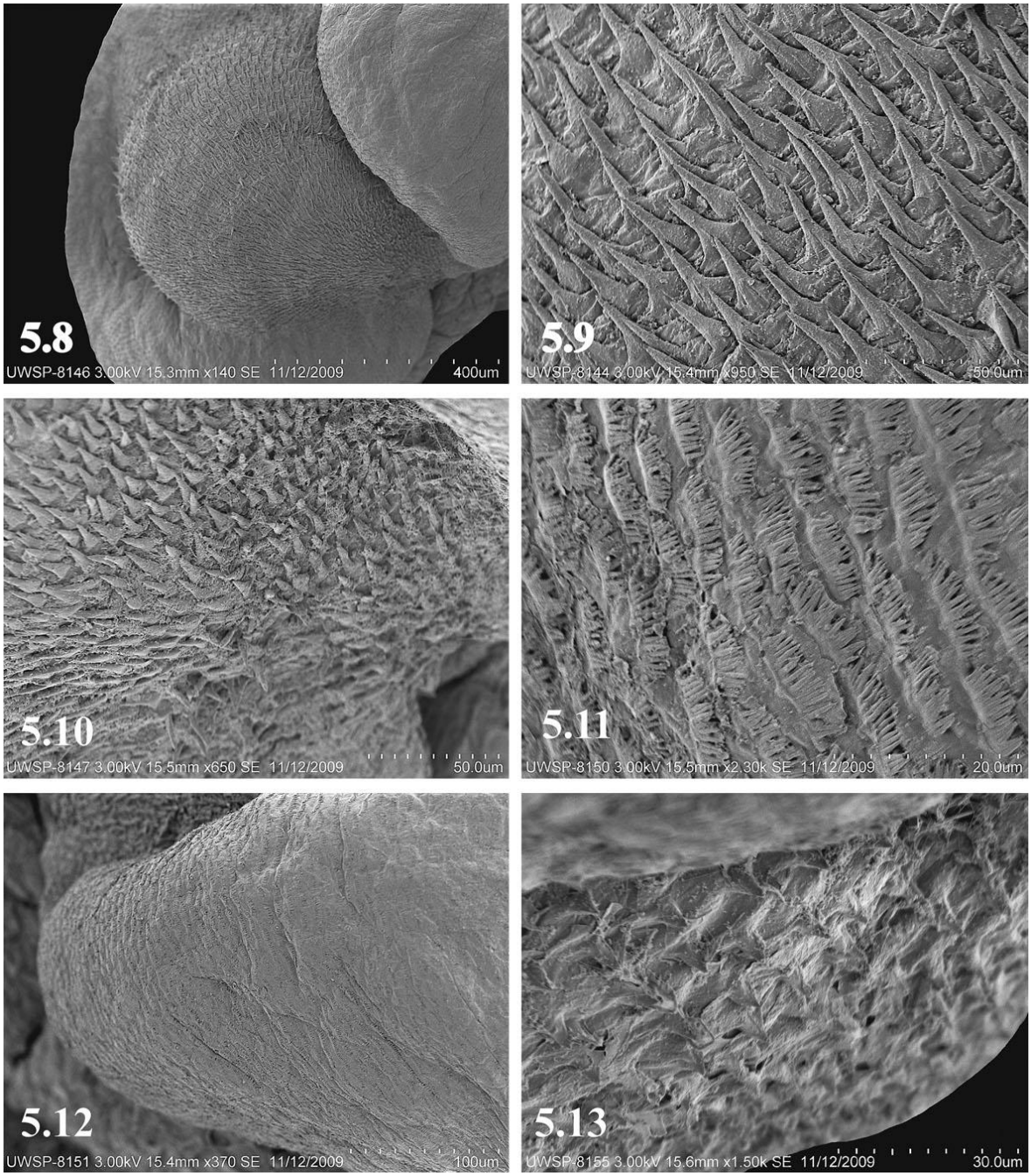
Male. Macropterous. Forewing length 10.0-12.3 mm. General body color pale yellow in life with few pale brown markings. Dorsum of head usually with medium brown bands connecting ocelli forming an inverted V-band pattern; area anterior to median ocellus pale brown, medium brown diffuse area anteriorly to frons and a pair of raised brown tubercles anterolateral to median ocellus, (Fig. 5.1). Antennal scape, pedicel and flagella 1-8 pale yellow, flagellum after segment 8 pale brown. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities irregular, raised, medium to pale brown, pronotal disks pale yellow, anterior and posterior margins diffuse medium brown (Fig. 5.1). Meso- and metanota with paired anterolateral medium brown humps, remainder with irregular diffuse medium brown markings. Wings hyaline with pale brown veins. Legs and sterna pale yellow, tibia with a thin brown vertical band near proximal ⅓, tarsi pale brown, pale yellow ventrally. Sternum 8 with a pale brown vesicle, ca. 2X as wide as long, posterior end evenly rounded, extending posteriorly to near anterior margin of sternum 9 (Fig. 5.2). Terga pale yellow. Paraprocts lightly sclerotized, short, stout, rounded apically, deflected ventrad slightly at tips, not extending over tergum 10 (Figs. 5.3, 5.5). Cerci pale yellow proximally, pale brown beyond segment 7. Aedeagus with large posteroventral rounded lobe with large ovate patch of long, stout spinulae (Figs. 5.7b, 5.8, 5.9); basal patch of spinulae shorter and stouter (Figs. 5.7a, 5.10); posterior patch of concentrated horizontal rows of sclerotized plates with numerous short finger-like spinulae (Figs. 5.7c, 5.11); large posterodorsal lobe (Fig. 5.7e), dorsal triangular lobe (Fig. 5.7f) and large anterodorsal lobe covered with rows of small fine spinulae (Figs. 5.7g, 5.12); upper mesal section devoid of spinulae (Fig. 5.7d), lower mesal section to aedeagal stalk covered with small fine, sharp spinulae (Figs. 5.7h, 5.13).

Female. Forewing length 10.0-12.5 mm. General body color and morphology similar to male described above. Subgenital plate large, broadly triangular, usually with shallow posteromedian notch, produced posteriorly over ca. ¾ length of sternum 9 with apical portion deflected ventrally (Figs. 5.4, 5.6).

Ovum. Unknown.

Nymph. Mouthparts and habitus were illustrated by Frison (1942) and Poulton and Stewart (1991) illustrated the head color pattern, lacinia and partial terga.

Diagnosis. *Isoperla burksi* is a member of the *I. burksi* group which also includes *I. cotta* and *I. orata* (Table 1). Adults of *I. burksi* are similar in general appearance and coloration to several medium size pale yellow eastern *Isoperla* with brown or black bands connecting the ocelli with an inverted V-band pattern. *Isoperla burksi* is particularly similar to such regional sympatric species as *I. bilineata* and *I. richardsoni*. However, the fully everted male aedeagus is distinctive in having a large posteroventral rounded patch of concentrated long, stout spinulae, separating it from both *I. cotta* and *I. orata*. The female of *I. burksi* is distinctive in having a large broadly triangular subgenital plate with a posteromedian notch and a ventrally deflected apical section. *Isoperla burksi* is also similar to *I. tutelo* sp. n. and their separation is discussed under that species.



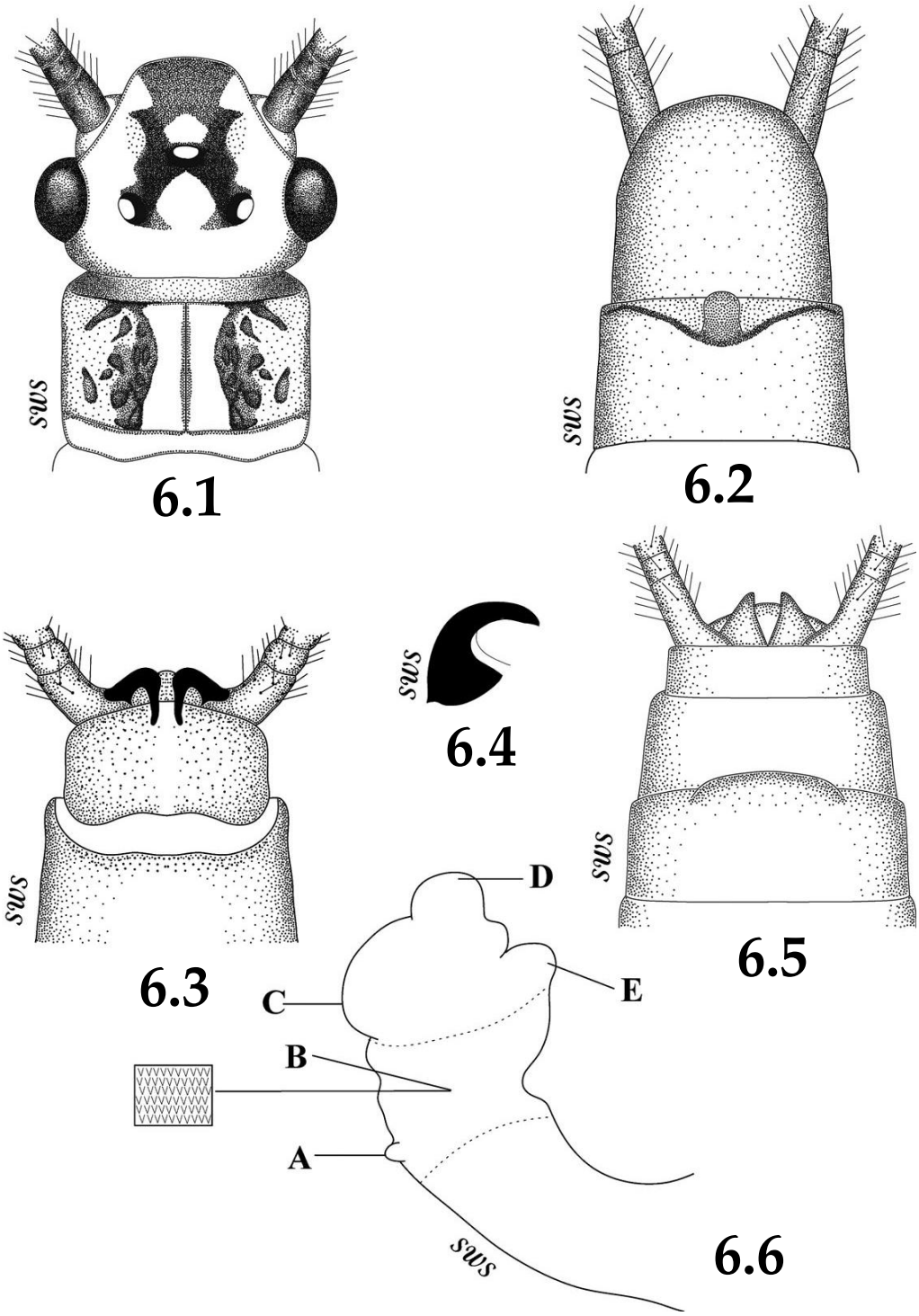
Figs. 5.8-5.13. *Isoperla burksi*. 5.8. Posteroventral aedeagal lobe. 5.9. Detail of spinulae on ovate patch on posteroventral aedeagal lobe. 5.10. Detail of basal spinulae on posteroventral aedeagal lobe. 5.11. Detail of posterior patch of sclerotized aedeagal plates. 5.12. Anterodorsal aedeagal lobe. 5.13. Detail of spinulae on lower mesal section of aedeagal stalk.

Biological Notes. The emergence of *I. burksi* generally occurs from mid-April to late May. Poulton and Stewart (1991) reported that it occurred in mostly permanent streams in the Ouachita and Boston Mountain subregions in their study, however, this species is uncommon throughout its range.

Stewart et al. (1988) reported that drumming males frequently produced consecutive calls prior to stopping to a fixed position between calls. The typical male signal was monophasic and consisted of 26.0 ± 10.3 beats with a mean interbeat frequency of 178.8 ± 18.0 ms. which was similar in their study to *I. sagittata.*

***Isoperla catawba* sp. n.**
Catawba Stripetail
(Figs. 6.1-6.6)

Material Examined: USA – Holotype ♂, **South Carolina:** Aiken Co., Upper Three Runs Creek, SRP rd. C, 5/V/1984, B.C. Kondratieff (USNM). **Paratypes: SC:** Same data as holotype, 13♂, 2♀ (CSUC); Same data as holotype but 25/IV/1984, 8♂, 9♀ (CSUC); Upper Three Runs Creek, Savannah River Plant, SRP "F", 4/V/1977, D.D. Herlong, S. Pritchard, 1♂ (BPSC); Edgefield Co., Turkey Creek, Rte. 68, 14/V/1984, B.C. Kondratieff, 1♂, 1♀ (CSUC).
Distribution: **USA – SC**
Male. Macropterous. Forewing length 7.0-8.5 mm. General body coloration pale yellow with medium and dark brown markings. Head with dark brown bands connecting ocelli extending anteriorly beyond median ocellus, interocellar area and hind margin of head pale yellow; small median pale area anterior to median ocellus; broad medial medium brown band extending from pale area to anterior margin of head. Antennal scape pale yellow, pedicel and flagellum medium brown (Fig. 6.1). Pronotum with a median pale hourglass-shaped longitudinal stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, medium to dark brown, pronotal disks pale yellow, anterior margin with broad bipartite medium brown bands; posterior margin mostly pale yellow; lateral margins with broad pale bands (Fig. 6.1). Meso- and metasternum mostly medium brown with irregular pale markings. Wings hyaline; veins medium brown. Femora pale yellow with medium brown dorsal band; tibia and tarsi medium brown. Sterna pale yellow, sternum 8 with a thin dark brown posterior band; vesicle well developed pale to medium brown, ca. 1.4X as long as wide, posterior margin evenly rounded, lateral margins ca. parallel, extending posteriorly slightly over sternum 9 (Fig. 6.2). Terga pale yellow with faint pale brown longitudinal stripes (2 lateral, one median) and 8 rows of faint longitudinal spots (3 lateral and one median) on segments 1-8 (fresh specimens); tergum 9 with sparse posterior row of short stout spinulae, tergum 10 with shallow median pale depression, scattered short fine setae on remainder of tergum (Fig. 6.3). Paraprocts heavily sclerotized with sharply pointed tips, deflected slightly apically, recurved over tergum 10, broad basally (Figs. 6.3, 6.4). Cercal segments 1-10 pale yellow, remaining segments medium brown. Aedeagus tubular with small posteroventral nipple (Fig. 6.6a); mesal area with concentrated band of short stout golden brown spinulae (Fig. 6.6b); large posterodorsal lobe (Fig. 6.6c); small rounded dorsal lobe (Fig. 6.6d); paired anterodorsal lobes (Fig. 6.6e); dorsal ⅓ appearing devoid of spinulae (a detailed study of spinule patterns using SEM was not possible due to limited everted male specimens available).
Female. Forewing length 9.0 mm. General body color and morphology similar to male described above. Eighth sternum with a low broadly rounded subgenital plate extending only slightly over anterior margin of sternum 9 (Fig. 6.5).
Ovum. Unknown.
Nymph. Unknown.
Etymology. With this name we honor the Catawba Native American people who have occupied the banks of the Catawba River since the 1500's. The Catawba are the only currently recognized Native American Nation presently located in South Carolina.
Diagnosis. *Isoperla catawba* sp. n. is a small pale yellow *Isoperla* with dark brown markings, and with *I. lenati* sp. n. and *I. nana,* is included in the *I. nana* group (Table 1). The most distinctive feature of *I.*



Figs. 6.1-6.6. *Isoperla catawba* sp. n. 6.1. Dorsal head and pronotal pattern. 6.2. Male posterior abdominal sterna. 6.3. Male posterior abdominal terga. 6.4. Male paraproct lateral view. 6.5. Female subgenital plate. 6.6. Male aedeagus lateral view; a. posteroventral nipple-like lobe, b. mesal band of concentrated short stout golden brown spinulae, c. posterodorsal lobe, d. dorsal lobe, e. paired anterodorsal lobes.

catawba sp. n. is the heavily sclerotized, recurved male paraprocts. The species is similar in general size and coloration to *I. lenati* sp. n., but the low, wide female subgenital plate, heavily sclerotized recurved male paraprocts and tubular shape and spinule pattern of the male aedeagus will distinguish this species from both *I. lenati* sp. n. and *I. nana.*

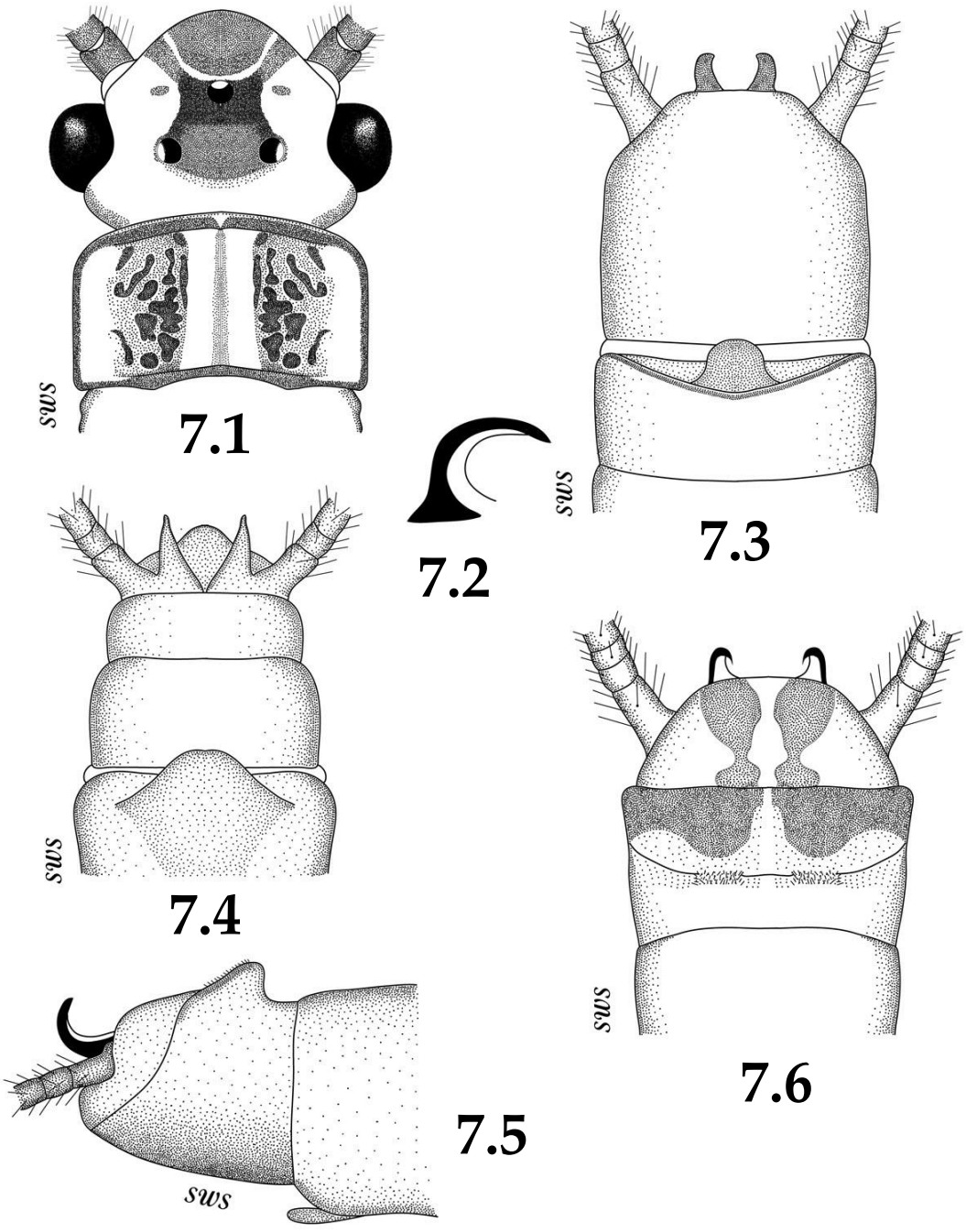
Biological Notes. The emergence period of *I. catawba* sp.n. occurs during May based on collection records, but nothing else is known about the biology or life cycle of this species. The aquatic insects of Upper Three Runs have been documented by Morse et al. (1980, 1983) revealing as remarkable and diverse an assemblage of aquatic insect taxa as is found anywhere in North America. The four species of *Isoperla* listed in Morse et al. (1980) were based on misidentifications except for *I. dicala*. Other species of *Isoperla* confirmed from Upper Three Runs are *I. davisi* and *I. lenati* sp. n. Two other apparent endemic stonefly species are known from the same stream systems, a taeniopterygid, *Taeniopteryx robinae* Kondratieff and Kirchner, and a chloroperlid, *Alloperla furcula* Surdick.

***Isoperla cherokee* sp. n.**
Hooked-spine Stripetail
(Figs. 7.1-7.26)

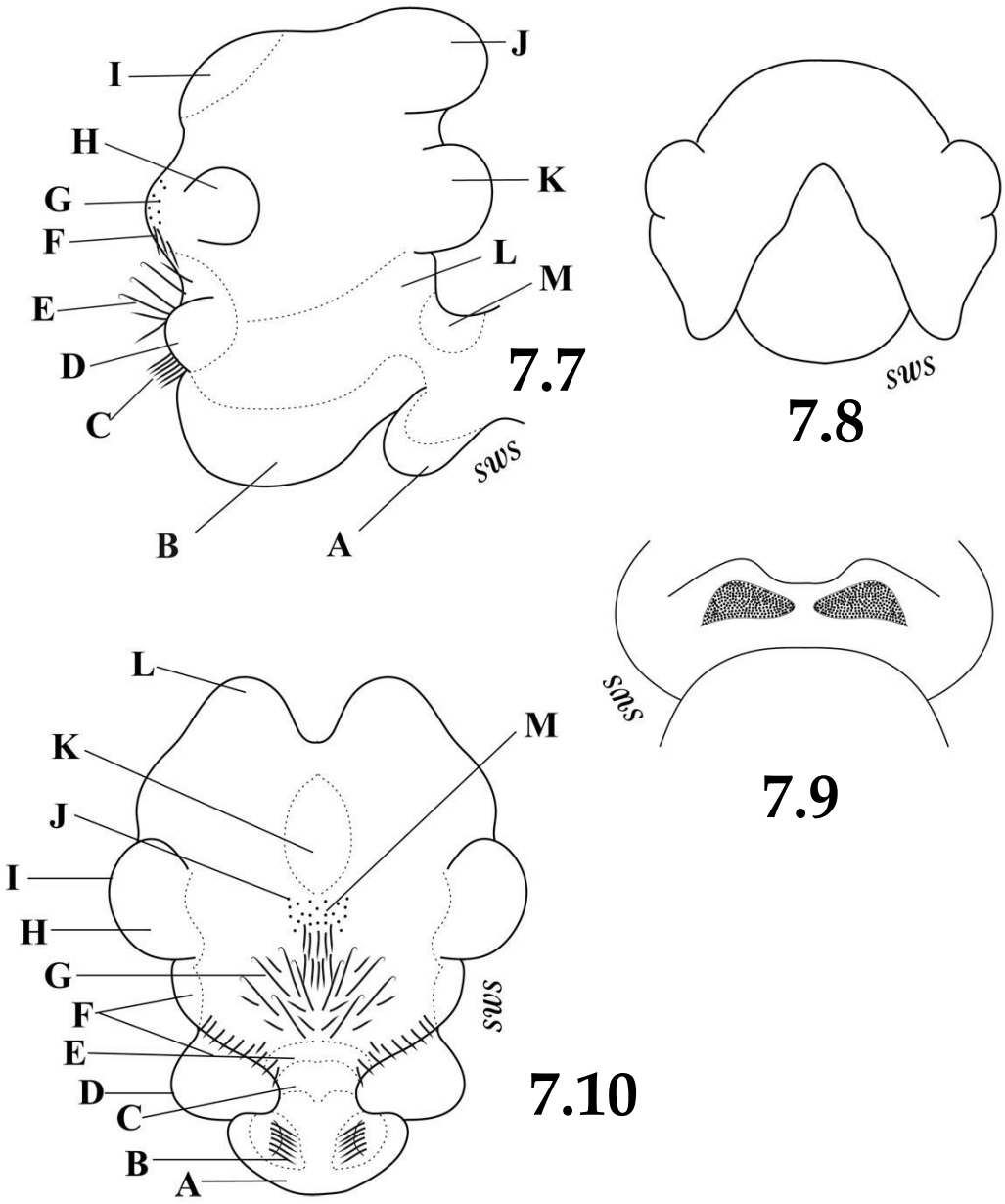
Material Examined: USA – Holotype ♂, **North Carolina:** Macon Co., Robin Branch, Wayah Bald, 35.10074°N, 83.35436°W, 20/V/2009, B.P. Stark, (USNM). **Paratypes: NC:** Macon Co., Robin Branch, Wayah Bald, 4720', 25/VI/1985, J.S. Weaver, J. Sieburth, 1♀ (BPSC); Robin Branch, Wayah Bald, 25/V/1993, B.C. Kondratieff, R.F. Kirchner, 4♂, 1 N (CSUC); Same locality as holotype, 20/V/2009, B.P. Stark,1♂, 2♀ (BPSC); Same locality, 25/V/1993, B.P. Stark, D. Kelly, R. Simmons, 1♂, 2♀ (BPSC); Same locality, 24/V/2006, B.P. Stark, 5♀ (BPSC); Same locality, 24/V/2006, B.P. Stark, I. Sivec, 1♀ (BPSC); Same locality, 9/VI/1998, B.P. Stark, J. Wise & J. Carter, 3♂, 1♀ (BPSC); Same locality, 9/VI/1998, B.P. Stark, 1♂ (BPSC); Same locality, 13/VI/1996, B.P. Stark, 1♂, 2♀ (BPSC); Wayah Creek, below Berties Falls, 3,800', 24/V/2006, B.P. Stark, I. Sivec, 1♀ (BPSC); Same locality, 20/V/2009, B.P. Stark, 1♂ (BPSC); Same locality, 9/V/2000, B.P. Stark, 3♂, 3♀ (BPSC); trib. Wayah Creek, Wayah Bald, 35.10077°N, 83.35368°W, 20/V/2009, B.P. Stark, 2♂, 3♀ (BPSC); Rattlesnake Spring, Wayah Bald, 5,100', 26/V/1981, B.P. Stark, J.S. Weaver III, 1♂, 4♀ (BPSC); Rattlesnake Spring, Wayah Bald, 12/V/2000, S.A. Grubbs, 5♂, 1♀ (SAGC); Dirty John Creek, Wayah Bald, 24/V/2005, B.P. Stark, 1♀ (BPSC); Wayah Crest Campground Spring, light trap, 30-31/V/1981, J.S. Weaver, R.W. Holzenthal, 1♂ (BPSC). **TN:** Sevier Co., Walker's Prong, Route 441, GSMNP, 16/V/1990, B.C. Kondratieff, R.F. Kirchner, J. Welch, 1♂, 3♀ (CSUC).

Distribution: **USA – NC, TN.**

Male. Macropterous. Forewing length 10.8-11.5 mm. General body coloration pale yellow with medium and dark brown markings. Head with large dark brown patch covering ocelli and interocellar area, darkest in a line connecting lateral ocelli with median ocellus and in a broad band posterior to median ocellus; medium brown bands extending from median ocellus to anterior margin of antennal bases; small pale brown spots lateral to median ocellus; thin U-shaped pale, thin band anterior to median ocellus; frons with large wide medium brown patch (Fig. 7.1). Antennal scape pale yellow, pedicel and flagellum dark brown. Pronotum with a median, pale slightly hourglass-shaped stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks pale yellow, anterior, posterior and lateral margins usually with thin dark band (Fig. 7.1). Meso- and metasterna pale yellow with wide medium brown lateral bands. Anterior margins of meso- and metanota mostly pale yellow; mesonotum with anterior mesal pale band extending approximately ⅔ length of notum; remainder of notum with irregular medium/dark brown markings, mesonotum with irregular shaped pale anteromedian areas. Wings hyaline; veins medium brown. Legs pale yellow, femora with dark dorsal band, tibia with dark brown band near proximal 1/5, tarsi pale brown. Sterna pale yellow, sternum 8 with a thin incomplete dark brown posterior band; vesicle well-developed medium brown, 2X as wide as long, posterior



Figs. 7.1-7.6. *Isoperla cherokee* sp. n. 7.1. Dorsal head and pronotal pattern. 7.2. Male paraproct lateral view. 7.3. Male posterior abdominal sterna. 7.4. Female subgenital plate. 7.5. Male posterior abdominal segments lateral view. 7.6. Male posterior abdominal terga.



Figs. 7.7-710. *Isoperla cherokee* sp. n. 7.7. Male aedeagus lateral view; a. posteroventral projecting lobe, b. large ventral lobe with rows of small fine hair-like spinulae, c. spines along inner margin of conical lobes, d. paired ventrolateral conical lobes, e. long stout reddish brown spines above conical lobes, f. medium length stout reddish brown spines, g. patch of short stout spinulae, h. paired posterodorsal lobes i. rows of small hair-like spinulae, j. paired anterodorsal lobes, k. anteromesal lobe, l. mesal patch of scattered clumps of spinulae with apical fingers and sensillae basiconica, m. dorsobasal bipartie spine plate. 7.8. Male aedeagus dorsal view. 7.9. Dorsobasal sclerotized aedeagal plates. 7.10. Male aedeagus posterior view; a. ventral lobe, b. ventral stout spines, c. patch of wide flat plates with apical fingers, d. paired ventrolateral conical shaped lobes, e. posterior patch of sharp spinulae, f. patch of small fine hair-like spinulae, g. stout reddish brown spines, h. patch of small fine hair-like spinulae, i. paired posterodorsal lobes, j. patch of small sharp spinulae, k. mesal posterodorsal patch of concentrated short stout spinulae, l. paired anterodorsal lobes.

margin evenly rounded, extending posteriorly slightly over anterior margin of sternum 9 (Fig. 7.3). Terga pale yellow, male terga 4-7 with posterolateral patches of long fine setae which become progressively larger posteriorly (Fig. 7.11); occasionally a mesal medium brown longitudinal band on segments 1-8, tergum 9 elevated with sharp dorsal ridge and bipartite row of stout dark spinulae (Figs. 7.5, 7.6, 7.12); posterior ½ with bipartite medium brown patches armed with stout spinulae (Figs. 7.5, 7.6); tergum 10 depressed with bipartite mesal medium brown longitudinal patches (Figs. 7.5, 7.6). Paraprocts sclerotized, long, thin, recurved over tergum 10 slightly, broad basally, curved ventrad apically and tapering to sharp points (Figs. 7.2, 7.5, 7.6). Cerci pale yellow. Aedeagus with posterobasal projecting lobe armed with dense ventral patch of medium length stout spinulae (Figs. 7.7a, 7.13); large ventral lobe covered with rows of small fine (5-8) hair-like spinulae (Figs. 7.7b, 7.10a, 7.14); paired ventrolateral conical shaped lobes covered with rows of small fine (5-8) hair-like spinulae (Figs. 7.7d, 7.10d, f, 7.14); paired rows of 6-7 long, stout reddish brown (occasionally colorless in older material) spines along inner margin of conical lobes set on membranous mounds (Figs. 7.7c, 7.10b, 7.15, 7.16); posterior patch of sharp spinulae, wide basally below conical lobes, some with several apical fingers (Figs. 7.10e, 7.20) which grade into larger patch of wide flat plates with numerous apical fingers (Figs. 7.10c, 7.21); longer, stouter reddish-brown spines (largest with apical hook) above conical lobes (Figs. 7.7e, 7.10g, 7.16, 7.17); mesal row of stout medium length reddish-brown spines (9-13) oriented horizontally above longer stout reddish-brown spines (Figs. 7.7f, 7.10m, 7.16); small sharp mesal spinulae dorsal to mesal flat spine patch (Figs. 7.10j, m, 7.16); large, mesal posterodorsal patch of concentrated short stout spinulae above small sharp mesal spinulae (Figs. 7.7g, 7.10k, 7.19); paired posterodorsal lobes covered with rows of small fine (5-8) hair-like spinulae (Figs. 7.7h, 7.10h, i, 7.14); patch of short fine spinulae above paired posterodorsal lobes (Fig. 7.7i); paired anterodorsal lobes devoid of spinulae (Figs. 7.7j, 7.10l); mesal section of anteromesal lobe (Figs. 7.7k, 7.8) with scattered clumps of spinulae bearing numerous apical fingers and sensilla basiconica (Figs. 7.7l, 7.18); basal aedeagal stalk with dorsal bipartite sclerotized patches of concentrated stout sharp spinulae (Figs. 7.7m, 7.9, 7.22).

Female. Macropterous. Forewing length 12.0-12.8 mm. General body color and morphology similar to male described above. Eighth sternum with a broadly triangular subgenital plate, usually with a slight apical mesal emargination; plate margin extending slightly over anterior margin of sternum 9, usually darker than remainder of segment (Fig. 7.4).

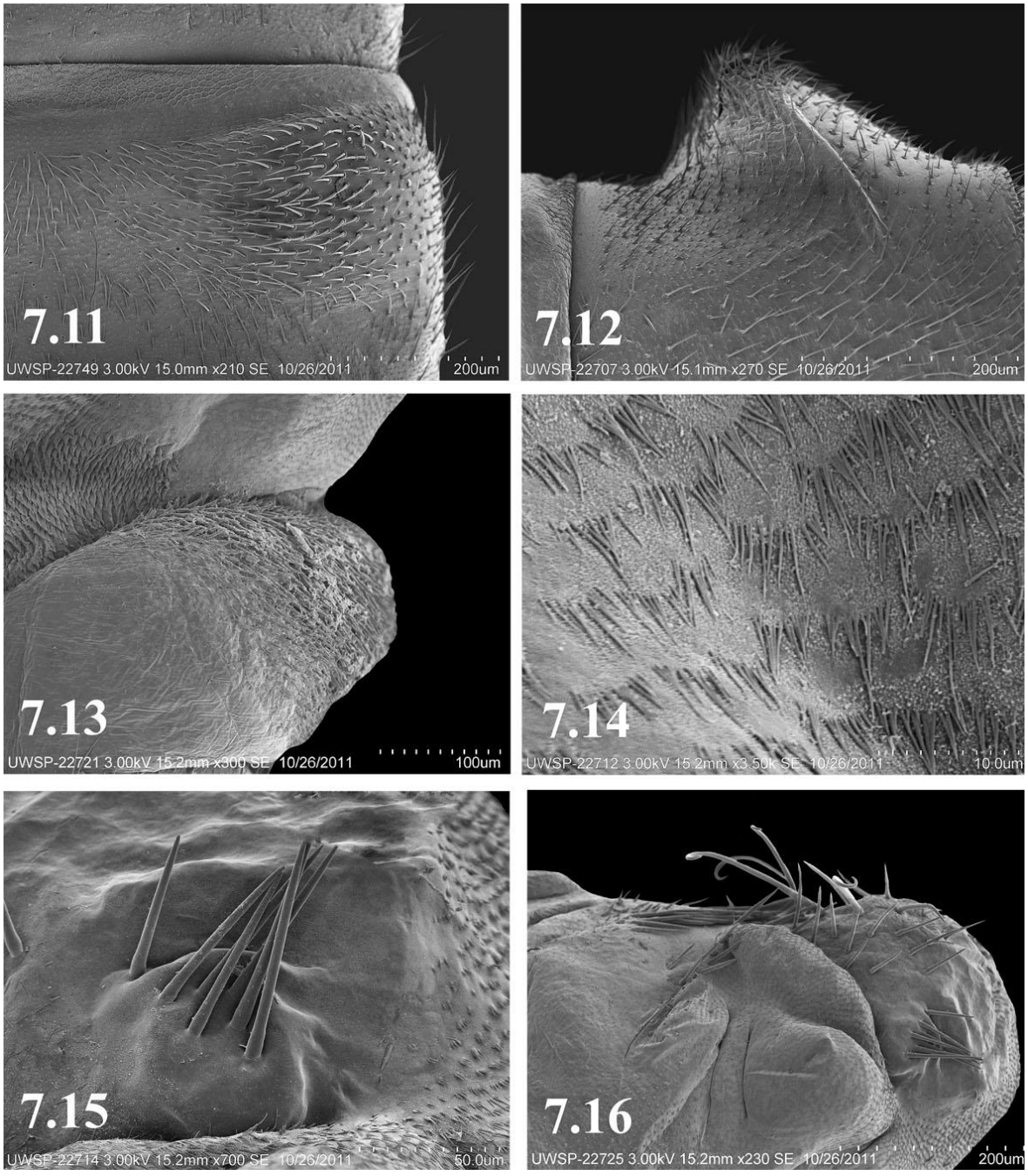
Ovum. General shape nearly circular, cross section concave (Figs. 7.23, 7.24). Color amber. Length 200 µm; width 180 µm. Collar low, button shaped, with large flat basal area (Figs. 7.23, 7.24, 7.25). Hexagonal follicle cell impressions not visible, chorionic surface covered with small pits; eclosion line absent; micropyles with thickened openings, arranged in a row of 3-4 near anterior ⅓ of egg (Fig. 7.26).

Nymph. Unknown.

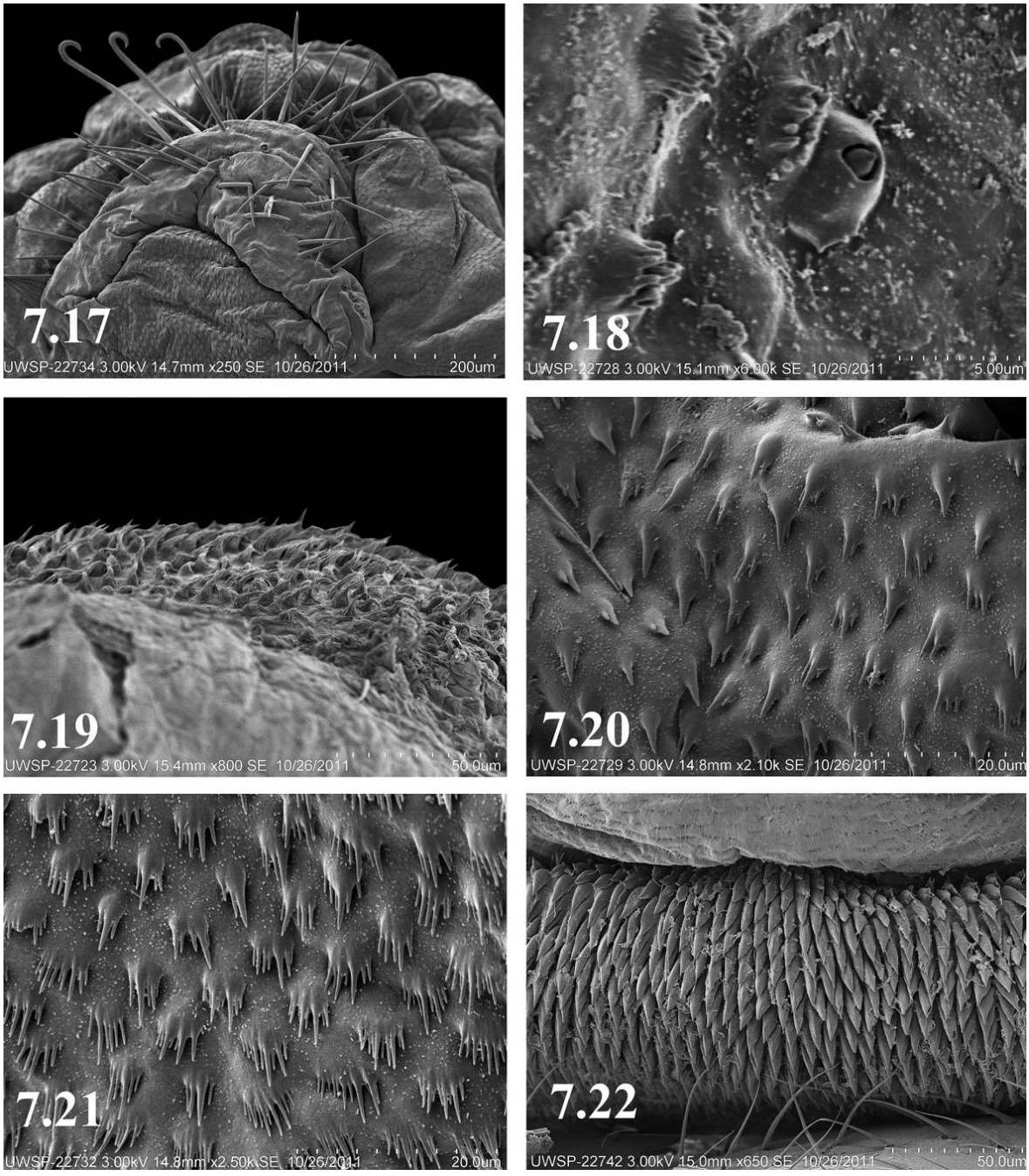
Etymology. The patronym honors the people of the Cherokee Nation who lived in western North Carolina, including Wayah Bald and the surrounding areas since the end of the last Ice Age.

Diagnosis. *Isoperla cherokee* sp. n. is a small pale brown *Isoperla* with dark brown markings typical of the *I. similis* group which includes several additional species (Table 1). It is most similar to the sympatric *I. starki* sp. n. in habitus but is slightly smaller. *Isoperla cherokee* sp. n. differs from *I. starki* sp. n. in having an elevated male ninth tergum, a different shape and spinule pattern on the aedeagus and in having a triangular female subgenital plate. It is distinguished from other eastern Nearctic *Isoperla,* especially those of the *I. similis* species group, by the large hooked-tip, reddish-brown aedeagal spines.

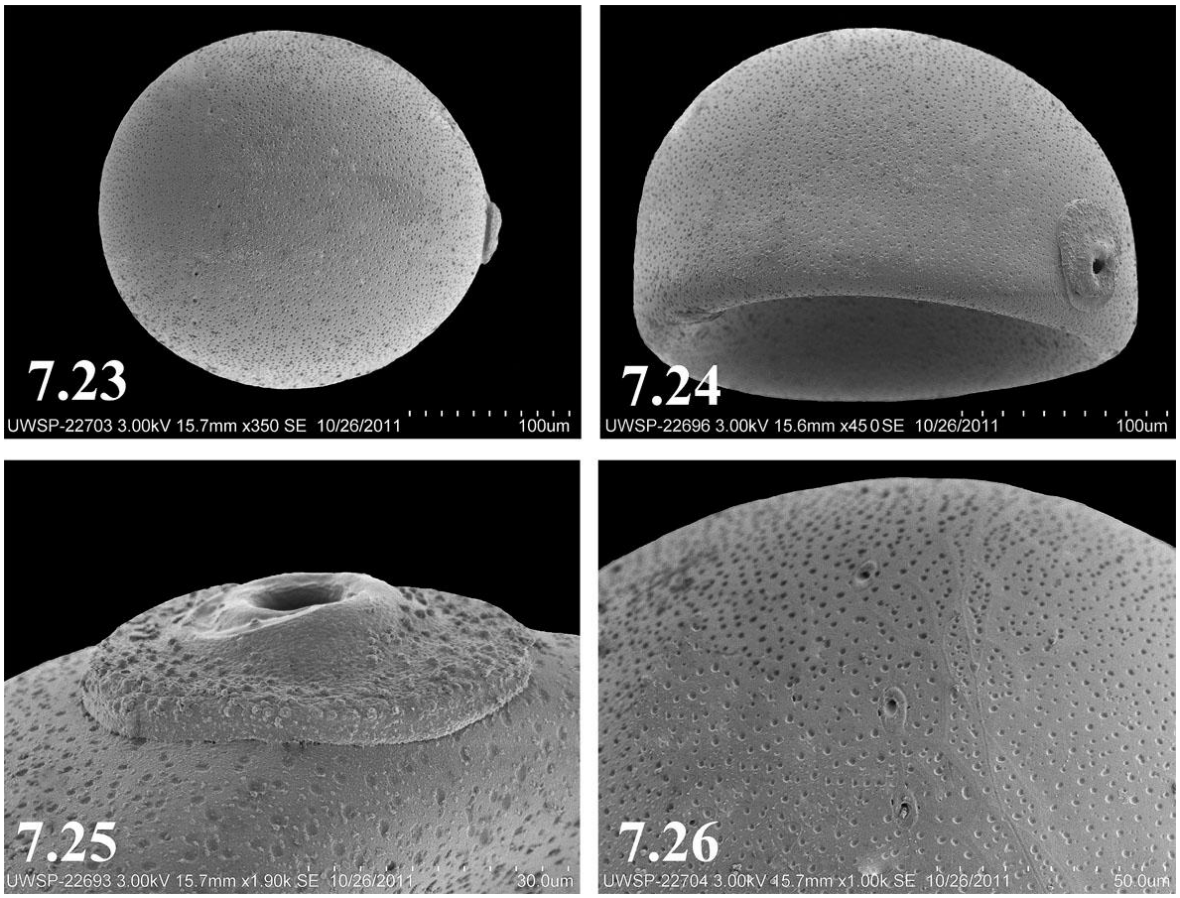
Biological Notes. Adults of *I. cherokee* sp. n. have been collected from mid-May through mid-June, and little is known about the biology or life cycle of this species. The species is apparently restricted to small 1st order streams with spring seeps and hypocrenon habitats at higher elevations in North



Figs. 7.11-7.16. *Isoperla cherokee* sp. n. 7.11. Detail of spinule patches on male terga 4-7. 7.12. Male tergum 9. 7.13. Posterobasal projecting aedeagal lobe. 7.14. Detail of spinulae on posterobasal projecting aedeagal lobe. 7.15. Detail of stout spines on inner margin of conical aedeagal lobe. 7.16. Detail of stout spines on inner margin of conical aedeagal lobe.



Figs. 7.17-7.22. *Isoperla cherokee* sp. n. 7.17. Detail of stout hooked spines above conical aedeagal lobe. 7.18. Detail of aedeagal sensillae basiconica on mesal section. 7.19. Detail of concentrated posterodorsal aedeagal mesal spinulae. 7.20. Detail of concentrated posterodorsal aedeagal mesal spinulae. 7.21. Detail of wide flat plates with apical fingers. 7.22. Detail of spinulae on dorsobasal bipartite aedeagal sclerotized plates.



Figs. 7.23-7.26. *Isoperla cherokee* sp. n. 7.23. Egg. 7.24. Egg lateral view showing concave section. 7.25. Egg collar. 7.26. Egg micropyles.

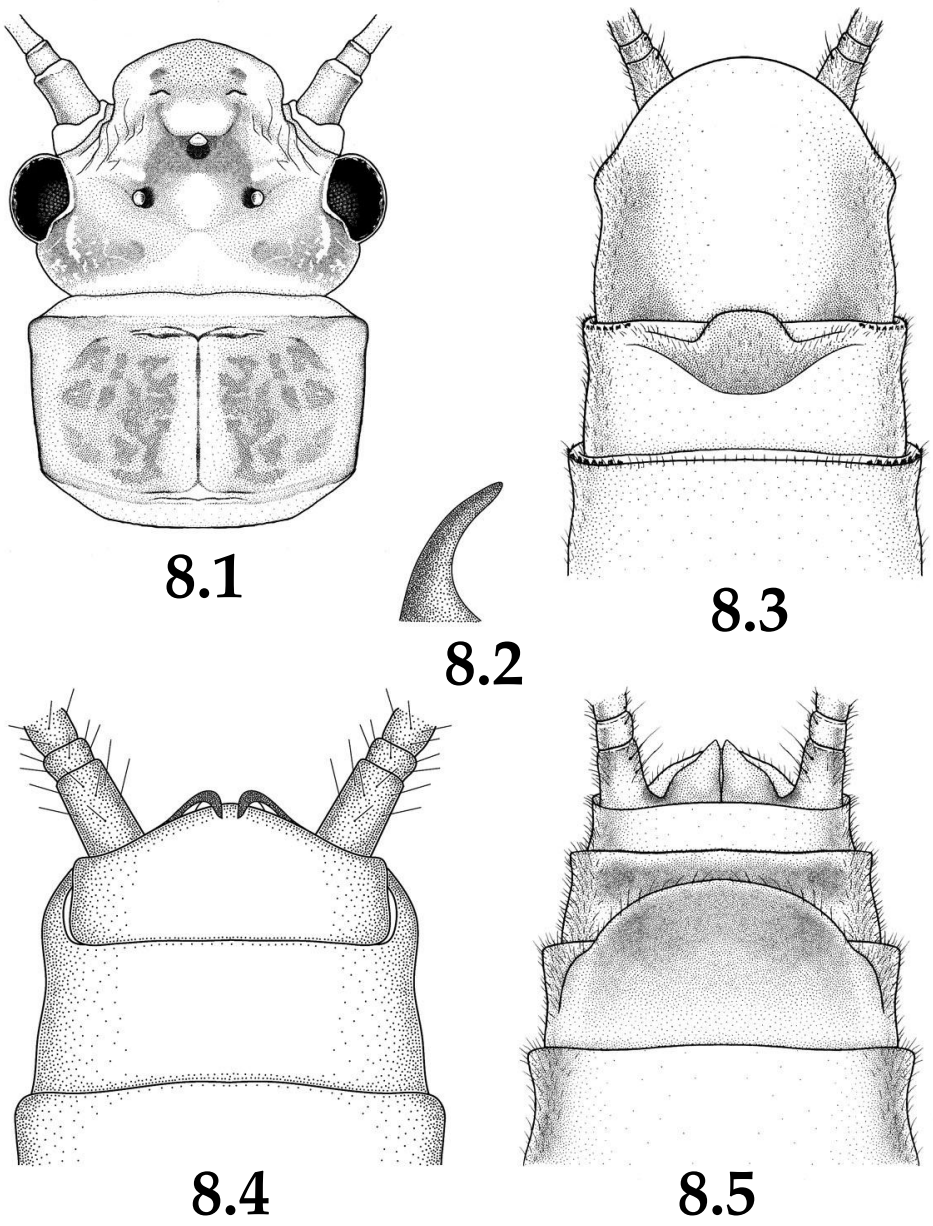
Carolina. The summit of Wayah Bald is an area mostly devoid of trees, which reaches an elevation of over 1,600 m in the Nantahala National Forest near Franklin, North Carolina. Several other uncommon or regionally endemic stonefly species, including *I. starki* sp. n., a peltoperlid, *Viehoperla ada* (Needham & Smith 1916) and a perlodid, *Oconoperla innubila* (Needham & Claassen 1925) occur in the numerous rheocrenes, especially Robin Branch, draining the mountain.

***Isoperla chickamauga* sp.n.**
Cloudland Stripetail
(Figs. 8.1-8.7)

Material Examined: USA – Holotype ♂, Georgia: Dade Co., small seep across Rte. 136, 1.1 mi. W 136/189 0.15 mi W entrance Cloudland Canyon State Park, 24/V/1981, C.H. Nelson (USNM). **Paratype: GA:** Dade Co., Same data as holotype, 1♀ (USNM).

Distribution: **USA – GA.**

Male. Macropterous. Forewing length 12.0 mm. General body yellow-orange with black markings. Dorsum of head with dark bands connecting ocelli widest near median ocellus, interocellar area pale, and an additional pale spot anterior to median ocellus; darker shading occurs lateral to median ocellus, frons mostly dark (Fig. 8.1). Pronotum brown with wide yellow middorsal stripe, middorsal pronotal suture brown, disks pale brown, rugosities dark brown, wide, irregularly



Figs. 8.1.-8.5. *Isoperla chickamauga* sp. n. 8.1. Dorsal head and pronotal pattern. 8.2. Male paraproct lateral view. 8.3. Male posterior abdominal sterna. 8.4. Male posterior abdominal terga. 8.5. Female subgenital plate.

shaped (Fig. 8.1). Antennae medium brown. Wings pale, veins brown. Legs brown. Terga dark brown. Paraprocts long, sclerotized, acute at tips, recurved slightly over tergum 10 (Figs. 8.2, 8.4). Sterna brown, sternum 8 with a large, dark sclerotized vesicle, as wide as long (Fig. 8.3). Cerci medium brown. Aedeagus membranous with expanded balloon-like apical section (Figs. 8.6d, 8.7d); pair of large lateral posteromedian lobes (Figs. 8.6c, 8.7c); posteroproximal lobe with a horizontal sclerotized

bone-shaped rod expanded apically, oriented ventrally (Figs. 8.6a, b, 8.7a, b) and anteromesal membranous lobe small (Fig. 8.7e).

Female. Macropterous. Forewing length 12.5 mm. General body color and morphology similar to male. Subgenital plate broadly rounded and produced over ⅔ of sternum 9 (Fig. 8.5).

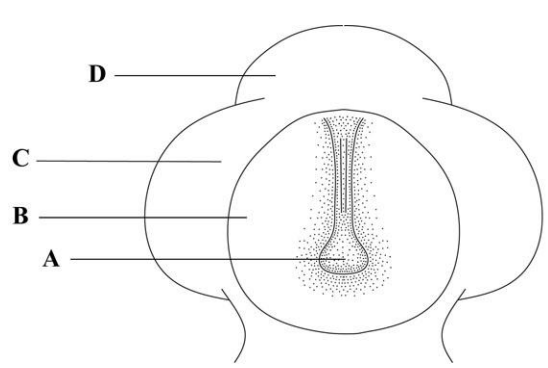
Ovum. Unknown.

Nymph. Unknown.

Etymology. We honor the Chickamauga band of the eastern Cherokee tribe of Native Americans from the northwestern corner of Georgia with this name.

Diagnosis. This species is unique among all eastern Nearctic *Isoperla* in having a single prominent aedeagal sclerotized rod that is oriented ventrally. Several western Nearctic *Isoperla* species have a sclerotized rod such as *I. acula* Jewett 1962, *I. denningi* Jewett 1954, *I. fulva* Claassen 1937, *I. marmorata* Needham & Claassen 1925, *I. petersoni* Needham & Christenson 1927, *I. rainiera* Jewett 1954, and *I. sordida* Banks 1906b (Szczytko and Stewart 1979a, Sandberg and Kondratieff 2013). The aedeagal rod of *I. chickamauga* sp.n. is most similar to *I. denningi*, a California endemic (Szczytko and Stewart 1979a, Sandberg and Kondratieff 2013).

Biological Notes. The emergence period of *I. chickamauga* apparently occurs during late May based on single collection record. No other information is available about the biology or life cycle of this enigmatic species. *Isoperla chickamauga* sp. n. is apparently rare and recent attempts by C.H. Nelson to recollect this species from the type locality have been unsuccessful.



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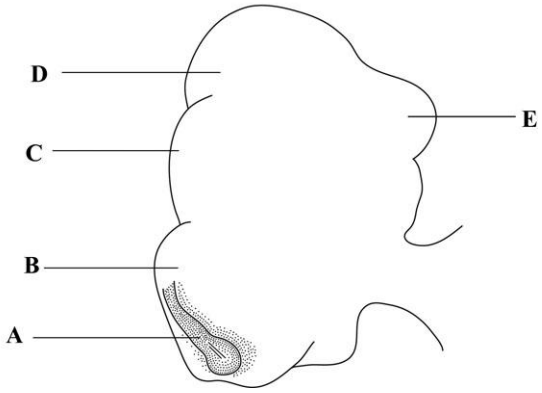


8.7

Figs. 8.6-8.7. *Isoperla chickamauga* sp. n. 8.6. Male aedeagus posterior view; a. horizontal bone shaped sclerotized rod, b. posteroproximal lobe, c. paired lateral posteromedian lobes, d. expanded balloon-like apical section. 8.7. Male aedeagus lateral view; a. horizontal bone shaped sclerotized rod, b. posteroproximal lobe, c. paired lateral posteromedian lobes, d. expanded balloon-like apical section, e. anteromesal lobe.

Isoperla citronella (Newport)
Obscure Stripetail

Perla citronella Newport 1851, 20:450. Lectotype ♀ (des. Ricker 1938, 22:144). St. Martins Falls, Albany River, Ontario. Not examined.

Distribution: **CANADA – ON** (Ricker 1964, Harper and Ricker 1994).

Male. Not positively associated.

Female. Description of the lectotype ♀ as given by Ricker (1938):

"Length to tip of wings about 12mm (head

absent); mesothorax with brown marking on the yellow above; metathorax yellow below; the hind legs yellow with a narrow brown band at the tip of the femur, the first tarsal segment conspicuously brown, the second yellow; veins of wings much darker; abdomen yellow below, brown above. Eighth sternite very slightly produced, its border shallowly emarginated."

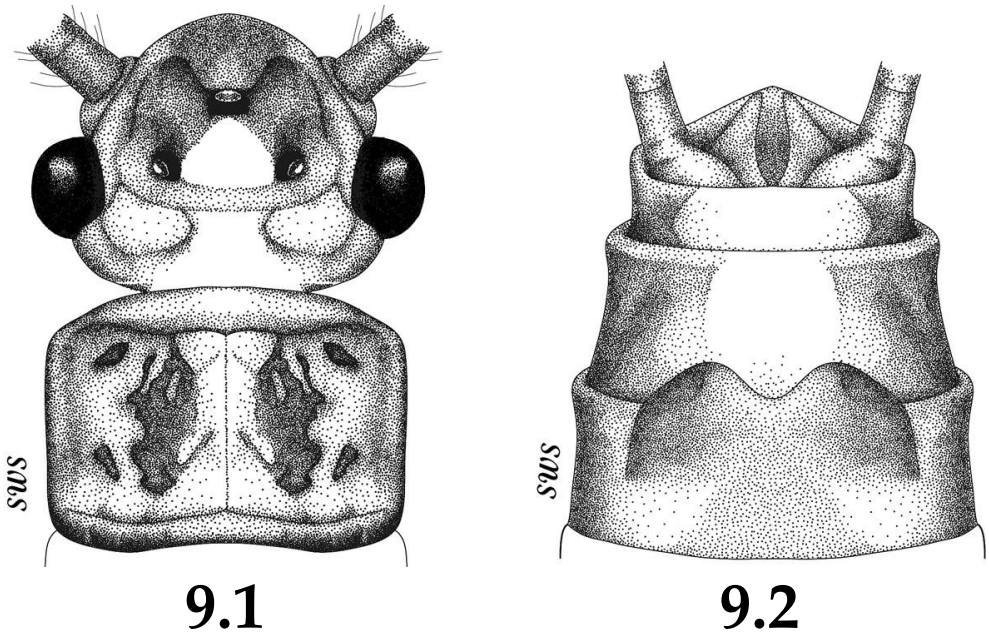
Ovum. Unknown.

Nymph. Unknown.

Diagnosis. The illustration by Ricker (1938) of the slightly produced subgenital plate of the lectotype female is most similar to that of *I. richardsoni*. Ricker (1938) additionally indicated that the male specimen "goes to *bilineata* Say in N. & C. key (p. 145), and to that species or *richardsoni* Frison in Frison's (1935: 434), but is not either of these." New material from the type locality will be required in order to clarify the status of this species. No material was available for study.

Ricker (1938) noted that Newport's type series included one male and one female. He designated the female as lectotype, but clearly had doubts about the association of the male with the female lectotype. Ricker stated "The differences in colour noted, particularly of the wings, suggest the possibility of incorrect association of the sexes; to meet this contingency, we designate the ♀ as lectotype, as being most likely to be recognized later…". Interestingly, Ricker (1964) and Harper and Ricker (1994) point out that George Barnston actually proposed the name *citronella*. Ricker (1964) classified *I. citronella* as "Rare and Unusual", and he mentions in this paper the existence of the original material and an apparent additional female from the Winisk River on the Hudson Bay coast.

Biological Notes. No information is available on the biology or life cycle of this species. Ricker (1944) noted that this species was a taxon known from the boreal forests of Ontario. Harper and Ricker (1994) indicated that *I. citronella* probably belongs to the "northwest element, the tundra region and adjacent transition to boreal forest." These authors also noted that *I. citronella* is the only endemic Ontario stonefly and listed two specimens, with a collection date of July 16. Ricker (1964) stated that the species name "citronella" represents the "curse of northern Canada" since citronella oil was pervasively used as a deterrent for black flies (Simuliidae), mosquitoes (Culicidae) and no-see-ums (Ceratopogonidae).



Figs. 9.1-9.2. *Isoperla conspicua*. 9.1. Dorsal head and pronotal pattern. 9.2. Female subgenital plate.

Isoperla conspicua Frison
Rare Stripetail
(Figs. 9.1-9.2)

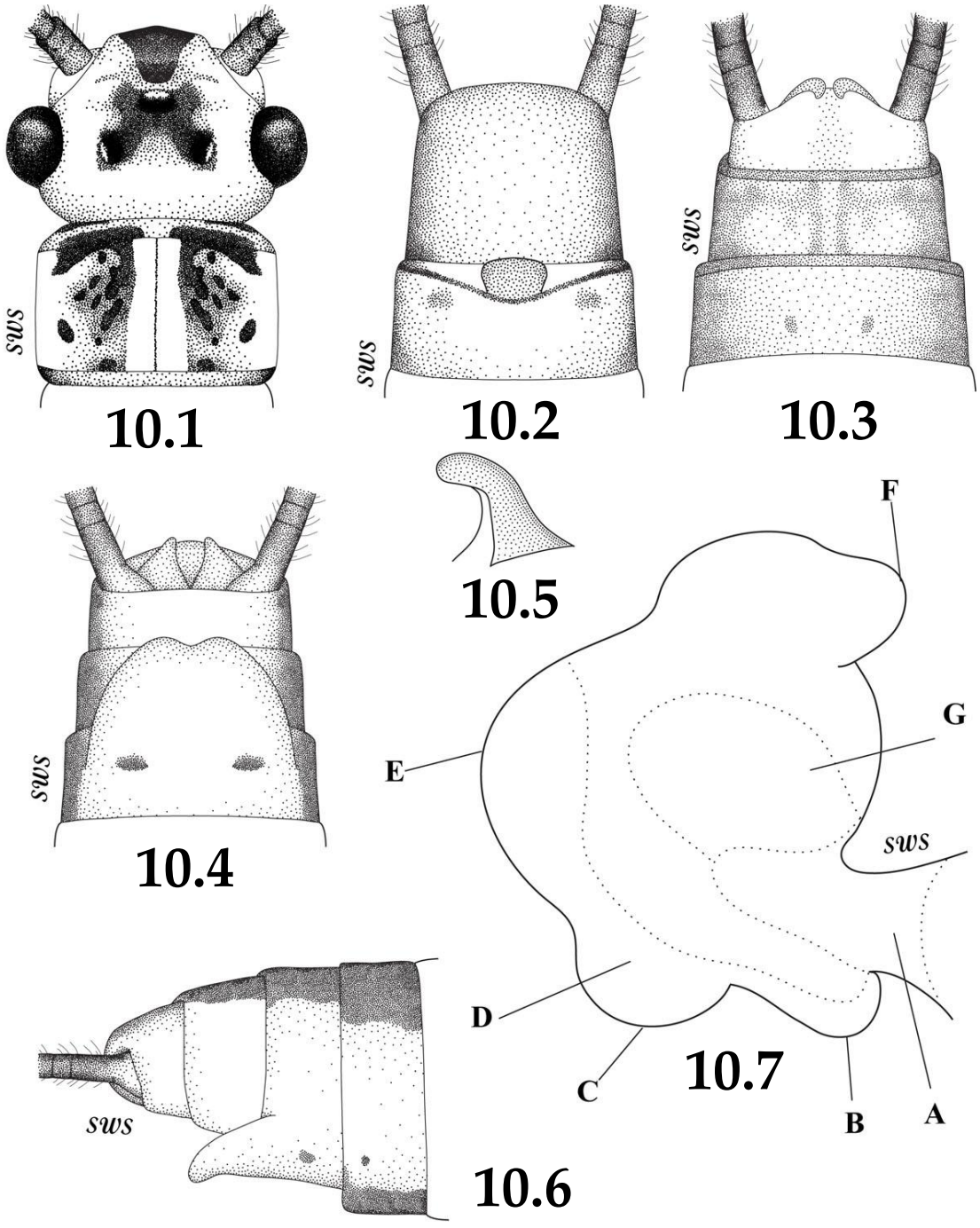
Isoperla conspicua Frison 1935, 20:445. Holotype ♀ (INHS), Rock Island (Rock Island Co.), Illinois. Examined.

Distribution: **USA – IL** (Frison 1935, DeWalt and Grubbs 2011, extinct).
Male. Unknown.
Female. Forewing length 10.1 mm. General body color pale brown with yellow and brown markings. Head pattern with broad medium brown bands extending anteriorly from median ocellus and posteriorly to lateral ocelli; small diffuse pale spot anterior to median ocellus; frons and clypeus medium brown; pale interocellar area enclosed posteriorly by a paler brown band; large rounded pale spots posterior to lateral ocelli extending to near base of compound eyes (Fig. 9.1). Pronotum with a median pale hour glass-shaped band, middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks pale yellow, anterior and posterior margins mostly pale yellow, lateral margins pale (Fig. 9.1). Antennae and legs brown. Meso- and metanota with broad pale areas. Abdomen paler than thorax. Posterior margin of tergia darker than anterior margins; three longitudinal bands and rows of small dark longitudinal spots faintly visible on terga 1-5. Cercal segments with distal margins darker than basal portion. Meso- and metathorax yellow brown with wide medium brown lateral bands. Sterna pale brown; sternum 8 with a broadly rounded subgenital plate deeply emarginate posteromedially, extending posteriorly over ⅓ length of sternum 9 (Fig. 9.2).
Ovum. Unknown.
Nymph. Unknown.
Diagnosis. The female subgenital plate of the single specimen known, the holotype, is more suggestive of the Perlodinae. An associated male is necessary to confirm this taxon as an *Isoperla* species. Additionally, no eggs were present in the holotype. Efforts to recollect this taxon at the type locality have been unsuccessful. DeWalt et al. (2005) considers the species to be extinct.
Biological Notes. The holotype was collected from the Mississippi River at Rock Island, Illinois in mid-May.

Isoperla cotta Ricker
Ontario Stripetail
(Figs. 1.3, 10.1-10.18)

Isoperla cotta Ricker 1952, 18:144. Holotype ♂ (INHS) Credit River, Terra Cotta, Ontario, Canada. Examined.

Distribution: **CANADA – NB** (Kondratieff and Baumann 1994), **NS** (Kondratieff and Baumann 1994), **ON** (Ricker 1952, Harper and Ricker 1994), **PQ** (Ricker 1952, Ricker et al. 1968); **USA – MI** (Ricker 1952, Grubbs and Bright 2001), **WI** (Hilsenhoff and Billmyer 1973), **WV** (Tarter and Nelson 2006).
New Records: **USA – ME**: Washington Co., Narraguagus River, Rte. 9, 2/VI/1998, B.C. Kondratieff, R.W. Baumann, 6♀ (CSUC). **NH**: Rockingham Co., Lamprey River, PC Farm site, jct. Hwy 43 & 107, V-12-2010, D.S. Chandler, 2♂, 1♀ (CSUC). Strafford Co., Packer's Falls, 13-20/V/?, D.S. Chandler, 1♂ (CSUC). **NY**: Clinton Co., Saranac River, main stem, Picketts Corners Road, 27/V/2006, L.W. Myers, 3♂, 3♀ (CSUC). Delaware Co., E Branch Delaware River, Rte. 28, SW Margaretville, 42.1242 N, 74.6726 W, 27/V/2009, B.C. Kondratieff, L.W. Myers, 2♂, 2♀ (CSUC). Franklin Co., South Branch Saramac River, Moore Pond Road, 28/V/2006, L.W. Myers, 2♂, 4♀ (CSUC). Hamilton Co., Sacandaga River, Hwy 30, Sacandaga Campground, 5/VI/1997, B.C. Kondratieff, R.W. Baumann, 1♂, 5♀ (CSUC); Oswego Co., N. B. Salmon River, CR 17, upstream Reservoir, 26/V/2009, L.W. Myers, B.C. Kondratieff, 1♂ (CSUC). Suffolk Co., headwaters, Connetquot River, Connetquot State Park, jct. Blue and Green Trails, N40.7863 W73.1685, 20/V/2008, B.C. Kondratieff, R.W. Baumann, L.W. Myers, 3♂ (reared) (CSUC). Warren Co., Hudson River, Rte. 28, North Creek, 30/V/2009, L.W. Myers, B.C. Kondratieff, 2♂, 7♀ (CSUC).
Male. Macropterous. Forewing length 8.9-9.5 mm. General body color pale yellow to nearly dusky white (sometimes with an olive green cast in fresh



Figs. 10.1-10.7. *Isoperla cotta*. 10.1. Dorsal head and pronotal pattern. 10.2. Male posterior abdominal sterna. 10.3. Male posterior abdominal terga. 10.4. Female subgenital plate. 10.5. Male paraproct lateral view. 10.6. Female subgenital plate lateral view. 10.7. Male aedeagus lateral view; a. patch of basal sharp stout spinulae, b. posteroventral paired lobes, c. single posteroventral lobe, d. patch of rows of fine hair-like spinulae, e. posteromesal lobe, f. anterodorsal lobe, g. large patch of dense short, blunt spinulae with apical hair-like projections.

material) with dark brown markings. Dorsum of head mostly pale yellow with broad dark brown to black bands connecting ocelli; interocellar area usually with a triangular pale spot (occasionally completely dark); frons with a broad dark brown or black inverted triangular spot separated from anterior ocellus by a thin pale band, widest anteriorly; posterior margin of head entirely pale or with a faint pale brown sinuous band (Fig. 10.1). Antennal scape medium brown, pedicel and flagellum segments dark brown, proximal segments paler. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities irregular, raised, dark brown, 2 medium irregular-shaped dark brown posterolateral spots; pronotal disks pale cream, anterior margin with dark brown bipartite bands, posterior margin light (Fig. 10.1). Meso- and metasterna with wide medium brown lateral patches, wide pale median band with large posteromedian medium brown patches; meso- and metanota mostly pale yellow with large median dark brown patches. Wings dusky, veins medium brown. Legs pale yellow with medium brown outer margins, tibia with thin horizontal medium brown band near proximal ½ on outer surface. Sterna pale brown, sternum 8 with a pale brown vesicle, ca. ½ as long as wide, posterior margin evenly rounded, expanded slightly over base and extending to near anterior margin of sternum 9 (Fig. 10.2). Terga pale brown, with median and lateral longitudinal medium brown bands and 3 lateral and 2 median medium brown spots on each tergum (sometimes faint in preserved material). Tergum 10 pale brown with a median depressed area and minute, bipartite posteromedian spinule patches (Fig. 10.3). Paraprocts lightly sclerotized, blunt apically, usually extending only to level of tergum 10 (Figs. 10.3, 10.5). Cerci medium brown. Aedeagus with a wide patch of sharp, stout spinulae on basal stalk (Figs. 10.7a, 10.8, 10.9, 10.10), paired posteroventral lobes (Figs. 10.7b, 10.11); single posteroventral lobe and posteromesal lobe with posterior patch composed of fine rows of hair-like spinulae and occasional elongate, stout sensilla basiconica (Figs. 10.7b, c, d, e, 10.11, 10.12); anterodorsal lobe (Fig. 10.7f), mesal section covered with dense concentration of short, blunt spinulae bearing single long apical hair-like projections (Figs. 10.7g, 10.13); double anterodorsal lobes and remainder of aedeagus without spinulae (Fig. 10.7f).

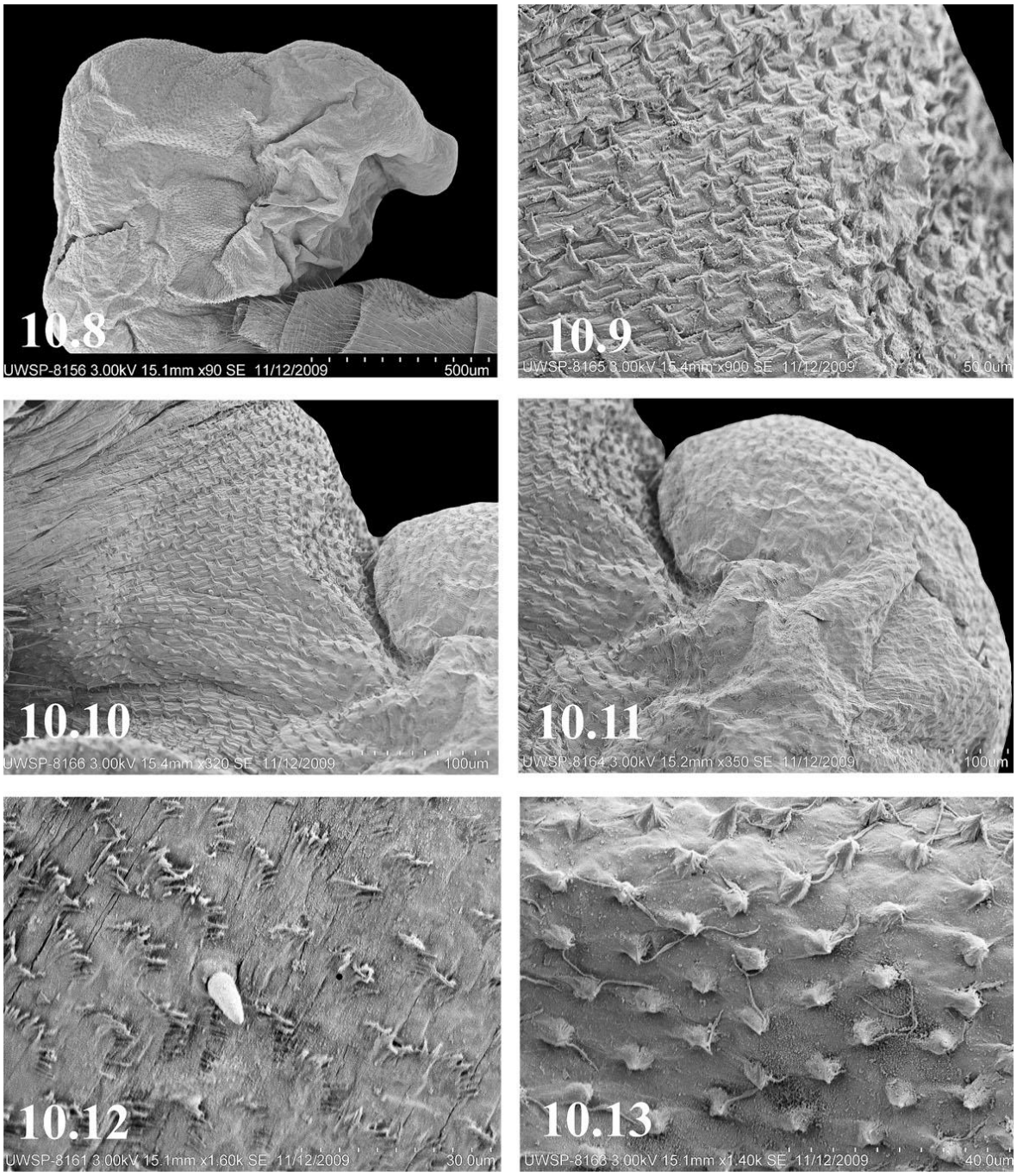
Female. Forewing length 9.8-10.6 mm. General body color and morphology similar to male described above. Eighth sternum with long, evenly rounded subgenital plate usually extending slightly over sternum 9, generally paler than preceding sterna; bipartite medium brown lateral spots near base; posterior margin with shallow median emargination, apical ¼ usually deflected ventrad (Figs. 10.4, 10.6).

Ovum. General shape oblong, cross section concave (Figs. 10.14, 10.15). Color pale brown. Length 262 μm; width 191 μm. Collar developed, low with raised longitudinal carinae (Figs. 10.16, 10.17), eclosion line absent. Hexagonal follicle cell impressions well developed, ridges thickened and elevated, floors flat with numerous small shallow punctations, micropyles set on top of follicle cell ridges singularly in a sinuous row near anterior ⅓ (Fig. 10.18).

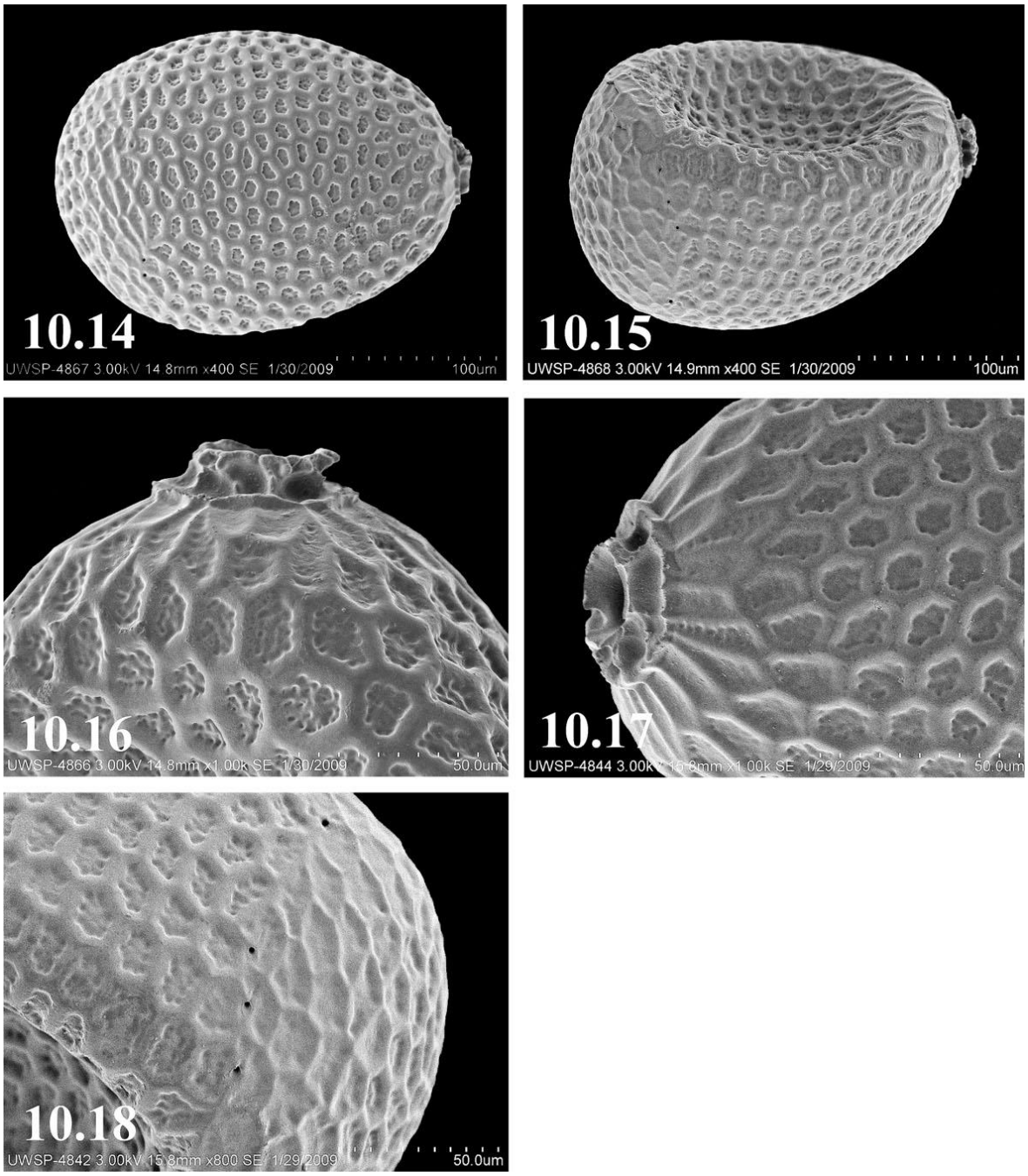
Nymph. Frison (1935) described the male and female nymph and illustrated the labrum, mandibles, maxillae and habitus. Hilsenhoff and Billmyer (1973) illustrated the lacinia and provided a key for separation from other Wisconsin *Isoperla* species. Stark et al. (1998) and Stewart and Stark (2002) provide a color photograph of the habitus.

Diagnosis. *Isoperla cotta* is a yellow brown species and live adults usually have an olive green cast (Stark et al. 1998). This species is included in the *I. burksi* group (Table 1). In general habitus adults are most similar to *I. holochlora*. These species are similar in size, have pale coloration with dark brown bands connecting ocelli and a large dark brown patch on the frons. Males of *I. cotta* can be separated from *I. holochlora* by the shape of the male paraprocts and shape and spinule patterns of the aedeagus (*I. holochlora* has sclerotized spine patches). Females of *I. cotta* can be distinguished from *I. holochlora* by the shorter evenly rounded and deflected subgenital plate. *Isoperla holochlora* has an elongate acutely triangular shaped subgenital plate. *Isoperla francesca* and *I. orata* are also similar sympatric species. However, these two

species can be distinguished from *I. cotta* by details of the male aedeagus. The eggs can be distinguished by the general shape, chorionic pattern and type of collar structure.



Figs. 10.8-10.13. *Isoperla cotta*. 10.8. Male aedeagus lateral view. 10.9. Detail of spinulae on aedeagal basal stalk. 10.10. Aedeagal basal stalk. 10.11. Aedeagal posteroventral lobe. 10.12. Detail of aedeagal sensillae basiconica. 10.13. Detail of spinulae on mesal section of aedeagus.



Figs. 10.14-10.18. *Isoperla cotta*. 10.14. Egg. 10.15. Egg showing concave profile. 10.16. Egg collar. 10.17. Egg collar lateral view. 10.18. Detail of egg micropyles.

Biological Notes. Harper (1973) found that *I. cotta* had a simple univoltine life cycle in southern Ontario. Ova required an incubation period of 47 days in the laboratory under simulated stream temperatures and hatching was synchronous. Growth was slow and continuous until emergence

in mid-May. Harper and Ricker (1994) included *I. cotta* in their "Great Lakes-St. Lawrence" grouping in their study of Ontario stoneflies and indicated that this species was often collected in soft water streams. Hilsenhoff and Bilmyer (1973) reported that *I.* cotta was found in small to medium size streams in Wisconsin and Stark et al. (1998) stated that it was uncommon in high quality trout streams throughout its range. Emergence generally occurs from mid-May to early July with the main emergence period typically occurring during early to mid-June.

Ziminske (1989) found that the male call was a simple monophasic signal with a mean of 9.5 (± 5.9, range 3-25) drum beats and a mean beat interval of 91.3 (± 19.6) ms. *Isoperla cotta* females did not answer *I. cotta* male calls or male calls from four other Wisconsin *Isoperla* species. He found significant differences ($p < 0.05$) in mean number of beats, beat interval and total signal length between populations in North Fish and Ripley Creeks, Wisconsin.

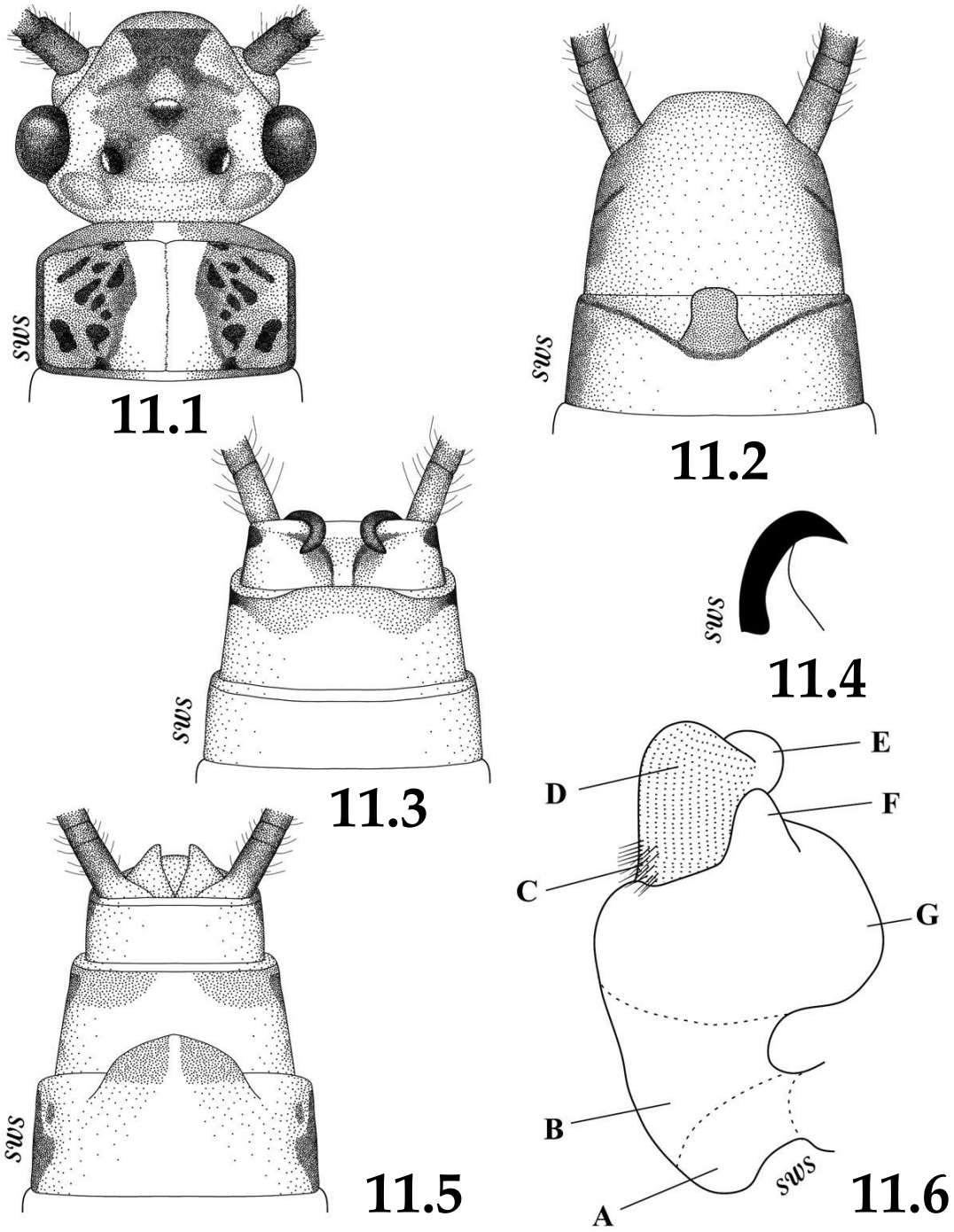
Isoperla davisi James
Alabama Stripetail
(Figs. 11.1-11.16)

Isoperla davisi James 1974, 67:966. Holotype ♂ (INHS) Saugahatchee Creek, (Tallapoosa Co.), Alabama. Examined.
Isoperla coushatta Szczytko and Stewart 1976, 36:211. Holotype ♂ (INHS) Saddler Creek (Anderson Co.), Texas. **New synonym**. Examined.
Isoperla coushatta: Szczytko and Stewart, 1977, 103:358.
Isoperla coushatta: Poulton and Stewart, 1991, 38:47.

Distribution: **USA** – **AL** (James 1974, Grubbs 2011), **AR** (Poulton and Stewart 1991), **DE** (Lake 1980), **FL** (Pescador et al. 2000), **LA** (Stewart et al. 1976), **MS** (Stark 1979), **NC** (Kondratieff et al. 1995), **OK** (Stark et al. 1986), **TX** (Szczytko and Stewart 1976, Szczytko and Stewart 1977), **VA** (Kondratieff and Kirchner 1987).

New Records: **USA** **–MO**: Bulter Co., Lake Wappapello campground, Poplar Bluff, 17/V/1958, O.S. Flint, Jr., 164♂, 59♀ (USNM); **SC:** Aiken Co., Mill Creek, @SRP E2, Savannah River Plant, 12/IV/1977, Herlong, Prichard, 1♂, 1♀ (BPSC). Barnwell Co., Myers Branch, SREL, boardwalk nr. confluence Steel Creek, 24/III/1984, B.C. Kondratieff, 1♂, 1♀ (CSUC); Steel Creek, 750 m upstream SRP Road A, 12/III/1984, B.C. Kondratieff, 1♂, 4♀ (CSUC). Florence Co., Lynches River, Lynches River, County Park, off Ben Gause rd., 4/V/2012, B.C. Kondratieff, D. Leatherman, 1♀ (CSUC).

Additional Records: **USA** – **AL:** Choctaw Co., Bogueloosa Creek, near Toxey, 24/IV/1984, S. Harris, McHee, 1♂ (BPSC); Spring Creek, Hwy 17, 4 mi S. of Butler, 24/IV/1984, S. Harris, McHee, 1♂ (BPSC). Clark Co., Fishers Creek, Whatley, 8/V/1986, S. Harris, P. O'Neil, 22♂, 3♀ (BPSC). DeKalb Co., South Sauty Creek, Rte. 35, 5 km NW Rainsville, 7/5/2008, S.A. Grubbs, 4♂, 16♀ (SAGC). **FL:** Alachua Co., Blues Creek, NW Gainesville, 20/III/1997, A.K. Rasmussen, 2♂, 1♀ (FAMU). Gadsen Co., Rocky Comfort Creek, 2nd bridge, Hwy 65-B, 6 mi S. of Hwy 268, 27/III/1975, J. Jones, J. Archer, D. Barnhart, R. Tyson, 3♂ (FAMU). Jefferson Co., unnamed stream, @NFREC-Monticello, Hwy 90, 4 km W. Monticello, 4/IV/1998, A.K. Rasmussen, 3♂, 4♀ (FAMU). **LA:** Orleans Parish, New Orleans, 19/V/1951, J.H., 1♂ (INHS). **MS:** Franklin Co., trib. Richardson Creek, 5N2E Sec 2, 24/IV/1992, C. Hardy, 2♂ (BPSC); Richardson Creek, 5N2E Sec 2, 24/IV/1993, C. Hardy, 1♂ (BPSC); Richardson Creek, Homochitto National Forest, 8/IV/1991, B.P. Stark, 3♂ (BPSC); Moore Branch, 6N3E Sec 1, 22/IV/1993, C. Hardy, 1♂, 1♀ (BPSC); Porter Creek, 5N4E Sec 22, 13/IV/1993, C. Hardy, 3♂ (BPSC); trib. Sawhaw Branch, 6N3E Sec. 2, 19/IV/1993, C. Hardy, 3♀ (BPSC); Tallys Creek, Homochitto National Forest, 6/IV/1991, B.P. Stark, 1♂, 1♀ (BPSC); Same location, 29/IV/1991, B.P. Stark, 1♀ (BPSC); trib. Porter Creek, 5N4E Sec 21, 13/IV/1993, C. Hardy, C. Boll, 1♂ (BPSC). Newton Co., Chunky River, Good Hope, 30/III/1988, B. Taylor, 3♀ (BPSC). Simpson Co., Bush Creek, Hwy 472, 13/V/1991, B.P. Stark, 2♂ (BPSC); Mill Creek, Hwy 472, 17/III/1988, B.P. Stark, 1♂, 1♀ (BPSC); Tanyard Creek, Hwy 28, 13/IV/1991, B.P. Stark 5♂, 2♀ (BPSC); Westville Creek, below jct. Hale Branch, 13/IV/1991, B.P. Stark, 5♀ (BPSC). **NC**: Chatham Co., Terrell Creek,

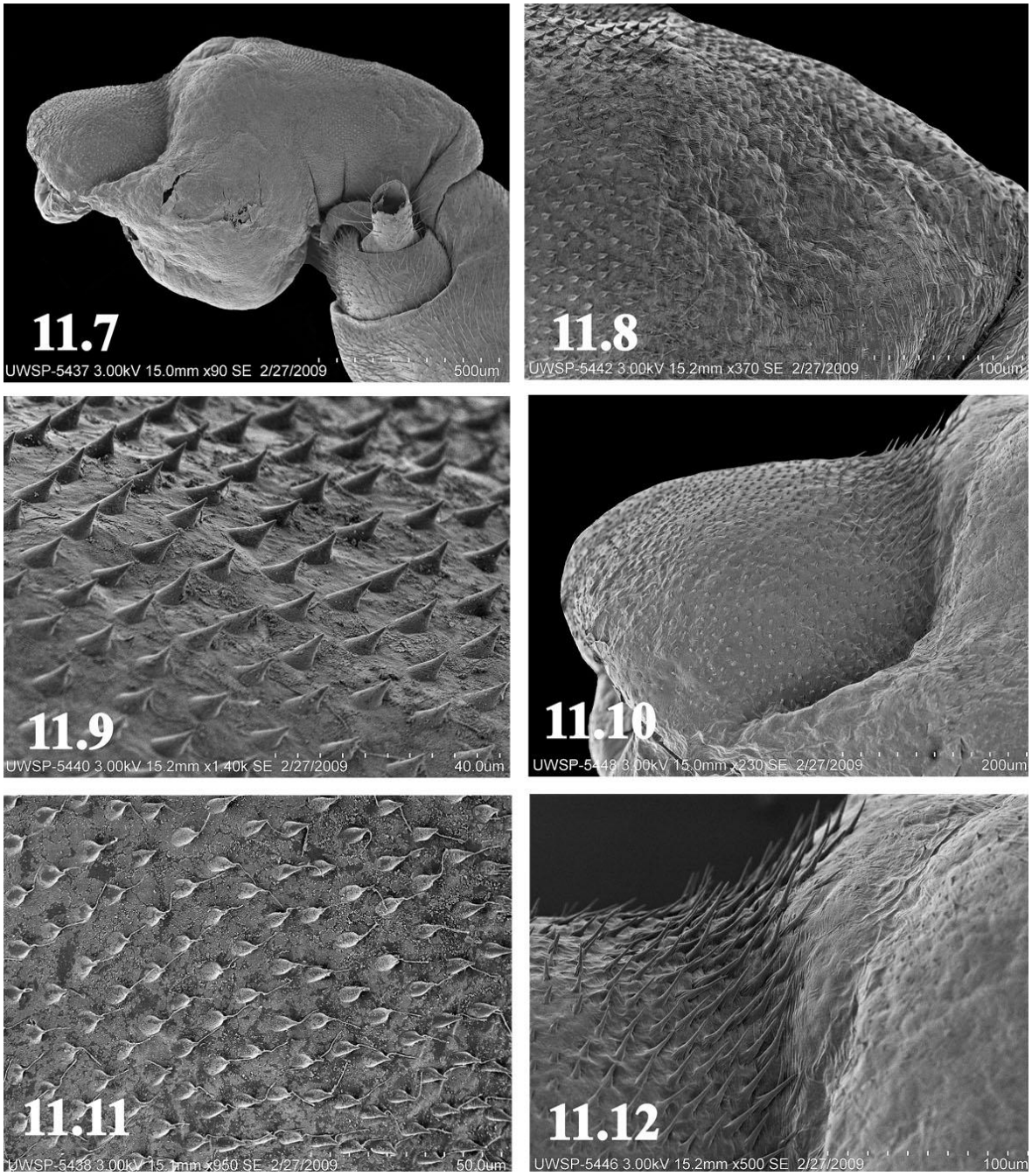


Figs. 11.1-11.6. *Isoperla davisi*. 11.1. Dorsal head and pronotal pattern. 11.2. Male posterior abdominal sterna. 11.3. Male posterior abdominal terga. 11.4. Male paraproct lateral view. 11.5. Female subgenital plate. 11.6. Male aedeagus lateral view; a. basal band of fine rows of hair-like spinulae, b. wide mesal band of concentrated short stout, sharp spinulae, c. elongate sharp spinulae, d. cone shaped dorsal lobe covered with short stout spinulae, e. anterior flat lip-like lobe of dorsal cone shaped lobe, f. paired dorsal elongate lobe void of spinulae, g. anteromesal lobe void of spinulae.

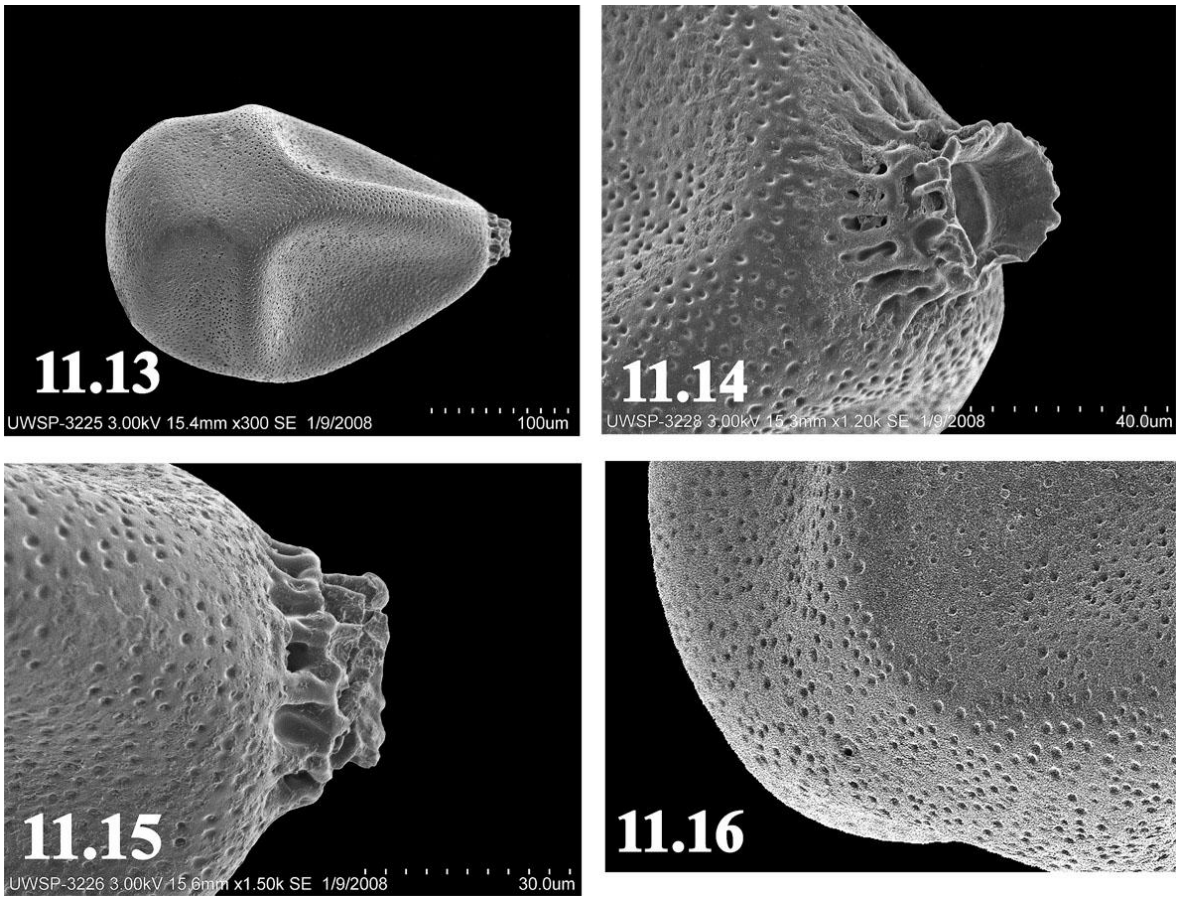
@ NC 87, 30/III/2012, S. Beaty, V. Holland, M. Walters, 2♀, 2 exuviae (CSUC). Edgecombe Co., Swift Creek, W Logsboro rd., NW Tarboro, 18/V/2004, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat, 2♀ (CSUC); Fishing Creek, Marbrey Rd. N of Tarboro, 5/V/2005, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat, 3♂, 4♀ (CSUC). Robeson Co., Lumber River, Chicken bridge, 2mi SE Pembroke, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 1♂ (CSUC). Halifax Co., trib. Bear Swamp, Hwy 561, NW of Enfield, 38.28039 N 77.87800 W, 15/V/2010, B.C. Kondratieff, R.E. Zullig, D.R. Lenat, R.F. Kirchner, 2♂, 1♀ (CSUC). Hoke/Moore Co.'s., Little River, Morrison Bridge rd., SE of Southern Pines, 4/V/2005, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat & R.E. Zuellig, 4♀ (CSUC). Wilkes Co., Huntington Creek, Hwy 115, NW of Elkville, 2/V/2005, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat, 2♀ (CSUC). **VA:** Greenville/Sussex Co. line, Nottaway River, Nottaway rd., CR 651, N. of Emporia, 5/V/2005, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, 1♂ (CSUC). Henrico Co., Chickahominy River, ca. 4 km upstream Bottoms Bridge, 7/V/1999, I.T. Wilson, 3♂, 2♀ (BPSC). Middlesex Co., Dragon Run, CR 603 East Mascot, 22/V/2002, B.C. Kondratieff, R.F. Kirchner, 1♂ (CSUC). Sussex Co., 6 mi SE Sussex, Chub Sandhills, 21/V/1996, S.M. Roble, R.L. Hoffman, 14♂, 3♀ (CSUC).

Male. Macropterous. Forewing length 7.5-8.7 mm. General body color pale brown with dark brown markings. Dorsum of head with broad dark brown bands connecting ocelli; interocellar area usually with pale spot generally enclosed (occasionally opened) posteriorly by wide pale brown bands; medium brown bands extend laterally from anterior ocellus to near antennal bases; small pale spot located anterior to median ocellus; large rectangular dark patch on frons widest at anterior margin, hind margin usually with large demarked pale brown patches with paler centers occur posteromedially from each eye (Fig. 11.1). Antennal pedicel pale brown, scape medium brown, flagellum medium to dark brown. Pronotum with wide hour glass shaped median pale stripe, middorsal pronotal suture a thin brown line; rugosities irregular, raised, dark brown; pronotal disks medium brown, anterior and posterior margins with medium brown bipartite bands (Fig. 11.1). Meso- and metasterna uniformly pale yellow; meso- and metanota mostly medium brown with broad U-shaped median pale brown bands. Wings dusky, veins dark brown. Legs pale brown, femur with a continuous dorsal medium brown band, tibia with a large horizontal medium brown band on proximal ⅓ on outer surface. Sterna pale yellow, sternum 8 with a pale brown vesicle, ca. as long as wide at base, posterior margin evenly rounded, ca. ⅔ as wide as base and extending slightly over anterior margin of sternum 9 (Fig. 11.2). Terga pale yellow, usually with a median medium brown band on segments 1-9 and 3 lateral and 2 median medium brown spots on terga 1-9 (sometimes faint in preserved material); tergum 9 with posterior band of small spinulae, posterolateral corners with thin medial brown bands; tergum 10 usually pale (occasionally with medium brown bipartite median patches); median area strongly depressed and pale; posterolateral corners with small medium brown spot (Fig. 11.3). Paraprocts heavily sclerotized, extending over ⅓ length of tergum 10, sharply pointed apically, distinctly curved outward near ½ of their length (Fig. 11.3). Cerci medium to dark brown. Aedeagus with ventral band of fine rows of hair-like spinulae near base (Figs. 11.6a, 11.8) and wide mesal band of concentrated short, stout sharp spinulae (Figs. 11.6b, 11.7, 11.9); large cone-shaped dorsal lobe covered with short stout spinulae with elongate hair-like tips (Figs. 11.6d, 11.7, 11.10, 11.11); posterior base of lobe with concentrated patch of elongate sharp spinulae (Figs. 11.6c, 11.7, 11.10, 11.12); anterior margin of lobe extended into a flat lip-like lobe devoid of spinulae (Figs. 11.6e, 11.7); paired dorsally elongated lobes devoid of spinulae near anterior base of large cone-shaped lobe (Figs. 11.6f, 11.7); large anteromesal lobe devoid of spinulae (Figs. 11.6g, 11.7).

Female. Forewing length 9.0-9.5 mm. General body color and morphology similar to male described above. Eighth sternum with broadly triangular subgenital plate extending ca. ⅓ distance over sternum 10, posterior margin with distinct bipartite



Figs. 11.7-11.12. *Isoperla davisi*. 11.7. Male aedeagus lateral view. 11.8. Detail of basal aedeagal spinulae. 11.9. Detail of spinulae on aedeagal basal stalk. 11.10. Cone shaped dorsal aedeagal lobe. 11.11. Detail of spinulae on cone shaped dorsal aedeagal lobe. 11.12. Detail of posterior spinulae at base of cone shaped dorsal aedeagal lobe.



Figs. 11.13-11.16. *Isoperla davisi*. 11.13. Egg. 11.14. Egg collar. 11.15. Egg collar. 11.16. Egg micropyle.

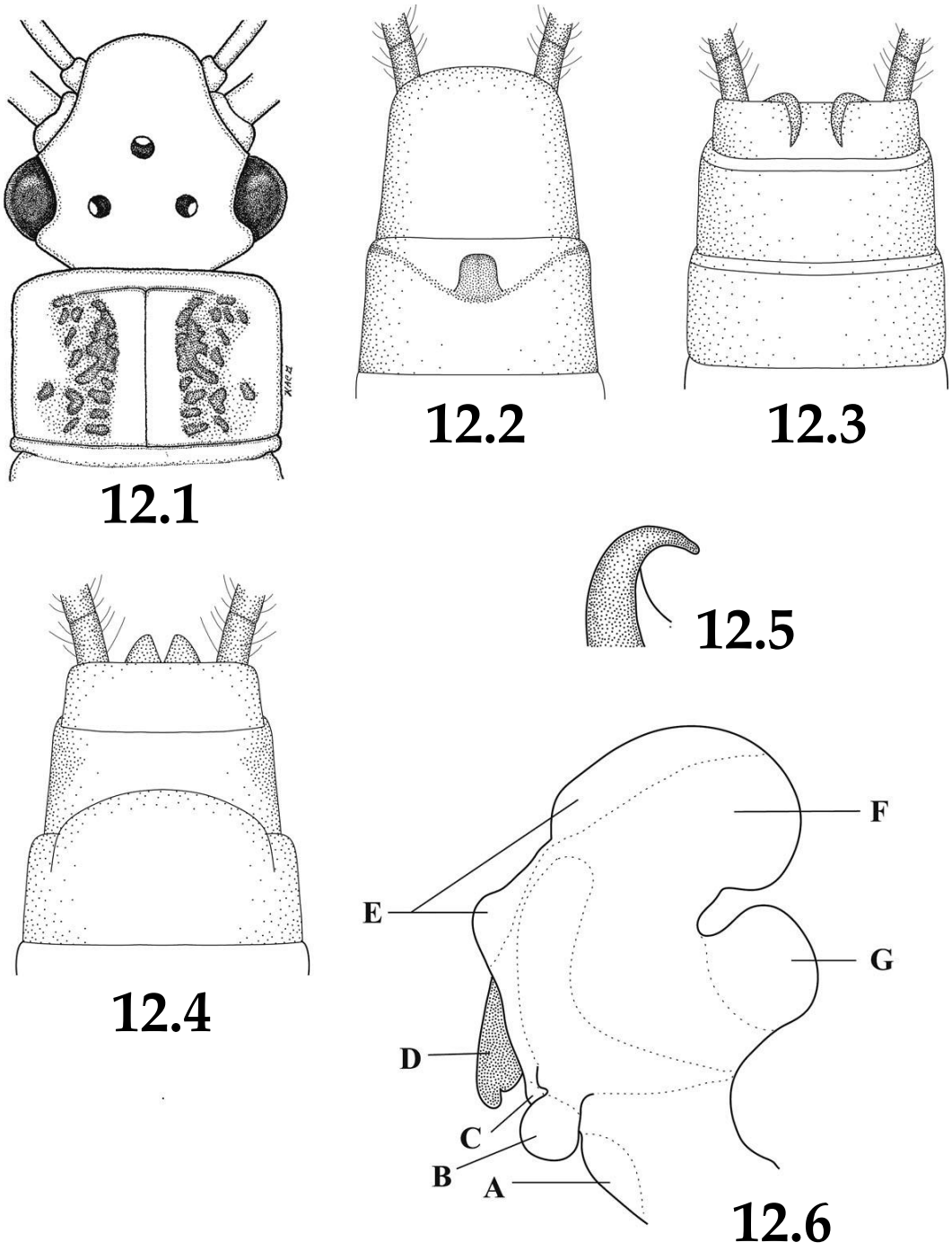
medium brown triangular patches divided medially by a pale band (Fig. 11.5).

Ovum. General shape oblong with cross-shaped ridges, cross section triangular (Fig. 11.13). Color pale brown. Length 298 µm; width 205 µm. Collar developed, elevated, base offset with thickened longitudinal ridges, apical section elongate with raised longitudinal carinae (Figs. 11.13-11.15). Hexagonal follicle cell impressions not visible, chorionic surface covered with small shallow punctations, eclosion line absent, micropyles flush with chorionic surface, arranged singularly below wide horizontal ridge near anterior ⅓ of egg (Figs. 11.13, 11.16).

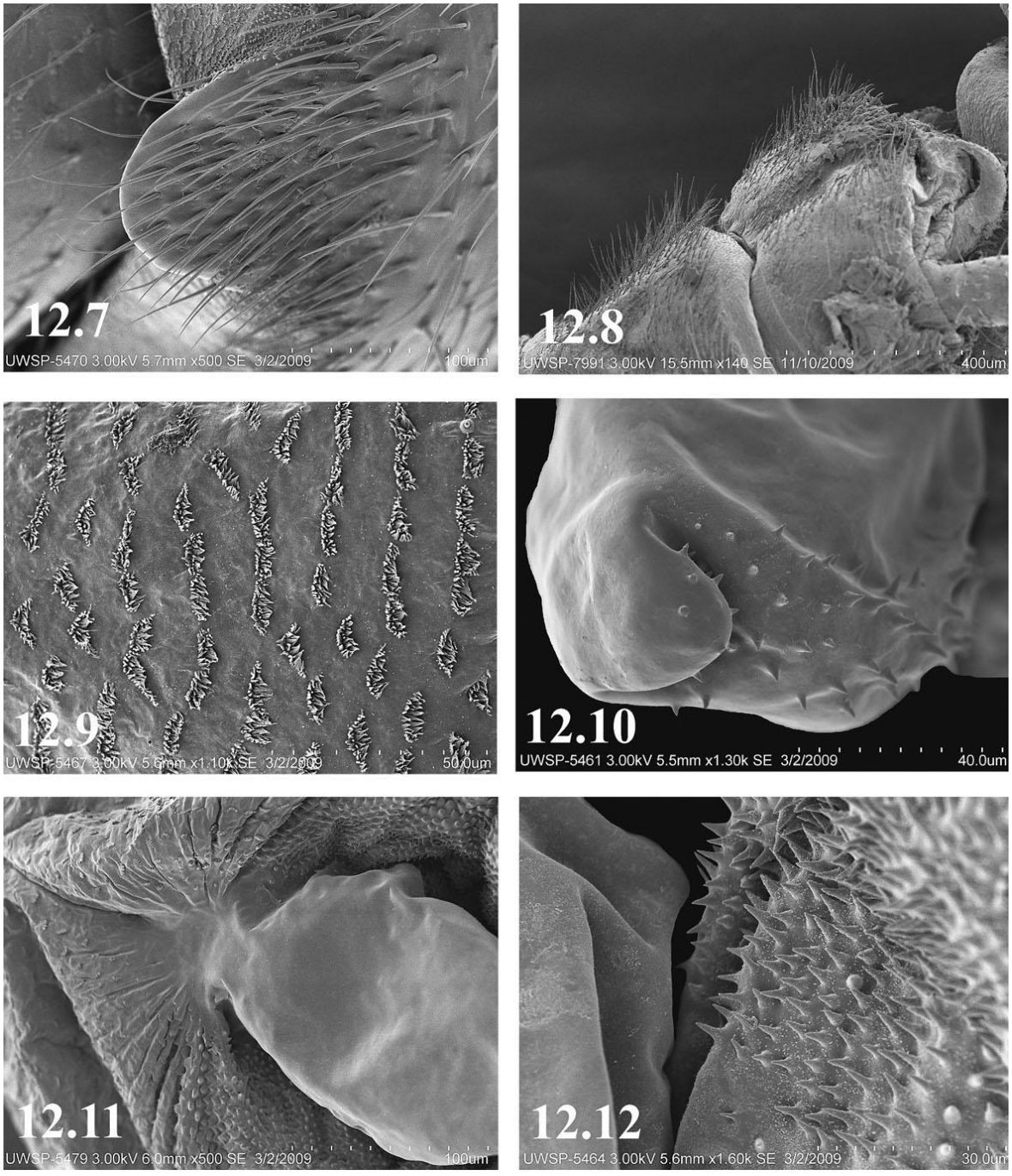
Nymph. Szczytko and Stewart (1976) and Poulton and Stewart (1991) described and illustrated the nymph as *I. coushatta*.

Diagnosis. This member of the *I. decolorata* group (Table 1) is a common medium size brown species. The most distinctive feature in the male is the heavily sclerotized, long, acutely outcurved paraprocts and in the female, the dark brown triangular posterior patches on the subgenital plate. The head pattern of *I. davisi* is similar to *I. irregularis* and *I. namata* but the large pale brown patches posteromedially to each compound eye are distinctive for this species. *Isoperla davisi* has a broad geographical distribution from Texas and Oklahoma through the Gulf Coastal Plains to Florida and northward along the Atlantic Coastal Plain to Delaware. Examination of the types of *I. davisi* and *I. coushatta* revealed the above synonymy.

Biological Notes. Poulton and Stewart (1991)



Figs. 12.1-12.6. *Isoperla decepta*. 12.1. Dorsal head and pronotal pattern. 12.2. Male posterior abdominal sterna. 12.3. Male posterior abdominal terga. 12.4. Female subgenital plate. 12.5. Male paraproct lateral view. 12.6. Male aedeagus lateral view; a. patch of long hair-like spinulae, b. paired posterobasal lobe, c. concentrated patch of stout sharp spinulae, d. sclerotized posteromesal blade –like structure, e. posteromesal lobe, f. anteriorly directed dorsal lobe, g. anteromesal lobe.



Figs. 12.7-12.12. *Isoperla decepta*. 12.7. Male vesicle. 12.8. Male 9th and 10th terga. 12.9. Rows of stout hair-like spinulae on posteromesal aedeagal lobe. 12.10. Apical tip of sclerotized aedeagal blade-like structure. 12.11. Striated fingers at base of sclerotized aedeagal blade-like structure. 12.12. Ventrobasal spinulae below sclerotized aedeagal blade-like structure.

collected this species in clean streams with sand and gravel substrates and indicated that it was restricted to Gulf Coastal Plain streams and Crowley's Ridge in their study. The nymph of *I. davisi* apparently prefers shifting sand streams with woody debris snags and leaf packs, and is often common in remnant "black water" streams of the southeastern Coastal Plain. Emergence generally occurs from late March to early June throughout its range. There is essentially no information on the biology of this species.

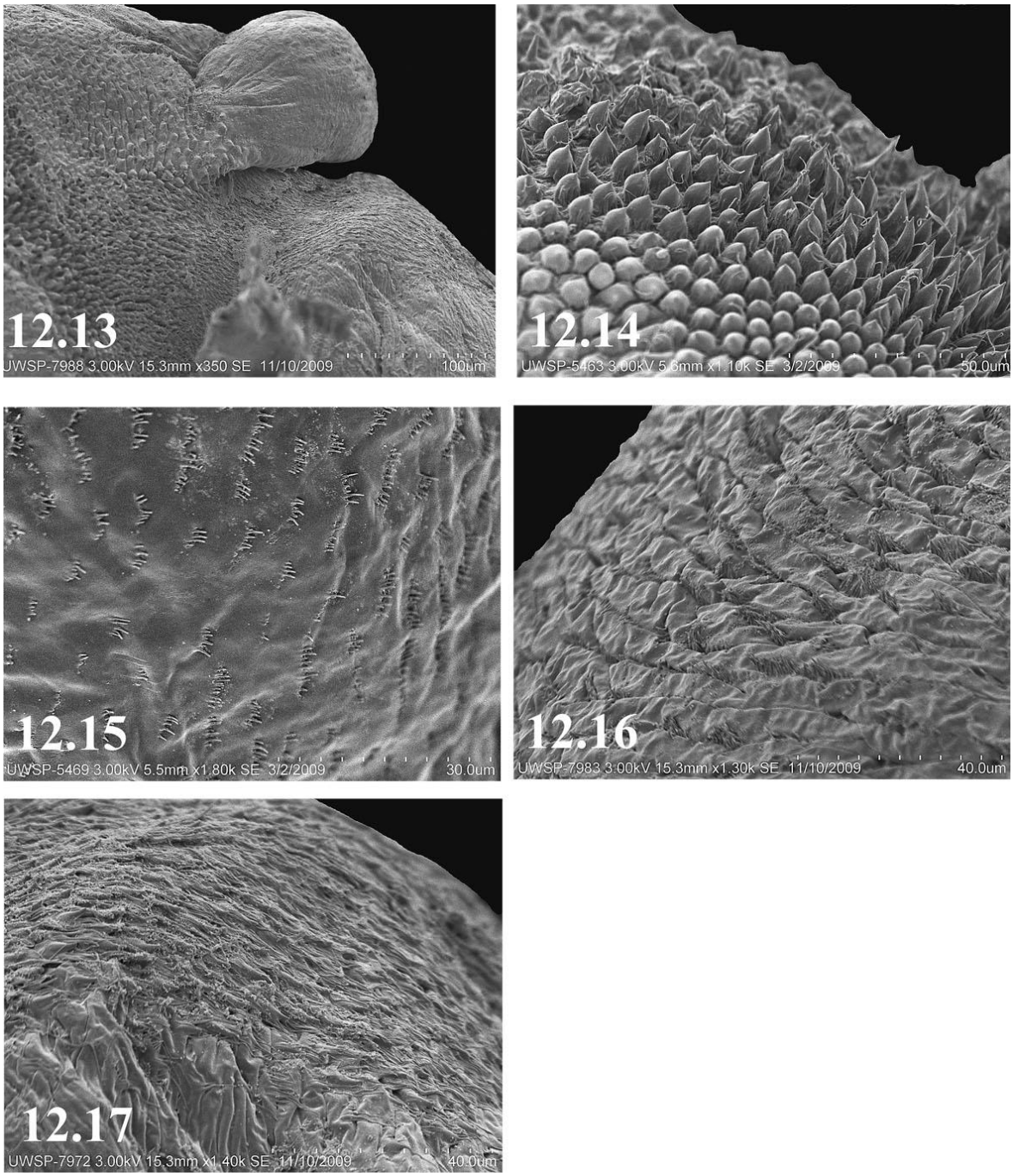
Isoperla decepta Frison
Yellow Stripetail
(Figs. 12.1-12.19)

Isoperla decepta Frison 1935, 20:447. Holotype ♂ (INHS) New Columbia (Massac Co.), Illinois. Examined.
Isoperla decepta: Poulton and Stewart, 1991, 38:47.

Distribution: USA – **AL** (Grubbs 2011), **IL** (Frison 1935, DeWalt and Grubbs 2011), **IN** (Grubbs 2004, Ricker 1945, DeWalt and Grubbs 2011), **KY** (Tarter et al. 2006, **MO** (Poulton and Stewart 1991), **OH** (Gaufin 1956), **ON** (Harper and Ricker 1994).

Material Examined: USA – **AL:** Clark Co., Fishers Creek, nr. Whatley, 8/V/1986, S. Harris, P. O'Neil, 44♂, 11♀ (BPSC). Cleburne Co., Shoal Creek, Shoal Creek Campground, 25/V/1984, S. Harris & P. Lago, 4♂, 2♀ (BPSC). Jackson Co., trib. Larkin Fork, Paint Rock River, Rte. 63, 1km SE Francisco, 27/IV/2008 S.A. Grubbs, 1♂, 2♀ exuviae (SAGC). Lauderdale Co., Anderson Creek, 6 km NE. of Rogersville, 21/IV/2002, S.A. Grubbs, 1♂, 6♀ (SAGC). Limestone Co., Cairo Branch Elk River, 16 km NE Rogersville, 21/IV/2002, S.A. Grubbs, D.E. King, 3♂, 5♀ (SAGC). Tallapoosa Co., Josie Leg Creek, off Hwy 22, 19/VI/1983, S. Harris, P. Lago, 1♂ (BPSC); Same locality, 19/V/1984, 1♀ (BPSC). **IL:** Alexander Co., Cooper Creek, 3 km WSW Mill Creek, 19 April 1993, M.A. Harris, D.W. Webb, 2♂, 2♀ (INHS). **KY:** Adair Co., Sulphur Creek, 6 km ENE of Columbia, 27/IV/2002, S.A. Grubbs, 1♂, 1♀ (SAGC); trib. Casey Creek, Rte. 551, 16 km S. of Campbellsville, 27/IV/2002, S.A. Grubbs, 1♂, 1♀ (SAGC). Edmonson Co., Cub Creek, KY 70, E. Roundhill, 11/V/2000, B.C. Kondratieff, R.F. Kirchner, 2♂, 6♀ (CSUC). Grayson Co., Bennett Fork, Caney Creek, immediately upstream of Caneyville Reservoir, 2 km W. of Caneyville, 20/IV/2000 S.A. Grubbs, 3♂, 4♀ (SAGC). Warren Co., Saltlick Creek, US 231, 8 km W of Bowling Green, 28/IV/2000, S.A. Grubbs, 1♂, 1 N (SAGC); Beltcher Creek, 4 km SE of Hadley, 19/IV/2004, S.A. Grubbs, 2♂, 3♀ (SAGC). **MO:** Webster Co., Finley Creek, Hwy K, S Seymont, 17 March 2004, B.C. Kondratieff, R.E. Zuellig, 4♂, 4♀ (reared) (CSUC). Moniteau Co., trib. N Moreau Creek, Hwy E., 3 mi. S. Clarksburg, B.C. Poulton, 5♂, 3♀ (reared), 23 N (BPSC). **OH:** Franklin Co., Sharon Woods, 30/V/1958, A.R. Gaufin, 4♂, 2♀ (BYUC). Seneca Co., Venice, Indian Creek 5/V/1953, A.R. Gaufin, 2♀, 24 N (BYUC). **TN:** Sumner Co., trib. Little Trammel Creek, Turners Station, 11/V/2000, B.C. Kondratieff, R.F. Kirchner, 1♂, 5♀ (CSUC); trib. Little Trammel Creek N Turners Station nr. jct. TN 174 & Old Hwy 31, 11/V/2000, B.C. Kondratieff, R.F. Kirchner, 1♂, 2♀ (CSUC). Trousdale Co., trib. Second Creek, Crenshaw rd., 9/IV/1994, B.C. Kondratieff, R.F. Kirchner, 12♂, 5♀, 7 N (CSUC).
New Records: USA –**MI:** Emmet Co., Maple River, 6/VI/1948, A.R. Gaufin, 2♀ (BYUC).

Male. Macropterous. Forewing length 7.3-9.3 mm. General body color almost entirely pale yellow in life with few pale brown markings. Dorsum of head usually entirely pale yellow, occasionally with faint, thin, incomplete pale brown bands connecting ocelli (Fig. 12.1). Antennal scape, pedicel and flagellum segments 1-8 pale yellow, flagellum after segment 8 pale brown. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities irregular, raised, medium to pale brown, pronotal disks pale yellow, anterior and posterior margins pale yellow (Fig. 12.1). Meso- and metanota mostly pale yellow with faint, irregular pale brown markings. Wings hyaline with pale brown veins. Legs and sterna pale yellow; tibia with a thin brown vertical band near proximal ⅓; tarsi pale brown on dorsum, yellow ventrally. Sternum 8 with a pale brown vesicle, ca. 1.25X long as wide, posterior end not expanded; lateral margins nearly straight, expanded slightly at base, extending to near



Figs. 12.13-12.7. *Isoperla decepta*. 12.13. Posteromesal aedeagal lobe. 12.14. Spinulae at base of posteromesal lobe. 12.15. Rows of hair-like spinulae on anteromesal aedeagal lobe. 12.16. Ridges on anteromesal aedeagal lobe. 12.17. Patch of long hair-like spinulae below paired posterobasal aedeagal lobes.

anterior margin of sternum 9; ventral surface covered with very long stout setae (Figs. 12.2, 12.7). Terga pale yellow, with dense patch of stout long setae (Figs. 12.3, 12.8). Paraprocts lightly

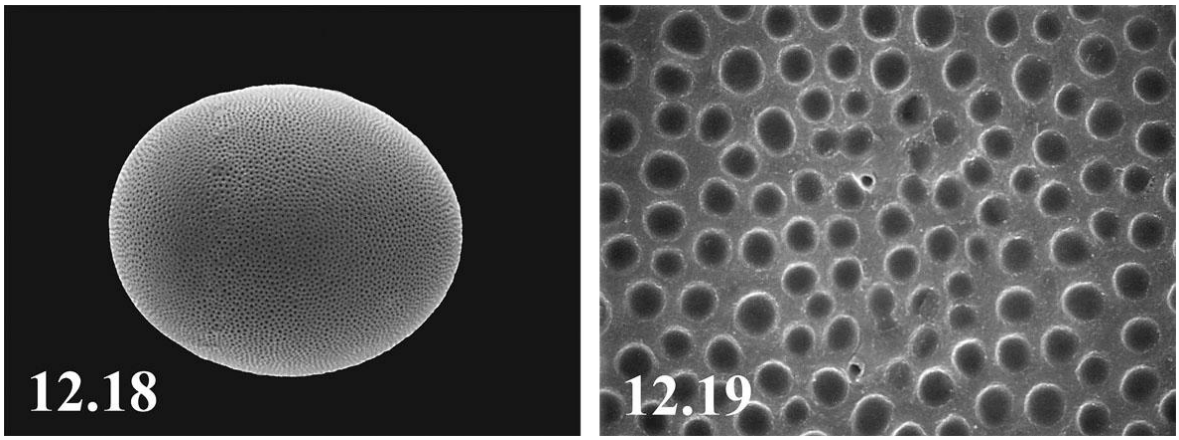
sclerotized, elongate, sharply pointed apically, extending over ca. ¼-½ length of tergum 10 (Figs. 12.3, 12.5). Cerci pale yellow proximally, pale brown apically. Aedeagus with large, round anteriorly directed dorsal lobe (Fig. 12.6f) and smaller anteromesal lobe (Fig. 12.6g); posteromesal lobe with heavy rows of stout hair like spinulae (Figs. 12.6e, 12.9); elongate sclerotized blade-like structure with apical tip deflected ventrally below posteromesal lobe, apical margin and margin below deflected tip with scattered concentrations of stout sharp spinulae (Figs. 12.6d, 12.10); dorsobasal area of sclerotized blade with a series of membranous striated fingers with scattered fine spinulae (Fig. 12.11); ventrobasal area below sclerotized blade with heavy concentration of stout, sharp spinulae (Figs. 12.6c, 12.12); paired, rounded posterobasal lobes constricted basally (Fig. 12.6b) below posteromesal lobe, apical ¾ without spinulae, basal ¼ with scattered short stout spinulae which grade into a heavy patch of longer stout blunt spinulae extending dorsally up to base of posteromesal lobe and ventrally to near ventral base of anteromesal lobe (Figs. 12.13, 12.14); anteromesal lobe with membranous ridges and rows of fine-hair like spinulae (Figs. 12.15, 12.16); patch of long hair-like spinulae below paired posterobasal lobes (Figs. 12.6a, 12.17).

Female. Forewing length 8.6-10.5 mm. General body color and morphology similar to male described above. Subgenital plate broadly rounded, produced posteriorly over ca. ¼ length of sternum 9 (Fig. 12.4).

Ovum. General shape oblong, cross section circular (Fig. 12.18). Color pale brown. Length 345 µm; width 260 µm. Collar and eclosion line absent (Fig. 12.18); hexagonal follicle cell impressions faintly visible, ridges thickened and elevated, floors with small shallow pits, micropyles on top of FCI ridges singularly or in pairs near anterior ⅓ adjacent to eclosion line (Figs. 12.18, 12.19).

Nymph. Mouthparts and habitus illustrated by Frison (1935) and Poulton and Stewart (1991) illustrated the head color pattern, lacinia and partial terga.

Diagnosis. *Isoperla decepta* is assigned to the *I. irregularis* group (Table 1). The affinities of these species are supported by an oblong egg with no collar, reduced hexagonal follicle cell impressions, a nymphal lacinia with reduced or absent subapical tooth and marginal setae continuing to near the base, and a deeply cleft right mandible with two or three apical teeth. The aedeagal structure of this group is variable but usually includes unusual sclerotized structures. *Isoperla decepta* is the only Nearctic *Isoperla* species with the combination in the male of a pale yellow head without dark markings and a sclerotized elongate posteromedian blade-like aedeagal structure with sharp stout spinulae. The lack of dark pigmentation on the head is reminiscent of variants of *I. dicala*, but details of the aedeagal armature,



Figs. 12.18-12.19. *Isoperla decepta*. 12.18. Egg. 12.19. Detail of egg chorion.

female subgenital plate and egg are distinctive. The Ontario record (Harper and Ricker 1994) for this species needs verification.

Biological Notes. Frison (1935) found the nymphs in small fast flowing streams with sand and gravel substrates. Poulton and Stewart (1991) reported that it occurred commonly in the Missouri and Mississippi River border subregions and was tolerant to high levels of organic loading. Frison (1935) found that *I. decepta* emerged diurnally which was unusual compared to other Illinois *Isoperla* species. Emergence occurs from mid-March to mid-May depending on locality, but the earliest date found in collection records was mid-March in Missouri. Clifford (1966) reported that females laid eggs during the last week of May in an intermittent stream in south-central Indiana. Adult females crawled beneath rocks at the sides of pools or along shallow seepage areas where water was scarcely discernable to lay eggs.

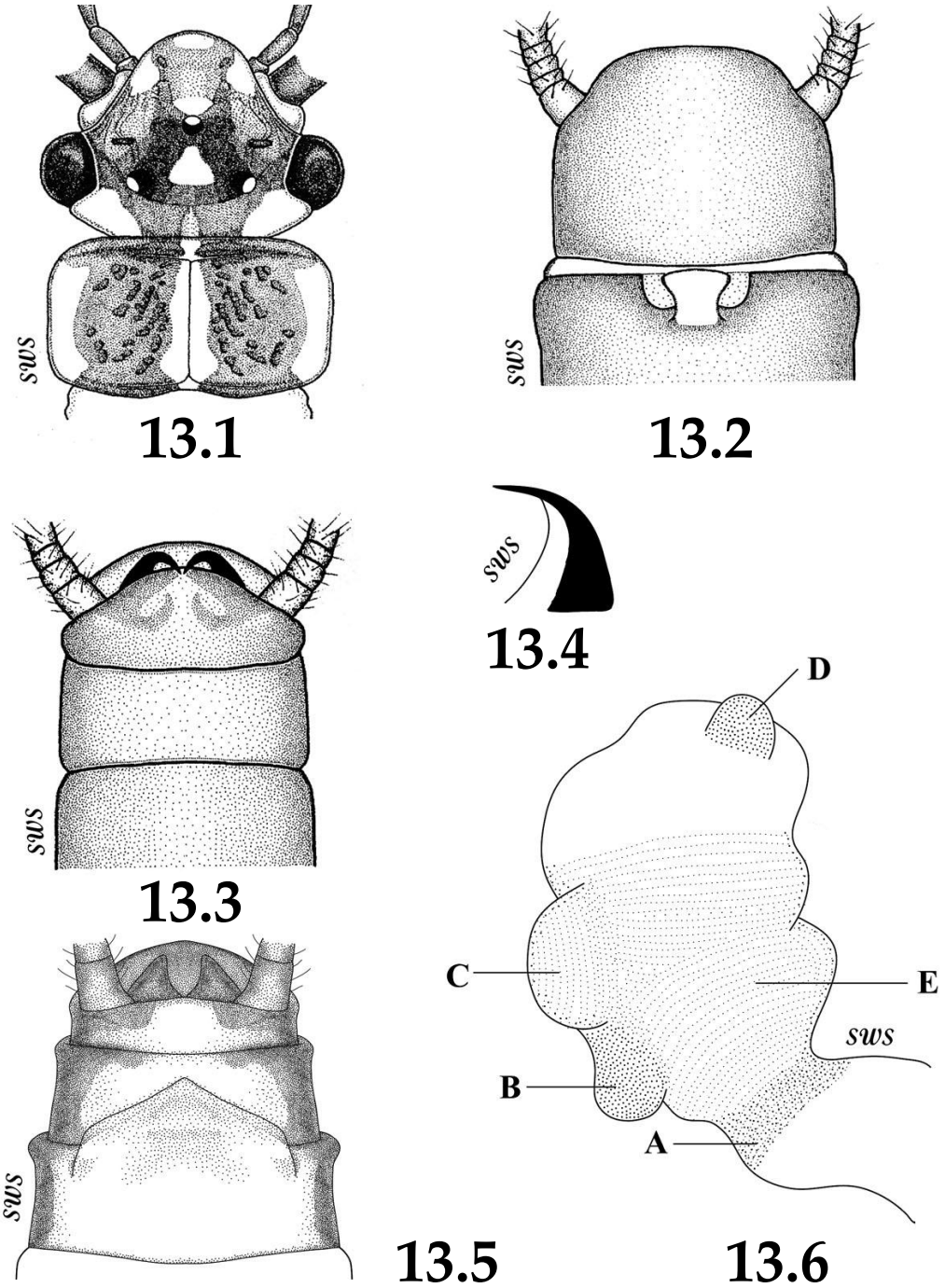
Isoperla decolorata (Walker)
Bearlake Stripetail
(Figs. 13.1-13.9)

Perla decolorata Walker, 1852, 1:170. Holotype ♀ (BMNH) Great Bear Lake, Northwest Territory, Canada. Examined.
Isoperla decolorata: Claassen, 1940, 232: 199.
Isoperla decolorata: Ricker, 1944, 317:183.
Isoperla decolorata: Ricker and Judd, 1955, 66:256.
Isoperla decolorata: Ricker 1964, 34:56.
Isoperla decolorata: Ricker and Scudder, 1975, 342.
Isoperla decolorata: Szczytko and Stewart, 2002, 128:3.
Isoperla decolorata: Stewart and Oswood 2006, 179.
Isoperla decolorata: Miyazaki and Lehmkuhl, 2011, 143.

Eastern Distribution – CANADA – MB (Ricker 1944, 1964), **ON** (Ricker 1944).

Material Examined. CANADA – BC: Coal River, mi. 593, 21/VIII/1948, W.R. Mason, 1♀ (CNIC). **MB:** Churchill, /VII/1937, 1♂, Churchill, Churchill River, 22/VIII/1949, R. Gawatkin, 1♂ (CNIC). **NT:** Aklavik, 28/VI/1956, R.E. Leech, 1♀ (CNIC); Same locality, 6/VII/1956, 1♀ (CNIC); Norman Wells, 5-7/VII/1949, W.R. Mason, 1♂, 1♀ (CNIC); Anderson River nr. Hurky Bend, 9/VIII/1974, 3♂, 2♀ (CNIC); Same locality, 9/VIII/1979, 3♂, 1♀ (CNIC); Reindeer Station, 28/VI/1948, 1♂ (CNIC); Same locality, 22/VI/1948, V.R. Vockeroth, 1♂ (CNIC); Fort Good Hope, Mackenzie River, 4/VIII/1971, J.F. Flanagan, 2♂, 2♀ (CNIC); Mackenzie River, Dempster Hwy, Arctic Red River, 67° 27'19.57"N, 133° 45'31.73"W, 22/VI/1996, J.C. Abbott, K.W. Stewart, 11♂, 3♀, 1 exuvium, 1 N (UNTC); Muskox Lake, 5/VII/1955, V.G. Chillcott, 1♀ (CNIC); Same locality, 20/VII/1953, V.G. Chillcott, 1♀ (CNIC); Mackenzie River delta, NWT Pipeline Project, WC2-30090772-5e, N. Snow, 1♂, 5♀, 6 exuviae, 1 N (CNIC). **YK:** Klokut Archeological Site, 6 mi. N Old Crow, 1-3/VII/1977, R.E. Roughley, 1♂, 1 exuvium, 1 N (CNIC); Mill, Dawson rd., 12/VIII/1960, 1♀ (CNIC); Rampart House, 5/VII/1951, J. E. H. Martin, 2♂, 2♀ (CNIC); Whitehorse, 23/VIII/1959, R. Madge, 9♂, 12♀ (CNIC); Same locality, 28/VIII/1959, 1♂, 2♀ (CNIC); Same locality, 1-17/VIII/1949, L.R. Pickering, 1♂ (CNIC). **USA – AK:** Denali National Park, Killik River, nr. jct. with Colville River, 1/VIII/1987, C.M. White, 2♂, 2♀ (BYUC); Umiat, 30/VII/1959, R. Madge, 1♂, 4♀ (CNIC); Same locality, 10/VII/1959, 1♂, 3♀ (CNIC); 25/VII/1959, J.E.H. Martin, 1♀ (CNIC); Yukon River, mouth of Charley River, 10/VII/1974, D.G. Huggins, 8 N, 1♂, 3♀ (CSUC).

Male. Macropterous. Forewing length 12.0-13.0 mm. General body color pale brown. Dorsum of head with medium brown bands extending from antennal bases and posterior margin of eyes to ocelli; darker brown bands connect ocelli; pale ovoid spots occur anterior to median ocellus and on median frontoclypial area; occiput with broad, median pale brown band extending from lateral ocelli to posterior margin of head; interocellar area with pale triangle (Fig. 13.1). Antennae medium brown. Pronotum with median pale stripe, disks medium brown, rugosities dark, anterior and posterior margins dark brown, lateral margins with pale bands (Fig. 13.1). Meso- and metanota dark brown, mesonota with anterior median pale band extending ½ length of nota. Wings pale, veins medium brown. Legs pale yellow with dark brown dorsal bands on outer surface. Terga medium brown with 2 mesal longitudinal rows of small pale spots; sterna pale yellow. Eighth sternum with a well-developed vesicle, paler than remainder of



Figs. 13.1-13.6. *Isoperla decolorata*. 13.1. Dorsal head and pronotal pattern. 13.2. Male posterior abdominal sterna. 13.3. Male posterior abdominal terga. 13.4. Male paraproct lateral view. 13.5. Female subgenital plate. 13.6. Male aedeagus lateral view; a. proximal band of concentrated small fine spinulae, b. posteroventral lobe with concentrated small fine spinulae, c. paired posteromedian lobe with sparse fine spinulae, d. paired small apical lobe with concentrated small fine spinulae, e. mesal area with scattered small fine spinulae.

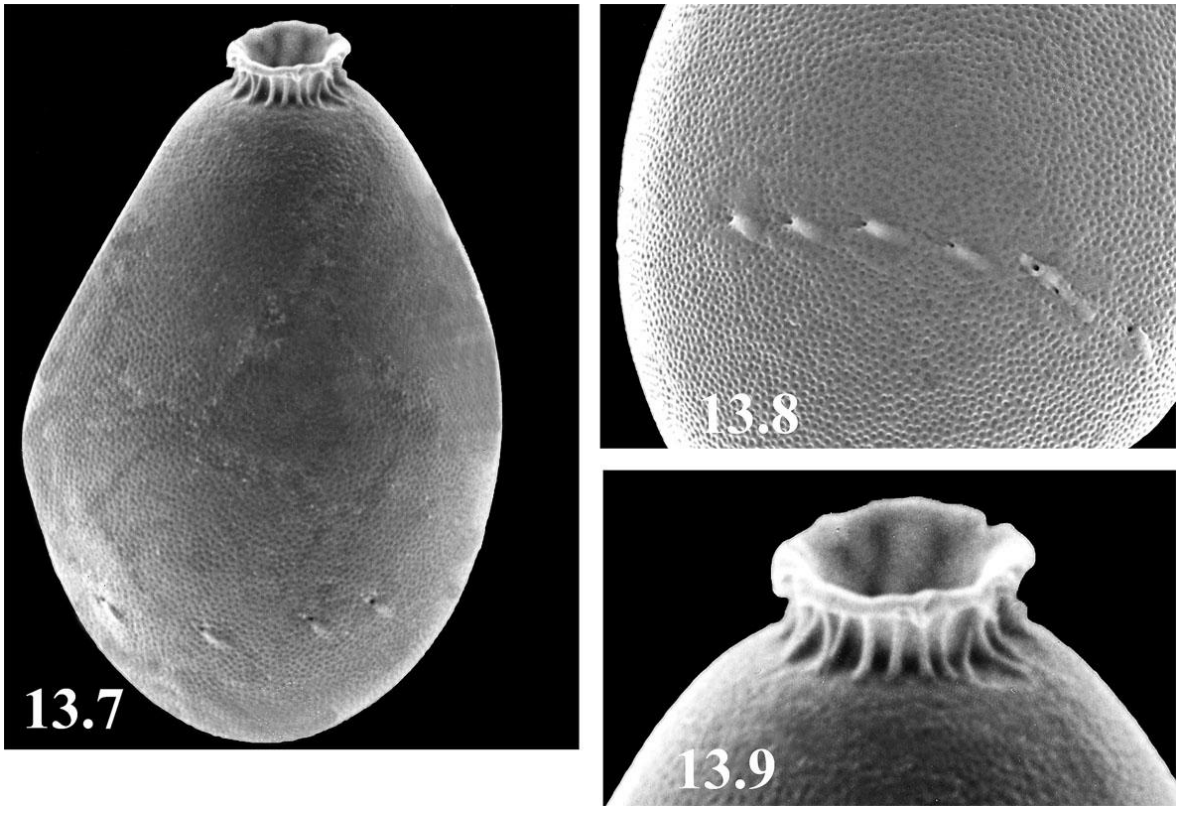
segment and 2X as long as wide with tip expanded and basal area constricted (Fig. 13.2). Tenth tergum entire, unique paired mesoposterior dark pigment pattern creating a pale median arrowhead shaped spot; paraprocts sharply pointed, extending slightly over tergum 10 (Figs. 13.3, 13.4). Aedeagus entirely membranous with 2 small apical lobes bearing concentrated small fine spinulae (Fig. 13.6d); 2 posteromedian large lobes bearing sparse fine spinulae (Fig. 13.6c); 1 posteroventral lobe with concentrated small fine spinulae (Fig. 13.6b); apical ½ of aedeagus without spinulae, mesal area with scattered small fine spinulae (Fig. 13.6e) and proximal area armed with band of concentrated small fine spinulae (Fig. 13.6a).

Female. Macropterous. Body length 13.0-15.0 mm; forewing length 13.0-14.0 mm. Body coloration and morphology similar to male. Subgenital plate broadly triangular usually with posteromedially produced nipple; plate produced posteriorly to anterior ½ of sternum 9 (Fig. 13.5).

Ovum. General shape oval, cross section circular. Color pale brown. Length 250-275 μm; width 170-190 μm (Fig. 13.7). Collar with apically flanged rim; stalked with elevated longitudinal carinae (Figs. 13.7, 13.9). Choronic surface covered with numerous shallow punctations; hexagonal follicle cell impressions faintly visible. Eclosion line absent; micropyle row subequatorial; orifices small and located on raised sperm guides (Figs. 13.7, 13.9).

Nymph. Described by Szczytko and Stewart (2002).

Distribution. Ricker (1944) stated that *I. decolorata* occurred only in streams near the treeless tundra, and Szczytko and Stewart (2002) indicated that it may be transcontinental. It is known from Alaska, British Columbia, Manitoba, Northwest Territories, Saskatchewan, and Yukon (DeWalt et al. 2013).



Figs. 13.7-13.9. *Isoperla decolorata*. 13.7. Egg. 13.8. Egg micropyles. 13.9. Egg collar.

Diagnosis. *Isoperla decolorata*, *I. davisi* and *I. transmarina* comprise the *I. decolorata* species group (Table 1). *Isoperla decolorata* is possibly sympatric only with *I. transmarina* of the group. The species has often been confused in the literature, frequently with a sympatric western Nearctic species, *I. petersoni* Needham and Christenson (Szczytko and Stewart 1979a), but males and females of *I. decolorata* can be distinguished from eastern species by characters in the keys; the long sclerotized aedeagal whip of the male of *I. petersoni* (Szczytko and Stewart 1979a) easily distinguishes it from the male of *I. decolorata*. Females of *I. decolorata* can be distinguished from those of *I. petersoni* by the triangular shaped subgenital plate of *I. decolorata* (the subgenital plate of *I. petersoni* is broadly rounded with a median notch). Ova of *I. decolorata* can be separated from those of *I. petersoni* by the absence of raised follicle cell impressions and the absence of a subequatorial elevated, thickened transverse polar ridge that is typical of *I. petersoni*. The abdominal pigment pattern is most similar to that of *I. slossonae*; however the range of *I. slossonae* is more southern and does not overlap geographically with *I. decolorata.*

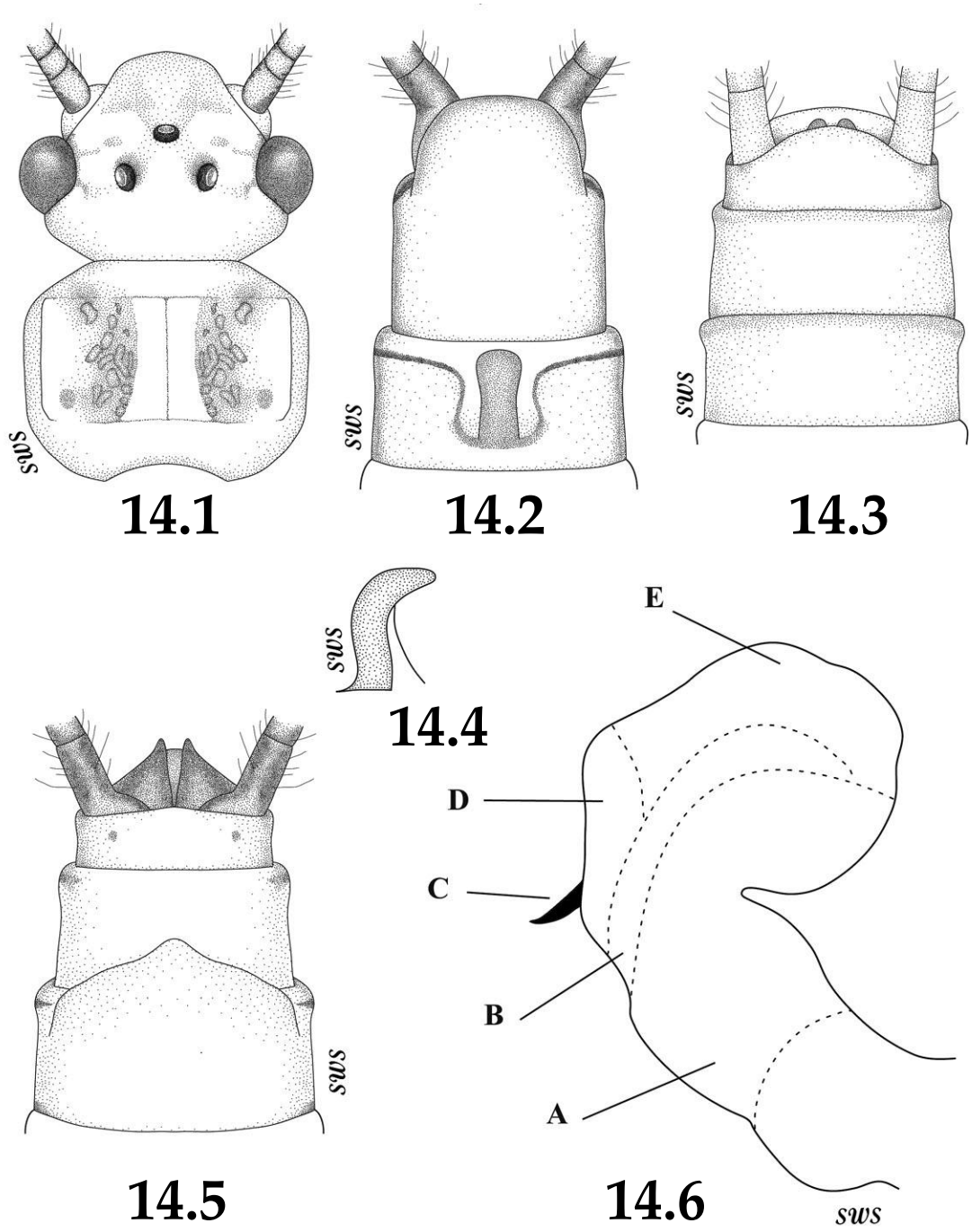
Biological Notes. *Isoperla decolorata* occurs in large river systems of the Far North (Ricker 1944). The emergence period occurs from late June through mid-August in Alaska and Canada (Stewart and Oswood 2006). Essentially nothing is known about the ecology or life cycle of this species. Stewart and Oswood (2006) indicated that nymphs could be collected from several large Alaskan rivers by "dragging a kicknet through shallow backwater".

Isoperla dicala Frison
Sable Stripetail
(Figs. 1.4, 14.1-14.13)

Isoperla dicala Frison 1942, 22:321. Holotype ♂ (INHS) Free Soil, Great Sable River (Mason Co.), Michigan. Examined.
Isoperla dicala: Hitchcock, 1974, 107:197.
Isoperla dicala: Poulton and Stewart, 1991, 38:48.

Distribution: **CANADA – MB** (Burton 1984), **NB** (Frison 1942, Ricker 1947, Kondratieff and Baumann 1994), **ON** (Harper and Ricker 1994), **PQ** (Ricker et al. 1968); **USA – AL** (Stark and Harris 1986, Grubbs 2011), **FL** (Stark and Gaufin 1979), **IA** (Heimdal et al. 2004), **IN** (Frison 1942, Ricker 1945, Grubbs 2004, DeWalt and Grubbs 2011), **KY** (Tarter et al. 2006), **MA** (Neves 1978), **ME** (Mingo 1983), **MI** (Frison 1942, Grubbs and Bright 2001), **MN** (Frison 1942), **MO** (Frison 1942, Poulton and Stewart 1991), **MN** (Harden and Mickel 1952, Lager et al. 1979), **NC** (Kondratieff et al. 1995), **OH** (DeWalt et al. 2012), **PA** (Surdick and Kim 1976, Masteller 1996b), **SC** (McCaskill and Prins 1968, Kondratieff et al. 1995), **TN** (Frison 1942), **WI** (Hilsenhoff and Billmyer 1973), **VA** (Kondratieff and Kirchner 1987), **WV** (Tarter and Nelson 2006).

Material Examined: USA – FL: Walton Co., Alaqua Creek, Base rd. 201, Pine Allen Bridge, Eglin Air Force Base, 30°37′00″N, 86°09′52″W, UV Blacklight, 17 April 2006, R.W. Flowers, M.L. Pescador, A.K. Rasmussen, B.A. Richard, 10♂ (FAMU). **KY:** McCreay Co., Cumberland River, Cumberland Falls State Park, Hwy 90, 11/V/1988, B.C. Kondratieff, 44♂, 11♀ (CSUC). **ME:** Penobscot Co., Penobscot River, W Enfield, 7/VI/1968, S.G. Jewett, Jr., 8♂, 13♀ (USNM). **NC:** Davie/Davidson Co., Yadkin River Boat Access NC 801 E Deadman Road, 3/V/2003, B.C. Kondratieff, R.F. Kirchner, 1♂ (CSUC). **PA:** Pike Co., Delaware River, Dingmans Ferry, 29/V/1996, B.C. Kondratieff, 5♂, 1♀ (CSUC). **WI:** Douglas Co., Bois Brule River Bryle River State Forest, Rte. FF, 20 August 1992, B.C. Kondratieff, 2♂, 7♀ (CSUC). **WV:** Fayette Co., Glade Creek, Babcock State Park, 21/V/1990, R.W. Baumann, S.M. Clark, 1♀ (BYUC). Mercer Co., Eads Mill, Bluestone River, 27/V/1992, B.C. Kondratieff, R.F. Kirchner, 5♂,10♀ (CSUC); Bluestone River at Eads Mill CR 3, 27/V/1992, B.C. Kondratieff, R.F. Kirchner, 10♂, 3♀ (CSUC). **VA:** Bland Co., Wolf Creek, CR 642 and US 52, 27/V/1992, B.C. Kondratieff, R.F. Kirchner, 1♂, 1♀ (CSUC). Giles Co., Big Walker Creek, Hwy 100, Poplar Hill, 24/V/1990, R.W. Baumann, S.M. Clark, B. Sargent, 4♂, 2♀ (BYUC); Sinking Creek, Hwy 42, Newport Park, 24/V/1990, R.W. Baumann, S.M. Clark, B. Sargent, 2♂, 3♀ (BYUC). Smyth Co., North Fork Holston River, Rte. 42, Saltville, 20/V/1993, B.C. Kondratieff, R.F. Kirchner, 1♂, 1♀ (CSUC); Rte. 600, St. Clair Bottom, S. Fork Holston River,



Figs. 14.1-14.6. *Isoperla dicala*. 14.1. Dorsal head and pronotal pattern. 14.2. Male posterior abdominal sterna. 14.3. Male posterior abdominal terga. 14.4. Male paraproct lateral view. 14.5. Female subgenital plate. 14.6. Male aedeagus lateral view; a. mesal patch of concentrated short stout spinulae, b. band of long dense hair-like spinulae, c. stout posteromedian sclerotized spine, d. rows of small fine hair-like spinulae, e. anteriorly directed dorsal lobe.

18/V/1990, B.C. Kondratieff, J.L. Welch, 7♂, 3♀ (CSUC); South Fork Holston River, St. Claire Bottom, 18/V/1990, B.C. Kondratieff, R.F. Kirchner, J.L. Welch, 7♂, 4♀ (CSUC); North Fork Holston River, County rd. 620 jct. County rd. 716, 20/V/1993, B.C. Kondratieff, R.F. Kirchner, 6♂, 4♀ (CSUC).

New Records: USA – CT: New Haven Co., Mill River, Mt. Carmel, 18/V/1960, S.W. Hitchcock, 4♂, 5♀ (USNM). **GA:** Union Co., Wolf Creek, 3.5 mi N. Neel Gap, 8/VI/1945, P.W. Fattig, 4♂ (INHS). **MS:** Simpson Co., Strong River, 3 mi W. of Pinola, Hwy 28, 22/V/1988, B.P. Stark, 6♂, 5♀ (BPSC). **NY:** Oneida Co., Lansing Kill, Hillside rd., Rte. 46, 28/V/2009, B.C. Kondratieff, L.W. Myers, 1♂ (CSUC).

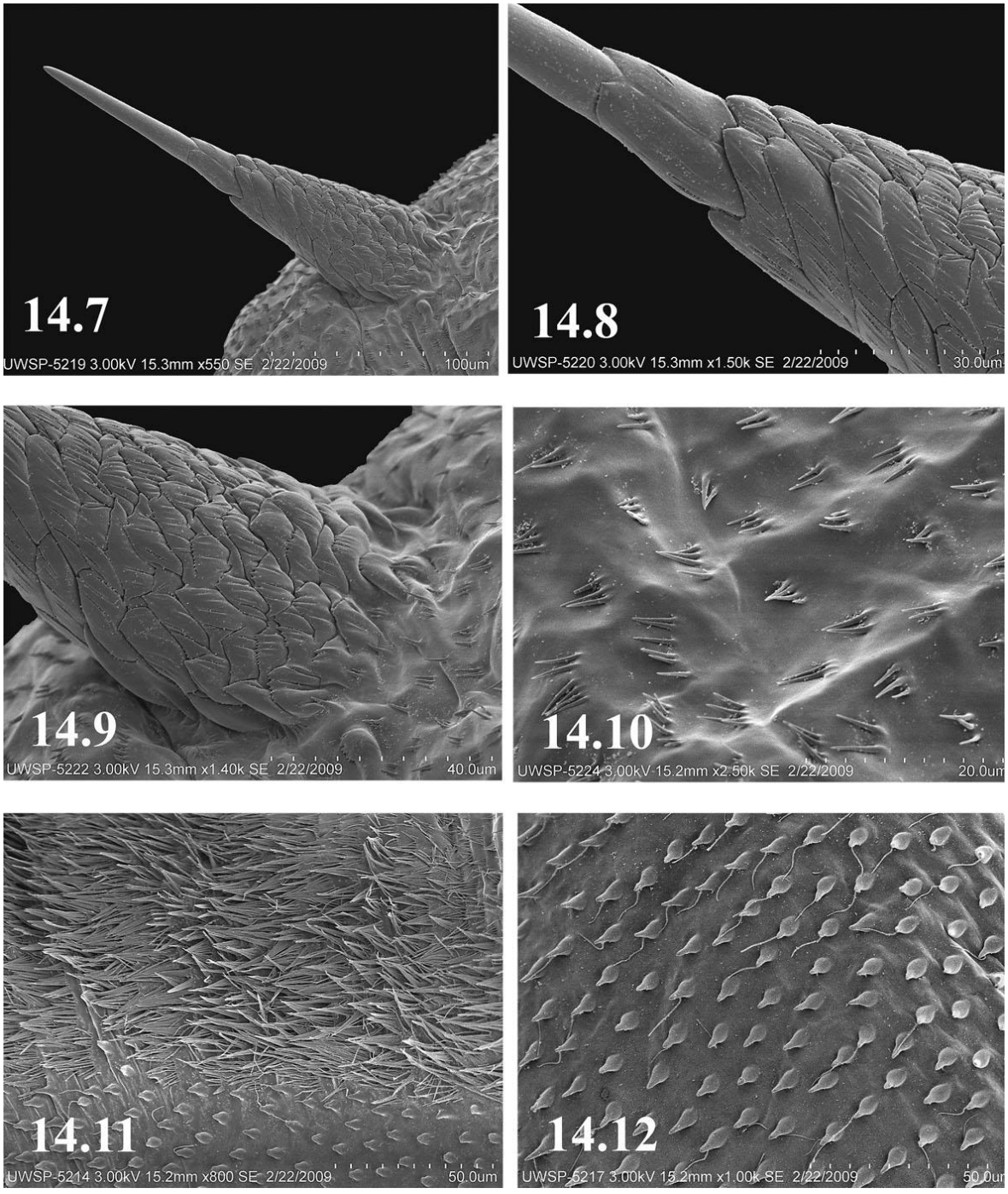
Male. Macropterous. Forewing length 8.6-11.0 mm. General body color pale yellow in life with medium brown markings. Dorsum of head usually entirely pale yellow, occasionally with thin, medium brown bands connecting anterior ocellus with posterior ocelli forming a typical inverted V-pattern; occasionally lateral bands absent and only a short horizontal band at anterior ocellus (Fig. 14.1). Antennal scape, pedicel and flagellum segments 1-8 pale yellow, flagellum beyond segment 9 dark brown. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities irregular, raised, medium to pale brown, pronotal disks pale yellow, anterior margin with short medium brown bands near disks; posterior and lateral margins pale yellow (Fig. 14.1). Meso- and metanota mostly pale yellow with irregular medium brown markings near posterior margin. Wings hyaline with pale brown veins. Legs and sterna pale yellow, tibia with a thin medium brown band near proximal ⅓. Sternum 8 with an elongate medium brown well developed vesicle ca. 3X long as wide, set in a deep U-shaped depression ¾ length of vesicle; posterior end expanded slightly, lateral margins nearly straight, but expanded at base and extending to near anterior margin of sternum 9 (Fig. 14.2). Terga pale yellow, tergum 10 entire (Fig. 14.3). Paraprocts lightly sclerotized, bluntly pointed apically extending slightly over level of tergum 10 (Figs. 14.3, 14.4). Basal cercal segments usually medium brown, apical segments pale yellow. Aedeagus with large, round anteriorly directed dorsal lobe (Fig. 14.6e), long tubular basal stalk, and long, stout posteromedian spine (Figs. 14.6c, 14.7, 14.8, 14.9); posteromedian spine enclosed within a sheath of striated overlapping plates; apical plates elongate, basal plates shorter (Figs. 14.7, 14.8, 14.9); posteromedian area surrounding spine base with rows of small, fine hair-like spinulae which continue posterodorsally (Figs. 14.6d, 14.10); area posteroventral to spine with a band of long dense hair-like spinulae which continue mesally to dorsal lobe (Figs. 14.6b, 14.11); large mesal patch of concentrated, short stout spinulae from near basal stalk to median of dorsal lobe and extending to anterior margin (Figs. 14.6a, 14.12).

Female. Forewing length 11.1-12.5 mm. General body color and morphology similar to male described above. Subgenital plate usually broadly triangular produced posteriorly over ca. ½ length of sternum 9, usually with a posteromedian small nipple (Fig. 14.5).

Ovum. General shape oblong, cross section circular (Fig. 14.13). Color pale brown. Length 310 µm; width 250 µm. Collar well developed with slight apically flanged rim; stalked with elevated longitudinal carinae, base with irregular ridges (Fig. 14.13). Eclosion line well-developed near anterior ⅓ of egg body, wide and flat (Fig. 14.13). Hexagonal follicle cell impressions well-developed, ridges thickened and elevated, floors with small shallow pits, micropyles on top of FCI ridges singularly or in pairs adjacent to eclosion line (Fig. 14.13).

Nymph. Mouthparts and habitus were illustrated by Frison (1935). Poulton and Stewart (1991) illustrated the head color pattern, lacinia and partial terga and Hilsenhoff and Billmyer (1973) illustrated the lacinia. Stark et al. (1998) and Stewart and Stark (2002) provide a color photograph of the habitus.

Diagnosis. Among all known Nearctic *Isoperla* males, including those in the *I. bilineata* group the male of *I. dicala* is distinctive in having an elongate vesicle and a large, elongate posteromedian aedeagal spine. There is considerable variation in the color pattern of the adult head throughout the



Figs. 14.7-14.12. *Isoperla dicala*. 14.7. Stout sclerotized posteromedian aedeagal spine. 14.8. Median detail of sclerotized posteromedian aedeagal spine. 14.9. Basal detail of sclerotized posteromedian aedeagal spine. 14.10. Rows of hair-like spinulae at base of sclerotized posteromedian aedeagal spine. 14.11. Dense patch of hair-like spinulae at base of sclerotized posteromedian aedeagal spine. 14.12. Short stout basal aedeagal spinulae.

geographical range, within and between populations. The color pattern can vary from an entirely pale yellow color (similar to *I. decepta*) to one with a short horizontal bar at the anterior ocellus, or one with a dark inverted V-pattern connecting the ocelli. In addition, the subgenital plate of the female varies from a wide triangular plate to one with a pronounced posteromedian nipple. This common and geographically widespread species occurs from eastern Canada south to Florida and Mississippi and west to the Ozarks of Missouri and Arkansas.

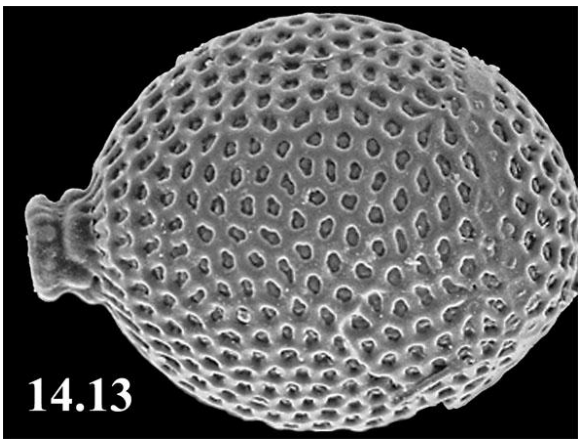


Fig. 14.13. *Isoperla dicala* egg.

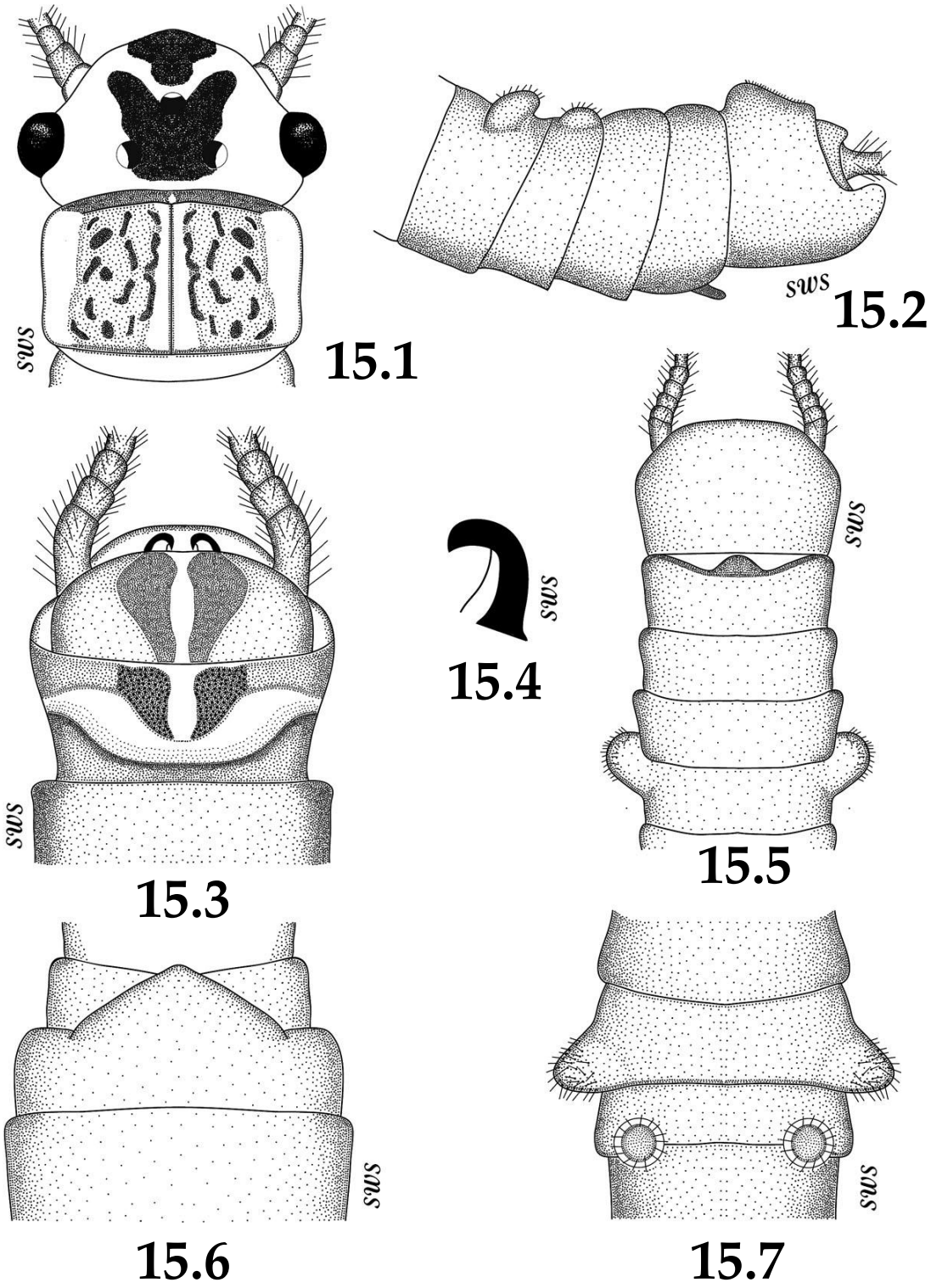
Biological Notes. Poulton and Stewart (1991) reported that this species in the Ozark and Ouachita mountains is restricted to springs or streams that remain cool throughout the summer. Otherwise, *I. dicala* is a species of larger streams and rivers throughout its range. Harper and Pilon (1970) indicated that emergence of this species is in late June in Quebec. Adults are readily attracted to lights. Kondratieff and Despins (1983) documented the adult flight period from late May to early July in Virginia. Stark et al. (1998) mentioned emergence of adults from April through June.

Ziminske (1989) reported that the drumming call of *I. dicala* males was monophasic with 21-24 beats and a mean beat interval of 191.5 ± 36.1 ms and the female answer was also monophasic with 2 beats and a beat interval 649.6 ms.

Isoperla distincta Nelson
Twisted Stripetail
(Figs. 15.1-15.7)

Isoperla distincta Nelson 1976, 49:212. Holotype ♂ (USNM) Goforth Creek (Polk Co.), Tennessee. Examined.

Distribution: USA – TN (Nelson 1976).
Additional Records: **USA – TN**: Polk Co., Rock Creek, off Rte. 30, Parksville Lake Campground, Cherokee National Forest, 13/IV/2010, C.H. Nelson, E.S. Nelson, 1♂ (CSUC).
Male. Macropterous. Forewing length 9.2-9.3 mm. General body coloration pale yellow with medium brown markings. Dorsum of head with large dark brown Y-shaped patch covering ocelli and interocellar area, extending anterolaterally beyond median ocellus; frons with median small medium brown band extending to near anterior ocellus (Fig. 15.1). Antennal scape pale yellow, pedicel medium brown; flagellum segments1-6 pale yellow, remaining flagellum segments medium brown. Pronotum with a median pale hourglass-shaped stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks pale yellow, anterior margin with broad bipartite medium brown bands; posterior margin with thin dark brown band; lateral margins with broad pale bands (Fig. 15.1). Meso- and metasterna pale yellow with medium brown lateral bands. Meso- and metanota medium brown with irregular shaped pale anteromedian and posteromedian areas. Wings hyaline with medium brown veins. Femora mostly medium brown with a thin median brown band and large median pale area, tibia mostly pale yellow with proximal 1/5 medium brown; tarsi medium brown. Sterna pale yellow, sternum 8 with a thin incomplete dark brown posterior band; vesicle well-developed medium brown, 2X as wide as long, posterior margin evenly rounded, extending posteriorly to near anterior margin of sternum 9 (Fig. 15.5). Terga pale yellow; segment 5 with elongate rounded spinulose posterolateral protuberances deflected posterolaterally; segment 6 with smaller rounded spinulose posterolateral protuberances with apical end concave (Figs. 15.2,



Figs. 15.1-15.7. *Isoperla distincta*. 15.1. Dorsal head and pronotal pattern. 15.2. Male abdomen lateral view. 15.3. Male posterior abdominal segments. 15.4. Male paraproct lateral view. 15.5. Male abdominal sterna. 15.6. Female subgenital plate. 15.7. Male abdominal terga 5 and 6.

15.5, 15.7). Posterior ¾ of tergum 9 distinctively elevated with a broadly rounded rim bearing bipartite mesal triangular medium brown patches covered with short stout spinulae; tergum 10 depressed with bipartite mesal longitudinal medium brown bands (Figs. 15.2, 15.3). Paraprocts sclerotized, long, recurved over tergum 10, broad basally, tapering to sharp points apically (Figs. 15.3, 15.4). Cerci pale yellow, segments 1-5 deflected mesally, remaining segments straight. Aedeagus (not extruded) but bearing sclerotized plates, setae and distinct spinule patterns as illustrated by Nelson (1976).

Female. Body length 7.3-8.5 mm; forewing length 10.3-10.5 mm. General body color and morphology similar to male described above. Eighth sternum with a broadly triangular subgenital plate extending to near anterior margin of sternum 10 (Fig. 15.6).

Ovum. Unknown.

Nymph. Unknown.

Diagnosis. *Isoperla distincta* is a medium size pale yellow *Isoperla* with dark brown markings, and is a member of the *I. similis* group (Table 1). The male is distinguished from all Nearctic *Isoperla* by the remarkable elevated spinulose posterolateral lobes on terga five and six and by the incurved cerci. Males of the related Palearctic Isoperlinae genus *Kaszabia* (*K. spinulosa*, Raušer 1968) from Mongolia have similar abdominal lobes; however, they occur on terga three and four and are very different in structure from those of *I. distincta.* The paired aedeagal spinulose sclerotized rods of *K. spinulosa* are also are similar to *I. distincta* as is the general shape of the female subgenital plate. Additional material of *I. distincta,* including males with fully everted aedeagi and females with mature eggs are needed before generic placement and analysis can be made.

Biological Notes. Only one additional adult male has been collected since the original type material was collected. The type specimens were collected from small second to third order streams (C.H. Nelson, personal communication). Based on the type series collected in 1974, 1975, and the additional male in 2010, emergence apparently occurs in mid-April.

Isoperla emarginata Harden and Mickel
Crescent Stripetail
(Figs. 16.1-16.4)

Isoperla emarginata Harden and Mickel 1952, 201:40. Holotype ♀ (UMSP) Grand Marais (Cook Co.), Minnesota. Examined.

Distribution: **USA – MN** (Harden and Mickel 1952).

Male. Unknown.

Female. Macropterous. Forewing length 14 mm. General body pale brown with dark brown markings. Head pattern background pale yellow; crescent shaped thin dark brown bands connecting ocelli and extending slightly antero- and posterolaterally; small oblong pale brown spots lateral to thin dark brown bands; interocellar area pale; V-shaped pale brown patch extending from anterior ocellus to clypeus (Fig. 16.1). Antennal scape pale yellow, pedicel and flagellum medium brown. Pronotum with a median pale stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown; pronotal disks pale yellow, anterior margin with short, broad bipartite medium brown bands (Fig. 16.1). Meso- and metanota pale yellow anteriorly with irregular dark brown markings posteriorly. Wings hyaline, veins pale brown. Femora and tibia pale yellow with thin medium brown dorsal and ventral bands on outer surface; tibia with medium brown, thin vertical band near proximal on outer surface; tarsi medium brown. Sterna pale yellow, eighth sternum with a large broadly truncate subgenital plate with deep mesal apical emargination, extending posteriorly over ½ sternum 9 (Fig. 16.2). Terga yellowish-brown; cerci pale yellow proximally becoming pale brown distally.

Ovum. General shape obliquely round, cross section round (Fig. 16.3). Color pale brown. Length 265 μm; width 230 μm. Collar absent (Fig. 16.3). Hexagonal follicle cell impressions well-developed with raised thickened ridges, floors shallow with numerous small pits; micropyles arranged singularly or in pairs on top of follicle cell ridges near anterior ⅓ of ova (Figs. 16.3, 16.4).

Nymph. Unknown.

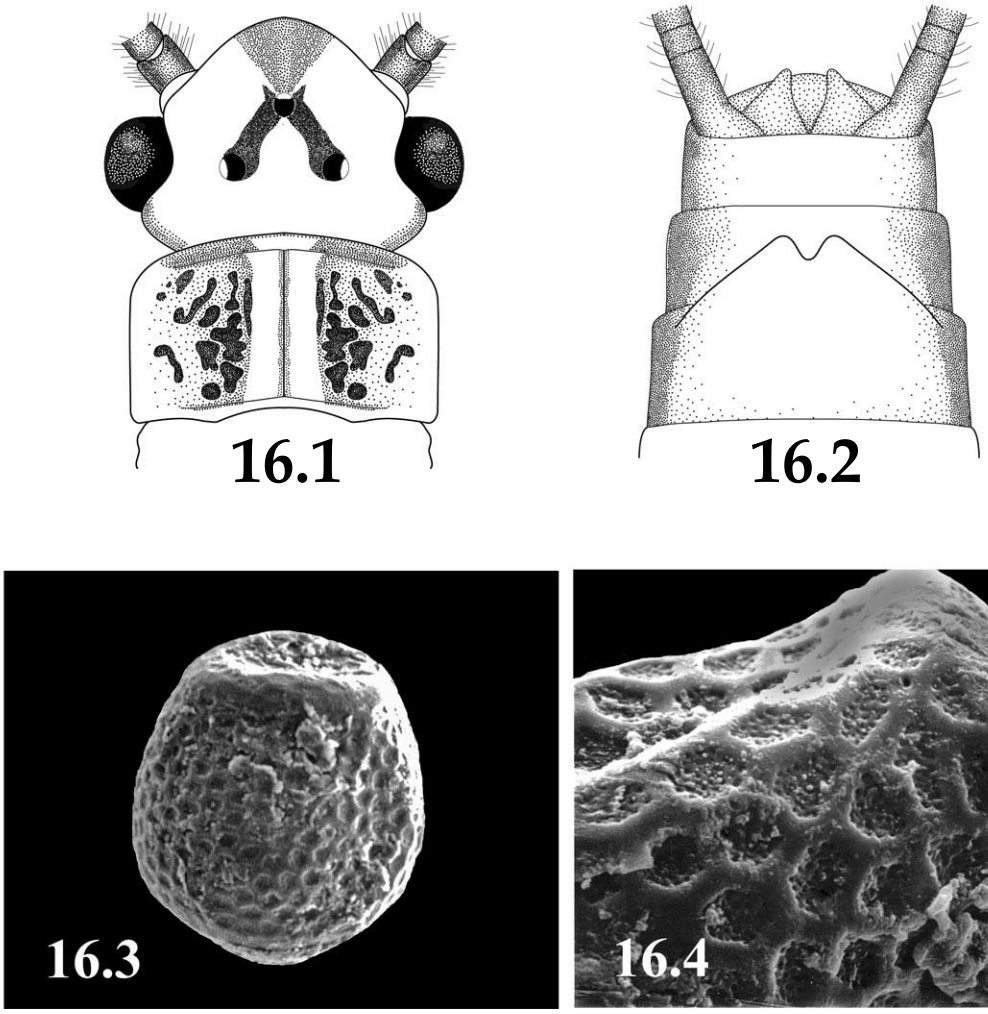


Fig. 16.1-16.4. *Isoperla emarginata*. 16.1. Dorsal head and pronotal pattern. 16.2. Female subgenital plate. 16.3. Egg. 16.4. Detail of egg chorion and micropyle.

Diagnosis. The single known specimen, the holotype female collected more than 74 years ago, appears to be similar to *I. montana* in general appearance, body coloration and shape of the subgenital plate. The ova are distinctive with *I. emarginata* having a round cross section and no collar, and the ova of *I. montana* having a triangular cross section and a developed collar. The subgenital plate and head pattern are similar to that of *I. orata* and *I. burksi,* and females of these species are difficult to separate. The ova cross section of *I. francesca* and *I. orata* are concave, and they are triangular in *I. signata* and *I. namata*; however, the ovum of *I. burksi* is unknown.

Biological Notes. The holotype female of *I. emarginata* was collected on 13 July 1939 at Grand Marais, Minnesota along Lake Superior. Recent efforts by the authors to collect at the type locality have not produced any specimens that can be referred to this species.

***Isoperla fauschi* sp. n.**
Lumber Stripetail
(Figs. 17.1-17.15)

Material Examined: USA – Holotype ♂, **North Carolina:** Robeson Co., Lumber River, Chicken Road Bridge, 2 mi. SE Pembroke, 2/V/2003, B.C. Kondratieff, R.F. Kirchner (USNM). **Paratypes: NC:** Same data as holotype, 11♂, 7♀ (CSUC); Shoe Heel Creek, US 501 Bridge, 1 mi. NW of Raemon, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 2♂, 5♀ (CSUC). Cumberland/Harnett Co., Little River, Hwy 401 S. of Lillington, 35.26261 N, 81.70441 W, 30/V/2006, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat, 13♀ (CSUC). **VA:** Sussex Co., Chub Sandhills, 6 mi. SE of Sussex, 12/V/1996, M. Roble, R. Hoffman, 4♂, 6♀ (CSUC).

Distribution: **USA – NC, VA**

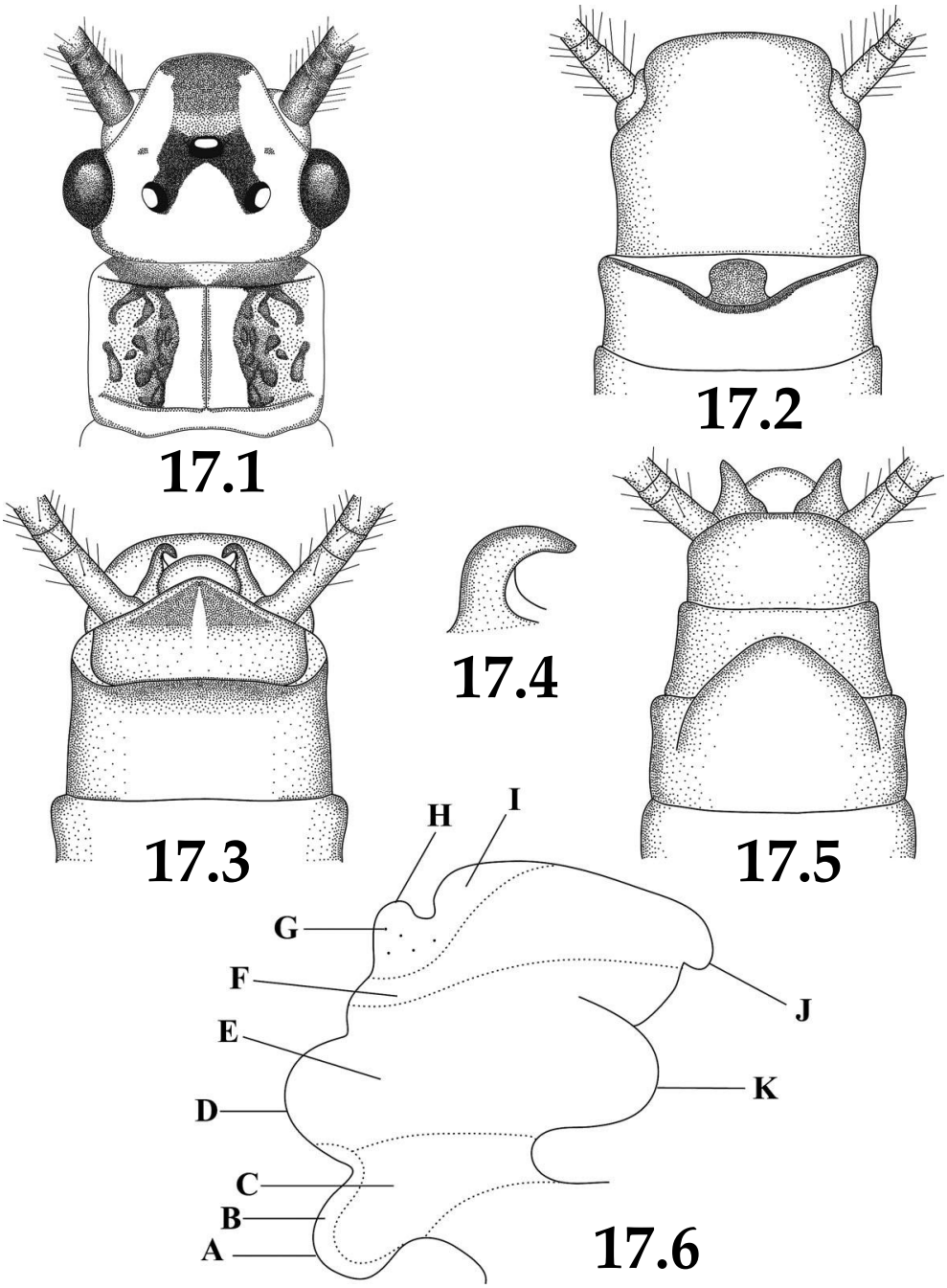
Male. Macropterous. Forewing length 9.5-11.3 mm. General body coloration pale yellow to pale brown with medium and dark brown markings. Dorsum of head with dark brown bands connecting ocelli truncate near median ocellus; interocellar area and hind margin of head pale yellow; small median pale area anterior to median ocellus; broad medial medium brown band extending from pale area to anterior margin of head. Antennal scape pale yellow, pedicel medium brown, flagellum segments 1-10 pale yellow with thin dark distal margin, remaining flagellar segments pale brown (Fig. 17.1). Pronotum with a median pale slightly hourglass- shaped longitudinal stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, medium/dark brown; pronotal disks pale yellow, anterior margin with broad bipartite medium brown bands; posterior margin mostly pale yellow; lateral margins with broad pale bands (Fig. 17.1). Mesonotum dark brown with anterior broad heart-shaped pale yellow area, metanotum mostly dark brown with irregular anterior pale yellow markings. Wings hyaline; veins medium brown. Legs pale yellow, femora with dark brown dorsal band and thin median band on outer surface, tibia with thin dark brown dorsal band and vertical dark brown band near proximal 1/5; tarsi pale brown. Sterna pale yellow, sternum 8 with a thin dark brown posterior band; vesicle well-developed, medium brown, ca. as wide as long, posterior margin evenly rounded, extending posteriorly to near anterior margin of sternum 9 (Fig. 17.2). Terga pale yellow occasionally with a faint pale brown longitudinal band on segments 1-9: tergum 9 with a dark brown posterior band and short fine spinulae; tergum 10 with bipartite medium brown triangular patches (occasionally faded in older preserved material), median area pale yellow and slightly depressed (Fig. 17.3). Paraprocts with posterior margin and tips sclerotized, remainder lightly sclerotized, nearly erect, not recurved over tergum 10, broad basally, tapering to blunt tips apically (Figs. 17.3, 17.4). Cerci pale yellow. Aedeagus with posteroventral lobe (Fig. 7.6) bearing a posterior band of long sharp spinulae (Fig. 17.6a) and a ventral band of short stout spinulae (Figs. 17.6c, 17.8); large posteromesal lobe and mesal section with concentrated short flat rounded plates (Figs. 17.6d, e, 17.9); large dorsal patch devoid of spinulae (Fig. 17.6f); small posterodorsal lobe with scattered sensilla basiconica and long fine hair-like spinulae (Figs. 17.6g, h, i, 17.10, 17.11, 17.12); large paired dorsal lobes with anterodorsal nipples devoid of spinulae (Fig. 17.6j); large anteroventral lobe with concentrated short flat scale-like plates (Figs. 17.6k, 17.9).

Female. Forewing length 9.5-12.3 mm. General body color and morphology similar to male described above. Eighth sternum with a broadly triangular subgenital plate (occasionally with a shallow mesal emargination), base of plate extending anteriorly to near ½ anterior length of sternum 8 and extending posteriorly to approximately ½ length of sternum 9 (Fig. 17.5).

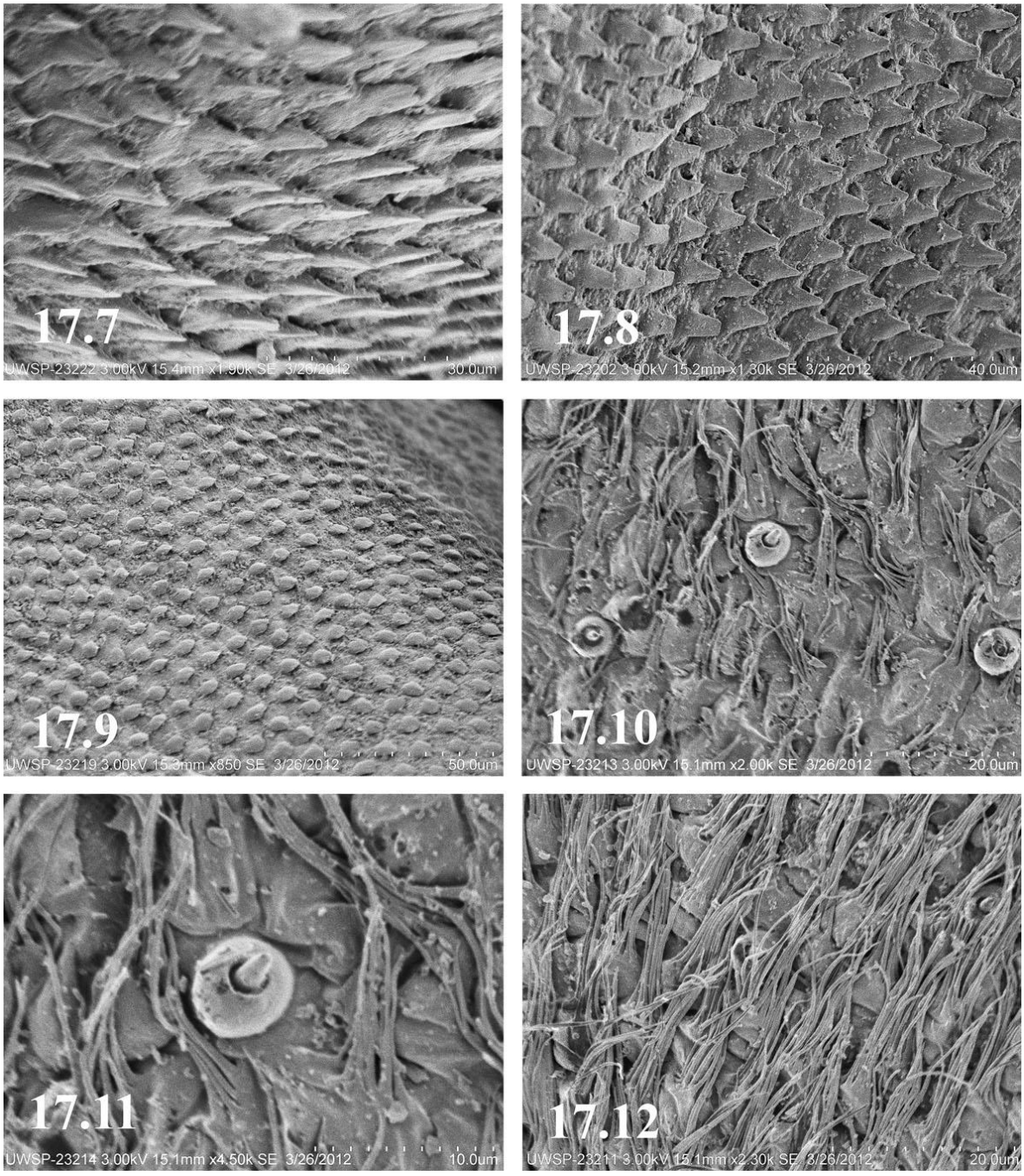
Ovum. General shape approximately square, bottom flat, cross section triangular, end depressed (Figs. 17.13, 17.14). Color pale yellow. Length 200 μm; width 176 μm. Collar low, rim shallow with short longitudinal carinae, positioned in an apical depression with large flat basal area (Fig. 17.14). Hexagonal follicle cell impressions well-developed with elevated thickened ridges; floors of FCI with numerous small pits; micropyles positioned singularly on top of FCI ridges near anterior ⅓ of egg (Figs. 17.13, 17.15).

Nymph. Unknown.

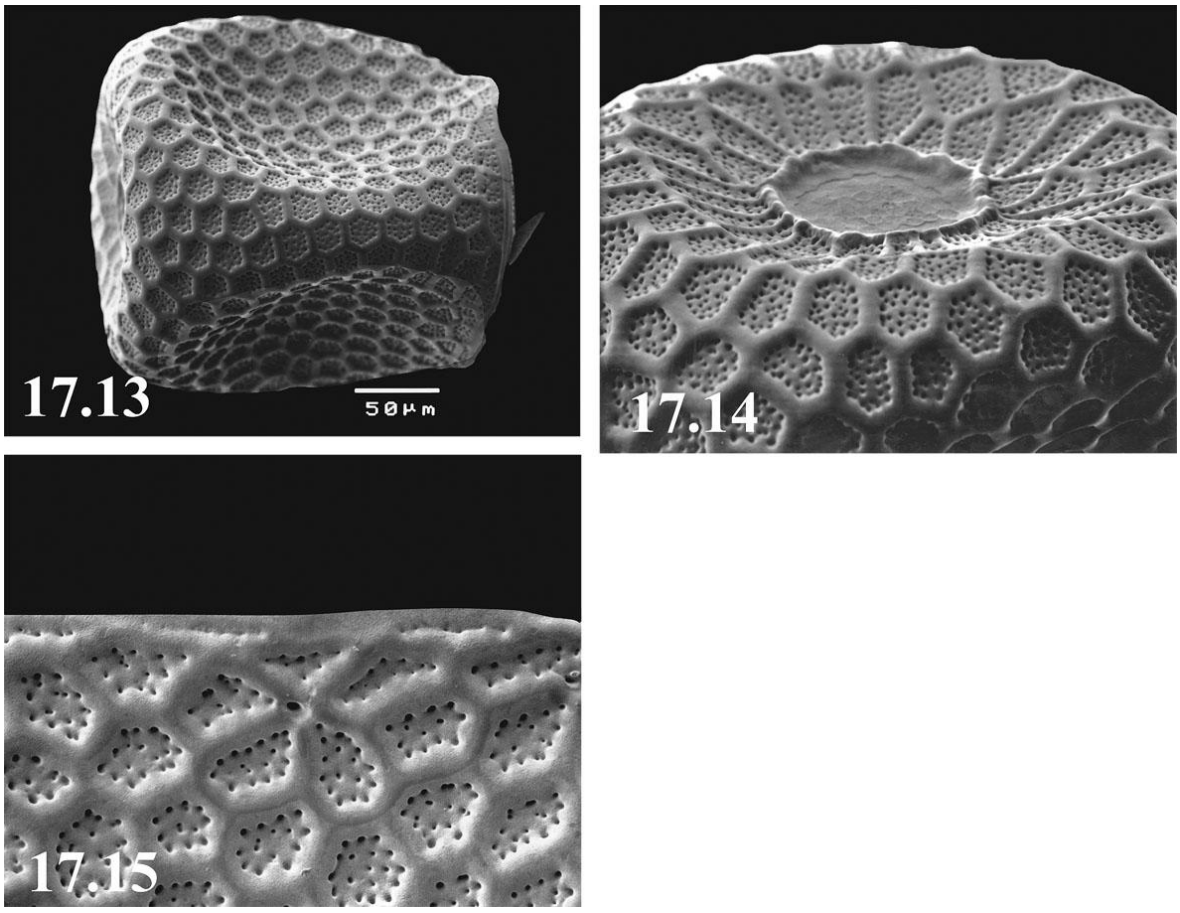
Etymology. The patronym honors Dr. Kurt D. Fausch, Colorado State University, Fish, Wildlife,



Figs. 17.1-17.6. *Isoperla fauschi*. 17.1. Dorsal head and pronotal pattern. 17.2. Male posterior abdominal sterna. 17.3. Male posterior abdominal terga. 17.4. Male paraproct lateral view. 17.5. Female subgenital plate. 17.6. Male aedeagus lateral view; a. posteroventral lobe, b. band of long sharp spinulae, c. ventral band of short stout spinulae, d. posteromesal lobe, e. mesal band of concentrated short flat rounded plates, f. dorsal area without spinulae, g. scattered patch of sensillae basiconica and long fine hair-like spinulae, h. posterodorsal lobe, i. scattered patch of sensillae basiconica and long fine hair-like spinulae, j. paired dorsal lobes, k. anteroventral lobe.



Figs. 17.7-17.12. *Isoperla fauschi*. 17.7. Posterior band of long sharp aedeagal spinulae. 17.8. Ventral band of short stout aedeagal spinulae. 17.9. Sclerotized short blunt aedeagal plates. 17.10. Scattered sensillae basiconica on posterior aedeagal lobe. 17.11. Detail of sensillae basiconica on posterior aedeagal lobe. 17.12. Detail of long fine hair like spinulae.



Figs. 17.13-17.15. *Isoperla fauschi*. 17.13. Egg. 17.14. Detail of egg collar area. 17.15. Detail of egg chorion and micropyle.

and Conservation Biology. His contributions to fisheries science have been immense both nationally and internationally.

Diagnosis. *Isoperla fauschi* sp.n. is a smaller pale yellow species with dark brown markings, and is a member of the *I. bilineata* group (Table 1). The shape of the female subgenital plate, egg and shape and spinule pattern of the male aedeagus will distinguish the species from all other Nearctic *Isoperla*. In the key to the males, *I. fauschi* sp.n. will key to the couplet that includes the relatively poorly known northeastern North American species, *I. gibbsae*, also a member of the *I. bilineata* group. *Isoperla fauschi* sp.n. appears restricted to larger shifting sand streams of the Atlantic Coastal Plains of Virginia and North Carolina.

Biological Notes. Based on the collection records above the emergence period of *I. fauschi* sp.n. occurs from early May to early June. Nothing is known about the biology or life cycle of this species. The type locality is in the Sand Hills Ecoregion (Level IV) of the Atlantic Coastal Plain of North Carolina. A portion of the Lumber River is designated a National Wild and Scenic River. Mean width of the Lumber River in this area is about 16 m. The substrate is mostly sand and gravel, although important habitats also include bank areas, snags, and leaf packs. The water is humic-colored, with median pH values of 5.8 and minimum pH values <5.0. Collections of both

immature and adult aquatic insects at this site have documented a high diversity of mayflies, stoneflies and caddisflies. Many rare benthic macroinvertebrate species have been recorded at this site, potentially making it one of the most important conservation areas in North Carolina. Rare stoneflies of this region include chloroperlids *Haploperla fleeki* Kondratieff and Kirchner (Kondratieff et al. 2005), *Alloperla lenati* Kondratieff and Kirchner (Kondratieff and Kirchner 2004) and the perlids, *Perlesta leathermani* Kondratieff and Zuellig, and *P. bjostadi* Kondratieff and Lenat (Kondratieff et al. 2008).

Isoperla francesca Harper
Northeastern Stripetail
(Figs. 18.1-18.21)

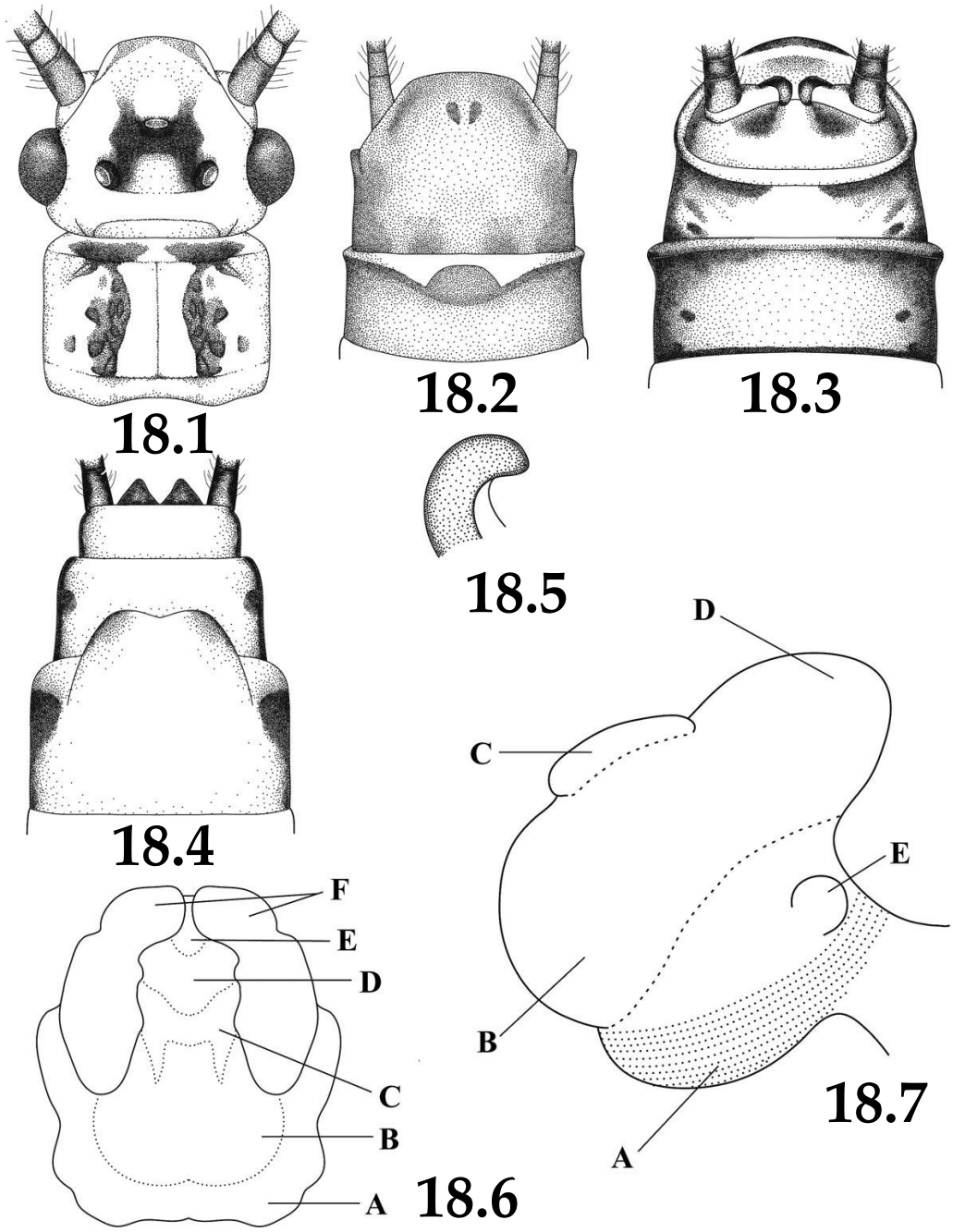
Isoperla francesca Harper 1971, 49:688. Holotype ♂ (CNIC) Station de Biologie de l'Université de Montréal, St-Hippolyte, Québec. Examined.

Distribution: **CANADA – NB** (Kondratieff and Baumann 1994), **PQ** (Harper 1971); **USA – ME** (Mingo 1983).

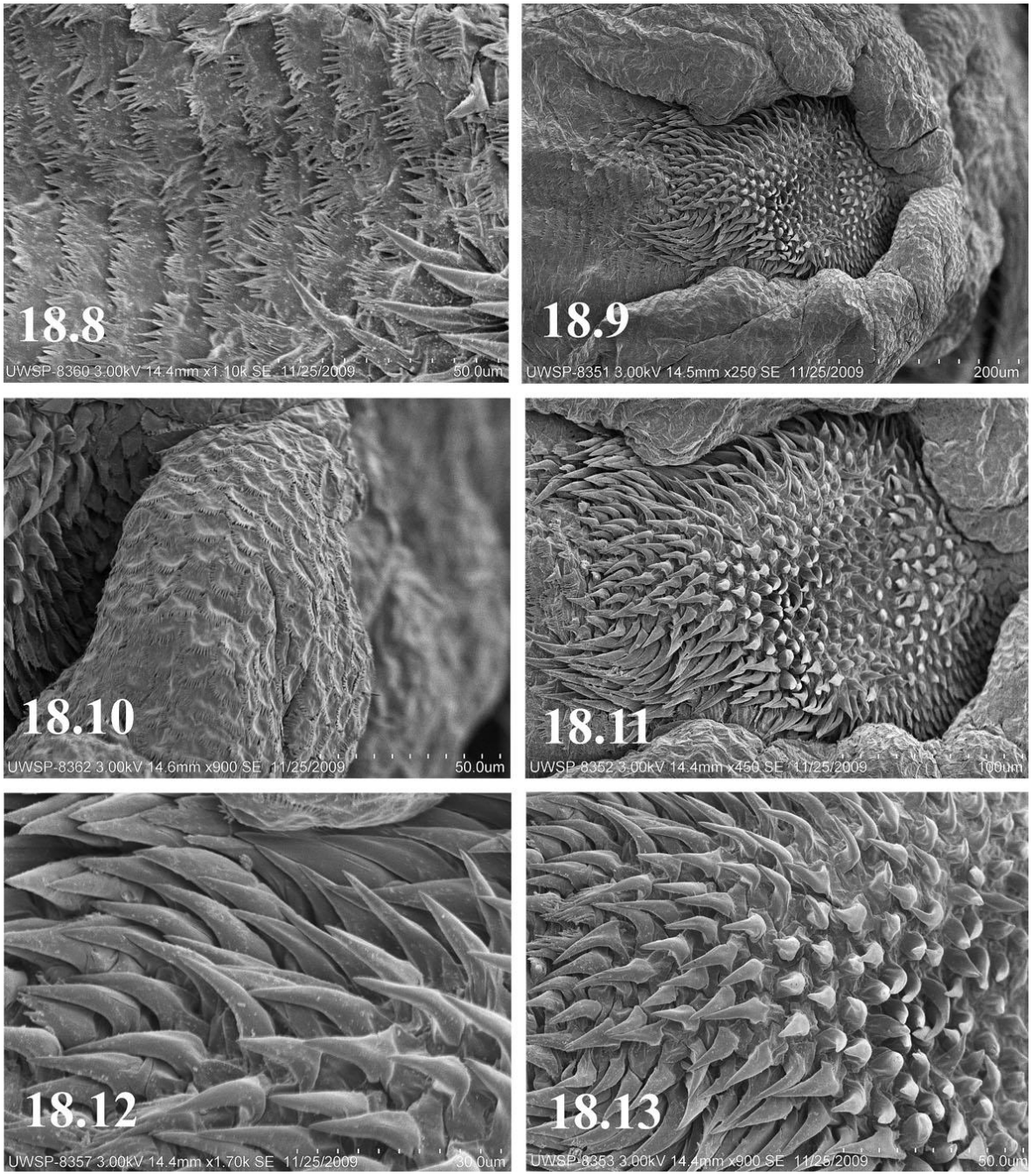
New Records: **CANADA – NB:** York Co., trib. Magaguadavic River, Hwy 3, SE Thomston Corner, 14/VI/1993, R.W. Baumann, B.C. Kondratieff, 2♂, 5♀ (CSUC). **NS**: Victoria Co., Upper Baddeck River, N Baddeck, 21/VI/1993, R.W. Baumann, B.C. Kondratieff, 1♂ (CSUC). **USA – NY**: Clinton Co., True Brook, True Brook Road, 14/VI/2008, L.W. Myers, 1♂, 1♀ (CSUC). Essex Co., Rocky Branch, Nugent rd., Jay Water Supply Tower, 25/VI/2008, L.W. Myers, T. Mihnuc, R. Mowrey, 1♂, 1♀ (NYSM); Cascade Brook, Rte. 73 near lake outlet, 27/VI/2007, L.W. Myers, B.C. Kondratieff, 7♂, 21♀ (CSUC); Adirondack Lodge, 21/VII/1923, ? 1♂, 7♀ (NYSM). Hamilton Co., Beaver Meadow Brook, 6 mi. E. of Indian Lake, 13/VI/1999, J. McCabe, 1♂, 4♀ (NYSM); East Branch Sacandaga River, Rte. 8, Griffin, 43.4655'N, 74.2267'W, 30/V/2009, L.W. Myers, 1♂, 1♀ (NYSM).

Additional Records:- CANADA – NB: Carleton Co., Gibson Creek, Hwy 105, Northampton, 15/VI/1993, R.W. Baumann, B.C. Kondratieff, 3♂, 3♀ (CSUC). Charlotte Co., Digdequash River, Hwy 27, 15/VI/1993, R.W. Baumann, B.C. Kondratieff, 2♂, 1♀ (CSUC). Kings Co., Cunningham Creek, Hwy 7, Northwest of Nerepis, 25/VI/1993, R.W. Baumann, B.C. Kondratieff, 1♂, 1♀ (CSUC). York Co, Pokiok Stream, Hwy 635, below Lake George, 18/VI/1993, R.W. Baumann, B.C. Kondratieff, 1♂ (CSUC); trib. Magaguadavic River, SE. Thompson Corner, 15/VI/1993, B.C. Kondratieff, R.W. Baumann, 3♀ (CSUC).

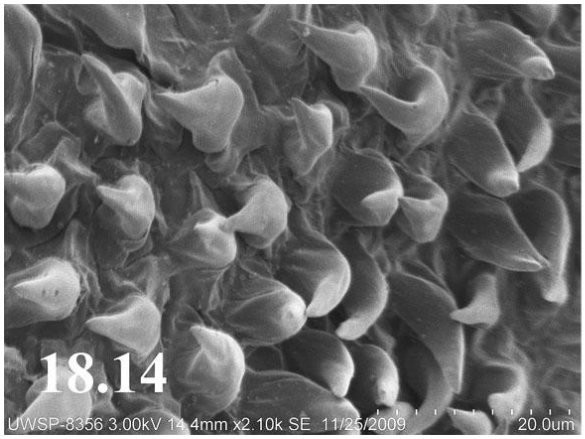
Male. Macropterous. Forewing length 9.1-10.2 mm. General body pale brown with dark brown markings. Dorsal head pattern background pale yellow; broad dark brown bands connecting ocelli, truncate anteriorly; thin medium brown bands extending anterolaterally from median ocellus; interocellar area pale (Fig. 18.1). Antennal scape pale yellow, pedicel medium brown, flagellum segments 1-7 usually pale yellow, remaining flagellar segments medium/dark brown. Pronotum with a median pale hourglass-shaped stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks pale yellow, anterior margin with short, broad bipartite medium brown bands (Fig. 18.1). Meso- and metasterna pale yellow with pale brown lateral bands. Meso- and metanota pale yellow with irregular medium brown markings and large U-shaped thin dark brown median band, truncate posteriorly. Wings hyaline, veins pale brown. Femora and tibia pale yellow, femora with thin dark brown dorsal band on outer surface; tibia medium brown, thin vertical medium brown band near proximal 1/5 of outer surface; tarsi medium brown. Sterna pale yellow, sternum 8 with a thin dark brown posterior band; vesicle well-developed medium brown, ca. 2 x as wide as long; posterior margin evenly rounded, extending posteriorly to near anterior margin of sternum 9 (Fig. 18.2). Paired posteromedian aedeagal spine patches usually visible through exoskeleton of sternum 9 (Fig. 18.2). Terga pale brown with faint brown lateral and median longitudinal bands, usually 3 lateral and 2 median longitudinal rows of faint brown spots on terga 1-9 (sometimes absent in preserved material). Paraprocts lightly sclerotized, short, stout, apically blunt and usually not recurved over tergum 10 (Figs. 18.3, 18.5). Cerci pale brown. Aedeagus with large posteroventral

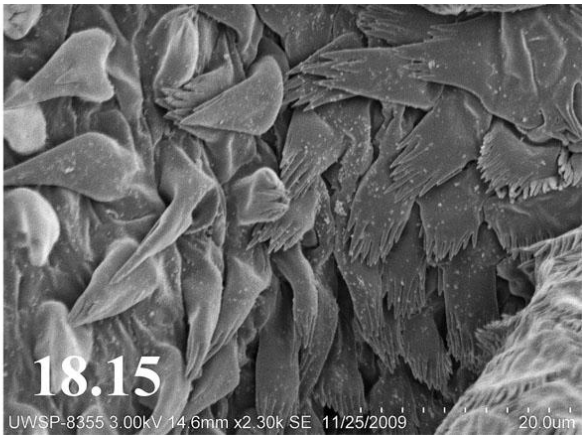


Figs. 18.1-18.7. *Isoperla francesca*. 18.1. Dorsal head and pronotal pattern. 18.2. Male posterior abdominal sterna. 18.3. Male posterior abdominal terga. 18.4. Female subgenital plate. 18.5. Male paraproct lateral view. 18.6. Male aedeagus oblique dorsoposterior view; a. posteroventral lobe, b. posteromedian lobe, c. paired sclerotized median patch of long stout spinulae, d. patch of short stout light spinulae with hooked tips, e. patch of elongate plates with short finger-like spinulae, f. paired posterodorsal horseshoe-shaped lobe. 18.7. Male aedeagus lateral view; a. posteroventral lobe covered with short stout spinulae, b. posteromedian lobe, c. paired posterodorsal horseshoe-shaped lobe, d. anterodorsal lobe, e. paired anteroventral lobe.



Figs. 18.8-18.13. *Isoperla francesca*. 18.8. Aedeagal shelf-like rows with apical fine hair-like projections. 18.9. Paired posterodorsal elongate horseshoe-shaped aedeagal lobes. 18.10. Detail of scallop-shaped plates on horseshoe-shaped aedeagal lobe. 18.11. Detail of spinulae between posterodorsal elongate horseshoe-shaped aedeagal lobes. 18.12. Detail of long stout spinulae on paired sclerotized median aedeagal patch. 18.13. Detail of short stout spinulae on paired sclerotized median aedeagal patch.





Figs. 18.14-18.15. *Isoperla francesca*. 18.14. Detail of short stout hooked tip spinulae on paired sclerotized median aedeagal patch. 18.15. Detail of elongate aedeagal plates with numerous apical finger-like projections.

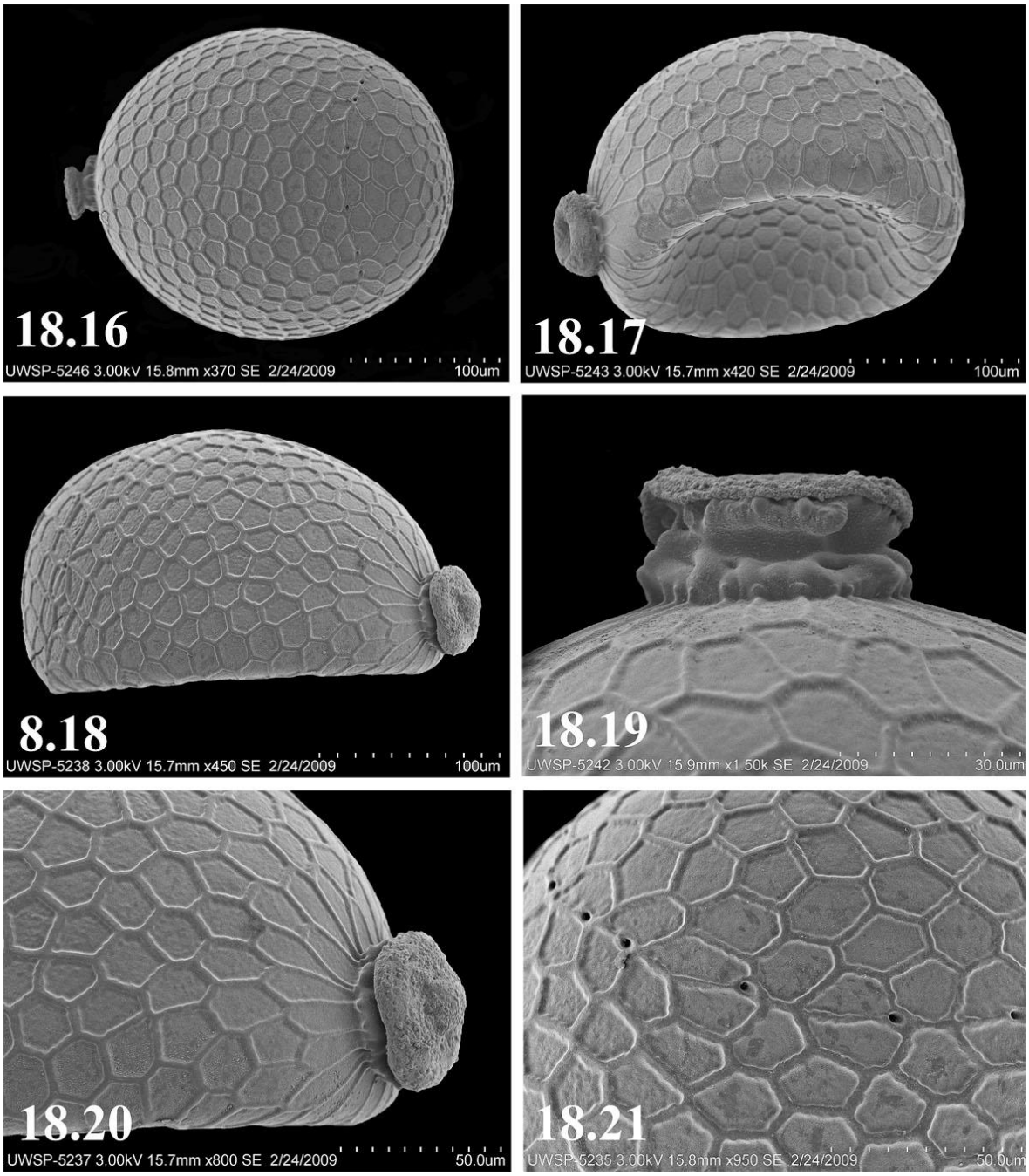
lobe covered with short stout spinulae (Figs. 18.6a, 18.7a); posteromedian lobe covered with shelf-like rows with numerous short fine hair-like apical projections (Figs. 18.6b, 18.7b, 18.8); paired posterodorsal horseshoe-shaped, elongate lobes covered with scallop-shaped plates with numerous short fine hair-like spinulae (Figs. 18.6f, 18.7c, 18.9, 18.10); area between horseshoe shaped lobes with paired sclerotized median patch of long stout spinulae (Figs. 18.6c, 18.11, 18.12); area above long stout spinulae with concentrated short stout, pale spinulae with hooked tips (Figs. 18.6d, 18.13, 18.14); small area above hooked tip spinulae with elongate plates bearing numerous short finger-like spinulae (Figs. 18.6e, 18.15); anterodorsal lobe with shelf-like rows having numerous short fine hair-like spinulae (Fig. 18.7d); anteroventral lobe devoid of spinulae (Fig. 18.7e).

Female. Forewing length 9-11 mm. General body color and morphology similar to male described above. Eighth sternum with a large broadly truncate subgenital plate with mesal emargination; plate deflected ventrally near apex and extending posteriorly over ½ sternum 9 (Fig. 18.4).

Ovum. General shape oblong, cross section concave (Figs. 18.16, 18.17, 18.18). Color pale brown. Length 265 µm; width 214 µm. Collar well-developed, flared apically, basal area offset with a low ridge bearing short, stout longitudinal struts (Figs. 18.16, 18.17, 18.19). Anchor biscuit-shaped with small mushroom bodies (Figs. 18.18, 18.20). Hexagonal follicle cell impressions well-developed with thickened ridges; floors shallow with no visible pits. Micropyles arranged in a row of 6-7 along a thin ridge forming an eclosion line near anterior ⅓ of egg (Figs. 18.16, 18.21).

Nymph. Described by Harper (1971).

Diagnosis. *Isoperla francesca*, a member of the *I. signata* group but in general habitus is most similar to *I. orata* of the *I. burksi* group (Table 1). The subgenital plate and head pattern are similar to *I. orata* and *I. burksi* and females of these species are difficult to separate. The ova cross section of *I. francesca* is concave, but it is triangular in *I. signata* and *I. namata* which permits separation for females of those species; the ova of *I. burksi* is unknown. The posterior aedeagal spine patches of *I. francesca* males are similar to those of *I. signata* and *I. namata*, however the spine patch is smaller in *I. francesca* and the head pattern is much paler. In addition, the paraprocts of *I. francesca* are short, stout and lightly sclerotized, whereas *I. signata* and *I. namata* have



Figs. 18.16-18.21. *Isoperla francesca*. 18.16. Egg dorsal. 18.17. Egg oblique lateral view showing concave section. 18.18. Egg lateral view. 18.19. Egg, detail of collar and anchor. 18.20. Egg, detail of collar and anchor lateral view. 18.21. Egg, detail of chorion and micropyles.

darkly sclerotized paraprocts that are recurved over tergum 10. *Isoperla francesca* is relatively uncommon with no records at this time available south of New York. See additional discussion

under *I. orata*.

Biological Notes. Harper et al. (1991) suggested a univoltine life cycle for this species in Quebec. In New York, adults were collected from late May to mid-June, usually from small to medium-sized rocky streams of good water quality.

Isoperla frisoni Illies
Wisconsin Stripetail
(Figs. 1.5, 19.1-19.14)

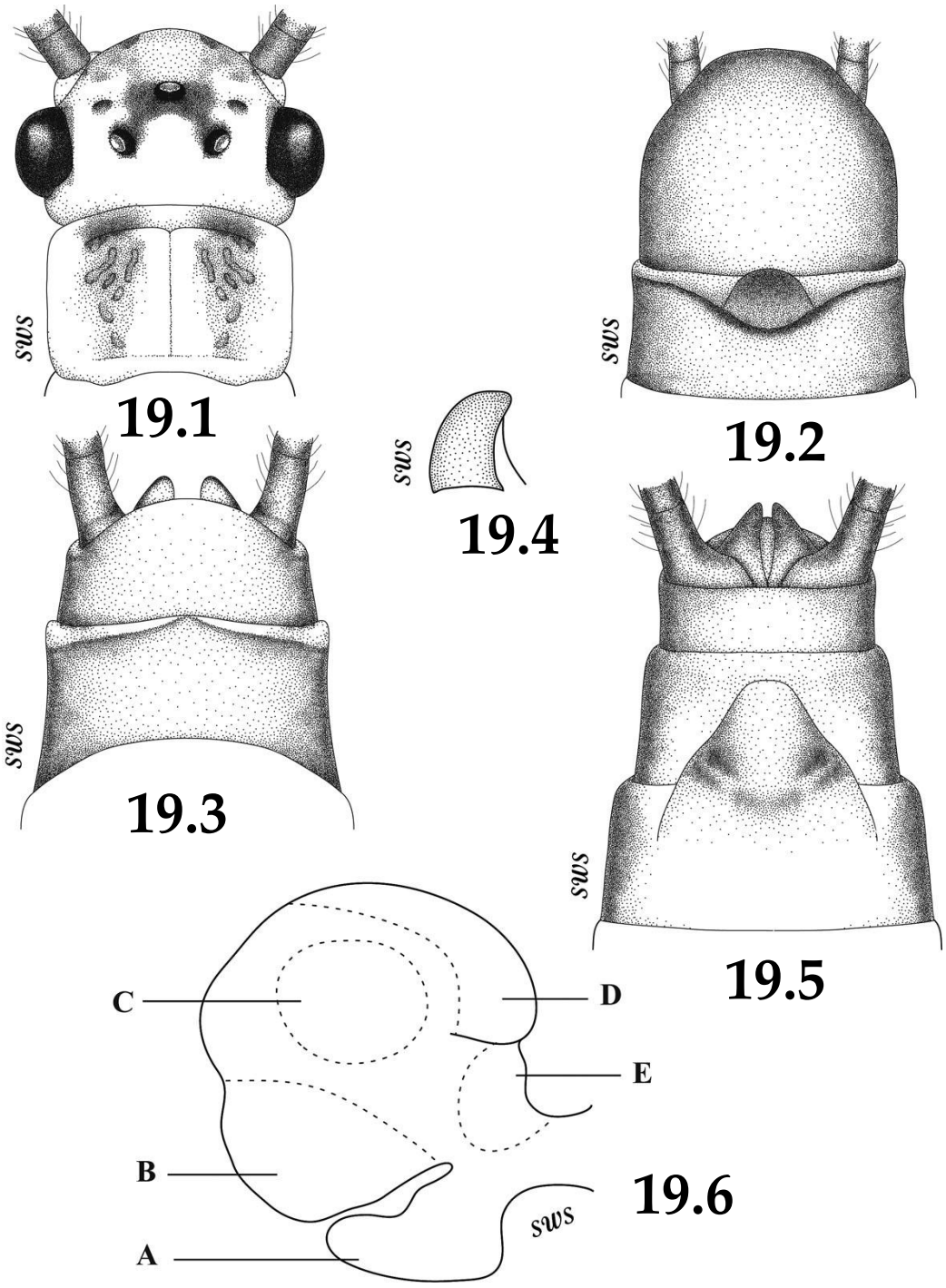
Isoperla frisoni Illies 1966:402. Replacement name.
Isoperla truncata Frison 1937, 21:94. Holotype ♀ (INHS) Namakagon River, Spooner. (Washburn Co.), Wisconsin. Examined. Homonym of Navás, 1918 (Illies, 1966).

Distribution: **CANADA – MB** (Burton 1984), **NB** (Ricker 1947), **NS** (Ricker 1947, Kondratieff and Baumann 1994), **ON** (Harper and Ricker 1994), **PE** (Kondratieff and Baumann 1994), **PQ** (Ricker et al. 1968); **USA – CT** (Hitchcock 1974), **DE** (Lake 1980), **IN** (Frison, 1937, Ricker 1945, Grubbs 2004, DeWalt and Grubbs 2011), **ME** (Mingo 1983), **MI** (Frison 1937, Grubbs and Bright 2001), **MN** (Harden and Mickel 1952, Lager et al. 1979), **NC** (Kondratieff et al. 1995), **PA** (Masteller 1996b), **WI** (Frison 1937, Hilsenhoff and Billmyer 1973).

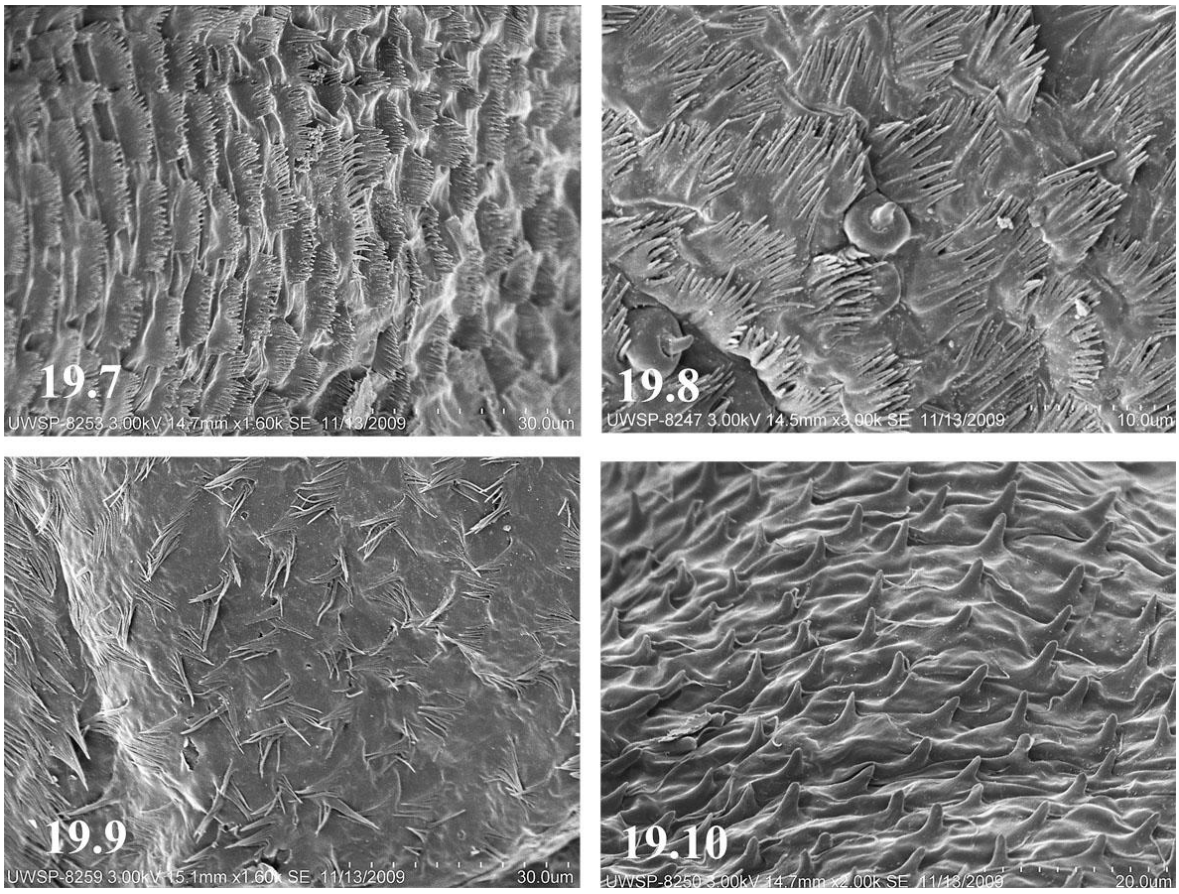
New Records: USA – GA: Cherokee Co, Etowah River, jct. State rd. S 861, 6 ½ mi. ESE Ball Ground, 22-25/VI/1971, W.L. Peters, J.G. Peters, L. Berner, W.M. Beck, M.L. Pescador, 4♂, 1♀ (FAMU). **NY:** Hamilton Co., trib. Marlon River, BLT, Rte. 28 nr. Utowana Lake 43°50.023'N, 074°32.811'W, 29 July 2007, L.W. Myers, 1♂, 14♀ (CSUC). **SC:** Oconee Co., Chattooga River, Hwy 28, 16/VI/1969, A. Douglas, 1♂, 17♀ (USNM). Orangeberg Co., N. Edisto River, Edisto Gardens, 7/IV/1985, B.C. Kondratieff, 1♂ (CSUC). **TN:** Cook Co., Long Branch, Long Branch rd., Cherokee National Forest, 22/V/1994, B.C. Kondratieff, R.F. Kirchner, 1♂, 1♀ (CSUC). **VA:** Giles Co., Sinking Creek, Rte. 42, Newport News, 4/V/1981, B.C. Kondratieff, 1♂ (CSUC). Grayson Co., New River, 3 mi. W Galax, Rte. 94, bridge, 18/V/1994, B.C. Kondratieff, R.F. Kirchner, 4♂, 5♀ (CSUC). Montgomery Co., Little River, Rte. 787, off Rte. 693, 19/V/1979, B.C. Kondratieff, 3♂, 1♀ (CSUC).

Additional Records: CANADA – PQ: Kill Kinney Co., trib. Lac Cromwell, 7/VI/1997, S.W. Szczytko and P. Harper, 12♂, 6♀ (CSUC). **USA – ME:** Somerset Co., Moose River, Demo rd. below Long rd., 12/VI/1993, B.C. Kondratieff, R.W. Baumann, 13♂, 10♀ (CSUC). **VA:** Grayson Co., New River, 3mi W Galax, Rte. 94 bridge, 18/V/1994, B.C. Kondratieff, R.F. Kirchner, 1♂, 1♀ (CSUC).

Male. Macropterous. Forewing length 8.0-9.5 mm. General body color pale yellow or cream in life with medium brown markings. Dorsum of head with dark brown bands connecting ocelli, lateral bands sometimes faint or incomplete, anterior ends near median ocellus truncate, usually with 2 medium brown spots laterad of anterior ocellus (Fig. 19.1). Antennal pedicel pale yellow, scape medium brown, flagellum segments 1-4 pale yellow, flagellum beyond segment 4 medium brown. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities irregular, raised, medium to pale brown, pronotal disks pale yellow, anterior margin with short medium brown bands near disks, posterior and lateral margins pale yellow (Fig. 19.1). Meso- and metanota mostly pale yellow with irregular medium brown U-shaped marking on mesonotum, and medium brown median heart-shaped mark on metanotum in fresh specimens. Wings dusky with medium brown veins. Outer surface of femora and tibia pale yellow with darker dorsal margin, tibia with medium brown proximal band. Tarsi medium brown. Sterna pale yellow, sternum 8 with a well-developed vesicle nearly as wide as long, extending to anterior margin of sternum 9 (Fig. 19.2); terga 1-8 with thin medium brown median longitudinal band, pale lateral brown bands occasionally visible. Paraprocts lightly sclerotized, wide, stout, blunt apically and projecting just to level of tergum 10 (Figs. 19.3, 19.4). Cerci uniformly pale brown. Aedeagus entirely membranous with small stout posterobasal tube-like lobe (Fig. 19.6a), large posteroventral lobe (Fig. 19.6b) and paired anterodorsal lobes (Fig. 19.6d); posteroventral tube-like lobe covered with dense concentration of small scallop-shaped plates with numerous short finger-like apical spines and an occasional sensilla basiconica (Figs. 19.6b, 19.7); mesal section with



Figs. 19.1-19.6. *Isoperla frisoni*. 19.1. Dorsal head and pronotal pattern. 19.2. Male posterior abdominal sterna. 19.3. Male posterior abdominal terga. 19.4. Male paraproct lateral view. 19.5. Female subgenital plate. 19.6. Male aedeagus lateral view; a. posteroventral lobe, b. posteroventral lobe, c. mesal area with large scallop-shaped plates, d. paired anterodorsal lobe, e. anterobasal area with dense patch of short sharp spinulae.



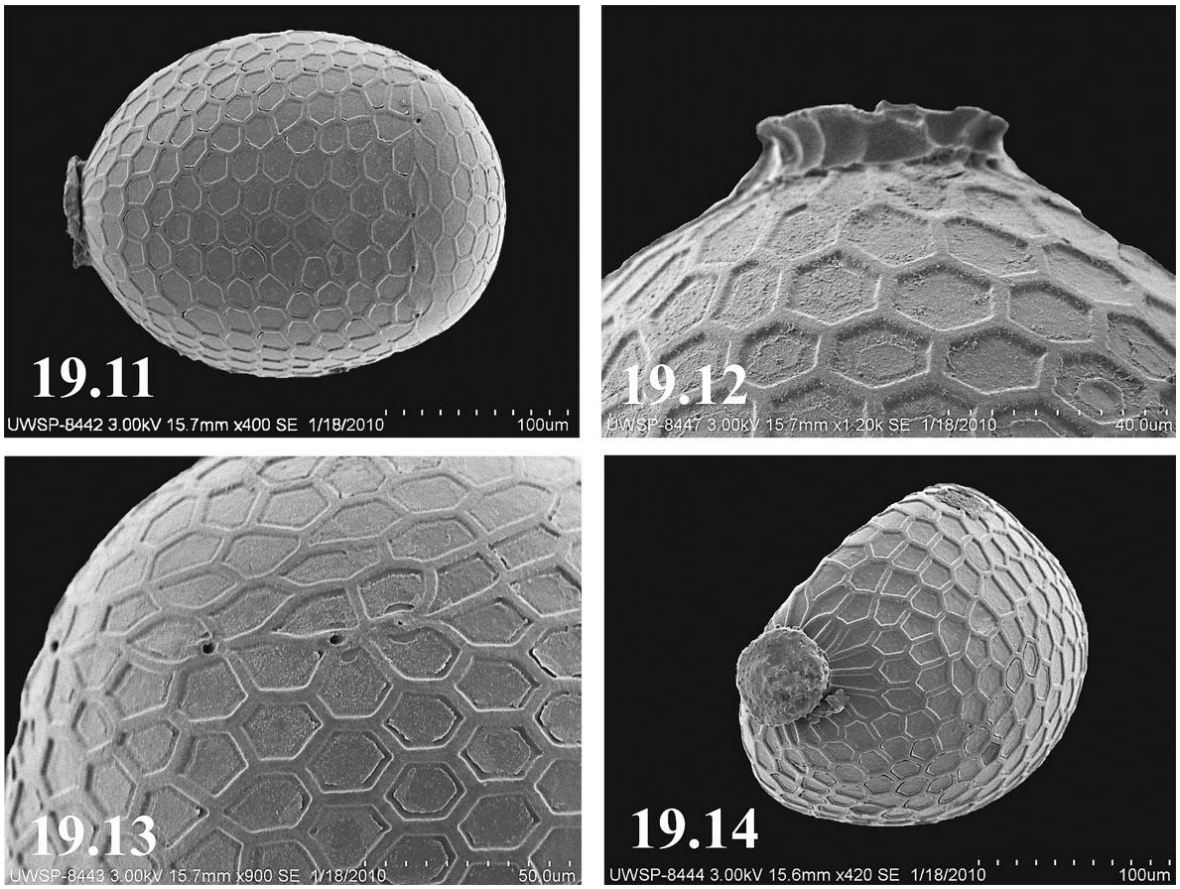
Figs. 19.7-19.10. *Isoperla frisoni*. 19.7. Scallop-shaped plates with short apical finger-like projections. 19.8. Scallop-shaped plates with long apical finger-like projections. 19.9. Scattered rows of fine hair-like spinulae. 19.10. Anterobasal area with dense patch of short, sharp spinulae.

patch of larger scallop-shaped plates with longer apical spines and numerous sensilla basiconica (Figs. 19.6c, 19.8); paired anterodorsal lobes covered with scattered rows of fine hair-like spinulae (Figs. 19.6d, 19.9); anterobasal area with dense patch of short, sharp spinulae (Figs. 19.6e, 19.10).

Female. Forewing length 9.0-12.3 mm. General body color and morphology similar to male described above. Subgenital plate broadly truncate with median posterior nipple; nipple length variable; plate produced posteriorly over ca. ½ length of sternum 9; distal end usually deflected ventrally (Fig. 19.5).

Ovum. General shape oblong, cross section concave (Figs. 19.11, 19.14). Color pale brown. Length 244 μm; width 192 μm. Collar well-developed with raised longitudinal carinae (Figs. 19.11, 19.12). Hexagonal follicle cell impressions well-developed; ridges thickened and elevated, floors flat. Micropyles set on top of FCI ridges singularly in a sinuous row near the anterior pole; poorly developed eclosion line composed of a series of connected follicle cell impression ridges (Fig. 19.13).

Nymph. Mouthparts and habitus were illustrated by Frison (1935) and Hilsenhoff and Billmyer (1973) illustrated the lacinia. Stark et al. (1998) and Stewart and Stark (2002) provide a color photograph of the habitus.



Figs. 19.11-14. *Isoperla frisoni*. 19.11. Egg. 19.12. Detail of egg collar. 19.13. Detail of egg chorion and micropyles. 19.14. Egg oblique lateral view showing concave profile.

Diagnosis. *Isoperla frisoni,* like other *I. bilineata* group species (Table 1), is a small pale-yellow *Isoperla* with dark bands connecting the ocelli forming an inverted V-pattern. The most distinctive morphological feature of *I. frisoni* is the apically truncate female subgenital plate. The male is probably most similar to *I. cotta*, a sympatric species of the *I. burksi* group; *I. frisoni* can be distinguished by the combination of the clypeus and frons lacking a dark brown spot, the paraprocts being weakly sclerotized, wide and bluntly pointed, and the aedeagus lacking paired anterodorsal lobes, but having a stout posterobasal tube-like lobe.

Biological Notes. Harper and Ricker (1994) found *I. frisoni* commonly occurred in both soft water and hard water small trout and warm bass-type streams in Ontario. Harper (1973), Harper and Pilon (1970) and Harper and Magnum (1969) studied the life cycle and growth of *I. frisoni* in Ontario and Quebec and found that it had a univoltine life cycle and a short emergence period (late May to early June). Harper (1973) reported a long adult life span for this univoltine species, and egg hatching required a 45-47 day incubation period that was synchronous (ca. 4 days for 90% hatch of each egg batch).

Ziminske (1989) found that the male drumming call of *I. frisoni* was monophasic and had a mean number of 3.6 ± 0.5 beats and an interbeat frequency of 96.6 ± 9.3 ms. Females did not respond to male calls.

Isoperla gibbsae Harper
Quebec Stripetail
(Figs. 20.1-20.7)

Isoperla gibbsae Harper 1971, 49:685. Holotype ♂ (LEMQ) Rigaud, Comté de Vaudreuil, Québec. Examined.

Distribution: **CANADA – PQ** (Harper 1971); **USA – CT** (Hitchcock 1974).

New Records: USA – MA: Station 22, 24/VI/1959, J.F. Hanson, 2♂, 11♀ (USNM). **NY:** Ulster Co., 21/IV/1967, P.P. Harper, 5♂, 2 N (LEMQ).

Additional Records: USA – CT: Fairfield Co., Aspetuck River, 22/VI/1965, S.W. Hitchcock, 2♀ (USNM); Easton, Sport Hill rd., 14/V/1968, S.W. Hitchcock, 3♂, 3♀ (USNM). Hartford Co., Canton, Avery Brook, 20/V/1960, S.W. Hitchcock, 1♀ (USNM). New Haven Co., 18/VI/1965, S.W. Hitchcock, 1♂, 1♀, 1 N (USNM). New London Co., Experimental Lab, 7/VI/1967, S.W. Hitchcock, 1♂, 1♀, 1 exuvium (USNM); Same locality, 5/VI/1967, S.W. Hitchcock, 3♂, 2♀, 5 exuviae, 1 N (USNM), Same locality, 20/V/1968, S.W. Hitchcock, 1♂, 1♀ (USNM); Same locality, 2/VI/1967, S.W. Hitchcock, 4♀, 2 N (USNM).

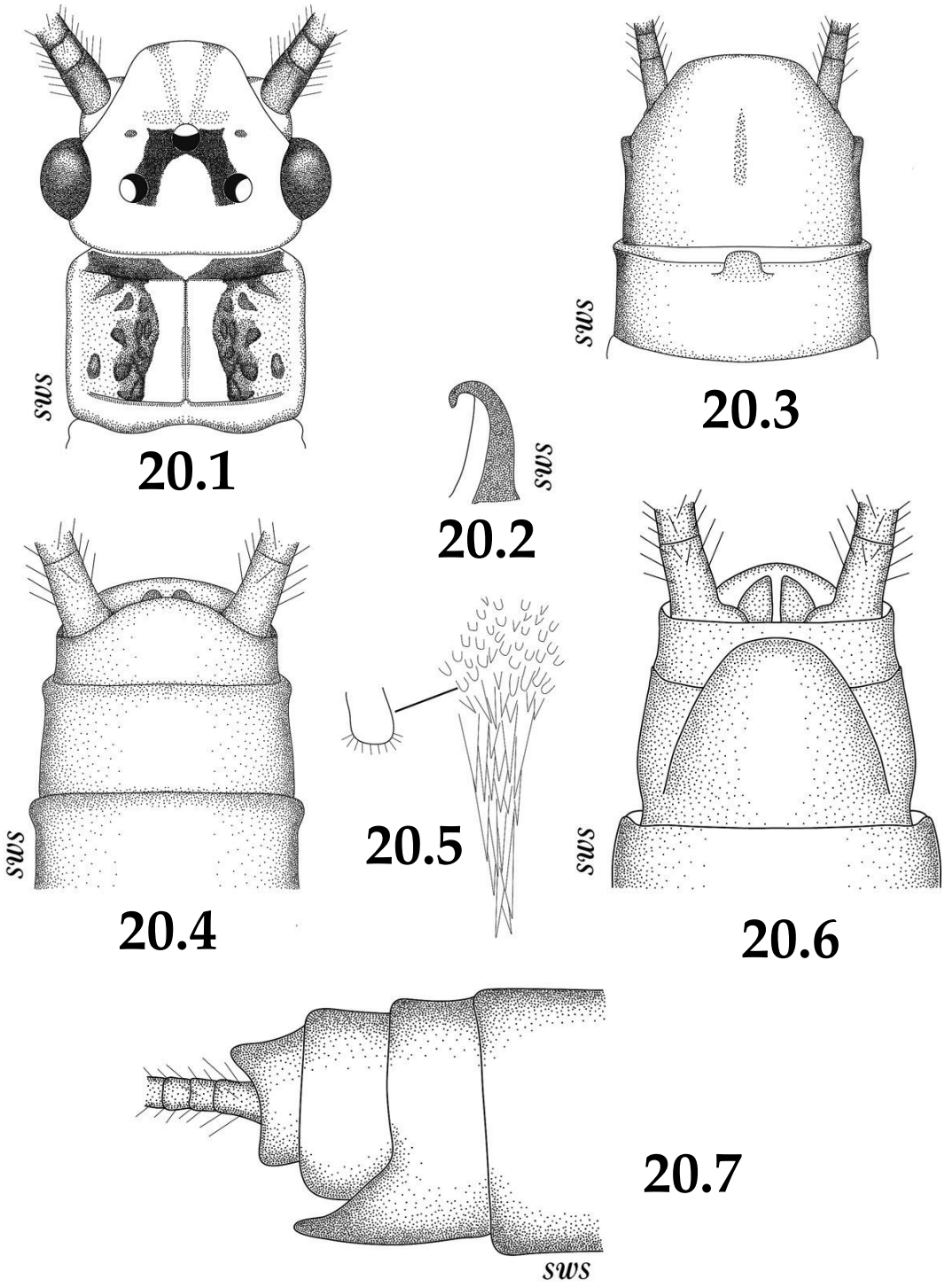
Male. Macropterous. Forewing length 9.1-10.4 mm. General body coloration pale yellow with medium and dark brown markings. Dorsum of head with wide dark brown bands connecting ocelli, truncate anteriorly; interocellar area pale; small medium brown spots lateral to anterolateral margin of dark brown bands connecting ocelli; faint pale brown bands extending from median ocellus to anterior margin of head, expanded laterally near ocellus (Fig. 20.1). Antennal scape pale yellow, pedicel and flagellum medium brown. Pronotum with a median pale slightly hourglass-shaped stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks pale yellow; anterior, margin with thin wide bipartite dark brown band (Fig. 20.1). Meso- and metasterna pale yellow with thin medium brown lateral bands. Mesonotum mostly pale yellow with scattered irregular medium brown markings; metanotum mostly medium brown with pale anteromedian band. Wings hyaline; veins medium brown. Femora pale yellow with faint dorsal pale brown near distal end; tibia pale brown with medium brown proximal band ca. ¼ length of tibia. Sterna pale yellow, sternum 8 with a small vesicle ca. as wide as long; posterior margin evenly rounded, not extending over anterior margin of sternum 9 (Fig. 20.3). Terga pale yellow, terga 9 and 10 unmodified (Fig. 20.4). Paraprocts lightly sclerotized, long, thin, not recurved over tergum 10, broad basally, deflected downward apically and tapering to sharp points (Figs. 20.2, 20.4). Cerci pale yellow. Aedeagus not everted. Cleared aedeagus with a posteromedian band of large stout reddish brown spines (occasionally visible under the exoskeleton of sternum 9) as indicated by Harper (1971) (Fig. 20.3). This posteromedian reddish brown spine patch consists of closely packed spines that become progressively longer apically; spines basally set on short flat-like plates with numerous apical finger-like spines becoming shorter and interspersed with short, stout sharp spines (Fig. 20.5).

Female. Forewing length 10.3-11.2 mm. General body color and morphology similar to male described above. Eighth sternum with a broad elongate semi ovate-shaped subgenital plate, usually extending to near posterior margin of sternum 10 and not deflected ventrally (Figs. 20.6, 20.7).

Ovum. Unknown.

Nymph. Described by Harper (1971).

Diagnosis. *Isoperla gibbsae* is a small pale yellow *Isoperla* with brown markings. It is tentatively placed in the *I. bilineata* group (Table 1), but is most similar in general habitus to *I. francesca,* a sympatric member of the *I. signata* group. No males were available with fully everted aedeagus, but the male *I. gibbsae* differs from *I. francesca* by the presence of a single reddish brown posteromedian aedeagal spine patch (see in comparison of *I. francesca*) and by the shape of and length of the female subgenital plate. The inverted V-pattern connecting the ocelli is truncate anteriorly in both species. The female subgenital plate of *I. gibbsae* is also similar in general shape to *I. burksi, I. orata* and *I. cotta,* but it is not deflected ventrally apically as in these species; the species also differs markedly



Figs. 20.1-20.7. *Isoperla gibbsae*. 20.1. Dorsal head and pronotal pattern. 20.2. Male paraproct lateral. 20.3. Male posterior abdominal sterna. 20.4. Male posterior abdominal terga. 20.5. Detail of male aedeagal posteromedian sclerotized spine plate. 20.6. Female subgenital plate ventral view. 20.7. Female subgenital plate lateral view.

in the shape and spinule patterns of the aedeagus. The brown inverted V-pattern connecting the ocelli around a pale interocellar area is generally similar to *I. bilineata, I. burksi, I. cotta, I. dicala* (not all specimens), *I. orata,* and *I. richardsoni,* however the inverted V-pattern of the head is not truncate anteriorly in all species. Additionally, these species can be separated from *I. gibbsae* by the shape of the female subgenital plate and shape and spinule patterns of the aedeagus. Hitchcock (1974) indicated that *I. gibbsae* is related to *I. bilineata* and has been likely confused with these *I. bilineata*-like species in the literature, especially in the northeastern United States and eastern provinces of Canada. Currently, this species is poorly known and the distribution of *I. gibbsae* may be wider than the above records indicate. The record of *I. gibbsae* from West Virginia (Kirchner 1978) requires verification. Interestingly, no fresh material was available for study despite much recent collecting efforts in northeastern North America, especially New York (Myers et al. 2011) and Atlantic Canada (Kondratieff and Baumann 1994).

Biological Notes. The emergence period of *I. gibbsae* occurs from late April through late June. Nothing is known about the biology or life cycle of this species.

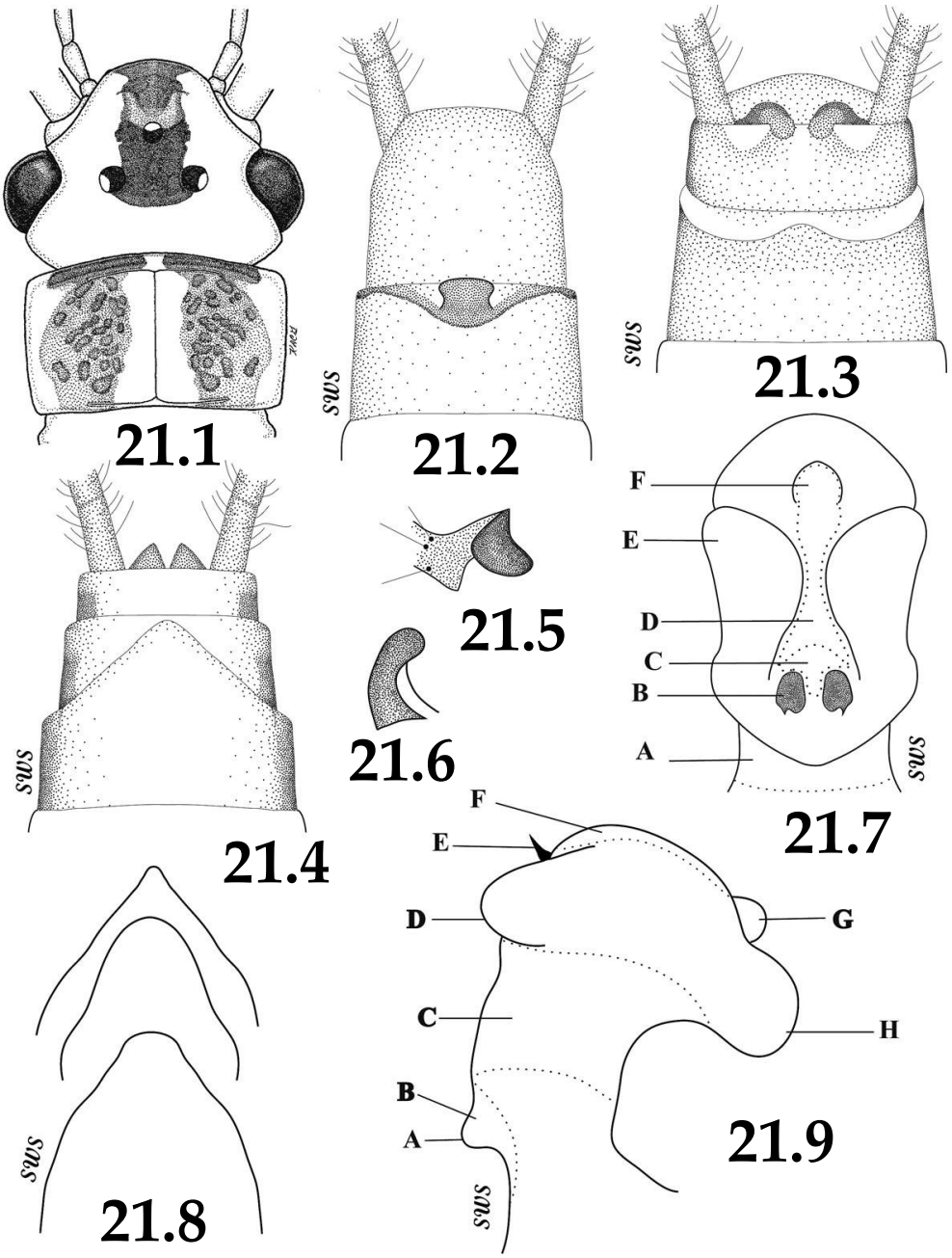
Isoperla holochlora (Klapálek)
Pale Stripetail
(Figs. 21.1-21.22)

Chloroperla holochlora Klapálek 1923, 63:28. Lectotype ♀ (ISNB) Georgia (designated Ricker 1938).
Isoperla holochlora: Frison, 1942, 22:311.

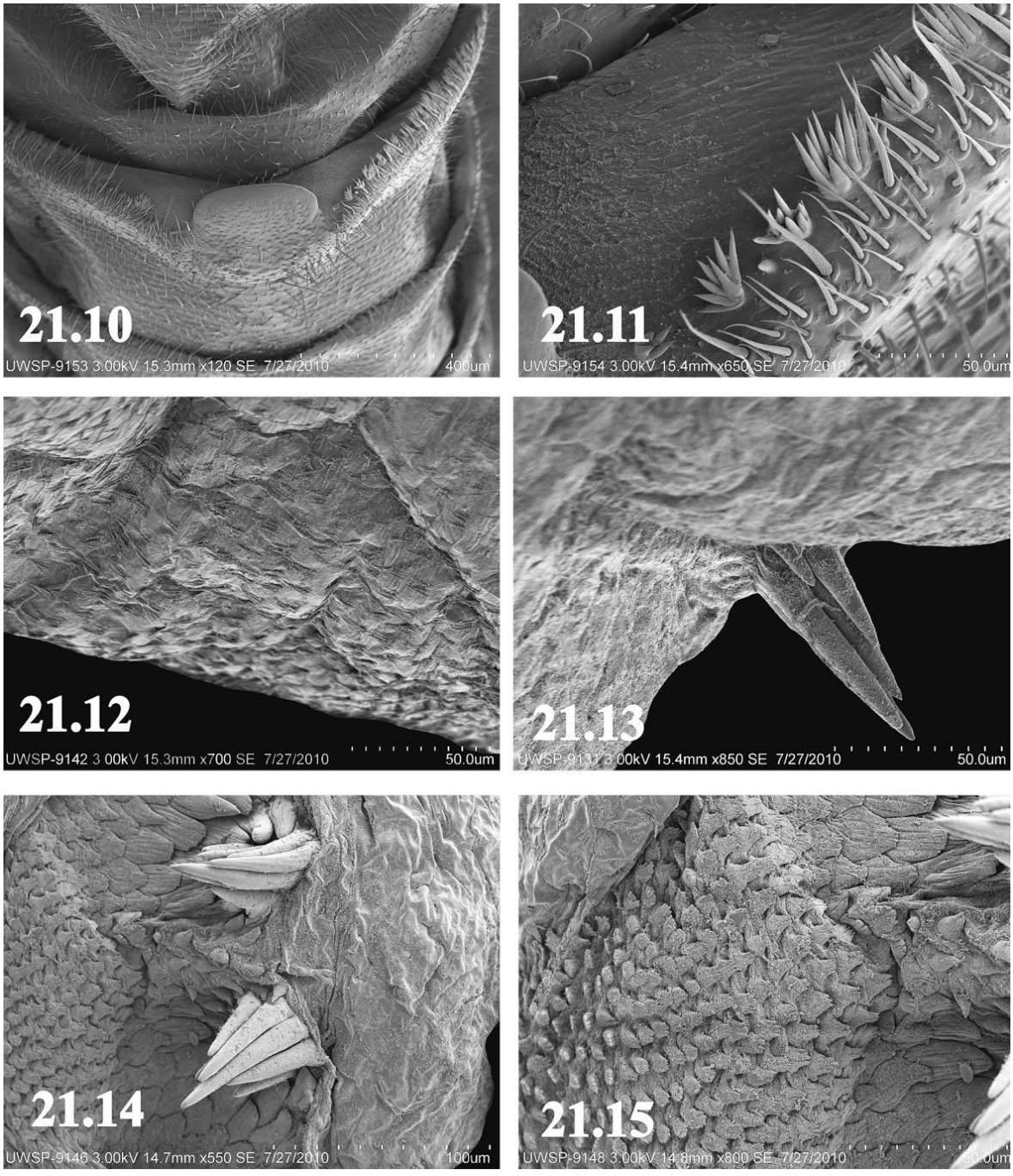
Distribution: **CANADA – NS** (Kondratieff and Baumann 1994); **PQ** (Ricker et al. 1968). **USA – CT** (Hitchcock 1974), **DE** (Lake 1980), **KY** (Tarter and Chaffee 2004, Tarter et al. 2006), **MD** (Duffield and Nelson 1990, Grubbs 1997), **ME** (Frison 1942, Mingo 1983), **NC** (Frison 1942, Kondratieff et al. 1995), **NY** (Frison 1942), **OH** (DeWalt et al. 2012), **PA** (Frison 1942, Surdick and Kim 1976, Grubbs 1996, Masteller 1996b), **SC** (McCaskill and Prins 1968, Kondratieff et al. 1995), **TN** (Frison 1942), **VA** (Frison 1942), (Kondratieff and Kirchner 1987), **WV** (Tarter and Nelson 2006).

New Records: USA – AL: Lee Co., Chewacla Creek, Hwy 26, 26/V/1984, S. Harris, P. Lago, 1♀ (INHS).

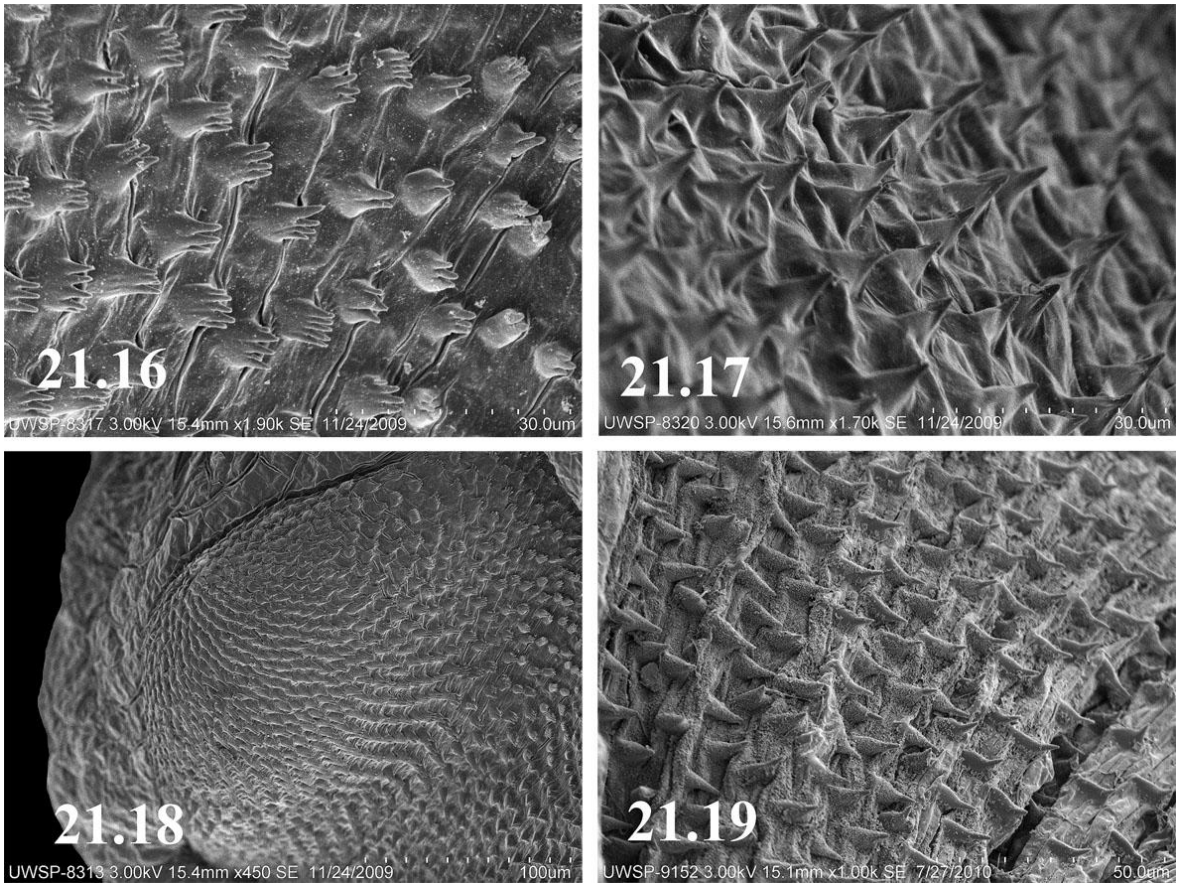
Additional Records: USA – CT: Middlesex Co., Succor Brook, Haddam, 15/VI/1967, S.W. Hitchcock, 1♀ (USNM). **DE:** New Castle Co., Newark , trib. White Clay Creek, 6/VI/1975, R.W. Lake, 2♀ (USNM). **KY:** Rowan Co., Triplett Creek, Rte. 32, 3 mi. SW Morehead, 1/V/1987, B.C. Kondratieff, R.F. Kirchner, 2♂, 1♀, 2 N (CSUC). **NC:** Yancey Co., South Toe River, ¼ mile upstream of Black Mountain Campground, UVL trap, 23/VII/1983, S. Hamilton, R. Holzenthal, J.S. Weaver, H. Malicky, 2♂, 5♀ (BPSC). **NY:** Franklin Co., Oregon Brook, Mud Pond rd., 44.5392N 74.0539W, 15/VIII/2008, L.W. Myers, 1♂, 1♀ (CSUC); trib. Salmon River, jct. CR 27 and Brick Church rd., 44.7563N, 74.2157W, 31/VII/2008, L.W. Myers, C. Binggeli, 3♂, 11♀ (CSUC). Greene Co., Lanesville 412, 42°08'N 74°15 10"W, 16/VIII/1978, T.L. McCabe, 2♂, 3♀ (NYSM); Stony Brook BLT, High Falls rd., Ext., 42°11.041'N, 073°58.309'W. 24/VI/2007, L.W. Myers, B.C. Kondratieff, 2♂, 2♀ (CSUC). Hamilton Co., Payne Brook, Cedar River rd., 43°42.781'N, 074°29.765'W, 14/IX/2007, L.W. Myers, 1♂, 1♀ (CSUC). Saratoga Co., Wolf Creek, CR1, NW Glens Falls, 43.3575N, 73.8783W, 17/VII/2008, L.W. Myers, 1♂ (CSUC). **OH:** Butler Co., Hwy 128, SW of Fairfield, 28/IV/1953, A.R. Gaufin, 4 N (BYUC). **PA:** Cumberland Co., 1 mi W Mt. Holly Springs, 20/VII/1994, J. Earle, 1♂, 1♀ (JEIC). Lane Co., Kleinhaus Creek, Paupack Hills, Cypress Lane, 28/V/1996, B.C. Kondratieff, 1♀ (CSUC). **SC:** Anderson Co., Broadway Creek, Watershed E., trib. Rock Creek, N S4-670, 3-4/V/1980, J.S. Weaver, 19♂, 15♀ (BYUC). Cherokee Co., Long Branch Creek, Kings Mountain Nat. Military Park, 29/V/2006, J. Robinson, 7♂, 1♀ (CSUC). **TN:** Sevier Co., GSMNP, W trib. Porters Creek, 8 km SW of access gate, 35°41.3N, 83°23.6W, Malaise trap, 4/VIII/1999, J. Cooper, 1♂, 1♀ (CSUC); GSMNP, W trib. Porters Creek, 8 km SW of access gate, 35°41.3N, 83°23.6W, Malaise trap, 16/VII/1999, J. Cooper, 6♀ (CSUC); Same locality, 23/VII/1999, J. Cooper, 8♀ (CSUC). **VA:** Floyd Co., Blue Ridge Parkway MP146-0, Site H, 18-19/VII/2007, C.R. Parker, 1♂, 1♀ (CSUC).



Figs. 21.1-21.9. *Isoperla holochlora*. 21.1. Dorsal head and pronotal pattern. 21.2. Male posterior abdominal sterna. 21.3. Male posterior abdominal terga. 21.4. Female subgenital plate. 21.5. Male paraproct dorsal view. 21.6. Male paraproct lateral view. 21.7. Male aedeagus oblique dorsoposterior view; a. basal stalk with small fine hair-like spinulae, b. posterodorsal sclerotized spine plates, c. area of large flat scales, d. patch of concentrated short, stout sharp spinulae, e. paired posterodorsal lobes, f. small dorsal lobe. 21.8. Variations in shape of female subgenital plate. 21.9. Aedeagus lateral view; a. posterobasal nipple, b. fine hair-like spinulae, c. patch of scale-like plates, d. paired posterodorsal lobes, e. paired posterodorsal sclerotized spine patches, f. patch of concentrated short, stout sharp spinulae, g. small dorsal lobe, h. anteromesal lobe.



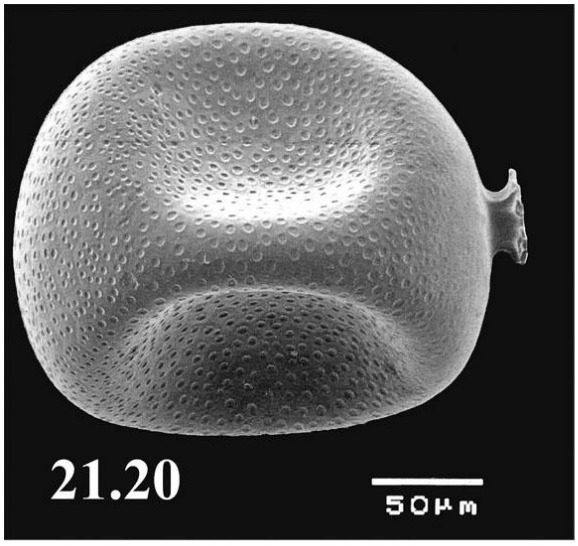
Figs. 21.10-21.15.*Isoperla holochlora*. 21.10. Male vesicle. 21.11. Setal fringe on posterior margin of male 8th sternum. 21.12. Small hair-like spinulae on aedeagal basal stalk. 21.13. Stout long apical spines on aedeagal sclerotized spine plates. 21.14. Detail of stout long apical spines on aedeagal sclerotized spine plates. 21.15. Large flat aedeagal scales.

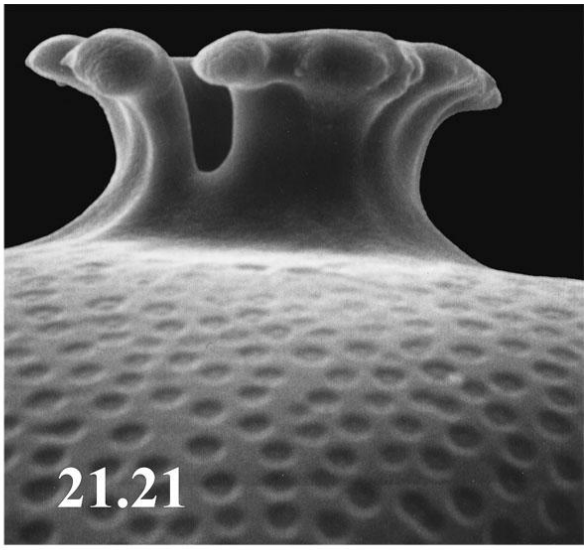


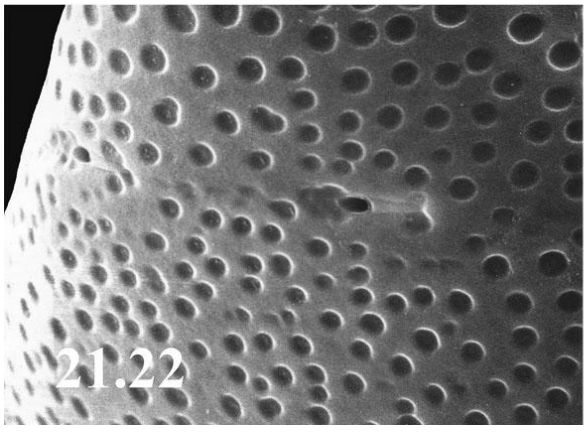
Figs. 21.16-21.19. *Isoperla holochlora*. 21.16. Small scale-like aedeagal plates with fine apical fingers. 21.17. Concentrated short, stout sharp aedeagal spinulae. 21.18. Concentrated short stout spinulae on dorsal aedeagal lobe. 21.19. Large mesal band of short, stout aedeagal spinulae.

Male. Macropterous. Forewing length 9.0-10.2 mm. General body color pale yellow in life with medium to dark brown markings. Dorsal head pattern variable, usually with a broad rectangular dark brown to black patch connecting ocelli and covering interocellar area; occasionally medium brown bands connecting ocelli and interocellar area pale and sometimes with medium brown small rounded patches lateral to median ocellus; U-shaped median, pale brown band anterior to median ocellus, frons usually with a dark brown band extending to anteromedian margin and expanded anteriorly (Fig. 21.1). Antennal scape and pedicel pale yellow, flagellum medium to dark brown. Pronotum with wide median, hourglass-shaped pale stripe; middorsal pronotal suture a thin brown line; rugosities irregular, raised, medium to dark brown in fresh specimens; pronotal disks pale yellow, anterior margin with medium brown band, posterior margin pale brown (Fig. 21.1). Meso- and metanota mostly pale yellow with diffuse medium brown markings. Wing membrane dusky, veins medium brown. Femora, tibia and tarsi mostly pale yellow, tibia with wide medium brown band on proximal ¼. Sterna pale yellow, sternum 8 with a medium brown vesicle, ca. as long as wide, expanded slightly posteriorly and evenly rounded extending to near anterior

margin of sternum 9 (Figs. 21.2, 21.10). Posterior margin of sternum 8 with medium brown band and bearing an inner row of long single setae and an outer row consisting of clumps of 6-11 shorter setae (Fig. 21.11). Terga pale yellow, tergum 9 with a posteromedian protuberance (Fig. 21.3). Paraprocts lightly sclerotized, short, stout, broadly rounded apically, recurved slightly over tergum 10, curved inward apically (Figs. 21.3, 21.5, 21.6). Cerci pale yellow. Aedeagus with small posterobasal nipple covered with fine hair-like spinulae (Figs. 21.9a, b, 21.12); paired posterodorsal lobes with no spinulae (Figs. 21.7e, 21.9d); paired posterodorsal sclerotized plates with large stout spines (Figs. 21.7b, 21.9e, 21.13, 21.14); apical tip of patches with 6-7 stout long spines (Figs. 21.7b, 21.9e, 21.13, 21.14); base of patches with large flat scales, some with finger-like apical extensions (Figs. 21.7c, 21.14, 21.15) which grade into smaller scale-like plates with many fine apical fingers (Figs. 21.7c, 21.16); posterodorsal area above spine plates with band of concentrated short, stout sharp spinulae (Figs. 21.7d, 21.9f, 21.17); small dorsal lobe with concentrated short stout spinulae (Figs. 21.7f, 21.9g, 21.18); mesal area with broad band of short, stout, sharp spinulae (Figs. 21.7a, 21.9c, 21.19) and anteromesal lobe (Fig. 21.9h).







Figs. 21.20-21.22. *Isoperla holochlora*. 21.20. Egg. 21.21. Egg, detail of collar. 21.22. Egg, detail of chorion and micropyles.

Female. Forewing length 10.0-12.2 mm. General body color and morphology similar to male described above. Subgenital plate variable but usually elongate, triangular, produced posteriorly over ca. ¾ length of sternum 9 (Figs. 21.3, 21.8).

Ovum. General shape oblong, cross section triangular. Color pale tan. Length 250 µm; width 195 µm (Fig. 21.20). Collar well-developed with apically flanged rim, stalked with elevated longitudinal carinae, (Figs. 21.20, 21.21). Choronic surface covered with numerous small, shallow punctations; hexagonal follicle cell impressions not visible. Eclosion line absent. Micropyles positioned singularly near anterior ⅓ of egg body; orifices slightly elongate (Fig. 21.22).

Nymph. Mouthparts and habitus were illustrated by Frison (1942).

Diagnosis. As a member of the *I. signata* group (Table 1), *I. holochlora* is similar in general appearance and coloration to numerous pale yellow eastern *Isoperla* with dark brown bands connecting the ocelli and forming an inverted V-pattern. However the broadly rounded, paddle-shaped paraprocts of the male are distinctive as well as the elongate, triangular female subgenital plate, only shared by *I. powhatan* sp. n. of the *I. bilineata* group. The male of *I. holochlora* shares with members of the *I. signata* group, including *I. kirchneri* sp. n., *I. nelsoni* sp. n., *I. namata,* and *I. signata,* the paired posteromedian aedeagal spines that are, however, shorter and of a different shape. Additionally, the overall shape of the aedeagus and spinule patterns are distinctive. The egg is also different in shape and chorionic sculpturing. There is however, considerable variation in the length of the subgenital plate and the color pattern of the head with the interocellar area usually dark brown or black but sometimes with only medium brown bands connecting ocelli and the interocellar area pale even among individuals of the same population. The typical dark brown median band anterior to the median ocellus is also sometimes obscure and pale. The pale yellow head color pattern is suggestive of many other eastern *Isoperla* species including *I. montana, I. bilineata, I. dicala* (dark form), *I. richardsoni*, and others. Ricker (1938) designated a lectotype female from a series of four cotypic specimens in the Musée Royal d'Histoire Naturelle, Brussels, Belgium. He indicated that one of the four cotypes was probably a different species based on size and a differently shaped subgenital plate. He also studied the two male cotypes from Morrison, Georgia and suggested that they were probably the same species as the lectotype female. Frison (1942) studied one of the cotypic males and compared them to material from Tennessee and North Carolina and stated that they were the same species.

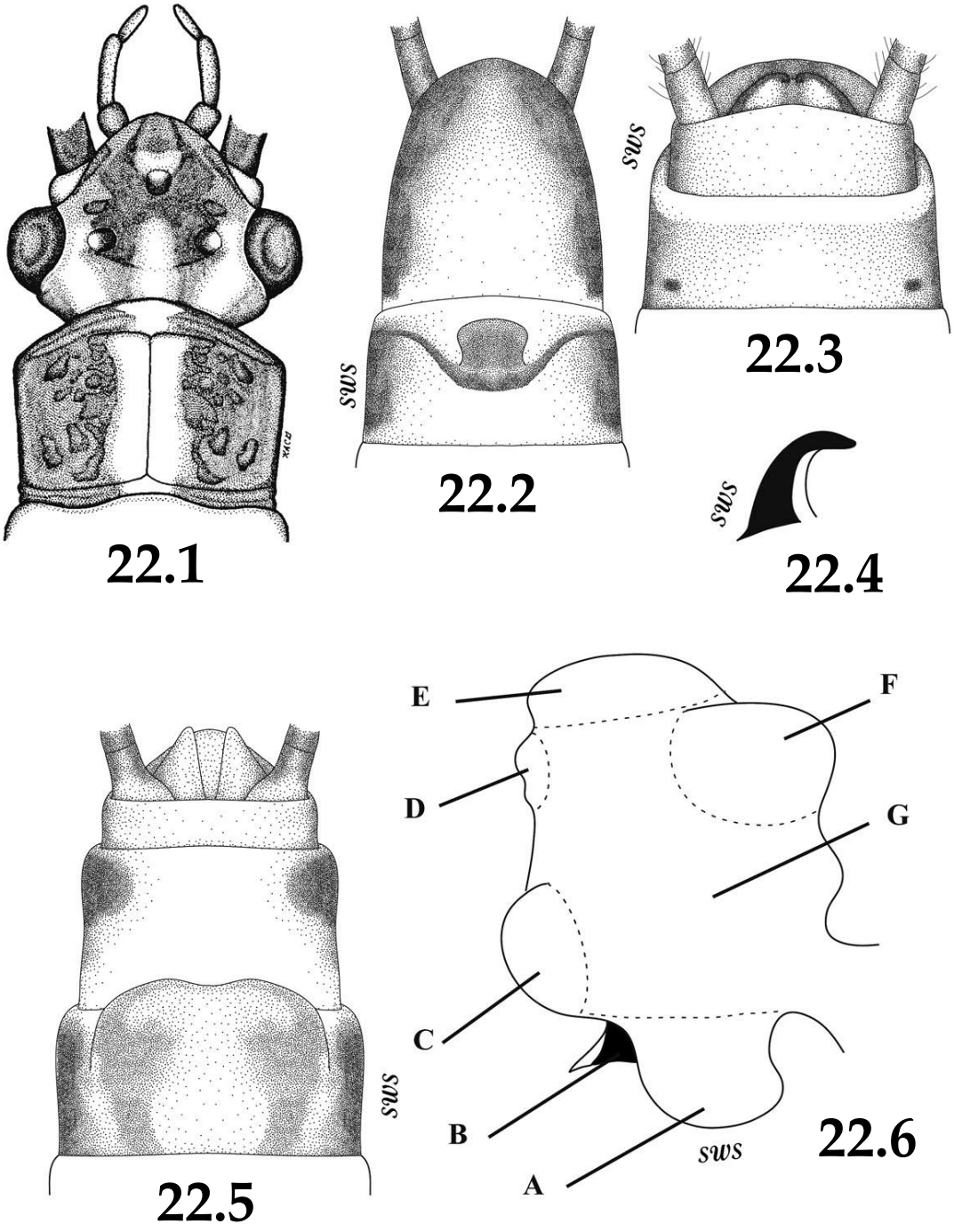
Biological Notes. The primary emergence period generally occurs during mid-June but in rare cases adults can be collected as early as late April (North Carolina) or as late as mid-July (Quebec) (Ricker et al. 1968).

Isoperla irregularis (Klapálek)
Texas Stripetail
(Figs. 22.1-22.15)

Chloroperla irregularis Klapálek 1923, 63:28. Holotype ♀ "Boll", Texas (NHMW). Examined.
Isoperla mohri Frison 1935, 20:455. Holotype ♂ (INHS). Watson (Effingham Co.), Illinois, **New Synonym**, Examined.
Isoperla irregularis: Ricker, 1938, 22:147.
Isoperla mohri: Szczytko and Stewart, 1976:219.
Isoperla mohri: Szczytko and Stewart, 1977, 103:356.
Isoperla mohri: Poulton and Stewart, 1991, 38:48.

Distribution: **USA – AR** (Poulton and Stewart 1991), **IL** (Frison 1935, Poulton and Stewart 1991, DeWalt and Grubbs 2011 as *I. mohri*), **KS** (Stewart and Huggins 1977), **LA** (Stewart et al. 1976), **MO** (Poulton and Stewart 1991), **OK** (Stark and Stewart 1973a, Poulton and Stewart 1991), **TX** (Klapálek 1923, Szczytko and Stewart 1977).

Male. Macropterous. Forewing length 8.6-10.3 mm. General body color yellow to orange in life, pale to medium brown in alcohol with darker brown or black markings. Dorsum of head with dark brown bands connecting anterior ocellus with posterior ocelli; dark brown spots occur laterad to bands above lateral ocelli; interocellar area with round pale spot usually connecting with pale area at posterior margin of head; a pale spot occurs anterior to median ocellus; frontoclypeal area with



Figs. 22.1-22.6. *Isoperla irregularis*. 22.1. Dorsal head and pronotal pattern. 22.2. Male posterior abdominal sterna. 22.3. Male posterior abdominal terga. 22.4. Male paraproct lateral view. 22.5. Female subgenital plate. 22.6. Male aedeagus; a. posteroventral lobe, b. posteromedial sclerotized spine, c. paired posteromedial lobe, d. concentrated patch of thin, hair-like spinulae, e. dorsal lobe, f. anterodorsal lobe, g. large area of small nubs.

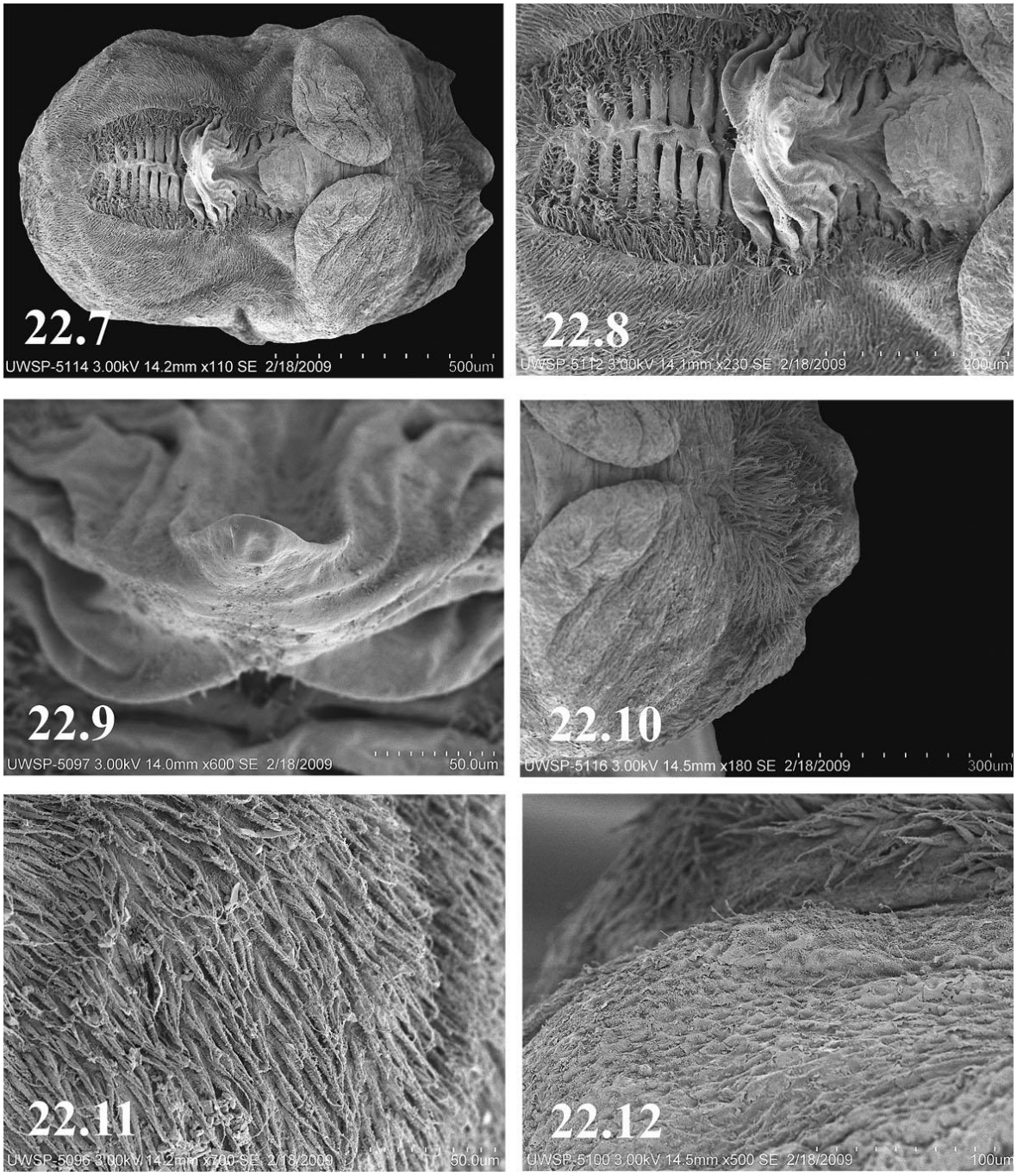
broad dark brown band enclosing pale spot; dark brown lateral bands below eyes extending to posteroventral margin of head (Fig. 22.1). Antennal scape, pedicel and flagellum dark brown to black. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities irregular, raised, dark brown to black; pronotal disks medium brown, anterior, posterior and lateral margins medium brown (Fig. 22.1). Meso- and metanota mostly medium brown with narrow pale longitudinal stripe and irregularly shaped posteromedian pale spots. Wings dusky with dark brown veins. Legs medium brown, dorsal surface of femora and tibiae darker, small callus at femora base, tibia with dark narrow vertical band near proximal end. Sterna pale yellow in alcohol and yellowish orange in life, pleura dark brown; 8 rows (2 median and 3 each laterally) of small dark longitudinal spots on segments 1-8; sternum 8 with dark brown well-developed vesicle set in a U-shaped depression; vesicle ca. 1.5X long as wide, expanded posteriorly, constricted near mid-length and extending to near anterior margin of sternum 9 (Fig. 22.2). Terga pale yellow in alcohol to yellowish orange in life; 8 rows (2 median and 3 each laterally) of small dark longitudinal spots on segments 1-9. Paraprocts heavily sclerotized, sharply pointed apically extending slightly over level of tergum 10 (Figs. 22.3, 22.4). Cerci dark brown to black. Aedeagus with irregular shaped posteroventral lobe (Fig. 22.6a); large tab-shaped, paired posteromedial lobes (Fig. 22.6c); large dorsal lobe (Fig. 22.6e) and paired anterodorsal lobes (Fig. 22.6f); large stout, upturned posteromedial sclerotized spine with horizontal sclerotized bars (Figs. 22.6b, 22.7, 22.8, 22.9); posteromedial area surrounding spine with large vertical indented sclerotized structure consisting of 8 horizontal bars above spine and 8 larger horizontal bars below spine; lateral bars connected by vertical median sclerotized rod, dorsal membranous tongue-shaped lobe extending over apical end of sclerotized structure partially covering the first 3 lateral bars (Figs. 22.7, 22.8); lateral edges of horizontal bars with dense overlapping concentration of very long thin hair-like spinulae; long, thin hair-like spinulae covering posteroventral lobe and extending dorsally to base of paired posteromedial lobes and entire mesal area (Figs. 22.7, 22.8); paired tab-like posteromedial lobes, dorsal lobe and anterodorsal lobes covered with small low nubs and occasional long fine spinulae (Figs. 22.6e, 22.6f, 22.12); base of dorsal lobe with large, dense patch of long thin hair-like spinulae (Figs. 22.6d, 22.11); remainder of aedeagus covered with small nubs (Fig. 22.6g).

Female. Forewing length 10.1-12.1 mm. General body color and morphology similar to male described above. Subgenital plate produced posteriorly over ¼ length of sternum 9, usually with irregular dark brown vertical bands near margins of subgenital plate; plate rounded posteriorly usually with a wide shallow emargination; posterolateral corners of sternum 9 with large dark brown spots (Fig. 22.5).

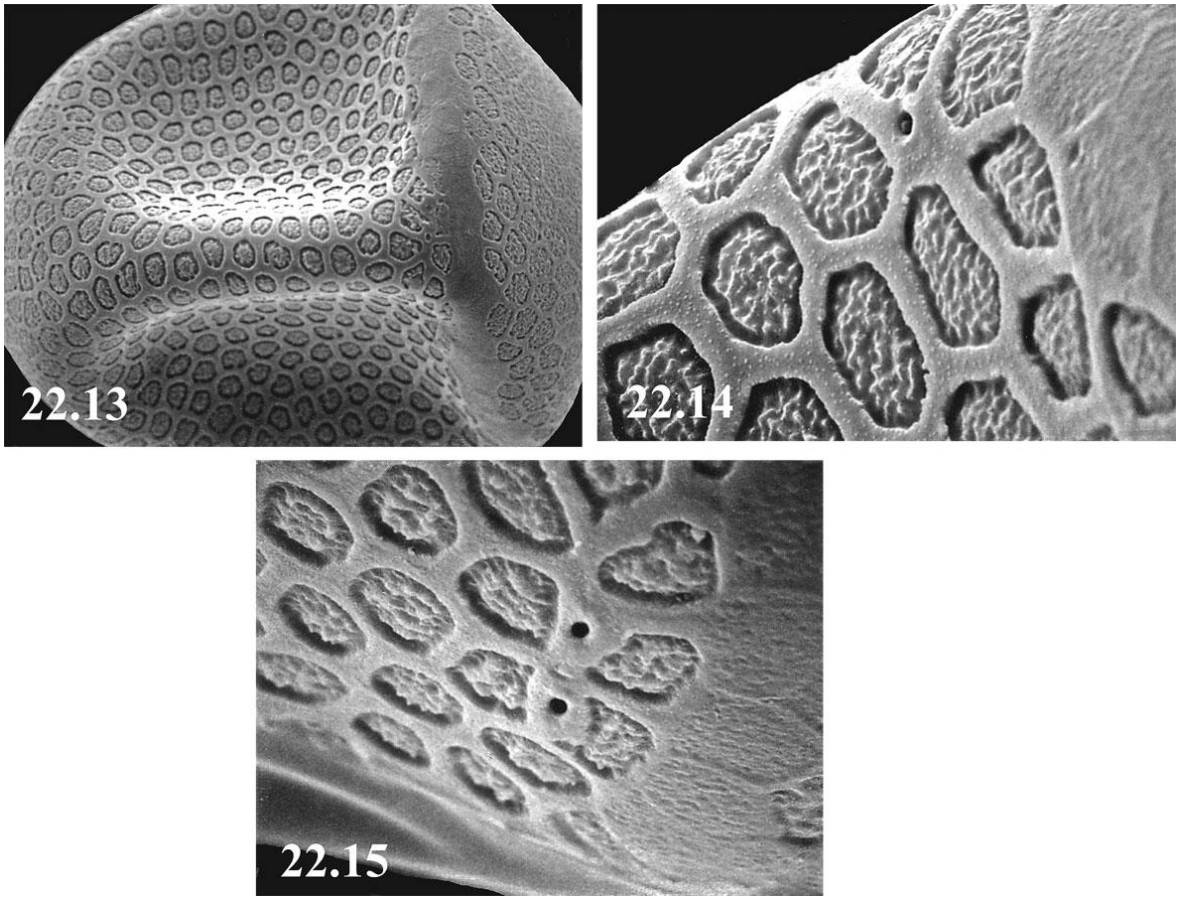
Ovum. General shape oblong, cross section triangular with median raised ridge (Fig. 22.13). Color pale brown. Length 310 μm; width 250 μm. Collar absent, eclosion line well-developed near anterior ⅓ of egg body, wide and elevated (Figs. 22.14, 22.15). Hexagonal follicle cell impressions well-developed, ridges thickened and elevated, floors with small shallow pits. Micropyles set on top of FCI ridges singularly or in pairs adjacent to eclosion line (Figs. 22.14, 22.15).

Nymph. Mouthparts and habitus illustrated by Frison (1935). Poulton and Stewart (1991) illustrated the head color pattern, lacinia and abdominal terga.

Diagnosis. The *I. irregularis* group (Table 1), consists of *I. irregularis* and three other sympatric species, *I. decepta, I. ouachita,* and *I. szczytkoi*. This grouping is supported by a shared, concave egg with no collar, nymphal lacinia with reduced or absent subapical tooth and marginal lacinial setae continuing to near the lacinial base, and a deeply cleft right mandible with two or three apical teeth. The most distinctive feature of *I. irregularis* used to distinguish the male from males of the above three species, is the posteromedian indented aedeagal sclerite armed with horizontal rods and a large upturned spine. The female can be separated by the shape of the subgenital plate, head pattern and the shape and chorionic sculpturing of the egg.



Figs. 22.7-22.12. *Isoperla irregularis*. 22.7. Male aedeagus lateral view. 22.8. Detail of posterior aedeagal spine plate with upturned spine and sclerotized horizontal bars. 22.9. Detail of apical view of sclerotized upturned aedeagal spine. 22.10. Spinulae pattern on paired posteromedial lobe. 22.11. Dense patch of long thin hair-like aedeagal spinulae. 22.12. Detail of small nubs on dorsal and anterodorsal aedeagal lobes.



Figs. 22.13-22.15. *Isoperla irregularis*. 22.13. Egg. 22.14. Detail of egg chorion. 22.15. Detail of egg micropyles.

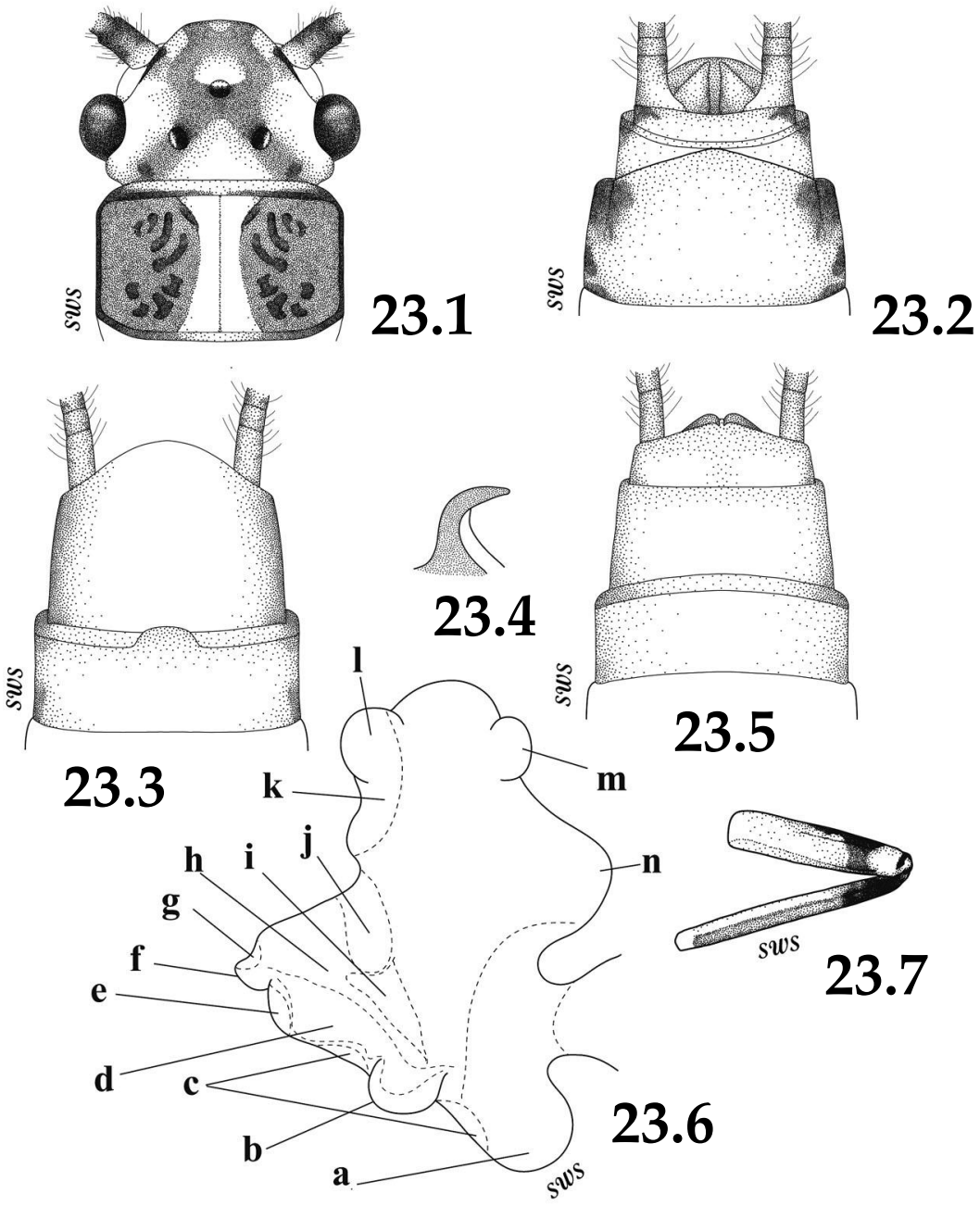
This species has been reported from numerous watersheds of the Ozarks of Arkansas, Missouri, and Oklahoma (Poulton and Stewart 1991). No recent material from Texas was available for study. The examination of the types of *Chloroperla irregularis* and *I. mohri* Frison indicated the above synonymy.

Biological Notes. Poulton and Stewart (1991) reported that nymphs of *I. irregularis* (as *I. mohri*) occurred in intermittent Arkansas and Oklahoma streams that are dry during the summer. Additionally, the food habits of the nymph changed from omnivory to carnivory during development (Feminella and Stewart 1986). Emergence occurs between mid-March through April based on collection records. Stewart et al. (1988) found that the male drumming call was monophasic with 1-17 beats (mean 7.3 ± 4.4 beats) and had a beat interval of 352.8 ± 34.7 ms.

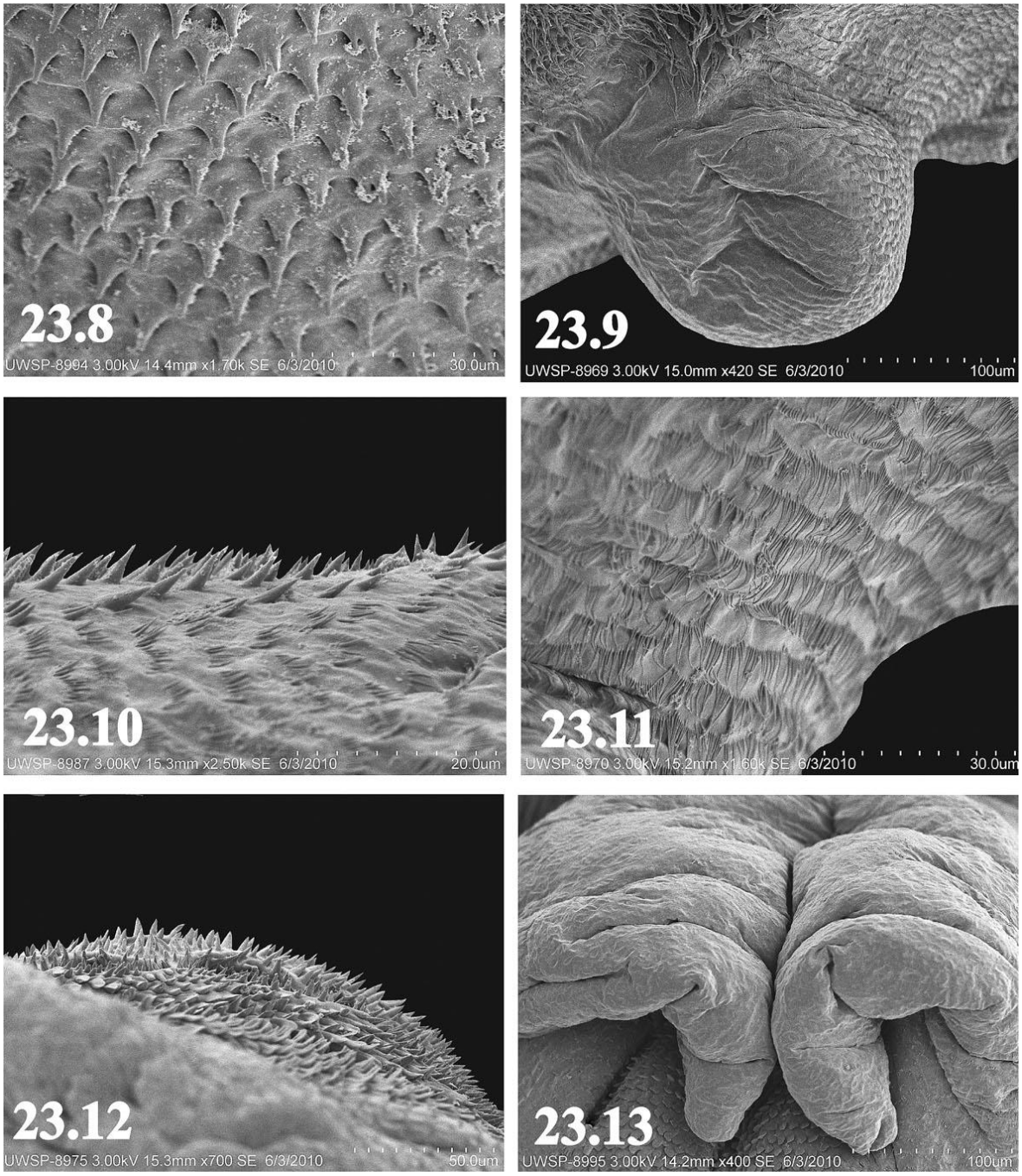
Isoperla jamesae Grubbs & Szczytko
Natchez Trace Stripetail
(Figs. 23.1-23.23)

Isoperla jamesae Grubbs and Szczytko 2010, 6:241-247. Holotype ♂ (USNM) North Fork Cypress Creek (Lauderdale Co.) Alabama. Examined.

Distribution: **USA- AL** (Grubbs and Szczytko 2010), **MS** (Grubbs and Szczytko 2010).



Figs. 23.1-23.7. *Isoperla jamesae*. 23.1. Dorsal head and pronotal pattern. 23.2. Female subgenital plate. 23.3. Male posterior abdominal sterna. 23.4. Male paraproct lateral view. 23.5. Male posterior abdominal terga. 23.6. Male aedeagus lateral view; a. patch of small sharp stout spinulae, b. dense rows of long hair-like spinulae, c. patch of dense stout spinulae, d. patch of small fine spinulae, e. dense patch of concentrated stout sharp spinulae below paired posteromedian finger-like lobes, f. paired posteromedian finger-like lobes, g. patch of flat scales, h. patch of sharp stout spinulae, i. patch of slender long hair-like spinulae, j. patch of concentrated stout spinulae with apical long hairs, k. dense patch of short stout, blunt spinulae, l. paired posterodorsal lobe, m. paired anterodorsal lobe, n. anteromedian lobe. 23.7. Outer surface of right hind leg.



Figs. 23.8-23.13. *Isoperla jamesae*. 23.8. Basal patch of small sharp, stout aedeagal spinulae. 23.9. Paired aedeagal posteroventral lobe. 23.10. Stout sharp aedeagal spinulae above and below posteroventral lobes. 23.11. Dense rows of long hair-like aedeagal spinulae. 23.12. Patch of dense stout sharp aedeagal spinulae below paired posteromedian finger-like lobes. 23.13. Detail of paired posteromedian aedeagal lobes.

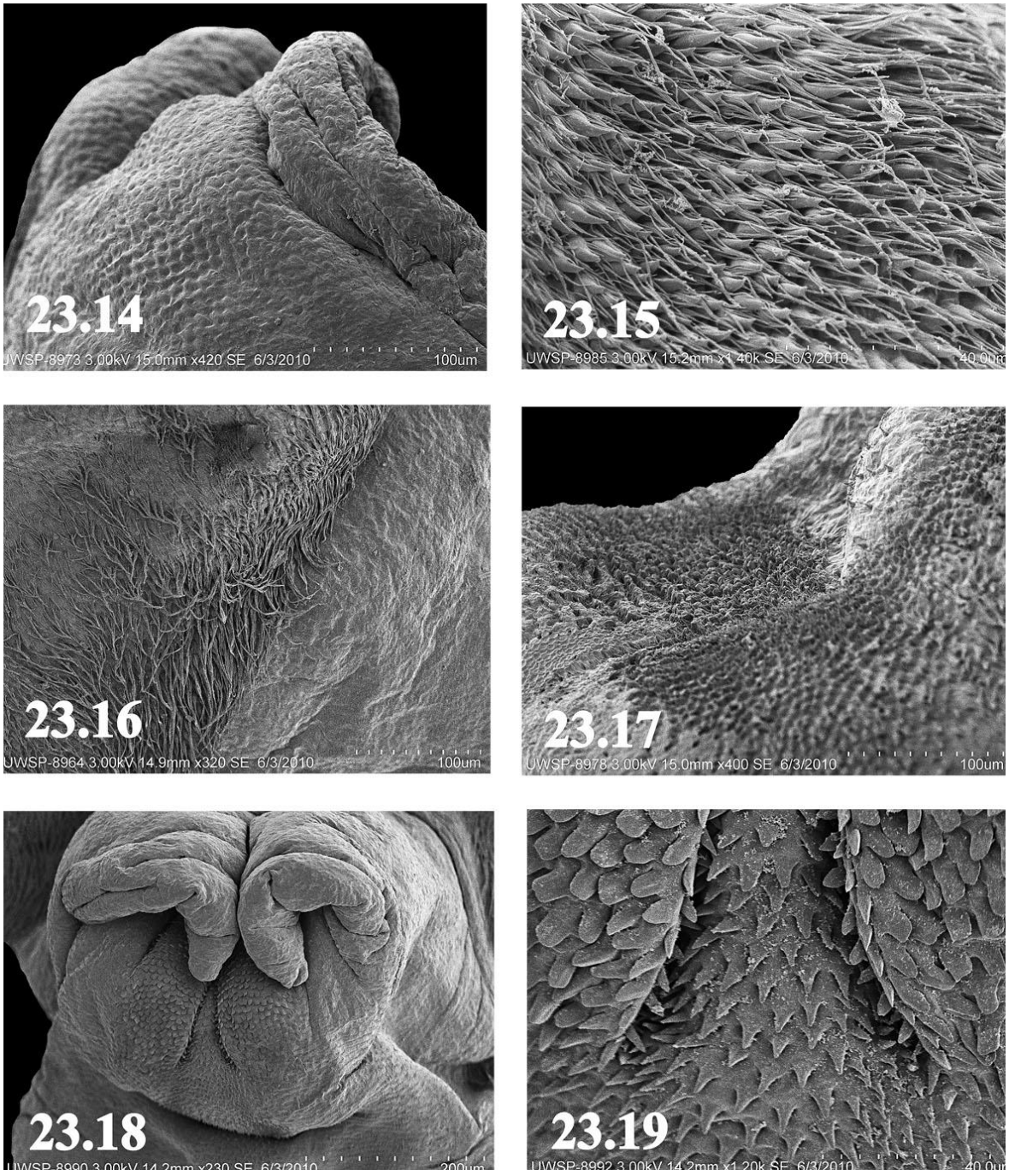
Male. Macropterous. Forewing length 7.0-8.0 mm. General body color pale brown with dark brown markings. Dorsum of head with diffuse wide medium brown bands connecting ocelli and extending to posterior margin of head, terminating in two darker brown spots; interocellar area mostly dark usually with a faint, thin median pale line, occasionally completely dark; thin medium brown bands extending anteriorly and deflected inward from median ocellus; bands wider on frons (Fig. 23.1). Antennae and scape dark brown, flagellum medium brown. Pronotum with wide median pale stripe; disks medium brown, rugosities darker, thick and rounded; anterior margin dark brown, lateral margins medium brown (Fig. 23.1). Meso- and metanota medium brown with irregular darker markings. Wings pale, veins dark brown. Outer surface of femora pale brown, with wide dark brown band near distal end (Fig. 23.7); numerous small stout setae and occasional longer setae on outer surface; outer surface of tibia medium brown with dark brown dorsal band proximally (Fig. 23.7); surface with numerous small stout setae and occasional longer setae. Sterna pale brown; sternum 8 with a small, weakly sclerotized, low vesicle extending posteriorly to anterior margin of sternum 9; vesicle ca. 3X as broad as long (Fig. 23.3). Terga pale brown; lateral and dorsal patches of bright red pigmentation on segments 1-7 in fresh material. Tenth tergum weakly sclerotized medially; paraprocts weakly sclerotized, bluntly pointed apically, produced forward only to level of tergum 10 (Figs. 23.4, 23.5). Aedeagus membranous with large basal posterior lobe (Fig. 23.6a), paired posteroventral lobes (Fig. 23.6b), paired posteromedian finger-like lobes (Figs. 23.6f, 23.13, 23.18), paired posterodorsal lobes (Fig. 23.6l), paired anterodorsal lobes (Fig. 23.6m) and large anteromedian lobe (Fig. 23.6n). Large posterobasal lobe and basomedian section of aedeagus covered with small, stout sharp spinulae (Figs. 23.6a, 23.8); paired posteroventral lobes and inner posterior margin covered with dense rows of long hair-like spinulae (Figs. 23.6b, 23.9, 23.11); posterior margin above and below posteroventral lobes with patch of stout spinulae (Figs. 23.6c, 23.10); area between paired anteromedian and posteroventral lobes with patch of small fine spinulae (Fig. 23.6d); paired anteromedian lobes finger-like, deflected ventrally at apex and curved outward at tips (Fig. 23.6f); medial patch of sharp stout spinulae above and below lobes (Fig. 23.6h); lateral patches of stout spatula-shaped scales lateral to medial patch of sharp stout spinulae (Figs. 23.6h, 23.18, 23.19); dense patch of stout, sharp spinulae below paired posteromedian finger-like lobes (Figs. 23.6e, 23.12); patch of flat scales above posteromedian finger-like lobes (Figs. 23.6g, 23.14); patch of dense stout spinulae with apical long hairs above scale patch extending from posterior margin medially to near level of paired posteromedian finger-like lobes (Figs. 23.6j, 23.16); patch of slender long hair-like spinulae extending below spinulae with apical long hairs to near base of posteroventral paired lobes (Figs. 23.6i, 23.15); patch of short stout spinulae extending from above paired posteromedian lobes to base of paired posteroventral lobes (Fig. 23.6h); dense patch of short stout, blunt spinulae on posteroapical area near posterodorsal lobe (Figs. 23.6k, 23.17).

Female. Macropterous. Forewing length 8.0-9.0 mm. General body coloration, head and pronotal pigmentation patterns similar to male described above, however without abdominal red coloration. Subgenital plate broadly triangular (sometimes rounded apically), 5.6X as wide as long, produced to near posterior margin of sternum 9 (Fig. 23.2).

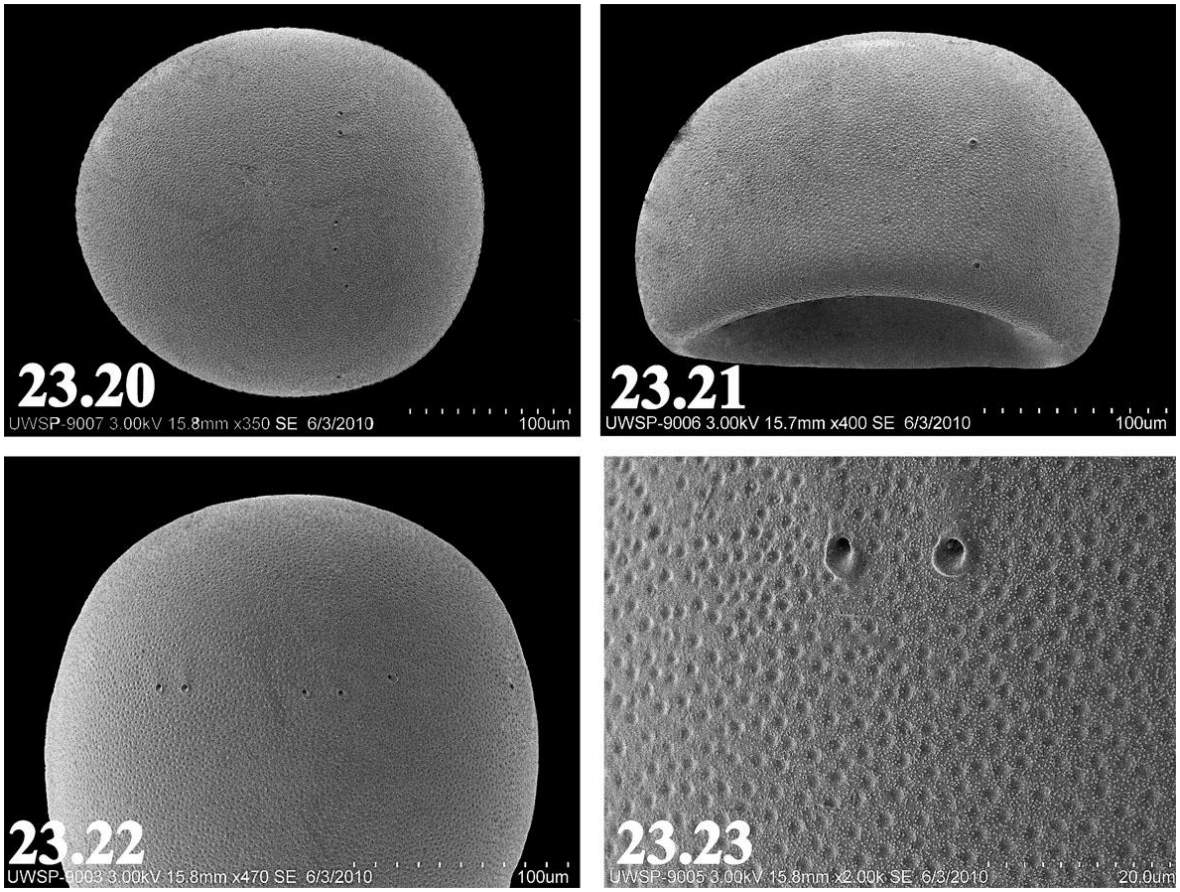
Ovum. General shape nearly spherical, cross section concave, collar absent (Figs. 23.20, 23.21). Color pale brown. Length 254 μm, width 228 μm. Chorionic surface covered with numerous small, shallow punctations; eclosion line, hexagonal follicle cell impressions and ridges absent (Figs. 23.20, 23.21, 23.22). Micropyles positioned near anterior ⅓ of egg body in a row of 6-8; orifices with thickened flared ridges (Figs. 23.22, 23.23).

Nymph. Unknown.

Diagnosis. *Isoperla jamesae* males can be distinguished from other eastern species of *Isopela*, especially those of similar sympatric species such as *I. davisi*, by the unique shape, spinule patterns and unusual finger-like lobes of the entirely membranous aedeagus. Females can be separated from other known eastern *Isoperla* by the



Figs. 23.14-23.19. *Isoperla jamesae*. 23.14. Patch of flat scales above posteromedian aedeagal lobes. 23.15. Patch of slender long hair-like aedeagal spinulae. 23.16. Dense aedeagal spinulae with apical long hairs. 23.17. Dense patch of short stout, blunt aedeagal spinulae. 23.18. Posterior view of paired posteromedian aedeagal lobes. 23.19. Detail of stout spatula-shaped scales and medial patch of sharp spinulae below paired posteromedian finger like lobes.



Figs. 23.20-23.23. *Isoperla jamesae*. 23.20. Egg. 23.21. Egg, lateral view showing concave profile. 23.22. Egg, posterior end. 23.23. Egg, detail of chorion and micropyles.

distinctive color pattern of the head with dark brown bands extending from the median ocellus to the frons. The egg lacks a collar, having a nearly round and concave shape and no follicle cell impressions or ridges visible. At present, *I. jamesae* is not included in a species group.

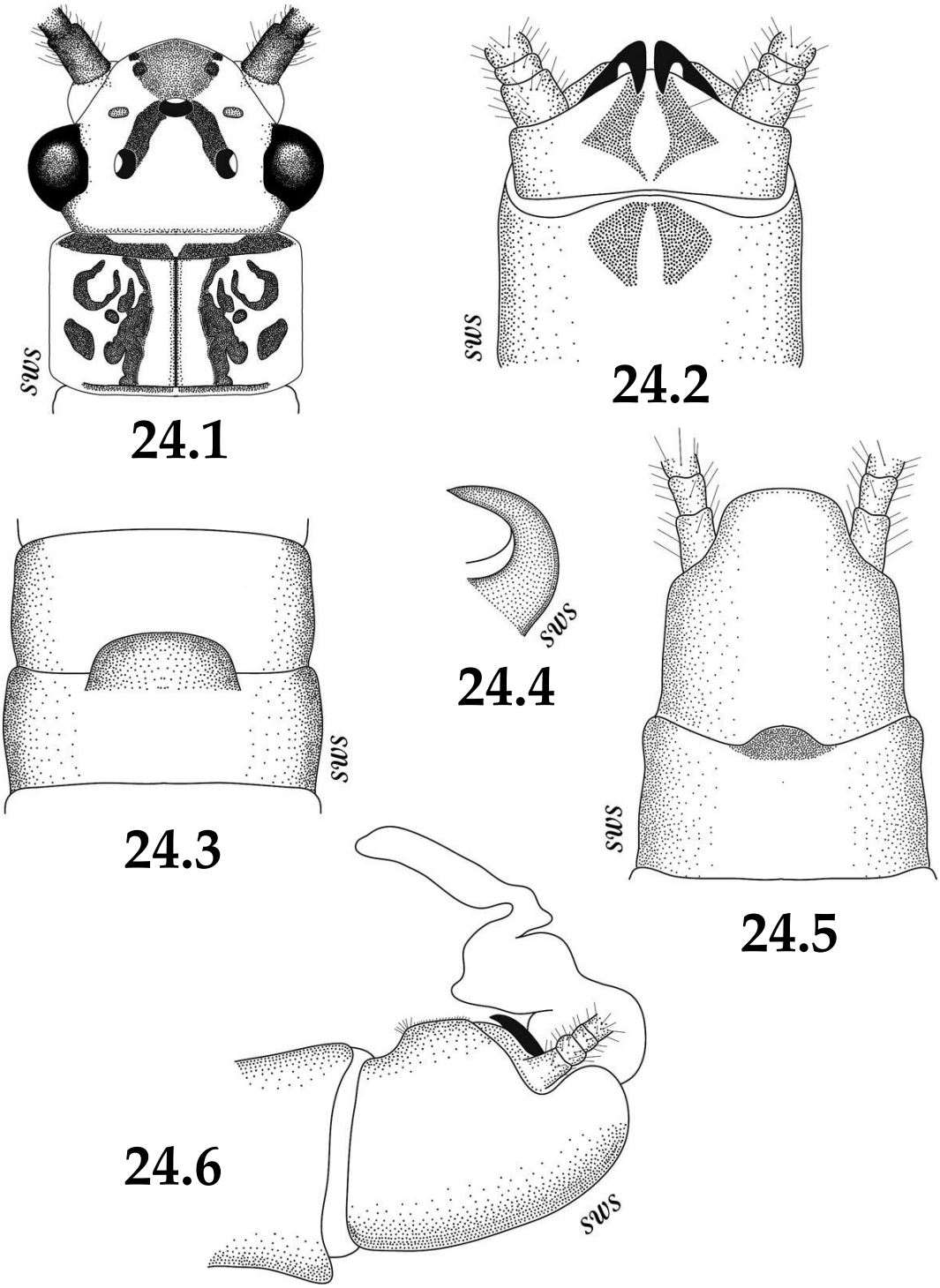
Biological Notes. The type locality is a small, upland stream draining a combination of forested and agricultural lands. *Isoperla jamesae* emerges from mid April through mid-May (Grubbs and Szczytko 2010). *Amphinemura alabama* Baumann 1996, *A. nigritta* (Provancher 1876), *Leuctra rickeri* James 1976, *Alloperla caudata* Frison 1934, and *Haploperla brevis* (Banks 1895) were other stonefly species collected at the type locality with *I. jamesae*.

Isoperla jewetti Szczytko and Stewart
Grande Stripetail
(Figs. 24.1-24.9)

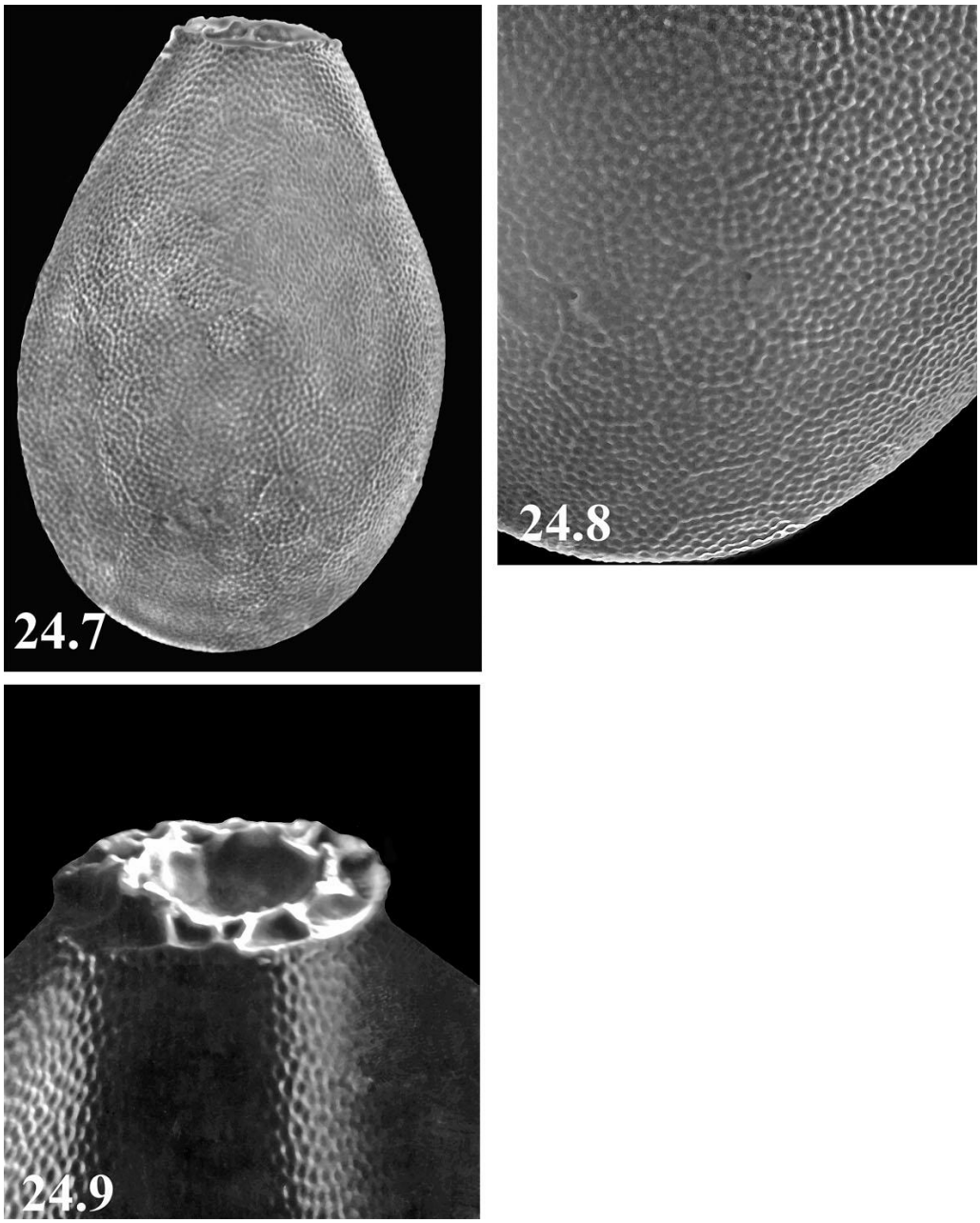
Isoperla longiseta Frison, 1942, 22:318. In part.
Isoperla jewetti: Szczytko and Stewart, 1976, 36:215. Holotype ♂ (INHS) Marathon (El Paso Co.), Texas. Examined.
Isoperla jewetti: Szczytko and Stewart, 1977, 103:355.

Distribution: **USA – CO** (Szczytko and Stewart 1979a), **TX** (Szczytko and Stewart 1977, Szczytko and Stewart 1979a).

Male. Brachypterous. Forewing length 2.8- 3.0 mm. General body pale yellowish brown with dark



Figs. 24.1-24.6. *Isoperla jewetti*. 24.1. Dorsal head and pronotal pattern. 24.2. Male posterior abdominal terga. 24.3. Female subgenital plate. 24.4. Male paraproct lateral view. 24.5. Male posterior abdominal sterna. 24.6. Lateral view male aedeagus and posterior 9th and 10th abdominal segments.



Figs. 24.7-24.9. *Isoperla jewetti*. 24.7. Egg. 24.8. Detail of egg chorion and micropyles. 24.9. Detail of egg collar.

brown markings. Dorsum of head pale yellow with medium brown bands connecting ocelli; interocellar area pale; wide medium brown band extending from median ocellus to clypeus, paired lateral dark brown spots on clypeus and anterior to median ocellus (Fig. 24.1). Antennal scape pale yellow, pedicel and flagellum pale brown. Pronotum with a median hourglass-shaped pale stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark

brown, pronotal disks pale yellow; anterior margin with broad bipartite medium brown bands (Fig. 24.1). Meso- and metasterna pale yellow with medium brown lateral bands. Meso- and metaterga with anteromedian pale patches, posterior ½ with irregular medium brown markings. Sterna pale brown, sternum 8 with a low wide medium brown vesicle; vesicle ca. 2.5X as wide as long, extending posteriorly to near anterior margin of sternum 9 (Fig. 24.5). Terga pale brown; posterior ¾ of tergum 9 elevated with posterior crescent shaped bipartite sclerotized median patches of short stout spinulae; anterior ⅓ depressed to level of tergum 8 (Fig. 24.2). Tenth tergum with medial bipartite sclerotized medium brown triangular patches with small fine spinulae (Fig. 24.2). Paraprocts moderately sclerotized, slender, elongate tapering to fine points apically, and extending slightly over tergum 10 (Figs. 24.2, 22.4). Aedeagus membranous with an elongate finger-like apical tube (Fig. 24.6).

Female. Macropterous. Forewing length 8.0-9.0 mm. General body color and morphology similar to male described above. Eighth sternum with an elongate truncate subgenital plate produced slightly over sternum 9 (Fig. 24.3).

Ovum. Described by Szczytko and Stewart (1979a). General shape oblong, cross section circular (Fig. 24.7). Color pale brown. Length 210 µm; width 130 µm. Collar a low rim, flared slightly (Figs. 24.7, 24.9). Hexagonal follicle cell impressions faintly visible, floors shallow with numerous shallow pits; eclosion line absent. Micropyles arranged singularly on top of FCI ridges near anterior ⅓ of egg (Figs. 24.7, 24.8).

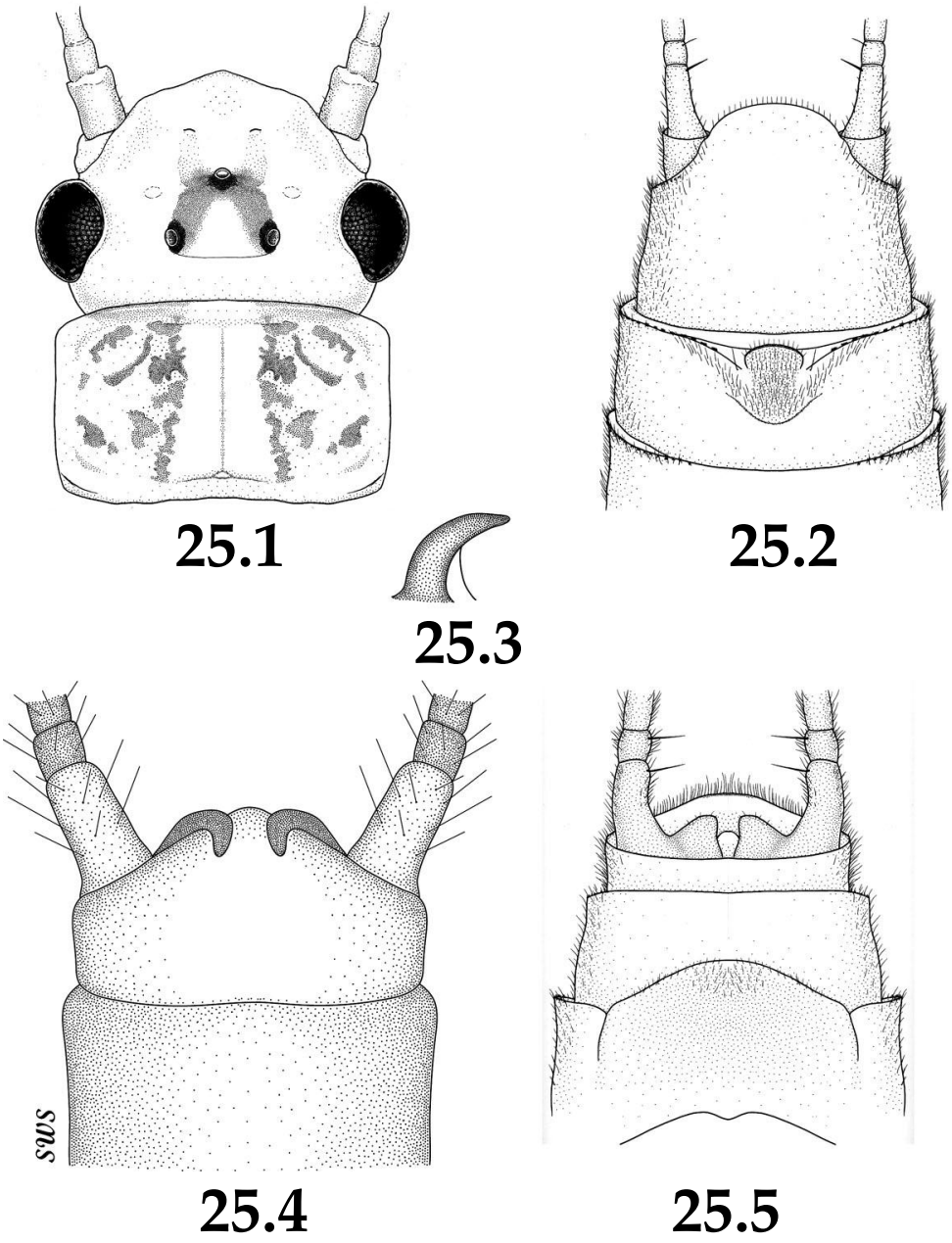
Nymph. Described by Szczytko and Stewart (1979a) and Frison (1942) as *I. longiseta*.

Diagnosis. The male of *I. jewetti* is most similar to *I. longiseta*, another member of the *I. longiseta* group which also includes *I. quinquepunctata* (Table 1). *Isoperla. jewetti*, however, is brachypterous, has shorter, stouter paraprocts, and the aedeagus has a single long finger-like apical tube (Szczytko and Stewart 1979a). The head pattern, vesicle shape, elevated posterior ½ of tergum 9 and spinule patterns on male terga nine and ten are similar in both species. The female subgenital plates of these species are similar and they cannot be reliably separated without associated males (Szczytko and Stewart 1979a). The eggs of the two species are also similar but those of *I. jewetti* apparently are smaller, the sperm guides shorter and the collar less developed than in eggs of *I. longiseta* (Szczytko and Stewart 1979a). *Isoperla jewetti* is known only from a series of adult specimens from El Paso County in extreme southwestern Texas, and a single male reported from a disjunct high elevation (2,860 m) site in Huerfano County, Colorado (Szczytko and Stewart 1979a). The Texas specimens were collected on 22 April 1939 from an irrigation ditch south of El Paso, Texas. Several attempts to recollect the species from the type locality have been unsuccessful and the species is considered extirpated at that site (Szczytko and Stewart 1979a). Additionally, several efforts to collect additional material from the La Veta Pass, Sangre de Cristo Mountains, Colorado site have also been unsuccessful. In a negative ruling on a petition to list *I. jewetti* as "critically imperiled" (U.S. Fish and Wildlife Service 2010) listed Radium Springs, Dona Ana Co., New Mexico as another locality based on six nymphs collected in 1978 and 1980 (Wild Earth Guardians 2009). The identification of these specimens is unconfirmed.

Biological Notes. Essentially nothing is known about the biology of this species.

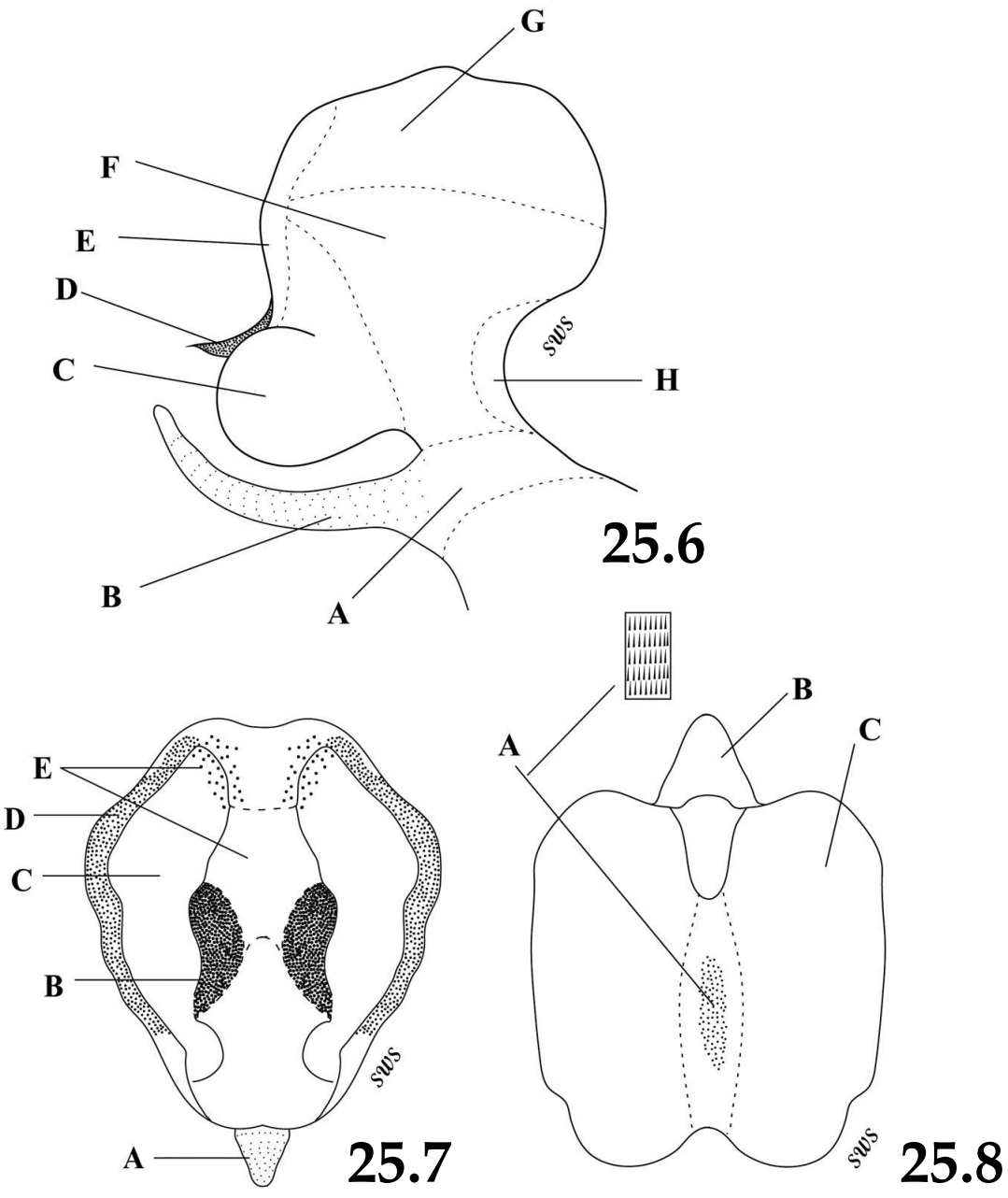
Isoperla kirchneri sp. n.
Two-spine Stripetail
(Figs. 25.1-25.22)

Material Examined: USA – Holotype ♂, **Virginia:** Grayson Co., Opossum Creek, Rte. 603, 2 mi E Fox Creek, 24/V/1994, S.W. Szczytko, B.P. Stark, J.B. Sandberg (USNM). **Paratypes: NC:** Avery Co., Gragg Prong nr. jct. of Lost Cove Creek, Roseborough Road, 19/IV/2007, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat, 1♂, 1♀, 5 N (CSUC). Burke Co., Jacob Fork, Old NC 18, 19/IV/2007, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat, 3♂, 5♀ (CSUC). Caldwell Co., Johns River, Johns River rd., 1. 1 mi. NW Collettsville, 18/IV/2007, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat, 1♂ (CSUC); Yadkin River, Grandin Road, nr. Grandin, 18/IV/2007, B.C. Kondratieff, R.F. Kirchner & D.R.

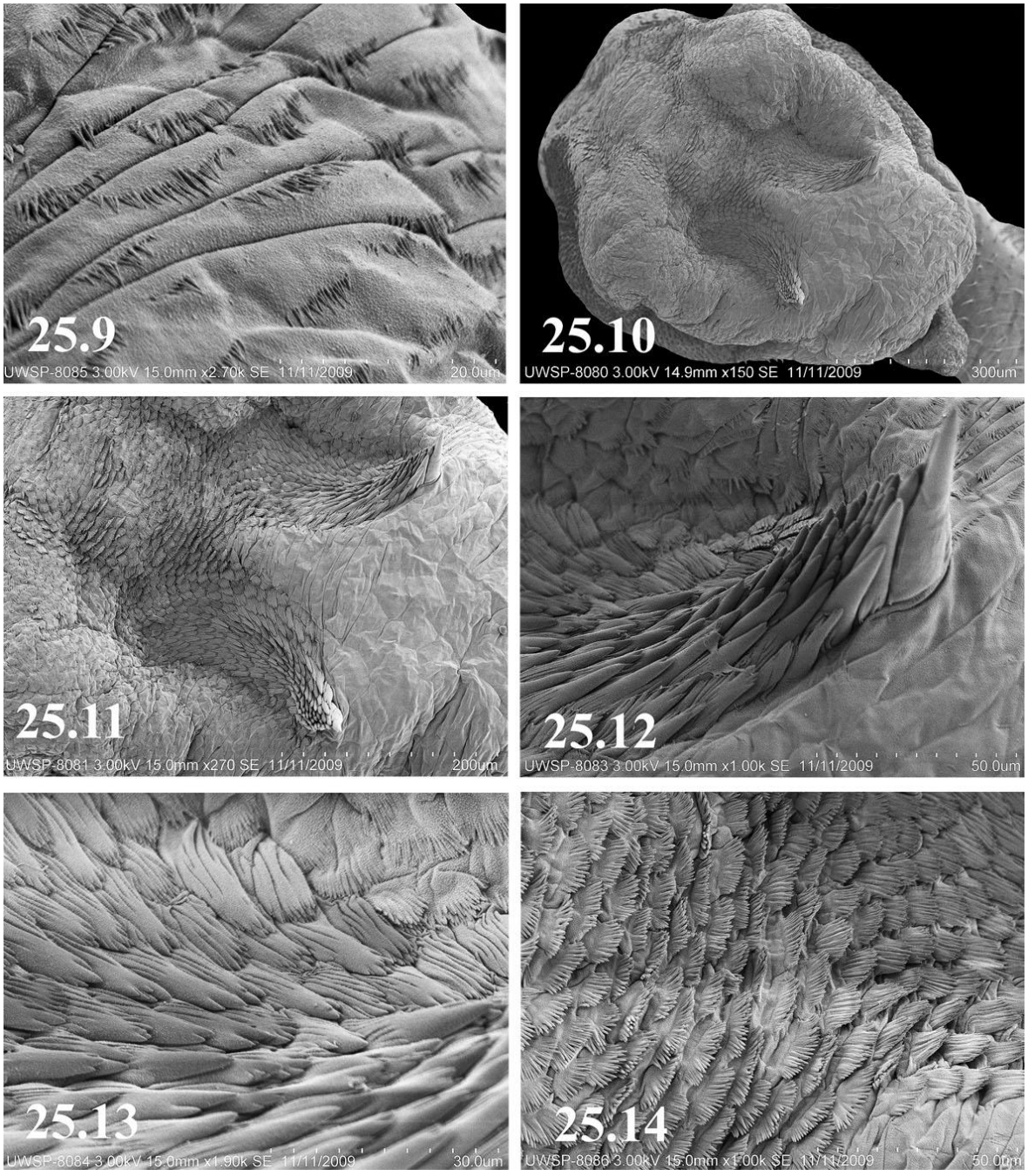


Figs. 25.1-25.5. *Isoperla kirchneri* sp. n. 25.1. Dorsal head and pronotal pattern. 25.2. Male posterior abdominal sterna. 25.3. Male paraproct lateral view. 25.4. Male posterior abdominal terga. 25.5. Female subgenital plate.

Lenat, 2♂, 4♀ (CSUC). Wilkes Co., Basin Creek, Long Bottom Road, Doughton Park, 18/IV/2007, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat, 3♂, 5♀ (CSUC); Middle Fork Reddings River, Old NC 16, E Wilbar, 2/V/2005, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat, 8♂, 11♀ (CSUC); Basin Creek, Long Bottom Road, Doughton Park, 18/IV/2007, B.C. Kondratieff, R.F. Kirchner, D.R.Lenat, 2♂, 2♀ (reared) (CSUC). Surry Co., Fisher River, Ladonia Church Road, 18/IV/2007, B.C. Kondratieff, R.F.

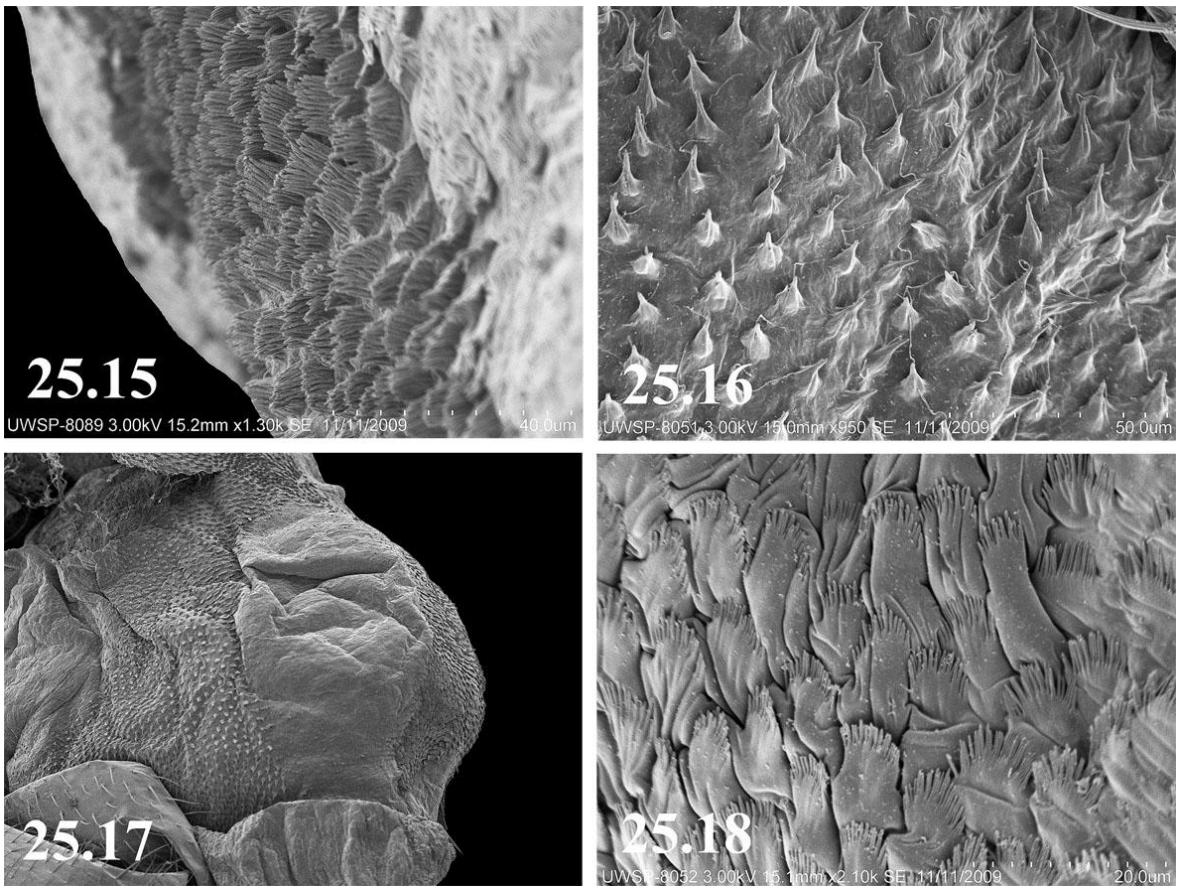


Figs. 25.6-25.8. *Isoperla kirchneri* sp. n. 25.6. Male aedeagus lateral view; a. patch of small fine rows of hair-like spinulae on basal stalk, b. posterobasal tube, c. posteromedian lobe, d. paired posteromedian spine plates, e. patch of small self-like plates with apical finger-like projections, f. mesal patch of short stout spinulae, g. expanded dorsal lobe void of spinulae, h. patch of short truncated plates with fine hair-like apical projections. 25.7. Male aedeagus posterior view; a. posterobasal tube. b. paired posteromedian spine plates, c. posterior paired longitudinal hemispherical lobes, d. longitudinal band of dense rows of fine reddish brown hair-like spinulae, e. patch of with numerous apical finger-like projections. 25.8. Male aedeagus dorsal view; a. dorsomedian linear patch of medium length golden brown spines, b. posterobasal tube, c. posterior paired longitudinal hemispherical lobes.



Figs. 25.9-25.14. *Isoperla kirchneri* sp. n. 25.9. Patch of small fine rows of hair-like spinulae on basal stalk. 25.10. Paired posteromedian spine plates. 25.11. Detail of paired posteromedian spine plates. 25.12. Detail of apical spines of paired posteromedian spine plates. 25.13. Detail of elongate truncate plates with apical finger-like projections near base of paired posteromedian spine plates. 25.14. Small self-like plates with apical finger-like projections at base of paired posteromedian spine plates.

Kirchner, D.R. Lenat, 8♂, 25♀ (CSUC). **NY:** Albany Co., Catskill Creek, Rte. 145, nr. Cooksburgh, 21/V/2008, L.W. Myers, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC). Delaware Co., Lake Brook, Hwy 10, SW Stamford, 7/V/1991, R.W. Baumann, S. Wells, 1♂ (BYUC). Essex Co., Boquet River, Rte. 9 jct. Otis Lane, 17/II/2008, emerged 15III/2008, L.W. Myers, R. Mowrey, 3♂, 1♀ (reared) (CSUC). Greene Co., West Kill, Hwy 42, West Kill Catskill Mts., 8/V/1991, R.W. Baumann, S. Wells, 9♂, 3♀ (BYUC). **PA:** Potter Co., East Fork Sinnemahoning Creek, Shoemaker Clubhouse, 14/V/1998, J. Earle, 2♂, 1♀ (JEIC). **TN:** Sevier Co., Little River, Sinks area, GSMNP, 5/V/1979, B.P. Stark, 1♂, 15♀ (BPSC). **VA:** Augusta Co., Calfpasture River, U.S. 250, Augusta, 29/V/2002, B.C. Kondratieff, R.F. Kirchner, 1♂, 1♀ (CSUC). Giles Co., Little Stony Creek, Rte. 460, Pembroke, 8/IV/1980, B.C. Kondratieff, 2♂, 3♀ (CSUC). Grayson Co., Lewis Fork, Rte. 603, 20/VI/1981, B.C. Kondratieff, 3♀ (CSUC); Opossum Creek, Rte. 603, 2 mi. E Fox Creek, 24/V/1994, S.W. Szczytko, B.P. Stark, J. Sandberg, 4♂, 67♀ (CSUC). **WV:** Pocahontas Co., Greenbrier River, Rte. 219, 30/IV/1987, B.C. Kondratieff, R.F. Kirchner, 2♂ (CSUC); East Fork Greenbrier River, Hwy 28, Island Campground, 15/V/1990, R.W. Baumann, R.F. Kirchner, 1♂, 2♀ (BYUC).



Figs. 25.15-25.18. *Isoperla kirchneri* sp. n. 25.15. Detail of longitudinal band of dense rows of fine reddish brown hair-like spines. 25.16. Large mesal patch of short stout, sharp spinulae. 25.17. Paired longitudinal band of dense rows of fine reddish brown hair-like spines. 25.18. Anteroventral patch of short truncated plates with fine hair-like apical projections.

Additional Records. NC: Ashe Co., South Fork New River, Hwy 221, W. Scottville, 2/V/2005, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat, 1♂, 4♀ (CSUC).

Distribution. **USA – NC, NY, PA, TN, VA, WV.**

Male. Macropterous. Forewing length 10.0-12.0 mm. General body yellow-brown with darker markings. Dorsum of head with brown to black bands connecting lateral ocelli to anterior ocellus, truncate at anterior ocellus; sometimes two short brown bands extend anteriorly from anterior ocellus, or interocular area diffuse to almost completely brown; a well-defined to diffuse spot on frons (Fig. 25.1). Antennal scape pale yellow, pedicel light brown, flagellum segments 1-5 pale yellow, remaining segments medium brown. Pronotum yellow, middorsal pronotal suture brown, disks pale; rugosities raised, dark brown (Fig. 25.1). Meso- and metanota brown with darker brown markings. Wings pale, veins brown. Legs pale yellow, distal ends of femora brown; tibiae brown proximally, femora with a medium brown dorsal longitudinal band. Terga brown, terga 9 and 10 paler; 8 rows of longitudinal spots on each tergum, 3 each laterally and 2 medially. Paraprocts medium in length, sclerotized, tips bluntly pointed, recurved over tergum 10 and curved slightly outward apically (Figs. 25.3, 25.4). Sterna pale brown-yellow; sternum 10 paler. Sternum 8 with well-developed, sclerotized vesicle, as wide as long, broadly rounded (Fig. 25.2); posterior margin dark and bearing long setae. Basal cercal segment pale yellow, remaining segments medium brown. Aedeagus with a long, tapered posterobasal tube curved and narrowed distally (Figs. 25.6b, 25.7a, 25.8b); patch of small fine rows of hair-like spinulae on basal stalk (Figs. 25.6a; 25.9); large posteromedian rounded lobe devoid of spinulae (Figs. 25.6c; 25.10); paired posteromedian spine plates with dense, stout reddish brown spines above membranous lobe (Figs. 25.6d, 25.7b, 25.10, 25.11, 25.12); distal spines longest and stoutest (Figs. 25.11, 25.12), distal spines grade proximally into elongate, truncate plates with numerous apical finger-like projections (Figs. 25.11, 25.12, 25.13); small shelf-like plates with numerous apical finger-like projections at base of spine plates which extend medially to dorsal base of hemispherical lobes (Figs. 25.7e, 25.14); large paired, longitudinally hemispherical membranous lobes lateral to spine plates (Figs. 25.7c, 25.8c, 25.10); paired longitudinal band of dense rows of fine reddish brown hair-like spines lateral to each hemispherical lobe (Figs. 25.6e, 25.7d, 25.15, 25.17); large dorsal area devoid of spinulae (Fig. 25.6g, 25.8c); median dorsal linear patch of medium length golden brown spines between hemispherical lobes (Fig. 25.8a); mesal area with a large patch of short stout spinulae (Figs. 25.6f, 25.16); anteroventral margin with a patch of short truncate plates with fine hair-like apical projections (Figs. 25.6h, 25.18).

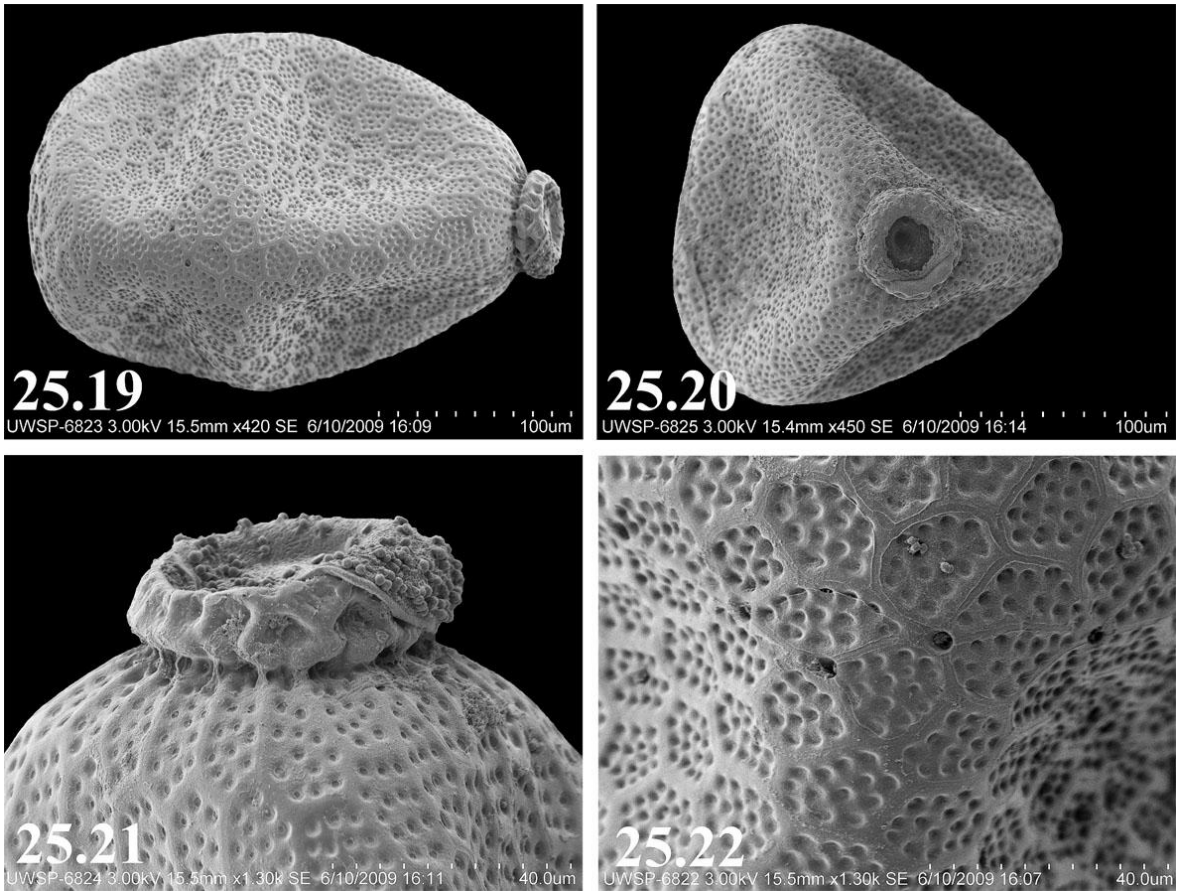
Female. Macropterous. Forewing length 11-13 mm. General body color and morphology similar to male except sterna yellow. Subgenital plate, elongate, produced ⅓ to ½ length of tergum 9, broadly rounded to emarginate at apex (Fig. 25.5).

Ovum. General shape oblong, cross section triangular, distinct cross shaped ridges dividing anterior and posterior poles; anterior end nearly flat (Figs. 25.19, 25.20). Color pale brown. Length 268 μm; width 137 μm. Collar well-developed, base with raised longitudinal carinae (Figs. 25.19, 25.20, 25.21). Hexagonal follicle cell impressions well-developed with thickened ridges, floors shallow with numerous small pits. Micropyles arranged in groups of 3 on FCI ridges near anterior ⅓ of egg; eclosion line absent (Figs. 25.19, 25.22).

Nymph. Not described.

Etymology. We honor our friend Ralph F. Kirchner, Huntington, West Virginia. Fred recognized this species as distinct from *I. namata* many years ago and also assisted in numerous collections of *Isoperla* specimens used in this study and in many other ways which made this study possible.

Diagnosis. *Isoperla kirchneri* sp. n. as a member of the *I. signata* group (Table 1) is most similar to *I. namata, I. signata*, and *I. siouan* sp. n. *Isoperla kirchneri* sp. n. shares with the above species sclerotized posteromedian spine plates bearing dense, stout reddish brown spines, and ova having a triangular cross section. *Isoperla kirchneri* sp. n. is most similar in general appearance to *I. siouan* sp.



Figs. 25.19-25.22. *Isoperla kirchneri* sp. n. 25.19. Lateral view of egg. 25.20. Dorsal view of egg. 25.21. Detail of egg collar. 25.22. Detail of egg chorion and micropyles.

n., however the aedeagus of *I. siouan* sp. n. lacks a ventral tube. In addition, the shape and specific spinule patterns of the aedeagus, and the shape and sclerotization of the male paraprocts differ. The head pattern of *I. kirchneri* sp. n. is paler than that of *I. namata* or *I. signata,* and the shape and details of the aedeagal spinule patterns are distinctive. *Isoperla namata* and *I. kirchneri* sp. n. have a membranous ventral aedeagal tube, whereas *I. signata* and *I. siouan* sp. n. lack this structure. The color pattern of the head is also similar to that of *I. montana*, but the aedeagus of *I. montana* has a single arrowhead-shaped spine plate. Females of these species which lack mature eggs, are often difficult to separate.

Isoperla kirchneri sp. n. is one of the more common Appalachian species and has been confused in the literature with *I. namata* mostly due to the close habitus similarity of the nymphs. *Isoperla kirchneri* sp.n. and *I. signata* are sympatric in northeastern North America and with *I. siouan* sp. n. in the southern Appalachians. The known distribution of *I. kirchneri* sp. n. does not overlap geographically with *I. namata,* but is sympatric with *I. montana* in northeastern North America. Additional collecting will perhaps indicate that *I. kirchneri* sp. n. is more widely distributed than present data suggests. We expect it to be found throughout the Appalachians at moderate elevations in relatively pristine medium sized

streams.

Biological Notes. Preliminary data on the life history of *I. kirchneri* sp. n. in Stony Creek, Giles Co., Virginia indicates a typical univoltine life cycle with adult emergence in early April. Early instars were first collected at this stream in late October. Throughout its range adult emergence apparently occurs from early April to late May.

Isoperla lata Frison
Dark Stripetail
(Figs. 1.6, 1.7, 26.1-26.14)

Isoperla lata Frison 1942, 22:334. Holotype ♂ (INHS). Boulder Junction (Vilas Co.), Wisconsin. Examined.
Isoperla lata: Ricker, 1947, 26:409.
Isoperla lata: Harden and Mickel, 1952, 201:40.
Isoperla lata: Sandberg and Szczytko, 1997, 30:143.

Distribution: **CANADA – NB** (Kondratieff and Baumann 1994), **NS** (Frison 1942, Ricker 1947, Kondratieff and Baumann 1994), **ON** (Harper and Ricker 1994), **PQ** (Frison 1942, Ricker et al. 1968); **USA – ME** (Mingo 1983), **MI** (Frison 1942, Grubbs and Bright 2001), **MN** (Harden and Mickel 1952, Lager et al. 1979), **NC** (Kondratieff et al. 1995), **NY** (Myers et al. 2011), **TN** (Frison 1942), **WI** (Frison 1942, Hilsenhoff and Billmyer 1973).

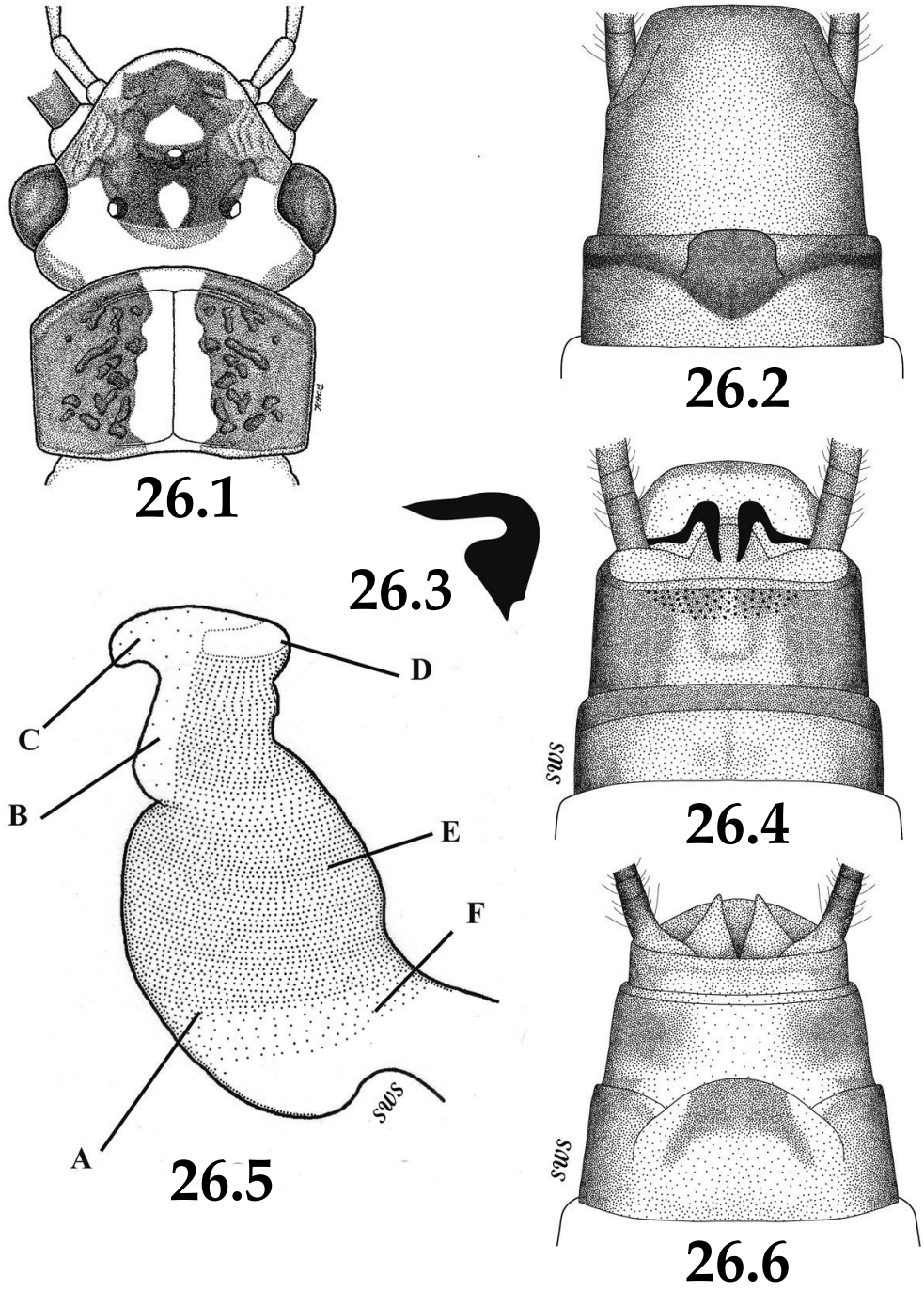
New Records: **CANADA – LB:** Goose Brook, Hwy 500, E Churchhill Falls, 13/VI/1997, B.C. Kondratieff, R.W. Baumann, 2♂, 6♀ (CSUC); **USA – WV**: Pocahontas Co., East Fork Greenbrier River, Forest rd. 51 off WV Rte 28, 26/IV/1987, B.C. Kondratieff, R.F. Kirchner, 1♂ (CSUC).

Additional Records. CANADA – NB: Queens Co., Number Ten Brook, Hwy 101, 25/VI/1993, B.C. Kondratieff, R.W. Baumann, 1♀ (CSUC). **PQ:** Rivier Jacqui, Rte 389, S Fermont, 14/VI/1997, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC).

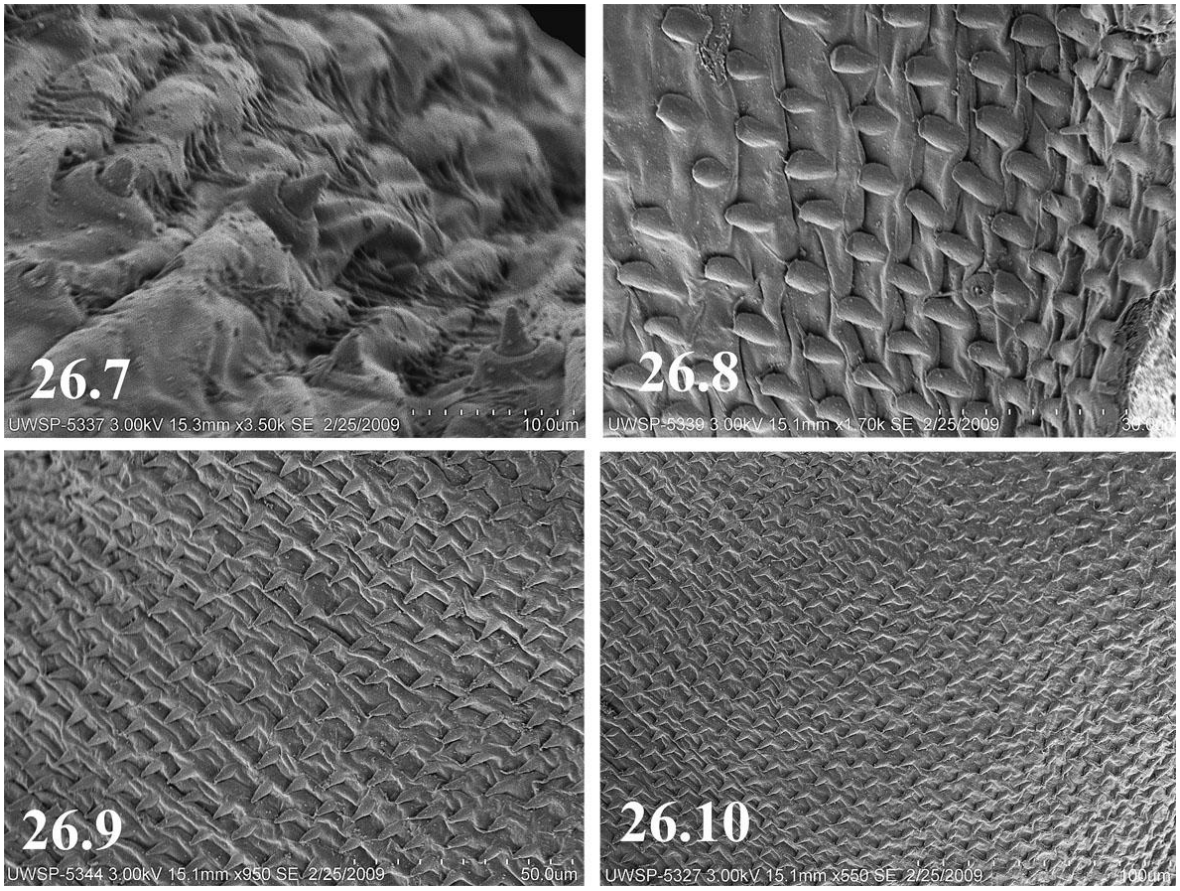
Male. Macropterous. Forewing length 8.9-10.2 mm. General body color dark brown to black in life, medium to dark brown in alcohol with darker brown or black markings. Dorsum of head with dark brown bands connecting ocelli widest near anterior ocellus; bands extend to near antennal bases and to narrow bands anterior to frons; frons with wide medium brown band and narrow pale brown band connecting posterior ocelli; interocellar area with irregular pale spot; mottled medium brown bands extend from posterior margin of head anterolaterally to median inner margin of eyes; frontoclypeal area with broad dark band; a large diamond-shaped pale spot posterior to dark band extends posteriorly to anterior ocellus (Fig. 26.1). Antennal scape pale brown, pedicel and flagellum dark brown. Pronotum with wide median pale stripe; middorsal pronotal suture a thin brown line; rugosities black and raised, pronotal disks dark brown; anterior, posterior and lateral margins dark brown to black (Fig. 26.1). Meso- and metanota mostly medium brown with irregularly shaped anterior pale spots. Wings dusky with dark brown/black veins. Femora generally medium brown, dorsal margin darker, tibia pale brown. Sterna medium brown. Sternum 8 with dark brown well-developed vesicle ca. 1.25X as wide as long, usually broadly rounded posteriorly and extending to near anterior margin of sternum 9 (Fig. 26.2). Terga medium brown; posterior ⅔ of tergum 9 with median patch of short stout spinulae; tergum 10 with posteromedian depressed area extending anteriorly for ⅔ length of segment (Fig. 26.4). Paraprocts heavily sclerotized, long, thin, sharply pointed, tapered apically, and extending approximately ⅓-½ length over tergum 10 (Figs. 26.3, 26.4). Cerci medium brown with a single long, stout, dorsal and ventral hair at posterior margins. Aedeagus membranous with expanded posterobasal area (Fig. 26.5a); apical area much narrower with a posterodorsal beak-like lobe armed with short, stout flat plates (Fig. 26.5c) and smaller paired anterodorsal lobes (Fig 26.5d); posterior area below beak-like lobe with stout blunt spinulae and scattered sensilla basiconica and low ridges with fine hair-like spinulae (Figs. 26.5b, 26.7, 26.8); large mesal section covered with dense short, sharp spinulae (Figs. 26.5e, 26.9); basal and apical areas bearing short flat, stout plates (Figs. 26.5f, 26.10).

Female. Forewing length 11.3-12.5 mm. General body color and morphology similar to male described above. Subgenital plate produced posteriorly over ⅓-½ length of sternum 9, broadly rounded posteriorly (Fig. 26.6).

Ovum. General shape oblong, cross section



Figs. 26.1-26.6. *Isoperla lata*. 26.1. Dorsal head and pronotal pattern. 26.2. Male posterior abdominal sterna. 26.3. Male paraproct lateral view. 26.4. Male posterior abdominal terga. 26.5. Male aedeagus lateral view; a. expanded posterobasal area, b., c. posteromedian lobe, d. patch of stout blunt spinulae and scattered sensillae basiconica, c. posterodorsal beak-like lobe with patch of short flat plates, d. paired anterodorsal lobes, e. anteromesal dense patch of short stout spinulae, f. basal patch of short flat, stout plates. 26.6. Female subgenital plate.

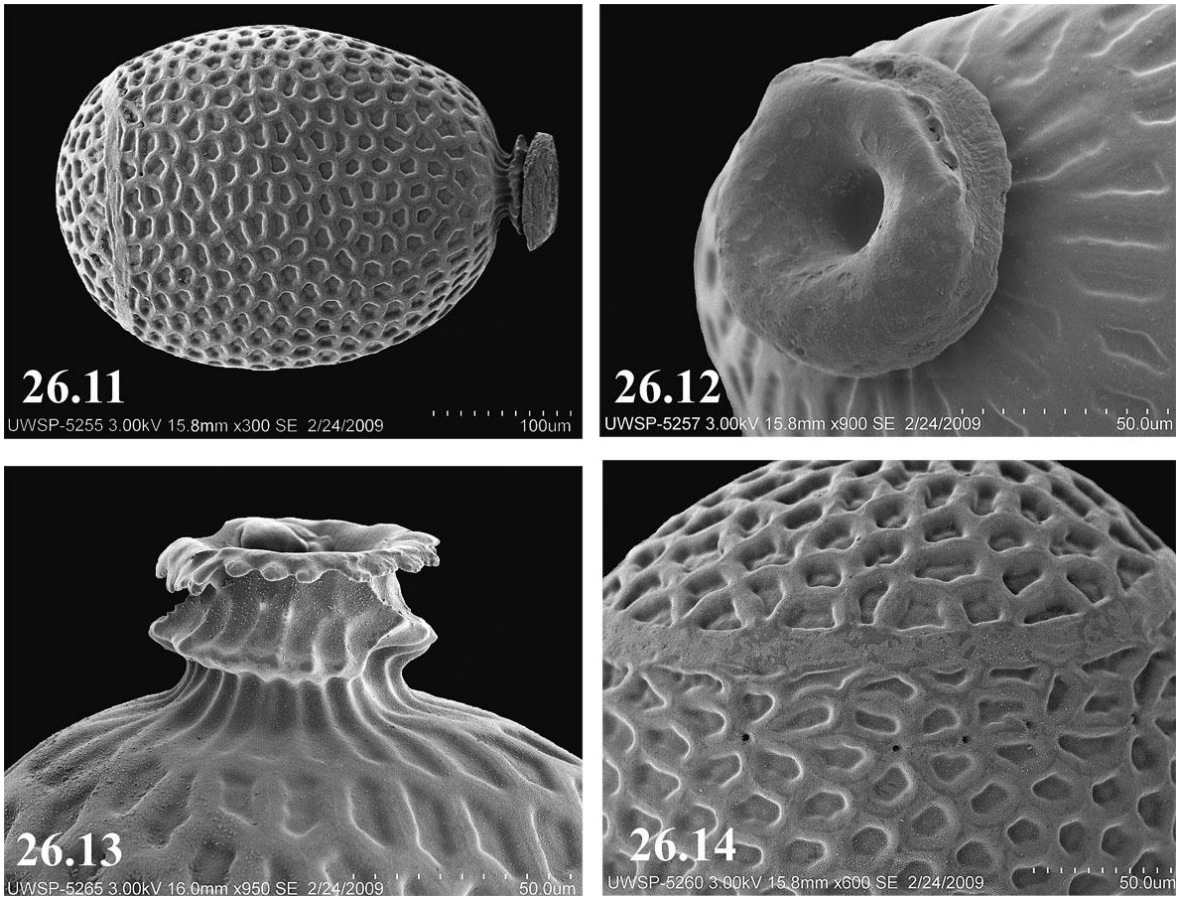


Figs. 26.7-26.10. *Isoperla lata*. 26.7. Scattered posterodorsal aedeagal sensillae basiconica. 26.8. Stout blunt spinulae below posterodorsal aedeagal lobe. 26.9. Dense mesal patch of short sharp aedeagal spinulae. 26.10. Short flat, stout basal aedeagal plates.

circular. Color pale brown. Length 345-371 µm; width 250-260 µm (Fig. 26.11). Collar well-developed, apically flanged, donut shaped apically with central depression; collar stalked, margins bearing longitudinal carinae; collar offset from egg body by shoulder with longitudinal carinae, base with raised irregular ridge (Figs. 26.12, 26.13). Choronic surface covered with irregular hexagonal follicle cell impressions with walls raised, thick and floor flat with numerous small, shallow punctations (Figs. 26.11, 26.14). Eclosion line, well-developed, raised and thickened near anterior pole (Figs. 26.11, 26.14). Micropyles positioned singularly on FCI ridges above eclosion line, openings without accessory structure (Figs. 26.11, 26.14).

Nymph. Mouthparts and habitus were illustrated by Frison (1942) and Harden and Mickel (1952). Hilsenhoff and Billmyer (1973) illustrated the lacinia. Sandberg and Szczytko (1997) described the first instar nymph and Stark et al. (1998) and Stewart and Stark (2002) provided a color photograph of the habitus.

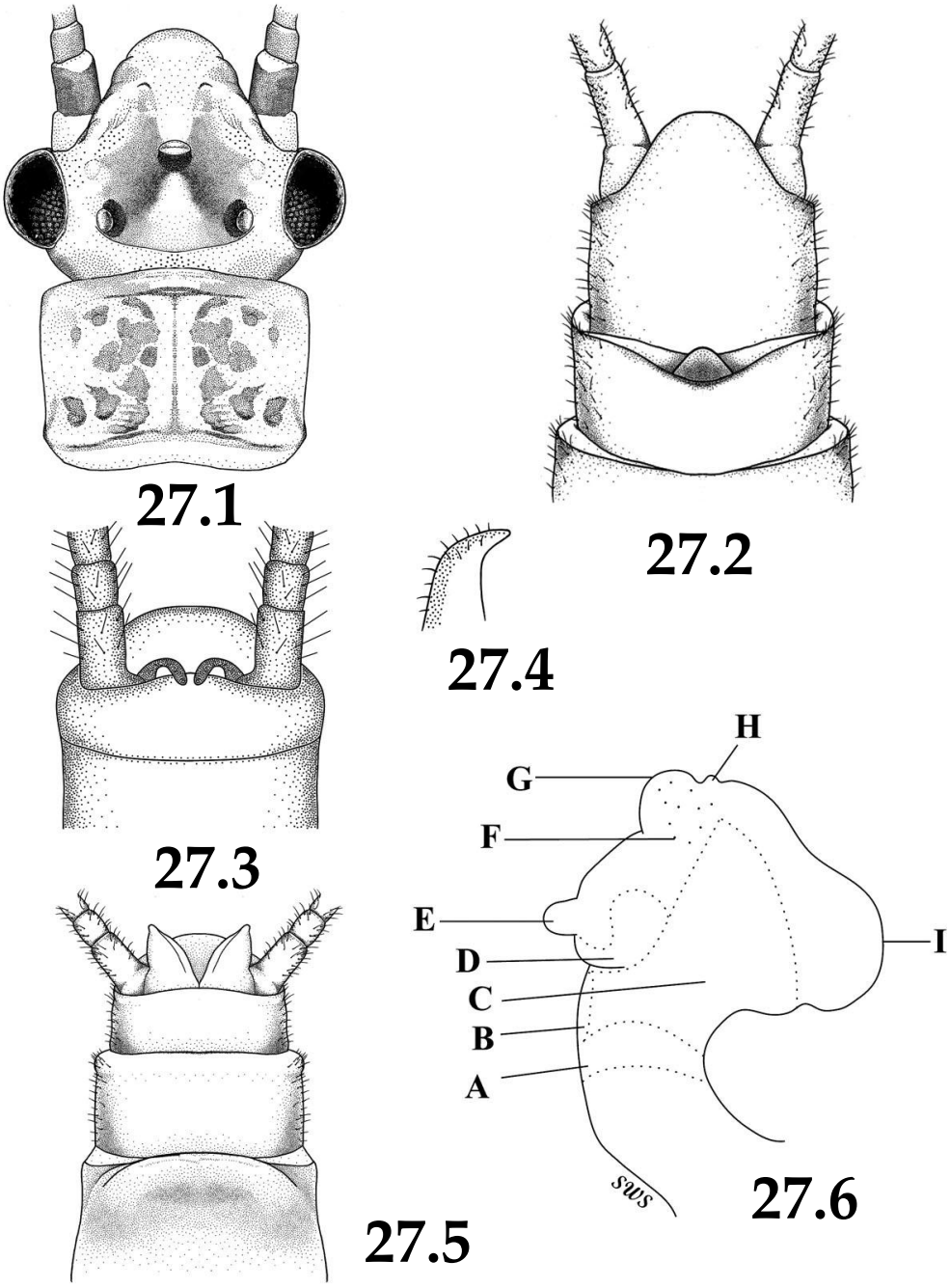
Diagnosis. Of the *I. lata* group species (Table 1), *I. lata* is most similar to *I. pseudolata* sp. n., described herein from North Carolina, but can be separated from that species by the shape and spinule patterns of the aedeagus and the larger more rounded



Figs. 26.11-26.14. *Isoperla lata*. 26.11. Egg. 26.12. Oblique dorsal view of egg collar. 26.13. Detail lateral view of egg collar. 26.14. Detail of egg chorion, eclosion line and micropyles.

female subgenital plate. *Isoperla lata* can also be distinguished from other eastern *Isoperla* by the combination of very long, sharply pointed male paraprocts, unique head pattern, shape and spinule pattern of the aedeagus and wide eclosion line of the ova.

Biological Notes. Nymphs of *I. lata* generally occur in smaller streams throughout its range and adults are rarely collected. Sandberg and Szczytko (1997) and Harper and Magnin (1969) described the life cycle of *I. lata* and reported a slow univoltine life cycle with a synchronous emergence pattern. Sandberg and Szczytko (1997) reported that male and female nymphs had ca. 18 and 19 instars respectively and adults emerged from late April through early May in Wisconsin when stream temperatures were approximately 9-14° C. The in-stream incubation period was 40-46 days and the first instars hatched synchronously over a 2 day period when stream temperatures reached 20° C. Nymphs were carnivorous throughout the nymphal development period. In Canada, emergence generally occurs from mid June to early July (Harper and Magnin 1969). Ziminske (1989) reported that the typical male drumming call was grouped and had a mean number of 3.1 ± 0.3 beats/group which is similar to *I. marlynia*. The mean number of beat groups was 4.6 ± 0.7 and ranged from 3-6; the intergroup interval was 615.7 ± 121.0 ms and the beat interval was 24.2 ± 4.0 ms.



Figs. 27.1-27.6. *Isoperla lenati* sp. n. 27.1. Dorsal head and pronotal pattern. 27.2. Male posterior abdominal sterna. 27.3. Male posterior abdominal terga. 27.4. Male paraproct lateral view. 27.5. Female subgenital plate. 27.6. Male aedeagus lateral view; .a. transverse patch of small fine row of hair-like spinulae on basal stalk, b. small basoventral patch of concentrated long hair-like spinulae, c. large mesal patch of short, stout, sharp spinulae, d. dense patch of shelf-like pates with long apical hair-like projections, e. posteromesal nipple-like lobe, f. patch of elongate sensillae basiconica and long hair-like spinulae, g. posterodorsal lobe, h. small dorsal nipple-like lobe, i. anteromesal lobe.

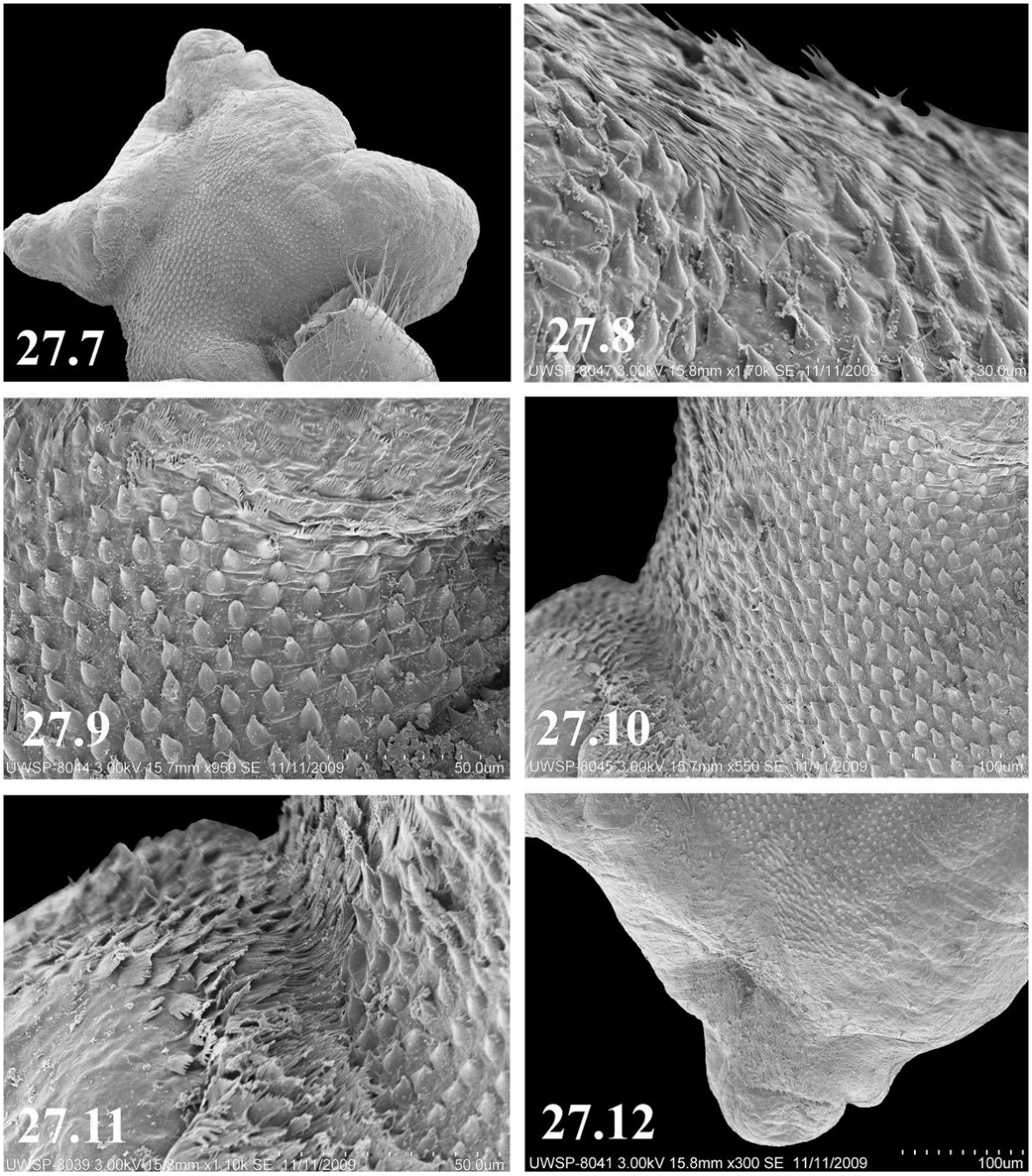
***Isoperla lenati* sp. n.**
Little Stripetail
(Figs. 27.1-27.16)

Material Examined: USA – Holotype ♂, **North Carolina**: Richmond Co., Naked Creek, Derby Road, 3mi NW Hoffman, 11/V/2002, B.C. Kondratieff, R.F. Kirchner (USNM). **Paratypes: FL:** Santa Rosa Co., Alligator Creek, Blackwater State Forest @ Red Rock Road, Bryant Bridge Road, 2.5 mi NW Holt, 1/III/1999, M.L. Pescador, A.K. Rasmussen, 1♂, 6♀ (FAMU); Junipers Creek, Blackwater River State Forest, 10/III/1999, B.C. Kondratieff, R.W. Baumann, 8♂, 9♀ (CSUC); Big Juniper Creek, Blackwater State Forest, Red Rock rd., 10 mi NW Holt, 1/III/2000, A.K. Rasmussen, 6♂, 2♀ (FAMU); Alligator Creek, Blackwater State Forest @ Red Rock Road, Bryant Bridge Road, 2.5 mi NW Holt, 1/III/1999, M.L. Pescador, A.K. Rasmussen, 1♂, 6♀ (FAMU). **NC:** Hoke Co., Rockfish Creek, 6 mi E Raeford, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 1♂, 7♀ (CSUC); Rockfish Creek, Vass rd., Silver City, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 4♂, 2♀ (CSUC). Hoke/Moore Co. line, Little River, Morrison Bridge rd, E Southern Pines, 4/V/2005, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat, 4♂, 4♀ (CSUC). Moore Co., Nicks Creek, Beulah Hill Church rd., 1 mi NW Murdocsville, 1/V/2003, B.C. Kondratieff, R.F. Kirchner, 5♂, 2♀ (CSUC); Little River, 1 mi S Thomas Crossroads, 1/V/2003, B.C. Kondratieff, R.F. Kirchner, 2♂, 3♀ (CSUC); Little River, 1 mi S of Thomas Crossing, 1/V/2003, B.C. Kondratieff, R.F. Kirchner, 11♂, 14♀ (CSUC); Nicks Creek, 1 mi. NW of Murdocksville, 1/V/2003, B.C. Kondratieff, R.F. Kirchner, 21♂, 27♀ (CSUC). Robeson Co., Shoe Heel Creek, US 501 bridge, NW of Roemon, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 2♂, 4♀ (CSUC). Richmond Co., Rocky Ford Creek, CR 1424, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 7♂, 11♀ (CSUC); Same locality as holotype, 7♂, 3♀, 2 N (CSUC); Naked Creek, 3 mi NW Hoffman, Derby rd., 1/V/2003, B.C. Kondratieff, R.F. Kirchner, 3♂, 2♀ (CSUC); Lumber River, NC 904, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 1♂ (CSUC).

Additional Records: USA – GA: Houston Co., Mossy Creek, 4.5 mi N Perry, 31/III/1945, 3♂, 1♀, P. W. Fattig (INHS). **NC:** Hoke/Scotland Co., Lumber River, 1 mi NE Wagram, US 401, 1/V/2003, B.C. Kondratieff, R.F. Kirchner, 1♂, 2♀ (CSUC). Hoke/Moore Co. line, Little River, Morrison Bridge rd, E Southern Pines, 18/V/2004, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat, 3♀ (CSUC). **SC:** Aiken Co., Hollow Creek, off Rte 57, 1/V/1984, B.C. Kondratieff, 1♂, 5♀ (CSUC); Upper Three Runs Creek, SC Rte. 113, 7/IV/1984, B.C. Kondratieff, 7♂, 3♀ (CSUC).

Distribution: USA – Atlantic Coastal Plain of FL, GA, NC, SC.

Male. Macropterous. Forewing length 6.5-8.0 mm. General body yellow to pale brown with darker markings, abdomen red in life. Dorsum of head with ocelli connected with brown bands, enclosing a pale spot (Fig. 27.1); head often dark to epicranial suture in Florida specimens; sometimes open anteriorly; elongate pale spot usually anterior to anterior ocellus; frons and clypeus brown (Fig. 27.1). Antennae and scape brown. Pronotum with wide median pale stripe, middorsal pronotal suture brown; disks paler with rugosities wide and dark brown (Fig. 27.1). Meso- and metanota brown with paler markings. Wings pale, veins brown. Legs pale brown. Terga pale brown in alcohol, red in life, usually with pale brown middorsal stripe, sometimes reduced or faded on some segments. Sterna pale brown to yellow in alcohol, reddish in life. Sternum 8 with well-developed vesicle, 2X wide as long (Fig. 27.2). Paraprocts slender, dorsally sclerotized, tapering to rounded apex, basally crenulate (Figs. 27.3, 27.4) and sometimes extending barely over edge of tergum 10. Aedeagus with transverse patch of small fine row of hair-like spinulae on basal stalk (Fig. 27.6a); small basoventral patch of concentrated long hair-like spinulae (Figs. 27.6b; 27.8); large mesal patch of short, stout, sharp spinulae (Figs. 27.6c, 27.7, 27.9, 27.10); small posteroventral patch of concentrated long hair-like spinulae (Fig. 27.6b), posteromesal lobe with apical nipple (Figs. 27.6e, 27.7); base of lobe with dense patch of shelf-like pates bearing long apical hair-like projections (Figs. 27.6d; 27.7, 27.11); dorsal lobe (Fig. 27.6g) with scattered sharp elongated sensilla basiconica



Figs. 27.7-27.12. *Isoperla lenati* sp. n. 27.7. Aedeagus lateral view. 27.8. Dense patch of aedeagal shelf-like plates with long apical hair-like projections. 27.9. Detail of large mesal patch of short, stout, sharp aedeagal spinulae. 27.10. Large mesal patch of short stout, sharp aedeagal spinulae. 27.11. Dense patch of aedeagal shelf-like plates with long apical hair-like projections. 27.12. Aedeagal posterodorsal lobe.

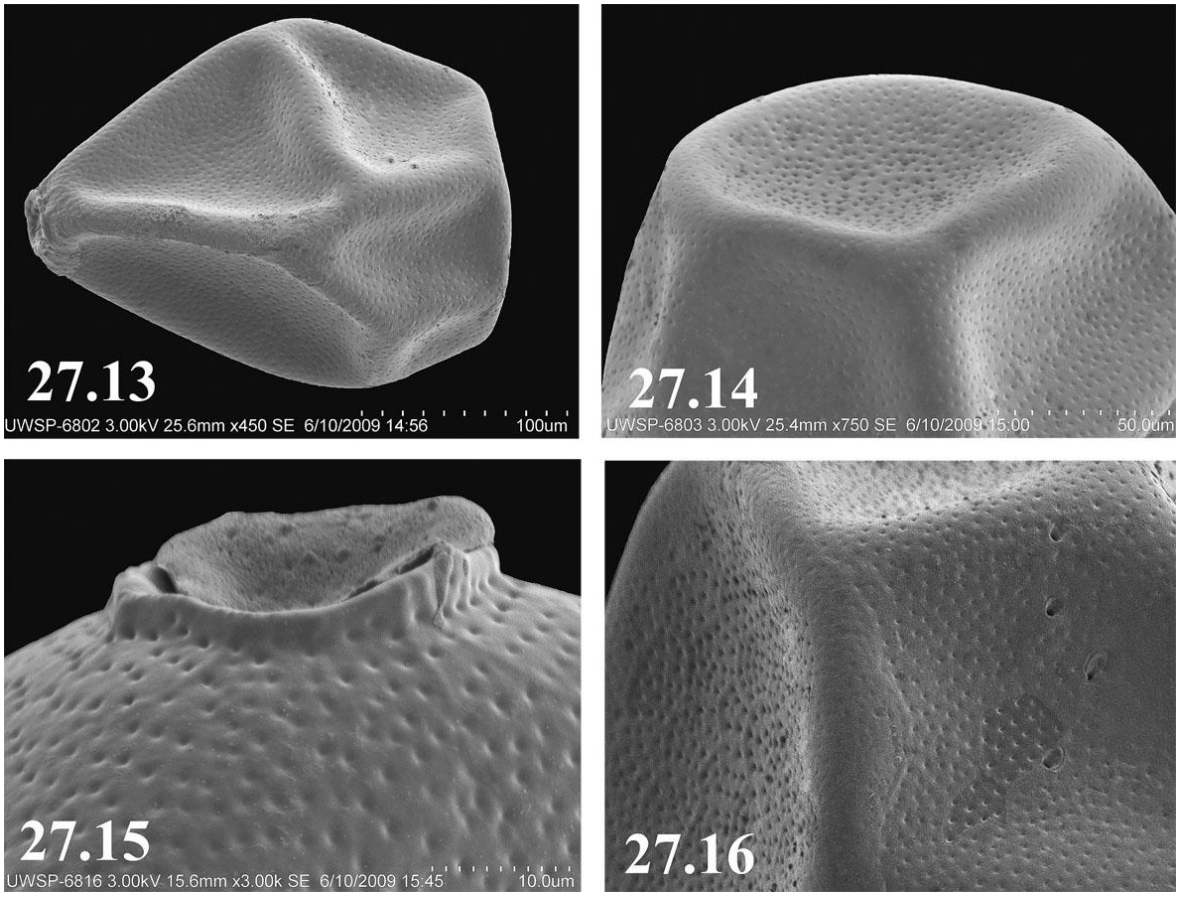
and long hair-like spinulae (Figs. 27.6f, 27.7, 27.12); small membranous dorsal nipple-like lobe anterior to dorsal lobe (Fig. 27.6h); large anteromedian lobe devoid of spinulae (Figs. 27.6i, 27.7).

Female. Macropterous. Forewing length 9.0-10.0 mm. General body color and morphology similar to male. Subgenital plate produced ¼ length or less of sternum 9, broadly rounded, usually with slight posteromedial emargination and deflected ventrally near posterior ½ (Fig. 27.5).

Ovum. General shape oblong, cross section posterior ½ triangular, anterior ½ quadrangular with distinct horizontal ridges dividing anterior and posterior poles; longitudinal ridge divided at horizontal ridge into 2 distinct anterior ridges; bottom nearly flat (Figs. 27.13, 27.14). Color pale brown. Length 237 µm; width 179 µm. Collar developed, low; base with pits extending to near apical rim (Figs. 27.13, 27.15). Chorionic surface covered with numerous shallow pits, hexagonal follicle cell impressions not visible. Micropyles scattered in groups of 3 or 4 on chorionic surface adjacent to horizontal ridges and not in a linear arrangement; orifices usually with a shallow anterior sperm groove; eclosion line absent (Figs. 27.13, 27.16).

Nymph. Unknown.

Etymology. We honor David R. Lenat, Raleigh, North Carolina, a well-known aquatic ecologist and friend, who assisted in the collection of *Isoperla* throughout North Carolina resulting in the discovery of numerous new species. Dave made collecting in North Carolina a joy.



Figs. 27.13-27.16. *Isoperla lenati* sp. n. 27.13. Egg lateral view. 27.14. Detail of egg posterior end. 27.15. Detail of egg collar. 27.16. Detail of egg chorion and micropyles.

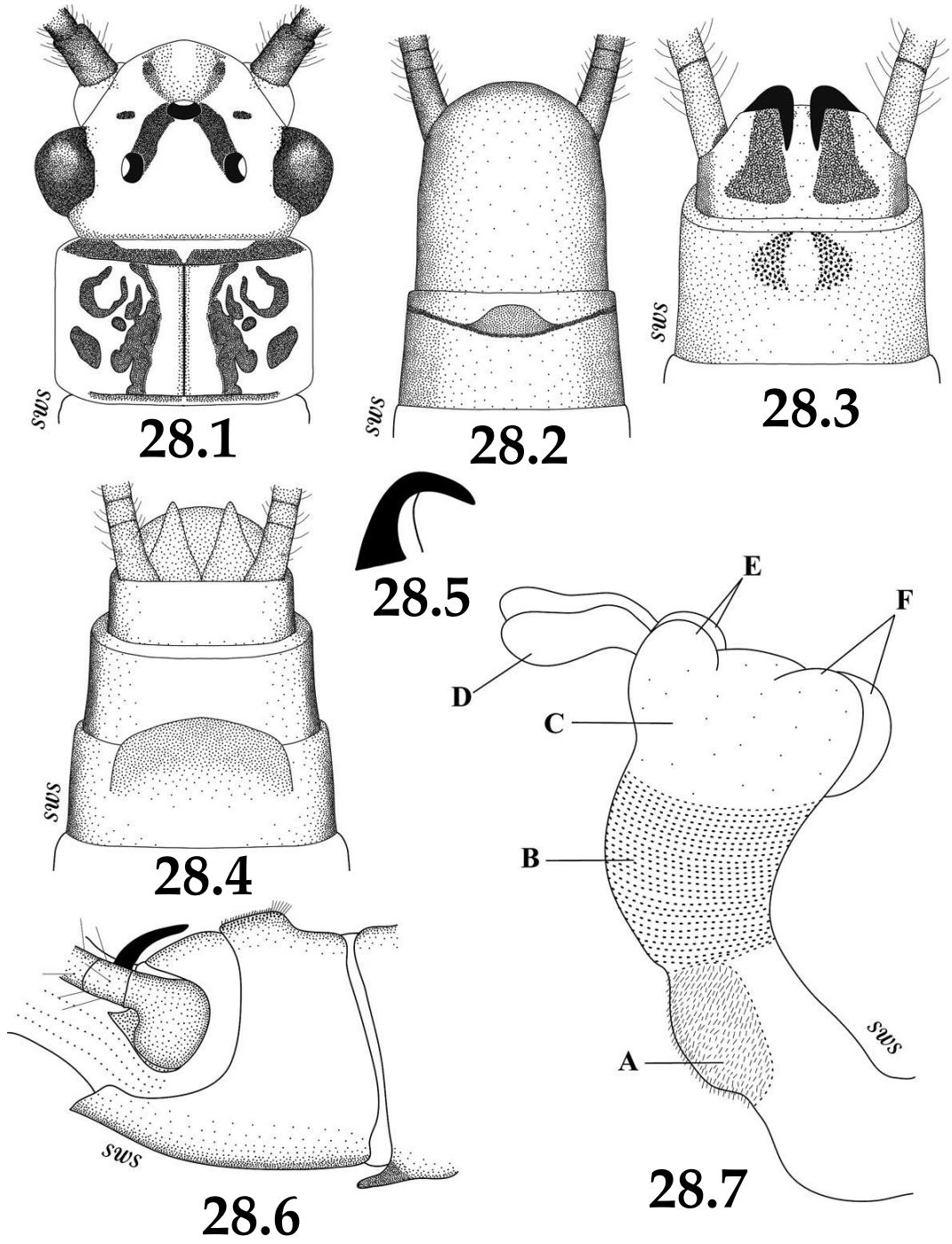
Diagnosis. *Isoperla lenati* sp. n. is a small pale brown *Isoperla* (body length 4.5-6.0 mm) with dark markings. The species is one of the smaller eastern *Isoperla* and is included in the *I. nana* group with *I. catawba* sp. n. and *I. nana* (Table 1). The aedeagus of these species is characterized by an elongate basal tubular stalk and an expanded dorsal area. *Isoperla lenati* sp. n. can be distinguished from the other species of the group by the specific head color pattern, shape of the female subgenital plate, unique egg, shape of the male paraprocts and shape and spinule pattern of the aedeagus. One of the more striking characteristics of this species is the bright red abdomen in live males which is similar to that of *I. quinquepunctata* and occasionally *I. longiseta.* The egg of this species is unique in cross section having the posterior ½ triangular and the anterior ½ quadrangular, and also in not having a linear arrangement of the micropyles. There is some variation in the degree of dark coloration of the head pattern in this species between populations. It is interesting to note that William E. Ricker previously recognized this species as new based on the above Georgia specimens.

Biological Notes. The detailed life history of this species is unknown. *Isoperla lenati* sp. n. emerges from early March through early May. Many of the above localities where this species appears to be relatively common are associated with the Sand Hills region of North Carolina, ancient beach dunes which generally divide the Piedmont from the Atlantic Coastal Plain. All the above listed North Carolina collections sites have reported good to excellent water quality, acidic pH and humic water (D.R. Lenat, personal communication). Stream substrate is largely sand and gravel, but nymphs of *I. lenati* sp. n. are usually associated with submerged leaf-pack or woody snag habitats. Morse et al. (1980, 1983) described the aquatic insects of communities and associated habitats of Upper Three Runs on the Atlantic Coastal Plain of South Carolina.

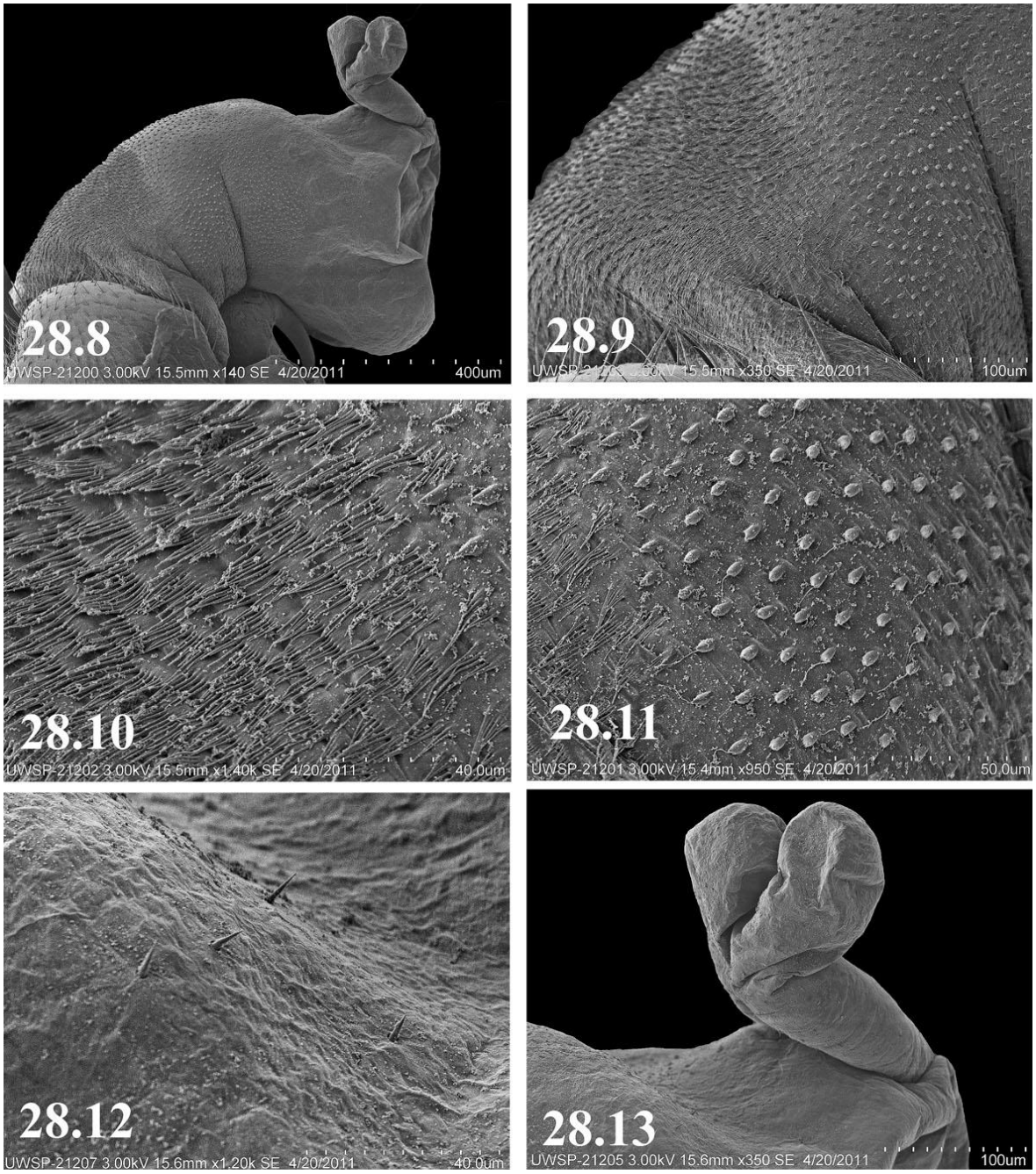
Isoperla longiseta Banks
Plains Stripetail
(Figs. 28.1-28.16)

Isoperla longiseta Banks 1906b 38:337. Holotype ♀ (MCZC) Onaga (Pottawatomie Co.), Kansas. Examined.
Isoperla longiseta: Needham and Claassen, 1925, 2:156.
Isoperla longiseta: Baumann et al., 1977: 31:46.
Isoperla longiseta: Szczytko and Stewart, 1979a, 32:20.

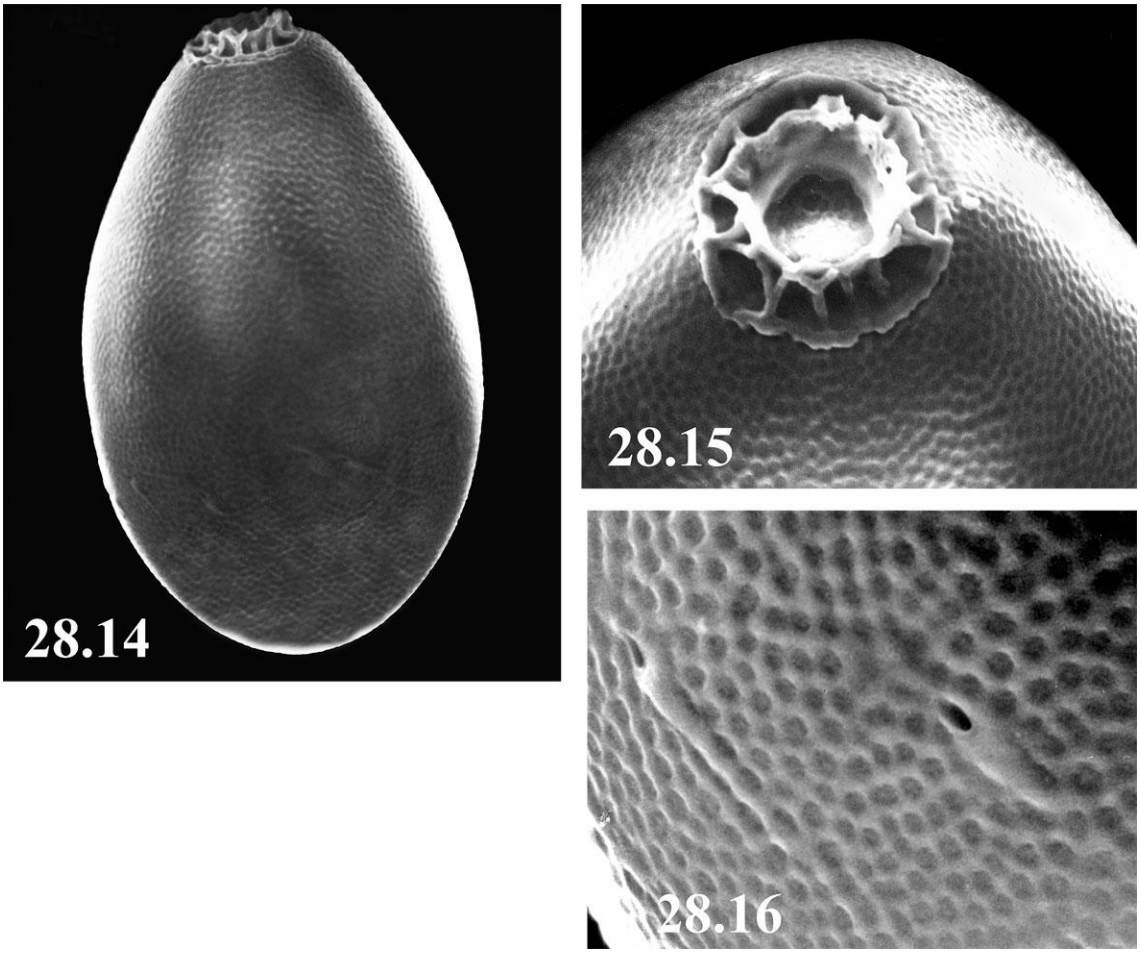
Eastern Distribution: **CANADA – ON** (Harper and Ricker 1994), **PQ** (Ricker et al. 1968?). **USA – IA** (Frison 1942, Heimdal et al. 2004, extirpated), **IL** (Frison 1935, Frison 1942, DeWalt et al. 2005, DeWalt and Grubbs 2011, extirpated), **KS** (Banks 1906b, Needham and Claassen 1925), **MN** (Frison 1942, Harden and Mickel 1952), **MO** (Frison 1942), **ND** (Kondratieff and Baumann 1999), **SD** (Frison 1942, Huntsman et al. 1999, Huntsman et al. 2001).
Additional Records: CANADA – SK: Shuard Creek, 11 mi. South of Piapot, 23/VII/1975, L. Dodsall, 1♀ (BYUC). **USA – KS:** Cheyenne Co., S. Fork Republican River, 11 mi W, 7 mi S. St. Francis, 5/VI/1970, D. Huggins, 6♂, 2♀, 6N (BYUC).
Male. Macropterous. Forewing length 6-8 mm. General body pale yellow to pale brown with dark brown markings. Dorsal head pattern variable, dorsal background pale yellow to pale brown, usually with medium brown bands connecting ocelli and thin medium brown bands extending anteriorly beyond median ocellus forming an H-pattern (occasionally indistinct) (Fig. 28.1). Antennal scape pale yellow, pedicel and flagellum medium brown. Pronotum with a median pale stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks pale yellow; anterior margin with broad bipartite medium brown bands (Fig. 28.1). Meso- and metasterna pale yellow without dark markings. Meso- and metanota pale yellow with irregular medium brown markings. Wings hyaline with pale brown veins. Femora and tibia pale yellow, tibia with thin medium brown vertical band on outer surface near proximal ⅓; tarsi pale brown. Sterna pale yellow, sternum 8 with a low wide medium brown vesicle ca. 2.5X as wide as long; vesicle extends posteriorly to near anterior margin of sternum 9 (Fig. 28.2). Terga red to red brown; terga 9 and 10 pale brown, posterior ½ of tergum 9 elevated with crescent shaped median bipartite patch of stout spinulae; anterior edge with



Figs. 28.1-28.7. *Isoperla longiseta*. 28.1. Dorsal head and pronotal pattern. 28.2. Male posterior abdominal sterna. 28.3. Male posterior abdominal terga. 28.4. Female subgenital plate. 28.5. Male paraproct lateral view. 28.6. Male lateral view posterior abdominal segments. 28.7. Male aedeagus lateral view; .a. posteroventral patch of rows of long hair-like spinulae, b., wide mesal section band of concentrated short stout spinulae, c. apical section with scattered long hair-like spinulae, d. paired posterodorsal tubular lobes, e. paired posterodorsal small rounded lobes, f. paired anterodorsal lobes.



Figs. 28.8-28.13. *Isoperla longiseta*. 28.8. Male aedeagus lateral view. 28.9. Posteroventral patch of rows of aedeagal long hair-like spinulae. 28.10. Detail of posteroventral patch of rows of aedeagal long hair-like spinulae. 28.11. Mesal patch of dense short stout aedeagal spinulae. 28.12. Apical section with scattered long hair-like aedeagal spinulae. 28.13. Paired posterodorsal tubular aedeagal lobes.



Figs. 28.14-28.16. *Isoperla longiseta*. 28.14. Egg. 28.15. Detail of egg collar, dorsal view. 28.16. Detail of egg chorion and micropyles.

a linear patch of fine setae, anterior ½ depressed to level of tergum 8 (Figs. 28.3, 28.6). Tenth tergum with bipartite median sclerotized medium brown triangular patches bearing small fine spinulae (Fig. 28.3). Paraprocts sclerotized, slender, elongate tapering to fine points apically and extending over ca. ⅓ length of tergum 10 (Figs. 28.3, 28.5). Cerci pale yellow and ca. 2X length of abdomen; distal margin of flagellum with thin pale brown band. Aedeagus with wide posteroventral patch consisting of rows of long hair-like spinulae (Figs. 28.7a, 28.8, 28.9, 28.10); mesal section with wide band of dense short stout spinulae (Figs. 28.7b, 28.8, 28.9, 28.10 28.11); apical section with scattered long hair-like spinulae (Figs. 28.7c, 28.12); posterodorsal section bearing paired posterodorsal tubular lobes (Figs. 28.7d, 28.8, 28.13) and paired posterodorsal small rounded lobes (Fig. 28.7e); paired anterodorsal lobes present (Fig. 28.7f).

Female. Macropterous. Forewing length 8-10 mm. General body color and morphology similar to male except live females lack the red to red brown abdomen. Eighth sternum with a semicircular subgenital plate extending posteriorly over ¼ length of sternum 9; posterior ½ usually darker than rest of segment (Fig. 28.4).

Ovum. Described by Szczytko and Stewart (1979a). General shape oblong, cross section circular. Color pale brown (Fig. 28.14). Length 210 µm; width 130 µm. Collar well-developed, flared apically with elevated longitudinal carinae; base slightly offset from egg body (Figs. 28.14, 28.15). Hexagonal follicle cell impressions faintly visible; floors shallow with numerous shallow pits; eclosion line absent. Micropyles raised with associated raised sperm guides, arranged in pairs or threes near anterior ⅓ of egg (Figs. 28.14, 28.15, 28.16).

Nymph. Described by Szczytko and Stewart (1979a).

Diagnosis. *Isoperla longiseta*, is similar to *I. jewetti* and *I. quinquepunctata* which are also placed in the *I. longiseta* group (Table 1). These three species occur at the far western range of the Eastern North American *Isoperla* as treated in this review. The abdomen of live males is red to red brown, as are those of *I. quinquepunctata*, and the cerci are about twice the length of the abdomen. *Isoperla longiseta* is most similar to the rare or possibly extirpated *I. jewetti* but males differ in having longer more slender paraprocts, two posterodorsal tubular aedeagal lobes and macropterous wings (Szczytko and Stewart 1979a). The female subgenital plate of *I. longiseta* is more evenly rounded and less truncate than in *I. jewetti.* The head pattern, vesicle shape, elevated posterior ½ of tergum 9 and spinule patterns on the male terga 9 and 10 are similar in both species. There are no other eastern *Isoperla* species that appear to be closely related to *I. longiseta*. Heimdal et al. (2004) and DeWalt et al. (2005) consider *I. longiseta* to be extirpated from Iowa and Illinois, respectively.

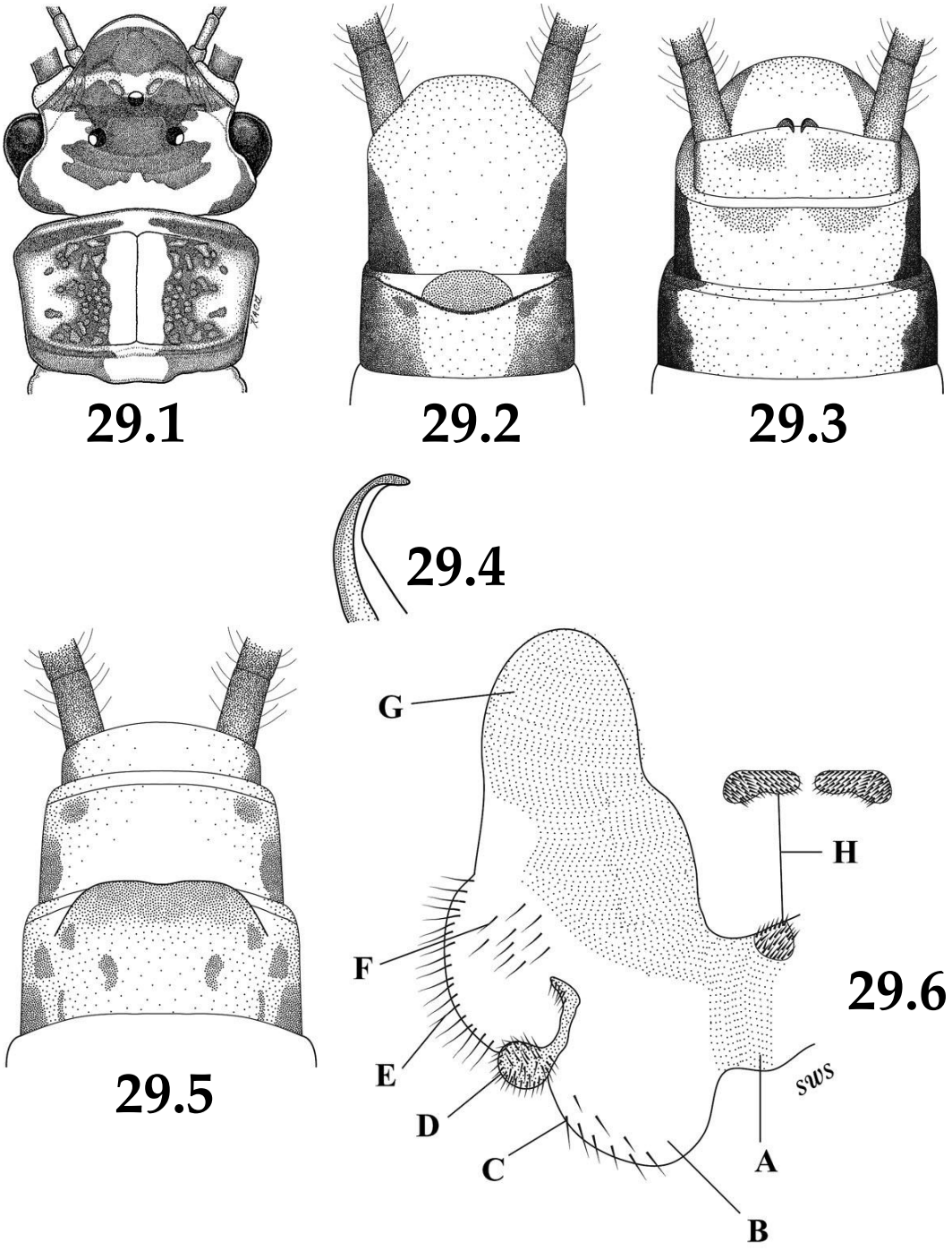
Biological Notes. Ricker (1943, 1946, 1964), Baumann et al. (1977) and Harper and Ricker (1994) consider *I. longiseta* a species associated with grassland streams. The species is abundant in large silty rivers of the upper Great Plains and the inter-mountain regions of the Great Basin of Saskatchewan, Alberta, North Dakota and south to Missouri (Szczytko and Stewart 1979a, Kondratieff and Baumann 1999, Huntsman et al. 2001, Stark et al. 2009). Harden and Mickel (1952) concluded the species occurs in medium to large Minnesota prairie rivers that are "sluggish" such as the Missouri, the James, and the Red River of the North. A slow seasonal nymphal development was reported by Barton (1980) in northeastern Alberta. Eggs hatched in August, followed by steady growth through the winter and early spring, and by rapid growth in June and July. Barton (1980) reported maximum emergence in early June, but adults were active until late August. Interestingly, Barton (1980) remarked about the behavior of nymphs walking on the underside of the surface film of streams until a solid object was encountered which allowed them to crawl out of the water to emerge. Dosdall and Lehmkuhl (1979) documented a nonseasonal univoltine life cycle in Saskatchewan with emergence in mid-June until the end of July. Baumann et al. (1977) noted that *I. longiseta* emerged from May to mid-July.

Isoperla major Nelson and Kondratieff
Big Stripetail
(Figs. 29.1-29.9)

Isoperla major Nelson and Kondratieff 1983, 76:270. Holotype ♂ (USNM) Burkes Garden (Tazewell Co.), Virginia. Examined.

Distribution: **USA – VA** (Nelson and Kondratieff 1983).

Male. Macropterous. Forewing length 14.0-15.0 mm. General body medium brown. Dorsal background of head yellow with large dark brown X-shaped patch covering mesal area, including interocellar area, and extending laterally to near antennal bases and posteriorly to near hind margin of head; posterior ends with slight lateral extensions, thin pale M-shaped band anterior to median ocellus; anterior margin of frons with medium brown patch; posterolateral margins with dark bands extending from base of eyes to posterior margin of head (Fig. 29.1). Submentum with mesal dark brown patch. Antennal scape, pedicel, and flagellum dark brown. Pronotum with wide median pale stripe, middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks yellow; anterior and posterior margins with bipartite median dark brown bands (Fig. 29.1). Meso- and metasterna with anterior wide transverse medium brown band



Figs. 29.1-29.6. *Isoperla major*. 29.1. Dorsal head and pronotal pattern. 29.2. Male posterior abdominal sterna. 29.3. Male posterior abdominal terga. 29.4. Male paraproct lateral view. 29.5. Female subgenital plate. 29.6. Male aedeagus lateral view; a. ventral band of dense, small stout spinulae, b. posteroventral lobe, c. sparse patch of long stout, light brown spines, d. paired posterolateral sclerites, e. posteromesal patch of long reddish brown spines, f. mesal patch of scattered stout reddish brown spines, g. dorsal patch of small fine hair-like spinulae, h. paired dorsobasal paired rectangular spine plates with small stout reddish brown spines.

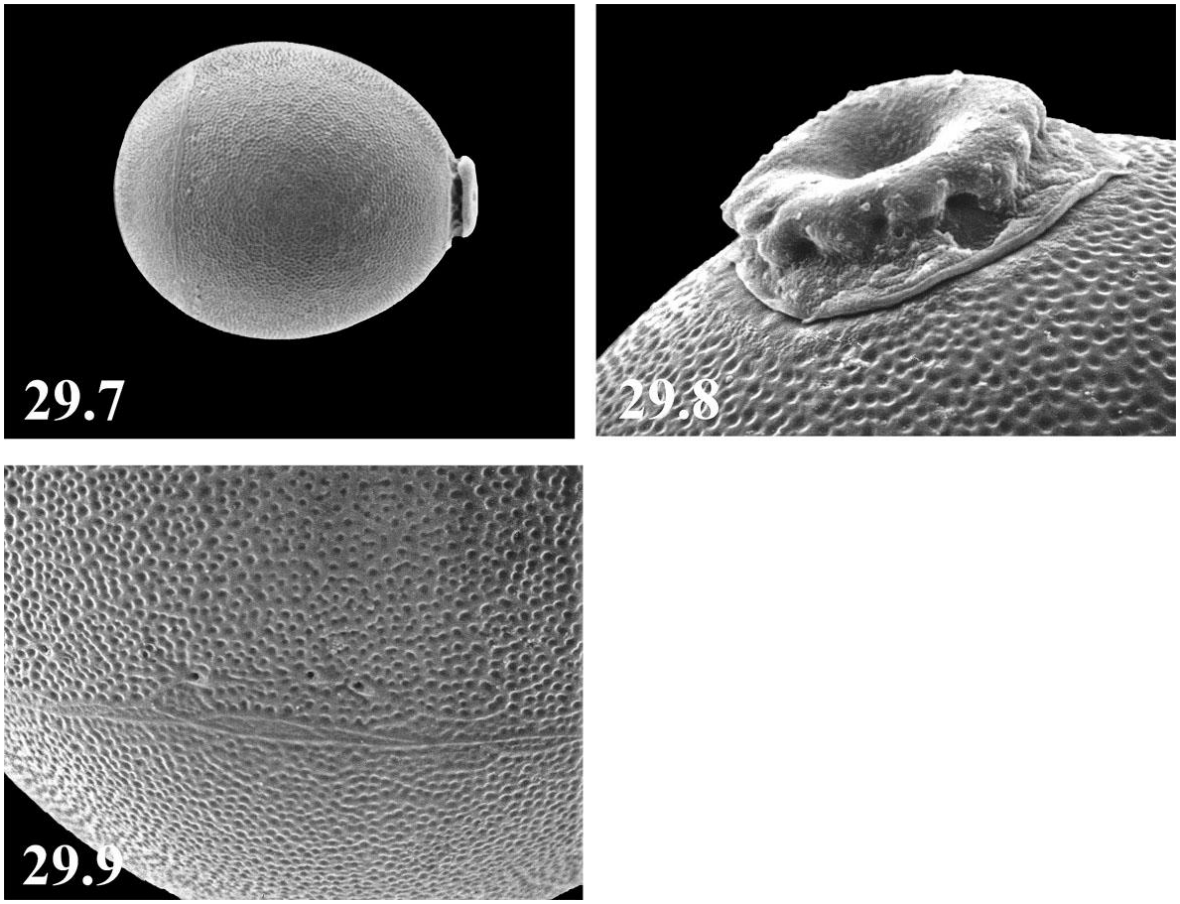
with paler median area. Meso- and metanotum with round dark brown anterior spots and incomplete median pale bands. Wings pale brown, veins dark brown. Femora yellow with thin dark brown dorsal band and dark brown horizontal band on distal 1/5; tibia yellow with thin dark brown dorsal band and horizontal dark brown band on proximal 1/6, tarsi dark brown. Sterna 1-8 amber, sternum 8 with paired dark brown lateral spots; posterior margin with a thin dark brown band. Vesicle amber, broad, ca. 2X as wide as long; posterior margin evenly rounded extending posteriorly to anterior margin of sternum 9; sternum 9 yellow with posterolateral dark brown bands (Fig. 29.2). Terga 1-5 amber with darker lateral bands; segments 6-10 pale yellow; terga 9 and 10 with bipartite mesal patch of short fine spinulae, mesal area of tergum 10 slightly depressed (Fig. 29.3). Posterior margin of paraprocts sclerotized, recurved forward only to level of tergum 10; apices acutely pointed, posterior margins fringed with fine setae (Fig. 29.4). Basal cercal segments 1-3 amber, remaining segments dark brown. Aedeagus with posteroventral area covered with dense, small stout spinulae (Fig. 29.6a); dorsobasal area with paired rectangular shaped sclerotized spine plates bearing small stout reddish brown spines (Fig. 29.6h); large posteroventral lobe with sparse patch of long stout, pale brown spines (Figs. 29.6b, c); paired posterolateral sclerites with enlarged rounded posterior ends and elongate arm and anterior hook shaped ends; posterior ends with heavy concentration of medium length stout reddish brown spines; anterior ends with 7-8 medium length stout reddish brown spines (Fig. 29.6d); posteromesal area with patch of long reddish brown spines (Fig. 29.6e); mesal area with sparse patch of stout reddish brown spines (Fig. 29.6f); expanded dorsal lobe and anterior margin covered with small fine hair like spinulae (Fig. 29.6g).

Female. Forewing length 15.0-17.5 mm. General body color and morphology similar to male described above. Eighth sternum with low broadly truncate subgenital plate with a slight, shallow median emargination; plate produced posteriorly to anterior margin of sternum 9; posterior margin of plate with a diffuse median brown band and paired medium brown spots near base and near mesal area; anterolateral margin with dark brown bands (Fig. 29.5). Ninth sternum mostly yellow with dark brown anterolateral patches and paired posterior brown spots; sternum 10 yellow with small dark brown anterolateral bands (Fig. 29.5).

Ovum. General shape oblong, cross section circular (Fig. 29.7). Color pale brown. Length 360 µm; width 320 µm. Collar base, elevated with thickened longitudinal ridges; apical portion expanded with pronounced flared ridges (Figs. 29.7, 29.8). Hexagonal follicle cell impressions slightly visible; chorionic surface covered with small shallow pits; eclosion line wide, smooth and slightly raised with low sinuous ridge. Micropyles arranged singularly, openings slightly elevated and positioned above eclosion line near anterior ⅓ of egg (Figs. 29.7, 29.9).

Nymph. Nelson and Kondratieff (1983) described the nymph and illustrated the habitus, head and tergal spinule patterns, cercal setation and mouthparts.

Diagnosis. *Isoperla major* is the largest known species of eastern Nearctic *Isoperla* ranging in body length from 10-14 mm. It is a member of the *I. similis* group of species (Table 1). *Isoperla major* appears most closely related to *I. similis* and shares several details of the secondary and primary sexual characteristics with that species. The major differences between the two species occur in body coloration, size, and in aedeagal structure and emergence phenology. The overall body coloration of *I. major* is paler than *I. similis*. The head patterns differ in that *I. major* has a pale thin M-shaped band anterior to the median, and the posterior ends of the large mesal dark brown patch have lateral extensions. The pronotal disks of *I. major* are pale brown, in contrast to the dark brown to black disks of *I. similis*. Terga 1-5 of *I. major* are amber and terga 6-10 are pale yellow; terga 1-8 of *I. similis* are pale brown, usually with 3 lateral and 2 median rows of faint brown spots and a mesal pale brown band on segments 1-3; segments 9 and 10 are pale yellow. The sterna of *I. major* are amber and medium to dark brown in *I. similis*. Sternum nine



Figs. 29.7-29.9. *Isoperla major*. 29.7. Egg. 29.8. Detail of egg collar. 29.9. Detail of egg chorion, micropyles and eclosion line.

of *I. similis* is mostly pale yellow and medium to dark brown in *I. similis.* The subgenital plate of *I. major* has a diffuse posterior medium brown band, whereas the subgenital plate of *I. similis* is mostly medium brown with a distinctive pale mesal triangular-shaped band. The male aedeagus of *I. major* differs from that of *I. similis* in the following details: absence of a posteromesal tear- shaped concentrated patch of long stout reddish brown spines, but presence of a sparse concentration of long light spines (Fig. 29.6f); absence of paired mesoposterior and mesoanterior lobes; dorsobasal spine patches short and generally rectangular shaped (Fig. 29.6h). The male paraprocts of *I. major* are more elongate and more sharply pointed apically than are those of *I. similis* (Fig. 29.4). The ova are similar and cannot be distinguished at this time. Additionally, the male of *I. major* may be distingished from males of the sympatric *I. pseudosimilis* by the absence on the aedeagus of that species of paired posterolateral sclerites (see Fig. 44.6 in description of *I. pseudosimilis* sp. n.). Females of these species may be distinguished on the basis of a more broadly rounded subgenital plate which has a darkly pigmented posterior margin in *I. pseudosimilis* sp. n. (see Fig. 44.5 in description of *I. pseudosimilis* sp. n. the female).

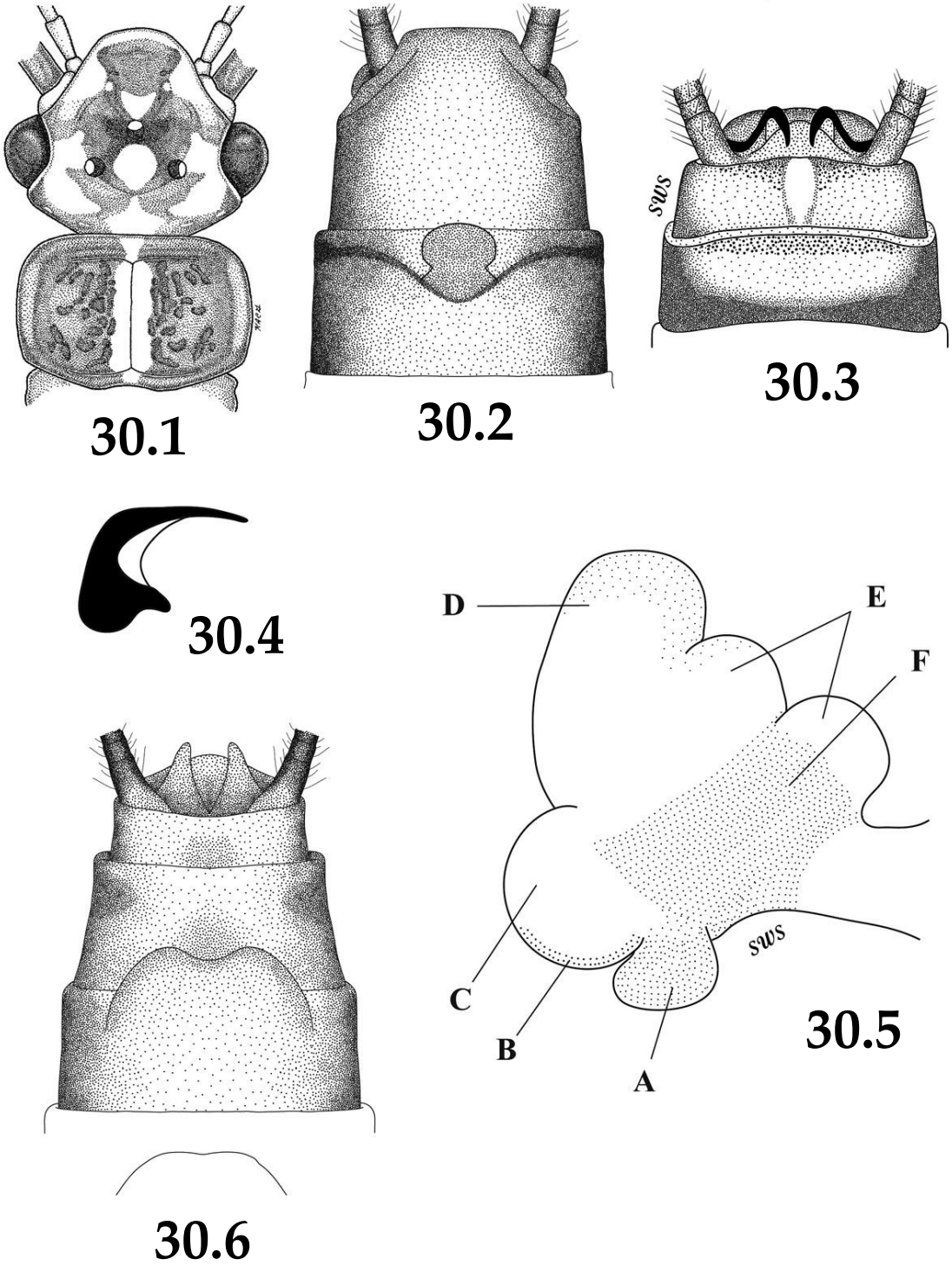
Biological Notes. As stated above *I. major* is known

only from the type locality and essentially there is no information available about the biology of this species, other than what was presented by Nelson and Kondratieff (1983). The emergence period is from early to mid-September and it appears to be restricted to higher elevation clean, spring-fed first order stream systems of western Virginia.

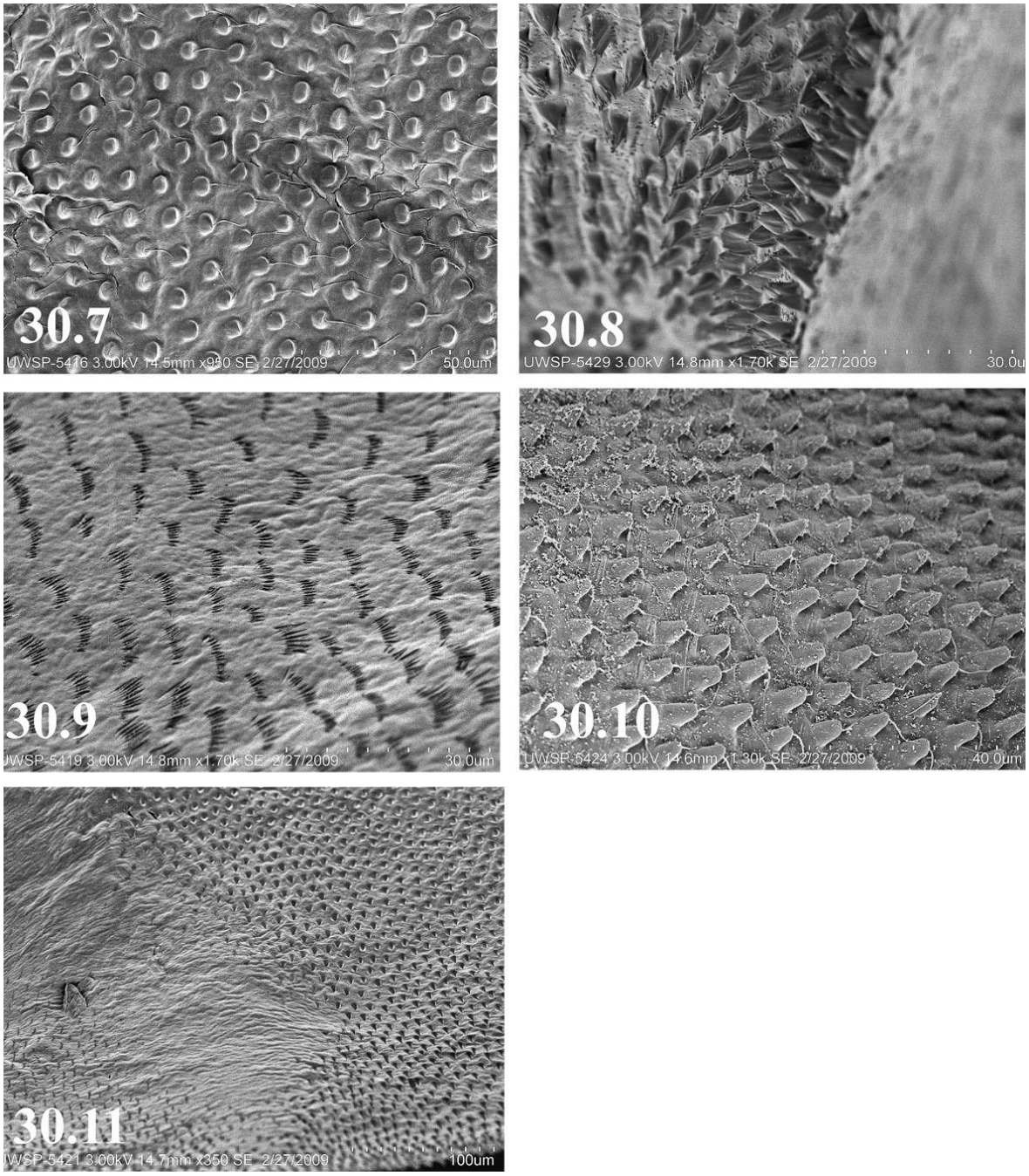
Isoperla marlynia Needham and Claassen
(Midwestern Stripetail)
(Figs. 1.8, 30.1-30.15)

Isoperla marlynia Needham and Claassen 1925, 2:148. Holotype ♂ (CUIC) Lakehurst (Ocean Co.), New Jersey. Examined.
Chloroperla montana Banks 1898:199, in part.
Isoperla clio Needham and Claassen 1925, 2:139, in part.
Isoperla clio: Frison, 1935, 439 nymph.
Isoperla marlynia: Frison, 1942, 22:330.

Distribution: **CANADA – MB** (Frison 1942, Ricker 1944, Burton 1984), **NB** (Ricker 1947), **NS** (Kondratieff and Baumann 1994), **ON** (Harper and Ricker 1994), **PQ** (Ricker 1944, Ricker et al. 1968, Harper et al. 1975), **USA – CO** (Kondratieff and Baumann 2002, Zuellig et al. 2006), **IA** (Heimdal et al. 2004), **IL** (Frison 1942, DeWalt and Grubbs 2011), **IN** (Frison 1942, Ricker 1945, Grubbs 2004, DeWalt and Grubbs 2011 extirpated), **KY** (Tarter et al. 2006, **ME** (Needham and Claassen 1925), **MI** (Frison 1942), **MN (**Harden and Mickel 1952), **NE** (Rhodes and Kondratieff 1996), **NJ** (Needham and Claassen 1925), **PA** (Surdick and Kim 1976, Masteller 1996b**, VA** (Frison 1942), **WI** (Frison 1942), **WV** (Tarter and Nelson 2006).
New Records: USA –NY: Franklin Co., Ampersand Brook, Coreys rd. nr. Pickerel Pond Outlet 44°11.930'N, 74°17.496'W, 27/VI/2007, L.W. Myers, B.C. Kondratieff, 1♂, 5♀ (CSUC). Herkimer Co., Middle Branch Moose River, Rte. 28, Old Forge, 5/VI/2008, L.W. Myers, R. Mowrey, 1♂ (CSUC).
Additional Records: USA – ME: Washington Co., Machias River, Rte. 9, 2/VI/1998, B.C. Kondratieff, R.W. Baumann, 1♂, 3♀ (CSUC). **NE:** Hall Co., Platte River, Mormon Island State Park, 20/IV/1980, R.W. Baumann, 3♀ (BYUC). Lincoln Co., South Platte River, North Platte, 18/III/2004, M. Garhart, 20♂, 22♀ (CSUC). Red Willow Co., Republican River, 1 mi S of Perry, 19/II/1994, B.C. Kondratieff, H. Rhodes, emerged 12/III//1994, 1♂, 4♀ (CSUC). Scottsbluff Co., North Platte River @ Scottsbluff, emerged 25/VI/1989, B.C. Kondratieff, 1♂, 1♀ (CSUC).
Male. Macropterous. Forewing length 10.3-11.4 mm. General body color dark brown in life, medium to dark brown in alcohol with darker brown or black markings. Dorsum of head with dark brown bands connecting anterior ocellus with posterior ocelli; medium brown bands extend from ocellar triangle to antennal bases; interocellar area with pale triangular spot, usually closed posteriorly; medium brown bands extend from base of interocellar area to hind margin of head; medium brown bands extend from posterior margin of head laterally to base of eyes; posteromedian area with pale broadly triangular spot; frontoclypeal area with broad dark band widest anteriorly, and a pale spot posterior to dark band extends to anterior ocellus (Fig. 30.1). Antennal scape, dark brown, pedicel and flagellum pale brown. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities dark and raised, pronotal disks medium brown; anterior and lateral margins medium brown (Fig. 30.1). Meso- and metanota mostly dark brown with irregularly shaped anterior pale spots. Wings dusky with dark brown veins. Legs medium brown, dorsal surface of femora darker; a small callus located at base of femora; tibia with dark narrow vertical band near proximal end; proximal area near vertical band darker than distal portion. Lateral margins of sterna dark brown with wide median pale band extending to sternum 9. Sternum 8 with medium brown well-developed vesicle set in a U-shaped depression, nearly as long as wide; vesicle expanded posteriorly, extending to near anterior margin of sternum 9 (Fig. 30.2). Terga pale to medium brown but anterior margins darker and usually with 3 lateral rows and 2 median rows of dark longitudinal spots; posterior ⅔ of terga 9 and 10 much paler than proceeding terga in fresh specimens; tergum 10 with scattered setae near posterior margin; a posteromedian depressed area extends anteriorly for ½ segment (Fig. 30.3).

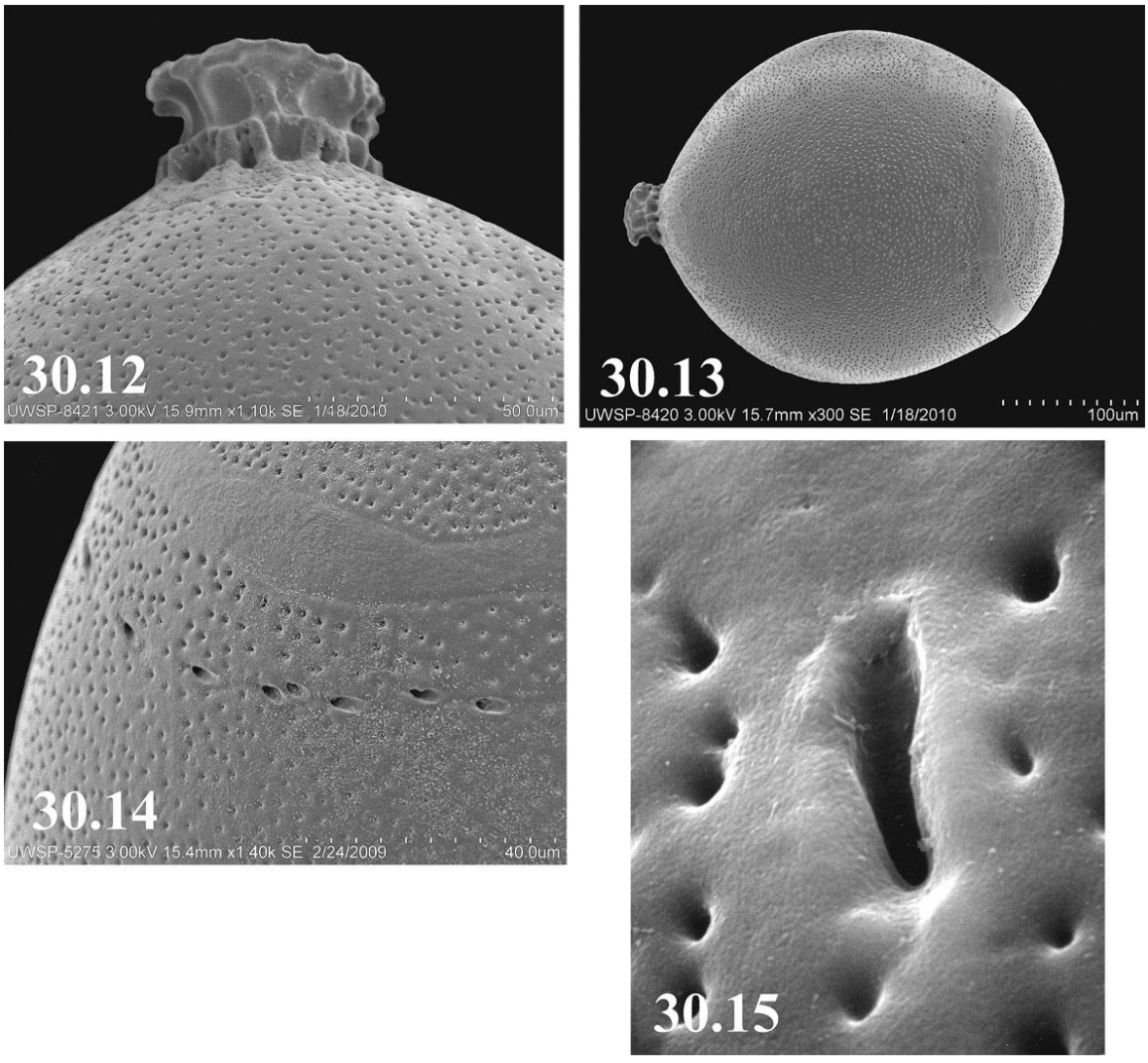


Figs. 30.1-30.6. *Isoperla marlynia*. 30.1. Dorsal head and pronotal pattern. 30.2. Male posterior abdominal sterna. 30.3. Male posterior abdominal terga. 30.4. Male paraproct lateral view. 30.5. Male aedeagus lateral view; a. posteroventral lobe, b. patch of stout spinulae, c. posteromesal lobe, d. dorsal lobe, e. anterior lobes, f. broad dense patch of stout spinulae. 30.6. Female subgenital plate.



Figs. 30.7-30.11. *Isoperla marlynia*. 30.7. Patch of raised scattered bumps on apical aedeagal lobe. 30.8. Posteroventral patch of stout spinulae on posteromesal aedeagal lobe. 30.9. Scattered rows of fine hair-like spinulae on aedeagal lobes. 30.10. Mesal area of dense stout aedeagal spinulae. 30.11. Small fine spinulae on posteroventral aedeagal lobe.

Paraprocts heavily sclerotized, long, thin, sharply pointed apically; tips curved outward slightly, occasionally twisted, extending approximately ½ distance over tergum 10; scattered sensilla basiconica occur on outer surface (Figs. 30.3, 30.4). Cerci medium brown with dark distal bands on each segment. Aedeagus with large dorsal (Fig. 30.5d) and posteromedial lobes (Fig. 30.5c) and smaller posteroventral membranous lobe (Fig. 30.5a). Two anterior membranous lobes occur (Fig. 30.5e). On each the mesal section bears a broad area of dense stout spinulae extending to near base of stalk (Figs. 30.5f, 30.10) and the apical lobe has small, raised scattered bumps above the mesal section (Figs. 30.5d, 30.7); posteromesal lobe with posteroventral patch of stout spinulae (Figs. 30.5b, 30.8); posteroventral lobe covered with small fine spinulae (Figs. 30.5a, 30.11); surface of all membranous lobes bear scattered rows of fine hair-like spinulae (Fig. 30.9).



Figs. 30.12-30.15. *Isoperla marlynia*. 30.12. Detail of egg collar. 30.13. Egg. 30.14. Detail of egg chorion, micropyles and eclosion line. 30.15. Detail of egg micropyle.

Female. Forewing length 11.3-12.5 mm. General body color and morphology similar to male. Subgenital plate produced posteriorly over ½ length of sternum 9, broadly rounded posteriorly usually with a shallow or deep posteromedian notch; posterior margin usually darker (Fig. 30.6).

Ovum. General shape broadly oval, cross section circular. Color pale brown. Length 326 µm; width 260 µm (Fig. 30.13). Collar well-developed with apically flanged rim; stalked collar elevated and bearing longitudinal carinae; base with raised irregular ridge (Figs. 30.12, 30.13). Choronic surface covered with numerous small, shallow punctations; hexagonal follicle cell impressions faintly visible (Figs. 30.13, 30.14). Eclosion line well-developed, wide, sinuous, with smooth surface devoid of punctations. Micropyle row positioned adjacent to eclosion line; orifices elongate, occurring in slit-like openings in groups of 8 or less (Figs. 30.14, 30.15).

Nymph. Mouthparts and habitus were illustrated by Frison (1942). Hilsenhoff and Billmyer (1973) illustrated the lacinia. *Isoperla marlynia* nymphs exhibit probably the greatest variation in color patterns of any eastern *Isoperla* species as discussed by Frison (1942) and Harden and Mickel (1952). Stark et al. (1998) and Stewart and Stark (2002) provided a color photograph of the habitus.

Diagnosis. *Isoperla marlynia* can be separated from all other eastern *Isoperla*, including other members of the *I. lata* group (Table 1) by the combination of elongate, sharply pointed male paraprocts, distinctive head pattern, shape and spinule pattern of the aedeagus and details of the ova. The shape of the subgenital plate varies from an evenly rounded posterior margin to a margin with a shallow or deep emargination. DeWalt et al. (2005) indicated that *I. marlynia* has been extirpated from Illinois.

Biological Notes. Nymphs of *I. marlynia* typically occur in small to large rivers. Nymphs are often associated with submerged wood in riffles and runs. Emergence occurs during March and early April in southern populations and during May through June in northern Midwestern populations and as late as late-July in Manitoba and as early as mid- to late February in Colorado.

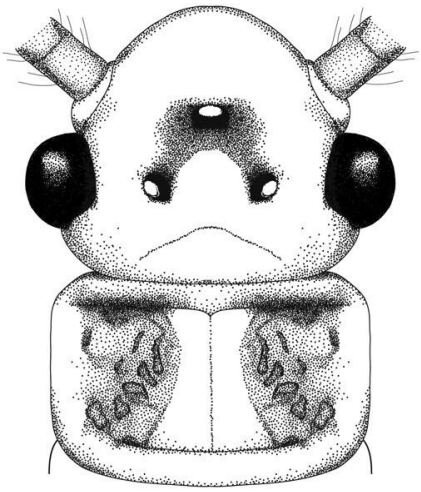
Ziminske (1989) reported that the typical male drumming call was grouped and had a mean number of 10.8 ± 2.4 beats with a mean of 3.2 ± 1.0 beats/group and a mean interbeat interval of 38.2 ± 6.2 ms. The female signal generally consisted of a single beat.

Isoperla maxana Harden and Mickel
Minnesota Stripetail
(Figs. 31.1-31.4)

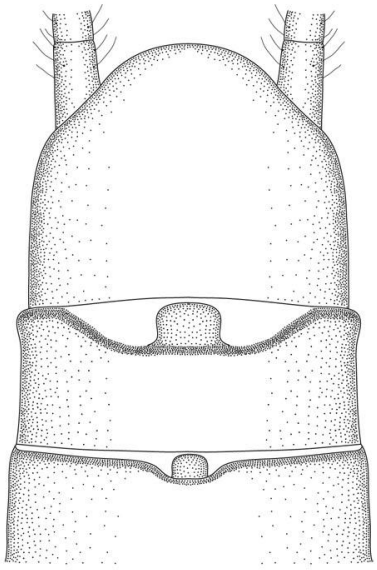
Isoperla maxana Harden and Mickel 1952, 201:42. Holotype ♂ (UMSP) Fishhook River (Hubbard Co.), Minnesota. Examined.

Distribution: **USA – MN** (Harden and Mickel 1952).

Male. Macropterous. Forewing length 8.0 mm. General body pale yellow with medium brown markings. Dorsal background of head pale yellow with medium brown bands connecting ocelli; pigmented area near anterior ocellus truncate; interocellar area pale yellow (Fig. 31.1). Antennal scape and pedicel light brown, flagellum pale yellow. Pronotum with a pale hourglass-shaped median stripe; mid dorsal pronotal suture a faint pale brown line; rugosities irregular, raised, pale brown; pronotal disks pale yellow, anterior margin with diffuse bipartite medium brown bands (Fig. 31.1). Meso- and metasterna pale yellow with pale brown lateral bands. Meso- and metanota mostly pale yellow with irregular pale brown markings. Wings hyaline with pale brown veins. Femora and tibia mostly pale yellow, tarsi pale brown. Sterna pale yellow, posterior margin of sternum 7 with a thin medium brown band and small posteromedian lobe ca. as wide as long; posterior margin of sternum 8 with a wider medium brown band and a well-developed vesicle ca. as wide as long, extending posteriorly to near anterior margin of sternum 9 (Fig. 31.2). Terga with pale brown median and lateral longitudinal stripes; lateral stripes paler than median stripe (Fig. 31.3). Tenth tergum with posteromedian depressed area paler than rest of tergum (Fig. 31.3). Paraprocts unsclerotized, projecting posteriorly and not recurved over tergum 10 (Fig. 31.4). Cerci pale yellow. The aedeagus is entirely membranous with variably sized spinule patches; posteroventral



31.1



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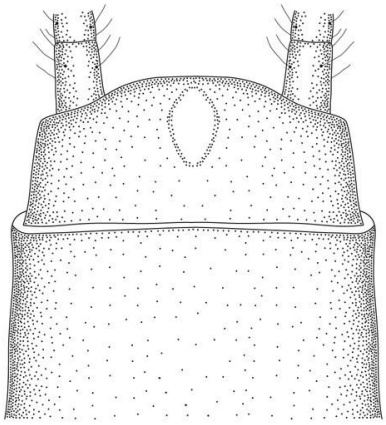

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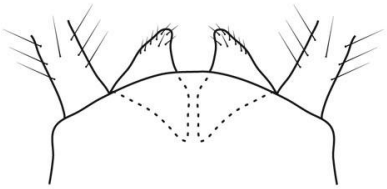


31.4

Figs. 31.1-31.4. *Isoperla maxana*. 31.1. Dorsal head and pronotal pattern. 31.2. Male posterior abdominal sterna. 31.3. Male posterior abdominal terga. 31.4. Detail of dorsal view of male paraprocts.

margin with a membranous nipple devoid of spinulae.

Female. Unknown.

Ovum. Unknown.

Nymph. Unknown.

Diagnosis. The holotype male of *I. maxana* is a small pale yellow species known from a single low order sand bottom stream in west central Minnesota. The male is unique among all other known North American *Isoperla* in possessing a

small posteromedian lobe on sternum 7 and in having unsclerotized flat paraprocts. The holotype, the only known specimen, was collected in 1948. We have attempted to recollect this species at the type locality on three different occasions without success. The male aedeagus ruptured upon clearing and eversion and, therefore, no definitive analysis of aedeagal armature can be provided. It is difficult to speculate on the relationship of *I. maxana* with other eastern *Isoperla* species since the female, egg and nymph are unknown.

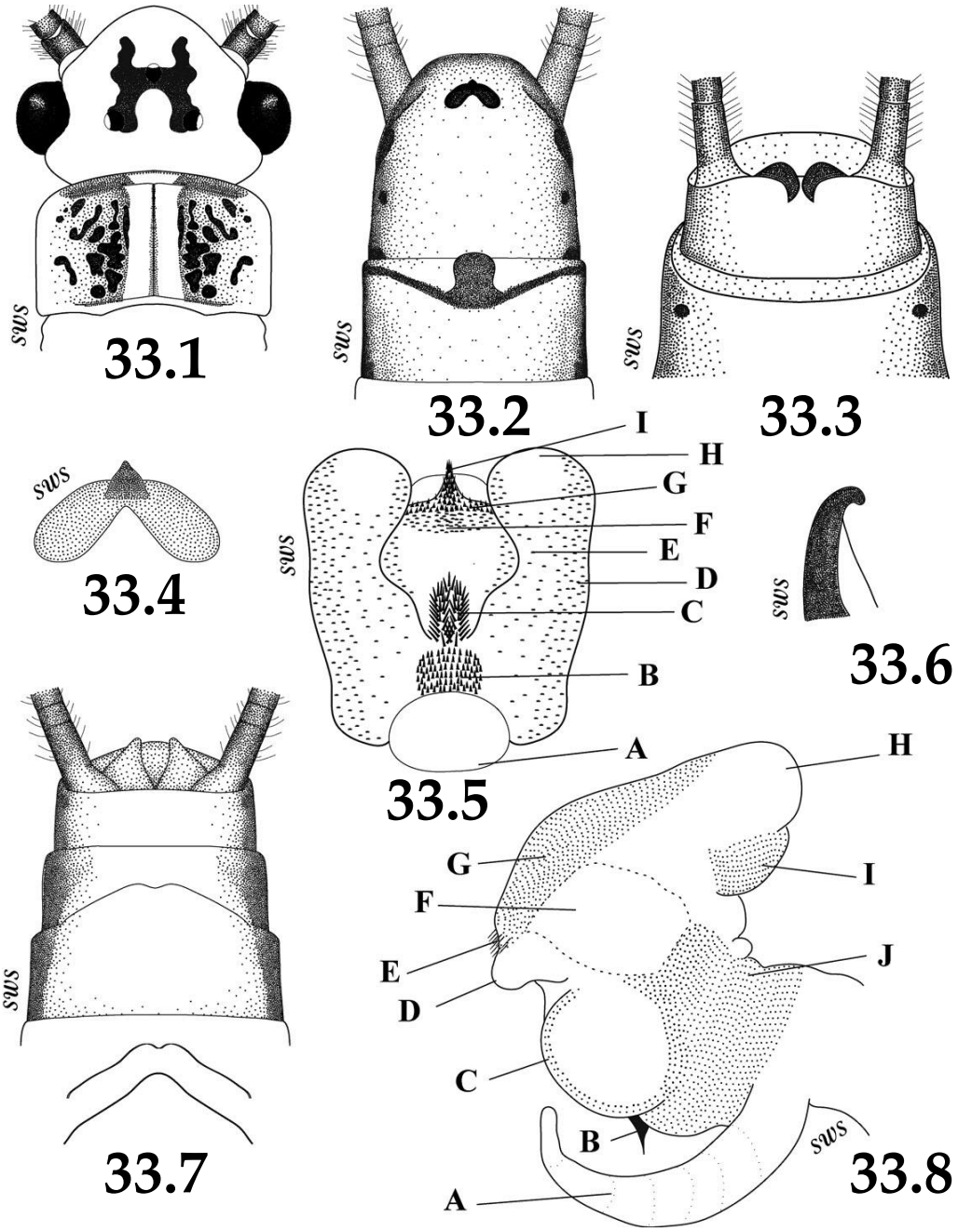
Biological Notes. The Fishhook River originates at Fishhook Lake (663 ha) north of Park Rapids, Minnesota and flows through a small impoundment that is part of a city park. The stream becomes a third order sandy drainage with few riffles below the impoundment southeast of the town. This species may have been extirpated due to the impoundment, increased urban development, and agriculture in the watershed since 1948.

Isoperla montana Banks
Montane Stripetail
(Figs. 33.1-33.28)

Chloroperla montana Banks 1898, 25:199. Holotype ♂ (MCZ) Mt. Washington, New Hampshire. Examined.
Isoperla montana: Needham and Claassen, 1925, 2:155.
Walshiola montana: Banks, 1947, 54:283.
Isoperla montana: Frison, 1942, 22:331.
Isoperla montana: Harden and Mickel, 1952, 201:43.

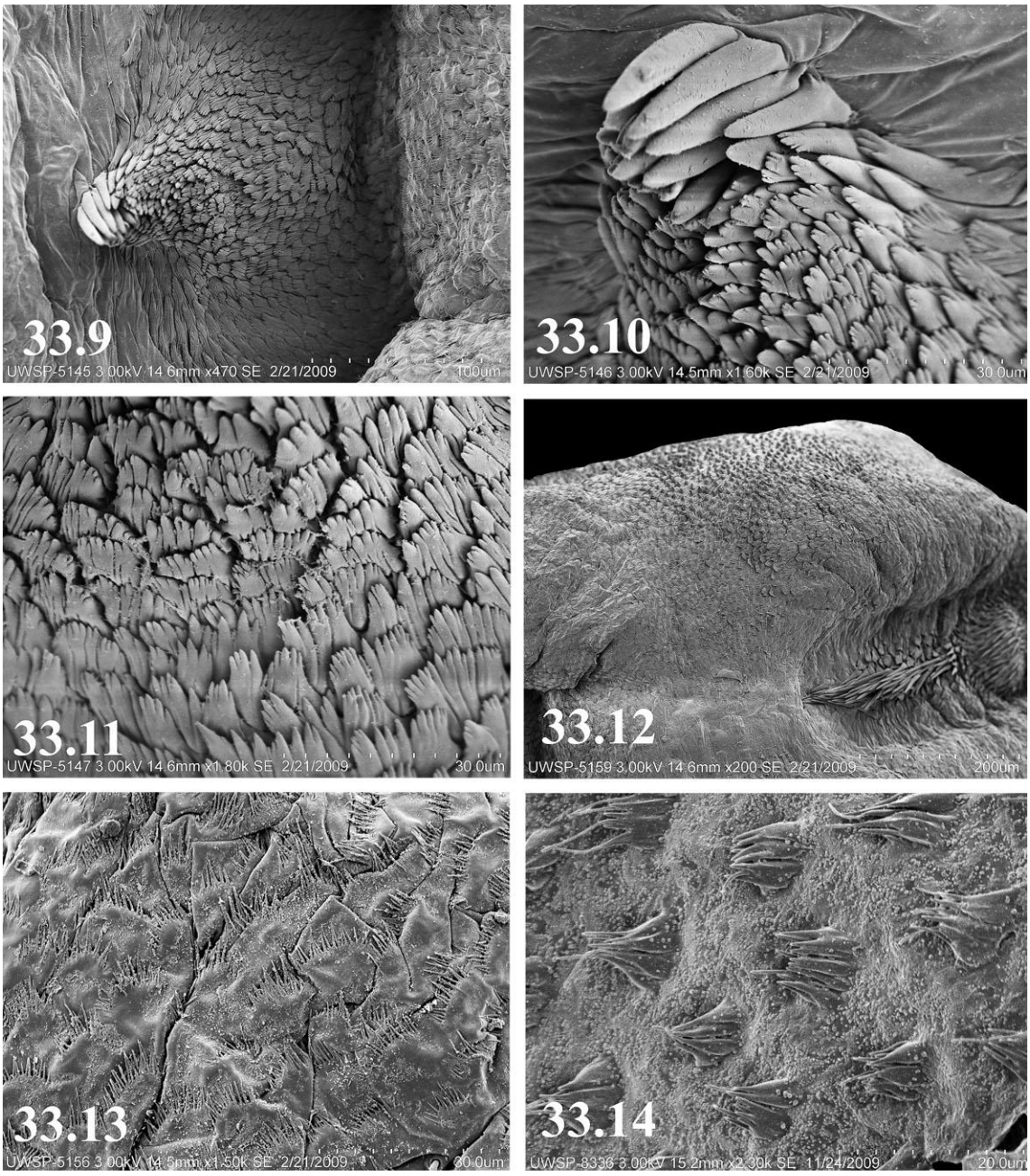
Distribution: **CANADA –NS** (Ricker 1947), **ON** (Harper and Ricker 1994), **PQ** (Ricker et al. 1968). **USA – CT** (Hitchcock 1974), **DE** (Lake 1980), **IN (**DeWalt and Grubbs 2011), **MD** (Grubbs 1997), **ME** (Needham and Claassen 1925), **MN** (Needham and Claassen 1925, Harden and Mickel 1952), **NH** (Needham and Claassen 1925), **OH** (DeWalt et al. 2012, Grubbs et al. 2013), **PA** (Surdick and Kim 1976, Grubbs 1996, Masteller 1996), **VA** (Kondratieff and Kirchner 1987).

New Records: **USA –KY:** Johnson Co., Paint Creek, 6/V/1976, R.F. Kirchner, 1♂, 11♀ (CSUC). **NC:** Jackson Co., Scott Creek, Skyland Drive, 22 June 2013, B.C. Kondratieff, C. Verdone, 2♀ (CSUC). **NJ:** Hunterdon Co., Wickecheoke Creek, NW Sergentsville, 3/V/1991, R.W. Baumann, S. Wells, 1♂ (BYUC). **NY:** Albany Co., Onesquethaw Creek, jct. Grosbeck and Flat Rock rd., 24/V/2008, L.W. Myers, B.C. Kondratieff, 2♂, 2♀ (CSUC). Clinton Co., Stillwater Brook, Morhous rd., off Rand Hill rd., W Jericho, 28/V/2008, L.W. Myers, R. Mowrey, 2♂, 4♀ (NYSM); trib. True Brook, Clark Hill rd., Saranac, 2/VI/2010, L.W. Myers, 1♂ (CSUC). Essex Co., Hoisington Brook, Ledge Hill rd. off Rte. 9n, nr. Westport, 23/V/2008, L.W. Myers, B.C. Kondratieff, R.W. Baumann, 1♂ (NYSM). Greene Co., overflow area, Kiskatorn Brook, Hearts Content rd. 0.7 mi. S Winter Clove, 15/IV/2009, L.W. Myers, 4♂, 3♀ (CSUC). Oneida Co., Alder Creek, Rte. 12 nr. Alder Creek, Station, 22/V/2008, L.W. Myers, B.C. Kondratieff, R.W. Baumann, 1♂ (NYSM). Orange Co., spring-fed trib. Ramapo River, Rte. 17, N Arden Rd, 41.2741NW 74.1532W, 21/V/2008, B.C. Kondratieff, L.W. Myers, R.W. Baumann, 22♂, 3♀ (CSUC). Oswego Co., Little Sandy Creek, Hwy 13, S Lacona, 17/VI/1997, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC); North Branch Salmon River, CR 17, upstream of Reservoir, 28/V/2009, L.W. Myers, B.C. Kondratieff, 2♂, 2♂ (CSUC). Rennselaer Co., Dill Brook, Dill Brook rd., W Stillham, 9/IV/2009, emerged 28/IV/2009, L.W. Myers, 2♂, 1♀ (CSUC). Saratoga Co., Alplaus Kill, Rte. 67, Galway, 26/V/2009, L.W. Myers, 1♂ (CSUC). Ulster Co., Lucas Creek, Ralph Vedder rd., 21/V/2008, B.C. Kondratieff, L.W. Myers, R.W. Baumann, 3♂, 2♀ (CSUC). Tompkins Co., Slatterville, 13/VI/1904, ?, 1♂ (CUIC). **SC:** Anderson Co., Broadway Creek, 1 mi. N. of 5-4-63, 9/IV/1980, J.S. Weaver, E.R. Taylor, 1♂ (BPSC). **VA:** Carroll Co., New River, Route 606, 20/IV/1980, B.C. Kondratieff, 1♂ (CSUC). Franklin Co., Grassy Fork Creek, Co. rd. 613, 21/V/2002, B.C. Kondratieff, R.F. Kirchner, 1♂ (CSUC). Montgomery Co., Mill Creek, Rte. 785, 12/IV/1979, R. Wallace, 1♂ (CSUC); Same locality, 15/IV/1980, B.C. Kondratieff, 3♂, 7♀ (CSUC); North Fork Roanoke River, Rte. 603, 18/V/1983, M. Spencer, 1♂, 2♀ (CSUC). Russell Co., Loup Creek, Rte. 619, 12/IV/1980, B.C. Kondratieff, 1♂ (CSUC). Smyth Co., North Fork Holston River, Rte. 42, Saltville, 20/V/1993, B.C. Kondratieff, R.F. Kirchner, 1♀ (CSUC). Tazewell Co., Station Springs Creek, MBC, Burkes Garden, 17/V/1994, B.C.



Figs. 33.1-33.8. *Isoperla montana*. 33.1. Dorsal head and pronotal pattern. 33.2. Male posterior abdominal sterna. 33.3. Male posterior abdominal terga. 33.4. Aedeagal arrowhead-shaped sclerotized spine plate. 33.5. Male aedeagus dorsal view; a. small posteromesal lobe, b. dorsal rounded mound of dense concentration of long stout, rust colored spines, c. median row of long stout, rust colored spines, d. dense clumps of fine hair like spinulae, e. paired posteroventral lobes, f. rows of shallow shelf like scales with numerous fine hair like apical extensions, g. sclerotized arrowhead-shaped spine plate, h. area void of spinulae, i. upturned apical spines of sclerotized arrowhead-shaped spine plate. 33.6. Male paraproct lateral view. 33.7. Female subgenital plate. 33.8. Male aedeagus lateral view; a. posterobasal elongate membranous tube, b. sclerotized arrowhead-shaped spine plate, c. rows of shallow shelf like scales with numerous fine hair like apical

extensions, d. small posteromesal lobe void of spinulae, e. small clump of elongate stout colorless spines, f. mesal patch of dense short blunt spinulae, g. patch of elongate spines with band of concentrate short stout spinulae, h. anterodorsal lobe, i. rows of fine hair like spinulae, j. wide dense band of short, sharp spinulae.

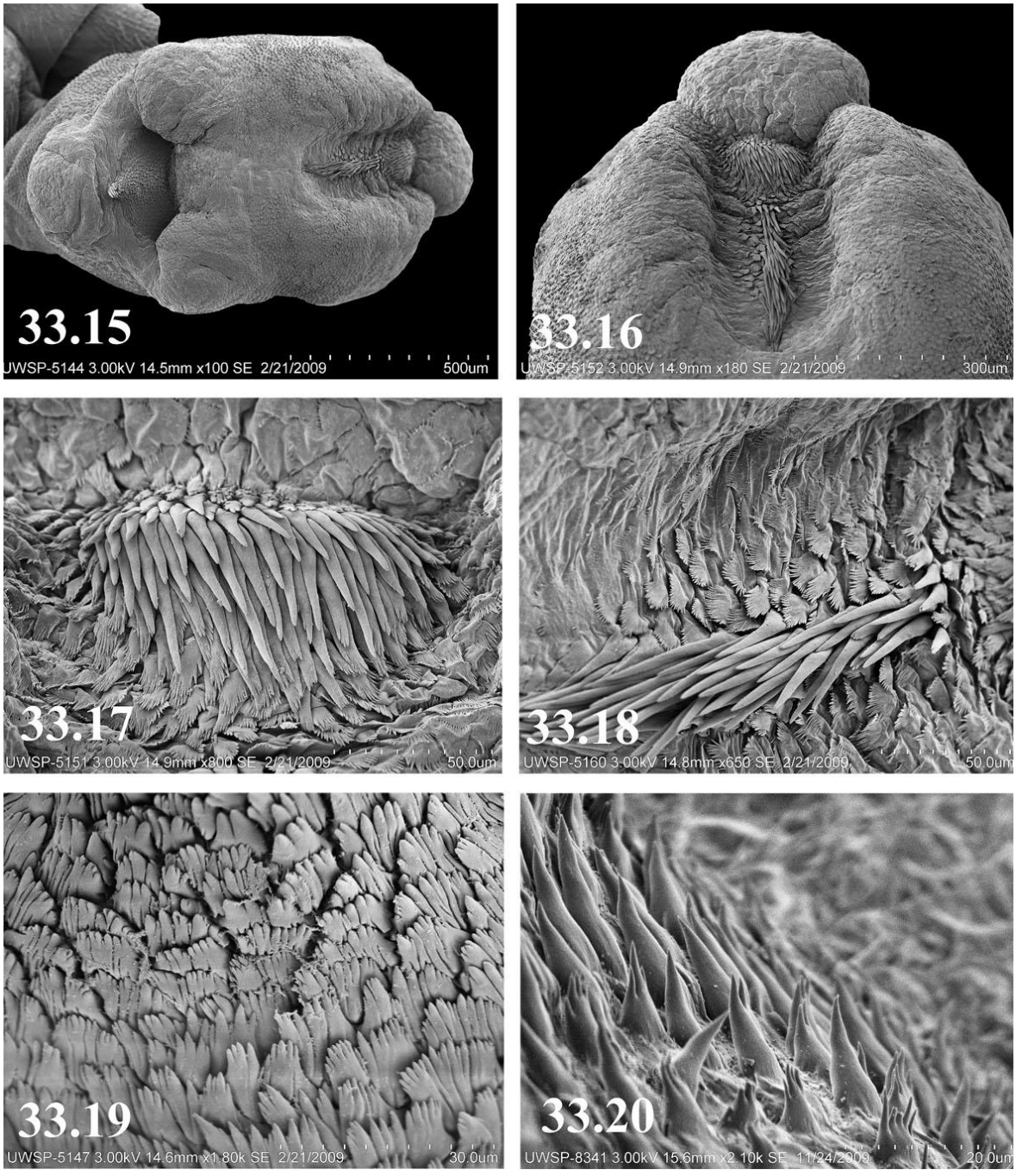


Figs. 33.9-33.14. *Isoperla montana*. 33.9. Posterior sclerotized arrowhead-shaped spine plate. 33.10. Detail of apical spines of sclerotized arrowhead-shaped aedeagal spine plate. 33.11. Detail of broad flat sclerotized aedeagal plates with numerous small apical finger-like projections. 33.12. Posteroventral aedeagal lobe with rows of shallow shelf-like scales. 33.13. Detail of rows of shallow shelf-like aedeagal scales with apical hair-like projections. 33.14. Dense clumps of fine hair like aedeagal spinulae.

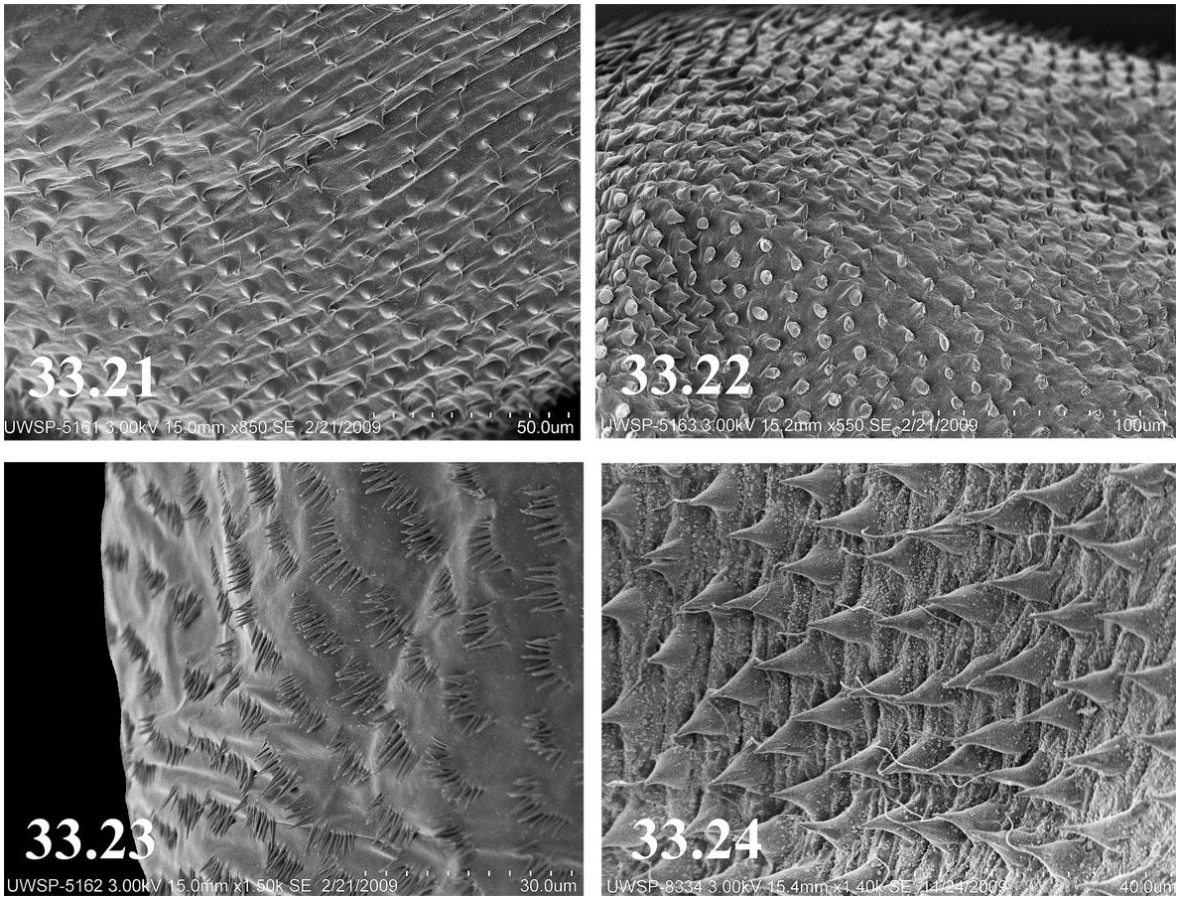
Kondratieff, R.F. Kirchner, 8♂, 7♀ (CSUC); Station Springs Creek, off Rte. 623, MBC, Burke's Garden, B.C. Kondratieff, 18/V/1979, 10♂, 18♀ (CSUC); headwaters of Station Springs Creek, MBC Farm, Burkes Garden, of Rte. 666, 8/V/1982, B.C. Kondratieff, 4♂ (CSUC). Wythe Co: East Fork Stony Fork of Reed Creek, Rte. 717, 17/V/1990, R.W. Baumann, R.F. Kirchner, 4♂, 2♀ (BYUC). **WV:** Webster Co., Back Fork Elk River, Webster Springs, 9/V/1980, J. Hill, 1♂, 1♀ (CSUC).

Additional Records: USA – IN: Montgomery Co., trib. Sugar Creek North Shades State Park, along IN 234, 4 May 2008, R.E. DeWalt, 2♂, 3♀ (INHS). **PA:** Clinton Co., Fishing Creek, Sieg Conference Center Narrow Road, 9/VI/2013, B.C. Kondratieff, J.B. Sandberg, 7♂, 10♀ (CSUC). Lehigh Co., Jordan Creek, Pleasant Corners, 12/V/2000, J. Earle, 2♂, 2♀ (JEIC). Perry Co., Dark Run, 4/VI/1993, J. Earle, 1♂ (JEIC).

Male. Macropterous. Forewing length 10.50-11.63 mm. General body yellow to pale brown with dark brown to black markings. Live males may have reddish abdomens. Dorsal background of head pale yellow with dark brown bands connecting ocelli and extending anteriorly to near frons (anterior arms occasionally pale brown or faint); interocellar area, frons and posterior margin pale yellow (Fig. 33.1). Antennal scape pale yellow, pedicel, and flagellum medium brown. Pronotum with a median pale stripe; middorsal pronotal suture a faint light brown line; rugosities irregular, raised, dark brown, pronotal disks pale yellow; anterior margin with a broad bipartite medium brown band (Fig. 33.1). Meso- and metasterna pale yellow with pale brown lateral bands. Mesonotum with irregular anterior light patches, posterior ½ medium brown; metanotum with a large medium brown heart-shaped patch and anteromedian pale spot. Wings hyaline with medium brown veins. Femora pale yellow with thin dark brown dorsal band; tibia pale yellow with broad dark brown band on proximal 1/5; tarsi medium brown. Sterna pale yellow, sternum 8 with a thin dark brown posterior band, lateral margins with thin medium brown bands. Vesicle dark brown, slightly longer than wide; posterior margin evenly rounded, extending posteriorly to anterior margin of sternum 9 (Fig. 33.2). Ninth sternum pale yellow, lateral margins with anterior and medial dark brown spots. Terga 1-8 pale brown, usually with 3 lateral and 2 median rows of faint brown spots and median dark brown band; terga 9-10 pale yellow (Fig. 33.3). Paraprocts sclerotized, recurved over tergum 10, deflected outward apically; tips pointed and deflected downward (Figs. 33.3, 33.6). Cerci medium brown. Aedeagus with a large posterobasal elongate membranous tube (Fig. 33.8a) and a sclerotized posterior arrowhead-shaped spine plate above elongate tube (Figs. 33.4, 33.5g, 33.8b, 33.9); apex of structure upturned with 8-9 large stout rust colored spines (Figs. 33.5i, 33.8b, 33.9, 33.10); base of plate with broad flat sclerotized plates with numerous small apical finger-like projections (Figs. 33.5g, 33.11); inner margin of paired posteroventral lobes above arrowhead-shaped structure (Fig. 35.5e) covered with rows of shallow shelf-like scales with numerous fine hair-like apical extensions (Figs. 33.5f, 33.8c, 33.12, 33.13); outer margin of paired posteroventral lobes with dense clumps of fine hair-like spinulae (Figs. 33.5d, 33.14); posterior area of paired posteroventral lobes devoid of hair-like apical extensions (Fig. 33.5h); small posteromesal lobe devoid of spinulae above paired lobes (Figs. 33.5a, 33.8d, 33.15, 33.16); depressed posteromesal valley below lobe with a dorsal rounded mound of dense long stout rust colored spines (Figs. 33.5b, 33.15, 33.16, 33.17), and a median row of long stout rust colored spines (Figs. 33.5c, 33.15, 33.16, 33.18); areas basal and lateral to median spine row bearing sclerotized shelves with finger-like apical projections (Figs. 33.18, 33.19); posteromesal area above posteromesal lobe armed with a small clump of elongate stout colorless spines (Figs. 33.8e, 33.20); posterior margin above patch of elongate spines with band of concentrated short stout spinulae (Figs. 33.8g, 33.21); mesal area with dense short blunt spinulae that transition into dense short stout sharp spinulae (Figs. 33.8f, 33.22); anterodorsal lobe devoid of spinulae (Fig. 33.8h); area below anterodorsal lobe with rows of fine hair like-spinulae (Figs. 33.8i, 33.23); a wide dense band of short, sharp spinulae occur above posterobasal tubular lobe (Figs. 33.8j, 33.24).



Figs. 33.15-33.20. *Isoperla montana*. 33.15. Aedeagus posterior view. 33.16. Posteromesal aedeagal lobe. 33.17. Detail of dorsal rounded mound of dense long tout, rust colored spines. 33.18. Median spine row and sclerotized aedeagal shelves. 33.19. Detail of sclerotized aedeagal shelves with finger like apical projections. 33.20. Patch of elongate stout colorless aedeagal spines.



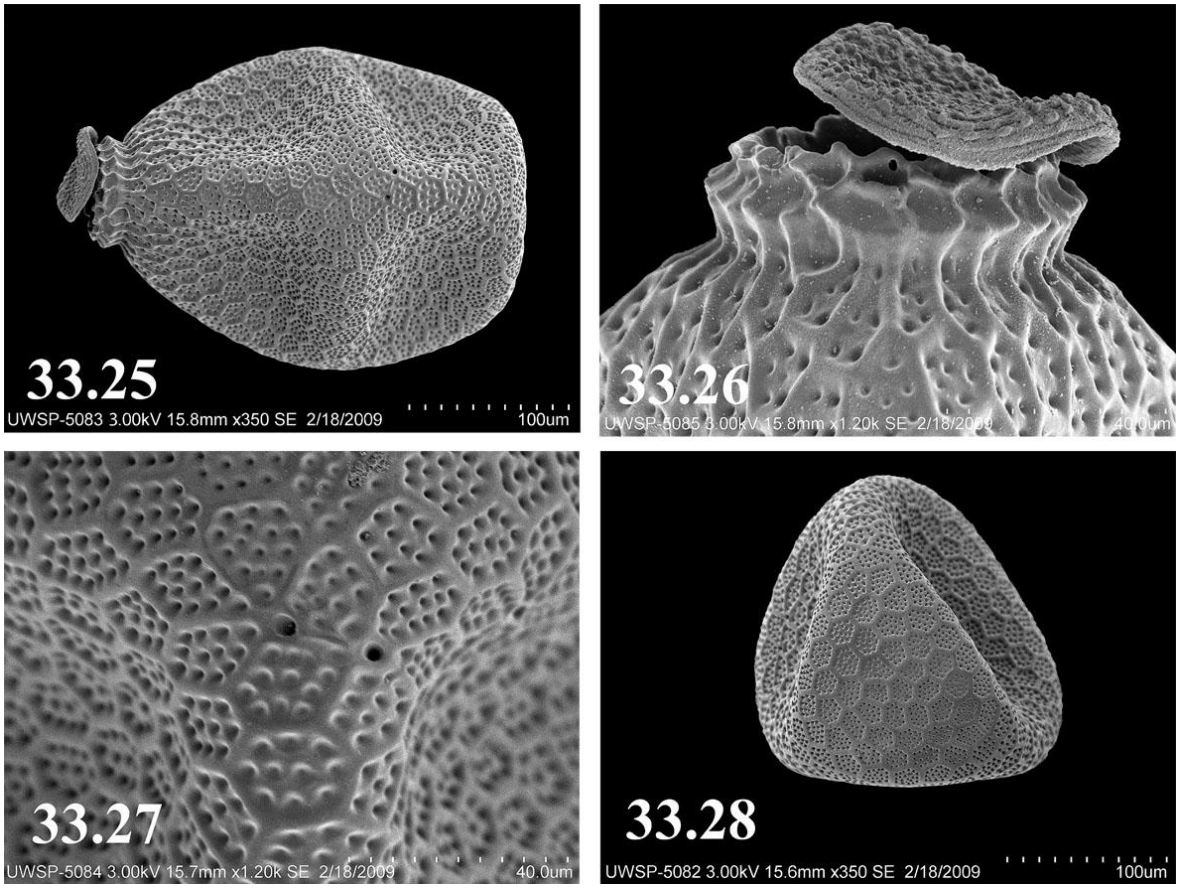
Figs. 33.21-33.24. *Isoperla montana*. 33.21. Dense posterior band of short stout aedeagal spinulae. 33.22. Dense short blunt aedeagal spinulae. 33.23. Rows of fine hair like aedeagal spinulae. 33.24. Dense band of short sharp aedeagal spinulae above posterobasal tube.

Female. Forewing length 11.3-12.6 mm. General body color and morphology similar to male described above. Eighth sternum with a broadly triangular subgenital plate extending posteriorly over ⅓ length of sternum 9; plate usually with a shallow posteromedian emargination (occasionally pointed) (Fig. 33.7). Sterna 9 and 10 mostly pale yellow with some irregular lateral pale brown markings (Fig. 33.7).

Ovum. General shape oblong, cross section triangular, distinct cross shaped ridges dividing anterior and posterior poles; anterior end nearly flat (Figs. 33.25, 33.28). Color pale brown. Length 416 µm; width 311 µm. Collar well-developed, flared apically with elevated longitudinal ridges; base not offset from egg body (Figs. 33.25, 33.26). Hexagonal follicle cell impressions well-developed with thickened ridges and floors with numerous shallow pits. Eclosion line absent, micropyles arranged singularly or in pairs, positioned on top of cross ridges near anterior ⅓ of egg (Figs. 33.25, 33.27).

Nymph. Unknown.

Diagnosis. *Isoperla montana*, together with *I. nelsoni* sp. n. and *I. smithi* sp. n., form the *I. montana* group (Table 1). The males of *I. montana* and *I. nelsoni* sp. n. both possess a sclerotized arrowhead shaped spine plate and a posteroventral membranous



Figs. 33.25-33.28. *Isoperla montana*.33.25. Egg. 33.26. Detail of egg collar. 33.27. Detail of egg chorion and micropyles. 33.28. Posterior view of egg.

aedeagal tube. The male of *I. montana* can be distinguished from *I. nelsoni* sp. n. by the different dorsal head pattern and by comparing the shape of the everted aedeagus. *Isoperla montana* in general habitus also resembles *I. kirchneri* sp. n. However, *I. montana* is distinguished by the darker anterior arms of the medium brown bands connecting the ocelli and by shorter male paraprocts deflected downward at tips. In addition, it has a sclerotized arrowhead-shaped spine plate on the aedeagus and a more triangular shaped female subgenital plate. *Isoperla kirchneri* sp. n. has two elongate aedeagal spine plates and is more similar in structure to *I. namata* and *I. signata* in that regard. The aedeagal sclerites are usually readily visible beneath the male sternum nine in both species. Misidentifications can occur if the paired spine plates of *I. kirchneri* sp. n. become twisted and overlap, resulting in a spine plate that appears similar to that of *I. montana.* These two species can be separated by the head color pattern. *Isoperla nelsoni* sp. n. has medium brown bands connecting the ocelli and some pale brown coloration within the interocellar area; in addition, the ocellar bands lack anterior arms, but have a rather wide bowl-shaped medium brown anterior patch near the frons. *Isoperla montana* has anterior arms to the medium brown ocellar bands, a pale interocellar area and no wide medium brown anterior patch near the frons (Fig. 33.1). *Isoperla montana* is a

common species of mainly relatively pristine medium-size streams of the Appalachians from Atlantic Canada south to Virginia and North Carolina, but also west to Indiana and Minnesota.

Biological Notes. Harper et al. (1991) reported a univoltine life cycle in Quebec. Early instars appeared in June and July following emergence in May. Growth was rapid and nymphs overwintered. Emergence occurs from early April to early June throughout its range. Females can often be observed in late afternoon and early evening returning to the stream from nearby riparian areas to oviposit. Stewart et al. (1988) studied the drumming behavior of *I. montana* from West Virginia and described the male call as having a mean number of beats of 6.8 ± 0.8 and a mean interbeat frequency of 168.6 ± 11.0 ms. Only one female answer was obtained and it consisted of 2 beats. They stated that the drumming call of *I. montana* was most similar to that of the western North American species, *I. fulva* in number of beats and beat interval.

Isoperla myersi sp. n.

Paddle Stripetail

(Figs. 32.1-32.7)

Material Examined: USA – Holotype ♂, **New York**: Ulster Co., Big Indian Hollow, Oliverea rd., 42.0283N, 74.4089W, 27/V/2009, L.W. Myers, B.C. Kondratieff (USNM). **Paratype: NY:** Same data as holotype, 1♂ (CSUC).

Distribution: USA – NY.

Male. Macropterous. Forewing length 8.0-9.0 mm. General body yellow with darker markings. Dorsum of head with dark brown X-band connecting lateral ocelli to anterior ocellus; anterior ends of bands extend forward of anterior ocellus; interocellar area pale; frons and clypeus pale brown (Fig. 32.1). Antennae and scape brown. Pronotum medium brown with wide median pale stripe, middorsal pronotal suture brown; rugosities pale brown; margins with thin medium brown bands (Fig. 32.1). Meso- and metanota pale with paired medium brown anteromedian round patches; mesonotum with thin U-shaped median dark brown sclerotized carina with medium brown patch; metanotum with thin V-shaped median dark brown sclerotized carina with medium brown patch. Wings pale, veins brown. Femur pale yellow with medium brown dorsal band; tibia pale brown with darker vertical band near proximal ⅓. Terga pale yellow. Paraprocts lightly sclerotized, wide, short and broadly rounded at apex, wrinkled basally and flat, paddle-shaped dorsally, extending slightly over tergum 10 (Figs. 32.2, 32.3, 32.5). Cerci pale yellow. Sterna pale yellow. Sternum 8 with well-developed rounded pale brown vesicle, ca. as long as wide, evenly rounded at posterior margin with small fine marginal hairs; posterior margin of sterna with a band, margined by comb-like and long setae (Fig. 32.4). Aedeagus membranous with a posteromedian lobe, (Fig. 32.7a), a large dorsal lobe (Fig. 32.7b), a pair of large anteromedian lobes (Fig. 32.7c), a wide mesal paddle-shaped band of stout golden brown spinulae (Figs. 32.6a, 32.7d) and a posteromesal paddle-shaped patch of minute dark brown spinulae (Fig. 32.6b).

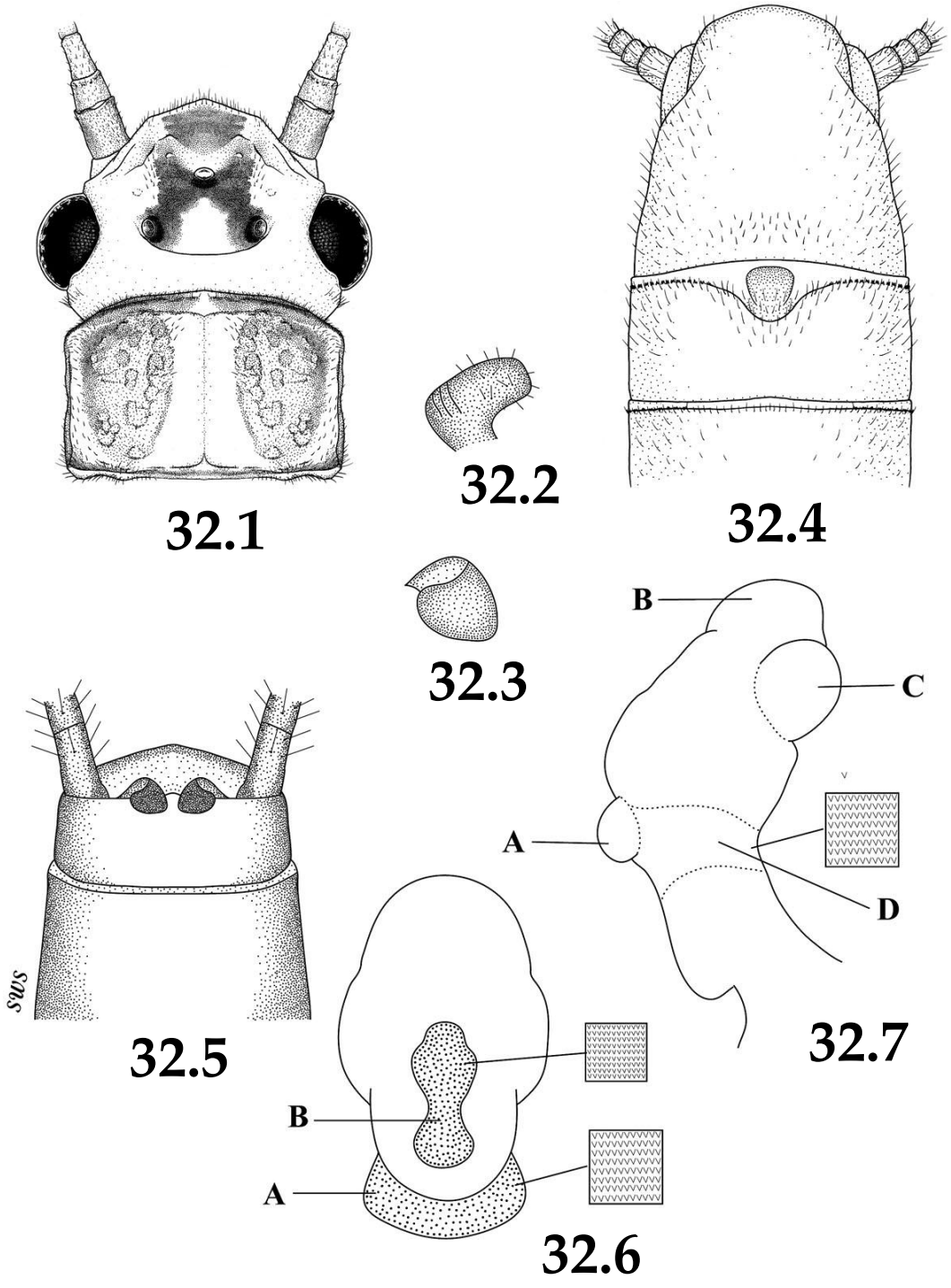
Female. Unknown.

Ovum. Unknown.

Nymph. Unknown.

Etymology. The patronym honors Luke W. Myers, Lake Champlain Research Institute, SUNY Plattsburgh, Plattsburgh, New York for his enthusiastic studies of the stoneflies and other aquatic insects of New York state.

Diagnosis. *Isoperla myersi* sp. n., a member of the *I. bilineata* group (Table 1), is a small pale yellow species. It can be distinguished in the male by the unusual posteromedian paddle-shaped spinule patch on the everted aedeagus. This character and the short, broad round paraprocts, will separate this species from all *I. bilineata* group species and all eastern Nearctic *Isoperla*. The paraprocts of *I. myersi* sp. n. are suggestive of *I. holochlora* but are larger, and the shape and spinule pattern of the extruded aedeagus will distinguish the two taxa. Additionally, the aedeagus of *I. myersi* sp. n. resembles that of *I. orata,* but can be distinguished from that species by the wide posteromesal paddle-shaped band of stout golden brown spinulae and by shape of the vesicle which in *I. myersi* sp. n., is as wide as long. The discovery of this species was a surprise considering the



Figs. 32.1-32.7. *Isoperla myersi* sp. n. 32.1. Dorsal head and pronotal pattern. 32.2. Male paraproct lateral view. 32.3. Male paraproct dorsal view. 32.4. Male posterior abdominal sterna. 32.5. Male posterior abdominal terga. 32.6. Male aedeagus posterior view; a. mesal band of stout golden brown spinulae, b. posteromesal paddle-shaped patch of minute dark brown spinulae. 32.7. Male aedeagus lateral view; a. posteromedian lobe, b. dorsal lobe, c. paired anteromedian lobe, d. mesal band of stout golden brown spinulae.

extensive studies of the aquatic insects of New York state (see Myers et al. 2011).

Biological Notes. The emergence period of *I. myersi* sp. n. occurs during late May based on collection records. There is no information available about the biology or life cycle of this species.

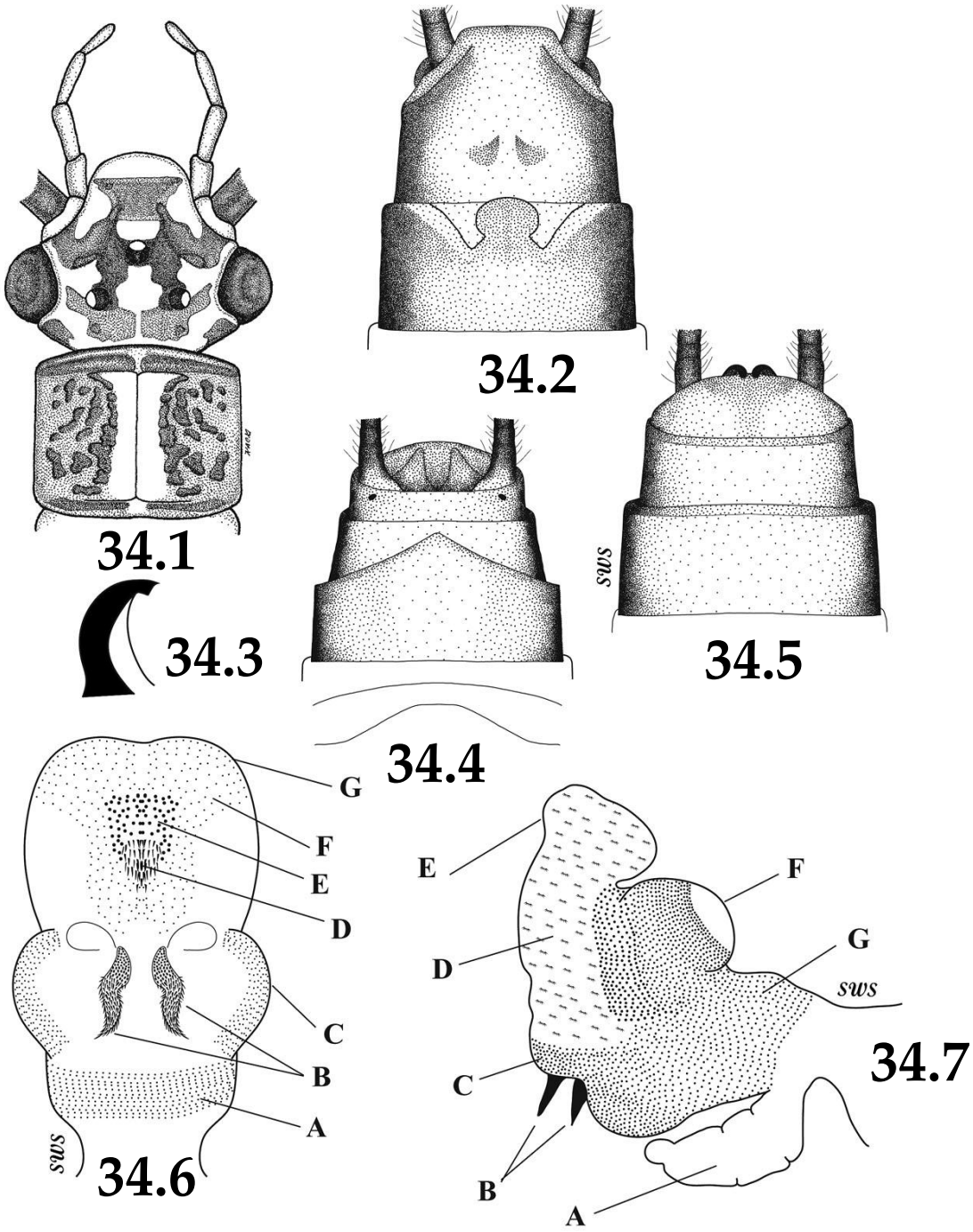
Isoperla namata Frison
Ozark Stripetail
(Figs. 34.1-34.22)

Isoperla namata Frison 1942, 22:327. Holotype ♂ (INHS) Silva (Wayne Co.), Missouri. Examined.

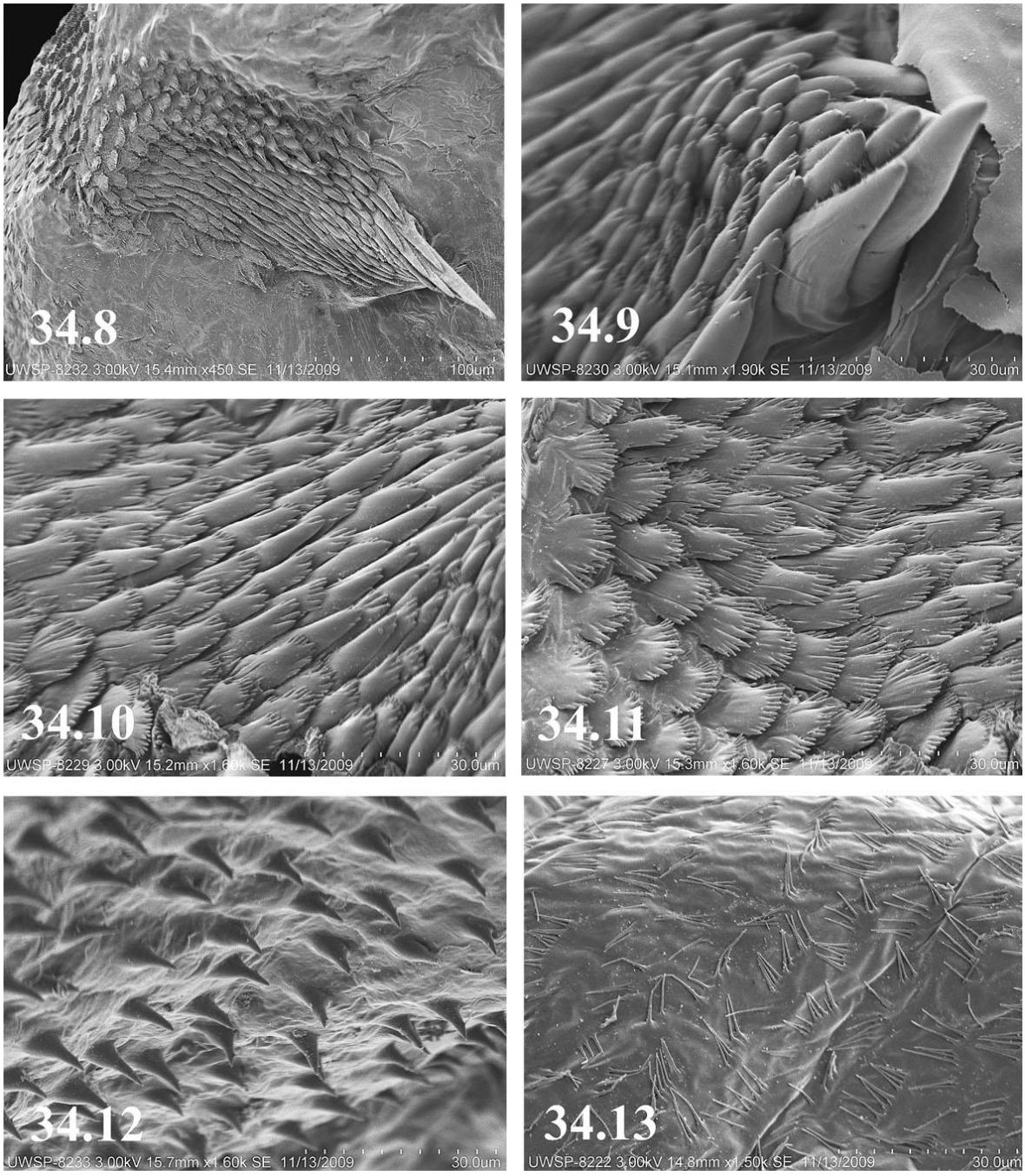
Distribution: **USA – AR** (Feminella and Stewart 1986, Poulton and Stewart 1991), **IL (**DeWalt and Grubbs 2011), **IN** (Frison 1942, Ricker 1945, Grubbs 2004, DeWalt and Grubbs 2011), **MO** (Frison 1942, Poulton and Stewart 1991), **OH (**Tkac and Foote 1978), **OK** (Ernst and Stewart 1985, Poulton and Stewart 1991, Stark and Stewart 1973a).

Male. Macropterous. Forewing length 8.6-10.3 mm. General body color yellow in life, pale to medium brown in alcohol with darker brown or black markings. Dorsum of head with dark brown bands connecting anterior ocellus with posterior ocelli; dark brown bands extend from anterior ocellus to antennal bases; interocellar area with pale triangular spot, nearly closed posteriorly by medium brown bands; medium to pale brown bands extend from base of interocellar area to near inner median margin of eyes; medium brown lateral bands occur anterior to eyes; posteromedian area pale; frontoclypeal area with broad dark band widest anteriorly, irregular U-shaped pale patch anterior to median ocellus (Fig. 34.1). Antennal scape, pedicel, and flagellum medium brown in alcohol and dark brown to black in life. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities irregular, dark brown and raised, pronotal disks medium brown; anterior, posterior and lateral margins medium brown (Fig. 34.1). Meso- and metanota mostly medium brown with irregularly shaped antero- and posteromedian pale spots. Wings dusky with dark brown veins. Legs medium brown, dorsal surface of femora darker, small callus at femora base; tibia with dark narrow vertical band near proximal end; proximal area near vertical band darker than distal portion. Sterna pale yellow in alcohol and yellow in life, pleura medium brown; sternum 8 with medium brown well-developed vesicle set in a U-shaped depression, 0.5X as long as wide, expanded posteriorly, constricted near mid-length and extending to near anterior margin of sternum 9 (Fig. 34.2). Terga pale yellow in alcohol to yellow in life, with a dark median longitudinal stripe, and wider longitudinal dark bands; terga usually with 3 lateral rows and 2 median rows of dark longitudinal spots. Paraprocts heavily sclerotized, sharply pointed apically with a slight ventral spur, extending slightly over level of tergum 10 (Figs. 34.3, 34.5). Cerci medium brown to dark brown. Aedeagus with an irregular shaped dorsal lobe (Figs. 34.6g, 34.7e), a large rounded anteromedial lobe (Fig. 34.7f), a posteromesal sclerotized pair of spine plates (Figs. 34.6b, 34.7b, 34.8), a pair of posteromedial lobes near patches (Fig. 34.7c), a pair of sclerotized spine patches with single large pointed apical spine and several smaller pointed stout spines at base of apical spine (Figs. 34.6b, 34.7b, 34.8, 34.9); additional elongate spines with apical finger-like projections occur below apical area (Figs. 34.8, 34.9, 34.10) and much shorter, scallop-shaped sclerotized plates with numerous fine apical projections occur at base of patch (Figs. 34.8, 34.11); mesal section with broad area of dense sharp stout spinulae extending to near base of tube (Figs. 34.6a, 34.7g, 34.12); posteroapical section and apical lobe with rows of fine hair-like spinulae (Figs. 34.6f, 34.7d, 34.13); small, stout spinulae occur above mesal section (Figs. 34.6c, 34.7c,); posteromedial apical area with sharp spinulae and occasional sensilla basiconica (Figs. 34.6d, 34.14, 34.15); area above posteromedial apical area with patch of small sharp spinulae (Figs. 34.6e, 34.16); long posterobasal protruding membranous tube near base of stalk (Fig. 34.7a).

Female. Forewing length 10.1–12.1 mm. General body color and morphology similar to male described above. Subgenital plate produced posteriorly over ½ to ¾ length of sternum 9, triangular to broadly rounded posteriorly (Fig. 34.4)



Figs. 34.1-34.7. *Isoperla namata*. 34.1. Dorsal head and pronotal pattern. 34.2. Male posterior abdominal sterna. 34.3. Male paraproct lateral. 34.4. Female subgenital plate. 34.5. Male posterior male terga. 34.6. Male aedeagus posterior view; a. broad area of dense sharp stout spinulae, b. paired posteromesal sclerotized spine plates, c. patch of small stout spinulae, d. patch of long stout spinulae, e. patch of small sharp spinulae, f. rows of fine hair-like spinulae, g. dorsal lobe. 34.7. Male aedeagus lateral view; a. long posterobasal tube, b. paired posteromesal sclerotized spine plates, c. paired posteromedial lobes, d. rows of fine hair-like spinulae, e. dorsal lobe, f. anteromedial lobe, g. broad area of dense sharp stout spinulae.

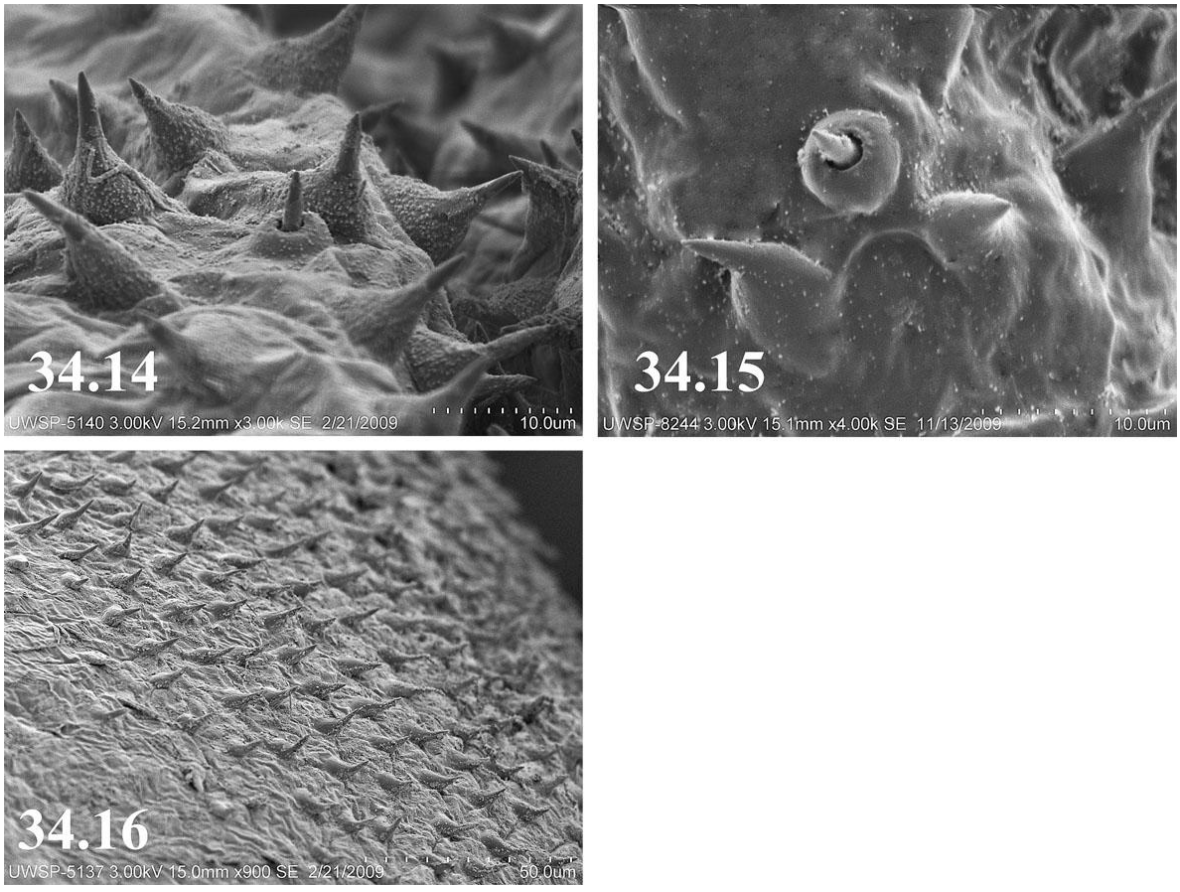


Figs. 34.8-34.13. *Isoperla namata*. 34.8. Posteromesal sclerotized aedeagal spine plate. 34.9. Detail of apical spines of posteromesal sclerotized aedeagal spine plate. 34.10. Detail of elongate spines with apical projections below apical spines of posteromesal sclerotized aedeagal spine plate. 34.11. Detail of scallop-shaped spine plates at base of posteromesal sclerotized spine plate. 34.12. Sharp stout mesal aedeagal spinulae. 34.13. Rows of fine hair-like aedeagal spinulae.

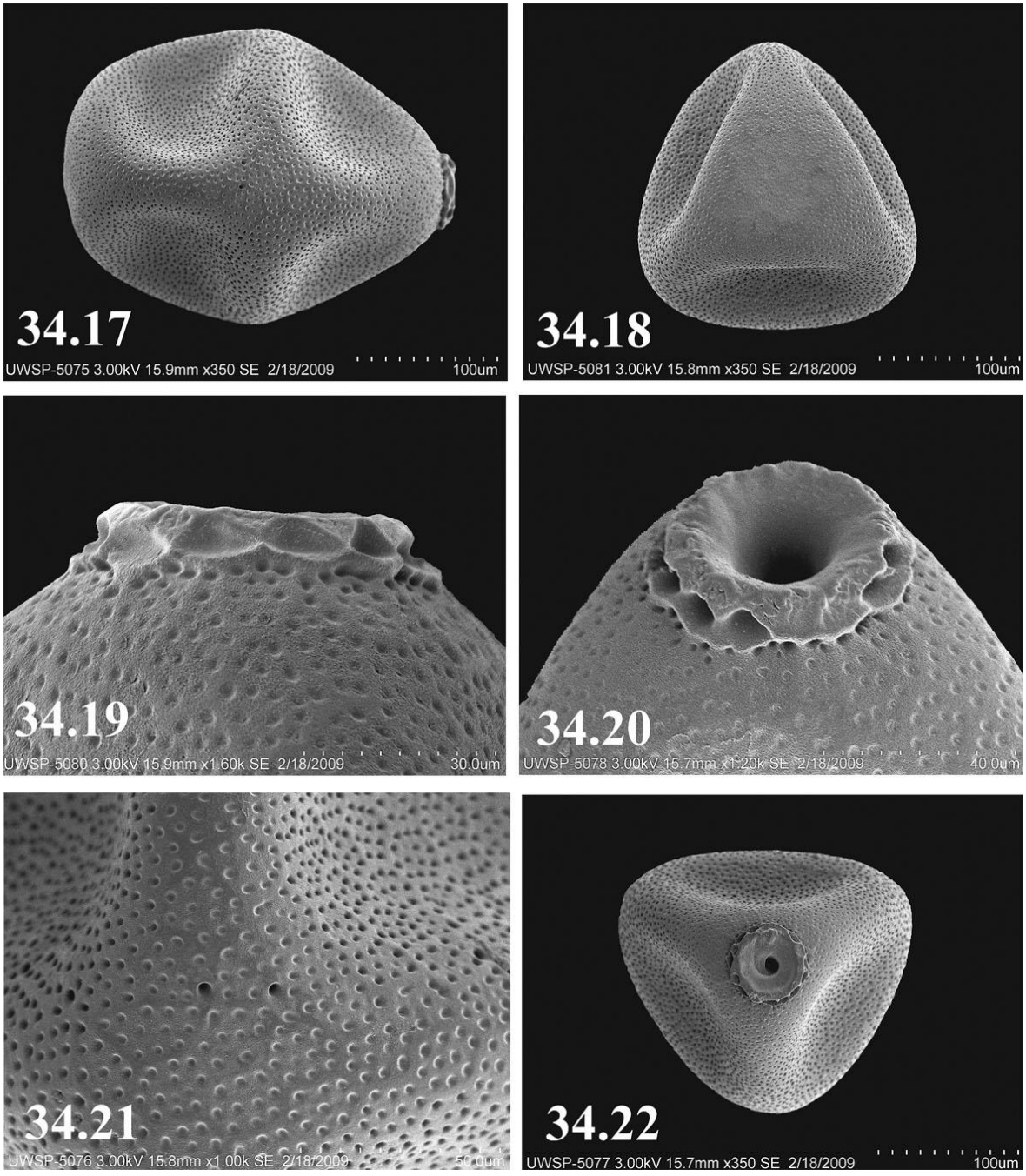
Ovum. General shape oblong, cross section triangular (Figs. 34.18, 34.22); distinct cross-shaped broad ridges divide posterior and anterior poles, anterior end nearly flat (Figs. 34.17, 34.18). Color pale brown. Length 279 µm; width 214 µm. Collar low, with apically flanged rim; base with raised longitudinal carinae (Figs. 34.19, 34. 20). Choronic surface covered with numerous small, shallow punctations; hexagonal follicle cell impressions faintly visible, not elevated (Figs. 34.17, 34.21). Eclosion line absent; micropyles positioned near anterior ⅓ on faint ridges; orifices small without accessory structure, usually in groups of 1 or 2 (Figs. 34.17, 34.21).

Nymph. Mouthparts and habitus were illustrated by Frison (1942) and Poulton and Stewart (1991) illustrated the head color pattern and partial terga. The nymphs of *I. namata*, *I. kirchneri* sp. n., and possibly *I. montana* are very similar and it is not possible to separate them at this time. All nymphal records of *I. namata* outside the Midwest and the Ozarks, especially from the southeastern U.S. are probably misidentifications and very likely represent *I. kirchneri* sp. n.

Diagnosis. This species is assigned to the *I. signata* group (Table 1). This association is based on the posterior aedeagal spine patches, and the triangular egg cross section. *Isoperla namata* can be distinguished from other members of the species group by details of the head color pattern, shape of the aedeagus, and details of the spinule patterns and posterior aedeagal spine patches. Separation of adults in this species group is difficult and is based on fully everted aedeagal characters. *Isoperla namata* is sympatric with *I. signata* in the Midwest



Figs. 34.14-34.16. *Isoperla namata*. 34.14. Sharp aedeagal spinulae and sensillae basiconica. 34.15. Detail of aedeagal sensillae basiconica. 34.16. Small sharp aedeagal spinulae.



Figs. 34.17-34.22. *Isoperla namata*. 34.17. Egg. 34.18. Egg posterior view. 34.19. Detail of egg chorion. 34.20. Detail of egg collar. 34.21. Detail of egg chorion and micropyles. 34.22. Egg dorsal view of collar.

and allopatric with *I. kirchneri* sp. n. and *I. holochlora*. *Isoperla namata* and *I. signata* have dark brown bands on the head and *I. kirchneri* sp. n. and *I. holochlora* only have an inverted V-pattern

connecting the ocelli. Both *I. namata* and *I. kirchneri* sp. n. have a posterobasal membranous aedeagal tube and *I. signata* and *I. holochlora* lack this structure. There is some variation in the subgenital plate of *I. namata* from evenly rounded and low to a more produced and triangular plate. Most previously published records outside the Midwest and the Ozarks, especially those throughout the Appalachians (e.g. Earle et al. 2004, Tarter et al. 2006, Tarter and Nelson 2006) probably refer to *I. kirchneri* sp. n. or another similar species.

Biological Notes. Emergence of adults of *I. namata* occurs between mid-March and mid-June based on collection records. Emergence occurs generally from mid-April through mid-May in Midwestern streams. Poulton and Stewart (1991) collected *I. namata* commonly in permanent medium and small streams in Oklahoma and Arkansas.

Isoperla nana (Walsh)
Least Stripetail
(Figs. 1.9, 35.1-35.15)

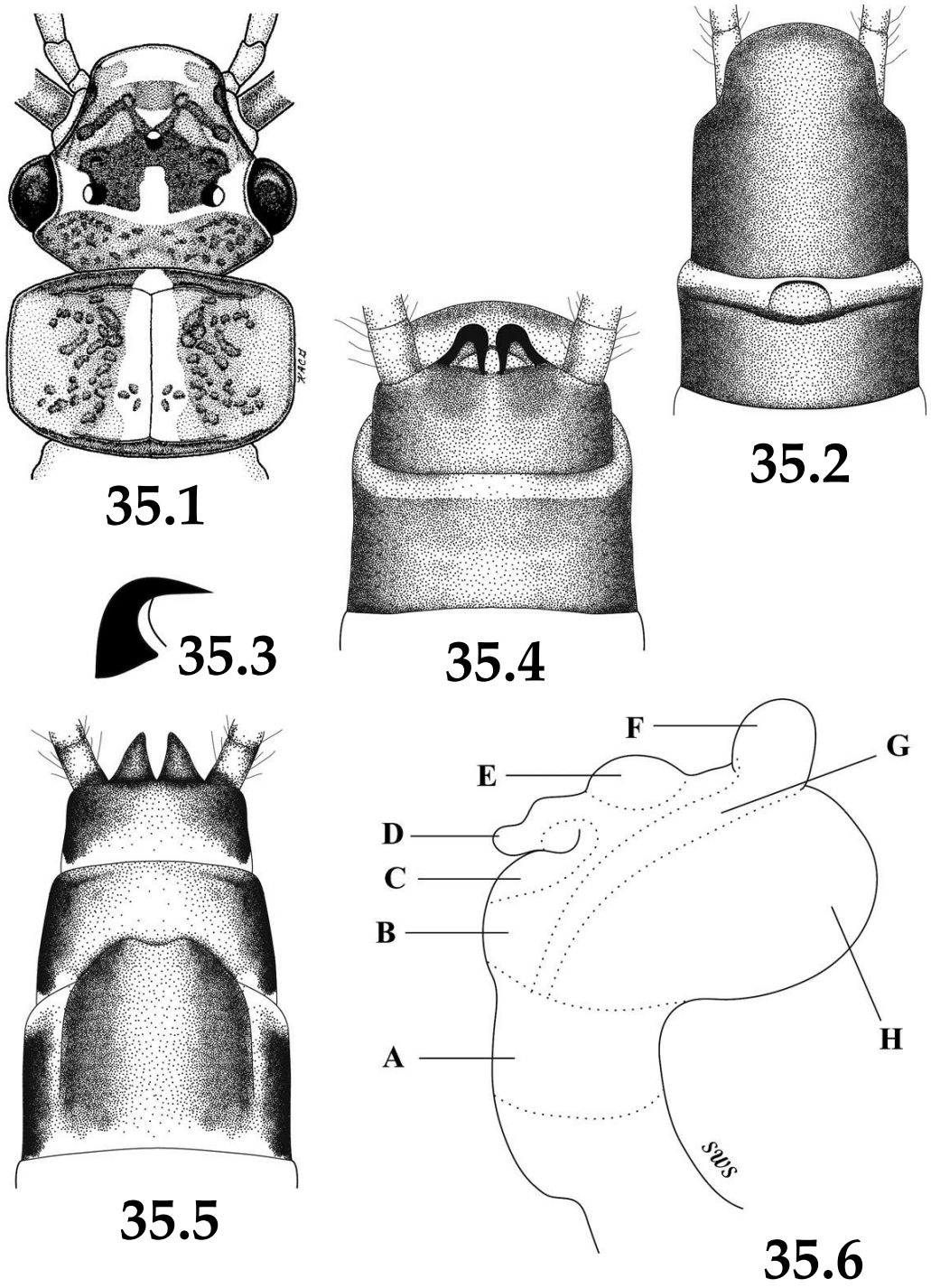
Chloroperla nana Walsh 1862, 13:367. Holotype ♀? (destroyed), Rock Island (Rock Island Co.), Illinois.
Chloroperla minuta Banks 1900, 26:244. Holotype ♂ (MCZC) Columbus (Franklin Co.), Ohio. Syn. Ricker, in Illies, 1966:411.
Isoperla minuta: Needham and Claassen, 1925, 2:147.
Isoperla minuta: Frison, 1935, 20:453.
Nanoperla minuta: Banks, 1947, 54:283.
Isoperla nana: Ricker, 1965, 22:495.

Distribution: **CANADA – ON** (Harper and Ricker 1994), **PQ** (Ricker et al. 1968); **USA – IL** (Needham and Claassen 1925, Frison 1935, DeWalt and Grubbs 2011), **IN** (Ricker 1945, Grubbs 2004, DeWalt and Grubbs 2011), **KY** (Tarter et al. 2006), **MI** (Grubbs and Bright 2001), **OH** (Banks 1900, Needham and Claassen 1925, Gaufin 1956, Fishbeck 1987, DeWalt et al. 2012, Grubbs et al. 2013), **PA** (Masteller 1996b), **WI** (Hilsenhoff and Billmyer 1973).

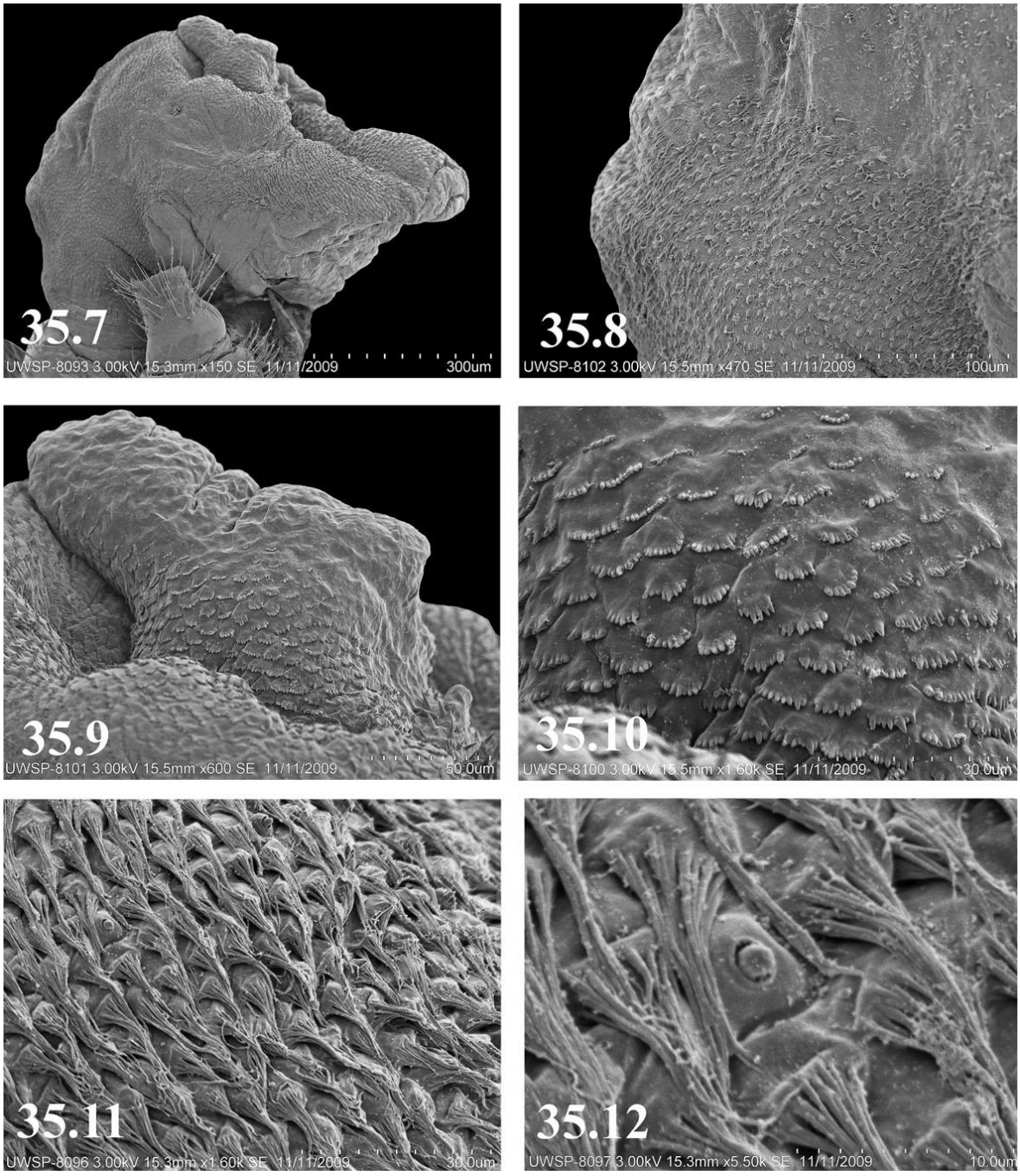
New Records: USA – NY: Montgomery Co., Evaskill, Waite rd., nr. Amsterdam, 30/V/2008, L.W. Myers, 6♂, 6♀ (CSUC). Oswego Co., Salmon River, CR 48, 28/V/2009, L.W. Myers, B.C. Kondratieff, 2♂, 2♀ (CSUC).

Additional Records – CANADA – ON: Greenville Co., Jack River, Hwy 16, S Ottawa, 16/VI/1997, B.C. Kondratieff, R.W. Baumann, C.R. Nelson, 2♂, 2♀ (CSUC). **USA – IL**: Macon Co., 18/V/1985, P. Skelley, 2♂, 2♀ (BYUC). Vermilion Co., Middle Fork Vermilion River, Kickapoo State Park, 6/VI/2002, B.C. Kondratieff, R.W. Baumann, 1♀ (CSUC). **IN**: Henry Co., Big Blue River, Highway 102, 5/VI/2002, B.C. Kondratieff, R.W. Baumann, 9♂ (CSUC). **OH:** Ashland Co., Hog Hollow, Mochican State Park, 1/VI/1989, R.W. Baumann, R.F. Kirchner, 7♂, 7♀ (BYUC). Ashtabula Co., spring-fed trib. Crooked Creek, Callahan rd, 2/VI/1989, R.W. Baumann, R.F. Kirchner, 1♀ (BYUC), Crooked Creek, Callahan rd, 2/VI/1989, R.W. Baumann, R.F. Kirchner, 1♂, 4♀ (BYUC). Clinton Co., Trace Run, off Hwy 73, abv. Caeser Creek Lake, 6/VI/1989, R.W. Baumann, R.F. Kirchner, 1♂, 4♀ (BYUC). Franklin Co., Hayden Run below Hayden Falls, 21/V/1983, S.M. Clark, 3♂, 3♀ (BYUC). Greene Co., Little Miami River, John Bryan State Park, 7/VI/1989, R.W. Baumann, S.M. Clark, 2♂, 3♀ (BYUC). Highland Co., small trib. Rocky Fork Lake, Rocky Fork State Park, 8/VI/1989, R.W. Baumann, S.M. Clark, 1♂, 3♀ (BYUC); Hardens Creek, 2 mi. S. Centerfield, CR 85 Bridge, 25/V/1992, B.C. Kondratieff, 1♂, 2♀ (CSUC). Lorain Co., Buck Creek near Rochester, 28/V/1983, S.M. Clark, K. Nedreberg, 16♂, 17♀ (BYUC); Same locality, 12♂, 22♀ (BYUC); Small trib. Vermilion River near Rugby, 28/V/1983, S.M. Clark, K. Nedreberg, 1♂, 2♀ (BYUC). Montgomery Co., Wolf Creek, Sycamore State Park, 7/VI/1989, R.W. Baumann, S.M. Clark, 1♀ (BYUC). Mahoning Co., Grays Run, Lowellville, 3/VI/1989, R.W. Baumann, R.F. Kirchner, 8♂, 15♀ (BYUC). Noble Co., Depue Run, rd. 166, abv. Senecaville Lake, 4/VI/1989, R.W. Baumann, S.M. Clark, 2♂, 3♀ (BYUC). Preble Co., stream entering Action Lake, Pine Loop Trail, Hueston Woods State Park, 6/VI/1989, R.W. Baumann, S.M. Clark, 4♀ (BYUC). Ross Co., Deer Creek, NW Chillicothe, 6/VI/1989, R.W. Baumann, S.M. Clark 5♂, 6♀ (BYUC). Warren Co., Jonahs Run, Hwy 73, abv. Caeser Creek Lake, 6/VI/1989, R.W. Baumann, S.M. Clark, 13♂, 16♀ (BYUC).

Male. Macropterous. Forewing length 5.1-6.0 mm. General body color brown with dark brown



Figs. 35.1-35.6. *Isoperla nana*. 35.1. Dorsal head and pronotal pattern. 35.2. Male posterior abdominal sterna. 35.3. Male paraproct lateral. 35.4. Male posterior male terga. 35.5. Female subgenital plate. 35.6. Male aedeagus posterior view; a. basal patch of small, stout sharp spinulae, b. , c. rows of sclerotized scale-like plates with short stout apical fingers, d. small posteromedian nipple-shaped lobe, e. low dorsal lobe, f. anterodorsal lobe, g. patch of long fine hair-like spinulae, h. anteromesal lobe.



Figs. 35.7-35.12. *Isoperla nana*. 35.7. Aedeagus lateral view. 35.8. Dense patch of small stout sharp basal aedeagal spinulae. 35.9. Detail of small posteromedian nipple shaped aedeagal lobe. 35.10. Detail of rows of sclerotized aedeagal scale-like plates. 35.11. Detail of clustered rows of long fine hair-like aedeagal spinulae. 35.12. Detail of aedeagal sensillae basiconica.

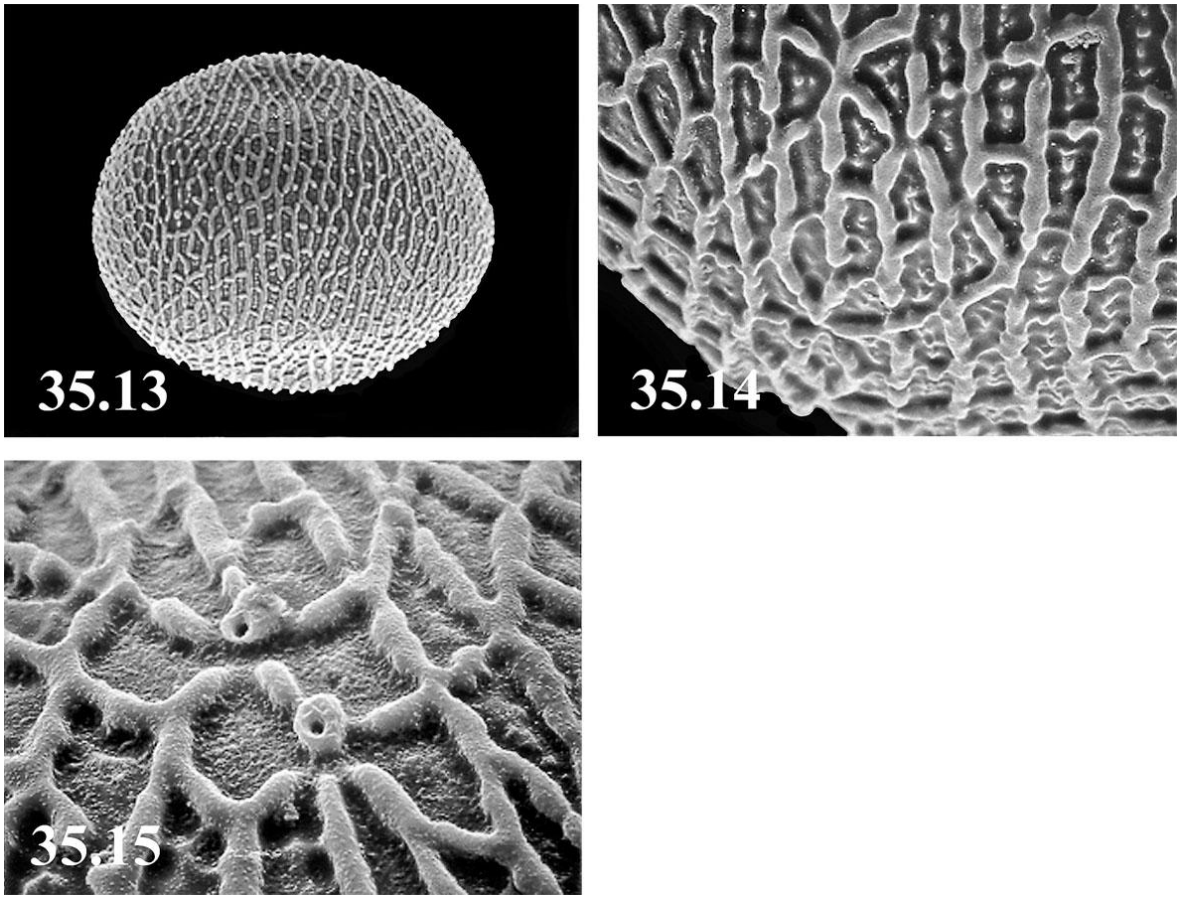
markings. Dorsum of head mostly medium to pale brown with small pale rectangular shaped interocellar spot; dark brown bands connect ocelli and a small, thin darker W-shaped band occurs anterior to median ocellus; a pale brown transverse band extends to antennal bases and a small pale V-shaped spot is located anterior to median ocellus; frons with a wide pale band; posterior margin of head with wide dark brown band with darker reticulate markings band usually thinner medially (Fig. 35.1). Antennal scape and pedicel dark brown, flagellum segments 1-5 pale brown, remaining segments dark brown. Pronotum with wide median pale stripe, middorsal pronotal suture a thin brown line; rugosities small, irregular, raised, dark brown, pronotal disks medium brown; anterior and posterior margins medium brown (Fig. 35.1). Meso- and metasterna with broad transverse dark brown band extending ca. ½ length of segments. Meso- and metanota mostly medium brown with irregular dark brown markings. Wings dusky, veins medium brown, costal area in fresh specimens white; occasionally, apex of wings does not exceeding abdominal length. Femora medium brown, tibia and tarsi pale brown; tibia with a thin horizontal dark band near proximal ⅓ on outer surface. Sterna medium brown, sternum 8 with a pale brown vesicle, ca. as ½ as long as wide; posterior vesicle margin evenly rounded, not expanded and extending to near anterior margin of sternum 9; posterior margin of segment with thin dark brown band (Fig. 35.2). Terga medium brown, tergum 10 with a median depressed area and bipartite darker brown patches (Fig. 35.4). Paraprocts heavily sclerotized, nearly black, sharply pointed apically, usually recurved to or slightly beyond level of tergum 10 (Figs. 35.3, 35.4). Cerci mostly medium brown, paler proximally. Aedeagus with wide basoventral patch of dense small stout, sharp spinulae (Figs. 35.6a, 35.7, 35.8); small posteromedian nipple-shaped lobe with bulbous base, apex without spinulae (Figs. 35.6d, 35.7, 35.9); base of lobe with rows of sclerotized scale-like plates bearing numerous short stout apical fingers below nipple-shaped lobe (Figs. 35.6c, 35.10); a sparse patch of hair-like spinulae present (Fig. 35.6b); small, low dorsal lobe covered with clustered rows of long fine hair-like spinulae (10-15 per cluster) and occasional sensilla basiconica (Figs. 35.6e, 35.11); long erect anterodorsal tubular-shaped lobe covered with dense clustered rows of long fine hair-like spinulae (10-15 per cluster) (Figs. 35.6f, 35.12); patch of long fine hair-like spinulae extend in narrow mesal patch from dorsal tubular lobe to ventral patch of dense small stout, sharp spinulae (Figs. 35.6g, 35.11, 35.12); anteromesal lobe and remainder of aedeagus without spinulae (Fig. 35.6h).

Female. Forewing length 5.5–6.5 mm. General body color and morphology similar to male described above, but relatively paler brown. Eighth sternum with long, narrow subgenital plate, usually with pale median longitudinal band; base of band extends anteriorly to ¾ length of segment; lateral margins nearly parallel for ¾ length of plate; posterior margin with wide, shallow median notch; plate produced posteriorly over ca. ½ length of sternum 9 (Fig. 35.5).

Ovum. General shape oblong, cross section concave (Fig. 35.13). Color pale brown. Length 324 µm; width 270 µm. Collar absent (Fig. 35.13); chorion covered with reticulate raised, thickened ridges, some not connected (Figs. 35.13, 35.14). Micropyles positioned singularly on top of ridges near anterior ⅓ of egg body; openings usually expanded, donut shaped; eclosion line absent (Figs. 35.14, 35.15).

Nymph. Frison (1935) described the male and female nymph and illustrated the labrum, mandibles, maxillae and habitus. Hilsenhoff and Billmyer (1973) provided a photograph of the lacinia. Randrianandrasana (2007) studied the food habitats of the nymphs. Stark et al. (1998) provided a color photograph of the habitus.

Diagnosis. *Isoperla nana* is a distinctive small brown species with white margins of the forewings occurring primarily in midwestern North America, but ranging north and east of Quebec. It is most similar to *I. lenati* sp. n. another member of the *I. nana* group (Table 1). These species are similar in size and are the smallest known species of North American *Isoperla*. Males of *I. nana* can be separated from *I. lenati* sp. n. males by the wider vesicle, the heavily sclerotized elongate and sharply pointed



Figs. 35.13-35.15. *Isoperla nana*. 35.13. Egg. 35.14. Detail of egg chorion. 35.15. Detail of egg micropyles.

paraprocts, and the shape and spinule pattern of the aedeagus. The female of *I. nana* has a longer subgenital plate and an egg with unusual raised reticulate chorionic sculpturing which the eggs of *I. lenati* sp. n. lack. Additionally, in fresh specimens, the abdomen of *I. nana* is brown, whereas *I. lenati* sp. n., have bright red abdomens. The egg of *I. nana* is quite distinctive among eastern *Isoperla* in having the chorion covered with a reticulate network of mostly connected raised ridges.

Biological Notes. Relatively little is known about the biology of *I. nana*. Hilsenhoff and Billmeyer (1973) reported that it had a univoltine life cycle. Frison (1935) reported the emergence of this species generally occurs from early May to early July with the maximum abundance of adults usually occurring during late May. Frison (1935) also indicated that the distribution in Illinois corresponded with the upland prairie region and that the nymphs were herbivores. Based on our collecting records this species is one of the more common, if not the most common, *Isoperla* species in small, low gradient streams in Illinois, Indiana, and Ohio. Ziminske (1989) found that male *I. nana* rarely drummed and he obtained only 5 signals from numerous males observed. He reported the male call had a mean of 18.6 (± 5.4) drum beats and a mean beat interval of 120.0 (± 45.0) ms and females did not answer live or recorded male calls.

***Isoperla nelsoni* sp. n.**
Nelson Stripetail
(Figs. 36.1-36.11)

Material Examined: USA **– Holotype** ♂, **Tennessee:** Morgan Co., Clear Creek off Ridge rd., 22/V/1994, B.C. Kondratieff, R.F. Kirchner (USNM). **Paratypes: AL:** Cleburne Co., small creek abv. Cheaha Lake, Cheaha State Park, 14/V/1988, R.W. Baumann, B.C. Kondratieff, R.F. Kirchner, C.R. Nelson, 1♂, 6♀ (BYUC). **GA:** Dade Co., small stream, Rte. 136, 9.1 mi W jct. 136/193, just past entrance to Cloudland Canyon State Park, 8/V/1980, C.H. Nelson, 3♂, 1♀ (CHNC). **NC:** Macon Co., Bridal Veil Falls, near Highlands, 8/V/2000, B.P. Stark, B.Y. Bryan, 1♂, (BPSC). **TN:** Cumberland Co., N. Fork Elmore River, 22/V/1994, B.C. Kondratieff, R.F. Kirchner, 2♂ (CSUC). Hamilton Co., Shoal Creek, Shoal Creek rd. off Rte. 127, Signal Mountain, 29/V/1981, C.H. Nelson, 3♂, 3♀ (CHNC). Marion Co., small seep trib. North Suck Creek, 7.4 mi W. jct. 27/127, Prentice Cooper State Forest, 15/V/1981, C.H. Nelson, 1♂ (CHNC). Sequatchie Co., Brush Creek, N Dunlap, S. 12/V/2000, B.C. Kondratieff, R.F. Kirchner, 1♂ (CSUC). **VA:** Tazewell Co., Station Springs Creek, MBC rd., Burkes Garden, 17/V/1994, B.C. Kondratieff, R.F. Kirchner, 2♂ (CSUC); springs into Station Springs Creek, Burkes Garden, 18/V/1979, B.C. Kondratieff, 2♂ (CSUC).

Distribution: USA **– AL, GA, KY, NC, TN, VA.**

Male. Macropterous. Forewing length 10.0-10.5 mm. General body color pale yellow. Dorsum of head with a large dark brown interocellular patch, a brown patch anterior to median ocellus (Fig. 36.1). Antennae pale yellow. Pronotum yellow, middorsal pronotal suture brown, disks pale; rugosities wide, brown (Fig. 36.1). Wings pale, veins pale. Legs pale yellow. Sterna pale yellow. Sternum 8 with a lightly sclerotized vesicle, as wide as long, broadly rounded, almost obscured by long hairs (Fig. 36.2). Terga pale yellow. Paraprocts short, stout, lightly sclerotized, tips acute, recurved slightly over tergum 10 crenulated ⅔ of length (Figs. 36.3, 36.4). Cerci pale yellow. Aedeagus membranous with expanded balloon-like apical section (Fig. 36.7g), a small pair of posterodorsal nipple-like lobes (Fig. 36.7f,), a pair of large posteroproximal hemispherical lobes (Figs. 36.7d, 36.8c); posteroproximal sclerotized triangular spine plate bearing a sharp ventral or distal elongate spine and shorter basal spines (Figs. 36.7c, 36.8d). A large ventrobasal recurved membranous tube (Figs. 36.7a, 36.8a) and paired small basal lobes ventral to triangular spine patch (Figs. 36.7b, 36.8b) are also present on the aedeagus; mesal section with large area of dense short stout spinulae (Fig. 36.7e).

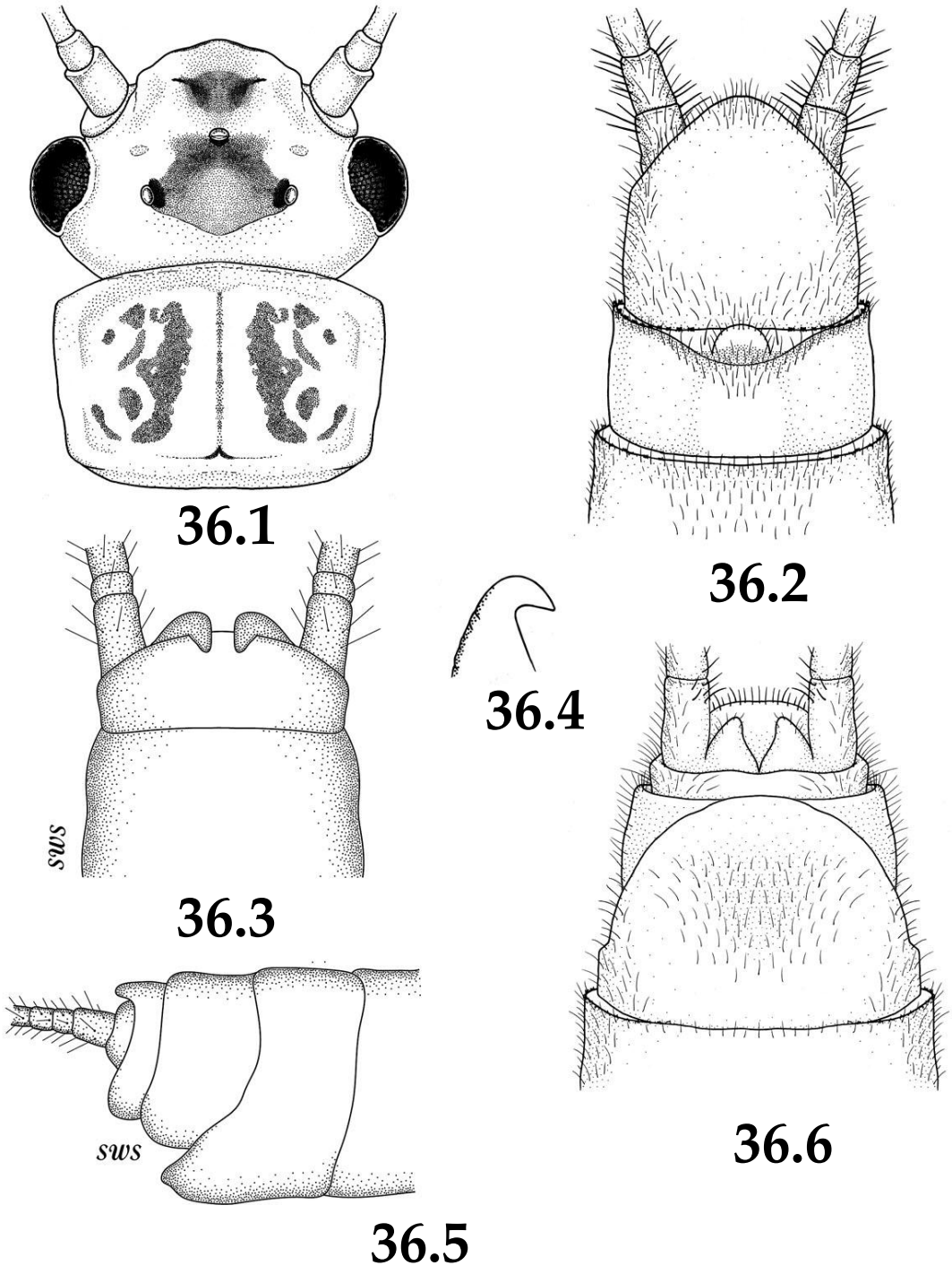
Female. Macropterous. Forewing length 11.5 mm. General body color and external morphology similar to male. Subgenital plate, large, produced nearly to posterior margin of sternum 9, broadly rounded and scoop-shaped in lateral view (Fig. 36.5).

Ovum. General shape approximately square, cross section triangular with distinct horizontal ridges dividing anterior and posterior poles, anterior pole nearly flat (Fig. 36.9). Color pale brown. Length 303 μm; width 233 μm. Collar poorly developed, low, apical rim with irregular lobes (Figs. 36.9, 36.10). Hexagonal follicle cell impressions well-developed with elevated thin ridges giving the chorion a "lacey" appearance; floors shallow with numerous shallow pits (Figs. 36.9, 36.11). Micropyles scattered in groups of 4 or 5 on top of thin FCI ridges near anterior ⅓ of egg; openings elevated with a donut-shaped cap (Figs. 36.9, 36.11). Eclosion line absent (Fig. 36.9).

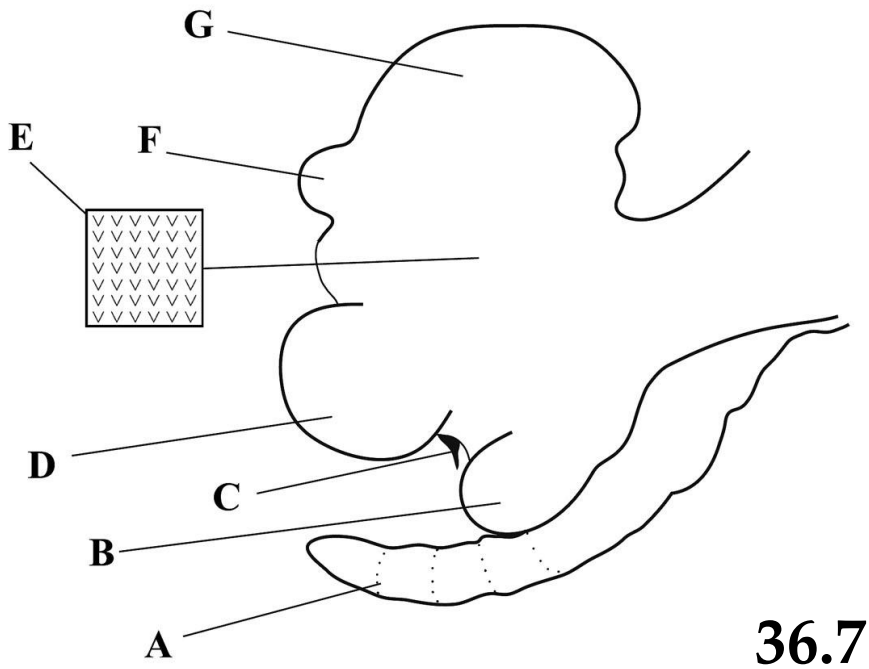
Nymph. Unknown.

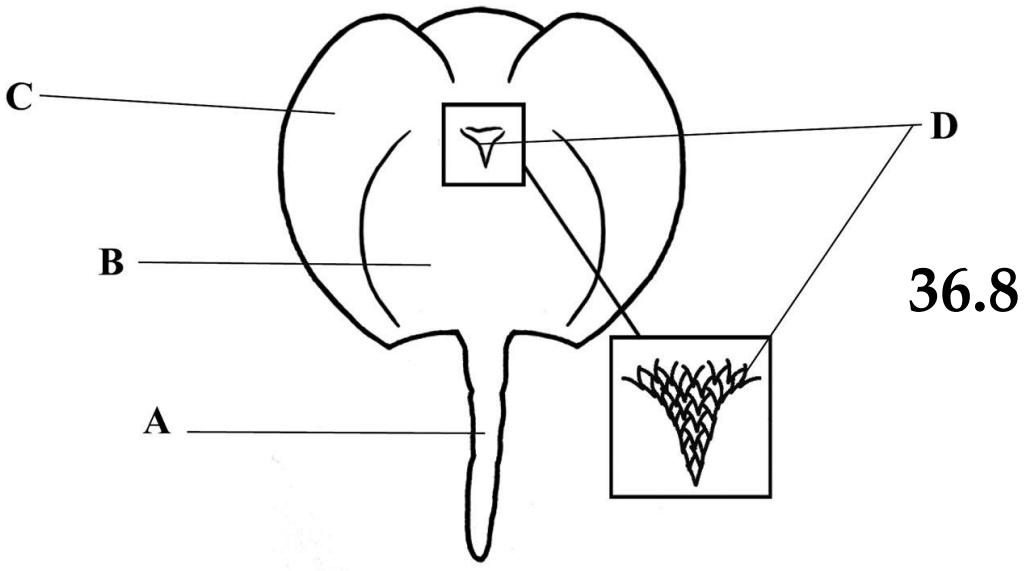
Etymology. We named this species in honor of Dr. Charles H. Nelson, Professor Emeritus, University of Tennessee Chattanooga who has made numerous significant contributions to the study of stoneflies, and who first collected this species and recognized it as new.

Diagnosis. *Isoperla nelsoni* sp. n. is a member of the *I. montana* group which includes *I. montana* and *I. smithi* sp. n. (Table 1). It shares the sclerotized "arrowhead" shaped aedeagal spine plate with these species. However, it differs from both in the specific spinule pattern of the aedeagal armature, and in the shape and size of the female subgenital plate and head color pattern. From existing records listed above, *I. nelsoni* sp. n. appears to be rather

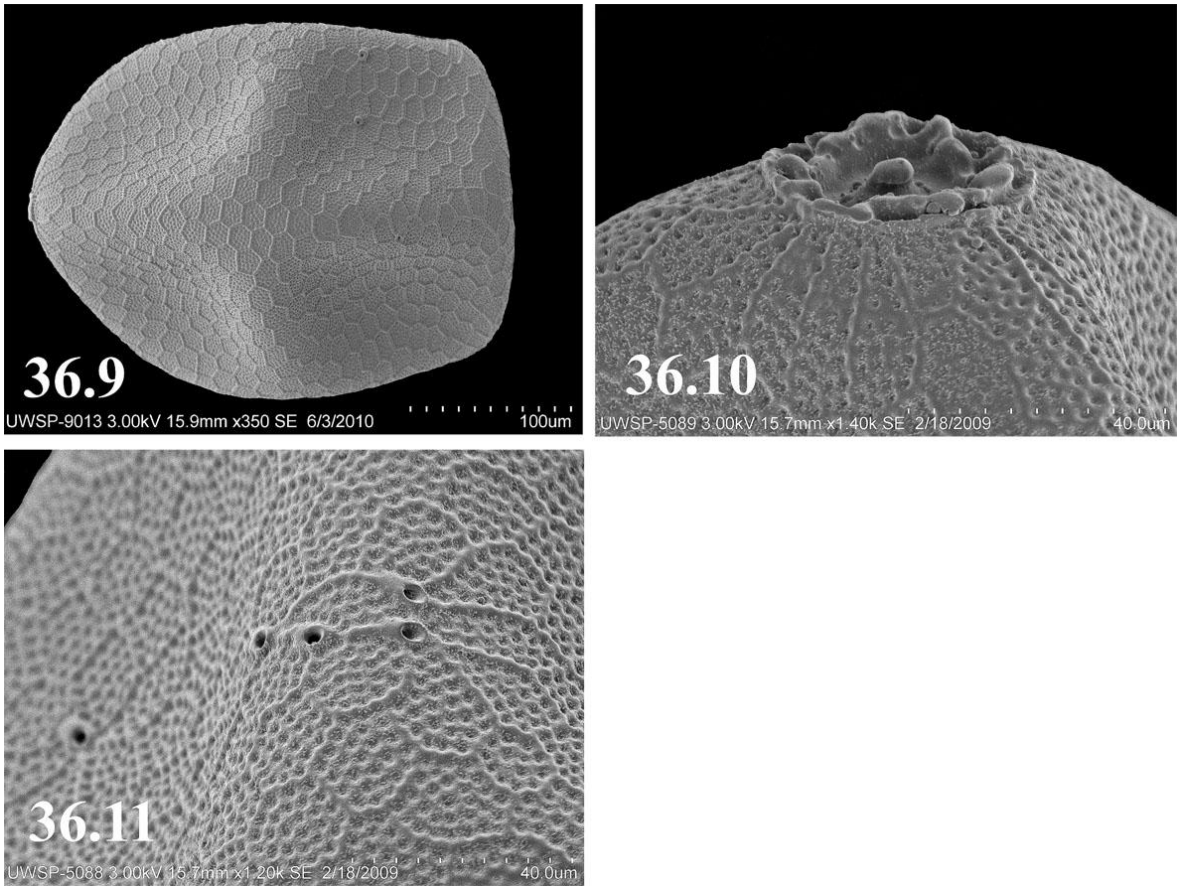


Figs. 36.1-36.6. *Isoperla nelsoni* sp. n. 36.1. Dorsal head and pronotal pattern. 36.2. Male posterior abdominal sterna. 36.3. Male posterior male terga. 36.4. Male paraproct lateral. 36.5. Female subgenital plate lateral view. 36.6. Female subgenital plate ventral view.





Figs. 36.7-36.8. *Isoperla nelsoni* sp. n. 36.7. Male aedeagus lateral view; a. ventrobasal recurved membranous tube, b. paired small basal lobes, c. posteroproximal sclerotized triangular spine plate, d. paired posteroproximal hemispherical lobes, e. large area of dense short stout spinulae, f. small paired posterodorsal nipple-like lobes, g. expanded balloon-like apical section. 36.8. Male aedeagus posterior view; a. ventrobasal recurved membranous tube, b. paired small basal lobes, c. paired, large posteroproximal hemispherical lobes, d, posteroproximal sclerotized triangular spine plate.



Figs. 36.9-36.11. *Isoperla nelsoni* sp. n. 36.9. Egg. 36.10. Detail of egg collar. 36.11. Detail of egg chorion and micropyles.

widespread in the southern Appalachians west to the southern part of the Appalachian Plateau of Tennessee.

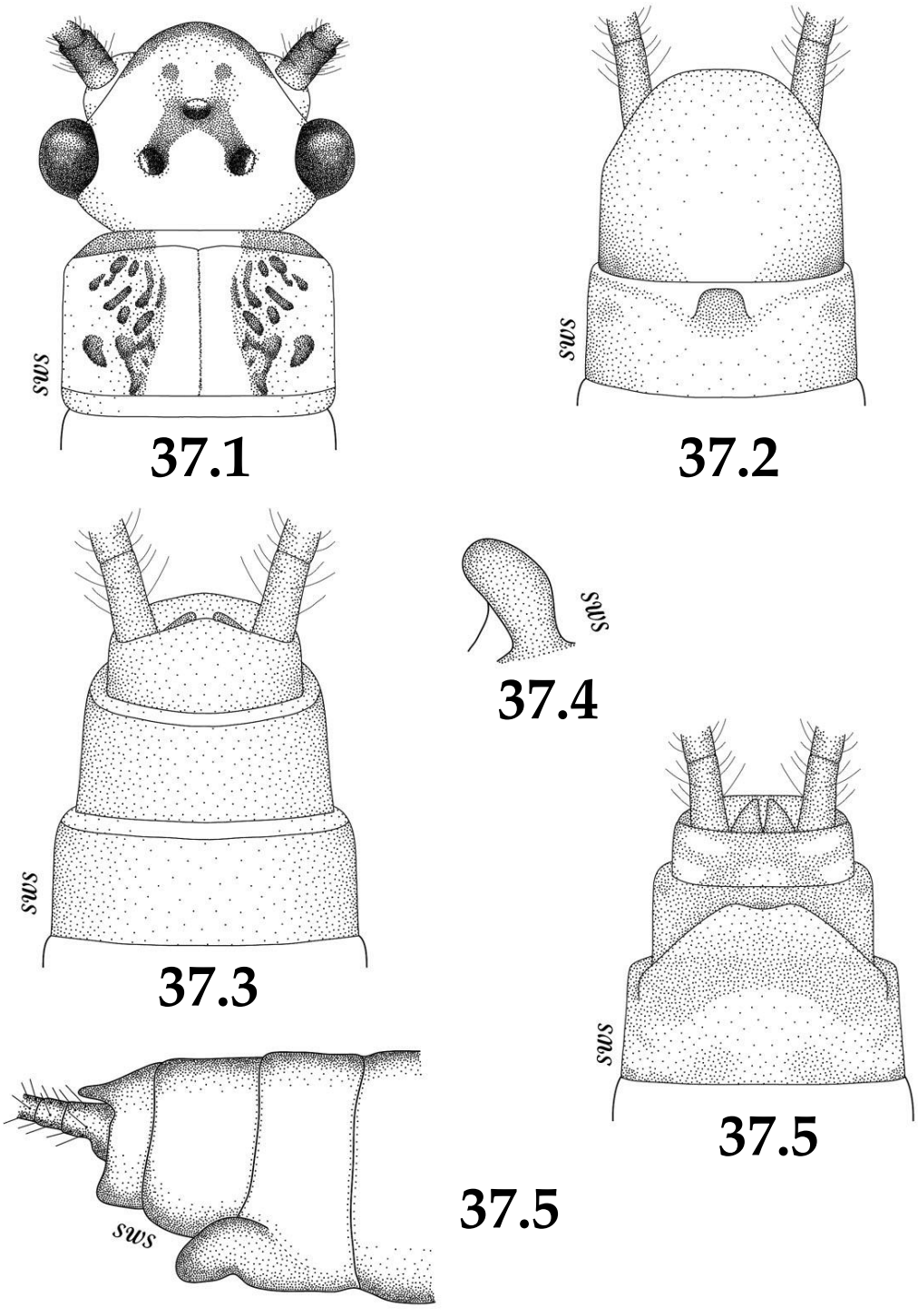
Biological Notes. *Isoperla nelsoni* sp. n. emerges from early to mid-May based on the limited collection records. The biology of this species is unknown. This species has been collected from a pristine spring source (see Nelson and Kondratieff (1983) for a description of Burkes Garden, Virginia) to medium and large streams that have been impacted by agriculture or urban development.

Isoperla orata Frison
Colorless Stripetail
(Figs. 37.1-37.12)

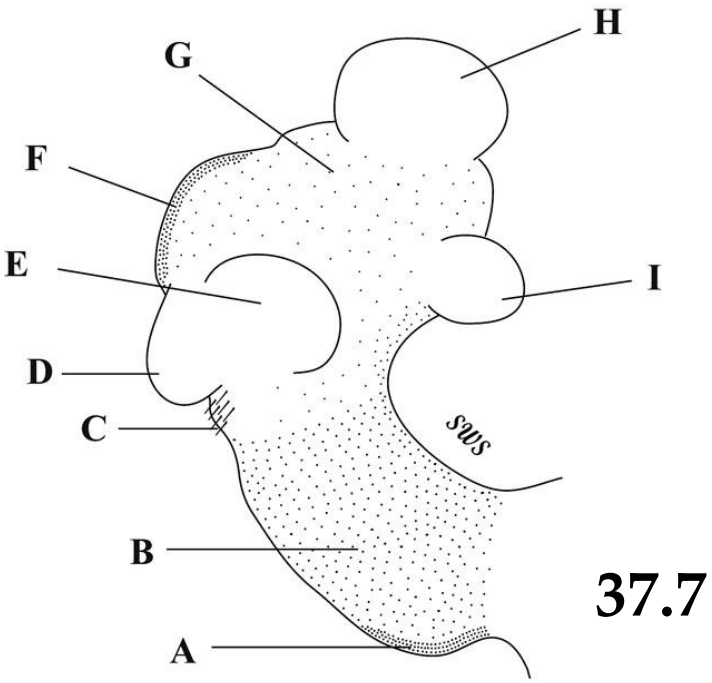
Isoperla orata Frison 1942, 22:323. Holotype ♀, Sevier Co., Gatlinburg, LeConte Creek (INHS), Tennessee. Examined.

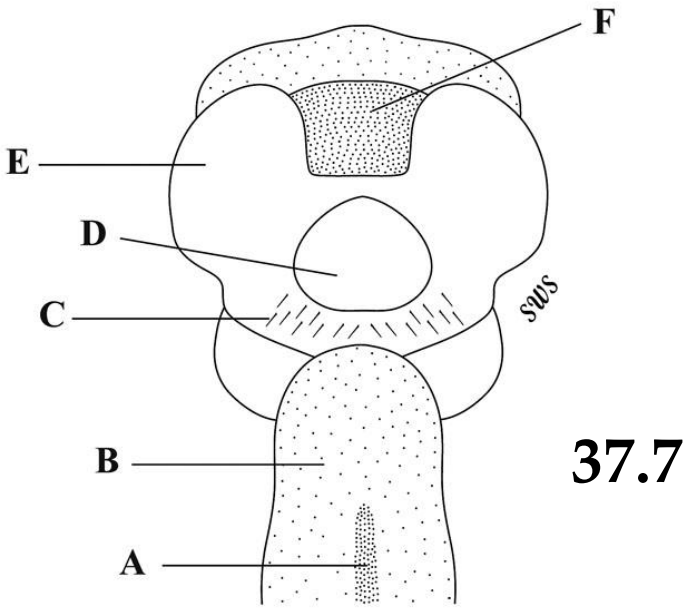
Material Examined. **USA – Paratypes: TN:** Sevier Co., Same location as holotype, 14/V/1939, T.H. Frison, H.H. Ross, 5♂, 5♀ (INHS); Same locality, 14/VI/1940, T.H. Frison et al., 1♀ reared, 16♀ not reared (INHS); Fork of Little Pigeon River, 27/V/1934, T.H. Frison, 1♂, 4♀ (INHS); Fighting Creek Gap, 15/V/1939, T.H. Frison, H.H. Ross, 1♂, 2♀ (INHS); Elkmont, 13/VI/1940, T.H. Frison et. al., 1♀ (INHS).

Additional Records. NC: Haywood Co., E. Fork Pigeon River, Shining Rock, US 276, 25/V/1993,



Figs. 37.1-37.6. *Isoperla orata*. 37.1. Dorsal head and pronotal pattern. 37.2. Male posterior abdominal sterna. 37.3. Male posterior male terga. 37.4. Male paraprocts lateral view. 37.5. Female subgenital plate lateral view. 37.6. Female subgenital plate ventral view.





Figs. 37.7-37.8. *Isoperla orata*. 37.7. Male aedeagus lateral view; a. posterobasal patch of dense short, stout spinulae, b. scattered fine spinulae on basal stalk, c. posteromedian scattered patch of long stout colorless hair-like spinulae, d. small posterodorsal lobe, e. paired large rounded mesal lobes, f. posterodorsal patch of dense short, stout golden brown spinulae, g. dorsal patch of scattered small fin spinulae, h. large anterodorsal lobe, i. paired small anteromesal lobes. 37.8. Male aedeagus posterior view; a. posterobasal patch of dense short, stout spinulae, b. scattered fine spinulae on basal stalk, c. posteromedian scattered patch of long stout colorless hair-like spinulae, d. small posterodorsal lobe, e. paired large rounded mesal lobes, f. posterodorsal patch of dense short, stout golden brown spinulae.

B.C. Kondratieff, R.F. Kirchner, 5♂, 1♀ (CSUC); Cataloochee Creek, GSMNP, 16/V/1990, B.C. Kondratieff, R.F. Kirchner, L.W. Myers, 5♂ (CSUC). Macon Co., Cullasaja River, Rte. 28, N Falls, 24/V/1993, B.C. Kondratieff, R.F. Kirchner, 1♂, 1♀ (CSUC). Wilkes Co., Hunting Creek, Hwy 115, NW of Elkville, 2/V/2005, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat, 1♂ (CSUC). **PA:** Clinton Co., Fishing Creek, Sieg Conference Center Narrow Road, 9/VI/2013, B.C. Kondratieff, J.B. Sandberg, 8♂, 5♀ (CSUC).**VA:** Giles Co., Big Stoney Creek, Rte. 635, 14/VI/1977, Powell, 1♂, 1♀ (CSUC); Little Stoney Creek, Rte. 460, 19/V/1978 (emerged 8/V/1978), B.C. Kondratieff, 1♂ (CSUC).

Distribution. **NC, PA, TN, VA.**

Literature Records. CANADA – NB (Ricker 1947), **PQ** (Ricker et al. 1968). **USA – CT** (Hitchcock 1974), **KY** (Tarter et al. 2006), **ME** (Mingo 1983), **MN** (Harden & Mickel 1952, Lager et al. 1979), **NC** (Frison 1942), **NH** (Frison 1942), **NY** (Frison 1942, Myers et al. 2011), **OH** (Gaufin 1956), **PA** (Frison 1942, Surdick & Kim 1976, Masteller 1996b), **SC** (Kondratieff et al. 1995), **TN** (Frison 1942), **VA** (Kondratieff & Kirchner 1987), **VT** (Frison 1942), **WV** (Tarter and Kirchner 1980, Tarter & Nelson 2006).

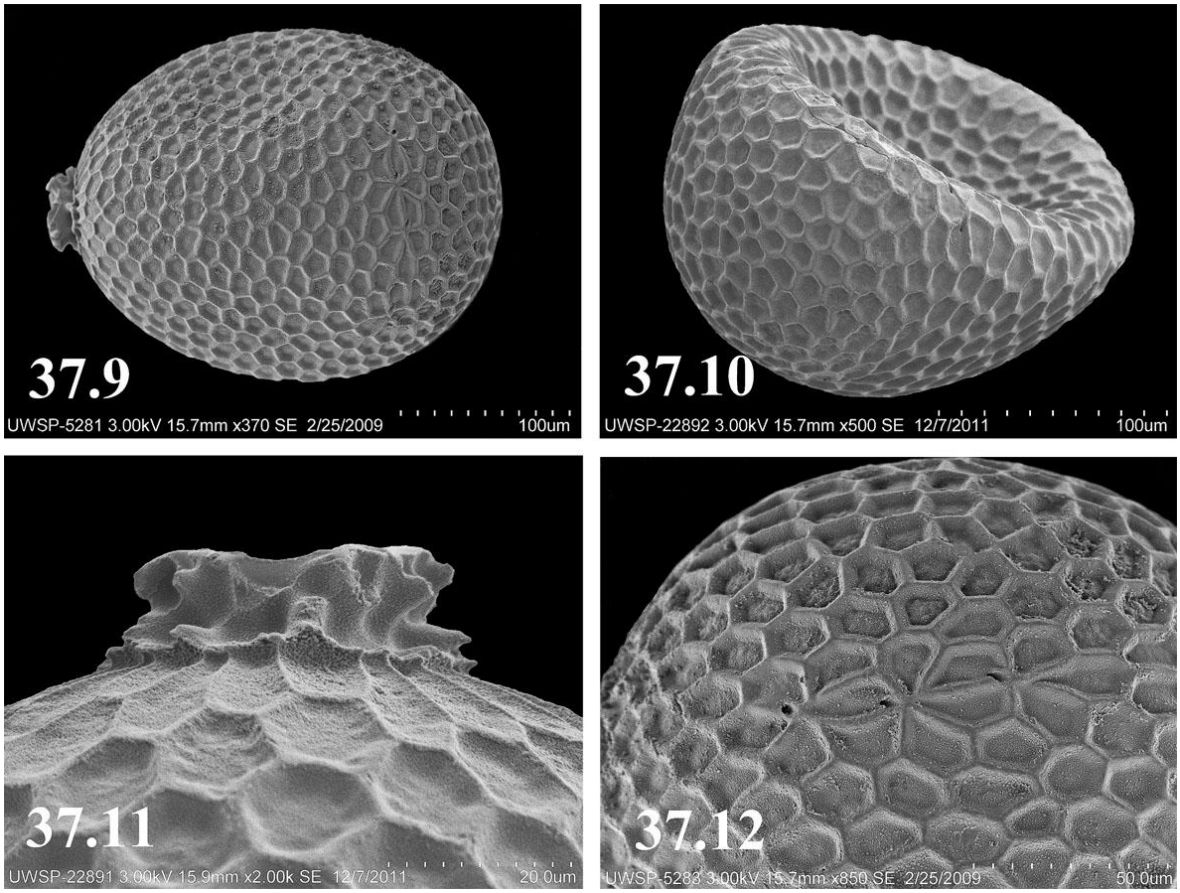
Male. Macropterous. Forewing length 8.5-9.5 mm. General body color pale yellow to pale brown with darker markings. Dorsum of head pale yellow with brown bands connecting anterior and posterior ocelli; bands truncate anteriorly; two small round medium brown spots anterior to median ocellus (Fig. 37.1). Antennal scape pale yellow, pedicel brown, flagellum 1-7 pale yellow, distal segments brown. Pronotum with median hourglass-shaped pale yellow stripe; middorsal pronotal suture a faint pale brown line; rugosites irregular, raised, dark brown, pronotal disks pale yellow; anterior margin with short brown bipartite brown bands (Fig. 37.1). Meso- and metanota pale yellow with irregular brown markings and large U-shaped thin brown median band. Meso- and metasterna pale yellow with pale brown bands. Wings hyaline, veins pale brown. Femora and tibia pale yellow, femora with thin dark brown dorsal band on outer surface, tarsi brown. Terga pale yellow to pale brown with faint brown lateral and median longitudinal bands. Sterna pale yellow; sternum 8 with well-developed vesicle; vesicle slightly wider than long; posterior margin evenly rounded, extending posteriorly to near anterior margin of sternum 9 (Fig. 37.2). Paraprocts lightly sclerotized, short, stout, broadly rounded apically, slightly visible, but not overlapping tergum 10 (Figs. 37.3, 37.4). Cerci pale brown. Aedeagus bearing a median posterobasal patch of dense short stout spinulae (Figs. 37.7a, 37.8a), scattered fine spinulae on an elongate tubular basal stalk (Figs. 37.7b, 37.8b), a posteromedian scattered patch of long, stout, colorless, hair-like spines (Figs. 37.7c, 37.8 c), a small posteromedian nipple-like lobe devoid of spinulae (Figs. 37.7d, 37.8d), a pair of large rounded mesal lobes (Figs. 37.7e, 37.8e), a posterodorsal patch of dense short, stout golden brown spinulae (Figs. 37.7f, 37.8f), a dorsal patch of scattered small fine spinulae (Fig. 37.7g), a large anterodorsal lobe devoid of spinulae (Fig. 37.7h) and paired small anteromesal lobes devoid of spinulae (Fig. 37.7i).

Female. Forewing length 9.0-11.0 mm. General body color and morphology similar to male described above. Eighth sternum with a large broadly truncate subgenital plate with slight mesal emargination; plate extending posteriorly over ½ sternum 9, margin deflected ventrally near apical ⅓ (Figs. 37.5, 37.6).

Ovum. General shape oblong, cross section concave, anterior pole round (Figs. 37.9, 37.10, 37.12). Color pale brown. Length 266 µm; width 209 µm. Collar well-developed, with irregular longitudinal ridges and flared apically; base offset from egg body by low shoulder (Figs. 37.9, 37.11). Hexagonal follicle cell impressions well-developed with elevated thick ridges; floors with numerous shallow pits (Figs. 37.9, 37.10, 37.12). Micropyles scattered in a row of 3 or 4 on top of FCI ridges near posterior ⅓ of egg; openings slit-like (Figs. 37.9, 37.12). Eclosion line absent (Figs. 37.9, 37.12).

Nymph. Described by Frison (1942).

Diagnosis. The adult males and females of *I. orata* resemble closely the general appearance of other *I. burksi* group species, especially the sympatric *I. burksi,* but are most similar in general habitus to a *I. signata* group species, *I. francesca* and to a *I. bilineata*



Figs. 37.9-37.12. *Isoperla orata*. 37.9. Egg. 37.10. Posterior view of egg. 37.11. Detail of egg collar. 37.12. Detail of egg chorio n and micropyles.

group species, *I. myersi* sp. n. (Table 1). The male of *I. orata* can be distinguished from these three species if the aedeagus is fully everted. The aedeagus of *I. burksi* has a large ovate shaped patch of long stout spinulae; the aedeagus of *I. francesca* has a pair of sclerotized posteromedian spine plates and the aedeagus of *I. myersi* sp. n. has a wide posteromesal paddle-shaped band of stout golden brown spinulae. Additionally, the vesicle of *I. orata* and *I. myersi* sp. n. are as wide as long, whereas in *I. burksi*, the vesicle is one-half times wide as long and in *I. francesca*, about two times as wide as long. Frison (1942) designated a female as the holotype, no doubt because the deflected or downturned subgenital plate apex presented a diagnostic character, with only subtle morphological characters of the male detected at that time. However, the deflected subgenital plate character is also present in females of *I. burksi*, *I. cotta*, and *I. francesca* (females of *I. myersi* sp. n. are unknown) and the females of these species are very similar (although the head pattern of *I. cotta* is generally darker) and without associated males they are difficult to distinguish. The ova of *I. burksi* are unknown but the ova of *I. francesca* are concave in cross section. Ricker (1947) remarked that "…*orata* is unusually variable or a group of several closely related forms found in Canada from Ontario eastward." Harden and Mickel (1952) supported Ricker's original comments. Some of

this uncertainty may have been resolved with the subsequent descriptions of *I. cotta* and *I. francesca*. Ricker (1952) stated that "…the three species *burksi, cotta*, and *orata* are a closely-related group and may not always be separated, particularly as nymphs." Hitchcock (1974) also suggested that *I. orata* "…belongs to *burksi-cotta* group of *Isoperla* and may be conspecific with them", clearly reflecting the difficulty of identification. Additional study of this group of species with fully everted males will be required to completely clarify identifications. We have only included state records above that we were able to verify. Other literature records such as Ohio (Gaufin 1956) and Florida (Stark and Gaufin 1979) need to be verified by males with fully everted aedeagi, especially those from northeastern North America and those outside the higher Appalachian highlands. For example, DeWalt et al. (2012) and Grubbs et al. (2013) do not include this species in their recent review of Ohio stoneflies.

Biological Notes. Frison (1942) indicated that *I. orata* is a species "…most abundant in mountainous areas of the eastern states." Putatively, Harper and Pilon (1970) reported a May emergence period in Quebec for this species. Limited available information indicates that nymphs occur in rather pristine medium-sized southern Appalachian streams.

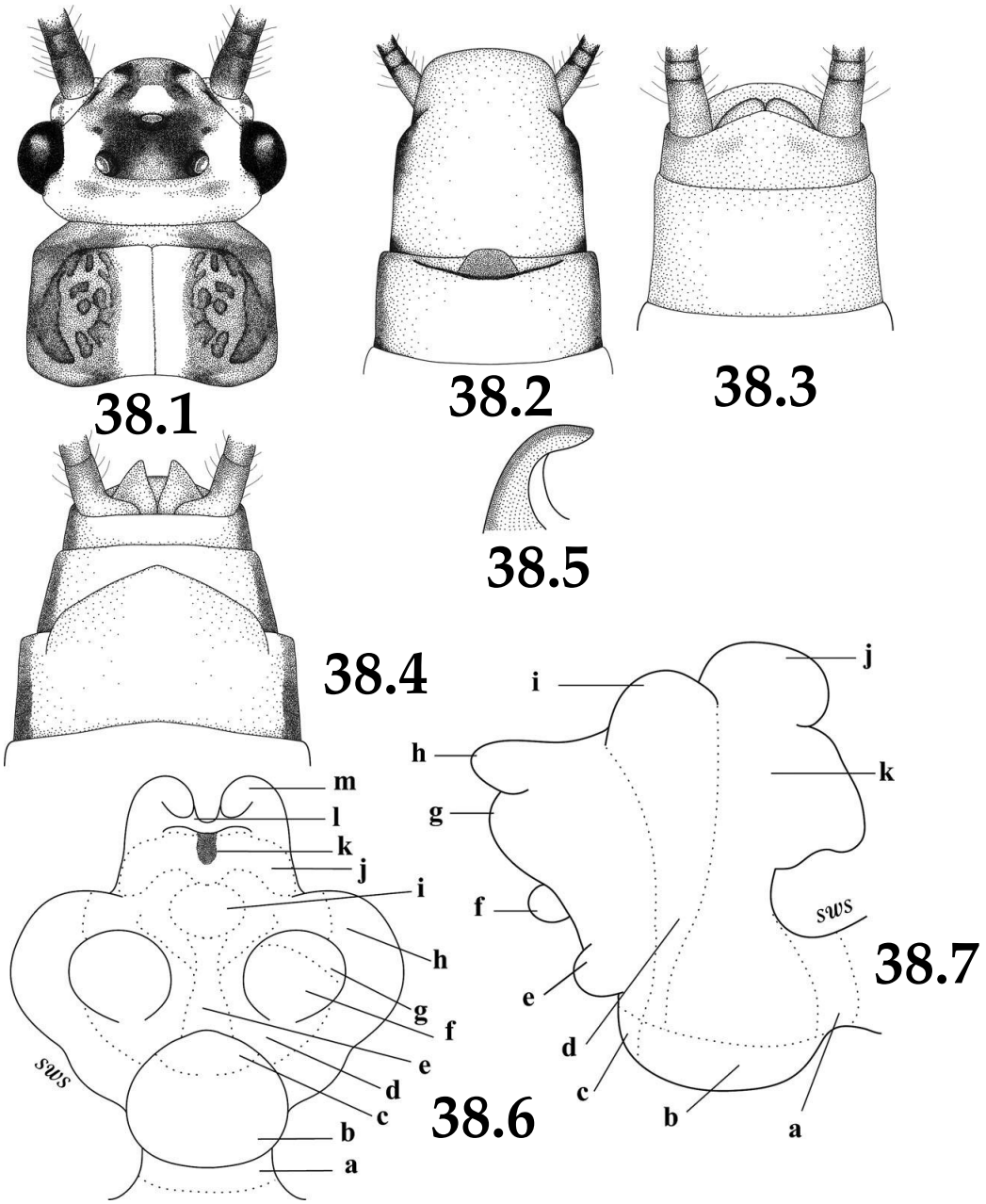
Isoperla ouachita Stark and Stewart
Ouachita Stripetail
(Figs. 38.1-38.23)

Isoperla ouachita Stark and Stewart 1973b, 84:193. Holotype ♂ (USNM) Pine Creek (Latimer Co.), Oklahoma. Examined.
Isoperla ouachita: Poulton and Stewart, 1991, 38:48.

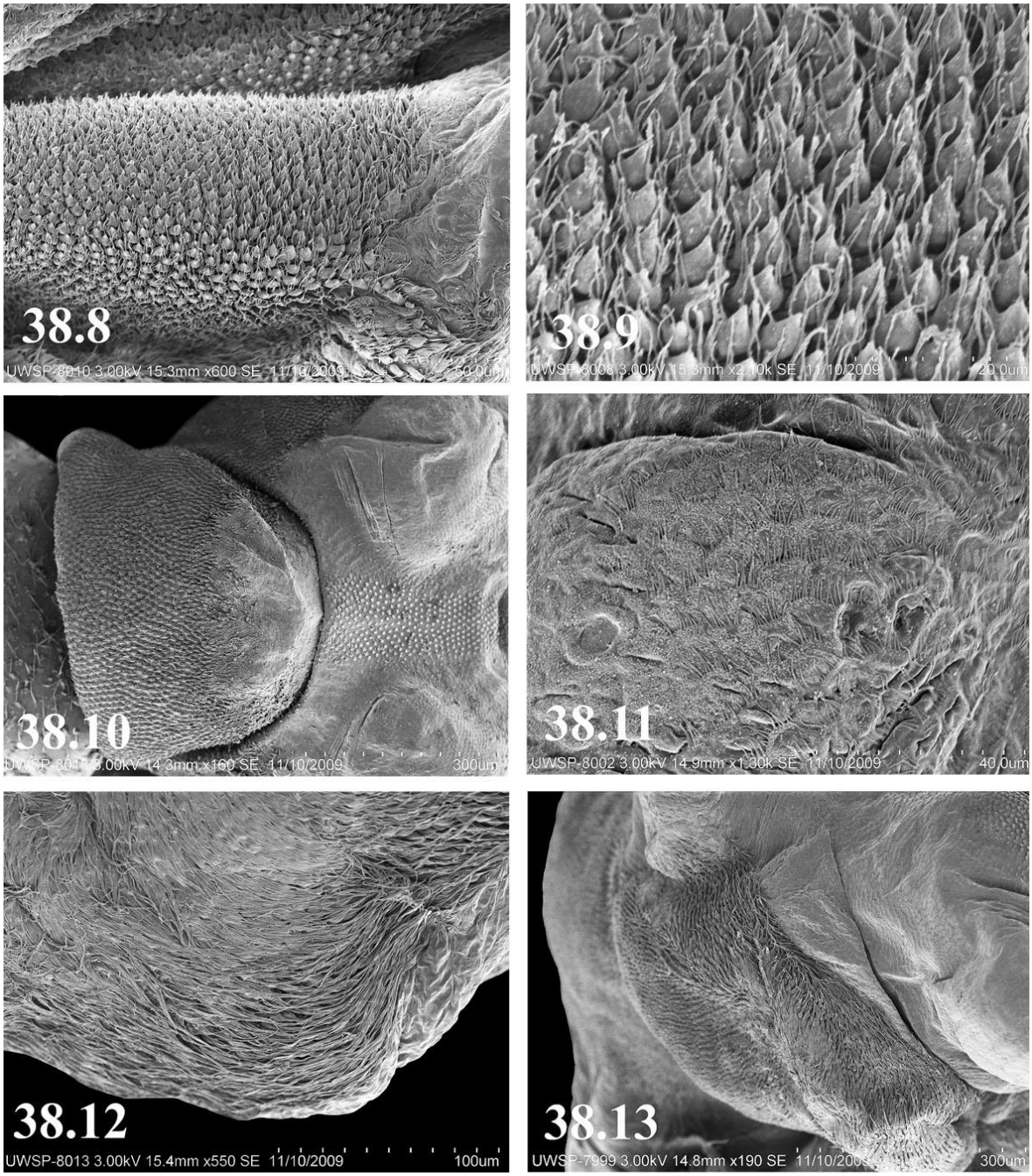
Distribution. **USA – AR** (Poulton and Stewart 1991), **MO** (Poulton and Stewart 1991), **OK** (Stark and Stewart 1973b, Poulton and Stewart 1991).

Additional Records. USA – AR: Perry Co., Dry Run Creek., Hwy 7, 6 mi. S. Hollis, 18/IV/1985, B.C. Poulton, 1♂, 3♀, 23 N (BYUC). Garland Co., Middle Fork River, Hwy 7, 15/IV/1971, R.A. Haick, C.R. Haick, 7♂, 3♀, 3 N (BYUC). Scott Co., Rock Creek, Hwy 378, 4 mi. SE Mansfield, 11/V/1988, B.C. Poulton, 9♂, 3♀, 6N (BYUC). **MO:** Iron Co., Stouts Creek, Ironto, Hwy 21, 22/V/2006, B.C. Kondratieff, R.W. Baumann, 2♂, 4♀ (CSUC); Little Taum Sauk Creek, CR 204, 22/V/2006, B.C. Kondratieff, R.W. Baumann, 1♂, 5♀ (CSUC). Madison Co., Marble Creek Recreation Area, 21/V/2006, B.C. Kondratieff, R.W. Baumann, 1♂ (CSUC). **OK:** Delaware Co., Whitewater Creek., near Lake of the Cherokees, 1/V/1972, R.W. Baumann, 4♀, 1 N (BYUC). Latimer Co., Pine Creek, 10/IV/1972, B.P. Stark, 2♂, 1♀ (paratypes, BPSC). Turkey Creek, 8/IV/1971, B.P. Stark, 3♂, 1♀ (paratypes, BPSC). LeFlore Co., Cedar Creek, below Cedar Lake, Hwy 59, 30/IV/1972, R.W. Baumann, 2♀ (BYUC). Pushmataha Co., Walnut Creek, Albion, 12/IV/1976, B.P. Stark, 6♂, 1♀, 12 N (BPSC).

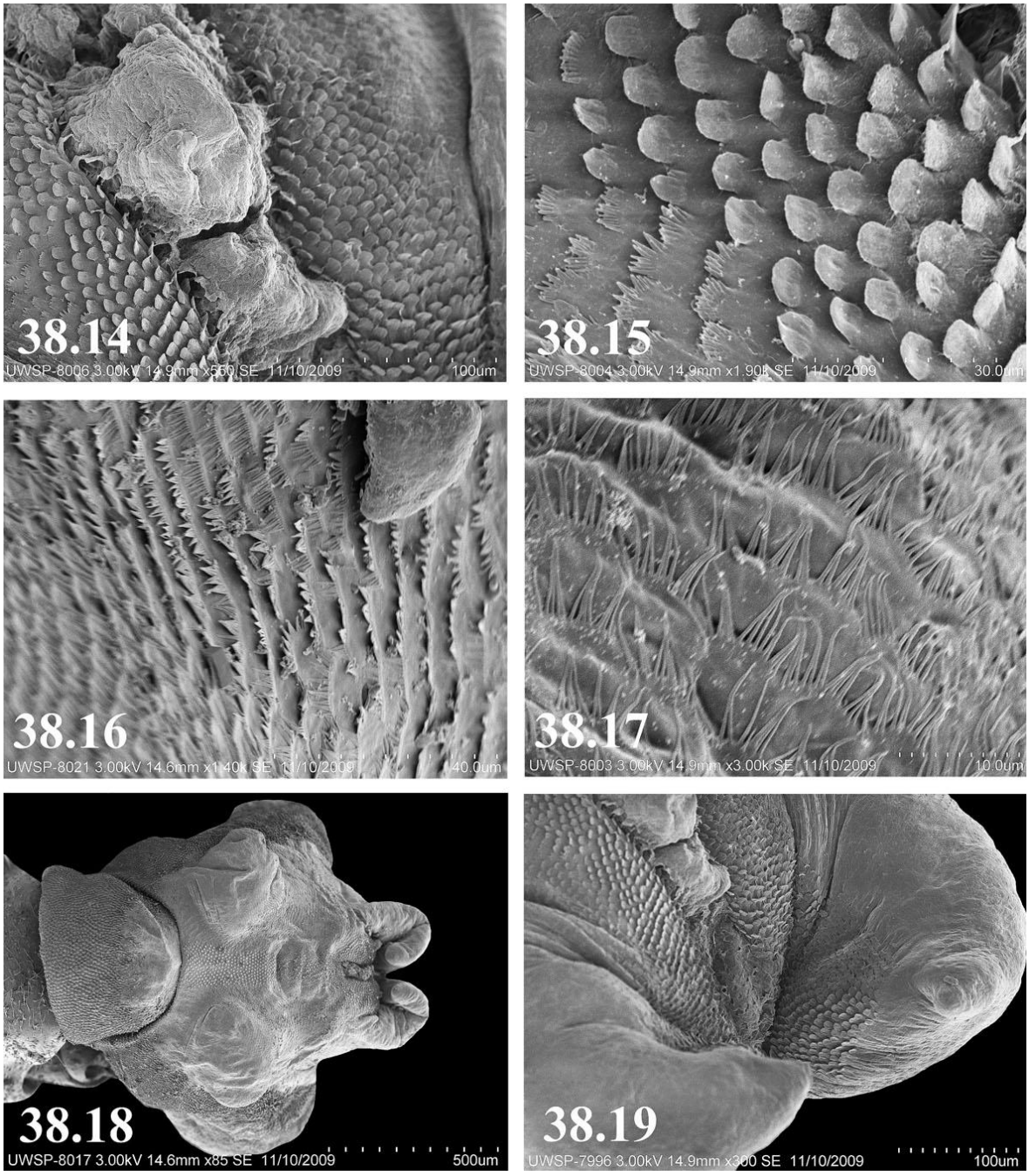
Male. Macropterous. Forewing length 6.5-9.2 mm. General body color almost entirely pale yellow in life with medium brown markings. Dorsum of head pale yellow with ocelli usually connected with wide medium brown bands enclosing interocellar area; interocellar area occasionally with a pale posterior median inverted V-patch; pigment continuing in narrow bands to frons, triangular pale spot anterior to median ocellus; anteromedian area of frons with a square shaped pale brown patch; diffuse pale brown markings posterolateral to posterior ocelli; posterior margin of head mostly pale yellow (Fig. 38.1). Antennal scape, pedicel and flagellum pale yellow. Pronotum with wide median pale stripe; middorsal pronotal suture a thin brown line; rugosities irregular, raised, medium brown, pronotal disks pale brown; anterior and posterior margins pale brown (Fig. 38.1). Meso- and metanota pale yellow with thin U-shaped band. Wings dusky, veins medium brown. Legs and sterna pale yellow, femora with a thin outer medium brown band near distal ⅓; tibia with medium brown band near proximal ¼. Sterna pale yellow, sternum 8 with a pale yellow or pale brown vesicle, ca. as ½ as long as wide; posterior margin of vesicle evenly rounded, not expanded; lateral margins angled inward slightly posteriorly, and extending slightly over anterior margin of sternum 9 (Fig. 38.2). Terga pale yellow. Paraprocts moderately sclerotized along outer margin, elongate, bluntly pointed apically, and usually



Figs. 38.1-38.7. *Isoperla ouachita*. 38.1. Dorsal head and pronotal pattern. 38.2. Male posterior abdominal sterna. 38.3. Male posterior terga. 38.4. Female subgenital plate. 38.5. Male paraproct lateral. 38.6. Male aedeagus posterior view; a. basal patch of small stout spinulae, b. posteroventral lobe, c. area without spinulae, d. area without spinulae, e. depressed median area with mesal band of stout sclerotized scales, f. posteromedian paired lobes, g. patch of small fine hair-like spinulae, h. dense patch of long hair-like spinulae, i. small posteromedian lobe, j. dense patch of large blunt stout sclerotized scales, k. posteromedian area with an elevated golden brown sclerotized cover, l. patch of dense sclerotized scales, m. paired posterodorsal finger-like lobes. 38.7. Male aedeagus lateral view; a. basal patch of small stout spinulae, b. posteroventral lobe, c. area void of spinulae, d. dense patch of long hair-like spinulae, e. paired lateral posteromedian lobes, f. small posteromedian lobe, g. area of dense sclerotized scales, h. paired posterodorsal finger-like lobes, i. paired rounded dorsal lobes, j. anterodorsal lobe, k. area void of spinulae.

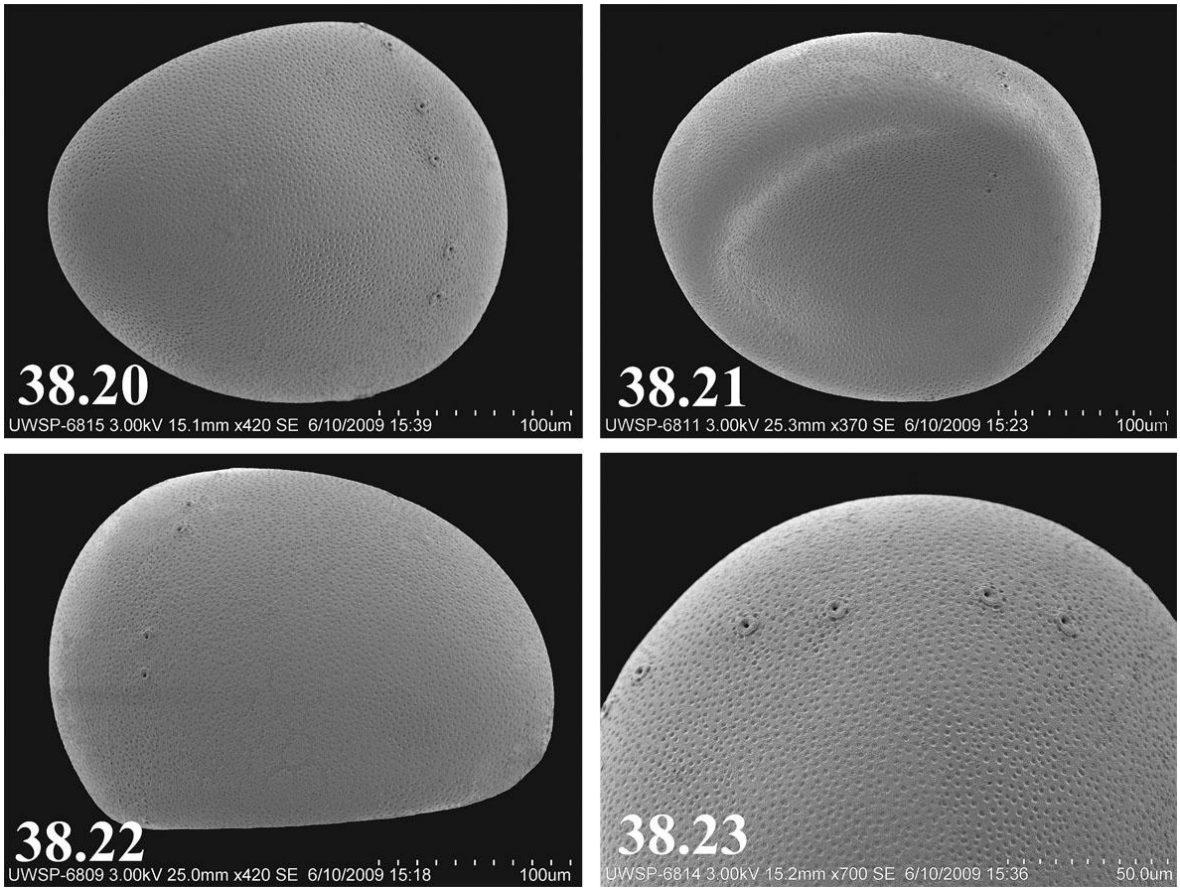


Figs. 38.8-38.13. *Isoperla ouachita*. 38.8. Basal patch of small stout aedeagal spinulae. 38.9. Detail of small stout sharp aedeagal spinulae on posteroventral lobe. 38.10. Posteroventral aedeagal lobe. 38.11. Rows of small fine hair-like spinulae and lateral posteromedian aedeagal lobes. 38.12. Detail of dense patch of long hair-like aedeagal spinulae. 38.13. Dense patch of long hair-like aedeagal spinulae.



Figs. 38.14-38.19. *Isoperla ouachita*. 38.14. Posteromedian aedeagal area with elevated golden brown sclerotized cover. 38.15. Dense patch of large blunt stout sclerotized aedeagal scales. 38.16. Rows of dense medium fine hair-like aedeagal spinulae set on elevated ridges. 38.17. Small fine rows of hair-like spinulae covering anterodorsal lobe and most of anterior margin of aedeagus. 38.18. Male aedeagus posterior view. 38.19. Detail of paired posterodorsal finger-like lobes.

extending to level of tergum 10 (Figs. 38.3, 38.5). Cerci pale yellow. Aedeagus with patch of dense small stout, sharp spinulae on stalk (Figs. 38.6a, 38.7a, 38.8), a large posteroventral lobe covered with dense patch of stout, sharp spinulae (Figs. 38.6b, 38.7b, 38.9, 38.10), a small area along dorsomedian margin without spinulae (Figs. 38.6c, 38.10) and a pair of medium size, rounded, lateral, posteromedian lobes with membranous lumps and rows of small, fine hair-like spinulae on dorsal margin (Figs. 38.6f, g, 38.7e, 38.11); outer area lateral to paired lobes covered with dense patch of long hair-like spinulae which extend distally to paired dorsal lobes (Figs. 38.6h, 38.7d, 38.12, 38.13); posteromedian depressed area with an elevated golden brown sclerotized cover supported by basal rods (Figs. 38.6k, 38.14,); a dense patch of large, blunt, stout sclerotized scales occurs lateral to depressed area (Figs. 38.6j, 38.7g, 38.14, 38.15); rows of dense fine hair-like spinulae are positioned on elevated ridges lateral and posteroventral to scales (Figs. 38.14, 38.15, 38.16); a small round posteromedian lobe (Fig. 38.6i, 38.7f) is located below median depressed area and bears a mesal band of stout sclerotized scales which continue posteroventrally between rounded posteroventral lobes (Figs. 38.6e, 38.6j, 38.7f, 38.10); area below lobes without spinulae or scales (Figs. 38.6d, 38.7c, 38.10, 38.18); a pair of posterodorsal finger-like lobes, bent medially at tips above posteromedian depressed area, occur on inner subapical margins with dense, stout sclerotized scales, but remainder of lobes without spinulae (Figs. 38.6m, 38.7h, 38.18, 38.19). Dorsally, a pair of rounded lobes occur



Figs. 38.20-38.23. *Isoperla ouachita*. 38.20. Egg lateral view showing concave profile. 38.21. Egg. 38.22. Egg oblique view showing concave profile. 38.23. Detail of egg chorion and micropyles.

which are covered with a concentrated patch of very long hair-like spinulae (Figs. 38.7i, 38.12); rounded anterodorsal lobe and most of anterior area of aedeagus covered with rows of small, fine hair-like spinulae (Figs. 38.7j, k, 38.17).

Female. Forewing length 8.5-9.8 mm. General body color and morphology similar to male described above. Subgenital plate broadly triangular, occasionally with a posteromedian small nipple, produced posteriorly over ca. ¾ length of sternum 9 (Fig. 38.4).

Ovum. Pear-shaped tapering posteriorly, cross section concave; anterior end round, collar absent (Figs. 38.20, 38.21, 38.22). Color pale brown. Length 242 µm; width 199 µm. Hexagonal follicle cell impressions faintly visible; chorionic surface covered with numerous shallow pits. Micropyles arranged in pairs along a row near anterior ⅓; openings with a thickened donut shaped cap (Figs. 38.20, 38.22, 38.23). Eclosion line absent (Figs. 38.21, 38.22, 38.23).

Nymph. Stark and Stewart (1973b) illustrated the nymphal head pattern and Poulton and Stewart (1991) illustrated the head color pattern, lacinia and terga.

Diagnosis. *Isoperla ouachita* is assigned to a group of primarily sympatric Ozark-Ouachita Mountain species, the *I. irregularis* group, which includes *I. decepta, I. szczytkoi* and *I. irregularis* (Table 1). This cluster of species is shares a concave egg lacking a collar, reduced hexagonal follicle cell impressions on the egg chorion, a nymphal lacinia with reduced or absent subapical tooth, marginal setae continuing to near the lacinial base and a deeply cleft right mandible with 2 or 3 apical teeth. *Isoperla ouachita* is the only known Nearctic *Isoperla* species in which the aedeagus has a depressed elongate posterior area with a sclerotized covering supported by basal rods. Among sympatric regional species, the color pattern of the head is distinctive in having the interocellar area mostly medium brown with medium brown bands extending from the anterior ocellus to the frons.

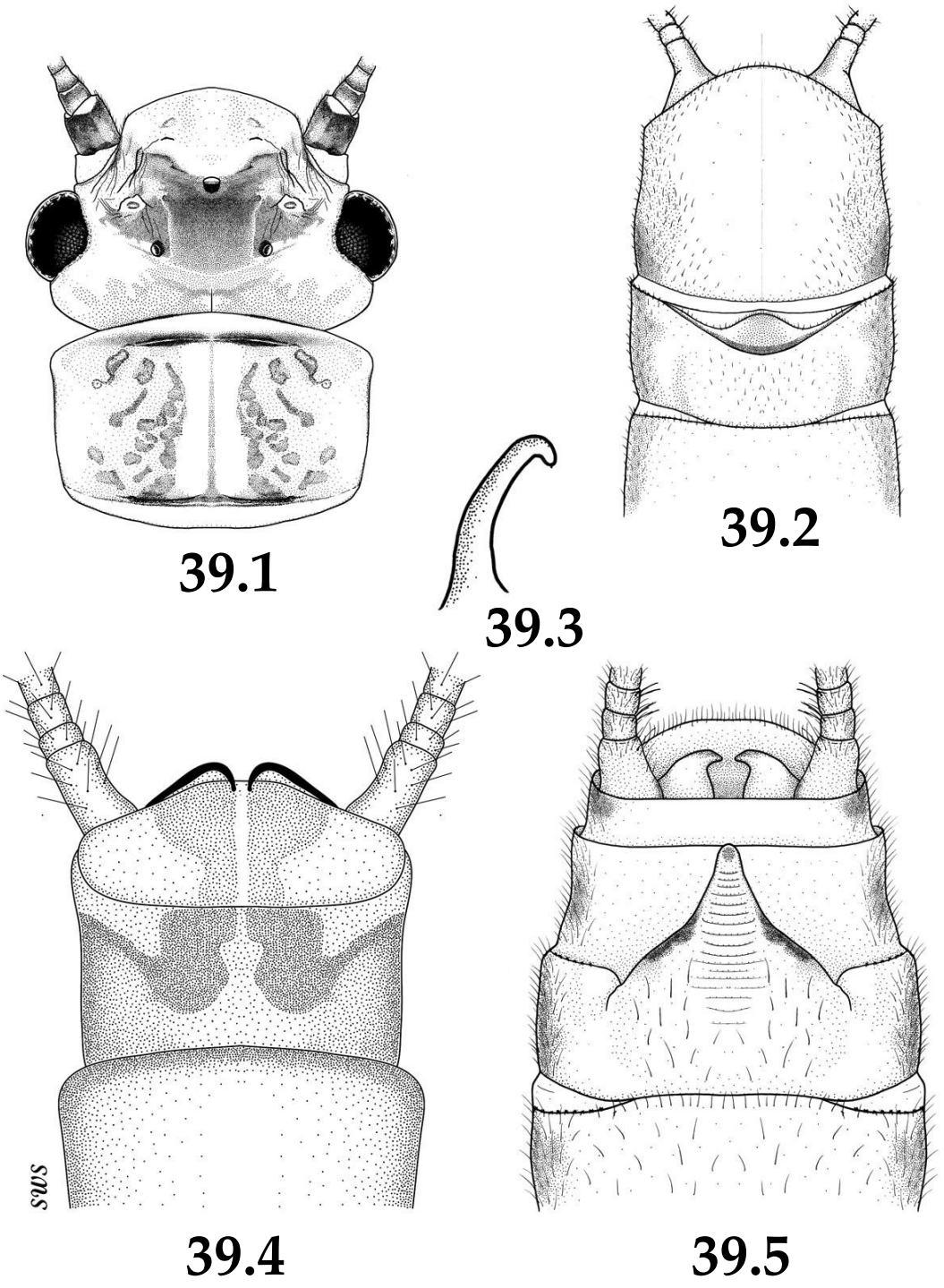
Biological Notes. Poulton and Stewart (1991) reported that *I. ouachita* was the most common and widespread *Isoperla* species in the Ozark-Ouachita Mountains in their study. They found that it occurred commonly in intermittent streams that were dry during the summer period. Emergence usually occurred during mid-March to late May (Poulton and Stewart 1991).

Isoperla pauli sp. n.
Mt. Mitchell Stripetail
(Figs. 39.1-39.15)

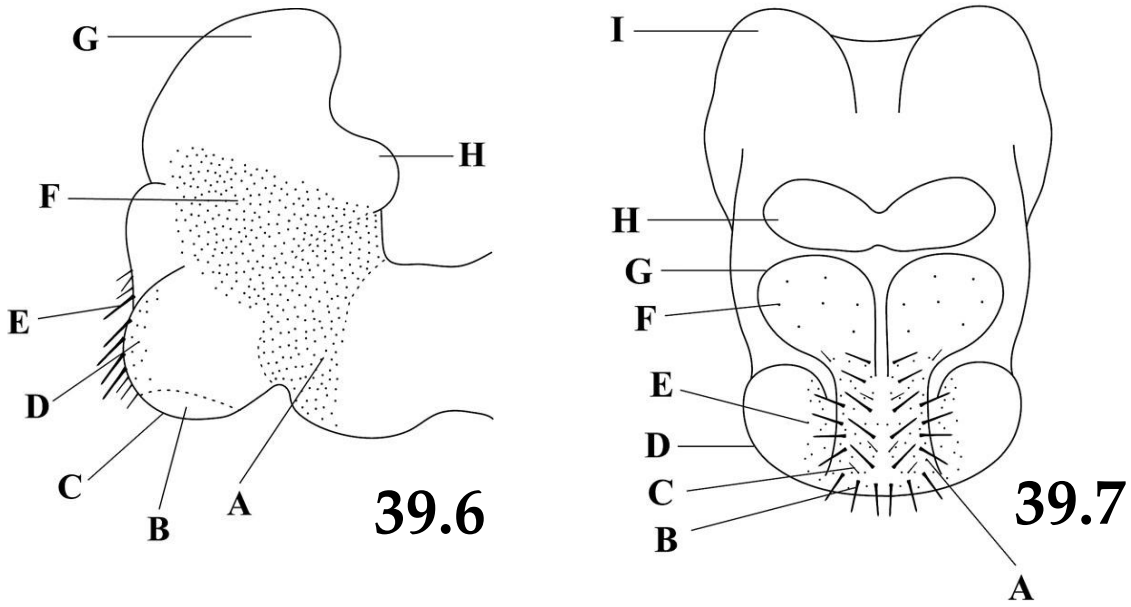
Material Examined. USA – Holotype ♂, North Carolina: Avery Co., Wilson Creek, Blue Ridge Parkway, NE of Linville, 38.10044N, 80.80894W, 13/V/2010, B.C. Kondratieff, R.E. Zuellig, D.R. Lenat, R.F. Kirchner (USNM). **Paratypes: NC:** Same data as holotype 2♂, 2♀ (CSUC). Avery Co., Wilson Falls, Wilson Creek, 20/V/1950, ?, 1♂, 1♀, 1N (USNM). Watauga Co., stream along Blue Ridge Parkway (Dixson Creek?), mile marker 301, NE Linville, 36.10804N, 81.78629W, 13/V/2010, B.C. Kondratieff, R.E. Zuellig, D.R. Lenat, R.F. Kirchner, 1♀ (CSUC). Yancey Co., Lower Creek, Commissary Trail, Old Mt. Mitchell Trail, Mt. Mitchell State Park, 35.7593N, 82.2672W, 12/VII/2007, B.C. Kondratieff, R.E. Zuellig, D.R. Lenat, 1♂, 7♀ (CSUC).

Distribution. USA – NC.

Male. Macropterous. Forewing length 13.0 mm. General body color gray green in life, brown in alcohol, with darker brown markings. Dorsum of head with transverse brown band enclosing ocelli, truncate in shape medially, head with darker shading anteriorly and posteriorly (Fig. 39.1). Antennae and scape brown. Pronotum with wide median pale stripe, middorsal pronotal suture narrowly brown; rugosities wide, brown (Fig. 39.1). Meso- and metanota brown with paler markings. Wings pale, veins brown. Legs brown, dorsal surfaces darker. Sterna pale yellow. Sternum 8 with well-developed, broadly rounded vesicle, 2X as wide as long (Fig. 39.2). Terga with darker posterior shading; tergum 9 with bipartite median irregularly shaped dark brown markings, a pale brown medial patch between dark brown patches and a concentrated transverse band of short stout spicules on posterior ⅓; tergum 10 with bipartite, median pale brown inverted triangular markings and lightly sclerotized depressed longitudinal



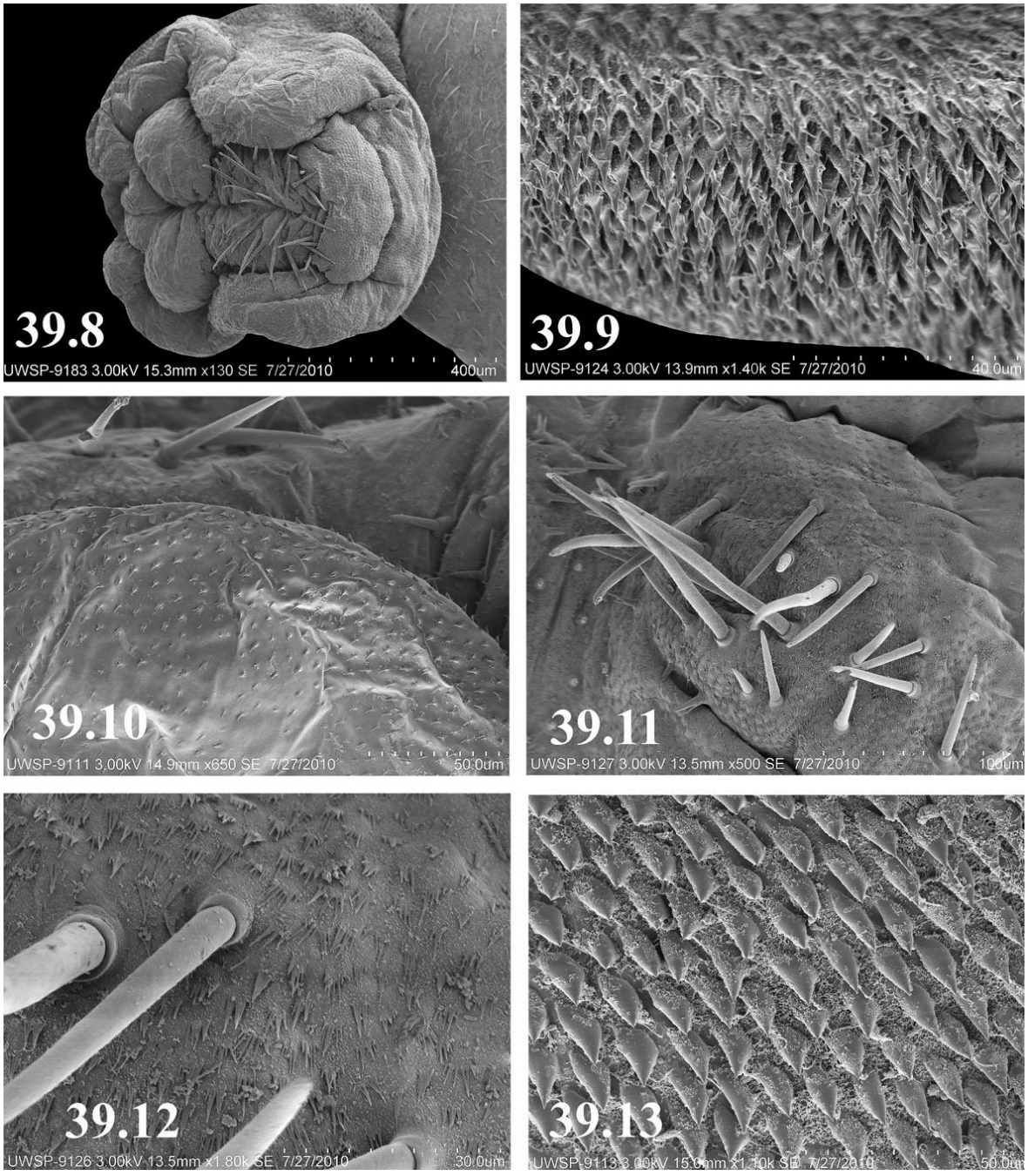
Figs. 39.1-39.5. *Isoperla pauli* sp. n. 39.1. Dorsal head and pronotal pattern. 39.2. Male posterior abdominal sterna. 39.3. Male paraproct lateral view. 39.4. Male posterior abdominal terga. 39.5. Female subgenital plate.



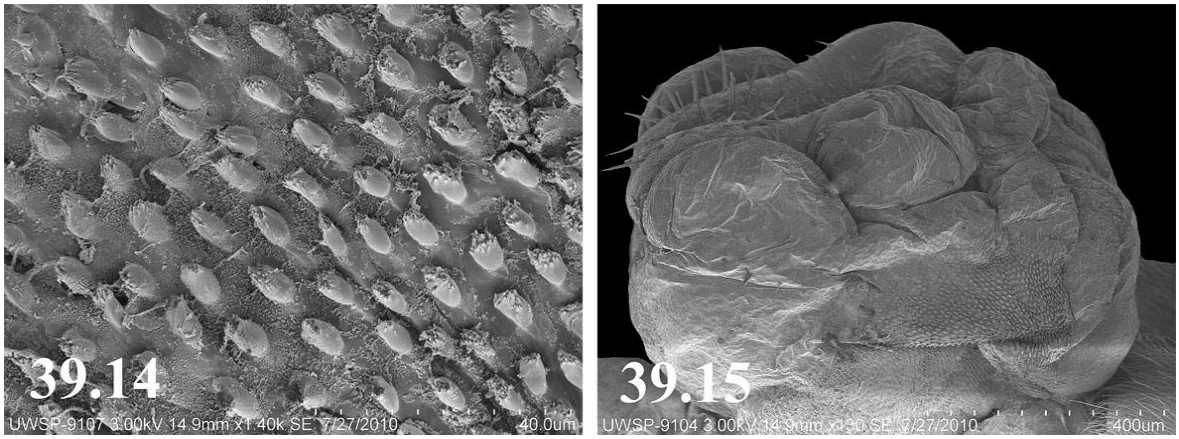
Figs. 39.6-39.7. *Isoperla pauli* sp. n. 39.6. Male aedeagus lateral view; a. paired posteroventral lobes, b. large dense patch of short stout basal spinulae, c. paired posteroventral lobes, d. area with scattered stout sensillae basiconica, e. long stout rust colored spines and scattered smaller spines with socketed bases, f. large mesal patch of dense short stout spinulae, g. large paired hemispherical lobes, h. anteromesal lobe. 39.7. Male aedeagus posterior view; a. rows of fine hair-like spinulae, b. long stout rust colored spines, c. small rust colored spines, d. paired posteroventral lobes, e. scattered rows of fine hair-like spinulae, f. dorsal area with scattered stout sensillae basiconica, g. paired median elongate hemispherical lobes, h. elongate horizontal membranous lobe constricted medially, i. paired dorsal hemispherical lobes.

median band between inverted triangular patches, remainder of tergum pale yellow (Fig. 39.4). Paraprocts long, narrow, dorsally sclerotized and bearing lateral short, ventral setae; tips rounded, incurved medially and deflected ventrally at tips which extend slightly over level of tergum 10 (Figs. 39.2, 39.4). Aedeagus with paired posteroventral rounded lobes (Figs. 39.6c, 39.7d) with ventral patch of dense sharp spinulae (Figs. 39.6b, 39.9); dorsal area of lobes with scattered rows of fine hair-like spinulae (Figs. 39.7e, 39.10); posteromedian section with paired median elongate hemispherical lobes widest dorsally (Figs. 39.7g, 39.8, 39.15); dorsal area with scattered, stout sensilla basiconica (Figs. 39.6d, 39.7f); ventral half with long, stout rust colored spines (Figs. 39.6e, 39.7b, 39.8, 39.11, 39.12, 39.15) and scattered smaller spines with socketed bases (Fig. 39.7c); area near base of spines with rows of fine hair-like spinulae (Figs. 39.7a, 39.12); elongate membranous horizontal lobe distinctively constricted medially above paired elongate hemispherical lobes (Figs. 39.7h, 39.15); a pair of large membranous hemispherical lobes occur dorsally (Figs. 39.6g, 39.7i); basal area bearing a large dense patch of short stout spinulae (Figs. 39.6a, 39.13, 39.15); lateromedian area with a large dense patch of stout blunt spinulae (Figs. 39.6f, 39.14, 39.15), and an anteromesal lobe (Fig. 39.6h).

Female. Macropterous. Forewing length 13.0-15.0 mm. General body color and morphology similar to male. Subgenital plate produced to or beyond sternum 9, broad basally, converging to a rounded



Figs. 39.8-39.13. *Isoperla pauli* sp. n. 39.8. Male aedeagus oblique posterior view. 39.9. Ventral patch of short stout aedeagal spinulae. 39.10. Scattered rows of fine hair-like aedeagal spinulae. 39.11. Long stout rust colored aedeagal spines. 39.12. Basal detail of smaller rust colored aedeagal spines. 39.13. Basal dense patch of short stout aedeagal spinulae.



Figs. 39.14-39.15. *Isoperla pauli* sp. n. 39.14. Dense patch of stout blunt aedeagal spinulae. 39.15. Male aedeagus oblique posterolateral view.

narrow apex, and distally bearing a subapical ribbed pattern (Fig. 39.5).

Ovum. Unknown.

Nymph. Unknown.

Diagnosis. *Isoperla pauli* sp. n. is a member of the *I. pseudosimilis* sp. n. group of five newly described species including *I. pseudosimilis* sp. n., *I. reesi* sp. n., *I. stewarti* sp. n. and *I. yuchi* sp. n. (Table 1). These species are associated with high elevation rheocrenes and small streams of the southern Appalachians. The distinctive paraprocts of the male (Fig. 39.3) and the unusually shaped subgenital plate of the female (Fig. 39.5) distinguishes this species from all other eastern North America *Isoperla* species.

Etymology. The species is named in honor of Austin Paul, a ranger at Mt. Mitchell State Park, who graciously allowed the collectors access to this unique area of North Carolina.

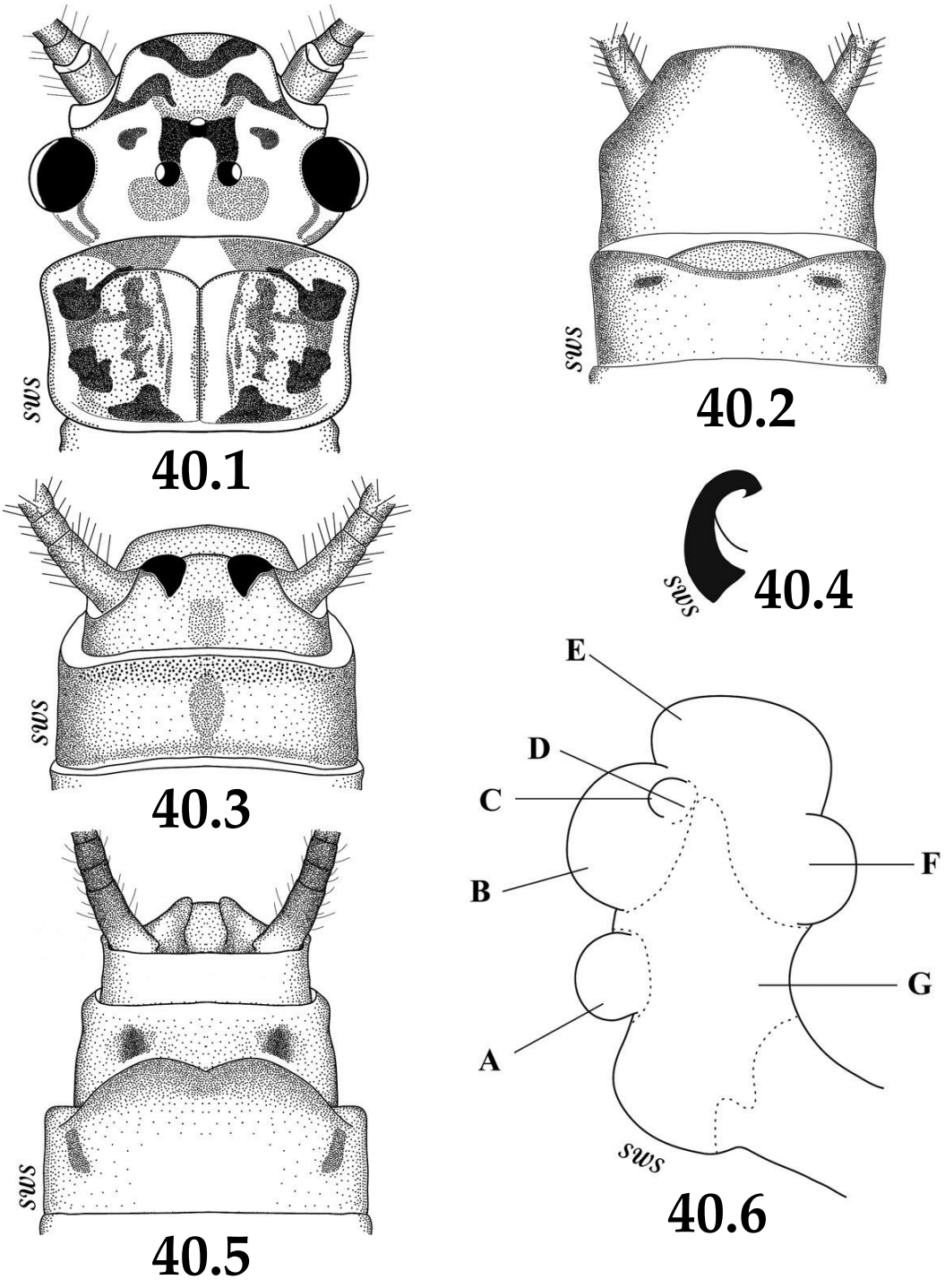
Biological Notes. Adults of *I. pauli* sp. n. were collected from high elevation (>1,800 m) first order drainages including a small stream draining Mt. Mitchell, the highest point east of the Mississippi River. Mt. Mitchell is part of the Black Mountains of the southern Appalachians, which reach an elevation of 2,037 m. It also occurs at several streams draining the higher crests along the Blue Ridge Parkway in North Carolina. Members of this species complex, including *I. pauli* sp. n., are highly restricted in distribution and are considered rare and should be considered as taxa of conservation concern. Adult emergence occurs from mid-May to mid-July.

Isoperla phalerata (Needham)
Rockies Stripetail
(Figs. 1.10, 40.1-40.12)

Dictyogenus? phalerata Needham in Smith 1917, 43:485. Holotype ♀ (CUIC), New Mexico.
Isogenus phaleratus: Ricker, 1952, 19:131.
Isoperla phalerata: Szczytko and Stewart, 1979a, 32:40.
Isoperla phalerata: Huntsman et al., 1999:12.

Eastern Distribution. **USA – SD** (Huntsman et al. 2001).

Additional Records. USA – SD: Custer Co., Custer State Park, Iron Creek, Jct. Rts. 87 & 16A, 22/VI/1993, S. Harris & Cooley, 1♂, 2♀ (BYUC). Lawrence Co., South Fork Rapid Creek, rd. 231, Black Fork Campground, 12/VII/1997, R.W. Baumann, B.C. Kondratieff, 1♂, 5♀ (BYUC); South Fork Rapid Creek, South Fork Campground, 12/VII/1997, R.W. Baumann, B.C. Kondratieff, 2♀ (BYUC). Pennington Co., Spring Creek, Hwy 385,



Figs. 40.1-40.6. *Isoperla phalerata*. 40.1. Dorsal head and pronotal pattern. 40.2. Male posterior abdominal sterna. 40.3. Male posterior abdominal terga. 40.4. Male paraproct lateral view. 40.5. Female subgenital plate. 40.6. Male aedeagus lateral view; a. posteromedian lobe, b. posterodorsal lobe, c. paired posterodorsal mesal lobe, d. patch of stout upturned spinulae, e. dorsal balloon-shaped lobe, f. paired anteromesal lobes, g. large mesal patch of dense short stout spinulae with long filamentous tips.

abv. Sheridan Lake, 15/VI/1993, R.W. Baumann, B. Huntsman, 1♂, 2♀ (BYUC).

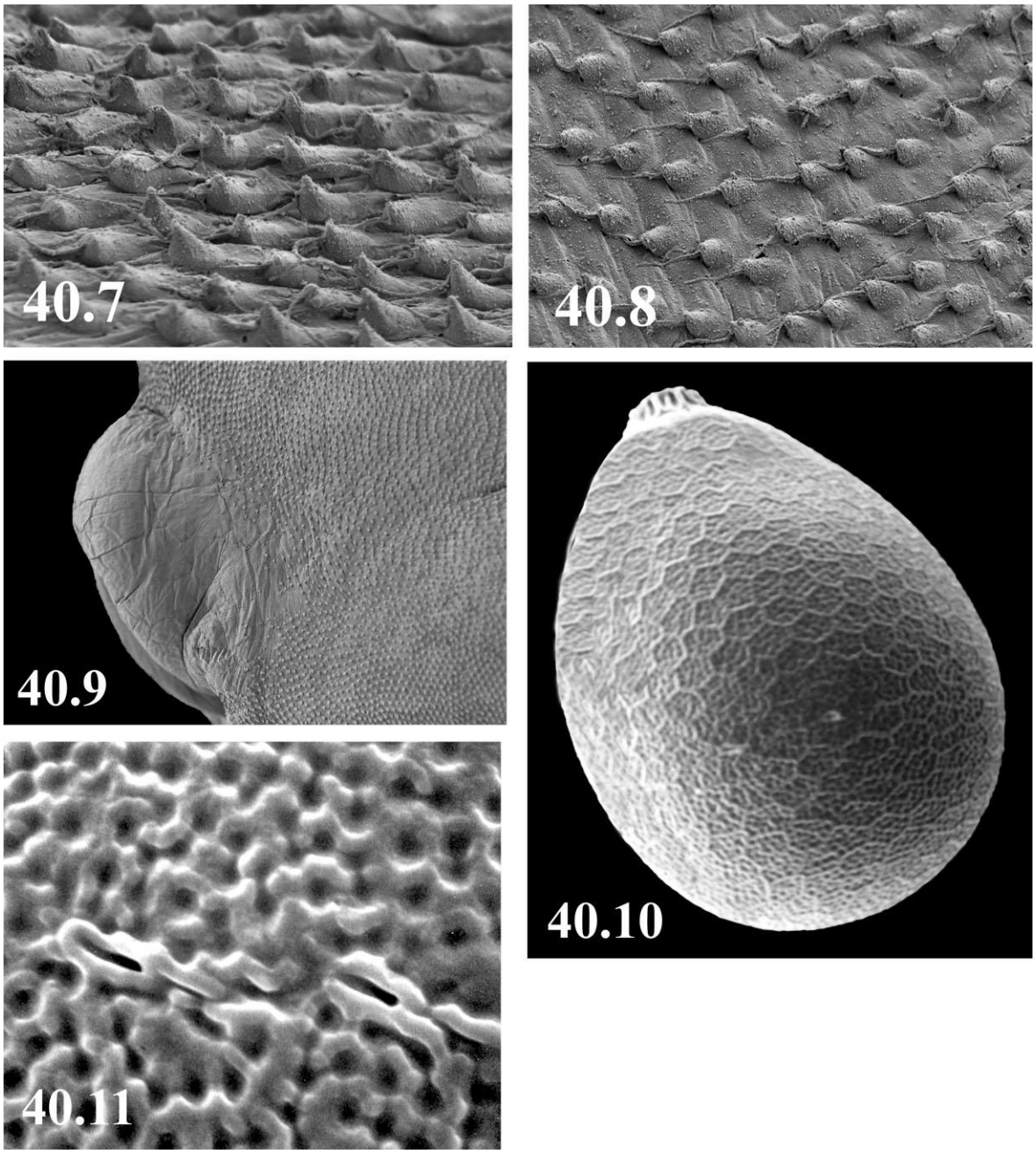
Male. Macropterous. Forewing length 9-11 mm. General body color pale yellow to pale brown with dark brown markings. Dorsal head pattern background pale yellow; dark brown/black N-shaped bands connecting ocelli, truncate near median ocellus; interocellar area pale, open posteriorly; rounded medium brown spots at posterior end of dark brown ocellar bands; small elliptical dark brown spots laterad to median ocellus; dark brown bands extend from base of antennae anteriorly to near frons and extend posteriorly to near median ocellus; frons with a large wide V-shaped dark brown/black median band (Fig. 40.1). Antennal scape pale yellow, pedicel and flagellum medium brown. Pronotum with a median pale stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown/black; pronotal disks pale yellow; anterior margin with broad bipartite medium brown bands; lateral margins pale (Fig. 40.1). Meso- and metasterna pale yellow with medium brown transverse bands. Prosternum with a medium brown median band bifurcated posteriorly. Meso- and metanota dark brown/black; mesonotum with large anterior pale patches with thin dark brown longitudinal median band; metanotum with anteromedian triangular pale area. Wings pale brown with dark brown veins. Legs pale brown; femora with thin medium brown dorsal and ventral bands on outer surface and a wide vertical medium brown band near distal ⅓; tibia with thin medium brown vertical band on outer surface near proximal ⅓; tarsi medium brown. Sterna and terga pale yellow with 3 lateral and 2 median longitudinal rows of small medium brown spots; terga with 2 lateral and one median longitudinal brown bands. Abdominal pleurites with a wide pale band on segments 1-9. Sternum 8 with a low wide medium brown vesicle ca. 4X as wide as long, which extends posteriorly to near anterior margin of sternum 9 (Fig. 40.2). Ninth tergum with posterior row of short stout spinulae and median brown band; tergum 10 with median brown band which extends to near middle of segment (Fig. 40.3). Paraprocts sclerotized, extending over ca. ⅓ length of tergum 10, slightly deflected laterad at tips; tips with a small downward projecting spine (Figs. 40.3, 40.4). Cerci pale brown with thin band at distal margins. Aedeagus with small posteromedian lobe (Fig. 40.6a), a large posterodorsal lobe (Fig. 40.6b), a pair of posterodorsal mesal lobes (Fig. 40.6c.), a large dorsal balloon-shaped lobe (Fig. 40.6e), and paired anteromedian membranous lobes (Fig. 40.6f) devoid of spinulae; spinulae at base of posterodorsal mesal lobes stout and distinctively upturned (Figs. 40.6d, 40.7); mesal area covered with dense, short, stout spinulae with long filamentous tips (Figs. 40.6g, 40.8, 40.9).

Female. Macropterous. Forewing length 11-15 mm. General body color and morphology similar to male described above. Eighth sternum with a large wide, low subgenital plate with median emargination, which extends posteriorly over ⅓ the length of sternum 9; posterior margin usually darker than rest of plate; thin median brown bands near anterolateral ends of plate deflected mesally (Fig. 40.5).

Ovum. Described by Szczytko and Stewart (1979a). General shape oblong, cross section circular. Color pale brown (Fig. 40.10). Length 280 µm; width 200 µm. Collar well-developed, flared apically with elevated longitudinal carinae; base slightly offset from egg body (Figs. 40.10, 40.12). Hexagonal follicle cell impressions visible; floors shallow with numerous shallow pits; eclosion line absent. Micropyles raised with associated low sperm guides; orifices arranged in pairs or threes near anterior pole (Figs. 40.10, 40.11).

Nymph. Described by Szczytko and Stewart (1979a). Stark et al. (1998) and Stewart and Stark (2002) provided a color photograph of the habitus.

Diagnosis. *Isoperla phalerata* is placed with a group of species which includes *I. slossonae* (Table 1) and the western species, *I. pinta* Frison 1937 (Szczytko and Stewart 1979a). *Isoperla phalerata* is most similar to *I. pinta* and is sympatric with it in several western states. These two species are difficult to separate due to similarities and variations in color patterns and thus they have been confused in the literature. The color pattern of the head and pronotum of *Isoperla phalerata* is generally paler



Figs. 40.7-11. *Isoperla phalerata*. 40.7. Spinulae at base of posterodorsal mesal aedeagal lobes with upturned tips. 40.8. Detail of large mesal dense patch of short stout aedeagal spinulae with long filamentous tips. 40.9. Posteromedian aedeagal lobe and mesal patch of spinulae. 40.10. Egg. 40.11. Detail of egg chorion and micropyles.

than that of *I. pinta,* the paraprocts are less recurved and the number of crossveins in the radial sector of the forewings appears to be variable. There are also slight differences in the

spinule pattern of the aedeagus and tergum 9. The ovum of *I. phalerata* has lower thinner chorionic ridges, more uniform chorionic pits and lower micropyles than occur in specimens of *I. pinta*. The eastern North American species, *I. slossonae* is closely related to both of these species, and shares the distinctive contrasting "checker board" pattern of the pronotum, the dark brown vertical band on the femora, a similar aedeagus, a vesicle ca. 3-4X as wide as long, and the di-phasic drumming signal. *Isoperla slossonae* appears to be allopatric in distribution to both *I. phalerata* and *I. pinta*, and can be distinguished in the male by the different aedeagal shape, and in the female by the choronic surface of the ovum lacking distinct hexagonal follicle cell impressions.

Biological Notes. *Isoperla phalerata* emergence occurs from early May to late July in the western part of its range and in mid-June into July in South Dakota. There is no life history or ecological information available for this species.

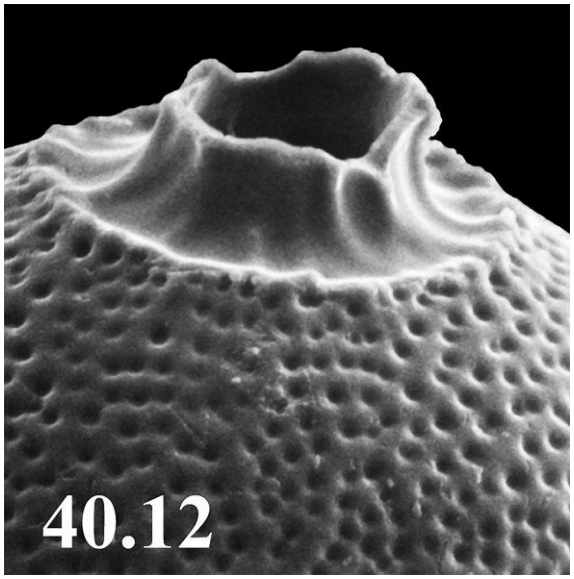


Fig. 40.12. *Isoperla phalerata*. Detail of egg collar.

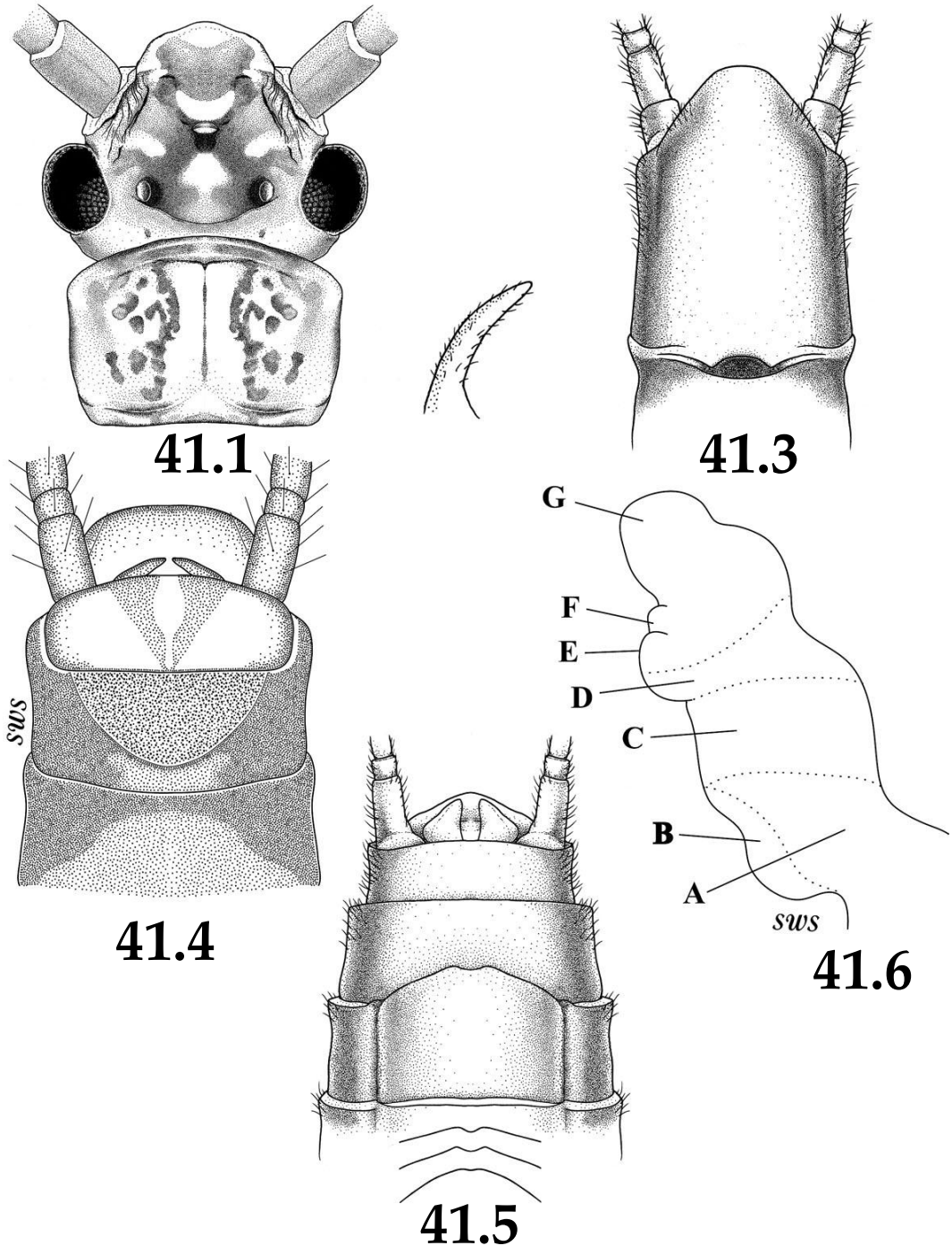
***Isoperla poffi* sp. n.**
Pentagonal Stripetail
(Figs. 41.1-41.16)

Isoperla A, Pescador et al. 2000:76.

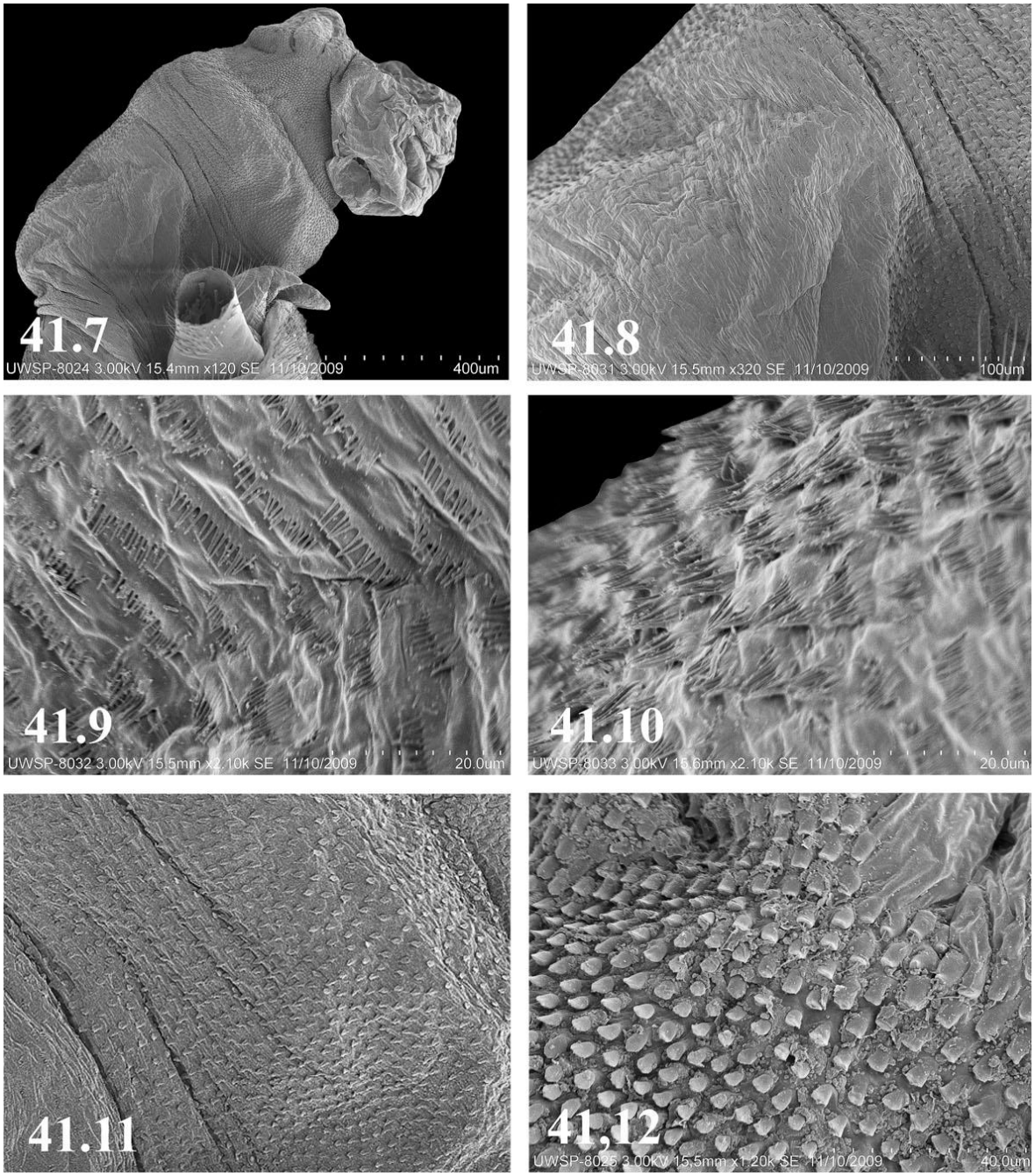
Material Examined. **USA – Holotype** ♂, **North Carolina**: Hoke/Scotland County line, Lumber River, US 401, 1 mi E Wagram, 1/V/2003, B.C. Kondratieff, R.F. Kirchner (USNM). **Paratypes: FL**: Okaloosa Co., Shoal River, Hwy 85, 24/IV/1973, A.R. Gaufin, 3♂, 4♀ (BYUC); Blackwater River at Bryant Bridge, NW of Holt, 2/IV/1971, W.L. Peters, J.G. Peters, 1♂ (FAMU); Same locality, 4/III/1972, 2♀ (FAMU); Same locality, 7/IV/1972, 2♀ (FAMU); Blackwater River, Florida A&M Univ. Biol. Sta., 4.5 mi NW Holt, 18/V/1975, W.L. Peters, J.G. Peters, 1♀ (FAMU); Same locality, 5/III/1976, 3♂ (FAMU); Same locality, 19/III/1977, 1♀; Same locality, 6/V/1977, 1♀ (FAMU); Same locality, 27/III/1986, 1♀; Same locality, 5-6/V/1988, 3♂, 8♀ (FAMU). **NC:** Columbus/Robeson County line, Lumber River, US 74 at Boardman, 3/V/2003, B.C. Kondratieff, R.F. Kirchner, 35♂, 24♀ (CSUC). Hoke/Scotland County line, same data as holotype, 13♂, 38♀ (CSUC). Robeson Co., Lumber River, NC Rte. 904, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 6♂, 8♀ (CSUC); Lumber River, Chicken Road bridge, 2 mi. SE Pembroke, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 14♂, 12♀ (CSUC); Shoe Heel Creek, US 581 bridge, 1 mi. NW Raemon, 2/V/2003, B.C. Kondratieff, R.F. Kirchner, 3♀ (CSUC). **SC**: Aiken Co., Savannah River, River Mile 160, Savannah River Site, 2/I/1985, B.C. Kondratieff, N.L. Poff, 5♂, 5♀; 2 N (CSUC).

Distribution. **USA – Atlantic Coastal Plain of FL, NC, SC.**

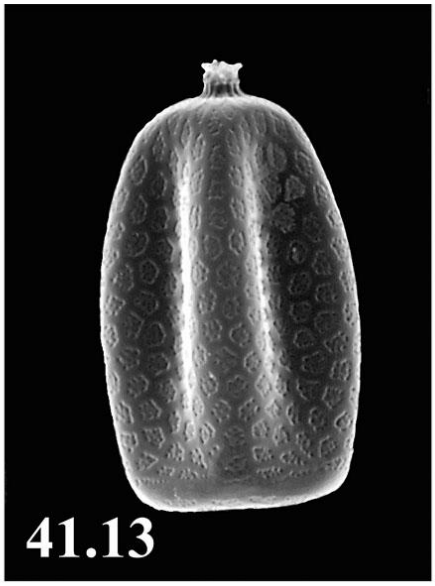
Male. Macropterous. Forewing length 9.0-10.0 mm. General body color brown with darker markings. Dorsum of head with brown to dark brown X-band connecting lateral ocelli to median ocellus; interocellar area pale, usually surrounded posteriorly by brown pigment; thin brown bands extend laterally from edges of X-band; pale round to U-shaped spot usually anterior to median ocellus; frons and clypeus brown; lateral edges of head capsule posterior to compound eye usually brown (Fig. 41.1). Antennae and scape brown. Pronotum with wide median pale stripe, middorsal pronotal suture brown; disks paler with rugosities wide, dark brown (Fig. 41.1). Meso- and metanota brown with paler markings. Wings pale, veins brown. Femur pale brown, tibia and tarsus brown.

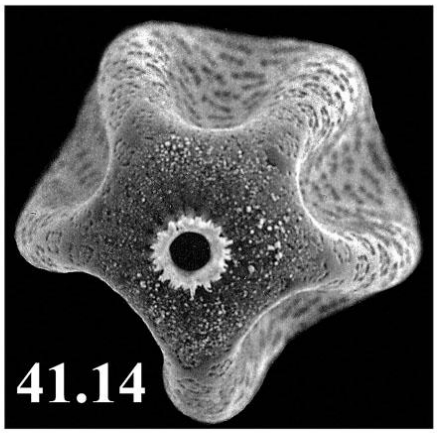


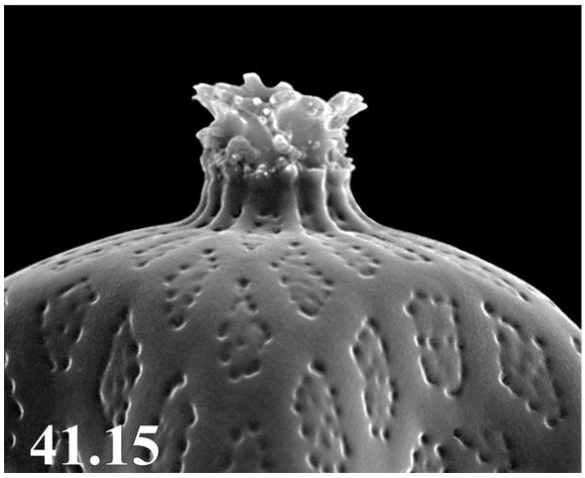
Figs. 41.1-41.6. *Isoperla poffi* sp. n. 41.1. Dorsal head and pronotal pattern. 41.2. Male paraproct lateral view. 41.3. Male posterior abdominal sterna. 41.4. Sterna male posterior abdominal terga. 41.5. Female subgenital plate. 41.6. Male aedeagus lateral view; a. rows of small fine hair-like spinulae, b. posteroventral patch of dense long hair-like spinulae, c. large median patch of short sharp spinulae, d. patch of short, stout blunt spinulae, e. posteromedian lobe, f. small lobe above posteromedian lobe, g. large dorsal lobe.

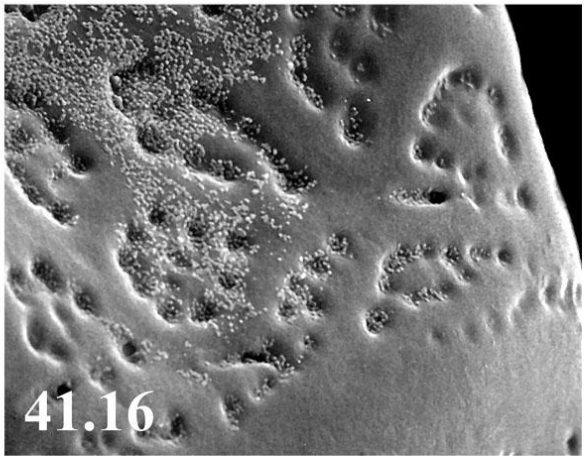


Figs. 41.7-41.12. *Isoperla poffi* sp. n. Male aedeagus lateral view. 41.8. Rows of small fine hair-like spinulae on aedeagal basal stalk. 41.9. Detail of small fine hair-like spinulae on aedeagal basal stalk. 41.10. Posteroventral area with dense rows of long hair-like aedeagal spinulae. 41.11. Median patch of short, stout sharp aedeagal spinulae. 41.12. Detail of short, stout blunt aedeagal spinulae.









Figs. 41.13-41.16. *Isoperla poffi* sp. n. 41.13. Egg. 41.14. Anterior view of egg collar. 41.15. Detail of egg collar lateral view. 41.16. Detail of egg chorion and micropyles.

Sterna paler brown with sternum 10 sometimes pale brown. Sternum 8 with well-developed, broadly rounded vesicle, 2X as wide as long (Fig. 41.3). Terga medium brown, often with darker posterior shading; tergum 9 with depressed pale brown median area with short stout spicules; tergum 10 mostly pale yellow with bipartite medial inverted triangular- shaped pale brown patches; median area between patches depressed and not sclerotized (Fig. 41.4). Paraprocts short, broad at base, dorsally sclerotized and crenulated bearing short setae; tips sharply pointed, sometimes extending barely over level of tergum 10, flattened and tab-like (Figs. 41.2, 41.4). Aedeagus with rows of small fine hair-like spinulae on basal stalk (Figs. 41.6a, 41.7, 41.8, 41.9); posteroventral patch consists of dense long hair-like spinulae (Figs. 41.6b, 41.8, 41.10); large median patch consists of short, sharp spinulae (Figs. 41.6c, 41.7, 41.11); a patch of short, stout, blunt spinulae occurs above median patch of

sharp spinulae (Figs. 41.6d, 41.12); posteromedian lobe (Fig. 41.6e) and small membranous lobe above posteromedian devoid of spinulae (Fig. 41.6f); large dorsal lobe devoid of spinulae (Fig. 41.6g).

Female. Macropterous. Forewing length 11.0-13.0 mm. General body color and morphology similar to male. Subgenital plate produced ⅓ length or less of sternum 9, broadly rounded with posteromedial emargination or broad U-shaped notch; apex sometimes almost truncate with a medial emargination (Fig. 41.5).

Ovum. General shape oblong, cross section pentagonal with 5 distinct longitudinal ridges; anterior end nearly flat (Figs. 41.13, 41.14). Color pale brown. Length 275 µm; width 231 µm. Collar developed, elevated with longitudinal carinae, flared slightly apically; basal area not offset from egg body; anchor crown shaped with numerous lobes (Figs. 41.13, 41.14, 41.15). Hexagonal follicle cell impressions well-developed with wide, thickened ridges; floors shallow with numerous small pits; eclosion line wide, positioned near the egg anterior pole. Micropyles arranged singularly on top of FCI ridges adjacent to eclosion line (Figs. 41.13, 41.16).

Nymph. Unknown.

Etymology. We honor Dr. N. LeRoy Poff, an internationally recognized aquatic ecologist at Colorado State University, with this patronym. Dr. Poff is a friend of the junior author who also assisted in the collection of some of the type material.

Diagnosis. The distinctive shape and spinule pattern of the aedeagus, shape of the female subgenital plate, male paraprocts, and head color pattern of this unassigned species will distinguish *I. poffi* sp. n. from all other eastern *Isoperla* species. The pentagonal egg shape is also distinct among eastern species and only the western Nearctic species, *Cascadoperla trictura* (Hoppe 1938) has an egg with a polygonal cross section (Szczytko and Stewart 1979a), however it is 9 sided. The egg of *I. poffi* sp. n. is most similar in general appearance to that of the Palearctic species, *I. albanica* Aubert, however the egg of that species is quadrangular and does not have a developed eclosion line (Murányi 2010).

Biological Notes. *Isoperla poffi* sp. n. is associated with large Coastal Plain streams that typically have shifting sand substrates and ample submerged woody snag habitats. The emergence period for this species is long, extending from mid-January through early May. The appearance of adults in late January from the Savannah River is the earliest known emergence time of any Eastern *Isoperla* species. The Blackwater River of Florida, considered one of the last pristine sand bottom large streams remaining on the southeastern Coastal Plain, has been well described by Peters and Jones (1973).

Isoperla powhatan sp.n.

Powhatan Stripetail

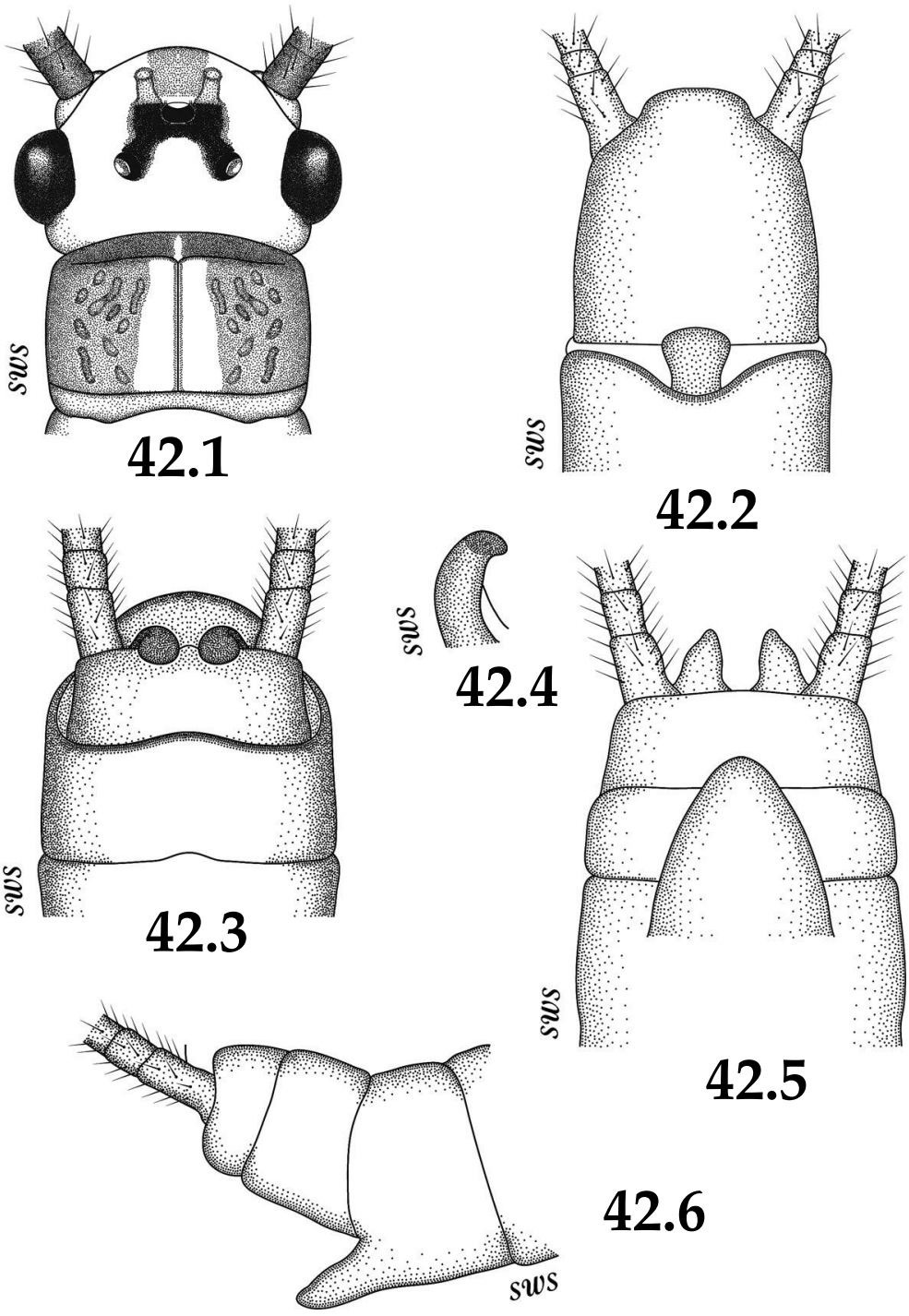
(Figs. 42.1-42.12)

Material Examined. USA – Holotype ♂,Virginia: Prince William Co., Catharpin Creek, Jackson Hollow Campground area, Bull Run Mountain, 38 52.6°N, 77 41.4°W, Malaise Trap 28/VI – 13/VII/2012, D.R. Smith (USNM). **Paratypes: VA:** Same locality as holotype, Malaise Trap #2, 28/VI/-13/VII/2012, 6♂ (USNM); Same locality, Malaise Trap #4 28/VI/-13/VII/2012, 1♂, 3♀ (USNM); Same locality, Malaise Trap #5, 28/VI/-13/VII/2012, 2♂, 3♀ (USNM); Same locality, Malaise Trap #2, 26/V/-11/VI/2012, 1♀ (USNM); Same locality, Malaise Trap #4, 26/V/- 11/VI/2012, 4♂, 1♀ (USNM); Same locality, 28/V/11/-VI/2012, 1♂, 1♀ (USNM); Same locality, 12-27/VI/2012, 10♂, 13♀ (USNM); Same locality, Malaise Trap #1, 8-25/VII/2011, 3♀ (USNM); Same locality, Malaise Trap #3, 26/V/-11/VI/2012, 1♂, 1♀ (USNM); Same locality, Malaise Trap #4, 12-27/VI/2012, 1♂, 5♀ (USNM); Same locality, Malaise Trap #2, 12-27/VI/2012, 5♂, 5♀ (USNM); Same locality, Malaise Trap #5, 12-27/VI/2012, 1♂, 2♀ (USNM).

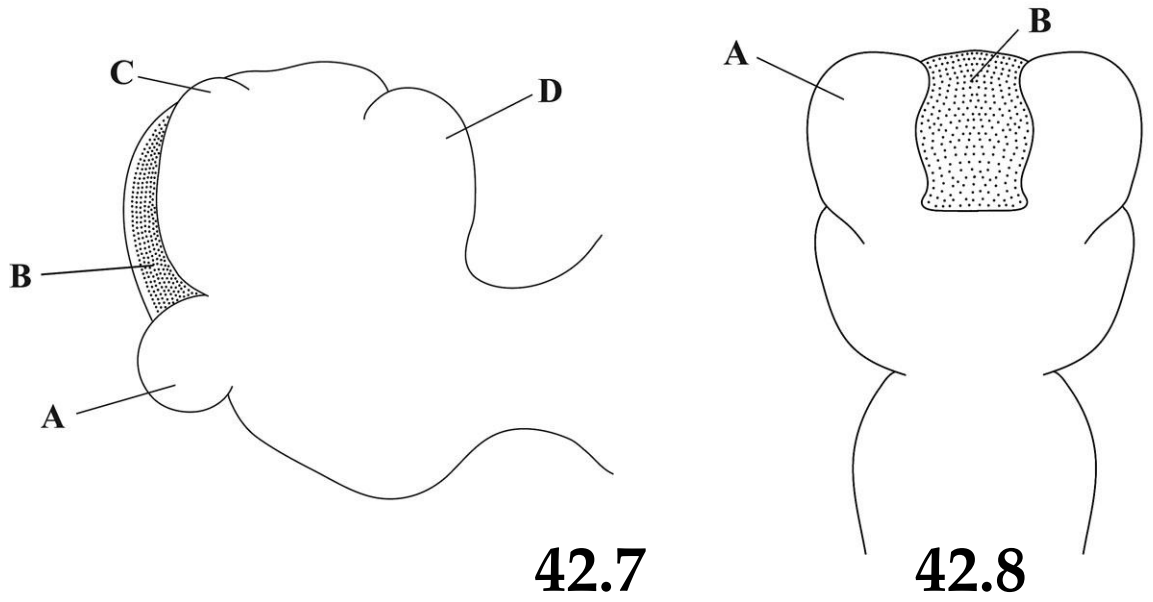
Other Material. USA – PA: Chester Co., East Branch White Clay Creek, 0.6 mi. W London Grove, Stroud Wet Lab, 20/V/1980, D.H. Funk, 1♀ (SRCC).

Distribution. - USA – PA, VA.

Male. Macropterous. Forewing length 7.5-9.3 mm. General body color pale yellow with medium/dark brown markings. Dorsum of head with dark



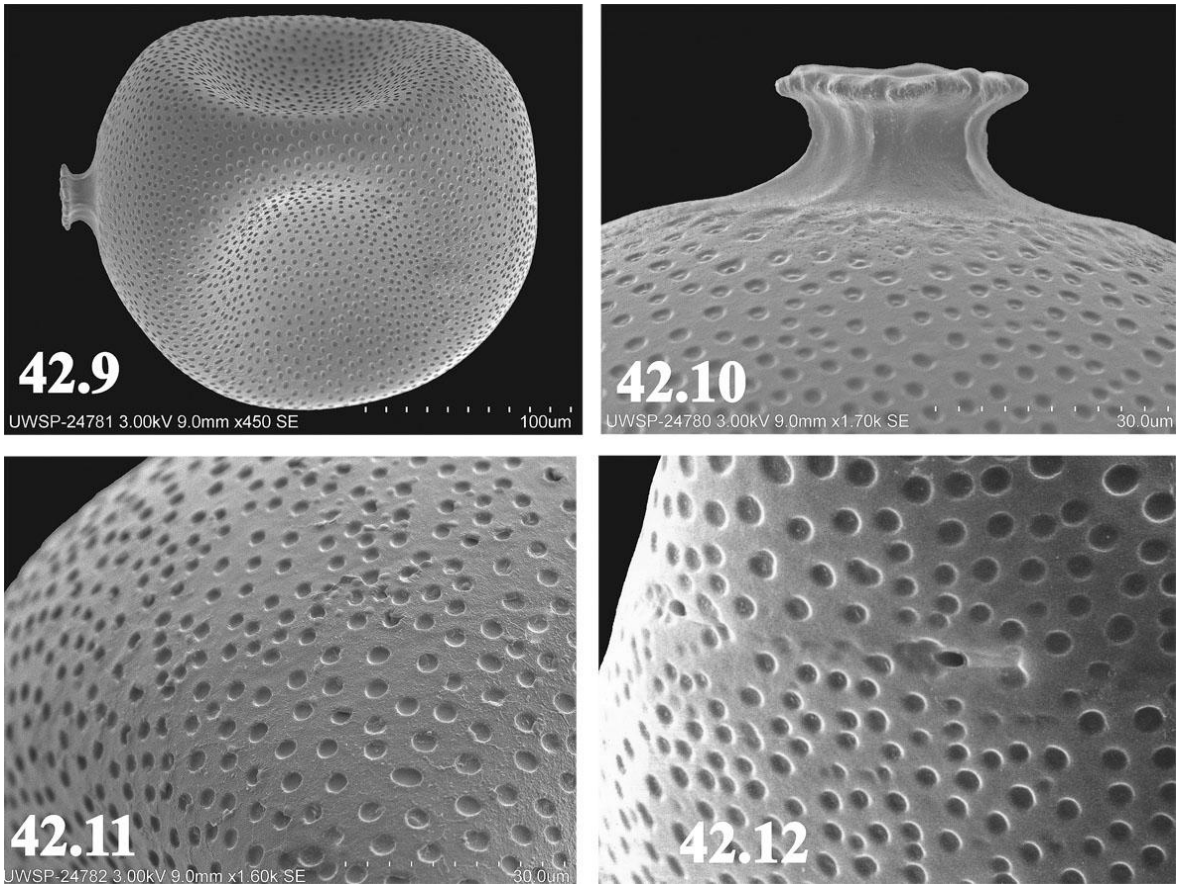
Figs. 42.1-42.6. *Isoperla powhatan* sp. n. 42.1. Dorsal head and pronotal pattern. 42.2. Male abdominal sterna. 42.3. Male posterior abdominal terga. 42.4. Male paraproct lateral view. 42.5. Female subgenital plate. 42.6. Female subgenital plate lateral view.



Figs. 42.7-42.8. *Isoperla powhatan* sp. n. 42.7. Male aedeagus lateral view; a. posteromesal rounded lobes, b. broad band of dense posterodorsal stout sharp golden brown spinulae, c. paired membranous dorsal lobes, d. paired rounded membranous lobes. 42.8. Male aedeagus posterior view; a. paired membranous dorsal lobes, b. broad band of dense stout sharp golden brown spinulae.

brown/black bands connecting ocelli, interocellar area pale; paired pale brown bands extend anteriorly from median ocellus terminating in anterior tubercles; pale brown median patch extends from median ocellus to anterior margin of head; posterior margin of head pale (Fig. 42.1). Antennal scape and pedicel pale yellow, flagellum segments 1-4 pale brown, remaining segments nearly black. Pronotum with a broad, pale median stripe; discs pale brown, rugosities medium brown, irregular shaped, raised; anterior margin medium brown with a thin pale median band; posterior margin pale brown (Fig. 42.1). Meso- and metanota pale yellow; mesonotum with paired anteromedian rounded medium brown patches; remainder of notum with irregular pale brown markings. Wings hyaline, veins medium brown. Femur pale brown with dorsal pale brown longitudinal band; tibia pale brown with vertical dark band near proximal ⅓; tarsi medium brown. Sterna pale yellow; sternum 8 with a well-developed moderately sclerotized vesicle ca. 1.3X long as wide; vesicle slightly darker than rest of segment, expanded posteriorly; thin dark brown band along posterior margin (Fig. 42.2). Terga pale yellow; tergum 9 with a thin posterior dark brown band and slight posteromedian projection, (Fig. 42.3); tergum 10 unmodified, pale yellow (Fig. 42.3). Paraprocts moderately sclerotized, tips flat, broadly rounded apically, paddle-shaped and recurved slightly over tergum 10, (Figs. 42.3, 42.4). Cerci pale yellow. Aedeagus membranous with paired posteromesal rounded lobes (Fig. 42.7a), a broad band of dense posterodorsal stout sharp golden brown spinulae (Figs. 42.7b, 42.8b), a pair of membranous dorsal lobes (Figs. 42.7c, 42.8a) and a pair of anterodorsal rounded membranous lobes (Fig. 42.7d).

Female. Macropterous. Forewing length 9.1-10.0 mm. General body color and external morphology similar to male. Subgenital plate, narrowly triangular, distinctly deflected ventrad (Fig. 42.6), approximately as wide as long; base extends



Figs. 42.9-42.12. *Isoperla powhatan* sp. n. 42.9. Egg. 42.10. Anterior view of egg collar. 42.11. Detail of egg collar lateral view. 42.12. Detail of egg chorion and micropyles.

anteriorly for approximately 0.3 length of sternum 8; base produced posteriorly over approximately ⅓ length of sternum 10 (Fig. 42.5).

Ovum. General shape nearly round, cross section triangular (Fig. 42.9). Color cream, nearly transparent. Length 233 µm; width 165 µm. Collar developed, flared apically; stalk with longitudinal carinae (Figs. 42.9, 42.10). Chorionic surface covered with numerous shallow pits and hexagonal follicle cell impressions; eclosion line absent. Micropyles positioned singularly, nearly flush with chorion near anterior ⅓; short sperm guides present (Figs. 42.11, 42.12).

Nymph. Unknown.

Etymology. We honor the Powhatan Native American confederation of tribes who historically occupied eastern Virginia near the type locality.

Diagnosis. *Isoperla powhatan* sp. n., as a member of the *I. bilineata* group (Table 1), is a small pale yellow species with brown bands connecting the ocelli and forming an inverted V-head pattern. Among the species included in the *I. bilineata* group, the male of *I. powhatan* sp. n. can be distinguished by the presence on the fully everted aedeagus of a broad band of dense posterodorsal stout sharp golden brown spinulae. The female of *I. powhatan* sp. n. is most similar to *I. holochlora* of the *I. signata* group in the shape of the female subgenital plate, but the dorsal head pattern of *I. holochlora* is generally darker than *I. powhatan* sp. n.

and has a broad rectangular dark brown to black patch connecting ocelli and covering the interocellar area (in some specimens this may be pale). The frons usually has a median dark brown band. The subgenital plate is deflected ventrad in *I. powhatan* sp. n. and is flat in *I. holochlora*. In the male, the aedeagus of *I. holochlora* has paired posterodorsal sclerotized spine plates with large stout spines. The aedeagus of *I. powhatan* sp. n. lacks sclerotized spine plates, but has a broad band of dense, posterodorsal stout, sharp golden brown spinulae. This species probably has a wider distribution than available records indicate.

Biological Notes. *Isoperla powhatan* sp. n. emerges from late May through late June. Details of the biology of this species are unknown. Most specimens reported in this study were collected using a Malaise trap. Bull Run Mountain is the most easterly chain in the northern Piedmont region of Virginia and includes unique woodland ecosystems associated with ridges. Several watersheds originate in these mountains.

Isoperla pseudolata sp. n.

Blacktail Stripetail

(Figs. 43.1–43.7)

Material Examined. **USA – Holotype ♂, West Virginia:** Pocahontas Co., East Fork Greenbrier River, Forest rd 51, WV Rte 28, 26/IV/1987, B.C. Kondratieff, R.F. Kirchner (USNM). **Paratypes: NC:** Haywood Co., Cataloochee Creek, Great Smoky Mountain National Park, 20/IV/1985, B.C. Kondratieff, R.F. Kirchner, 1♂, 1♀ (CSUC). **VA:** Giles Co., Little Stony Creek, Route 460, Pembroke, 28/III/1982, emerged 5/IV/1982, B.C. Kondratieff, 1♂ (CSUC). **WV:** Nicholas Co., Panther Creek, WV 39, 6 mi W Richwood, nr. Nettie, 5/III/1983, B.C. Kondratieff, R.F. Kirchner, 1♂, 4♀ (CSUC). Pocahontas Co., Same data as holotype, 1♂, 2♀ (CSUC).

Distribution. **USA – NC, VA, WV.**

Male. Macropterous. Forewing length 11-12 mm. General body color dark brown to black. Dorsum of head yellow but with a large brown central patch and darker bands which connect ocelli; interocellar area pale (occasionally pale brown); posterior margin of ocellar area enclosed by median brown band which connects lateral ocelli; pale M-shaped band anterior to median ocellus thin (Fig. 43.1). Antennae dark brown to black. Pronotum brown to black with wide yellow middorsal stripe; rugosities wide, dark brown (Fig. 43.1). Wings suffused with brown, veins brown. Legs brown. Sterna dark brown, sternum 8 with a large wide, evenly rounded, dark brown vesicle, wider than long; sternum 9 yellow posteriorly (Fig. 43.2). Terga dark brown; tergum 9 with median bipartite inverted triangular medium brown patches with concentrated short stout spinulae; tergum margins dark brown; tergum 10 with inverted triangular pale brown patches bearing short stout spinulae; tergum 10 margins pale brown, remainder of tergum pale (Fig. 43.4). Paraprocts heavily sclerotized, black, long, with acute tips, recurved slightly over tergum 10 (Figs. 43.3, 43.4). Cerci dark brown to black. Aedeagus membranous, basally bulbous and laterally bearing a patch of pale brown spinulae; apically the aedeagal body is constricted and forms a smaller finger-like apical lobe encircled by variable length rows of dense dark brown to golden brown spinulae; apical lobe covered with spinulae to near apex; apex bare and enlarged, but tapered to a small nipple (Figs. 43.6, 43.7).

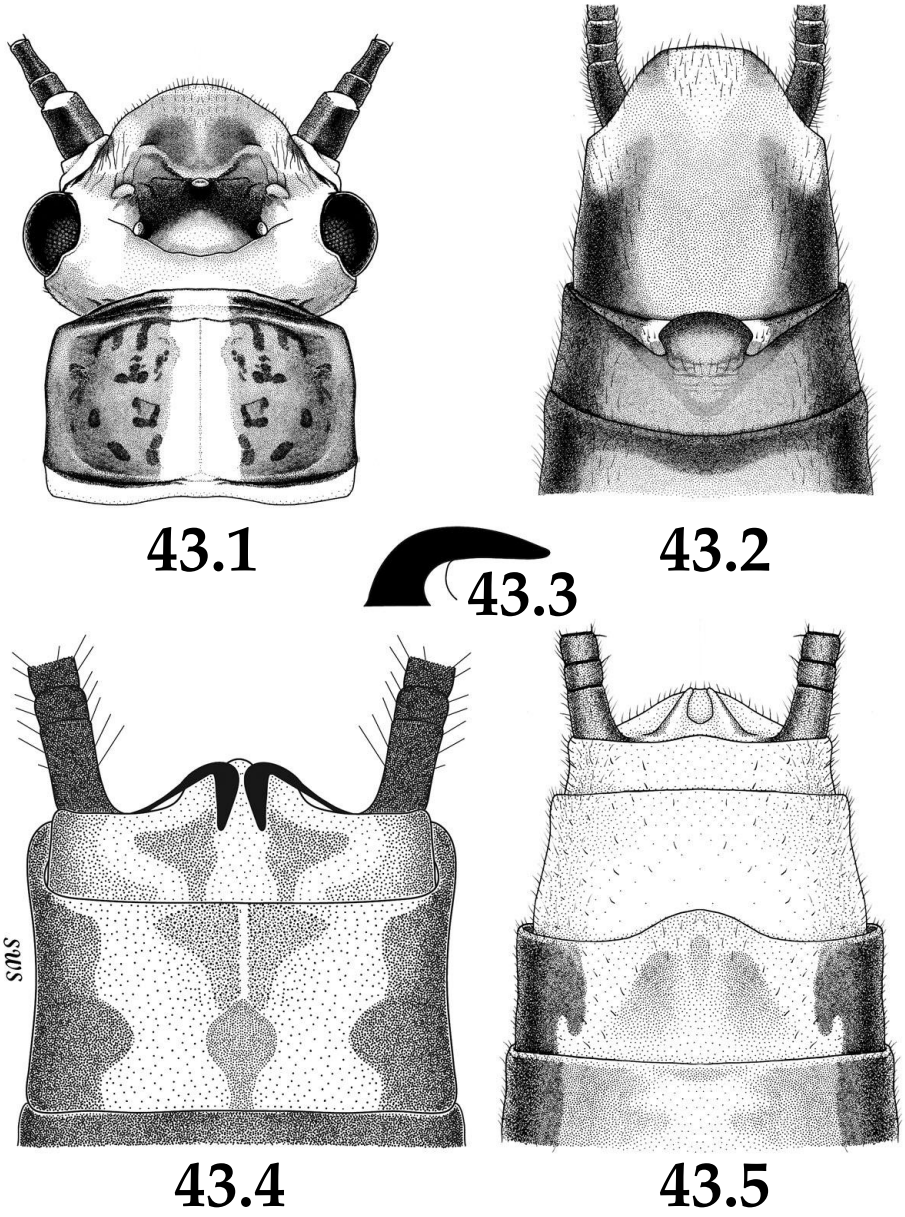
Female. Macropterous. Forewing length 12.0-13.0 mm. General body color and morphology similar to male, ventrally often paler. Subgenital plate, short, base ca. 40% posterior width of 8th sternum; plate broadly rounded and produced slightly over sternum 9 (Fig. 43.5).

Ovum. Unknown.

Nymph. Unknown.

Etymology. The name *pseudolata* sp. n. is proposed because of the close similarity in general habitus and coloration to the sympatric species, *I. lata*.

Diagnosis. The everted aedeagus of *I. pseudolata* is perlid-like, and is especially similar to species of *Acroneuria* in this respect. This character distinguishes the male from other *I. lata* group species, *I. lata* and *I. marlynia* (Table 1). The everted aedeagus of *I. pseudolata* sp. n. has a distinctive apical lobe encircled by variable length rows of dense golden brown spinulae. Additionally, the

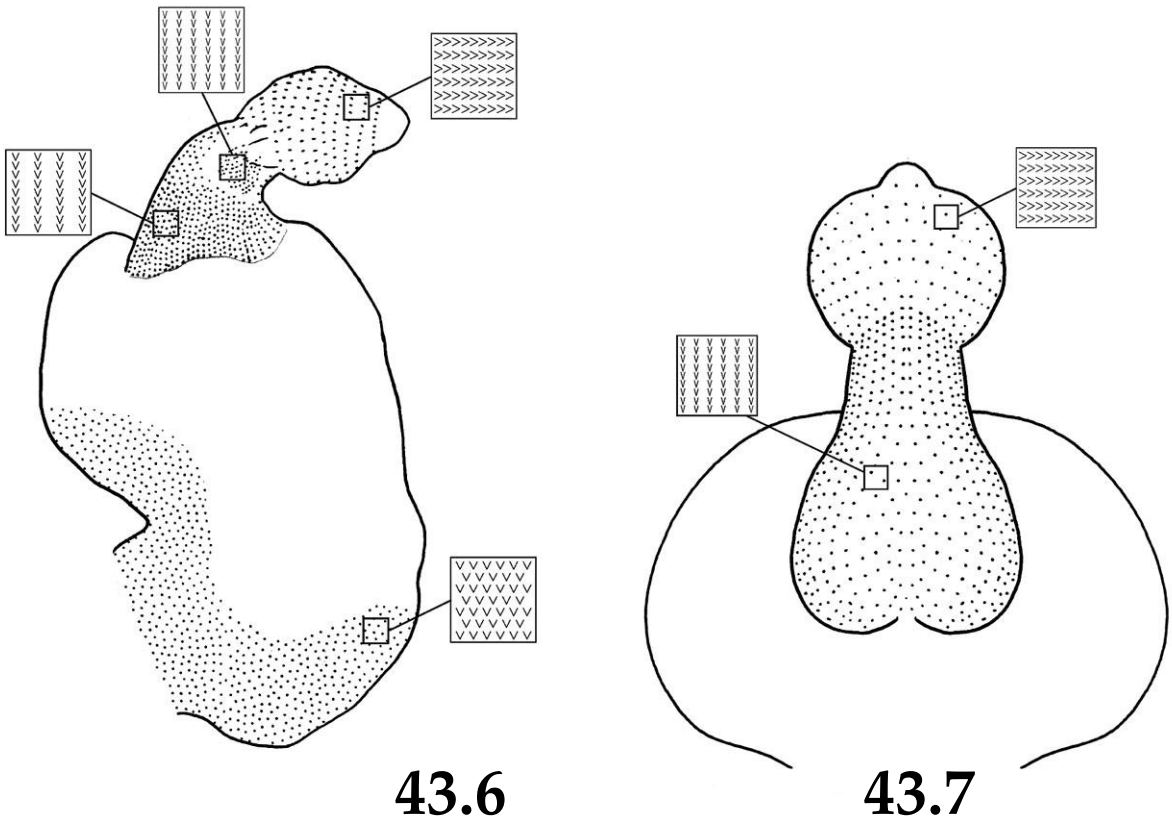


Figs. 43.1-43.5. *Isoperla pseudolata* sp. n. 43.1. Dorsal head and pronotal pattern. 43.2. Male posterior abdominal sterna. 43.3. Male paraproct lateral view. 43.4. Male posterior abdominal terga. 43.5. Female subgenital plate.

large yellow vesicle and nearly black paraprocts that are long and acute at the tips distinguishes the male from *I. lata*. *Isoperla pseudolata* sp. n. is one of the darker colored and larger eastern *Isoperla* species.

Biological Notes. The localities listed above where *I. pseudolata* sp. n. has been collected are relatively pristine, larger, higher gradient Appalachian streams. The emergence period for this species is from March to April. At all known sites, this

species was emerging with the perlodid *Isogenoides hansoni* (Ricker 1952). Nothing is known about the ecology of this species. Interestingly, *I. pseudolata* sp. n. was collected with *I. lata* at the type locality.

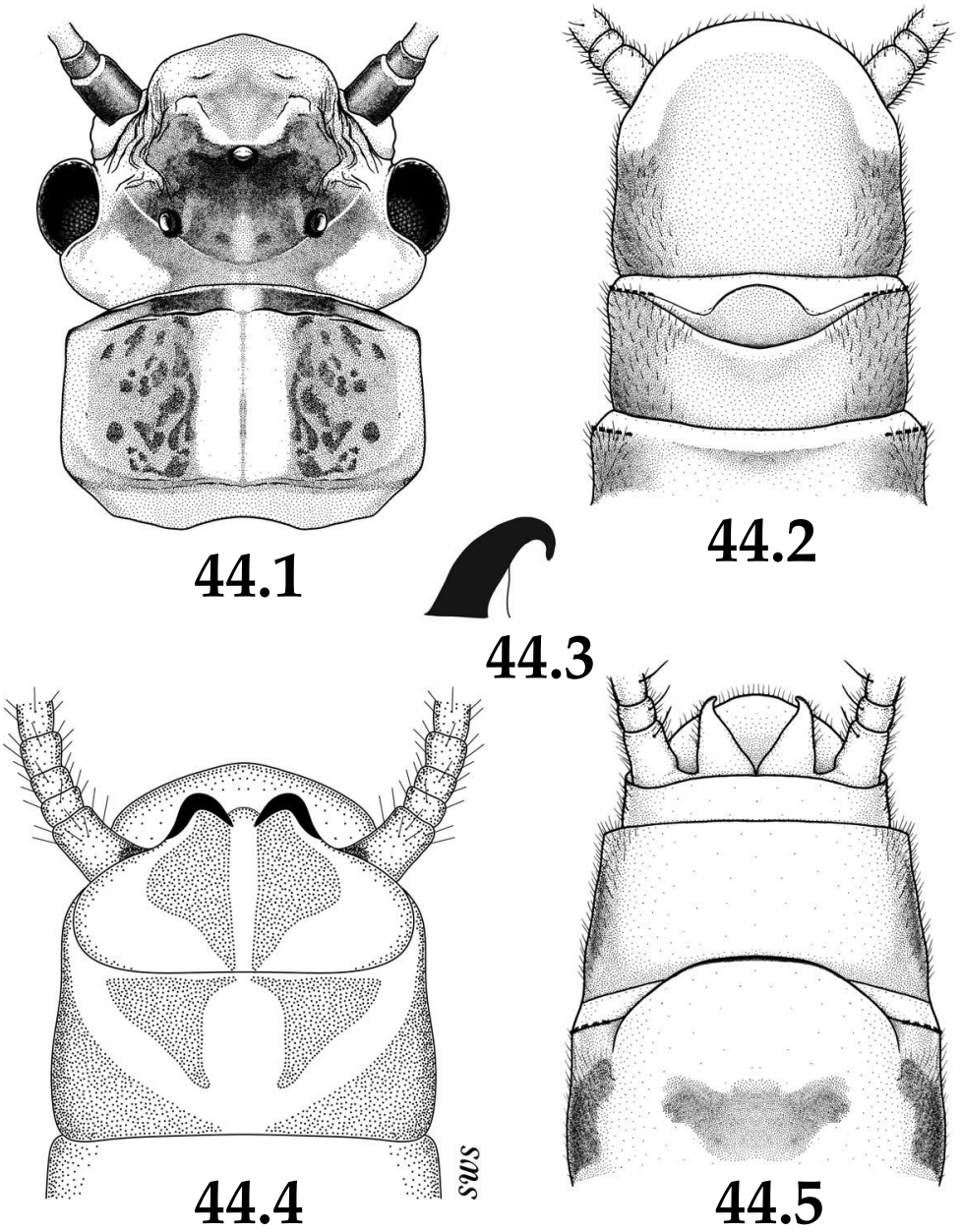


Figs. 43.6-43.7. *Isoperla pseudolata* sp. n. 43.6. Male aedeagus lateral view. 43.7. Male aedeagus posterodorsal view.

***Isoperla pseudosimilis* sp. n.**
Confusing Stripetail
(Figs. 44.1-44.22)

Isoperla similis Frison, 1942, 22:325, in part, not Hagen (1861, 26).

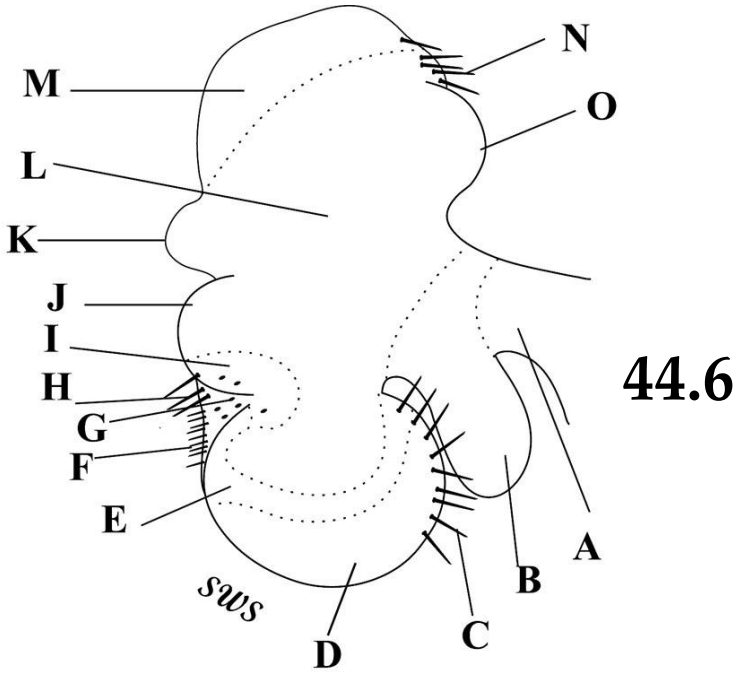
Material Examined. USA – Holotype ♂, New York: Franklin Co., Dutton Brook, Rte. 3, nr. Saranac Lake, 44.2495N 74.2382W, 7/V/2008, L.W. Myers, (USNM). **Paratypes: CT:** New Haven Co., small stream, Sleeping Giant State Park, 25/V/1959, S.W. Hitchcock, 10♀ (USNM). **MA:** Berkshire Co., West Brook, SE Stockbridge, Beartown State Forest, 27/IV/1991, R.W. Baumann, M.F. Whiting, 1♀ (BYUC). Franklin Co., Paradise Trail, Sunderland, 23/IV/1938, L. Bartlett, 2♂ (USNM). **ME:** Somerset Co., East Branch Sandy Stream, Hwy 201, 12/VI/1993, R.W. Baumann, D.S. Potter, 5♀ (BYUC); Trout Book, Hwy 15, abv. Long Lake, 12/VI/1993, R.W. Baumann, D.S. Potter, 1♂ (BYUC); Sandy Stream, US Rte. 201, 2/VI/1993, B.C. Kondratieff, R.W. Baumann, 4♀ (CSUC). **NC:** Macon Co., Stoney Fork, abv. waterfall, FS rd. 63, 13/VI/2008, J.L. Robinson, 1♂ (CSUC). Mitchell Co., trib. Little



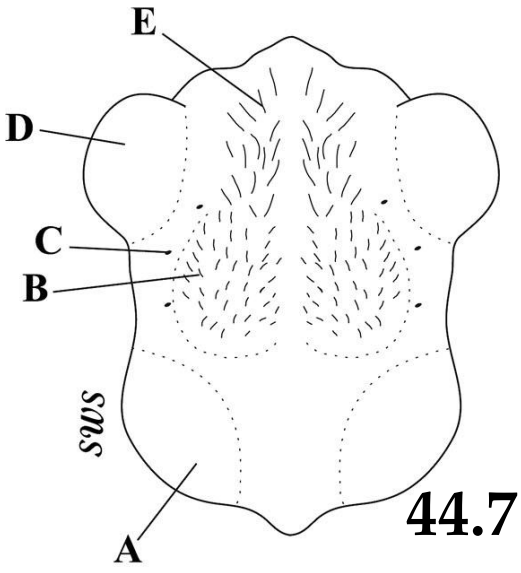
Figs. 44.1-44.5. *Isoperla pseudosimilis* sp. n. 44.1. Dorsal head and pronotal pattern. 44.2. Male posterior abdominal sterna. 44.3. Male paraproct lateral view. 44.4. Male posterior terga. 44.5. Female subgenital plate ventral view.

Figs. 44.6-44.8. *Isoperla pseudosimilis* sp. n. 44.6. Male aedeagus lateral view; a. basal stalk with rows of fine hair-like spinulae, b. elongate posterobasal lobe, c. anterior row of 7-8 stout golden brown spines, d. large paired posteroventral rounded lobes, e. band of short, sharp spinulae, f. variable length stout, honey colored spines with basal sockets, g. patch of elongate sensillae basiconica, h. dorsal row of long stout spines, i. small, shallow plates with numerous fine finger-like projections surrounding sensillae basiconica, j. paired posteromesal lobes, k. small conical lobe above posteromesal lobe, l. dorsomesal area

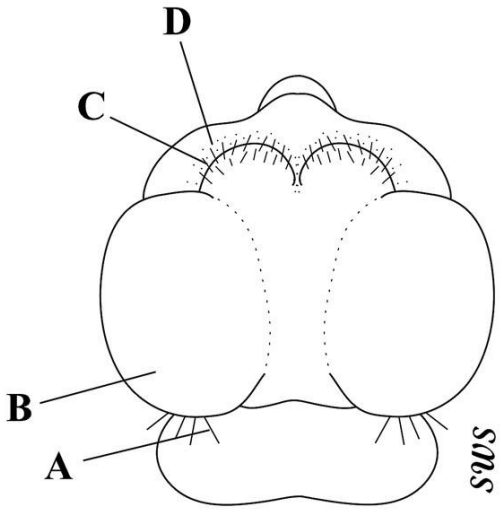
with large concentration of flat scale-like plates, m. paired dorsal lobes, o. anteromesal lobe, n. anterodorsal row of 5-7 long stout, honey colored spines with basal sockets, o. anteromesal lobe. 44.7. Male aedeagus posterior view; a. paired posteroventral lobes, b. mesal patch of variable length stout, honey colored spines with basal sockets, c. small spines with basal sockets, and elongate sensillae basiconica, d. paired dorsal lobes, e. long stout honey colored spines. 44.8. Male aedeagus dorsal view; a. anterodorsal row of 5-7 long stout, honey colored spines with basal sockets, b. paired dorsal lobes, c. long stout honey colored spines, d. patch of variable length stout, honey colored spines with basal sockets.



44.6

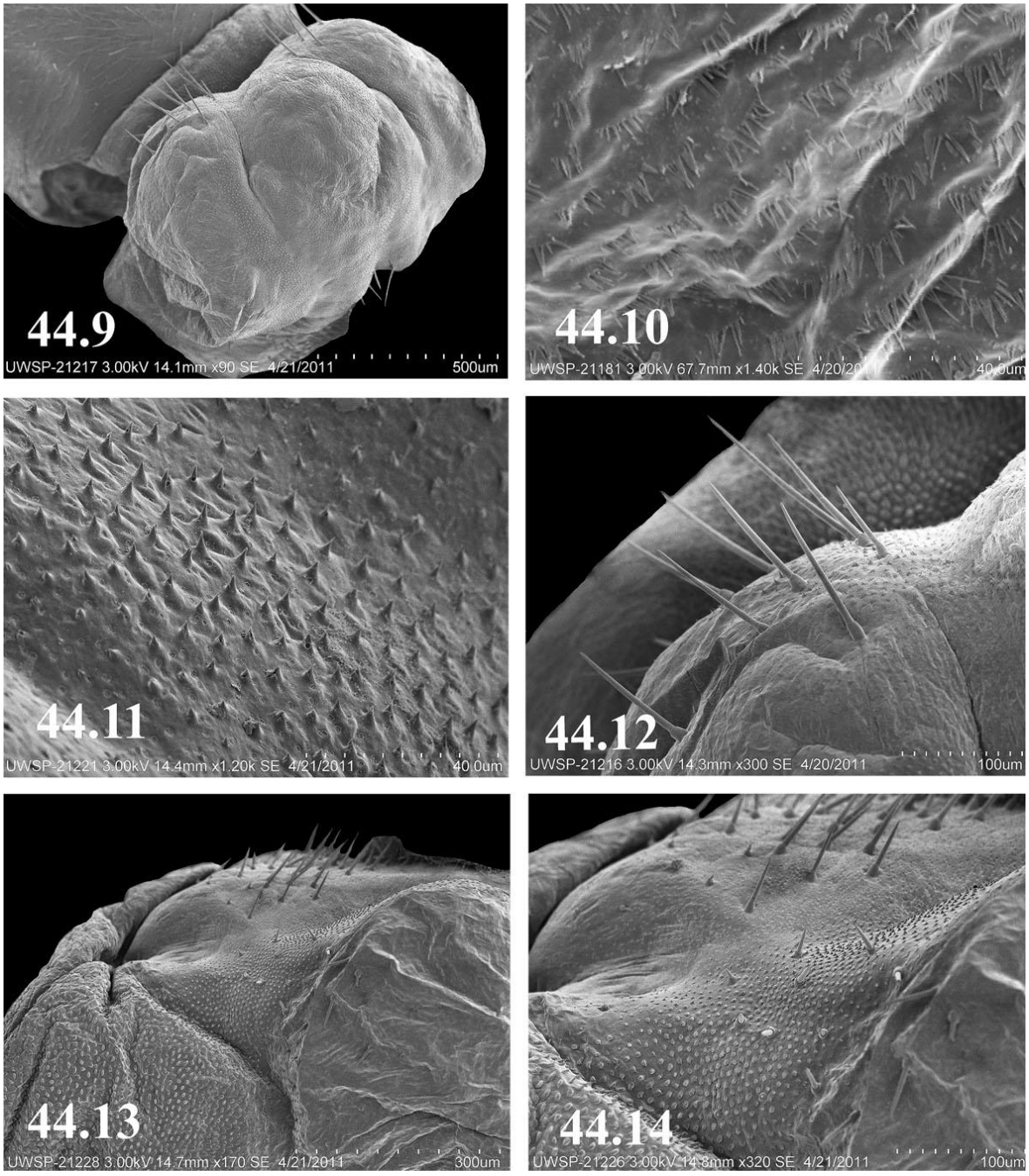


44.7



44.8

Rock Creek, Hwy 261, E. Roan Mountain, 36.10112N, 82.09245W, 14/V/2010, B.C. Kondratieff, R.E. Zuellig, D.R. Lenat, R.F. Kirchner, 20♂, 1♀ (CSUC). Swain Co., Bear Creek, Bear Creek Trail, 1.3 km Poplar Flats Campground, GSMNP, 9/III/2003, D. Etnier, 1♂ (CSUC). Watauga Co.,Boone Fork, CR 151 W Boone Fork, 2/V/2005, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat, 1♂ (CSUC). **NH:** Grafton Co., Hancock Branch, Pemigewasset River, Kancamagus Hwy, 7/IV/1980, R.W. Baumann, S. Earnshaw, 1♂, 1♀ (BYUC). **NJ:** Sussex Co., Little Flat Brook, Hwy 650, SE Milford, 5/V/1991, R.W. Baumann, S. Wells, 2♀ (BYUC). Warren Co., Dunnfield Creek, Hwy I-80, Worthington State Forest, 3/V/1991, R.W. Baumann, S. Wells, 3♂, 3♀ (BYUC). **NY:** Clinton Co., spring, Recore rd., West Chazy, 23/V/2010, L.W. Myers, 2♂, 3♀ (CSUC). Cortland Co., Kenny Brook, N Truxton, 6/V/1991, R.W. Baumann, S. Wells, 1♀ (BYUC). Delaware Co., spring fed trib. Emory Brook, Rte. 28, Fleischmanns, 27/V/2009, L.W. Myers, B.C. Kondratieff, 1♂, 3♀ (CSUC). Essex Co., trib. North Fork Boquet River, Noble Mountain, 9/V/2006, L.W. Myers, 2♂ (CSUC); Ottis Brook, Glen Road, 3/V/2008, emerged, 13/V/2008, L.W. Myers, 1♂, 1♀ (CSUC); Nichols Brook, Shackett rd., 23/V/2008, B.C. Kondratieff, R.W. Baumann, L.W. Myers, 1♀ (CSUC); Dutton Brook, Rte. 3, nr. Saranac Lake, 44.2495N, 74.2382W, 7/V/2008, L.W. Myers, 1♂, 2♀ (CSUC). Greene Co., Stony Clove Creek, Lanesville, 412 m, 4/VI/1978, T.L. McCabe, 1♂ (NYSM); Same locality, 1/VI/1978, 1♂, 1♀ (in copula, NYSM), Same locality, 11/VI/1978, 2♀ (NYSM). Hamilton Co., Dog Creek., trib. Sacandaga River, Hwy 30, 5 mi. S Lake Algonquin, Adirondack Mts., 30/IV/1991, R.W. Baumann, J. Whiting, 1♂ (BYUC); trib. Seventh Lake, Rte. 28, Seventh Lake Mountain, 18/III/2009, emerged 12/IV/2009, L.W. Myers, 2♂, 1♀ (CSUC). Otsego Co., trib. Butternut Creek., Hwy 23, 1 mi. E. Morris, 7/V/1991, R.W. Baumann, S. Wells, 4♂, 4♀ (BYUC). Rensselear Co., Comstock Hollow, jct. Southeast Hollow-Comstock Hollow rds., 19/IV/2009, emerged 20/IV/2009, L.W. Myers, 1♂ (CSUC). Red Pond Brook, below Red Pond, near Berkshire Bird Sanctuary, 28/IV/1991, R.W. Baumann, M.F. Whitting, 4♂, 3♀ (BYUC). Red Pond Brook, below Red Pond, near Berkshire Bird Sanctuary, 28/IV/1991, R.W. Baumann, S. Wells, 4♂, 3♀ (BYUC). Sullivan Co., Fish Cabin Creek, Hwy 97, jct. Delaware River, 4/V/1991, R.W. Baumann, S. Wells, 1♂ (BYUC); Dog Creek, trib. Sacandaga River, Hwy 30, 5 mi. S Lake Algonquin, Adirondack Mountains, R.W. Baumann, M.F. Whiting, 1♂ (BYUC); Main Branch Neversink River, ca. 1 mi. S. Claryville, Rte. 19, 41°54′04″N 74°34′53″W, 16/V/2005, D.H. Funk, 1♂ (DFIC); Same locality, 11/V/2004, D.H. Funk, 1♂ (DFIC). Ulster Co., Esopus Creek, Hwy 47, S. Big Indian Hollow, Catskill Mts., 8/V/1991, R.W. Baumann, S. Wells, 1♂ (BYUC). **PA:** Centre Co., Fillmore, 8/V/1949, S.W. Frost, 1♂, 3♀ (USNM). Chester Co., Spring Creek, Buck Run, 3.5 mi NW Unionville, elev. 300′, 39°55′17″N, 75°47′22″W, 28/III/2007, D.H. Funk, 1♂, 1♀ (DFIC); Same locality, 29/III/2007, D.H. Funk, 1♂, 1♀ (DFIC), Same locality, 16/IV/2007, D.H. Funk, 2♀ (DFIC). Lane Co., Kleinhans Creek, Pawpack Mills, Cypress Lane, 28/V/1996, B.C. Kondratieff, 1♀ (CSUC). Hollow Potter Co, Black Stump Creek, 12/V/1993, L.L. Jackson, 21♂ (DFIC). **TN:** Sevier Co., Greenbrier Cove, GSMNP, 3 mi. abv. Ranger Station, 17/V/1983, B.C. Kondratieff, B.P. Stark, R.F. Kirchner, 1♀ (CSUC); Little Pigeon River, Newfound Gap, 14/V/1939, T.H. Frison, H.H. Ross, 5♂, 1♀ (INHS); Newfound Gap, GSMNP, between pass and chimneys, 11/V/1944, T.H. Frison, H.H. Ross, 2♂, 1♀ (INHS); Twin Creek, ATBI Plot, Malaise trap, GSMNP, 29/III/ -15/IV/1999, C.R. Parker, 9♂, 1♀ (CSUC); Same locality, Malaise Trap 1, 15/IV/ - 26/IV/1999, C.R. Parker, I.C. Stocks, Petersen, 6♂, 1♀ (CSUC); Same locality, 26/III/ - 8/IV/2002, I.C. Stocks, 27♂, 6♀ (CSUC); Goshen Prong, ATBI Plot, Malaise trap, GSMNP, 14/III/ - 15/IV/2003, I.C. Stocks, 27♂, 7♀ (CSUC). **VA:** Giles Co., headwaters Johns Creek, Rte. 632, 5/V/1980, B.C. Kondratieff, 1♀ (CSUC); Little Stony Creek, Rte. 613, 24/VI/1978, B.C. Kondratieff, 1♂, 3♀; Little Stony Creek, small stream nr. entrance to Cascades, 3/IV/1980, B.C. Kondratieff, 2♀ (CSUC); Same locality, 8/IV/1980, B.C. Kondratieff, 1♂, 2♀ (CSUC); White Rocks Branch, White Rocks Campground, 12/V/1981, B.C. Kondratieff, 2♂ (CSUC); Doe Run, Hwy 613, near Mountain Lake,

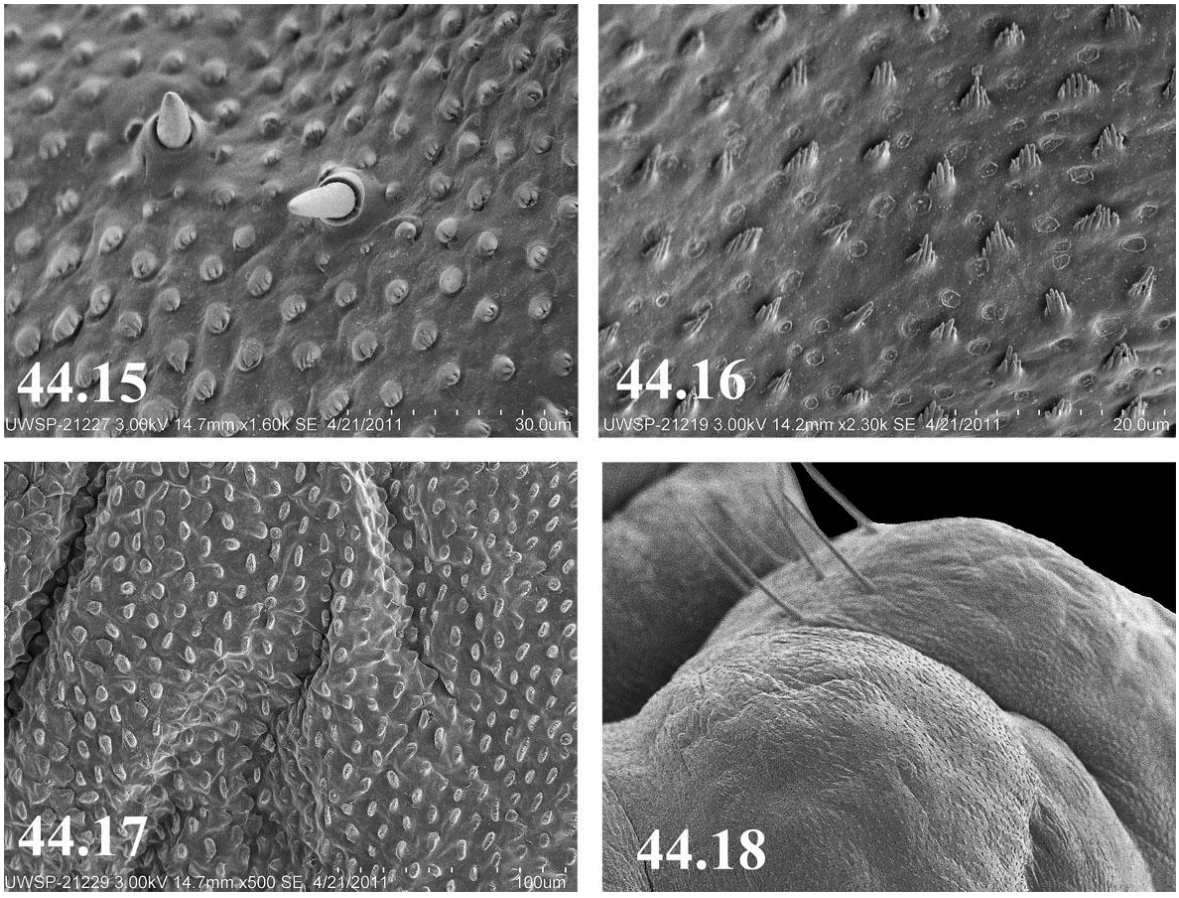


Figs. 44.9-44.14. *Isoperla pseudosimilis* sp. n. 44.9. Male aedeagus lateral view. 44.10. Rows of fine hair-like basal aedeagal spinulae. 44.11. Patch of short stout sharp aedeagal spinulae on posterobasal aedeagal lobe. 44.12. Detail of anteroventral row of long stout honey colored aedeagal spine. 44.13. Patch of variable length stout, honey colored aedeagal spines with basal sockets and sensillae basiconica. 44.14. Detail of variable length stout, honey colored aedeagal spines with basal sockets.

24/V/1990, S.W. Szczytko, R.W. Baumann, B.P. Stark, J. Parham, D. Tanner, 4♂, 1♀ (BYUC); Small spring fed stream, @ entrance to Cascades, Rte. 623, 3/IV/1980, B.C. Kondratieff, 1♀ (CSUC); Same locality, 28/1980, B.C. Kondratieff, 1♂, 2♀ (CSUC). Grayson Co., Fox Creek, Hwy 603, Mt. Rogers Recreation Area, 8 mi. E 600 Jct. 25/V/1990, B.P. Stark, J. Parham, D. Tanner, 2♀ (BPSC); Lewis Fork, Rt. 603, 19/IV/1980, B.C. Kondratieff, 1♂ (CSUC); Same locality, 10/IV/1981 (emerged in lab), B.C. Kondratieff, 1♂ (CSUC); Same locality, 28/III/1981, B.C. Kondratieff, 1♂ (CSUC); Lewis Fork, CR 603 bridge, 4 mi W Troutdale, 21/IV/1979, R.F. Kirchner, 1♂, 1♀ (CSUC). Loudoun Co., Goose Creek, Rt. 621, 15/IV/1973, C.R. Parker, 1♀ (CSUC). Madison Co., Seeps at Big Meadows, 28/V/1984, R.W. Baumann, C.R. Nelson, 1♂ (BYUC). Montgomery Co., Tom's Creek, Glade rd., 13/IV/1978, B.C. Kondratieff, 1♀ (CSUC); Craig Creek, 8 mi. down Rt. 621, 26/V/1978, G.D. Hutton, 1♀ (CSUC). Page Co., Hogcamp Brook, Shenandoah National Park, 22-23/V/1970, O.S. Flint, Jr., 2♂, 2♀ (USNM). Patrick Co., Spring flowing into Rock Castle Creek, Rt. 605, Rte. 8, 14/IV/1979, B.C. Kondratieff, 1♂ (CSUC). Rockbridge Co., Guys Run, 6 km from Maury River, Rte. 39, 19/V/1978, B.C. Kondratieff, 1♀ (CSUC); Nettle Creek @ Yankee Horse Ridge Overlook, Blue Ridge Parkway, 22/V/1990, R.W. Baumann, S.M. Clark, 1♂, 2♀ (BYUC). Smyth Co., East Fork Stoney Creek, 11/V/1986, B.C. Kondratieff, 2♀ (CSUC); Grindstone Camp Creek, 4.5 mi. W Troutdale, 11//V/1975, R.L. Hoffman, 1♀ (CSUC); Grindstone Campground, Mt. Rogers, 12/III/1980 (emerged in lab), B.C. Kondratieff, 1♂ (CSUC); Grindstone Branch, Rte. 603, 18/V/1980, B.C. Kondratieff, 3♀ (CSUC); Same locality, 30/V/1981, B.C. Kondratieff, 1♂ (CSUC); Same locality, 9/V/1981, B.C. Kondratieff, 1♀ (CSUC); Raccoon Branch, South Fork Holston River, Raccoon Branch Campground, 21/V/1984, Paucano, C.R. Nelson, 1♂ (BYUC); St. Clair Creek, Rt. 600, Skulls Cap Campground, 18/V/1990, R.W. Baumann, R.F. Kirchner, 2♀ (BYUC). Tazewell Co., E. Fork Cave Creek, Rt. 662, Rte. 61, 10/VI/1978, B.C. Kondratieff, 1♀ (CSUC); Springs 3,100', Burkes Garden W end, 26/IV/1981, R.L. Hoffman, 5♀ (CSUC); Station Springs Creek, MBC rd., Burkes Garden, 17/V/1994, B.C. Kondratieff, R.F. Kirchner, 1♂, 3♀ (CSUC); Stations Springs Creek, Rt. 623, Moore Brook, 18/V/1979, B.C. Kondratieff, 2♂, 3♀ (CSUC); Same locality, 8/V/1979, B.C. Kondratieff, 1♂, 1♀ (CSUC); Headwaters of Station Spring Creek, MBC Ranch, Burkes Garden, Rt. 666, 8/V/1982, B.C. Kondratieff, 2♀ (CSUC). Washington Co., Straight Branch, near junction Feather Branch, Rt. 58, 19/IV/1980, B.C. Kondratieff, 1♀ (CSUC); Little Moccasin Creek, Rt 690, 15/V/1997, B.P. Stark, R.F. Kirchner, 1♂, 1♀ (CSUC). Wythe Co., E. Fork Stony Creek, 11/V/1986, B.C. Kondratieff, 3♀ (CSUC); Same locality, 12/IV/1975, emerged 14/IV/1975, R.F. Kirchner, 1♂ (CSUC); Same locality, 23/V/1976, 2♀ (CSUC). **VT:** Bennington Co, E. Fork of Goodman Brook of W. Branch of Battenkill, 43°13'47"N, 73°07'11"W, elev. 1,420', 9/VI/1983, A.C. Graham, 1♀ (BYUC), Same locality, 29/IV/1980, A.C. Graham, D.T. Mulvey, 2♂ (BYUC). **WV:** Logan Co., Frogtown Hollow, 25/IV/1976, R.F. Kirchner, 1♂ (CSUC). Pendleton Co., Headwaters Seneca Creek, Judy Springs Trail, 15/V/1990, R.W. Baumann, R.F. Kirchner, 4♂, 4♀ (BYUC). Tucker Co., Fernow Experimental Forest, light trap, 2/VI/1989, ?, 6♂, 4♀ (CSUC); Same locality, 8//VI/1989, 1♀ (CSUC). Pocahontas Co., Charles Creek, FS 102, Cranberry Glades, 10/VI/1979, R.F. Kirchner, C.B. Passmore, 2♂ (CSUC); Hills Creek Scenic Area, Rte. 89, 14/V/1990, B.C. Kondratieff, R.F. Kirchner, J.L. Welch, 3♀ (CSUC); Hills Creek, 15 mi. E Richwood, 15/V/1986, B.C. Kondratieff, 1♂, 2♀ (CSUC); West Branch, abv. North Fork. Cherry River, Rte. 395/55, 17/V/1993, B.C. Kondratieff, R.F. Kirchner, 2♂, 3♀ (CSUC). Randolph Co., headwaters of Gandy Creek, rd. 103, nr. Spruce Knob, 15/V/1990, R.W. Baumann, R.F. Kirchner, 1♂ (BYUC); Big Run of Gandy Creek of Dry Fork, 2/VI/1975, R.F. Kirchner, M. Little, 1♀ (CSUC).

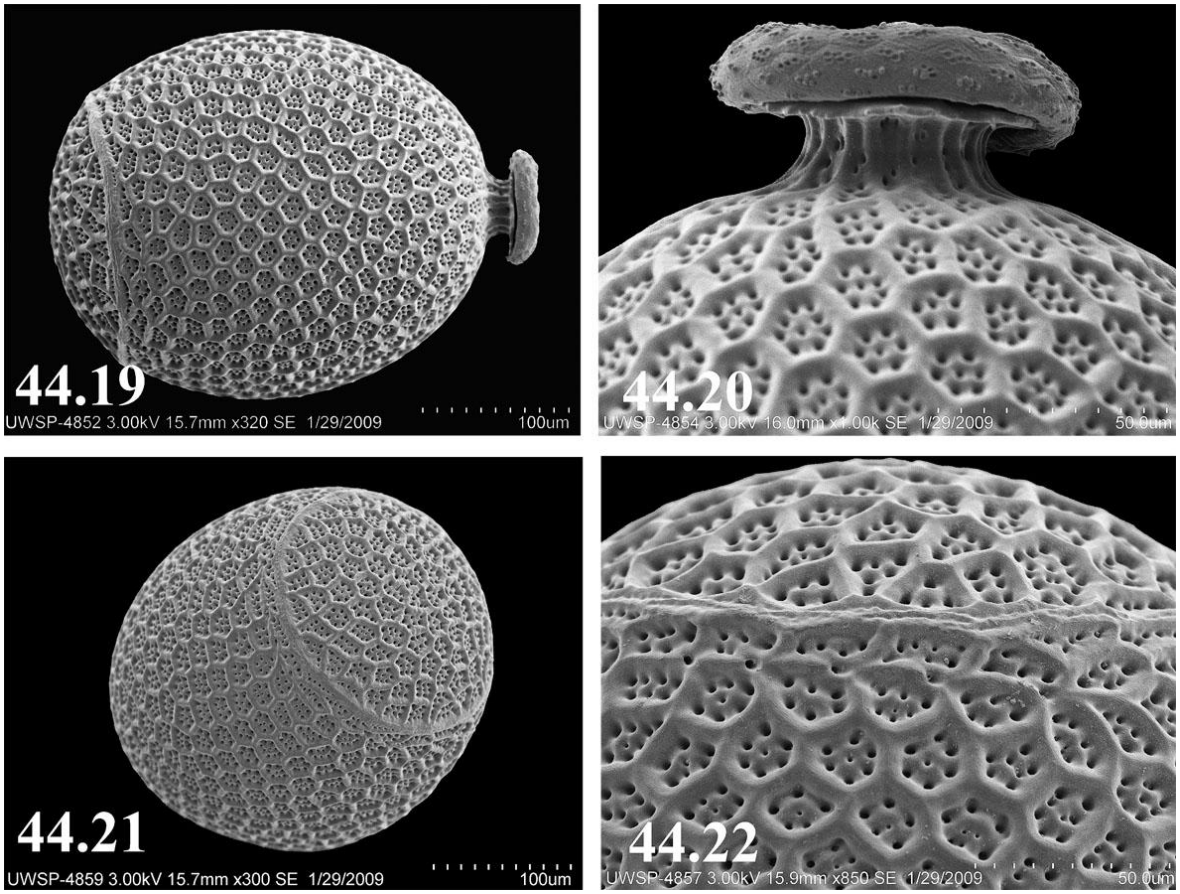
Distribution. **– CT, MA, ME, NC, NH, NY, PA, TN, VA, VT, WV.**

Male. Macropterous. Forewing length 11.0-13.0 mm. General body brown with yellow markings. Dorsum of head with a large brown star-shaped interocellular patch and a pale U-shaped line



Figs. 44.15-44.18. *Isoperla pseudosimilis* sp. n. 44.15. Detail of aedeagal sensillae basiconica. 44.16. Small, shallow plates with numerous fine finger-like projections surrounding aedeagal sensillae basiconica. 44.17. Flat scale-like aedeagal plates. 44.18. Anterodorsal row of 5-7 long stout, honey colored aedeagal spines with basal sockets.

anterior to median ocellus; frons pale brown (Fig. 44.1). Antennae brown. Pronotum brown with wide yellow middorsal stripe, middorsal pronotal suture brown; rugosities wide and dark brown, disks pale brown (Fig. 44.1). Wings pale, veins brown. Legs brown dorsally, yellow ventrally. Mesonotum with large paired anterior medium brown rounded patches; median area of mesonotum bears an irregular medium brown patch, remainder of mesonotum pale yellow. Anterior margin of metanotum mostly medium brown, posterior margin pale yellow. Sterna brown; sternum 8 often tinted with yellow, sternum 9 yellow posteriorly. Sternum 8 with a large wide, evenly rounded, darkly sclerotized vesicle, wider than long (Fig. 44.2). Terga brown, tergum 9 tinted with yellow, tergum 10 usually yellow; terga 9-10 with bipartite submedian pale brown patches; median area depressed (Fig. 44.4). Paraprocts long, thin, erect, sclerotized, acute at tips; tips deflected down, slightly incurved and recurved to level of tergum 10



Figs. 44.19-44.22. *Isoperla pseudosimilis* sp. n. 44.19. Egg. 44.20. Detail of egg collar. 44.22. Egg oblique posterior view. 44.22. Detail of egg chorion and eclosion line.

(Figs. 44.3, 44.4). Cerci pale yellow basally, pale brown apically. Aedeagus with elongate posterobasal lobe (Fig. 44.6b), a large pair of posteroventral rounded lobes (Fig. 44.6d, 44.7a) with anterior row of 7-8 stout golden brown spines (Fig. 44.6c), a pair of posteromesal lobes (Fig. 44.6j), a small conical lobe above posteromesal lobe (Fig. 44.6k), a pair of dorsal lobes (Fig. 44.6m, 44.7d, 44.8b), and an anteromesal lobe (Fig. 44.6o). Basal stalk with rows of fine hair-like spinulae (Figs. 44.6a, 44.10); elongate posterobasal lobe with concentrated patchof short, sharp spinulae extending over basal stalk (Figs. 44.6b, 44.11); large paired posteroventral lobes with anteroventral row of long stout, honey colored spines with basal sockets (Figs. 44.6c, 44.12), and mesal band of short, sharp spinulae (Figs. 44.6e, 44.11); area below paired posteromesal lobes with mesal patch of variable length stout, honey colored spines with basal sockets, dorsal spines longest (Figs. 44.6f, h, 44.7b, e, 44.8c, 44.13, 44.14); smaller spines with basal sockets, and elongate sensilla basiconica (Figs. 44.6g, 44.7c, 44.15) lateral to median long stout spine patch (Figs. 44.6h, 44.7e, 44.9); small, shallow plates with numerous fine finger-like projections surrounding sensilla

basiconica (Figs. 44.6i, 44.16, 44.8d); small conical lobe located above posteromesal lobe and dorsomesal area with large concentration of flat scale-like plates (Figs. 44.6k, l, 44.17); large paired dorsal lobes devoid of spinulae but with anterodorsal row of 5-7 long stout, honey colored spines with basal sockets on each lobe (Figs. 44.6n, 44.3a, b, 44.18); anteromesal lobe devoid of spinulae (Fig. 44.6o).

Female. Macropterous. Forewing length 12.0-13.0 mm. General body color and morphology similar to male, ventrally often paler. Subgenital plate, short, broadly truncate to almost rounded, produced slightly over sternum 9; anterior edge darkly sclerotized (Fig. 44.5).

Ovum. General shape oblong, cross section circular; anterior end nearly circular (Figs. 44.19, 44.22). Color pale brown. Length 318 µm; width 252 µm. Collar well-developed with apically flanged rim and raised longitudinal carinae; base not offset from egg body (Figs. 44.19, 44.20). Hexagonal follicle cell impressions well-developed; ridges elevated, thickened, floors shallow with 5-10 small pits. Micropyles arranged in groups of 3 or 4 on FCI ridges adjacent to eclosion line; eclosion line elevated, thickened and striated (Figs. 44.19, 44.21, 44.22).

Nymph. Unknown.

Etymology. We selected *I. pseudosimilis* sp. n. as the species name because of the confusion in the literature due to the close similarity in general appearance and coloration to *I. similis*.

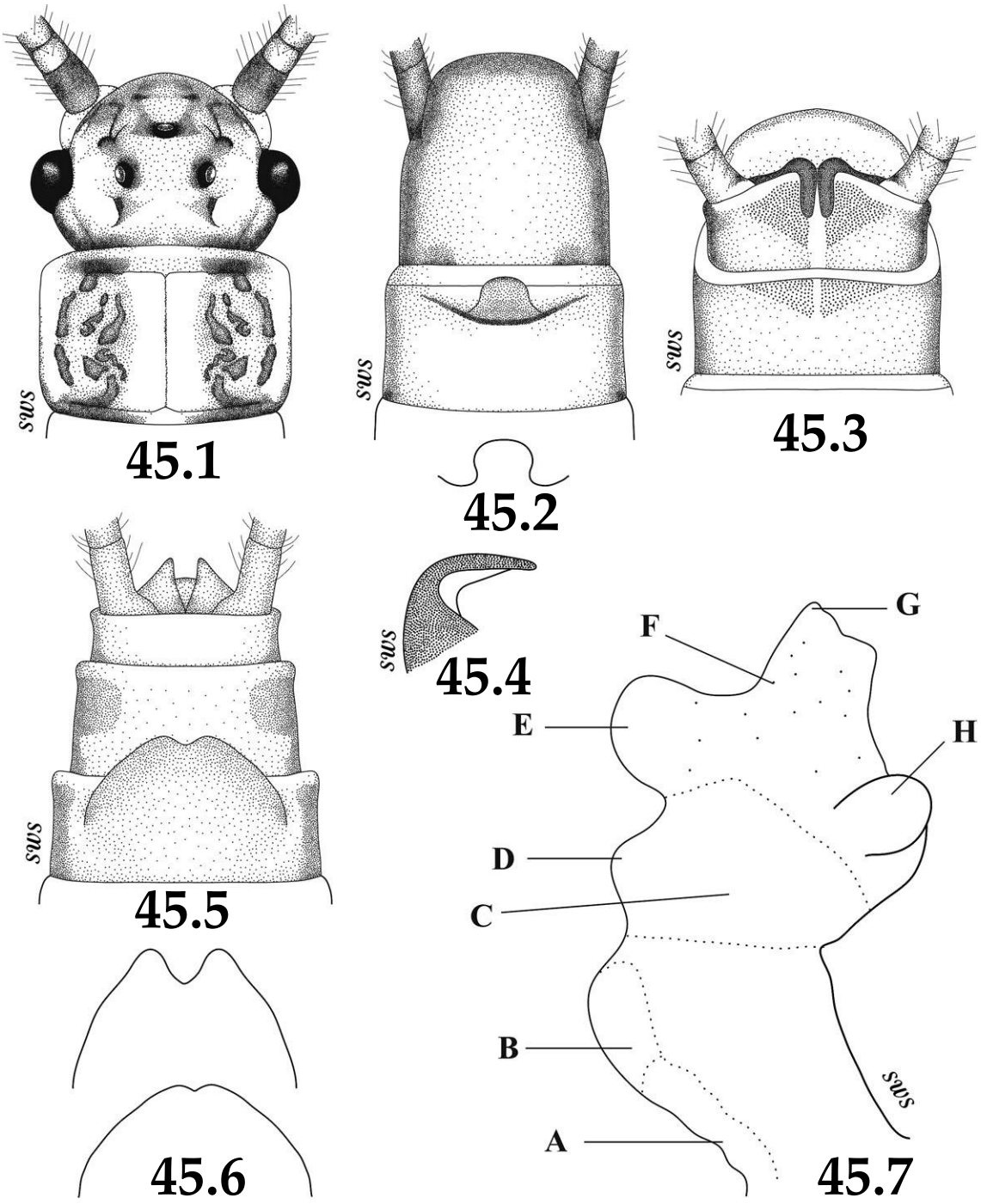
Diagnosis. *Isoperla pseudosimilis* sp. n. is a relatively common and widespread medium size brown Appalachian *Isoperla*. It is included in a group of species in which males have an aedeagus with long, stout straight, golden brown spines, but lack spine bearing plates (Table 1). *Isoperla pseudosimilis* sp. n., however in general habitus and size, is most similar to *I. similis*, a member of the *I. similis* group. It is possibly sympatric with *I. reesi* sp. n. *Isoperla pseudosimilis* sp. n. has a paler color pattern than *I. similis* and has a thin pale W-shaped band anterior to the median ocellus which *I. similis* lacks, and the pronotal disks are also paler. The male sternum nine of *I. similis* is generally uniformly dark brown with a mesal medium brown stripe, whereas sternum nine of *I. pseudosimilis* sp. n. is almost entirely pale yellow with some lateral and anterior darker bands. The paraprocts of *I. pseudosimilis* sp. n. are distinctively bent downward apically, pointed and curved slightly outward and the paraprocts of *I. similis* are straight, nearly erect and blunt apically. The aedeagus of *I. similis* has paired posterolateral sclerotized plates and the aedeagus of *I. pseudosimilis* sp. n. lack these sclerotized structures. The female subgenital plate of *I. similis* is truncate posteriorly with dark brown bands and a pale yellow median, inverted triangular band, whereas the subgenital plate of *I. pseudosimilis* sp. n. is generally pale yellow with a basal irregularly shaped medium brown spot. *Isoperla reesi* sp. n. can be distinguished from *I. pseudosimilis* sp. n. by the arrangement of the large golden brown spines on the aedeagus and the slender and straight paraprocts that are curved almost 90°. The parabolic subgenital plate of *I. reesi* sp. n. has a thickened anterior margin and is darkly pigmented and also lacks the large dark pigment blotch at the base of the subgenital plate which *I. pseudosmilis* sp. n. has. Additionally, the dorsal head pattern of *I. reesi* sp. n. will separate it from both *I. pseudosimilis* sp. n. and *I. similis*. *Isoperla reesi* sp. n. may be restricted to the Mt. Rogers/White Top area of southwestern Virginia. *Isoperla similis* appears to be a species of pristine streams of Piedmont Plateau and Atlantic Coastal Plain.

Biological Notes. The emergence period of *I. pseudosimilis* sp. n. occurs from mid-March until the end of June. There is no information available about the biology or life cycle of this species, despite its frequent abundance in small to medium sized pristine streams of the Applachian Mountains.

Isoperla quinquepunctata (Banks)
Fivespot Stripetail
(Figs. 1.11, 45.1-45.20)

Chloroperla quinquepunctata Banks 1902, 34:124. Holotype ♀ (MCZC) Gallinas River, Las Vegas (San Miguel Co.), New Mexico.

Isoperla extensa Claassen, 1937 69:81. Holotype ♀ (CUIC) Lincoln (Lancaster Co.), Nebraska. **New Synonymy**. Examined.



Figs. 45.1-45.7. *Isoperla quinquepunctata*. 45.1. Dorsal head and pronotal pattern. 45.2. Male posterior abdominal sterna. 45.3. Male posterior terga. 45.4. Male paraproct lateral view. 45.5. Female subgenital plate ventral view. 45.6. Variations in female subgenital plate. 45.7. Male aedeagus lateral view; a. posteroventral patch of long hair-like spinulae, b. posteroventral lobe, c. mesal section with dense short stout spinulae, d. small posteromesal lobe, e. large posterodorsal lobe, f. sparse concentration of sensillae basiconica and flat hair-like spinulae, g. dorsal conical shaped lobe, h. paired small anteromesal lobe.

Isoperla patricia Frison, 1942 22:313. Holotype ♂ (INHS) Spearfish River, Spearfish (Lawrence Co.), South Dakota. Examined. Syn. Szczytko and Stewart 1979a, 32:27.
Isoperla quinquepunctata: Szczytko and Stewart, 1979a, 32:27.

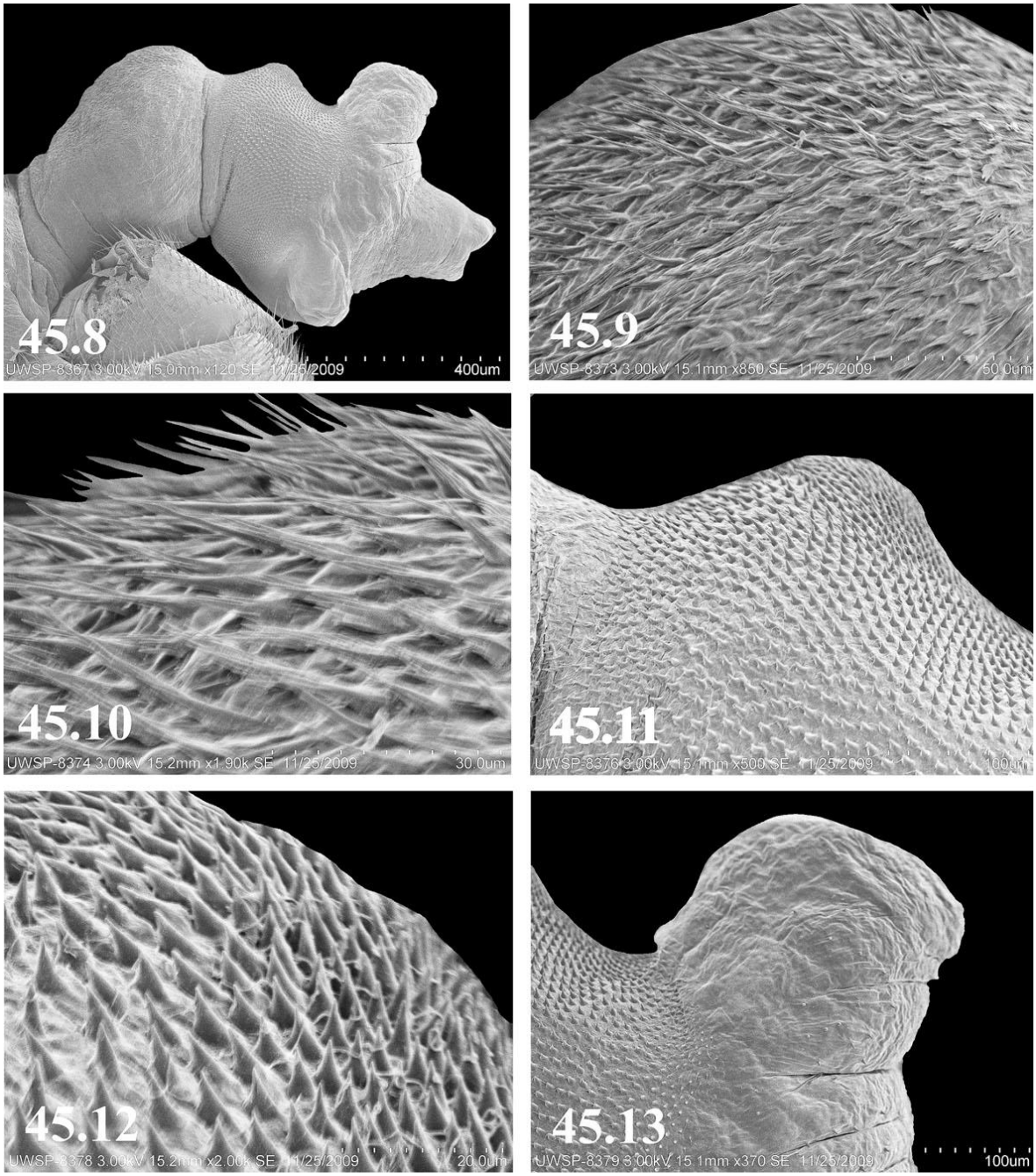
Eastern Distribution. USA **– KS (**Huggins 1981), **NE** (Claassen 1937, Rhodes and Kondratieff 1996), **SD** (Frison 1942, Huntsman et al. 1999, Huntsman et al. 2001).

Additional Records. CANADA **– SK:** Shuard Creek, 11 mi. S Piapot, 23/VII/1975, L. Dosdall, 1♀ (BYUC).

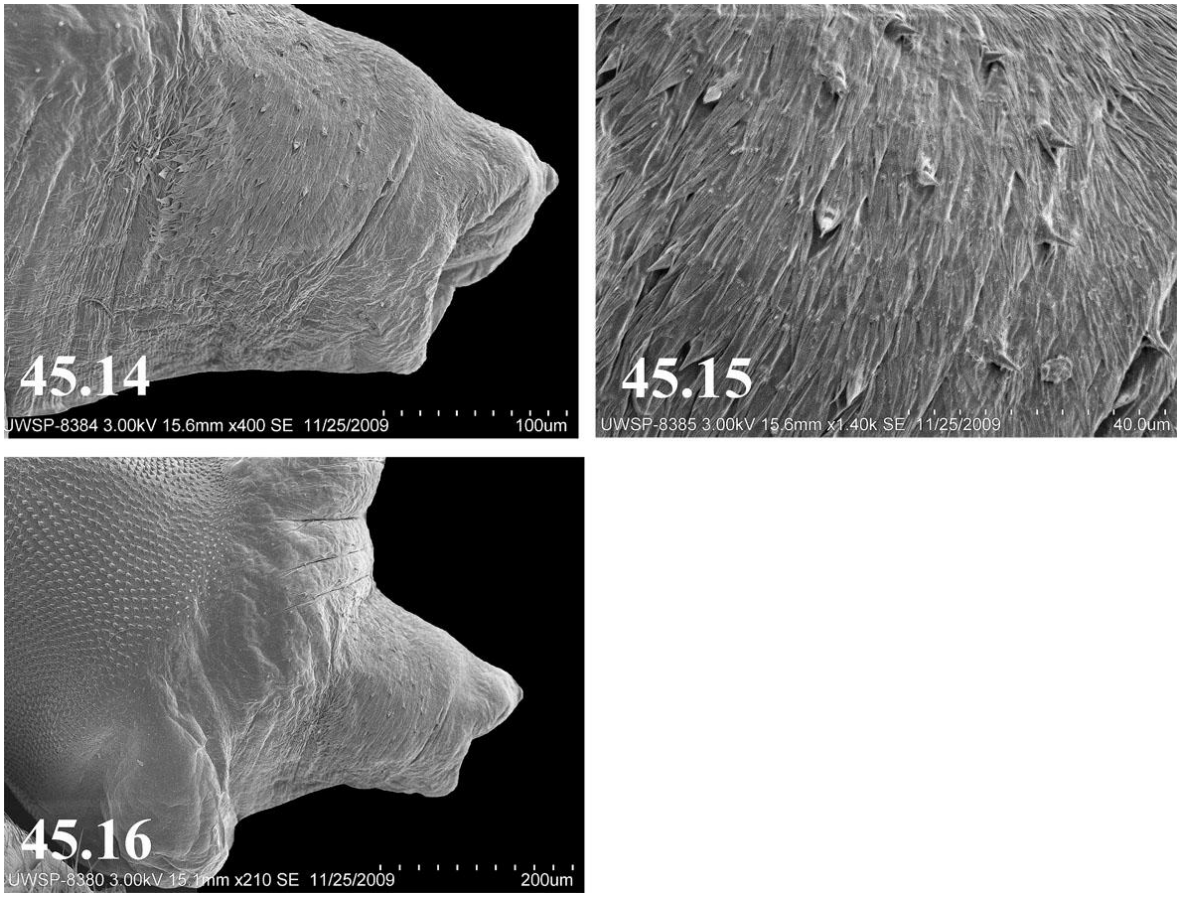
Male. Macropterous/brachypterous. Forewing length 7.0-9.0 mm (macropterous); 3.0-4.0 mm (brachypterous). General body pale brown with dark brown markings. Head pattern variable; dorsal background pale brown/pale yellow, usually with a medium brown transverse band through anterior ocellus (occasionally also with medium brown bands connecting ocelli and extending posteriorly), two dark brown spots posterolateral to median ocellus, interocellar area pale, and usually with two small crescent shaped pale brown spots caudad to posterior ocelli; frons with irregular diffuse light brown markings (Fig. 45.1). Antennal scape light brown, pedicel medium brown; flagellum 1-4 usually light brown, remaining flagellar segments medium brown. Pronotum with a median pale stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks pale brown, anterior margin with short, broad bipartite medium brown bands (Fig. 45.1). Meso- and metasterna pale yellow with pale brown lateral bands. Meso- and metanota dark brown/black; mesonotum with a broad distinctive V-shaped pale yellow area extending across notum; anterolateral corners with large rounded bright yellow raised areas; metanotum mostly dark brown/black with a median inverted medium brown arrowhead-shaped patch. Wings hyaline with medium brown veins. Femora and tibia pale yellow; femora with thin dark brown medial band on outer surface; tibia with incomplete thin dark brown medial band and thin vertical medium brown band near proximal 1/5 on outer surface; tarsi medium brown. Sterna pale yellow, sternum 8 with a thin incomplete dark brown posterior band; vesicle well-developed medium brown, slightly wider than long (occasionally constricted near base, posterior margin evenly rounded, extending posteriorly to near anterior margin of sternum 9 (Fig. 45.2). Terga 1-8 bright red in fresh specimens, segments 1-5 usually with faint brown median band, terga 9-10 pale brown; tergum 9 with posteromedian bipartite patches of stout spinulae and incomplete shallow median unsclerotized furrow; tergum 10 darker with complete median unsclerotized furrow and posteromedian triangular bipartite patches of stout spinulae, (Fig. 45.3). Paraprocts sclerotized, long, recurved over ¼ length of tergum 10, meeting medially, slightly deflected outward apically with tips bluntly pointed (Figs. 45.3, 45.4). Cerci pale yellow, medium brown band on distal end of each segment. Aedeagus with posteroventral patch of long hair-like spinulae (Figs. 45.7a, 45.8, 45.9); posteroventral lobe covered with longer stouter spinulae (Figs. 45.7b, 45.8, 45.10); small posteromesal lobe and mesal section with dense short stout spinulae (Figs. 45.7c,d, 45.8, 45.11, 45.12); large posterodorsal lobe devoid of spinulae (Figs. 45.7e, 45.13); dorsal conical shaped lobe with sparse concentration of sensilla basiconica and flat hair-like spinulae (Figs. 45.7f,g, 45.14, 45.15); paired small anteromesal lobes devoid of spinulae (Figs. 45.7h, 45.16).

Female. Forewing length 9.0-11.0 mm. General body color and morphology similar to male described above except abdomen not red in life. Eighth sternum with a broadly triangular subgenital plate extending posteriorly over ⅓ length of sternum 9; plate usually darker than rest of segment (occasionally entirely medium brown) with a posteromedian emargination (emargination varies from shallow to deep within a population) (Figs. 45.5, 45.6).

Ovum. General shape oblong, cross section posterior ½ triangular, anterior ½ round, (Fig. 45.17). Color pale brown. Length 240 µm; width 190 µm. Collar well-developed, flared apically with thick elevated longitudinal ridges, base not offset from egg body (Figs. 45.17-45.19). Hexagonal



Figs. 45.8-45.13. *Isoperla quinquepunctata*. 45.8. Male aedeagus lateral view. 45.9. Posteroventral patch of long hair-like aedeagal spinulae. 45.10. Long stout spinulae on posteroventral aedeagal lobe. 45.11. Small posteromesal aedeagal lobe. 45.12. Large mesal patch of dense short, stout aedeagal spinulae. 45.13. Large posterodorsal aedeagal lobe.

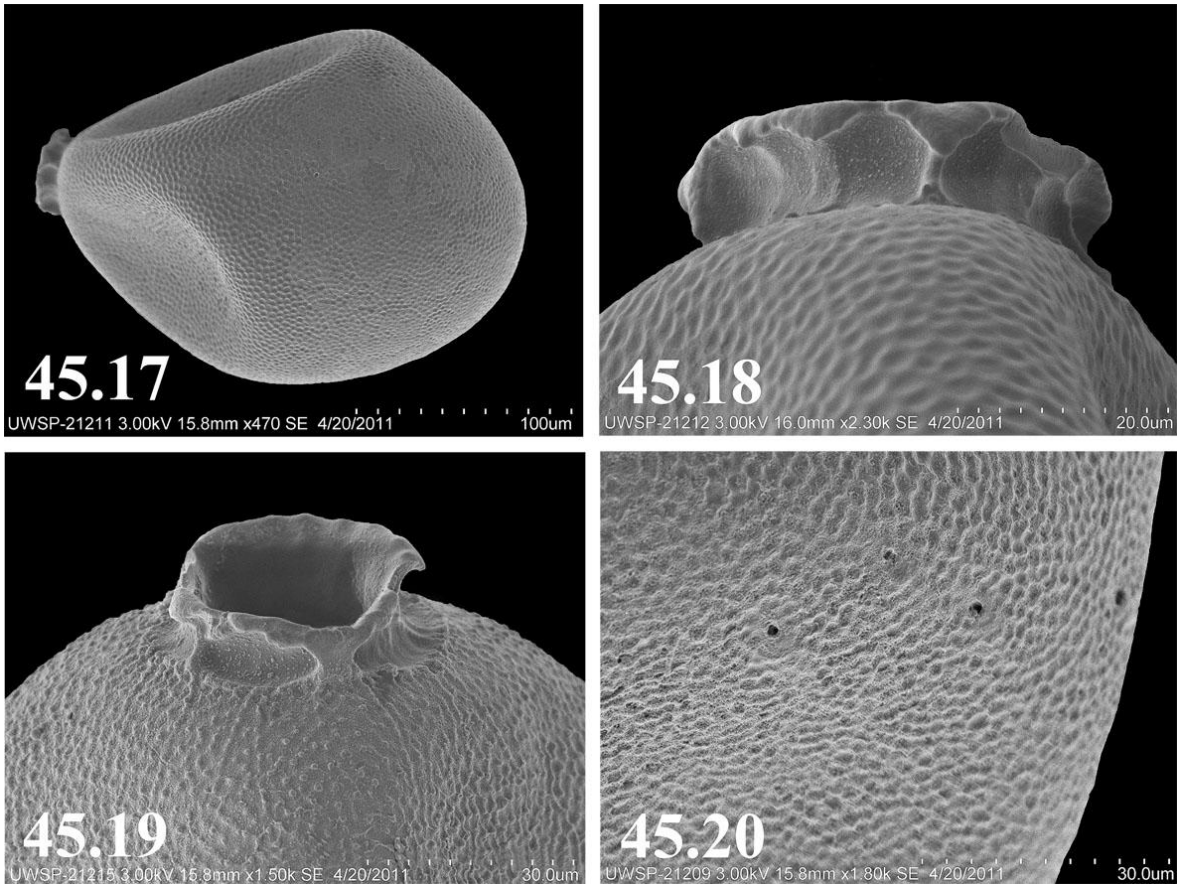


Figs. 45.14-45.16. *Isoperla quinquepunctata*. 45.14. Detail of dorsal conical shaped aedeagal lobe. 45.15. Detail of aedeagal sensillae basiconica. 45.16. Dorsal conical shaped aedeagal lobe.

follicle cell impressions faintly visible, floors shallow with numerous shallow pits; eclosion line absent. Micropyles arranged singularly near anterior ⅓ of egg (Figs. 45.17-45.20).

Nymph. Described by Szczytko and Stewart (1979a) and Frison (1942) as *I. patricia*. Stark et al. (1998) provide a color photograph of the habitus.

Diagnosis. *Isoperla quinquepunctata* is most similar to *I. longiseta* of the *I. longiseta* group (Table 1), a species with which it is sometimes sympatric. Males of *I. quinquepunctata* can be separated from *I. longiseta* by the longer, broader more bluntly shaped paraprocts, by lack of paired dorsal aedeagal tubular processes and by details of the aedeagal spinule pattern and lobes. Females can be distinguished by the longer subgenital plate with posteromesal notch. The head color pattern of *I. quinquepunctata* is variable as well as individual body size, wing length of males, vesicle shape, extent of setation on the male tergum nine and ten and the degree of emargination of the female subgenital plate, even within a single population (Szczytko and Stewart (1979a)). One of the more distinctive characters of *I. quinquepunctata* is the dark brown/black meso- and metanota which contrast markedly with the overall general pale yellow body coloration in fresh specimens. In addition, the broad V-shaped pale yellow area



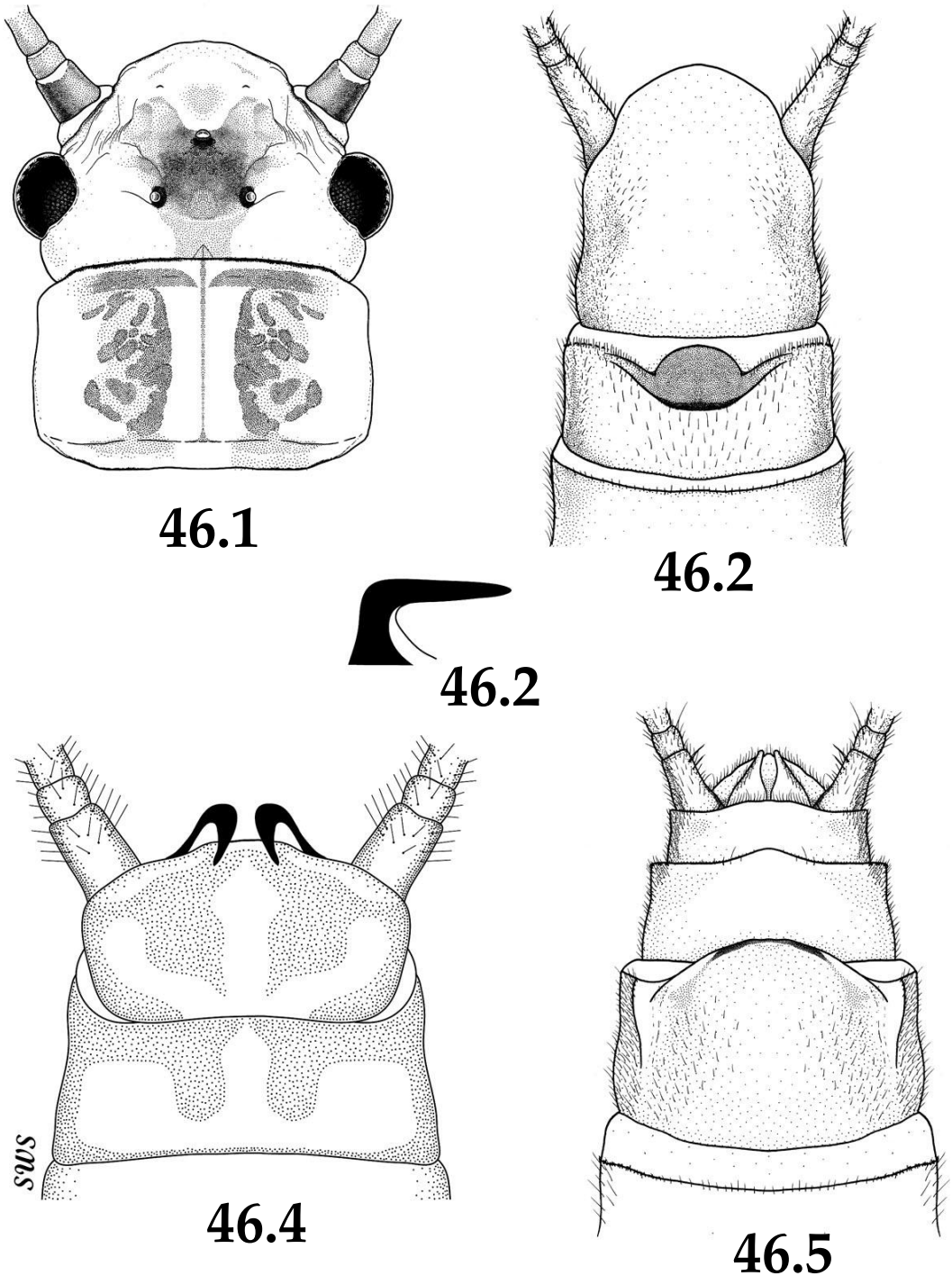
Figs. 45.17-45.20. *Isoperla quinquepunctata*. 45.17. Egg. 45.18. Detail of egg collar. 45.19. Oblique anterior view of egg collar. 45.20. Detail of egg chorion and micropyles.

extending across the mesonotum and the large rounded bright yellow raised areas on the anterolateral mesonotal corners are also distinctive. Among the species of *Isoperla* considered to be eastern North American in distribution, *I. quinquepunctata* occurs only at the western fringes of the Great Plains including the Black Hills of South Dakota. Examination of the holotype of *I. extensa* confirmed the above synonymy.

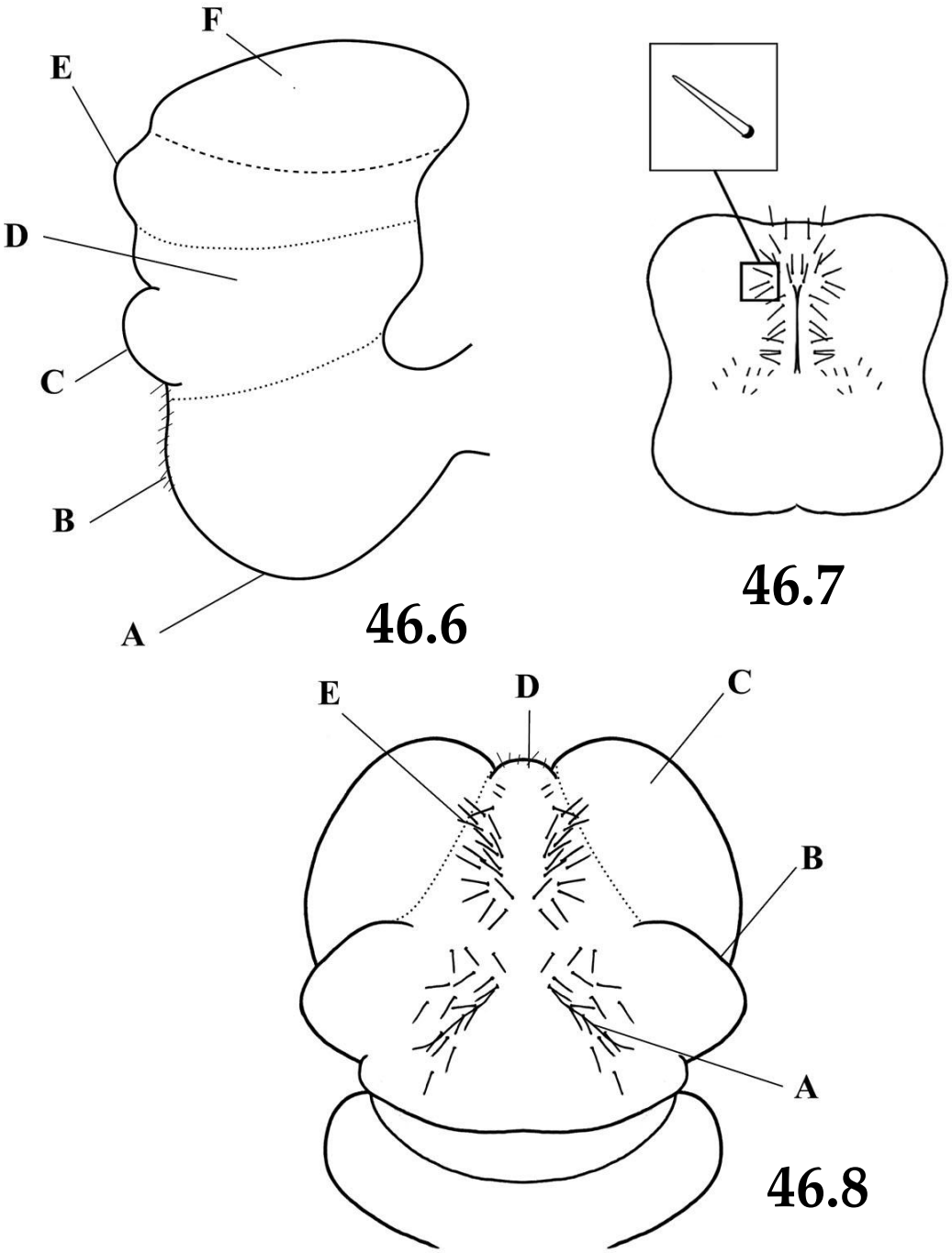
Biological Notes. *Isoperla quinquepunctata* is a common species of medium and large steams and rivers throughout much of western United States. It reaches the Great Plains and is also common in the Black Hills of South Dakota (Huntsman et al. 1999). This species appears to be eurythermic and emergence occurs from early May in southern populations and early July in northern populations. Martinson et al. (2012) reported on the life history and feeding habits in two different habitats in Colorado.

Szczytko and Stewart (1979b) studied the drumming behavior of *I. quinquepunctata* and stated that it exhibited the greatest variability of the four western *Isoperla* species they studied (*I. phalerata, I. mormona* (Banks), *I. fulva*). They indicated that it drummed frequently in the laboratory and males and females produced monophasic signals with a 2-way communication sequence. Male calls consisted of 9.2 ± 2.8 beats with a beat frequency of 43.3 ± 5.3 ms. The female

answer had 2.1 ± 2.6 beats with a beat frequency of 214.2 ± 3.9 ms. Females always answered the male call before completion and usually answered following the 6th beat.



Figs. 46.1-46.5. *Isoperla reesi* sp. n. 46.1. Dorsal head and pronotal pattern. 46.2. Male posterior abdominal sterna. 46.3. Male paraproct lateral view. 46.4. Male posterior terga. 46.5. Female subgenital plate ventral view.



Figs. 46.6-46.8. *Isoperla reesi* sp. n. 46.6. Male aedeagus lateral view; a. large posteroventral lobe, b. bipartite posteromedian patches of stout golden brown spines, c. paired posteromedian lobes, d. wide band of dense short, rounded spinulae encircling mesal section of aedeagus, e. small posterodorsal lobe with short hair-like setae, f. large paired dorsal hemispherical lobes with dense short stout spinulae. 46.7. Male aedeagus ventral view. 46.8. Male aedeagus posterior view; a. bipartite posteromedian patch of large stout golden brown spines, b. paired posteromedian lobes, c. large paired dorsal hemispherical lobes, d. small posterodorsal lobe with short hair-like setae, e. bipartie patch of medium size golden brown spines.

***Isoperla reesi* sp. n.**
Elk Garden Stripetail
(Figs. 46.1-46.9)

Material Examined. USA **– Holotype** ♂, **Virginia**: Smyth Co., Spring Seeps, Elk Garden, 17/V/1990, B.C. Kondratieff, J. Welch (USNM). **Paratypes: VA**: Same data as holotype, 1♂, 3♀ (CSUC); Big Branch headwaters, Rte. 600, 23/V/2006, B.P. Stark, I. Sivec, 2♂ (BPSC).

Distribution. USA **– VA**.

Male. Macropterous. Forewing length 11.0-12.0 mm. General body pale yellow with brown markings. Dorsum of head with brown bands which connect lateral ocelli to anterior ocellus and a brown square-like spot on frons (Fig. 46.1). Antennal scape brown, flagellar segments tinted with brown. Pronotum pale yellow with wide median pale stripe; middorsal pronotal suture brown; rugosities darker brown, lateral margins with broad pale band (Fig. 46.1). Meso- and metanota brown with paler markings. Wings pale, subcosta pale, other veins brown. Legs pale yellow, tibia basally brown, distal end of femora dark brown. Sterna paler; sternum 8 with large vesicle, ca. 1.6X as wide as long, darker than remainder of sternum, evenly rounded at apex, with small fine hairs (Fig. 46.2). Terga pale yellow. Paraprocts broad at base with elongate anteriorly projecting arm; apex slender and pointed, slightly deflected outward at tips and slightly recurved over posterior margin of tergum 10 (Figs. 46.3, 46.4). Cerci pale yellow. Aedeagus membranous with large paired dorsal hemispherical lobes with dense short stout spinulae (Figs. 46.6f, 46.8c), a small posterodorsal lobe with short hair-like setae (Figs. 46.6e, 46.8d), a pair of posteromedian lobes, proximally covered by short, stout golden spinulae (Fig. 46.6c, 46.8b), a wide band of dense short, rounded spinulae encircling mesal section of aedeagus (Fig. 46.6d), a bipartite posteromedian patch of medium size, stout golden brown spines (Figs. 46.7, 46.8e), a ventral bipartite spine patch with large, stout golden brown spines (Figs. 46.6b, 46.8a) and a large posteroventral lobe devoid of spinulae (Fig. 46.6a).

Fig. 46.9. *Isoperla reesi* sp. n. Male VA: Smyth Co., Big Branch headwaters, Mt. Rogers, 23/V/2006, B.P. Stark. Photo by Bill P. Stark.

Female. Macropterous. Forewing length 12.0-14.0 mm. General body color and morphology similar to male. Subgenital plate produced ¼ length or less of tergum 9, broadly triangular; apex sometimes almost narrowly rounded (Fig. 46.5).

Ovum. Unknown.

Nymph. Unknown.

Etymology. We honor David Rees, aquatic ecologist, Timberline Aquatics Inc., Fort Collins, Colorado, who has frequently assisted the junior author with his studies on the aquatic insects of Colorado.

Diagnosis. *Isoperla reesi* sp. n. is a medium size pale brown *Isoperla* included in the *I. pseudosimilis* sp. n. species group (Table 1) which inhabits higher elevations of the southern Appalachians. The aedeagus of the male of these species lack sclerotized spine plates but have long stout straight golden brown spines. It is most similar to *I. pseudosimilis* sp. n., a species with which it is sympatric, but is generally paler in body coloration. The distinctive spinule pattern of the fully everted aedeagus, the slender and pointed paraprocts, and the broadly triangular female subgenital plate will distinguish these two species.

Biological Notes. The emergence period of *I. reesi* sp. n. occurs from early May through mid-June based on collection records. There is no information available about the biology or life cycle of this species. This species is apparently a hypocrenon species that may be more common than current records indicate.

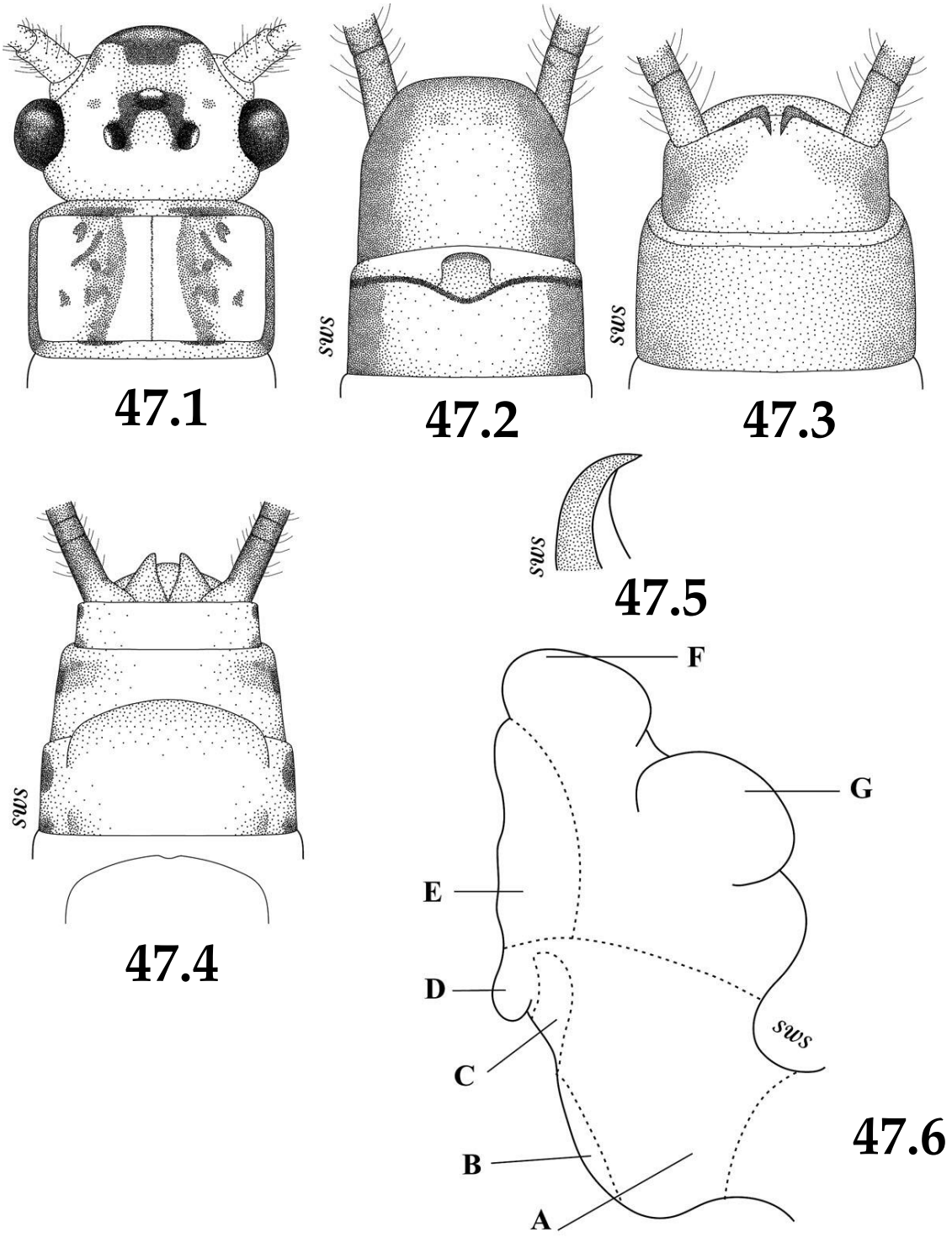
Isoperla richardsoni Frison
Sterling Stripetail
(Figs. 1.12, 47.1-47.16)

Isoperla richardsoni Frison 1935, 20:459. Holotype ♀ (INHS) Rock River, Sterling (Whiteside Co.), Illinois. Examined.

Distribution. **USA – IA** (Heimdal et al. 2004), **IL** (Frison 1935, DeWalt and Grubbs 2011 extirpated), **IN** (DeWalt and Grubbs 2011 extirpated), **MN** (Harden and Mickel 1952), **WI** (Hilsenhoff and Billmyer 1973). Note: DeWalt and Grubbs (2011) regard this species as extirpated from Illinois, however our recent records from Pope Co., listed below, indicate it is present in the state.

Additional Records. **USA – IL:** Pope Co., Dixon Springs Agric. Exp. Station, 19/V/2006, B.C. Kondratieff, R.W. Baumann, 3♂ (CSUC). **WI**: Iron Co., Manitowish River, Hwy 39, 2.5 mi S Manitowish wayside, 7/VI/2009, S.W. Szczytko, A.J. Van Erem, 28♂, 23♀ (CSUC).

Male. Macropterous. Forewing length 7.5-8.7 mm. General body color pale yellow with dark brown markings. Dorsum of head with broad dark brown bands (occasionally narrower) which connect ocelli; bands truncate at anterior ocellus; interocellar area pale, not enclosed posteriorly; two pale brown spots lateral to anterior ocellus (occasionally faint); frons with a medium brown to dark brown patch, widest anteriorly (sometimes faint in preserved material); remainder of head pale yellow (Fig. 47.1). Antennal pedicel, scape light brown; flagellum segments 1-6 pale brown, remaining segments medium to dark brown. Pronotum with wide hourglass-shaped median pale stripe; middorsal pronotal suture a thin brown line; rugosities irregular, raised, medium brown, pronotal disks pale yellow; anterior margin with thin medium brown bipartite band (Fig. 47.1). Meso- and metasterna uniformly pale yellow; mesonotum with large anterolateral medium brown patches with pale center; median, broad pale band with 2 small posteromedian medium brown spots. Metanotum mostly medium brown with irregular darker markings; anteromedian margin with large V-shaped pale patch. Wings cloudy, veins pale brown. Legs pale brown, dorsal margin of femur with a longitudinal medium brown band; tibia with a horizontal medium brown band on proximal ¼ on outer surface. Sterna pale yellow; sternum 8 with a thin dark posterior band and a pale brown vesicle, ca. ¾ as wide as long, expanded slightly apically; posterior margin evenly rounded, extending slightly over anterior margin of sternum 9 (Fig. 47.2). Terga pale yellow, with a median medium brown band on segments 1-9 and 3 lateral and 2 median medium brown spots on terga 1-9 (sometimes faint in preserved material); tergum 10 paler than preceding segments and median area slightly depressed (Fig. 47.3). Paraprocts moderately



Figs. 47.1-47.6. *Isoperla richardsoni*. 47.1. Dorsal head and pronotal pattern. 47.2. Male posterior abdominal sterna. 47.3. Male posterior terga. 47.4. Female subgenital plate ventral view. 47.5. Male paraproct lateral view. 47.6. Male aedeagus lateral view; a. dense basal path of short, stout spinulae with long fine hair-like apical tips, b. band of long sharp posteroventral spinulae, c. dense posteromesal patch of long hair like spinulae, d. small posteromesal lobe, e. rows of short, fine hair-like spinulae, f. large dorsal lobe, g. paired anterior dorsal lobes void of spinulae.

sclerotized, recurved slightly over tergum 10, sharply pointed apically and curved slightly inward near tips (Figs. 47.3, 47.5). Cercal segments 1-10 pale brown, remaining apical segments medium brown. Aedeagus with small posteromesal lobe (Fig. 47.6d), a large dorsal lobe (Fig. 47.6f) and paired anterior dorsal lobes devoid of spinulae (Fig. 47.6g), a dense posteromesal patch of long hair-like spinulae below posteromesal lobe (Figs. 47.6c, 47.7), a basal area with large dense patch of short, stout spinulae and long, fine hair-like apical tips (Figs. 47.6a, 47.8, 47.9), a posteroventral area with narrow band of longer, sharper spinulae (Figs. 47.6b, 47.10) and a posterodorsal area above posteromesal lobe with rows of short, fine hair-like spinulae (Figs. 47.6e, 47.11).

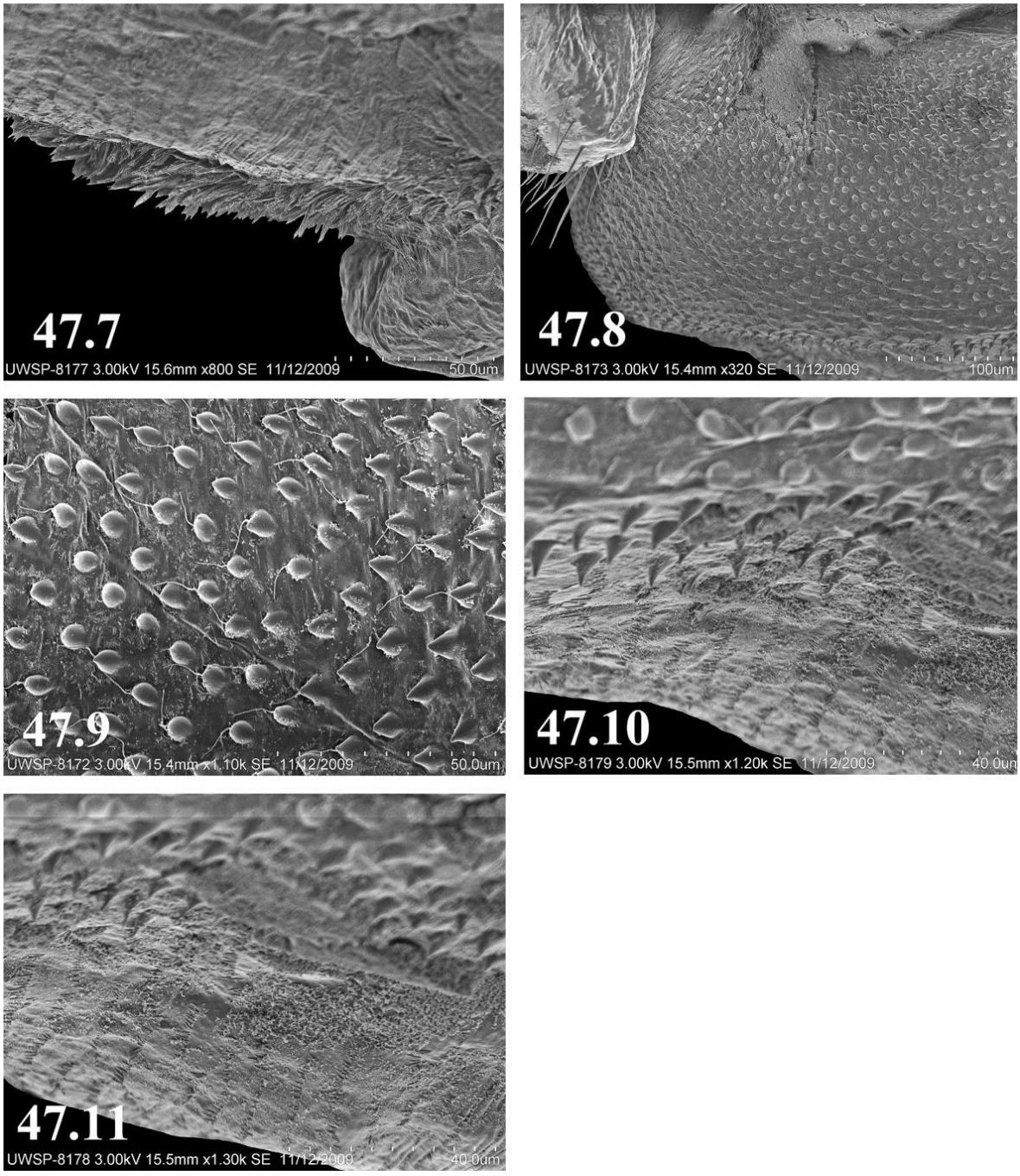
Female. Forewing length 9.0-9.5 mm. General body color and morphology similar to male described above. Eighth sternum with low, broad evenly rounded (occasionally with posteromesal emargination) subgenital plate extending ca. ⅓ distance over sternum 9 (Fig. 47.4).

Ovum. General shape oblong, cross-shaped ridges on one side, cross section triangular, anterior end slightly concave (Figs. 47.12, 47.14, 47.16). Color pale brown. Length 298 µm; width 205 µm. Collar developed, elevated with offset base and thickened longitudinal ridges, apically elongate but with raised longitudinal carinae (Figs. 47.12-47.14). Hexagonal follicle cell impressions well-developed; ridges raised and thickened floors flat with numerous shallow punctations; eclosion line absent. Micropyles arranged singularly on follicle cell ridges near anterior ⅓ of egg (Figs. 47.15, 47.16).

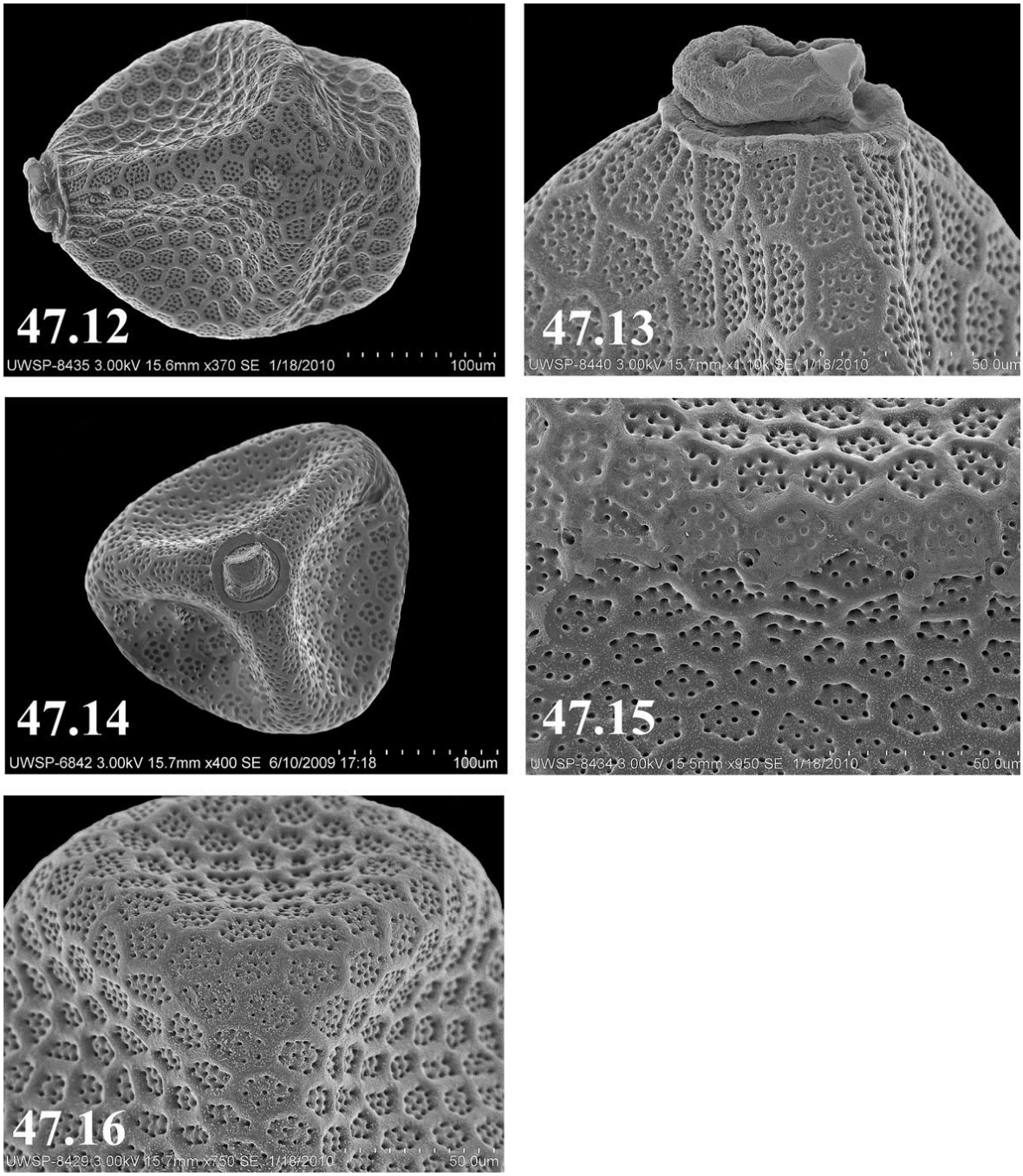
Nymph. Frison (1935) described the nymph and illustrated the habitus of the female nymph and details of the mouthparts. Harden and Mickel (1952) and Hilsenhoff and Billmyer (1973) provided keys for distinguishing *I. richardsoni* adults and nymphs from those of *I. bilineata* and other *Isoperla* species in Minnesota and Wisconsin, respectively. Stark et al. (1998) and Stark and Stewart (2002) provided a color photograph of the habitus.

Diagnosis. This is another pale yellow *Isoperla* species that has a dark inverted V-pattern which connect the ocelli and is shared with other *I. bilineata* group species (Table 1). The color pattern and size of the adults is close to *I. bilineata* which has perpetuated misidentification of this species. Males and females of *I. richardsoni* can be distinguished from those of *I. bilineata* by details of the male paraprocts, aedeagus and shape and size of the female subgenital plate as discussed above. There is some head color pattern variation among individuals even within a population from the same locality. In fresh specimens there is usually a dark triangular spot on the frons, but in preserved material it may be washed out. Generally the dark inverted V-bands connecting the ocelli are thicker than in *I. bilineata;* however, in other cases the bands may be thin as in *I. bilineata*. The female subgenital plate of *I. richardsoni* is a low evenly rounded plate sometimes with a posterior mesal emargination and the subgenital plate of *I. bilineata* is generally broadly triangular and longer. The ovum of this species is typical of many species in this group having a triangular cross section, developed collar, and defined follicle cell impressions with raised thickened ridges and flat floors with numerous shallow punctations. *Isoperla richardsoni* ova differ from *I. bilineata* ova in having a cross shaped ridge and no eclosion line. Szczytko and Stewart (1978) reported that males of *I. richardsoni* could be separated from *I. bilineata* by details of the male aedeagus and female subgenital plate as discussed above.

This species has an upper Midwestern distribution and previously reported records from the Southeast are probably in error. It is one of more uncommon species represented in collections examined. Tarter and Chaffee (2004), and Tarter et al. (2006) reported *I. richardsoni* from Kentucky and Tarter and Nelson (2006) reported it from West Virginia. We did not have the opportunity to study this material; however we feel that these specimens were possibly misidentified and the records may be invalid. Hitchcock (1974) reported *I. richardsoni* from East Haddam Connecticut as well as three other localities. We studied one cleared male from East Haddam labeled as *I. richardsoni* by S.G. Jewett, Jr. and determined that it was



Figs. 47.7-47.11. *Isoperla richardsoni*. 47.7. Dense posteromesal patch of long hair-like spinulae below posteromesal aedeagal lobe. 47.8. Dense basal patch of short, stout aedeagal spinulae with long, fine hair like apical tips. 47.9. Detail of dense basal patch of short, stout aedeagal spinulae with long, fine hair like apical tips. 47.10. Posteroventral area with narrow band of long, sharp aedeagal spinulae. 47.11. Posterodorsal area above posteromesal lobe with rows of short, fine hair-like aedeagal spinulae.



Figs. 47.12-47.16. *Isoperla richardsoni*. 47.12. Egg. 47.13. Detail of egg collar. 47.14. Egg anterior view. 47.15. Detail of egg chorion and micropyles. 47.16. Egg posterior end.

misidentified. We therefore consider published records of *I. richardsoni* from Connecticut as invalid until records can be confirmed from everted male specimens.

Biological Notes. Harden and Mickel (1952) reported that *I. richardsoni* was common in Minnesota and they, and Frison (1935), found it was usually associated with *I. bilineata* in medium and large rivers. Ziminske (1989) described the male call as a grouped signal with a mean of 16.7 ± 4.3 beat groups/signal, a mode of 3 beats/group and a mean beat interval of 26.2 ± 11.5 ms. He reported that males produced the signal by a rapid reverberation of the abdomen after the first beat. Female answers to the male call were monophasic with 7-8 beats and a mean beat interval of 222.7 ± 37.0 ms. He described the male second signal as a grouped beat signal with 8.0 beat groups/signal, a mean of 3.0 beats/group and a mean beat interval of 125.9 ± 23.8 ms. He collected pre-emergent nymphs from submergent vegetation near submerged roots and also rocks. He found that emergence was fairly synchronous in the Wisconsin River, Wisconsin with most of the adults emerging in 2-3 days. Emergence occurs from early May through early July (Harden and Mickel (1952).

Isoperla sagittata Szczytko and Stewart
Arrowhead Stripetail
(Figs. 48.1-48.7)

Isoperla sagittata Szczytko and Stewart 1976, 36:217. Holotype ♂ (USNM) Little Crow Creek (Newton Co.), Texas. Examined.
Isoperla sagittata: Szczytko and Stewart, 1977, 103:362.

Distribution. **USA –** TX (Szczytko and Stewart 1976).

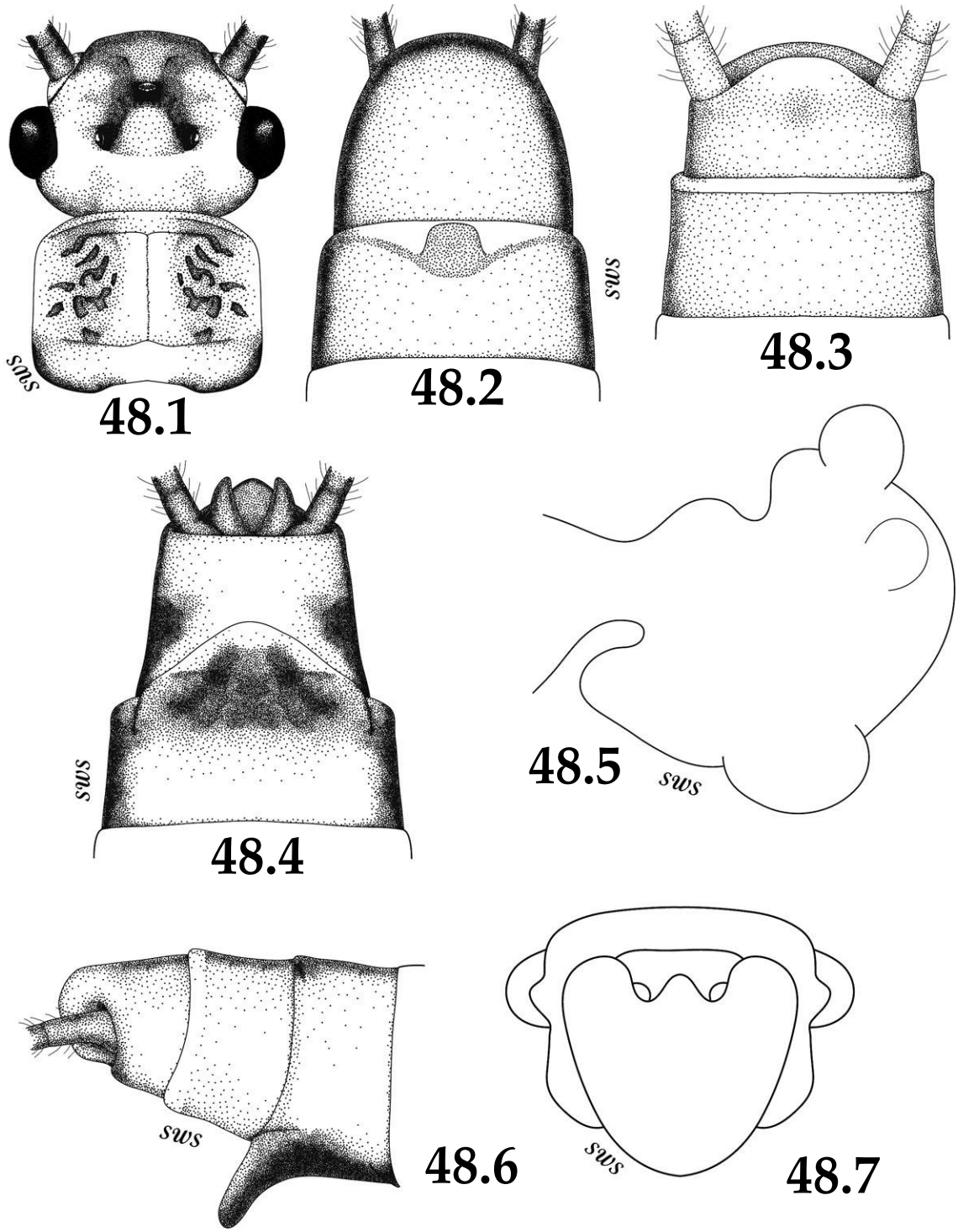
Male. Macropterous. Forewing length 7.1 mm. General body pale yellow with medium brown markings. Dorsum of head pale yellow with medium brown bands which connect ocelli; pale brown bands extend anteriorly to near frons forming an X-shaped pattern; interocellar area and posterior margin pale yellow (Fig. 48.1). Antennal scape and flagellum pale yellow, pedicel medium brown. Pronotum with a median pale stripe wider posteriorly; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, medium brown, pronotal disks pale yellow; anterior margin with diffuse bipartite pale brown bands (Fig. 48.1). Meso- and metasterna pale yellow with pale brown lateral bands. Meso- and metanota pale brown with irregular anterior pale patches. Wings hyaline with medium brown veins. Femora pale yellow with thin medium brown dorsal band; tibia pale yellow with medium brown band on proximal 1/5; tarsi pale brown. Sterna pale yellow; sternum 8 with a thin pale brown posterior band; vesicle well-developed, pale brown, about as long as wide with posterior margin evenly rounded and extending posteriorly to near anterior margin of sternum 9 (Fig. 48.2). Ninth sternum pale yellow; lateral margins with anterior and medial dark brown spots. Terga bright orange red; segments 1-8 with 3 lateral and 2 median rows of faint brown spots and a median pale brown band; terga 9-10 pale yellow (Fig. 48.3). Paraprocts unsclerotized, short, stout, blunt apically and not recurved over tergum 10. Cerci pale brown. Aedeagus entirely membranous with median dorsal lobe, paired dorsolateral lobes, and paired posteroventral lobes (Fig. 48.5); ventral surface with an elevated heart-shaped area (Fig. 48.7).

Female. Forewing length 11.3-12.6 mm. General body color and morphology similar to male described above. Sternum 8 with a broadly triangular, ventrally deflected subgenital plate which extends posteriorly over ⅓ length of sternum 9 (Figs. 48.4, 48.6). Sterna 9 and 10 mostly pale yellow with some irregular lateral pale brown markings (Fig. 48.7).

Ovum. Unknown.

Nymph. Described by Szczytko and Stewart (1976).

Diagnosis. No additional material of this pale yellow in life, small-size species has become available since the original description and therefore no detailed description of aedeagal morphology can be provided. *Isoperla sagittata* appears to most closely resemble *I. burksi* based on color pattern and shape of the female subgenital plate. The fully extruded membranous aedeagus of *I. sagittata* has a median dorsal lobe, paired dorsolateral lobes, and paired posteroventral lobes, whereas the extruded aedeagus of *I. burksi* has a large posteroventral rounded lobe, a large posterodorsal lobe, a dorsal triangular lobe, and a large anterodorsal lobe. Additionally, this rare species is apparently endemic to eastern Texas, and



Figs. 48.1-48.7. *Isoperla sagittata*. 48.1. Dorsal head and pronotal pattern. 48.2. Male posterior abdominal sterna. 48.3. Male posterior terga. 48.4. Female subgenital plate ventral view. 48.5. Male aedeagus lateral view. 48.6. Female subgenital plate lateral view. 48.7. Male aedeagus posterior view.

is most likely imperiled because of changes in streams conditions due to agriculture, water withdrawal, and other impacts to these unique eastern Texas perennial streams.

Biological Notes. *Isoperla sagittata* is apparently restricted to small sand bottom streams of eastern Texas. *Isoperla davisi* has also been collected from the type locality. Adults emerge from mid- to late February (Szczytko and Stewart 1976).

***Isoperla sandbergi* sp. n.**
Cheaha Stripetail
(Figs. 49.1-49.9)

Material Examined. USA – Holotype ♂, Alabama: Cleburne Co., Dry Creek abv. Cheaha Lake, Cheaha State Park, Clear Creek off Ridge Road, 14/V/1988, B.C. Kondratieff, R.F. Kirchner, R.W. Baumann, C.R. Nelson (USNM). **Paratype: AL:** Same data as holotype, 1♀ (CSUC).

Distribution. USA – AL.

Male. Macropterous. Forewing length 8.1 mm. General body pale yellow. Dorsum of head with a large medium brown interocellular patch with lateral thin bands, which extend to antennal bases; brown median patch anterior to median ocellus extends to frons (Fig. 49.1). Antennal scape pale yellow, pedicel and flagellum pale brown. Pronotum pale yellow, middorsal pronotal suture brown; disks pale; rugosities irregularly shaped and medium brown; anterior margin with median bipartite dark brown band; posterior margin with continuous dark brown band; lateral margins with wide pale yellow bands (Fig. 49.1). Meso- and metanota with paired anteromedian large rounded medium brown patches, remainder of sterna with irregular pale brown markings. Wings hyaline, veins medium brown. Femur pale yellow with dorsal medium brown longitudinal band; tibia and tarsi pale brown, tibia with proximal vertical dark band near proximal ¼. Sterna pale yellow; sternum 8 with a well-developed moderately sclerotized vesicle ca. as wide as long; thin dark brown band at posterior margin of sternum 8 (Fig. 49.2). Terga pale yellow; tergum 9 with elevated low mesal ridge with bipartite row of stout golden brown spinulae (Figs. 49.4, 49.5); posterior ½ with bipartite medium brown broadly triangular patches with scattered spinulae (Fig. 49.4); tergum 10 with bipartite medium brown patches with scattered spinulae (Fig. 49.4). Paraprocts moderately erect, lightly sclerotized, tips bluntly pointed and recurved slightly over tergum 10 (Figs. 49.3, 49.4, 49.5). Cerci pale brown. Aedeagus membranous with an expanded balloon-like apical section (Fig. 49.7j), a sclerotized convex shaped posteroventral plate with heavily sclerotized ventral margin (Figs. 49.7a, 49.9a), a large posteroventral lobe (Figs. 49.7c, 49.9b) a small pair of posteroventral lobes (Figs. 49.7b, 49.9c) bearing a row of 11-15 stout, dark reddish brown stout spines near inner base (Figs. 49.7d, 49.9d), a scattered patch of posterior medium length golden brown spines (Figs. 49.7e, 49.9e) with longer stout golden brown spines dorsally (Figs. 49.7f, 49.9f) a pair of rounded posteromesal lobes (Fig. 49.7h) which bear a patch of small spines at bases (Fig. 49.7g), a pair of posterodorsal membranous lobes (Fig. 49.7i) and a basal aedeagal stalk with dorsal bipartite sclerotized spine plates of dense stout sharp spinulae (Figs. 49.7k, 49.8).

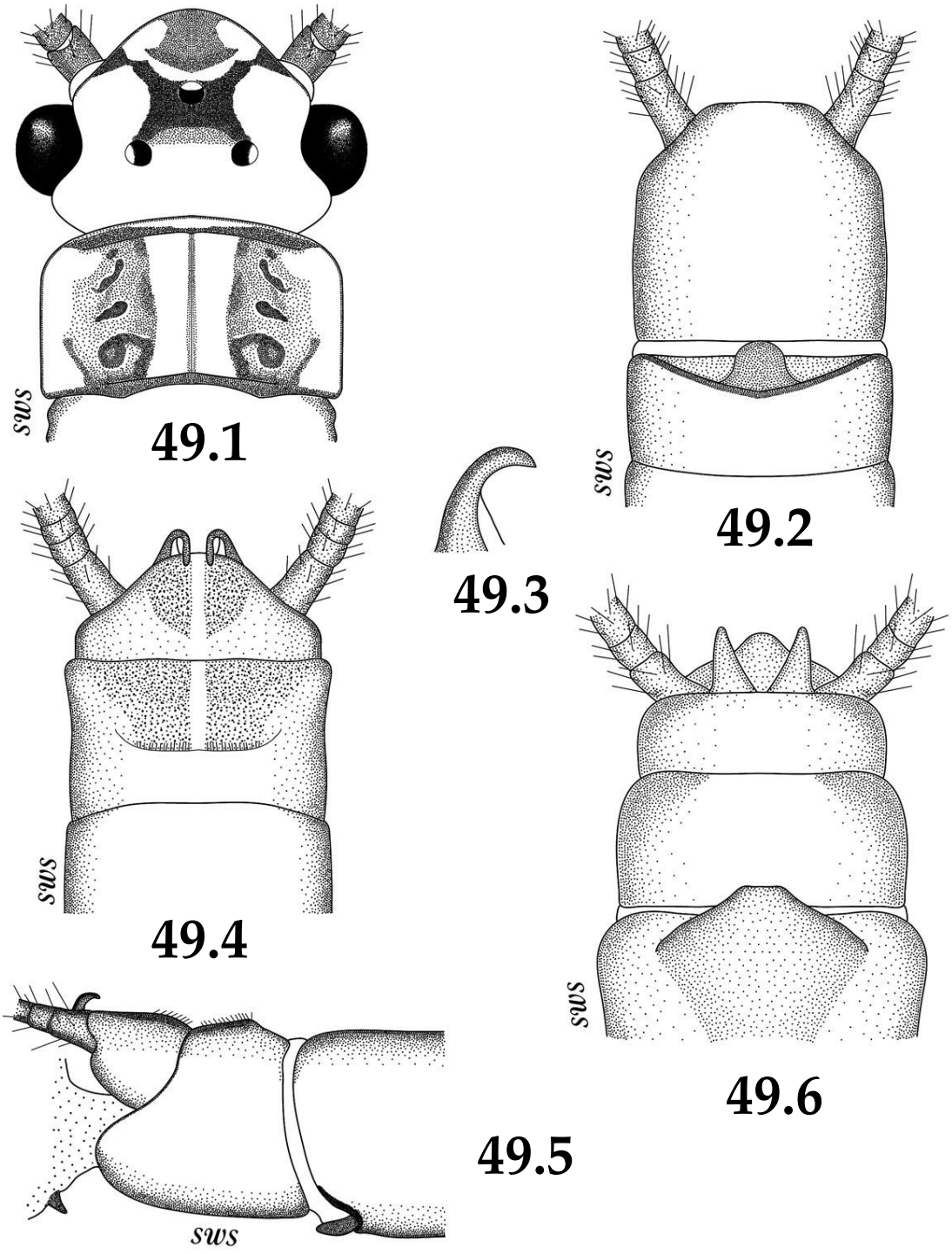
Female. Macropterous. Forewing length 9.1 mm. General body color and external morphology similar to male. Subgenital plate, broadly triangular, darker than rest of sternum, produced slightly over sternum 9; posteromedian margin slightly truncate (Fig. 49.6).

Ovum. Unknown.

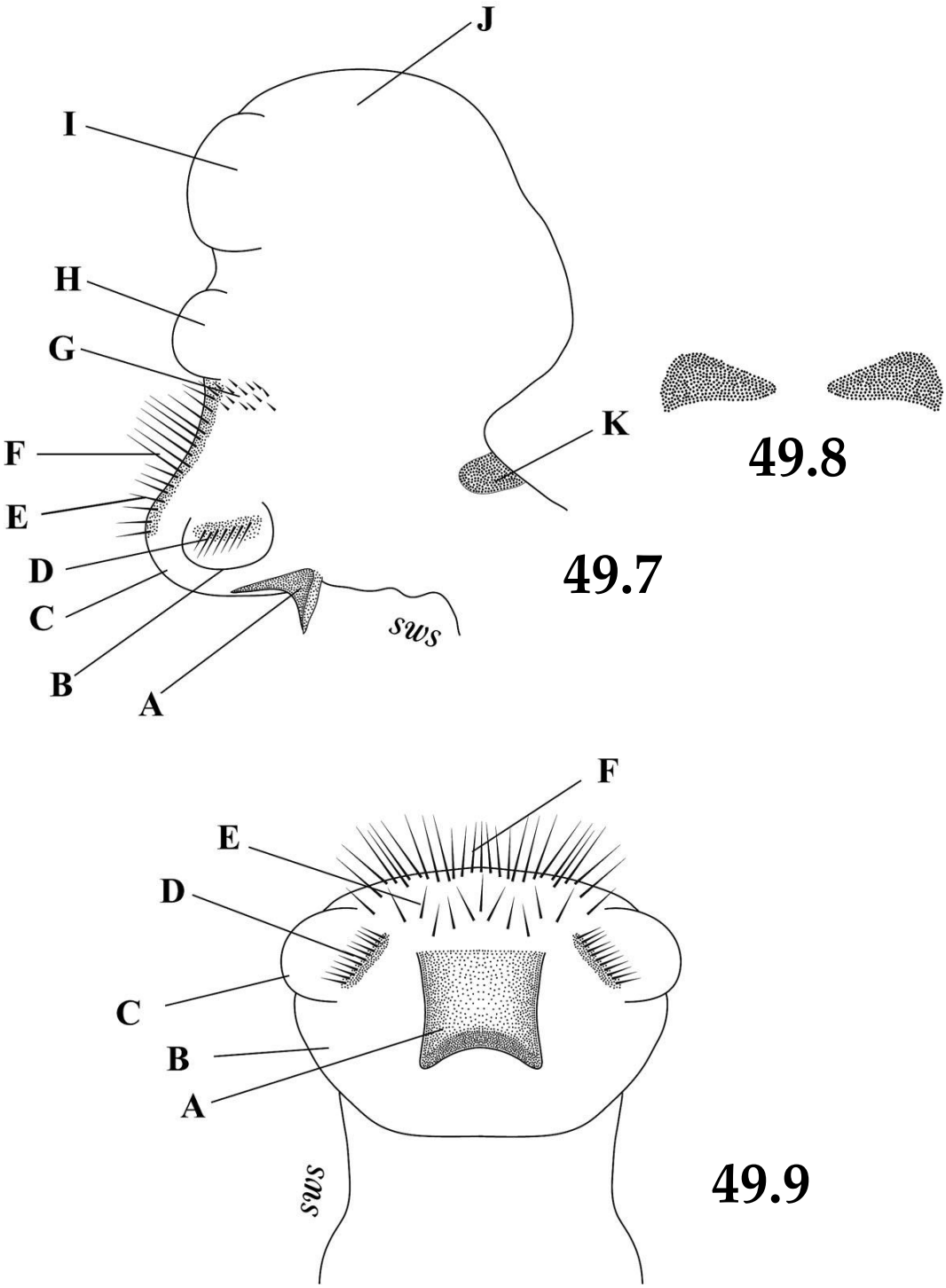
Nymph. Unknown.

Etymology. This species is named in honor of our friend and colleague, Dr. John B. Sandberg, California State University, Chico who has contributed much to the study of vibrational communication in stoneflies and to the study of *Isoperla* in California.

Diagnosis. *Isoperla sandbergi* sp. n. is a small pale yellow species with medium brown markings and is a member of the I. *similis* species group (Table 1). These species all share long reddish brown or golden brown aedeagal spines and sclerotized spine-bearing plates. The most distinctive feature of the male of *I. sandbergi* sp. n. is the large sclerotized posteroventral convex plate of the aedeagus. No other Nearctic *Isoperla* male is known



Figs. 49.1-49.6. *Isoperla sandbergi* sp. n. 49.1. Dorsal head and pronotal pattern. 49.2. Male posterior abdominal sterna. 49.3. Male paraproct lateral view. 49.4. Male posterior terga ventral view. 49.5. Male posterior abdominal segments lateral view. 49.6. Female subgenital plate ventral view.



Figs. 49.7-49.9. *Isoperla sandbergi* sp.n. 49.7. Male aedeagus lateral view; a. sclerotized convex shaped posteroventral plate with heavily sclerotized ventral margin, b. small paired, posteroventral lobes, c. large posteroventral lobe, d. row of 11-15 stout, dark reddish brown stout spines, e. scattered patch of posterior medium length golden brown spines, f. long stout golden brown spines, g. patch of small spines at bases of lobes, j. expanded balloon-like apical section, h. paired rounded posteromesal lobes, i. paired

posterodorsal membranous lobes, j. expanded balloon-like apical section, k. dorsal bipartite sclerotized spine plates of dense stout sharp spinulae. 49.8. Detail of paired posterodorsal sclerotized spine plates. 49.9. Male aedeagus posteroventral view; a. sclerotized convex shaped posteroventral plate with heavily sclerotized ventral margin, b. large posteroventral lobe, c. small paired, posteroventral lobes, d. row of 11-15 stout, dark reddish brown stout spines near inner base, e. scattered patch of posterior medium length golden brown spines, f. long stout golden brown dorsal spines, e. medium length golden brown spines.

to possess a similar structure. *Isoperla sandbergi* sp. n. is most similar in general body coloration and secondary sexual characters to *I. cherokee* sp. n. but is distinguished by the shape of the aedeagus which bears a large sclerotized posteroventral convex plate, and by the absence of posterolateral patches of long fine setae on male terga 4-7. There are also slight differences in the spinule pattern of male terga nine and ten and in the height of the elevated ridge on tergum nine. The females cannot be reliably separated at this time. These two species are apparently endemic to isolated, pristine, low order stream habitats of the southern Appalachians.

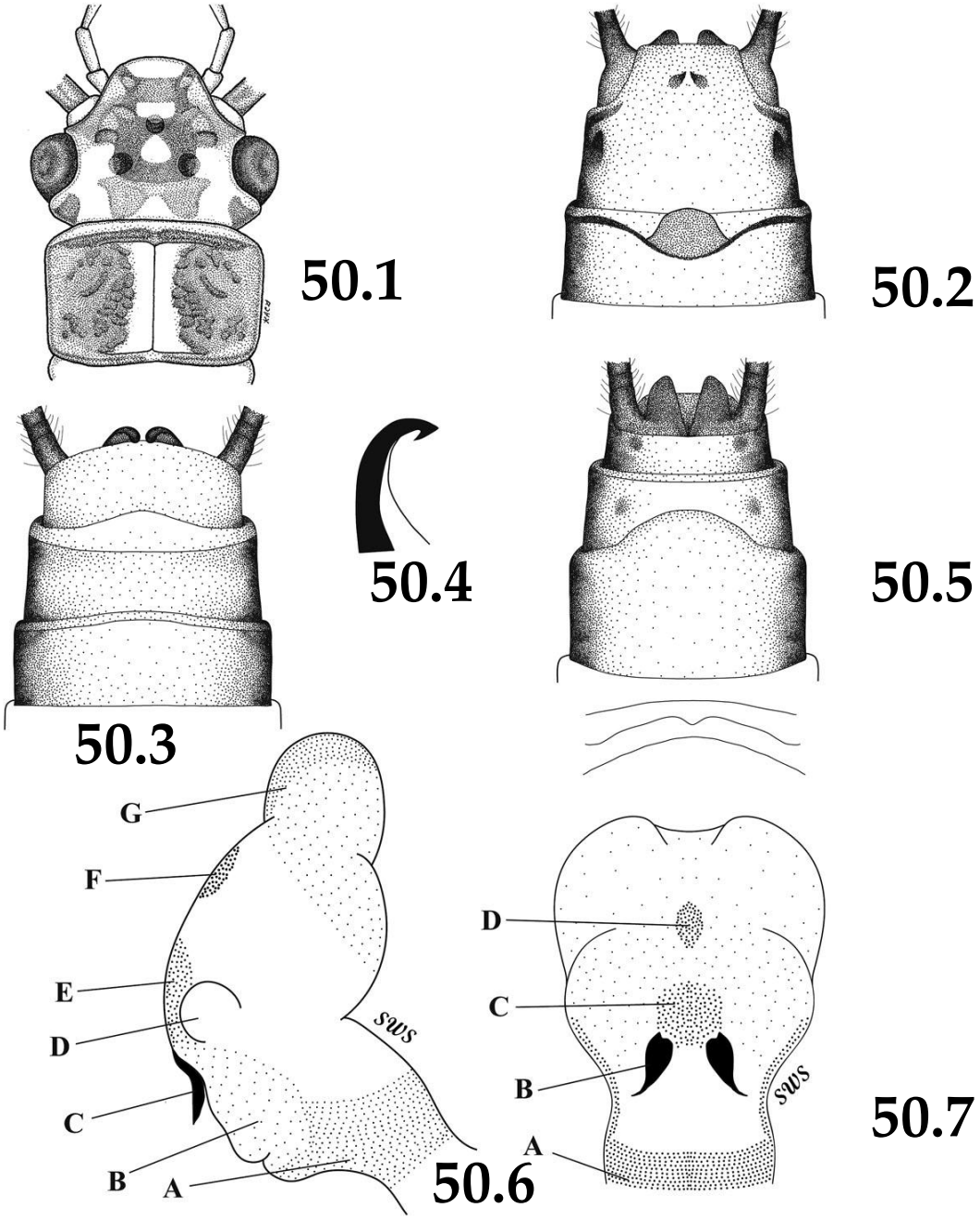
Biological Notes. *Isoperla sandbergi* sp. n. emerges in mid-May based on the single collection record. Details of the biology of this species are unknown. Cheaha State Park encompasses portions of the foothills of the southern Appalachian Mountains and includes the highest point in Alabama, 734 m. The type locality is known for other endemic stonefly taxa such as the perlids *Beloneuria jamesae* Stark and Szczytko and *Hansonoperla cheaha* Kondratieff and Kirchner.

Isoperla signata (Banks)
Transverse Stripetail
(Figs. 1.13, 50.1-50.23)

Perlinella signata Banks 1902, 34:124. Holotype ♀ (MCZC) Michigan. Examined
Isoperla signata: Claassen, 1940:206.
Walshiola signata: Banks, 1947, 54:283.
Pictetia bimaculata Banks 1948. 55:122. Holotype ♀ (MCZC) Digby, Nova Scotia. Syn. Ricker in Illies, 1966:419.
Isoperla signata: Ricker, 1947:26:409.

Distribution. CANADA – **MB** (Burton 1984), **NB** (Ricker 1947, Kondratieff and Baumann 1994), **NS** (Ricker 1947, Kondratieff and Baumann 1994, Needham and Claassen 1925), **ON** (Harper and Ricker 1994). **USA – AR** (Poulton and Stewart 1991), **CT** (Hitchcock 1974), **IA** (Heimdal et al. 2004), **ME** (Mingo 1983), **MI** (Grubbs and Bright 2001), **MN** (Harden and Mickel 1952, Lager et al. 1979), **MO** (Poulton and Stewart 1991), **NY** (Needham and Claassen 1925), **OH** (Gaufin 1956, DeWalt et al. 2012, Grubbs et al. 2013), **OK** (Poulton and Stewart 1991), **PA** (Surdick and Kim 1976, Masteller 1996b), **VA** (Kondratieff and Kirchner 1987), **WI** (Hilsenhoff and Billmyer 1973), **WV** (Tarter and Nelson 2006).

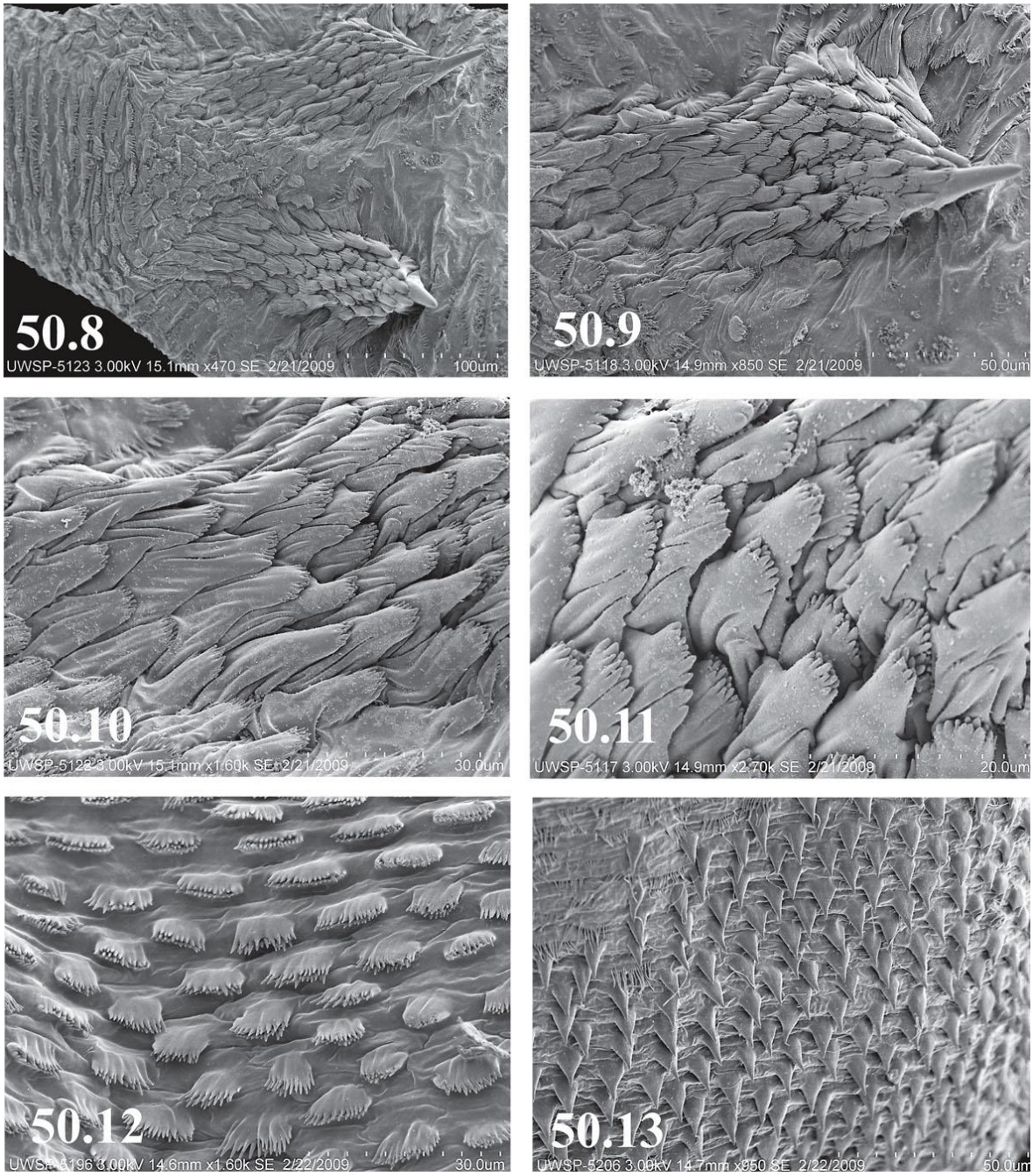
Additional Records. CANADA – **NB:** Charlotte Co., trib. Digdequash River, Hwy 127, 15/VI/1993, B.C. Kondratieff, R.W. Baumann, 1♀ (CSUC). Northumberland Co., Barnaby River, Hwy 126, 17/VI/1992, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC). Victoria Co., St. John River, Grand Falls at light Falls, 15/VI/1993, B.C. Kondratieff, R.W. Baumann, 2♂, 1♀ (CSUC). York Co., trib. Magaguadaveie River, Rte. 3, 14/VI/1993, B.C. Kondratieff, R.W. Baumann, 4♂, 1♀ (CSUC). **NS:** Antigonish Co., Tracadie River, Hwy 16, 22/VI/1993, B.C. Kondratieff, R.W. Baumann, 3♂, 2♀ (CSUC). Colchester Co., Waughs River, The Falls, Hwy 256, 3/VI/1998, B.C. Kondratieff, R.W. Baumann, 4♂, 4♀ (CSUC); North River, S Nuttby, Hwy 311, 22/VI/1993, B.C. Kondratieff, R.W. Baumann, 3♂, 9♀ (CSUC); Baileys Brook, West Falls, Rte. 256, 3/VI/1998, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC); Cumberland Co., Philip River, Oxford Junction, Rte. 321, 3/VI/1998, B.C. Kondratieff, R.W. Baumann, 8♂, 12♀ (CSUC). Hants Co., Nine Mile River, Hwy 14, 23/VI/1993, B.C. Kondratieff, R.W. Baumann, 5♂, 2♀ (CSUC). Inverness Co., Broad Cove River, Glenville, Hwy 19, 21/VI/1993, B.C. Kondratieff, R.W. Baumann, 1♂, 3♀ (CSUC); Glen Brook, N Melford, Hwy 105,



Figs. 50.1-50.7. *Isoperla signata.* 50.1. Dorsal head and pronotal pattern. 50.2. Male posterior abdominal sterna. 50.3. Male posterior terga. 50.4. Male paraproct lateral view. 50.5. Female subgenital plate ventral view. 50.6. Male aedeagus lateral view; a. basal stalk with dense stout spinulae, b. rows of fine hair-like spinulae and an occasional sensillae basiconica, c. paired large posteromedian sclerotized spine plates, d. paired small posteromedian lobes, e. rows of short, wide scales with fine, multiple apical projecting fingers, f. dense patch of elongate, stout sharp spines, g. large rounded dorsal membranous lobe. 50.7. Male aedeagus posterior view; a. basal stalk with dense short stout spinulae, b. paired large posteromedian sclerotized spine plates, c. rows of short, wide scales with fine, multiple apical projecting fingers, d. dense patch of elongate, stout sharp spines.

11/VI/1998, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC); Inhabitants River, Hwy 105, 1/VI/1998, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC); Margaree River, East Margaree, 21/VI/1993, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC). Picton Co., Barneys River, Avondale, 20/VI/1993, B.C. Kondratieff, R.W. Baumann, 1♂ (CSUC). **USA – ME:** Washington Co., Tomah Stream, Hwy 6, 13/VI/1993, B.C. Kondratieff, R.W. Baumann, 3♂, 10♀; Same locality, 14/VI/1993, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUC); Same locality but 12/VI/1998, B.C. Kondratieff, R.W. Baumann, 1♂, 3♀ (CSUC); Machias River, Rte. 9, 2/VI/1998, B.C. Kondratieff, R.W. Baumann, 6♀ (CSUC). **NY:** Essex Co., East Branch Ausable River, Route 9 near Rattlesnake Knob, 44°20.858N, 073° 45.523'W, 27/VI/2007, L.W. Myers, B.C. Kondratieff, 2♂, 6♀ (CSUC); East Branch Ausable River, Andrus rd., Upper Jay, 22/V/2007, L.W. Myers, 4♂, 5♀ (CSUC). Oswego Co., Little Sandy Creek, Hwy 13, S Lacona, 17/VI/1997, B.C. Kondratieff, R.W. Baumann, 1♂ (CSUC); North Branch Salmon River, CR 17, upstream reservoir, 26/V/2009, L.W. Myers, B.C. Kondratieff, 4♂, 4♀ (CSUC). Warren Co., Hudson River, Rte. 28, North Creek, 43°43.702'N 74° 01.101'W, 21/V/2007, L.W. Myers, 2♂, 1♀ (CSUC). Washington Co., Machias River, Rte. 9, 2/VI/1998, B.C. Kondratieff, R.W. Baumann, 6♀ (CSUC).

Male. Macropterous. Forewing length 9.0-12.6 mm. General body color dark brown in life, medium to dark brown in alcohol with darker brown or black markings. Dorsum of head with dark brown bands which connect anterior ocellus with posterior ocelli, medium brown bands extend from anterior ocellus to antennal bases; interocellar area with pale triangular spot, usually closed posteriorly; medium brown bands extend from base of interocellar area to hind margin of head; small, medium brown lateral patches occur below compound eyes; wide pale rectangular spot located anterior to median ocellus; frontoclypeal area with broad dark band with narrow dark brown bands which extend anteriorly; pale median rectangular spot is located anterior to dark band which extends to anterior margin of head (Fig. 50.1). Antennal scape, pedicel and flagellum dark brown. Pronotum with wide median pale stripe; middorsal pronotal suture a thin brown line; rugosities dark brown to black, and raised; pronotal disks medium brown; anterior and posterior margins dark brown, lateral margins medium brown (Fig. 50.1). Meso- and metanota mostly medium brown with two large dark brown anterior irregularly shaped spots which extend posteriorly ½ length of nota; posterior ½ with large median rectangular medium brown patch with bipartite black triangular patches orientated anteriorly. Wings dusky medium brown with dark brown veins. Legs medium brown. Sterna pale brown with broad median pale area, but darker laterally; sternum 8 with medium brown well developed vesicle darker than remainder of segment, nearly as long as wide; vesicle evenly rounded posteriorly, extending to near anterior margin of sternum 9; paired sclerotized aedeagal spine plates usually visible below cuticle of sternum 9 (Fig. 50.2). Terga pale to medium brown with 3 lateral and 2 median rows of dark longitudinal spots; faint broad median medium brown stripe on abdominal terga 1-7. Paraprocts heavily sclerotized; paraprocts long, thin, pointed apically with a distinct ventral spur and extending slightly over tergum 10 (Figs. 50.3, 50.4). Cerci medium brown with dark distal bands on each segment. Aedeagus with large rounded dorsal membranous lobe (Fig. 50.6g) a pair of small posteromedian lobes (Fig. 50.6d), a pair of large posteromedian sclerotized spine plates (Figs. 50.6c, 50.7b, 50.8, 50.9) with base of spine plates bearing dense wide blunt spines terminating in multiple short apical fingers (Figs. 50.6e, 50.9, 50.11), elongate blunt spine plates with apical fingers occur near base of sclerotized spine plates (Fig. 50.10), spine patches terminate with one large, heavy, pointed apical spine and several intermediate length stout pointed spines (Figs. 50.8, 50.9), rows of short, wide scales with fine, multiple apical fingers project above base of paired sclerotized spine patches (Figs. 50.6e, 50.7c, 50.12), posteroventral margin below sclerotized spine patches bear rows of fine hair-like spinulae and an occasional sensilla basiconica (Figs. 50.6b, 50.18), posteromedian area above wide scales armed with a dense patch of elongate, stout sharp spinulae (Figs. 50.6f, 50.7d, 50.17), a small patch of small



Figs. 50.8-50.13. *Isoperla signata.* 50.8. Paired large posteromedian sclerotized aedeagal spine plates. 50.9. Detail of paired large posteromedian sclerotized aedeagal spine plates. 50.10. Elongate blunt aedeagal spines with apical fingers near base of posteromedian spine plates. 50.11. Dense wide blunt aedeagal spines terminating in multiple short apical fingers at base of posteromedian sclerotize spine plates. 50.12. Rows of short, wide aedeagal scales with fine, multiple apical projecting fingers above base of paired sclerotized spine patches. 50.13. Dense stout, sharp spinulae on aedeagal stalk.

sharp spinulae occurs below apical lobe (Figs. 50.6g, 50.19), a patch of dense sharp spinulae with apical filaments occurs below patch of sharp apical spinulae (Fig. 50.14), basal stalk bears a broad area of dense stout spinulae which extend to near base (Figs. 50.6a, 50.7a,50.13), a group of small, raised, triangular shaped, scattered knobs, each with a single elongate filament occur above mesal section (Fig. 50.16) and a membranous lobe with scattered groups of fine setae is located posteroventrally (Figs. 50.6b, 50.15).

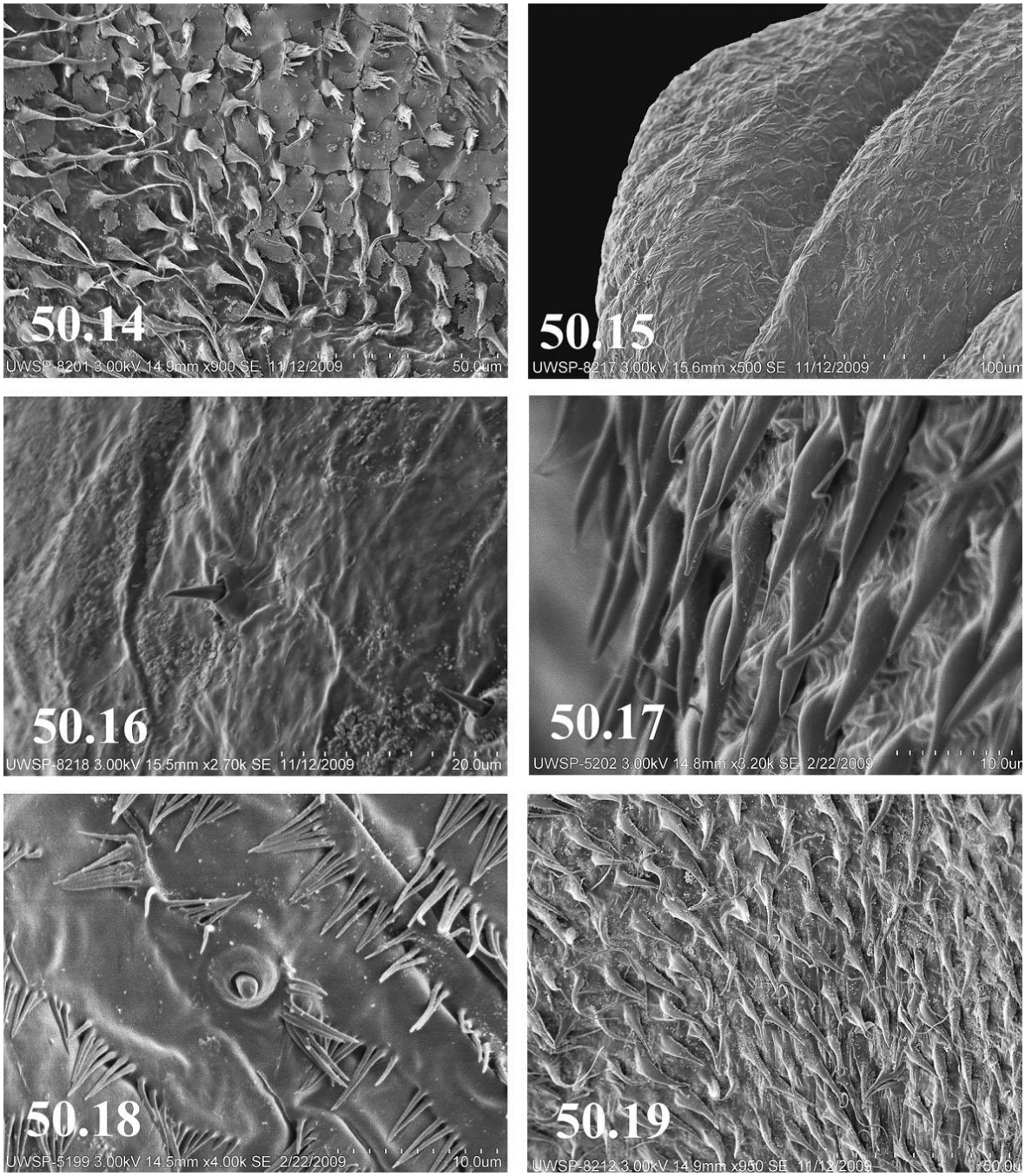
Female. Forewing length 10.6-12.9 mm. General body color and morphology similar to male described above. Subgenital plate produced posteriorly over ½ length of sternum 9, broadly rounded posteriorly, sometimes with a shallow or posteromedian notch; posterior margin usually darker (Fig. 50.5).

Ovum. General shape oblong, cross section triangular; distinct cross shaped ridges divide anterior and posterior poles; anterior pole nearly flat (Figs. 50.19, 50.20, 50.22, 50.23). Color pale brown. Length 230 μm; width 170 μm. Collar well-developed with apically flanged rim; stalked with elevated longitudinal carinae; base with raised irregular ridge (Figs. 50.19, 50.20, 50.21). Choronic surface covered with numerous small punctations; ridges of hexagonal follicle cell impressions raised and thickened (Figs. 50.19-50.22). Eclosion line absent. Micropyles positioned near anterior ⅓ on FCI ridges; orifices small, usually occurring in groups of 3 or more (Fig. 50.22).

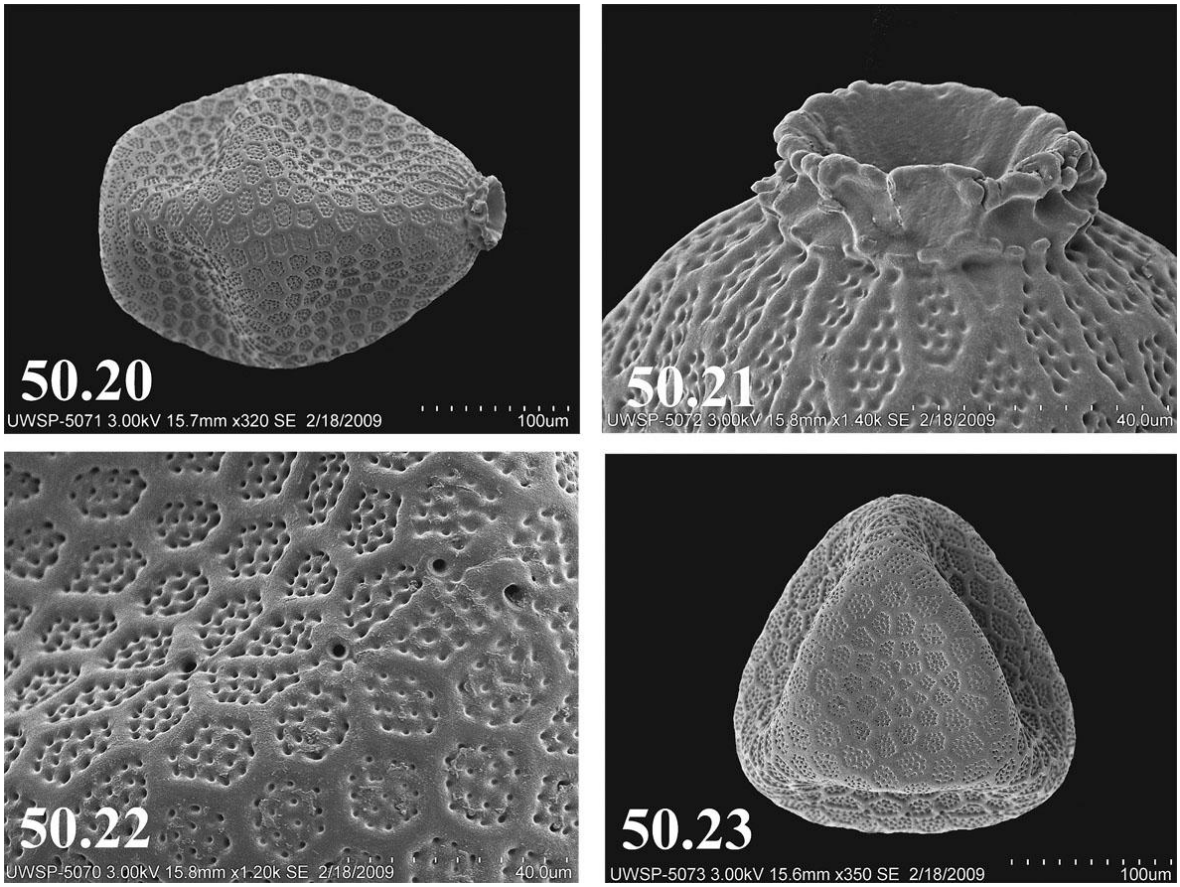
Nymph. Claassen (1931) described the habitus, Hilsenhoff and Billmyer (1973) illustrated the lacinia and Poulton and Stewart 1991 illustrated the head, pronotum, lacinia, and abdominal terga. Stark et al. (1998) and Stewart and Stark (2002) provided a color photograph of the habitus.

Diagnosis. This medium size dark species is assigned to the *I. signata* group (Table 1) based on egg and aedeagal characteristics. This group includes *I. signata, I. kirchneri* sp. n., *I. siouan* sp. n. and *I. namata.* These species can be distinguished using the keys and illustrations. Frison (1942) previously stated that the shape of the female subgenital plate, male vesicle, paraprocts and general adult color pattern of *I. signata* are similar to those of *I. namata.* Additionally, we have found the general aedeagal characters and egg morphology are also similar between these two species. However, details of the adult head color pattern are different. The shape of the subgenital plate of the female varies from an evenly rounded posterior margin or a margin with a shallow or even with a deep emargination. Therefore, due to the morphological similarity of both species, it is not surprising that *I. namata* has been confused in the literature commonly with *I. signata.* It is most likely that all records of *I. namata* from the southeastern U.S. are either *I. signata*, *I. kirchneri* sp. n. or *I. siouan* sp. n. *Isoperla namata* typically has an Ozarkian distribution and *I. signata* is widely distributed especially throughout northeastern and midwestern North America.

Biological Notes. *Isoperla signata* typically occurs in small and medium size rivers. However, this species can be collected from larger relatively pristine rivers throughout its range. Jop and Szczytko (1984) studied the life cycle and production of *I. signata* in a central Wisconsin trout stream and found that it had an S_2 (slow) univoltine life cycle and nymphs were present in the stream for ca. 11 months. They indicated that both male and female nymphs went through 14 instars. The 2 week synchronous emergence began in early May when mean daily stream temperature was ca. 10°C and was completed when mean daily stream temperature reached 18°C. The incubation period for ova was ca. 36 days and there was a differential hatch lasting ca. 51 days. They calculated the total annual production using the size frequency method as 3.0 gm^{-2} wet weight and the annual turnover ratio was 3.56. Nymphs were associated with small gravel substrates from June-March and to organic debris during April and May. Nymphal food habits ranged from herbivore-detritivore in early and middle instars and omnivores in later instars. Graham (1982) reported that males exhibited a monophasic drumming call with 4-5 beats and an interbeat frequency of 190 ± 10.6 ms. The emergence period for this species is extensive and occurs between mid March and mid June based on collection records. Emergence occurs during mid-March to late June in northern



Figs. 50.14-50.19. *Isoperla signata*. 50.14. Dense sharp aedeagal spinulae with apical filaments below apical lobe. 50.15. Membranous posteroventral aedeagal lobe with scattered groups of fine hair like setae. 50.16. Small sharp aedeagal sensillae basiconica. 50.17. Dense posteromedian aedeagal patch of elongate, stout sharp spines. 50.18. Detail of aedeagal sensillae basiconica and rows of fine hair-like spinulae. 50.19. Small patch of small sharp spines below apical aedeagal lobe.



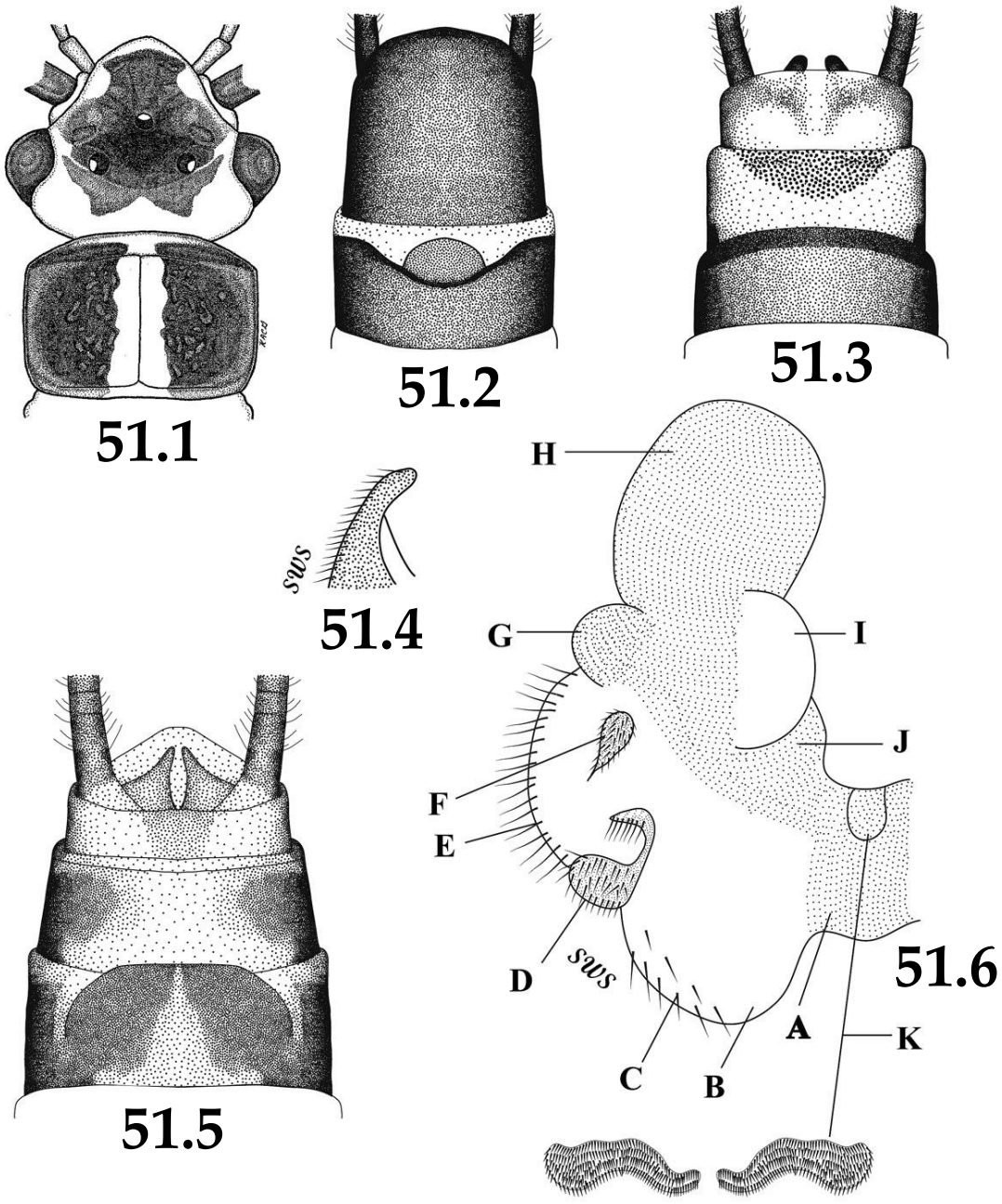
Figs. 50.20-50.23. *Isoperla signata*. 50.20. Egg. 50.21. Detail of egg collar. 50.22. Detail of egg chorion and micropyles. 50.23. Detail of egg posterior end.

populations and from mid-March to late April in southern populations. Emergence varies from late March to late June in Wisconsin depending on the size of the river and groundwater contribution.

Isoperla similis (Hagen)
Black Stripetail
(Figs. 51.1-51.17)

Perla similis Hagen 1861:26. Holotype ♀ (MCZC) Pennsylvania. Examined.
Isoperla similis: Frison, 1942, 22:325.

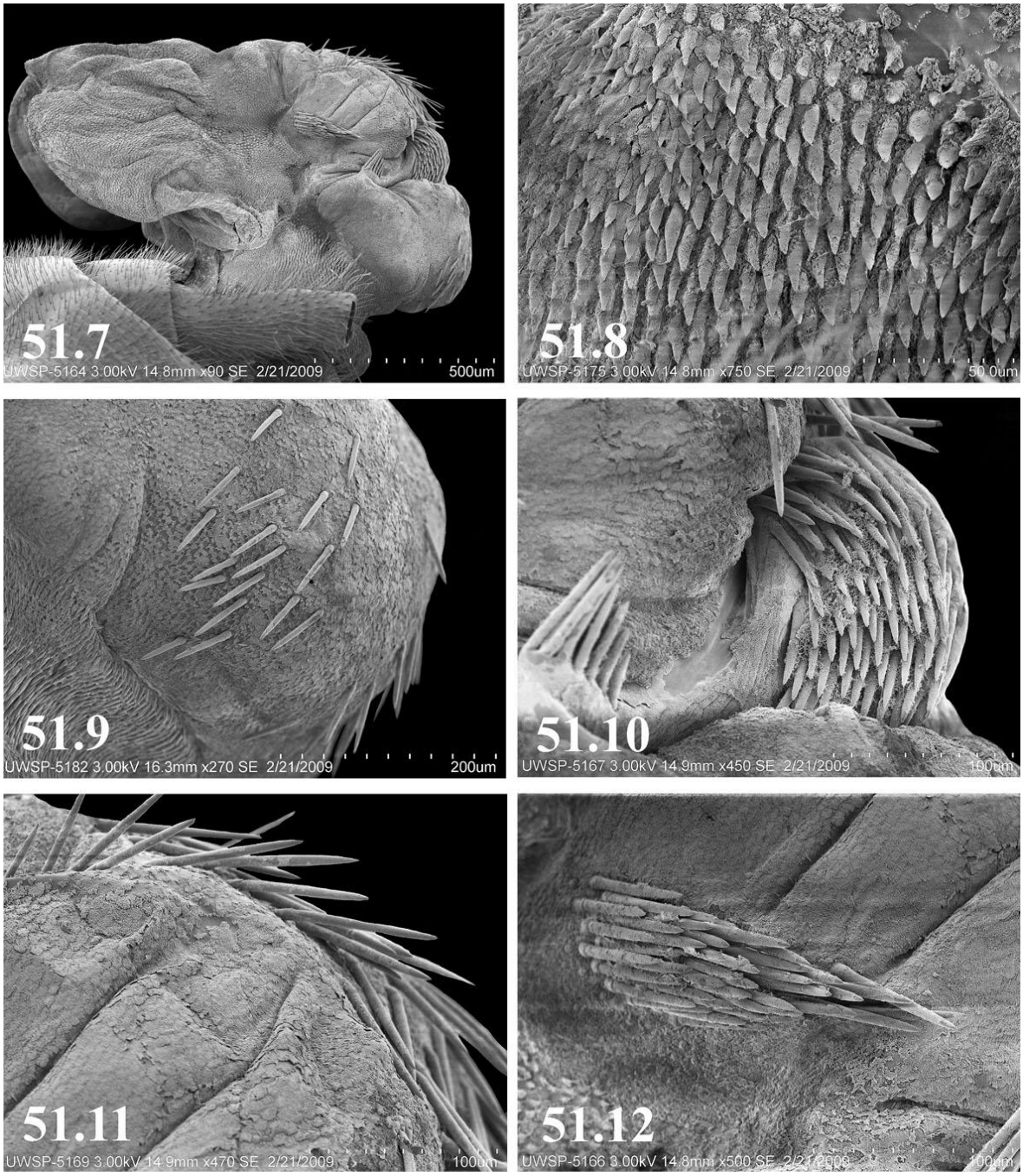
Distribution. USA- **CT** (Frison 1942), **NH** (Frison 1942), **NY** (Frison 1942), **PA** (Frison 1942).
New Records. USA- **MD:** Frederick Co., Fishing Creek, Mountaindale, 1/V/1959, P.H. Freytag, 1♀ (USNM). **NJ:** Sussex Co., Parker Brook, Hwy 650, SE Milford, 4/V/1991, R.W. Baumann, S. Wells, 2♀ (BYUC). **VA:** Albemarle Co., Crozet, 5/V/1937, M. Bobb, 1♀ (USNM). Alleghany Co., Lick Run, Rte. 39, 11/V/1981, W. Nilsen, 1♀ (USNM). Fairfax Co., Great Falls, Potomac River, 3/IV/1938, B.D. Burks, 1♀ (INHS). Montgomery Co., Mill Creek, Route 785, 12/IV/1979, S. Jurewkez, 1♀ (USNM). Prince William Co., Bull Run Mtn., Jackson Hollow, Campground area, Malaise trap #1, 38 52.8'N, 77°41.4'W, 13-27/V/2011, D. R. Smith, 1♂ (USNM). Rockbridge Co., Guys Run, M6T area, 11/V/1981, Martin, 1♀ (CSUC); Marl Creek, Rt. 703, S. Briggs, 1♂ (CSUC).



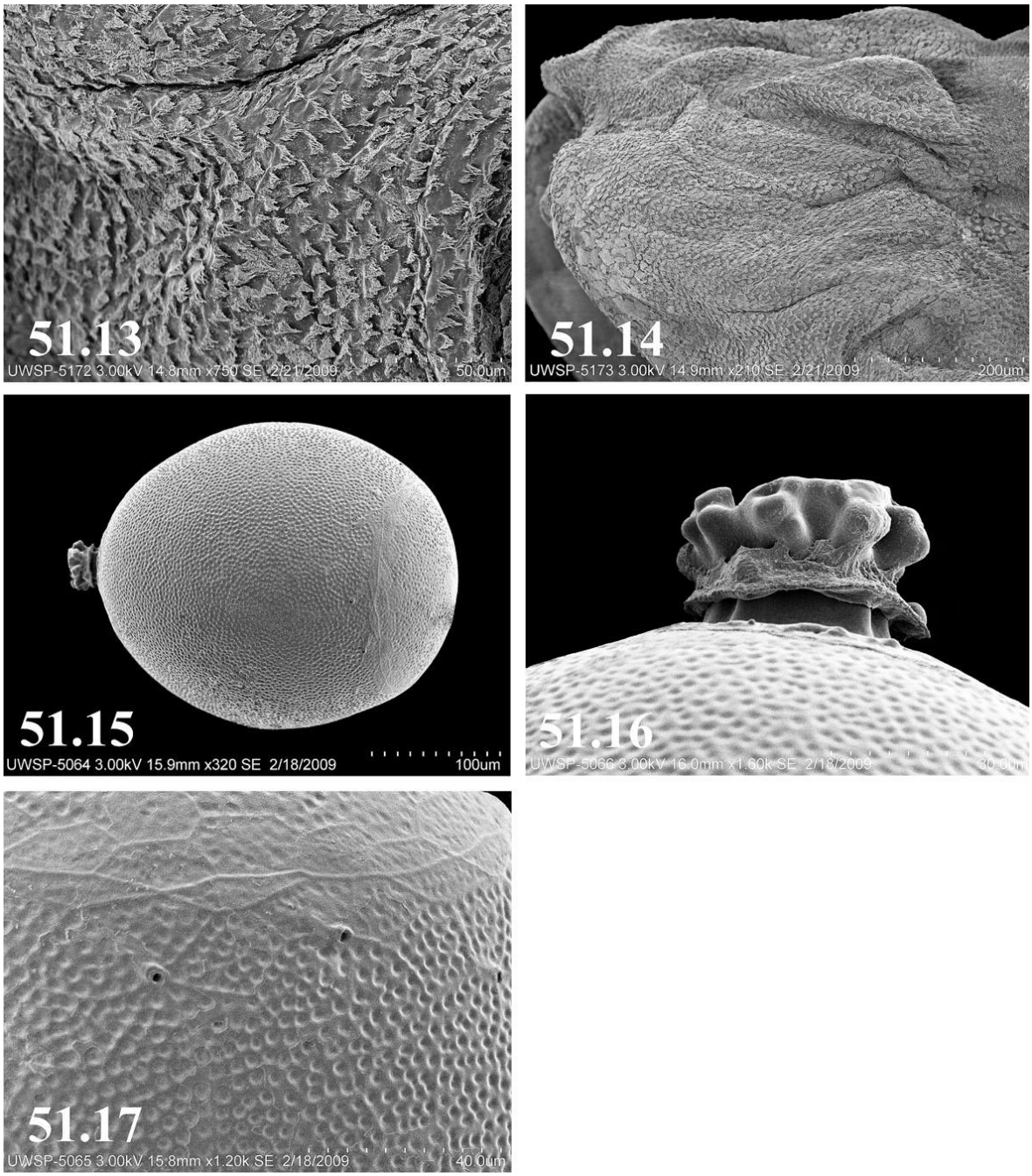
Figs. 51.1-51.6. *Isoperla similis*. 51.1. Dorsal head and pronotal pattern. 51.2. Male posterior abdominal sterna. 51.3. Male posterior terga. 51.4. Male paraproct lateral view. 51.5. Female subgenital plate ventral view. 51.6. Male aedeagus lateral view; a. posteroventral area covered with dense small stout spinulae, b. large posteroventral lobe, c. sparse concentration of long stout, light brown spines, d. paired posterolateral sclerites with enlarged rounded posterior ends and reduced anterior hook shaped ends, e. posteromesal margin with dense patch of finer reddish brown spines, f. paired mesal "tear" shaped patch of dense stout reddish brown spines g. small paired mesoposterior lobes, h. large balloon-shaped paired dorsal lobes, i. mesoanterior lobe void of spinulae, j. patch of short stout sharp spinulae, k. dorsobasal area with paired "eye brow" shaped spinule plates with stout reddish brown spines.

Additional Records. USA – CT: Litchfield Co., Macedonia Brook, abv. Rocky Glen Campground, Macedonia Brook State Park, 26/VI/1991, R.W. Baumann, J. Whiting, 1♂ (BYUC). New Haven Co., Wallingford, 12/V/1962, J.B. Kring, 1♂ (INHS). **NY:** New York, Suffolk Co., Rattlesnake Brook, Blue Trail, 20/V/2008, B.C Kondratieff, R.W.Baumann, L.W. Myers, 1♂ (CSUC). **PA:** Chester Co. Walton Spring, E. Branch WCC, 0.6 mi NW London Grove, elev. 400', 39°52'30"N, 75°46'49"W, 11/IV/1979, ?, 5♂ (DFIC); Same locality, 2/V/1979, 1♂, 7♀ (DFIC); Same locality, 4/V/1979, 1♂ (DFIC); Same locality, 9/V/1979, 1♂, 8♀ (DFIC); Same locality, 16/V/1979, 3♀ (DFIC); Same locality, 18/V/1979, 10♂, 2♀ (DFIC); Same locality, 19/IV/1978, D.H. Funk, 1♂, 1♀ (DFIC); wet lab @ Stroud Water Research Center, London Grove, elev. 325', 39° 51'32"N, 75°47'02"W, 9/V/1980, D.H. Funk, 1♂ (DFIC); Same locality, 9/IV/1980, D.H. Funk, 1♂, 1♀ (DFIC); East Branch White Clay Creek, 0.75 mi WNW London Grove, elev. 365, 39°57'15"N, 75°47'13"W, 9/V/1979, ?, 2♂ (DFIC); East Branch White Clay Creek, 0.6 mi W London Grove, 1.9 mi SE Mortonville, elev. 330', 39°55'25"N, 75°45'27"W, 18/IV/1979, D.H. Funk, 1♂ (DFIC); Same locality, 9/V/1979, ?, 1♂ (DFIC); Same locality, 1♀, 2/V/1979, ? (DFIC).

Male. Macropterous. Forewing length 9.5-11.5 mm. General body dark brown to black with yellow markings. Dorsal background of head yellow with a large dark brown patch covering the mesal area including interocellar area (occasionally a black V-shaped band and small median pale spot anterior to median ocellus); medium to dark brown patch extends anteriorly to frons and posteriorly to near posterior margin; posterior ends of bands pointed, posteromedian area with pale triangular patch and posterior margin yellow (Fig. 51.1). Mesal area of submentum with a round dark brown patch. Antennal scape, pedicel, and flagellum dark brown to black. Pronotum with wide median pale hourglass-shaped stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown to black; pronotal disks dark brown, anterior and posterior margins with broad bipartite median dark brown bands (Fig. 51.1). Meso- and metasterna with anterior wide transverse medium brown band with paler median area. Meso- and metanotum with irregular shaped median pale band. Wings pale brown, veins dark brown. Femora, tibia and tarsi medium brown; femora with a thin mesal dark brown band on outer surface; tarsi with wide proximal horizontal dark brown band. Sterna medium brown; sternum 8 with a broad pale vesicle, ca. 2X as wide as long; posterior margin of vesicle evenly rounded and extending posteriorly to anterior margin of sternum 9 (Fig. 51.2). Ninth sternum medium brown with slightly paler mesal area. Terga 1-8 pale brown usually with 3 lateral and 2 median rows of faint brown spots; medium brown mesal band on segments 1-3, segments 9-10 pale yellow; segment 9 with anterolateral dark spots and posteromedian patch of small stout spinulae; tergum 10 with mesal area slightly depressed (Fig. 51.3). Paraprocts moderately sclerotized, extending only to level of tergum 10, nearly erect and blunt apically with posterior margin fringed with fine setae (Fig. 51.4). Cerci dark brown to black. Aedeagus (Figs. 51.6, 51.7) with posteroventral area covered with dense small stout spinulae (Figs. 51.6a, 51.7, 51.8), a dorsobasal pair of eyebrow-shaped spine plates covered with stout reddish brown spines, (Figs. 51.6k, 51.8), a large posteroventral lobe with sparse concentration of long stout, pale brown spines (Figs. 51.6b,c, 51.7, 51.9), a posterolateral pair of sclerotized spine plates bearing enlarged rounded posterior ends and reduced anterior hook shaped ends, posterior ends bear dense medium length stout reddish brown spines and anterior ends have 7-8 medium length stout reddish brown spines (Figs. 51.6d, 51.7, 51.10). In addition, the aedeagus is armed on the posteromesal margin with a dense patch of large length finer reddish brown spines (Figs. 51.6e, 51.7, 51.11), a mesal pair of tear-shaped patches of dense large, stout reddish brown spines (Figs. 51.6f, 51.7, 51.12), a small mesoposterior pair of lobes (Figs. 51.6g) and a large balloon-shaped pair of dorsal lobes covered with dense rows of small fine hair like spinulae (Figs. 51.6h, 51.7, 51.13, 51.14); mesoanterior lobe devoid of spinulae (Fig. 51.6i); patch of short stout sharp spinulae located below mesoanterior lobe (Fig. 51.6j).



Figs. 51.7-51.12. *Isoperla similis*. 51.7. Male aedeagus lateral view. 51.8. Dorsobasal aedeagal area with paired eye brow-shaped spinule plates with stout reddish brown spines. 51.9. Large posteroventral lobe with sparse concentration of long stout, light brown aedeagal spines. 51.10. Posterior ends of paired posteroventral aedeagal sclerites anterior ends with 7-8 medium length stout reddish brown spines. 51.11. Posteromesal margin patch of large reddish brown aedeagal spines. 51.12. Paired mesal tear-shaped patch of dense large, stout reddish brown aedeagal spines.



Figs. 51.13-51.17. *Isoperla similis*. 51.13. Balloon-shaped paired dorsal aedeagal lobes covered with dense rows of small fine hair like spinulae. 51.14. Large balloon-shaped paired dorsal aedeagal lobes. 51.15. Egg. 51.16. Detail of egg collar. 51.17. Detail of egg chorion and micropyles.

Female. Forewing length 11.4-12.9 mm. General body color and morphology similar to male described above. Eighth sternum with low broadly truncate subgenital plate (occasionally with a

small, shallow V-shaped median notch) slightly extending over sternum 9; median area of plate bears a triangular shaped pale band, remainder of plate medium brown (Fig. 51.5). Sternum 9 with dark brown posterolateral patches, sternum 10 yellow, occasionally with a pale brown median band (Fig. 51.5).

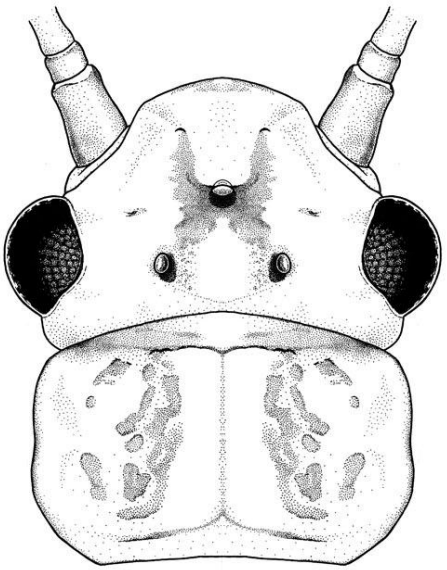
Ovum. General shape oblong, cross section circular, (Fig. 51.15). Color pale brown. Length 425 µm; width 395 µm. Collar base, elevated with thickened longitudinal ridges; apical portion expanded with pronounced flared ridges (Figs. 51.15, 51.16). Hexagonal follicle cell impressions slightly visible; chorionic surface covered with small shallow pits. Eclosion line wide, smooth, slightly raised with low sinuous ridges. Micropyles arranged singularly, openings slightly elevated, positioned adjacent to eclosion line near anterior ⅓ of egg (Figs. 51.15, 51.17).

Nymph. Claassen (1931) provided a description of the putative nymph from Ithaca, New York based on an exuvium which may refer to *I. pseudosimilis* sp. n. Frison (1942) also described the nymph, and illustrated the habitus and mouthparts, but the locality of the specimens used for the description is unknown. The nymph of *I. similis* may actually be undescribed.

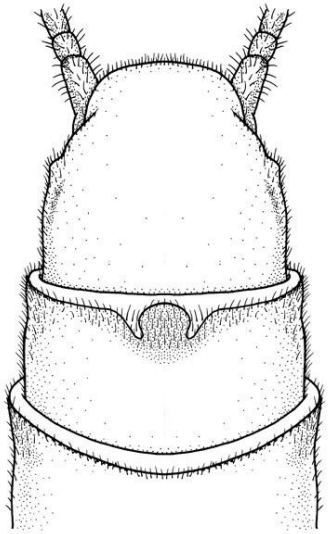
Diagnosis. We follow the concept of *I. similis* as presented by Frison (1942), especially in regard to his illustrations of the adults. However, Frison's (1942) listing of material included both *I. similis* and *I. pseudosimilis* sp. n., especially in regard to the North Carolina and Tennessee records. The female holotype from Pennsylvania is identical to females listed above, and the male is definitely associated. *Isoperla similis* is a member of the *I. similis* group (Table 1). As compared to other species in the group, *I. similis* is nearly black with much of the head dark brown or black including the interocellar area. It superficially resembles *I. pseudosmilis* sp. n., *I. slossonae*, and *C. clio* in general size and dark coloration, but has been confused in the literature with *I. pseudosimilis* sp.n. throughout its range; however details of the aedeagus, egg and general body coloration of *I. similis* and *I. pseudosimilis* sp. n. will allow confident separation. *Isoperla similis* is darker than *I. pseudosimilis* sp.n. and lacks the thin pale W-shaped band anterior to the median ocellus. The pronotal disks are also darker than in *I. pseudosimilis* sp. n., and the male sternum nine is generally uniformly dark brown with a mesal medium brown stripe, whereas the sternum nine of *I. pseudosimilis* sp. n. is almost entirely pale yellow with some lateral and anterior darker bands. The female subgenital plate of *I. similis* is truncate posteriorly with dark brown bands and a pale yellow median inverted triangular band, whereas the subgenital plate of *I. pseudosimilis* sp. n. is generally pale yellow with a basal irregularly shaped medium brown spot. The paraprocts of *I. pseudosimilis* sp. n. are distinctively hooked and acutely pointed apically and the paraprocts of *I. similis* are straight, almost erect and blunt apically. The aedeagus of *I. similis* has paired posterolateral sclerotized spine plates with spinulose enlarged rounded posterior ends and reduced anterior hook-shaped ends and the aedeagus of *I. pseudosimilis* sp. n. lacks sclerotized structures. The aedeagus of *I. similis* also has dorsobasal paired eyebrow-shaped spine plates with stout reddish brown spines and *I. pseudosimilis* sp. n. lacks these structures. *Isoperla similis* is most closely related to *I. major* in details of the secondary and primary sexual characteristics with the major differences being body coloration, size, and differences in aedeagal structure and emergence phenology as discussed above.

We have only included distribution records for *I. similis* that we have been able to confirm with properly everted male specimens. All other published records for this species should be viewed as suspect; most probably refer to *I. pseudosimilis* sp. n. Current confirmed records indicate that *I. similis* is distributed from Connecticut to Virginia along the Piedmont Plateau and Atlantic Coastal Plain apparently inhabiting remnant pristine lower order streams of relatively good water quality.

Biological Notes. Based on the above records, the emergence period of *I. similis* ranges from mid-April through the end of May. Essentially nothing is known about the biology of this species.



52.1



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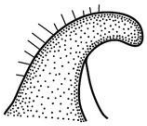

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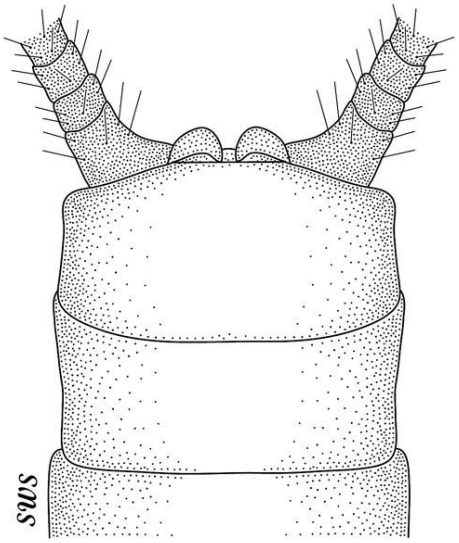

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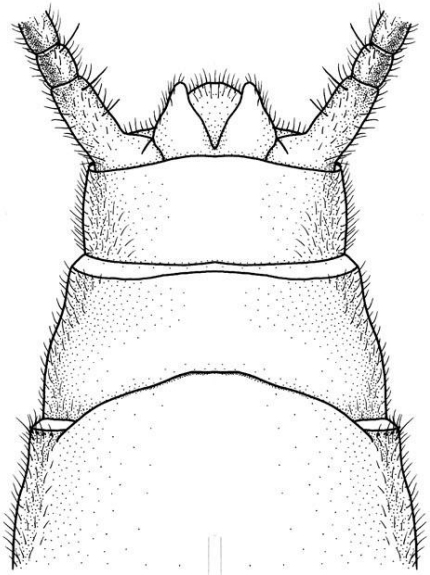


52.5

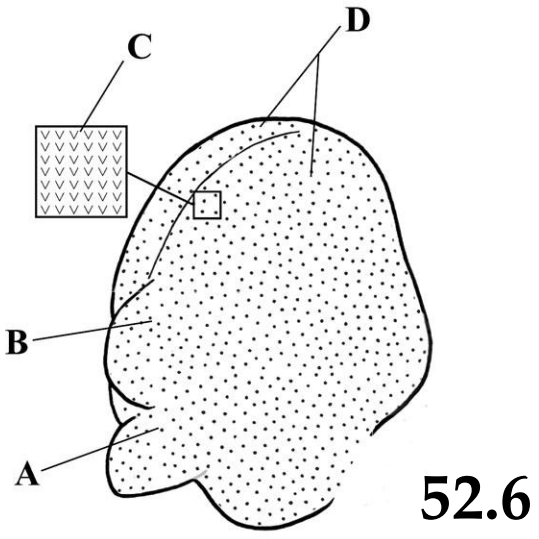
Figs. 52.1-52.5. *Isoperla siouan* sp. n. 52.1. Dorsal head and pronotal pattern. 52.2. Male posterior abdominal sterna. 52.3. Male paraproct lateral view. 52.4. Male posterior terga. 52.5. Female subgenital plate ventral view.

***Isoperla siouan* sp. n.**
Siouan Stripetail
(Figs. 52.1-52.7)

Material Examined. USA – Holotype ♂, **North Carolina**: Moore Co., small stream to McLendons Creek, Bethleham Church Road, Moore Game Land, 1/V/2003, B.C. Kondratieff, R.F. Kirchner (USNM). **Paratypes: NC:** Same data as holotype, 2♀ (CSUC).

Distribution. **USA – NC**.

Male. Macropterous. Body length 8.0 mm; forewing length 9.5 mm. General body pale yellow with brown markings. Dorsum of head with brown X-band which connects lateral ocelli to anterior ocellus and extends to frons; two faint spots occur posterolateral to median ocellus (Fig. 52.1). Antennae medium brown, scape brown. Pronotum pale brown with wide median pale stripe; middorsal pronotal suture brown; rugosities darker brown (Fig. 52.1). Meso- and metanota brown with paler markings. Wings pale, veins brown. Legs pale brown with brown shading. Terga yellowish brown, segments 9 and 10 unmodified (Fig. 52.4). Cerci dark brown. Paraprocts short, stout, lightly sclerotized; broadly rounded tips extend barely to edge of tergum 10 (Figs. 52.3, 52.4). Sterna paler; sternum 8 with well-developed vesicle, ca. as wide as long; vesicle evenly rounded at apex, slightly constricted at base, with small fine hairs (Fig. 52.2). Aedeagus membranous with expanded, paired, hemispherical apical lobes (Figs. 52.6d, 52.7d), a pair of ventroproximal lobes (Figs. 52.6a, 52.7b) and a pair of posteromedian lobes (Fig. 52.6b). Entire aedeagus covered with short stout spinulae (Fig. 52.6c); median posterodorsal sclerotized a median ridge-like row of large, heavy reddish brown spinesis located posterodorsally (Fig. 52.7c) and a posteroventral pair of sclerotized spine plates bear heavy reddish brown spines between the ventroproximal lobes; elongate patches are armed with tooth shaped spines with longest having incurved tips (Fig. 52.7a).



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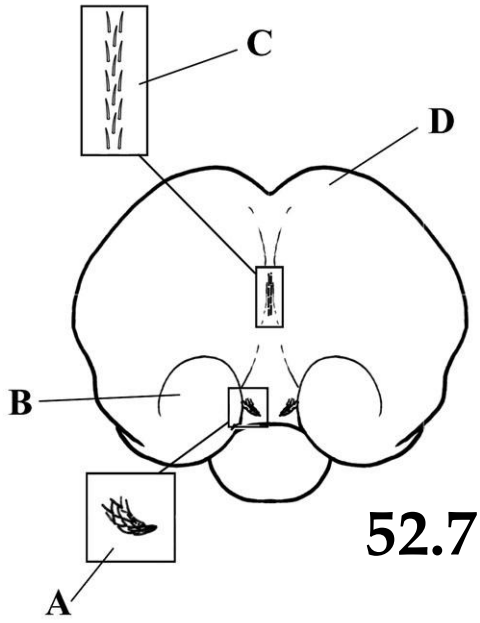


52.7

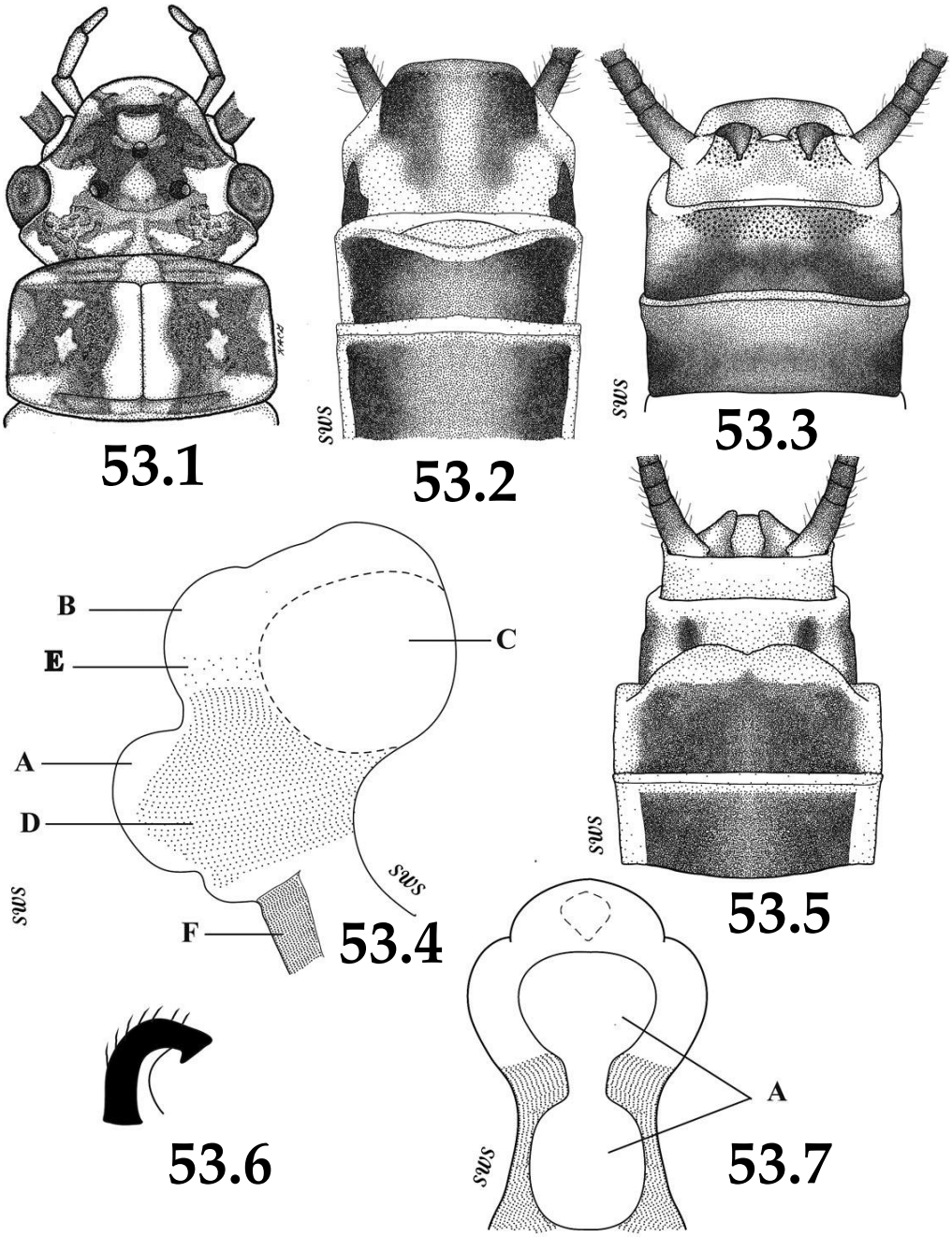
Figs. 52.6-52.7. *Isoperla siouan* sp. n. 52.6. Male aedeagus lateral view; a. paired ventroproximal lobes, b. paired posteromedian lobes, c. short stout spinulae, d. expanded paired hemispherical apical lobes. 52.7. Male aedeagus posterior view; a. paired posteroventral sclerotized spine plates with heavy reddish brown spines, b. paired ventroproximal lobes, c. median posterodorsal sclerotized ridge-like row of large, heavy reddish brown spines, d. expanded paired hemispherical apical lobes.

Female. Macropterous. Forewing length 11.0-11.5 mm. General body color and morphology similar to male. Subgenital plate produced ¼ length or less of sternum 9, broadly rounded (Fig. 52.5).
Ovum. Unknown.
Nymph. Unknown.
Etymology. With this species name we honor the Carolina Siouan Native American people. The Siouan were among the original inhabitants of North Carolina in the area of the type locality.
Diagnosis. *Isoperla siouan* sp. n. is a small pale colored *Isoperla* with dark brown bands connecting the ocelli. It is a member of the *I. signata* group (Table 1) and it shares the posterior spine plates with long reddish brown spines with these species. *Isoperla namata* and *I. kirchneri* sp. n. have a posterobasal tube, whereas *I. siouan* sp. n. and *I. signata* lack this structure. The head color pattern of *I. siouan* sp. n. is most similar to *I. kirchneri* sp. n., however the shape of the female subgenital plate, paraprocts, male vesicle and shape and specific spinule pattern of the aedeagus allow separation of these two species.
Biological Notes. No biological information is available for this species. *Isoperla siouan* sp. n. emerges in early May based on the single collection record. The type locality is in the Sandhills of North Carolina, a strip of ancient beach dunes that divides the Piedmont from the Coastal Plain. The major vegetational community consists of Longleaf Pine (*Pinus palustris* Miller), Loblolly Pine (*Pinus taeda* L.), and species of oak.

Isoperla slossonae (Banks)
Colorful Stripetail
(Figs. 1.14, 53.1-53.13)

Perla slossonae Banks 1911, 37:335. Holotype ♀ (MCZC) Franconia (Grafton Co.), New Hampshire. Examined.
Clioperla annecta Needham and Claassen 1925, 11:140. Holotype ♀ (CUIC) Black Rock (Clinton Co.), New York. Syn. Frison 1942, 22:329.
Isoperla slossonae: Frison, 1942, 22:329.

Distribution. **CANADA** – **NB** (Ricker 1947, Ricker 1964), **NS** (Frison 1942, Ricker 1947, Kondratieff and Baumann 1994), **PE** (Kondratieff and Baumann 1994), **PQ** (Needham and Claassen 1925). **USA – IA** (Heimdal et al. 2004), **ME** (Frison 1942), **MI** (Frison 1942), **MN** (Frison 1942, Harden and Mickel 1952, Lager et al. 1979), **NC** (Kondratieff et al. 1995), **NH** (Needham and Claassen 1925, Frison 1942), **NY** (Needham and Claassen 1925), **PA** (Masteller 1996a), **WI** (Frison 1942, Hilsenhoff and Billmyer 1973), **WV** (Tarter and Nelson 2006), Griffith and Perry (1992).
New Records. USA –VA: Montgomery Co., Mill Creek, 0.5 mi Rte. 785, 4/IV/1977, D.L. LaRoche, 2♂, 2♀ (CSUC); Mill Creek at Old Mill, 18/III/1977, B.C. Kondratieff, 4♀ (CSUC); Mill Creek, Rte. 785, 15/IV/1980, J. Clark, 1♂ (CSUC); Mill Creek, Rte 785, 1/VI/1978, C.R. Parker, 2♀ (CSUC); Mill Creek, Rte. 785, 29/III/1977, P.K. Powell, 1♀ (CSUC); Mill Creek, Rte. 785, 14/IV/1981, G. Kelley 1♀ (CSUC); Mill Creek Rte. 785, 14/IV/1981, B.C. Kondratieff, 3♂ 5♀ (CSUC). Floyd Co., Dodd Creek, Rte. 8, nr. jct. Rte. 748, 22/IV/1980, 29/III/1977, B.C. Kondratieff, 4♂, 2♀ (CSUC); Same locality, 28/III/1980, B.C. Kondratieff, 1♀ (CSUC). Giles Co., Little Stony Creek, US 460 bridge, 12/IV/2001, J.B. Sandberg, 1♂, 1♀ (BYUC).
Additional Records. ME: Somerset Co., Trout Brook, Hwy 15, abv. Long Lake, 12/VI/1993, R.W. Baumann, D. Potter, 3♀ (BYUC). **PA:** Clinton Co., Fishing Creek, Sieg Conference Center Narrow Road, 9/VI/2013, B.C. Kondratieff, J.B. Sandberg, 6♀ (CSUC).
Male. Macropterous. Forewing length 9.0-11.0 mm. General body color dark brown in life, medium to dark brown in alcohol with darker brown or black markings. Dorsum of head with dark brown bands which connect ocelli and extend to antennal bases; pale spot in interocellar area closed posteriorly; medium brown bands extend from base of interocellar area to hind margin of head; medium brown bands extend from posterior margin of head laterally to base of eyes; frontoclypeal area with narrow, transverse medium brown band enclosing pale irregular shaped spot anterior to median ocellus (Fig. 53.1). Antennae medium to dark brown, scape dark brown. Pronotum with wide median pale stripe; middorsal pronotal suture with thin brown line; rugosities indistinct, dark; pronotal disks dark brown to black with several



Figs. 53.1-53.7. *Isoperla slossonae*. 53.1. Dorsal head and pronotal pattern. 53.2. Male posterior abdominal sterna. 53.3. Male posterior terga. 53.4. Male aedeagus lateral view; a large posteromedial lobe, b. posterodorsal membranous lobe, c. paired large anterodorsal membranous lobes, d. mesal broad area of dense stout spinulae, e. small, raised scattered bumps with single setae, f. sclerotized extension of 9th sternum extending onto posterobasal stalk. 53.5. Female subgenital plate ventral view. 53.6. Male paraproct lateral view. 53.7. Male aedeagus posterior view; a. posterior membranous dumbbell-shaped raised area.

irregular shaped pale spots; anterior margin dark brown to black, lateral margins dark with a lateromedian pale spot (Fig. 53.1). Mesonotum mostly dark brown with broad pale anteromedian spot; metanota with small anteromedian pale spot. Wings dusky with dark brown veins. Legs medium brown, femora usually with a distal dark vertical brown band; tibia with proximal dark brown band. Sterna dark brown, abdominal pleural fold membranous, pale, well-developed on segments 1-8; sternum 8 with well-developed, wide, low vesicle, 3x as wide as long; vesicle usually paler than rest of sternum and expanded posteriorly to near anterior margin of sternum 9; sternum 9 paler than anterior sterna with irregular dark brown markings (Fig. 53.2). Terga dark brown; tergum 9 with posterior band of short stout spinulae; tergum 10 with a small, bipartite patch of short stout spinulae, paler than anterior terga (Fig. 53.3). Paraprocts sclerotized, stout, bluntly pointed apically; paraproct tips curve outward slightly, and extend ⅓ distance over tergum 10; tips with a sharp ventral spur visible when viewed laterally (Figs. 53.3, 53.6). Cerci medium brown. Aedeagus with large posteromedial lobe (Fig. 53.4a) and smaller posterodorsal membranous lobe (Fig. 53.4b), a pair of large anterodorsal membranous lobes (Fig. 53.4c), a mesal broad area of dense stout spinulae which extend to near base of stalk (Figs. 53.4d, 53.9), a group of small, raised scattered bumps each with a single seta above mesal section (Figs. 53.4e, 53.10), membranous lobes with scattered groups of fine hair-like spinulae (Figs. 53.4c, 53.8), sclerotized extension of sternum 9 extending onto posterobasal stalk (Fig. 53.4f), posterior margin with a membranous dumbbell-shaped raised area (Fig. 53.7a).

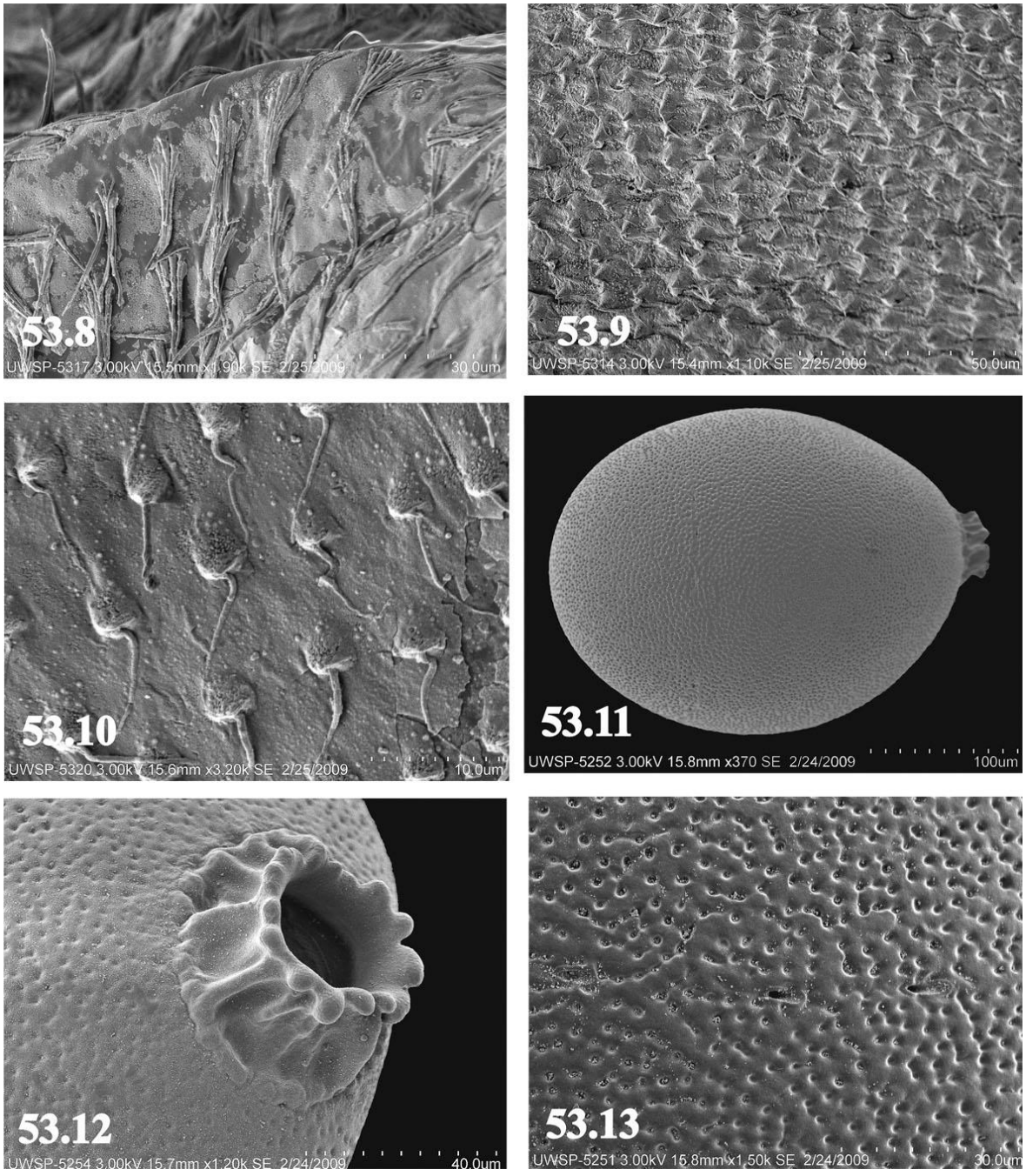
Female. Forewing length 11.0-13.0 mm. General body color and morphology similar to male described above. Subgenital plate produced posteriorly over ½ length of sternum 9, broadly rounded usually with a posteromedian emargination; posterior margin usually with broad pale area (Fig. 53.5).

Ovum. General shape oval, cross section circular. Color pale brown. Length 298 μm; width 224 μm (Fig. 53.11). Collar well-developed with apically flanged rim, stalked with elevated longitudinal carinae; base with raised irregular ridge (Fig. 53.12). Choronic surface covered with numerous small, shallow punctations; hexagonal follicle cell impressions faintly visible. Eclosion line absent. Micropyles arranged singularly, row sub-equatorial; orifices small occurring with slit-like openings (Fig. 53.13).

Nymph. Frison (1942) provided the original description and illustrated the habitus, lacinia and labium. Harden and Mickel (1952) illustrated the labrum, mandibles, labium, maxillae and habitus and Hilsenhoff and Billmyer (1973) illustrated the lacinia. Stark et al. (1998) and Stewart and Stark (2002) provided a color photograph of the habitus.

Diagnosis. This species belongs to the *I. phalerata* group (Szczytko & Stewart 1979a) (Table 1). This affinity is supported by the unusually colorful contrasting pigment pattern on the body, the presence of a dark brown vertical band on the femora, a well-developed membranous abdominal pleura on segments 1-8, similar aedeagal characteristics and the di-phasic drumming signal. *Isoperla slossonae* can be distinguished from other eastern *Isoperla* by the distinctive dark, contrasting color pattern especially the "checker board" pattern of the pronotum, the dark distal femoral vertical band and the shape and spinule pattern of the aedeagus. This is one of the larger and darker eastern *Isoperla* species; however, there is significant color variation among the different populations. The northern populations (Maine, Vermont, and Canadian Maritimes) are considerably darker than southern populations (West Virginia, Virginia, North Carolina) and the Midwestern populations are intermediate in darkness of coloration.

Biological Notes. *Isoperla slossonae* typically is found in low order streams and small rivers. Graham (1982) reported that the drumming signal of *I. slossonae* was di-phasic and very similar to that of *I. phalerata* and *I. pinta.* The male signal consisted of two phases with the first phase having a mean of 13.9 (± 9.54) beats and a mean interbeat frequency of 71.63 (± 27.09) ms. The second phase of the male signal had a mean of 12.68 (± 3.61) beats and a mean interbeat frequency of 18.86 (± 5.33) ms. The



Figs. 53.8-53.13. *Isoperla slossonae*. 53.8. Scattered groups of fine hair-like aedeagal spinulae. 53.9. Broad mesal area of dense stout aedeagal spinulae. 53.10. Raised scattered aedeagal bumps above mesal section with single apical setae. 53.11. Egg. 53.12. Oblique dorsal view of egg collar. 53.13. Detail of egg chorion and micropyles.

female signal was monophasic and had a mean of 9.79 (± 9.22) beats and a mean interbeat frequency of 73.90 (± 45.00) ms. Emergence occurs between late March and mid June based on collection records.

***Isoperla smithi* sp. n.**
West Virginia Stripetail
(Figs. 54.1-54.6)

Material Examined. USA – Holotype ♂, West Virginia: Hardy Co., 3 mi. NE Mathias, 38°55'N, 78°49'W, Malaise trap, 16-31/V/2000, D. Smith (USNM). **Paratypes: VA:** Montgomery Co., small trib. Craigs Creek, 0.6 mi E Hwy 460, 1/VI/1992, B.C. Kondratieff, 4♂, 7♀ (CSUC). Rappahannock Co., Rocky Run, Hughes River, end of Rte. 707, 11/VI/1979, P. Firth, L. Firth, 2♂ (CSUC). **WV:** Hardy Co., Same locality as holotype, 16-31/V/2000, D. Smith, Malaise trap, 3♂, 8♀ (USNM); Same locality, 2-23/VI/1996, T. Henry, D. Miller, D. Smith, 2♂, 32♀ (USNM); Same locality, 28/V/-9/VII/1995, T. Henry, D. Miller, D. Smith, 3♂, 10♀ (USNM); Same locality, 19/V-1/VI/1996, T. Henry, D. Miller, D. Smith 8♂, 9♀ (USNM); Same locality, 6-24/VI/2003, D. Smith, Malaise trap, 1♂, 54♀ (USNM); Same locality, 30/VI/-13/VII/2000, D. Smith, Malaise trap, 1♂, 11♀ (USNM); Same locality, 10-24/VIII/2003, D. Smith, Malaise trap, 4♀ (USNM); Same locality, 16-29/VI/2000, D. Smith, Malaise trap, 7♀ (USNM); Same locality, 28/V-4/VI/2004, D. Smith, Malaise trap, 7♂, 11♀ (USNM); Same locality, 15/V-5/VI/2003, D. Smith, Malaise trap, 1♂, 1♀ (USNM); Same locality, 31/V/-12/VI/2001, D. Smith, Malaise trap, 1♂, 1♀ (USNM); Same locality, 5-10/VI/1994, 15/V-5/VI/2003, D. Smith, Malaise trap, 14♂, 11♀ (USNM); Same locality, 25/VI/-9/VII/2003, D. Smith, Malaise trap, 6♀ (USNM); 5 km SW Lost City, T. Henry, D. Miller, D. Smith, 35♀ (USNM). Kanawha Co., Buzzard Branch, 16/V/1994, B.C. Kondratieff, R.F. Kirchner, 2♀ (CSUC).

Distribution. USA – VA, WV.

Male. Macropterous. Forewing length 10.0-11.0 mm. General body pale yellow. Dorsum of head with brown bands which connect lateral ocelli to anterior ocellus; bands truncate at anterior ocellus, interocular area diffuse brown with a pale central spot and a large brown spot anterior to anterior ocellus (Fig. 54.1). Antennae brown, scape pale brown. Pronotum yellow, middorsal pronotal suture brown, disks pale brown; rugosities wide, slightly darker (Fig. 54.1). Meso- and metanota yellow with brown markings. Wings pale, veins brown. Legs yellow. Terga brown; tergum 10 paler. Paraprocts medium in length, sclerotized dorsally with tips blunt and recurved over tergum 10 (Figs. 54.2, 54.5). Sterna yellow. Sternum 8 with well-developed, sclerotized vesicle, as wide as long and broadly rounded (Fig. 54.3); posterior margin of sternum dark. Cerci yellow. Unextruded aedeagus membranous with a posteroproximal sclerotized triangular arrowhead-shaped, spine patch covered with stout golden ventrally projecting spinulae (Fig. 54.4d), which bear a sharp elongate distal spine (Fig. 54.4c); proximal lobe with dense golden brown stout spinulae (Fig. 54.4a) and an elongate row of golden brown setal spines (Fig. 54.4b).

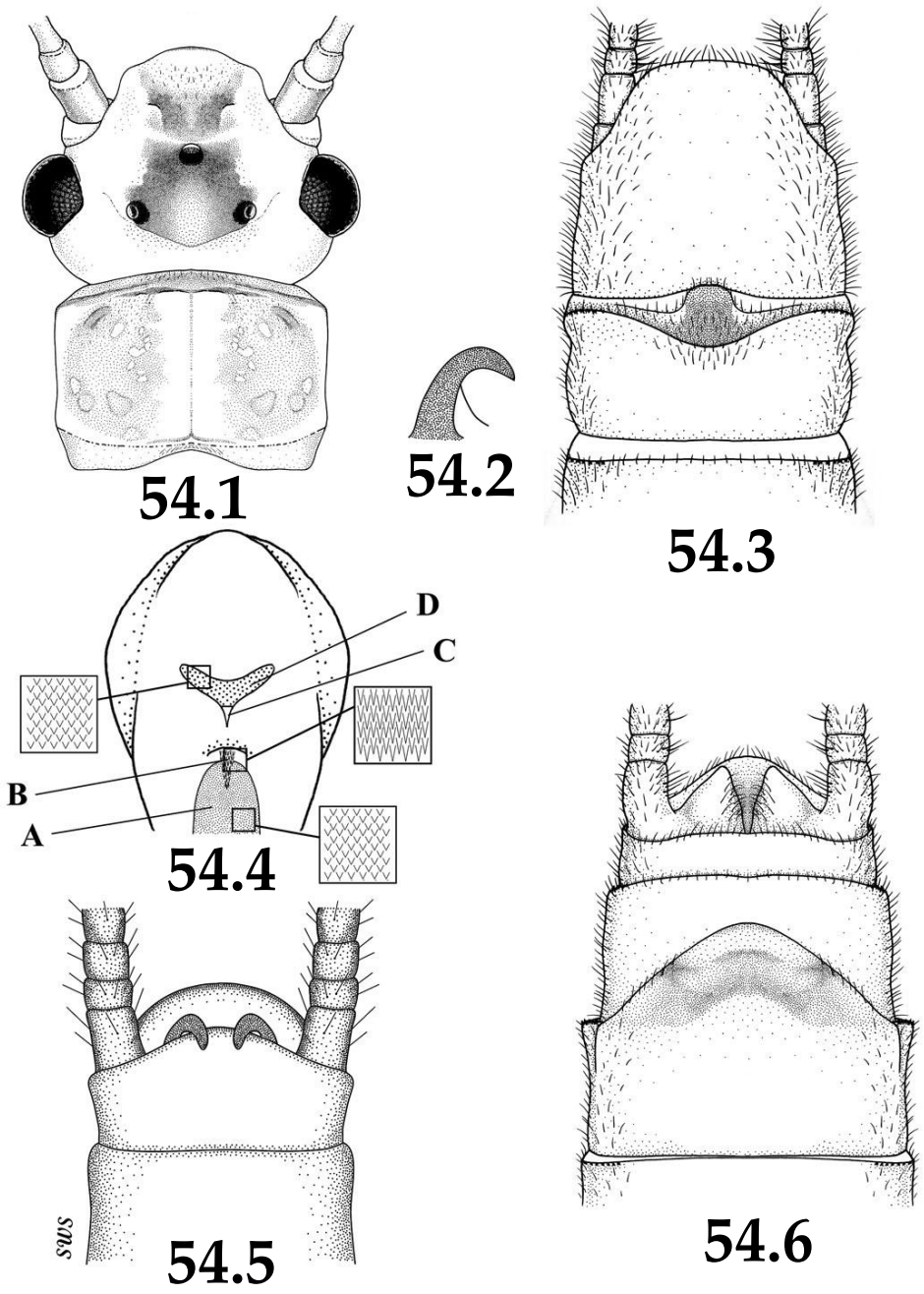
Female. Macropterous. Forewing length 11-13 mm. General body color and morphology similar to male. Subgenital plate, elongate, produced ½ or more of the length of sternum 9, subtriangular with apex rounded (Fig. 54.6). In some specimens the apical ⅓ of the plate is strongly deflected ventrally.

Ovum. Unknown.

Nymph. Unknown.

Etymology. The patronym honors Dr. David R. Smith, Systematic Entomology Laboratory, Agricultural Research Service, U.S.D.A., Washington, D.C., who collected the holotype and other specimens of *Isoperla* useful for our studies in Malaise traps set for collecting Hymenoptera.

Diagnosis. *Isoperla smithi* sp. n. is a member of the *I. montana* species group (Table 1) which includes *I. montana* and *I. nelsoni* sp. n. The head pattern is most similar to *I. nelsoni* sp. n. and is darker than that of *I. montana.* It differs from these species by the specific shape and spinule patterns of the aedeagus; however, it shares the distinctive sclerotized arrowhead-shaped aedeagal spine plate with these species. Since we did not have a specimen with everted aedeagus to study, it is uncertain whether this species possesses a posterobasal membranous aedeagal tube as present



Figs. 54.1-54.6. *Isoperla smithi* sp.n. 54.1. Dorsal head and pronotal pattern. 54.2. Male paraproct lateral view. 54.3. Male posterior abdominal sterna. 54.4. Male aedeagus posterior view; a. proximal lobe with dense golden brown stout spinulae, b. elongate row of golden brown setal spines, c. sharp elongate distal spine on triangular arrowhead-shaped, spine plate, d. posteroproximal sclerotized triangular arrowhead-shaped, spine plate covered with stout golden ventrally projecting spinulae. 54.5. Male posterior terga. 54.6. Female subgenital plate ventral view.

on the aedeagus of the other two species of the group. *Isoperla smithi* sp. n. is an uncommon species, but ranges from the Appalachian Plateau of West Virginia to the Piedmont of Virginia.

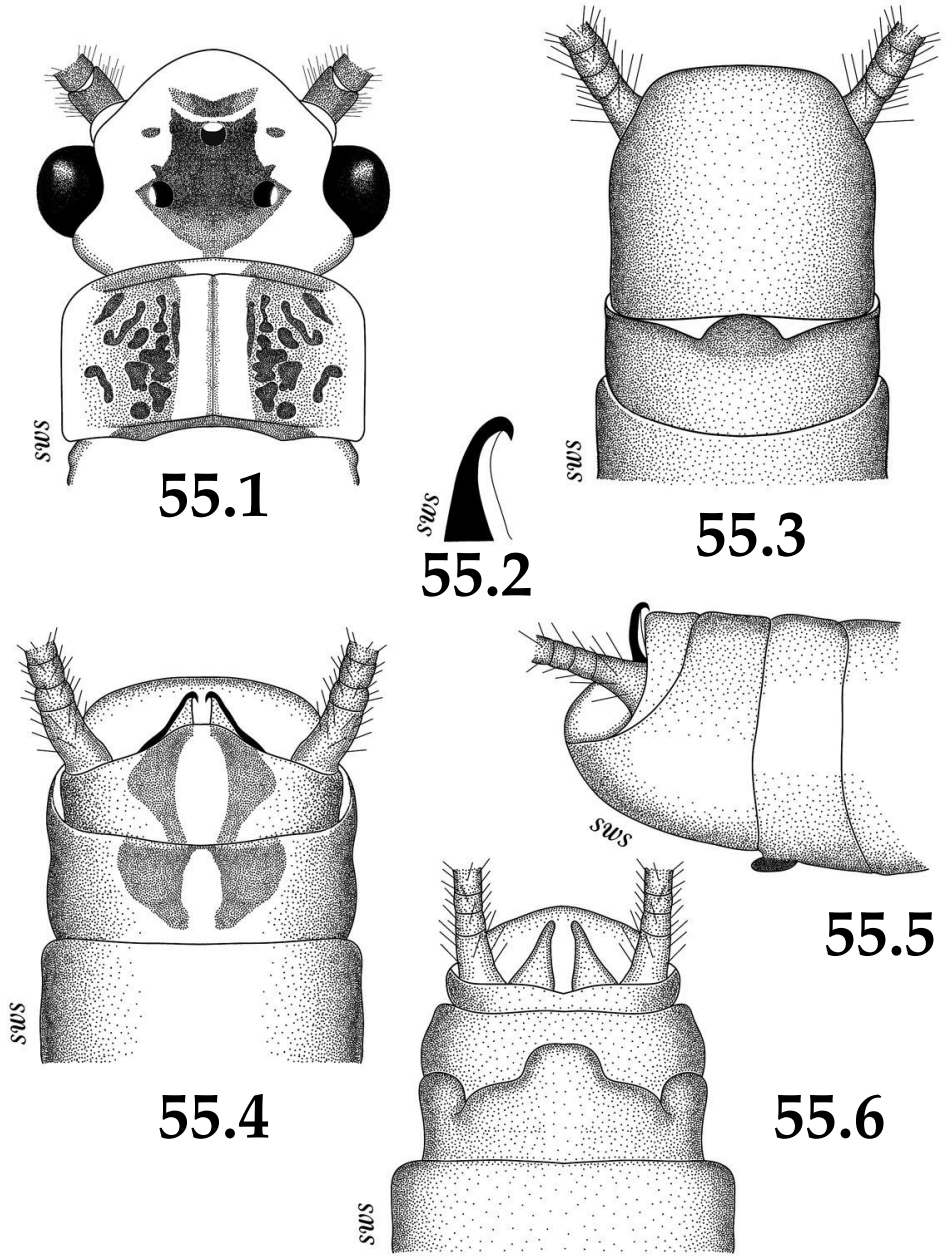
Biological Notes. *Isoperla smithi* sp. n. apparently emerges from mid- to late May based on collection records. The life history and ecology of this species are unknown.

Isoperla starki sp. n.
Wayah Stripetail
(Figs. 55.1-55.24)

Material Examined. **USA – Holotype** ♂, **North Carolina:** Macon Co., Robin Branch, Wayah Bald, 35.10074°N, 83.35436°W, 20/V/2009, B.P. Stark (USNM). **Paratypes. NC:** Macon Co., Same locality as holotype, 35.10074°N, 83.35436°W, 20/V/2009, B.P. Stark,1♂, 2♀ (BPSC); Same locality, 24/V/2006, B.P. Stark, I. Sivec, 1♂ (BPSC); Same locality, 9/VI/1998, B.P. Stark, J. Wise, J. Carter, 3♂, 1♀ (BPSC); Same locality, 9/VI/1998, B.P. Stark, 1♂ (BPSC); Same locality, 13/VI/1996, B.P. Stark, 2♀ (BPSC); Wayah Creek, below Berties Falls, 9/V/2000, B.P. Stark, 1♂ (BPSC); Same locality, 24/V/2006, B.P. Stark, I. Sivec, 1♀ (BPSC).

Distribution. **USA – NC.**

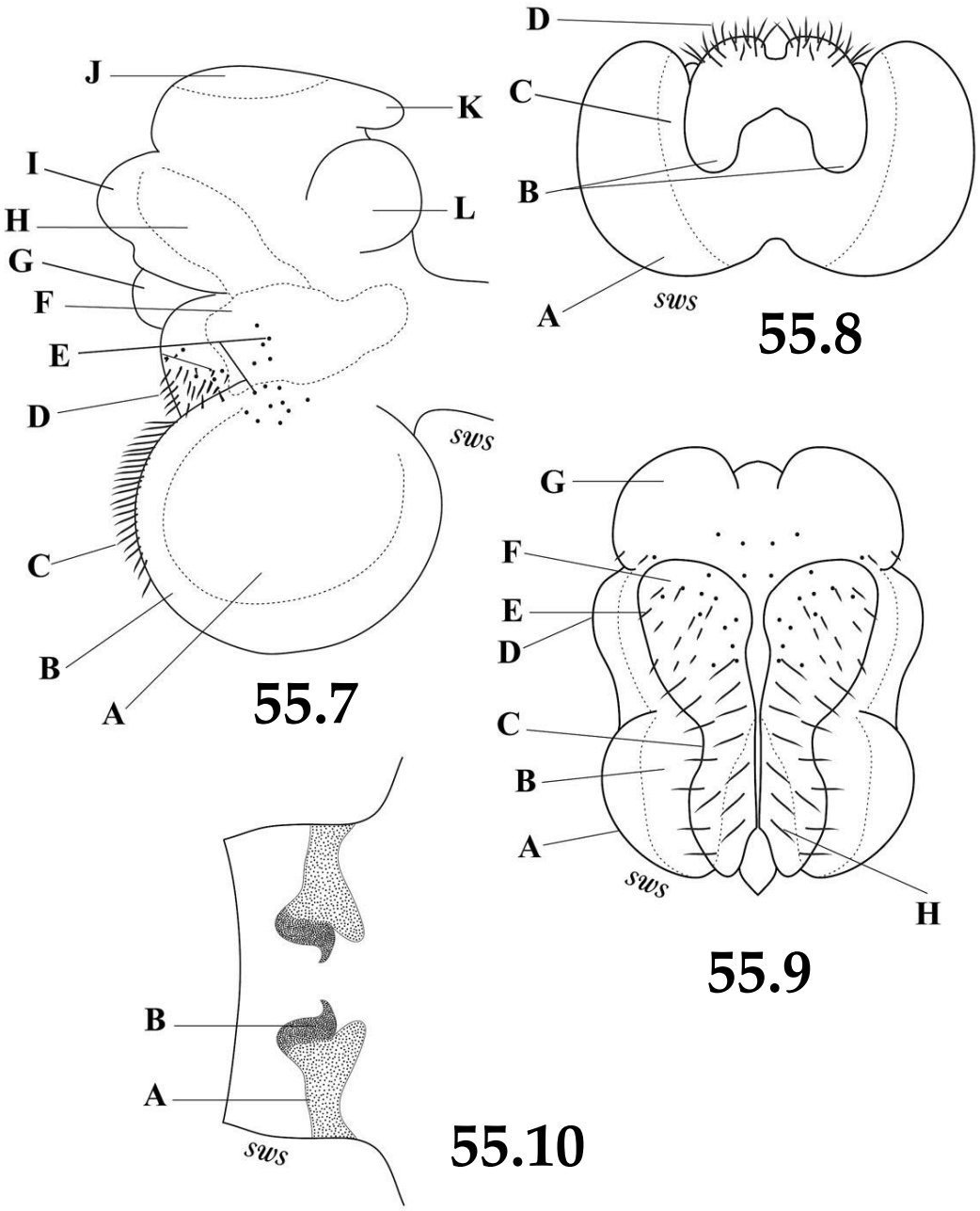
Male. Macropterous. Forewing length 10.8-11.5 mm. General body coloration pale yellow with medium and dark brown markings. Dorsum of head with large dark brown patch covering ocelli and interocellar area, extending anterolaterally beyond median ocellus; a small triangular patch of minute stout setae occur anterior to lateral ocelli; pale brown triangular band extends from lateral ocelli to posterior margin of head; small pale brown spots occur lateral to median ocellus; thin pale brown anteromedian patch forward of median ocellus is separated from large dark brown interocellar area by thin pale band (Fig. 55.1). Antennal scape pale yellow, pedicel and flagellum dark brown. Pronotum with a median pale slightly hourglass-shaped stripe; middorsal pronotal suture a faint pale brown line; rugosities irregular, raised, dark brown, pronotal disks pale yellow, anterior margin with broad bipartite medium brown bands; posterior margin with thin dark brown band; lateral margins with broad pale bands (Fig. 55.1). Meso- and metasterna pale yellow with wide medium brown lateral bands. Meso- and metanota mostly medium/dark brown with irregular shaped pale anteromedian areas. Wings hyaline, veins medium brown. Legs pale brown; femora with dark dorsal band, tibia with dark brown band near proximal 1/5, tarsi medium brown. Sterna pale yellow; sternum 8 with a thin incomplete dark brown posterior band; vesicle well-developed, medium brown, 2X as wide as long; posterior vesicle margin evenly rounded, extending posteriorly slightly over anterior margin of sternum 9 (Fig. 55.3). Terga pale brown with a mesal medium brown longitudinal band on segments 1-8; terga 9-10 with bipartite medium brown mesal triangular patches (occasionally faded in older preserved material); terga 9-10 not elevated (Figs. 55.4, 55.5). Paraprocts sclerotized, long, thin, erect and not recurved over tergum 10; paraprocts broad basally, tapering to sharp points apically and deflected ventrad at tip (Figs. 55.2, 55.4, 55.5). Cerci pale yellow. Aedeagus with paired, large rounded, posteroventral lobes (Figs. 55.7a, 55.7b, 55.8a, 55.9a) which bear low plates with numerous short stout finger-like spinulae, usually armed with a median larger spine (Figs. 55.7b, 55.11, 55.12, 55.13, 55.8a); posteromedian margin with paired posteromedian bipartite, elongate hemispherical lobes which bear long, stout, socketed spines on ventral ½ (Figs. 55.7c, 55.8b, 55.9c, h, 55.14, 55.15); area between hemispherical lobes and outer large lobes devoid of spinulae (Figs. 55.8c, 55.9b, 55.14); ventral area of hemispherical lobes surrounding large socketed spinulae covered with small shell-like plates with numerous small, fine projecting spines (Fig. 55.15); apical ⅓ of hemispherical lobes with sparse concentration of medium length stout, socketed spines (Figs. 55.7d, 55.9e) and scattered stout sensilla basiconica (Figs. 55.7e, 55.9f, 55.16); mesal area above ventral lobes with scattered stout sensilla basiconica and rows of short sharp spinulae (Figs. 55.7f, 55.17); posteromesal area with paired small rounded lobes (Figs. 55.7g, 55.9d) and large cone-shaped lobe (Fig. 55.7i) devoid of spinulae; area mesal to lobes with dense short stout

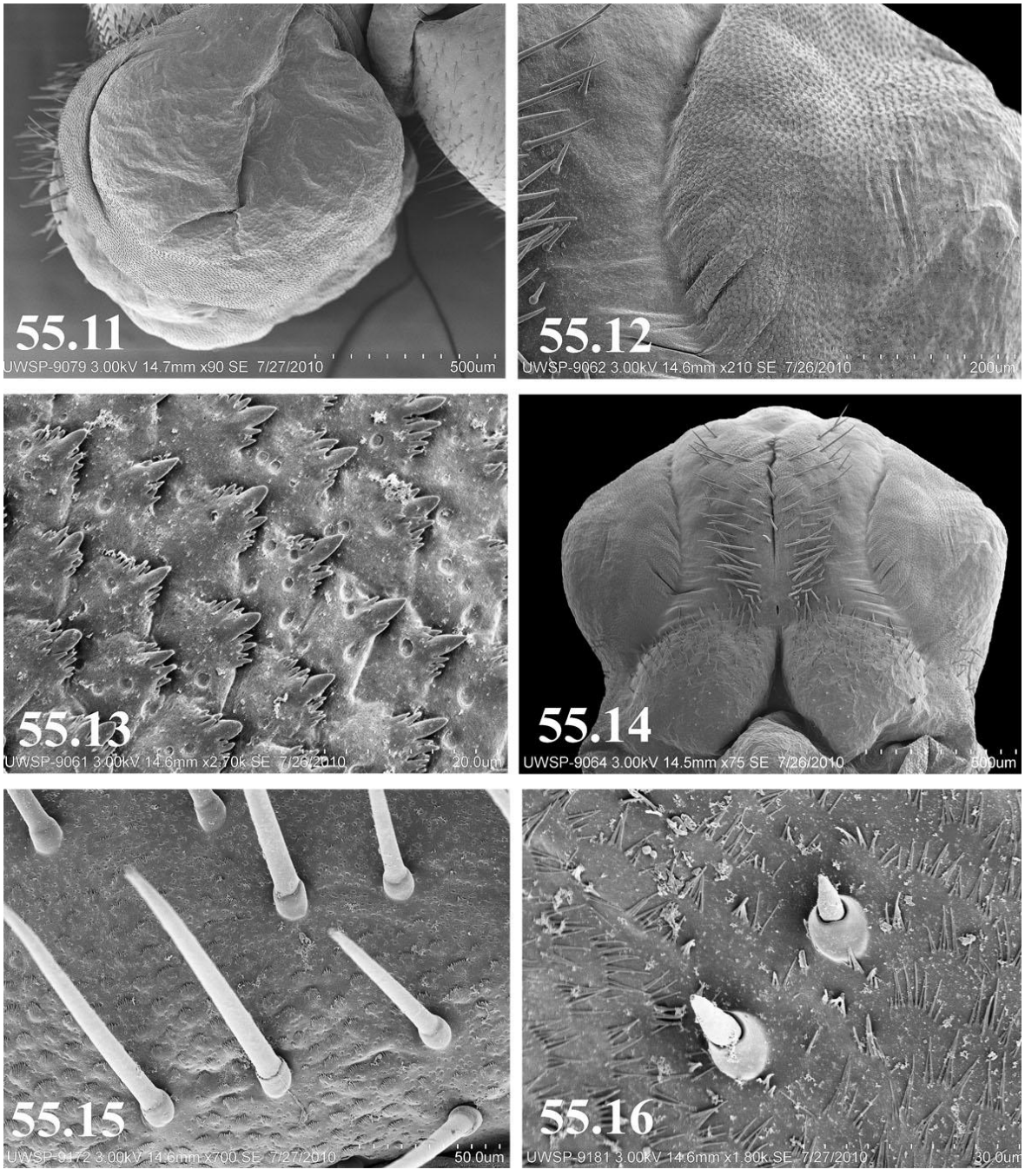


Figs. 55.1-55.6. *Isoperla starki* sp. n. 55.1. Dorsal head and pronotal pattern. 55.2. Male paraproct lateral view. 55.3. Male posterior abdominal sterna. 55.4. Male posterior abdominal terga. 55.5. Male posterior abdominal segments lateral view. 55.6. Female subgenital plate ventral view.

Figs. 55.7-55.10. *Isoperla starki* sp. n. 55.7. Male aedeagus lateral view; a. low plates with numerous short stout finger-like spinulae usually with a median larger spine, b. paired, large rounded, ventral lobes, c. long, stout, socketed spinulae, d. sparse concentration of medium length stout, socketed spines, e. scattered stout sensillae basiconica, f. patch of scattered stout sensillae basiconica and rows of short sharp spinulae, g. posteromesal small rounded lobe, h. dense short stout finger-like spinulae usually with a median larger spine, i. large cone-shaped lobe, j. dorsal area with a cap of long hair-like spinulae, k.

paired finger-like anterodorsal lobes void of spinulae, l. anteromesal paired rounded lobes void of spinulae. 55.8. Male aedeagus dorsal view; a. paired, large rounded, ventral lobes, b. paired median bipartite, elongate hemispherical lobes, c. area void of spinulae, d. long, stout, socketed spinulae. 55.9. Male aedeagus posterior view; a. paired, large rounded, ventral lobes, b. area void of spinulae, c. bipartite, elongate hemispherical lobes, d. e. sparse concentration of medium length stout, socketed spines, f. area of scattered stout sensillae basiconica, g. paired small rounded posteromesal lobes, h. long, stout, socketed spinulae. 55.10. Paired bipartite dorsobasal sclerotized aedeagal spine plates with stout spinulae.

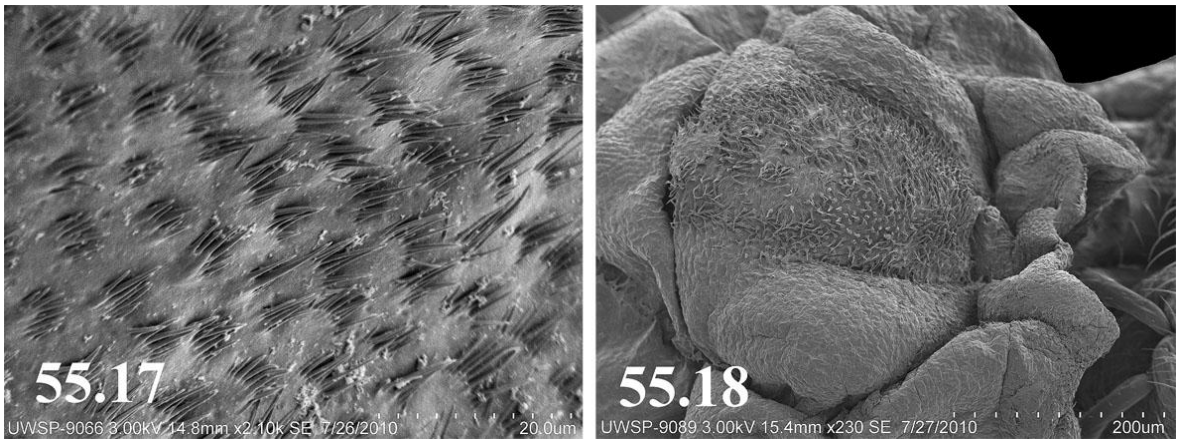




Figs. 55.11-55.16. *Isoperla starki* sp. n. 55.11. Paired, large rounded, posteroventral aedeagal lobes. 55.12. Low plates with numerous short stout finger-like aedeagal spinulae usually with a median larger spine. 55.13. Detail low plates with numerous short stout finger-like aedeagal spinulae usually with a median larger spine. 55.14. Paired posteromedian bipartite, elongate hemispherical aedeagal lobes. 55.15. Long, stout, socketed aedeagal spines on ventral ½ of hemispherical lobes. 55.16. Detail of aedeagal stout sensillae basiconica.

finger-like spinulae usually bearing a median larger spine (Figs. 55.7h, 55.13); dorsal area with a patch of long hair-like spinulae (Figs. 55.7j, 55.17, 55.18); anterodorsal area with paired finger-like lobes devoid of spinulae (Fig. 55.7k); anteromesal paired rounded lobes devoid of spinulae (Fig. 55.7l); basal stalk with paired bipartite dorsobasal sclerotized spine plates with stout spinulae (Fig. 55.10 a) and mesal hooked sclerotized spines (Figs. 55.10b).

Female. Forewing length 12.0-12.8 mm. General body color and morphology similar to male described above. Sternum 8 with a broad subgenital plate with apically truncate nipple, which extends to near ½ posterior margin of sternum 10 (Fig. 55.6).



Figs. 55.17-55.18. *Isoperla starki* sp. n. 55.17. Detail of aedeagal rows of long hair-like spinulae on dorsal area. 55.18. Aedeagal spinulae on dorsal area.

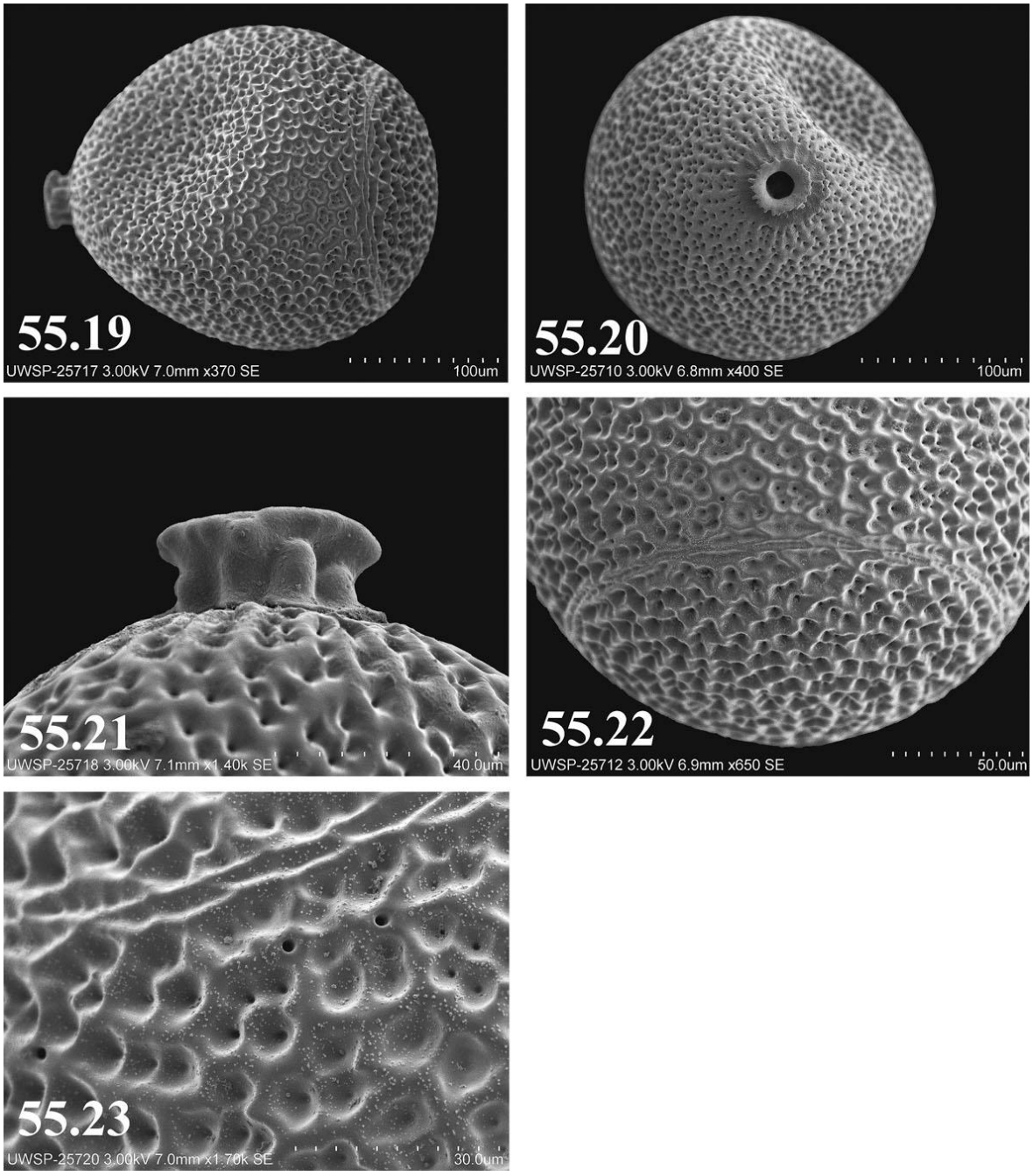
Ovum. General shape oblong, cross section concave (Figs. 55.19, 55.20). Color pale brown. Length 297 µm; width 246 µm. Collar elevated, with apically flanged rim; base with raised thick longitudinal carinae (Figs. 55.19, 55.20, 55.21). Hexagonal follicle cell impressions well-developed, walls raised, ridges thick (Figs. 55.22, 55.23). Eclosion line developed with low sinuous ridges. Micropyles positioned singularly on FCI ridges near anterior ⅓; orifices small without accessory structure (Figs. 55.22, 55.23).

Nymph. Unknown.

Etymology. We honor the well-known plecopterologist, valued collaborator and friend, Dr. Bill P. Stark, Mississippi College, who has extensively collected the streams of Wayah Bald and provided the first material of this species. He also provided much additional material used in this study.

Diagnosis. *Isoperla starki* sp. n. is a medium sized pale yellow *Isoperla* with dark brown markings and a member of the *I. similis* species group (Table 1). It can be distinguished in the male from these latter species by the long, thin sclerotized erect paraprocts and by the distinctive shape of the everted aedeagus which has posteroventral lobes bearing a median larger spine. The broad subgenital plate of the female with a distinctive truncate nipple is unique among known eastern North American *Isoperla*.

Biological Notes. Adult *I. starki* sp. n. were collected from mid-May through mid-June. Nothing is known about the biology or life cycle of this species. Nymphs are apparently restricted to spring seeps and similar habitats. Wayah Bald rises to 1,624 m, and is named after the Cherokee Native American word, "Wa ya" for the red wolves (*Canis lupus rufus* Audubon & Bachman) that once lived



Figs. 55.19-55.23. *Isoperla starki* sp. n. 55.19. Egg. 55.20. Egg, dorsal view showing concave profile. 55.21. Detail of egg collar. 55.22. Detail of egg eclosion line. 55.23. Detail of egg micropyles.

Fig. 55.24. *Isoperla starki* sp. n. Female NC: Macon Co., Robin Branch, 24/V/2006, B.P. Stark. Photo by Bill P. Stark.

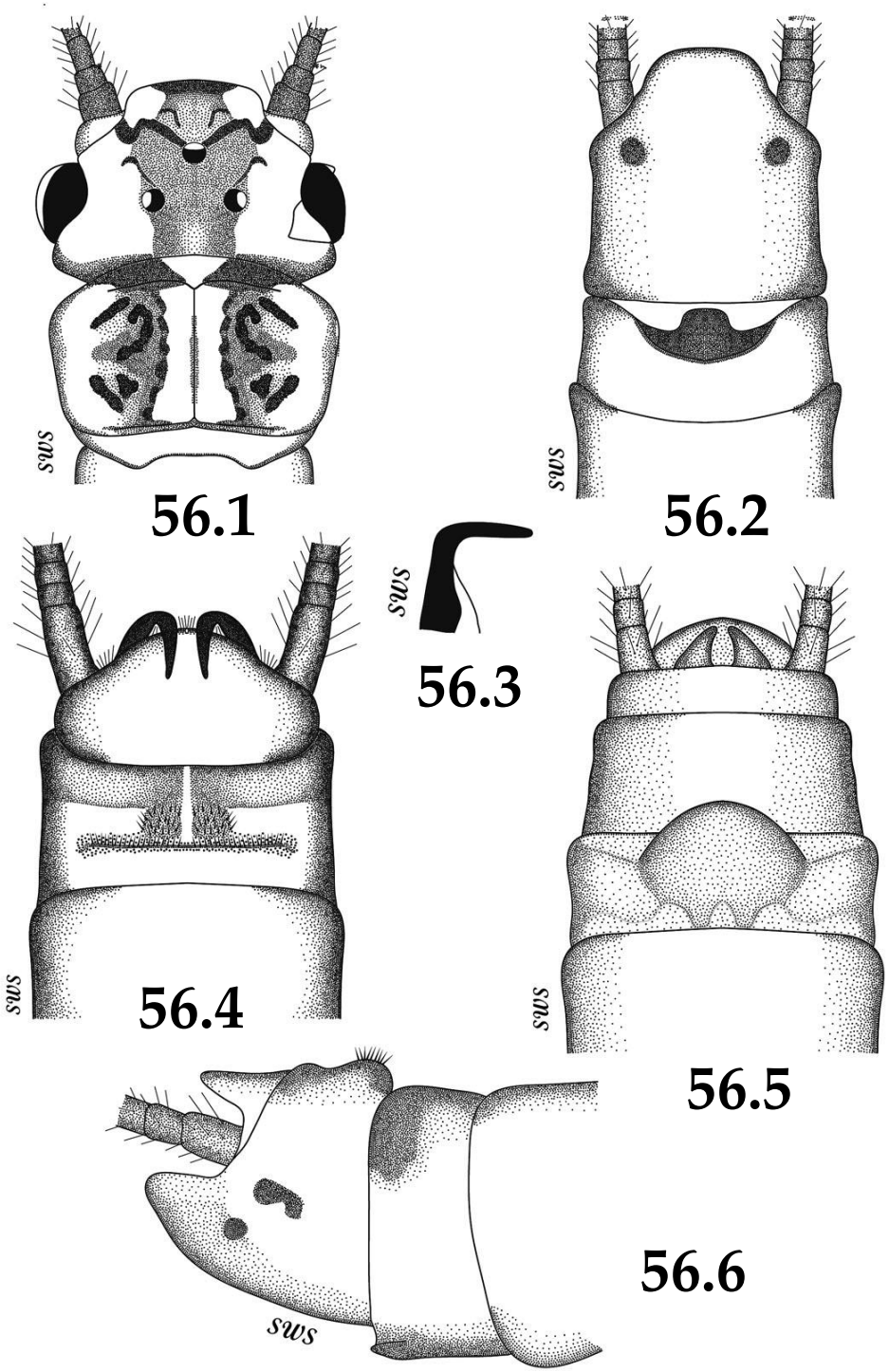
on its slopes. The type locality is a first order high gradient stream with numerous spring seep tributaries at approximately 1,433 m elevation in the Nantahala National Forest. This habitat is best described as hypocrenon and, as such, is unique and potentially in peril from watershed changes including land use and global climate change. Other common stoneflies of interest that occur in Robin Branch are robust populations of the perlid *Beloneuria georgiana* (Banks) and peltoperlid *Viehoperla ada* (Needham and Smith).

Isoperla stewarti sp. n.
Stewart Stripetail
(Figs. 56.1-56.9)

Material Examined. USA – Holotype ♂, North Carolina: Yancey Co., Right Prong, Hwy 128, Mt. Mitchell State Park, 35.72971N, 82.28294W, 14//V/2010, B.C. Kondratieff, R.E. Zuellig, D.R. Lenat, R.F. Kirchner (USNM). Paratypes: NC: Yancey Co., Spring near top of Mt. Mitchell, Hwy 128, Mt. Mitchell State Park, 35.76647N, 82.26453W, 14/5/2010, B.C. Kondratieff, R.E. Zuellig, D.R. Lenat, R.F. Kirchner 2♂, 1♀ (CSUC). VA: Grayson Co., Springs off Lewis Fork Trail, Rte. 603, 11/V/1986, K.W. Stewart, B.C. Kondratieff, R.F. Kirchner, 1♂ (CSUC).

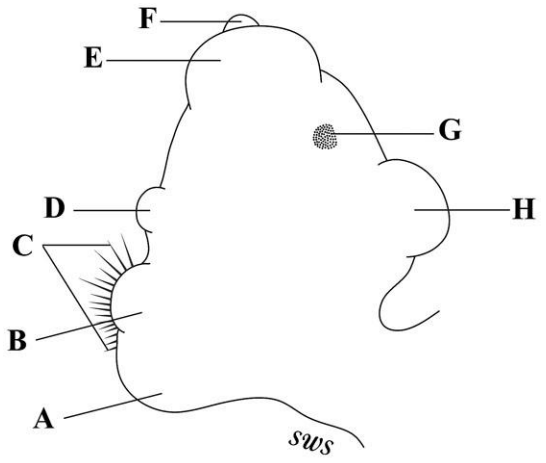
Distribution. USA – NC, VA.

Male. Macropterous. Forewing length 10.8-11.3 mm. General body pale yellow with medium to dark brown markings. Dorsum of head with a pale brown patch covering interocellar area and extending anteriorly to frons and posteromedially to hind margin of head; small thin medium brown bands extending anterolaterally from each lateral ocelli; wider undulating dark brown band extending anterolaterally from median ocellus to near antennal base; small thin anteromedian dark brown bands anterior to wide dark brown undulating band; frons dark brown (Fig. 56.1). Antennal scape pale yellow, pedicel and 1st flagellum segment dark brown, flagellar segments 2-5 pale brown, remaining segments medium brown. Pronotum pale yellow with wide median pale stripe, middorsal pronotal suture brown; disks pale, rugosities dark brown, lateral margins with wide pale bands; anterior margin with median

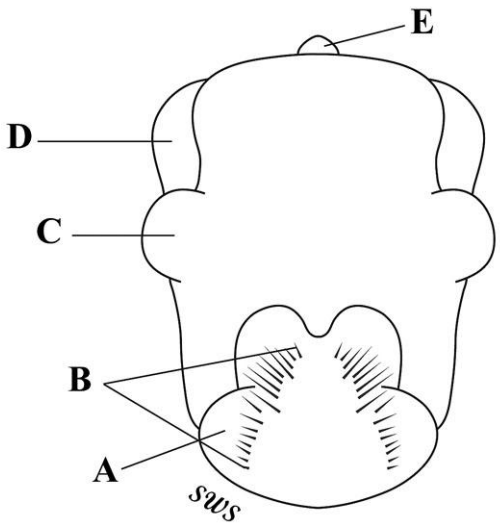


Figs. 56.1-56.6. *Isoperla stewarti* sp. n. 56.1. Dorsal head and pronotal pattern. 56.2. Male posterior abdominal sterna. 56.3. Male paraproct lateral view. 56.4. Male posterior abdominal terga. 56.5. Female subgenital plate ventral view. 56.6. Male posterior abdominal segments lateral view.

bipartite dark brown bands, posterior margin pale yellow (Fig. 56.1). Meso- and metanota with paired anteromedian large rounded medium brown patches; metesonotum mostly pale brown with pale mesal band; metanotum mostly pale brown. Wings hyaline, veins dark brown. Femur pale yellow with dorsal dark brown longitudinal band; tibia and tarsi medium brown, tibia with proximal vertical dark band near proximal ¼. Sterna pale brownish yellow. Sternum 8 with well-developed sclerotized vesicle, darker than rest of segment, broadly rounded apically, ca. 1.5X as wide as long; small round, dark brown spots near posterolateral corners (Fig. 56.2). Terga 1-7 pale brown, segments 5-7 with anterolateral patches of small, stout spinulae; segments 8-10 pale yellow; tergum 9 with a low median ridge on anterior ¼ which bears long stout setae (Figs. 56.4, 56.6); area posterior to ridge depressed slightly with bipartite pale brown mesal patches armed with medium length stout setae and scattered spinulae; posterior margin of tergum 10 fringed with medium length pale setae (Fig. 56.4). Cerci pale yellow. Paraprocts long, sclerotized, tips pointed, distal ½ nearly straight and extending over tergum 10 (Figs. 56.3, 56.4). Aedeagus membranous with large posterobasal lobe (Figs. 56.7a), a pair of posteroventral rounded lobes (Figs. 56.7b, 56.8a) which bear long stout golden brown dorsal spines and shorter ventral spines (Figs. 56.7,c, 56.8b), a small pait og rounded posteromesal lobes (Figs. 56.7d, 56.8c) a large pair of dorsal lobes (Figs. 56.7e, 56.8d), a small dorsal nipple-like lobe (Figs. 56.7f, 56.8e), a pair of anterodorsal patches of stout spinulae (Fig. 56.7g), a pair of anteromesal rounded medium sized lobes (Fig. 56.7h) and without sclerotized dorsal spine plates on aedeagal stalk.



56.7

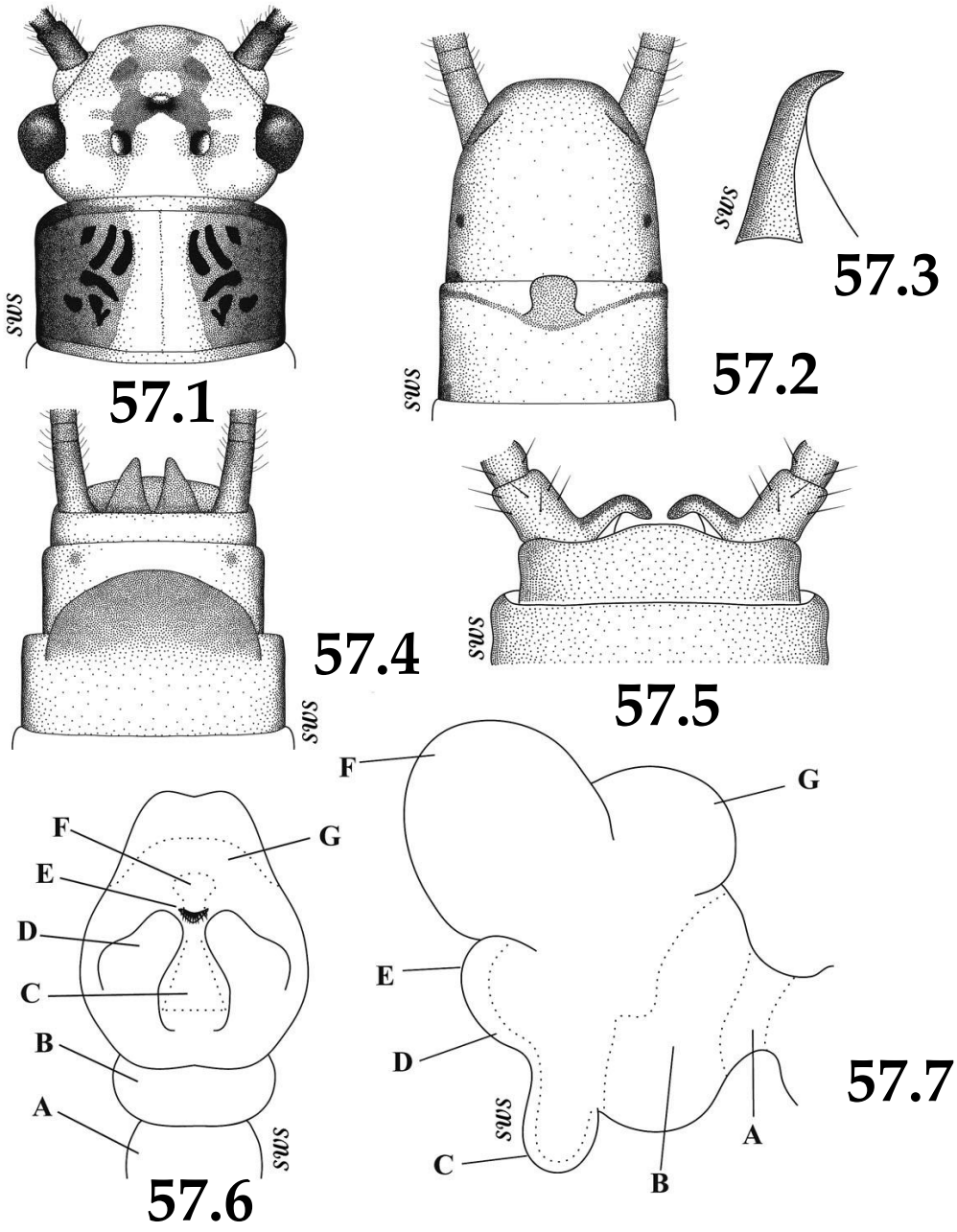


56.8

Figs. 56.7-56.8. *Isoperla stewarti* sp. n. 56.7. Male aedeagus lateral view; a. large posterobasal lobe, b. paired posteroventral rounded lobes, c. long stout golden brown spines, ventral spines shorted than dorsal spines, d. small paired rounded posteromesal lobes, e. large paired dorsal lobes, f. small dorsal nipple-like lobe, g. paired anterodorsal patches of stout spinulae, h. paired anteromesal rounded medium sized lobes. 56.8. Male aedeagus posterior view; a. paired posteroventral rounded lobes, b. long stout golden brown spines, ventral spines shorted than dorsal spines, c. small paired rounded posteromesal lobes, d. large paired dorsal lobes, e. small dorsal nipple-like lobe.

Fig. 56.9. *Isoperla stewarti* sp. n. VA: Smyth Co., CR600, Mt Rogers, 10/V/2012, B.P. Stark. Photo by Bill P. Stark.

Female. Forewing length 11.6 mm. General body color and morphology similar to male described above. Sternum 8 with a broadly triangular subgenital plate extending the length of sternum 9; darker than rest of segment (Fig. 56.5).
Ovum. Unknown.
Nymph. Unknown.
Etymology. The patronym honors the late Dr. Kenneth W. Stewart from the University of North Texas. Ken provided immense leadership in the study of the stoneflies in North America. He trained numerous professional stonefly workers in North America, and was a dear friend to both authors. He was part of an expedition that collected paratypes of this species.
Diagnosis. *Isoperla stewarti* sp. n. is a member of the *I. pseudosimilis* sp. n. species group (Table 1) that are distinguished by the presence of long stout straight golden or reddish brown aedeagal spines, and the absence of sclerotized spine bearing plates. The most distinctive characteristic of this species is the thin, dark, broadly W-shaped, dark brown band which extends anterolaterally from the median ocellus instead of the more typical thin pale bands other species in the group exhibit. Aedeagal shape and spine pattern are also distinctive for this species. These characters should allow separation from other species of *I. pseudosimilis* sp. n. species group. *Isoperla stewarti* sp. n. is most similar to *I. cherokee* sp. n. in general size and body coloration, however the shape and spinule pattern of the aedeagus and shape of the paraprocts are different. The head pattern of *I. stewarti* sp. n. also has thin dark bands which extend anterolaterally from the median ocellus to the antennal bases, whereas in *I. cherokee* sp. n. this band is pale; in addition, the paraprocts are nearly straight in *I. stewarti* sp. n. and those of *I. cherokee* sp. n. are distinctly bent and deflected downward. The aedeagus of *I. stewarti* sp. n. lacks the paired dorsal sclerotized spine plates on the aedeagal stalk and they are present in *I. cherokee* sp. n. (member of the *I. similis* group). The female subgenital plate is also most similar to *I. cherokee* sp. n., but is more broadly rounded and the color pattern of the head is different. The Mt. Mitchell area is also the apparent type locality of *I. bellona*, but that species, placed in the *I. similis* group, has



Figs. 57.1-57.7. *Isoperla szczytkoi*. 57.1. Dorsal head and pronotal pattern. 57.2. Male posterior abdominal sterna. 57.3. Male paraproct lateral view. 57.4. Female subgenital plate ventral view. 57.5. Male posterior abdominal terga. 57.6. Male aedeagus posterior view; a. concentrated patch of small stout rounded basal spinulae, b. dense patch of small sharp spinulae, c. triangular-shaped depressed area with dense small, shallow scale-liked sclerotized plates, d. paired posteroventral elongate lobes void of spinulae, e. wide "V" shaped horizontal row of 6-8 elongate, stout golden brown sclerotized teeth, f. posteromedian rounded lobe above basal area with concentrated small, shallow scale-liked sclerotized plates, g. area of dense stout, blunt, peg-like spinulae. 57.7. Male aedeagus lateral view; a. concentrated patch of small stout rounded basal spinulae, b. dense patch of small sharp spinulae, c. paired posteroventral elongate lobes void of spinulae, d. area of dense small, shallow scale-liked sclerotized plates, e. posteromedian rounded lobe, f. large posterodorsal, g. paired anteromesal lobes.

distinct spine plates on the adeagus, and these are lacking on the aedeagus of *I. stewarti* sp. n..

Biological Notes. *Isoperla stewarti* sp. n. is a second member of the *I. pseudosimilis* sp. n. species group to occur on Mt. Mitchell, along with *I. pauli* sp. n., and apparently with *I. bellona*. The type locality is a small stream draining Mt. Mitchell, the highest point east of the Mississippi River. Mt. Mitchell is part of the Black Mountains of the southern Appalachians which reach an elevation of 2,037 m. Paratypes were collected from rheocrenes draining Mt. Rogers, the highest natural point in Virginia with a summit elevation of 1,746 m. This area includes the northernmost habitat of the high elevation southern Appalachian spruce-fir forests. Nothing is known about the biology of this species. *Isoperla stewarti* sp. n. emerges in mid-May based on the collection records. Another stonefly of interest that was collected at the Mt. Mitchell site was the rare leuctrid, *Leuctra mitchellensis* Hanson.

Isoperla szczytkoi Poulton and Stewart
Magazine Stripetail
(Figs. 57.1-57.16)

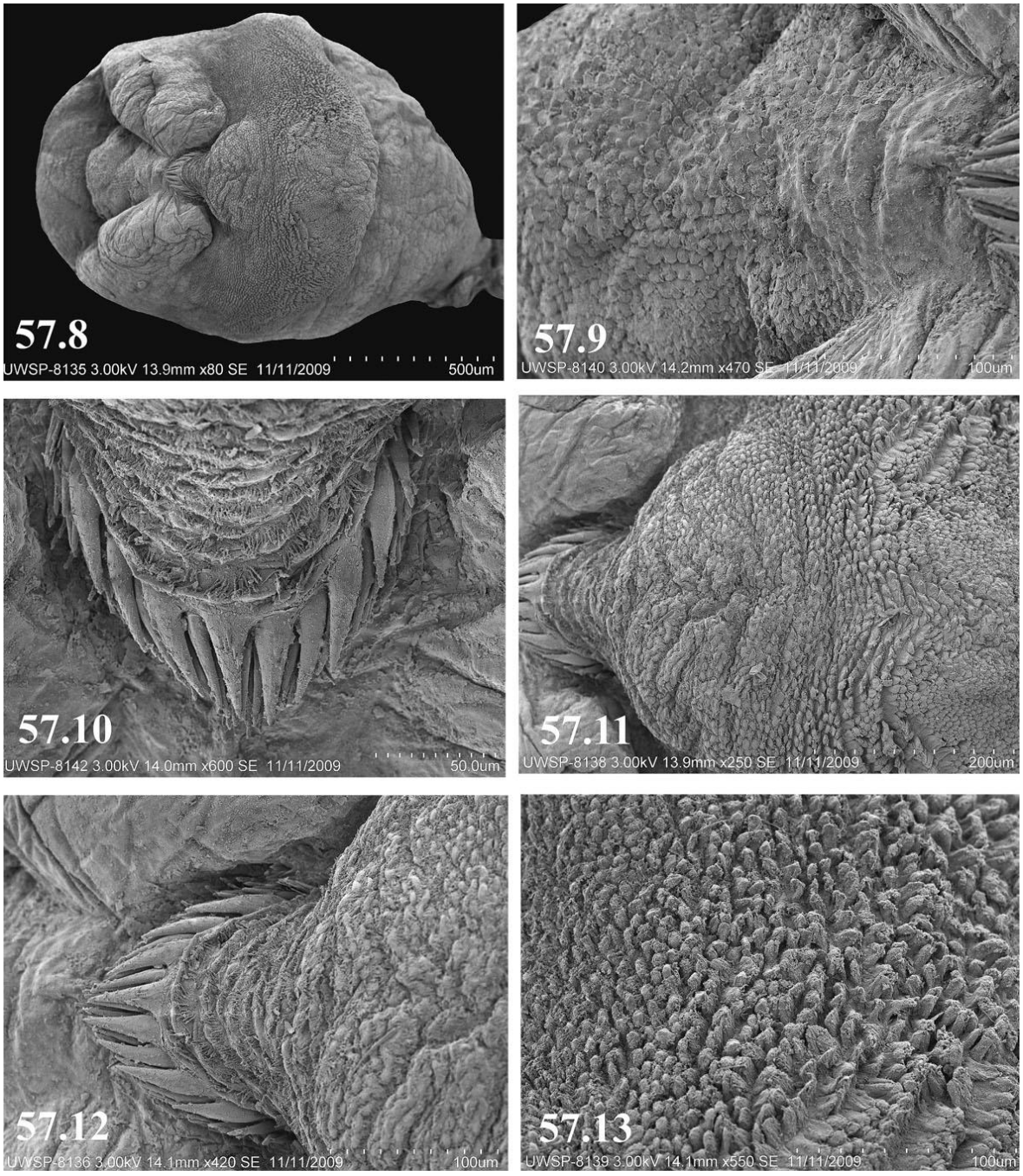
Isoperla szczytkoi Poulton and Stewart 1987, 89:298. Holotype ♂ (USNM), Gutter Rock Creek (Logan Co.), Arkansas. Examined.
Isoperla szczytkoi: Poulton and Stewart, 1991, 38:49.

Distribution. **USA – AR** (Poulton and Stewart 1987, Poulton and Stewart 1991).

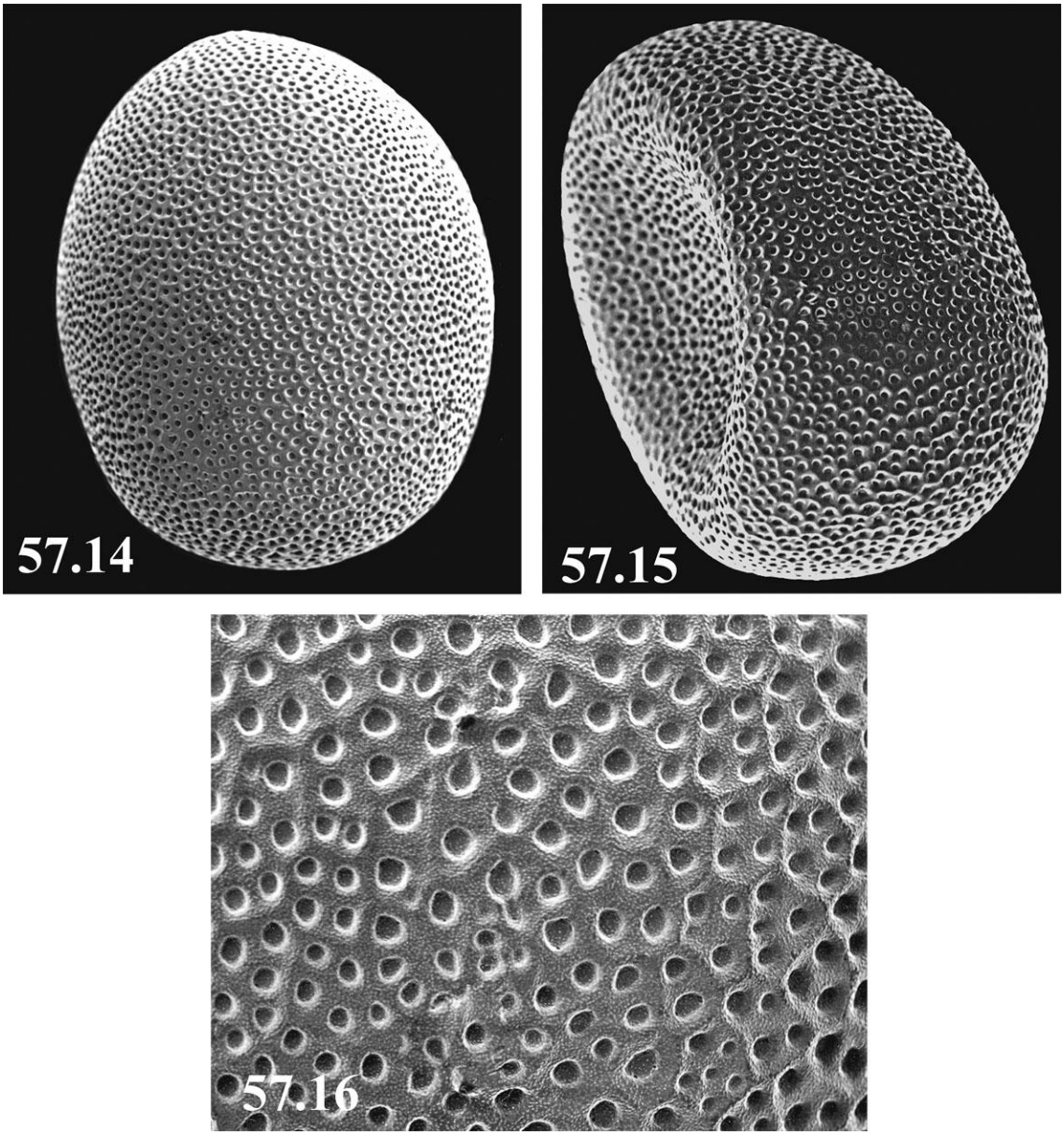
Male. Macropterous. Forewing length 8.6-11.4 mm. General body color pale brown in life with medium to dark brown markings. Dorsal head pattern with medium brown bands which connect ocelli and extend forward to frons; several diffuse lateral patches occur posterior to median ocellus and diffuse pale brown bands extend from lateral ocelli to posterior margin of head; a nearly round pale spot is located anterior to median ocellus (Fig. 57.1). Antennal scape, pedicel and flagellum medium brown. Pronotum with wide median, hourglass-shaped pale stripe; middorsal pronotal suture a thin brown line; rugosities irregular, raised, dark brown in fresh specimens, pronotal disks medium brown; anterior and posterior margins with medium brown bands interrupted medially (Fig. 57.1). Meso- and metanota mostly pale yellow with paired anterolateral round medium brown patches; pale median broad bands and diffuse medium brown markings occur posteriorly. Wings dusky, veins dark. Femora mostly pale yellow with an incomplete broad vertical medium brown band on distal ½; tibia and tarsi medium brown. Sterna pale yellow; sternum 8 with a medium brown vesicle, ca. 1.5-2 times as long as wide; vesicle evenly rounded posteriorly, extending to slightly over anterior margin of sternum 9 and usually darker than rest of segment (Fig. 57.2). Terga pale yellow. Paraprocts moderately sclerotized on outer margin, short, pointed apically, nearly erect, recurved slightly over tergum 10 and curved inward apically (Figs. 57.3, 57.5). Cercal segments 1-3 pale brown, remaining segments medium brown. Aedeagus with paired posteroventral elongate lobes devoid of spinulae (Figs. 57.6d, 57.7c, 57. 8), a triangular depressed posteromedian area between lobes which bear dense small, shallow scale-like sclerotized plates (Figs. 57.6c, 57.9), posteromedian area above triangular area with a wide V-shaped horizontal row of 6-8 elongate, stout golden brown sclerotized teeth and numerous additional small, more slender teeth occur beneath outer teeth (Figs. 57.6e, 57.8, 57.9, 57.10), a narrowed basal area above teeth is covered with shallow ridges and rows of fine hair-like setae which are difficult to discern (Fig. 57.10), a posteromedian rounded lobe bears dense small, shallow scale-like sclerotized plates (Figs. 57.6f, 57.8, 57.7d, e, 57.11, 57.12), the posteromesal area lateral to rounded lobe bears dense stout, blunt, peg-like spinulae (Figs. 57.6g, 57.13), a large posterodorsal (Fig. 57.7f) and a pair of anteromesal lobes (Fig. 57.7g) are devoid of spinulae, basal area armed with a dense patch of small sharp spinulae (Figs. 57.6b, 57.7b), and the basal stalk bears a dense patch of small stout rounded spinulae (Figs. 57.6a, 57.7a).

Female. Forewing length 11.0-12.9 mm. General body color and morphology similar to male described above. Subgenital plate broadly rounded posteriorly and extending to anterior ⅓-½ of sternum 9 (Fig. 57.4).

Ovum. General shape oval, cross section circular.



Figs. 57.8-57.13. *Isoperla szczytkoi*. 57.8. Male aedeagus oblique posterior view. 57.9. Triangular-shaped depressed aedeagal area with dense small, shallow scale-liked sclerotized plates. 57.10. Detail of wide "V" shaped horizontal row of 6-8 elongate, stout golden brown sclerotized aedeagal teeth. 57.11. Posteromedian rounded aedeagal lobe. 57.12. Posteromedian area above triangular area with a wide "V" shaped horizontal row of 6-8 elongate, stout golden brown sclerotized teeth. 57.13. Posteromesal dense stout, blunt, peg-like aedeagal spinulae.



Figs. 57.14-57.16. *Isoperla szczytkoi*. 57.14. Egg. 57.15. Egg lateral view showing concave profile. 57.16. Detail of egg chorion.

Color pale tan. Length 350 µm; width 270 µm (Fig. 57.14). Collar absent (Figs. 57.14, 57.15). Choronic surface covered with numerous small, deep punctations; hexagonal follicle cell impressions slightly visible, walls thickened and elevated slightly. Eclosion line absent. Micropyles not apparent (Fig. 57.16).

Nymph. Mouthparts and habitus were illustrated by Poulton and Stewart (1987).

Diagnosis. *Isoperla szczytkoi* is assigned to the *I. irregularis* group which includes four sympatric species (Table 1). This placement is supported by

the presence of a concave egg with no collar, reduced hexagonal follicle cell impressions, a nymphal lacinia with reduced or absent subapical tooth and marginal lacinial setae which continue to near the base and a deeply cleft right mandible with two or three apical teeth. The male of *I. szczytkoi* is distinguished from the above species by the posterior wide V-shaped patch of six to eight long, stout posteromedian aedeagal teeth.

Biological Notes. *Isoperla szczytkoi* is known only from the type locality Gutter Rock Creek on Mt. Magazine in Logan Co., Arkansas. This first order stream is intermittent, typical of the region. Mt. Magazine, the highest mountain in Arkansas, is a flat-topped plateau with a sandstone cap which reaches an elevation of 823 m. Based on the limited collecting data the emergence period generally occurs during mid to late April. Poulton and Stewart (1991) did not find *I. szczytkoi* in other streams in the area and indicated that it was probably restricted to the type locality.

Isoperla transmarina (Newman)
Boreal Stripetail
(Figs. 1.15, 58.1-58.16)

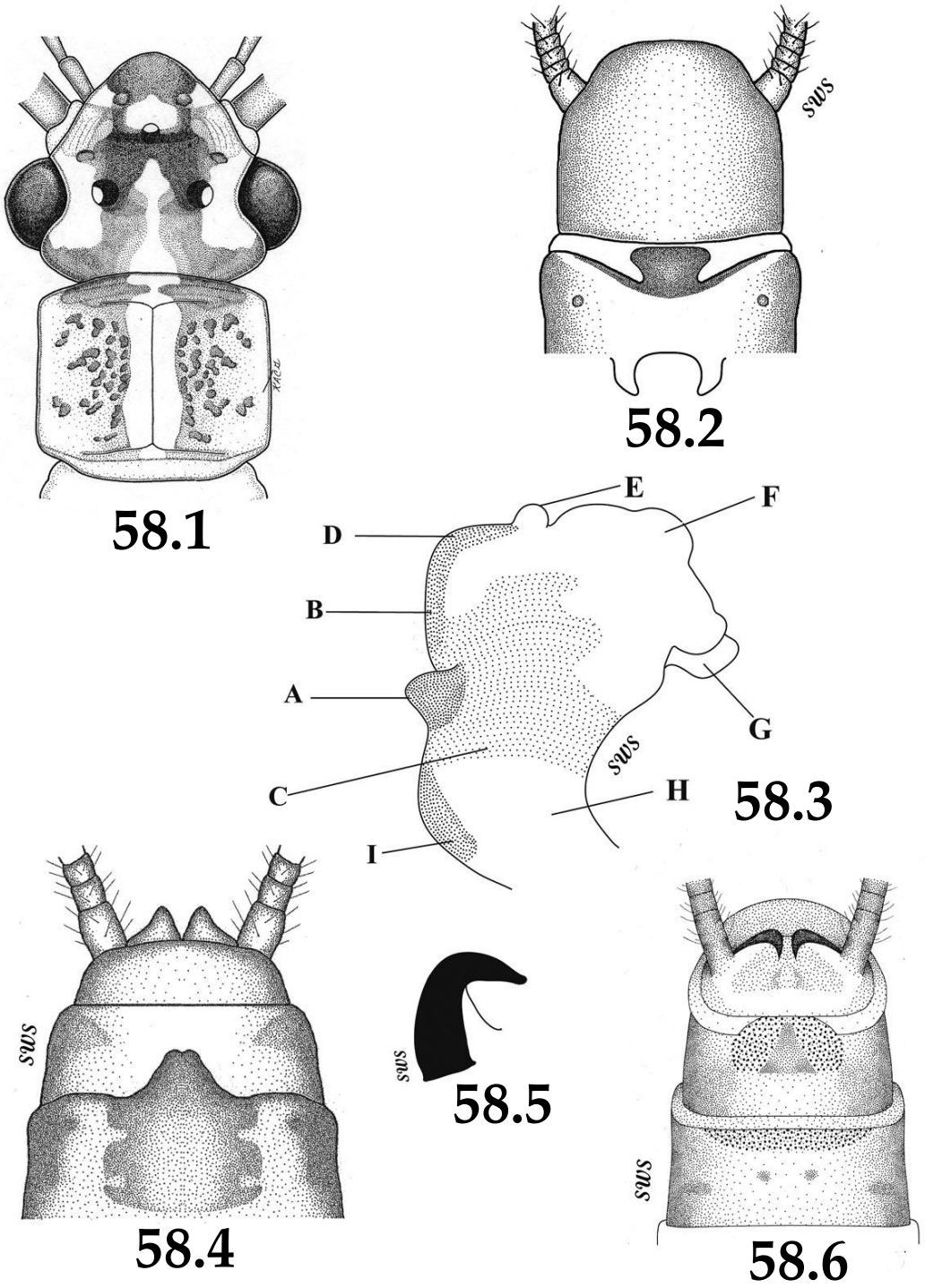
Chloroperla transmarina Newman 1838, 5:499. Holotype ♀ (BMNH), Trenton Falls, (Oneida Co.) New York, "North America". Examined.
Isoperla ventralis Banks 1908, 15:66. Lectotype ♂ (MCZC) Grand Lake, Newfoundland. syn. Frison, 1942, 22:316.
Isoperla fumosa Neave 1933 65:235. syn. Ricker, 1946:6, Pigeon River, Canada.
Isoperla transmarina: Ricker, 1946:6.
Isoperla transmarina: Frison, 1942, 22:316.

Distribution. **CANADA – BC** (Ricker and Scudder 1975), **LB** (Brinck 1958), **MB** (Ricker 1944, Frison 1942, Burton 1984), **NF** (Banks 1908, Brinck 1958), **NS** (Kondratieff and Baumann 1994), **PE** (Kondratieff and Baumann 1994), **PQ** (Ricker 1944, Ricker et al. 1968, Harper and Pilon, 1975, Ricker et al. 1968), **ON** (Ricker 1944, Frison 1942, Harper and Ricker 1994, Harper 1973), **SK** (Dosdall and Lemkuhl 1979). **USA – CT** (Hitchcock 1974), **DE** (Lake 1980), **IA** (Heimdal et al. 2004), **KY** (Tarter and Chaffee 2004, Tarter et al. 2006), **MI** (Frison 1942), **ME** (Mingo 1983), **MN** (Frison 1942, Harden and Mickel 1952, Lager et al. 1979), **NB** (Kondratieff and Baumann 1994), **NC** (Kondratieff et al. 1995), **NY (**Newman 1838), **OH** (Gaufin 1956, DeWalt et al. 2012, Grubbs et al. 2013), **PA** (Surdick and Kim 1976, Masteller 1996a), **SD** (Huntsman et al. 1999, 2001), **WI** (Frison 1942, Hilsenhoff and Billmyer 1973), **WV** (Tarter and Nelson 2006).

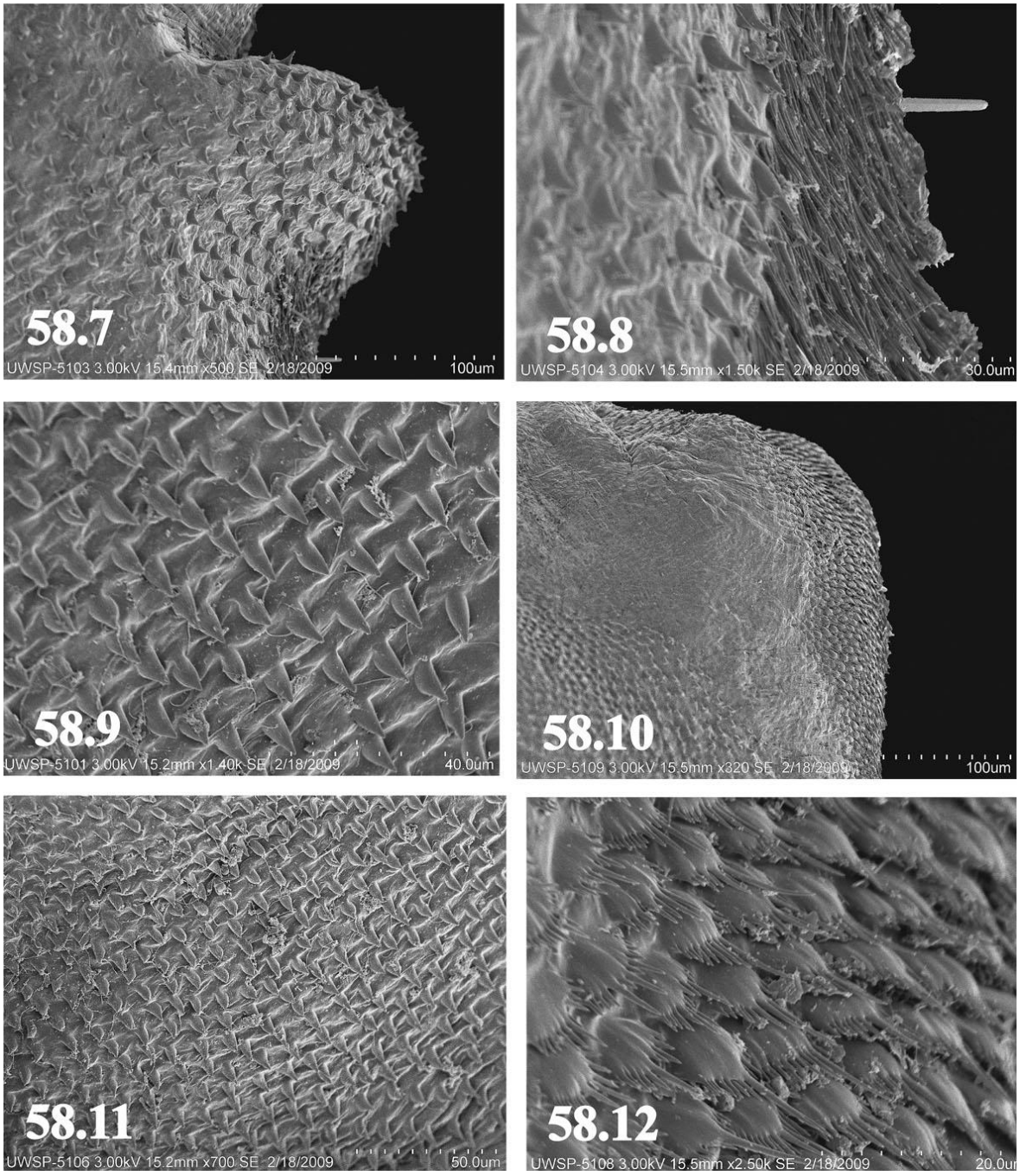
New Records. USA – NH: Coos Co., Androscoggin River, 25 km N Milan, Rte 16, 6/V/2011, D.S. Chandler, 3♂ (CSUC).

Additional Records. CANADA - NF: Gandy Brook, Hwy 470, N Rose Blanche, 10/VI/1998, B.C. Kondratieff, R.W. Baumann, 3♂, 4♀ (CSUC). **PQ:** Riviere Antrim, Hwy 389, N Baie Comeau, 14/VI/1997, B.C. Kondratieff, R.W. Baumann, 2♂, 2♀ (CSUC). **USA – NY:** Essex Co., West Branch Ausable River, The Notch, Rte. 86, 24/V/2006, L.W. Myers, 2♂, 1♀ (CSUC); West Branch Ausable River, The Notch, Rte. 86 near Wilmington, 13/III/2006, L.W. Myers, R. Younghanz, 1♂, 1♀ (CSUC); Nichols Brook, Shackett rd., 23/V/2008, B.C. Kondratieff, R.W. Baumann, L.W. Myers, 1♂, 3♀ (CSUC). Franklin Co., North Branch Saranac River, Goldsmith rd., 29/V/2006, L.W. Myers, 1♂ (CSUC); North Branch Saranac River, Loon Lake rd., 44°32.748'N, 074°02.568'W, 13/III/2007, L.W. Myers, T. Mihuc, 4♂, 5♀ (CSUC).

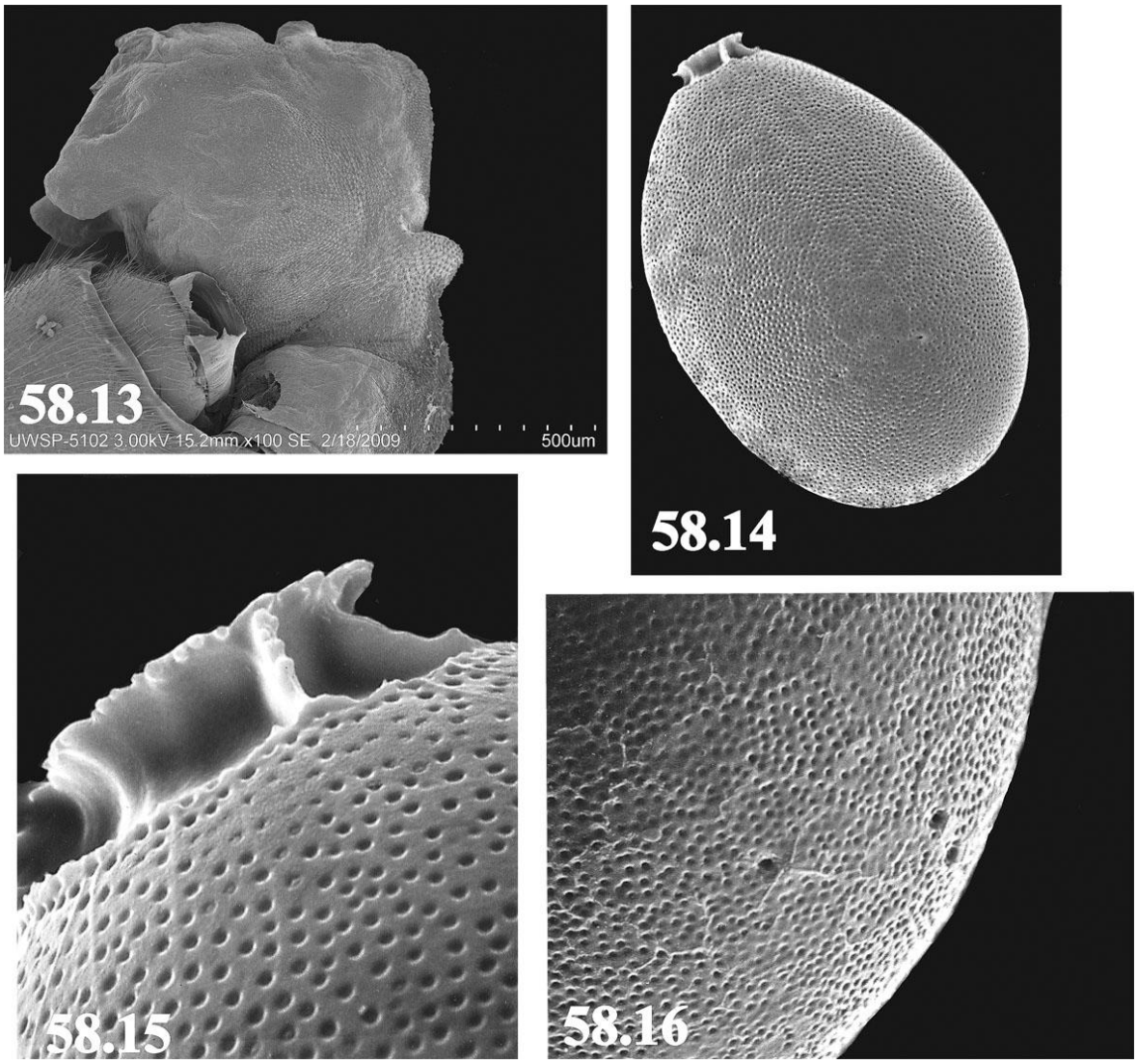
Male. Macropterous. Forewing length 8.8-10.0 mm. General body color medium to dark brown in life, pale brown in alcohol, with darker brown markings. Dorsum of head with dark brown bands connecting anterior ocellus with posterior ocelli; pale spear-shaped spot in interocellar area open posteriorly to hind margin of head; medium brown bands extend from lateral ocelli to posterior margin of head and laterally to base of eyes; frontoclypeal area with wide medium brown spot extending posteriorly to dark brown ocelli band; a pale median spot located anterior to anterior ocellus (Fig. 58.1). Antennae and scape medium brown. Pronotum with wide median pale stripe, middorsal pronotal suture with thin brown line; rugosities small, medium brown, pronotal disks pale; anterior margin dark brown, lateral margins pale (Fig. 58.1). Meso- and metanota pale brown with darker markings. Wings dusky with dark brown veins.



Figs. 58.1-58.6. *Isoperla transmarina*. 58.1. Dorsal head and pronotal pattern. 58.2. Male posterior abdominal sterna. 58.3. Male aedeagus lateral view; a. posteromedial heavy spinulose lobe, b. dense finer hair-like spines and a few scattered stout spines, c. wide mesal area covered with short stout golden brown spinulae, d. posterodorsal margin with a band of stout spinulae, e. small dorsal membranous lobe, f. low anterodorsal lobe, g. paired anterior lobes, h. basal stalk with dense stout spinulae, i. posteroventral margin with shell-like scales with numerous projecting fine hairs. 58.4. Female subgenital plate ventral view. 58.5. Male paraproct lateral view. 58.6. Male posterior abdominal terga.



Figs. 58.7-58.12. *Isoperla transmarina*. 58.7. Posteromesal heavy spinulose aedeagal lobe. 58.8. Long dense finer hair-like spines and a few scattered stout spines. 58.9. Wide aedeagal mesal area with dense short stout golden brown spinulae. 58.10. Posterodorsal aedeagal margin with a dense band of stout spinulae. 58.11. Basal aedeagal stalk with dense stout spinulae. 58.12. Posteroventral aedeagal margin with shell-like scales with numerous projecting fine hairs.



Figs. 58.13-58.16. *Isoperla transmarina*. 58.13. Male aedeagus lateral view. 58.14. Egg. 58.15. Detail of egg collar. 58.16. Detail of egg chorion and micropyles.

Legs medium brown, dorsal surfaces darker. Sterna pale; sternum 8 with well-developed, broadly rounded medium brown vesicle; vesicle typically mushroom-shaped, occasionally more evenly rounded posteriorly, darker than rest of sternum and expanded posteriorly, usually 2X as wide as long (Fig. 58.2). Terga pale brown with broad mesal dark brown band; tergum 9 with posterior band of short stout spinulae; tergum 10 with bipartite patch of short stout spinulae; posteromedian margin with tongue-like lobe sometimes extending over tergum 10 (Fig. 58.6). Paraprocts sclerotized, short, pointed apically with tips curved outward slightly and barely extending over tergum 10 (Figs. 58.5, 58.6). Cerci medium brown. Aedeagus with posteromesal heavy spinulose lobe (Figs. 58.3a, 58.7); long dense finer hair-like spines and a few scattered stout spines

continue ventrally to median section (Figs. 58.3b, 58.8); dorsal lobe small (Fig. 58.3e); anterodorsal lobe low (Figs. 58.3f, 58.13); paired anterior lobes (Figs. 58.3g, 58.13) devoid of spinulae; wide mesal area with dense short stout golden brown spinulae (Figs. 58.3c, 58.9); most of posterodorsal margin with a dense band of stout spinulae (Figs. 58.3d, 58.10); basal stalk with dense stout spinulae (Figs. 58.3h, 58.11); posteroventral margin with shell-like scales bearing numerous projecting fine hairs (Figs. 58.3i, 58.12).

Female. Macropterous. Forewing length 10.3-11.3 mm. General body color and morphology similar to male described above. Subgenital plate produced posteriorly over ½ length of sternum 9; plate broad basally, constricted to a truncate apex with shallow or deep emargination (Fig. 58.4).

Ovum. General shape oval, cross section circular. Color pale brown. Length 237 µm; width 162 µm (Fig. 58.14). Collar with apically flanged rim; stalked with elevated longitudinal carinae (Figs. 58.14, 58.15). Choronic surface covered with numerous shallow punctations; hexagonal follicle cell impressions faintly visible (Figs. 58.14, 58.16). Eclosion line absent. Micropyles single, row subequatorial; orifices small, located in depressions (Fig. 58.16).

Nymph. Frison (1942) provided a description and illustrated the maxilla, labium and habitus. Harden (1942) and Harden and Mickel (1952) also illustrated the habitus, labrum, mandibles, labium and maxilla. Hilsenhoff and Billmyer (1973) provided a photograph of the lacinia and Stark et al. (1998) provided a color photograph of the habitus.

Diagnosis. This species of the *I. decolorata* group (Table 1) can be distinguished from other eastern North American *Isoperla* species, especially from the only potential sympatric *I. decolorata* group species. *I. decolorata*, by the dark color pattern, shape of the female subgenital plate, large, apically expanded medium brown vesicle and shape and spinule pattern of the aedeagus. The male of *I. transmarina* is distinctive within the group in having a posterior band of short stout spinulae on tergum nine.

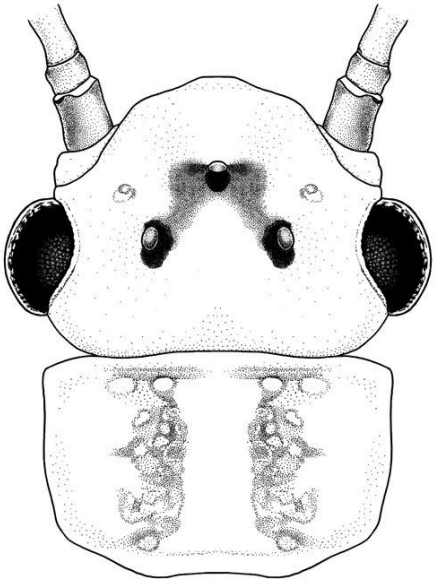
Biological Notes. *Isoperla transmarina* is usually collected from low order streams and small to medium sized rivers; however, it is not uncommon to collect specimens of this species in larger rivers such as the Wisconsin River, Wisconsin. *Isoperla transmarina* is one of the most widely distributed eastern *Isoperla*, with a range which extends from Saskatchewan to the Canadian Maritime Providences south to North Carolina and west across the Midwest to northeastern Wyoming. Emergence occurs from late March (North Carolina) to early July (Manitoba). However, peak emergence is generally in March in the Upper Midwest based on collection records. *Isoperla transmarina* has a one year life cycle in Quebec (Harper 1991), Ontario (Harper 1973), and Minnesota (Krueger and Cook 1981). Egg hatch is synchronous and apparently begins in late July and early August; nymphal growth continues throughout the winter (although slowed) until emergence in May. Graham (1982) reported that male calls from signals recorded from Wisconsin were monophasic with 3-17 beats (mean 9.0 ± 3.2) and beat frequency 200.3 ± 59.4 ms.

Isoperla tutelo sp. n.
North Carolina Stripetail
(Figs. 59.1-59.7)

Material Examined. USA – **Holotype** ♂, **North Carolina**: Caldwell Co., Johns River, Old Johns River Road, 1.1 mi. NW Collettsville, 18/IV/2007, B.C. Kondratieff, R.F. Kirchner, D.R. Lenat (reared) (USNM). **Paratypes: NC:** Caldwell Co., Same data as holotype, 5♀ (reared) (CSUC).

Distribution. USA – **NC**.

Male. Macropterous. Forewing length 9.5 mm. General body pale yellow with brown markings. Dorsum of head with a dark brown R-shaped band which connects lateral ocelli to anterior ocellus; two brown spots are located lateral to median ocellus (Fig. 59.1). Antennae and scape brown. Pronotum pale yellow with wide median pale stripe; middorsal pronotal suture brown; disks pale, rugosities dark brown, margins pale (Fig. 59.1). Meso- and metanota pale yellow with brown markings. Wings pale, veins light brown. Legs pale brown with brown markings. Sternum 8 with well-



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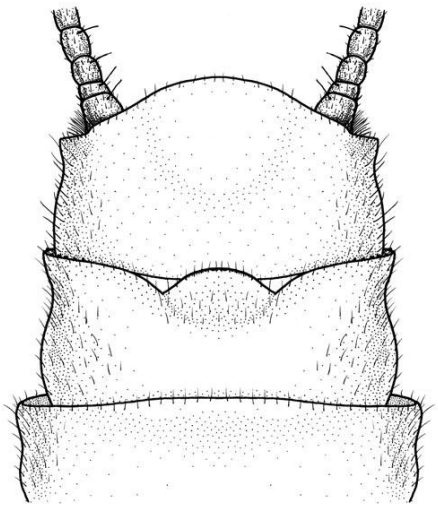

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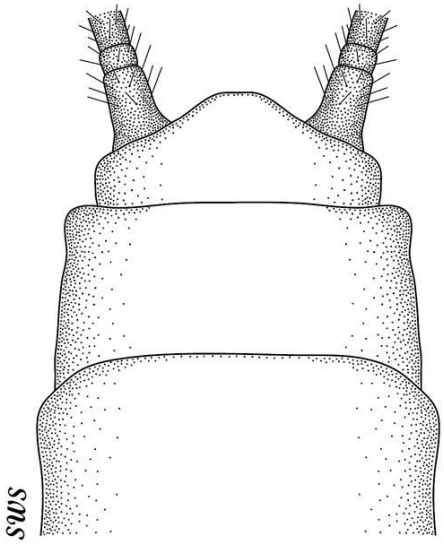

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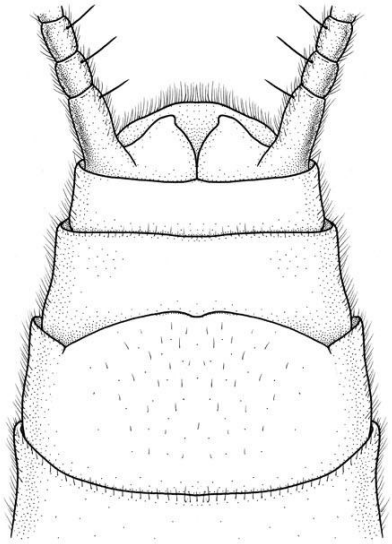
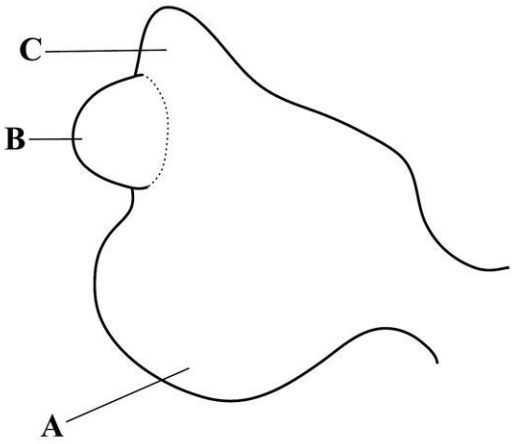
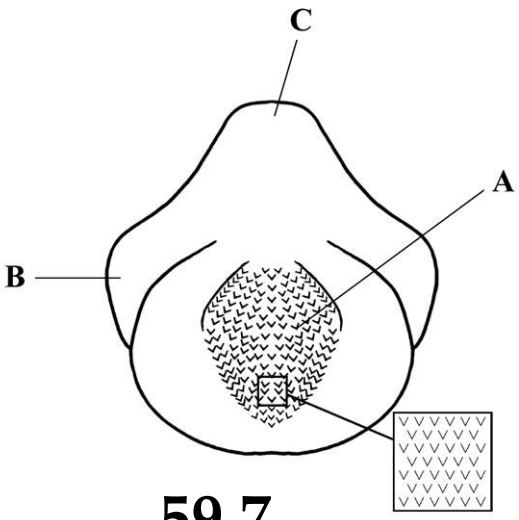


59.5

Figs. 59.1-59.5. *Isoperla tutelo* sp. n. 59.1. Dorsal head and pronotal pattern. 59.2. Male posterior abdominal sterna. 59.3. Male paraproct lateral view. 59.4. Male posterior abdominal terga. 59.5. Female subgenital plate ventral view.



59.6



59.7

Figs. 59.6-59.7. *Isoperla tutelo* sp. n. 59.6. Male aedeagus lateral view; a. posteroventral indented patch of broadly pointed spinulae, b. paired posterodorsal lobes, c. pointed apical lobe. 59.7. Male aedeagus posterior view; a. posteroventral indented patch of broadly pointed spinulae, b. paired posterodorsal lobes, c. pointed apical lobe.

developed lightly sclerotized vesicle; vesicle broadly rounded at apex, with small fine hairs (Fig. 59.2). Terga pale yellow with pale brown shading posteriorly and laterally; terga 1-7 with a pale brown middorsal stripe. Cerci dark brown. Paraprocts short, stout, lightly sclerotized, tips blunt and extending barely to level of tergum 10 (Figs. 59.3, 59.4). Aedeagus membranous with pointed apical lobe (Figs. 59.6c, 59.7c); posterodorsal lobes paired (Figs. 59.6b, 59.7b); posteroventral indented patch of broadly pointed spinulae distinct, edges of patch indicated by overlapping spinulae with medially located spinulae becoming shorter dorsally (Figs. 59.6a, 59.7a).

Female. Macropterous. Forewing length 10.0 -11.5 mm. General body color and morphology similar to male. Subgenital plate produced ⅓ length or less of sternum 9, broadly rounded, with a slight medial emargination (Fig. 59.5).

Ovum. Unknown.

Nymph. Unknown.

Etymology. We honor the Tutelo Native American people with this name. The Tutelo were one of the original inhabitants of North Carolina northeast of the type locality.

Diagnosis. *Isoperla tutelo* sp. n., placed as a member of *I. bilineata* group (Table 1), is a small pale yellow species with typical dark inverted V-bands (truncate anteriorly) connecting the ocelli. The most distinctive characteristic of this species occurs in the male genitalia and is based on the posteroventral indented patch of broadly pointed spinulae present on the aedeagus. The expression of this character in *I. tutelo* sp. n. is most similar to that of *I. burksi* (*I. burksi* group). In addition both *I. burksi* and *I. tutelo* sp. n. have brown pigment bands which connect the ocelli. However, these species differ in the shape of the aedeagus, shape of the male paraprocts, head color pattern, and female subgenital plate and these differencs allow separation of these two species. *Isoperla burksi* was

reported from North Carolina by (Kondratieff et al. 1995) and confirmed by specimens examined during this study.

Biological Notes. Nothing is known about the biology of this species. *Isoperla tutelo* sp. n. emerges in mid-April based on the single collection record. The Johns River in Caldwell County has an "Excellent" rating based on macroinvertebrate collections by the North Carolina Division of Water Quality, with mayfly/stonefly/caddisfly (EPT) taxa richness of 49 species for a single summer collection. The section of the river where *I. tutelo* sp. n. was reared is classified as having "High Quality." Although there are other similar nearby streams with "Excellent" water quality (for example Wilson Creek and Linville River). This species apparently has an extremely limited distribution and this suggests the need for further protection of this portion of the Johns River watershed (David Lenat, personal communication).

Isoperla yuchi sp. n.

Yuchi Stripetail

(Figs. 60.1-60.8)

Material Examined. **USA – Holotype** ♂, **Virginia:** Smyth Co., South Fork Holston River, Rte. 600, St. Clare Bottom, 18//V/1990, B.C. Kondratieff, R.F. Kirchner, J. Welch (USNM). **Paratypes: VA:** Smyth Co., Same data as holotype, 2♀ (CSUC); Davis Branch, Rt. 600 near Elk Gardens, 18/V/1999, B.P. Stark 1♂,1♀ (BPSC); Seeps at Davis Branch, near Elk Gardens, 14/V/1997, B.P. Stark 1♂ (BPSC).

Distribution.**USA – VA**.

Male. Macropterous. Forewing length 10.8-11.3 mm. General body pale yellow with medium/dark brown markings. Dorsum of head with a dark brown patch covering interocellar area, and with lateral arms which extend anteriorly from median ocellus; medium brown patch near lateral ocelli extends posteriorly; small median medium brown patch anterior to median ocellus separated from dark brown patch by thin pale U-shaped line; small medium brown patches located anterior to lateral ocelli (Fig. 60.1). Antennal flagellum, scape and pedicel pale yellow. Pronotum pale yellow with wide median pale stripe; middorsal pronotal suture brown; disks pale, rugosities dark brown; lateral margins with wide pale bands; anterior margin with median bipartite dark brown bands (Fig. 60.1). Meso- and metanota pale yellow with thin dark brown U-shaped posterior bands; rounded anteromedian paired spots pale brown. Wings pale, veins pale brown. Femur and tibia pale yellow; femur with dorsal medium brown band; tibia with transverse medium brown proximal band extending ¼ length of tibia; tarsi pale brown. Terga pale yellow with thin pale brown median longitudinal band on segments 1-8; tergum 9 not elevated but with bipartite mesal, triangular shaped medium brown patches (Fig. 60.4). Cerci pale brown. Paraprocts stout, dorsal surface moderately sclerotized, tips blunt and extending over tergum 10 (Figs. 60.2, 60.3, 60.4). Sternum 8 with well-developed lightly sclerotized vesicle, broadly rounded at apex, ca. 2 ½X as wide as long (Fig. 60.2). Aedeagus membranous with paired dorsal lobes (Figs. 60.6f, 60.7b); large paired mesal lobes hemispherical (Figs. 60.6b, 60.7a, 60.8b); large posteromesal lobe cone-shaped (Figs. 60.6c, 60.7d) and bearing large golden brown stout spines (Figs. 60.6d, 60.7c, 60.8c); medium size golden brown stout spines located dorsal to patch of large spines (Figs. 60.6e, 60.7e); posteroventral patch consists of 12 -14 large stout golden brown spines (Figs. 60.6a, 60.8a).

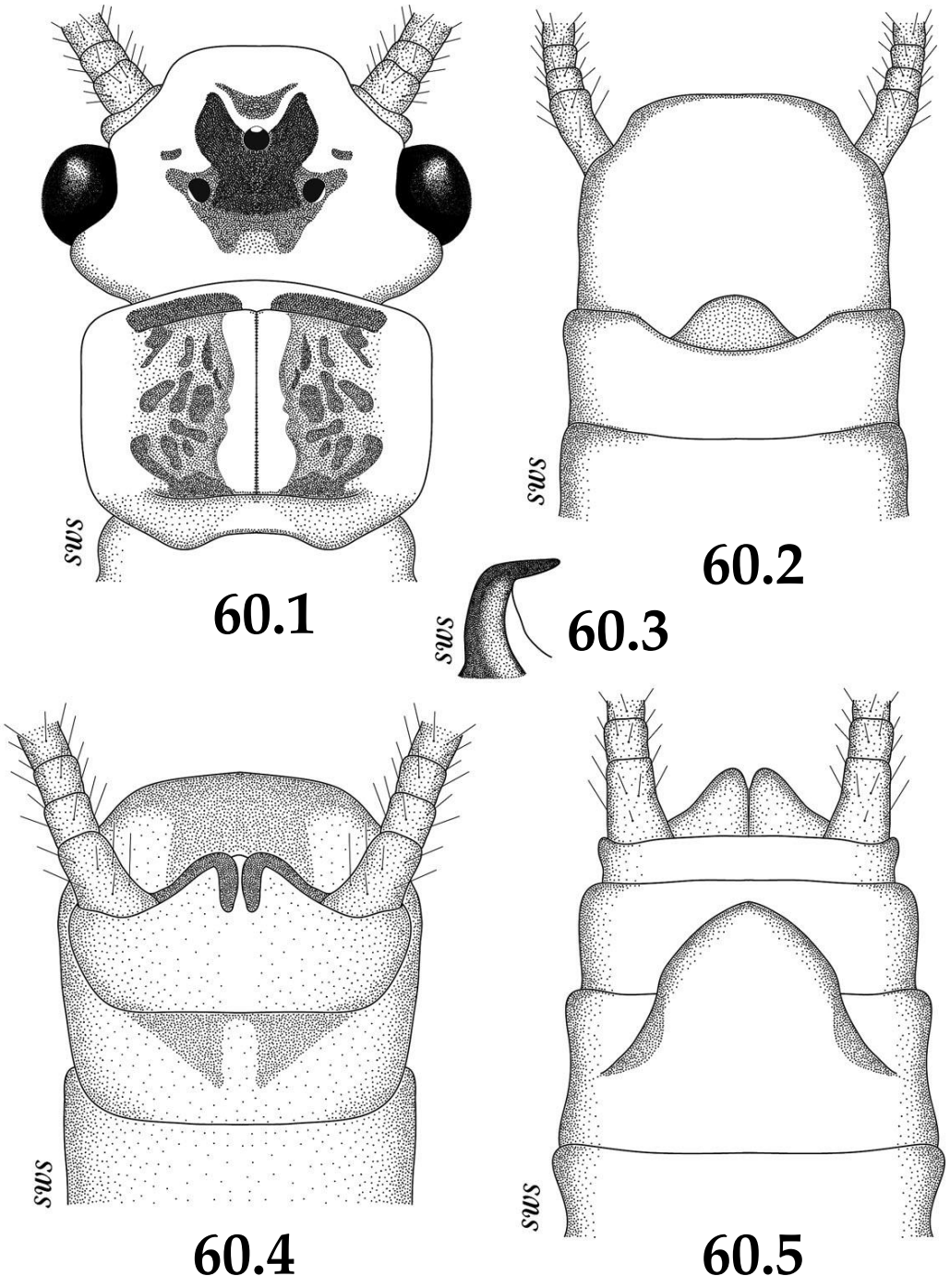
Female. Macropterous. Forewing length 12.3-13.1 mm. General body color and morphology similar to male. Subgenital plate thick, produced ca. ¾ length of sternum 9 and broadly triangular; base extends to ca. ½ length of sternum 8 (Fig. 60.5).

Ovum. Unknown.

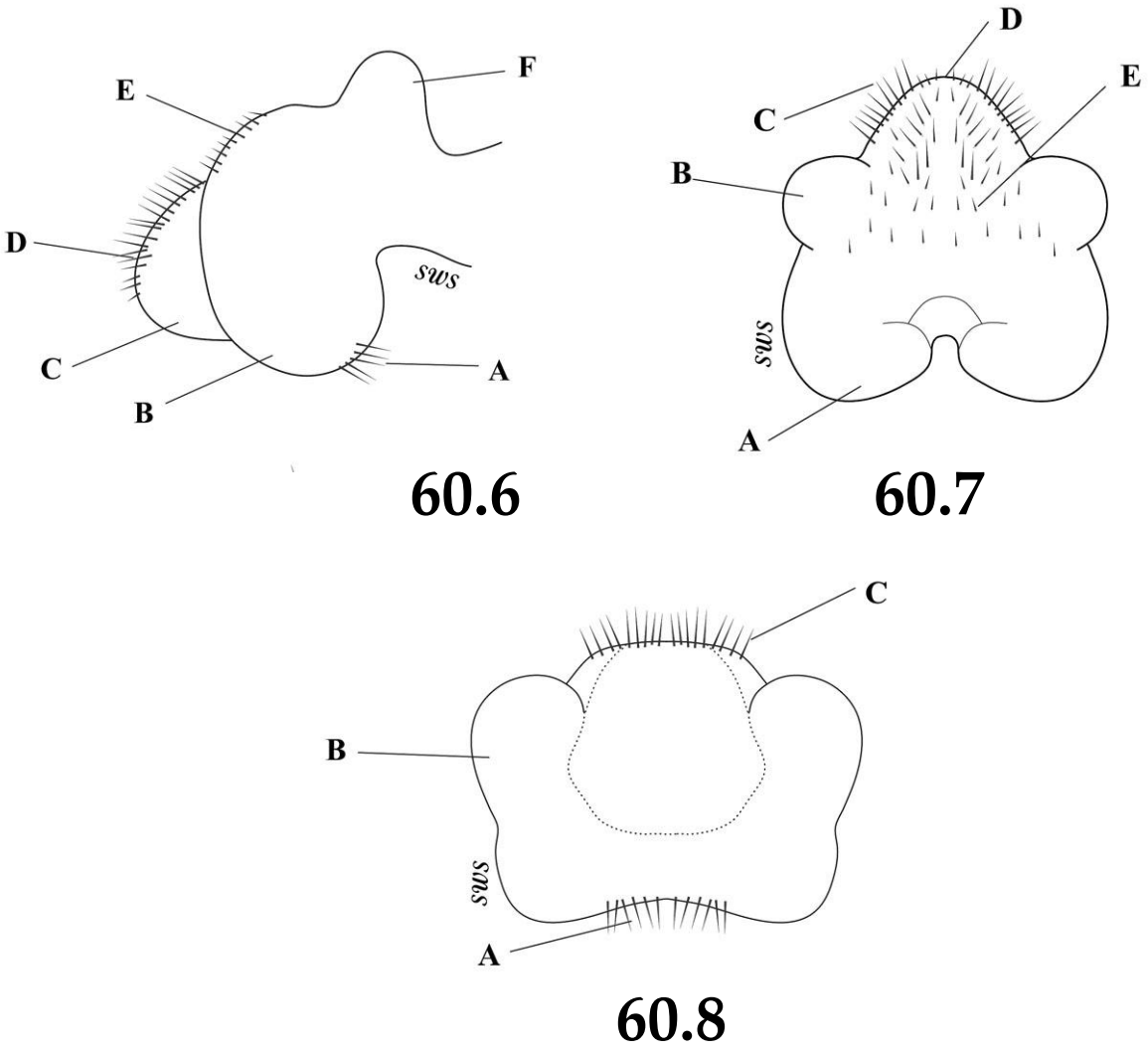
Nymph. Unknown.

Etymology. We honor the Yuchi Native American tribe with this name. They were the original inhabitants of Virginia near the type locality.

Diagnosis. *Isoperla yuchi* sp. n. is a medium sized pale yellow species with medium brown markings. It is a member of the *I. pseudosimilis* sp. n. species group (Table 1) that have long reddish brown or golden brown aedeagal spines but lack sclerotized spine bearing plates. The most distinctive characteristics of *I. yuchi* sp. n. are the aedeagal shape and spine pattern and the shape of the

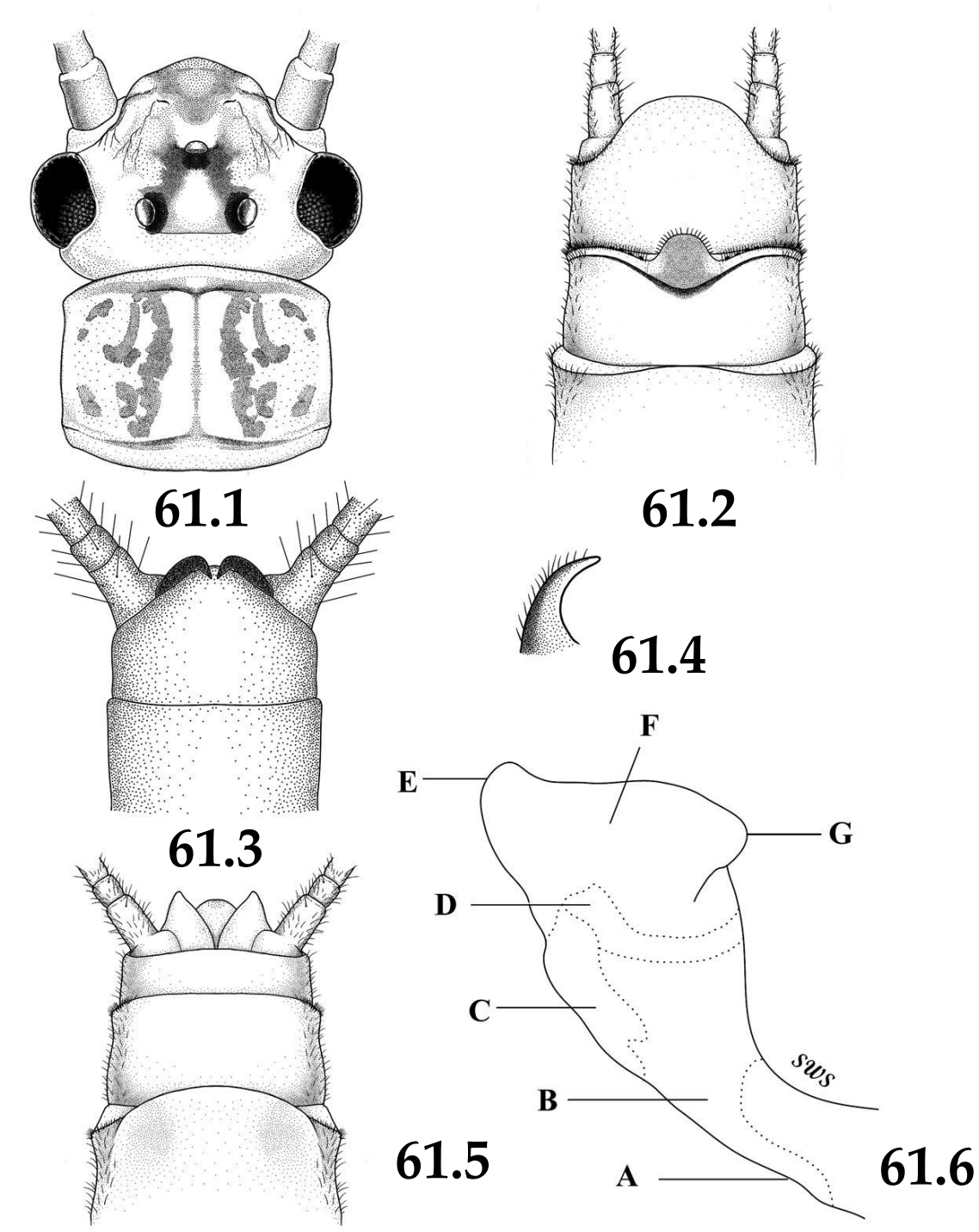


Figs. 60.1-60.5. *Isoperla yuchi* sp. n. 60.1. Dorsal head and pronotal pattern. 60.2. Male posterior abdominal sterna. 60.3. Male paraproct lateral view. 60.4. Male posterior abdominal terga. 60.5. Female subgenital plate ventral view.



Figs. 60.6-60.8. *Isoperla yuchi* sp. n. 60.6. Male aedeagus lateral view; a. posteroventral patch of 12 -14 large stout golden brown spines, b. large paired hemispherical mesal lobes, c. large posteromesal conical-shaped, d. posteromesal patch of large golden brown stout spines, e. patch of medium size golden brown stout spines, f. with paired dorsal lobes. 60.7. Male aedeagus dorsal view; a. large paired hemispherical mesal lobes, b. paired dorsal lobes, c. large posteromesal golden brown stout spines, d. large posteromesal conical-shaped lobe, e. medium size golden brown stout spines. 60.8. Male aedeagus ventral view; a. posteroventral patch of 12 -14 large stout golden brown spines, b. large paired hemispherical mesal lobes, c. large posteromesal golden brown stout spines.

female subgenital plate. These characters should allow separation from other species in the group. *Isoperla yuchi* sp. n. is most similar to *I. starki* sp. n. of the *I. similis* species group in general size and body coloration, however the shape and spinule pattern of the aedeagus, paraproct shape and shape of the female subgenital plate are different. Because the only male specimen we had for study was the designated holotype we were unable to determine if the paired bipartite dorsal spine patches on the basal stalk were present as in several other species in this group.



Figs. 61.1-61.6. *Isoperla zuelligi* sp. n. 61.1. Dorsal head and pronotal pattern. 61.2. Male posterior abdominal sterna. 61.3. Male paraproct lateral view. 61.4. Male posterior abdominal terga. 61.5. Female subgenital plate ventral view. 61.6. Male aedeagus lateral view; a. long tubular ventral section, b. large ventral and mesal patch of concentrated short stout spinulae, c. posteromedian rows of fine hair-like spinulae, d. band of concentrated short stout rounded spinulae, e. posterodorsal conical lobe, f. dorsal area void of spinulae, g. anterodorsal conical lobe.

Biological Notes. Nothing is known about the biology of this species. *Isoperla yuchi* sp. n. emerges in mid-May based on the single collection record. At the type locality, the South Fork of the Holston River is considered an excellent trout stream with relatively high diversity of aquatic insects. At this site several uncommon Virginia stoneflies such as the perlodid *Diploperla morgani* Kondratieff and Voshell and the perlid *Paragnetina ichusa* Stark and Szczytko were abundant.

Isoperla zuelligi sp. n.
Uwharrie Stripetail
(Figs. 61.1-61.14)

Material Examined. USA – Holotype ♂, **North Carolina:** Montgomery Co., Barnes Creek, Ophir Road, South of Ophir, Uwharrie National Forest, 18/V/2004; B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat (USNM). **Paratypes: NC:** Montgomery Co., Same data as holotype, 2♂, 8♀ (CSUC); Uwharrie River, NC 109 bridge, Uwharrie National Forest, 18/V/2004, B.C. Kondratieff, R.F. Kirchner, R.E. Zuellig, D.R. Lenat, 7♂, 5♀ (CSUC).

Distribution. **USA – NC.**

Male. Macropterous. Forewing length 8.0-9.0 mm. General body pale brown to brown with darker markings. Dorsum of head with brown to dark brown X-band which connects lateral ocelli to anterior ocellus; anterior ends of bands short, barely extending forward of anterior ocellus; interocellar area pale; frons and clypeus brown (Fig. 61.1). Antennae and scape brown. Pronotum pale brown with wide median pale stripe, middorsal pronotal suture brown; rugosities wide, dark brown (Fig. 61.1). Meso- and metanota brown with paler markings. Wings pale, veins brown. Front legs pale brown, mid tibia brown, hind femur and tibia brown. Sterna pale brown; sternum 8 with well-developed rounded vesicle, ca. as long as wide, evenly rounded posteriorly with darker medial pigment and small fine marginal hairs; posterior margin of sternum with a thin dark band, bordered by marginal comb-like and long setae (Fig. 61.2). Terga pale brown. Paraprocts dorsally sclerotized, paler ventrally; tips acute (Figs. 61.3, 61.4) and extending barely over edge of tergum 10 (Fig. 61.3). Aedeagus membranous with long tubular ventral section (Fig. 61.6a) and expanded dorsal area (Figs. 61.6f, 61.7); large patches of dense short stout spinulae occur ventrally and mesally (Figs. 61.6b, 61.8); fine hair-like spinulae are located in posteromedian rows (Figs. 61.6c, 61.9); a band of dense short stout rounded spinulae is located above mesal patch of sharp spinulae (Figs. 61.6d, 61.10); conical lobes occur posterodorsally (Figs. 61.6e, 61.7) and anterodorsally (Figs. 61.6g, 61.7); dorsal area devoid of spinulae (Figs. 61.6f, 61.7).

Female. Macropterous. Forewing length 8.0-11.5 mm. General body color and morphology similar to male, head with additional brown shading. Subgenital plate produced ¼ length or less of sternum 9; plate broadly rounded (Fig. 61.5).

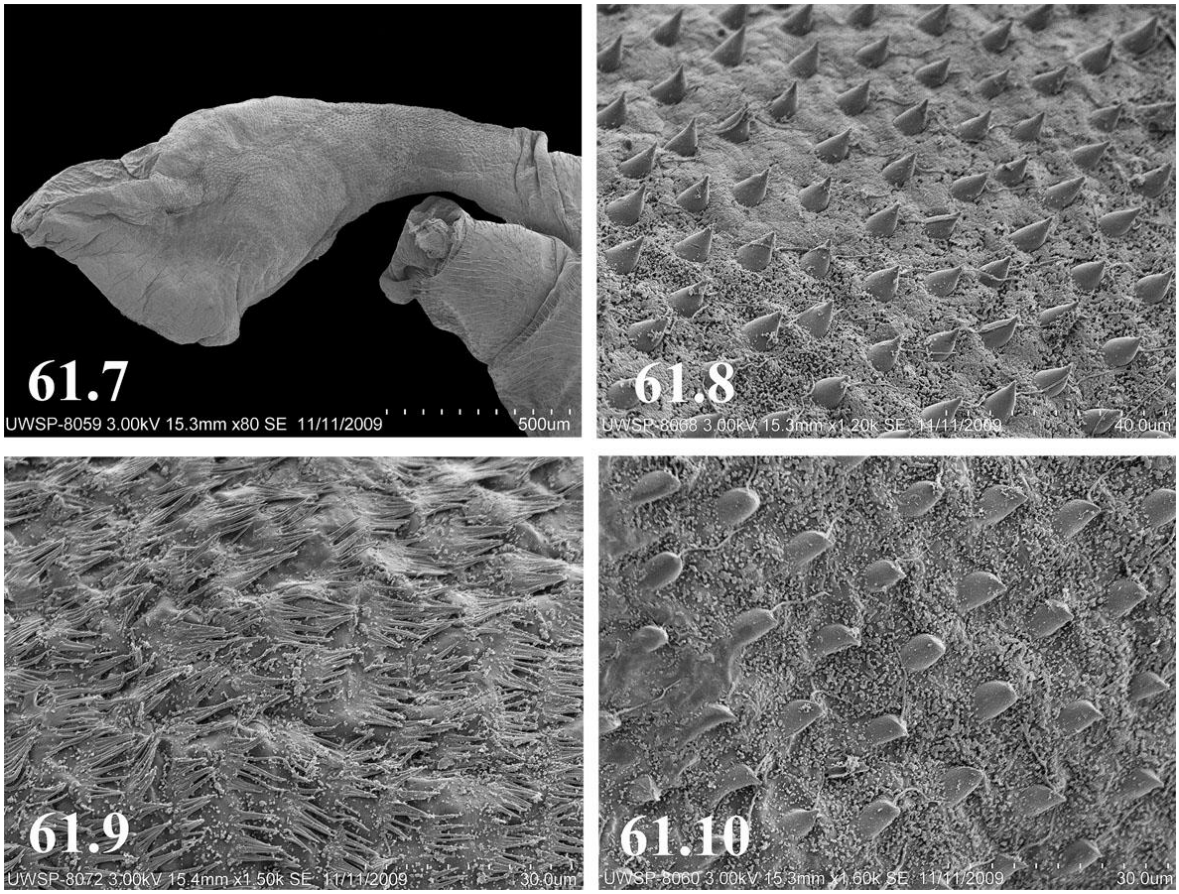
Ovum. General shape oblong, cross section triangular, distinct cross shaped ridges dividing anterior and posterior poles; anterior end nearly flat (Figs. 61.11, 61.13). Color pale brown. Length 258 µm; width 226 µm. Collar developed, low, flared apically, basal area offset with a low ridge (Figs. 61.11, 61.12). Anchor elongate, truncate apically (Figs. 61.11, 61.12). Hexagonal follicle cell impressions well-developed with thickened ridges; floors shallow with numerous small pits. Micropyles arranged singularly or in groups of 3 on FCI ridges near anterior ⅓ of egg; eclosion line absent (Figs. 61.11, 61.13, 61.14).

Nymph. Unknown.

Etymology. We honor Dr. Robert E. Zuellig, WRD Ecologist, U.S. Geological Survey, Fort Collins, Colorado, who greatly assisted in important collections of eastern *Isoperla* specimens.

Diagnosis. *Isoperla zuelligi* sp. n. is tentively placed in the *I. bilineata* group (Table 1). *Isoperla zuelligi* sp. n. can be distinguished from other species of the group by the acute shape of the tips of the male paraprocts, the shape and spinule pattern of the fully everted aedeagus and in the female by the specific head color pattern, short rounded subgenital plate, and the distinctive egg.

Biological Notes. Nothing is known about the biology of this species. The emergence period occurs during May. The type locality is located in the Uwharrie National Forest that encompasses the ancient Uwharries. These are among the earth's



Figs. 61.7-61.10. *Isoperla zuelligi* sp. n. 61.7. Male aedeagus lateral view. 61.8. Large ventral and mesal patch of dense short stout aedeagal spinulae. 61.9. Posteromedian rows of fine hair-like aedeagal spinulae. 61.10. Band of dense short stout rounded aedeagal spinulae.

oldest mountain ranges and were formed by a chain of volcanoes some 500 million years ago. The volcanic peaks are thought to have once had elevations greater than 6,000 m. Today the highest areas are 305 m or less.

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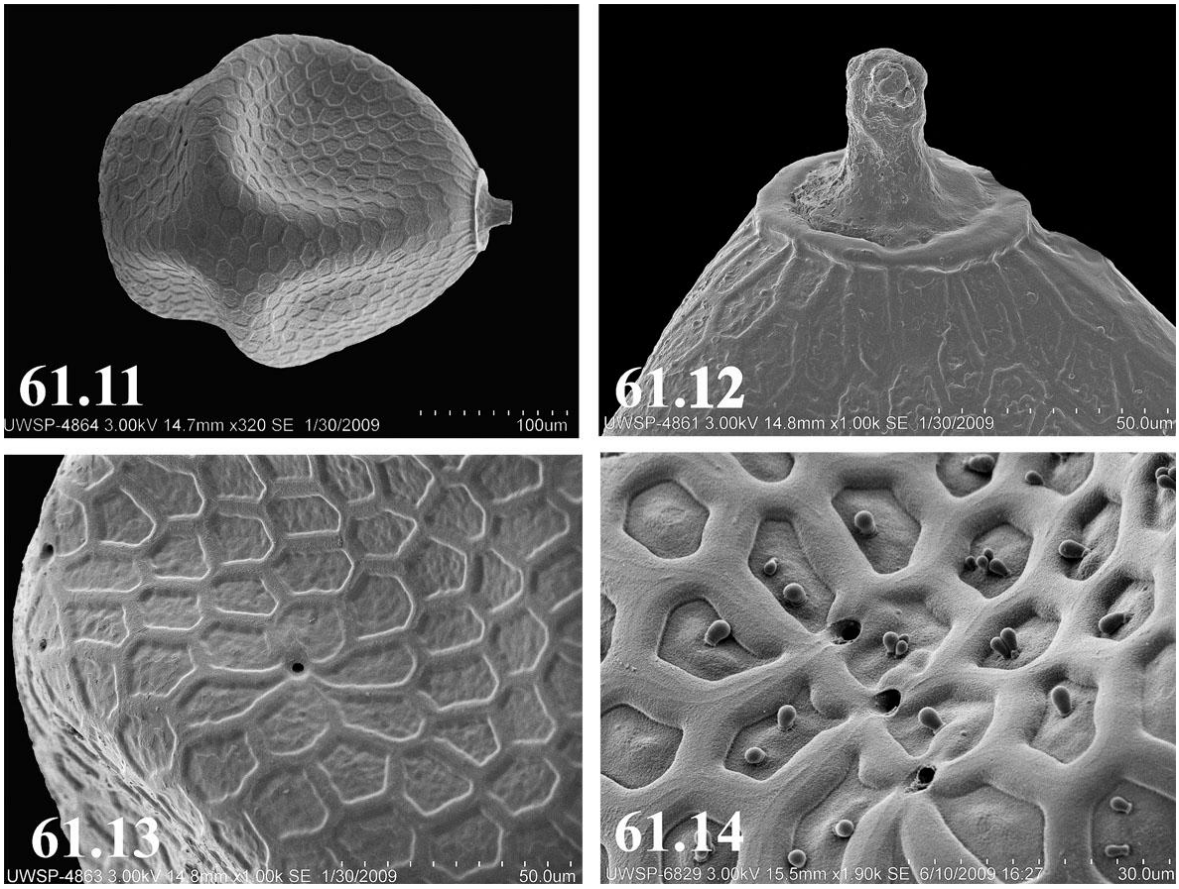

Figs. 61.11-61.14. *Isoperla zuelligi* sp. n. 61.11. Egg. 61.12. Detail of egg collar. 61.13. Detail of egg chorion. 61.14. Detail of egg micropyle.

Richard W. Baumann, Brigham Young University, the late Kenneth W. Stewart University of North Texas and Bill P. Stark Mississippi College and Jeffrey J., Dimick University of Wisconsin/Stevens Point for their comradery during stonefly collecting trips that greatly benefited this study. Much important *Isoperla* material was collected during several Atlantic Canada expeditions organized and led by Dr. Richard W. Baumann. We thank Drs. Charles H. Nelson, Richard W. Baumann, and Bill P. Stark for detailed reviews that improved the manuscript. Finally we thank all those persons who loaned or submitted specimens and importantly provided encouragement and were patient, allowing us to complete the manuscript. We thank Dr. Ignac Sivec, Ljubljana, Slovenia for making special efforts to assist us to prepare the manuscript for final publication. We would also like to thank our wives, family and children for the overwhelming support and encouragement throughout the research and preparation of this paper which made it possible.

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