AN UPDATE ON THE STONEFLY FAUNA (INSECTA, PLECOPTERA) OF MARYLAND, INCLUDING NEW AND EMENDED STATE RECORDS AND AN UPDATED STATE CHECKLIST

Scott A. Grubbs

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

ABSTRACT
The stonefly fauna of Maryland is updated. An unassociated female of Perlesta Banks, 1906 is described under informal designation, complete with light microscopy micrographs of head and pronotal pigmentation patterns plus scanning electron microscopy (SEM) images of eggs. New state records are presented for Cultus verticalis (Banks, 1920), Neoperla catharae Stark & Baumann, 1978, and P. mihucorum Kondratieff & Myers, 2011. Light microscopy and SEM micrographs are also presented for P. mihucorum. Published state records of Isoperla Banks, 1906 and Sweltsa onkos (Ricker, 1952) are emended given recent descriptions in both genera. Distribution maps for S. onkos and S. hoffmani Kondratieff & Kirchner, 2009, plus for all species of Isoperla and Perlesta known to occur in the Appalachian Mountain region of western Maryland, are provided. An updated state checklist of 114 species is included.

Keywords: Plecoptera, Perlidae, Perlesta, state records, Maryland

INTRODUCTION

Since 2004, taxonomic and locality information on the Maryland fauna have been included in systematic treatments of Allocapnia Claassen, 1928 (Grubbs & Sheldon 2008), Leuctra Stephens, 1836 (Grubbs 2015, Grubbs & Wei 2017), Prostoia Ricker, 1952 (Grubbs et al. 2014), Soyedina Ricker, 1952 (Grubbs 2006), Sweltsa Ricker, 1943 (Kondratieff & Kirchner 2009, Stark et al. 2011), Perlesta Banks, 1906 (Grubbs & DeWalt 2008, 2012), and Isoperla Banks, 1906 (Szczytko & Kondratieff 2015).

Stemming from the recent taxonomic treatments of Sweltsa and Isoperla, several species whose distribution in Maryland were in question, or are now more readily identified, were re-examined.
Perlesta was also examined closely, revealing unassociated females with potentially unique egg characteristics plus a surprising range extension for *P. mihucorum* Kondratieff & Myers, 2011 were present in material collected by the author during the 1990’s. Scanning electron and light microscopy micrographs are included to further facilitate identification of these two species. In addition, two additional new state records, several species emendations, and an updated state checklist is provided.
METHODS
Specimens examined for this project were obtained from Western Kentucky University, Bowling Green (WKUC). Locality data for all specimen records, in decimal degrees, were obtained either directly on site with GPS units or georeferenced from museum label data (if possible) using Acme Mapper 2.1 (http://mapper.acme.com). All specimen data are available as a comma separate values file prepared in Darwin Core Archive file format (http://illiesia.speciesfile.org/Papers/MarylandPlecopteraproject_DwC-A.csv). Specimens for scanning electron microscopy (SEM) were serially dehydrated in 75%, 95%, and 100% ethanol for 10 minutes each and placed in hexamethyldisilizane for 30 minutes. Dehydrated specimens were attached to aluminum stubs with double-stick tape and coated with gold-palladium in an Emscope SC500. Coated specimens were examined using a Jeol JSM-6510LV scanning electron microscope and digital images were captured with an IXRF system. Digital images were also obtained using Auto-Montage software with a Leica MZ16 stereomicroscope equipped with a JVC KY-F75U digital camera.

RESULTS

Taxonomy

Perlesta MD-5
(Figs. 1–6, 21)

Female. Forewing length 9.5–11.0 mm (n = 3). Head light pale yellow with a golden brown intraocellar patch that is slightly open anteriorly, plus a light golden-brown triangular patch anterior to the anterior ocellus; m-line indistinguishable (Figs. 1–2). Pronotum light golden brown with no medial stripe (Figs. 1–2). Subgenital plate ca. ½ width of 8th abdominal sternum, lacking pigmentation. Lobes distinct, rounded laterally, bordered by a v-shaped notch.

Egg. Oval (Fig. 3). Collar small and straight-sided, raised about chorionic surface, flange lacking (Figs. 4–5); chorion covered by a patchwork of amoeboid-like polygons (Figs. 4, 6); micropyles present in anterior ¼ (Fig. 6).

Material examined. USA, Maryland, Allegany Co., Sideling Hill Creek, near Bellegrove, at light, 39.70443, -78.32840, 3 August 1996, S.A. Grubbs, 2♀ (WKUC); same but 14 July 1998, S.A. Grubbs, 2♀ (WKUC).

Remarks. The eggs appear different from all other species of eastern Nearctic Perlesta. A brief description was provided here in hope that females can be associated with males at some point in the future. These eggs may pertain to one of three Perlesta species whose eggs are unknown and found along the Atlantic Coastal Plain region of Virginia and North Carolina: P. beatyi Kondratieff, Zuellig & Lenat, 2011, P. bjostadi Kondratieff & Kirchner, 2006, and P. durfeei Kondratieff, Zuellig & Kirchner, 2008. The egg of P. leathermani Kondratieff & Zuellig, 2006 also has a small, “button-like” collar (their Fig. 8). The light head pigmentation of MD-5 (Figs. 1–2), however, appears different from the darker P. leathermani (Kondratieff et al. 2006, their Fig. 1).

New state records

Neoperla catharae Stark & Baumann, 1978 is known from several central and eastern US states (DeWalt et al. 2018). The new records are near the eastern end of this species range.

Perlesta mihucorum Kondratieff & Myers, 2011 was described from upstate New York and has been collected from large streams and small rivers. This is a common species across the panhandle region of western Maryland plus one additional record in the upper Piedmont region.

Remarks. Males of P. mihucorum are readily identified by the combination of paraprocts with subapical tooth mostly anteriorly-directed and not visible in caudal view (Figs. 8–10) and aedeagus with small caecum ca. as long as wide and narrow dorsal patch (Figs. 11–12). Males from Maryland and West Virginia examined in this study were keyed to couplet 12 in Stark (2004), mainly because of the first choice in couplet 10 (“Paraproct spine distinct in lateral aspect”). This is in contrast to Kondratieff & Myers (2011), who illustrated (their Fig. 4) and stated “…tooth inconspicuous in lateral view”. This initially led this author to conclude
that the Maryland and West Virginia specimens represented an undescribed species. However, paraproct tooth aspect is herein considered interspecific variability, especially since characteristics of the male caecum, female subgenital plate, and egg align well with the definition of *Perlesta mihucorum* from New York.

Regarding females, this is the only species of *Perlesta* with the combination of a subgenital plate with well-developed lobes and deep v-shaped notch (Fig. 14–15) and egg with a smooth chorion and a wide collar that is distinctly stalked, ribbed, and flanged apically (Figs. 16–18). Both males and females have prominent pale yellow median bands.
Figs. 13–18. Perlesta mihucorum, Maryland, Conococheague Creek; 13, female, head + pronotum, dorsal profile; 14, female, subgenital plate, ventral view, 90X; 15, female, subgenital plate, details of left lobe, ventral view, 400X; 16, entire egg, 270X; 17, egg, posterior pole and collar, 1200X; 18, egg, anterior pole and micropyles, 430X.

on the pronotum (Figs. 7, 13). The eggs shown with SEM appear inseparable as in Kondratieff & Myers 2011 (their Figs. 9–14).

The known disparate ranges of *P. mihucorum* as reported from New York (Kondratieff & Myers 2011) and herein from Maryland and West Virginia (Fig. 19) are due to incomplete understanding of the distribution of this species. The new state records were unexpected yet not completely surprising considering how little is still known about *Perlesta* taxonomy and biogeography. Examination of material from the adjacent or intervening states of
Fig. 19. Distribution map of *Perlesta mihucorum* in eastern North America. The New York localities were plotted using the coordinates provided in Kondratieff & Myers (2011).

Delaware, New Jersey, and Pennsylvania should enhance understanding of the distribution of this species. This species is also probably in northern Virginia, more widespread in West Virginia, and likely present in several New England states. Six species of *Perlesta* in total, including the three females conditionally determined as MD-5, are now known from Maryland. All six species are distributed in the small Appalachian region of western Maryland (Figs. 19–22).

*Cultus verticalis* (Banks, 1920) is a widespread Appalachian species known from Georgia northeastward to New Hampshire and Quebec (DeWalt et al. 2018). The females reported here were gravid and eggs of *C. verticalis* are distinct from *C. decisus* (Walker, 1852) (Kondratieff 2004). This state record is not surprising.
Figs. 20–22. Distribution maps of five *Perlesta* species in western Maryland, USA, based on material examined during this study. 20, *P. ephelida*; 21, *P. nelsoni, P. placida*, and *P. MD sp. 5; 22, *P. teaysia*. MD = Maryland, VA = Virginia, WV = West Virginia.

Species emendations and updates

*Sweltsa hoffmani* Kondratieff & Kirchner, 2009 and *Sweltsa onkos* (Ricker, 1936).

A total of 59 vials of material collected and determined as *S. onkos* by the first author in the 1990s from western Maryland were reexamined. Specimens of 55 vials, all from the Appalachian Plateau and Ridge and Valley Physiographic Provinces, now pertain to *S. hoffmani* (Fig. 23). Only three series from the Blue Ridge Physiographic Province (Frederick Co.) are of *S. onkos* (Fig. 23). Kondratieff & Kirchner (2009, their pp. 297) likewise listed a single series of *S. onkos* from Frederick County (Fig. 23). The *S. onkos* collections presented in Duffield & Nelson (1990, their Fig. 1) may also refer to “true” *S. onkos*. 
Fig. 23. Distribution map of *Sweltsa hoffmani* and *S. onkos* in western Maryland, USA, based on material examined during this study plus one record in Kondratieff & Kirchner (2009). MD = Maryland, PA = Pennsylvania, VA = Virginia, WV = West Virginia.

**Isoperla Banks, 1906**

The eastern Nearctic species of *Isoperla* were revised by Szczytko & Kondratieff (2015), resulting in 22 new species descriptions, revised species definitions, and several new state records. Consequently, all *Isoperla* species listed from Maryland by Duffield & Nelson (1990) and Grubbs (1997) require clarification and updates.

**Isoperla burksi Frison, 1942** was reported from Maryland by Duffield & Nelson (1990) (Fig. 24). The author has not collected males of this species from western Maryland, although undetermined females that may refer to either *I. burksi* or *I. orata* Frison, 1942 have been found at two localities (Fig. 24). Males with extruded aedeagi or females with mature eggs are needed for positive determination.

**Isoperla dicala Frison, 1942** was reported from Maryland by Grubbs (2003) but not included as occurring in the state by Szczytko & Kondratieff (2015). The small series reported in Grubbs (2003) from one location (Fig. 23) were determined as *I. dicala* by Dr. Szczytko ca. 15 years ago.

**Isoperla gibbsae Harper, 1971** was reported from Maryland in Duffield & Nelson (1990) (Fig. 26) but not included as occurring in the state by Szczytko & Kondratieff (2015). This species is retained in the Maryland state list pending verification. Szczytko & Kondratieff (2015) similarly noted that the West Virginia record of *I. gibbsae* (Kirchner 1978) requires verification.

**Isoperla holochlora Klapálek, 1923** was reported from Maryland by Duffield & Nelson (1990) (Fig. 25).
This species was included by Szczytko & Kondratieff (2015) from the state. The author collected this Appalachian species from western Maryland from several localities during 1995–1997 (Fig. 25).

*Isoperla kirchneri* Szczytko & Kondratieff, 2015 was described from Virginia and is currently known from New York south to North Carolina and Tennessee (DeWalt et al. 2018). The presence of this species in western Maryland is not surprising (Fig. 26). The specimens reported as *I. namata* Frison, 1942 by Grubbs (1997) were identified using Szczytko & Kondratieff (2015) and all now refer to *I. kirchneri*. *Isoperla namata* is herein removed from the Maryland state list.

*Isoperla montana* (Banks, 1898) was reported from Maryland by Grubbs (1997) and subsequently listed by Szczytko & Kondratieff (2015) as occurring in the state. The author presents several additional localities in western Maryland (Fig. 24).

*Isoperla pseudosimilis* Szczytko & Kondratieff 2015 was described from upstate New York and is currently known from the New England states south to North Carolina and Tennessee (DeWalt et al. 2018). This montane species was likewise expected from Maryland and all material determined by the author in the mid-1990s as *I. similis* (Hagen, 1861) were newly determined as *I. pseudosimilis* using Szczytko & Kondratieff (2015) (Fig. 27).

*Isoperla similis* (Hagen, 1861) was reported from Maryland by Duffield & Nelson (1990) (Fig. 27). This species has since been redefined by Szczytko & Kondratieff (2015) and is now considered a species found mainly along the Piedmont and Atlantic Coastal Plain regions. Szczytko & Kondratieff (2015) included *I. similis* from Maryland based on a single female from the Blue Ridge Physiographic Province (Fig. 27).

**DISCUSSION**

Although smaller in total land area, the updated species total (n = 114, Table 1) reported here for Maryland is comparable to that of Alabama (107 species, Grubbs 2011) and Georgia (100 species, Verdone et al. 2017). Maryland is the 9th smallest state in the US with only 21% and 24% of land area compared to Alabama and Georgia, respectively. Furthermore, at least 111 of the 114 species (= 97%) have been collected from the four western panhandle counties (Garrett, Allegany, Washington, and Frederick) that traverse the Appalachian Mountain region of the state. This high proportion suggests that habitat availability and quality is still sufficient to support a diverse regional species pool. Elevations in the Appalachian Plateau, Ridge and Valley, and Blue Ridge Physiographic Provinces in western Maryland range from ca. 60 m (= ca. 200 ft) at the Potomac River to 1024 m (= 3360 ft) on Backbone Mountain. The western panhandle is also sparsely populated compared to central and eastern portions of the state and is home to several protected areas. Notable examples include Savage River State Forest (220 km², Garrett Co.), Green River State Forest (192 km², Allegany Co.), and Catoctin Mountain Park, a National Park Service unit in Frederick Co. (25 km²). There are also several additional state forests, state parks, and wildlife management areas distributed across these four counties. By comparison, there is markedly less surface relief in the Piedmont and Coastal Plain Provinces within the eastern Maryland, ranging from sea level to only 391 m (= 1282 ft) at the summit of Sugarloaf Mountain. This region of the state is also more densely populated.

What is lacking is a broader understanding about statewide distribution patterns of stoneflies across Maryland. For example, how many species with Appalachian distributions are found eastward into the Piedmont region? How many species are restricted in the Coastal Plain region? These questions, and several more, can be addressed following a comprehensive examination of material housed in museums and private collections, a summary of the valid literature, and focused collection efforts in the areas of the state either lightly sampled or supporting species clusters indicative of important biological diversity.
ACKNOWLEDGEMENTS

Dr. John Andersland (Western Kentucky University) kindly assisted with scanning electron microscopy. Two anonymous reviewers, Bill P. Stark, and R. Edward DeWalt provided very helpful comments that improved this manuscript.

Table 1. List of Maryland stoneflies. New and emended records are marked by an asterisk (*)

**Family Capniidae**

Allocapnia aurora Ricker, 1952  
Allocapnia curiosa Frison, 1942  
Allocapnia frisoni Ricker & Ross, 1964  
Allocapnia frumi Kirchner, 1982  
Allocapnia granulata (Claassen, 1924)  
Allocapnia harperi Kirchner, 1980  
Allocapnia illinoensis Frison, 1935  
Allocapnia maria Hanson, 1942  
Allocapnia nivicola (Fitch, 1847)  
Allocapnia pygmaea (Burmeister, 1839)  
Allocapnia recta (Claassen, 1924)  
Allocapnia rickeri Frison, 1942  
Allocapnia vivipara (Claassen, 1924)  
Allocapnia wrayi Ross, 1964  
Allocapnia zola Ricker, 1952  
Paracapnia angulata Hanson, 1961

**Family Leuctridae**

**Subfamily Leuctrinae**

Leuctra alexanderi Hanson, 1941  
Leuctra carolinensis Claassen, 1923  
Leuctra duplicata Claassen, 1923  
Leuctra ferruginea (Walker, 1852)  
Leuctra grandis Banks, 1906  
Leuctra rickeri James, 1976  
Leuctra sibleyi Claassen, 1923  
Leuctra tenella Provancher, 1878  
Leuctra tenuis (Pictet, 1841)  
Leuctra variabilis Hanson, 1941  
Paraleuctra sara (Claassen, 1937)

**Subfamily Megaleuctrinae**

Megaleuctra flinti Baumann, 1973

**Family Nemouridae**

**Subfamily Amphinemurinae**

Amphinemura delosa (Ricker, 1952)  
Amphinemura nigrita (Provancher, 1876)  
Amphinemura wui (Claassen, 1936)
Subfamily Nemourinae
Ostrocera albipennis (Walker, 1852)
Ostrocera complexa (Claassen, 1937)
Ostrocera truncata (Claassen, 1923)
Paranemoura perfecta (Walker, 1852)
Prostoia completa (Walker, 1852)
Prostoia similis (Hagen, 1861)
Shipsa rotunda (Claassen, 1923)
Soyedina carolinensis (Claassen, 1923)
Soyedina kondratieffi Baumann & Grubbs, 1996
Soyedina vallicularia (Wu, 1923)
Soyedina washingtoni (Claassen, 1923)

Family Taeniopterygidae
Subfamily Brachypterainae
Oemopteryx contorta (Needham & Claassen, 1925)
Strophopteryx appalachia Ricker & Ross, 1975
Strophopteryx fasciata (Burmeister, 1839)
Taenionema atlanticum Ricker & Ross, 1975

Subfamily Taeniopteryginae
Taeniopteryx burksi Ricker & Ross, 1968
Taeniopteryx lonicera Ricker & Ross, 1968
Taeniopteryx maura (Pictet, 1841)
Taeniopteryx metequi Ricker & Ross, 1968
Taeniopteryx nivalis Fitch, 1847
Taeniopteryx parvula Banks, 1918
Taeniopteryx ugola Ricker & Ross, 1968

Family Chloroperlidae
Subfamily Chloroperlinae
Alloperla aracoma Harper & Kirchner, 1978
Alloperla atlantica Baumann, 1974
Alloperla biserrata Nelson & Kondratieff, 1980
Alloperla chloris Frison, 1934
Alloperla imbecilla (Say, 1823)
Alloperla usa Ricker, 1952
Haploperla brevis (Banks, 1895)
Suwallia marginata (Banks, 1897)
*Sveltsa hoffmani Kondratieff & Kirchner, 2009
Sveltsa lateralis (Banks, 1911)
*Sveltsa onkos (Ricker, 1936)
Sveltsa palearata Surdick, 2004
Sveltsa pocahontas Kirchner & Kondratieff, 1988

Subfamily Paraperlinae
Utaperla gaspesiana Harper & Roy, 1975
Family Perlidae
Subfamily Acroneuriinae
Acroneuria abnormis (Newman, 1838)
Acroneuria arenosa (Pictet, 1841)
Acroneuria carolinensis (Banks, 1905)
Acroneuria filicis Frison, 1942
Acroneuria frisoni Stark & Brown, 1991
Acroneuria lycorias (Newman, 1839)
Attaneuria ruralis (Hagen, 1861)
Eccoptura xanthenes (Newman, 1838)
Hansonoperla appalachia Nelson, 1979
Perlesta ephelida Grubbs & DeWalt, 2012
*Perlesta mihucorum Kondratieff & Myers, 2011
Perlesta nelsoni Stark, 1989
Perlesta placida (Hagen, 1861)
Perlesta teaysia Kirchner & Kondratieff, 1997
*Perlesta sp. M-5
Perlinella drymo (Newman, 1839)
Perlinella ephyre (Newman, 1839)

Subfamily Perlinae
Agnetina annulipes (Hagen, 1861)
Agnetina capitata (Pictet, 1841)
Agnetina flavescens (Walsh, 1862)
*Neoperla catharae Stark & Baumann, 1978
Neoperla robisoni Poulton & Stewart, 1986
Neoperla stewarti Stark & Baumann, 1978
Paragnetina immarginata (Say, 1823)
Paragnetina media (Walker, 1852)

Family Perlodidae
Subfamily Isoperlinae
Clioperla clio (Newman, 1839)
Isoperla burksi Frison, 1942
Isoperla dicala Frison, 1942
Isoperla gibbsae Harper, 1971
Isoperla holochlora Klapálek, 1923
*Isoperla kirchneri Szczytko & Kondratieff, 2015
Isoperla montana (Banks, 1898)
*Isoperla pseudosimilis Szczytko & Kondratieff, 2015
*Isoperla similis (Hagen, 1861)

Subfamily Perlodinae
*Cultus verticalis (Banks, 1920)
Diploperla duplicata (Banks, 1920)
Diploperla robusta Stark & Gaufin, 1974
Isogenoides hansoni (Ricker, 1952)
Malirekus iroquois Stark & Szczytko, 1988
Remenus bilobatus (Needham & Claassen, 1925)
Yugus kirchneri Nelson, 2001

Family Peltoperlidae

Peltoperla arcuata Needham, 1905
Tallaperla elisa Stark, 1983
Tallaperla maria (Needham & Smith, 1916)

Family Pteronarcyidae

Pteronarcy s biloba Newman, 1838
Pteronarcy s dorsata (Say, 1823)
Pteronarcy s proteus Newman, 1838

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Submitted 15 February 2018, Accepted 10 April 2018, Published 30 April 2018
Hosted and published at the University of Illinois, Illinois Natural History Survey, Champaign, Illinois, U.S.A.

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