

NEW MISSOURI MAYFLY (EPHEMEROPTERA) STATE AND COUNTY RECORDS¹

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ABSTRACT: Seven mayfly species represent new state records, and an additional eight mayfly species represent new county records for Missouri. These 15 species from eight families increased the total Ephemeroptera species richness of the state to 110. Many species reported here include habitat specialists and large-river species collected as either larvae or adults. *Homoeoneuria ammophila* (Spieth) was collected from the Missouri River, a species having otherwise sparse records in North America, and the predacious, widespread *Pseudiron centralis* (McDunnough) was collected from the Mississippi River following an absence in Missouri records for over 65 years. Ongoing threats from land-use change and climate alterations make aquatic insect distribution records critically important. Greater sampling efforts should be concentrated in large-river habitats.

KEY WORDS: Baetidae, Baetiscidae, Caenidae, Heptageniidae, Leptophlebiidae, Oligoneuriidae, Pseudironidae, Siphonuridae, Diversity, Aquatic insects, Midwest, Large rivers

INTRODUCTION

Habitat variability provides the framework for high community diversity, and such diversity is present in the temperate streams of Missouri (Covich, 1988). Missouri encompasses a diverse range of aquatic habitats including lentic ephemeral pools, springs, intermittent headwater streams, and 10th-order rivers. Waters run through prairie, Ozark, and lowland ecological regions. Land cover includes natural grassland, deciduous forest, evergreen forest, bottomland forest, and agriculture fields, all of which overlie various geologies (mainly limestone, sandstone, shale, dolomite, and clay). Additionally, streams vary in elevation between 70 m and 540 m above sea level (Missouri Department of Natural Resources, 1986). Anthropogenic changes such as habitat alteration and loss (Zwick, 1992; Barber-James et al., 2008; Málnás et al., 2011), precipitation changes (Barber-James et al., 2008), temperature regime change (Barber-James et al., 2008), water pollution (Hrovat et al., 2009; Jacobus et al., 2019), and mining operations (Lefcort et al., 2010; Pond, 2010) threaten mayfly diversity. A recent report by the Illinois Natural History Survey predicted range shifts for 400 Ephemeroptera, Plecoptera, and Trichoptera (EPT) species in the upper Midwest due to extreme climate alterations by the end of this century (DeWalt et al., 2014), indicating how important taxonomic documentation is today. Currently, Missouri mayfly (Ephemeroptera) diversity is comparable to other Great Plains and Midwestern states such as Oklahoma, Kansas (McCafferty and Jacobus, 2018), Iowa (McCafferty et al., 2003; McCafferty et al., 2006), and Nebraska (McCafferty et al., 2001). Mayfly diversity is higher to the east of

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Missouri in Kentucky, Tennessee (Long and Kondratieff, 1996; McCafferty et al., 2010), and Illinois (McCafferty and Jacobus, 2018).

Previously, Sarver and Kondratieff (1997) compiled a comprehensive survey of Missouri mayflies and reported 92 nominal species with 51 new state records. In 2000, Wiersema and Burian published a state record for the newly described species *Centroptilum ozarkensum*. In 2004, Wiersema and McCafferty published new state records for four additional mayfly taxa from material contributed by the Missouri Department of Natural Resources. Those records included *Anafroptilum minor* (McDunnough), *Procloeon rubropictum* (McDunnough), *Procloeon rufostrigatum* (McDunnough), and *Procloeon simplex* (McDunnough). In 2007, Ferro and Sites published new state records for five additional mayfly taxa. Those records included *Caenis tardata* McDunnough, *Neoleptophlebia mollis* (Eaton), *Paraleptophlebia guttata* (McDunnough), *Serratella serrata* (Morgan), and *Siphonurus marshalli* Traver. In 2007, Webb et al. published a state record for the newly described species *Heptagenia whitingi*. In 2009, McCafferty published a new state record for *Iswaeon anoka* (Daggy). In 2015, Klubertanz reported a new state record for the mayfly taxon *Procloeon fragile* (McDunnough). Additional new records presented in this manuscript represent a continued effort to fully document the species and distributions of Ephemeroptera within Missouri.

METHODS

Most larval mayfly specimens reported here were collected by the Bioassessment Unit of the Missouri Department of Natural Resources during routine field work in the fall and spring seasons. Standardized methods using bottom aquatic kick nets, with a 500 μm mesh net, were used to collect macroinvertebrate community samples from the standard habitats of riffle (RIF), depositional (DEP), rootmat (RTM), and woody debris (WOD) (Missouri Department of Natural Resources, 2019). One additional non-standard habitat included in-stream aquatic vegetation (VEG). Field collection methods not specified previously included drift nets (DN), experimental benthic trawls (beam trawl with 3.175 mm mesh netting) in sandy and gravel glides (BT), sweep netting adults (SN), and black lighting adults over a white sheet during the evening (BL). The material reported here is deposited at the Missouri Department of Natural Resources, Environmental Services Program.

RESULTS

The new mayfly records listed here include 15 species from 8 families, which expands the former species distribution records and increases the species richness of the state to 110 taxa. Seven new state records are reported (*).

Baetidae

Anafroptilum ozarkense (Wiersema and Burian)

Previous Records: [Shannon County (Co.)] Holotype and additional material were reported by Wiersema and Burian (2000) and were described as *Centroptilum ozarkensum* Wiersema and Burian. [Oregon Co.] Jacobus and Wiersema (2014) reported material collected by R. Sarver (larvae).

New County Records: [Douglas Co.] Spring Creek, 36.809544N -92.146141W, RTM habitat, III-23-1999, R. Sarver, (larvae). [Lawrence Co.] Center Creek, 37.047070N -94.037460W, DEP and RTM habitats, III-25-1998, R. Sarver, (larvae). [Newton Co.] North Indian Creek, 36.797729N -94.224953W, RTM habitat, III-11-1997, R. Sarver, (larvae).

Corrected County Records: [Phelps Co., Pulaski Co.] Sarver and Kondratieff (1997). *Procloeon album* (McDunnough) records are now retracted due to re-examination of previously collected specimens and comparison to *Anafroptilum ozarkense* (Wiersema and Burian) larvae and larval exuviae from reared adults collected from the type locality. Previous *Procloeon album* records are now reported as *Anafroptilum ozarkense* (Wiersema and Burian). This change affects Missouri species names but not numbers.

Remarks: Jacobus and Wiersema (2014) confirmed the status of *Anafroptilum Kluge* and combined *Centroptilum ozarkensum* Wiersema and Burian as *Anafroptilum ozarkense*.

**Baetis brunneicolor* McDunnough

New State Record: [Shannon Co.] Sinking Creek, 37.330143N -91.388588W, RIF and RTM habitats, III-24-1999, R. Sarver, (larvae).

Remarks: *Baetis brunneicolor* was collected in the neighboring states of Illinois (Moriyara and McCafferty, 1979); Nebraska, Iowa (Klubertanz, 2015); Kentucky, and Tennessee (McCafferty et al., 2010). Its presence in Missouri was expected.

**Callibaetis floridanus* Banks

New State Record: [Oregon Co.] Eleven Point River, 36.700696N -91.200717W, VEG habitat, VII-15-2000, R. Sarver, (larvae).

Remarks: A tentative record for *C. floridanus* was reported by Sarver and Kondratieff (1997) based on records from an unpublished Ph.D. dissertation (Check, 1982) in which locality information was not reported. The records presented here are the first detailed locality records for the state.

Fallceon quilleri (Dodds)

Previous Records: [Missouri—counties not reported] Moriyara and McCafferty (1979).

New County Records: [Barton Co.] East Drywood Creek, 37.619083N -94.549362W, RTM habitat, IV-6-1998, R. Sarver, (larvae). [Greene Co.] Galloway Creek, 37.130360N -93.234310W, RIF habitat, III-22-2007, R. Sarver, (larvae).

[Vernon Co.] West Fork Drywood Creek, 37.710529N -94.583336W, RTM habitat, IV-6-1998, R. Sarver, (larvae).

Remarks: Previous records were literature records from Morihara and McCafferty (1979) in which locality information was not provided. The records presented here are the first detailed locality records for the state.

Iswaeon anoka (Daggy)

Previous Records: [Taney Co.] McCafferty (2009). [Dallas Co.] Klubertanz (2015).

New County Record: [Oregon Co.] Eleven Point River, 36.775488N -91.279767W, VEG habitat, VII-15-2000, R. Sarver, (larvae).

Corrected County Record: [Ozark Co.] Sarver and Kondratieff (1997). The previous *Baetis punctiventris* (McDunnough) record is now retracted and is reported as *Iswaeon anoka*. This change is supported by taxonomic revisions published by McCafferty et al. (2005) and affects Missouri species names but not numbers.

Remarks: *Pseudocloeon anoka* Daggy had been placed as a junior synonym of *Plauditus punctiventris* (McDunnough) (previously *Pseudocloeon*, then *Baetis*) by McCafferty and Waltz (1990). McCafferty et al. (2005) erected *Iswaeon* McCafferty and Webb as a new subgenus of *Heterocloeon* McDunnough, and *Pseudocloeon anoka* was newly combined in the subgenus as *Heterocloeon (Iswaeon) anoka* (Daggy). The subgenus *Iswaeon* was later elevated to genus by Guenther and McCafferty (2008).

Procloeon viridoculare (Berner)

Previous Records: [Nodaway Co., Vernon Co.] Sarver and Kondratieff (1997) reported as *Procloeon irrubrum* (Lowen and Flannagan).

New County Records: [Adair Co.] Chariton River, 40.233211N -92.686665W, WOD habitat, IX-20-2000, R. Sarver, (larvae). [Bollinger Co.] Little Whitewater River, 37.492504N -89.997607W, DEP habitat, IX-22-1999, R. Sarver, (larvae). [Hickory Co.] Little Niangua River, 37.930428N -93.092743W, DEP habitat, IX-17-1996, R. Sarver, (larvae). [Livingston Co.] Grand River, 39.758501N -93.603724W, WOD habitat, VII-12-1996, R. Sarver (larvae). [Osage Co.] Maries River, 38.369368N -91.985040W, VIII-21-1996, R. Sarver, (larvae).

Remarks: *Procloeon irrubrum* (Lowen and Flannagan) was placed as a junior synonym of *Procloeon viridoculare* (Berner) by Wiersema and McCafferty (2004). This synonymy affects Missouri species names but not numbers.

**Pseudocentroptiloides usa* Waltz & McCafferty

New State Record: [Grundy Co.] Honey Creek, 40.137380N -93.522270W, RTM habitat, IX-27-2005, R. Sarver, (larvae). [Buchanan Co.] Third Fork Platte River, 39.762983N -94.640667W, DEP habitat, IX-20-2005, R. Sarver, (larvae).
Remarks: The holotype was described from Indiana (Waltz and McCafferty,

1989), and specimens have been collected from the neighboring states of Kentucky and Tennessee (McCafferty et al., 2010).

Baetiscidae

**Baetisca laurentina* McDunnough

New State Record: [Crawford Co.] Meramec River, 37.987510N -91.373651W, IV-24-1971, J. Halter, (larvae). [Crawford Co.] Meramec River, 38.014929N -91.321421W, III-29-1975, Unknown, (larvae).

Remarks: The larvae collected in 1975 were a part of the reference collection at the Missouri Department of Natural Resources, Environmental Services Program, Jefferson City, Missouri.

Caenidae

**Cercobrachys fox* Sun and McCafferty

New State Record: [Gentry Co.] Middle Fork Grand River, 40.240551N -94.402527W, DEP habitat, IX-16-1999, R. Sarver, (larvae). [Livingston Co.] Grand River, 39.758501N -93.603724W, RIF habitat, VIII-10-2004, R. Sarver, (larvae).

Remarks: *Cercobrachys fox* has been reported from the surrounding states of Iowa, Nebraska, and Kansas (Sun and McCafferty, 2008). Records from Missouri were expected.

Heptageniidae

Macdunnoa persimplex (McDunnough)

Previous Record: [Marion Co.] Mississippi River, Traver (1935), (adult).
New County Records: [Cape Girardeau Co.] Mississippi River, 37.455183N -89.462837W, DN collection, VI-4-1998, R. Sarver, (larvae). [Perry Co.] Mississippi River, 37.604160N -89.510356W, WOD habitat, VI-3-1998, R. Sarver, (larvae).

Remarks: Burks (1953) reported larvae of *Heptagenia persimplex* McDunnough from the Mississippi River in Quincy, Illinois. *Macdunnoa persimplex* has been reported from large rivers in the surrounding states of Iowa (McCafferty et al., 2003), Nebraska (McCafferty et al., 2001), and Tennessee (McCafferty et al., 2010).

**Raptoheptagenia cruentata* (Walsh)

New State Record: [Cole Co.] Missouri River, 38.575018N -92.158883W, RIF habitat, V-21-2000, R. Sarver, (larvae). [Gasconade Co.] Missouri River, 38.707975N -91.434610W, BL collection, VI-18-1997, B. Poulton, (adults). [Perry Co.] Mississippi River, 37.604160N -89.510356W, RIF habitat, VI-3-1998, R. Sarver, (larvae).

Remarks: *Raptoheptagenia cruentata* has recently been collected in Arkansas

(McCafferty et al., 2010), Iowa (McCafferty et al., 2003), and Tennessee (McCafferty et al., 2010). Distribution records shown in the Mayfly Central Database (McCafferty and Jacobus, 2018) include the northeastern and southeastern regions of the United States, encompassing Missouri.

Leptophlebiidae

Neoleptophlebia mollis (Eaton)

Previous Records: [Barry Co., Camden Co., Dallas Co., Laclede Co., McDonald Co., Miller Co.] Ferro and Sites (2007) as *Paraleptophlebia mollis* (Eaton).

New County Records: [Shannon Co.] Backbone Hollow, 37.407794N -91.350022W, SN collection, V-16-2000, R. Sarver, (adults). [Shannon Co.] Pea Vine Hollow, 37.403226N -91.357309W, DEP habitat, V-16-2000, R. Sarver, (larvae).

Remarks: Tiunova and Kluge (2016) recognized *Neoleptophlebia* Kluge at genus rank and moved this species out of *Paraleptophlebia* Lestage.

Oligoneuriidae

**Homoeoneuria ammophila* (Spieth)

New State Record: [Howard Co.] Missouri River, 39.073214N -92.923366W, BT collection, IX-29-1998, B. Poulton, (larvae).

Remarks: The genus *Homoeoneuria* was first described in North America from a collection in Indiana (Spieth, 1937). More recently, *Homoeoneuria* has been reported in the southeastern United States (McCafferty et al., 2010), Nebraska (McCafferty et al., 2001), Iowa (McCafferty et al. 2006), and Missouri (Jungclaus-Meier et al., 2010). Specimens reported here were identified to species using the key by Pescador and Peters (1980); both the morphological characters and geographic distribution supported identification as *Homoeoneuria ammophila*.

Pseudironidae

Pseudiron centralis McDunnough

Previous Records: [Marion Co.] Mississippi River, Traver (1935), (♀ adult).

New County Records: [Cape Girardeau Co.] Mississippi River, 37.276617N -89.517411W, BT collection, V-10-2001, Missouri Department of Conservation, (larvae). [Perry Co.] Mississippi River, 37.604160N -89.510356W, BT collection, V-11-2001, Missouri Department of Conservation, (larvae).

Remarks: Burks (1953) reported larvae of *Pseudiron centralis* from the Mississippi River in Quincy, Illinois. Pescador (1985) reported the distribution of *Pseudiron centralis* in North America, as well as providing ecological notes stating that larvae are most often found in sandy substrate in large to medium size rivers. The larval records reported here using the benthic trawl collection method were collected in 1-7 m depths of flowing water from a gravel or sand substrate.

Siphonuridae

Siphonurus marshalli Traver

Previous Records: [Barry Co., Wayne Co.] Ferro and Sites (2007).

New County Records: [Vernon Co.] Little Drywood Creek, 37.776527N - 94.394081W, RTM habitat, IV-7-1998, R. Sarver, (larvae). [Vernon Co.] Little Drywood Creek, 37.651054N -94.387802W, RTM habitat, IV-8-1998, R. Sarver, (larvae).

Remarks: New county records in this manuscript expand the range of *Siphonurus marshalli* in Missouri from the Ozark to the prairie ecological region. Larvae were collected specifically from root mat habitat, which is somewhat consistent with pool and bank habitats reported by Ferro and Sites (2007) in the Ozarks.

DISCUSSION

In a survey by Sarver and Kondratieff (1997), mayfly distributions from surrounding states served as predictors of possible species presence within Missouri. Twenty-nine species were listed as uncollected but likely present, and since then 10 of these species have been collected and identified. These included *Caenis tardata*, *Neoleptophlebia mollis*, *Paraleptophlebia guttata*, *Proclleon rubropictum*, *Proclleon rufostrigatum* (Wiersema and McCafferty, 2004), *Serratella serrata*, *Siphonurus marshalli* (Ferro and Sites, 2007), *Baetis brunneicolor*, *Baetisca laurentina*, and *Raptoheptagenia cruentata* (current manuscript).

Mayfly records from large-river species are sparse (Barber-James et al., 2008), and there is a need to document species presence to track habitat preferences and future distribution shifts. Large-river species listed here included *Baetisca laurentina* (Berner and Pescador, 1980), *Homoeoneuria ammophila* (current manuscript; Spieth, 1937), *Macdunnoa persimplex* (Burks, 1953), *Pseudiron centralis* (Pescador, 1985), and *Raptoheptagenia cruentata* (Stagliano, 2016). Several species listed here are associated strongly with sandy habitats, including *Cerco-brachys fox* (Sun and McCafferty, 2008), *Homoeoneuria ammophila* (Jungclaus-Meier et al., 2010), *Pseudiron centralis* (Pescador, 1985), *Pseudocentropiloides usa* (McCafferty, 1991), and *Raptoheptagenia cruentata* (Stagliano, 2016). Sandy habitats and large rivers are subjected to a high amount of anthropogenic stress due to habitat alteration and pollution (Benke, 1990; Jacobus, 2013). For instance, anthropogenic stress attributed to the Kansas City urbanized area in Missouri and Kansas has been documented to decrease aquatic biotic condition indices in the downstream Missouri River macroinvertebrate community (Poulton et al., 2003). However, documenting changes in large-river biota is difficult because of limited access and the need for specialized sampling equipment. Although systematic large-river sampling has not been conducted in Missouri, some mayflies are considered rare. The last recorded collection of *Pseudiron centralis* in the adjacent state of Illinois was in 1961 (Favret and DeWalt, 2002).

Surprisingly, *P. centralis* specimens were collected from the Mississippi River in Missouri at two localities in 2001. This represents a 66-year lapse from the last collection in Missouri, which was reported by Traver (1935) from a female specimen collected along the Mississippi River. Long and Kondratieff (1996) listed the large river species *Macdunnoa persimplex* and *Pseudiron centralis* as threatened in Tennessee, making their documentation in Missouri important. Over 40 species of mayflies are classified as missing in Illinois because collection efforts have not reconfirmed species presence for more than 30 years (Favret and DeWalt, 2002). There is a crucial need to document species present in Missouri's large-river systems and in sandy habitats to better understand the diversity, distribution and ecological function currently occurring in those streams.

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