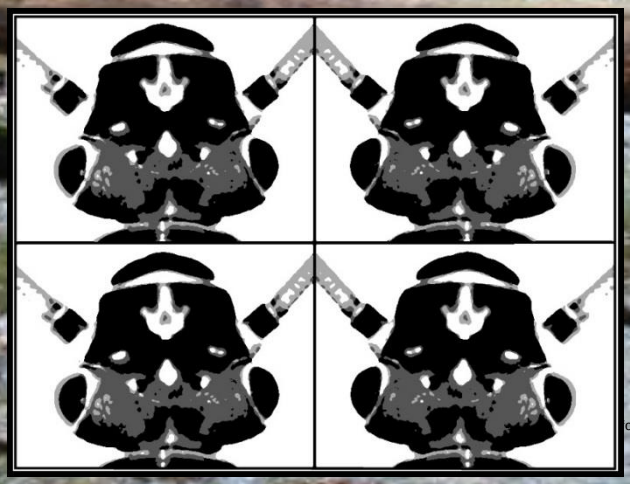
The PLECOPTERA of North Carolina



A Biologist's Handbook

For the Identification of Stonefly Nymphs

With Standard Taxonomic Effort Levels

Steven R. Beaty

Biological Assessment Branch
Division of Water Resources
North Carolina Department of Environment Quality

The PLECOPTERA
of North Carolina

A Biologist's Handbook for the Identification of Stonefly Nymphs
with Standard Taxonomic Effort Levels

Steven R. Beaty

Version 4.0
22 December 2015

North Carolina Department of Environment Quality
Division of Water Resources
Biological Assessment Branch
4401 Reedy Creek Rd
Raleigh, North Carolina 27607

Suggested Citation
Beaty, S. R. 2015. The Plecoptera of North Carolina: A Biologist's Handbook for the Identification of Stonefly Nymphs with Standard Taxonomic Effort Levels. Version 4.0. North Carolina Department of Environmental Quality, Division of Water Resources, Biological Assessment Branch. Raleigh, North Carolina. iv + 91 pp.

Cover: Mitchell River, Alleghany County, North Carolina

Copies of this document are available at:
http://portal.ncdenr.org/web/wq/ess/bau

Disclaimer: This manual contains taxonomic information which is often of a dynamic nature. The descriptions and the data on the following pages may change without warning as data becomes available and as the systematics of the Plecoptera is revised or corrected. Every attempt is made to keep information up to date with current trends in stonefly research with periodic revisions. However, due to resource allocations, changes to this manual may not proceed in a timely manner.

Acknowledgements

This manual would not exist if not for the early efforts of former BAU supervisor Trish McPherson to get her biologists on the same page. The taxonomic, field, and mental prowess of current BAB benthic biologists Eric Fleek, Victor Holland, Michael Walters, and Larry Eaton, was instrumental in obtaining and validating data and providing rigor to the descriptions provided herein. Former BAB biologists Tracy Morman, Deirdre Black, Bill Crouch, Blair Prusha, Larry Ausley, Richard Thorp, Cathy Tyndall, and Dave Penrose collected and identified much of the material utilized in this manual. For field sampling and sample processing, including the digging out of old specimens, the efforts of Mike Turner, Matt Stillwell, Michelle Simonson, and Michael Shepard are appreciated. Mark Hale deserves special mention for providing database and GIS assistance for difficult and unwieldy datasets.

Also I thank the many systematic and stonefly experts that have weighed in on this manual, or earlier versions, either by providing verifications, additional taxonomic characters for identification, taxonomic and locational data, comments, specimens, or rearing advice: Boris Kondratieff, Bill P. Stark, Stan Szczytko, and John Sandberg. Much of the information contained in this document would remain a mystery if not for the myriad number of stonefly workers across the world who provided the foundation and the keystones to the body of Plecoptera work that currently exists and on which this manual was based.

Lastly, many records and specimens for taxa contained in this manual (and for some the *only* records and specimens known) as well as valuable comments were provided by Dave Lenat, former BAB aquatic biologist, creator of North Carolina's Biotic Index.

CONTENTS

Families and genera of Plecoptera known to occur in North Carolina.
A name in ( ) indicates that the NC DWR Biological Assessment Branch has no nymphal records for that genus.

CONTENTS

SYSTELLOGNATHA continued

APPENDIX

INTRODUCTION

The Plecoptera, commonly called stoneflies, are a small order of insects that occur in both terrestrial and freshwater ecosystems. The terrestrial adult stage of stoneflies is typically short, days to a month or so, while the majority of their lifespan occurs, from months to years, in the aquatic stage, either as an egg or nymph. Plecoptera are Holarctic in distribution and present on every continent except Antarctica. As of 2008, worldwide, there were 16 families, 286 genera and upwards of 3500 known species of stoneflies (Fochetti and Tierno de Figueroa, 2008) with new species continually being described. North America is home to 9 families, 106 genera and almost 700 species of stoneflies (Dewalt et al., 2015).

In North Carolina, this order of insects currently consists of 9 families and 48 genera with a total of 167 described species. Stoneflies occur in almost all flowing waters of North Carolina from headwater, high elevation seeps and springs to lowland streams and large rivers. They are particularly substantive and diverse in clean, cool or cold Piedmont and Mountain streams. Similar to other aquatic insects, stoneflies are an important link in both aquatic and terrestrial food webs serving as both predator and prey of other macroinvertebrates and as prey for fish and birds. Stoneflies are also important economically, not as pests, but as a universally utilized bait by sportsmen angling for trout, bass, and other sport fishes. As an important link in the trophic interactions of freshwater systems, stoneflies, along with other benthic macroinvertebrates, are an indispensable component in our local streams and lakes.

Plecoptera are among the most intolerant insects occurring in aquatic habitats. The restrictive ecological requirements and poor dispersal abilities of stoneflies often results in their elimination from aquatic systems before any other group of insects, including other intolerant orders such mayflies (Ephemeroptera) and caddisflies (Trichoptera). Through either their presence or absence, nymphal stoneflies (among others) reflect the general health of streams and rivers and are important indicator taxa for water quality programs across the United States and the world. Whether attributable to reduced habitat, degraded water quality, or the increased water temperatures and reduced flows caused by climate change, the disappearance of stoneflies from some State waters is occurring at an increasing rate. Unfortunately, and as a complication to identification, many stoneflies are unknown or undescribed in the aquatic nymphal stage. With the continued degradation of North Carolina streams and the subsequent threat of extirpation of some stoneflies from local waters, it will become increasingly difficult to associate and describe nymphal stoneflies with their adult counterparts.

North Carolina's Division of Water Resources Biological Assessment Branch (BAB) has one of the most rigorous macroinvertebrate sampling protocols in the nation and has over 35 years of long-term data on many North Carolina water bodies. Most large rivers and streams have been sampled extensively over this 35-year period, with many small headwater streams inventoried as well, resulting in over 7500 site records. This has yielded the discovery of several new stonefly species from within the state, many of which are endemic to North Carolina. A few of these recently discovered species are even named in honor of BAB biologists. It is our hope that ongoing protections to our state's waters will facilitate the discovery of even more species, help associate life stages of existing species, and protect those species which are vulnerable to habitat loss and water degradation.

This document was created to help North Carolina Division of Water Resources biologists as well as biologists in independent and outside agencies identify the stonefly taxa present in local North Carolina waters and to stay current on recent taxonomic changes (e.g. synonymies or new species). It should also help to maintain a consistent level of taxonomic resolution between interacting organizations, which is an important criterion for rigorous and defensible data sets. The "taxonomic effort levels" suggested in this manual are based on many factors including the number of known associated species within a genus, availability of identification keys, difficulty of the keys and time utilized in the identification process.

For additional information on North Carolina's aquatic biomonitoring program including macroinvertebrate sampling methods, biological metrics, macroinvertebrate tolerance values, and stream habitat evaluations please visit North Carolina Division of Water Resources, Biological Assessment Branch's webpage at:
http://portal.ncdenr.org/web/wq/ess/bau

How to Use this Manual

The target users of this manual are aquatic biologists and taxonomic workers in North Carolina and surrounding states. It is therefore assumed that the user has some basic knowledge of stonefly biology including taxonomy, morphology, and life histories. Users not acquainted with stoneflies are advised to familiarize themselves with the first eight chapters of *An Introduction to the Aquatic Insects of North America* (Merritt et al., 2008) which describes subjects as diverse as sampling techniques, ecology, life histories, and morphology of aquatic insects. Additionally, the *Nymphs of the North American Stonefly Genera (Plecoptera),* Second Edition by K. W. Stewart and d B. P. Stark is unsurpassed in both information as well as quality of illustrations of all genera of stonefly nymphs occurring in North America. *The Plecoptera of North Carolina* is not intended as an exhaustive resource of stonefly species occurring within North Carolina and, instead, should be:

1) used as an aid in conjunction with other aquatic entomology literature and taxonomic sources
2) used to standardize taxonomic determinations between governmental agencies and outside organizations
3) be considered a quality control document.

The user assumes all risk and responsibility in taxonomic determinations made in conjunction with this manual.

Taxonomic Validity

The stonefly taxa documented herein are grouped and presented in the same phylogenetic order as presented by Stewart and Stark (2002, 2008). Genera within each family or subfamily are presented in alphabetical order. Along with primary literature, taxonomic names were verified using the Plecoptera Species File (http://plecoptera.speciesfile.org). Nomenclature used herein is valid as of late 2015 unless otherwise noted. As of this printing, the federally funded Integrated Taxonomic Information System (ITIS) website maintains approximately a four-year lag in valid nomenclature.

Taxonomic Treatments

Each genus entry has an accompanying diagnosis for the aquatic nymphal stage with the primary characters for each genus *italicized.* The order in which the identification characters are listed typically follows that of the anterior regions to the posterior regions (head to tail). Distributional and general habitat notes (including trophic status) are included with each genus. For distribution data, only states bordering or near North Carolina are included. The suggested level of taxonomic resolution is noted and represents the operational taxonomic unit (OTU) used by NCDWR biologists. This is followed by a list of species known to occur in or near North Carolina. If the genus in question is to be identified to species, a list of characteristics for each species is given unless only one species is present in North Carolina or it is a monotypic genus. All lengths in the descriptions refer to pre-emergent nymphs although some specimens may fall outside indicated ranges. Some genera that are not identifiable to the species level may have species notes included for reference only and are provisional. A "Notes" section follows with comments on taxonomic difficulties, synonymies, or special status. Included with each genus entry are distribution maps and seasonality charts for the appropriate taxonomic level indicated, most often species level. These are further described below. Finally, a list of suggested identification keys completes each genus entry. Additional literature for adults is presented to facilitate identifications when biologists have associated material. Many of the references are duplicated from genus to genus for convenience.

A caveat: Typically, as with most published taxonomic descriptions, characters presented here are most often based on a series of mature specimens and available published literature. However, as variation among individuals and between populations is common in most stonefly species, not every specimen will fit the written description, particularly those that are damaged or immature. Often, ecoregion or seasonality data, in conjunction with the description, may be helpful to verify the identity of the taxon. When uncertain, the specimen should be left at the next highest taxonomic level. Certainty in identifications is best achieved by consulting with other aquatic invertebrate taxonomists with regional experience.

Symbols used in taxonomic treatments and with taxonomic nomenclature are as follows:

( ) = valid published records for North Carolina but no BAB nymphal records, or nymph is undescribed

***** = no published records, either adult or nymphal, for North Carolina but may eventually be found

Common abbreviations in this document are as follows:

Two letter postal codes for states, e.g. NC, SC, TN, VA, etc.
DWR—Division of Water Resources; BAB—Biological Assessment Branch
GSMNP—Great Smoky Mountains National Park; BRP—Blue Ridge Parkway
CP —Coastal Plain; SH —Sand Hills: SB —Slate Belt

Various taxonomic entries may also refer to tolerance or intolerance of the organism. North Carolina macroinvertebrate tolerance values are based on published data (Lenat, 1993) and were updated in 2010. These values, if known, are provided in the appendix at the end of this manual. However, text descriptions of "tolerant" or "intolerant" are ambiguous without a defined associated tolerance value range. The generalized tolerances provided in-text follows that as shown in Table 1 and are provided only as a guide.

Table 1. Descriptors and associated tolerance value ranges for aquatic macroinvertebrates in North Carolina (NC DENR, 2013).

General Descriptor	Tolerance Value Range
very intolerant	0.0-1.9
intolerant	2.0-3.9
facultative	4.0-5.9
tolerant	6.0-7.9
very tolerant	8.0-9.9

Distribution Maps

This manual provides stonefly distributions within North Carolina's Level III Ecoregions. Griffith et al. (2002) described four Level III Ecoregions in North Carolina: Blue Ridge, Piedmont, Southeastern Plains and the Middle Atlantic Coastal Plain. However, in contrast to Griffith et al., DWR Biological Assessment biologists recognize only three Level III Ecoregions: Mountains, Piedmont, and Coastal Plain (Figure 1). In this case, the Coastal Plain refers simply to the combined area of Griffith's Southeastern Plains and Middle Atlantic Coastal Plain. This designation of three Level III ecoregions is used because aquatic insects within the Southeastern Plains (with the exception of the Sand Hills) and the Middle Atlantic Coastal Plain occur in similar habitats and flow regimes, have comparable seasonal patterns, and are affected by the similar landuse types. Also, both the Southeastern Plains and Middle Atlantic Coastal Plain are east of the Fall Line which appears, based on distributional data, to be the best biological separator between the Piedmont and the geographical areas to the east.

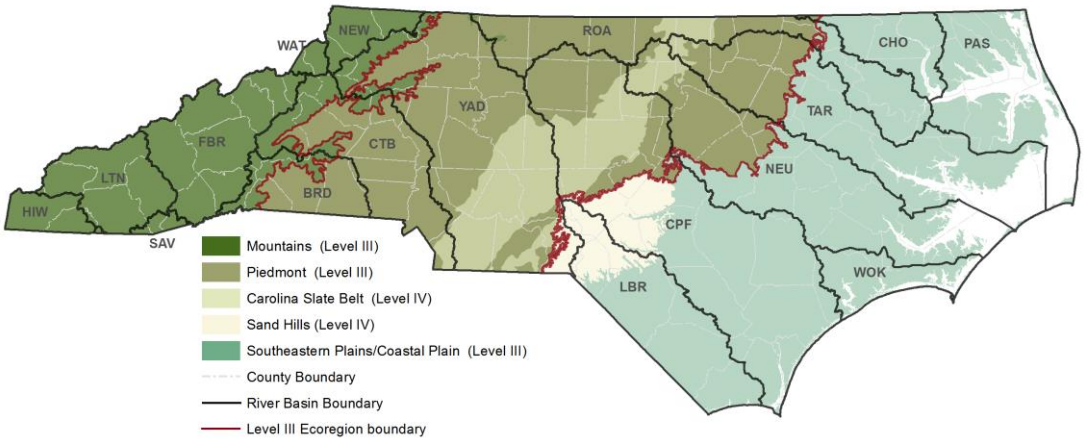


Figure 1. Approximate Level III and select Level IV Ecoregions within North Carolina with regards to stonefly distributions (modified from Gritffith et al., 2002).

While Level III Ecoregions adequately describe the distribution of many aquatic insects, taxonomically important Level IV Ecoregions (Sand Hills and Carolina Slate Belt) are also mentioned within the text of many genus and species entries and are indicated on all maps herein. In addition to distributions within ecoregions, the text may also refer to distributions with respect to North Carolina's 17 river basins (Figure 1, Table 2).

The distribution maps included at the end of each genus entry are based upon BAB macroinvertebrate collections, up to 35 years of data in many cases. Recently described, synonomized or elevated taxa may include only a few years of records and are noted. Additionally, every attempt was made to verify records that appear outside normal ranges, particularly with taxa that have highly disjunct distributions or outlier records. In many cases this was done by re-identifying decades-old specimens. If specimens were not located or were too damaged for accurate identification, the record was removed from consideration.

Table 2. North Carolina's 17 river basins.

Basin	Basin Code
Broad	BRD
Cape Fear	CPF
Catawba	CTB
Chowan	CHO
French Broad	FRB
Hiwassee	HIW
Little Tennessee	LTN
Lumber	LBR
Neuse	NEU
New	NEW
Pasquotank	PAS
Roanoke	ROA
Savannah	SAV
Tar-Pamilico	TAR
Watauga	WAT
While Oak	WOK
Yadkin-Pee Dee	YAD

In cases of rarely collected taxa, county or specific locational data is also presented in the text. Figure 2 depicts all 100 North Carolina counties.

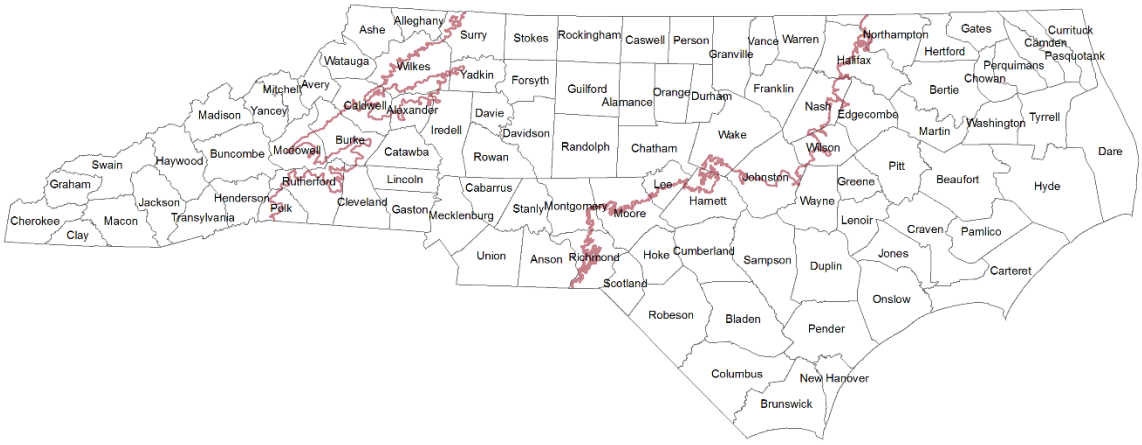


Figure 2. Counties of North Carolina. Red lines depict Level III ecoregions, from left to right: Mountains, Piedmont, Coastal Plain.

Seasonality Charts

The majority of the field season for BAB biologists typically coincides with the late spring and summer due to many logistical factors. However, the preponderance of spring and summer aquatic sampling can exclude many important or rare taxa that may only be collected from streams in cooler months and, in fact, many species are not collected during the summer at all. Sampling the same stream in the winter will usually result in a different benthic community than that which exists in mid-summer. Knowing when a taxon might occur in the stream allows for targeting of unknown species for rearing studies, life history accounts, or development of appropriate water quality metrics.

The seasonality charts presented in this manual are not typical seasonality charts. Rather than depicting the adult seasonal flight times commonly presented in life history studies, they instead depict the percent occurrence of the larva of the target taxon (operational taxonomic unit or OTU) in a stream macroinvertebrate sample over the course of one year. The charts are normalized by total number of samples collected each month (seasonal sampling effort) resulting in a percent (%) of occurrence of the target taxon. For example, the % occurrence for an OTU in May would be calculated by the following equation:

$$\%\ \text{OTU occurrence in May samples} = \frac{\#\ \text{OTU records in May}}{\text{total}\ \#\ \text{of May samples}}$$

Calculation for each month can be graphically represented for the hypothetical taxon, *Negaperla carolina* as represented in Figure 3.

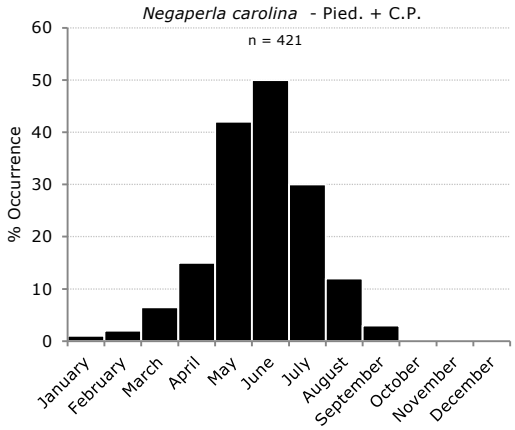


Figure 3. Generalized seasonality chart. In this example the OTU is recorded in approximately 50% of all June samples from the Piedmont and Coastal Plain. Transition from larva to adult (emergence) typically coincides with the falling limb of the graph, while the rising limb represents larval growth.

The data represented by these seasonality charts includes only records from the Level III Ecoregions where the OTU commonly occurs or where the preponderance of records are. For example, Piedmont and Coastal Plain records are eliminated from analyses of predominately mountain taxa and so on. Additionally, graphs depicting taxa that have significant representation in more than one Level III Ecoregion may be composites of the ecoregions in which the taxon is present. However, as the onset of adult emergence in the Mountains typically lags that of the Piedmont and Coastal Plain (which have similar emergent periods to each other for many taxa) by up to one month, most composite graphs are of the Piedmont and Coastal Plain regions.

While some charts illustrate a "clean" unimodal pattern indicating a univoltine, single cohort population, other graphs are bimodal, multimodal, or have no apparent trend. A bimodal graph can indicate univoltine species with multiple cohorts, a bivoltine species, or the presence of cryptic species. However, single species with multiple cohorts can also be represented by a graph with no apparent pattern or with a significant occurrence every month. This type of graph can also be interpreted as depicting a long-lived semivoltine species which occurs as a nymph over the course of two or three years. The point is that while some information can be gleaned from these graphs, such as when the aquatic stage of a taxon generally occurs (winter/spring, spring/summer, all year, etc.) or when adult emergence is most likely to begin, caution should be used when extrapolating from these charts. Many confounding factors can reduce the rigor of these graphs including the presence of multiple species (as happens in genus level identifications), multiple cohorts, semivoltinism, delayed or extended emergence, larval diapause, drought effects, etc.

With the caveats explained above, the seasonality charts contained herein provide a dual purpose. First, they offer an additional level of quality control. For example, the presence of an early season stonefly such as *Isoperla orata* in a late summer sample is likely due to an erroneous identification. Secondly, these charts can identify, in many cases, the general time when adults emerge. This is useful information for biologists when collecting adults for taxonomic verification or rearing purposes. It should also be noted that these seasonal patterns may shift as available data increases, taxonomic groups are reevaluated, as environmental disturbances such as reduced flows during drought conditions become more prevalent, or as a response to changing climatic conditions. Also, as a final warning, the effects of seasonal sampling bias will not be totally eliminated by normalizing the data and therefore the charts should be used with that in mind.

Appendix

An appendix table with a list of species (alphabetical on family then genus then species), tolerance value data, number of DWR records, and important species notes follows at the end of the manual.

Request for Data

In an effort to maintain accurate reporting of taxonomic data contained herein, the authors invite users of this manual to report, if possible, new or unusual taxa found and disjunct records of stoneflies occurring within North Carolina. Reporting of data should contain information on the waterbody the taxon was recorded from including the nearest road crossing, GPS coordinates (decimal degrees), elevation (if possible), date of collection, method of collection, names of the collectors, and habitat collected from (if known), as well as any other pertinent information pertaining to the taxa collected. *Specimens may be required by BAB taxonomists for verification of certain taxa and/or distributional records.*

Comments and corrections on the text of the Plecoptera of North Carolina are welcome and will be thoughtfully considered for future revisions. For data or error reporting please contact the author via the BAB website.

Family CAPNIIDAE

Commonly called "snowflies", winter stoneflies of the family Capniidae emerge during the late fall and early winter. The adults in the Southeast are small and dark and have long, conspicuous multisegmented cerci. They fly during the coldest times of the year, often until early spring at higher elevations, and are sometimes visible as dark moving specks on snow and ice near stream margins or crawling on bridge structures.

Nymphs are brown, often nondescript, and can attain lengths up to 10 mm, although they are usually much smaller. They are detritivorous and are typically found on submerged leaf packs during the fall and winter and are likely in the hyporheic sediments during either a slow growth period or egg diapause during the summer. Most Capniidae likely have a life-span of up to one year (univoltine) although this information is incomplete or unknown for many members of this family.

Capniidae in North Carolina are widespread in the Piedmont and Mountain ecoregions and can be found in small intermittent reaches, mid-size perennial streams, and larger rivers. The family in North Carolina is represented by three genera and 10 species.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by a combination of the following characters:

1) Small, linear body with elongate abdomen
2) When extended, hind legs not reaching past mid abdominal segments
3) Head pseudo-hypognathus (position intermediate to horizontal or vertical)
4) Type I mouthparts:
    a. glossa and paraglossa of equal length and shape
    b. labial palpi reach to or barely exceed labium (glossa and paraglossa)
5) Mentum reduced, not covering base of maxillae
6) Metanotal wing pads with mid-line mostly parallel with the long axis of the body
7) Hind wing pads no more than 2 times as long as wide
8) Second tarsal segment of legs much shorter than first segment
9) Thorax and abdomen without gills
10) Distal abdominal segments typically wider than proximal segments
11) Abdominal sterna with sublateral membranous pleural folds present on segments 1-9

SUBFAMILIES AND GENERA IN NC:

Capniinae: *Allocapnia, Nemocapnia, Paracapnia*

NOTES: *Allocapnia* is, by far, the most commonly encountered Capniidae genus within North Carolina and nymphs are often abundant in routine bioassessments during the late fall and winter. In contrast, both *Paracapnia* and *Nemocapnia* are much less common in the region, likely having restrictive habitat requirements contributing to overall rarity.

Seven North American genera of Capniidae do not occur in the southeastern U.S. and are not treated herein. Untreated genera include the western distributed *Bolshecapnia*, *Eucapnopsis*, *Isocapnia*, *Mesocapnia*, *Sierracapnia*, and *Utacapnia*, as well as the western and northern distributed *Capnia* and *Capnura*. Refer to Stewart and Stark (2002, 2008) for details on separating these genera. Nymphs of *Sierracapnia* are unknown (Bottorff and Baumann, 2015).

Separation of the nymphs between the two winter stonefly families Capniidae and Leuctridae has historically been difficult due to the overall small size of the nymphs and the overall similarity of the habitus types. Traditional characters to separate the families such as the number of abdominal segments possessing a lateral pleural fold or the extent of the mentum are often difficult to see in preserved, and particularly small, specimens. However, careful attention to characters such as wing pad shape and size in addition to using seasonality (i.e. *Allocapnia* nymphs will likely not be collected during mid-summer while *Leuctra* may be) should assist in correct diagnoses.

Most capniid nymphs are highly intolerant to various forms of pollution and are good indicators of water quality.

Allocapnia

Genus Diagnosis: Nymphs 5-10 mm. *Inner margin of hind wings pads unnotched or notched apically, sometimes reduced*; abdomen elongate and cylindrical, usually with segments 5 or 6-8 usually wider than anterior segments (i.e. not parallel sided); abdominal terga with posterior setal fringe; *cercal segments without dorsal or ventral fringe of intercalary hairs*, apical segments with whorls of apical setae; body hair inconspicuous.

Habitat and Trophic level: Nymphs prefer leaf packs during their active growing stage in the fall and winter and many species may diapause in the hyporheic zone during the summer. Detritivorous (shredders). Clingers.

Distribution and Occurrence: *Allocapnia* is recorded primarily from Mountain and Piedmont ecoregions. Common late fall through winter.

Species in NC: LEAVE AT GENUS

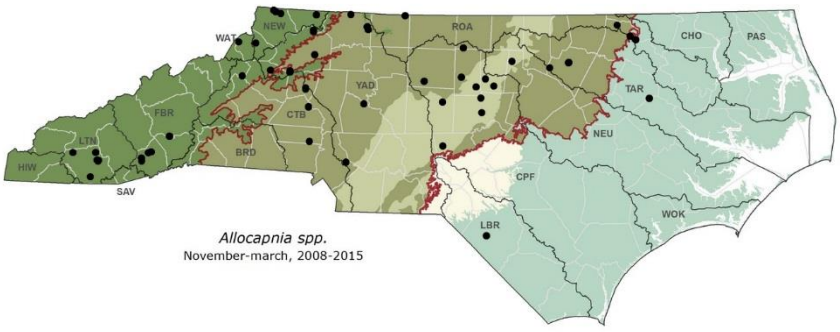
(aurora), (fumosa), (nivicola), (recta), (rickeri), (stannardi), (virginiana), (wrayi)

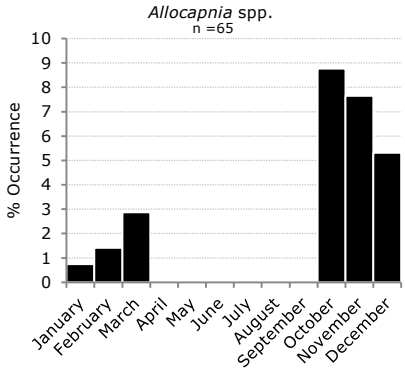
Notes: There are at least eight species of *Allocapnia* in North Carolina, of which at least three (*A. fumosa*, *A. stannardi*, and *A. wrayi*) are undescribed as nymphs. Species level identifications are not recommended although a provisional key is provided by both Harper and Hynes (1971) and Stark and Lacey (2005).

Spring and summer records of *Allocapnia* are most likely misidentifications of *Leuctra*. The map depicting *Allocapnia* distribution was created by using only records between late winter and early spring from 2008-2015 and with random identification verifications. This was performed to reduce the overlap with *Leuctra* records.

Allocapnia fumosa is listed as "vulnerable to extirpation" by Morse et al. (1997).

Allocapnia generally have fast univoltine life cycles (Mackay, 1969; Ernst and Stewart, 1985a; Harper et al., 1989; Grubbs et al., 2006).





Taxonomic references:

nymphs:

Harper, P. P. and H. B. N. Hynes. 1971a. The Capniidae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 921-940.

adults:

Ross, H. H. and W. E. Ricker. 1971. The classification, evolution, and dispersal of the winter stonefly genus *Allocapnia*. Illinois Biological Monograph 45.

Nemocapnia

Genus Diagnosis: Nymphs 5-7 mm. Purplish-brown reticulations on head, most conspicuous within ocellar triangle; *hind wing pads notched medially*; *cerci with dorsal and ventral fringe of long silky hairs.*

Habitat and Trophic level: Gravel and detritus in areas of faster flows of smaller streams to larger rivers. Nymphs may diapause in the hyporheic zone during the summer and fall. Possibly detritivorous (shredders).

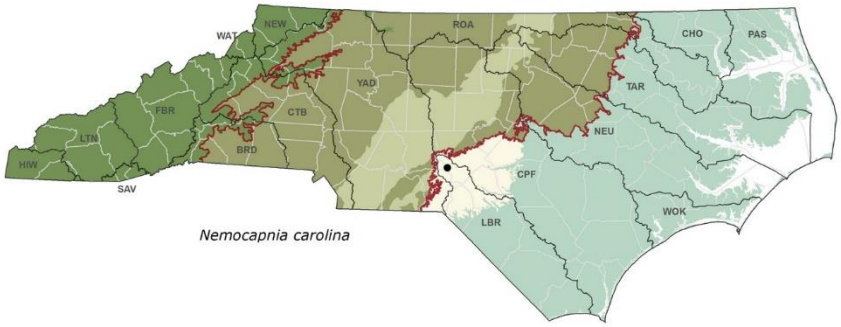
Distribution and Occurrence: Nymphs occur during the winter but are rarely collected. *Nemocapnia* appears to be an early season emerger.

Species in NC: MONOTYPIC

carolina – see Genus Diagnosis

Notes: Little is known about the habitat requirements or the life history for *Nemocapnia carolina* and few habitat references are available in the primary literature. The above habitat information is general information that pertains to many members of the Capniidae.

DWR BAB has one Sand Hills *Nemocapnia carolina* record from Jackson Creek in Moore County (1989) and it has not been collected in the immature stage since. *Nemocapnia carolina* nymphs and adults have also been collected by an outside agency from the Pee Dee River (Feb., 2001, specimens retained by BAB) and the Black River (B. Kondratieff, Jan. 1996).



Taxonomic references:

nymphs and adults:

Harper, P. P. and H. B. N. Hynes. 1971. The Capniidae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 921-940.

Paracapnia

Genus Diagnosis: Nymphs 6-8 mm. Head with a purplish-brown reticulate color pattern; *pronotum fringed with many long bristle-like hairs, longest at corners*; *body setose, with numerous long setae*; *cerci with apical circlet of hairs and with, at most, 1 short dorsal and 2 ventral intercalary hairs.*

Habitat and Trophic Level: Nymphs typically occur in small headwater streams, possibly in leaf packs or in the hyporheos. Detritivorous (shredders).

Distribution and Occurrence: Nymphs are collected late fall through mid-winter in the Mountains only.

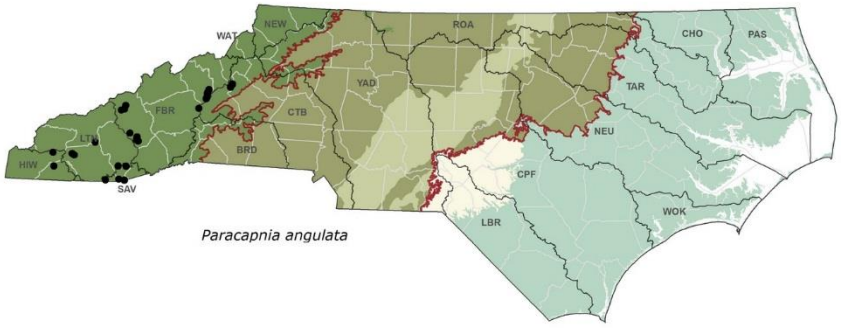
Species in NC: TAKE TO SPECIES

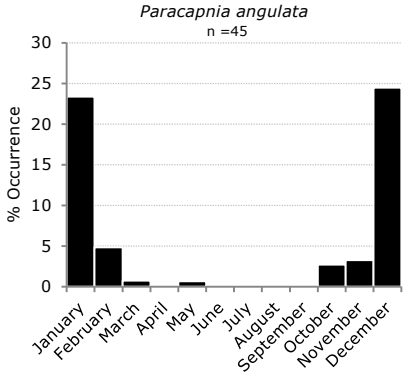
angulata – Head pattern of purplish pigmentation outlining entire frontoclypeus, with a short bar from median ocellus to the anterior edge of the frontoclypeus, and with a, sometimes incomplete, transverse pigment bar from antennal pedicels through median ocellus; occiput usually with purplish bars along, but removed from, epicranial stem to postoccipital margin; setae on inner surface of tibia short, only half as long as width of tibia; middle and distal segments of cerci each with one long intermediate hair on ventral surface near the base.

Nymphs are not normally collected during routine bioassessment sampling which occurs during the late spring through the fall.

Notes: *Paracapnia angulata* is the only known species of *Paracapnia* in the southeastern United States. *Paracapnia opis* has a much more northerly distribution. *Allocapnia* usually co-occurs with *Paracapnia* and the former is oft misidentified as the latter. The two genera have noticeably different setation patterns and *P. angulata* has a conspicuous and extensive head pattern. Also, some *Leuctra* have a similar head pattern as *Paracapnia angulata* but setation patterns and abdominal pleural fold formula will separate these genera.

Paracapnia angulata was found to have univoltine life cycle in southern Ontario streams (Harper and Hynes, 1972) and *Paracapnia opis* a fast univoltine cycle in New York intermittent streams (Delucchi and Peckarsky, 1989).





Taxonomic references:

nymphs:

Harper, P.P. and H.B.N. Hynes. 1971a. The Capniidae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 921-940.

adults:

Stark, B. P. and R. W. Baumann. 2004. The winter stonefly genus *Paracapnia* (Pelcoptera: Capniidae). Monograph of the Western North American Naturalist. 2: 96-108.

Family LEUCTRIDAE

Stoneflies of this family are commonly referred to as "rolled-winged" stoneflies or "needleflies". The overall appearance to a small needle is based upon the adult wings being somewhat curled around the sides of the abdomen while at rest. Overall, adults are typically small and dark and have very short 1-2 segmented cerci. Despite being commonly thought of as winter stoneflies, species members of Leuctridae, particularly those of the genus *Leuctra*, emerge throughout the year; some species emerging in the fall or winter months and others in the spring or summer.

Nymphs, similar to capniids, are small (except *Megaleuctra*) and brown with inconspicuous markings. They are primarily found on leaf packs in areas of good flow although some species may take refuge in the hyporheos. Nymphs of some genera are frequently collected in large numbers. Many Leuctridae are univoltine and transition through all life stages (egg, nymph, adult) within one year, although at least one *Leuctra* species is semivoltine in some systems. The life histories for some Leuctridae are unknown.

The Leuctridae of North Carolina are represented by three genera and at least 14 species occur in most ecoregions except the Coastal Plain. Nymphs can be collected from small intermittent headwater streams to larger rivers.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by the combination of the following characters:

1) Small, linear body with elongate abdomen
2) When extended, hind legs not reaching past mid abdominal segments
3) Head pseudo-hypognathus (position intermediate to horizontal or vertical)
4) Type I mouthparts:
    a. glossa and paraglossa of equal length and shape
    b. labial palpi reach to or barely exceed labium (glossa and paraglossa)
5) Mentum, to some extent, covering bases of maxillae
6) Metanotal wing pads with mid-line mostly parallel with the long axis of the body
7) Hind wing pads more than 2.5 times as long as wide on mature specimens
8) Second tarsal segment of legs much shorter than first segment
9) Thorax and abdomen without gills
10) Abdomen usually parallel sided, slightly narrowed distally
11) Abdominal sterna with sublateral membranous pleural folds present on segments 1-7

SUBFAMILIES AND GENERA IN NC:

Leuctrinae: *Leuctra, Paraleuctra*

Megaleuctrinae: *Megaleuctra*

NOTES: Similar to the Capniidae, the Leuctridae of North Carolina are dominated by one genus, *Leuctra*, which represents almost all of the nymphal collection records within the state. Whereas *Leuctra* are frequently abundant both *Megaleuctra* and *Paraleuctra* are rarely collected at all.

Six genera of the North American Leuctridae do not occur in North Carolina and are not treated further. *Calileuctra*, *Despaxia*, *Moselia*, *Perlomyia*, and *Pomoleuctra* are distributed within the western Nearctic. *Zealeuctra,* an eastern Nearctic genus, has species recorded from TN and VA but appears to primarily be an Ozark and upper Midwestern genus. However, *Zealeuctra* may eventually be recorded from North Carolina. Refer to Stewart and Stark (2002, 2008) for details on separating these genera.

Separation of the nymphs between the two winter stonefly families Leuctridae and Capniidae has historically been difficult due to the overall size of the nymphs and the overall similarity of the habitus types. Foolproof taxonomic characters, such as the number of abdominal segments with pleural folds or the extent of the mentum, can be difficult to see in small or preserved specimens. A combination of morphological characters will most likely be needed to correctly determine the identity of the specimens for workers unacquainted with these families. Additionally, seasonal or distributional data may also assist in correct generic determinations.

Nymphs of Leuctridae, like most stoneflies, are intolerant to various forms of pollution and are good indicators of water quality.

Leuctra

Genus Diagnosis: Nymphs 6-9 mm. Labial palpi extend past rest of labium; *abdominal sternites 1-4 with pleural folds*; abdomen parallel sided, posterior margins of each tergum with a setal fringe; *pair of terminal setae on lobe of last abdominal segment.*

Habitat and Trophic Level: Nymphs occur in small streams to larger rivers, often in sandy or gravelly areas but also on cobbles in riffles. Detritivorous (shredders).

Distribution and Occurrence: Widespread and very common during the spring and summer.

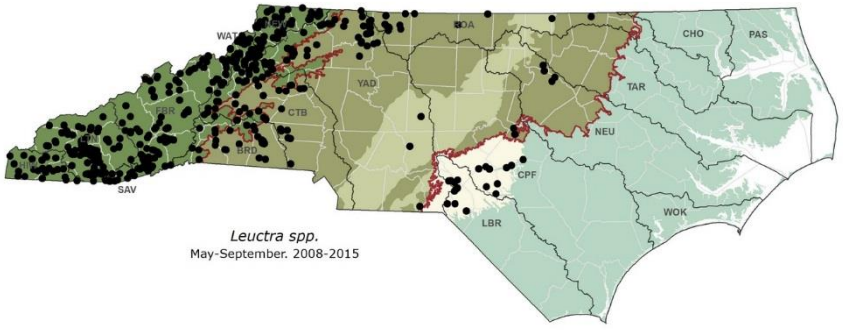
Species in NC: LEAVE AT GENUS

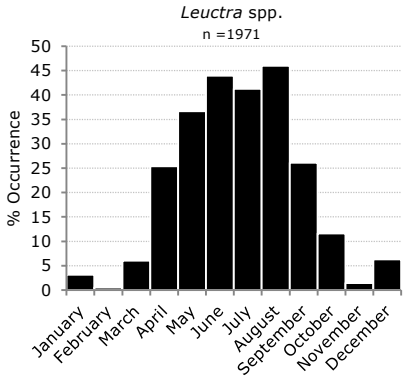
(alexanderi), (biloba), (carolinensis), (ferruginea), (grandis), maria *, (mitchellensis), moha *, (monticola), (nephophila), (sibleyi), tenella *, (tenuis), (triloba), truncata *, variabilis

Notes: North Carolina has at least ten species of *Leuctra*. Species determinations are not recommended as the nymphs of many species are still undescribed.

Leuctra maria, *L. tenella*, *L. tenuis*, *L. truncata*, and *L. variabilis* have been recorded from Great Smoky Mountain National Park (GSMNP). *Leuctra variabilis* has also been collected from Ridges Mountain, Randolph County (B. Kondratieff, C. Verdone, - unpublished data, 2013). *Leuctra moha* has been recorded from GA and SC.

Leuctra ferruginea has been found to be semivoltine in smaller, cooler streams and univoltine in larger, warmer streams (Harper, 1973a; Ernst and Stewart, 1985a; Huryn and Wallace, 1987). Grubbs et al. (2006) found that some *Leuctra* species exhibit a fast univoltine life cycle in an intermittent headwater Kentucky stream.





Taxonomic references:

nymphs and adults:

Harper, P. P. and H. B. N. Hynes. 1971b. The Leuctridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 915-920.

Hitchcock, S. W. 1974. Guide to the Insects of Connecticut. Part VII. The Plecoptera or Stoneflies of Connecticut. Bulletin of the State Geological and Natural History Survey of Connecticut. 107. vi + 262 pp. ***NOTE:* keys 8 species of which only 3 occur in NC **

Megaleuctra

Genus Diagnosis: *Large, stout, nymphs 15-20 mm.* Pronotum completely fringed laterally with short, stout setae; male nymphs have characteristic 10th tergum composed of fused paraprocts forming a long, triangular caudal projection; female nymphs with a small mesal triangular projection on posterior margin of sternum 8; body setose, with dense covering of surface hair.

Habitat and Trophic Level: Nymphs are found in leaf matter that has a thin cover of flowing water within high elevations headwaters, springs, and seeps. Detritivorous (shredders).

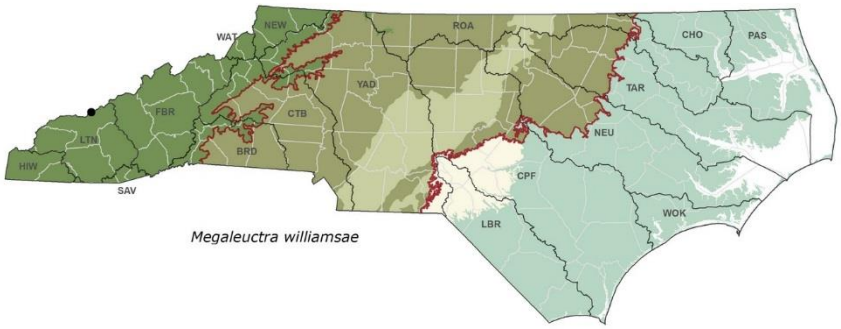
Distribution and Occurrence: Nymphs occur in high elevation mountain streams only. Rare.

Species in NC: TAKE TO SPECIES

williamsae – see Genus Diagnosis

Notes: *Megaleuctra williamsae* is the only known species in North Carolina and has been collected by BAB only from Beech Flats Prong in GSMNP, although there are other non-BAB records along the BRP (B. Kondratieff, D. Lenat). A second species, *Megaleuctra flinti* is recorded from VA and more northern states. Listed by both the NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014) and by Morse et al. (1997) as "vulnerable to extirpation".

The life history and habits of *Megaleuctra williamsae* are unknown.



Taxonomic references:

nymphs:

no comprehensive treatment of nymphs available

adults:

Baumann, R. W. and B. P. Stark. 2013. The genus *Megaleuctra* Neave (Plecoptera: Leuctridae) in North America. Illiesia 9(06): 65-93.

(Paraleuctra)

Genus Diagnosis: Nymphs 6-9 mm. Labial palpi short; mesosternal Y-arms with double stem and a dark median line; terga without posterior setal fringes; *abdominal segments 1-6 with pleural fold*; *abdominal hairs sparse*; body typically patterned.

Habitat and Trophic Level: Unknown. Pre-emergent nymphs are probably hyporheic and difficult to collect. Possibly detritivorous (shredders).

Distribution and Occurrence: Nymphs are most likely to be collected late winter through early spring in the Mountains.

Species in NC: TAKE TO SPECIES

(sara) – see Genus Diagnosis

Notes: *Paraleuctra sara* is the only known species in eastern North America and has been recorded from GSMNP. Adult *P. sara* were collected in 2010 from Little Bear Creek in Mitchell County, NC. The BAB reference specimen (nymph) is from an outside collection and unknown location in Haywood County (1988) and as such is not a valid BAB record. There are adult records from multiple mountain counties across the NC Appalachians (B. Kondratieff, R. Kirchner, and D. Lenat, April 2007) and therefore *Paraleuctra sara* appears more common than the occurrence of nymphal records would indicate.

There are no published life history studies on *Paraleuctra*.

Taxonomic references:

nymphs:

Harper, P. P. and H. B. N. Hynes. 1971b. The Leuctridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 915-920.

adults:

Stark, B. P. and J. W. Kyzar. 2000. Systematics of Nearctic *Paraleuctra* with description of a new genus (Plecoptera: Leuctridae). Tijdschrift voor Entomologie 144: 119-135.

Family NEMOURIDAE

"Forestflies", or nemourids, are often referred to as spring stoneflies due to adult emergence occurring, for many species, in late winter through spring. Adults of this family are small (less than 9 mm) and dark with wings flat along the abdomen at rest, and with one segmented cerci. Adults typically emerge in spring or early summer.

Nymphs, also small, are nondescript brown to reddish orange, are often hairy in appearance, and mature specimens have wingpads appearing swept to the side, diverging from the body axis. Nymphs are detritivores and can be found clinging to leaf packs or pocketed in gravelly areas, cobble riffles, or other such areas that may trap detritus or flocculent algae. Many species of Nemouridae are reported to have one year life cycles although much is yet unknown of the life histories of many species.

There are seven genera and at least 14 species of Nemouridae occurring in North Carolina. The family is widespread across the state, but a particular genus or species might only be found in one ecoregion or have highly disjunct and localized populations. Nymphs can be collected from small intermittent streams to larger rivers although waterbody size may be highly restrictive for some species.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by a combination of the following characters:

1) Small body, short and robust
2) Legs, when extended, reach beyond apex of abdomen
3) Head hypognathus (vertically oriented)
4) Type I mouthparts:
    a. glossa and paraglossa of equal length and shape
    b. labial palpi reach to or barely exceed labium (glossa and paraglossa)
5) Metanotal wing pads with mid-line highly divergent with the long axis of the body
6) Second tarsal segment of legs much shorter than first segment
7) Thorax and abdomen with or without cervical (neck) gills
8) Abdomen usually narrowed distally

SUBFAMILIES AND GENERA IN NC:

Amphinemurinae: *Amphinemura,*

Nemourinae: *Ostrocerca, Paranemoura, Prostoia, Shipsa, Soyedina, Zapada*

NOTES: *Amphinemura* are the most widespread and abundantly collected genus of Nemouridae in North Carolina. Other genera such as *Prostoia* and *Shipsa* are also frequently encountered but have been often confused for one another thereby confusing distribution and occurrence data. Other regional taxa, such as *Ostrocerca* and *Zapada*, are much rarer and are not often collected during typical bioassessment studies which do not target the habitats of these genera, typically high elevation headwater springs and streams.

Six Nearctic genera are not treated in this manual: *Lednia*, *Malenka*, *Nanonemoura*, and *Visoka* are western Nearctic in distribution only while *Nemoura* and *Podmosta*, present in the western US, also occur in more northerly eastern Nearctic states and Canada. Reference Stewart and Stark (2002, 2008) for information on separating these genera from the Southeastern taxa.

The tolerance values of some genera (e.g *Ostrocerca* and *Zapada*) are unknown, others, such as *Amphinemura* and *Prostoia*, are relatively tolerant to some forms of pollution as compared to other taxa of stoneflies. These genera are often collected in streams with high silt loads but which may otherwise have good water quality.

Amphinemura

Genus Diagnosis: Nymphs 5-8 mm. Pro- and mesonotum well fringed by short, stout setae; femora without transverse row of stout setae; *four anterior thoracic gill clusters, consisting of two lateral pairs each with each cluster of five or more equal length branches, present ventrally in the prosternal region.*

Habitat and Trophic Level: In both small, headwater streams and larger streams and rivers (may be species specific); detritivorous (shedders and facultative collectors).

Distribution and Occurrence: *Amphinemura* nymphs are typically collected winter through spring with a summer diapause and a fall emergence. A widespread genus, though less common in the North Carolina Coastal Plain.

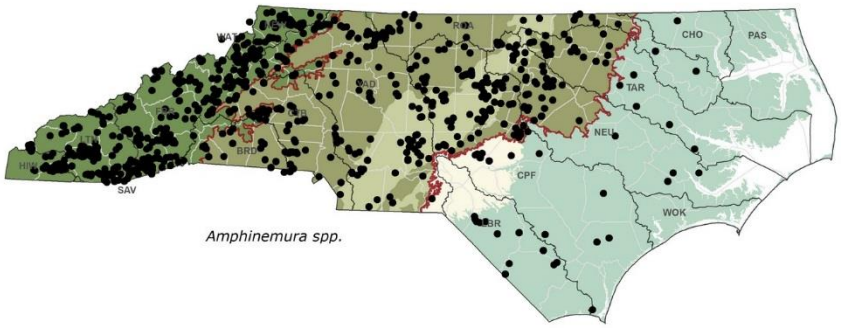
Species in NC: LEAVE AT GENUS

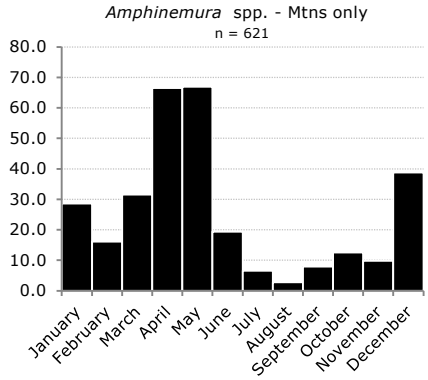
(appalachia), (delosa), (nigritta), (wui)

Notes: The four above *Amphinemura* species have been recorded from GSMNP. Male and female adults of *A. appalachia* are described in Baumann (1996a) although the nymphs are not described. Records of *A. delosa* from GSMNP do not report which state (TN or NC) the specimens were obtained from although there are multiple records of *A. delosa* from Swain Co. (C. Parker, unpublished data).

A nymphal key to the eastern species of *Amphinemura* is currently in preparation by B. P. Stark (2016) but it does not provide characters for *A. appalachia*.

Amphinemura are reported to be fast-univoltine (Mackay, 1969; Harper, 1973a, Ernst and Stewart, 1985a; Delucchi and Peckarsky, 989).





Taxonomic references:

nymphs:

Harper, P. P. and H. B. N. Hynes. 1971c. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 1129-1142.

adults:

Hitchcock, S. W. 1974. Guide to the Insects of Connecticut. Part VII. The Plecoptera or Stoneflies of Connecticut. Bulletin of the State Geological and Natural History Survey of Connecticut. 107. vi + 262 pp.

Ostrocerca

Genus Diagnosis: Nymphs 5-7 mm. *Pronotum with an irregular lateral fringe of moderate spines*; anterior thoracic gills absent; *fore tibia with a sparse fringe of silky hairs AND a complete submarginal row of large, heavy bristles*; *ventral bristles of cercal whorls of apical segments longer than other bristles*; *tenth tergite of male extended and apically cleft.*

Habitat and Trophic Level: Found in springs and small, cold headwater springs and streams; in gravel and leaf packs. Detritivorous (shredders).

Distribution and Occurrence: A spring emergent taxon in the Mountains only. Nymphs are rarely collected.

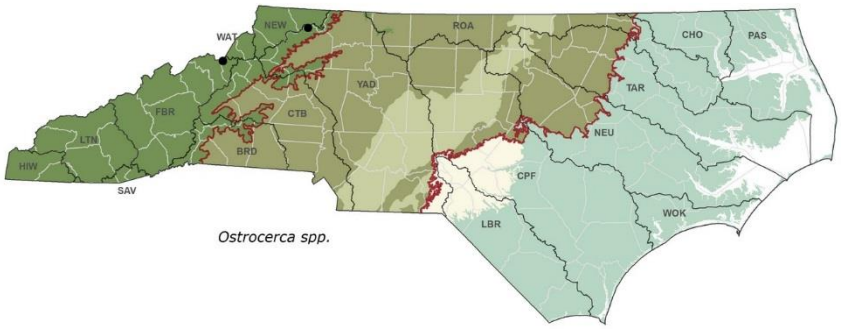
Species in NC: LEAVE AT GENUS

(albidipennis), (truncata)

Notes: Baumann (1975) revised the nemourid world fauna and contains many useful illustrations for separating out some of the more difficult genera in the Family Nemouridae. Due to the difficulty in identifying the submarginal rows of tibial spines with a typical dissecting scope it is recommended that the fore tibia be slide-mounted.

Two species of *Ostrocerca* have been collected from North Carolina; B. Kondratieff has records for *O. truncata* from Haywood, Madison, and Watauga Counties and records of *O. albidipennis* from Ashe County (unpublished data, personal communication). North Carolina *O. truncata* specimens from Wilkes County (courtesy of D. Lenat) and Avery County have tergites 1-6 dorsally brown which get lighter towards segments 8-10.

Many *Ostrocerca* species have a univoltine life cycle (Mackay, 1969; Stewart and Anderson, 2010).



Taxonomic references:

nymphs:

Harper, P. P. and H. B. N. Hynes. 1971c. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 1129-1142.

adults:

Hitchcock, S. W. 1974. Guide to the Insects of Connecticut. Part VII. The Plecoptera or Stoneflies of Connecticut. Bulletin of the State Geological and Natural History Survey of Connecticut. 107. vi + 262 pp.

(Paranemoura)

Genus Diagnosis: Robust, though small, nymphs 4.5-6.0 mm. Pronotum with marginal stiff setae inconspicuous; anterior thoracic gills absent; *fore tibiae with sparse silky hair*; *tenth tergum of male nymph produced apically; female nymph with a concave emargination on the posterior margin of the seventh sternal segment*; *cerci with short and sparse intersegmental setae*; light mid-dorsal abdominal stripe.

Habitat and Trophic Level: Unknown. Nymphs occur in small to medium sized streams.

Distribution and Occurrence: Nymphs may be collected during the winter, emergence from March through June. Ecoregions are unknown but may occur in Mountain and Piedmont areas.

Species in NC: TAKE TO SPECIES

(perfecta) – see Genus Diagnosis

Notes: *Paranemoura perfecta* is the only species in southeastern United States. There are no BAB nymphal records for North Carolina.

Much is unknown about the life history and habitat of *Paranemoura perfecta* nymphs but it may be similar to other nemourids.

Taxonomic references:

nymphs:

Harper, P. P. and H. B. N. Hynes. 1971c. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 1129-1142.

adults:

Baumann, R. W. 1996b. A review of the stonefly genus *Paranemoura* (Plecoptera: Nemouridae) and a new species from the northeast. Proceedings of the Entomological Society of Washington. 98(4): 818-826.

Prostoia

Genus Diagnosis: Nymphs small, 5-6 mm, and stout. Right mandible with 5 teeth, 1 large basal tooth and a cluster of 4 large apical teeth; *rounded pronotum with marginal fringe of short, small, irregularly spaced spines*; anterior thoracic gills absent; *fore tibiae with dorsal fringe of fine hairs, usually complete but sparse; ventral (inner) tibial fringe of silky setae absent; outer marginal setae of fore tibia thick, conspicuous, in two rows.*

Habitat and Trophic Level: Nymphs occur in fast and slow areas of streams on rocks, in leaf packs, and in mosses. Detritivorous (shredders and facultative scrapers), clingers.

Distribution and Occurrence: Widespread, though primarily Mountains and Piedmont. Nymphs are relatively common during winter and early spring.

Species in NC: TAKE TO SPECIES (provisional)

(completa) – tibiae with a well-developed dorsal fringe of setae; cerci with short intercalary hairs present on several middle and distal segments.

This is a common species in the east and possibly in North Carolina. It occurs in small streams to large rivers (Kondratieff and Kirchner, 1984a).

(hallasi) – tibiae with a poorly developed dorsal fringe of setae, a few short setae present distally; cerci with short intercalary hairs present on several middle and distal segments, hairs may be short.

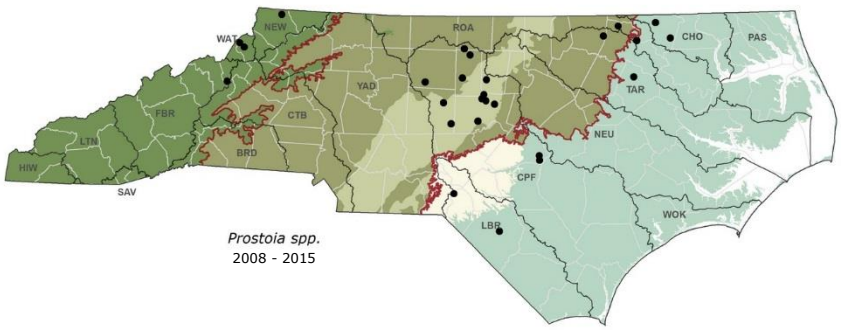
Prostoia hallasi was described from the Great Dismal Swamp and recorded from streams that only flow early. However, *P. hallasi* range has been greatly expanded northwards by Grubbs et al. (2014) and BAB reference specimens with dissected genitalia are recorded from Northern Outer Piedmont (Durham County).

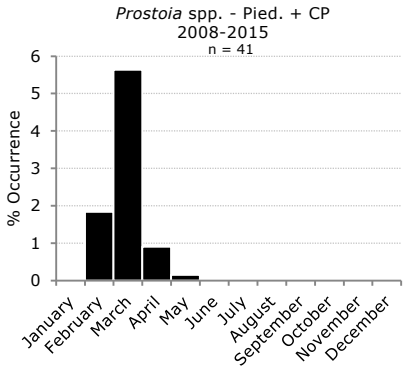
similis* – cerci with short intercalary hairs present only on distal segments or absent altogether.

Prostoia similis has been recorded from SC, TN, VA, and WV as well as GSMNP and therefore is included as it is likely to occur in NC.

Notes: Leg spines can be difficult to observe even with the leg mounted and cleared thus making this genus difficult to separate from *Shipsa*. The complete absence of an inner fringe of silky setae on the fore tibiae may be a better character for separation of these two taxa, in addition to the size of ultimate instar nymphs, mandibular, and cercal characters. Speciation between the three regional species hinges on the development of the intercalary setae on the cerci which has yet to be proven reliable. Also, nymphs of *Prostioa hallasi* can be misidentified as *Ostrocerca* due to having a poorly developed tibial fringe.

Prostoia are reported as univoltine (Harper, 1973a; Ernst and Stewart, 1985a).





Taxonomic references:

nymphs:

Harper, P. P. and H. B. N. Hynes. 1971c. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 1129-1142.

adults:

Grubbs S. A., R. W. Baumann, E. R. DeWalt and T. Tweddale. 2014. A review of the Nearctic genus *Prostoia* (Ricker) (Plecoptera, Nemouridae), with the description of a new species and a surprising range extension for *P. hallasi* Kondratieff & Kirchner. ZooKeys 401: 11–30.

Shipsa

Genus Diagnosis: Nymphs 6-8.5 mm. Right mandible with 4 teeth, 2 basal and 2 apical; *long pronotum with no marginal fringe (or of very small spines)*; anterior thoracic gills absent; fore tibiae with a *complete outer fringe of long setae and a sparse inner fringe*; *tibia with inconspicuous short stout spines on outer margins near base of fine setal fringe*; abdominal terga with numerous intercalary spinules with darker origins; cerci with fringe longest ventrally but also with a short dorsal setal fringe.

Habitat and Trophic Level: Nymphs occur in fast and slow areas of medium to large streams on rocks and in leaf packs. Detritivorous (shredders and scrapers), sprawlers.

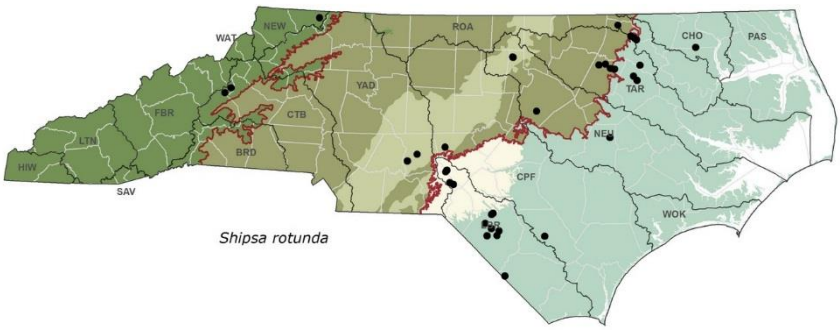
Distribution and Occurrence: Mostly collected from east of the Slate Belt during the winter months. Relatively uncommon.

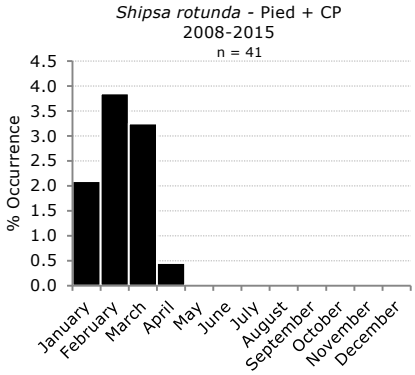
Species in NC: MONOTYPIC

rotunda – see Genus Diagnosis

Notes: Separation of *Shipsa* from *Prostoia* can be difficult, particularly on small immature specimens, even if the tibiae are slide mounted. The presence of a sparse inner fringe of silky setae on the fore tibiae of *Shipsa* nymphs in conjunction with overall size and mandibular characters can aid in separation of late instar nymphs of these two taxa.

Shipsa rotunda is reported to be univoltine (Harper, 1973a).





Taxonomic references:

nymphs and adults:

Harper, P. P. and H. B. N. Hynes. 1971c. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 1129-1142.

Hitchcock, S. W. 1974. Guide to the Insects of Connecticut. Part VII. The Plecoptera or Stoneflies of Connecticut. Bulletin of the State Geological and Natural History Survey of Connecticut. 107. vi + 262 pp.

Soyedina

Genus Diagnosis: Nymphs 6.5-8.5 mm. *Pronotum with angulate corners and a distinct sublateral notch; pronotum with well-developed lateral fringe or short, closely set, thick setae; wing pads divergent*; legs short, stout.

Habitat and Trophic Level: Found in leaf packs in seeps and small, cold streams. Detritivorous (shredders).

Distribution and Occurrence: Nymphs are typically collected from December to April, mostly in the Mountains. Relatively rare.

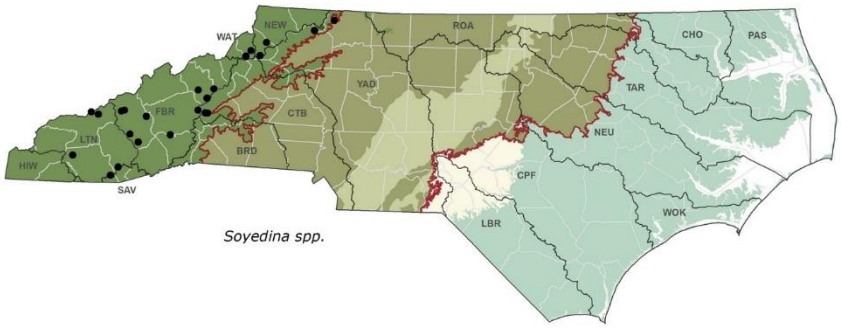
Species in NC: LEAVE AT GENUS

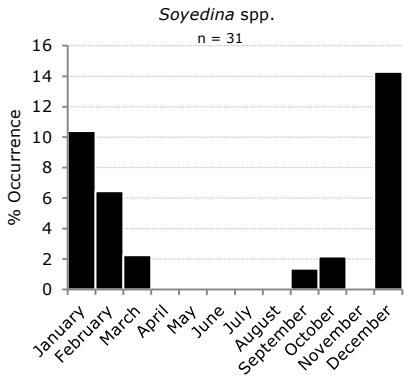
(carolinensis), (kondratieffi), n. sp.*, (washingtoni)

Notes: Taxonomically, *Soyedina* may be confused with *Nemoura*, a genus that does not occur in the southeastern United States.

The only eastern nymph to be described is *S. vallicularia* which has been recorded from VA, TN, and WV and more northerly states. Adults of *S. kondratieffi* were described from Upper Ball Creek in Macon County (Coweeta Hydrologic Laboratory) and co-occurred with *S. carolinensis* and *S. washingtoni.* A new species of *Soyedina* has been recorded from GSMNP but, as of yet, has not been described (B. C. Kondratieff, pers. comm.).

Some *Soyedina* are reported to have a univoltine life cycle (Harper, 1973a; Mackay, 1969).





Taxonomic references:

nymphs:

Harper, P. P. and H. B. N. Hynes. 1971c. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 1129-1142.

adults:

Baumann, R. W. and S. A. Grubbs. 1996. Two new species of *Soyedina* (Plecoptera: Nemouridae) from the Appalachian Mountains. Entomological News. 107(4): 220-224.

Hitchcock, S. W. 1974. Guide to the Insects of Connecticut. Part VII. The Plecoptera or Stoneflies of Connecticut. Bulletin of the State Geological and Natural History Survey of Connecticut. 107. vi + 262 pp.

Zapada

Genus Diagnosis: Nymphs 5-8 mm. *Anterior thoracic gills simple or with 2-4 branches*; *prominent pronotal fringe of blunt, stiff setae*; *femora with a distinct transverse row of spinous setae.*

Habitat and Trophic Level: Nymphs occur in small, cold, high elevation headwater streams and springs; on leaf packs. Detritivorous (shredders). Clingers.

Distribution and Occurrence: Collected during fall and winter in the Mountains only. Very rare in eastern Nearctic. North Carolina may be the southern distributional limit.

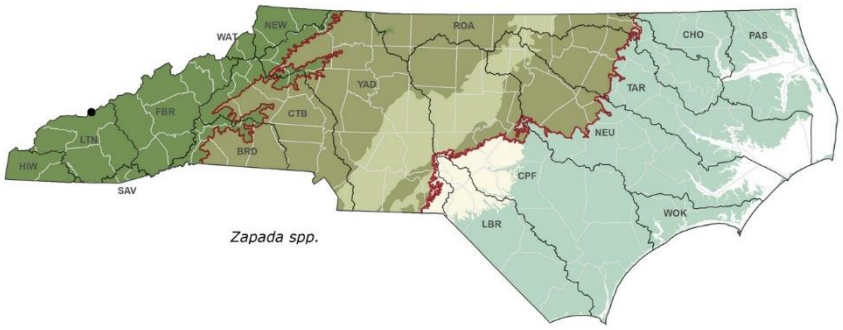
Species in NC: TAKE TO SPECIES

chila*, (fumosa)

Notes: *Zapada fumosa* has recently been described by Grubbs et al. (2015) and is reported from NC and VA although the nymph is unknown. The nymph of *Zapada chila* remains undescribed and is now recorded only from the TN side of GSMNP as the historical NC records have been invalidated. The previous nymphal records from NC and from a high elevation stream in GSMNP (Beech Flats Prong) may have actually been nymphs of *Z. fumosa.* However, these North Carolina nymphs cannot be located and therefore may represent either species. A provisional key of the nymphs by B. P. Stark (2016, in press) separates both of these species and relies on the adult structure of remnant nymphal cervical gills.

While *Zapada* species are common in the western United States, *Zapada chila* is listed by both the NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014) and by Morse et al. (1997) as "vulnerable to extirpation".

Some western *Zapada* species have been widely reported as being semivoltine while *Z. katahdin* has been reported as univoltine (Baumann and Mingo, 1987).



Zapada spp.

Taxonomic references:

nymphs:

Harper, P. P. and H. B. N. Hynes. 1971c. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 1129-1142.

adults:

Grubbs, S. A., R. W. Baumann, and A. L. Sheldon. 2015. A review of eastern Nearctic *Zapada* with a new species from the Great Smoky Mountains (Plecoptera, Nemouridae). Freshwater Science 34(4): 1312-1323.

Family TAENIOPTERYGIDAE

Winter stoneflies of the Family Taeniopterygidae are also known as "willowflies". Adults in this group are medium sized, dark, and at rest, they hold their wings flat across the dorsum of the abdomen but with curled tips. The adult cerci are short but multisegmented for the members of the subfamily Brachypterinae but reduced to a single segment in the Taeniopteryginae. Adults typically fly during late winter or spring.

Nymphs are small to moderately sized, often exceeding 10 mm, and many species have contrasting color patterns of dark and pale areas. The wingpads have a side-swept appearance and are strongly divergent. Nymphs are shredders of leaf material and other detrital matter and can be collected clinging to leaf packs in areas of moderate flow. Of the species of Taeniopterygidae that have had their life histories investigated, most are reported as having a one year (univoltine) life cycle.

The Southeastern regional Taeniopterygidae fauna is composed of five genera and 14 species and is widespread across North Carolina with two genera restricted to the Appalachian Mountains. Nymphs occur in small streams to larger rivers with some species occurring at high elevations.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by the combination of the following characters:

1) Moderately robust body
2) Legs, when extended, reach to apex of abdomen
3) Head pseudo-hypognathus (position intermediate to horizontal or vertical)
4) Type I mouthparts:
    a. glossa and paraglossa of equal length and shape
    b. labial palpi reach to or barely exceed labium (glossa and paraglossa)
5) Metanotal wing pads with mid-line highly divergent with the long axis of the body
6) Second tarsal segment of legs subequal to first segment
7) Thorax and abdomen with without cervical (neck) gills but may have telescoping thoracic coxal gills
8) Abdomen usually narrowed distally
9) Body often with a contrasting color pattern

SUBFAMILIES AND GENERA IN NC:

Brachypterinae: *Bolotoperla, Oemopteryx, Strophopteryx, Taeniionema*

Taeniopteryginae: *Taeniopteryx*

NOTES: *Strophopteryx* and *Taeniopteryx* are frequent and abundantly collected genera in North Carolina and are often the dominant taxa in early spring benthic bioassessments. Other taxa such as *Bolotoperla*, *Oemopteryx*, and *Taeniionema*, may not regularly be encountered as nymphs due to apparent restrictive habitats (e.g. high elevations), possible rarity, or may simply be overlooked due to misidentifications or seasonal sampling bias.

Of the six Nearctic Taeniopterygidae genera only *Doddsia* does not occur in the eastern Nearctic and is not treated further in this manual. *Doddsia* is the only North American genus with a complete fringe of silky setae on the dorsum of the cerci.

Taxonomic separation of genera in the subfamily Brachypterinae can be difficult and relies on careful examination of setation patterns, particularly on the basal segments of the antennae and cerci. Careful manipulation of the specimens being examined and a movable, high quality light source are essential in proper generic determinations.

Taeniopteryx is one of the most tolerant stonefly groups and is often found in waterbodies with average water quality and low dissolved oxygen, and is particularly prevalent in swamp streams. *Strophopteryx* are more sensitive and prefer faster and cleaner waters. The pollution tolerance of other taxa are unknown.

Bolotoperla

Genus Diagnosis: Nymphs stout, 8-10 mm. Body typically dark brown; maxillary lacinia without dense short hairs on palm and with a ventral bristle comb; inner hairs of mandible extend to molar ridge; *mediodorsal fringe of hairs on antennal scape and the basal 2-3 antennal segments*; coxae without gills; posterior margin of pronotum wider than anterior margin; clothing hairs sparse on basal half of ninth sternal segment; *dorsal fringe of fine, silky hairs on basal cercal segments*, each cercal segment darker on posterior dorsal half making the cerci appear somewhat banded.

Habitat and Trophic Level: *Bolotoperla* prefers rocky riffles of second through fourth order streams. Feeding strategy is unknown but may be shredder or scrapers. Clingers.

Distribution and Occurrence: Nymphs occur February through March in the Mountains. Rarely collected.

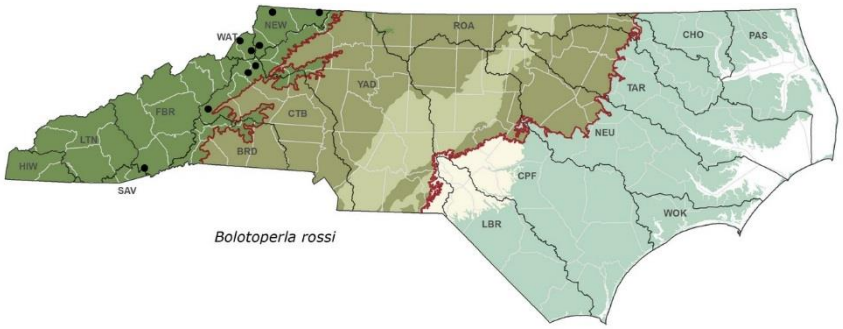
Species in NC: MONOTYPIC

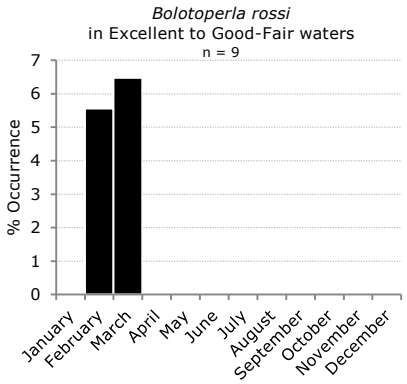
rossi – see Genus Diagnosis

Notes: Accurate identification of this species relies on the often difficult to see basal cercal and antennal fringe. Along with the antennal fringe, mandibular and pronotal characteristics will help separate *Bolotoperla rossi* from other taeniopterygids.

Recorded from GSMNP and listed by NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014). The most recent BAB record is from Beaverdam Creek, Watauga Count (23 March, 2009).

The life history of *Bolotoperla rossi* remains unknown.





Taxonomic references:

nymphs:

Kirchner, R. F. and P.P. Harper. 1983. The nymph of *Bolotoperla rossi* (Frison) (Plecoptera: Taeniopterygidae: Brachypterinae). Journal of the Kansas Entomological Society 56(3): 411-414.

adults:

Stewart, K. W. 2000. Taeniopterygidae (The Willowflies), pp. 55-87. *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 No. 1, vii + 100 p.

(Oemopteryx)

Genus Diagnosis: Nymphs 10-15 mm. *Maxillary lacinia with dense short hairs on palm and no ventral bristle comb*; *inner hair row of mandible extending onto molar surface*; distinct dorsal basal antennal segments without fringe of silky hairs, although 1-2 hairs may be present basally; pronotum equal to or less than width of head; coxal gills absent; *tibiae with outer (dorsal) hair fringe only*; *apical half of ninth sternal segment straight to convex laterally, clothing hairs numerous on basal half*; cerci without dorsal basal fringe of setae (*O. contorta* only).

Habitat and Trophic Level: Nymphs may diapause in hyporheic during the summer in small streams. Possibly detritivorous (shredders).

Distribution and Occurrence: Collected in the winter from the Mountains only. Rarely collected.

Species in NC: TAKE TO SPECIES

(contorta) - cerci without silky hairs on first 10-12 basal segments (present in other *Oemopteryx* species).

Notes: The absence of a basal antennal fringe will separate this genus from *Bolotoperla* while the absence of a ventral comb on the lacinia and the shape and setation of the ninth sternite will separate it from *Strophopteryx limata*. *Oemopteryx contorta* will separate from *Taenionema atlanticum* by differences in the shape of the pronotum and the inner patch of mandible hairs.

Although *Oemopteryx contorta* is the only recorded *Oemopteryx* species in NC, BAB has not, to date, collected any nymphs. However, we have collected 2 adult females from Bearpen Creek at Wayah Bald, Macon Co., (5 April, 14). Nymphs of this species were collected in one EPA sample from the Pigeon River (January 1993) but have not been validated and also along the BRP (D. Lenat). *Oemopteryx contorta* has also been recorded from GSMNP, TN, VA, and WV.

Oemopteryx contorta is reported as univoltine (Nelson, 1982).

Taxonomic references:

nymphs:

Nelson, C. H. 1982. Notes on the life histories of *Strophopteryx limata* (Frison) and *Oemopteryx contorta* (Needham and Claassen) (Plecoptera: Taeniopterygidae) in Tennessee. Tennessee Academy of Science. 57: 9-15.

adults:

Stewart, K. W. 2000. Taeniopterygidae (The Willowflies), pp. 55-87. *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 No. 1, vii + 100 p.

Strophopteryx

Genus Diagnosis: Nymphs 7-13 mm. Coxal gills absent; *maxillary lacinia without dense short hairs on palm and with a ventral bristle comb*; *inner hair row of mandible extending to but not onto molar surface*; *tibiae with outer (dorsal) and inner (ventral) hair fringe* (except *S. limata*); *a single dorsal hair on basal 3-6 cercal segments* (absent in *S. fasciata*); *apical half of ninth sternal segment concave laterally, clothing hairs sparse on basal half*; typically with a contrasting body pattern.

Habitat and Trophic Level: Nymphs prefer organic materials trapped within rocky riffles. Detritivorous (shredders) and herbivorous (scrapers).

Distribution and Occurrence: Widespread, less common on the Coastal Plain. Collected during fall and winter.

Species in NC: TAKE TO SPECIES

(appalachia) – nymphs 7-8.5 mm; abdominal terga yellow with darker yellow or light brown transverse bands on anterior half of each tergite; abdominal tergites lacking median transverse row of dots; sparse dorsal fringe of hair on the basal segments of cerci.

Strophopteryx inaya was placed as a synonym of *S. appalachia* by Stewart (2000).

(fasciata) – nymphs 9.5-10 mm; abdominal terga yellow with uneven, dark brown transverse bands on anterior half of each tergite; median row of transverse dark dots on each tergite; ventral tibial hair fringe present but sparse; no hair fringe on the basal segments of cerci.

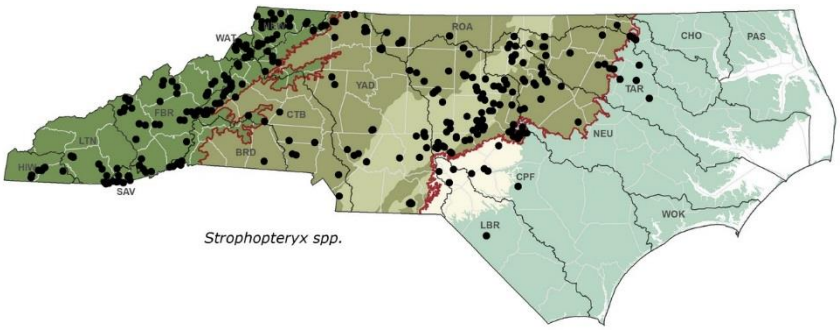
Recorded from GSMNP.

(limata)– nymphs 6.0-7.0 mm; dorsum uniformly brown, tergites with distinct transverse row of dark spots with lateral spots more closely spaced and elongate; tibiae with outer (dorsal) hair fringe only; sparse dorsal fringe of hair on the basal segments of cerci.

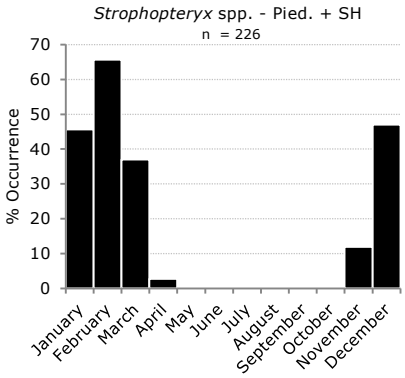
Nymphs have been collected from West Fork Pigeon River near the Blue Ridge Parkway (March, 2011) and recorded from GSMNP but there are no BAB bioassessment records.

Notes: Specimens of *Strophopteryx limata* may be difficult to be separate from *Oemopteryx contorta* but the presence of a ventral comb on the lacinia of *Strophopteryx* should eliminate any confusion between the two. A slide-mount of the mouthparts is therefore recommended.

Strophopteryx limata is reported to be univoltine (Nelson, 1982; Huryn and Wallace, 1987).



Strophopteryx spp.



Taxonomic references:

nymphs:

Earle, J. I. and K. W. Stewart. 2008. Description of the Nymph of *Strophopteryx appalachia* Ross and Ricker (Plecoptera: Taeniopterygidae), and Key to *Strophopteryx* Nymphs. Proceedings of the Entomological Society of Washington 110(3): 551-555.

adults:

Stewart, K. W. 2000. Taeniopterygidae (The Willowflies), pp. 55-87. *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 No. 1, vii + 100 p.

Taenionema

Genus Diagnosis: Nymphs 6.5-11 mm. Lacinia with ventral comb of bristles; palm mostly devoid of hairs; *inner patch of mandibular hairs not extending to or near the scraping ridge*; posterior margin of pronotum wider than anterior margin; coxal gills absent; *tibiae with dorsal setal fringe only, ventral hair fringe absent, dorsal fringe weak on tarsi;* ninth sternal plate broad apically, setae sparse on basal half; *dorsal cercal fringe absent*; body color brown, with conspicuous pattern of brown mottling on head and pronotum, a transverse series of faint brown dots present on each tergum.

Habitat and Trophic Level: Found in small streams, most likely in riffles with leaf detritus. Detritivorous (shredders) and herbivorous (scrapers).

Distribution and Occurrence: In the Mountains with nymphs collected during winter months. Rarely collected.

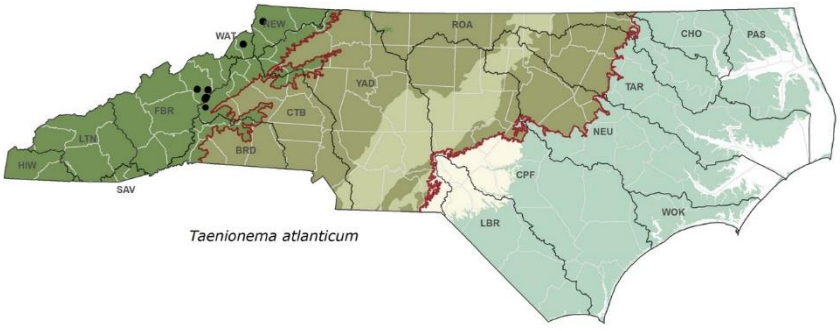
Species in NC: TAKE TO SPECIES

atlanticum – see Genus Diagnosis

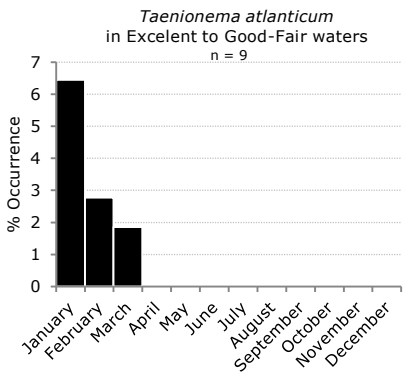
Notes: *Taenionema,* particularly small specimens, can be difficult to separate from *Strophopteryx*. However, the combination of the lack of ventral tibial hair fringe and lack of basal dorsal cercal fringe should separate these two genera. Slide-mounting the mandible is also recommended. Historic identifications (prior to 1996) have not been verified and may be erroneous.

Taenionema atlanticum is the only species to occur in the eastern United States and has been recorded from GSMNP.

Taenionema atlanticum is univoltine (Harper et al., 1989).



Taenionema atlanticum



Taxonomic references:

nymphs:

Harper, P.P. and H. B. N. Hynes. 1971d. The nymphs of the Taeniopterygidae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology. 49: 941-947.

Stewart, K.W. 2009. New descriptions of North American *Taenionema* larvae (Plecoptera: Taeniopterygidae). Illiesia, 5(12):128-145.

adults:

Stewart, K. W. 2000. Taeniopterygidae (The Willowflies), pp. 55-87. *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 No. 1, vii + 100 p.

Taeniopteryx

Genus Diagnosis: Inner patch of mandibular hairs not extending to or near the scraping ridge; posterior margin of pronotum wider than anterior margin; *nymphs have a single telescopic gill* (sometimes retracted) *on the coxa of each leg*; *complete dorsal cercal fringe*; some species have a median dorsal stripe.

Habitat and Trophic Level: Collected from leaf detritus in slow water areas. Detritivorous (shredders and collectors), herbivorous (scrapers), and some species may be facultatively predaceous. Sprawlers/clingers.

Distribution and Occurrence: Widespread. Primarily found in late fall through winter.

Species in NC: LEAVE AT GENUS

burksi – male nymphs 8.7-9.5 mm, female nymphs 10-12 mm. Femora almost entirely light; light dorsal abdominal stripe bordered by thin, dark stripes; light stripe continues onto head to the epicranial suture; terga with slender bristles and posterior margin with short peg setae and the occasional long hair; cerci half as long as body with proximal third dark and the remainder yellow. Adult males may be needed for confirmation.

lita – male nymphs 8-9.5 mm, female nymphs 8.3-10.2 mm. Anterior frontoclypeal area with short pale longitudianl stripe bordered by dark brown; light dorsal stripe not bordered by dark brown; medial stripe very narrow on head but then expands to become rectangular in ocellar triangle; dark femora; developing cerci not twisted (sometimes visible through integument).

(lonicera) – male nymphs 6-7.5 mm, female nymphs 8-10 mm. Anterior frontoclypeus pale with two large oblique brown dashes; head mostly light with two dark rectangular bars in front of eyes; developing cerci twisted.

Collected by B. Kondratieff and R. Kirchner in various Sand Hills and Coastal Plain streams.

(maura) – male nymphs 8.7-9.5 mm, female nymphs 10-12 mm. Light dorsal abdominal stripe bordered by dark stripes; light stripe continues onto head to the epicranial suture; terga with slender bristles and posterior margin with short peg setae and the occasional long hair; inner margin of hind femur of ultimate instar males with developing femoral spur of adult. Adult males may be needed for confirmation.

Recorded from GSMNP.

metequi – male nymphs 7.5-8.1 mm, female nymphs 10-11 mm. Ocellar triangle mostly brown; dorsal stripe wide on occiput, with darker reticulations; mostly dark femora; tibiae and basal two tarsi pale; tarsus 3 dark brown; all bristles on tergites long and curled.

(nelsoni) – male nymphs 6-7.5 mm, female nymphs 10-12 mm. No mid-dorsal stripe; proximal third of antennae and cerci with whorls of long setae; cerci setose; habitus cryptic with detrital material on body hairs.

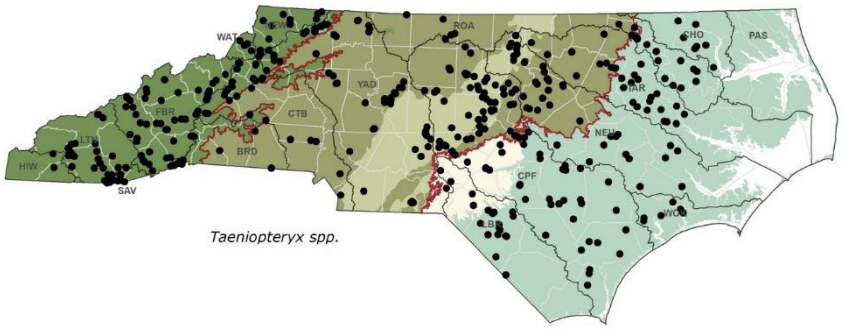
This species was described from VA but is also known from Panthertown Creek, NC. Listed as "vulnerable to extirpation" by Morse et al. (1997).

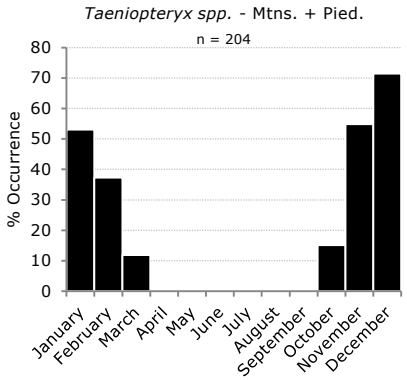
parvula – male nymphs 6.8 mm, female nymphs 7.3-12.3 mm. Abdomen not striped; pronotum margined with yellow; abdominal terga with long bristles, many apically curved; epiproct triangular when viewed dorsally.

ugola – male nymphs 7.6 mm, female nymph 7-9.7 mm. Abdominal stripe present but faint or absent; stripe on thorax reduced to light patches on posterior of meso- and metanotum; broad V-shaped yellow patch between eyes narrowed posteriorly into fine yellow line; pale band around base of eyes.

Notes: The general consensus among BAB taxonomists is a lack of confidence in species key due to either geographic differences and/or variation in nymphal coloration. Also, it may be very difficult to separate *T. burksi* and *T. maura* nymphs without associated adults. Therefore, it is best to leave *Taeniopteryx* at genus. Any attempts to separate *Taeniopteryx* species should be considered provisional.

Most species of *Taeniopteryx* are probably univoltine and *T. maura* and *T. parvula* have been reported as such from Québec (Harper et al., 1991).





Taxonomic references:

nymphs:

Fullington, K. E. and K. W. Stewart. 1980. Nymphs of the stonefly genus *Taeniopteryx* (Plecoptera: Taeniopterygidae) of North America. Journal of the Kansas Entomological Society 53(2): 237-259.

Kondratieff, B. C. and R. F. Kirchner. 1982. *Taeniopteryx nelsoni*, a new species of winter stonefly from Virginia (Plecoptera: Taeniopterygidae). Journal of the Kansas Entomological Society 55(1): 1-7.

Kondratieff, B. C. and R. F. Kirchner. 1984b. New species of *Taeniopteryx* (Plecoptera: Taeniopterygidae) from South Carolina. Annals of the Entomological Society of America 77(6): 733-736.

adults:

Stewart, K. W. 2000. Taeniopterygidae (The Willowflies), pp. 55-87. *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 No. 1, vii + 100 p.

Family CHLOROPERLIDAE

The green stoneflies, so named due to the often pale yellow or light greenish color of the adults, are also commonly known as "sallflies" or Yellow Sallies by fly fisherman. Adult chloroperlids are fragile and have a small, lightly colored habitus. They hold their wings flat across the abdomen while at rest and have cerci that are, while not reduced, relatively short and multisegmented. Adults can be encountered during the late spring through the summer.

Nymphs are small, most being less than 10 mm, and usually pale brown to yellow brown. The wing pads of the nymphs are short and basally broad, with the lateral margins somewhat curvilinear or arced and the cerci are short and highly tapered, usually about half the length of the abdomen. Most nymphs appear to be predaceous but may also be facultative shredders or scrapers. Mature nymphs can be found clinging to gravel, cobbles, or debris in riffles or moss. Earlier instars are hyporheic burrowers and can be found as deep as half a meter. The life histories of many species have not been investigated and are therefore unknown. However there are some species reported as having a one year life cycle and others as having a 1-2 year life cycle.

The North Carolina Chloroperlidae fauna is composed of five genera and 17 species which are restricted mostly to the Mountains and Piedmont but are often locally abundant. They are most common in small to medium sized streams but may also be found in high elevation, headwater streams to medium sized rivers.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by the combination of the following characters:

1) Small, elongate and cylindrical body
2) Legs, when extended, reach to apex of abdomen
3) Type II mouthparts:
    a. glossa poorly developed or absent, paraglossa large and much longer than glossa
    b. labial palpi reach well beyond labium (glossa and paraglossa)
4) Outer margin of wing pads curvilinear or arced, inner margins nearly straight
5) Second tarsal segment of legs shorter than first segment
6) Thorax and abdomen without gills
7) Cerci typically shortened, about half to 2/3 length of abdomen, and highly tapered

SUBFAMILIES AND GENERA IN NC:

Chloroperlinae: *Alloperla, Haploperla, Rasvena, Suwallia, Sweltsa*

NOTES: All Chloroperlidae in North Carolina, except *Rasvena,* are commonly collected during routine spring and summer bioassessments, predominantly in the Mountains, when nymphs are preparing to emerge. *Rasvena,* on the other hand, is rarely encountered being restricted to high elevation headwater streams.

Of the 14 North American genera, 9 are not treated in this manual and include three genera in Paraperlinae - *Kathroperla*, *Paraperla* and *Utaperla;* and six genera in the Chloroperlinae - *Alaskaperla*, *Bisancora*, *Neaviperla*, *Plumiperla*, *Sasquaperla*, and *Triznaka*. These 9 genera are distributed in the western or far northern Nearctic. Refer to Stewart and Stark (2002, 2008) for details on separating most of these genera. Nymphs of the recently resurrected genus *Neaviperla*, previously synonymized with *Suwallia* (Alexander and Stewart, 1999), can be separated from *Suwallia* by the long basal cercal segment with an accessory whorl of subapical spines in addition to an apical whorl.

Nymphs of Chloroperlidae prefer high quality waters and are intolerant to various forms of pollution.

Alloperla

Genus Diagnosis: Nymphs 5.7-9.6 mm. Head with posterolateral margins rounded with eyes large and set midlaterally (except set forward in *Alloperla usa*); pronotum with setae usually restricted to corners; mesal portion of posterior margin of abdominal sternum eight lacking setae; *middle and distal segments of cerci with a dorsal and ventral fringe of long setae, each segment with 2-6 long intercalary setae* (sparsely setose in *Alloperla usa*).

Habitat and Trophic Level: Primarily found in gravel and riffle areas of small to medium streams but can also be found in leaf packs. Many nymphs are hyporheic for much of their life cycle. Nymphs are generalist feeders and also predaceous on chironomid larvae. Clingers.

Distribution and Occurrence: Mainly collected March through May in the Mountains. Uncommonly collected.

Species in NC: LEAVE AT GENUS

(atlantica), (chloris), (lenati), (nanina), (neglecta), (petasata), (usa)

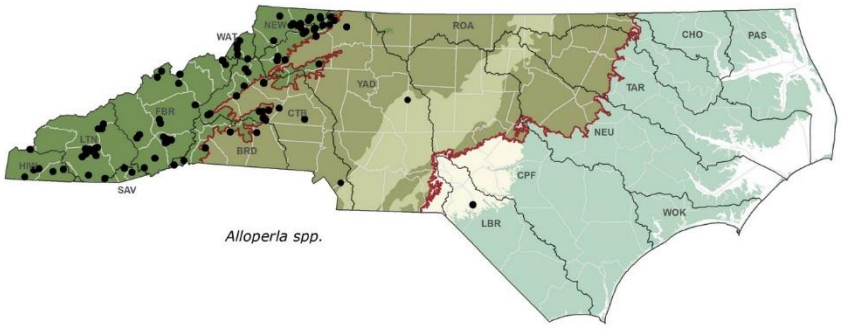
Notes: North Carolina has at least seven species of *Alloperla* of which three are undescribed in the immature aquatic stage (including *A. lenati*). Adults of *A. lenati* were described from Lumber River, Hoke County, within the Sand Hills Level IV ecoregion and is a disjunct population from the mostly mountainous *Alloperla*.

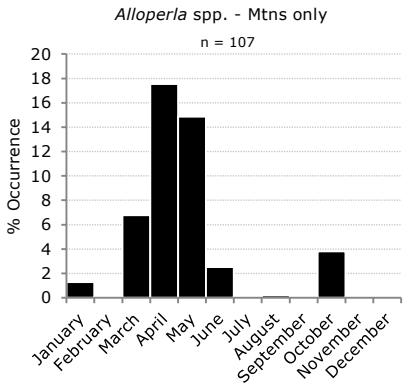
Some North Carolina specimens that may be *Alloperla* have a large quadrate head with small eyes set forward similar to the western genus *Kathroperla*. This character persists from early instar to middle instar specimens but the head becomes less quadrate in late instars. Also, these specimens have little to no cercal fringe both dorsally and ventrally and may represent *Alloperla usa*. Early instar specimens collected reach up to 9 mm with undeveloped wing pads suggesting this species may be large in the ultimate stage. At least one pre-emergent *Alloperla usa* nymph collected by BAB biologists had a length of 9.6 mm.

Alloperla and some other chloroperlids are likely under-collected due to the nymphs presence in the hyporheos. The abundance of the nymphs in samples may be low even after intense survey efforts while the adults can be locally abundant (D. Lenat, personal communication).

A recent publication of nymphs of Nearctic *Alloperla* (Stark and Kondratieff, 2010) treats only four of the seven species known to occur in North Carolina. *Alloperla lenati* is listed by NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014).

There a few life history studies of currently valid *Alloperla* species although at least one species, *A. prognoides*, exhibits a univoltine life cycle (Ray et al., 2010).





Taxonomic references:

nymphs:

Stark, B. P. and B. C. Kondratieff. 2010. Larvae of eight eastern Nearctic *Alloperla* species (Plecoptera: Chloroperlidae). Illiesia, 6(20): 267-276.

adults:

Kondratieff, B. P. and R. F. Kirchner. 2004. *Alloperla lenati*, a new species of stonefly from North Carolina (Plecoptera: Chloroperlidae) and two new state records (Plecoptera: Perlodidae). Annals of the Entomological Society of America. 97(3):361-363.

Surdick, R. F. 2004. Chloroperlidae (The Sallflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin New Series Volume 14 Number 4. vi + 192 pp.

Haploperla

Genus Diagnosis: Nymphs 3.5-7.5 mm. *Pronotum with sparse setae an anterior margin, longest and most numerous at anterior corners*, sparse or absent anteromedially, relatively abundant on posterior margin; *longest pronotal hairs at least 0.3-0.4 times the pronotal width*; *inner margin of hind wing pads subparallel to body axis*; pronotum and tergites lightly setose; *anterior edge of pronotum with few long hairs, posterior edge with long hairs abundant*; *fore leg with fringe of long setae on tibia*; cerci without dorsal or ventral intercalary hairs, setae at apex of cercal segments only; body light brown, nearly concolorous.

Habitat and Trophic Level: Primarily found in gravel and riffle areas of small to medium streams but can also be found in leaf packs and in the hyporheos. Predaceous on chironomid larvae but also facultative collectors and scrapers. Clingers.

Distribution and Occurrence: Collected from Mountains and Piedmont usually late fall through spring. A relatively common genus.

Species in NC: TAKE TO SPECIES

brevis – ultimate instar nymphs 5.0-6.5 mm. Frontoclypeus pale brown, darker than occiput; pronotum pale brown laterally with pale median band: ventral margin of fore femora with 2-3 long setae (Stark, 2016 in press).

Haploperla brevis is common in mountain and piedmont streams of good water quality.

fleeki – nymphs undescribed. *Preliminary nymph description:* ultimate instar nymph 5.0-5.5 mm; anterior frontoclypeus mottled brown, particularly laterally; pronotum with lateral margins dark, contrasting with light brown almost diamond shaped interior; anterior edge of mesonotum thinly margined with brown to dark brown; lateral margins of wing pads with long irregularly spaced stiff setae; legs pale; femora lacking long fine setal fringe, fringe not well developed on tibiae, sparse; abdominal terga 1-10 with anterior 1/3 to 1/2 of each tergum with transverse, uneven bands, bands bi-lobed and narrower medially, wider submedially and widest anterolaterally; ventral surface pale; cerci with about 12 segments, each segment with a circlet of short apical spines interspersed with longer setae, no intercalary hairs. The body pattern is visible on both early and late instars.

Adults were described from Lower Little River in Moore County in the Sand Hills (Kondratieff et al., 2005) which is currently the only known locality for this species.

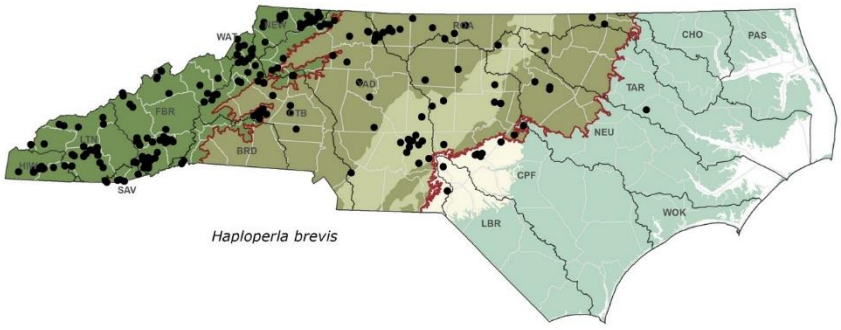
(parkeri) – nymphs unknown.

Described from Shot Pouch Creek in Macon County and recorded from GSMNP. See notes.

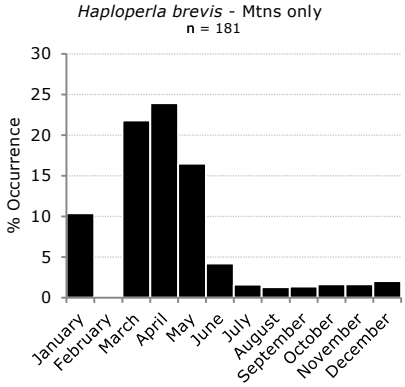
Notes: We have collected mature nymphs from small pristine headwater streams in high elevation counties (Alleghany, Avery, Buncombe, Graham, Swain, and Macon - 2011-2015) which key to *Haploperla.* These nymphs have an approximate length of 3.5-4.5 mm at maturity, are unpatterned, and have long hairs on the lateral margins of the wing pads. *Haploperla brevis* are larger (up to 6.5 mm) and *H. fleeki* are patterned. The size of these nymphs are similar to that of *Rasvena terna* but, unlike *Rasvena*, the anterior edge of the pronotum is lightly setose. These are an unknown species and may possibly be *H. parkeri*. Until these nymphs are reared, they should be left at genus.

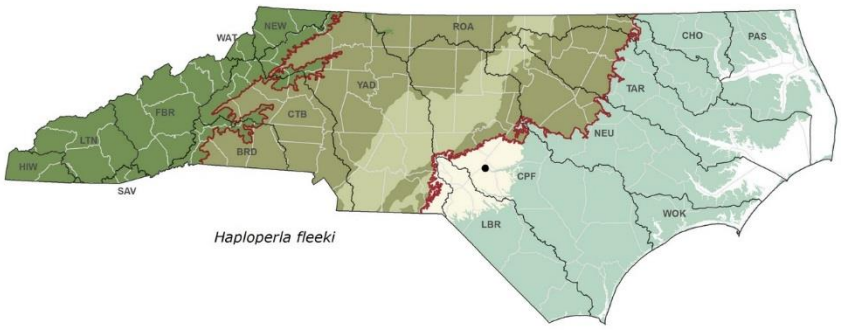
Haploperla fleeki is listed by NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014).

At least *Haploperla brevis* has a univoltine life cycle (Ernst and Stewart, 1985a).

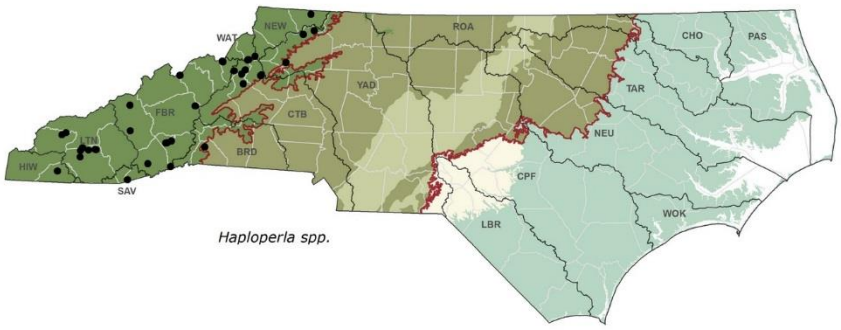


Haploperla brevis

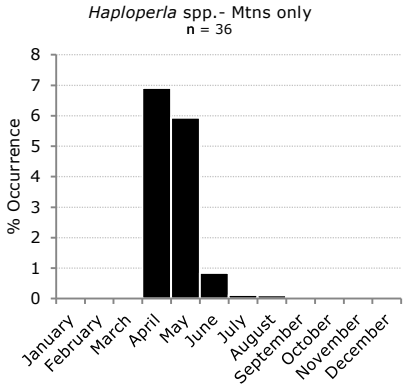




Haploperla fleeki



Haploperla spp.



Taxonomic references:

nymphs:

Surdick, R. F. 1985. Nearctic genera of Chloroperlinae (Plecoptera: Chloroperlidae). Illinois Biological Monographs 54: 1-146.

adults:

Kondratieff, B. C., River F. Kirchner, and D. L. Lenat. 2005. Two new species of *Haploperla* Navás (Plecoptera: Chloroperlidae) from North Carolina, U.S.A. Proceedings form the Entomological Society of Washington. 107(4): 859-863.

Surdick, River F. 2004. Chloroperlidae (The Sallflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin New Series Volume 14 Number 4. vi + 192 pp.

Rasvena

Genus Diagnosis: *Mature nymphs less than 5.5 mm (often near 4.5 mm).* Mandible lacking ventral submarginal patch of bristles; *each abdominal segment with a transverse row of four faint dots near anterior margins, appearing as interrupted stripes*; long hairs numerous on corners as well as on the anterior and posterior margins of pronotum, shorter laterally; *long pronotal fringe hairs are at least 0.3-0.4 times the pronotal width; inner margin of hind wing pads subparallel to body axis; dark clothing hairs on pronotum, wing pads and abdominal terga.*

Habitat and Trophic Level: Unknown.

Distribution and Occurrence: Nymphs are found in small pristine headwater streams in the mountain during the spring. Rarely collected.

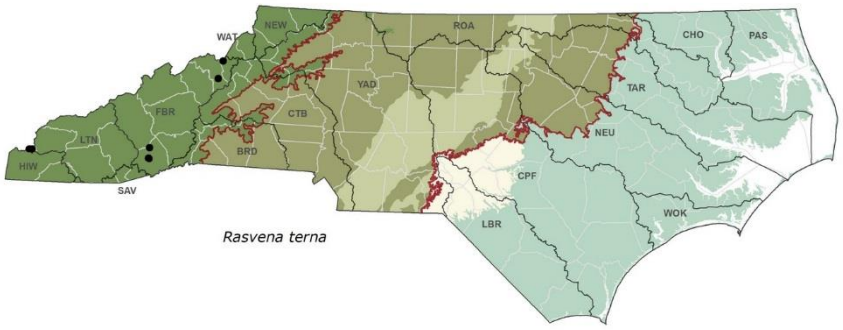
Species in NC: MONOTYPIC

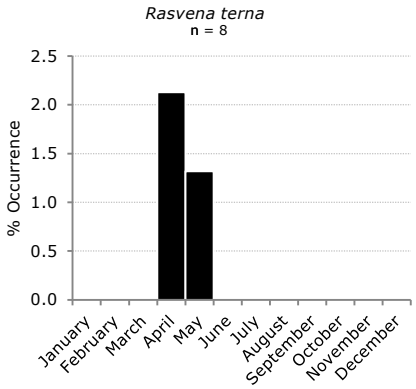
***terna* –** see Genus Diagnosis.

Notes: Similar to *Haploperla* but with longitudinal, if faint, pigmentation. The abdominal pigmentation may be obscure in smaller specimens but the pronotal setation patterns should separate *Rasvena* from *Haploperla*. Also, as is often the case with many chloroperlids, abdominal segments may be partially withdrawn onto the preceding segment, obscuring the true abdominal pigmentation by giving the overlapping portion a darker banded appearance. The very setose anterior margin of the pronotum will also suffice to separate *Rasvena* from *Haploperla* nymphs.

Recorded from GSMNP and listed by NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014).

The life cycle of *Rasvena terna* is unknown.





Taxonomic references:

nymphs:

Surdick, R. F. 1985. Nearctic genera of Chloroperlinae (Plecoptera: Chloroperlidae). Illinois Biological Monographs 54: 1-146.

adults:

Surdick, River F. 2004. Chloroperlidae (The Sallflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin New Series Volume 14 Number 4. vi + 192 pp.

Suwallia

Genus Diagnosis: Nymphs 6-8 mm (*S. marginata*). Sparse or absent lateral fringe hairs on pronotum but relatively dense anteriorly; *longest fringe hairs no more than 0.2 times the pronotal width*; *inner margin of hind wing pads divergent from axis of body*; sterna without dark clothing hairs; posterior cercal hairs much shorter than cercal segments in distal half of cerci.

Habitat and Trophic Level: Primarily found in gravel and riffle areas of small to medium streams but can also be found in leaf packs. Detritivorous (shredders), herbivorous (scrapers) and facultatively predaceous, clingers.

Distribution and Occurrence: Primarily a mountain species occurring in small to medium rivers. Nymphs are relatively common and can be found late fall through mid-summer.

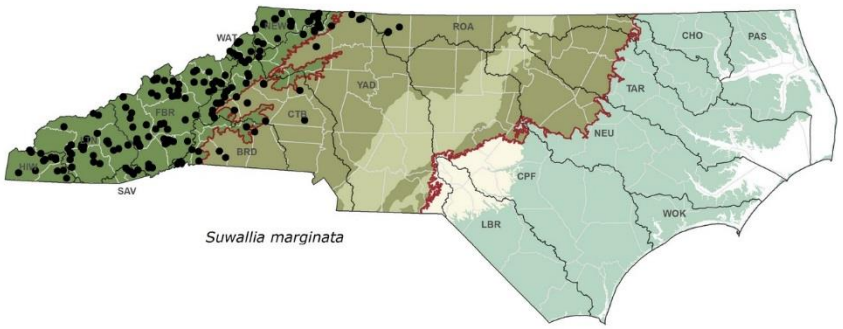
Species in NC: TAKE TO SPECIES

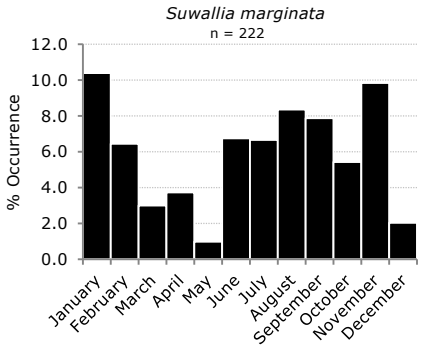
marginata

Notes: *Suwallia marginata* is the only species in eastern North America. North Carolina is the southern limit for this more northerly-distributed species.

Nymphs of *Suwallia marginata* can be difficult to separate from *Haploperla* nymphs. The length of the pronotal setae and the shape of hind wing pads are crucial characters and care should be taken when making a determination between these two genera. There are many historical misidentifications of both *Alloperla* cf. *usa* and *Haploperla* as *Suwallia* and vice-versa. Its seasonality graph should be viewed with skepticism.

There are no known life history studies for *Suwallia* although pre-emergent black-wing pad nymphs can be found during June and early July in the North Carolina Mountains.





Taxonomic references:

nymphs:

Surdick, R. F. 1985. Nearctic genera of Chloroperlinae (Plecoptera: Chloroperlidae). Illinois Biological Monographs 54: 1-146.

adults:

Surdick, River F. 2004. Chloroperlidae (The Sallflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin New Series Volume 14 Number 4. vi + 192 pp.

Sweltsa

Genus Diagnosis: Nymphs 7-8.5 mm. Inner margin of hind wing pads divergent; *thick depressed black clothing hairs laterally on all thoracic sterna*; *no intercalary hairs on cercal segments*; body typically pale brown.

Habitat and Trophic Level: Primarily found in gravel and riffle areas of small to medium streams but can also be found in leaf packs. Predaceous on chironomid larvae and facultative collectors.

Distribution and Occurrence: Very common in Mountains, uncommon in the Piedmont. Nymphs are most prevalent in the fall through spring but can be collected year round.

Species in NC: LEAVE AT GENUS

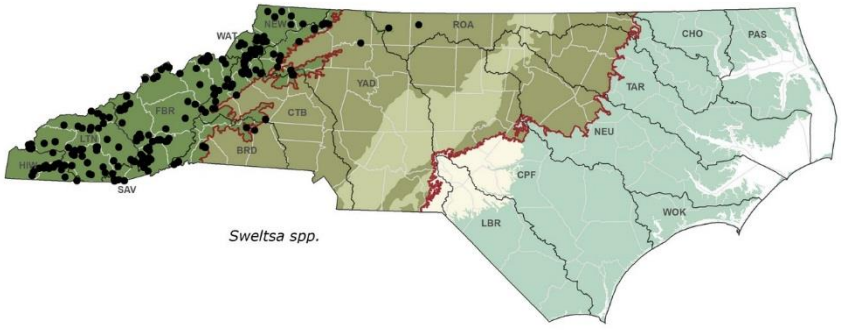
(holstonensis), (lateralis), (mediana), (urticae), (voshelli)

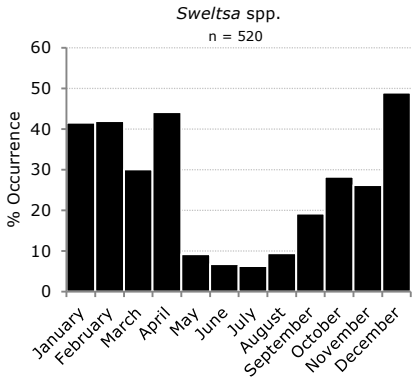
Notes: The numerous dark clothing hairs on the thoracic sterna is a diagnostic character for *Sweltsa*. Nymphs of most species are undescribed although members of the *Sweltsa mediana* group have a median dorsal abdominal stripe and includes *S. urticae* and *S. voshelli*. This stripe is the adult pattern showing through the nymphal integument.

Stark et al. (2011) published a provisional key to nymphs of eastern *Sweltsa*. However, of the ten species currently known to occur in the eastern US, only five species are known from NC of which only three are described. The key, therefore, is of limited usefulness. Nymphs of *Sweltsa holstonensis* and *S. voshelli* remain unknown.

S. urticae is "vulnerable to extirpation" per Morse et al. (1997).

At least some *Sweltsa* species are reported to be semivoltine (as *Alloperla onkos* - Mackay, 1969, Harper, 1973; as *Alloperla mediana* – Cushman et al., 1977; *S. lateralis* - Huryn and Wallace, 1987).





Taxonomic references:

nymphs:

Stark, B. P., B. C. Kondratieff, R .F. Kirchner, and K. W. Stewart. 2011. Larvae of Eight Eastern North American *Sweltsa* (Plecoptera: Chloroperlidae). Illiesia 7(04):51-64.

adults:

Surdick, River F. 2004. Chloroperlidae (The Sallflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin New Series Volume 14 Number 4. vi + 192 pp.

Family PELTOPERLIDAE

The "roachflies" as the Peltoperlidae are otherwise known, get this common name from the overall shape and similarity of the nymphs to another insect, the cockroach. This similarity does not extend to the adult peltoperlids however, which are small to moderately sized, yellow brown to dark brown, with dark smoky wings held flat at rest, and with long or short multisegmented cerci. Adults commonly fly during the spring and summer.

The distinctive nymphs reach about 12mm in length and are typically orange brown to dark brown in color. They have overlapping thoracic dorsal plates which cover the posterior portion of the head and first few abdominal segments. It is this compact, stout habitus that gives the nymphs a somewhat roach-like appearance. Nymphs are shredders and are strongly associated with well-conditioned leaf packs although they can be found in almost any area where detritus collects, and are particularly abundant in leaf packs caught in riffles and other areas of good flow. At least some species in this family have 1-2 year life cycles while the voltinism of other species remains unknown.

There are 3 genera and at least 8 species of peltoperlids in North Carolina. They are distributed primarily in the Appalachian Mountains and Foothills and restricted to high quality, and for two genera, small high elevation streams.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by the combination of the following characters:

1) Body compact and stout, roachlike
2) Legs short and stout, when extended not reaching or barely reaching abdominal apex
3) Head hypognathus (vertically oriented)
4) Type I mouthparts:
    a. glossa and paraglossa of equal length and shape
    b. labial palpi reach to or barely exceed labium (glossa and paraglossa)
5) Posterior of head partially hidden under anterior flap of pronotum
6) Pro-, meso-, and metathoracic dorsal plates overlapping succeeding segment and margined with closely set short stout setae
7) Thoracic sternal plates shield-like, produced posterolaterally into lobes and overlapping next segment
8) At least meso- and metanota with conically shaped infra- and supracoxal gills
9) Second tarsal segment of legs shorter than first segment
10) Abdomen narrowed distally
11) Cerci short, about 2/3 length of abdomen, and highly tapered

SUBFAMILIES AND GENERA IN NC:

Peltoperlinae: *Peltoperla, Tallaperla, Viehoperla*

NOTES: The genus *Tallaperla* is the dominant peltoperlid in North Carolina streams and is present in most mountain lotic systems. In mountain streams with excellent water quality, *Tallaperla* are often so numerous their accumulated biomass can overwhelm routine bioassessment samples. Relict populations exist in some hilly piedmont areas although usually in fewer numbers. Unlike *Tallaperla*, *Viehoperla* and *Peltoperla* are rarely collected and are restricted to small, high quality, high elevation headwater streams, springs, and seeps.

Three genera not treated here, *Sierraperla*, *Soliperla* and *Yoraperla* are restricted to the western Nearctic. These genera can be separated from the eastern Nearctic fauna by having the posterior margin of the metasternal plate truncate or nearly straight across instead of the deeply emarginate metesternal plate present in the genera of North Carolina. Refer to Stewart and Stark (2002, 2008) for details on these characters.

Peltoperlidae nymphs autohemmorage, or expel hemolymph, under stress. This can be seen in preserved specimens as a white exudate originating from under the thoracic nota and coxae.

This family is highly intolerant to pollution and will be present only in streams and rivers of good to excellent water quality.

(Peltoperla)

Genus Diagnosis: Nymphs 8-11 mm. Gills absent from prothorax; *supracoxal thoracic gills with two filaments*; *meso- and metanota with large, solid, dark pigment spots lateral to ecdysial suture* (see Notes); posterior edge of prosternal plate with mesal V-shaped emargination; *metasternal plate with short, broad posterior wings; hind femora with sparse fringe of long silky setae;* overall body coloration brown.

Habitat and Trophic Level: Collected from leaf packs. Detritivorous (shredders).

Distribution and Occurrence: Nymphs occur late summer through spring in small, cold, mountain springs and seeps.

Species in NC: LEAVE AT GENUS

arcuata*, (tarteri)

Notes: There is at least one generic key that describes *Peltoperla* as having two pair of pale circular spots on each side of the pronotal ecdysial line (as pictured in Stewart and Stark, 2002), however this may be an unreliable character as it was removed from later keys and BAB photos of *Peltoperla* do not show any such distinctive light circular dots on the pronotum. Additionally, *Tallaperla elisa* (from reared material – D. R. Lenat, pers. comm.), also has dark pronotal spots suggesting that the dorsal femoral fringe may be the best character to separate *Peltoperla* and *Tallaperla*.

There are no published records of *Peltoperla* in North Carolina either of adults or nymphs. However, *Peltoperla arcuata* has been recorded from TN, VA, and WV while *P. tarteri* has been recorded from VA and WV and reared from NC nymphs. Additionally, *Peltoperla* nymphs have been collected from NC Blue Ridge Parkway seeps by D. R. Lenat (source of BAB photos).

Of the two Nearctic species only the nymph of *P. arcuata* has been reported to be semivoltine (Yokum et al., 1995) while *P. tarteri* has been reported to be univoltine (Ruggles and Tarter, 1991).

Taxonomic references:

nymphs:

Stark, B. P. and K. W. Stewart. 1981. The Nearctic Genera of Peltoperlidae (Plecoptera). Journal of the Kansas Entomological Society 54(2): 285-311.

adults:

Stark, B. P. 2000. Peltoperlidae (The Roachflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 Number 1. vii + 100 pp.

Tallaperla

Genus Diagnosis: Nymphs 7-10 mm. Gills absent from prothorax; *thoracic gills double*; meso- and metanota without large, solid, dark pigment spots (except *T. elisa*) and small indistinct spots may be present on dark forms; posterior edge of prosternal plate mostly straight across although a shallow, broadly curved mesal emargination may be present; metasternal plate with long posterior wings; *hind femora with dense fringe of long silky setae;* overall body coloration reddish brown to dark brown.

Habitat and Trophic Level: Collected from leaf packs particularly in areas of fast flow. Detritivorous (shredders).

Distribution and Occurrence: Common in clean Mountain and Northern Inner Piedmont streams. Collected almost year round.

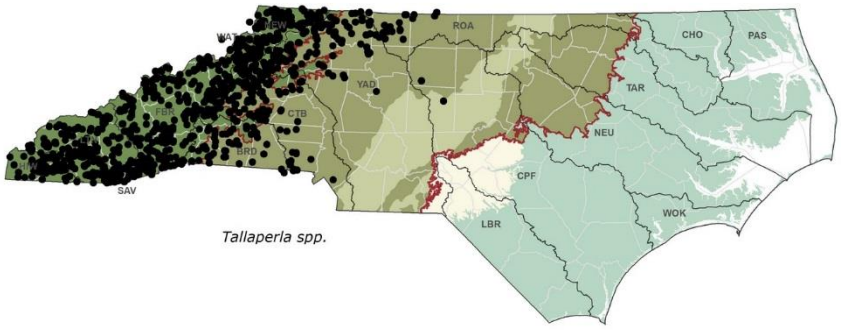
Species in NC: LEAVE AT GENUS

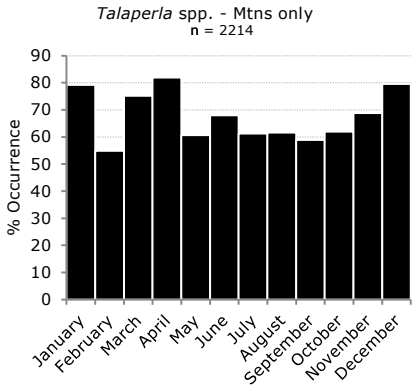
(anna), (cornelia), (elisa), (laurie), (maiyae), (maria)

Notes: Of the six species recorded from NC, only nymphs of *T. maria* have been described. Adults of *T. maiyae were* described from Wilkes County, NC. Both *Tallaperla maria* and *T. maiyae* have been reared from multiple NC small headwater streams. While historically found in higher quality Piedmont streams, there are few recent records of *Tallaperla* from these areas. This suggests that this genus is slowly being extirpated from Piedmont streams, most likely due to development pressures.

All known species of *Tallaperla* have female derived nomenclatural epithets. *Tallaperla elisa* is listed as "vulnerable to extirpation" by Morse et al. (1997).

Some species of *Tallaperla* may be semivoltine (*T. maria*; Yokum et al., 1995).





Taxonomic references:

nymphs:

Stark, B. P. and K. W. Stewart. 1981. The Nearctic Genera of Peltoperlidae (Plecoptera). Journal of the Kansas Entomological Society 54(2): 285-311.

adults:

Kondratieff, B. C., R. F. Kirchner, R. E. Zuellig, and D. R. Lenat. 2007. A new species of Tallaperla (Plecoptera: Peltoperlidae) from North Carolina, U. S. A. Entomological News 118 (1): 81-82.

Stark, B. P. 2000. Peltoperlidae (The Roachflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 Number 1. vii + 100 pp.

Viehoperla

Genus Diagnosis: Nymphs 7-9 mm. *Supracoxal thoracic gills with a single filament*; *small dark spots on meso- and metanota*; posterior edge of prosternal plate mostly straight across; metasternal plate with short, broad posterior wings; *hind femora lacking fringe of long silky setae or at most with a few hairs;* overall body coloration brown to dark brown with a pair of small dark anteromedial spots on meso- and metanota (may be inconspicuous in older specimens).

Habitat and Trophic Level: Collected from leaf packs. Detritivorous (shredders).

Distribution and Occurrence: Occurs in undisturbed, small, cold streams, springs, and splash zones in Mountains from spring through early fall. Rarely collected.

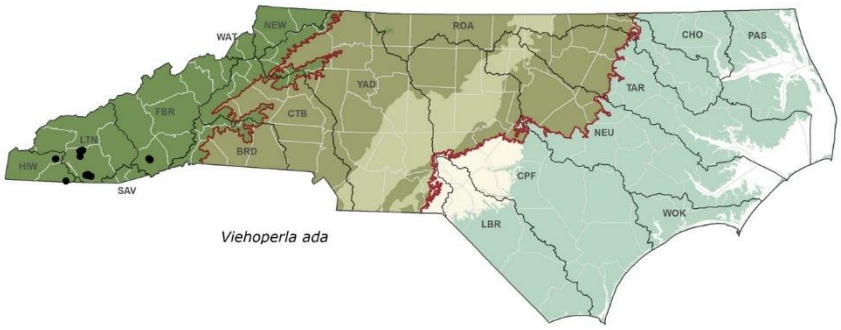
Species in NC: MONOTYPIC

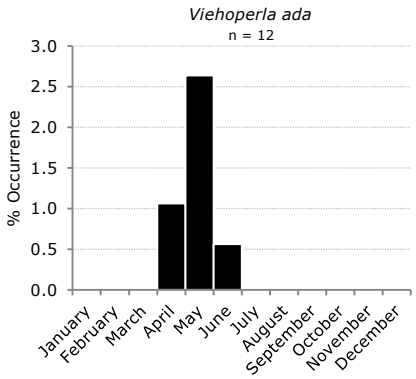
***ada* –** see Genus Diagnosis.

Notes: *Viehoperla* co-occur with *Tallaperla* and thus can be overlooked. The description of *Viehoperla ada* describes nymphs collected from about 1,200' to over 5,100' above sea level (Stark and Stewart, 1982). All current BAB records occur below 3,300' with a mean altitude of 2400' above sea level.

Recorded from multiple southwestern NC counties as well as GSMNP. *Viehoperla zipha* was synonymized with *V. ada* in Stark and Stewart (1981).

Viehoperla ada may be semivoltine but there are no published life history accounts of this species.





Taxonomic references:

nymphs:

Stark, B. P. and K. W. Stewart. 1982b. The nymph of *Viehoperla ada* (Plecoptera: Peltoperlidae). Journal of the Kansas Entomological Society 55: 494-498.

adults:

Stark, B. P. 2000. Peltoperlidae (The Roachflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 Number 1. vii + 100 pp.

Family PERLIDAE

This large family is commonly referred to as the "the stones". The Stones (likely both the rolling and non-rolling kind) are widely known among fly fisherman who often make artificial lures, or "wet flies", that emulate the nymphs of this family. The common name likely comes from their preferred habitat of cobbles and gravel in stream riffles and rapids. The adults are small to moderately large and often have contrasting color patterns on the head, pronotum and legs, typically of pale yellows and browns. The adults fold their brown wings flat along the abdomen while at rest and typically have long multisegmented cerci. Adults typically emerge and fly during the late spring and summer.

Perlid nymphs range from less than 10 mm to almost 30 mm with the species members of a particular genus approximately similar in size. The nymphs are usually contrastingly colored with various shades of yellow and brown, often quite beautifully, and have tufts of finely branched gills along the lateral edges of the ventral thorax. As predators, they sprawl on rocks and logs in areas of flow actively hunting other aquatic insects, including other stoneflies, although early instars are omnivorous and include detritus in their diet. By and large, the larger members of this family are semivoltine and have life spans of 1-2 years whereas the smaller species are typically univoltine. However, this is a general trend and is not a strict rule as the life histories of many species have not been fully investigated.

There are 10 genera with at least 40, and likely more, species of Perlidae in North Carolina. They are widespread and present in every ecoregion and exist in permanent small headwater streams to large rivers, cold water systems to warm water systems, as well as clean and clear water to turbid waters of dubious quality.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by the combination of the following characters:

1) Body robust, somewhat flattened, and usually patterned
2) Legs, when extended, exceeding abdominal apex
3) Head prognathous (oriented forward)
4) Type II mouthparts:
    a. glossa poorly developed or absent, paraglossa large and much longer than glossa, often appearing apically attached to the glossa
    b. labial palpi reach well beyond labium (glossa and paraglossa)
5) Thoracic sterna with tufts of finely branched gills at lateral edges, anal gills may or may not be present
6) Second tarsal segment of legs shorter than first segment
7) Abdomen parallel to subparallel
8) Cerci as long or longer than abdomen, gradually tapered

SUBFAMILIES AND GENERA IN NC:

Acroneurinae: *Acroneuria, Attaneuria, Beloneuria, Eccoptura, Hansonoperla, Perlesta, Perlinella*

Perlinae: *Agnetina, Neoperla, Paragnetina*

NOTES: North Carolina has representative species for each eastern Nearctic Perlidae genus. Of these genera, *Acroneuria, Paragnetina*, and *Perlesta* are widespread and the most commonly encountered. *Eccoptura* is not known from the Coastal Plain and *Neoperla* is rare in the Mountains. *Agnetina*, *Attaneuria*, *Beloneuria*, and *Hansonoperla* are mostly restricted to the Mountains and rarely collected while *Perlinella* is restricted to the Piedmont and Coastal Plain.

Perlidae not treated herein include the western Nearctic genera *Calineuria*, *Doroneuria*, and *Hesperoperla*; the western and far northern genus *Claassenia*; and, finally, *Anacroneuria,* a genus distributed from the southwestern US to the Neotropics. Refer to Stewart and Stark (2002, 2008) for details on separating most of these genera.

Perlidae have variable tolerance to pollution or stress with some taxa able to withstand moderate siltation and others tolerating lower dissolved oxygen concentrations. Still other species are highly sensitive and are only found in pristine conditions. The voltinism of the nymph in certain circumstances may provide an indication of stable water qualities over the short term (2-3 years) and the presence of multiple cohorts of semivoltine species suggest good water quality conditions are persisting over the long term. Additionally, long lived cold stenothermic stoneflies may be susceptible to, and therefore indicators of, changing water temperatures associated with climate change.

Acroneuria

Genus Diagnosis: Head with 3 ocelli; frontoclypeus usually with a pale stylized M-pattern; *setal row or ridge on occiput absent*; *postocular fringe with row of several thick setae*; *cerci with basal fringe of silky setae*; posterior pronotal flange wider than anterior or lateral flange; thick, close-set pronotal marginal setae present on antero- and posterolateral corners, incomplete anteriorly; anal gills present or absent.

Habitat and Trophic Level: Typically collected from hard substrates in well-aerated, fast moving riffles but can also be found in woody debris, particularly in crevices, in slower moving water. Predaceous – engulfers. Clingers.

Distribution and Occurrence: Generally widespread during the late spring through fall, though less common in the Coastal Plain. See species accounts.

Species in NC: TAKE TO SPECIES

abnormis – male nymphs 15-20 mm, female nymphs 25-30 mm. Dorsum of head with a well-defined M-shaped head pattern, sometimes with interruptions; posterior margins of abdominal tergites light, dark tergal bands irregular; *or* dorsum of head without distinctive M-shaped head pattern and abdomen uniformly brown; anal gills always absent.

Widespread and highly variable, *Acroneuria abnormis* may be a complex of species. Nymphs occur year round and may be semivoltine although no life history studies could be found.

arenosa – male nymphs 14-17 mm, female nymphs 20-24 mm. Dorsum of head with M-shaped pattern, sometimes faint to absent or broken onto 3 light spots; abdomen mostly uniformly brown but with an incomplete, narrow, pale anterior band; anal gills present.

Nymphs of this species are uncommon but widespread during the spring through fall particularly in the Piedmont and Coastal Plain. It should be noted that no verified nymphal specimens have been collected in NC within the last 5 years casting doubt on the veracity of the distribution map and seasonality chart.

(arida) – nymphs unknown.

North Carolina adult records are from Haywood County. Also recorded from GA, TN, and GSMNP. Listed as "vulnerable to extirpation" by Morse et al. (1997) and may possibly already be extirpated.

carolinensis – male nymphs 17-19 mm, female nymphs 21-23 mm. Dorsum of head with light M-shaped pattern; dorsum of abdomen banded with the anterior half pale and posterior margins of terga dark; anal gills usually absent.

Acroneuria carolinensis is relatively common in the northeastern Mountains and Sand Hills year round but particularly in the early winter. There can be confusion with *A. lycorias* when both species are present in the same sample (see Notes).

evoluta – male nymphs 16-19 mm, female nymphs 21-23 mm. Dorsum of head with interrupted M-shaped head pattern, appearing as a transverse row of 3 light spots in line with the median ocellus; abdomen uniformly brown, not banded; anal gills present.

Uncommonly collected although nymphs appear to be more common during summer thru late fall. *Acroneuria evoluta* is widespread but prefers leaf packs in large Slate Belt and Coastal Plain rivers.

Nymphs key to *A. mela* in Unzicker and McCaskill (1982 – see notes), however *A. mela* is now a junior synonym of *A. evoluta* (Stark and Brown, 1991). The nymphal description of this species was previously confused with *A. frisoni* and BAB records of *A. evoluta* prior to 2008 are actually *A. frisoni.*

filicis – male nymphs 16-18 mm, female nymphs 20-23 mm. Dorsum of head with light M-shaped pattern; abdomen banded with posterior margin light; dark tergal bands expanded posteriorly near median line (sometimes obscurely), expansions reaching posterior margin of tergum and giving the appearance of 3 light spots along posterior edge; dark bands remain constant in width laterally and on at least segments 8-9 cover at least half the segment; posterior margin of segment 10 dark and often coalesced with the anterior band; anal gills present.

Nymphs are collected from the Mountains. One verified record from Randolph County is from a high quality stream in the Uwharrie National Forest within the ancient Uwharrie Mountains, thought to be the oldest Mountains on the North American continent. Also recorded from GA, SC, TN, VA, WV, and GSMNP.

frisoni – male nymphs 14-17 mm, female nymphs 16-21 mm. Dorsum of head with broad light M-shaped pattern; abdomen banded with posterior half of terga light and of uniform thickness; anal gills present.

Nymphs key to *A. evoluta* in Unzicker and McCaskill (1982 – see notes). However, the true distribution is unknown due to prior confusion with *Acroneuria evoluta*. Recorded from GSMNP.

internata* – male nymphs 15-18 mm, female nymphs 21-24 mm. Dorsum of head with interrupted M-shaped head pattern, appearing as a transverse row of 3 light spots in front of anterior ocellus; abdomen banded, dark bands on terga 8-9 may be medial with a narrow pale basal and narrow apical band, the pale basal (anterior band) may be absent on more anterior segments; dark bands of uniform thickness; anal gills absent.

Some *Acroneuria* populations in the New River Basin match this description; however the anterior abdominal banding is marginally darker than the lighter posterior area and may instead be *Acroneuria abnormis* or an unknown species. No adult records for this species exist for NC but as it is recorded from VA, WV, and GSMNP, it may eventually be found here.

lycorias – male nymphs 15-18 mm, female nymphs 17-20 mm. Dorsum of head with well-developed, light M-shaped pattern; posterior 1/4 to 1/3 of abdominal terga darkly banded, sometimes narrowed medially; anal gills usually present, sometimes small.

There can be confusion with *A. carolinensis* when both species are present in the same sample (see Notes). Found in Mountains (mostly the Catawba River basin) and Sand Hills. Though uncommon, nymphs can be collected year round.

perplexa – male nymphs 15-18 mm, female nymphs 19-23 mm. Dorsum of head with light M-shaped pattern of uniform thickness throughout; abdomen banded with anterior bands dark and posterior tergal bands light, the dark tergal bands expanded posteriorly near median line not reaching posterior margin of tergite and notched medially; dark bands decrease in width laterally; anal gills present.

There are four BAB records of *A. perplexa*, which appear to be misidentifications of *A. filicis*. However, based on adult records from GSMNP it is possible that *A. perplexa* occurs in NC.

petersi* – nymph unknown.

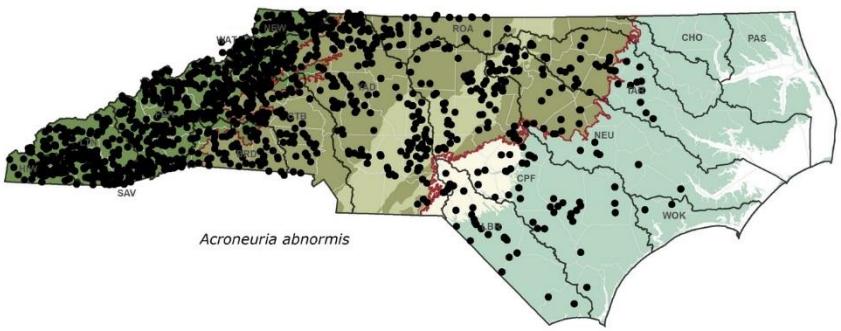
Recorded from AL, GA, TN and GSMNP. Listed as "vulnerable to extirpation" by Morse et al. (1997).

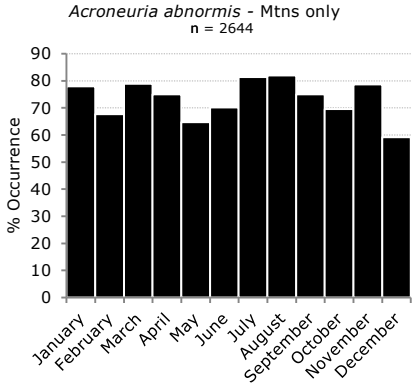
Notes: The above descriptions are based on ultimate to pre-emergent nymphs and may not hold for earlier instars. It is probable that some nymphs occurring in North Carolina are undescribed or unrecorded species. Additionally, a fair amount of variation exist with color patterns and, therefore, separation of species should be considered provisional. Difficult or immature specimens may best be left at genus.

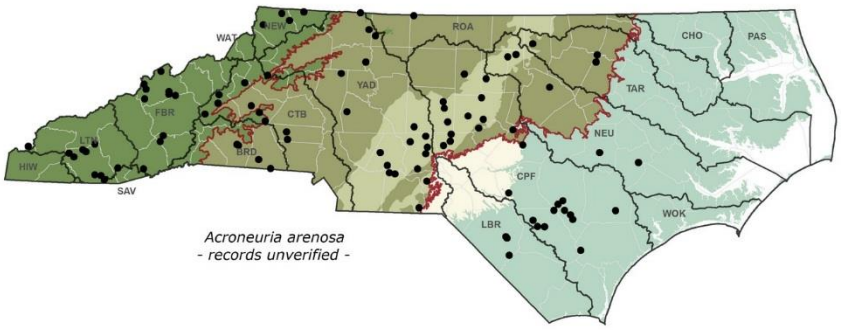
Stark and Brown (1991) mentions that old *A. evoluta* descriptions (such as found in Unzicker and McCaskill, 1982) refer instead to *A. frisoni.* Additionally, *A. mela* was synonymized with *A. evoluta* (Stark and Brown, 1991). Finally the distribution maps for *A. carolinensis* and *A. lycorias* suggest that these two species have historically been confused with each other. There are some populations of *Acroneuria carolinensis* that have either sparse anal gills, anal gills only on one paraproct, or missing the gills entirely (particularly smaller specimens). This has led to confusion over the true identity of sample specimens or the identification of both species together in the same sample. Therefore, the maps of *A. carolinensis* and *A. lycorias* likely contain many erroneous records. When a series of instars are present with variable anal gills, or identifications are tentative, they should be identified as *Acroneuria carolinensis/lycorias*.

Three *Acroneuria* species, *A. kirchneri*, *A. kosztarabi*, and *A. yuchi* have been described from VA and may eventually be found to occur in NC. However, only the nymphs of *A. kirchneri* are known and may be inseparable from *A. frisoni.*

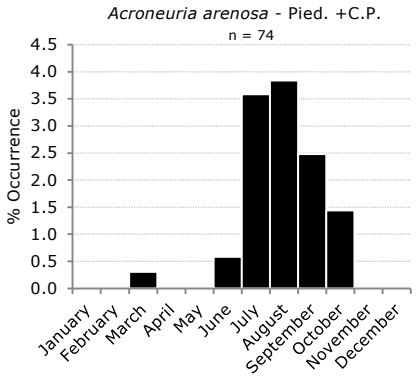
Life history studies of *Acroneuria* species are sparse and therefore a definitive life history strategy cannot be stated for this genus. However, anecdotal BAB observations as well as those from other investigators (B. Kondratieff personal communication) suggest that most *Acroneuria* may be semivoltine. In fact, *A. carolinensis* was reported as semivoltine by Schmidt and Tarter (1985) and *A. lycorias* as semivoltine life cycle by Peckarsky (1979). However, at least one species, *A evoluta*, has been reported as univoltine in an Ozark stream (Ernst and Stewart, 1985a - though this may refer to *A. frisoni*).

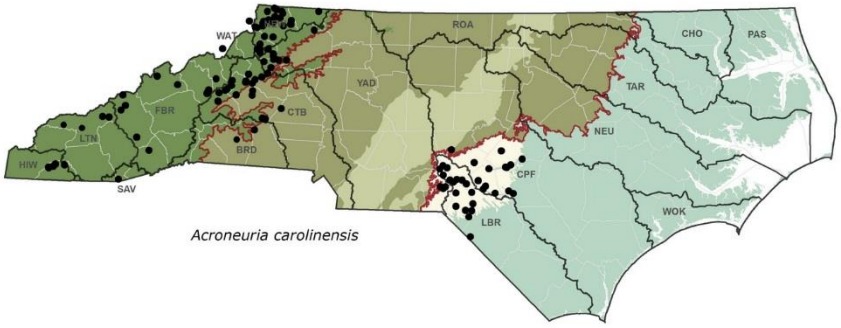




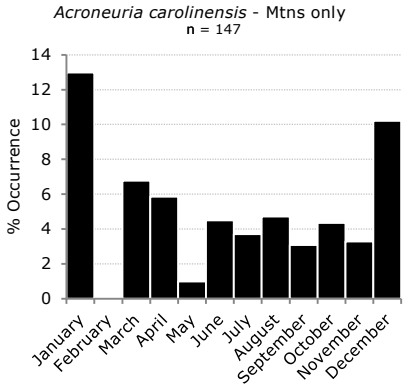


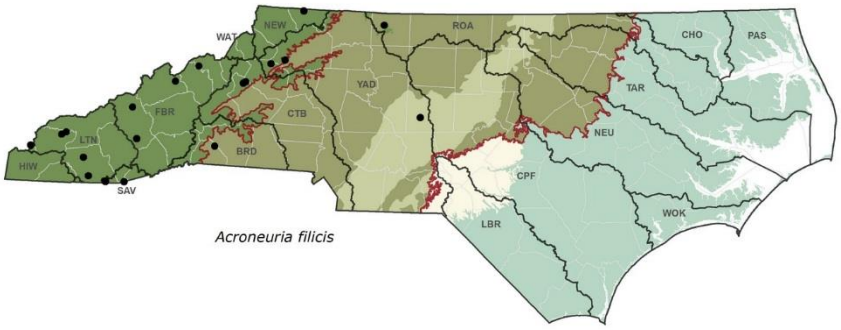
Acroneuria arenosa
- records unverified -



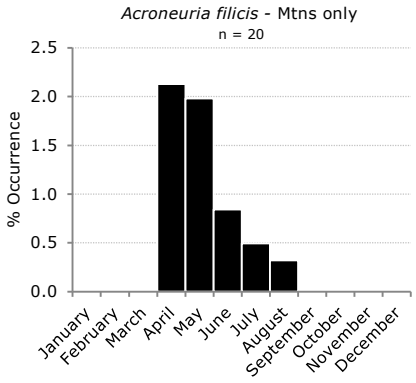


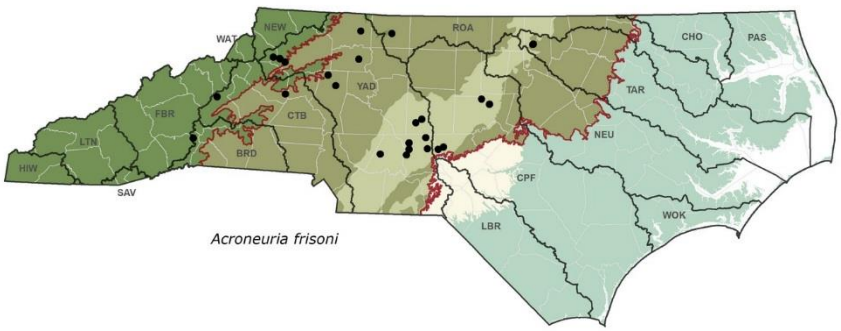
Acroneuria carolinensis



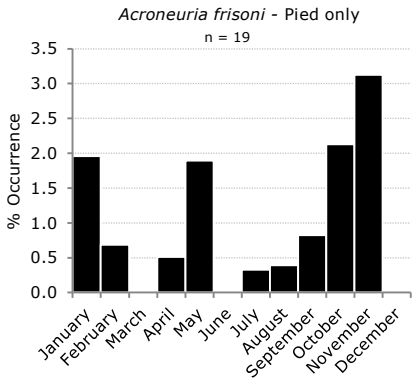


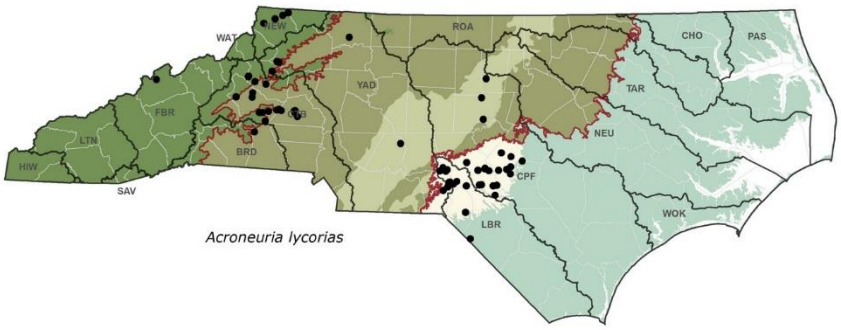
Acroneuria filicis

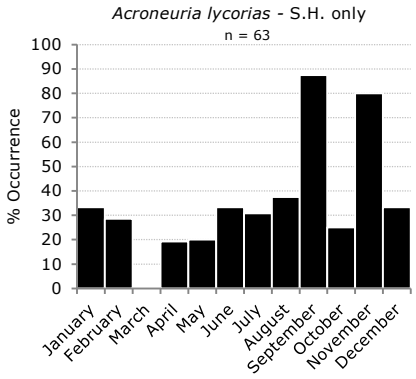




Acroneuria frisoni







Taxonomic references:

nymphs:

Unzicker, J. D. and V. H. McCaskill. 1982. Plecoptera, Chapter 5 (50 pp.). *In* A. R. Brigham, W. U. Brigham, and A. Gnilka, editors. *Aquatic Insects and Oligochaetes of North and South Carolina*. Midwest Aquatic Enterprises, Mahomet, Illinois. 837pp.

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Agnetina

Genus Diagnosis: Head with 3 ocelli; frontoclypeus usually with a wide, pale yellow transverse medial band; *occiput between eyes with a complete, close-set, transverse setal row of short peg-like setae*; *basal cercal segments lack fringe of long setae*; posterior spinule fringe of abdominal sternum segment 7 complete; *anal gills present, well-developed;* body color pattern usually dark brown with highly contrasting yellow.

Habitat and Trophic Level: Nymphs prefer cobble in fast flowing riffles. Predaceous – engulfers. Clingers.

Distribution and Occurrence: Nymphs occur primarily in mountain streams although they can be found in the Piedmont. Uncommon.

Species in NC: TAKE TO SPECIES

annulipes – reared pre-emergent female nymphs 15 mm. Head pattern roughly M-shaped with arms directed posterolaterally, some specimens may have an almost interrupted mask; dorsum of abdomen banded, with dark bands on anterior half of segment, sometimes segments 5 and 6 dark mostly to posterior margin, tergum 9 mostly dark with 2 pale submedial areas, tergum 10 almost completely dark including the apex.

Agnetina annulipes has been reared from the Uwharrie River with the exuvia matching the above nymphal description. Collected from the NC Mountains and Slate Belt, this species is also recorded from SC and VA.

Agnetina annulipes has a semivoltine life cycle (Harper, 1973b).

capitata – nymphs ?? mm. Lateral arms of M-pattern on head directed laterally; dark area between lateral ocelli sometimes lighter to median ocellus; dorsum of abdomen banded, posterior margins dark and with a triangular mesal area anteriorly projecting forming an apparent mid-dorsal longitudinal stripe; apex of tergum 10 light with dark pigmentation faintly continuous mesally, sometimes with a small median projection directed distally.

Collected primarily from smaller to moderately sized mountain streams and recorded from GSMNP. North Carolina appears to be the southern distributional limit of this species.

Agnetina capitata has a semivoltine life cycle (Harper, 1973b).

flavescens – *Published description:* nymphs ?? mm. Head pattern roughly M-shaped with arms directed posterolaterally and almost interrupted; a light triangular pale area between lateral ocelli; dorsum of abdomen banded, with dark bands on anterior half of segment, distal segments may have a narrow light band anterior to the dark band; apex of tergite 10 light with narrow dark pigment band interrupted mesally. *Variant nymph description:* pre-emergent male nymphs 11.0-11.5 mm. Head same as published description; dorsal and lateral aspect of abdomen banded, with dark bands on anterior third of each tergum, these bands with a mesal extension on all segments connected to a narrow band on posterior margin; anterior bands on at least segments 5-9 also with sublateral posteriorly directed extensions, often connected to posterior band on segments 5-6 or 7 giving the appearance of 2 pale spots; segments 7-9 lighter, anterior band may be obsolete, or not; dorsum of 10 with anterior band not interrupted medially and instead with a mesal posteriorly directed dark line connected to the thin dark posterior margin; the anterior band may be connected to posterior band at lateral margins giving the appearance of 2 pale elliptical spots submedially (similar to the description of *Agnetina annulipes*).

Nymphs with the above alternate description have been collected from the Cape Fear River, Mayo River, and the Dan River. Male nymphs have been reared and found to be *Agnetina flavescens* (verified by B. P. Stark) and represent a new nymphal variant for this species.

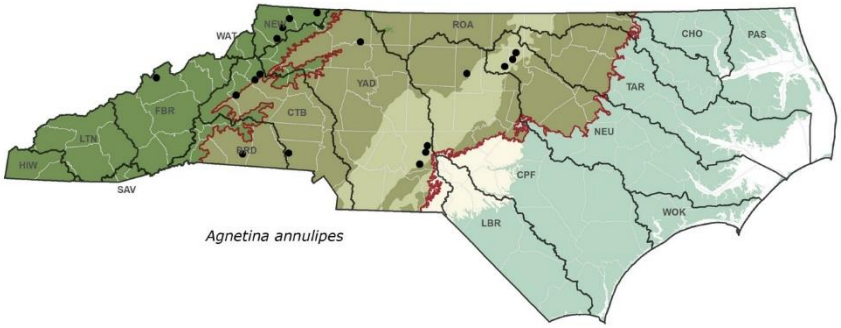
This species is collected primarily from the Mountains during the spring and summer and the variant form appears to be associated with larger streams and rivers.

Agnetina flavescens has a semivoltine life cycle (Ernst and Stewart, 1985a).

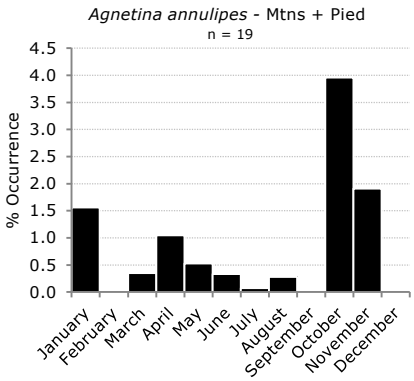
Notes: Some *Agnetina* nymphs collected from some large NC rivers do not key well (based on Stark, 1986) but have been reared and verified (by B. P. Stark) to be *Agnetina flavescens*. *Agnetina annulipes* has also been reared and nymphal exuvia of the two species do exhibit some differences (see species treatments). However, earlier instars may have an undeveloped habitus pattern and should be left at the genus level unless ultimate instar nymphs are also present.

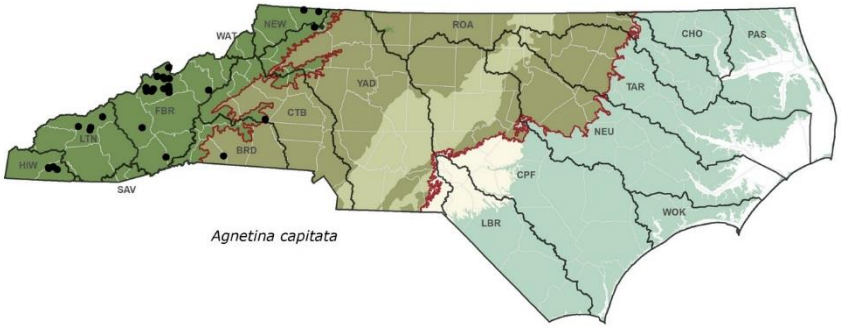
The distribution of *Agnetina annulipes* and *A. flavescens* has been confused by uncertain taxonomy and the presence of a variant nymphal form of *A. flavescens.* The published descriptions by Stark (1986) were based on small series of nymphs (pers. comm.) and therefore, the variant form of *A. flavescens* was likely not encountered.

Agnetina was previously known as *Phasganophora*.

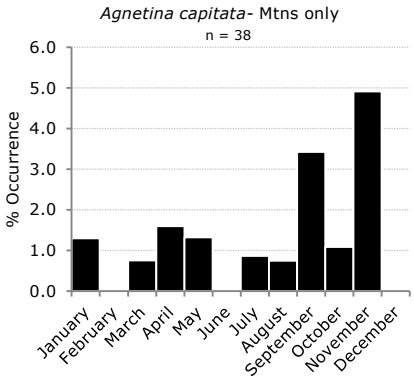


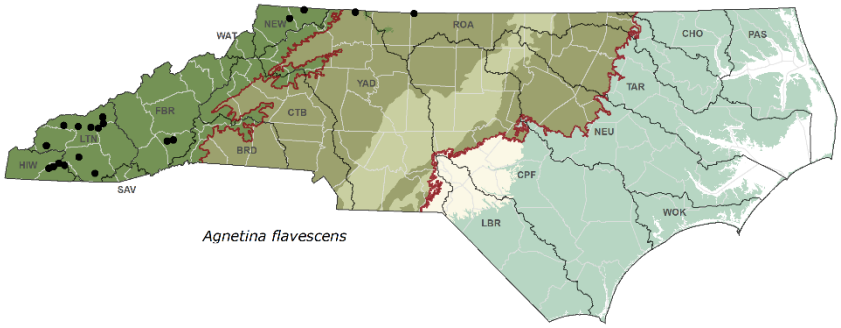
Agnetina annulipes



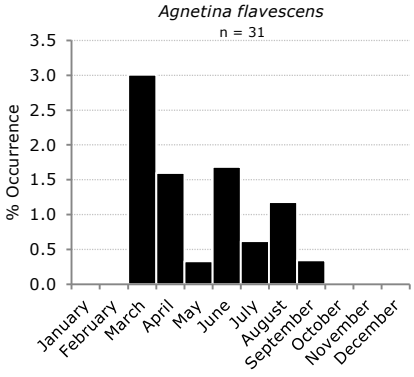


Agnetina capitata





Agnetina flavescens



Taxonomic references:

nymphs:

Stark, B. P. 1986. The Nearctic species of *Agnetina* (Plecoptera: Perlidae). Journal of the Kansas Entomological Society 59(3): 437-445.

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. Vol. 14 (4). vi + iv p.

Attaneuria

Genus Diagnosis: Nymphs 18-30 mm. Head with 3 ocelli; head yellow-brown, usually with an inconspicuous slightly darker M-line; a pattern of darker reticulations behind epicranial sutures; *occiput with a slightly irregular but mostly complete (setal row may be obsolete near epicranial stem), row of peg setae with small irregular gaps; lateral and posterior pronotal margins and posterior edge of abdominal tergites fringed with long, thin setae*; *pronotum about 2.5 times as wide as long; anal gills absent*; cerci with an inner fringe of long silky setae; body mostly unpatterned but covered with fine, dark clothing hairs.

Habitat and Trophic Level: Nymphs are associated with debris, probably in areas of deeper waters. Predaceous – engulfers. Clingers.

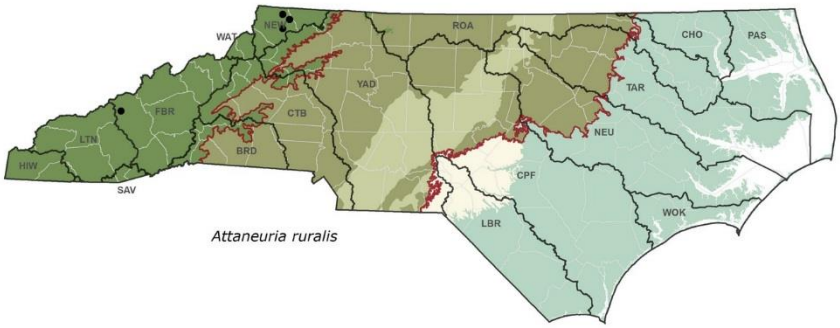
Distribution and Occurrence: Mountains only, particularly New River basin. Seasonal data unknown. Rarely collected.

Species in NC: MONOTYPIC

ruralis – see Genus Diagnosis.

Notes: One of the largest perlid stoneflies occurring in North Carolina, *Attaneuria ruralis* has been suggested as having a semivoltine life cycle (Frison, 1935).

DWR last collected nymphs of *Attaneuria ruralis* in the winter of 1998. This species is listed by NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014).



Taxonomic references:

nymphs:

Unzicker, J. D. and V. H. McCaskill. 1982. Plecoptera, Chapter 5 (50 pp.). *In* A. R. Brigham, W. U. Brigham, and A. Gnilka, editors. *Aquatic Insects and Oligochaetes of North and South Carolina.* Midwest Aquatic Enterprises, Mahomet, Illinois. 837pp.

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Beloneuria

Genus Diagnosis: Head with 3 ocelli; head with a well-defined pale M-pattern anterior to median ocellus; *no setal row or ridge on occiput*; *postocular fringe with scattered stiff setae*; *no basal silky setae on the cerci*; *pronotal flange uniformly narrow, fringe of thick, closely set setae, incomplete laterally*; *anal gills present*; body typically golden brown with pale yellow pattern and covered with fine, dark clothing hairs.

Habitat and Trophic Level: Nymphs prefer cobble and coarse woody debris in areas of good flow. Predators - engulfers. Clingers.

Distribution and Occurrence: Nymphs occur year round, preferentially in smaller, colder streams and seeps in the Mountains and Foothills. Uncommon.

Species in NC: LEAVE AT GENUS

georgiana – nymphs 14.0-? mm. Head without two light rectangular dashes anterolateral of the two posterior ocelli; appears to have more spicules on terga 8 than *B. stewarti*; lower half of hind femora with thick setae absent from apical third except along margins (new character – Stark, 2016 in press).

Nymphs of this species prefer high elevation headwater streams. Listed as "vulnerable to extirpation" by Morse et al. (1997).

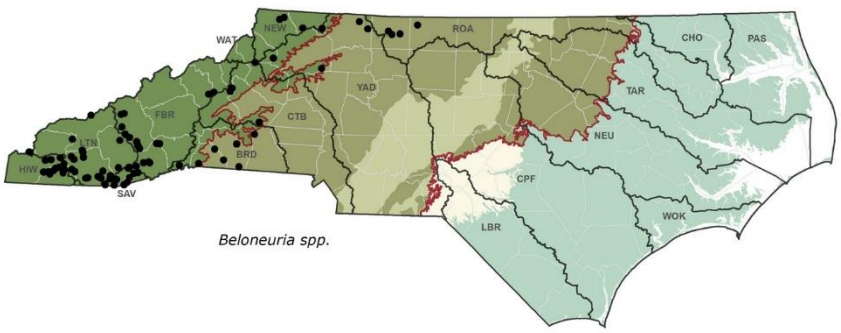
stewarti – nymphs ?? mm. Head with two light rectangular dashes anterolateral of the two posterior ocelli; appears to have more of a dorsal and ventral intercalary setal fringe on apical segments of cerci than *B. georgiana;* lower half of hind femora with thick setae distributed fairly evenly along basal 3/4 (new character – Stark, 2016 in press).

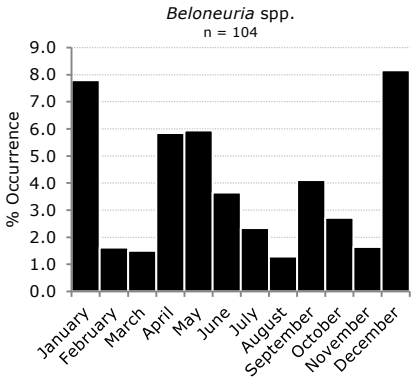
Beloneuria stewarti nymphs are associated with lower elevations and Piedmont areas. Listed as "vulnerable to extirpation" by Morse et al. (1997).

Notes: *B. georgiana* is pictured in Stewart and Stark (2002) while Stewart and Stark (2008) depicts the head of *B. stewarti.* Also, *B. stewarti* is misidentified as *B. georgiana* in Stark and Gaufin (1976b). Superficially, *Beloneuria* can be misidentified as either *Acroneuria* or *Perlesta* but the lack of a cercal fringe will separate the nymphs from these two genera.

New femoral setation patterns have been presented in a new stonefly key to the southeastern fauna (Stark, 2016 in press). *Beloneuria* species identifications should be considered provisional until the femoral setation patterns have been proven reliable, although preliminary use of this setation character appears promising.

Both *Beloneuria* species have been recorded from GSMNP. *Beloneuria* life cycles are unknown although may be semivoltine.





Taxonomic references:

nymphs:

Stark, B. P. and S. W. Szczytko. 1976. The genus *Beloneuria* (Plecoptera: Perlidae). Annals of the Entomological Society of America, 69(6): 1120-1124.

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Eccoptura

Genus Diagnosis: Nymphs 15-22 mm. Head with 3 ocelli; occiput without transverse row of spinules, setae restricted to postocular fringe; *head with a large, lobed, light yellow area anterior to the median ocellus*; pronotal fringe of thick, closely set setae; cerci with a sparse basal fringe of silky setae; *anal gills present*; abdominal terga 1-8 often with a pale irregular, submedial transverse band.

Habitat and Trophic Level: Typically collected from hard substrates in well-aerated, fast moving riffles. Predaceous.

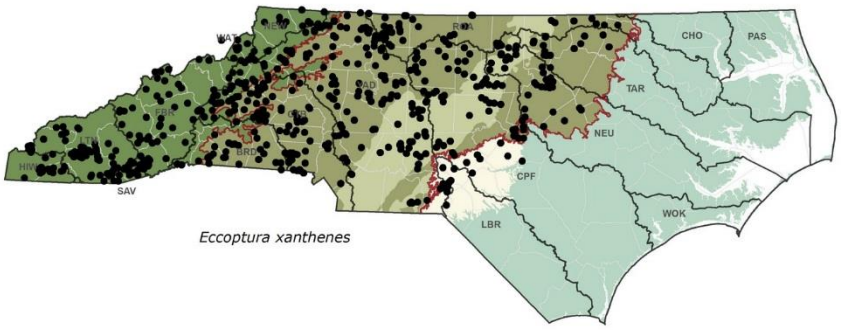
Distribution and Occurrence: Common in the Mountain, Piedmont, and Sand Hill ecoregions. Found in small streams year round but with a summer lull corresponding to emergence.

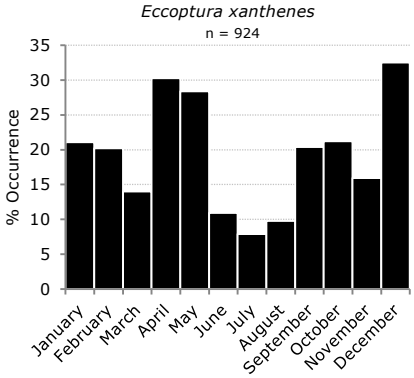
Species in NC: MONOTYPIC

xanthenes – see Genus Diagnosis.

Notes: A relatively common perlid in small high quality streams, smaller *Eccoptura* specimens may not have a developed color pattern but will have anal gills. Specimens without a developed pattern could be confused with young *Acroneuria* and *Beloneuria* but lacinial and cercal differences should separate these genera although it may be best to leave such specimens at Perlidae. Washed out or undeveloped head patterns may still have outline of the developing pale area on head

Eccoptura xanthenes is reported as semivoltine (Allen and Tarter, 1985).





Taxonomic references:

nymphs:

Stewart, K.W. and B.P. Stark. 2002. Nymphs of North American Stonefly Genera (Plecoptera). Second Edition. The Caddis Press. Columbus, Ohio, xii + 510pp.

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Hansonoperla

Genus Diagnosis: Nymphs 14-20 mm. Head with 3 ocelli; eyes set forward from hind margin of head; occiput devoid of spinules; *postocular fringe reduced to 1-2 long setae*; pronotal fringes consist of 2-3 longer setae at corners only; *femora and tibia without ventral setal fringe*; thoracic gills long and feathery; cerci without dorsal fringe; *anal gills absent*; nymph habitus long and slender, brown, with appressed brown clothing hairs, and with pale yellow M-pattern on head, often indistinct.

Habitat and Trophic Level: Collected from sand embedded cobbles and woody debris in pools and areas of slower flow including undercut banks or root mats. Most BAB collections occur in cold-water streams in areas of upwelling, although some of these streams are relatively large. Predacious.

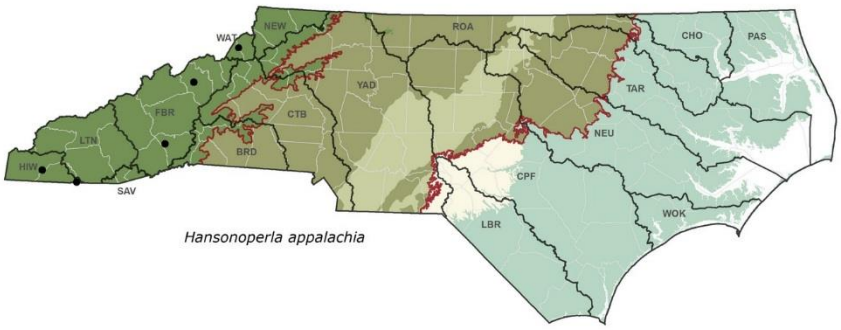
Distribution and Occurrence: Occurs in cool streams and seeps in the Mountains. A fall through winter species. Rarely collected.

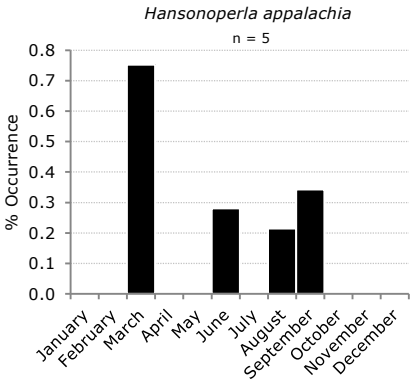
Species in NC: TAKE TO SPECIES

appalachia – see Genus Diagnosis.

Notes: Only the nymph of *Hansonoperla appalachia* has been described and is the only species to occur in North Carolina. It has also been recorded from SC, TN, VA, and GSMNP. *Hansonoperla* has been misidentified as *Perlinella* in some historic BAB samples and may, therefore, be more common than previously noted. The lack of a ventral femoral-tibial fringe of setae on *Hansonoperla* nymphs will separate these two genera. Additionally, the presence of ventral thoracic gills and long cerci will separate small *Hansonoperla* from the Chloroperlidae.

A reared BAB specimen died just prior to emergence but was verified as *H. appalachia* based on mature eggs. While exuviae and mature nymphs have been collected in late April suggesting a spring emergence, mature nymphs have also been collected from late summer *Hansonoperla appalachia* providing evidence of a semivoltine life cycle. However, the life history of *Hansonoperla* remains unknown. Similar to the Chloroperlidae, nymphs most likely dwell in the hyporheos prior to emergence, making them difficult to collect and skewing occurrence data.





Taxonomic references:

nymphs:

Kirchner, R. F. and B. C. Kondratieff. 1985. The nymph of *Hansonoperla appalachia* Nelson (Plecoptera: Perlidae). Proceedings of the Entomological Society of Washington 87(3): 593-596.

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Neoperla

Genus Diagnosis: Nymphs 7-12 mm. *Head with two large, closely-set lateral (posterior) ocelli only, anteromedial ocellus lacking*; complete elevated transverse ridge on occiput, ridge devoid of spinules and often darkly pigmented; *anal gills present*; head usually with a large, anterior dark band and pale medially to posteriorly (may be brown behind occipital sutures); body dark, dorsum of abdomen with contrasting light and pale transverse bands, with dark clothing hairs.

Habitat and Trophic Level: Nymphs prefer detritus in slower water but can be found in riffles as well. Predaceous.

Distribution and Occurrence: Common in the Piedmont and Coastal plain in small streams to large rivers. Uncommon in the Mountains. Nymphs are most abundant during the summer.

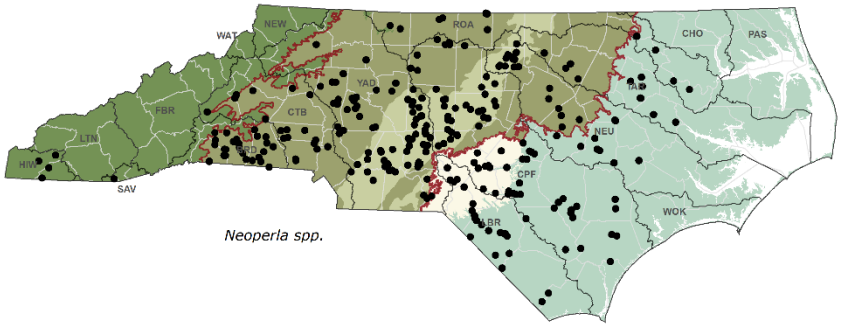
Species in NC: LEAVE AT GENUS

carlsoni*, (catharae), (clymene), (coosa), occipitalis*, (stewarti)

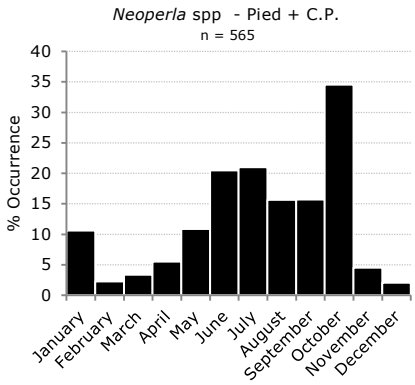
Notes: Of the four species known to occur in NC, only the nymphs of *N. clymene* and *N. carlsoni* have been described. Additionally, several species have light and dark morphs, further hampering species identifications of nymphs.

Neoperla carlsoni and *N. occipitalis* have been recorded from SC and VA while *N. coosa* has been additionally recorded from GSMNP.

Neoperla clymene is one of the few perlids that is univoltine (Vaughn and Stewart, 1974).



Neoperla spp.



Taxonomic references:

nymphs:

no comprehensive treatment for nymphs available

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B.P and B.J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Paragnetina

Genus Diagnosis: Head with 3 ocelli; *occiput with a complete, closely-set, regular transverse spinule row*; pronotal fringe of short, thick setae more or less complete, many setae clavate; posterior spinule fringe of abdominal sternum segment 7 incomplete; *cerci with dorsal setal fringe of fine setae, fringe variously developed*; anal gills usually absent although a few filaments may be present; usually distinctly patterned, but sometimes lacking contrasting colors.

Habitat and Trophic Level: Nymphs are typically collected from hard substrates in well-aerated, fast moving riffles. Predators – engulfers. Clingers.

Distribution and Occurrence: Widespread but most common in the Mountains and rare in the Slate Belt. See species accounts.

Species in NC: TAKE TO SPECIES

fumosa – nymphs 17-?? mm. Frons with a pair of yellow spots lateral to the median ocellar spot, median ocellar spot often congruous with pale yellow transverse band near labrum; thoracic nota with complex and extensive pattern of yellow markings; yellow femora with one sometimes two distinctive dark brown transverse bands; abdominal terga 3-4, 5 with a pair of pale markings and 8 and 9 mostly pale; terga may have 1-2 thick intercalary setae, particularly submedially on 8 and 9; anal gills present or absent; dorsal cercal fringe of silky setae on basal segments sparse, reduced to absent apically.

Common and widespread except for Slate Belt and outer Coastal Plain and collected spring through early winter.

ichusa – nymphs 15-23 mm. Head brown with small, light areas around each ocellus and tentoria; pronotal fringe interspersed with longer and tapered setae, particularly evident laterally and posteriorly; mesonotum with a small, inverted, triangular pale spot along the anteromedial border; femora brown; abdomen brown sometimes with small light mesal areas on tergites 7-9; terga 4-9 without short, thick intercalary setae and instead with long, thin setae originating from posterior margins; dorsal cercal fringe of silky setae on basal segments less sparse, reduced to absent apically; anal gills absent.

Collected mostly from the Mountains and primarily during the summer but can be found year round. Nymphs of this species are inseparable from *Paragnetina media* and identifications should be noted as *"Paragnetina ichusa/media"*.

immarginata – nymphs 18-30 mm. Head M-pattern with medial pale line extended anteriorly, often connected to pale frontoclypeal margin; pronotal fringe mostly of very short, thick, spine-like setae, a few longer setae interspersed and a few club-like; yellow femora distinctively patterned with dark brown longitudinal bar extending about 2/3 the length; abdominal terga banded, anterior half dark; dorsal cercal fringe of silky setae dense, developed on basal half; anal gills absent.

Strikingly patterned, this is the largest and most common *Paragnetina* in the North Carolina Mountains, although less common in the Piedmont. Nymphs occur year round.

kansensis – nymphs 16-?? mm. Dark area of frons without yellow spots near median ocellar spot or with two pair of small spots, one pair anterolateral and one pair posterolateral to the median ocellar spot; pronotal fringe interspersed with longer clavate setae, particularly posteriorly; thoracic nota with a scattered, often diffuse and sometimes obscured pattern of yellow markings; femora variable, some with obscure transverse bars, some brown; abdomen plain brown although segments 7-9 sometimes with lighter markings; terga 4-9 with several short, spine-like intercalary setae; dorsal cercal fringe of silky setae on basal quarter, reduced; anal gills usually present.

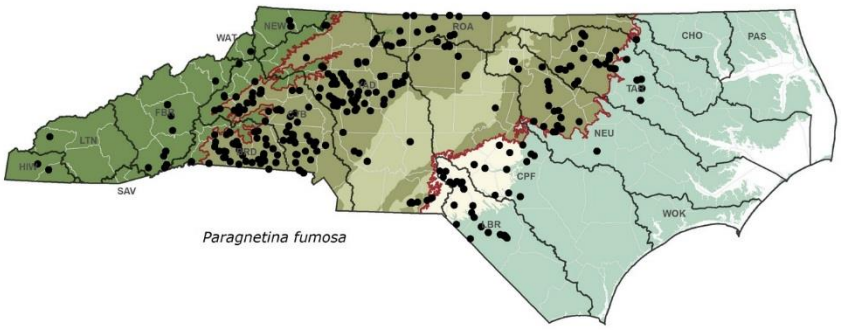
Relatively rare. Mostly found in Coastal Plain (with only a few Mountain and Piedmont records) during late spring through early fall.

media* – nymphs 15-25 mm. Nymphs are inseparable from *Paragnetina ichusa*.

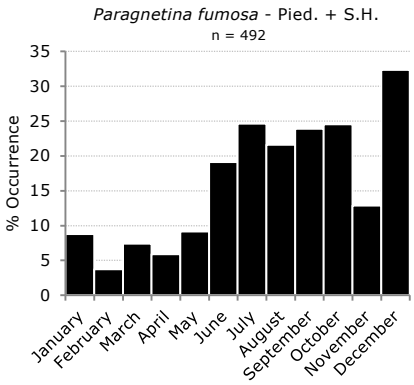
Adults recorded from VA and further north and west but also recorded from GSMNP.

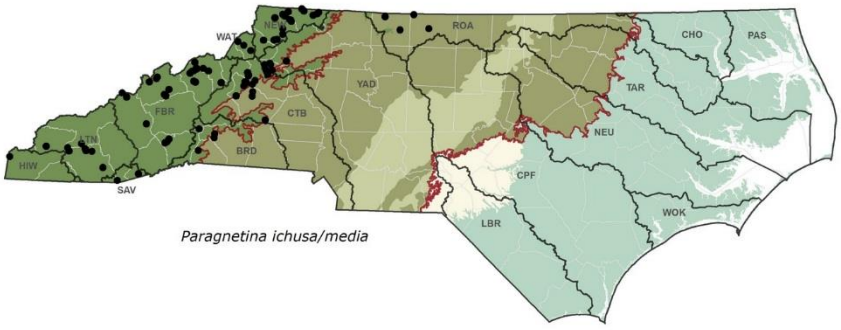
Notes: A relatively straightforward group, misidentifications of *Paragnetina* do occur, particularly as *Agnetina*. However, the presence or absence of a cercal fringe will separate these two genera. Also, *Paragnetina* species with undeveloped patterns can result in misidentifications although careful attention to body setation patterns and distributions may help separate problematic specimens.

Of the five species in North America, all are accounted for in or near North Carolina. While life history studies of *Paragnetina media* suggest it is semivoltine (Lehmkuhl, 1970; Tarter and Krumholz, 1971; Harper, 1973), it is also likely, based on BAB seasonality data, that the other *Paragnetina* species are also semivoltine.

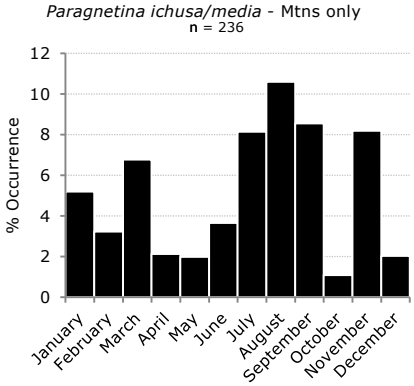


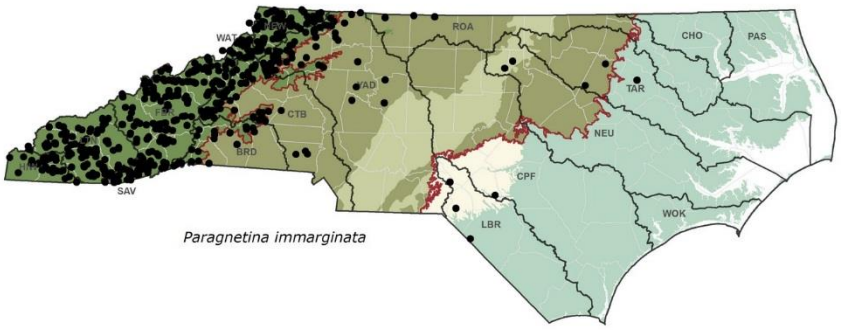
Paragnetina fumosa



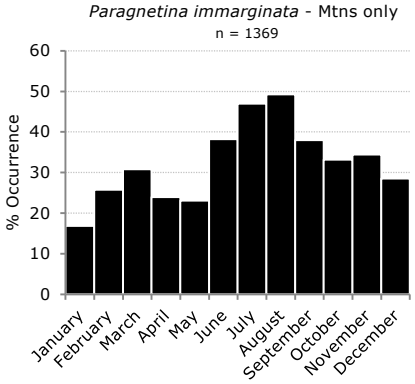


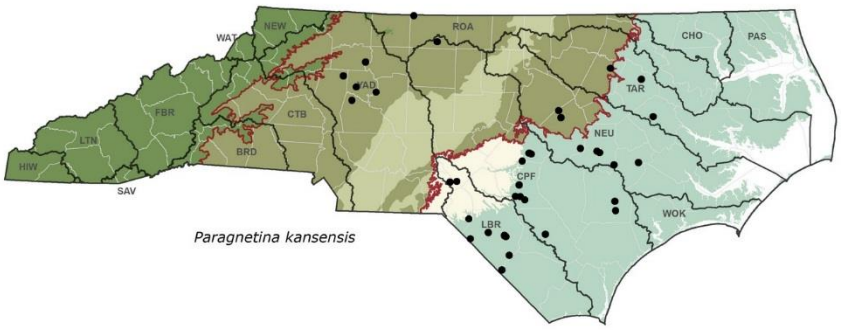
Paragnetina ichusa/media



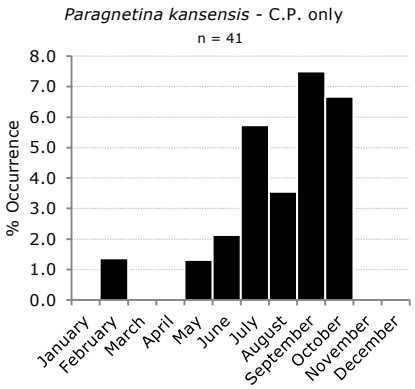


Paragnetina immarginata





Paragnetina kansensis



Taxonomic references:

nymphs:

Stark, B. P. and S. W. Szczytko. 1981. Contributions to the systematics of *Paragnetina* (Plecoptera: Perlidae). Journal of the Kansas Entomological Society 54(3): 625-648.

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Perlesta

Genus Diagnosis: Nymphs 8-12 mm. Head with 3 ocelli; head usually with a pale M-pattern on head, sometimes modified or incomplete; *setal row on occiput partial to complete, sinuate, and with irregular gaps*; *postocular fringe with row of several thick setae*; pronotal fringe broadly incomplete laterally or with widely spaced longer hairs only; *abdomen with numerous short, stout intercalary setae,* most often with pigmented bases giving abdomen a speckled appearance; *anal gills always well-developed*; body pigmentation and freckling variable but always covered with fine, dark clothing hairs.

Habitat and Trophic Level: Nymphs occur on cobble in riffles as well as leaf packs in slower flow areas. Some species associated with *Podostemum*. Early instars are detritivorous and become predacious as they mature.

Distribution and Occurrence: Common and widespread. Nymphs occur spring through midsummer, emerging late July through early August.

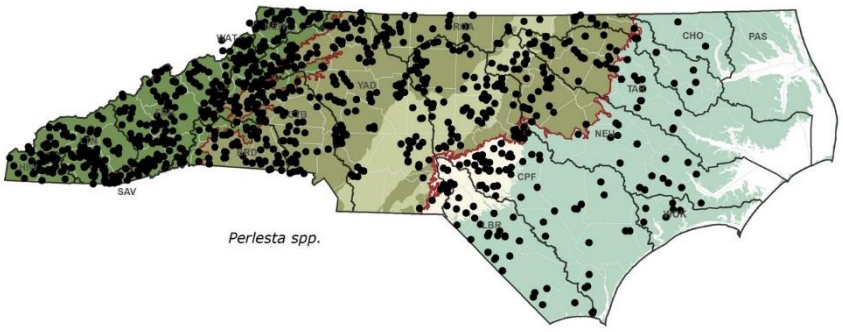
Species in NC: LEAVE AT GENUS

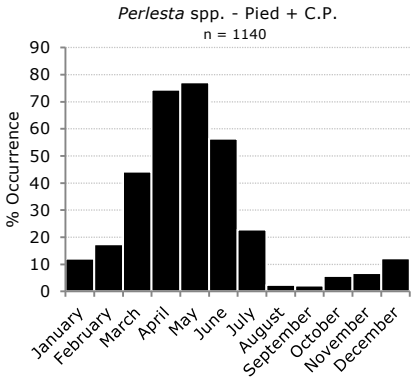
(beatyi), (bjostadi), cranshawi*, (decipiens), (durfeei), etnieri*, (frisoni), (georgiae), (leathermani), (nelsoni), placida, (puttmanni), (roblei), (shawnee), teaysia*

Notes: North Carolina has very high diversity of *Perlesta*, most of which are currently undescribed in the immature stage. While many nymphs appear highly freckled, some nymphs have few or inconspicuous freckles. It is inadvisable to use a new *Perlesta* key (Stark, 2016 in press) as it contains only 6 of the 17 regional species (two of which are not known from NC). Preliminary use of the key has led to immediate failure for most NC specimens. It is not uncommon to get 2-3 nymphal habitus forms at one site.

Perlesta georgiae was described from North Carolina, *Perlesta teaysia* was described from the New River system in southwest Virginia, and *P. cranshawi* was also described from Virginia. *Perlesta decipiens* has been recorded from GSMNP and Guilford County (C. Parker, unpublished data). While *Perlesta etnieri* is described from middle TN, it may, at some point, be found in NC. *Perlesta placida* is mostly a Piedmont species.

Most *Perlesta* species in NC will have emerged by late July but a few may linger into mid-August. Literature describes *Perlesta* as having a univoltine life cycle (*P. decipiens* - Snellen and Stewart, 1979).





Taxonomic references:

nymphs:

no comprehensive identification keys available

adults:

Grubbs, S. A. 2005. *Perlesta shawnee* (Plecoptera: Perlidae), a new stonefly species from Eastern North America. Aquatic Insects 27(1): 63-69.

Kondratieff, B.C., R. E. Zuellig, and D. R. Lenat. 2011. A new species of *Perlesta* (Plecoptera: Perlidae) from North Carolina with additional records for North Carolina and Virginia. Illiesia 7(27):297-301.

Kondratieff, B. C., R. E. Zuellig, R. F. Kirchner, and D. R. Lenat. 2006. Three new species of *Perlesta* (Plecoptera: Perlidae) from eastern North America and notes on new state records. Illiesia 2(5): 31-38.

Kondratieff, B. C., R. E. Zuellig, R. F. Kirchner, and D. R. Lenat. 2008. Two new species of *Perlesta* (Plecoptera: Perlidae) from eastern North America. Proceedings of the Entomological Society of Washington 110(3): 668-673.

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Perlinella

Genus Diagnosis: Head with 2 or 3 ocelli; eyes set forward from hind margin of head; occiput devoid of spinules; *postocular fringe consists of 1-3 long, slender bristles*; *2-5 long setae at pronotal corners; ventral femoral-tibial fringe of silky setae present, although reduced*; thoracic gills long and feathery; cerci without dorsal fringe but a few long apical hairs present on each segment in distal half; anal gills poorly developed or absent; nymph habitus long and slender, brown, with brown clothing hairs, and with a pale yellow M-pattern on head, often interrupted or indistinct.

Habitat and Trophic Level: Nymphs occur in gravelly areas and leaf packs. Young nymphs may inhabit the hyporheos. Predators – engulfers. Clingers.

Distribution and Occurrence: These uncommon nymphs occur primarily in the Sand Hills and southern areas of the Coastal Plain.

Species in NC: TAKE TO SPECIES

drymo – Nymphs 14 mm. Head with 3 ocelli, median ocellus small (visible even on earlier instars); head with a pale M-pattern; often with highly contrasting color pattern on thorax (especially on pronotum); dorsum of abdomen with faint median longitudinal stripe; small anal gills.

Nymphs are collected during the fall through winter primarily from the southern Coastal Plain and Sand Hills with sporadic records as far west as the Carolina Slate Belt. Relatively rare.

ephyre – nymphs 15-23 mm. Head with 2 ocelli, median ocellus lacking; body color yellow-brown, with little to no contrasting colors; anal gills present or absent.

Nymphs are collected from Sand Hills streams and rivers (Lumber R) typically during the fall through early spring. While this species is considered rare, multiple nymphs were successfully reared from Killets Cr. (Moore Co.) in 2015. Some DWR records for *P. ephyre* may refer to *P. zwicki*.

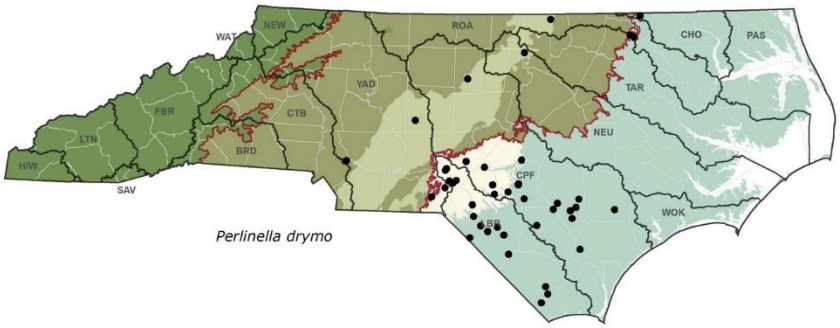
(zwicki) – nymphs ?? mm. Head with 2 ocelli, median ocellus lacking; body color brown, head with contrasting pale and dark areas; anal gills present or absent.

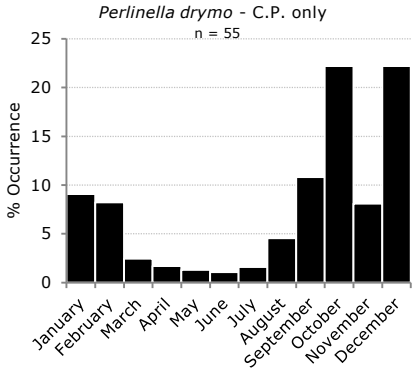
Nymphs may be difficult to separate from *P. ephyre* based on body coloration. The presence of pale areas on the head of *P. zwicki* is a diagnostic feature, however, there is little information, diagrams, or comparative material to test this character between the two species. Some DWR *Perlinella ephyre* records may actually be of *P. zwicki*.

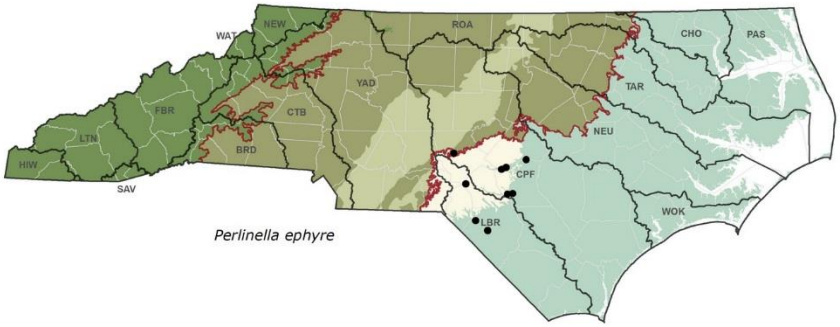
Perlinella zwicki is a Coastal Plain blackwater species. *Perlinella funipennis* was subsumed as a synonym of *P. zwicki* by Kondratieff et al. (1988).

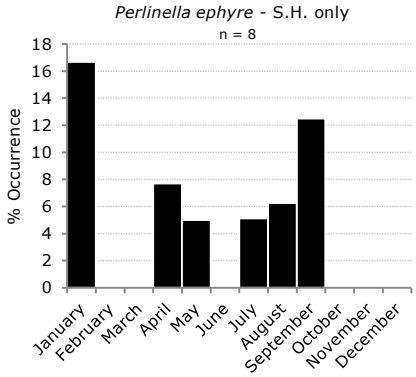
Notes: The habitus of *Perlinella* nymphs are similar to those of *Hansonoperla* but the presence of a ventral femoral-tibial setal fringe, though often difficult to see, will identify *Perlinella* nymphs. Also, small specimens could be confused as Chloroperlidae if care is not taken to verify the presence of ventral thoracic gills.

While the voltinism of *Perlinella* nymphs is unknown, nymphs typically emerge late winter to early spring for *P. drymo* and during the spring for *P. ephyre* and *P. zwicki* (Kondratieff et al., 1988).









Taxonomic references:

nymphs and adults:

Kondratieff, B. C, River F. Kirchner and K. W. Stewart. 1988. A review of *Perlinella* Banks (Plecoptera: Perlidae). Annals of the Entomological Society of America 89(1): 24-30.

adults:

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p

Family PERLODIDAE

Stoneflies of the Perlodidae family are also called "springflies" and "stripetails" referring to members of the subfamilies Perlodinae and Isoperlinae, respectively. The common name for Perlodinae references the typical flight season of the adults while that of the Isoperlinae refers to the typical color patterning of the nymphs. Adult perlodid stoneflies are of small to moderately large size with bodies ranging anywhere from 7 mm for some species of the Isoperlinae to over 20 mm for some Perlodinae. Adults are variously colored from light yellow or tan to dark brown or almost black, and many species have a conspicuously patterned head and pale striped pronotum. The dark wings of most species lie flat along the abdomen (males of some species can have reduced wings and are flightless) and all have medium to long multisegmented cerci. Adults fly during the spring and summer.

Nymphs of Perlodinae, like the adults, are variable in appearance. Sizes range from 6 mm to 20 mm and species are variously patterned with yellows and browns. Members of the Isoperlinae are typically highly contrasting and have obvious head patterns and dark stripes along the abdomen, while Perlodinae genera may have conspicuous, dramatic patterns or not. Nymphs lack the tufted lateral thoracic gills (although some western Nearctic genera have single finger-like thoracic or abdominal gills) but otherwise are similar in overall appearance to the Perlidae. Perlodidae are active predators but may be omnivorous in early instars or just prior to emergence. Nymphs cling to rocks and leaf packs in riffles or other areas with well-oxygenated water. Most Perlodidae that have had life history investigations have been reported as univoltine with the nymphs typically absent during the summer or early fall.

Perlodidae is the largest North American stonefly family and contains 30 genera. The known North Carolina perlodid fauna consists of 11 genera and at least 52 species. The family is widespread throughout the state with many genera restricted to certain ecoregions. Nymphs can be collected in all types of waterbodies but appear to be particularly speciose in small, pristine high elevation springs and streams.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by the combination of the following characters:

1) Body slender to robust, and usually conspicuously patterned
2) Legs, when extended, reaching to or exceeding abdominal apex
3) Head prognathous (oriented forward)
4) Type II mouthparts:
    a. glossa poorly developed or absent, paraglossa large and much longer than glossa, often appearing apically attached to the glossa
    b. labial palpi reach well beyond labium (glossa and paraglossa)
5) Metanotal wing pads with mid-line highly divergent with the long axis of the body
6) Eastern Nearctic genera lacking thoracic and abdomen gills, small submental gills may or may not be present
7) Second tarsal segment of legs shorter than first segment
8) Abdomen parallel to subparallel
9) Cerci as long or longer than abdomen, gradually tapered

SUBFAMILIES AND GENERA IN NC:

Isoperlinae: *Clioperla, Isoperla*

Perlodinae: *Cultus, Diploperla, Helopicus, Hydroperla, Isogenoides, Malirekus, Oconoperla, Remenus, Yugus*

Notes: Perlodidae in North Carolina are dominated by the genus *Isoperla* with 26 described species and a widespread distribution. Only three other genera, *Clioperla, Diploperla*, and *Helopicus* are commonly encountered outside of the Appalachian Mountains or Foothills. *Cultus*, *Isogenoides*, *Malirekus*, *Oconoperla*, and *Yugus* are restricted to the Mountains while *Remenus* can be sometimes found in the western Piedmont. *Hydroperla* is a Coastal Plain large river genus and is rarely, if ever, encountered during routine bioassessments.

Perlodidae genera not treated in this manual include the northern holoarctic *Arcynopteryx* and *Diura* as well as the western Nearctic genera *Baumannella, Calliperla, Cascadoperla, Chernokrilus, Cosumnoperla, Frisonia, Kogotus, Megarcys, Oroperla, Osobenus, Perlinodes, Pictetiella, Rickera, Salmoperla, Setvena, Skwala,* and *Susulus.* Refer to Stewart and Stark (2002, 2008) for details on separating these genera.

Nymphs are usually encountered in streams or rivers with good to excellent water quality. Some species, however, can withstand moderate siltation and might also be collected from agricultural or urbanized streams.

Clioperla

Genus Diagnosis: Robust nymph, 12-18 mm. Lacinia bidentate and mostly quadrate; *large, light medial area on dorsum of head (including most of ocellar triangle),* a faint M-pattern sometimes present in ultimate instars; dark area along anterior margin sometimes with linearized anterolateral spots; *dark bar along epicranial sutures almost connecting lateral ocelli to eyes; submental gills absent; pronotum surrounded by a dark border and with lateral edges pale*; dorsum of abdomen with longitudinal stripes sometimes vague and diffuse; *each tergite with up to 4-6 pale circular dots transversely across the segment, the 2 median dots often most prominent*; cerci darker than abdomen, with dorsal fringe of short, silky setae on apical segments only.

Habitat and Trophic Level: Nymphs can be found in detritus in riffles and in leaf packs. Omnivores: early instars are herbivore/detritivores, later instars are predators of leaf pack invertebrates. Clingers.

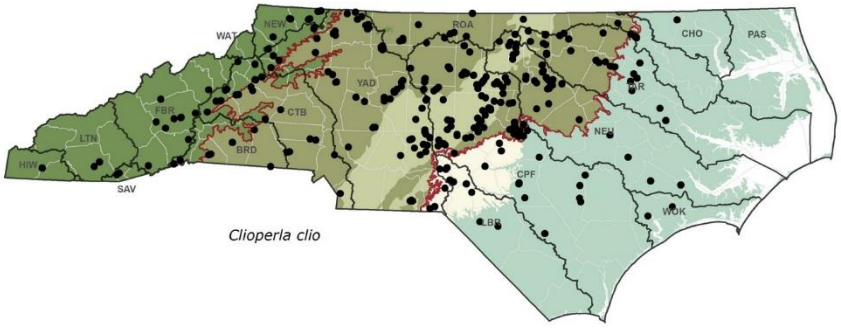
Distribution and Occurrence: Common and widespread in both small streams to small rivers. Nymphs occur October through April.

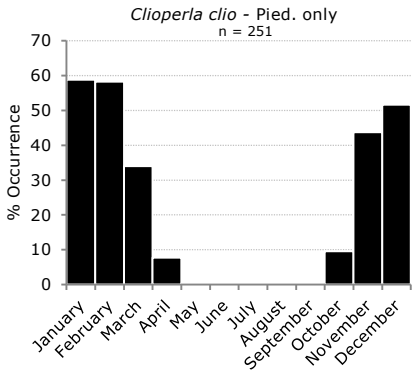
Species in NC: MONOTYPIC

clio – see Genus Diagnosis.

Notes: The color pattern may be obscured on small, immature nymphs. The lateral abdominal spiracles of the adult are sometimes visible through the nymphal integument as brown dots on segments 2-8.

Clioperla nymphs are facultative in regards to pollution tolerance. A member of the subgenus Isoperlinae, this species was historically known as *Isoperla clio*. *Clioperla* has a univoltine life cycle (Minshall and Minshall, 1966; Harper, 1973).





Taxonomic references:

nymphs:

Szczytko, S. W. and Stewart, K. W. 1981. Reevaluation of the Genus *Clioperla*. Annals of the Entomological Society of America 74(6): 563-569.

adults:

Szczytko, S. W. and B. C. Kondratieff. 2015. A review of the Eastern Nearctic Isoperlinae (Plecoptera: Perlodidae) with the description of twenty-two new species. Monographs of Illiesia, No. 1: 1-289.

Cultus

Genus Diagnosis: Lacinia bidentate, gradually tapering, and with two marginal hairs below the subapical tooth and a small patch of submarginal hairs near base; *submental gills absent*; pronotal fringe restricted to 2-3 long, thin setae at corners*; mesosternal Y-arms well developed*; *femora with a dense dorsal fringe of long silky setae*; femora without dark longitudinal bar on outside face; abdominal tergites dark anteriorly and light posteriorly; *strong setal fringe on dorsum of cerci*.

Habitat and Trophic Level: Nymphs are found beneath stones in riffles and in leaf packs. Predators – engulfers. Clingers.

Distribution and Occurrence: Common in the Mountains with a few scattered Piedmont records. Nymphs are collected primarily winter through spring. See species accounts.

Species in NC: TAKE TO SPECIES

decisus – nymphs 12-14 mm. Subapical tooth of lacinia less than 0.5 times the length of the apical tooth (mean 0.43x); young specimens may have a small pale ocellar spot; pale pronotal area somewhat diamond-shaped and located more medially.

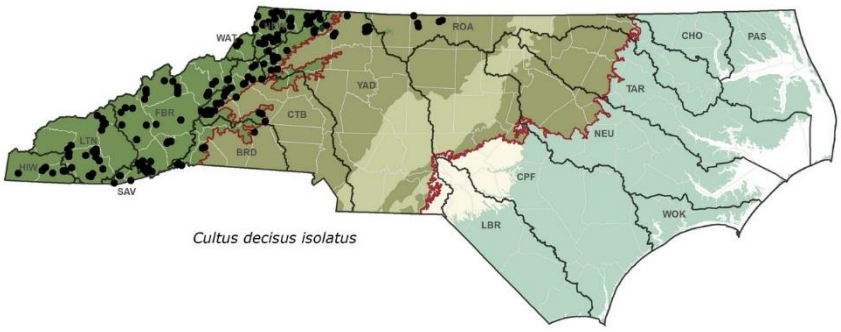
This is a species complex, with *C. decisus isolatus* in NC, GA, and VA, and *C. decisus decisus* farther north. Nymphs occur primarily in moderate streams to moderate rivers in the Mountains.

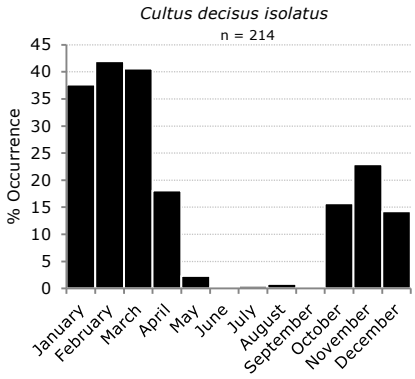
(verticalis) – nymphs 12-15 mm. Subapical tooth of lacinia approximately 0.6 times the length of the apical tooth; pale pronotal area located near the posterior margin, not diamond-shaped but diffuse.

This species may be restricted to small or moderately sized streams in the Mountains. Recorded from GSMNP.

Notes: In smaller specimens, the meso- and sometimes metanotum may be reddish. *Cultus* can be confused with *Helopicus subvarians* or *Diploperla morgani.* The presence of a dorsal setal fringe on the cerci will separate *Cultus* from *Diploperla* while the absence of submental gills on *Cultus* should separate it from *Helopicus.*

Cultus decisus has been reported as univoltine (Minshall and Minshall, 1966).





Taxonomic references:

nymphs:

Myers, L. W. and B. C. Kondratieff. 2009. Descriptions of the nymphs of eastern North American species of *Cultus* (Plecoptera: Perlodidae). Entomologica Americana 115(2):109-114.

adults:

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Stark, B. P., S. W. Szczytko and B. C. Kondratieff. 1988. The *Cultus decisus* complex of Eastern North America (Plecoptera: Perlodidae). Proceedings of the Entomological Society of Washington, 90(1): 91-96.

Diploperla

Genus Diagnosis: Lacinia subtriangular, bidentate with no marginal hairs and a very small patch of submarginal hairs, slender; submental gills present or not; pronotal setae restricted to 2-3 at corner; *fork and stem of mesosternal arms incomplete; long setal fringe on cerci reduced or absent, but with prominent circlet of long apical hairs on each segment.*

Habitat and Trophic Level: Nymphs occur in leaf packs. Predators – engulfers. Clingers.

Distribution and Occurrence: Found in the Mountains and Piedmont in small streams to small rivers during fall through early spring. See species accounts.

Species in NC: TAKE TO SPECIES

duplicata – nymphs 11-14 mm. Submental gills absent; femora without dorsal silky setal fringe, but with robust setae scattered over dorsal surface; head brown with lighter brown M-pattern, pattern expanded medially to labrum obliterating anterior margin of M-pattern; a pair of obliquely oriented, small, pale spots lateral to median ocellus; body light brown to brown in color with no distinct dark markings.

A relatively common species collected in the Mountains and Piedmont from October through May.

(kanawholensis) – nymphs 14-18 mm. Base of lacinia with 1-4 hairs; submental gills present; dark band enclosing ocellar triangle, not reaching anterior edge of lateral ocelli; femora with dorsal setal fringe; dark longitudinal streak on the femora; pronotum thickly edged with brown; meso- and metanota with anterior dark band and a pair of strap-like oblique brown bands at base of wingpads; abdomen with distinctive transverse yellow and dark brown banding; abdominal terga with dark brown transverse band along anterior margin and with a pair of submedial dots along the posterior edge of the dark band (new character - Stark, 2016 in press).

This nymph is very similar to *D. morgani* and may not be reliably separated (Kirchneri and Kondratieff, 1984). Many current BAB records may refer to this species as it has been collected from the Yadkin River in Caldwell Co. (B. Kondratieff). It may be restricted to more northern NC counties.

Many BAB specimens appear to be intermediate to *D. kanawholensis* and *D. morgani* with regards to head pattern. These specimens have brown pigment reaching posteriorly beyond the lateral ocelli and have dark areas along the anterolateral frontoclypeus anterior to the pale M-pattern lateral arms (Figure 1). Also, a pair of pale oval areas interrupt the posterior margin of the "mask". Some of these specimens have a pair of inconspicuous, dark submedial spots on the posterior edge of the dark abdominal bands which may be incorporated into the band thus appearing as small submedial extensions. However, some specimens lack this character altogether. *Diploperla* with this description have no conspicuous dorsal setal fringe on the cerci but instead have1-3 intercalary hairs on some middle to apical segments. These specimens should be denoted as "*Diploperla kanawholensis/morgani*".

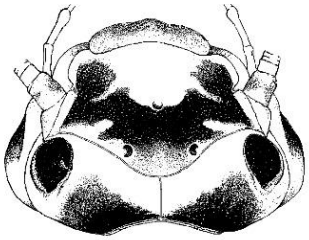


Figure 1. Dorsal view of an undescribed nymphal head pattern of *Diploperla*. This head pattern is also associated with a sparse, cercal setal fringe. Original illustration, S. Beaty.

morgani – nymphs 14-17 mm. Submental gills present; femora with dorsal setal fringe; a dark transverse band across medial portion of head encompassing lateral ocelli, posterior edge reaches to epicranial suture; dark longitudinal streak on the femora; pronotum thickly edged with brown; meso- and metanota with anterior dark band and a pair of strap-like oblique brown bands at base of wingpads; abdominal terga with dark brown transverse band along anterior margin; no dorsal setal fringe on cerci.

Many BAB specimens appear to be intermediate to D. *kanawholensis* and *D. morgani* (see description of *D. kanawholensis* above). These specimens should be denoted as "*Diploperla kanawholensis/morgani*".

Diploperla morgani are mostly found December through April in the Mountains and Foothills and are relatively rare. Also, many DWR specimens identified as *D. morgani* have the head pattern shown in Figure 1. Finally, many historical BAB records of *D. morgani* are erroneous identifications of *Cultus decisus.* Listed as "vulnerable to extirpation" by Morse et al. (1997).

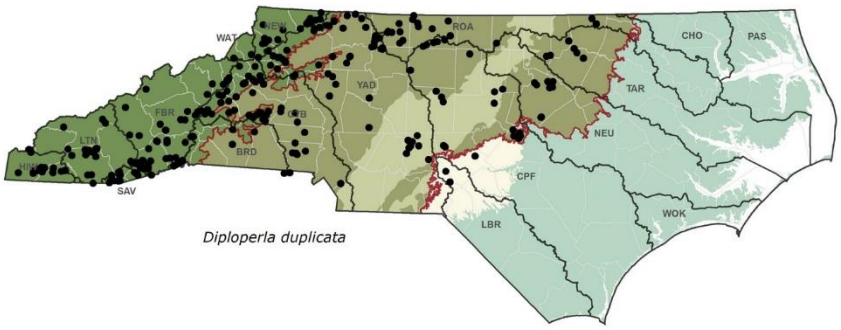
robusta* – nymphs 12-19 mm. Submental gills present; femora with reduced dorsal setal fringe; bands on tergites widely interrupted medially; femoral bands absent.

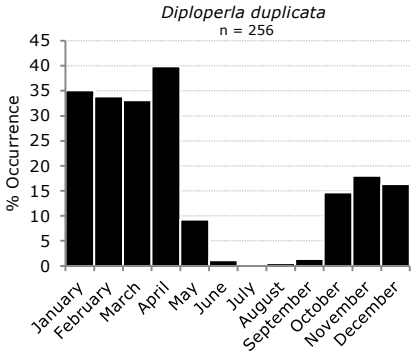
Range may be similar to the other species. Recorded from KY, TN, VA, WV, and GSMNP.

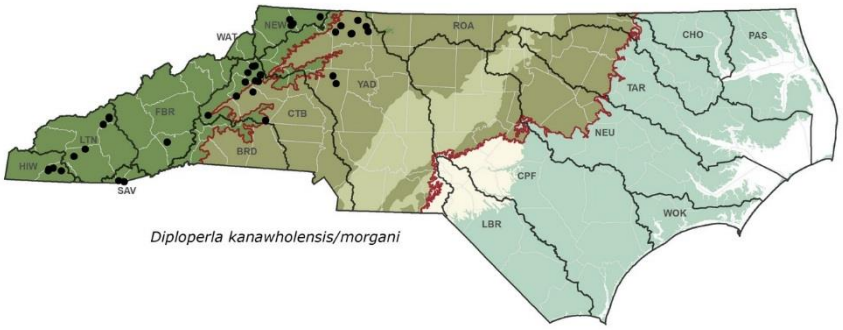
Notes: Careful attention should be given to generic characters and nymphal sizes of perlodid specimens. *Diploperla* nymphs, particularly those with contrasting color patterns, can easily be confused with *Cultus* or *Helopicus*. However, it should be noted that the 3 species, *Cultus decisus*, *Diploperla morgani*, and *Helopicus subvarians* do co-occur and have been recorded from the same stream samples.

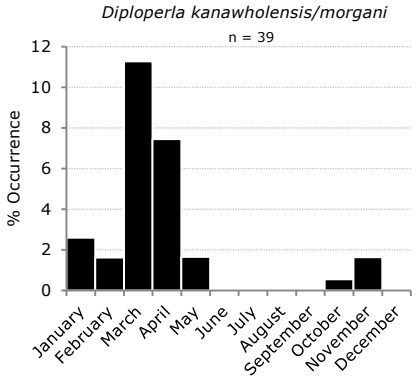
Specimens intermediate to *D. kanawholensis* and *D. morgani*, may be an unknown species as a series of *Diploperla* specimens collected from VA are also an unknown species (B. Kondratieff, personal communication). Reared nymphs and DNA analysis should clear up this conundrum.

The life cycle of *Diploperla robusta* was recorded as univoltine (Ashley et al., 1976) and casual BAB observations suggests that at least *D. duplicata* is as well.









Taxonomic references:

nymphs:

Kirchner, R. F. and B. C. Kondratieff. 1984. A new *Diploperla* from West Virginia (Plecoptera: Perlodidae). Proceedings of the Entomological Society of Washington 86(3): 648-652. (description of *D. kanawholensis*)

Kondratieff, B. C., R. F. Kirchner and J. R. Voshell Jr. 1981. Nymphs of *Diploperla*. Annals of the Entomological Society of America 74: 428-430.

adults:

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Helopicus

Genus Diagnosis: Lacinia triangular, bidentate, sometimes with a small tuft of setae originating on a small knob and with a row of marginal hairs approaching base; lacinia without distinct ventral patch of setae; *right mandible with five teeth, large outer tooth with fine serrations in basal half*; *labrum with prominent, setose, medial flap-like projection, often deflected ventrally from lateral aspect*; *prominent submental gills, about three times longer than wide*; *frons with a complete, dark transverse band through ocellar triangle*; occipital spinules not reaching the epicranial stem, row slightly curved; tibiae and femora with dense dorsal setal fringe; at least basal abdominal segments conspicuously narrower anteriorly and posteriorly with bulging membranous portion of each tergum; terga with numerous intercalary spines; cerci with a dense dorsal fringe of setae.

Habitat and Trophic Level: Nymphs are associated with leaf packs and submerged logs in high velocity water. Predaceous.

Distribution and Occurrence: Widespread but common only in the Mountains from fall through winter. See species accounts.

Species in NC: TAKE TO SPECIES

bogaloosa – nymphs 17-20 mm. Head with dark transverse band with anterior margin irregular, with two lobes projecting into anterior light frontoclypeal area; occiput yellow-brown; occipital spinules widely spaced, typically grouped into a single irregular row; pronotum widely margined with dark brown, mature specimens with brown mottling on central disc; wing pads with dark stripes on mature specimens; tibiae, tarsi, and dorsal surface of femora dark brown; abdomen yellow-brown with darker anterior transverse bands and with a submesal pair of dark dots, abdominal segment one often pale mesally; cerci dark brown.

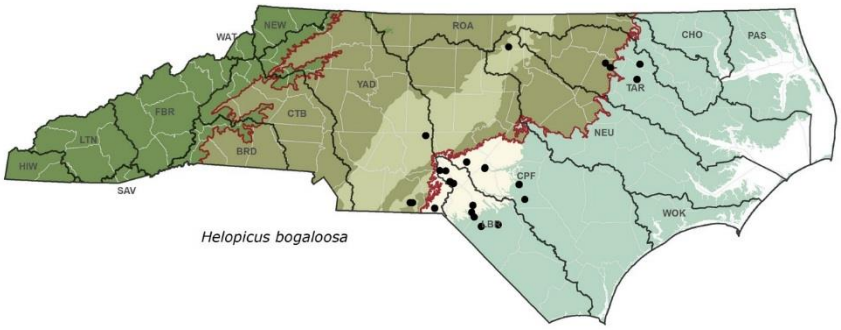
Nymphs of *Helopicus bogaloosa* are uncommon to rare. They have been collected October through March primarily in the Sand Hills and the Coastal Plain near the Fall Line.

subvarians – nymphs 17-20 mm. Head with anterior margin of dark, transverse ocellar band a straight line or mostly so; band often with a pair of linearized pale spots lateral to ocellar triangle; occiput mostly brown and separated from darker transverse medial band a pale narrow line; occipital spinules closely spaced, grouped into broad patch of 2-3 irregular rows in places; femora darker dorsally and on distal half of the out face; abdomen brown with darker anterior transverse bands and with 3 pairs of irregularly shaped dark dots, 2 lateral pairs and one mesal; cerci brown.

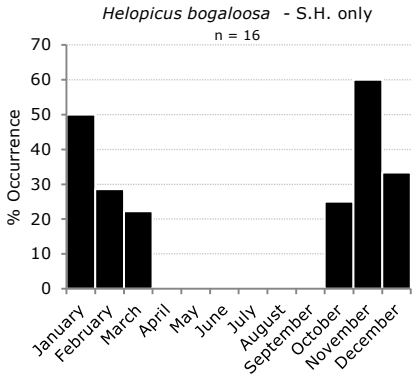
Nymphs in NC occur September through April in the Mountains and Slate Belt (Uwharrie Mountains) and are relatively uncommon.

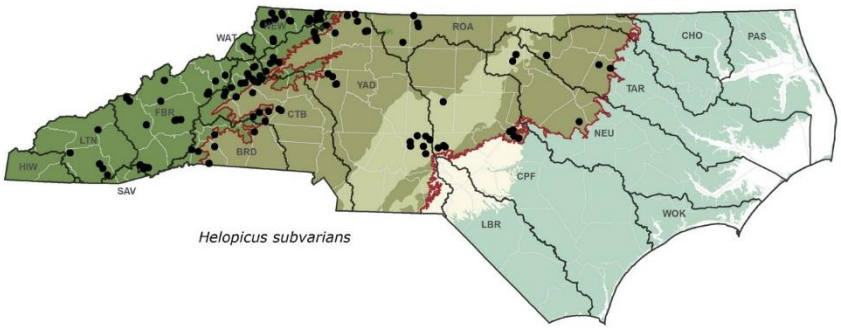
Notes: *Helopicus* nymphs tend towards having a noticeable medial frontal bulge on the clypeus. Although this character is not diagnostic for the genus, it may be useful for separating *Helopicus* from *Cultus* and *Diploperla*. It should be noted, however, that *Hydroperla phormidia* also possesses a labrum with a central bulge. In addition, the serrations present on the large tooth of the right mandible are difficult to see and can be worn down. Also, most North Carolina *Helopicus subvarians* specimens have small, pale *linear* spots lateral to the ocellar spot while *Hydroperla* have pale *oval* spots lateral to the ocellar triangle.

Both North Carolina species of *Helopicus* are suggested to be univoltine (Stark and Ray, 1982).

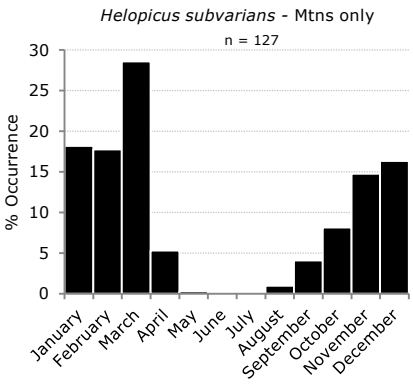


Helopicus bogaloosa





Helopicus subvarians



Taxonomic references:

nymphs:

Stark, B. P. and D. H. Ray. 1983. A revision of the genus *Helopicus* (Plecoptera: Perlodidae). Freshwater Invertebrate Biology 2(1): 16-27.

adults:

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

(Hydroperla)

Genus Diagnosis: Nymphs 14-20 mm; lacinia triangular, bidentate, sometimes with a small tuft of setae originating on a rudimentary knob, and with a row of marginal hairs approaching base; *right mandible with 4 teeth, distal tooth without serrations*; *submental gills 2-2.5 times longer than wide*; *transverse dark pigment band of frons interrupted with pale, oval spots lateral to the ocellar triangle (spots can be obscure), posteromedial edge of band not reaching epicranial suture*; occipital spinule row closely spaced, irregular and 2-3 spinules deep, row curved towards and reaching origin of epicranial stem; with a dorsal fringe of setae.

Habitat and Trophic Level: Nymphs are found in leaf packs associated with blue-green algae (Ray and Stark, 1991). Predaceous.

Distribution and Occurrence: Nymphs occur in larger brown-water rivers in the Coastal Plain during the late fall through early spring. Rarely collected.

Species in NC: TAKE TO SPECIES

(phormidia) – nymphs 13-27 mm. Labrum with central anteromedial projection; dark pigment band of anterior frontoclypeus absent, instead represented by 4 dark pigment patches; a pale M-pattern sometimes evident on head; meso- and metanota with a pair of submedial dark pigment spots removed toward the lateral edge (near center of each wing disk); abdomen yellow-brown with a transverse series of 6-8 dark pigment spots on anterior half of each abdominal segment; origins of intercalary spines of abdomen pigmented giving body a speckled appearance.

Hydroperla phormidia is listed by NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014).

Notes: *Hydroperla phormidia* is likely the only species in North Carolina, although the BAB has no nymphal records. Unzicker and McCaskill (1982) records of *H. fugitans* are apparently in error (Kondratieff and Painter, 1986). Carolina Power and Light biologists collected nymphs from the Pee Dee River near the NC/SC border (origin of BAB reference specimen) and Kondratieff and Kirchner (2004) found adults along Lumber River at Columbus/Robeson county line.

Hydroperla phormidia is suggested to be univoltine (Ray and Stark, 1981).

Taxonomic references:

nymphs:

Ray, D. H. and B. P. Stark. 1981. The Nearctic species of *Hydroperla* (Plecoptera: Perlodidae). Florida Entomologist 64: 385-395.

adults:

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Isogenoides

Genus Diagnosis: Lacinia triangular, bidentate with a distinct knob below the subapical tooth and with a row of marginal hairs approaching base; *mesosternum with median longitudinal suture joining fork of mesosternal grooves to transverse anterior suture*; *prominent submental gills, projecting about three times their basal width*; cerci with a dorsal setal fringe; body light brown with contrasting darker brown pattern, covered with clothing hairs.

Habitat and Trophic Level: Nymphs occur in cobble riffles and from gravel or cobble areas near banks. Early instars are hyporheic. Predaceous.

Distribution and Occurrence: Primarily collected in small streams to small rivers in the Mountains from late September through April. Relatively uncommon.

Species in NC: TAKE TO SPECIES

hansoni – nymphs 16-24 mm. Head with conspicuous, sharply delineated pale M-pattern anterior to median ocellus; ocellar triangle bordered by dark brown but with pale, ovalized central spot; occiput brown anteriorly with light brown reticulated areas enclosed by spinule row, pale along epicranial stem to occipital margin; pronotum widely margined with brown; dark transverse bands on anterior third to half of terga 1-9 and a dark, thin transverse band along each posterior margin.

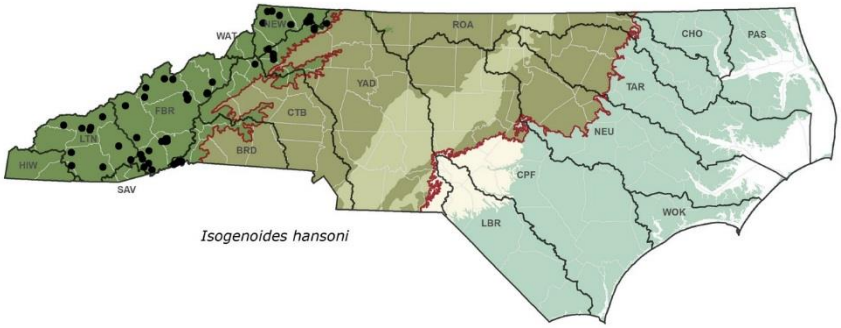
A relatively uncommon stonefly, nymphs of *Isogenoides hansoni* are typically found in cleaner mountain streams. Recorded from GSMNP.

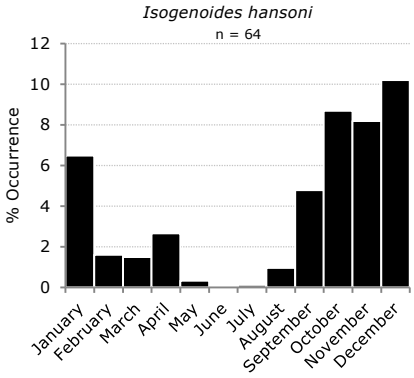
varians – nymphs 15-21 mm. Head with intraocellar area brown, without pale spot; with head with an indistinct M-head pattern, demarked by dark clothing setae; occiput brown anteriorly with lighter reticulated areas enclosed by spinule row, pale along epicranial stem to occipital margin; anterior and posterior pronotum flange and furrow brown, posterior furrow interrupted medially; general body color yellow, narrow light brown transverse bands on anterior margin of abdominal terga only.

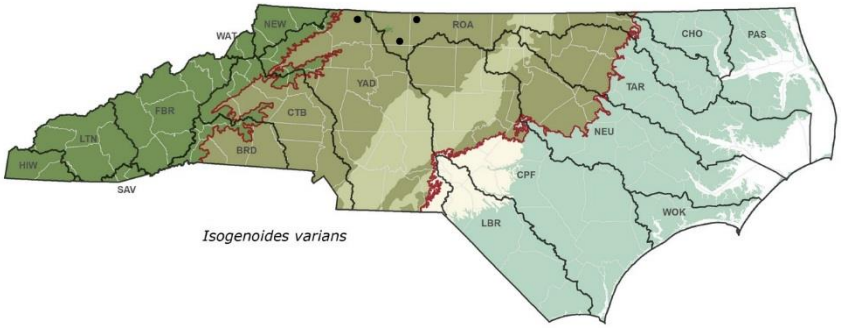
The few DWR BAB records of this species were originally identified as *I. hansoni* and were from northwestern Piedmont streams. Nymphs have since been collected from the Mayo River (Jan 2015) by D.R. Lenat. Also, one adult male collected by Kondratieff and Kirchner (2004) along Yadkin River at Davie/Davidson county line gives this species a Piedmont distribution. It is also probable that *Isogenoides varians* has been misidentified as *I. hansoni* in some mountain samples.

Notes: Small *Isogenoides* specimens will look similar to *Cultus* but will have long submental gills whereas Cultus nymphs lack these gills altogether. The medial mesosternal groove, diagnostic for this genus, is very difficult to see on younger instars.

Nymphs have been documented as inhabiting streams that support trout populations indicating that this genus is pollution intolerant. Unpublished observations (Sandberg and Stewart, 2005a) suggest a semivoltine life cycle for some species while some published literature reports both a univoltine cycle (Kreuger and Cook, 1981) and semivoltine cycle for others (Sandberg and Stewart, 2005b).







Taxonomic references:

nymphs and adults:

Sandberg J. B. and K. W. Stewart. 2005a. Holomorphology and systematics of the stonefly genus *Isogenoides* (Plecoptera: Perlodidae). Transactions of the American Entomological Society 131(3-4): 269-345.

Isoperla

Genus Diagnosis: *Isoperla* nymphs have a combination of most or all of the following characters (there are many exceptions to one or more of the following characters): lacinia bidentate; lacinial margin with row or tuft of at least 3-5 long setae below subapical tooth, some species with setae approaching base of lacinia; *submental gills absent*; occiput with irregular spinule row; pronotum completely edged with short, stout setae (may be interspersed with longer setae); mesosternal Y-arms straight; *dorsum of abdomen usually with longitudinal pigment bands (some distinct species with transverse bands, abdominal spots, or apparent uniform coloration)*; typically only dorsal margins of distal half of cerci fringed with setae or not at all; body covered with dark clothing hairs.

Habitat and Trophic Level: Nymphs occur under cobbles in riffles and in leaf packs. Omnivorous to predaceous and may change diet, particularly before emergence.

Distribution and Occurrence: *Isoperla* nymphs are typically collected during winter through spring. See species accounts.

Species in NC: TAKE TO SPECIES/GROUP

Described or distinctive nymphs – Nymphs of the following species can be separated relatively easily and are not cryptic with other *Isoperla* species known to occur in North Carolina. Identifications of the nymphs of two species are currently provisional; *Isoperla* cf. *fauschi* and *Isoperla* cf. *powhatan*. Also, two species in this list were not treated by the most recent *Isoperla* revision (Szczytko and Kondratieff, 2015) and are currently being described as new species by BAB biologists. Three others species, while unassociated, are very distinctive as nymphs, are easily identified, and retain their historical NC DWR placeholder names.

burksi – (photographic guide: pages 10-11) – pre-emergent nymphs 9.0-11.0. Lacinia with apical tooth subequal to or longer than palm length and with 2-3 thin marginal setae below the subapical tooth; large pale area anterior to median ocellus, ocellar spot large and usually closed behind but sometimes apparently open, though only narrowly; transverse bands along posterior margins of abdominal terga; cerci with dense dorsal fringe of silky setae on at least distal 3/4; clothing hairs dark.

This species is the eponymous member of the *burksi* Group. Nymphs of this species occur only in the Carolina Slate Belt streams during late winter and early spring and can tolerate silty conditions. Relatively rare.

davisi – (photographic guide: page 12) – pre-emergent nymphs 7.0-8.0. Lacinia recedes from base with 6-8 stout marginal spines below subapical tooth; both pale area anterior to median ocellus and pale ocellar spot enclosed; transverse brown bar on anterior frontoclypeus wider than brown area that encloses the anterior pale median area; dorsum of abdomen with distinctive longitudinal "5-lined" banding; median and sublateral bands darker and usually narrower than submedial bands and with intervening pale narrow lines (variably developed); cerci with dorsal fringe of setae on distal half; clothing hairs clear.

This species is a member of the *decolorata* Group. The nymph and adult of *I. davisi* are pictured in Pescador et al. (2000) and in Poulton and Stewart (1991) as *I. coushatta*. *Isoperla davisi* adults are widespread across the entire state of North Carolina but are more common in the Piedmont and Coastal Plain. Nymphs from NC with this pattern have been extensively reared and positively associated with *Isoperla davisi*. Previously identified as part of the "*Isoperla transmarina* group".

dicala – (photographic guide: pages 13-14) – pre-emergent nymphs 7.0-8.0. Typical lacinia with 4-5 (usually 4) stout marginal spines; head with small pale ocellar spot and pale crown-shaped area anterior to median ocellus; head sometimes with dark speckling and dark edges to pale areas (M-shaped); small pale ocellar spot enclosed; dorsum of abdomen with 3 dark longitudinal stripes, median and lateral bands narrower than intervening spaces and edged with pale lines (these lines can be inconspicuous); with 8 dark dots transversely, 3 pairs sublateral to lateral and 1 pair submedially (dots sometimes obscured by speckling); abdomen with many spicules with dark origins giving abdomen a freckled appearance, both dorsally and ventrally; cerci with dorsal fringe of silky setae on distal half.

Isoperla dicala is a member species of the *bilineata* Group. Though uncommon, nymphs are collected from cold, higher elevation streams of good to excellent water quality. They are collected through late winter to spring.

cf. *fauschi* – (photographic guide: pages 15-16) – nymphs are currently undescribed. *Preliminary nymph description:* pre-emergent nymphs 9.0-10.5 mm. Lacinia with low hump below subapical tooth and bearing 6-7 closely set, stout marginal spines; labrum with a pair of diffuse brown spots laterally; head with small pale ocellar spot open behind and a large, sub-oval, pale median area anterior to median ocellus open medially to the anterior frontoclypeal pale area (although sometimes narrowly); brown markings on occiput posterior the epicranial suture short and not extending to postoccipital margin; oblique dark stripes originating behind eyes and extending to post-occipital margin; meso- and metanota with distinctive comma-shaped arcs anteriorly and posteriorly; 3 longitudinal dark bands, each tergal segment portion tending towards an hour-glass shape; cerci with dorsal fringe of silky setae on distal half; clothing hairs dark.

Isoperla fauschi is a member species of the *bilineata* Group. To date, nymphs of *Isoperla* cf. *fauschi* has only been collected from Moore County in late winter to early spring, although adults have been reported extensively throughout the Sand Hills. Nymphs were reared and tentatively associated with two females. Males are needed for positive identification of nymphs.

frisoni – (photographic guide: pages 17-18) – pre-emergent nymphs 8.0-9.5 mm. Lacinia with low knob below subapical tooth which bears 3-4 stout marginal setae; dark transverse band on head with anterior margin M-shaped and with extensions to lateral ocelli; small oval to round pale mediolateral spots which interrupt the posterior edge of medial band; interrupting spots may be almost completely enclosed; pro-, meso-, and metanotum with anterior and posterior pairs of dark submedial spots, those on the pronotum usually larger and more irregular; abdomen with 3 dark, thin, regular longitudinal lines; cerci dark basally and with both a dorsal and ventral setal fringe on distal half; clothing hairs dark on head and thorax, dark hairs slowly transitioning to clear on distal half of abdomen.

Isoperla frisoni is a member of the *bilineata* Group. A recent record from the Mayo River (2015) is the first DWR nymphal record of *Isoperla frisoni* since 1990. Nymphs were also collected from Wilson Creek, Caldwell County in 2012 for rearing, although rearing failed. This species has been collected with *Isoperla* "Mayo R" n. sp. on multiple occasions by D. R. Lenat.

holochlora – (photographic guide: pages 19-22) – *Isoperla holochlora* may eventually turn out to be a group of species which are cryptic as adults or may perhaps be a split cohort of the same species. North Carolina nymphs of the "dark-form", as described below, have been extensively reared. Both males and females reared from the dark nymphs appear nearly morphologically identical, both in pattern and genital structure, to adults of *Isoperla holochlora* reared from the habitus illustrated by Frison (1942). The habitus illustration by Frison, herein referred to as the "light-form", is currently widely accepted to be the typical pattern of *I. holochlora* nymphs.

Notes on different "forms" and seasonality - Even though differences in the nymphal patterns and sizes currently allow for separation of the two distinct color "forms", there are also distributional and seasonal considerations. While these two distinct color forms are sympatric over much of their range, the dark-form is exclusive to the Appalachians, at least within North Carolina, and the light-form occurs in both the Mountains and the Piedmont. Additionally, dark-form *holochlora* nymphs emerge from early April to late May, 1-2 months earlier than light-form nymphs which typically begin emerging mid-June and continue until late July to mid-August. This light-form emergence period in NC is counter to that reported by the literature (see Szczytko and Kondratieff, 2015). It is our experience in North Carolina that light form *holochlora* nymphs typically mature throughout the summer and, while emergence may begin in mid-June, ultimate instar to pre-emergent nymphs can be collected into mid-August, at least in higher elevation streams. It is certainly possible that the early "rare events" reported by Szczytko and Kondratieff are emerging dark-form *holochlora* nymphs. When the two nymphal forms co-occur in a mountain stream in the spring, dark-form *I. holochlora* will be large and often pre-emergent whereas light-forms will be small. If a sampling event occurs in that same stream during the summer, only late instar light-form nymphs will be collected. Interestingly, in Frison's material notes (1942), the only reared adults, presumably from which his nymphal associations were made, were from late spring to early summer nymphal collections, past the normal emergence period of dark-form *holochlora*. Almost all early-season (i.e. April) NC specimens collected by Frison were collected as adults and therefore had most likely emerged from the dark-form *holochlora.* Frison did collect some early season nymphs but he makes no indication of their size or possible darker coloration.

Whether these forms are two different species or a cohort split of a single species remains to be determined. It is feasible that some eggs undergo diapause while other eggs develop immediately. Pending DNA analysis of each form will, hopefully, elucidate the relationship between these two variants as will additional reared material of the light-form *holochlora*. In the interim, the following descriptions will allow for separation and help retain valuable information on distributions and seasonality of each form.

Adult *Isoperla holochlora* are placed in the *signata* Group.

light-form – (photographic guide: pages 19-20) – pre-emergent nymphs 6.5-9.0 mm. A lighter orange-brown habitus with pale and dark brown markings; lacinia receding mostly evenly and with 6-7 stout marginal spines; pale area anterior to median ocellus always widely open to labrum, faint lateral M-arms sometimes present; an oval mediolateral spot on each side of the ocellar triangle; ocellar spot usually enclosed and sub-triangular to diamond-shaped; pale ocellar spot may be centrally darkened and in some specimens a faint pale area along the epicranial stem may be confluent with the ocellar spot; occiput brown, lateral areas with mottled pale reticulations; abdomen with 2 dark, lateral, longitudinal stripes and often with an obscure narrow medial stripe; each tergal portion of a stripe sub-parallel to wider posteriorly, edges of lateral stripes often edged with a pale line; cerci with dorsal fringe of silky setae on distal half, each cercal segment with 5 or more setae; clothing hairs dark.

Nymphs of this form occur in the piedmont and Mountains and is the only true summer *Isoperla* in North Carolina. All other species, including *I. holochlora* dark-form, emerge during the spring. While *Isoperla holochlora* light-form is pollution intolerant, current records include *Isoperla* cf. *powhatan,* (most likely also intolerant), which has a very similar habitus.

dark-form – (photographic guide: pages 21-22) – pre-emergent nymphs 9.5-12.0 mm. A brown to dark brown habitus with pale and obscure darker brown markings; lacinia receding evenly from subapical tooth and with 8-9 stout marginal spines; median pale area crown or trident-shaped, variously developed but usually enclosed by a thin brown line, if open to pale anterior frontoclypeal area then just barely, and sometimes darkened centrally; lateral points of crown may be reduced or truncated; a small enclosed light spot in ocellar triangle; occiput dark; body often uniformly brown, sometimes very dark; faint longitudinal lines on the abdomen sometimes present; cerci with a dorsal fringe of silky setae on distal half, each cercal segment with 5 or more setae; clothing hairs dark.

Nymphs occur in the Mountains from October to early June and are relatively common. Formerly called *Isoperla* sp. A*, Isoperla holochlora* dark-form is pollution intolerant. See the *holochlora* discussion above.

orata – (photographic guide: pages 27-28) – pre-emergent nymphs 7.5-8.5 mm. Lacinia with apical tooth subequal to palm length and with 3-4 (usually 3) thin marginal setae on small inconspicuous knob below the subapical tooth; head with a dark transverse band through the median ocellus with anterior edge M-shaped and with backward extensions to lateral ocelli; ocellar triangle with moderately sized pale spot, posterior brown area enclosing ocellar spot sometimes lighter than brown mask; pronotum mostly dark with an irregular pale area along median suture and with pale lateral edges; dorsum of abdomen with three dark longitudinal stripes, the central stripe often faint or discontinuous; small, obscure submedial brown dots present on each tergum and often incorporated into medial stripe; cerci with dorsal fringe of silky setae on distal half.

This is a member species of the *burksi* Group. These very intolerant nymphs occur in small to medium, cold water, mid-elevation streams in the early to mid-spring. *Isoperla orata* is widespread in the NC Mountains but are uncommonly collected.

poffi – (photographic guide: pages 29-30) – nymphs undescribed. *New nymph description:* pre-emergent nymphs 9.0-12.0 mm. Lacinia receding from base, with row of 4-8 stiff marginal setae; labrum with a small, dark, basomedial triangular mark; head with 4 enclosed pale spots, the medial spots large and triangular (ocellar spot) to subquadrate (median pale area) and the lateral spots smaller and somewhat ovalized; the brown areas between the 4 pale spots appearing as an "X"; dark brown dashes and sometimes a dark brown M-pattern (dark M line may be incomplete medially) superimposed on brown areas enclosing pale spots; occiput with brown areas along epicranial stem although somewhat removed; pronotum with pale stripe along median suture, lateral edges widely pale; abdomen with three longitudinal stripes, two lateral and one median, stripes confluent on anterior segments in some specimens; abdomen with a transverse row of 6-8 small dark dots on each tergum; venter of abdomen slightly speckled with paired median dots; head and abdomen may appear somewhat speckled in some specimens; cerci with dorsal fringe of silky setae on distal half.

This species is not assigned to a species group. The habitus of *Isoperla poffi* nymphs appears very similar to the *Isoperla bilineata* nymphal habitus (pictured in Stewart and Stark, 2002) and was identified as *I. bilineata* group in historical DWR samples. Once thought to occur in North Carolina, *Isoperla bilineata* distribution was revised by Szczytko and Kondratieff (2015) to occurring primarily in the Midwest and Canada. Exuviae of reared paratype *Isoperla poffi* from the Savannah River, SC were compared with extensive nymphal material from North Carolina coastal plain streams and found to be mostly identical (with some slight lacinial differences apparent among the North Carolina specimens along a longitudinal geographic gradient). Additionally, nymphs with this habitus were collected by DWR from the *I. poffi* type locality as well as other *I. poffi* sites. This association is relatively strong and therefore we believe it to be reliable.

Nymphs prefer slower waters and are restricted in North Carolina to the Coastal Plain swamp streams and rivers.

cf. *powhatan* – (photographic guide: pages 31-32) – nymphs undescribed. *Preliminary nymph description:* pre-emergent nymphs 7.5-9.0 mm. An overall very dark nymph with ground color brown to dark brown; lacinia receding evenly to subapical tooth and with 8-9 stout marginal; apical tooth of lacinia less than half as long as palm length and about 2/3 palm width; labrum brown, paler medially and anterolaterally; head with large irregular pale median area open anteromedially and confluent with pale anterior frontoclypeal area, open area usually narrower than the base of the median pale area; faint lateral arms of M-pattern may be present; pale anterolateral spots may or may not be present, if present then small and often obscure; ocellar spot present, usually an inverted U-shape, brown posterior invagination variously developed and may not appear on young nymphs (this character may not be stable); mediolateral spot usually present, may be obscure in some specimens; abdomen dark brown with 2 darker longitudinal stripes laterally and an inconspicuous medial stripe; cerci with reduced dorsal fringe of silky setae on distal half, each cercal segment with 0-4 dorsal setae (usually 2-3); clothing hairs mostly dark.

Although nymphs of this species are somewhat cryptic to *Isoperla holochlora*, their overall color and pattern is intermediate to that of the light-form and dark-form *I. holochlora*. While identification of *I. powhatan* is currently provisional and may not be possible in some cases, several aids to separate these difficult nymphs can be tried. Both *Isoperla powhatan* and dark-form *holochlora* emerge in the spring while light-form *I. holochlora* typically emerges during the summer (see discussion under *holochlora*). However, as with any organism that relies on color patterns and morphology for accurate identification, exceptions abound. Dark-form *holochlora* appear restricted to the Mountains while *I. powhatan* and light-form *holochlora* also occur in the Piedmont. Many records of light-form *holochlora* may, in fact, actually represent *I. powhatan*. The dorsal setation of the cerci, provided the cerci are mostly entire, is currently the best form of separation of these taxa. It appears that some light-form *holochlora* have the ocellar spot more U-shaped and therefore this feature should be used cautiously and only in conjunction with other characters. Reliable identification may ultimately prove impossible for *I. powhatan*. Pending DNA analysis may help clear up this quagmire. Taxonomists attempting this identification should denote specimens as "cf. *powhatan*" in the absence of reared material.

Isoperla powhatan is a member of the *bilineata* Group and has been successfully reared from Barnes Creek, Montgomery County, NC (the type locality of another recently described species, *Isoperla zuelligi*). This represents a range extension from that reported by Szczytko and Kondratieff (2015; PA, VA). Unreared nymphs collected concurrently with those that were reared were also used to generate the above description.

slossonae – (photographic guide: pages 35-36) – pre-emergent nymphs 9.0-12.0 mm. Extensive dark markings over entire body; lacinia barely receding, with 6-9 (usually 7) widely spaced stout marginal spines, and palm edge dense with long hair-like setae to its base; labrum with anteromedial edge pale; quadrate pale spot anterior to median ocellus with variably developed M-pattern lateral arms; pale subtriangular spot in ocellar triangle; occiput with small brown areas along epicranial stem; area behind eyes brown with oblique brown stripe to posterior margin of head; pronotum with extensive irregular pale areas including lateral margins; wingpads with thick, dark stripes bordered by pale areas; abdomen with two lateral and one median longitudinal stripes, often confluent on distal segments, median stripe with paired submedial dark dots; tergum 10 pale on posterior edge; abdomen highly speckled (dark spicule origins) particularly at stripes but also laterally and ventrally; posterior margin of tergite ten pale; dark bands near apices of femora and bases of the tibiae; cerci dark brown, with both dorsal and ventral fringe of silky setae on distal half; clothing hairs dark, small, sparse, interspersed with small spinous setae.

Nymphs are uncommon and occur in high quality medium streams to medium-sized rivers in the northeastern Blue Ridge, particularly in the New and Watauga River Basins. *Isoperla slossonae* exhibits a high degree of variability in habitus color pattern over its range, particularly the abdomen. Specimens from the southeastern US tend to be lighter while northern US specimens darker. Early instars could be confused with *Isoperla dicala* due to highly speckled bodies and incompletely developed pattern. However, leg patterns will separate the two species.

Isoperla slossonae is a member of the *phalerata* Group.

"Collins Cr" n. sp. – (photographic guide: pages 37-38) – *New species description:* pre-emergent nymphs 9.5-12.0 mm. A large but slender species. Lacinia receding evenly from subapical tooth and bearing 6-7 stout marginal setae and bearing a closely set submarginal row of 6-8 stout setae from apical tooth; length of apical tooth of lacinia between 1/3rd to 1/4th palm length and slightly shorter than palm width; head with 2 enclosed pale spots, an oval to diamond shaped ocellar spot and a large subtriangular median pale area; median pale area almost always with small dark extensions from the enclosing brown area toward but not reaching median ocellus (giving the pale median area a somewhat tri-lobed appearance); frons with extensive blackish spots within brown pattern including anterolateral dark spots near frontoclypeal pale area; occiput with brown areas along epicranial stem although somewhat removed; strong oblique dark stripes originating behind eyes and extending to post-occipital margin; abdomen with 3 longitudinal stripes, two lateral and one median, and with anterior transverse row of 8 small dark dots; median stripe weak, often interrupted; abdominal spicules with dark origins giving abdomen a speckled appearance; cerci with sparse dorsal fringe of silky setae on distal half; clothing hairs clear.

The adult male of "Collins Cr." n. sp. is very distinctive and has many characters that identify it as a new species. The nymph has been extensively reared from the type locality of Collins Creek, Orange County, NC. The nymph has historically been identified as *Isoperla bilineata* group. Re-examination of archived benthic samples has revealed this species to be relatively common but with a distribution limited to the Carolina Slate Belt ecoregion. Nymphs can be collected in winter to early spring with a short adult emergence period from mid-April to mid-May.

"Mayo R" n. sp. – (photographic guide: pages 39-40) – *New species description:* pre-emergent nymphs 7.5-9.0 mm. Lacinia receding evenly and bearing 5-6 stout marginal spines, some spines may be slightly widened apically; apical tooth approximately 2/3 as long as palm length and subequal to palm width; head with dark brown to black irregular transverse medial band with anterior margin M-shaped and with extensions back to lateral ocelli; small oval spots lateral to ocellar triangle which interrupt the posterior edge of transverse median band, pale spots may be almost completely enclosed; pronotum distinctive, with large irregular anterior dark blotches and smaller irregular posterior dark spots; thoracic nota with distinctive dark anterior and posterior submedial spots; abdomen vividly reddish-orange in life (less so in alcohol), each tergum with 3 anterior dark spots; dark median spots with small pale lateral dots on either side; cerci with a dense dorsal and ventral fringe of long silky setae in distal half; clothing hairs dark on head and thorax, dark hairs slowly transitioning to clear on distal half of abdomen.

Nymphs of *Isoperla* "Mayo R" are unique in lacking the abdominal stripes or mostly uniform abdominal coloration (as in *I. similis* or *pseudosimilis* groups) typical of most North American *Isoperla*, and instead bear dark abdominal spots. This species is striking in life with a vivid red-orange abdomen. Reared from nymphs, males and females are distinctive and represent a new species. Currently, *Isoperla* "Mayo R" has only been collected from the Mayo River near the VA border in Rockingham County.

nr. *holochlora* – (photographic guide: pages 41-42) – *Preliminary nymph description:* pre-emergent nymphs 7.5-9.0 mm. Lacinia receding evenly, broad basally, and bearing 5-6 stout marginal setae; length of apical tooth of lacinia about half the palm length and about 3/4 the palm width; head with distinctive pale M-pattern sometimes obscured by median pale area; frontoclypeus with anterolateral spots (spots may be obscure in some specimens); medial transverse band posterior to the M-pattern but anterior to median ocellus sometimes darker than remainder of head (appearing like a mask); ocellar spot obscure to absent, if present then small and faint; mediolateral spots always present; occiput with brown line along epicranial suture, a pale and brown reticulated pattern behind which is enclosed posteriorly by a heavily spiculate curved dark bar from near epicranial stem to eye; abdomen brown and laterally with 2 conspicuous, longitudinal dark stripes bordered by pale areas, and an obscure narrow median stripe; each tergal portion of the lateral abdominal stripes usually wider anteriorly and not reaching posterior edge of respective segment, subtriangular on posterior segments (but may be sub-parallel and reach posterior edge); cerci with a dense dorsal fringe of long silky setae in distal half (may be present in proximal half but sparse); clothing hairs dark.

Nymphs of this species are common and often abundant in clean streams in the NC Mountains and can be collected during winter into late spring. Reared nymphs, both males and females, represent a probable new species and are not treated in Szczytko and Kondratieff (2015). Superficial adult morphology of both males and females are similar to *I. holochlora* but the male aedeagus is most similar to *I. powhatan* with smaller, shorter spine patch. It is interesting that this nymphal habitus has been recognized and collected within NC for many years but adults have not apparently been collected or treated.

Isoperla nr. *holochlora* is a historical name within BAB (in use for over 25 years) based on its overall similar appearance to *Isoperla holochlora* although the head more closely resembles that of *similis/pseudosimilis* groups.

nr. *transmarina* – (photographic guide: pages 43-44) – *Preliminary nymph description:* pre-emergent nymphs 7.0-9.0 mm. Lacinia with low hump below subapical tooth and bearing 5-6 closely set stout marginal spines; apical tooth approximately 3/4 as long as palm length and subequal to palm width; labrum with basolateral dark spots; head with extensive dark markings, dominated by a transverse median stripe with large irregular extensions forward to the anterior frontoclypeal area and extensions back to lateral ocelli; bell-shaped median pale area narrowly open to pale anterior frontoclypeal area: ocellar spot large, enclosed, and usually roughly triangular; semi-quadrate pale area anterolateral to bell-shaped median spot; occiput with short, brown areas along epicranial stem directly behind ocellar spot and with strong oblique dark stripes originating behind eyes and extending to post-occipital margin; pronotum distinctive, with a pale medial stripe, submedial dark anterior and posterior maculations not meeting, and a pale lateral area containing a short parenthetical dark spot; abdomen with 3 longitudinal stripes, two lateral and one median, tergal portions somewhat hour-glass shaped; cerci with a dense dorsal fringe of long silky setae in distal half; clothing hairs dark.

The nymphal habitus strongly resembles that described for *Isoperla transmarina* by Frison (1942) whereas the reared female of this species shares the distinctive subgenital plate and head pattern of *Isoperla nelsoni* instead of that of *I. transmarina.* However, no confident identification can be made without reared males and therefore the identity of this nymphal habitus remains unknown. True *Isoperla transmarina* may be a more northerly species and not occur in NC at all.

Nymphs occur in clean, mountain streams although they are rarely collected. BAB biologists historically identified this species as part of the "*Isoperla transmarina* group".

sp. 10 – (photographic guide: pages 45-46) – *Preliminary nymph description:* pre-emergent nymphs 7.5-8.5 mm. An overall pale species with brown to dark brown markings; lacinia with small knob below subapical tooth bearing 4-5 (usually 4) closely set stiff marginal setae; length of apical tooth of lacinia 3/4 the palm length and subequal to palm width; no enclosed pale areas on head; frontoclypeus with 3 pairs of brown markings in parallel, two pairs anterior and one pair lateral to median ocellus, 2nd anterior pair (middle pair) may have brown extensions along the lateral M-arms; occiput with brown areas along either side of epicranial stem below pale ocellar triangle; oblique dark stripes originating behind eyes and extending to post-occipital margin; pronotum with large irregular anterior and posterior dark blotches; abdomen with two dark lateral and one median longitudinal stripes, median stripe slightly wider than lateral ones; cerci with a dense dorsal fringe of silky setae on distal half, setae very long on some segments being as long as segment itself; clothing hairs dark.

"*Isoperla* sp. 10" is a historical BAB designation; origin of this name is unknown. Reared males appear similar to *Isoperla lenati* both in coloration and aedeagal structure. However, females do not match *I. lenati* description and instead appear more closely aligned with *I. frisoni,* particularly with a truncate and posteriorly deflected subgenital plate. Until more reared material is available the identity of this habitus will remain unknown.

Nymphs of this habitus occur in tannic streams of the Sand Hills and are relatively rare but locally abundant.

kirchneri complex – (photographic guide: pages 23-24) – This complex of species share a similar nymphal habitus pattern, making separation, based only on nymphal material, difficult if not impossible. The name is a BAB determination, so named because *I. kirchneri* is, by far, the most common species with this general habitus pattern in North Carolina. Morphological characters for separation may prove valuable but have, as of yet, not been fully investigated. All *Isoperla* specimens with this habitus pattern should be identified as *"Isoperla kirchneri* complex*"* including *Isoperla kirchneri*, *Isoperla montana*, *Isoperla siouan*, and *Isoperla tutelo.* This grouping is provisional and is not meant to replace the adult species groups designated by Szczytko and Kondratieff (2015). "Complex", as used here, denotes cryptic or otherwise similar looking nymphs that are not necessarily sister species.

***(kirchneri)* –** (photographic guide: pages 23-24) – *New nymph description:* pre-emergent nymphs 8.0-9.5 mm. Apex of lacinia receding, constricted medially, and bearing 4-5 moderately spaced, stout marginal spines, 8-10 closely set submarginal setae and the palm edge dense with many long and thin hair-like setae along its entire length; head with irregular transverse M-type medial band, extensions back towards posterior ocelli variable; anterior frontoclypeus with 2 pair of small brown markings, some specimens with markings narrowly connected by brown lines or even widely coalesced into a larger brown area; brown areas near posterior ocelli on either side of the ecdysial line variable – sometimes extensive, sometimes barely there; abdomen with 3 longitudinal stripes; a transverse row of 6-8 dark spots on each tergum, particularly apparent on posterior segments; cerci with dorsal fringe of silky setae on distal half; abdominal clothing hairs dark. *Isoperla specimens with this habitus pattern should be identified as "Isoperla kirchneri complex".*

Isoperla kirchneri is placed in the *signata* Group. Nymphs of *Isoperla kirchneri* have been extensively reared but are currently inseparable from other members of the *kirchneri* complex. This appears to be the most common species in the complex occurring in North Carolina, particularly in the Mountains. Members of this complex were previously referred to as *Isoperla* nr. *namata*. However, *Isoperla namata* is geographically restricted to the Ozarks and the Midwest and is not considered to occur in the Southeast. The 1995 checklist for NC lists *Isoperla namata* based on historically misidentified material.

(montana) – nymph undescribed. Refer to *Isoperla kirchneri* description.

This species is the eponymous member of the *montana* Group. Nymphs of *Isoperla montana* have been reared but are currently inseparable from *Isoperla kirchneri* or other members of the *kirchneri* complex. All reared *I. montana* were from small to medium-sized, excellent quality Appalachian streams.

(siouan) – nymph undescribed. Refer to *Isoperla kirchneri* description.

Nymphs of *Isoperla siouan* have been reared but are currently inseparable from *Isoperla kirchneri* or other members of the *kirchneri* complex. Currently known only from Moore County (Sand Hills), NC from where the male holotype was described.

(tutelo) – nymph undescribed. Refer to *Isoperla kirchneri* description.

Nymphs of *Isoperla tutelo* from North Carolina have been reared (B. Kondratieff) but are currently inseparable from *Isoperla kirchneri* or other members of the *kirchneri* complex. *Isoperla tutelo* is known only from Johns River, Caldwell County, NC.

lata/pseudolata – (photographic guide: pages 25-26) – These two species share a similar habitus pattern making separation, based on nymphal material, difficult if not impossible. Characters for separation of these two species are preliminary and require more material for study. Denote these two species as *Isoperla lata/pseudolata.*

***lata* –** pre-emergent nymphs 11.0-12.5 mm (preliminary). Lacinia distinct, not receding, with apex as wide as base and covered with a dense brush of setae; head with wide, enclosed pale area anterior to median ocellus; ocellar triangle open behind and may be open to median ocellus in some specimens; pronotum with dark border except extreme lateral margins, with a mostly pale large area medially with slightly darkened center (*I. pseudolata*?) or may have dark markings connecting the anterior and posterior dark borders (*I. lata*?); abdomen with 3 longitudinal stripes, lateral stripes wide and median stripe narrow and obliterated on posterior half of each tergum (*I. pseudolata*?) or uninterrupted (*I. lata*?); abdomen with a sublateral dot near apical margin of sterna 2-8 (this character unknown for *I. lata*); cerci with dorsal and ventral fringe of silky setae (this character unknown for *I. lata*); clothing hairs dark. *Denote as Isoperla lata/pseudolata.*

This species is the eponymous member of the *lata* Group. *Isoperla lata* nymphs appear to be cryptic with those of *Isoperla pseudolata*, a recently described species by Szczytko and Kondratieff (2015). Nymphs are relatively rare and are collected from the Mountains only from September through May in excellent waters. See discussion under *Isoperla pseudolata.*

***(pseudolata)* –** nymph undescribed. Refer to *Isoperla lata* description.

Nymphs of this species cannot currently be reliably separated from *Isoperla lata* nymphs. Denote as *Isoperla lata/pseudolata*.

This species is a member of the *lata* Group. Recently described by Szczytko and Kondratieff (2015), *Isoperla pseudolata* nymphs are cryptic with those of *Isoperla lata*. Pattern differences between the two species are, as of yet, unproven while morphological differences remain unknown. Examined exuviae of reared *I. pseudolata* are very similar to nymphs collected by DWR. However, no confirmed *Isoperla lata* material, either nymphal or adult, has been obtained for study. Both species have been collected from Cataloochee Creek (Szczytko and Kondratieff, 2015). Nymphs are relatively rare and are collected from the Mountains only from September through May in excellent waters.

similis/pseudosimilis Groups – (photographic guide: pages 33-34) –nymphs of these two groups are currently inseparable without associated reared material. *Isoperla cherokee* has been reared from various localities and provided the most nymphal specimens for study. All specimens that match the description of *Isoperla cherokee* should identified as "*Isoperla similis/pseudosimilis* Groups". Some of the following species are unknown in the aquatic stage but adult collections from similar habitats, ecoregion, and their adult placement in either of these two species groups may justify placing those species here.

(bellona) – nymph unknown.

An enigmatic species, *Isoperla bellona* is a member to the *Isoperla similis* group. Material examined from South Carolina labeled as *I. bellona* included nymphs of the *Isoperla holochlora* light-form and nymphs that resemble *Isoperla* nr. *holochlora* (see description below). Neither any nymphs of *similis/pseudosimilis* habitus types or exuviae were present. Adults are apparently collected from near high elevation, headwater streams. Recorded from GSMNP. Listed as "vulnerable to extirpation" by Morse et al. (1997). Holotype female described from Black Mountain, North Carolina by Banks (1911).

(cherokee) – (photographic guide: pages 25-26) – nymph undescribed. *Preliminary nymph description:* pre-emergent nymphs 8.0 – 10.5 mm; lacinia barely receding, bearing 6-9 moderately spaced stout marginal spines with middle spines 3 and 4 longest and an additional 3-4 smaller marginal setae; 3 stout submarginal spines; length of apical tooth 2/3 the palm length and subequal to palm width; head with distinctive enclosed pale M and with pale anterolateral spots; anterolateral spots may be thin dashes or more ovalized; mediolateral spots present, may be confluent with pale area beside lateral ocelli; occiput with brown areas along epicranial suture and with pale and brown reticulated pattern behind; abdomen uniformly light brown with a light, inconspicuous median stripe; stripe with a pair of small pale submedial dots; may be additional small pale dots laterally on each segment; anterior 1/4 of each tergum with darker brown transverse stripe, stripe usually not seen as terga are often withdrawn slightly into previous segment (can be confused with the darkening caused by overlapping segments); cerci with very sparse dorsal fringe of silky setae on distal half (0-2 setae) or fringe completely absent; clothing hairs dark. *Specimens matching this description should be designated "Isoperla similis/pseudosimilis Groups".*

Isoperla cherokee is a species member of the *similis* Group and the nymphal habitus is currently inseparable from other members of the *similis* or *pseudosimilis* groups. This species has been reared and paratype material has been examined and it appears to be one of the smallest North Carolina members of the *similis/pseudosimilis* groups. This species is restricted to high elevation headwater seeps and streams in the Mountains and occurs in the North Carolina Appalachians.

(pauli) – nymph undescribed. Refer to *Isoperla cherokee* description.

A member of the *pseudosimilis* Group, the nymphal habitus of *Isoperla pauli* is currently inseparable from other members of the *similis* or *pseudosimilis* groups. Only one adult male has been successfully reared. Exuviae of one reared NC male and of reared female paratypes from Mt. Mitchell, NC are of the *similis/pseudosimilis* type. This species occurs in high gradient, high elevation headwater streams and the holotype male is recently described from Wilson Creek on the slopes of Grandfather Mountain by Szczytko and Kondratieff (2015).

(pseudosimilis) – nymph unknown.

This species is the eponymous member of the *pseudosimilis* Group. Recently described by Szczytko and Kondratieff (2015), this widespread species occurs in higher elevation small to medium sized streams and is so named due to its similarity to *Isoperla similis* in general habitus of the adults not the nymph.

(reesi) – nymph undescribed. Refer to *Isoperla cherokee* description.

This species is a member of the *pseudosimilis* Group. Examination of male and female paratypes with exuviae from along the Blue Ridge Parkway (inadvertently omitted from Szczytko and Kondratieff, 2015, B. Kondratieff, per. comm.) indicate that the nymph cannot currently be distinguished from other members of the *similis* or *pseudosimilis* groups. This species apparently occurs in high gradient, high elevation headwater streams of excellent quality.

(starki) – nymph unknown.

This species is a member of the *similis* Group. Recently described by Szczytko and Kondratieff (2015), this widespread species occurs in higher elevation small to medium sized streams. *Isoperla starki* was described from material collected from Wayah Bald, Macon County, NC.

(stewarti) – nymph undescribed. Refer to *Isoperla cherokee* description.

This species is a member of the *pseudosimilis* Group. Examination of loaned male and female specimens with exuviae from springs near the summit of Mt. Mitchell, the type locality, indicate that the nymph cannot currently be distinguished from other members of the *similis* or *pseudosimilis* groups. This species apparently occurs in high elevation headwater springs and streams of excellent quality.

Species unknown as nymphs – The following *Isoperla* species have not been reared and are otherwise unknown in the nymphal stage nor are they members of the *similis* or *pseudosimilis* species groups. The placement of the following species may change once the nymphs have been associated.

(lenati) – nymph unknown.

Isoperla lenati is a member of the *nana* Group. This species appears restricted to the Sand Hills (Szczytko and Kondratieff, 2015).

(nelsoni) – nymph unknown.

This species is a member of the *montana* Group. *Isoperla nelsoni* has been recorded from Bridal Veil Falls near Highlands, Macon County and may be widespread in the southern Appalachians (Szczytko and Kondratieff, 2015).

(zuelligi) – nymph unknown.

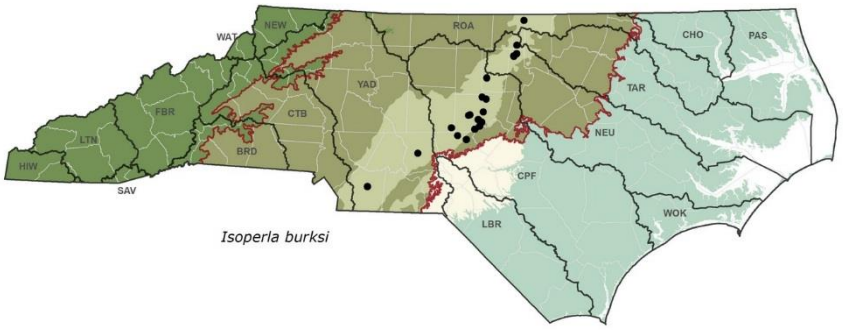
This species is a member of the *bilineata* Group. The type locality of *Isoperla zuelligi* is Barnes Creek, Montgomery County, NC (Szczytko and Kondratieff, 2015). Two males and two females have subsequently been collected from Barnes Creek (S. R. Beaty and D. L. Lenat, unpublished data, 2015), although no nymphs have yet been reared. In addition, *Isoperla powhatan* has been reared from Barnes Creek, a new NC record. Barnes Creek is a Slate Belt stream in the Uwharrie National Forest and while water quality is generally excellent, this stream suffers from moderate siltation and reduced summer flows.

Notes: Nymphal color patterns are still the primary way to distinguish between species, but like most stonefly species, there is variation within a series of specimens. Eventually morphological characters, such as the lacinia and setation patterns, may prove to be indispensable. In fact, a key to the Wisconsin Perlodidae (Hilsenhoff and Billmyer, 1973) relies heavily on lacinial morphology. The above species accounts are based on primary literature, BAB-reared specimens, and on occurrence within the BAB database. *Isoperla* species nomenclature is, for many of the described species above (e.g. nr. *holochlora*, sp. 10), temporary and, once sufficient numbers of reared specimens have been obtained and examined, will likely change.

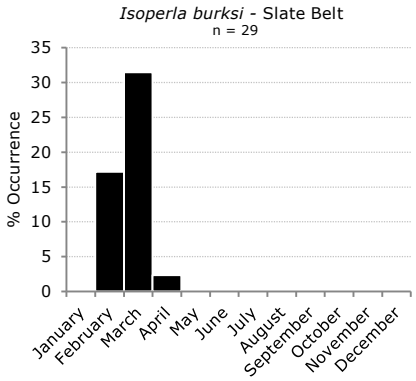
S. W. Szczytko and B. C. Kondratieff recently revised the adults of eastern Nearctic *Isoperla* but did not treat nymphs (see Szczytko and Kondratieff, 2015). However, the authors described 22 new eastern species of which 16 are recorded from North Carolina. Recent BAB rearing efforts have associated the nymphs of many of these new species and have also uncovered new species not treated by the recent *Isoperla* monograph. At least two species above are currently being described by BAB biologists.

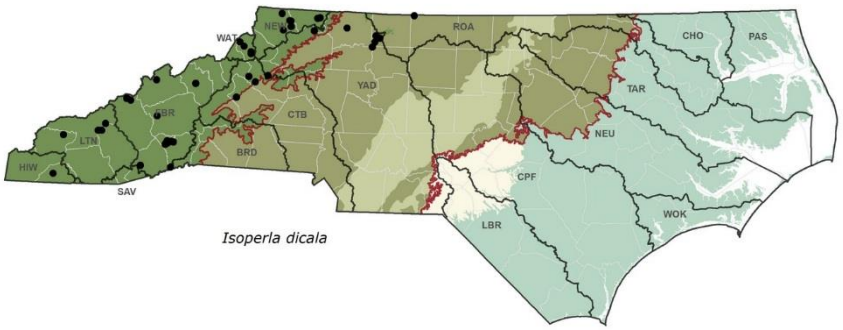
A companion photographic guide to the NC species of *Isoperla* is referenced above in most species treatments. Published in-house, this manual contains many useful photos of each species, distribution maps, and associated taxonomic characters. It can be downloaded from the web at http://portal.ncdenr.org/web/wq/taxonmanual. As *Isoperla* are important water quality indicators and frequently encountered during routine bioassessments, a need was seen to provide regional biologists and taxonomists a guide for accurate identification and a standardized nomenclature for *Isoperla* species in North Carolina and the surrounding states. We are also hopeful that DNA barcoding will provide a clearer picture of the relationships of regional *Isoperla* and help solidify the identity of the nymphal forms of North Carolina's amazing *Isoperla* fauna.

Isoperla are typically intolerant as a whole and usually have a slow univoltine life cycle (Mackay, 1969; Harper, 1973b; Hilsenhoff and Billmyer, 1973; Kreuger and Cook, 1981; Jop and Szczytko, 1984; Sandberg and Szczytko, 1997; Martinson et al., 2012) but may have a fast univoltine cycle (Ernst and Stewart, 1985a).

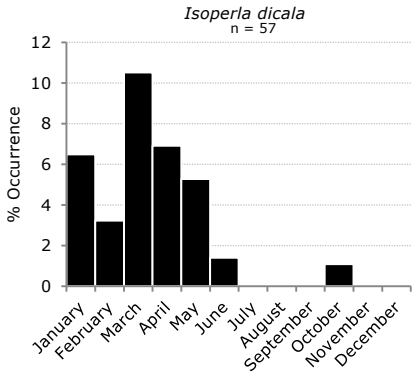


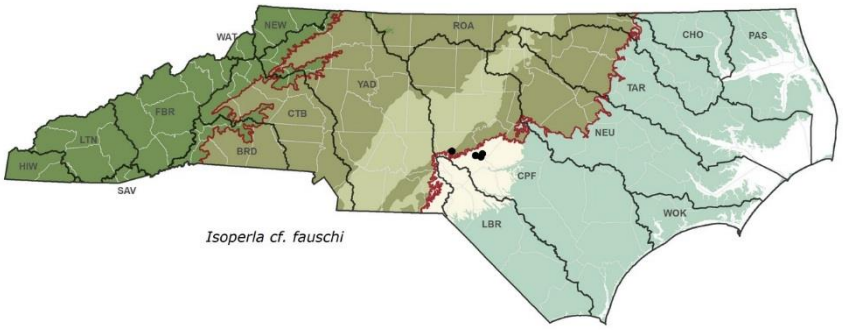
Isoperla burksi



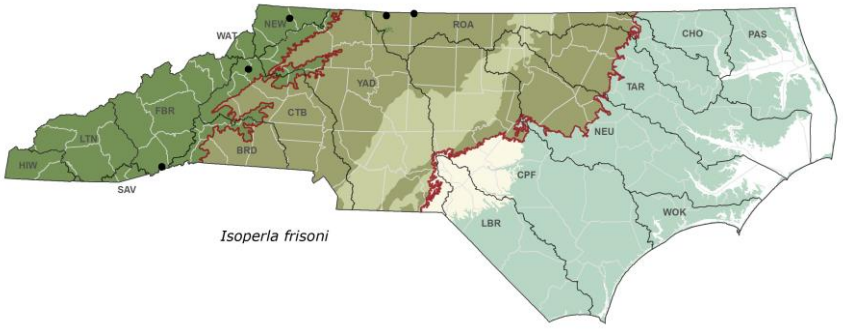


Isoperla dicala

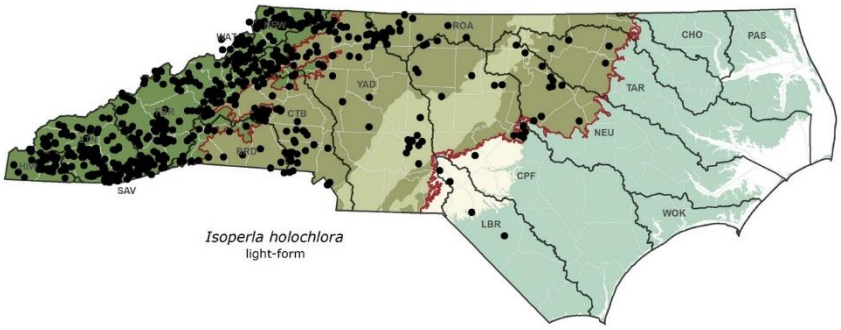




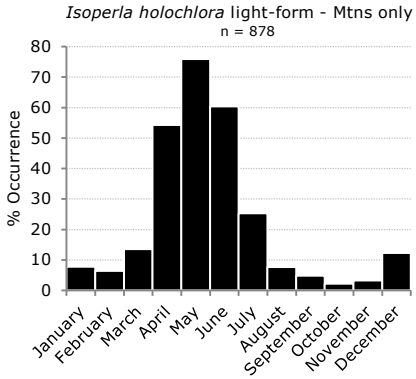
Isoperla cf. fauschi

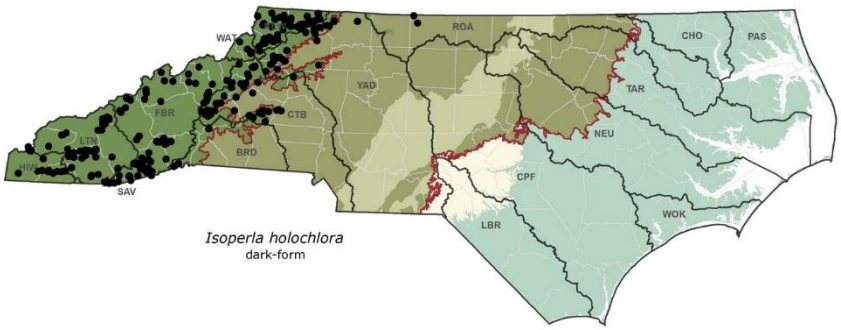


Isoperla frisoni

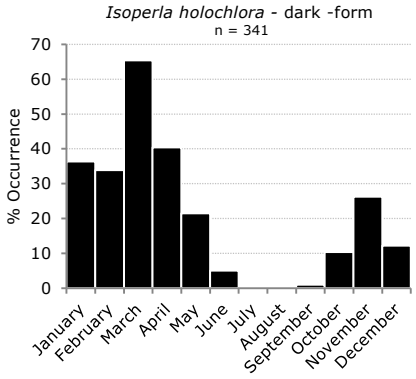


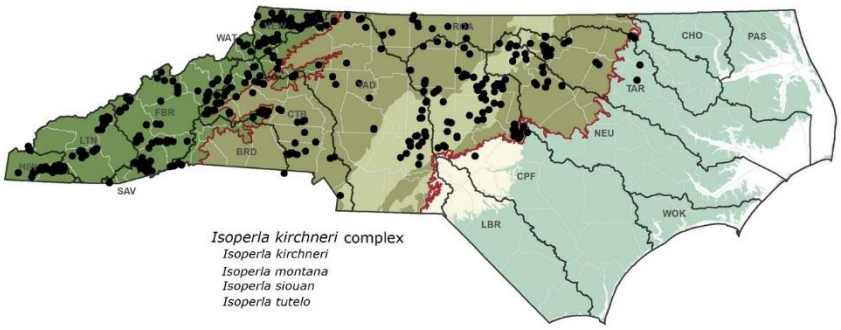
Isoperla holochlora
light-form



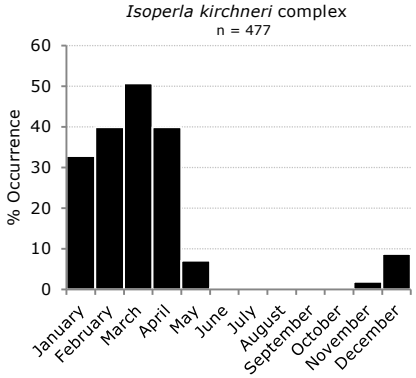


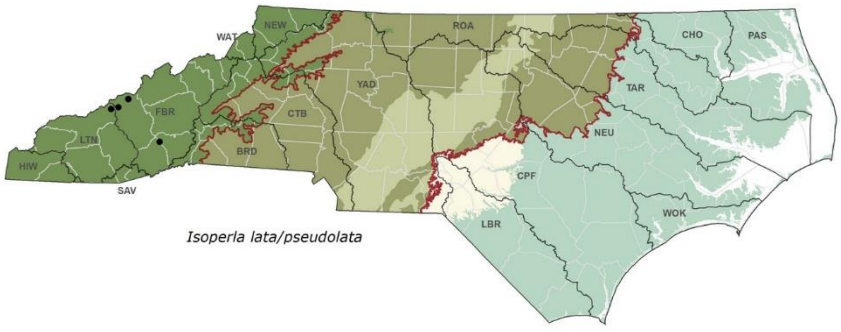
Isoperla holochlora
dark-form



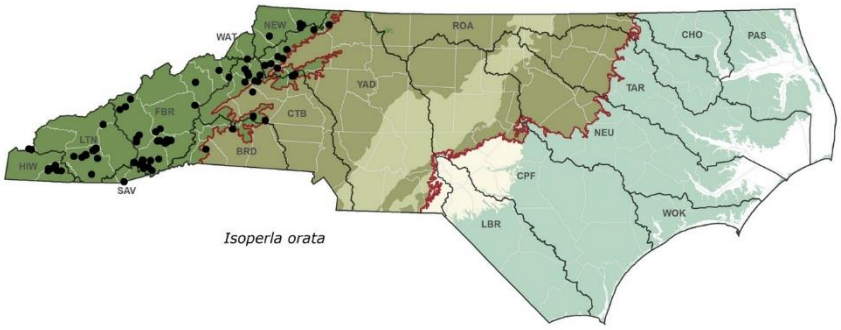


Isoperla kirchneri complex
Isoperla kirchneri
Isoperla montana
Isoperla siouan
Isoperla tutelo

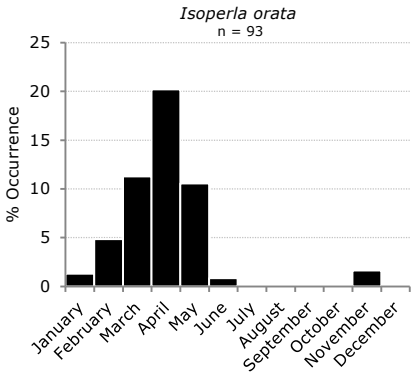


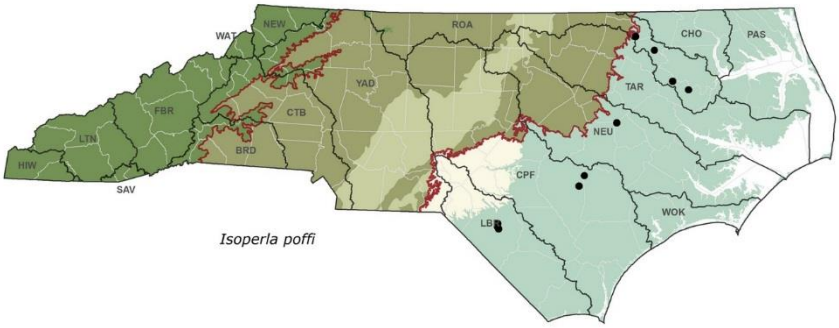


Isoperla lata/pseudolata

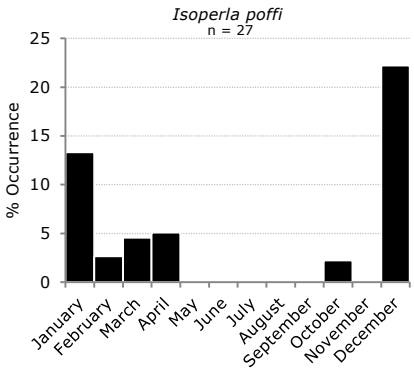


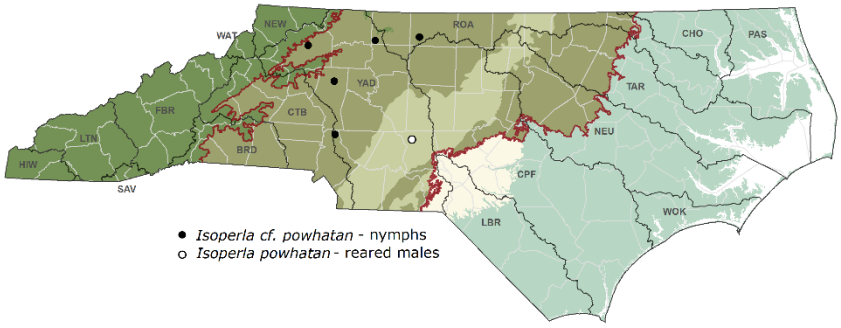
Isoperla orata

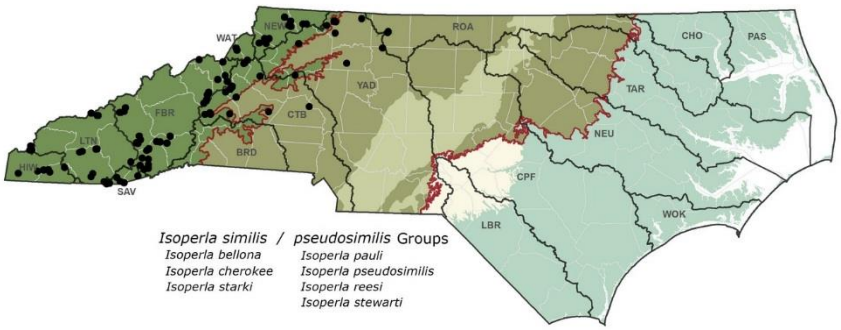


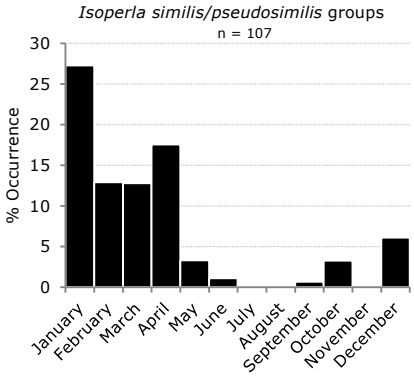


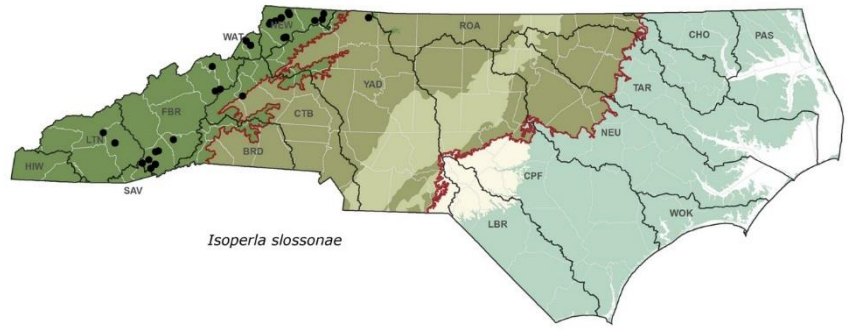
Isoperla poffi



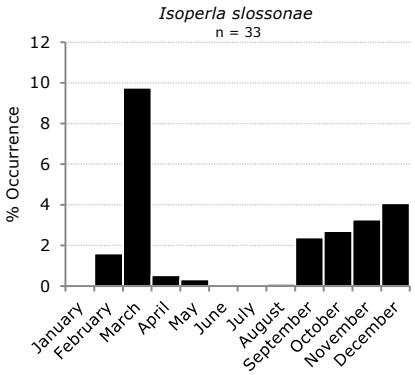


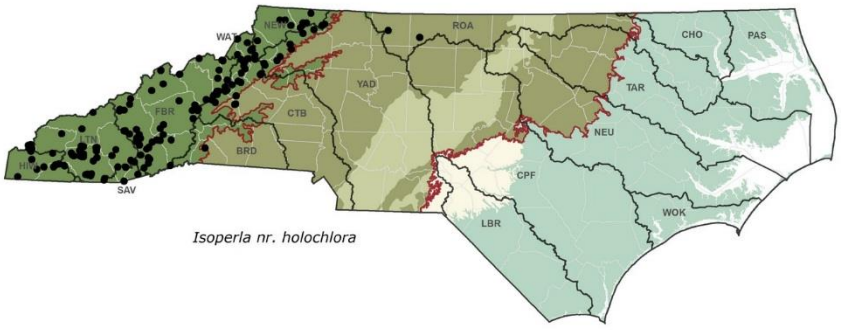




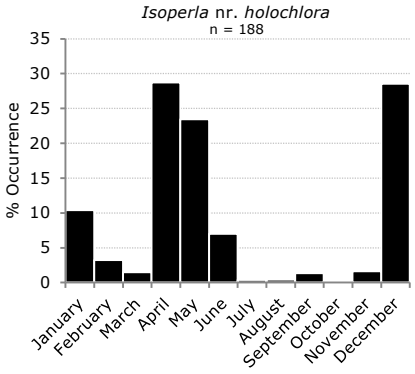


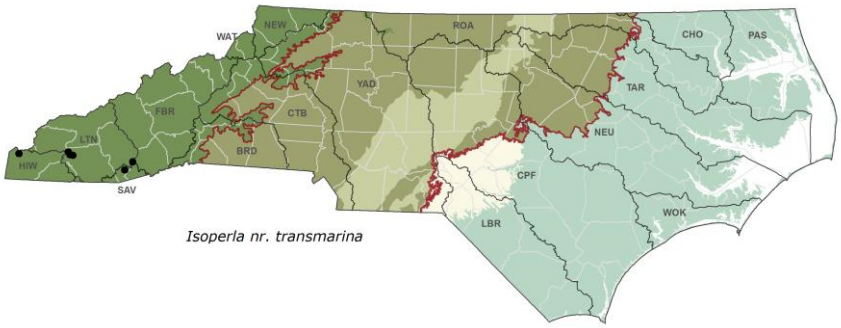
Isoperla slossonae



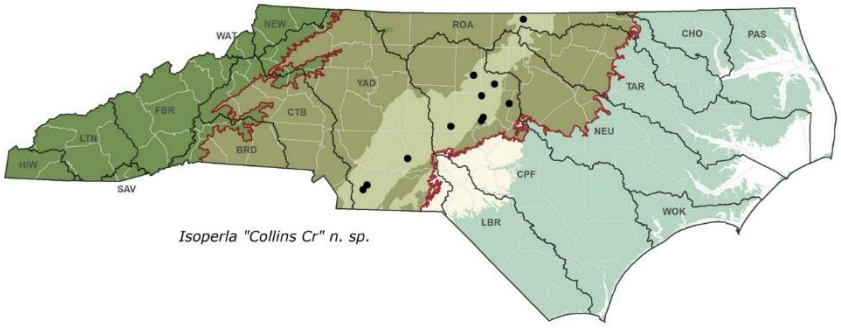


Isoperla nr. holochlora

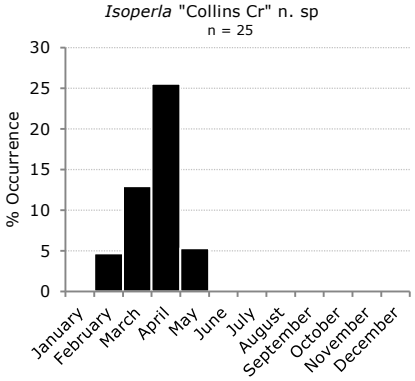


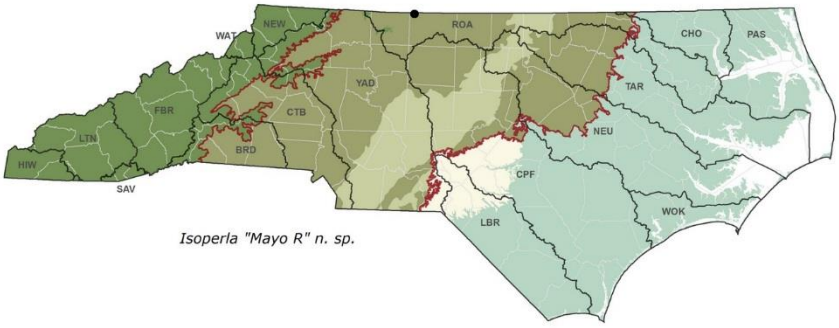


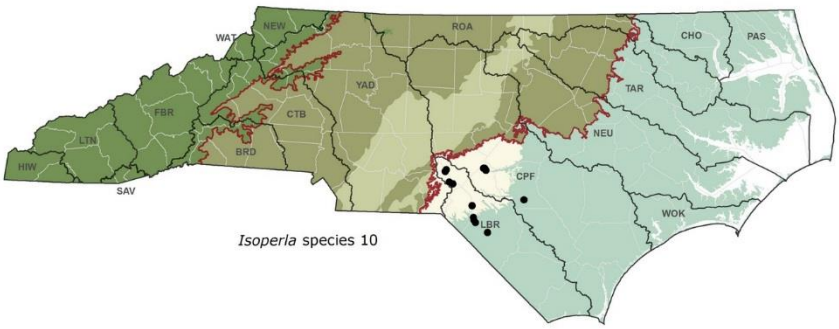
Isoperla nr. transmarina

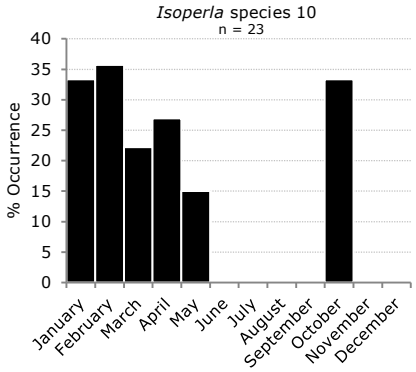


Isoperla "Collins Cr" n. sp.









Taxonomic references:

nymphs:

Beaty, S. R. 2015. A morass of *Isoperla* nymphs (Plecoptera: Perlodidae) in North Carolina: a photographic guide to their identification. Department of Environment and Natural Resources, Division of Water Resources, Biological Assessment Branch, Raleigh.

Hitchcock, S. W. 1974. Guide to the Insects of Connecticut: Part VII. The Plecoptera or Stoneflies of Connecticut. State Geological and Natural History Survey of Connecticut Bulletin 107: 191-211.

adults:

Szczytko, S. W. and B. C. Kondratieff. 2015. A review of the Eastern Nearctic Isoperlinae (Plecoptera: Perlodidae) with the description of twenty-two new species. Monographs of Illiesia, No. 1: 1-289.

Szczytko, S. W. and B. C. Kondratieff. 2015. A photographic atlas of the Eastern Nearctic Isoperlinae (Plecoptera: Perlodidae) species. Monographs of Illiesia, No. 2: 1-124.

Malirekus

Genus Diagnosis: *Lacinia with low marginal knob bearing a tuft of setae and ventral surface with a cluster of approximately 50 clothing hairs near base*; labrum concolorous; *head brown with distinct, completely enclosed pale M-pattern*; pair of linear spots anterior to M-pattern; large suboval pale spots lateral to ocellar triangle; a faint ocellar spot present; occiput with large oval areas with brown reticulations, enclosed posteriorly by dark band and occipital setal row; *a mostly single, irregular curved row of closely-set spinules on back of head, obsolete near midline*; cerci with dorsal fringe of short, silky setae; many dark clothing hairs, hairs absent from pale areas on head and body.

Habitat and Trophic Level: Nymphs most often occur under rocks in riffles. Predators – engulfers. Sprawlers.

Distribution and Occurrence: Typically collected from small mountain streams and rivers. Nymphs are most common and abundant from fall thru spring but early instars (3.5-5.0 mm) can be collected during the summer months.

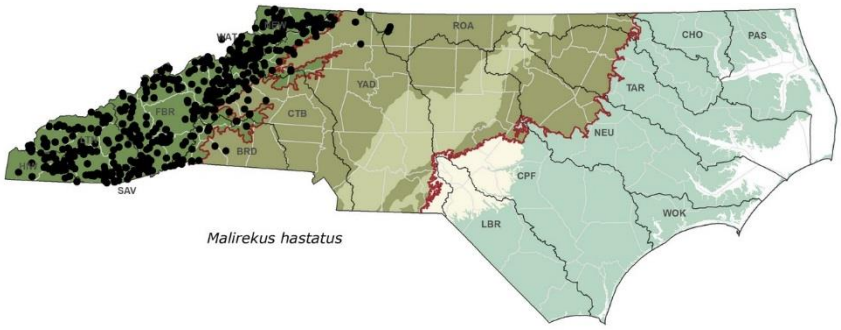
Species in NC: TAKE TO SPECIES

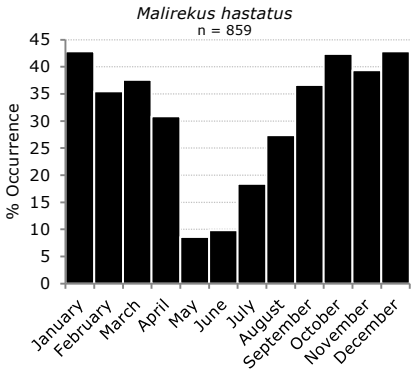
hastatus – Nymphs 15-19 mm. Conical submental gills; pronotal fringe consists of very short, closely spaced setae, and easily overlooked; pronotal disc brown with confused pale rugosities; abdomen brown and often with a pair of pale submedial dots, some specimens with pale lateral dots and an obscure longitudinal, slightly darkened stripe between pale submedial dots.

Malirekus hastatus is the only species to occur in the southeastern United States. In North Carolina it is ubiquitous in most high quality streams.

Notes: Separating *Malirekus* from *Yugus* by the single row of spinules on the occiput appears to work well. The patch of clothing hairs on the lacinia, a traditional diagnostic feature for separation of these two genera, may be difficult to see or is not always present as the hairs can fall off. Also, some North Carolina specimens have very small, apparently retracted, submental gills, particularly in pre-emergent nymphs. This can lead to confusion with *M. iroquois*, a northeastern species of *Malirekus*, which lacks submental gills entirely (Stewart and Stark 2002). Additionally, earlier instars of *Malirekus* can be mistaken for *Isoperla similis/pseudosimilis* species, particularly while separating the genera in the field. Many *Isoperla* nymphs have been lost to predation during rearing studies when live misidentified *Malirekus* were placed in containers with live *Isoperla*.

Malirekus hastatus has a slow univoltine life cycle (Huryn and Wallace, 1987).





Taxonomic references:

nymphs:

Stewart, K. W. and B. P. Stark. 2002. Nymphs of North American Stonefly Genera (Plecoptera). Second Edition. The Caddis Press. Columbus, Ohio, xii + 510pp. (habitus of *M. hastatus*)

adults:

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Oconoperla

Genus Diagnosis: Nymphs robust, stout; 11-14 mm. Labrum large; lacinia bidentate, *subapical tooth "bent" with distal ¾ strongly divergent from apical tooth*, with stout marginal setae on low shoulder below subapical tooth; head wider than long; head pattern with pale shallow M-shaped mark, two large anterolateral pale spots and with two curvilinear pale marks lateral to ocellar triangle; ocellar triangle may be paler than surrounding areas; submental gills absent; *posterolateral margins of pronotum notched*; *femora and tibiae without setal fringe*; tibia with 2 large spines apically; abdomen dark brown with pale areas medially and sublaterally and appearing to have pale stripes in some specimens, terga 7-9 with three medial pale dots arranged as a triangle, segment 10 with a medial pale stripe on anterior half; cerci without dorsal fringe of short, silky setae but with a sparse circlet of short apical hairs, and with numerous small intercalary spines; *habitus densely covered with long, dark clothing hairs both dorsally and ventrally, body dark brown.*

Habitat and Trophic Level: Nymphs occur under rocks in splash zones and seeps. Predominantly predaceous.

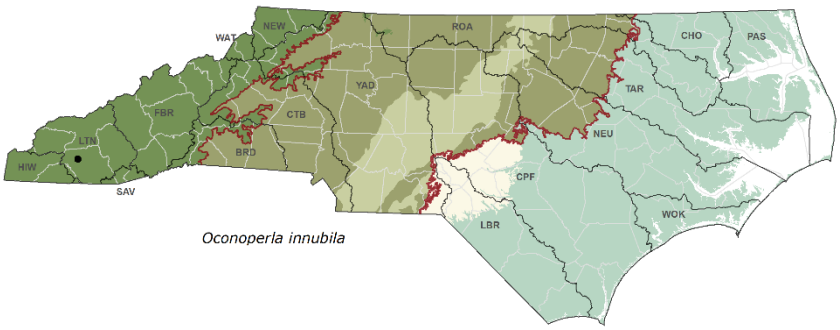
Distribution and Occurrence: Nymphs occur in small seeps and springs in high elevation Mountains. Rarely collected.

Species in NC: MONOTYPIC

***innubila*–** see Genus Diagnosis.

Notes: *Oconoperla innubila* was originally described from one adult female collected near Sunburst, NC (Haywood Co) by Needham and Claassen (1925) as *Perla innubila* which was then elevated to *Yugus innubilis* by Illies (1966). Stark (1985) placed his recently described *Oconoperla weaveri* (Stark and Stewart, 1982) as a synonym of *Oconoperla innubilis* after discovering that the holotype female *Perla innubila* was similar to *Oconoperla weaveri* females and probably represented a single species.

Oconoperla innubila has been collected from various seeps in North Carolina, most recently from a seep on Wayah Bald, one of the type localities. *Oconoperla* is recorded from TN, SC, and GSMNP and is listed as "vulnerable to extirpation" by Morse et al. (1997).



Oconoperla innubila

Taxonomic references:

nymphs:

Stark, B. P. and K.W. Stewart. 1982a. *Oconoperla*, a new genus of North American Perlodinae (Plecoptera: Perlodidae). Proceedings of the Entomological Society of Washington 84(4): 747-752.

adults:

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B.P and B.J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Remenus

Genus Diagnosis: Nymphs small, 6-9 mm. Head with faint M-line and faint pale oval marks on each side of ocellar triangle; *lacinia unidentate, with a wide, shallow base and with a single, long, spine-like tooth*; submental gills absent; pronotum sparsely fringed with widely spaced, moderately long setae, a few short setae may be interspersed; abdomen uniformly brown, cerci without dorsal fringe of short, silky setae but with a circlet of long apical hairs; habitus golden brown, without conspicuous markings.

Habitat and Trophic Level: Unknown. Predominantly predaceous. Clingers.

Distribution and Occurrence: Nymphs are commonly found March through June mostly in high quality headwater to small streams in the Mountains and Inner Piedmont.

Species in NC: LEAVE AT GENUS

bilobatus – cerci with well-developed whorls of apical setae on basal and mid-cercal segments (new character – Stark, 2016).

Originally described as *Perla bilobata* from Black Mountain, NC (Needham and Claassen, 1925).

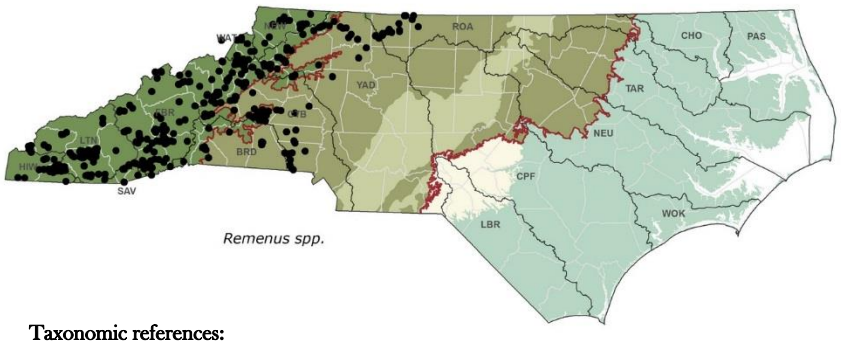
duffieldi* – nymphs undescribed. Cerci with poorly developed whorls of apical setae on basal and mid-cercal segments (new character – Stark, unpublished). Nymphs are otherwise similar to those of *R. bilobatus*.

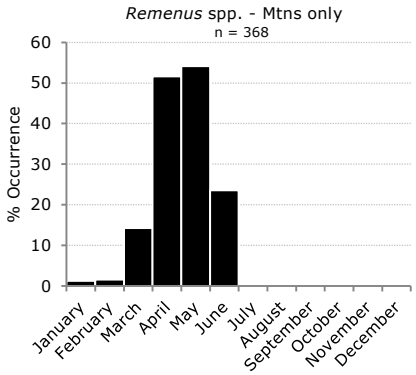
Occurs in small mountain streams. Described from Towns and Union Counties, GA (Kondratieff and Nelson, 1995), adjacent to Cherokee and Clay Counties, NC.

(kirchneri) – nymph unknown.

Adults have recently been collected from Avery County (B. Kondratieff et al., 2013, unpublished). *Remenus kirchneri* is known to inhabit small headwater spring-fed streams in Blue Ridge physiography. Adults are described from Patrick and Floyd Counties, VA (Kondratieff and Nelson, 1995) and recorded from Carter County, TN, adjacent to Avery County, NC.

Notes: While two of the three regional species are known as nymphs, their separation, currently, relies on the relatively fragile cerci. It is probable that nymphs of the other species are unknowingly being collected and, therefore, identifications should be left at genus. There are no life history studies of *Remenus*. Anecdotal BAB evidence suggests *Remenus* species are univoltine and inhabit, at least, leaf packs caught between cobbles in areas of fast current.





Taxonomic references:

nymphs:

no comprehensive identification keys available

adults:

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Yugus

Genus Diagnosis: Distinctive pale yellow M-line on head; *lacinia with prominent setal-tufted knob and marginal setal row that extends from knob to near base*; *labrum with yellow longitudinal mesal band*; *occiput with an irregular, close-set double or triple row of spinules, row not reaching epicranial stem*; submental gills short or absent; cerci with dorsal fringe of short, silky setae.

Habitat and Trophic Level: Unknown but possibly occur in riffles and leaf packs. Predominantly predaceous.

Distribution and Occurrence: Nymphs occur in the Mountains only from late summer through spring. Relatively common. See species accounts.

Species in NC: TAKE TO SPECIES/COMPLEX

arinus – nymphs 15-21 mm. Mandible with 4 teeth; incomplete M-pattern on head, open anteromedially to labrum as a longitudinal pale band; lateral margins of frontoclypeus widely dark brown with medial extensions; pale ocellar spot not enclosed by significantly darker pigmentation posteriorly and may be narrowly open behind; occiput with narrow brown band along epicranial suture, yellow posterior to postoccipital margin; pronotum margined with dark brown, diffusely pigmented rugosities mesally; abdomen with dark sharply delineated brown transverse anterior and posterior bands, anterior bands interrupted mesally; clothing hairs dark.

This species has a high contrast pigmentation pattern and the margins of the pigmentation areas are typically well delineated. Nymphs occur during the winter and spring in high quality waters and are uncommonly collected.

Yugus bulbosus complex – Nymphs in this complex separate from *Yugus arinus* by having a mandible with five teeth; complete pale M-line anterior of median ocellus; occiput with two oval areas enclosed by posterior spinule row and patterned with indistinct lines (reticulations). The following species may have diffuse pigmentation in some places making species distinctions difficult and should be designated as "*Yugus bulbosus* complex".

bulbosus – nymphs 10-15 mm. M-pattern on head diffusely pigmented anteromedially; anterolateral edge of frontoclypeus dark, interrupted mesally; pale ocellar spot enclosed; a pair of comma-shaped pale spots lateral to ocellar triangle, lateral ocelli with a small pale area on lateral side; occipital reticulations sometimes extending to post-occipital margin; area along epicranial stem and posterior to spinule row pale yellow, postoccipital margin with narrow brown band; abdomen with diffuse brown anterior and posterior bands, bands connected medial and sublateral extensions giving the abdomen the appearance of 2-4 ovoid spots on each segment (this may be difficult to see when segments are retracted), some specimens may have a terga with a pair of small anteromedial pale dots; clothing hairs dark.

Nymphs are collected during the winter through spring in the Mountains only. This is the most commonly collected species of *Yugus*.

kirchneri* – nymphs 12-16 mm. Labrum expanded mesally, with darker lateral areas barely extending to posterior margin; anterior margin of frontoclypeus dark, separating pale area on labrum from that on frontoclypeus; a smaller dark M-shaped mark within a larger pale area; pale ocellar spot small; dark pigmentation posterior to epicranial suture continues in some places to posterior margin of head; abdominal pattern similar to that of *Y. bulbous* (see Stewart and Stark, 2002).

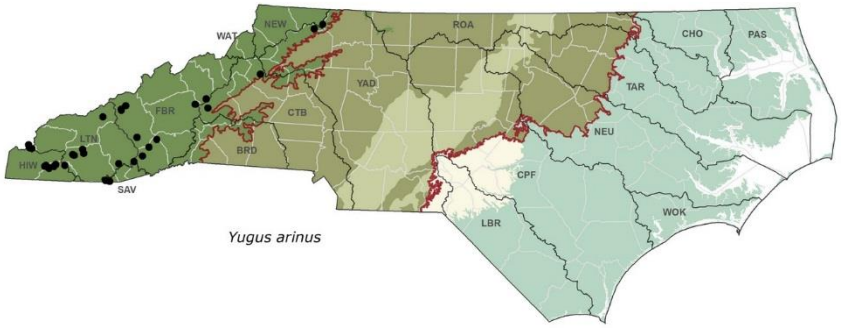
Currently there are no adult records of *Yugus kirchneri* for NC and it appears to be restricted to more northern states. It has been recorded from KY, PA, VA, and WV.

(kondratieffi) – nymphs 10-13 mm. M-line obscured anteriorly; anterolateral margins of frontoclypeus pale; occiput with yellow areas more extensive than in *Y. bulbosus*; abdominal pigmentation unknown but likely similar to other other species in the *Yugus bulbosus* complex.

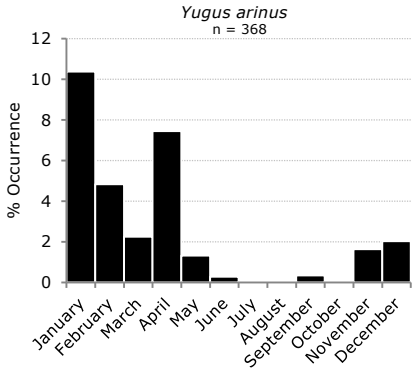
Yugus kondratieffi has been recorded from NC and VA.

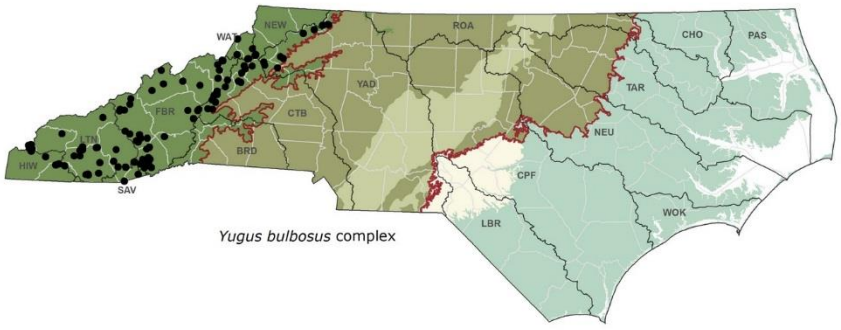
Notes: The setal row on occiput works well to separate *Yugus* nymphs from *Malirekus* nymphs. It is unclear how well *Yugus kondratieffi* will separate from *Yugus bulbosus*. It is possible that *Yugus bulbosus* has the pale ocellar spot surrounded by brown pigment conspicuously darker than the rest of the head as compared to *Y. kondratieffi* where the marginal pigment around the ocellar spot is not darker. However, all NC specimens examined do not have this character, yet otherwise have a head pattern exactly as depicted for *Y. bulbosus* in Nelson (2001). Perhaps the underlying adult head pattern can be seen in some preemergent specimens? Use Nelson (2001) to compare head patterns for each species. The head patterns in Nelson (2001) and Stewart and Stark (2002) for *Y. kirchneri* do not completely agree suggesting some variability in head patterns, possibly for all species.

Life history studies on any species of *Yugus* have not been found. Casual observation suggests a univoltine life cycle for *Yugus*.

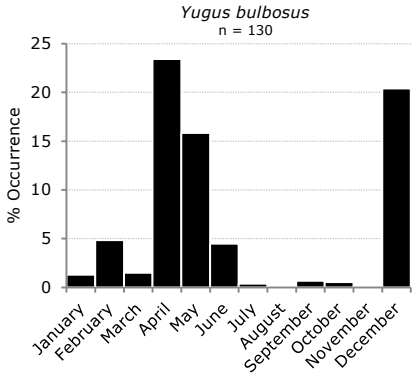


Yugus arinus





Yugus bulbosus complex



Taxonomic references:

nymphs:

Nelson C. H. 2001. The *Yugus bulbosus* complex, with a comment on the phylogenetic position of *Yugus* within the eastern Perlodini (Plecoptera: Perlodidae: Perlodinae). Proceedings of the Entomological Society of Washington. 103: 601-619.

adults:

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Family PTERONARCYIDAE

Stoneflies of the Family Pteronarcyidae are the largest in North American and are referred to as "giant stoneflies" or more commonly by fly fisherman, as "salmonflies". The common names refer either to the size of both the nymphs and adults or the prevalence in the diets of salmon and trout. Adults are large, usually more than 30 mm and sometimes exceeding 50 mm, and darkly colored dorsally with a lighter underside and orange intersegmental markings. Wings are smoky brown and are held flat along the abdomen while at rest and the cerci are moderately long and multisegmented. Adults emerge usually during late spring and early summer.

North Carolina pteronarcyid nymphs are large, between 35 and 50 mm at maturity, and are dark brown or black usually without conspicuous markings. Nymphs have characteristic tufts of filamentous gills at the lateral margin of the thoracic sterna and on the first 2 or 3 abdominal segments. They have long, often yellow-banded antennae and short to moderately long cerci. While most NC species have lateral projections off each abdominal segment, this is not a diagnostic character. Nymphs are primarily shredders and occur in leaf packs in riffles or root mats in flow, although they may also be facultative predators. As some of the longest living stoneflies, pteronarcyds can live 2-4 years, mostly as egg and nymph. However, lifespan may be species dependent and geographically determined.

Pteronarcyidae is a small family of only two North American genera. Only one genus, *Pteronarcys,* with 5 species occurs in the eastern Nearctic. This family is found throughout North Carolina in small streams to large rivers but is particularly common in the Mountains.

FAMILY DIAGNOSIS: Nymphs can be separated from those of other stonefly families by the combination of the following characters:

1) Body large and robust, dark brown to black
2) Legs, when extended, not reaching apex of abdomen
3) Head hypognathus (vertically oriented)
4) Type I mouthparts:
    a. glossa and paraglossa of equal length and shape
    b. labial palpi reach to or barely exceed labium (glossa and paraglossa)
5) Thoracic sterna and abdominal segments 1-2 or 1-3 with tufts of finely branched gills
6) Second tarsal segment of legs shorter than first segment
7) Abdomen narrowed distally
8) Cerci short, about half to 2/3 length of abdomen, and highly tapered

SUBFAMILIES AND GENERA IN NC:

Pteronarcyinae: *Pteronarycys*

Notes: While there are two genera of Nearctic Pteronarcyidae, only *Pteronarcys* occurs in the east. The other genus, *Pteronarcella*, is exclusively western in distribution and not treated further. The two genera can be separated by the number of abdominal segments with tufted gills; *Pteronarcys* has gills on abdominal segments 1 and 2 while *Pteronarcella* has gills on segments 1-3. Additionally the lateral pronotal margins are convex and rounded in *Pteronarcella* and concave with variably developed anterolateral hooks in *Pteronarcys*.

Pteronarcyidae nymphs display self-defensive behaviors under stress or provocation. Nymphs will autohemmorage, or expel hemolymph, when disturbed. This can be seen in preserved specimens as a white exudate originating from under the thoracic nota and coxae. Additionally, nymphs will exhibit thanatosis when disturbed by curling into a ball, becoming immobile, and feigning death.

Pteronarcyid nymphs are good water quality indicators and will typically not be collected from highly disturbed or altered streams. Because of their generally long life span as nymphs, the presence of *Pteronarcys* nymphs in a waterbody is highly suggestive of stable water quality conditions.

Pteronarcys

Genus Diagnosis: Large stoneflies, mature nymphs 35-50 mm. *Branched gills present on thoracic sterna and on abdominal sternites 1 and 2*; *lateral pronotal margins not convex*; cerci with a weak dorsal fringe of short setae; body typically dark and nymphs of most species have a transverse row of yellow spots on anterior margin of each tergite.

Habitat and Trophic Level: Nymphs occur in accumulated detritus under rocks in swift riffles as well as in leaf packs and on woody debris in areas of good flow. Nymphs are primarily detritivorous although they are also facultative predators. Clingers.

Distribution and Occurrence: Collected year round from small, high elevation streams to larger, warmer rivers. See species accounts.

Species in NC: TAKE TO SPECIES

biloba – anterolateral angles of pronotum of mature specimens conspicuously produced laterally into large rounded lobes, although less so in North Carolina specimens; lateral margins of meso- and metanota not produced laterally; abdominal hooks divergent, often with low knob on the posterior margin of one or more of the anterior pairs, hooks conspicuous on abdominal segments 7-8, with those on 8 subequal to or longer than those on 1; some specimens have short, dark, spinous clothing hairs arranged as wide, longitudinal submedial bands while others have clothing hairs distributed somewhat evenly over entire abdominal surface; antennae dark a with conspicuous pale narrow yellow medial band; cerci greater than half the length of the abdomen, with a wide pale medial band.

Nymphs occur year-round in the Mountains from June through February. Semivoltine. Records of *P. biloba* in the Piedmont ecoregion are probable misidentifications of *Pteronarcys proteus*.

comstocki – a pair of conspicuous yellow spots lateral to ocellar triangle; frontoclypeus with anterolateral projections and with triangular tubercles adjacent to, and partially obscuring, antennal pedicels; lateral angles of pro-, meso- and metanotum produced into spine-like processes; apices of each femur, tibia and tarsus pale yellow; lateral hooks divergent and conspicuous on abdominal segments 7-8; cerci less than half the length of the abdomen and with yellow submesal band.

Collected only recently (since 2007), *Pteronarcys comstocki* nymphs may have been erroneously identified as *P. biloba* in historical samples. The two species share a similar abdominal lateral projections formula. Listed by NC Natural Heritage Program as Significantly Rare (LeGrande et al., 2014).

dorsata – lateral angles of pronotum produced, anterolateral ones almost hook-like; psosterolateral corners of meso- and metanotum produced into short spine-like processes; no lateral projections on abdominal segments; each tergite with anterior and posterior abdominal spots sometimes appearing confluent to give the abdomen a longitudinally striped appearance (3-5 stripes possible); antennae and cerci brown, may be paler medially but not as a conspicuous band.

Nymphs of *Pteronarcys dorsata* are common and widespread (excluding Slate Belt) in North Carolina. They are univoltine in southern VA and associated with *Podostemum ceratophyllum* (Lechleitner and Kondratieff, 1983). In North Carolina, nymphs are most abundant from June to October.

proteus – anterolateral projections on pronotum reduced, barely discernible; lateral hooks appressed and not conspicuous on abdominal segments 7-8, the length of those on segment 5, as measured on the posterior surface, one-third to one-fourth the length of the tergite; lateral hooks of segments 6-7 not cleft or appearing double in lateral aspect; cerci typically more than half the length of the abdomen; antennae with a narrow to wide, yellow mesal band.

Relatively common in the northern Mountains and Foothills, there are verified records of *Pteronarcys proteus* occurring in high quality waters as far east as Franklin County, NC. Historically, this species has been confused with *P. scotti*. Merovoltine (3-4 years; 2-3 years in Quebec – Mackay 1969).

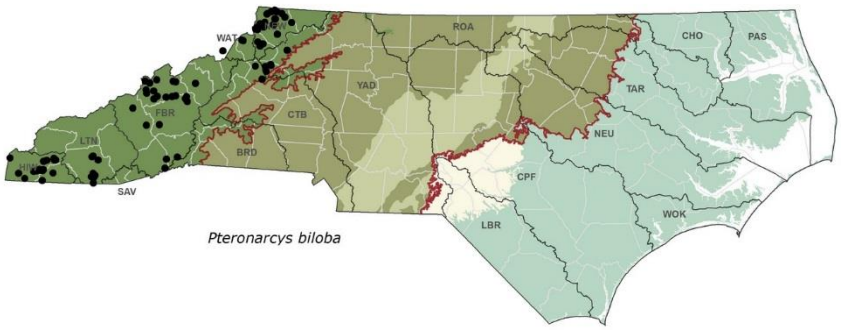
scotti – female nymphs up to 45 mm, males somewhat smaller; lateral margin of frontoclypeus with a low rounded protuberance adjacent to each antennal pedicel; anterolateral projections on pronotum easily discernible; lateral hooks appressed and not conspicuous on abdominal segments 6-8, the length of those on segment 5, as measured on the posterior surface, one-fifth to one-sixth the length of the tergite; lateral hooks of segments 6-7 almost always cleft or appearing double in lateral aspect, sometimes shallowly so; cerci somewhat reduced, about 0.4 the length of the abdomen; antennae and cerci typically brown with darker medial segments but may have an inconspicuous pale medial band.

Nymphs occur throughout the year in the Mountains and are the most common mountain species in NC. *Pteronarcys scotti* has historically been misidentified as *P. proteus*. *Pteronarcys scotti* is reported to be semivoltine and exhibits sexual dimorphism (Folsom and Manuel, 1983).

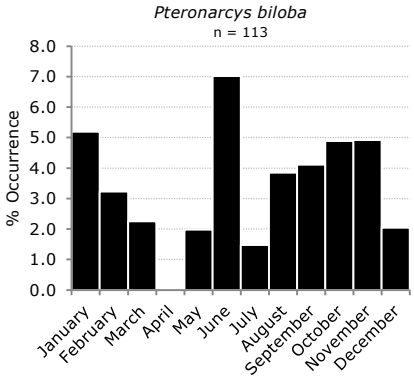
Notes: *Pteronarcys* species are conspicuously absent from the Carolina Slate Belt. *Pteronarcys pictetii,* the only other eastern Nearctic species, is apparently inseparable from *P. dorsata* but is restricted to the Midwest.

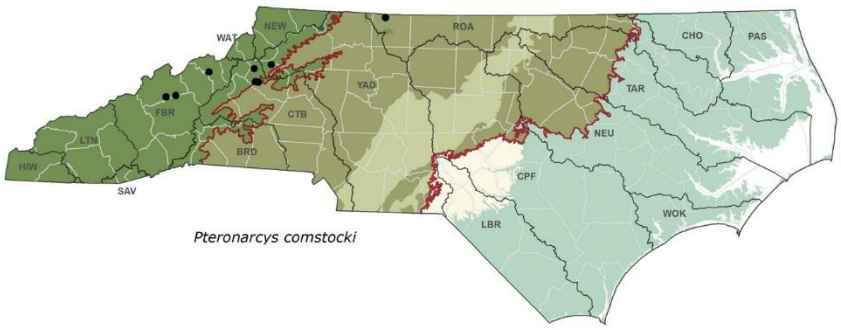
Confusion between the identity of *Pteronarcys proteus* and *P. scotti* nymphs has rendered many historical BAB records of *Pteronarcys proteus* invalid. However, *P scotti* and *P. proteus* can be separated as nymphs. In addition to the difference in the size of the abdominal projections of the two species (as per Ricker, 1952), *Pteronorcys scotti* has cleft abdominal projections on abdominal segments 6-7, as seen laterally. While these double tubercles may be inconspicuous or difficult to see, particularly on small specimens, most North Carolina *P. scotti* specimens will have this character. Also *P. proteus* has a conspicuous yellow antennal band while *P. scotti* antennae are rather drab in comparison. *Pteronarcys scotti* is not included in the Tarter (1975) key limiting its usefulness in NC as *P. scotti* is the most commonly occurring species in the state. A review of the North American *Pteronarcys* nymphs including an identification key and associated illustrations is in preparation by Myers and Kondratieff.

Although some species may be uni-, semi- or merovoltine as nymphs (see species accounts), others may have a long diapause as eggs and then nymphal growth up to a year after hatching (Townsend and Pritchard, 1998). Also, different cohorts coexist within the same stream yielding a range of nymphal sizes.

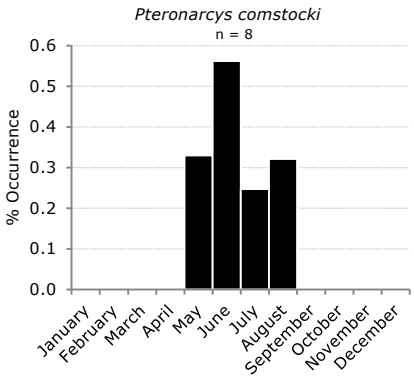


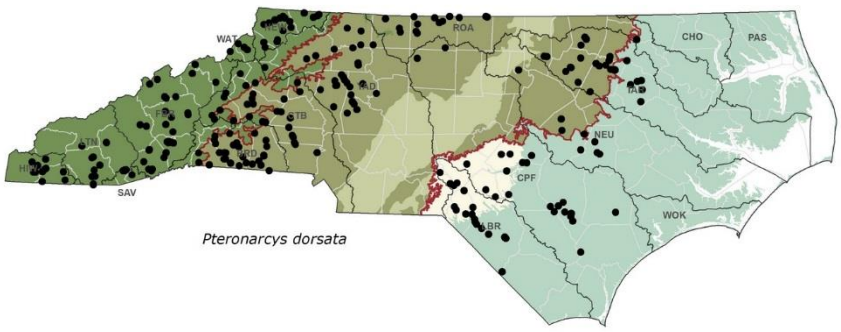
Pteronarcys biloba



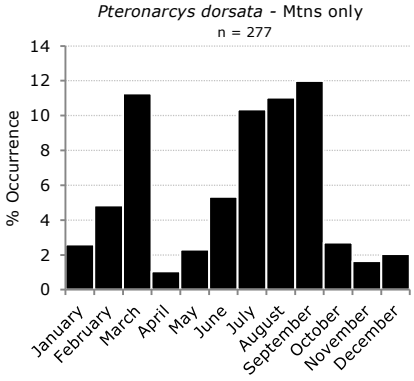


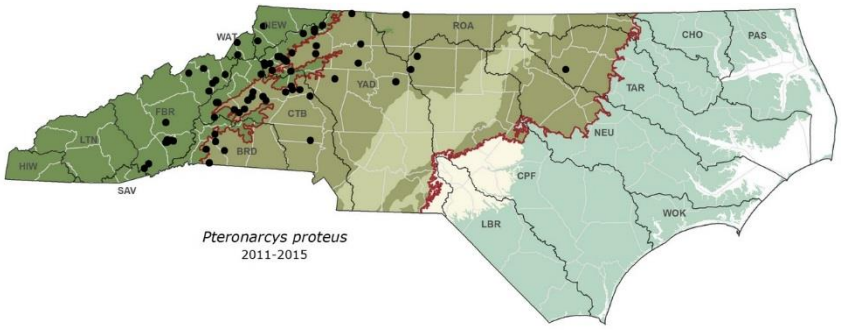
Pteronarcys comstocki



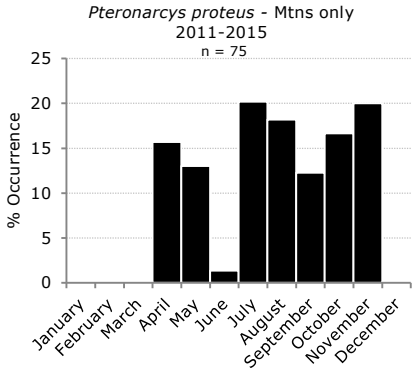


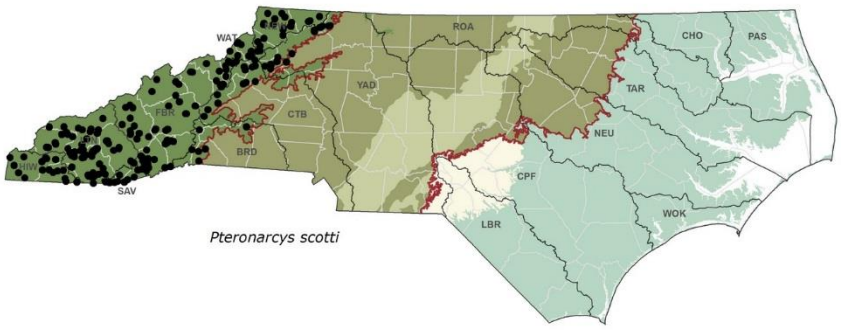
Pteronarcys dorsata



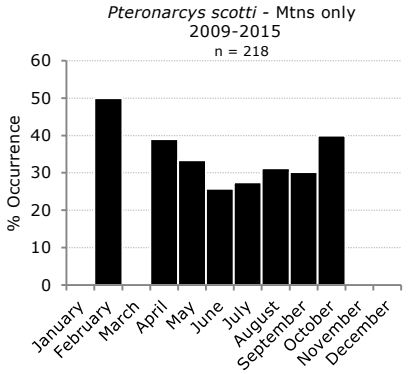


Pteronarcys proteus
2011-2015





Pteronarcys scotti



Taxonomic references:

nymphs:

Ricker, W. E. 1952. Systematic studies in Plecoptera. Indiana University Publications, Science Series 18: 1-200.

Tarter, D. C., M. L. Little, R. F. Kirchner, W.D. Watkins, R. G. Farmer and D. Steele. 1975. Distribution of pteronarcid stoneflies in West Virginia (Insecta: Plecoptera). Proceedings of the West Virginia Academy of Science 47: 79-85.

adult:

Nelson C. H. 2000. Pteronarcyidae (The Salmonflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 Number 1. vii + 100 pp.

LITERATURE CITED

A –

Allen, B. L. and D. C. Tarter. 1985. Life history and ecology of *Eccoptura xanthenes* (Plecoptera: Perlidae) from a small Kentucky (USA) stream. Transactions of the Kentucky Academy of Science 46: 87-91.

Alexander, K. D. and K. W. Stewart. 1999. Revision of the genus *Suwallia* Ricker (Plecoptera: Chloroperlidae). Transactions of the American Entomological Society 125(2): 185-250.

Ashley, D. L., D. C. Tarter, D. C and W. D. Watkins. 1976: Life history and ecology of *Diploperla robusta* Stark and Gaufin (Plecoptera: Perlodidae). Psyche 83(3-4): 310-318.

B –

Baumann, R. W. 1975. Revision of the Stonefly Family Nemouridae (Plecoptera): A Study of the World Fauna at the Generic Level. Smithsonian Contributions to Zoology No. 211. 74pp.

Baumann, R. W. 1996a. Three species of *Amphinemura* (Plecoptera: Nemouridae) from eastern North America. Entomological News 107(5): 249-254.

Baumann, R. W. 1996b. A review of the stonefly genus *Paranemoura* (Plecoptera: Nemouridae) and a new species from the northeast. Proceedings of the Entomological Society of Washington 98(4): 818-826.

Baumann, R. W. and S. A. Grubbs. 1996. Two new species of *Soyedina* (Plecoptera: Nemouridae) from the Appalachian Mountains. Entomological News 107(4): 220-224.

Baumann, R. W. and B. C. Kondratieff. 2009. A study of the eastern Nearctic *Alloperla* (Plecoptera: Chloroperlidae) with hirsute epiprocts using the scanning electron microscope. Illiesia 5(10): 99-107.

Baumann, R. W. and T. M. Mingo. 1987. *Zapada katahdin*, a New Stonefly (Plecoptera: Nemouridae) from the Northeast. Journal of the New York Entomological Society 5(2): 252-257.

Baumann, R. W. and B. P. Stark. 2013. The genus *Megaleuctra* Neave (Plecoptera: Leuctridae) in North America. Illiesia 9(06): 65-93

Beaty, S. R. 2015. A morass of *Isoperla* nymphs (Plecoptera: Perlodidae) in North Carolina: a photographic guide to their identification. Department of Environment and Natural Resources, Division of Water Resources, Biological Assessment Branch, Raleigh.

Bottorff, R. L. & R. W. Baumann. 2015. *Sierracapnia*, a new genus of Capniidae (Plecoptera) from western North America. Illiesia 11(09): 104-125.

C –

Cushman, R. M., J. W. Elwood and S. G. Hildebrand. 1977. Life history and production dynamics of *Alloperla mediana* and *Diplectrona modesta* in Walker Branch, Tennessee. American Midland Naturalist 98(2): 354-364.

D –

Delucchi, C. M. and B. L. Peckarsky. 1989. Life-history patterns of insects in an intermittent and a permanent stream. Journal of the North American Benthological Society 8: 308–321.

DeWalt, R. E. and B. D. Heinold. 2005. Summer emerging Ephemeroptera, Plecoptera, and Trichoptera of Abrams Creek, Great Smoky Mountains National Park. Proceedings of the Entomological Society of Washington 107(1): 34-48.

DeWalt, R. E., M. D. Maehr, U. Neu-Becker and G. Stueber. 2015. *Plecoptera Species File Online*. Version 5.0/5.0. [22 November 2015]. <http://Plecoptera.SpeciesFile.org>.

E –

Earle, J. I. and K. W. Stewart. 2008. Description of the Nymph of *Strophopteryx appalachia* Ross and Ricker (Plecoptera: Taeniopterygidae), and Key to *Strophopteryx* Nymphs. Proceedings of the Entomological Society of Washington 110(3): 551-555.

Ernst, M. R. and K. W. Stewart. 1985a. Growth and drift of nine stonefly species (Plecoptera) in an Oklahoma Ozark foothills stream, and conformation to regression models. Annals of the Entomological Society of America 78(5): 635-646.

Ernst, M. R. and K. W. Stewart. 1985b. Emergence patterns and an assessment of collecting methods for adult stoneflies (Plecoptera) in an Ozark foothills stream. Canadian Journal of Zoology 63(12): 2962-2968.

Ernst, M. R., B. C. Poulton and K. W. Stewart. 1986. *Neoperla* (Plecoptera: Perlidae) of the southern Ozark and Ouachita mountain region, and two new species of *Neoperla*. Annals of the Entomological Society of America 79(4): 645-661.

F –

Fiance, S. B. 1977. The genera of eastern North American Chloroperlidae (Plecoptera): Key to larval stages. Psyche 84: 308-316.

Fochetti, R. and J. M. Tierno de Figueroa. 2008 Global diversity of stoneflies (Plecoptera; Insecta)in freshwater. Hydrobiologia 595: 365-377.

Folsom, T. C. and K. L. Manuel. 1983. The life cycle of *Pteronarcys scotti* (Plecoptera: Pteronarcyidae) from the southern Appalachians, U.S.A. Aquatic Insects 5(4): 227-232.

Frison, T. H. 1929. Fall and winter stoneflies, or Plecoptera, of Illinois. Illinois Natural History Survey Bulletin 18: 343-409.

Frison, T. H. 1935. The Stoneflies, or Plecoptera, of Illinois. Illinois Natural History Survey Bulletin 20: 281-471.

Frison, T. H. 1942. Studies of North American Plecoptera with special reference to the fauna of Illinois. Illinois Natural History Survey Bulletin 22: 235-355.

Fullington, K. E. and K. W. Stewart. 1980. Nymphs of the stonefly genus *Taeniopteryx* (Plecoptera: Taeniopterygidae) of North America. Journal of the Kansas Entomological Society 53(2): 237-259.

G –

Griffith, G. E., Omernik, J. M., Comstock, J. A. Schafale, M. P., McNab, W. H., Lenat, D. R., MacPherson, T. F., Glover, J. B. and Shelburne, V. B. 2002. Ecoregions of North Carolina and South Carolina. Reston, VA, U.S. Geological Survey (map scale 1:1,500,000).

Grubbs, S. A. 2005. *Perlesta shawnee* (Plecoptera: Perlidae), a new stonefly species from eastern North America. Aquatic Insects 27(1): 63-69.

Grubbs, S. A. 2006. *Soyedina alexandria* and *S. calcarea* (Plecoptera: Nemouridae), new stonefly species from the eastern Nearctic region and notes on the life cycle of *S. calcarea*. Illiesia 2(6): 39-49.

Grubbs, S. A. 2012. An amended redescription of the male of *Perlesta etnieri* (Plecoptera: Perlidae) plus new *Perlesta* state records. Illiesia 8(09): 111-113.

Grubbs, S. A. and R. E. DeWalt. 2008. Taxonomic and distributional notes on *Perlesta teaysia, P. golconda*, and *P. shawnee* (Plecoptera: Perlidae). Illiesia 4(14): 143-149.

Grubbs, S. A., R. W. Baumann, and A. L. Sheldon. 2015. A review of eastern Nearctic *Zapada* with a new species from the Great Smoky Mountains (Plecoptera, Nemouridae). Freshwater Science 34(4): 1312-1323.

Grubbs S. A., R. W. Baumann, E. R. DeWalt and T. Tweddale. 2014. A review of the Nearctic genus *Prostoia* (Ricker) (Plecoptera, Nemouridae), with the description of a new species and a surprising range extension for *P. hallasi* Kondratieff & Kirchner. ZooKeys 401: 11–30.

Grubbs, S. A., C. M. Thomas, B. T. Hutchins and J. M. Taylor. 2006. Life cycles of *Allocapnia recta* and *Leuctra* spp. (Plecoptera: Capniidae and Leuctridae) across a flow gradient in a central Kentucky karst headwater stream. Southeastern Naturalist 5(2): 321-332.

H –

Harper, P. P. 1973a. Life histories of Nemouridae and Leuctridae in Southern Ontario (Plecoptera). Hydrobiologia 41(3): 309-356.

Harper, P. P. 1973b. Emergence, reproduction, and growth of setipalpian Plecoptera in southern Ontario. Oikos 24: 94-107.

Harper, P. P. and H. B. N. Hynes. 1971a. The Capniidae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology 49: 921-940.

Harper, P. P. and H. B. N. Hynes. 1971b. The Leuctridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology 49: 915-920.

Harper, P. P. and H. B. N. Hynes. 1971c. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology 49: 1129-1142.

Harper, P. P. and H. B. N. Hynes. 1971d. The nymphs of the Taeniopterygidae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology 49: 941-947.

Harper, P.P. and H.B.N. Hynes. 1972. Life-histories of Capniidae and Taeniopterygidae (Plecoptera) in southern Ontario. Archiv fur Hydrobiologie 3: 274-314.

Harper, P. P., M. Lauzon and F. Harper. 1991. Life cycles of 12 species of winter stoneflies from Quebec (Plecoptera; Capniidae and Taeniopterygidae). Canadian Journal of. Zoology 69: 787-796.

Hilsenhoff, W. L. and S. J. Billmyer. 1973. Perlodidae (Plecoptera) of Wisconsin. The Great Lakes Entomologist 6: 1-14.

Hitchcock, S. W. 1974. Guide to the Insects of Connecticut. Part VII. The Plecoptera or Stoneflies of Connecticut. Bulletin of the State Geological and Natural History Survey of Connecticut. 107. vi + 262 pp.

Huryn, A. D., and J. B. Wallace. 1987. The exopterygote insect community of a mountain stream in North Carolina, USA: Life histories, production, and functional structure. Aquatic Insects 9(4): 229-251.

J –

Jop, K. and S. W. Szczytko. 1984. Life cycle and production of *Isoperla signata* (Banks) in a Central Wisconsin trout stream. Aquatic Insects 6(2): 81-99.

K –

Kirchner, R. F. and P. P. Harper. 1983. The nymph of *Bolotoperla rossi* (Frison) (Plecoptera: Taeniopterygidae: Brachypterinae). Journal of the Kansas Entomological Society 56(3): 411-414.

Kirchner, R. F. and B. C. Kondratieff. 1984. A new *Diploperla* from West Virginia (Plecoptera: Perlodidae). Proceedings of the Entomological Society of Washington 86(3): 648-652.

Kirchner, R. F. and B. C. Kondratieff. 1985. The nymph of *Hansonoperla appalachia* Nelson (Plecoptera: Perlidae). Proceedings of the Entomological Society of Washington 87(3): 593-596.

Kirchner, R. F. and B. C. Kondratieff. 1997. A new species of *Perlesta* (Plecoptera: Perlidae) from Virginia. Proceedings of the Entomological Society of Washington 99(2): 290-293.

Kondratieff, B. C. 2004. Perlodidae (The Springflies). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Kondratieff, B. C. and J. L. Despins. 1983. Seasonal flight pattern of Plecoptera from North Otter Creek, Virginia. Enomological News 94(2): 41-44.

Kondratieff, B. C. and R. F. Kirchner. 1982. *Taeniopteryx nelsoni*, a new species of winter stonefly from Virginia (Plecoptera: Taeniopterygidae). Journal of the Kansas Entomological Society 55(1): 1-7.

Kondratieff, B. C. and R. F. Kirchner. 1984a. A new species of Nemouridae (Plecoptera) from the Great Dismal Swamp, Virginia, USA. Proceedings of the Entomological Society of Washington. 86(3): 578-581.

Kondratieff, B. C. and R. F. Kirchner. 1984b. New species of *Taeniopteryx* (Plecoptera: Taeniopterygidae) from South Carolina. Annals of the Entomological Society of America 77(6): 733-736.

Kondratieff, B. C. and R. F. Kirchner. 1991. New Nearctic Chloroperlidae (Plecoptera). Journal of the New York Entomological Society 99(2): 199-203.

Kondratieff, B. C. and R. F. Kirchner. 1996. Two species of *Hansonoperla* (Plecoptera: Perlidae) from eastern North America. Annals of the Entomological Society of America 89(4): 501-509.

Kondratieff, B. C. and R. F. Kirchner. 2004. *Alloperla lenati*, a new species of stonefly from North Carolina (Plecoptera: Chloroperlidae) and two new state records (Plecoptera: Perlodidae). Annals of the Entomological Society of America 97(3): 361-363.

Kondratieff, B. C. and C. H. Nelson. 1995. A review of the genus *Remenus* Ricker (Plecoptera: Perlodidae), with descriptions of two new species. Proceedings of the Entomological Society of Washington 97(3): 596-602.

Kondratieff, B. C. and W. B. Painter. 1986. Two new records of stoneflies (Plecoptera: Perlodidae) from South Carolina. Entomological News 97(1): 17-20.

Kondratieff, B. C. and J. R. Voshell, Jr. 1979. A Checklist of the stoneflies (Plecoptera) of Virginia. Entomological News 90: 241-246.

Kondratieff, B. C., R. F. Kirchner and D. R. Lenat. 1995. A review of stonefly records (Plecoptera: Hexapoda) of North Carolina and South Carolina. Brimleyana 23:25-40.

Kondratieff, B. C., R. F. Kirchner and D. L. Lenat. 2005. Two new species of *Haploperla* Navás (Plecoptera: Chloroperlidae) from North Carolina, U.S.A. Proceedings form the Entomological Society of Washington 107(4): 859-863.

Kondratieff, B. C., R. F. Kirchner and K. W. Stewart. 1988. A review of *Perlinella* Banks (Plecoptera: Perlidae). Annals of the Entomological Society of America 89(1): 24-30.

Kondratieff, B. C., R. F. Kirchner and J. R. Voshell Jr. 1981. Nymphs of *Diploperla*. Annals of the Entomological Society of America 74: 428-430.

Kondratieff, B.C., R. E. Zuellig, and D. R. Lenat. 2011. A new species of *Perlesta* (Plecoptera: Perlidae) from North Carolina with additional records for North Carolina and Virginia. Illiesia 7(27):297-301.

Kondratieff, B. C., R. F. Kirchner, R. E. Zuellig, and D. R. Lenat. 2007. A new species of *Tallaperla* (Plecoptera: Peltoperlidae) from North Carolina, U. S. A. Entomological News 118 (1): 81-82.

Kondratieff, B. C., R. E. Zuellig, R. F. Kirchner, and D. R. Lenat. 2006. Three new species of *Perlesta* (Plecoptera: Perlidae) from eastern North America and notes on new state records. Illiesia 2(5): 31-38.

Kondratieff, B. C., R. E. Zuellig, R. F. Kirchner, and D. R. Lenat. 2008. Two new species of *Perlesta* (Plecoptera: Perlidae) from eastern North America. Proceedings of the Entomological Society of Washington 110(3): 668-673.

Kreuger, C. C. and E. F. Cook. 1981. Life cycles, drift, and standing stocks of some stoneflies (Insecta: Plecoptera) from streams in Minnesota, U.S.A. Hydrobiologia 83(1): 85-92.

L –

Lechleitner, R. A. and B. C. Kondratieff. 1983. The life history of *Pteronarcys dorsata* (Say) (Plecoptera: Pteronarcyidae) in southwestern Virginia. Canadian Journal of Zoology 61: 1981-1985.

LeGrande, H. E, J. A. Ratcliffe and J. T. Finnegan. 2014. Natural Heritage Program List of the Rare Animal Species of North Carolina. Office of Land and Water Stewardship, North Carolina Department of Environment and Natural Resources. Raleigh, NC.

Lehmkuhl, D. M. 1970. Studies on growth and development of the stonefly, *Paragnetina media* Walker (Plecoptera: Perlidae). American Midland Naturalist 84(1): 274-278.

Lenat, D. R. 1993. A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water quality ratings. Journal of the North American Benthological Society 12: 279-290.

Lenat, D. R. and D. L. Penrose. 1987. New distribution records for North Carolina macroinvertebrates. Entomological News 98(2) 67-73.

Lenat, D. R., R. E. Zuellig, B. C. Kondratieff and S. R. Beaty. 2009. Distribution of *Neoperla* (Plecoptera: Perlidae) in North Carolina, with new state records for three species. Illiesia 5(15): 164-168.

M –

Mackay, R. J. 1969. Aquatic insect communities of a small stream on Mont. St. Hilaire, Quebec. Journal of Fisheries Research Board of Canada 26(5): 1157-1183.

Martinson, R. J., J. B. Sandberg and B. C. Kondratieff. 2012. Life history and food habits of *Isoperla quinquepunctata* (Banks) (Plecoptera: Perlodidae) from a spring source and Willow Creek in the Piceance Basin, Colorado. Illiesia 8(12): 125-133.

Minshall, G. W. and J. N. Minshall. 1966. Notes on the life history and ecology of *Isoperla clio* (Newman) and *Isogenus decisus* Walker (Plecoptera: Perlodidae). American Midland Naturalist 76(2): 340–350.

Myers, L. W. and B. C. Kondratieff. 2009. Descriptions of the nymphs of eastern North American species of *Cultus* (Plecoptera: Perlodidae). Entomologica Americana 115(2): 109-114.

N –

Needham, J. G. and P. W. Claassen. 1925. A monograph of the Plecoptera or stoneflies of America north of Mexico. Thomas Say Foundation Publications 2: 1-397.

Nelson, C. H. 1982. Notes on the life histories of *Strophopteryx limata* (Frison) and *Oemopteryx contorta* (Needham and Claassen) (Plecoptera: Taeniopterygidae) in Tennessee. Journal of the Tennessee Academy of Science 57(1): 9-15.

Nelson, C. H. 1996. Placement of *Helopicus rickeri* Stark in *Hydroperla* Frison (Plecoptera: Perlodidae) with the description of the adult female, nymph, and egg and a cladistics analysis of *Hydroperla*. Proceedings of the Entomological Society of Washington 98(2): 237-244.

Nelson C. H. 2000. Pteronarcyidae (The Salmonflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 Number 1. vii + 100 pp

Nelson C. H. 2001. The *Yugus bulbosus* complex, with a comment on the phylogenetic position of *Yugus* within the eastern Perlodini (Plecoptera: Perlodidae: Perlodinae). Proceedings of the Entomological Society of Washington 103: 601-619.

NC DENR. 2013. Standard Operating Procedures for Collection and Analysis of Benthic Macroinvertebrates. December 2013 (Version 4). North Carolina Department of Environment and Natural Resources Division of Water Resources, Environmental Sciences Section, Biological Assessment Branch. Raleigh, NC.

P –

Parker C. R, O. S. Flint, L. M. Jacobus, B. C. Kondratieff, W. P. McCafferty, and J. C. Morse. 2007. Ephemeroptera, Plecoptera, Megaloptera, and Trichoptera of Great Smoky Mountains National Park. Southeastern Naturalist, Special Issue 1: 159-174.

Peckarsky, B. L. 1979. A review of the distribution, ecology and evolution of North American species of *Acroneuria* and six related genera (Plecoptera: Perlidae). Journal of the Kansas Entomological Society 52: 787-809.

Pescador, M. L., A. K. Rasmussen and B. A. Richard. 2000. A Guide to the Stoneflies (Plecoptera) of Florida. Florida Department of Environmental Protection, Division of Water Resources Management, Tallahassee. 94 pp. + 72 p. Appendix

Poulton, B. C. and K. W. Stewart. 1991. The stoneflies of the Ozark and Ouachita Mountains (Plecoptera). Memoires of the American Entomological Society, No. 38: 1-116.

R –

Ray, D. H. and B. P. Stark. 1981. The Nearctic species of *Hydroperla* (Plecoptera: Perlodidae). Florida Entomologist 64: 385-395.

Ray, D. H., A. K. Rasmussen, J. G. Peters and B. P. Stark. 2010. The larva and egg of *Alloperla prognoides* (Plecoptera: Chloroperlidae), with ecological notes and new state records from Florida, U.S.A. Illiesia 6(19): 256-266.

Ricker, W. E. 1952. Systematic studies in Plecoptera. Indiana University Publications, Science Series 18: 1-200.

Ross, H. H. and T. H. Frison. 1937. Studies of Nearctic Insects. Illinois Natural History Survey Bulletin 21: 55-99.

Ross, H. H. and W. E. Ricker. 1971. The classification, evolution, and dispersal of the winter stonefly genus *Allocapnia*. Illinois Biological Monograph 45. University of Illinois Press, Urbana and Chicago, Illinois. 166 pp.

Ruggles, K. K. and D. C. Tarter. 1991. Ecological life history of *Peltoperla tarteri* (Plecoptera: Peltoperlidae) from Big Hollow of Paint Creek, Fayette County, WV. Psyche 98: 33-46.

S –

Sandberg J. B. and K. W. Stewart. 2005a. Holomorphology and systematics of the stonefly genus *Isogenoides* (Plecoptera: Perlodidae). Transactions of the American Entomological Society 131(3-4): 269-345.

Sandberg J. B. and K. W. Stewart. 2005b. Life history of the stonefly *Isogenoides zionensi* (Plecoptera: Perlodidae) from the San Miguel River, Colorado. Illiesia 1(4): 1-12.

Schmidt, D. A. and D. C. Tarter. 1985. Life history and ecology of *Acroneuria carolinensis* (Banks) in Panther Creek, Nicholas County, West Virginia (Plecoptera: Perlidae). Psyche 92: 393-406.

Snellen, R. K. and K. W. Stewart. 1979. The life cycle of *Perlesta placida* (Plecoptera: Perlidae) in an intermittent stream in northern Texas. Annals of the Entomological Society of America 72(4):659-666.

Stark, B. P. 1985. Notes on *Oconoperla* (Plecoptera: Perlodidae). Entomological News 96(4): 151-155.

Stark, B. P. 1986. The Nearctic species of *Agnetina* (Plecoptera: Perlidae). Journal of the Kansas Entomological Society 59(3): 437-445.

Stark, B. P. 2000. Peltoperlidae (The Roachflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 Number 1. vii + 100 pp.

Stark, B. P. 2004. Perlidae (The Stones). *In* Stark B. P and B. J. Armitage (eds). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin, New Series. 14 (4). vi + iv p.

Stark, B. P. 2016. Plecoptera, Chapter 3 (xx pp). *In* Morse, J.C., W.P. McCafferty, B.P. Stark, & L.M. Jacobus (Eds.). *Larvae of the Southeastern USA Mayfly, Stonefly, and Caddisfly Species*. PSA Publishing, Clemson University, Clemson, South Carolina, USA, Biota of South Carolina 9 (Technical Bulletin 1109): 1–???.

Stark, B. P. and R. W. Baumann. 2004. The winter stonefly genus *Paracapnia* (Pelcoptera: Capniidae). Monograph of the Western North American Naturalist. 2: 96-108.

Stark, B. P. and L. D. Brown. 1991. What is *Acroneuria evoluta* Klapálek (Plecoptera: Perlidae). Aquatic Insects, 13(1): 29-32.

Stark, B. P. and A. R. Gaufin. 1976a. The Nearctic species of *Acroneuria* (Plecoptera: Perlidae). Journal of the Kansas Entomological Society, 49(2): 221-253.

Stark, B. P. and A. R. Gaufin. 1976b. The Nearctic genera of Perlidae (Plecoptera). Miscellaneous Publications Entomological Society of America 10: 1-77.

Stark B. P. and B. C. Kondratieff. 1987 A new species of *Peltoperla* from eastern North America (Plecoptera: Peltoperlidae). Proceedings of the Entomological Society of Washington 89: 141-146.

Stark, B. P. and B. C. Kondratieff. 2010. Larvae of eight eastern Nearctic *Alloperla* species (Plecoptera: Chloroperlidae). Illiesia 6(20): 267-276.

Stark, B. P. and J. W. Kyzar. 2000. Systematics of Nearctic *Paraleuctra* with description of a new genus (Plecoptera: Leuctridae). Tijdschrift voor Entomologie 144: 119-135.

Stark B. P. and J. W. Lacey. 2005. Larvae of the winter stonefly genus *Allocapnia* (Plecoptera: Capniidae) in Mississippi, USA. Illiesia 1(3):10-20.

Stark, B. P. and D. H. Ray. 1983. A revision of the genus *Helopicus* (Plecoptera: Perlodidae). Freshwater Invertebrate Biology 2(1): 16-27.

Stark, B. P. and K. W. Stewart. 1981. The Nearctic Genera of Peltoperlidae (Plecoptera). Journal of the Kansas Entomological Society 54(2): 285-311.

Stark, B. P. and K. W. Stewart. 1982a. *Oconoperla*, a new genus of North American Perlodinae (Plecoptera: Perlodidae). Proceedings of the Entomological Society of Washington 84(4): 747-752.

Stark, B. P. and K. W. Stewart. 1982b. The nymph of *Viehoperla ada* (Plecoptera: Peltoperlidae). Journal of the Kansas Entomological Society 55: 494-498.

Stark, B. P. and S. W. Szczytko. 1981. Contributions to the systematics of *Paragnetina* (Plecoptera: Perlidae). Journal of the Kansas Entomological Society 54(3): 625-648.

Stark, B. P. and S. W. Szczytko. 1988. A new *Malirekus* species from eastern North America (Plecoptera: Perlodidae). Journal of the Kansas Entomological Society 61(2): 195-199.

Stark, B. P., S. W. Szczytko and R. W. Baumann. 1986. North American stoneflies (Plecoptera): systematics, distribution, and taxonomic references. The Great Basin Naturalist 46(3): 383-397

Stark, B. P., S. W. Szczytko and B. C. Kondratieff. 1988. The *Cultus decisus* complex of Eastern North America (Plecoptera: Perlodidae). Proceedings of the Entomological Society of Washington, 90(1): 91-96.

Stark, B. P., B. C. Kondratieff, R . F. Kirchner and K. W. Stewart. 2011. Larvae of Eight Eastern North American *Sweltsa* (Plecoptera: Chloroperlidae). Illiesia 7(04):51-64.

Stark, B. P., K. W. Stewart., S. W. Szczytko and R. W. Baumann. 1998. Common names of stoneflies (Plecoptera) from the United States and Canada. Ohio Biological Survey Notes 1: 1-18.

Stewart, K. W. 2000. Taeniopterygidae (The Willowflies), pp. 55-87. *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume I. Pteronarcyidae, Peltoperlidae, and Taeniopterygidae. Ohio Biological Survey Bulletin New Series Volume 14 No. 1, vii + 100 p.

Stewart, K.W. 2009. New descriptions of North American *Taenionema* larvae (Plecoptera: Taeniopterygidae). Illiesia 5(12):128-145.

Stewart, K. W. and N. H. Anderson. 2010. The life history of *Ostrocerca dimicki* (Frison) in a short-flow, summer-dry Oregon stream. Illiesia 6(06): 52-57.

Stewart, K. W. and B. P. Stark. 2002. Nymphs of North American Stonefly Genera (Plecoptera). Second Edition. The Caddis Press. Columbus, Ohio, xii + 510pp.

Stewart, K. W. and B. P. Stark 2008. Chapter 14. Plecoptera. pp 311-384. *In* R. W. Merrit, K. W. Cummins and M. B. Berg (editors). An Introduction to the Aquatic Insects of North America. Fourth edition. Kendall Hunt Publishing. Dubuque, Iowa. pp 1158.

Surdick, R. F. 1985. Nearctic genera of Chloroperlinae (Plecoptera: Chloroperlidae). Illinois Biological Monographs 54: 1-146.

Surdick, R. F. 2004. Chloroperlidae (The Sallflies). *In* B. P. Stark and B. J. Armitage (editors). Stoneflies (Plecoptera) of Eastern North America. Volume II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae). Ohio Biological Survey Bulletin New Series Volume 14 Number 4. vi + 192 pp.

Szczytko, S. W. and K. W. Stewart. 1981. Reevaluation of the Genus *Clioperla*. Annals of the Entomological Society of America 74(6): 563-569.

Szczytko, S. W. and B. C. Kondratieff. 2015. A review of the Eastern Nearctic Isoperlinae (Plecoptera: Perlodidae) with the description of twenty-two new species. Monographs of Illiesia 1: 1-289.

Szczytko, S. W. and B. C. Kondratieff. 2015. A photographic atlas of the Eastern Nearctic Isoperlinae (Plecoptera: Perlodidae) species. Monographs of Illiesia 2: 1-124.

T –

Tarter, D. C. and L. A. Krumholz. 1971. Life history and ecology of *Paragnetina media* (Walker) (Insecta: Plecoptera) in Doe Run, Meade County, Kentucky. American Midland Naturalist 86(1): 169-180.

Tarter, D. C., M. L. Little, R. F. Kirchner, W.D. Watkins, R. G. Farmer and D. Steele. 1975. Distribution of pteronarcid stoneflies in West Virginia (Insecta: Plecoptera). Proceedings of the West Virginia Academy of Science 47: 79-85.

Townsend, G. D. and G. Pritchard. 1998. Larval growth and development of the stonefly *Pteronarcys californica* (Insecta: Plecoptera) in the Crowsnest River, Alberta. Canadian Journal of Zoology 76: 2274-2280.

U –

Unzicker, J. D. and V. H. McCaskill. 1982. Plecoptera, Chapter 5 (50 pp.). *In* A. R. Brigham, W. U. Brigham, and A. Gnilka, editors. *Aquatic Insects and Oligochaetes of North and South Carolina*. Midwest Aquatic Enterprises, Mahomet, Illinois. 837pp.

V –

Vaught, G. L. and K. W. Stewart. 1974. The life history and ecology of the stonefly *Neoperla clymene* (Newman) (Plecotera: Perlidae). Annals of the Entomological Society of America 67(2): 167-178.

Y –

Yokum, K. A., T. R. Angradi and D. C. Tarter. 1995. Ecology of *Peltoperla arcuata* and *Tallperla maria* (Plecoptera: Peltoperlidae) and the Fenrow Experimental Forest, Tucker County, West Virginia. Psyche 102: 151-168.

Z –

Zwick, P. 1971. Notes on the genus *Perlinella* and a generic synonymy in North American Perlidae (Plecoptera). The Florida Entomologist 54(4): 315-320.

Zwick, P. 2006. New family characters of larval Plecoptera, with an analysis of the Chloroperlidae: Paraperlinae. Aquatic Insects 28(1): 13-22.

Confirmed stonefly genera and species occurring in North Carolina with NCBI tolerance data (T.V.). Taxa with fewer than 50 records, or with records that are historical, have no associated tolerance value. Values last updated in 2010. Total number of valid records are through Dec 2015. ‡ Records are historical.

Taxonomic Hierarchy	NCBI T.V.	Valid BAB nymph Records	Notes
FAMILY Genus Species			
CAPNIIDAE Banks, 1900			
Allocapnia Claassen, 1928	3.3	1158	
aurora Ricker, 1952			
fumosa Ross, 1964			Vulnerable to extirp. (Morse et al., 1997)
nivicola (Fitch, 1847)			
recta (Claassen, 1924)			
rickeri Frison, 1942			
stannardi Ross, 1964			
virginiana Frison, 1942			
wrayi Ross, 1964			
Nemocapnia Banks, 1938			
carolina Banks, 1938	---	1	Jackson Cr, Moore Co, 1989
Paracapnia Hanson, 1946			
angulata Hanson, 1961	---	46	
CHLOROPERLIDAE Okamoto, 1912			
Alloperla Banks, 1906	1.0	112	
atlantica Baumann, 1974			
chloris Frison, 1934			
lenati Kondratieff and Kirchner, 2004			Significantly Rare (NC NHP 2012), described from NC
nanina Banks, 1911			described from NC
neglecta Frison, 1935			
petasata Surdick, 2004			
usa Ricker, 1952			
Haploperla Navás, 1934		36	
brevis (Banks, 1895)	1.4	242	
fleeki Kondratieff and Kirchner, 2005	---	1	Significantly Rare (NC NHP 2012), described from NC, Lower Little R., Moore Co, 2004
parkeri Kondratieff and Kirchner, 2005			described from NC
Rasvena Ricker, 1952			
terna (Frison, 1942)	---	8	Significantly Rare (NC NHP 2012)
Suwallia Ricker, 1943			
marginata (Banks, 1897)	2.6	230	
Sweltsa Ricker, 1943	0.2	541	
holstonensis Kondratieff and Kirchner, 1998			Vulnerable to extirp. (Morse et al., 1997)
lateralis (Banks, 1911)			described from NC
mediana (Banks, 1911)			described from NC
urticae (Ricker, 1952)			Vulnerable to extirp. (Morse et al., 1997)
voshelli Kondratieff and Kirchner, 1991			
LEUCTRIDAE Klapálek, 1905			
Leuctra Stephens, 1836	1.5	1987	
alexanderi Hanson, 1941			
biloba Claassen, 1923			
carolinensis Claassen, 1923			described from NC
ferruginea (Walker, 1851)			
grandis Banks, 1906			described from NC
mitchellensis Hanson, 1941			
monticola Hanson, 1941			
nephophila Hanson, 1941			

CONTINUED

Taxonomic Hierarchy FAMILY Genus Species	NCBI T.V.	Valid BAB nymph Records	Notes
LEUCTRIDAE Klapálek, 1905 cont.			
sibleyi Claassen, 1923			
tenuis (Pictet, 1841)			
triloba Claassen, 1923			
variabilis Hanson, 1941			
Megaleactra Neave, 1934			
williamsae Hanson, 1941	---	1	Vulnerable to extirp. (Morse et al., 1997)
Paraleuctra Hanson, 1941			
sara (Claassen, 1937)			ref. specimen from outside collection
NEMOURIDAE Newman, 1853			
Amphinemura Ris, 1902	3.8	1037	
appalachia Baumann, 1996			
delosa (Ricker, 1952)			
nigritta (Provancher, 1876)			
wui (Claassen, 1936)			
Ostrocerca Ricker, 1952			ref. specimen from D. Lenat
albidipennis (Walker, 1852)			
truncata (Claassen, 1923)			
Paranemoura Needham & Claassen, 1925			
perfecta (Walker, 1852)			
Prostoia Ricker, 1952	5.2	230	
completa (Walker, 1852)			
hallasi Kondratieff and Kirchner, 1984			described from Great Dismal Swamp
Shipsa Ricker, 1952			
rotunda (Claassen, 1923)	---	41	
Soyedina Ricker, 1952	---	31	
carolinensis (Claassen, 1923)			described from NC
kondratieffi Baumann and Grubbs, 1996			described from NC
washingtoni (Claassen, 1923)			
Zapada Ricker, 1952			
fumosa Baumann and Grubbs, 2015	---	3	
PELTOPERLIDAE Claassen, 1931			
Peltoperla Needham, 1905			
tarteri Stark & Kondratieff, 1987			BRP seeps
Tallaperla Stark and Stewart, 1981	1.3	2221	
anna (Needham and Smith, 1916)			
cornelia (Needham and Smith, 1916)			
elisa Stark, 1983			Vulnerable to extirp. (Morse et al., 1997)
laurie (Ricker, 1952)			
maiyae Kondratieff, Kirchner, and Zuellig, 2007			described from NC
maria (Needham and Smith, 1916)			
Viehoperla Ricker, 1952			
ada (Needham and Smith, 1916)	---	12	
PERLIDAE Latreille, 1802			
Acroneuria Pictet, 1841	---	92	
abnormis (Newman, 1838)	2.1	3660	
arenosa (Pictet, 1841)	2.4	121	
arida (Hagen, 1861)			Vulnerable to extirp. (Morse et al., 1997)
carolinensis (Banks, 1905)	1.2	233	described from NC
evoluta Klapálek, 1909	1.7	69	
filicis Frison, 1942	---	21	
frisoni Stark and Brown, 1991	---	30	
lycorias (Newman, 1839)	2.1	101	
perplexa Frison, 1937	---	4‡	

CONTINUED

Taxonomic Hierarchy		NCBI T.V.	Valid BAB nymph Records	Notes
FAMILY	**Genus Species**			
PERLIDAE Latreille, 1802 cont.				
	Agnetina Klapálek, 1907	1.1	91	
	annulipes (Hagen, 1861)	---	31	
	capitata (Pictet, 1841)	---	41	
	flavescens (Walsh, 1862)	---	31	
	Attaneuria Ricker, 1954			
	ruralis (Hagen, 1861)	---	5	Significantly Rare (NC NHP 2012)
	Beloneuria Needham & Claassen, 1925	0.0	111	
	georgiana (Banks, 1914)			Vulnerable to extirp. (Morse et al., 1997)
	stewarti Stark and Szczytko, 1976			Vulnerable to extirp. (Morse et al., 1997)
	Eccoptura Klapálek, 1921			
	xanthenes (Newman, 1838)	4.7	955	
	Hansonoperla Nelson, 1979			
	appalachia Nelson, 1979	---	5	
	Neoperla Needham, 1905	2.1	653	
	catharae Stark and Baumann, 1978			
	clymene (Newman, 1839)			
	coosa Smith and Stark, 1998			
	stewarti Stark and Baumann, 1978			
	Paragnetina Klapálek, 1907	---	50	
	fumosa (Banks, 1902)	3.6	702	
	ichusa Stark and Szczytko, 1981	0.2	238	as *P. ichusa/media*
	immarginata (Say, 1823)	1.1	1391	
	kansensis (Banks, 1905)	1.9	75	
	Perlesta Banks, 1906	2.9	1924	incl. *P. placida* (dubious) records
	beatyi Kondratieff and Lenat, 2011			
	bjostadi Kondratieff and Lenat, 2006			
	decipiens (Walsh, 1862)			
	durfeei Kondratieff, Zuellig and Kirchner, 2008			
	frisoni Banks, 1948			
	georgiae Kondratieff, Zueliig, and Lenat, 2006			described from NC
	leathermani Kondratieff and Zuellig, 2006			
	nelsoni Stark, 1989			
	placida (Hagen, 1861)	n.a.	620‡	
	puttmanni Kondratieff and Kirchner, 2003			
	roblei Kondratieff and Kirchner, 2003			
	shawnee Grubbs, 2005			
	Perlinella Banks, 1900	---	22	
	drymo (Newman, 1839)	1.3	67	
	ephyre (Newman, 1839)	---	11	Significantly Rare (NC NHP 2012)
	zwicki Kondratieff, Kirchner, and Stewart, 1988			
PERLODIDAE Klapálek, 1909				
	Clioperla Needham & Claassen, 1925			
	clio (Newman, 1839)	5.2	414	
	Cultus Ricker, 1952	---	5	
	decisus (Walker, 1852)	1.5	217	NC subspecies - *C. d. isolatus*
	verticalis (Banks, 1920)			
	Diploperla Needham & Claassen, 1925	---	16	
	duplicata (Banks, 1920)	2.8	348	
	kanawholensis Kirchner and Kondratieff, 1984			as *kanawholensis/morgani*
	morgani Kondratieff and Voshell, 1979	---	42	Vulnerable to extirp. (Morse et al., 1997)
	Helopicus Ricker, 1952	---	16	
	bogaloosa Stark and Ray, 1983	---	31	
	subvarians (Banks, 1920)	1.2	155	

CONTINUED

Taxonomic Hierarchy	NCBI T.V.	Valid BAB nymph Records	Notes
FAMILY Genus Species			
PERLODIDAE Klapálek, 1909 cont.			
Hydroperla Frison, 1935			
phormidia Horn, 1970			Significantly Rare (NC NHP 2012)
Isogenoides Klapálek, 1912		8	
hansoni (Ricker, 1952)	---	65	
varians (Walsh, 1862)	---	2	
Isoperla Banks, 1906	3.2	169	
bellona Banks, 1911		n.a.	Vulnerable to extirp. (Morse et al., 1997), described from NC 111 records as similis/pseudosimilis gr.
burksi Frison, 1942	---	29	
cherokee Szcytko and Kondratieff, 2015		n.a.	111 records as *similis/pseudosimilis* gr.
davisi James, 1974		382	as *davisi/* nr. *transmarina*
dicala Frison, 1942	---	57	
fauschi Szcytko and Kondratieff, 2015		4	as cf. *fauschi*
frisoni Illies, 1966	---	9	
holochlora (Klapálek, 1923)	0.7	1707	includes light and dark-form records
kirchneri Szcytko and Kondratieff, 2015		n.a.	494 records as *kirchneri* group
lata Frison, 1942	---	29	many misIDs, as *lata/pseudolata*
lenati Szcytko and Kondratieff, 2015			
montana Szcytko and Kondratieff, 2015		n.a.	494 records as kirchneri complex
nelsoni Szcytko and Kondratieff, 2015			
orata Frison, 1942	0.0	94	
pauli Szcytko and Kondratieff, 2015		n.a.	111 records as *similis/pseudosimilis* gr.
poffi Szcytko and Kondratieff, 2015		142	as *poffi* /Collins Cr, ony coastal plain records are *poffi*
powhatan Szcytko and Kondratieff, 2015		5	as cf. *powhatan*
pseudolata Szcytko and Kondratieff, 2015		n.a.	many misIDs, as *lata/pseudolata*
pseudosimilis Szcytko and Kondratieff, 2015		n.a.	111 records as *similis/pseudosimilis* gr.
reesi Szcytko and Kondratieff, 2015		n.a.	111 records as *similis/pseudosimilis* gr.
siouan Szcytko and Kondratieff, 2015		n.a.	494 records as *kirchneri* complex
slossonae (Banks, 1911)	1.2	33	many historical misIDs
starki Szcytko and Kondratieff, 2015		n.a.	111 records as *similis/pseudosimilis* gr.
stewarti Szcytko and Kondratieff, 2015		n.a.	111 records as *similis/pseudosimilis* gr.
transmarina (Newman, 1838)	4.8	357	
tutelo Szcytko and Kondratieff, 2015		n.a.	494 records as *kirchneri* complex
zuelligi Szcytko and Kondratieff, 2015			
"Collins Cr" n. sp. (in prep)		142	as *poffi* /Collins Cr, only slate belt records are n sp Collins Cr
"Mayo R" n. sp. (in prep)		1	Mayo River
Malirekus Ricker, 1952			
hastatus (Banks, 1920)	1.0	868	
Oconoperla Stark & Stewart, 1982			
innubila (Needham and Claassen, 1925)			Vulnerable to extirp. (Morse et al., 1997), described from NC
Remenus Ricker, 1952			
bilobatus (Needham and Claassen, 1925)	0.9	407	described from NC
kirchneri Kondratieff & Nelson, 1995			
Yugus Ricker, 1952		16	
arinus (Frison, 1942)	---	36	
bulbosus (Frison, 1942)	---	130	
kondratieffi Nelson, 2001			

CONTINUED

Taxonomic Hierarchy			NCBI T.V.	Valid BAB nymph Records	Notes
FAMILY	**Genus**	**Species**			
PTERONARCYIDAE Newman, 1853					
	Pteronarcys Newman, 1838		1.8	1685	
		biloba Newman, 1838	0.0	115	
		comstocki Smith, 1917	---	8	Significantly Rare (NC NHP 2012)
		dorsata (Say, 1823)	2.4	547	
		proteus Newman, 1838	0.4	87	298 records prior to 2011 include *P. scotti*
		scotti Ricker, 1952		250	records since 2009, no prior records
TAENOPTERYGIDAE Klapálek, 1905					
	Bolotoperla Ricker and Ross, 1975				
		rossi (Frison, 1942)	---	9	Significantly Rare (NC NHP 2012)
	Oemopteryx Klapálek, 1902				
		contorta (Needham and Claassen, 1925)			
	Strophopteryx Frison, 1929		3.3	413	
		appalachia Ricker and Ross, 1975			
		fasciata (Burmeister, 1839)			
		limata (Frison, 1942)			
	Taenionema Banks, 1905				
		atlanticum Ricker and Ross, 1975	---	7	4 records are unverified/dubious
	Taeniopteryx Pictet, 1841		6.0	421	
		burksi Ricker and Ross, 1968	n.a.	82‡	
		lita Frison, 1942	n.a.	5‡	
		lonicera Ricker and Ross, 1968			
		maura (Pictet, 1841)			
		metequi Ricker and Ross, 1968	n.a.	44‡	
		nelsoni Kondratieff & Kirchner, 1982			
		parvula Banks, 1918	n.a.	2‡	
		ugola Ricker and Ross, 1968	n.a.	8‡	

Version	Date finalized	Author (editor)	Changes/Updates
4.1	22-Dec-2015	S. Beaty	**Changelog added** **Minor edits**
4.0	22-Dec-2015	S. Beaty	**Significant expansion and reformatting** Cover added Acknowledgements added Table of Contents reformated and expanded Introductory headings added Taxonomic Validity Taxonomic Treatments Distribution Maps Seasonality Charts Request for Data **Family treatments added** Family diagnosis Notes **Genus treatments extensively expanded and revised** Taxonomic effort levels revised Trophic Levels added Distribution Maps added Seasonality Charts added **References expanded** **List of Confirmed Species reformatted and updated**
3.3	20-Oct-2011	S. Beaty	**Minor edits/corrections** **Minor taxonomic revisions**
3.2		S. Beaty	**Minor edits/corrections**
3.1	16-Nov-2010	S. Beaty	**Minor edits/corrections**
3.0	4-Oct-2010	S. Beaty	**Significant expansion and reformat** Cover added Table of Contents added Introductory sections added How to use this manual **Species treatements expanded** Habitat added Distribution and Occurrence added Taxonomic effort levels revised Notes expanded **References expanded** **Appendix added** List of Confirmed Species

Version	Date finalized	Author (editor)	Changes/Updates
2.2	25-Jan-2010		**Minor edits**
2.1	27-Mar-2009	S. Beaty	**Species lists revised and expanded** **Minor edits**
2.0	29-May-2008	T. McPherson, S. Beaty	**Significant reorganization and reformat** Only Plecoptera treated. Ephemeroptera and Trichoptera with own dedicated document. Edits for taxonomic clarity Taxonomic effort levels revised References expanded
1.1	22-Feb-2006	T. Mcpherson (S. Beaty)	**Minor edits**
1.0	1-May-2005	T. Mcpherson	**Original document - EPT orders treated together**