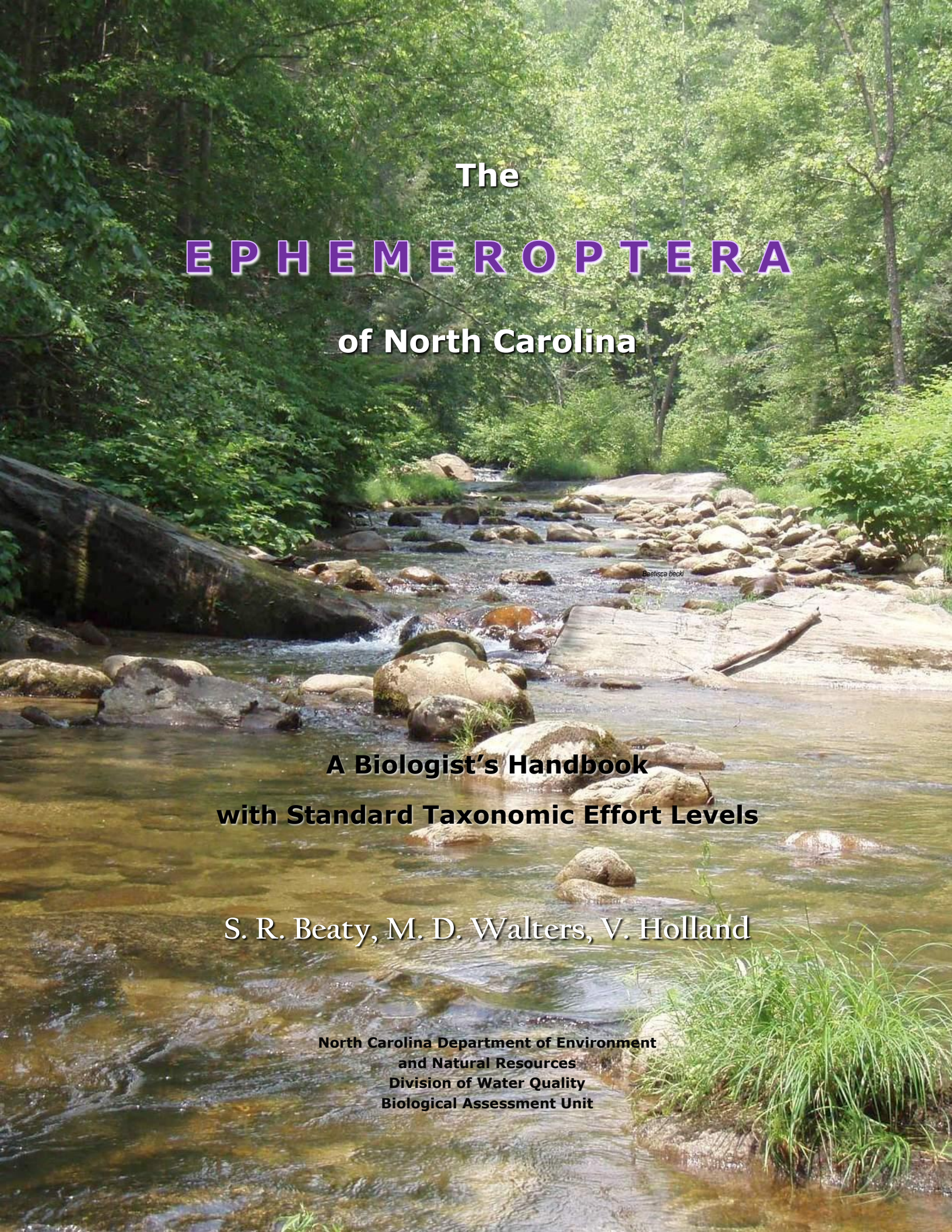

The EPHEMEROPTERA of North Carolina

A Biologist's Handbook with Standard Taxonomic Effort Levels

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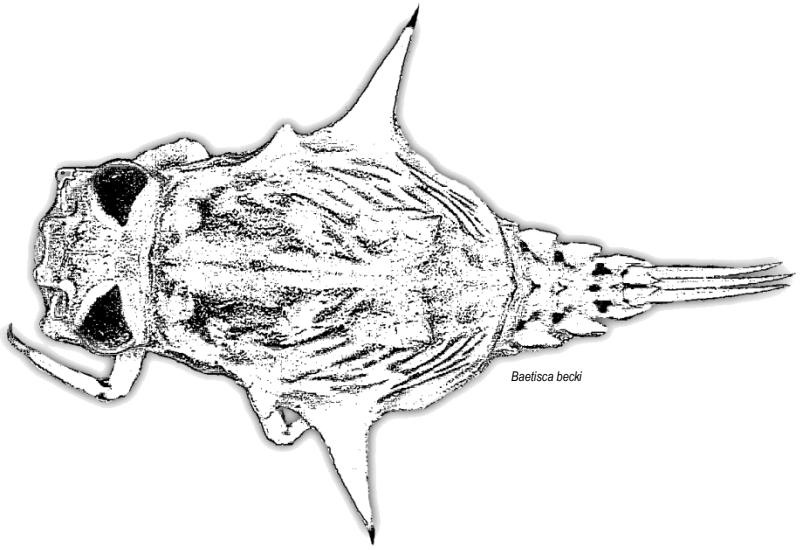
North Carolina Department of Environment
and Natural Resources
Division of Water Quality
Biological Assessment Unit



Cover: Wilson Creek, near Edgemont, Caldwell County, NC

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21 October 2013

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Families and Genera of Ephemeroptera known or suspected to occur in North Carolina

Introduction

North Carolina has one of the richest Ephemeroptera faunas in the eastern United States with at least 60 genera and over 200 species. This abundance of mayfly species can be attributed, in part, to the presence of multiple physiographic ecoregions (4 Level III ecoregions and 29 level IV ecoregions) spanning the width of the state along with a temperate, seasonal climate. The immature stages of mayflies, or nymphs, occur in almost all waters of the state and are an important link in trophic interactions by providing food for other macroinvertebrates, fish, and waterfowl. In addition, nymphal mayflies, as a group, are typically intolerant to both natural and anthropogenic stress. Some types of stressors to which mayflies are subjected include, but are not limited to, waterborne pollutants (i.e. metals, pesticides, and sediments), temperatures changes, and disturbances to flow regimes. However, it must be noted that not all perturbations affect mayflies equally. For example, one species may be tolerant to metals but functionally intolerant to changes in temperature or dissolved oxygen concentrations whereas another species may tolerate drought but not sedimentation. This "pollution" sensitivity facilitates the use of the mayfly nymphs as biological indicators of water quality, often in conjunction with other sensitive benthic macroinvertebrates such as Plecoptera (stoneflies) and Trichoptera (caddisflies).

North Carolina's Division of Water Quality's Biological Assessment Unit (BAU) has over 30 years of long-term macroinvertebrate data on many North Carolina water bodies. Most large rivers and streams have been sampled extensively over this 30-year period, with many small headwater streams inventoried as well, resulting in over 6700 collection records at 3100 unique sites. This has yielded the discovery of several new mayfly species from within the state, many of which are endemic to North Carolina. A few of these recently discovered species are named in honor of BAU biologists. As the population of North Carolina continues to grow, it is our hope that careful management of 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 quality degradation.

This document was created to help State of North Carolina biologists as well as biologists in independent laboratories and outside agencies identify the mayfly taxa present in local North Carolina waters and to stay current on recent taxonomic changes and research (e.g. synonymies or new species). It should also help to maintain a consistent level of taxonomic resolution between these 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 Quality, Biological Assessment Unit's webpage at:
http://portal.ncdenr.org/web/wq/ess/bau.

How to Use this Manual

The target users of this manual are taxonomic workers in North Carolina and surrounding states. It is therefore assumed that the user has some basic knowledge of mayflies including taxonomy, morphology, and life histories. Users not acquainted with these organisms 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. *The Ephemeroptera of North Carolina* is not intended as an exhaustive resource of mayflies occurring within North Carolina. Instead, it 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 mayfly taxa documented herein are presented in phylogenic order based on that of Merritt et al., 2008. Genera within each family or subfamily are presented in alphabetical order. Along with primary literature, valid genus/species names were verified using Mayfly Central (www.entm.purdue.edu/mayfly/). Taxonomic names used herein are valid as of early 2013 unless otherwise noted. As of this printing, the federally funded Integrated Taxonomic Information System (ITIS) website maintains approximately a two-year lag in valid nomenclature.

Taxonomic Treatments

Each genus entry has an accompanying diagnosis for the aquatic larval 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 NCDWQ 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 sizes in descriptions refer to pre-emergent nymphs although some specimens may fall outside indicated ranges. Some genera that are not identifiable to the species level have species notes included for reference only and are therefore 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 literature completes each genus entry with suggested keys denoted by an arrow. Most references can be obtained from http://www.ephemeroptera-galactica.com/. 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 mayfly 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.

Table 1. Descriptors and associated tolerance value ranges for aquatic macroinvertebrates in North Carolina.

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

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.

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

() = published records for North Carolina but no BAU larval records, or is undescribed
* = no published records for North Carolina but may eventually be found.
⇨ = suggested literature with taxonomic keys or descriptions
gray = entries in gray have been synonymized or combined with other species but synonymies not currently recognized by BAU.

Distribution Maps

This manual provides mayfly 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., DWQ Biological Assessment Unit 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. The designation the three Level III ecoregions is used for various logistical reasons but also 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 same 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.

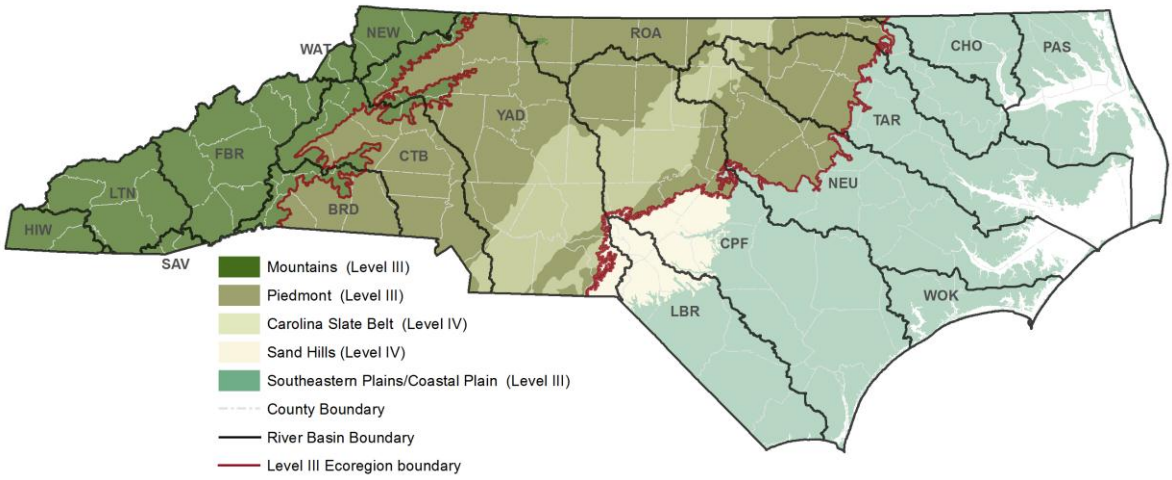


Figure 1. Approximate significant Level III and select Level IV ecoregions within North Carolina with regards to mayfly distributions.

While Level III ecoregions adequately described 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 large river basins (Figure 1, Table 2).

The distribution maps included at the end of each genus entry are based upon BAU macroinvertebrate collections, up to 30 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 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.

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.

Table 2. North Carolina's 17 river basins with basin codes.

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

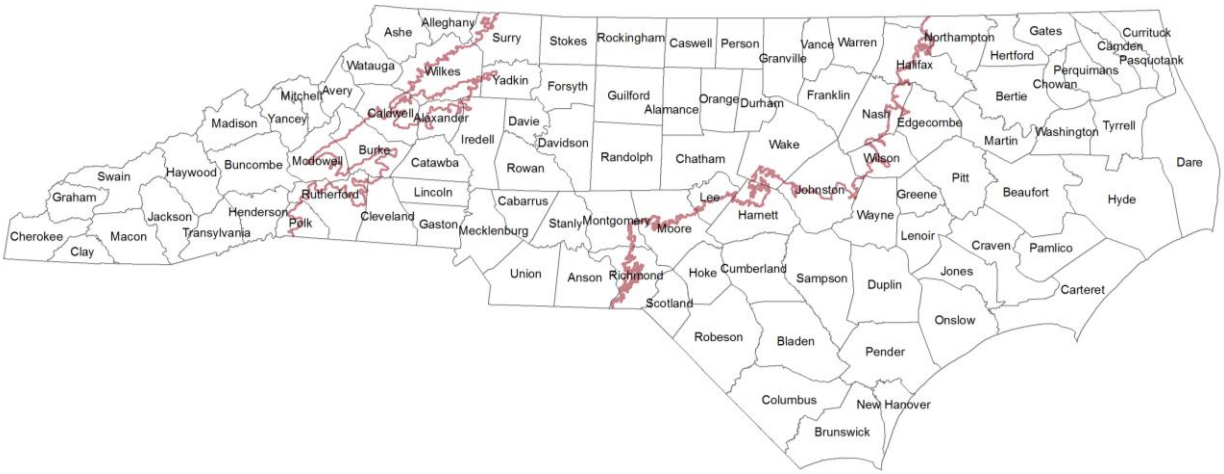


Figure 2. Counties of North Carolina. Red lines depict Level III ecoregions, from left to right: Mountains, Piedmont, Coastal Plain.

Seasonality Charts

The field season for BAU 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. 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 depict the percent occurrence 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:

$$\%\ \text{Occurrence in May samples} = \frac{\text{Total \# records of OTU in May}}{\text{Total \# of May Records}}$$

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

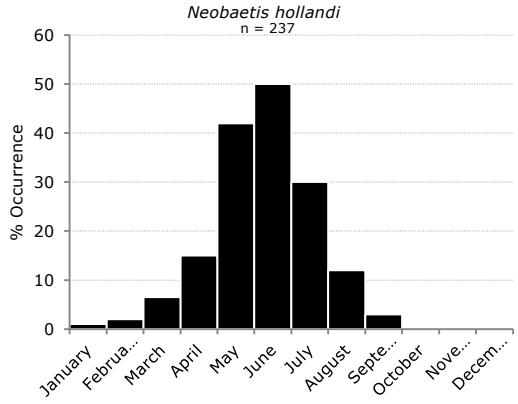


Figure 3. Generalized seasonality chart. In this example the OTU is recorded in approximately 50% of all June samples. Transition from larva to adult (emergence) typically coincides with the falling limb of the graph, while the rising limb represents larval growth.

The data represented by these seasonality charts includes only records from the Level III ecoregions where the taxon commonly occurs. 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 are composites of the ecoregions in which the taxon is present. However, 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) by up to one month, due in large part to a cooler climate. Therefore, interpretation of these graphs depends on the ecoregion the insect was collected from. In the example in Figure 3, mountain records of the hypothetical *Neobaetis hollandi* would trend towards later summer whereas Piedmont records would trend towards earlier summer.

While some charts illustrate a "clean" unimodal pattern indicating a univoltine, single cohort population, other graphs are bimodal or multimodal. 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 within each month. This type of graph can also be interpreted as depicting a long-lived semivoltine species which occurs as a larva over the course of two or three years. The point is that while some information can be gleaned from these graphs such as when a taxon generally occurs in the water (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 larval 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 provide an additional level of quality control. For example, the presence of an early season mayfly such as *Ephemerella needhami* in a late summer sample is likely due to an erroneous identification. Secondly, these charts can identify, in most cases, the general time when adults emerge. This is useful information for some 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 or as environmental disturbances such as reduced flows during drought conditions become more prevalent.

Appendices

A list of general taxonomic literature and regional checklists, which may also be useful to users of this manual, follows the taxonomic entries. Finally, an appendix table with a list of species (alphabetical on Family then Genus then species), associated distributional and tolerance value data, number of DWQ records, available reference specimens, and important 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 mayflies 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 (DD), 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 BAU taxonomists for verification of certain taxa and/or distributional records.*

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

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, along with the combined taxonomic and sampling efforts of both current and former BAU aquatic biologists: Eric Fleek, Tracy Morman, Deirdre Black, Bill Crouch, Blair Prusha, Larry Eaton, Larry Ausley, Richard Thorp, Cathy Tyndall, Dave Penrose, and Ross VanderVorste (honorary BAU member). For field sampling and sample processing, including the digging out of old specimens, we thank the tireless efforts of Michelle Simonson, Michael Shepard, Nate Hartsell, Mark Hale, Elizabeth Foote, and Sheri Ferrell. Also we thank the many systematic and taxonomic mayfly experts that have weighed in on this manual either by providing verifications, additional taxonomic characters for identification, taxonomic and locational data, comments, or specimens: Luke Jacobus, Boris Kondratieff, David Funk, R.D. Waltz, Nick Wiersema, F.L. Carle, and Jeff M. Webb. 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, aquatic biologist and creator of North Carolina's Biotic Index.

AMELETIDAE

Ameletus

Genus Diagnosis: *Maxillae with crown of pectinate spines*; claws shorter than tarsi on all legs; *gills composed of single lamellar portion and sclerotized band on lateral margin;* three caudal filaments; body variously patterned.

Habitat: Typically in cooler lotic waters, on a variety of substrates, particularly clean surfaces. Primarily collectors-gatherers but also facultative scrapers.

Distribution and Occurrence: Common in the Mountains and Piedmont. Nymphs collected winter through spring.

Species in NC: TAKE TO SPECIES

cryptostimulus – nymphs 8.5-13.5 mm; *setal row of mandible about 1.5 x the length of the setal gap*; labrum tan with darker medial subtriangular mark; *tarsi with a dark apical band only; posterior spinules present on abdominal terga 5 or 6-10;* each abdominal tergum with two pairs of pale spots, one submedian pair and a pair anterolateral to those, also with a small pair of dark brown submedial spots on each segment; abdominal tergum 2, and sometimes 7, mostly pale, terga 6-9 with an additional single, medial pale spot removed anteriorly; ventral surface of abdomen pale with segments 9 and 10 at least darkened laterally; caudal filaments basally brown and with a dark brown medial band followed by a pale band and tipped finally with brown. Recorded from GSMNP and small mountain streams.

lineatus – nymphs 12-14 mm (females); setal row of mandible approximately 4.8 times the length of the setal gap; tarsi with both dark basal and apical bands; posterior margin of abdominal terga 1 or 2-10 with spinules; abdomen dorsally with 2 large pale sublateral spots on 2-7 and with segments 2-3 and 6-7 with a submedian pale spot; terga 8-10 mostly dark with some pale etchings; segments 1-9 with dark comma-like submedian markings visible particularly when pale spots are partially fused; *sterna with median and lateral dark longitudinal stripes, edges clearly defined*, sometimes median stripe obscure or absent on sterna 1-4*, lateral stripes do not continue onto pleural folds and with pale spot on each segment anteriorly*; *caudal filaments with dark median band interrupted every four segments by very narrow pale bands*. Common in the Mountains and Piedmont. A parthenogenetic species.

ludens* – nymphs 9.5-? mm; setal row of mandible approximately 4.5 times the length of the setal gap; tarsi with both dark basal and apical bands; posterior margin of abdominal terga 1 or 2-10 with spinules; dorsal and *sternal abdominal coloration similar to A. lineatus with sternal maculations more extensive and without clearly defined borders, with lateral stripes continuous onto plural folds between segments, and with median stripe wider than that of A. lineatus; caudal filaments with dark median band interrupted every four segments by very narrow pale bands*. A parthenogenetic species. Possibly a northern variant of *A. lineatus*.

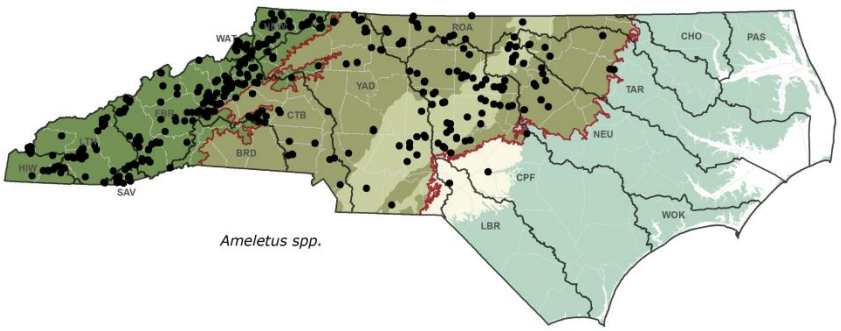
(sp. 3) – nymphs 6.5-? mm; Nymph is currently undescribed however BAU specimens indicate: *setal row of mandible continuous with molar brush;* head brown with pale spot between antennal pedicels; clypeus brown with pale apicolateral corners; labrum mostly brown with apical third paler, often with a tan "V" present; *mandibles mostly pale to base, contrasting sharply with clypeus and labrum giving head a striped appearance*; *tarsi with both dark basal and apical bands, apical band lighter; posterior spinules present on abdominal terga 2 (extremely small if present) or 3-10;* dorsum of abdomen with segments 2-6, 9-10 brown, pale submedian spots conspicuous on segments 2-3 or 4, obscure on 5-6, and with terga 1, 7-8 and part of segment 9 mostly pale; terga 2-9 with dark submedian comma-like dots; venter pale with except 9 and 10 darkened, especially laterally; *caudal filaments distinctive, mostly dark brown to black with basal 3-5 segments tan and apical quarter pale*, extreme tips may be brown. Recorded from Panthertown Valley, Jackson County and Blue Ridge Parkway, Burke County. These nymphs can be collected into late May.

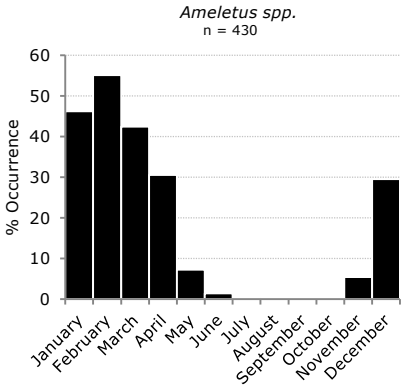
(tarteri) – nymphs 7.0-11.5 mm; *inner setal row of mandible approximately 2.8 times the length of the setal gap;* labrum tan with "V" of darker pigmentation medially; *tarsi with a dark apical band only*; *posterior spinules on abdominal terga 3 or 4-10;* abdomen tan, segments 1-9 with paired dark comma-like submedian markings, dark submedian marks on tergum 10 expanded anterolaterally; segment 2 pale, terga 3-6 with submedian pair of pale spots with 7 entirely pale and 8 and 9 mostly dark; ventral surface of abdomen pale with darker anterior margins of sterna and with lateral maculations on distal segments, 8 and 9 variably brown; sterna 2-9 with a variably dark pair of submedial spots and sometimes a larger pair of dots anterolateral to those, dots on 8 and 9 sometimes obscured by surrounding maculations; caudal filaments with brown medial band and tipped with brown and with intervening bands pale. Northern mountains (McDowell County).

(tertius) – nymphs 8.5-11.0 mm; *setal row of mandible continuous with the molar setal brush;* apical third of mandibles lighter than basal portion; apical third of labrum paler; *tarsi with both dark basal and apical bands*; *posterior spinules on abdominal terga 1 or 2-10; distinctively marked small species with dorsal terga 3-6 with two large, ovalized submedian pale spots* with one small anterolateral pair sometimes joined to form one large obliquely oriented oblong spot, segments 2 and 7-8 pale with 9-10 mostly dark; ventrally pale except sterna 9 and 10 darkened (also sometimes a portion of 8), other sterna may have darkened areas laterally and anteromedially; caudal filaments with wide, dark medial band. Some specimens have a narrow medial band and may represent a different species, however all other characters match this description. Found in Wilson Creek, Panthertown Creek, and GSMNP. Listed by NC Natural Heritage Program as Significantly Rare (2012).

AMELETIDAE

Notes: Intolerant as a genus. Sizes of mature male nymphs are at the lower end of the listed range. There are at least five species in North Carolina including *Ameletus sp. 3*, an undescribed species from Panthertown Creek. *Ameletus ludens* has not been recorded south of WV and KY. Currently there are no published keys to separate eastern *Ameletus* nymphs. An in-house key was developed, based on the above descriptions, to separate NC species. Additional species may be present (such as an *Ameletus nr. tertius*, a McCafferty ID from Wilson Creek area) but all known NC specimens tested readily key. A possible new species from a UT Eno River resembles *Ameletus tarteri* in almost every respect but specimens were washed out and immature thus no definitive identification could be made.





Key to the *Ameletus* of North Carolina

1 abdominal sterna with median and lateral dark longitudinal stripes, dark medial band on caudal filaments interrupted every fourth segment by a narrow, pale annulation 2

1' sterna variously patterned but without median and lateral dark stripes, dark medial band on caudal filaments without pale annulations 3

2 stripes narrow, edges of median and lateral dark longitudinal stripes clearly defined, sometimes median stripe incomplete, obscure, or absent on sterna 1-4, lateral stripes do not continue onto pleural folds ..... ***lineatus***

2' stripes wider, edges of median and lateral dark longitudinal stripes obscure, not clearly defined; lateral stripes continuous onto plural folds between segments; not currently known from NC ..... ***ludens***

3 mandibles with variably sized gap between setal row and molar brush; tarsi with conspicuous dark apical band only 4

3' mandibles without a gap between setal row and molar brush; tarsi with both a conspicuous dark basal and dark apical band (may be lighter and smaller than apical band), with a pale band between 5

4 posterior spinules present on abdominal terga 3 or 4-10; sterna 5-8 typically with a dark pair of submedial spots, dots on 8 or 9 possibly obscured by surrounding dark pigmentation ..... ***tarteri***

4' posterior spinules present on abdominal terga 5 or 6-10; venter of abdomen mostly pale with segments 8-9 at least darkened laterally ..... ***cryptostimulus***

5 caudal filaments with wide pale basal band, conspicuous; posterior spinules on abdominal terga 1 or 2-10; distinctively patterned species with a pair of large, ovalized, obliquely oriented pale spots on dorsal abdominal segments 3-6, segments 2, 7-8 mostly pale ..... ***tertius***

5' caudal filaments with very narrow pale basal band, filaments mostly dark except for pale apical quarter; posterior spinules present on abdominal terga 2 or 3-10 ..... ***sp. 3***

AMELETIDAE

Taxonomic references:

nymphs*:*

Burrows, W. L. 1987. A New Species of *Ameletus* (Ephemeroptera: Siphlonuridae) from eastern North America. Proceedings of the Entomological Society of Washington. 89(2): 284-287.
(description of *A. tarteri*)

Carle, F. L. 1978. A New Species of *Ameletus* (Ephemeroptera: Siphlonuridae) from western Virginia. Entomological Society of America 71: 581-584.

Needham, J. G. 1905. Ephemeridae, pp. 17-62. *In* J. G. Needham, K. J. Morton, and O. A. Johannsen, eds. New York State Museum Bulletin 86. 352 pp. (description of *A. ludens* nymph)

Unzicker, J.D. and P.H. Carlson1982. Ephemeroptera, Chapter 3 (97 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:

Zloty, J. 1996. A revision of the Nearctic *Ameletus* mayflies based on adult males, with descriptions of seven new species (Ephemeroptera: Ameletidae). The Canadian Entomologist 128: 293-346.

SIPHLONURIDAE

Siphlonurus

Genus Diagnosis: Nymph large; *antennae short, subequal to width of head;* all claws single; *bilamellate gills on abdominal segments 1 and 2; long posterolateral projections on abdominal segments 8 and 9;* often with black bands on ventral surface of abdomen; three caudal filaments.

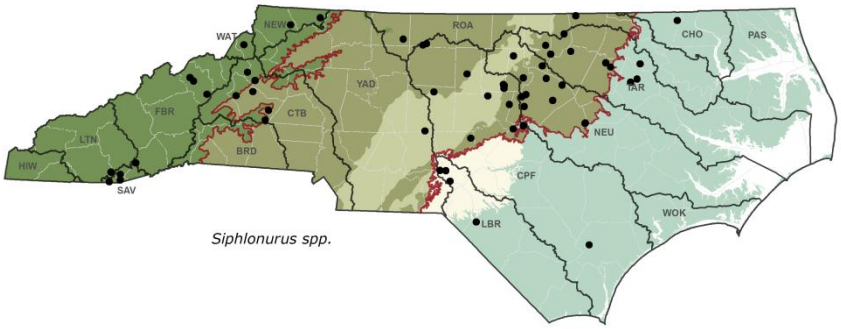
Habitat: Lentic and lotic, in pools or slow currents, also in swamps. Found in vegetation at edges. Primarily collectors-gatherers, facultative scrapers or grazers. May also be predatory on chironomids at later stages.

Distribution and Occurrence: Mountains and eastern Piedmont. Uncommon. Nymphs can be collected January through April.

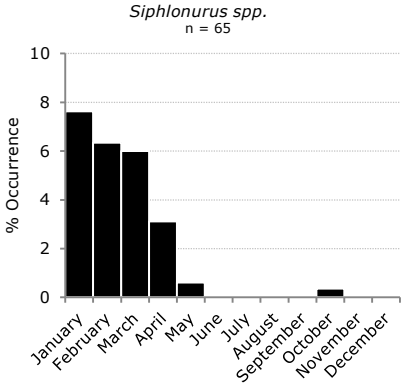
Species in NC: LEAVE AT GENUS

(decorus), (marginatus), (mirus), (quebecensis), (typicus)

Notes: At least five species of *Siphlonurus* occur in North Carolina. Some species could be confused with *Callibaetis* which has long antennae and rudimentary to very short posterolateral projections on abdominal segments 8 and 9. At least one *Siphlonurus* species has abdominal gills bunched together into a large group and appears very different from other *Siphlonurus* species. *Siphlonurus decorus* nymphs are undescribed and *Siphlonurus typicus* is recorded from GSMNP.



Siphlonurus spp.



Taxonomic references:

nymphs:

Unzicker, J.D. and P.H. Carlson1982. Ephemeroptera, Chapter 3 (97 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.

METRETOPODIDAE

Siphloplecton

Genus Diagnosis: Distal margin of labrum slightly emarginate; labial palpi large, truncate apically; *foreleg tarsal claws bifid with margins sparsely populated with long spines;* mid and hind claws long, more than half the length of the respective tarsus; three caudal filaments; body typically brown with various darker brown markings.

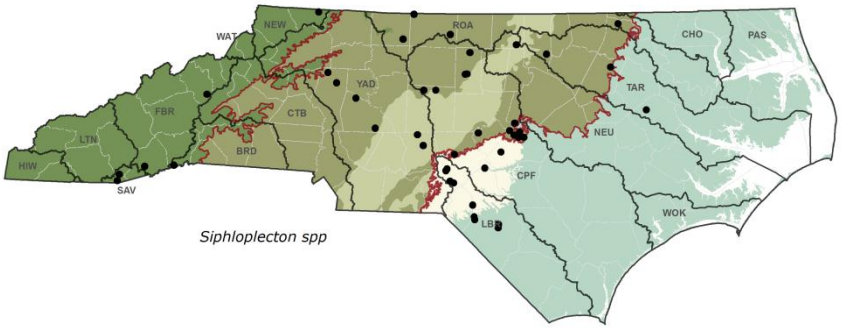
Habitat: Prefer larger rivers or lakes, in slow currents. Predator and facultative collectors-gatherers.

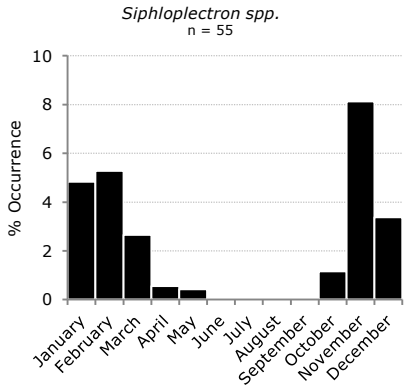
Distribution and Occurrence: Widespread. Uncommon in the Piedmont, rarely collected from the Coastal Plain. Typically collected November through March.

Species in NC: LEAVE AT GENUS

(basale), (costalense), (speciosum)

Notes: Nymphal sizes (for *S. speciosum*) range from 9 mm (male) to 16 mm (female). Most species have ventromedial longitudinal striping and sometimes lateral striping or spots. While the nymphs have been described (with the exception of *S. costalense*) and species keys developed, Berner (1978) could find little morphological difference between the different species and found the traits used for separation unreliable. He cautions against speciating nymphs without associated adult material. Boris Kondratieff collected adult *S. speciosum* from Lumber River at Wagram in 2003.





Taxonomic references:

nymphs:

Berner L. 1978. A review of the family Metretopodidae. Transactions of the American Entomological Society 104: 91-137.

Edmunds, G. F. Jr. 1976. The Mayflies of North and Central America. University of Minnesota Press, Minneapolis.

adults:

Berner L. 1978. A review of the family Metretopodidae. Transactions of the American Entomological Society 104: 91-137.

Acentrella

Genus Diagnosis: Sprawling flattened body; *labrum compact in appearance*, segment 3 of labial palp evenly rounded or almost triangular; hind *wing pads typically absent, and if present then minute and attached to membranous integument;* femora, tibiae and tarsi usually with row of long, fine setae; *femoral villopore present;* terga with paired dots; *two caudal filaments, median filament greatly reduced or apparently absent.*

Habitat: Lotic. Typically in rocky riffles, in moderate to fast currents. Collectors-gatherers.

Distribution and Occurrence: Very common in the Mountain and Piedmont particularly in the summer.

Species in NC: TAKE TO SPECIES

alachua – nymphs 3.8-4.5 mm; without dense row of setae on tibiae and tarsi; hind wing pads vestigial; *abdominal gills without gray pigmented area distally;* reduced median caudal filament greater in length than basal width of lateral filaments; *caudal filaments with alternating dark and light segments*, usually less distinct than in *A. parvula;* lightly colored, often with distinct color laterally on segment 5 and with paired ventral dots. Intolerant.

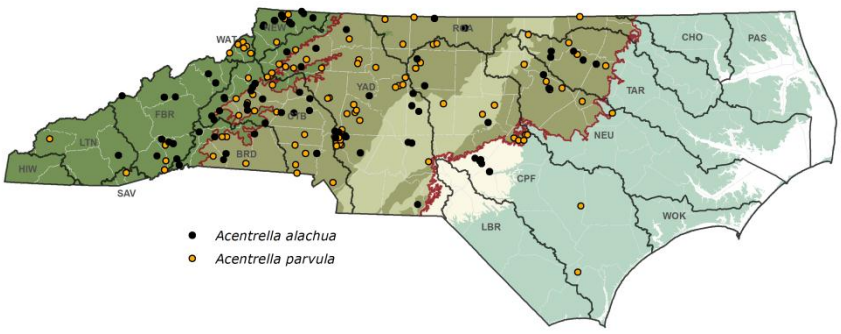
barbarae – nymphs 3.2-4.6 mm; *segment 3 of labial palpi triangular in appearance*; sparse, short setae on tibia and tarsi; *abdominal terga usually with posteromedial elevations; posterior margins of terga with blunt spinules with layered appearance;* paired submedial dots on terga 2-9, dorsum of segment 6 with large often diffuse medial spot; caudal filaments long with a very faint medial band. Beware: tergal elevations can vary in size or may be virtually absent within a population - the shape of the labial palpi may be the most reliable character in a population such as this. Described from GSMNP. Collected only from streams with excellent water quality. Recorded from GSMNP and adjacent streams in the Little Tennessee River Basin and the headwaters of West Fork Pigeon River.

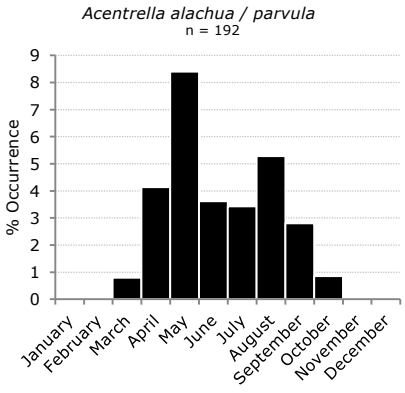
nadineae – large, nymphs 5.0-5.8 mm but usually larger than co-occurring *A. turbida;* hind wing pads strap-like and reduced or absent; *foretibia plus foretarsus length subequal to length of forefemur;* row of long setae on dorsal margins of tibiae and tarsi; *gills elongate, asymmetrical, and with basomedial pigmentation splotches;* distinct abdominal color pattern often tinged with red. Formerly *Acentrella femorella* (Waltz) in BAU database. Very intolerant.

parvula – nymphs 3.2 mm; without dense row of setae on tibiae and tarsi; hind wing pads vestigial; *abdominal gills usually with gray pigmented area medially to distally, often with discontinuous tracheation;* abdominal terga 2, 3, 5-7 mostly brown often with a pale anteromedial dot; tergum 4 pale laterally and brown anteromedially; terga 8 and 9 mostly pale but sometimes dark enough to have 3 pale, transversely oriented spots; *caudal filaments distinct with alternating dark and light bands;* reduced median caudal filament shorter in length than basal width of lateral filaments. Previously *B. armillatus*. Facultative.

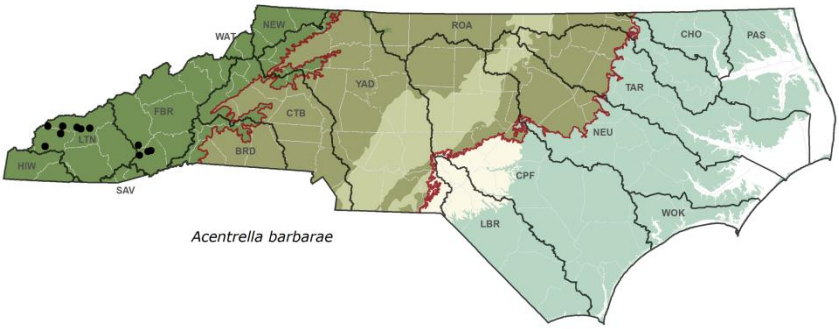
turbida gr. – nymphs 4-6 mm though most often on the smaller side; *dense row of long setae on dorsal margins of tibiae and tarsi;* foretibia plus foretarsus length conspicuously longer than length of forefemur (i.e. tibia alone is subequal to femur); hind wing pads absent or possibly vestigial; gills unpigmented. At least two different species have been noted within this group: one larger species with conspicuous, darkly sclerotized sternal thorns at the base of the meso- and metathoracic coxae and a small, setose species with small, lightly sclerotized sternal thorns. Note: Some populations of *A. turbida gr.* have tergal elevations similar to *A. barbarae* but can be separated by the long tibial setae. Two distinct cohorts can be seen, one in March-June and the other July-October. May be a complex of species. Common, particularly in the Mountains. Intolerant

Notes: A moderately intolerant genus, species of some species of *Acentrella* can be difficult to separate from *Plauditus*. Particularly, *Acentrella barbarae* with reduced or absent tergal elevations can be confused with *Plauditus cingulatus*. However, *P. cingulatus* has shorter caudal filaments and almost truncate labial palpi. See species descriptions for each genus for further help. *Acentrella ampla* was transferred to *Heterocloeon* in 2006. Many of the historical identifications of *Acentrella alachua* are most likely of *A. parvula* although BAU has seen specimens with banded tails (of both sexes) that differ considerably in body pigmentation.

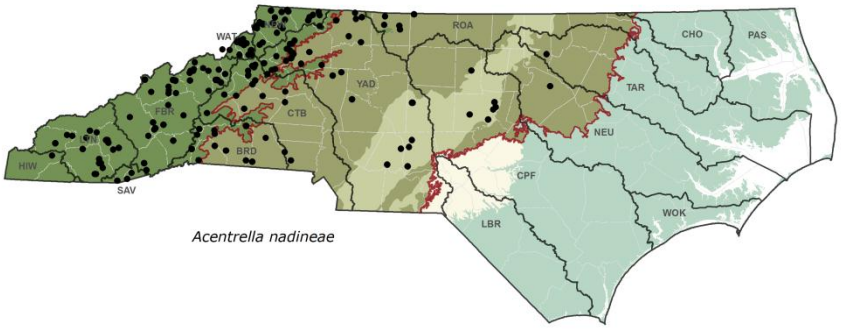




BAETIDAE

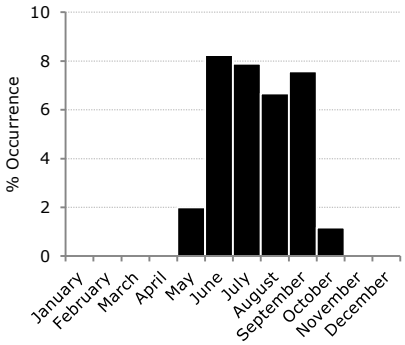


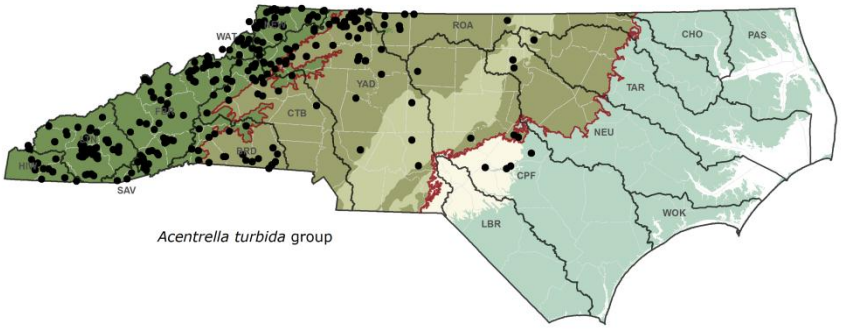
Acentrella barbarae



Acentrella nadineae

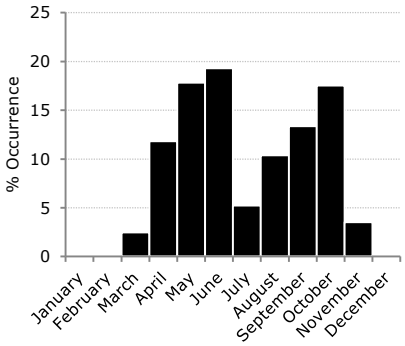
Acentrella nadineae
n = 208





Acentrella turbida group

Acentrella turbida group - Mtn only
n = 287



Taxonomic references:

nymphs:

Buriun, S. K. and L. W. Myers. 2011. A new species of *Acentrella* Bengtsson (Ephemeroptera: Baetidae) from New York and New England (USA), redescription of *A. parvula* (McDunnough), and key to known adult males of Nearctic *Acentrella*. Aquatic Insects 33(4): 305-334.

⇨Jacobus L. M. and W. P McCafferty. 2006. A new species of *Acentrella* Bengtsson (Ephemeroptera: Baetidae) from Great Smoky Mountains National Park, USA, Aquatic Insects. 28 (2): 101-111.

⇨Lugo-Ortiz, C. and W. P. McCafferty. 1998. A new North American Genus of Baetidae and key to *Baetis* Complex Genera. Entomological News 109 (5): 345-353.

⇨McCafferty, W. P., R. D. Waltz and J. M. Webb. 2009. *Acentrella nadineae*, a new species of small minnow mayflies (Ephemeroptera: Baetidae). Proceedings of the Entomological Society of Washington. 111(1): 12-17.

McCafferty, W. P., M. J. Wigle and R. D. Waltz. 1994. Systematics and biology of *Acentrella turbida* (McDunnough) (Ephemeroptera: Baetidae). Pan-Pacific Entomologist 70: 301-308.

Waltz, R. D. and W. P. McCafferty. 1987. Systematics of *Pseudocloeon*, *Acentrella*, *Baetiella*, and *Liebebiella*, New Genus (Ephemeroptera: Baetidae). Journal of New York Entomology Society. 95(4): 553-568.

Wiersema, N. A. 2000. A new combination for two North American small minnow mayflies (Ephemeroptera: Baetidae). Entomological News 111(2): 140-142.

adults:

McCafferty, W. P., M. J. Wigle and R. D. Waltz. 1994. Systematics and biology of *Acentrella turbida* (McDunnough) (Ephemeroptera: Baetidae). Pan-Pacific Entomologist 70: 301-308.

McCafferty, W. P., R. D. Waltz and J. M. Webb. 2009. *Acentrella nadineae*, a new species of small minnow mayflies (Ephemeroptera: Baetidae). Proceedings of the Entomological Society of Washington. 111(1): 12-17.

Acerpenna

Genus Diagnosis: *Second segment of labial palp with large subtriangular thumb at an acute angle;* labrum notched; *seventh gill slender and pointed apically;* hind wing pads present; three caudal filaments; body typically pigmented with high contrast areas.

Habitat: Lotic. Typically in areas of fast flow and on a variety of substrates. Collectors-gatherers.

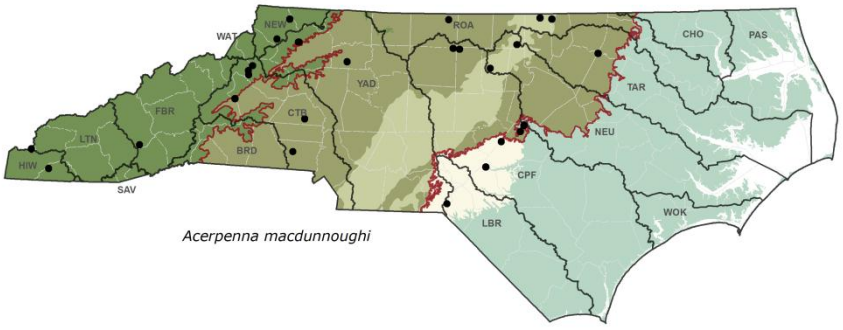
Distribution and Occurrence: A widespread and common genus.

Species in NC: TAKE TO SPECIES

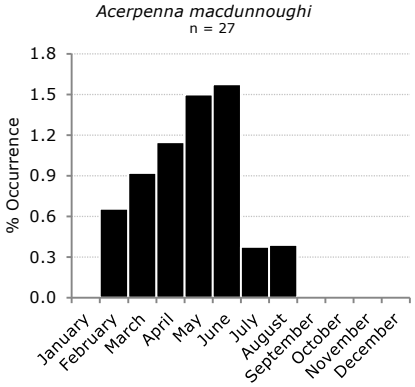
macdunnoughi – nymphs 4-6 mm; *gills on segment 7 slender and symmetrical, with both anterior and posterior margins serrate*. Found in GSMNP and Wilson Creek. Uncommon.

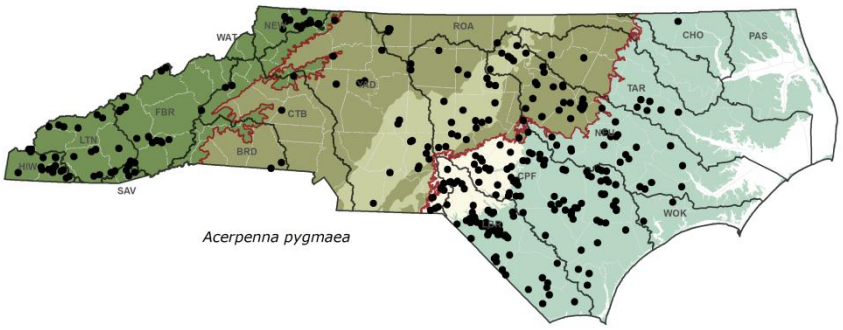
pygmaea – nymphs 3-5 mm; long antennae; *gills on abdominal segment 7 slender and very asymmetrical, with anterior margins smooth and posterior margins serrate;* dark submedial band on caudal filaments. Sexually dimorphic: males with abdominal terga 2, 6-7 darker than remaining terga and with terga 1-6 with a dark anteromedial spot, usually larger on segment 2; females with abdominal terga mostly same color each with a submedian pair of comma-shaped pale marks. Widespread but primarily a Coastal Plain species. Relatively intolerant.

Notes: Some *Acerpenna* have a seventh gill that appears to be intermediate in shape and just slightly asymmetrical. These specimens should have the seventh gill slide-mounted for verification. *Acerpenna* was previously classified under *Baetis*.

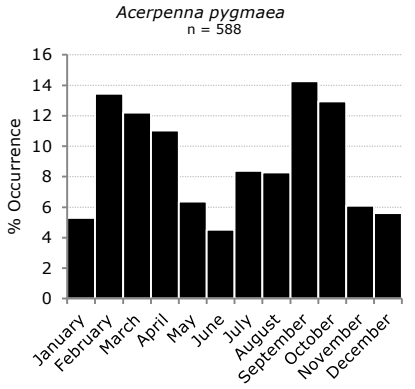


Acerpenna macdunnoughi





Acerpenna pygmaea



Taxonomic references:

nymphs:

⇨Bergman, E. A. and W. L. Hilsenhoff. 1978. *Baetis* (Ephemeroptera: Baetidae) of Wisconsin. The Great Lakes Entomologist 11: 125-35.

Unzicker, J. D. and P. H. Carlson1982. Ephemeroptera, Chapter 3 (97 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.

Waltz, R. D. and W. P. McCafferty. 1987. New genera of Baetidae for some Nearctic species previously included in *Baetis* Leach (Ephemeroptera). Annals of the Entomological Society of America 80(5): 667-671.

adults:

Bergman, E. A. and W. L. Hilsenhoff. 1978. *Baetis* (Ephemeroptera: Baetidae) of Wisconsin. The Great Lakes Entomologist 11: 125-35.

Apobaetis

Genus Diagnosis: Small body size; both mandibles with incisors cleft to base; segment 2 of labial palpi fused with segment 3 and with a setose anteromedial thumb-like projection, distal portion of palpal segment also heavily setose with long silky setae on outer aspect and apically pointed with a concave medial surface with a series of long, stout setae; *labrum without distal medial notch; claws subequal to respective tarsi;* hind wing pads absent; gills simple; body pale, pigmentation sparse except near lateral margins of terga 2 and 5; three caudal filaments.

Habitat: Lotic. Sand-loving (psammophilous), warm water species, typically in areas of faster flows. Trophic relationship unknown but possibly collectors-gatherers.

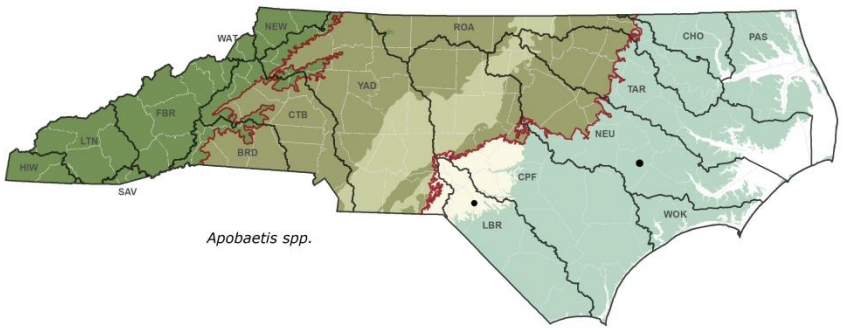
Distribution and Occurrence: Extant unknown, two Coastal Plain records. Rare.

Species in NC: TAKE TO SPECIES (provisional)

sp. 1 – nymphs 3.3- 4.5 mm; maxillary palpi four segmented with segment 3 as long as segment 1+2 and segment 4 very small, segment 2 shorter relative to the tip of the galealacinia than in *A. lakota; length of antennae about two times the width of the head; femora without series of long, stiff setae;* gills unknown, missing; sternum 9 with a dark transverse band along the anterior edge of the segment. Also known from GA and SC. This description based on one specimen. This specimen (Neuse River at NC 58, Lenoir Co., 2 Aug 2010, V. Holland), determined to be *A. etowah* by McCafferty (from photos), has large, dark transverse bands ventrally, one on either side of the head at the base of the mandibles and galealaciniae. Additionally, the setation on the "thumb" and on the outside edge of the labial palpi appears much heavier and with the setae much longer (about as long as the width of the apical segment) than in any diagram from either Day (1955) or McCafferty (2000).

(sp. 2) – nymphs 3.5- ? mm; apical edge of labrum with a very shallow U-shaped emargination that runs the width of the labrum; *length of antennae subequal to width of head, with apical segment slightly darkened;* forecoxae with a large dorsolateral dark spot; *femora with a basoventral series of long stiff setae;* abdominal terga 2 and 6 with large dark medial spots, that on two with an inverted V-shaped posterior border; mesosternum and abdominal sterna 1-9 with an anteromedial dark spot; gills with slight apicomedial pigmentation; caudal filaments relatively short (half the length of the abdomen) with a pale, narrow subapical dark band. This description is based on one specimen (Lumber River at NC 401, Scotland County, 24 Feb 2011, D. Lenat). Mouthparts have not been slide mounted and the specimen is no longer in BAU possession.

Notes: *Apobaetis* can be confused with *Paracloeodes* due to its small size and pale body color or with *Centroptilum* due to its cleft mandibles and long claws; however, both *Paracloeodes* and *Centroptilum* have a medially cleft labrum. Also, the shape of the apical segment of the labial palpi is diagnostic for *Apobaetis*. Additionally, *Apobaetis* superficially resembles *Pseudocentroptiloides*, but the lack of a labral notch in *Apobaetis* will also separate the two genera. Only two larval specimens have been collected in NC and neither specimen key readily to species and have apparent significant differences from each other. Each may therefore be a new or undescribed species. *Apobaetis indeprensus* was placed as a junior synonym of *Apobaetis etowah* by Meyer and McCafferty (2004). Anecdotal evidence (Day, 1955) suggests that, like *Paracloeodes*, *Apobaetis* may be pollution tolerant.



Apobaetis spp.

Taxonomic references:

nymphs:

⇨ Day W. C. 1955. New genera of mayflies from California (Ephemeroptera). Pan-Pacific Entomologist 31(3):121-137. (description of *Apobaetis indeprensus*)

Meyer M. D. and W. P. McCafferty. 2004. New synonym of *Apobaetis etowah* (Traver) (Ephemeroptera: Baetidae). Pan-Pacific Entomologist 79 (4/3): 249.

McCafferty WP. 2000. A new Nearctic *Apobaetis* (Ephemeroptera: Baetidae). Entomological News 111(4):265-269.

Baetis

Genus Diagnosis: *Segment two of labial palpi well developed often with thumb-like medial projection;* antennae at least twice as long as head capsule; legs tend to have femora much broader than tibia; *femoral villopore present;* tarsal claws with denticles; hind wing pads present or absent; *three caudal filaments, middle filament sometimes reduced.*

Habitat: Lotic, on hard substrates in riffles, along banks, or in submerged vegetation; in oxygenated areas. Primarily collectors-gatherers, facultative scrapers or grazers.

Distribution and Occurrence: Mostly found in the Piedmont and Mountains (and Coastal Plain for *B. intercalaris*) and very common.

Species in NC: TAKE TO SPECIES

brunneicolor – nymphs 6-10 mm; *antennal scape and pedicel without robust setae;* labial palpi with segment 2 less than twice as long as basal width of segment 3; inner margin of segment 2 concave and medial lobe moderately developed; pronotum uniformly shaded; paraproct surface without robust setae; *middle caudal filament less than half as long as lateral filaments;* caudal filament shading gradual. Mountains only, except French Broad Basin.

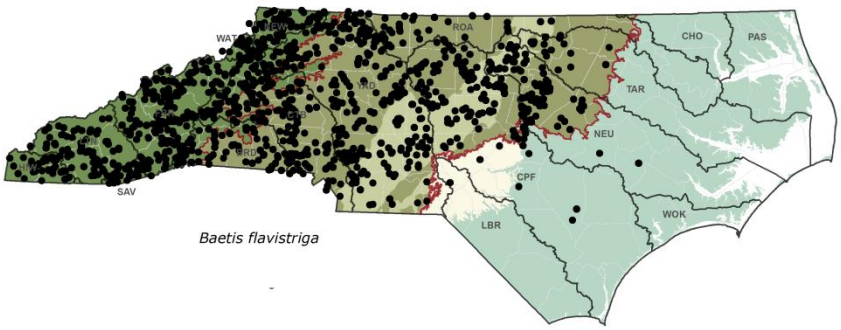
flavistriga – nymphs 3.5-6.0 mm; labial palpi with segment 2 less than twice as long as basal width of segment 3; medial lobe of segment 2 of labial palpi poorly developed; *two large submedian kidney shaped spots on abdominal terga; caudal filaments with medial dark band.* Found mostly in the Mountain and Piedmont from April-November. Common and tolerant.

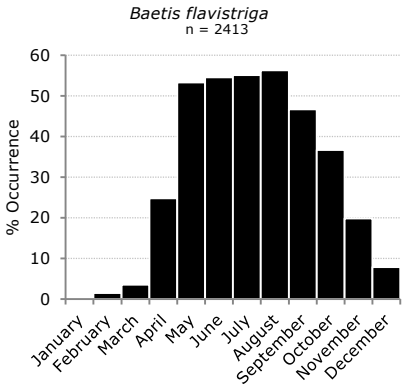
intercalaris – nymphs 5-6 mm; *mostly well marked abdominal terga with three posterior round pale areas,* though sometimes with pale areas very faint or missing; very mature specimens sometimes all gray-brown with paired pale submedian parentheses shaped marks; *gills extensively tracheated; caudal filaments with dark medial banding darker and located more basally than in B. flavistriga.* Very common and tolerant. Ubiquitous.

pluto – nymphs 4-6 mm; *head with areas lateral to antennal bases and eyes pale, frons and labrum brown giving head a longitudinally striped appearance* (noticeable in earlier instars as well); dorsal color pattern often distinct, tergum 5 relatively pale, segments 6 and 7 almost completely dark, mature specimens may have last 3-4 sterna much darker; middle caudal filament three-quarters to subequal in length to lateral filaments, usually with distinct dark band on caudal filaments medially. Can be confused with *B. tricaudatus.* Common in the Mountains and Piedmont. Intolerant.

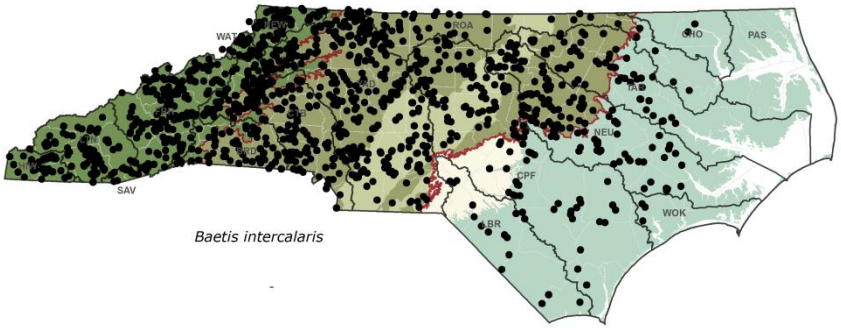
tricaudatus – nymphs 5-8 mm; distinct palpal "thumb"; *antennal scape and pedicel with robust setae;* gill margins without large robust setae and serrate; caudal filament shading gradual, less dark than in *B. intercalaris; middle caudal filament less than half as long as lateral filaments.* Primarily a Mountain species. Usually collected spring through fall. Relatively common and very intolerant.

Notes: It can be difficult to separate early instar *Baetis* nymphs particularly damaged specimens of *B. pluto and B. tricaudatus* based on abdominal color pattern alone. Also, *Baetis brunneicolor* can be separated from *B. tricaudatus* (with the lack of robust setae the best character), however, slide-mounts of the head may be necessary to see the antennal pedicel setae. Some two-tailed *Baetis* were moved to *Plauditus.* Some species may exhibit occasional parthenogenesis, or tychoparthenogenesis.

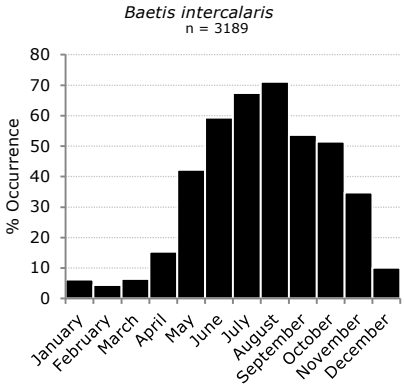


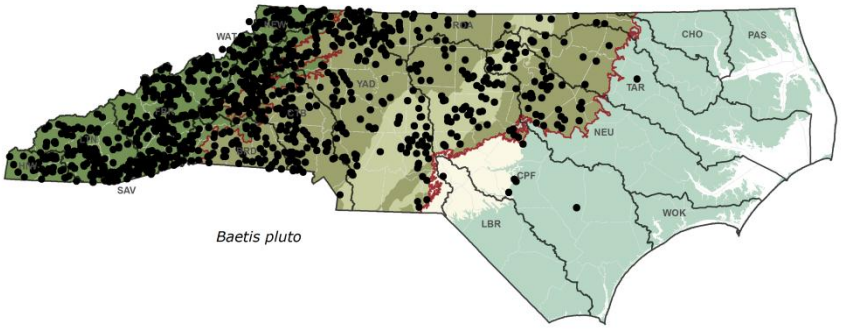


BAETIDAE

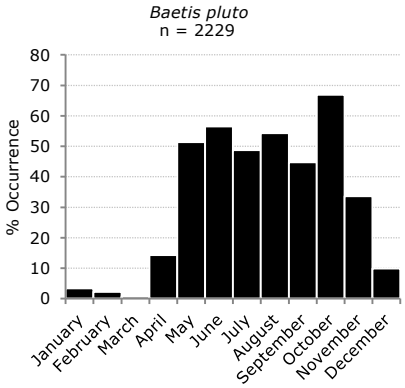


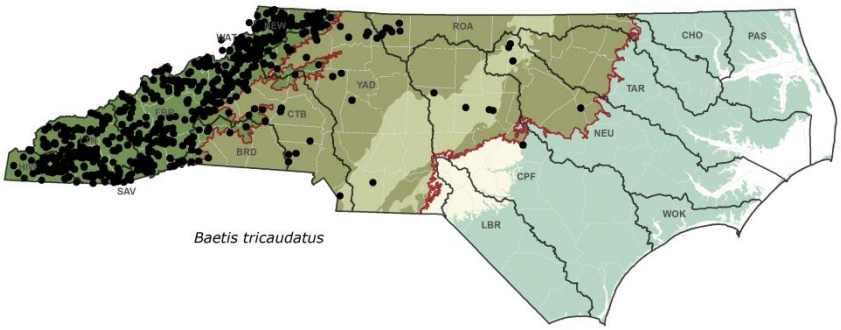
Baetis intercalaris



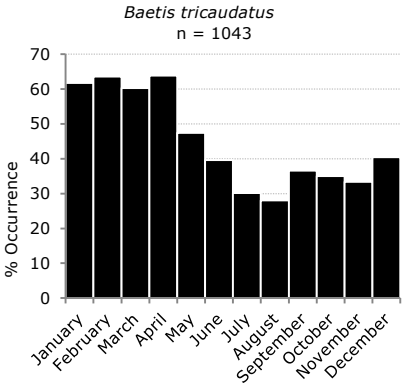


Baetis pluto





Baetis tricaudatus



Taxonomic references:

nymphs:

Bergman, E. A. and W. L. Hilsenhoff. 1978. *Baetis* (Ephemeroptera: Baetidae) of Wisconsin. The Great Lakes Entomologist 11: 125-35.

Morihara, D. K. and W. R. McCafferty. 1979. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). Transactions of the American Entomological Society 105: 139-221.

⇨Wiersema, N. A., C.R. Nelson and K. F. Kuehnl. 2004. A new small minnow mayfly (Ephemeroptera: Baetidae) from Utah, U.S.A. Entomological News 115:139-145.

adults:

Bergman, E. A. and W. L. Hilsenhoff. 1978. *Baetis* (Ephemeroptera: Baetidae) of Wisconsin. The Great Lakes Entomologist 11: 125-35.

BAETIDAE

Baetopus

Genus Diagnosis: *Head with distinct genal projections (ventrolateral horn) laterally below eyes; labrum rounded anteriorly and with small notch, with very long fine setae on dorsum;* distinctive labial palpi; villopore present; tarsal claws elongate; three caudal filaments, gradually tipped with brown; body pale overall but with mesocoxae dark and tergum 2 and 7 darker posteriorly, terga 2-7 may have obscure elongated submesal spot.

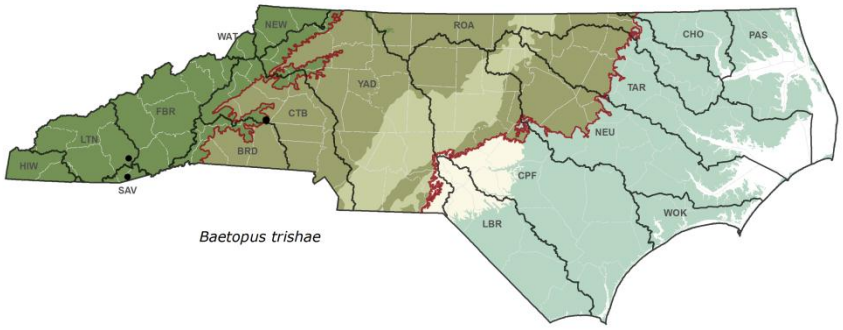
Habitat: Sandy substrates in small, high quality streams. Trophic relationship unknown but possibly collectors-gatherers.

Distribution and Occurrence: Mountains only. Exceedingly rare.

Species in NC: MONOTYPIC

trishae – see Genus Diagnosis. Adults are unknown.

Notes: Known in North America only from Panthertown Creek and Whitewater River, Jackson County, as well as Jacob Fork in Burke County. Very little is known about its biology anywhere. Listed by NC Natural Heritage Program as Significantly Rare (2012). Critically imperiled at the State (S1) and global (G1, G2) level.



Taxonomic references:

nymphs:

Waltz, R. D. 2002. *Baetopus trishae* (Ephemeroptera: Baetidae): A New Species and New Genus for North America. Entomological News 113 (3): 187-191.

Barbaetis

Genus Diagnosis: Nymphs 6-7.5 mm; setae on glossae and paraglossae; *antennae subequal to width of head; procoxae with filamentous osmobranchia; femoral villopore present;* hind wing pads present; no posterolateral projections on abdominal segments 8 and 9; *three subequal caudal filaments, with dark submedial band; dark bands on abdominal segments 2, posterior half of 7 and all of 8 belt-like, present both dorsally and ventrally.*

Habitat: Lotic, in gravel in clean streams. Collectors-gatherers.

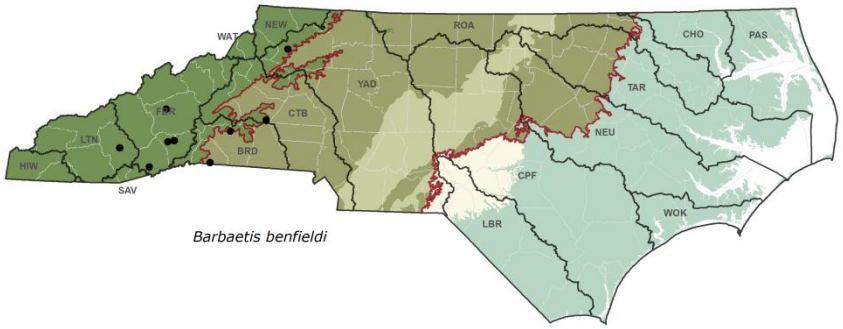
Distribution and Occurrence: Mountains. Rare. Found during the spring.

Species in NC: MONOTYPIC

benfieldi – see Genus Diagnosis. Adults are unknown.

Notes: *Barbaetis cestus* moved to *Plauditus. Barbaetis benfieldi* is listed by NC Natural Heritage Program as Significantly Rare (2012). Listed as "vulnerable to extirpation" by Morse et al. (1997).

BAETIDAE



Taxonomic references:

nymphs:

Waltz, R. D., W. P. McCafferty and J. H. Kennedy. 1985. *Barbaetis*: a new genus of eastern Nearctic mayflies (Ephemeroptera: Baetidae). The Great Lakes Entomologist: 161-165.

Callibaetis

Genus Diagnosis: *Labial palpi apparently two-segmented (may appear as a crease) with apex blunt though not truncate; antennae very long; numerous large, thin denticles on claws appearing hair-like;* hind wing pads present; *large lamellate gills on one or more segments with ventrally recurved flaps;* three subequal caudal filaments.

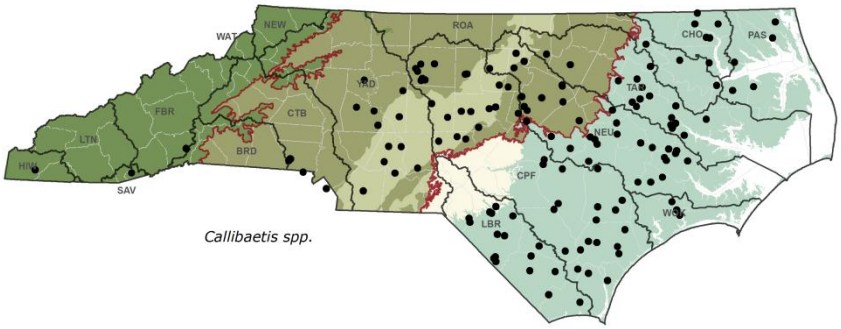
Habitat: Lentic and lotic, in slow moving waters among vegetation (particularly swamps). Collectors-gatherers.

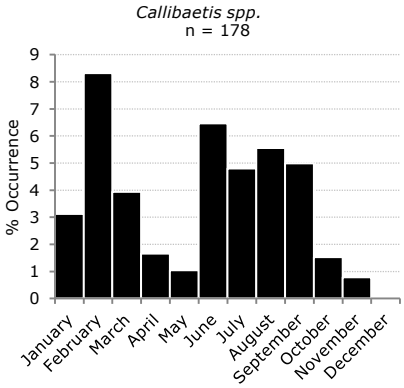
Distribution and Occurrence: Collected mostly from Piedmont and Coastal Plain. Nymphs can be found year round.

Species in NC: LEAVE AT GENUS

(floridanus), (fluctuans), (pretiosus)

Notes: A very tolerant genus. *Callibaetis pretiosus* is listed as "vulnerable to extirpation" by Morse et al. (1997).





Taxonomic references:

nymphs:

Berner, L. and M. L. Pescador. 1988. The Mayflies of Florida. University Presses of Florida. pg 415.

BAETIDAE

(Camelobaetidius)

Genus Diagnosis: Forelegs usually longer than hind legs; *tarsi bowed; tarsal claws distinctly spatulate and denticulate;* gills simple; hind wing pads present; three caudal filaments.

Habitat: Lotic, in larger streams and rivers. On cobble or hard substrates covered with algae in riffles or may be on silt and sand (?). Trophic status unknown.

Distribution and Occurrence: Extent unknown. See notes.

Species in NC: TAKE TO SPECIES (if found)

> ***(musseri)*** – nymphs 5.7-8 mm; thumb-like projection of second segment of labial palpi truncate; *labrum with 3-6 lateral simple setae; claws with 30-39 denticles (usually 30-35);* abdominal terga reddish brown with posterior margins pale, segments 3, 6 and 7 darker than others with tergum 8 pale in male nymphs (although color patterns are variable as a whole); sterna 1-9 most likely with dark posterior borders; three pale, subequal caudal filaments.

Notes: While North Carolina BAU has no records of *Camelobaetidius musseri*, a specimen was collected from the Little Tennessee River in Macon County *or* Balls Creek, Clay County by a non-DWQ entity in June, 2006 (as per McCafferty et al., 2010 and Dr. John Morse, personal communication). However, the site data on the specimen was lost. No other information is known. The more probable site, the Little Tennessee River, at NC 28 outside of Franklin, has been sampled nine times in the last 28 years by DWQ biologists. A QA of these samples confirms that no *Camelobaetidius* were previously collected. This is a huge range extension from the Southwestern US.

Taxonomic references:

nymphs:

Lugo-Ortiz C. R. and W. P. McCafferty. 1995. Taxonomy of the North and Central American species of *Camelobaetidius* (Ephemeroptera: Baetidae). Entomological News 106(4):178-192.

McCafferty, W. P. and T. H. Klubertanz. 1994. *Camelobaetidius* (Ephemeroptera: Baetidae) in Indiana and Iowa: new species and range extension. Proceedings of the Entomological Society of Washington 96:37–43.

⇨McCafferty, W. P. and R. P. Randolph. 2000. Further contributions to the spatulate clawed Baetidae (Ephemeroptera). Entomological News 111(4): 259-264

Traver J. .R and G. F. Edmunds. 1968. A revision of the Baetidae with spatulate-clawed nymphs (Ephemeroptera). Pacific Insects 10(3-4): 629-677.

adults:

Traver J. .R and G. F. Edmunds. 1968. A revision of the Baetidae with spatulate-clawed nymphs (Ephemeroptera). Pacific Insects 10(3-4): 629-677.

Centroptilum

Genus Diagnosis: Labrum with shallow medial emargination; *third segment of labial palpi end is broad and truncate; both mandibles with incisors fused less than halfway but usually cleft to base;* abdominal gills simple; *three subequal caudal filaments with a distinct band every third to fifth segment and typically without lateral bristles on apical quarter.*

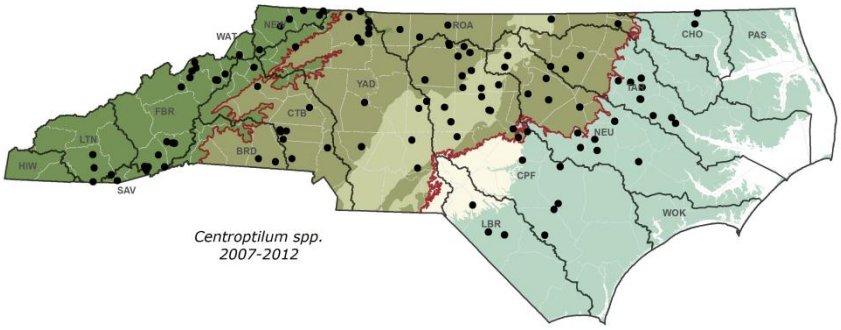
Habitat: Lentic and lotic. Found in small streams, springs, and the margins of large rivers and swamps on rocks or in vegetation. Primarily collectors-gatherers, facultative scrapers or grazers.

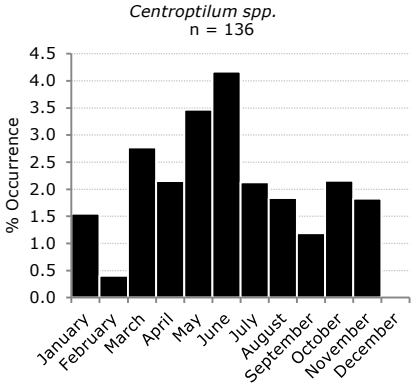
Distribution and Occurrence: Widespread. Very common.

Species in NC: LEAVE AT GENUS

> ***(alamance), (album), minor, (sp. A), triangulifer***

Notes: Some keys use the lack of apical setae on the caudal filaments as a key character. We have found that character to be unreliable as we often get specimens with cleft mandibles (both right and left) that have lateral setation to the end of each caudal filament. Use with caution! *Centroptilum* often has longer claws than *Procloeon. Procloeon sp. 2* was synonymized with *C. album. Centroptilum sp. 2* (one BAU record) was synonymized with *Pseudocentroptiloides morihara* which does not occur in the southeastern US. The occurrence of *C. minor* is based on four BAU records and identifications by Nick Wiersema (1998). Additionally, *Centroptilum sp. A* referred to by McCafferty et al. (2010) was collected from Little Ivy Creek (SR 1610, 22 July 97) and is retained by Nick Wiersema. Records of *Centroptilum* prior to 2007 are coded as *Centroptilum spp. (dubious)* in the BAU database and include many misidentifications of *Procloeon.* Please note that Kluge has a new genus, *Anafroptilum* (Kluge, 2011), which may include most current Nearctic species of *Centroptilum* (including *C. album* from NC). *Centroptilum* is sensitive to siltation but moderately tolerant overall.





Taxonomic references:

nymphs:

Funk, D. H., J. K. Jackson and B. W. Sweeney. 2006. Taxonomy and genetics of the parthenogenetic mayfly *Centroptilum triangulifer* and its sexual sister *Centroptilum alamance* (Ephemeroptera: Baetidae). Journal of the North American Benthological Society. 25(2): 417-429.

Jacobus, L. M., N. A. Wiersema, and J.M. Webb 2013. Identification of Far Northern and Western North American Mayfly Larvae (Insecta: Ephemeroptera), North of Mexico. Southwest Association of Freshwater Invertebrate Taxonomists, California State University, Long Beach. 107 pp. + suppl .-- *unpublished – used with permission*

Kluge, N. J. 2011. Non-African representatives of the plesiomorphion Protopatellata (Ephemeroptera: Baetidae). Russian Entomological Journal 20(4): 361-376.

Wiersema, Nick. 1998. Key to larvae of *Centroptilum*, *Procloeon* and *Pseudocentroptiloides* known from the Southeast with an emphasis on North Carolina (unpublished - version 2, 16 November 1998).

Wiersema, N. A. and W. P. McCafferty. 2004. New specific synonyms and records of North American *Centroptilum* and *Procloeon* (Ephemeroptera: Baetidae). Entomological News. 115(3): 121-128.

Diphetor

Genus Diagnosis: *No gill (or gill scars) on abdominal segment one;* villopore absent; *abdominal terga mostly brown with last segment often pale, sometimes with a pair of submedian pale dots;* three caudal filaments.

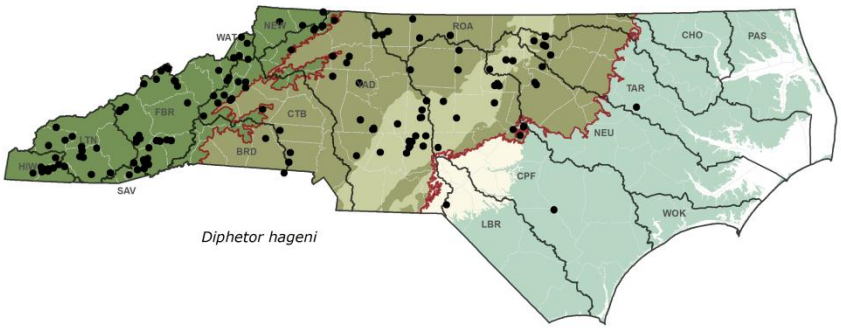
Habitat: Recorded from small streams. Possible collectors-gatherers.

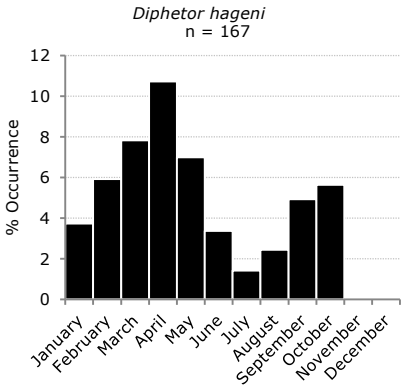
Distribution and Occurrence: Found mostly in the Mountains and Piedmont. Relatively common.

Species in NC: MONOTYPIC

hageni – see Genus Diagnosis.

Notes: Intolerant. *Diphetor hageni* superficially resembles *Pseudocloeon* but the lack of a gill scar, the more even abdominal pigmentation, and the often hump-backed appearance should separate the two genera. Pollution intolerant.





Taxonomic references:

nymphs:

Morihara, D. K. and W. R. McCafferty. 1979. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). Transactions of the American Entomological Society 105: 139-221.

Heterocloeon

Genus Diagnosis: *Forecoxae usually with a single filamentous gill or protuberance (osmobranchia);* tergal scales absent; *claw usually with two rows of denticles of which one row is a row of long denticles and the second row being small, squarish pegs* (400X magnification required) *or a ridge;* femoral villopore present; hind wing pads usually present; *two caudal filaments, median filament greatly reduced or apparently absent.* See subgenus diagnosis.

Habitat: Lotic, in riffles and on rocky substrates in slow to moderate currents. Scrapers.

Distribution and Occurrence: Usually collected in the summer. See species accounts.

Species in NC: TAKE TO SPECIES

Subgenus *Heterocloeon*: *Forecoxae with single gill (osmobranchia);* tibiae generally parallel-sided; 2 rows of denticles with first row of denticles becoming progressively longer; hind wing pads present but never very large; median caudal filament is reduced to one segment. Note: the osmobranchia can be broken off or lost on final instar specimens.

berneri* – nymphs 7-10 mm; *thoracic sterna and abdominal sternum 1 with protuberances bearing many bristles. Heterocloeon berneri* has been recorded from Oconee County, SC (adjacent to Transylvania County; McCafferty and Meyer, 2008) and may eventually be found in NC.

curiosum – nymphs 5-7 mm; labrum with 1 + 6-10 marginal setae; hind wing pads small; *gills clear with dark median area; conspicuous dorsal pattern;* caudal filaments unbanded; sexually dimorphic with males typically with higher contrast dorsally and with apical sterna 5-8 and half of 9 darkened (similar to *B. pluto*). Most common *Heterocloeon* in NC. Prefers larger rivers in Mountains and Piedmont and occurs from late spring through summer. Known as *Rheobaetis traverae* in Müller-Liebenau (1974). Pollution intolerant.

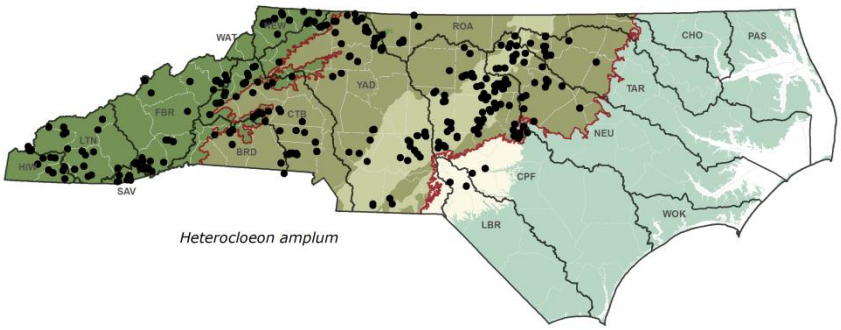
frivolum* – nymphs 4-5 mm; labrum with 1 + 5-8 setae, the separation between the medial seta and the lateral setae small compared to that of *H. curiosum;* hind wing pads relatively large; caudal filaments unbanded. Recorded from the TN portion of GSMNP.

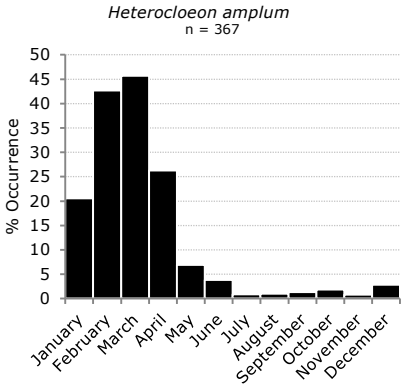
petersi – nymphs 7-8 mm; labrum with 1 + 3-5 marginal setae; *gills gray or gray-brown with light margin; no contrasting dorsal pattern.* Found in larger clean mountain streams and rivers. Listed as "vulnerable to extirpation" by Morse et al. (1997).

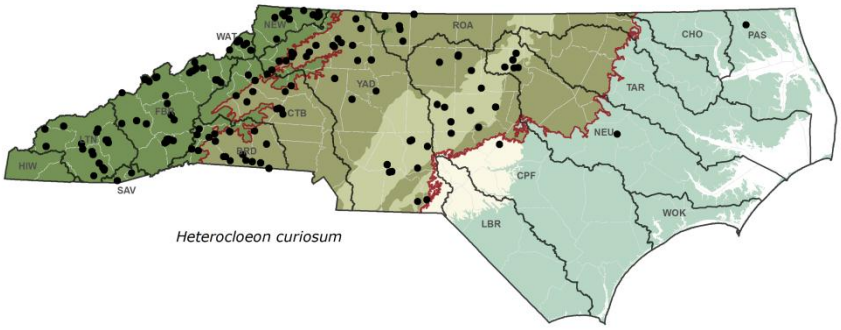
Subgenus *Jubilatum*: Contains largest *Heterocloeon* species; *no procoxal gills;* tibiae parallel-sided with small deeply forked setae; *one row of denticles becoming progressively longer and a secondary ridge without denticles*; hind wing pads usually small but sometimes absent; median caudal filament either reduced to one segment or of 3-5 segments but always subequal to or shorter than abdominal segment 10, unbanded.

amplum – nymphs 7-9 mm; *unique labial palpi (parallel-sided);* shortened leg setae; femora, tibiae and tarsi relatively shortened, tarsi slightly dilated apically with wide, pale medial band; gills large, suboval, with rudimentary trachea. Found in streams to rivers in the Mountains and Piedmont. Mainly collected during winter and spring months. Known previously as both *Baetis ampla* and *Acentrella ampla*. Moderately intolerant.

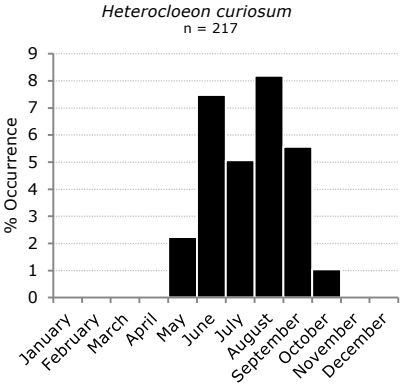
Notes: McCafferty et al. (2005) divided *Heterocloeon* into three subgenera: *H.* sensu stricto*, H. (Jubilatum)*, and *H. (Iswaeon)*. Guenther and McCafferty (2008) later elevated the subgenus *Iswaeon* to generic status citing its basal phylogeny and distinctiveness as reasons (see McCafferty et al., 2005 for discussion on its phylogeny).

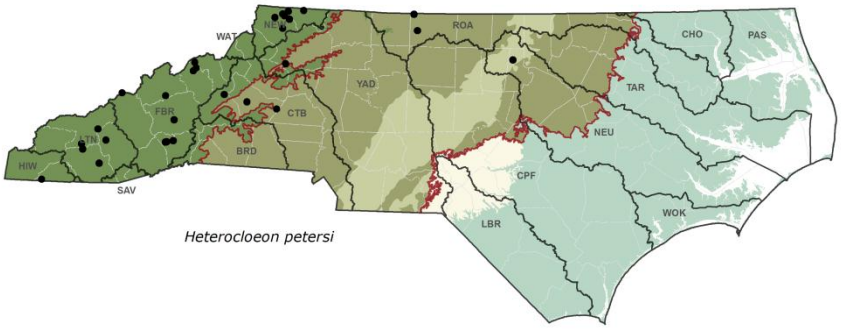




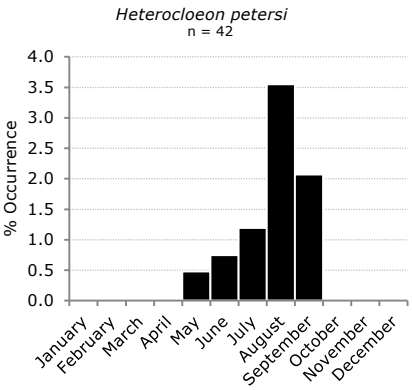


Heterocloeon curiosum





Heterocloeon petersi



Taxonomic references:

nymphs:

Guenther, J. L. and W. P. McCafferty. 2008. Mayflies (Ephemeroptera) of the Great Plains IV: South Dakota. Transactions of the American Entomological Society. 134(1): 147-171.

⇨McCafferty, W. P., Waltz, R. D. and L. M. Jacobus. 2005. Revision of *Heterocloeon* McDunnough (Ephemeroptera: Baetidae). Jrn of Insect Science 5:35.

Morihara, D. K. and W. P. McCafferty. 1979. The evolution of *Heterocloeon*, with the first larval description of *Heterocloeon frivolus* comb. n. (Ephemeroptera: Baetidae). Aquatic Insects 1(4): 225-231.

⇨Müller-Liebenau, I. 1974. *Rheobaetis*: a new genus from Georgia (Ephemeroptera: Baetidae). Ann of the Entomological Society of America 67(4): 555-567.

Iswaeon

Genus Diagnosis: *No procoxal osmobranchia; tibiae narrow at base and distinctly widened medially to apically, often appearing flattened;* tarsal claws with two rows of denticles, denticles in the primary row about same length (except for first few basal teeth); femoral villopore present; *hind wing pads absent*; two caudal filaments, median caudal filament reduced to about 6 segments and slightly longer than abdominal segment 10.

Habitat: Lotic, in riffles and on rocky substrates in slow to moderate currents. Scrapers or grazers.

Distribution and Occurrence: Primarily a mountain taxon and usually collected in the summer.

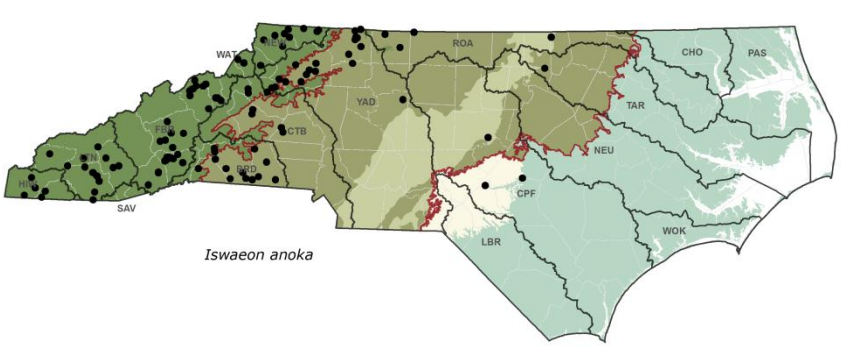
Species in NC: TAKE TO SPECIES

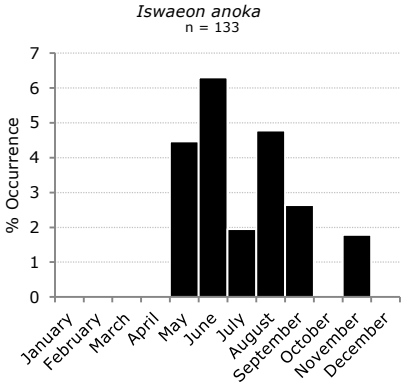
anoka – nymphs 2.8-4.1 mm; small, sometimes indistinct, dark dot at each tibial-femoral junction; large, a distinct dark spot laterally above the meso- and metanotal coxae; large median dark spots sometimes present on terga 2 and 6; *midventral dark spots sometimes present and variably developed on abdominal sterna 2-8 or 9; dorsum of abdomen often with a pale, median longitudinal stripe set against a darker background, sometimes reduced to small pale spots and interrupted on middle segments;* caudal filaments with dark medial band. Males smaller, darker than females. An uncommon and facultative species.

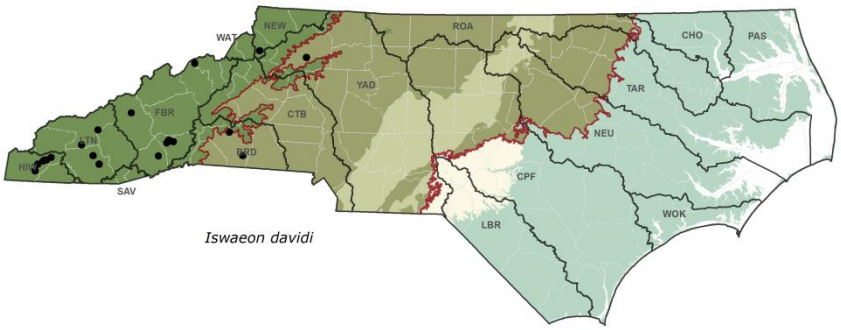
davidi – nymphs 3.8-4.2 mm; a small, sometimes indistinct, dark dot at each tibial-femoral junction; a large distinct dark spot laterally above the meso- and metanotal coxae*; a distinctive dark spot always present on dorsal abdominal segments 1-9 and usually on ventral abdominal segments 1-8 or 2-9,* spotting sometimes absent or faded on all or part of sternal segments; *typically no pale median longitudinal band on dorsum of abdomen;* caudal filaments with dark medial band and with distal fourth slightly darkened. Found in large mountain rivers. Rarely collected.

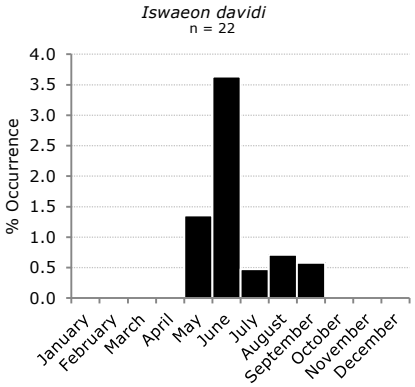
(rubrolaterale) – nymphs unknown. Adult male collected in Swain County, NC from an unnamed tributary to Raven's Fork in 2001 (McCafferty et al., 2005).

Notes: Formerly of *Heterocloeon, Iswaeon* was elevated to generic status by Guenther and McCafferty (2008) citing its basal phylogeny and distinctiveness as reasons (see McCafferty et al., 2005 for discussion on its phylogeny). *Pseudocloeon anoka* was revalidated as *I. anoka*, and *H. n. sp.* (BAU) became *I. davidi*.









Taxonomic references:

nymphs:

Daggy R. H. 1945. New species and previously undescribed naiads of some Minnesota mayflies (Ephemeroptera). Annals of the Entomological Society of America 38(3): 373-396. (description of *H. anoka* – as *Pseudocloeon anoka*)

Guenther, J. L. and W. P. McCafferty. 2008. Mayflies (Ephemeroptera) of the Great Plains IV: South Dakota. Transactions of the American Entomological Society. 134(1): 147-171.

⇨McCafferty, W. P., Waltz, R. D. and L. M. Jacobus. 2005. Revision of *Heterocloeon* McDunnough (Ephemeroptera: Baetidae). Journal of Insect Science 5:35.

Morihara, D. K. and W. P. McCafferty. 1979. The evolution of *Heterocloeon*, with the first larval description of *Heterocloeon frivolus* comb. n. (Ephemeroptera: Baetidae). Aquatic Insects 1(4): 225-231.

Labiobaetis

Genus Diagnosis: *Distal lobe present on antennal scape; subapical excavation on apical segment of maxillary palpi;* femoral villopore rudimentary or absent; *three subequal caudal filaments.*

Habitat: Lotic, in riffles on hard substrates, in moderate to fast currents. Primarily collectors-gatherers, facultative scrapers or grazers.

Distribution and Occurrence: See species accounts.

Species in NC: TAKE TO SPECIES

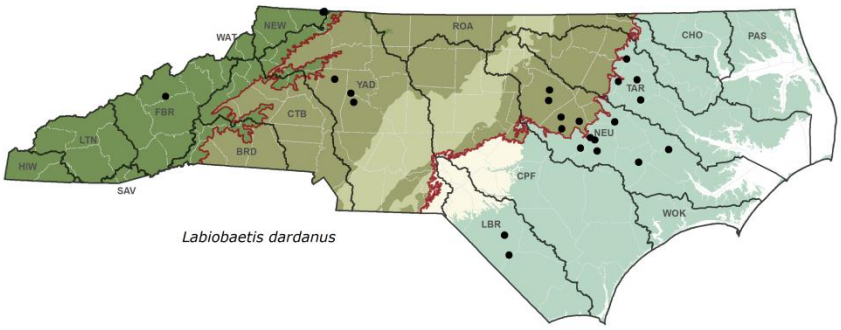
dardanus – nymphs 5-8 mm (see notes); *labral submarginal setae branched* (slide-mount labrum); *no pointed tubercle between mola and incisors on right mandible, at most roughened;* ventral row of setae on glossae in one irregular row in anterior half; lobe on antennal scape sometimes small; abdominal color pattern variable but usually dark (segments 2-3, 8 and anterior portion of 9 always dark) with 5 pale submedian spots, 2 anterior, 2 medial and a larger distal spot; sterna 6, 7 and/or 8-9 dark; caudal filaments with sharply delineated dark band. *L. dardanus* will key to *L. ephippiatus* in Unzicker and Carlson (1982). Found mostly in Piedmont and Coastal Plain.

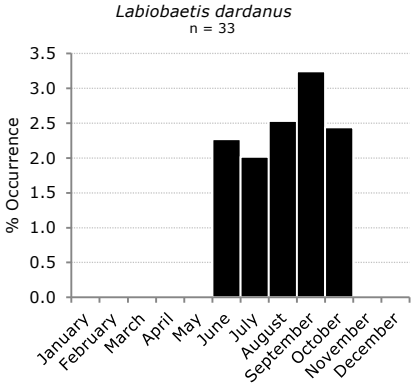
ephippiatus – nymphs 4-6 mm*; branched submarginal setae on labrum* (slide-mount labrum); *right mandible with prominent tooth like tubercle between incisor and mola;* ventral setae of glossae scattered or in two or more irregular rows; tracheation of gills not extensive; terga 2 and 5 brown laterally and with dark central spots and terga 6-10 with medial dark spots; last 2 terga and sterna can be brown to black; caudal filaments not as darkly banded and with a more gradual change in shading. Primarily found in Piedmont and Coastal Plain. Pollution intolerant.

frondalis – nymphs 5-8 mm; *spatulate submarginal setae on labrum* (slide-mount labrum); *a single row of dark, stout setae along posterior edge of femora* (>10 setae); gills with extensive tracheation on mature specimens; brown abdomen usually with pale submedian spots or arcs on each tergum anteriorly; caudal filaments lightly banded with a gradual change in shading. Widespread but less common in the Piedmont. Typically collected spring through fall. Faculative.

propinquus – nymphs 4-6 mm; *submarginal setae on labrum simple with paired setae;* tracheation of gills not extensive; usually has distinct color pattern, often with terga 2, 5, and 10 pale and typically with dark elongated spots down dorsal centerline. A dark morph exists that is similar in coloration to *L. dardanus* with head, thorax and abdomen dark and with sterna 1-4 or 5 with medial area pale. However, labral setation confirms this as *L. propinquus.* Most common *Labiobaetis* in NC during spring through fall. Widespread and facultative.

Notes: Formerly classified as *Pseudocloeon* and recently reinstatated as *Labiobaetis* (along with the gender specific species epithets) by McCafferty et al. (2010) possibly to standardize the classification of this genus globally. *Labiobaetis ephippiatus* and *L. dardanus* are difficult to separate unless the right mandible is mounted. Additionally, these two species may co-occur. Some *L. ephippiatus* records turned out to be *L. dardanus* and may, in fact, be far less common than *L. dardanus.* Some interesting *Labiobaetis* tentatively identified as *dardanus* have recently been collected from the Little River (Harnett County, 2011). These black wing-pad specimens are small, and may turn out to be a new species (pending DNA analysis). Pre-1997 records of *Labiobaetis* are coded *"Pseudocloeon spp. (dubious)"* in the BAU database.





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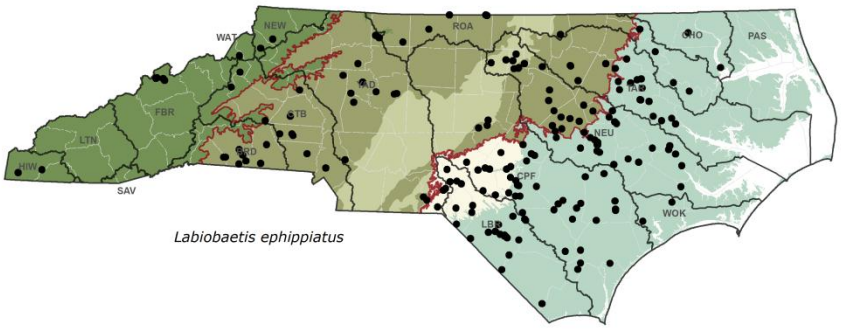
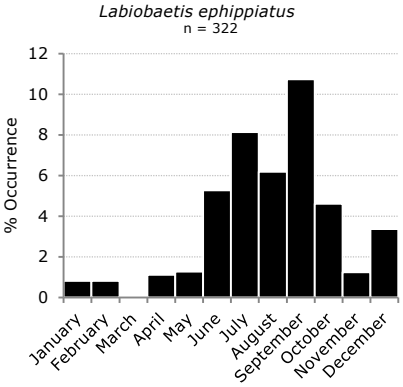
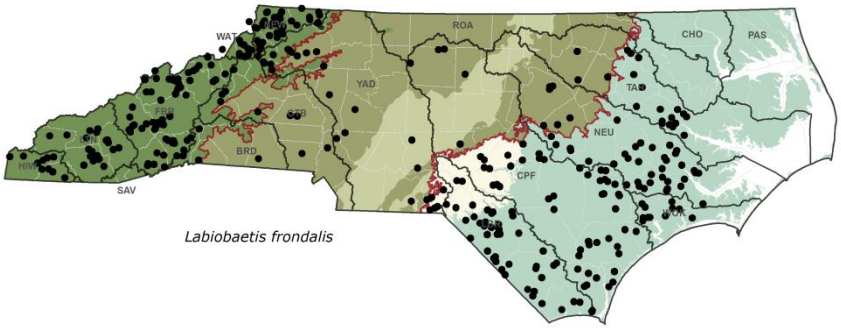
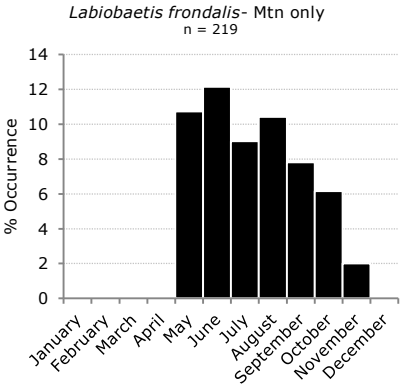


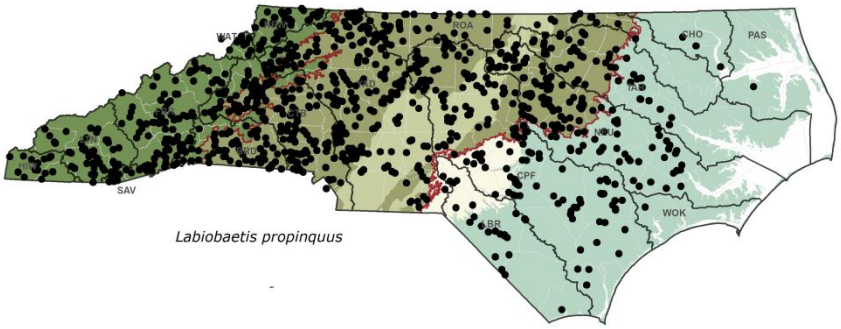
Labiobaetis ephippiatus



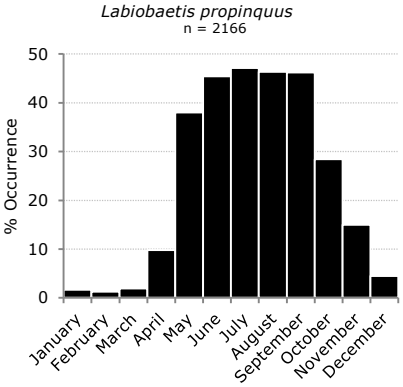


Labiobaetis frondalis





Labiobaetis propinquus



Taxonomic references:

nymphs:

⇨McCafferty, W. P. and R. D. Waltz. 1995. *Labiobaetis* (Ephemeroptera: Baetidae): New status, new North American species, and related new genus. Entomological News 106(1): 19-28

Soluk, D. A. 1998. The larva of *Baetis dardanus* McDunnough (Ephemeroptera: Baetidae). Entomological News 92(4): 147-151.

Unzicker, J. D. and P. H. Carlson. 1982. Ephemeroptera, Chapter 3 (97 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:

Durfee, R. S. and B. C. Kondratieff. 1997. Description of adults of *Labiobaetis apache* (Ephemeroptera: Baetidae) with additions and corrections to the inventory of Colorado mayflies. Entomological News 108(2): 97-101.

Paracloeodes

Genus Diagnosis: Small nymph; *distal segment of labial palpi pointed at apex; claws edentate and equal to half the length of respective tarsi; gills large, elongate and sub-oval; hind wing pads absent;* three subequal caudal filaments; dorsal spotting on abdominal segments variable, with some sternal pigmentation.

Habitat: Found in sandy creeks in deeper areas until maturity then nymphs migrate to within 1-2 feet of shore. Scrapers or grazers.

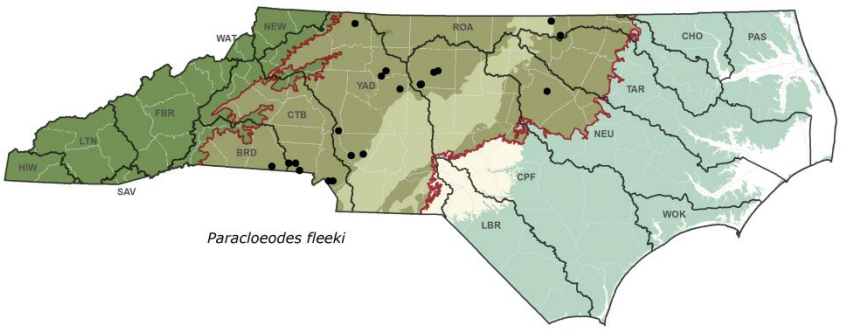
Distribution and Occurrence: Piedmont with a few Coastal Plain records. Relatively uncommon. Not collected during the winter months.

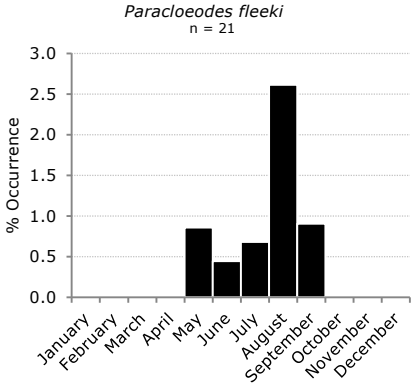
Species in NC: TAKE TO SPECIES

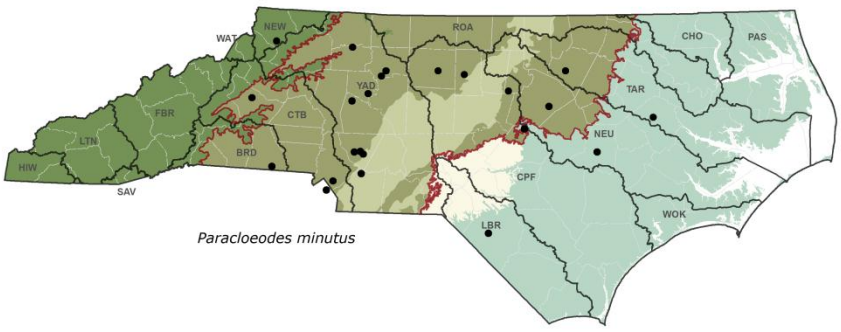
fleeki – nymphs 3.2-3.4 mm; *medial lobe of segment 2 of maxillary palpi is relatively angulate and non-protruding* (slide-mount for confirmation*); gills very long and with rudimentary tracheation;* dorsal coloration pale often with dark speckles and with segment 2 sometimes mostly dark and terga 3, 5-8 with elongate but small median dots; sternum with lateral tracheation that appears like a dark spot on segments 2-7 only. *Paracloeodes fleeki* is primarily found in the Southern Outer Piedmont ecoregion, an area between the Slate Belt and the mountains. Nymphs are usually collected from sandy substrates in medium-sized streams.

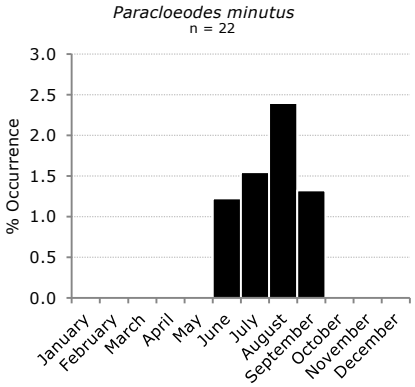
minutus – nymphs 3.2-3.4 mm; *medial lobe of maxillary palpi rounded and protruding;* has lateral edge spots at pleural fold; thick transverse anteromedial bars on sternum 5 or 6-9, often appearing to be in the intersegmental folds; dorsally spotted with segments 2 and 3 medially dark and 8 dark, segment 2 often with a pale spot with a dark outline. Primarily a Piedmont species.

Notes: *Paracloeodes* is very tolerant and is often found in highly impaired streams.









Taxonomic references:

nymphs:

⇨McCafferty, W. P. and D. R. Lenat. 2003. A new Nearctic *Paracloeodes* (Ephemeroptera: Baetidae). Entomological News 114 (1): 33-36.

Plauditus

Genus Diagnosis: *Segment 3 of labial palpi truncate to subquadrate, with medial margin almost straight (not receding from base);* tibiae and tarsi without row of long hairs; *no hind wing pads; two caudal filaments, median filament reduced to absent.*

Habitat: Lotic. In riffles, sometimes in sand or gravel with slow to moderate currents *(P. cestus).* Collectors-gatherers.

Distribution and Occurrence: Found mostly in the Mountains with some Piedmont records. Common.

Species in NC: TAKE TO SPECIES (see Notes)

cestus – nymphs 3.2-4.5 mm; *antennal length subequal to head length;* caudal filaments with wide dark band on distal half of caudal filaments; abdominal terga 1-9 with paired submedian dots; posterior of some segments sometimes with paired pale submedial spots (often hard to discern if background color is not significantly darker); dark terga variable, sometimes tergum 5 or 8, 9 or all three; sterna 4, 5 and 9 darkened, *segment 5 may be dark dorsally and ventrally appearing as a dark belt-like band;* no lateral tracheation on sterna. Previously known as *Barbaetis cestus.* Facultative.

gloveri – nymphs 3.2-5.0 mm; antennal length 1.5-2 times the head length; apical segment of labial palp slightly concave in lateral half and with a small distolateral point; tergum 2 with paired anteromedial dots and one central spot sometimes coalesced to form a V-like marking; terga 1-8 with paired submedian dots, with tergum 5 darkened laterally and segment 7 often darker, both dorsally and ventrally; fore- and mid-femora with dash markings; *thoracic sterna with large diffuse spots in intersegmental areas; abdominal sterna 1-5 or 6 with paired submedian dots and with a larger, darker posteromedian maculation* (usually appearing to be in the intersegmental folds); sterna with lateral tracheation (may have varying degrees of pigmentation); abdominal gills with tracheation obscured not reaching past basal half; caudal filaments either with no apparent band or three light narrow bands (basal band darkest).

dubius group: The following species have historically been artificially grouped by the BAU due to the difficulty in identification and incomplete species descriptions. Members of the *dubius* group have a variety of characters and can be left at *"dubius gr"* if the specimens are neither *P. cestus* nor *P. gloveri.* See species accounts below for tentative separation.

(bimaculatus) – nymphs 3.4-4.0 mm; legs with reddish-brown spot in middle of posterior face of femora; median caudal filament longer than width of lateral filaments at base; a pair of small dorsal submedian spots on terga 2-9 sometimes obscured on segments 2, 6 or 7; terga 6 and 7 (in male nymphs only) almost entirely reddish brown, sometimes a median spot on terga 2 and 6; *sternum 1 always reddish-brown and sometimes 6-7; lateral tracheation on sterna and at least sterna 5 and 6 with posteromedial dot, sometimes diffuse; gills on segment 7 tinged with reddish-brown;* caudal filaments with dark median band.

cingulatus – nymphs ?? mm; *abdomen evenly colored without contrasting colors although terga 4 and 8-10 frequently paler; no sternal maculations; caudal filaments unbanded.* Of the 25 BAU records (none recent) some may be misidentifications.

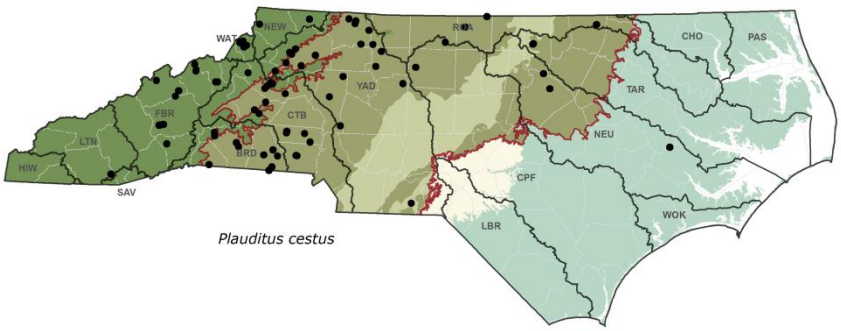
dubius – nymphs 3.0-3.5 mm; segment 9 with dark lateral dashes; sexually dimorphic color patterns: male – *enlarged medial spot on tergum 2 with 5-7 often dark; paired submedian spots on 3, 4, 8, 9 (spots on 5 obscured);* sterna with lateral tracheation and segments 3, 5-7 often tinged with reddish brown; female – *median spots on terga 2 and 6, paired submedian spots on terga 3-5, 7-9; terga 5-7 may be slightly darker than other terga which are generally pale overall;* caudal filaments with narrow dark median band.

punctiventris – nymphs ?? mm; wingpads vestigial and strap-like; *rear abdominal segments with faint white median stripe on dorsum; terga with a pair of dark submedian dots; anterior terga with pale subdorsal spots;* gills with extensive tracheation; caudal filaments with faint median band. Recorded from GSMNP.

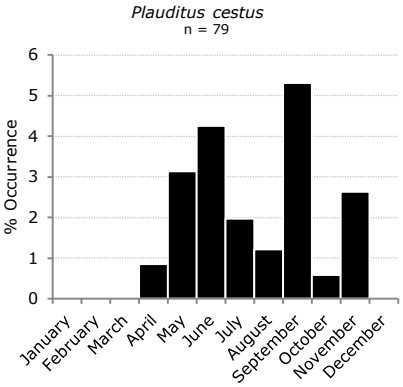
(virilis) – nymphs ?? mm; rear abdominal segments with pale median stripe on dorsum; *a pair of submedian pale spots on anterior of at least segments 2-4, with dark dorsal spots obscure but present on terga 2-9; sterna 5 and/or 6 possibly with obscure diffuse submedian maculations;* caudal filaments with dark median band. Recorded from GSMNP.

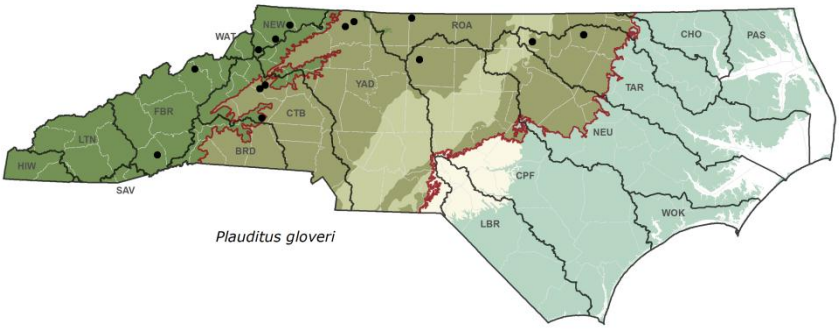
Notes: Currently, any *Plauditus* that is not *cestus* or *gloveri* is designated "*P. dubius* group". *Plauditus punctiventris* can be confused with *Iswaeon anoka* due to the similarity in dorsal coloration but does not have the medially inflated tibiae which is present in *Iswaeon.* An unpublished key provided by Luke Jacobus (CABW, 2011) appears to work well (with the caveat below) but, as of yet, has not been thoroughly vetted. There is some doubt as to the true identity of NC *Plauditus gloveri.* The aforementioned unpublished key separates *P. gloveri* and *P. punctiventris,* both of which have posteromedian spots on multiple sterna, by the presence *(P. punctiventris)* or absence *(P. gloveri)* of lateral tracheation on the sterna. However, NC *P. gloveri* specimens that match the original description (McCafferty and Waltz, 1998), including both dorsal and ventral pigmentation patterns as well as the shape of the labial palpi, have extensive lateral tracheation on the sterna. Additionally, the dorsal pattern of *P. punctiventris* is substantially different than that of *P. gloveri.* It may turn out that NC specimens are ultimately not *P. gloveri* and are, instead, an unknown species. However, for the present, specimens which match the above description should be identified as *P. gloveri.*

BAETIDAE



Plauditus cestus





Plauditus gloveri

Taxonomic references:

nymphs:

Berner, L. 1946. New species of Florida mayflies (Ephemeroptera). The Florida Entomologist 28(4): 61-82.
(description of *Plauditus bimaculatus* - as *Pseudocloeon bimaculatus*)

Jacobus, L. M. 2011. The mayfly family Baetidae in the Southeastern USA (Insecta: Ephemeroptera). Carolina Area Biologists Workshop, Hot Springs, North Carolina. 25 pp. Unpublished.

⇨Lugo-Ortiz, C. R. and W. P. McCafferty. 1998. A new North American genus of Baetidae and key to *Baetis* Complex Genera. Entomological News 109 (5): 345-353.

⇨McCafferty, W. P. and L. M. Jacobus. 2001. Revisions to *Plauditus cestus* and *P. gloveri* (Ephemeroptera: Baetidae). 2001. Entomological News 112: 305-310.

McCafferty, W. P. and R.D. Waltz. 1998. A new species of the small minnow mayfly Genus *Plauditus* (Ephemeroptera: Baetidae) from South Carolina. Entomological News 109: 354-356.

McDunnough, J. 1932. New species of North American Ephemeroptera II. The Canadian Entomologist 64: 209-215.
(nymphal key of *Plauditus cingulatus, dubius, punctiventris* and *virilis* - as *Pseudocloeon*)

Wiersema, N. A. and L. S. Long. 2000. Plauditus grandis (Ephemeroptera: Baetidae), a new small minnow mayfly from Tennessee. Entomological News 111: 45-48.

adults:

McDunnough, J. 1931. New species of North American Ephemeroptera. The Canadian Entomologist 63: 82-93.
(description of *Plauditus cingulatus* - as *Pseudocloeon*)

BAETIDAE

Procloeon

Genus Diagnosis: *At least the left (but usually both) mandibular incisor(s) half to completely fused from base;* segment 3 of labial palpi more rounded, less broad; claws usually half or less the length of tarsi; *gills rarely simple, usually with recurved dorsal lamellae on some or all segments;* gill tracheae symmetrical or palmate; prominent lateral spines on segments 8 and 9; *three subequal caudal filaments with dark band every third to fifth segment with lateral bristles usually to apices.*

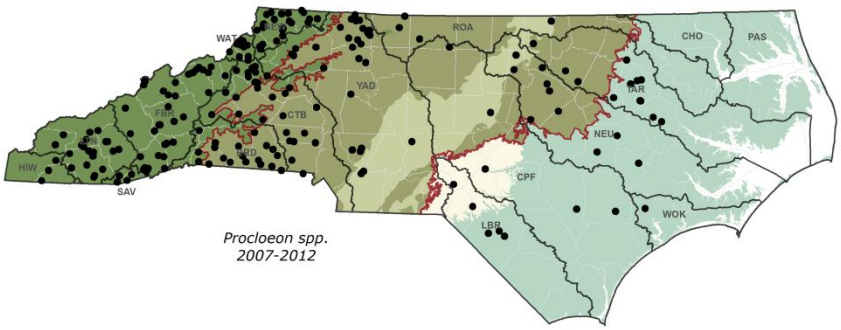
Habitat: Lentic and lotic, in slow to moderate currents in vegetation or on rocks. Collectors-gatherers, some may be facultative scrapers or grazers.

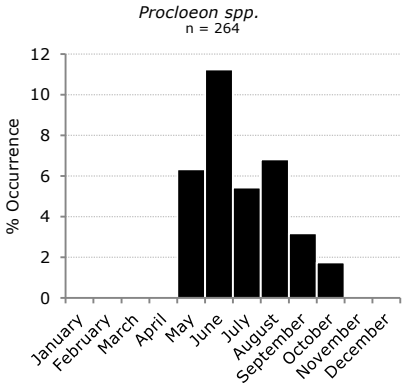
Distribution and Occurrence: A widespread genus but particularly common in the Mountains.

Species in NC: LEAVE AT GENUS

(fragile), (intermediale), n. sp., pennulatum *, (quaesitum), rivulare, (rubropictum), rufostrigatum, (simile), viridoculare

Notes: Procloeon is pollution intolerant as a genus. There are possibly up to ten or more *Procloeon* species in NC. Many *Procloeon* species (*bellum, intermediale, quaesitum, rubropictum*) are listed in Randolph (2002) as occurring in NC while some are recorded from SC (*bellum, quaesitum, rubropictum*) and TN (*pennulatum, rubropictum*). It appears that Southeast records of *P. bellum* are now attributable to *P. pennelatum* (McCafferty et al., 2010). BAU has records of *Procloeon "appalachia"* which is an invalid name and is referred to as *Procloeon n. sp.* here. This is the same species as the *Procloeon sp. A* currently being described by Wiersema and McCafferty (see data notes in McCafferty et al., 2010). Also, *Procloeon quaesitum* and *P. rivulare* are listed as "vulnerable to extirpation" by Morse et al. (1997). Records of *Procloeon* prior to 2007 are coded as *"Procloeon spp. (dubious)"* in the BAU database. Some species names in the BAU database are unverified.





Taxonomic references:

nymphs:

Wiersema, N. 1998. Key to larvae of *Centroptilum*, *Procloeon* and *Pseudocentroptiloides* known from the Southeast with an emphasis on North Carolina (unpublished, version 2, 16 November 1998. nondistributable)

McCafferty, W. P. 1993. Commentary on *Drunella tuberculata* and *Procloeon pennulatum* (Ephemeroptera: Ephemerellidae; Baetidae) in NC. Entomological News 104(5): 235-239.

Pseudocentroptiloides

Genus Diagnosis: Nymphs 7-8 mm; *labrum with a deep V-shaped notch along distal margin; glossae truncate; labial palpi 3-segmented and greatly broadened distally; claws edentate and longer than respective tarsi;* gills simple; three subequal caudal filaments; body pale to light brown, spicules along posterior margin if terga dark; tergum 6 may have large submedian dark spot; intersegmental fold between 7-9 pigmented.

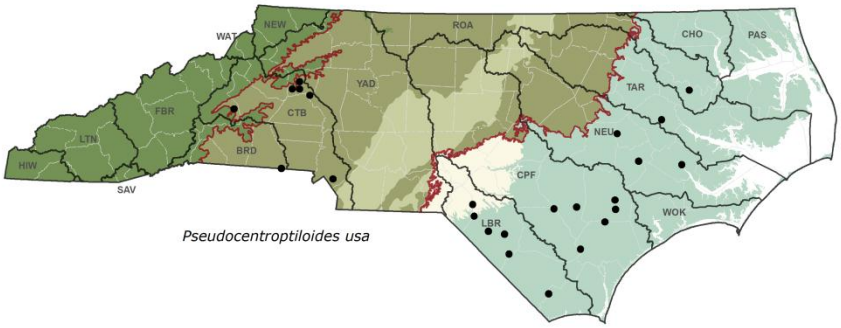
Habitat: Typically collected from larger rivers with sandy substrates. Collectors-gatherers.

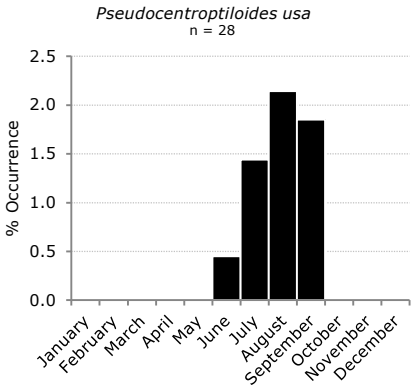
Distribution and Occurrence: Primarily a Coastal Plain species but also found in the Piedmont (Catawba R. basin). Rare but locally abundant and only collected during the summer.

Species in NC: TAKE TO SPECIES

usa – see Genus Diagnosis.

Notes: *Pseudocentroptiloides usa* is the only species in NC. The habitus of *Pseudocentroptiloides usa* is similar to that of *Apobaetis*. However, the deep labral notch lacking in *Apobaetis* should separate these two taxa.





Taxonomic references:

nymphs:

⇨Waltz, R. D. and W. P. McCafferty. 1989. New species, redescriptions, and cladistics of the genus *Pseudocentroptiloides* (Ephemeroptera: Baetidae). Journal of the New York Entomological Society 97(2): 151-158.

Wiersema, N. 1998. Key to larvae of *Centroptilum*, *Procloeon* and *Pseudocentroptiloides* known from the Southeast with an emphasis on North Carolina (Version 2, dated 16Nov98)

*Waynokiops**

Genus Diagnosis: Labrum with shallow medial emargination; *third segment of labial palpi broad and truncate with apical corner produced, lateral and distal margins densely setose;* both mandibles with incisors cleft to base; hind wing pads absent; claw subequal to respective tarsus in length; *abdominal segments produced posterolaterally and anterior terga with a large medial hook-like projection, projections decreasing in size posteriorly;* gills broad, bilamellate; three subequal caudal filaments with setal fringe entire throughout length.

Habitat: Lentic. Collected from ponds and lakes, at the margins. Trophic status unknown.

Distribution and Occurrence: Unknown.

Species in NC: MONOTYPIC

dentatogriphus* – see Genus Diagnosis

Notes: *Waynokiops dentatogriphus* has only been collected from lakes in AR, IN, OH, KY, and VA. It is possible this mayfly is present in NC or TN, however undersampling and its recent discovery and description most likely obfuscates its true geographical distribution. Little is known of *Waynokiops*.

Taxonomic references:

nymphs:

Hill, M.A. J. Pfeiffer and L. M. Jacobus. 2010. A new genus and new species of Baetidae (Ephemeroptera) from lakes and reservoirs in eastern North America. Zootaxa 2481: 61-68.

Homoeoneuria

Genus Diagnosis: *Procoxae without gill tuft at base; long setae on forelegs originating from ventral/anterior surface; foretarsi reduced, present as a small stub inserted preapically on tibia, claw absent*; abdominal sternum 1 with a finger-like anteromedial process; *first abdominal gill ventral, tuft-like; gills 2-7 simple, lanceolate, with posterior fringe of long setae.*

Habitat: Medium streams to larger rivers, in moderate to fast currents. Shallow burrower in areas of rippled sand. Collectors-filterers.

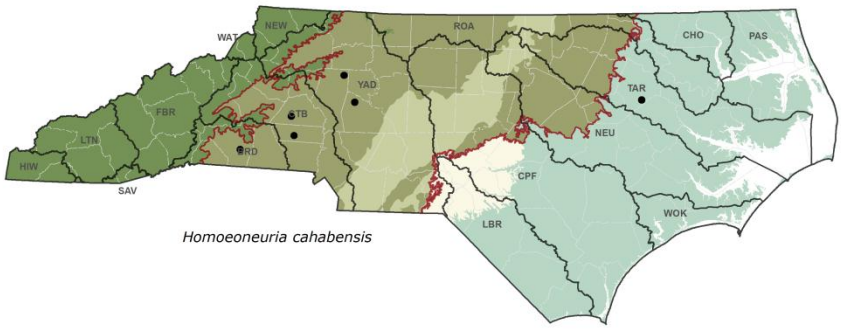
Distribution and Occurrence: Rare. See species accounts.

Species in NC: TAKE TO SPECIES

cahabensis – nymphs 7.0-10.7 mm; foretibia and tarsi strongly bowed; *coxae of legs with reddish brown basal spot; reddish brown markings on thoracic nota; apical potion of tibia curved upward.* Only species collected so far in NC. Found mostly in the Piedmont. Listed by NC Natural Heritage Program as Significantly Rare (2012).

dolani* – nymphs 9-12 mm; foretibia and tarsi strongly bowed; *coxae of legs without basal spot; no markings on thoracic nota; apical potion of tibia strait.* Should be in coastal waters.

Notes: *Homoeoneuria* is very distinct morphologically from other mayflies. One BAU *Homoeoneuria cahabensis* record is disjunct, collected from the Tar River (Edgecombe County, 2007). The specimen, however, cannot be located. The BAU reference specimen appears to be of *H. dolani* (Hunting Creek, Iredell County 1983) from measurements and overall nymphal size. However, the reference specimens are very old and in poor shape and therefore a definite identification cannot be made. Unzicker and Carlson (1982) note that *Homoeoneuria dolani* is the only species occurring in NC and is mentioned in Pescador and Peters (1980) as being in SC. Both species occur in SC according to McCafferty and Meyer (2008).



Homoeoneuria cahabensis

Taxonomic references:

nymphs:

⇨Pescador, M. L. and W. L. Peters. 1980. A Revision of the Genus *Homoeoneuria* (Ephemeroptera: Oligoneuriidae). Transactions of the American Entomological Society 106: 357-393.

Isonychia

Genus Diagnosis: Maxillae and *forecoxae with filamentous gill or gill tuft at base; forelegs with double row of long setae on inner margin of femora and tibiae;* meso- and metatarsal claws denticulate.

Habitat: Lotic, in riffles and near margins, in vegetation and on hard substrates including wood. Primarily collector-filterers, facultative predator.

Distribution and Occurrence: A very common and widespread genus.

Species in NC: LEAVE AT GENUS

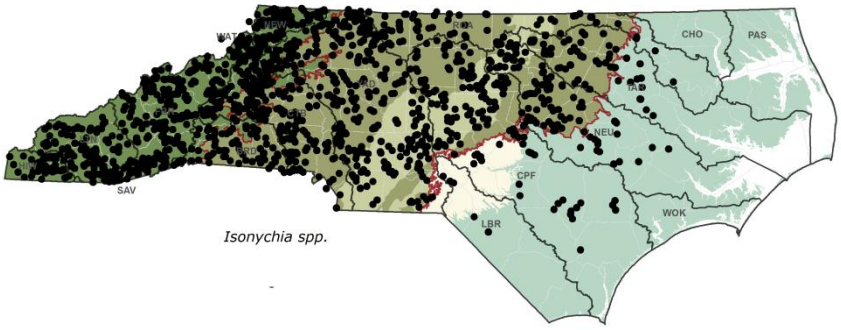
Subgenus *Isonychia*: nymphs 6-18 mm; *procoxal gills in tufts; posterior gills with apical stout marginal spines;* usually without diffuse dark spots in outer margin of each abdominal gill.

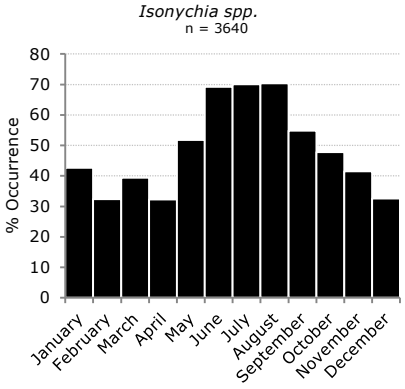
***(arida), (bicolor), (sicca), tuscalenensis* ***

Subgenus *Prionoides*: nymphs 10-18 mm; *procoxal gills single* (except *I. sayi*); *posterior gills without apical stout marginal spines;* usually with diffuse dark spots in outer margin of each abdominal gill.

(georgiae), (hoffmani), (obscura), (sayi), (serrata), (similis)

Notes: Often both subgenera will co-occur in the same stream. The species key is provisional and difficult to use. There may be seasonality differences between species as evidenced by the occurrence of multiple size classes in the same stream. *Isonychia sayi* has been recorded from NC (Harnett County, 2006) and SC (Oconee County) and *I. tuscalenensis* has been recorded from TN and southwestern VA. *Isonychia notata* was synonymized with *I. georgiae. Isonychia georgiae* is listed as "vulnerable to extirpation" by Morse et al. (1997). *Isonychia bicolor* has two generations per year, one large overwintering population, and one small summer population (Kondratieff and Voshell, 1983). These two populations may overlap in the Piedmont and Coastal Plain during the summer.





Taxonomic references:

nymphs:

Kondratieff, B. C. and J. R. Voshell, Jr. 1983. Subgeneric and species group classification of the mayfly genus *Isonychia* in North America (Ephemeroptera: Oligoneuriidae). Proceedings of the Entomological Society of Washington 85(1): 128-138. (to subgenus only)

Kondratieff, B. C. and J. R. Voshell, Jr. 1984. The North and Central American Species of *Isonychia* (Ephemeroptera: Oligoneuriidae). Transactions of the American Entomological Society. 110: 129-244.

Kondratieff, B. C, R. E. Zuellig and D. R. Lenat. 2006. Description of the adults of *Maccaffertium lenati* (Ephemeroptera: Heptageniidae), notes on its ecology and distribution, and a new North Carolina record for *Isonychia arida* (Ephemeroptera: Isonychiidae). Proceedings of the Entomological Society of Washington 108(4): 995-997.

adults:

Kondratieff, B. C. and J. R. Voshell, Jr. 1983. Subgeneric and species group classification of the mayfly genus *Isonychia* in North America (Ephemeroptera: Oligoneuriidae). Proceedings of the Entomological Society of Washington 85(1): 128-138. (to subgenus only)

McDunnough J. 1931. The genus *Isonychia* (Ephemeroptera). Canadian Entomologist 63:157-163.

Pseudiron

Genus Diagnosis: Mature nymph 11-16 mm; *body distinctly flattened with head and pronotum widest posteriorly; pronotum with posterolateral projections overlapping anterolateral corners of mesothorax;* pronotum with deep pit-like rectangular incisions medial to posterolateral projections, anterior margin of incision with setae; maxillary palpi 4-segmented; *tibia and tarsi distinctly bowed; claws longer than or subequal to tarsi and conspicuously constricted two-thirds to three-quarters from base; lanceolate gills with fibrilliform portion and finger-like projection arising ventrally about one-third distance from base;* abdominal segments 8 and 9 with small posterolateral projections; three caudal filaments; light yellowish-brown, anterior edges of terga with darker and coalesced medially into a anteromedial spot; tergum 7 with large dark subtriangular maculations anterolaterally, sterna pale with some lateral markings.

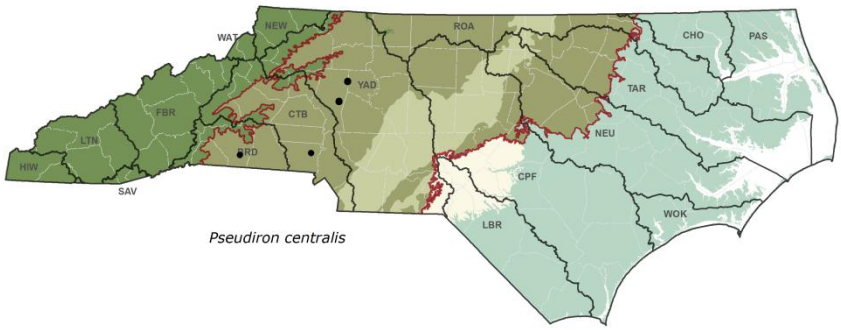
Habitat: Nymphs prefer sandy substrates in deep areas of medium streams to large rivers. Predatory on midges.

Distribution and Occurrence: Found in the Piedmont. Rarely collected.

Species in NC: MONOTYPIC

centralis – see Genus Diagnosis.

Notes: *Pseudiron centralis* is very mobile and difficult to collect. Two BAU records (1989, 1990) from Yadkin River basin in Iredell County. Two specimens have been collected by electrofishing, one from Broad River basin (Rutherford County, 2000) and one from the Catawba River basin (Gaston County, 2012). *Pseudiron centralis* is a predatory mayfly. Listed by NC Natural Heritage Program as Significantly Rare (2012).



Taxonomic references:

nymphs and adults:

Pescador, M. L. 1985. Systematics of the Nearctic genus *Pseudiron* (Ephemeroptera: Heptageniidae: Pseudironinae). The Florida Entomologist 68: 432-444.

Cinygmula

Genus Diagnosis: Body and head distinctly flattened; front of head incised medially; *maxillary palpi protrude at side of head; all gills on segments 1-7 similar in size and shape, although gill 1 slightly largest and gill 7 smallest;* fibrilliform portion of gills 2-6 absent or vestigial (reduced to one or two filaments); head, thorax, and dorsum of abdomen brown, usually with small, paired pale submedian spots; ventral surface of abdomen brown, particularly posterior segments, pale laterally; three caudal filaments without interfacing setae.

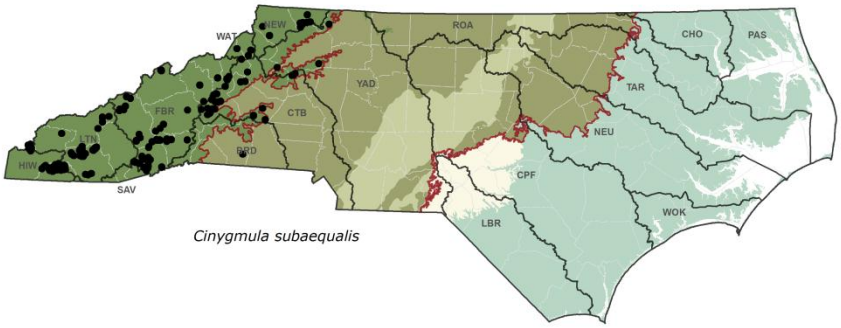
Habitat: Lotic, on cobbles in riffles with fast currents. Scrapers or grazers, facultative collectors-gatherers.

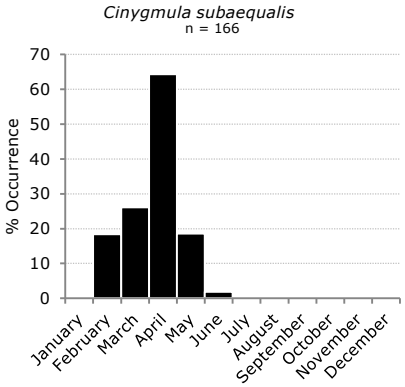
Distribution and Occurrence: In high quality mountain streams. Collected February through May.

Species in NC: TAKE TO SPECIES

subaequalis – see Genus Diagnosis.

Notes: Very intolerant. *Cinygmula subaequalis* is the only species in North Carolina and is often confused with *Heptagenia.* Specimens of *C. subaequalis* may be reddish in color (especially early instars) or otherwise have somewhat variable color patterns. Immature specimens may have a conspicuous large pale spot on the head covering the ocellar triangle, often easily seen on live specimens during field collections. Originally described from NC.





Taxonomic references:

nymphs:

Unzicker, J. D. and P. H. Carlson. 1982. Ephemeroptera, Chapter 3 (97 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.

Epeorus

Genus Diagnosis: Body and head distinctly flattened; claws without basal tooth but with three or more denticles; gills 2-6 inserted laterally but may extend ventromedially on segment 1; *two caudal filaments.*

Habitat: Clear, cool streams in areas of moderate to fast flow, particularly on rocks in riffles. Scrapers or grazers, facultative collectors-gatherers.

Distribution and Occurrence: Found in most relatively clean mountain waters and cooler piedmont waters (e.g. Uwharrie and Sauratown Mountains).

Species in NC: TAKE TO SPECIES

pleuralis group: *gills of abdominal segment 1 different from succeeding gills, enlarged anteromedially with expansions meeting or almost meeting ventrally.*

(fragilis) – *mature nymphs < 6.7 mm;* lateral margins of head capsule with abrupt transition near outer anterior corners of eyes, leaving eyes to hide much of the posterolateral margin of the head; ratio of head width to distance between antennal pedicels 2.11-2.45 (median 2.21); head with anterior margin mostly pale with a distinct "V" medially; *abdominal terga 3-7 without small, paired, dark submedial spots.* Recorded from Deep Creek, GSMNP.

pleuralis – *mature nymphs > 9.8 mm;* lateral margins of head capsule with abrupt transition near outer posterior corners of eyes, eyes hiding little of the posterolateral margin of the head; with a faint or indistinct "V" medially (may appear to be more of a triangle); *abdominal terga 3-7 with small, paired, dark submedial spots (sometimes faint)* and lacking dorsomedial protuberances at posterior edges of segments. Nymphs occur winter through spring.

vitreus group: gills of abdominal segment 1 similar in shape to succeeding gills, without anterolateral expansions.

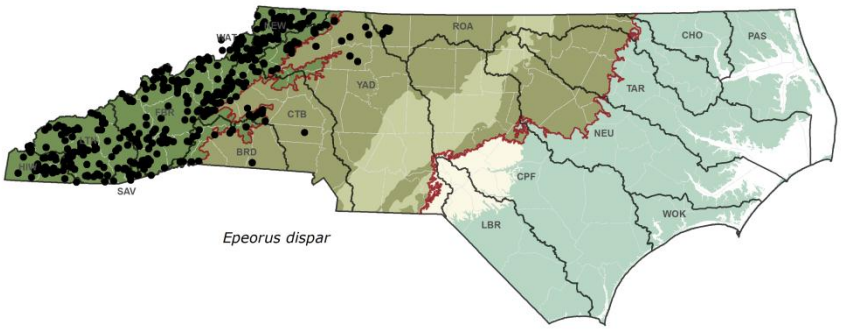
dispar – mature nymphs > 12 mm*; head distinctly wider anteriorly, posterior edge rounded between eyes; head mostly brown with pale elongate triangular spot anterior to median ocellus; outer posterolateral spines subequal or only slightly longer than inner posterolateral projections;* each terga with small but distinct median protuberance on posterior margin which get larger posteriorly; *dorsal projection of hind femur rounded;* abdominal gills with purplish brown pigmentation; gill 7 with longitudinal fold. Common during winter through spring.

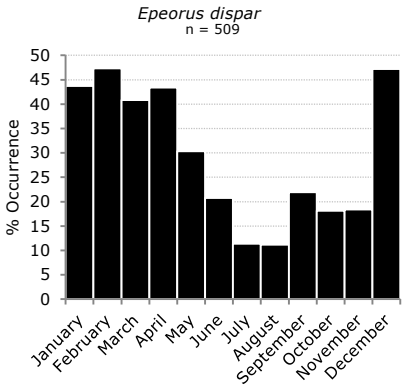
sp. 1 – mature nymphs > 9 mm; head oval, with greatest width at midline or beyond, rounded anteriorly, and straight posteriorly between eyes*; head mostly brown with anterior sixth of head paler;* dorsal (anterior) posterolateral spines subequal or only slightly longer than ventral posterolateral projections of abdomen; *terga 1-9 each with a small, black, medial protuberance on posterior margin, sharply pointed on anterior segments and produced basally into a short rounded longitudinal ridge on posterior segments;* submedial brown maculations on dorsum of abdomen absent; dorsal projection of apex of hind femur blunt; abdominal gills pale, slightly pigmented; gill 7 with small apical longitudinal fold. Collected from undisturbed, high gradient headwater streams.

subpallidus – mature nymphs > 8 mm; *head wider anteriorly but not rounded laterally or posteriorly, subquadrate;* head with 2 subrectangular anteromedial spots extended towards antennal bases and with a medial triangular pale spot projecting between anteromedial spots, lateral spots washed out, barely perceptible (on mature specimens); *pronotum with two cone-like tubercles medially;* outer posterolateral spines subequal or only slightly longer than inner posterolateral projections; terga 2 or 3-7 each with a very small median protuberance on posterior margin, sometimes vestigial; *dorsal projection of hind femur sharply pointed;* gill 7 may have slight longitudinal fold. Some records of *E. dispar* are most likely this species. Nymphs occur spring through summer.

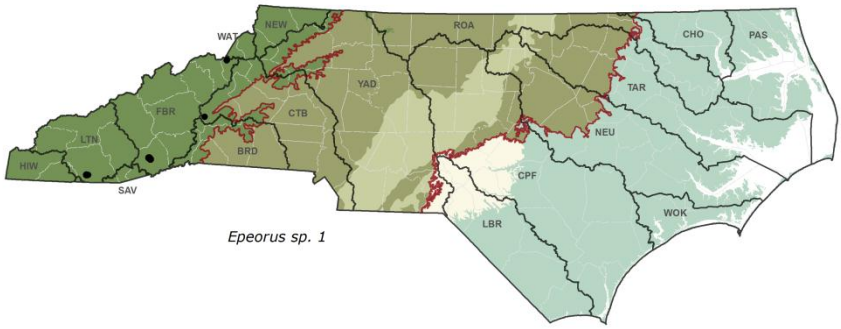
vitreus – nymphs 6-8 mm; *head with distinctive color pattern of four irregular pale spots on anterior margin of head, two submedial and two sublateral, and a stylized crown of three pale, basally fused projections anterior to median ocellus,* sometimes fused to pale area near anterior margin of head; *outer posterolateral spines longer than inner posterolateral projections.* Most commonly occurring *Epeorus* in NC particularly in the Appalachian and Uwharrie Mountains. The head color pattern is distinctive and reliable even in younger instars. Pale specimens will have the head pattern obscured. Formerly *E. rubidus.* A spring through summer species.

Notes: Each North Carolina *Epeorus* species is very intolerant to pollution. Small immatures should be left at genus if difficult to identify. *Epeorus sp. 1* is similar to both *Epeorus dispar* and *E. subpallidus*. It can be separated based on the absence of pronotal tubercles, the lack of submedial dark spots on the dorsum of the abdomen and the distinctive head shape. Also, the longitudinal fold of the seventh gill of mature specimens tend toward variability and is subject to interpretation and should therefore be considered a provisional character. Frequently, two or three species of *Epeorus* will co-occur in the same stream. Seasonality differences between species occur, tentatively; *E. pleuralis* emerges May through early June, *E. dispar* emerges May through late June, and *E. vitreus* emerges August through early September. Literature suggests that *Epeorus fragilis* emerges between early July and October. *Epeorus sp. 1* appears to emerge during the early fall (n=7). Emergence times are based on BAU data normalized for seasonal sampling effort (with the exception of *E. fragilis*). *Epeorus subpallidus* looks very similar to *E. dispar* and has been historically misidentified as such.

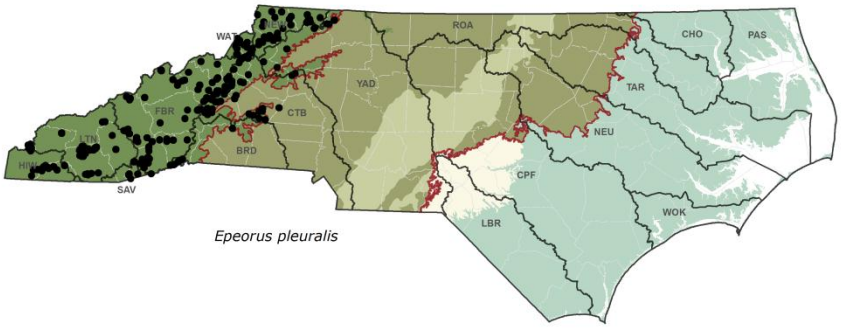




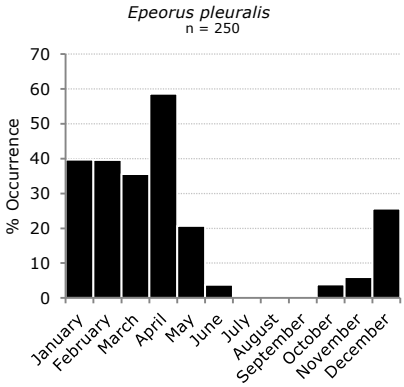
HEPTAGENIIDAE

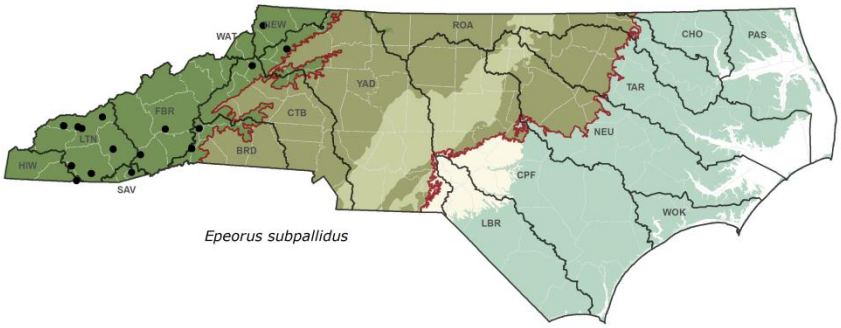


Epeorus sp. 1

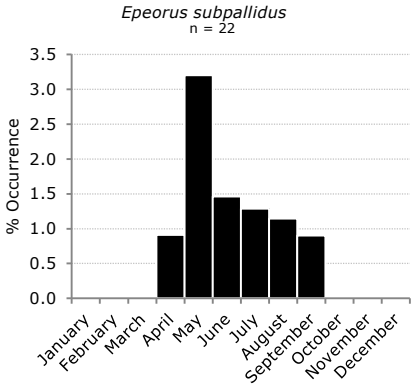


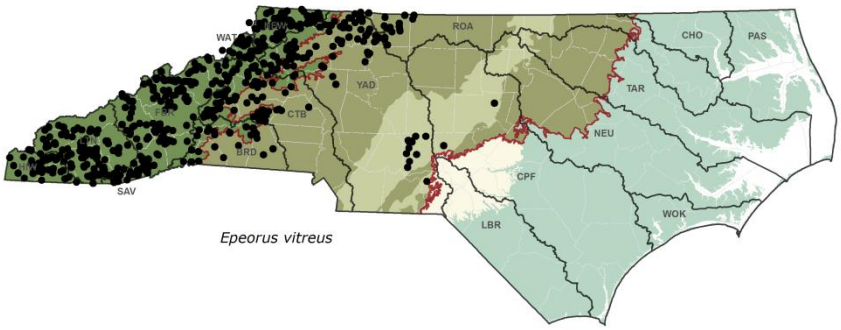
Epeorus pleuralis



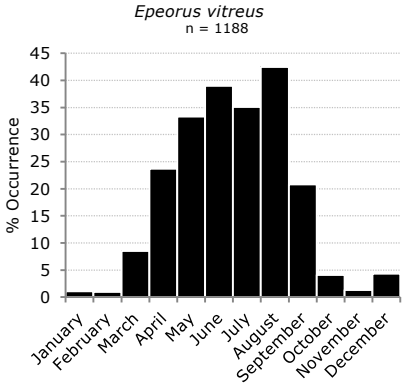


Epeorus subpallidus





Epeorus vitreus



HEPTAGENIIDAE

Taxonomic references:

nymphs:

Burian, S. K., B. I. Swartz, and P. C. Wick. 2008. Taxonomy of *Epeorus frisoni* (Burks) and key to New England species of *Epeorus*. Pp. 277–294 *In*: F. R. Hauer, J.A. Stanford, and R. L. Newell (eds.). International advances in the ecology, zoogeography and systematics of mayflies and stoneflies. University of California Publications in Entomology, Vol. 128, Berkeley.

⇨Webb, J. M and W. P. McCafferty. 2006. Contribution to the taxonomy of eastern North American *Epeorus* Eaton (Ephemeroptera: Heptageniidae). Zootaxa 1128: 57-64.

adults:

Morgan A. H. 1911. May-flies of Fall Creek. Annals of the Entomological Society of America 4:93-119, pl. 6-12. (description of adult *E. fragilis* – as *Iron fragilis*)

Heptagenia

Genus Diagnosis: Body and head distinctly flattened; front of head entire or only slightly incised medially; pronotum widest at anterior margin; claws without denticles but with a basal tooth; *gills of abdominal segments 1-7 with fibrilliform portion, dorsal lamellae of gills similar in shape but with gill 7 smaller than others;* three caudal filaments.

Habitat: Primarily lotic, in slow moving waters under stones or debris near banks or in pools. Scrapers or grazers, facultative collectors-gatherers.

Distribution and Occurrence: A widespread and relatively common genus. Can be found year round

Species in NC: LEAVE AT GENUS except *marginalis gr.* and *pulla*

marginalis group: *oblique black lines present on sides of dorsum of abdominal segments.*

(dolosa) – nymphs undescribed, although one larva has been collected and reared. As of yet no reliable diagnostic species characters have been found (Jacobus and Webb, 2013). Adults reported from GA (also one larva), NC, SC, and VA.

marginalis – short spines present at posterolateral on abdominal segments 6 and 7; apical spines on apex of caudal filament segments short, about one-eighth the respective segment. Common in the Mountains and Piedmont, also Slate Belt streams. Intolerant of pollution.

(townesi) – nymphs undescribed, although can apparently be separated from *H. marginalis* by having long spines on apex of each caudal filament segment, about one-third the length relative to the respective segment (Jacobus and Webb, 2013). Adults reported from GA, NC, SC, and TN.

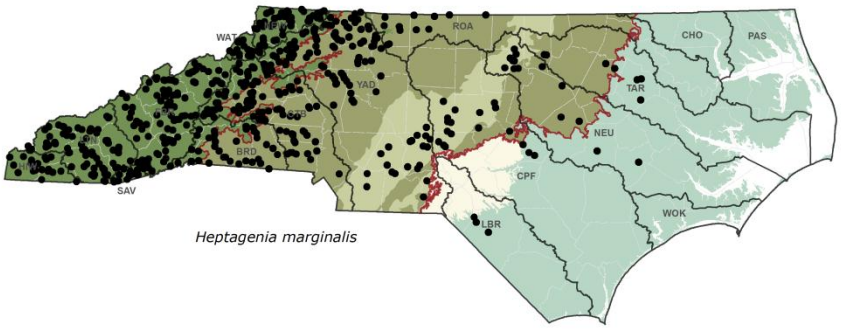
ungrouped species:

flavescens* – nymphs 15 mm; tergum 1 pale, 2-10 dark brown; pale submedian dots on 2-3, on 4-5 the spots coalesce to form inverted U-shaped marks, and with a large V-shaped pale areas on 8-9; venter pale except for brown markings on lateral margins of sterna 9. Known from GA, SC, VA, and WV.

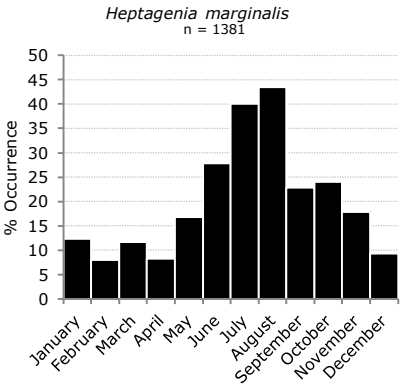
julia – *nymphs 8-9 mm; no black lines present on sides of dorsum of abdominal segments.* Found in Mountains or upper Piedmont. Recorded from GSMNP. Intolerant of pollution.

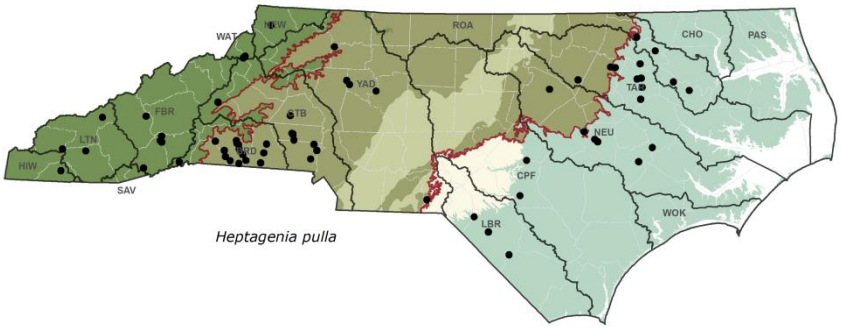
pulla – *nymphs 12* mm; no oblique black lines present on abdominal segments. Very similar to *H. julia* except for size. Collected from larger streams and rivers. Relatively common and widespread.

Notes: There are at least two unassociated species in NC. Species identifications should be tentative at best.

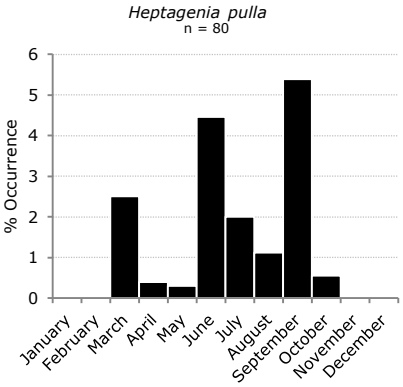


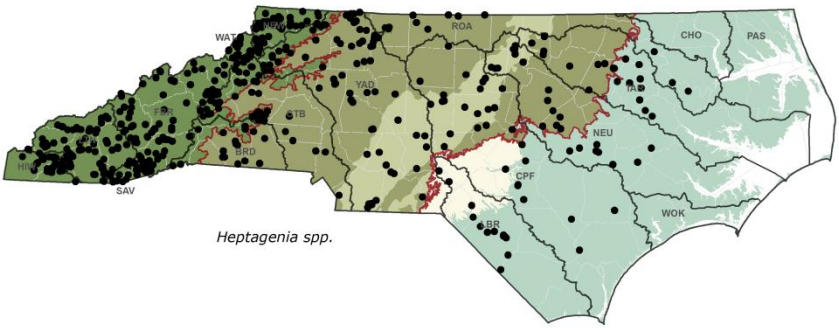
Heptagenia marginalis





Heptagenia pulla





Heptagenia spp.

Taxonomic references:

nymphs:

Daggy R. H. 1945. New species and previously undescribed naiads of some Minnesota mayflies (Ephemeroptera). Annals of the Entomological Society of America 38(3): 373-396. (description of *H. flavescens*)

Flowers, R. W. 1980. Two new genera of Nearctic Heptageniidae (Ephemeroptera). The Florida Entomologist 63: 296-307.

Flowers, R. W. 1980. A review of the Nearctic *Heptagenia* (Heptageniidae: Ephemeroptera). Pp. 93-102 *in* J. F. Flannagan and K. E. Marshall (eds.). Advances in Ephemeroptera Biology. Plenum, New York. (mouthparts to *H. flavescens* but no description)

Jacobus, L. M. and J. M. Webb. 2013. A new junior synonym for *Raptoheptagenia cruentata* (Walsh, 1863) and remarks about Nearctic *Heptagenia* Walsh, 1863 (Insecta: Ephemeroptera: Heptageniidae). Proceedings of the Indiana Academy of Science 121(2): 143-146.

⇨Unzicker, J. D. and P. H. Carlson. 1982. Ephemeroptera, Chapter 3 (97 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:

Flowers, R. W. 1980. Two new genera of Nearctic Heptageniidae (Ephemeroptera). The Florida Entomologist 63: 296-307.

Leucrocuta

Genus Diagnosis: Body and head distinctly flattened; *head wider than pronotum* (pronotum widest near middle); dark freckles on anterior portion of head; *gills of abdominal segments 1-6 with fibrilliform portion, dorsal lamellae of gills similar in shape but with gill 7 smaller than others; three caudal filaments with no intersegmental setae.*

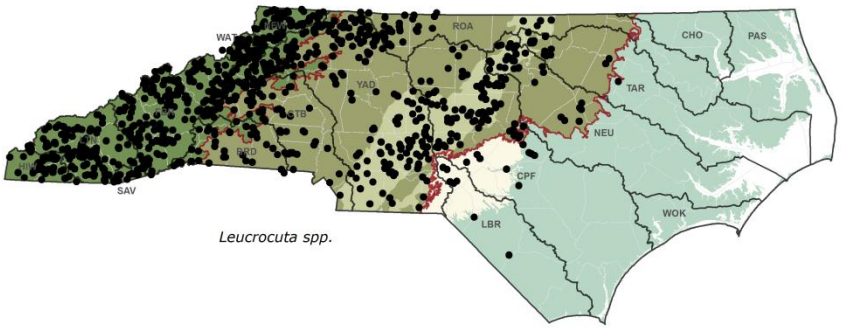
Habitat: Collected from small, clean streams, from moderate to fast riffles and possibly pools. Scrapers or grazers, facultative collectors-gatherers.

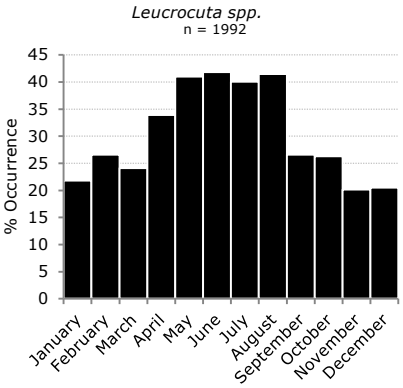
Distribution and Occurrence: In the Mountains and Piedmont, particularly the Slate Belt. Common.

Species in NC: LEAVE AT GENUS

aphrodite, hebe, (juno), (maculipennis), (thetis)

Notes: *Leucrocuta* is intolerant at the generic level. Most *Leucrocuta* in the Piedmont are probably *aphrodite*, however there are some undescribed species in the mountains. *Leucrocuta maculipennis* is reported from GA, SC, TN, VA, and WV and recently from NC (McCafferty et al., 2010).





Taxonomic references:

nymphs:

Flowers, R. W. 1980. Two new genera of Nearctic Heptageniidae (Ephemeroptera). The Florida Entomologist 63: 296-307.

McCafferty, W. P. 2004. Contribution to the systematics of *Leucrocuta, Nixe* and related genera (Ephemeroptera: Heptageniidae). Transactions of the American Entomological Society 130(1):1-9.

Unzicker, J. D. and P. H. Carlson. 1982. Ephemeroptera, Chapter 3 (97 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:

Flowers, R. W. 1980. Two new genera of Nearctic Heptageniidae (Ephemeroptera). The Florida Entomologist 63: 296-307.

Maccaffertium

Genus Diagnosis: Body and head distinctly flattened; *head width subequal to pronotal width; abdominal gills 1-6 with apex truncate, gill 7 filamentous;* three caudal filaments; body variously patterned.

Habitat: Primarily lotic, found in slow to fast flows on a variety of hard substrates. *Maccaffertium* are found year round in waters of all qualities. Scrapers or grazers, facultative collectors-gatherers.

Distribution and Occurrence: Widespread and abundant as a genus. See species accounts.

Species in NC: TAKE TO SPECIES

carlsoni – nymphs 12-14 mm; *no hairs and 7-9 spine-like setae on maxillary crown; protarsal claws without denticles; posterolateral projections present anterior to segment 6;* abdominal sterna pale, sometimes with faint submedian dots and oblique lines anterolaterally. Uncommon and primarily in small, mountain streams. Listed as "vulnerable to extirpation" by Morse et al. (1997). Intolerant.

exiguum – nymphs 9-11 mm; *no hairs and 4-9 (usually 5-6) spine-like setae on maxillary crown;* claws usually with denticles; *posterolateral projections absent anterior to segment 6; typically with a pale band at base of wing pads; pale ventrally.* Immatures may key to *M. terminatum.* Widespread and fairly common in summer. Intolerant.

ithaca – nymphs 9-14 mm; *15-35 (usually 20-30) hairs and 4-6 spine-like setae on maxillary crown; usually no denticles on tarsal claws; posterolateral projections absent anterior to segment 6; sterna 5, 6, or 7-8 with transverse sternal bands with anterolateral extensions, sometimes reduced to spots.* Similar to and often co-occurs with *M. modestum* in higher quality streams. Primarily a mountain species.

lenati – nymphs 11-14 mm; *maxillary crown with 25-35 hairs and 1-3 spine-like setae;* protarsal claws without denticles*; posterolateral projections absent anterior to segment 6; distinctive dorsal pattern with 1-2,4-5, and 7-8 (and 9 in immatures) pale with paired submedial dots and a larger anteromedial spot, with spot sometimes elongate or triangulate;* posterior edge of segments 7-9 typically with dark, transverse band, sometimes interrupted medially; *anteromedial dark triangular marking on ventral segments 7 or 8-9.* Intolerant and common to Slate Belt streams. Keys to couplet 18 in Bednarik and McCafferty (1979).

mediopunctatum – nymphs 7-10 mm; *0-9 (usually less than 5) hairs and 4-8 (usually 5-6) spine-like setae on maxillary crown;* protarsal claws usually with denticles; *posterolateral projections present anterior to segment 6; sternal maculations variable though usually with dark crossbands on sterna 2-8 and 9 with dark, obliquely oriented lateral bands, sometimes connected anteromedially.* A facultative summer species only found in the mountains, especially rivers.

meririvulanum – nymphs 10-16 mm; *no hairs and 7-10 spine-like setae on maxillary crown;* claws without denticles; *posterolateral projections absent anterior to segment 6; terga 5 and either 7-8, or 7-9 each with distinct V-shaped pale mark; ventrally pale.* A very intolerant, small mountain stream species.

mexicanum – nymphs 7-8 mm*; more than 30 hairs and 2-3 spine-like setae on maxillary crown;* protarsal claws without denticles; *posterolateral projections absent anterior to segment 6; terga 7-9 with pale areas coalesced to form a distinct V-shaped pale mark; ventrally pale*. Widespread in larger rivers but most abundant on the Coastal Plain. Common in summer. Formerly *Maccaffertium integrum* (now a subspecies). Facultative.

modestum – nymphs 8-11 mm; *has 15-50 (usually 20-40) hairs, 4-7 spine-like setae on maxillary crown; claws with denticles* (some specimens may have one protarsal claw with and the other without denticles); *posterolateral projections absent anterior to segment 6; highly variable dorsal and ventral color patterns;* two common ventral patterns: (1) presence of anteromedial bars on 7-9 with bar on 7 possibly obscure and that on 9 extended posterolaterally to form an inverted "U" or (2) sterna 2-8 with two pair of small dots; one pair anteromedially placed and the second pair posterior and lateral to the first pair, may be faint on anterior segments. Most common species in NC. Widespread and facultative, although absent from the Pasquotank River basin. *M. modestum* is most likely a complex of species (possibly including *annexum*, *rubromaculatum*, and *rubrum*)

pudicum – nymphs 11-14 mm; *15-40 (usually 20-30) hairs and 4-8 spines on maxillary crown; no denticles on protarsal claws ; posterolateral projections present anterior to segment 6; ventrally variable with anterior edges of sterna 3, 4, or 5-9 with irregular transverse markings, reduced on anterior segments on some specimens to medial blotches or oblique dashes and with sternum 9 with anteromedial markings extended to form an inverted "U" or sterna 1-9 varying to completely pale*. Mountains and Piedmont. Common in smaller streams. Anecdotal evidence suggests that all individuals within a single population will either have sternal maculation or all be lacking maculation. Populations may separate out based on sternal maculation present in degraded streams while maculation may be absent in clean streams.

pulchellum – nymphs 7-9 mm; *no hairs, 5-6 spine-like setae on maxillary crown; protarsal claws with denticles; tergum 7 mostly white; posterolateral projections absent anterior to segment 6; venter pale except for lateral marks on sterna 9*. Only three BAU records, from the New and Hiwassee River Basins. Identifications uncertain.

sinclairi* – nymphs 10-12 mm; *30-50 hairs and 2-4 (usually 3) spine like setae on maxillary crown; no denticles on tarsal claws; lateral projections anterior to segment 6;* sterna pale except 9 which sometimes has posterolateral brown areas. In small cold streams with slow current. Described from southeastern TN and since recorded from GSMNP. Also recorded from SC, VA, and WV. Listed as "vulnerable to extirpation" by Morse et al. (1997).

smithae – nymphs 7-9 mm; *25-40 (usually more than 30) hairs and 3-6 (usually 4-5) spine-like setae on maxillary crown;* protarsal claws with denticles; *posterolateral projections absent anterior to segment 6; sterna with dots and dashes* (as in some *M. modestum*). Rare, no verified adult records in NC and recorded from SC, GA and further south. Some BAU records are possibly suspect although one specimen from Hood Creek in Brunswick County (February 2003) was verified by McCafferty et al. (2010).

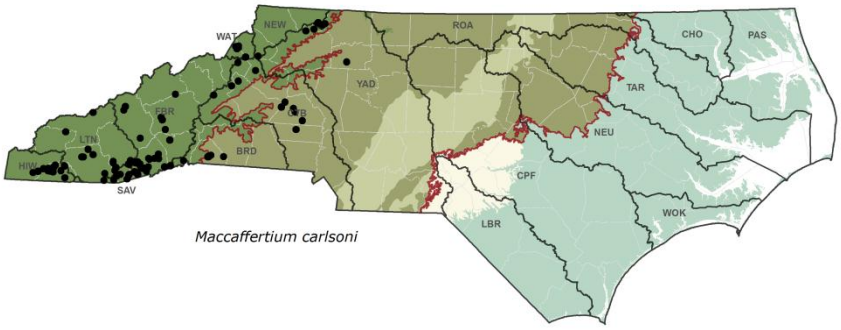
terminatum – nymphs 9-10 mm*; 0-8 hairs and 2-6 (usually 3-4) spine-like setae on maxillary crown;* with or without denticles on protarsal claws; *posterolateral projections absent anterior to segment 6; dorsal and ventral color patterns variable but usually mostly pale with dot-dash markings and with brown lateral longitudinal markings on sterna 4-9*, sterna 7-9 may have thin oblique dashes connected to lateral markings. Darker specimens without hairs may be immature *M. exiguum*. A highly variable species which may, in fact, be a complex. A widespread and relatively common taxon. Facultative.

vicarium – nymphs 10-18 mm; *12-40 (usually 20-35) hairs and 2-5 (usually 2-4) spine-like setae on maxillary crown;* protarsal claws *without denticles; posterolateral projections present anterior to segment 6; wide dark bands on posterior margins of both dorsum and sternum of abdomen, of even width on sternum and of variable width on dorsum*. Typically found in Good to Excellent waters in the Slate Belt in the fall through winter. Recorded from GSMNP.

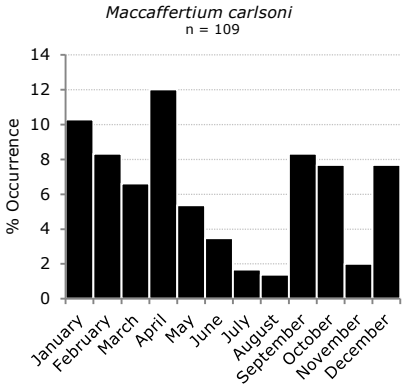
wudigeum – nymphs 8-10 mm (?); *no hairs and 5 spine-like setae on maxillary crown; protarsal claws with denticles; posterolateral projections present on segments 3-9;* dark coloration on outside edge of pronotum, clear on extreme lateral edge*; abdomen mostly brown dorsally, each segment with pair of submedian dark dots; ventrally pale*. This recently described species will key to couplet 4 in Bednarik and McCafferty (1979). Collected from upper Wilson Creek and the lower Linville River. Listed by NC Natural Heritage Program as Significantly Rare (2012).

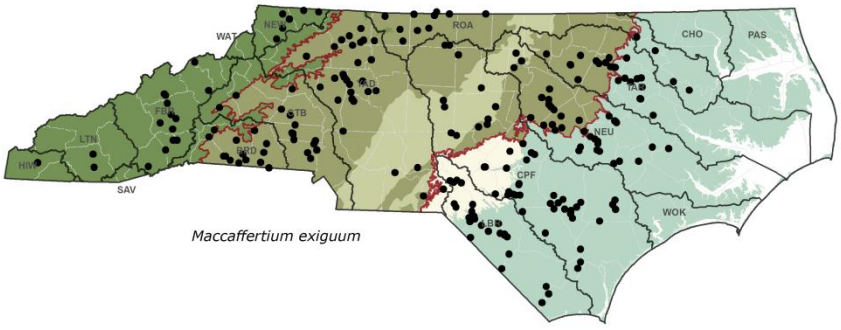
Notes: This group is taxonomically difficult due to interspecies variability and often requires slide-mounts of mouthparts and legs to get a species level identification. Additionally, many species listed above may actually represent species complexes (particularly *M. modestum*) and therefore may result in the same species designation for specimens of different size classes and of variable characters. Immature specimens often do not key well and should, therefore, be left at genus. Small streams will often only have 1-2 species while larger streams and rivers may have 4-5 species. All but one *Stenonema* species were transferred to *Maccaffertium* in 2004. It should be noted that due to misidentifications, the presence of species complexes, or immature specimens identified to species, the maps and seasonality charts presented below may be unreliable.

HEPTAGENIIDAE

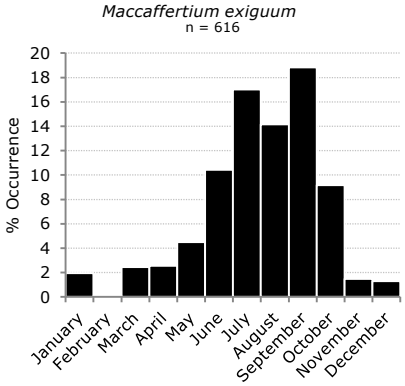


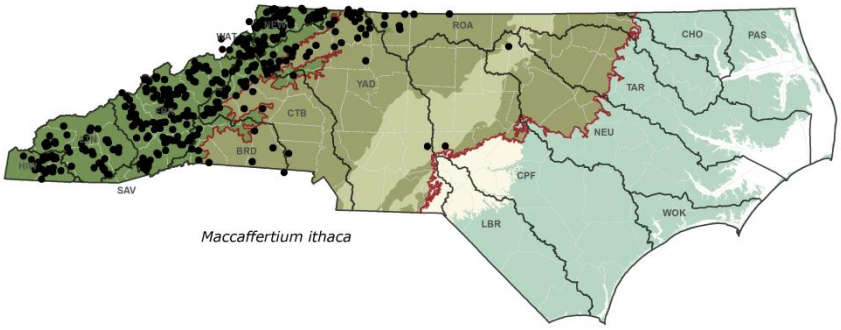
Maccaffertium carlsoni



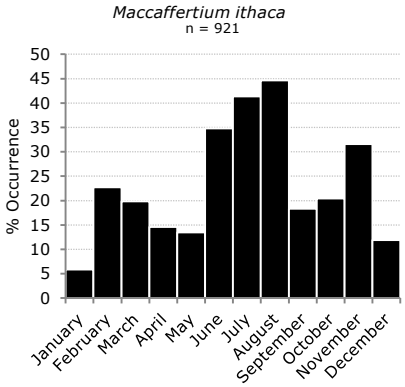


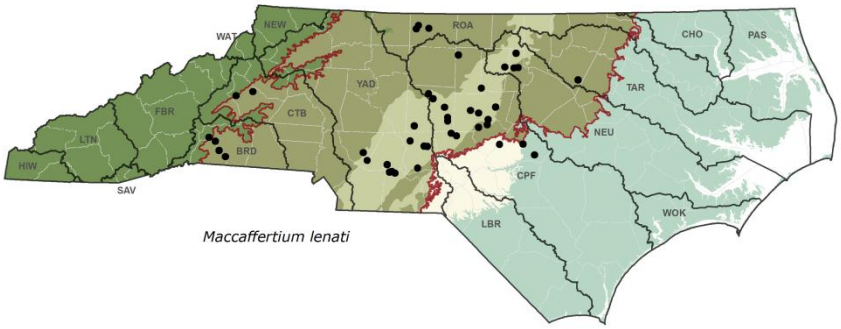
Maccaffertium exiguum



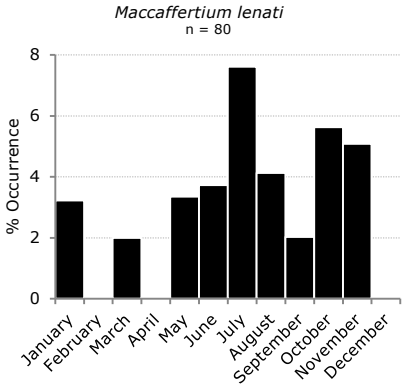


Maccaffertium ithaca

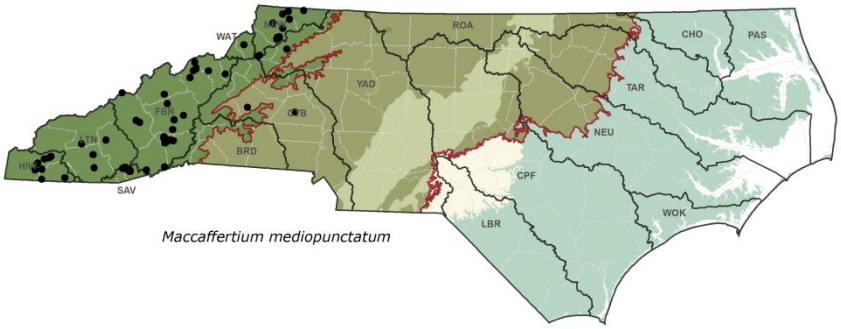




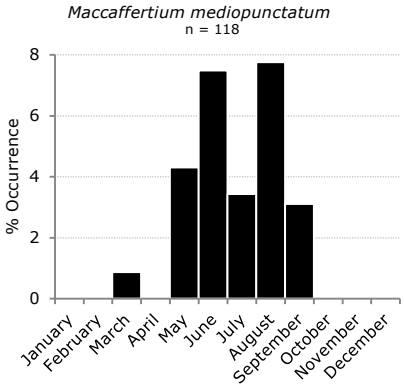
Maccaffertium lenati

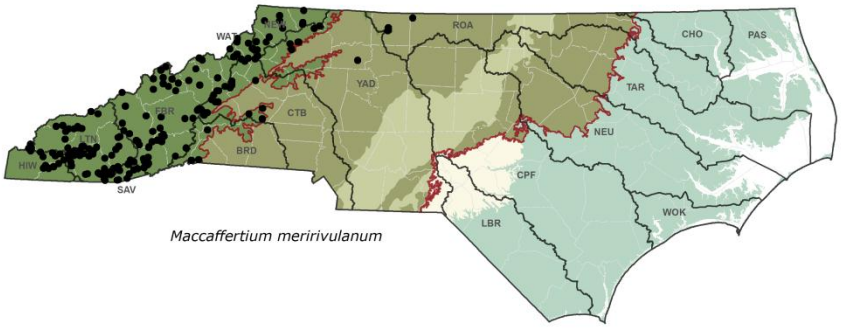


HEPTAGENIIDAE

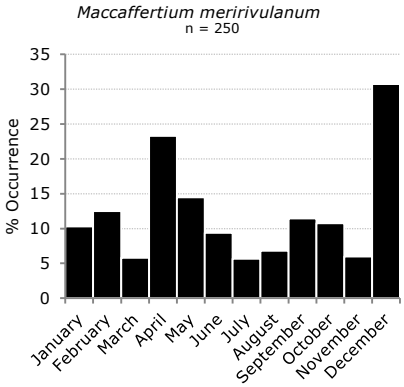


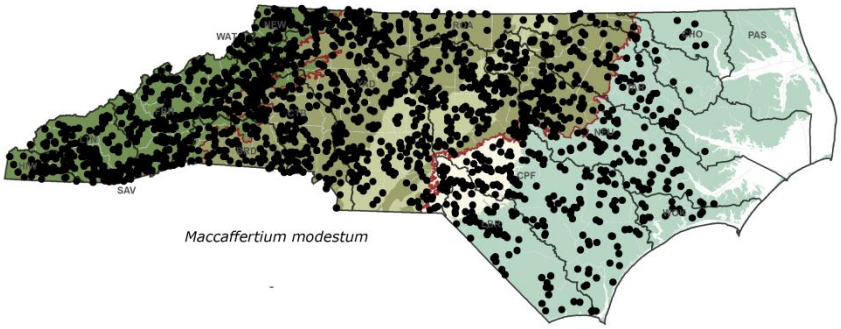
Maccaffertium mediopunctatum



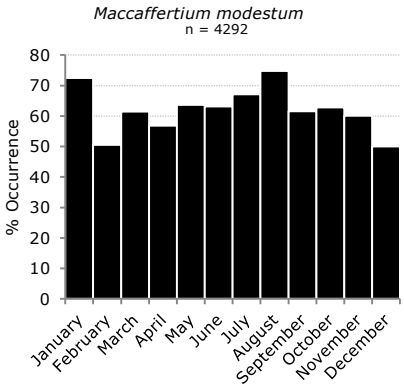


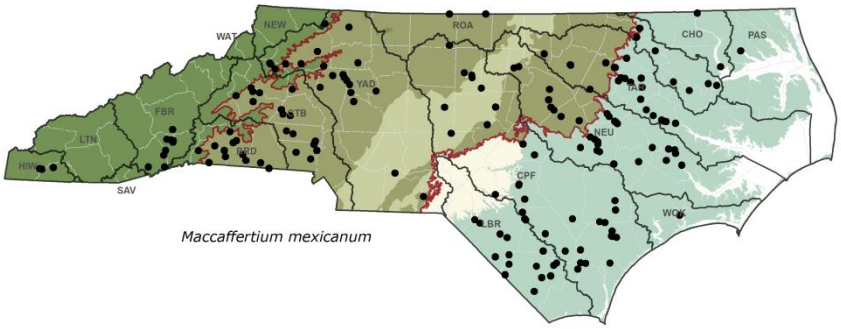
Maccaffertium meririvulanum



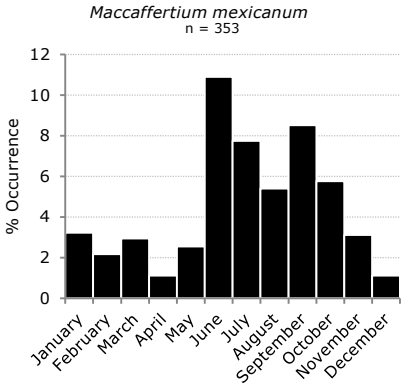


Maccaffertium modestum

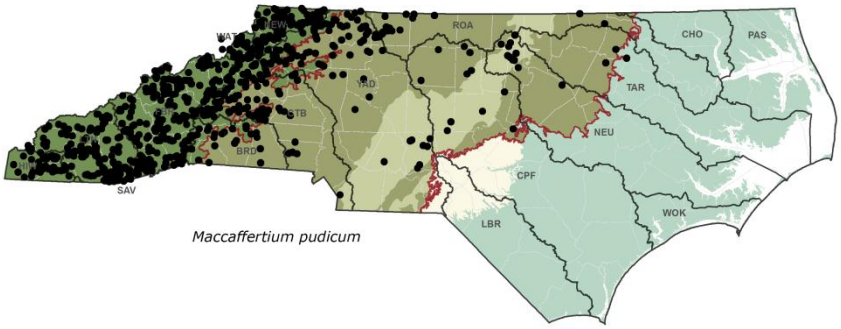




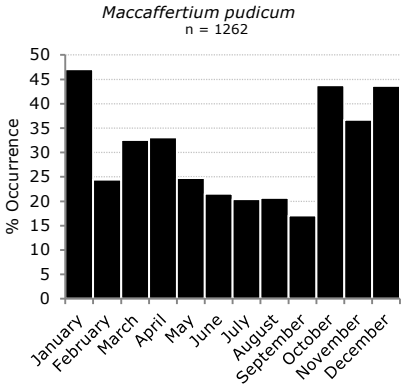
Maccaffertium mexicanum

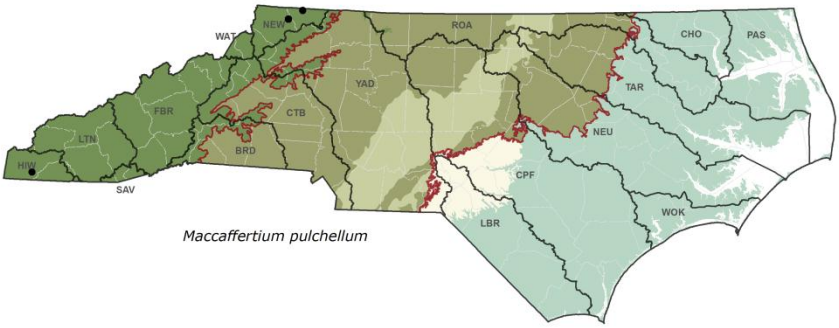


HEPTAGENIIDAE

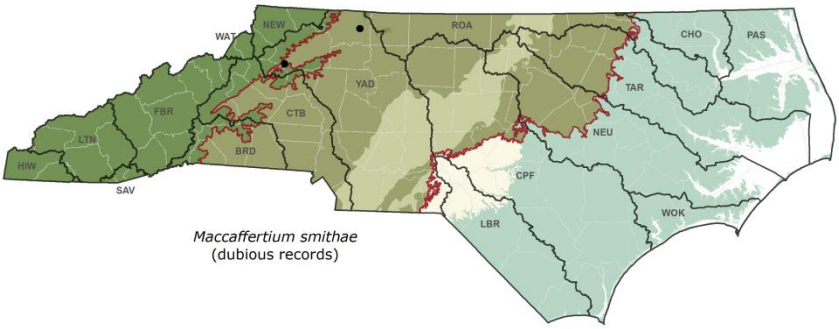


Maccaffertium pudicum

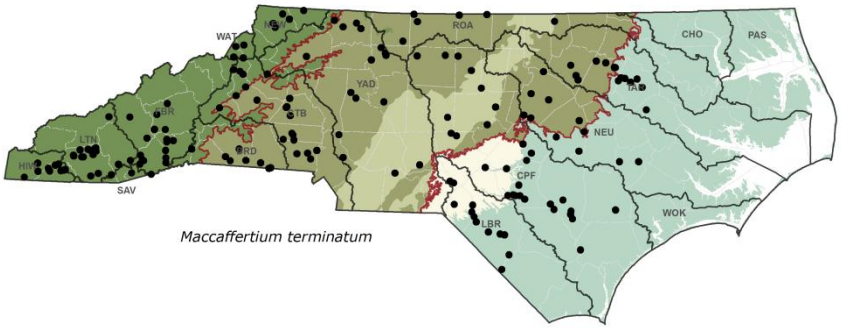




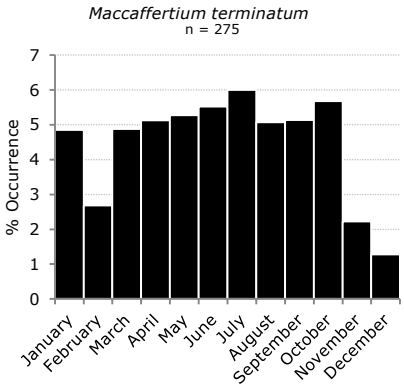
Maccaffertium pulchellum



Maccaffertium smithae
(dubious records)



Maccaffertium terminatum



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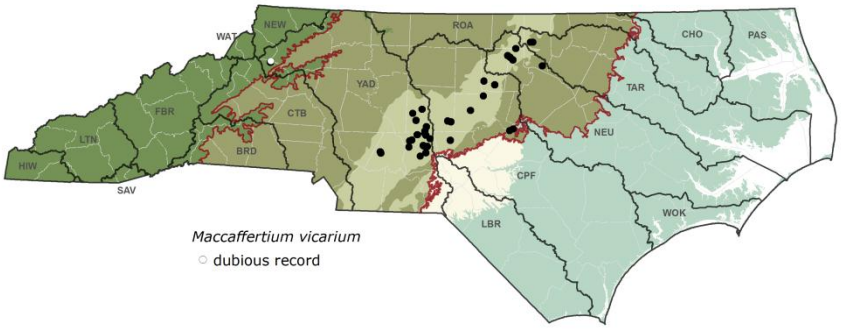

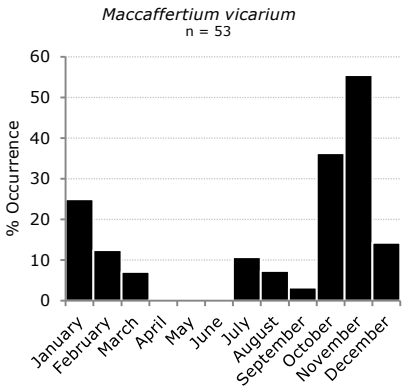

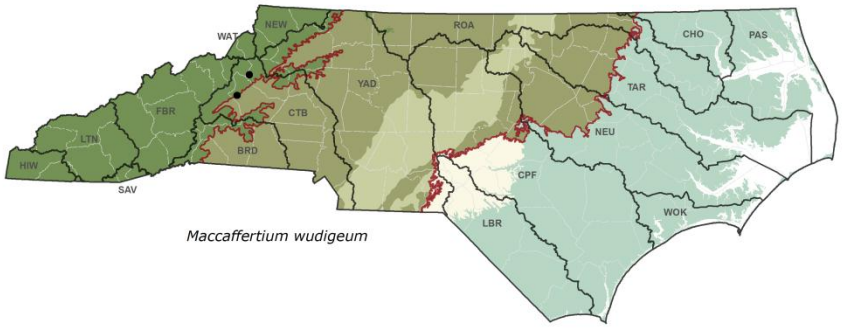

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⇨Bednarik, A. F. and W. P. McCafferty. 1979. Biosystematic revision of the genus *Stenonema* (Ephemeroptera: Heptageniidae). Canadian Bulletin of Fisheries and Aquatic Sciences 201: 1-73.

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adults:

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HEPTAGENIIDAE

Macdunnoa

Genus Diagnosis: Nymphs 6.1-8.3 mm; body and head distinctly flattened; *gills reduced on segment 6 and vestigial on segment 7; three caudal filaments with dark pigment at base and alternately banded; body dark brown;* ventral side dark with light dot-dash pattern.

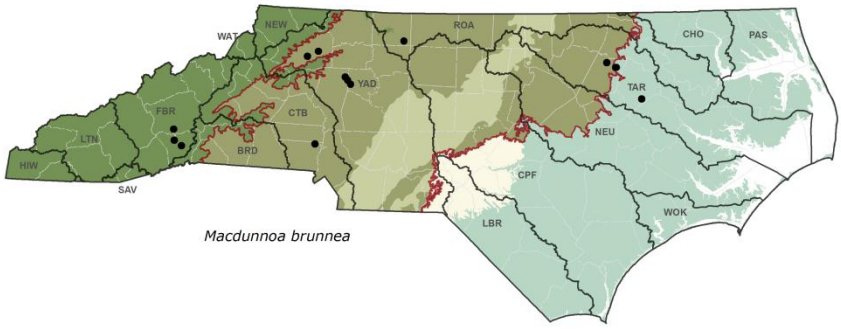
Habitat: *Macdunnoa* has a tendency towards larger streams and rivers, on detritus in deep, swift flows. Scrapers or grazers, facultative collectors-gatherers.

Distribution and Occurrence: Primarily occurs in the Piedmont with some records in the upper French Broad River Basin. Rarely collected. The few collections of *Macdunnoa brunnea* nymphs have occurred during the summer.

Species in NC: TAKE TO SPECIES

brunnea – see Genus Diagnosis.

Notes: *Macdunnoa brunnea* is the only species in southeast US and is listed by the NC Natural Heritage Program as Significantly Rare (2012).



Taxonomic references:

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Nixe

Genus Diagnosis: Body and head distinctly flattened; *head wider than or subequal to pronotum; head with a distinct pair of pale, narrowly separated but discontinuous spots near the anterior edge of the head, pale spots separated by a distance less than that between the antennal bases*; gills of abdominal segments 1-7 similar in shape but gill 7 smaller and lacking fibrilliform portion; *three caudal filaments with fine intersegmental setae*; dorsal color pattern usually brown ground color with extensive pale markings on each terga.

Habitat: In clean, cool streams in areas of fast flow. Scrapers or grazers, facultative collectors-gatherers.

Distribution and Occurrence: Occurs in mountain streams. Relatively rare.

Species in NC: LEAVE AT GENUS

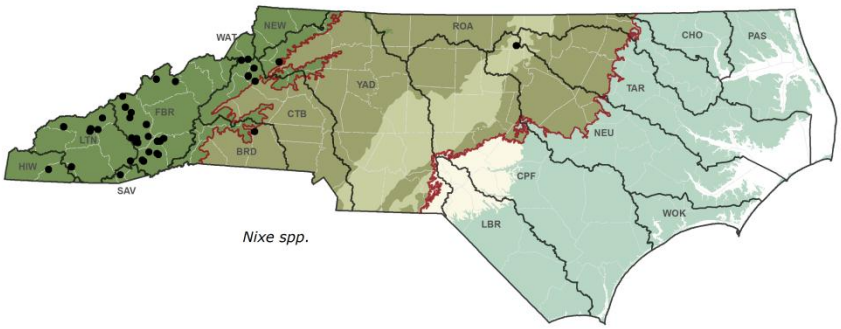
(inconspicua) – nymphs 5-7 mm; tergum patterned with tan interconnected lines on pale background; sternum pale with segments 6-9 with sublateral small, brown spots near anterior margin. Originally described as *Heptagenia inconspicua.*

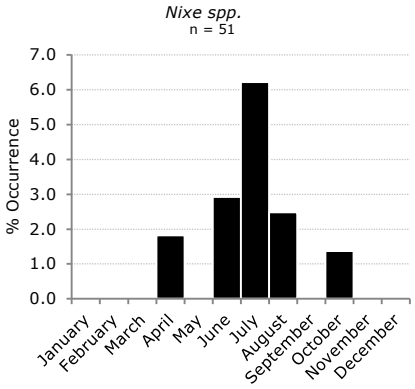
(perfida) – nymph description unavailable. Collected from GSMNP.

(spinosa) – nymphs unknown. Adult described from NC.

Notes: Intolerant. Split out from *Heptagenia*, and similar to *Ecdyonurus,* a genus which does not occur in the eastern US, *Nixe* will key to *Leucrocuta* in Unzicker and Carlson (1982). Most adult records in NC are of *N. spinosa.* Previous BAU records of *Nixe flowersi*, described from IN and recorded only from KY and OK, were erroneous and therefore determinations were backed off to genus level. Also, specimens identified as "*nr. inconspicua*" in the BAU

database (collected from Wilson Creek) have a dorsal color pattern similar to *N. inconspicua* and the ventral color pattern consists of dark speckling. These specimens are possibly *N. perfida* or *N. spinosa*.





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adults:

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Traver, J. R. 1933. Mayflies of North Carolina. Part III. The Heptageninae. Journal of the Elisha Mitchell Scientific Society 48(2): 141-206. (description of adult *N. spinosa*)

Rhithrogena

Genus Diagnosis: Body and head distinctly flattened; some species with small medial emargination at anterior margin of head; *abdominal gills 1 and 7 enlarged with anteromedial margins of gill 1 and the distomedial margins of gill 7 meeting to form a ventral disk;* three caudal filaments; color variable on mid-sized specimens.

Habitat: In clean, cool streams in areas of fast flow. Scrapers or grazers, facultative collectors-gatherers.

Distribution and Occurrence: See species descriptions. Uncommon.

Species in NC: LEAVE AT GENUS

amica – nymphs 9-12 mm; mostly all brown but there may possibly be two distinct color patterns. Collected in winter and early spring in Mountains only. Listed as "vulnerable to extirpation" by Morse et al. (1997).

exilis – nymphs 5-7 mm; terga 1 and 2 pale yellow, 3-6 reddish brown, 7 pale; middle portion of head yellow or light brown contrasting with darker lateral areas. Collected spring through early fall in Mountains. Described from NC (N. Fk. Swannanoa R.). Listed as "vulnerable to extirpation" by Morse et al. (1997).

(fasciata) – nymphs 5-7 mm; terga orange or orange brown. Spring and summer in Piedmont and Mountains. Described from Waynesville, NC.

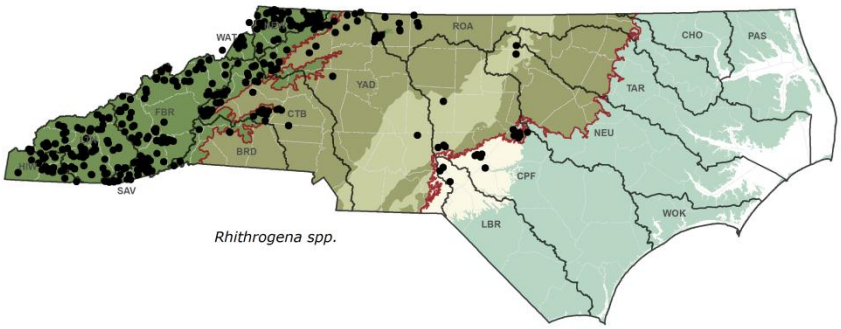
fuscifrons – nymphs 5-7 mm; middle portion of head dark brown; terga 1-basal half of 7 dark reddish brown, apical half of 7-9 yellow. Collected spring through early summer in Mountains. Described from near Hazelwood, NC. Listed as "vulnerable to extirpation" by Morse et al. (1997).

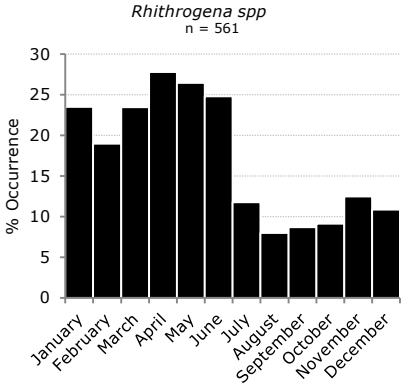
manifesta* – nymphs 6.5-7.5 mm; abdomen dark brown with terga 8-9 bright yellow; sterna 2-8 with dark median rectangular patch containing a narrow, dark, transverse line near posterior margin. *R. pellucida* was synonymized with *R. manifesta*. A late spring to early summer species. Recorded from SC, TN, and VA.

(rubicunda) – nymphs unknown. Described from Banner Elk, this species is known only from NC. Listed as "vulnerable to extirpation" by Morse et al. (1997). This may be *R. sp. 3* in Traver (1937).

uhari – nymphs 5-7 mm; abdominal terga light chestnut or cinnamon brown, with no pattern. Collected in winter and early spring. Recorded from the Mountains, Foothills, and Sand Hills. Type material from Uhari [*sic*] Mountains.

Notes: At least the two species *R. exilis* and *R. uhari* are very intolerant. Unknown nymphs and a fair amount of color variation and overlap of characters within populations can make *Rhithrogena* species determinations difficult. Any attempt to identify species should be provisional. Regardless, all small, immature specimens should be left at genus.





Taxonomic references:

nymphs:

Daggy R. H. 1945. New species and previously undescribed naiads of some Minnesota mayflies (Ephemeroptera). Annals of the Entomological Society of America 38(3): 373-396. (description of *R. manifesta* – as *R. pellucida*)

Traver, J. R. 1933. Mayflies of North Carolina. Part III. The Heptageninae. Journal of the Elisha Mitchell Scientific Society 48(2): 141-206. (description of *R. exilis, R. fasciata, R. fuscifrons,* and *R. uhari*)

Traver. J. R., 1937 Notes on mayflies of of the southeastern states (Ephemeroptera). Journal of the Elisha Mitchell Scientific Society 53(1): 27-86.

⇨Unzicker, J. D. and P. H. Carlson. 1982. Ephemeroptera, Chapter 3 (97 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.

Stenacron

Genus Diagnosis: Body and head distinctly flattened; *abdominal gills 1-6 with apex pointed, seventh gill filamentous; three caudal filaments, very long;* dorsum of body usually dark with variable pale markings.

Habitat: Primarily lotic, in areas of low current especially near stream edges and in pools, on cobbles and wood. Scrapers or grazers, facultative collectors-gatherers.

Distribution and Occurrence: A widespread and common genus.

Species in NC: TAKE TO SPECIES

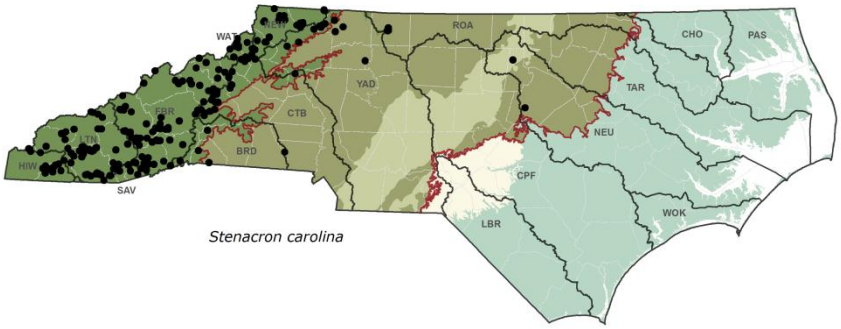
carolina – nymphs 10-13 mm; *length of pale subtriangular spot anterior to median ocellus approximately 2 X it's basal width; 7-10 spines on maxillary crown; dorsum of abdomen gray-brown without conspicuous markings,* although posterior edge of terga may have darker transverse banding; *sterna pale and typically without maculations;* caudal filaments all light gray-brown, slightly darker basally and without banding. Usually in small mountain streams. Typically collected spring to summer. Uncommon and very intolerant. Originally described from NC.

interpunctatum – nymphs 8-11 mm; *7-10 spines on maxillary crown; pale spot anterior to median ocellus approximately as long as wide, may be triangular to irregularly shaped; terga 2-9 with white longitudinal mid-dorsal streaks, often expanded into H-pattern on 8-9; sterna 2, 3, 4, or 5-9 with lateral dark markings* (longitudinally oriented in posterior segments), sterna sometimes with dot-dash pattern medially; caudal filaments with alternating banding pattern (may be faint). Collected year round. The most common and tolerant *Stenacron* species in NC. May exhibit occasional parthenogenesis.

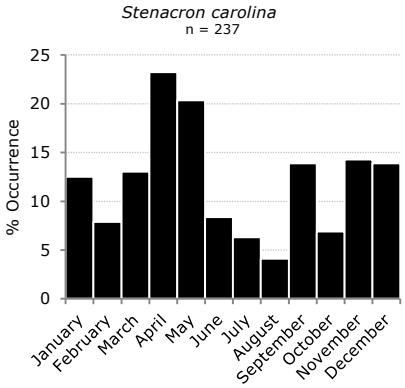
pallidum – nymphs 6-8 mm (see notes); *11-13 spines on maxillary crown; pale triangular spot anterior to median ocellus approximately as long as wide; dorsal surface usually all gray-brown, but can have pale streaks or H-pattern but thinner and less conspicuous than in S. interpunctatum; typically with sterna 6 or 7-9 with lateral dark marking* (some specimens may have fainter makings on anterior segments as well). Collected year round although more common during the spring and summer months. Common in Mountain, Northern Inner Piedmont, and Slate Belt streams. Often co-occurs with *S. interpunctatum* in cleaner streams.

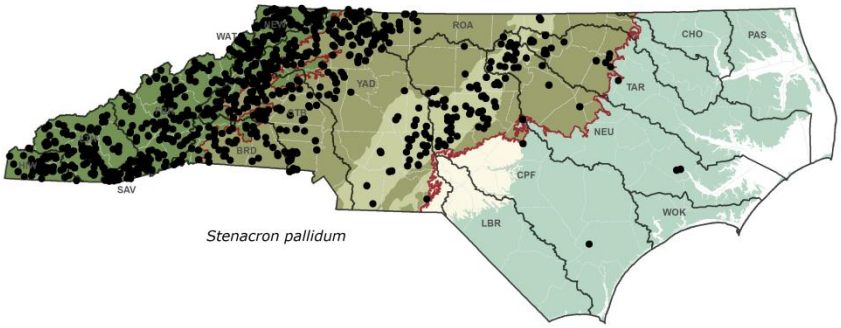
HEPTAGENIIDAE

Notes: Two species may often be collected from one stream site. Correct identifications are facilitated by slide-mounting mouthparts. Some BAU *Stenacron* specimens with 11-13 spines exceed the described nymphal size range for *S. pallidum* and range up to 11.5 mm in length. Other problems in species determinations include specimens that have differing numbers of spines on each maxilla, sometimes ranging over different species descriptions. Morphological characters should be given precedence over coloration although unsure designations should always be left at the genus level.

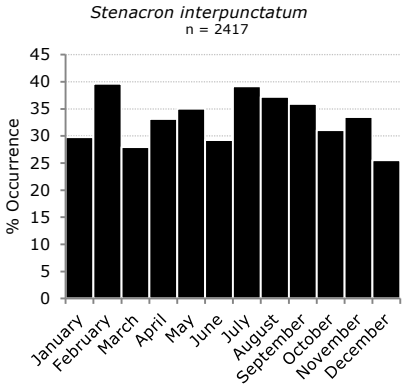


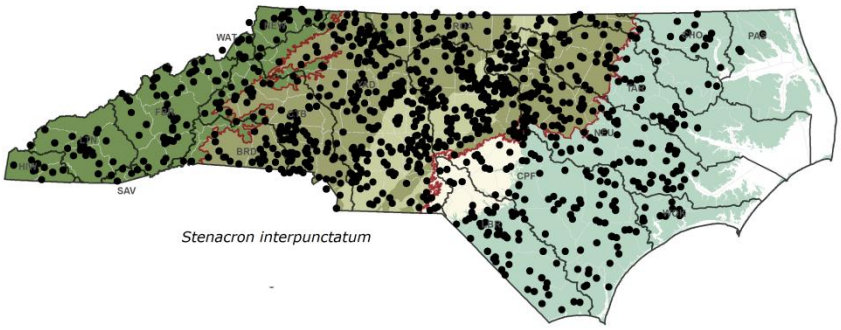
Stenacron carolina



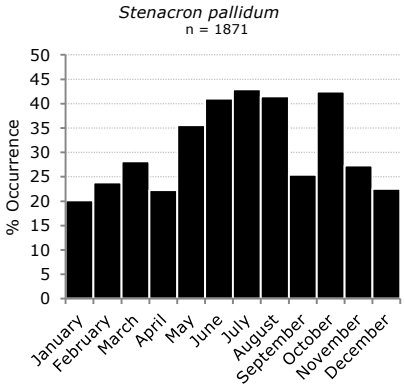


Stenacron pallidum





Stenacron interpunctatum



Taxonomic references:

nymphs:

Lewis, P. A. unpublished. Key to Stenacron and Stenonema (Heptageniidae) nymphs. (after Lewis, 1974 and Bednarik and McCafferty, 1979)

Lewis, P. A. 1974. Taxonomy and ecology of *Stenonema* mayflies (Heptageniidae: Ephemeroptera). Environmental Protection Agency (U.S.) Environmental Monitoring Series. EPA-670/4-74-006. 81 pp.

⇨Unzicker, J. D. and P. H. Carlson. 1982. Ephemeroptera, Chapter 3 (97 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.

Stenonema

Genus Diagnosis: Nymphs 8-12 mm; body and head distinctly flattened; *abdominal gills 1-6 with apex rounded, seventh gill filamentous; dorsum of abdomen dark with tergum 5 with conspicuous M-like pale pattern and part of 7 or 8-10 with expanded pale X-like pattern, intervening terga (3-4, 6-7) mostly dark brown with anteromedial pale spots; black spots anterolaterally on sterna 2-7 or 8 successively larger on posterior segments*, more extensive posterolateral markings on 9; three caudal filaments.

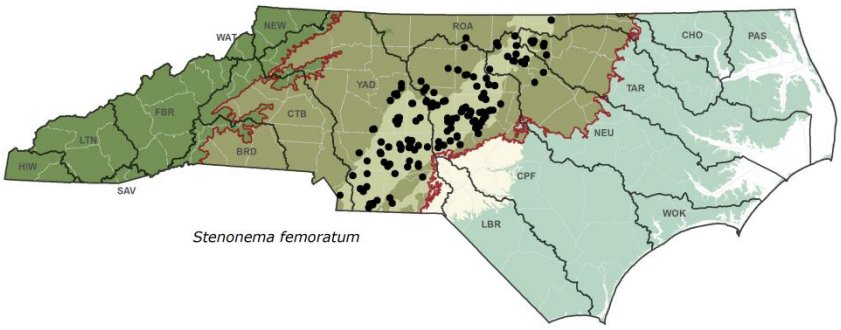
Habitat: Typically found in small temporary streams, often in disconnected pools, on hard substrates. Scrapers or grazers, facultative collectors-gatherers.

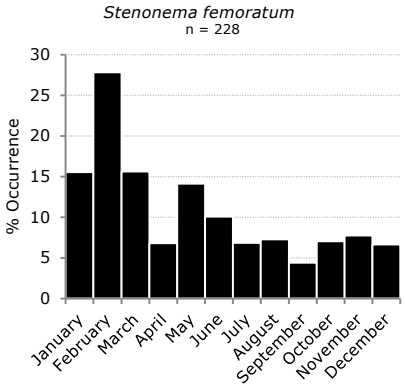
Distribution and Occurrence: Only common in Slate Belt streams. Can be collected year round although more abundant during winter and spring months when flows are good.

Species in NC: MONOTYPIC

femoratum – see Genus Diagnosis.

Notes: A Slate Belt indicator species. Tolerant of low dissolved oxygen and low flow conditions which are common conditions for Slate Belt streams during the summer and early fall. Some populations of *Stenonema femoratum* exhibit occasional parthenogenesis, or tychoparthenogenesis, which may be a function of temporary habitats and short adult life stages. All *Stenonema* species, excepting *S. femoratum,* were transferred to *Maccaffertium* in 2004.





Taxonomic references:

nymphs and adults:

⇨Bednarik, A. F. and W. P. McCafferty. 1979. Biosystematic Revision of the Genus *Stenonema* (Ephemeroptera: Heptageniidae). Canadian Bulletin of Fisheries and Aquatic Sciences 201: 1-73.

Attenella

Genus Diagnosis: Head, body or appendages without extensive long setae; *tarsal claws with denticles;* abdominal segment 1 with vestigial filamentous gill, may be absent on one side; *lamellate gills present on abdominal terga 4-7, those on 4 imbricate (not operculate) and covering half or less of gill 5.*

Habitat: Primarily lotic, typically in areas of slower flow on variety of substrates, particularly coarse particulate organic matter, also in substrate crevasses in areas of higher flows. Collectors-gatherers.

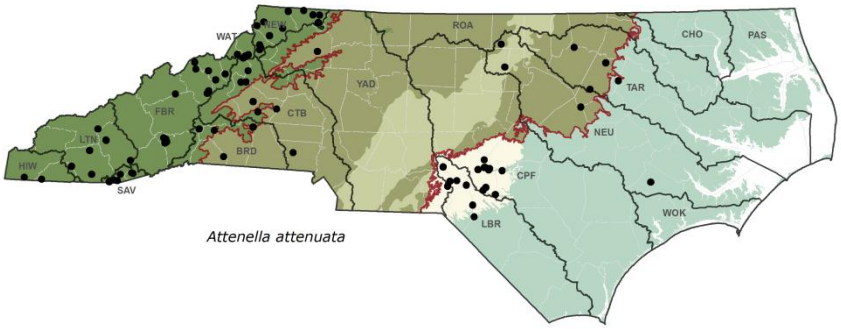
Distribution and Occurrence: Primarily a Mountains and Sand Hills taxon. Uncommon.

Species in NC: TAKE TO SPECIES

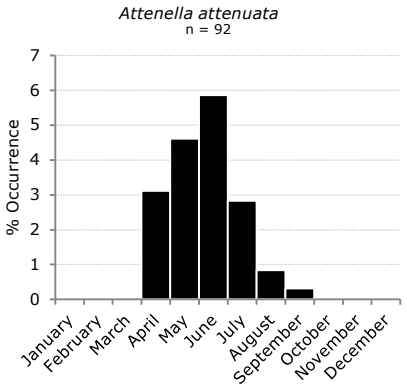
attenuata – nymphs 6-7 mm; *paired protuberances on pro- and mesonotum well developed; abdominal posterolateral projections elongate, particularly on segment 8;* may have a wide, pale medial stripe from tergum 1 extending to the anterior half of segment 5 and then continuing as a thin grayish black stripe through segment 9; female with dorsal tubercles on head. A late spring to early summer species. Very intolerant.

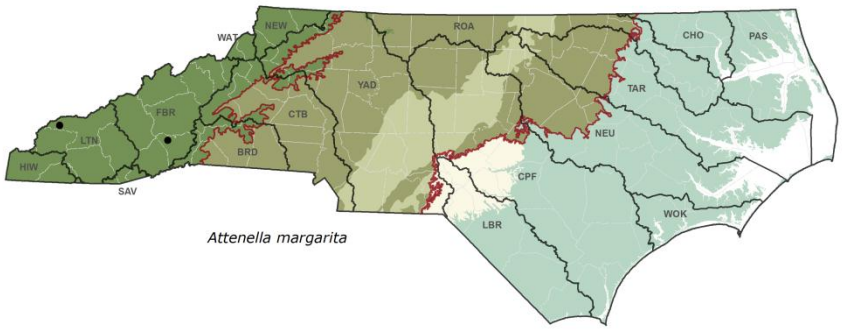
margarita – nymphs 6-9.5 mm; *paired protuberances on pro- and mesonotum not well developed; abdominal posterolateral projections rudimentary;* lateral margins of at least abdominal segments 2-8 with a dark medial maculation; dark caudal filaments with a conspicuous dark medial band. Only two verified BAU records from the Mountains. A large range extension from western states and the northeast US. Recorded from GSMNP. Listed by NC Natural Heritage Program as Significantly Rare (2012).

Notes: Part of the *Timpanoga* complex although the generalized larval habitus most closely resembles that of *Ephemerella* or *Serratella.*



Attenella attenuata





Attenella margarita

Taxonomic references:

nymphs and adults:

⇨Allen, R. K. and G. F. Edmunds, Jr. 1961. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) III. The subgenus *Attenuatella.* Kansas Entomological Society, 34: 161-173.

Jacobus, L. M. and E. D. Fleek. 2010. Insecta, Ephemeroptera, Ephemerellidae, *Attenella margarita* (Needham, 1927): Southeastern range extension to North Carolina, USA. Check List 6(2): 311-313.

McCafferty, W. P. and T-Q. Wang. 1994. Phylogenetics and the classification of the *Timpanoga* complex (Ephemeroptera: Ephemerellidae). Journal of the North American Benthological Society 13(4): 569-579.

Dannella

Genus Diagnosis: Maxillary palpi present but small; *tarsal claws without denticles; head, body and appendages with abundant long setae*; filamentous gills on segment 1 conspicuous and originate at lateral margin; paired dorsal abdominal tubercles absent; *lamellate gills present on abdominal terga 4-7, gill on 4 operculate with no more than a third of successive gills visible apically.*

Habitat: Primarily lotic, typically in areas of slower flow and silt, often collected from woody debris. Collectors-gatherers.

Distribution and Occurrence: Primarily a Mountains and Piedmont genus. See species accounts.

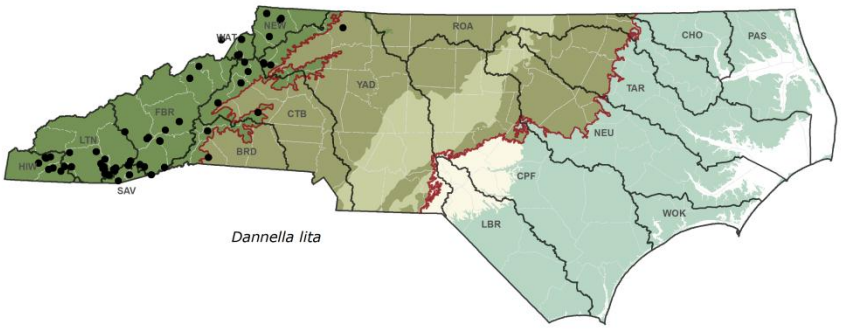
Species in NC: TAKE TO SPECIES (see Notes)

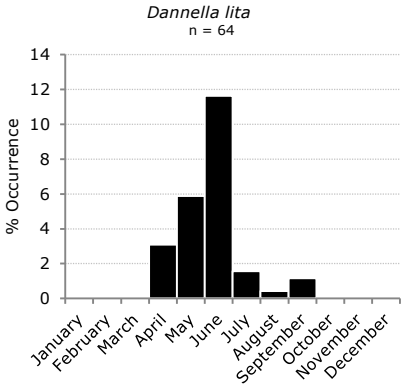
lita – nymphs 8 mm; *lateral margin of segments 2 and 3 produced into well-developed acute posterolateral projections* (2 can be small although still conspicuous); *posterolateral projections of segment 9 long, exceeding apex of segment 10;* dorsum of abdomen light brown with extensive brown maculations, both medially and laterally on segments 1-9, segment 8 may have faint markings. Collected in spring and early summer from clean mountain streams. Relatively rare. Recorded from GSMNP.

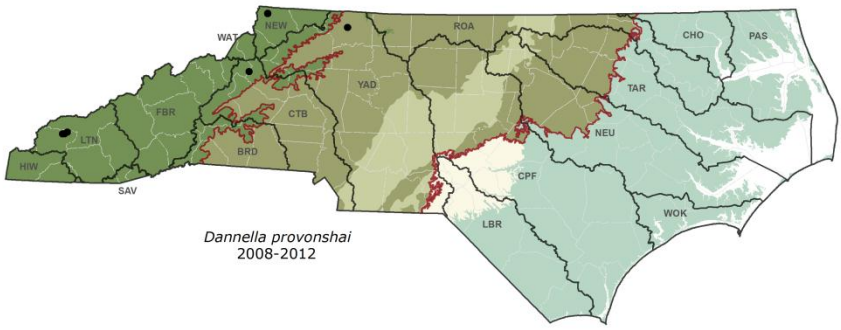
provonshai – nymphs 6 mm; *lateral margin of segment 2 not produced into posterolateral projection; segment 3 with small, rounded posterolateral projections;* posterolateral projections of 6-8 flat in plane of body with little up-curvature; posterolateral projections of segment 9 shorter, reaching about half to three-quarters the length of segment 10; *dorsum of abdomen uniformly light brown without extensive medial maculation although faint markings may be visible, particularly laterally.* Recorded from GSMNP.

simplex – nymphs 6-8 mm; *lateral margin of segments 2 and 3 not produced into posterolateral projections;* posterolateral projections of segment 9 shorter, reaching about half to three-quarters the length of segment 10; *abdominal terga 2-8 or 9 typically with dark medial maculations, and segments 3-4, 6 may be mostly brown on darker specimens.* Common in spring to early summer in Mountains, Piedmont, and Sand Hills. Relatively intolerant.

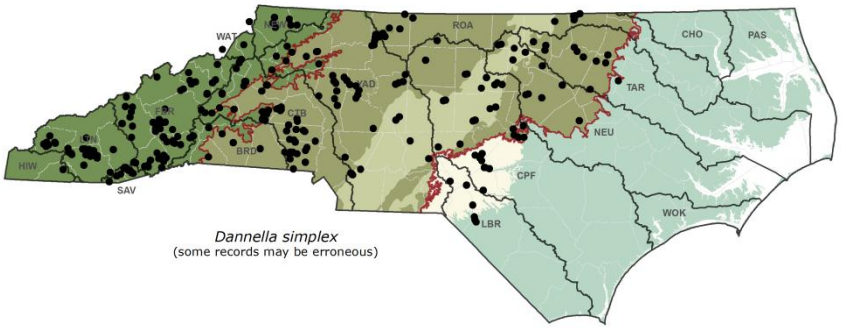
Notes: *Dannella* species should be identified with caution and strict adherence to the described species characters is essential. Specimens that do not readily match any of the above descriptions should be left at genus. Note that dorsal coloration may be obscured by debris and silt-laden setae. Taxonomic characters involving segmentation of the maxillary palpi are variable and unreliable. Furthermore, *Dannella* specimens have been collected that do not fit the description of any known NC species (i.e. having a well-produced and pointed posterolateral projection on segment 3 but with projections on 1 and 2 completely absent). *Dannella provonshai* has only been identified in North Carolina within the last 5 years and may be more common than previously thought as it appears that some historical records of *D. simplex* were misidentified *D. provonshai* or a variant thereof. Specimens given to Luke Jacobus for DNA analysis have revealed possible new species in the Appalachians (personal communication, 2011, 2013) but more work is needed.



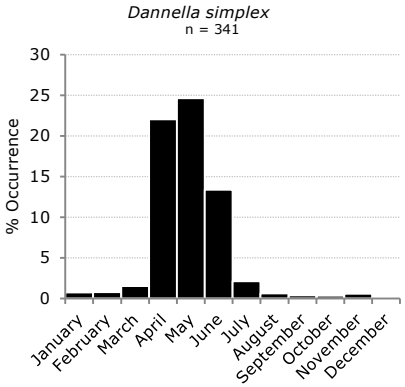




Dannella provonshai
2008-2012



Dannella simplex
(some records may be erroneous)



Taxonomic references:

nymphs:

⇨Allen, R. K. and G. F. Edmunds, Jr. 1962. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) IV. The subgenus *Dannella*. Journal of Kansas Entomological Society 35: 333-338.

⇨McCafferty, W. P. 1977. Biosystematics of *Dannella* and related subgenera of *Ephemerella* (Ephemeroptera: Ephemerellidae). Annals of the Entomological Society of America 70: 881-889.

McCafferty, W. P. and T-Q. Wang. 1994. Phylogenetics and the classification of the *Timpanoga* complex (Ephemeroptera: Ephemerellidae Journal of the North American Benthological Society 13(4): 569-579.

adults:

Allen, R. K. and G. F. Edmunds, Jr. 1962. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) IV. The subgenus *Dannella*. Journal of Kansas Entomological Society 35: 333-338.

Drunella

Genus Diagnosis: *Distinct tubercles present on leading edge of forefemora (all eastern species);* tarsal claws with 1-4 denticles; abdominal segment 1 without filamentous gill; *lamellate gills present on abdominal terga 3-7, not operculate.*

Habitat: Lotic, on rocks in riffles and other areas of moderate to fast flow. Some species are often associated with *Podostemum ceratophyllum* (riverweed). Primarily scrapers or grazers although some species (mostly western) may be facultative predators or collectors-gatherers.

Distribution and Occurrence: Largely confined to the mountains. See species accounts.

Species in NC: TAKE TO SPECIES

allegheniensis – nymphs 8-9 mm; *frons with a dark horizontal band; head with long occipital tubercles that diverge apically; long posteromedial tubercle on mesothorax, two oblique, lateral dark stripes converging at apex of tubercle; abdomen with paired dorsal tubercles always well-developed on segments 5-7;* sterna 1-8 with dot-dash markings, up to eight individual markings and sternum 9 typically pale. Common in the summer in the mountains and foothills with a disjunct population in the upper Roanoke River Basin (Dan R. and Mayo R.).

conestee – nymphs 8-9 mm; *head with moderately long lateral frontoclypeal projections, roughened, with a series of small occipital tubercles ("washboard abs") on vertex; abdomen with short paired dorsal tubercles always well-developed on segments 5-7; posterior edge of segments 8-10 with long hair, absent medially;* dorsum light brown with few distinctive markings; sternum pale. Collected in summer from smaller mountain streams. Common. Originally described from NC. Synonymized with *D. tuberculata* (McCafferty, 1993) although very distinct.

(cornuta) – nymphs 7.8-11.4 mm; *head smooth with moderately long conical, semiluner lateral frontoclypeal projections; median ocellar tubercle sharp;* femora with dense row of long, fine setae on posterior margin; *ratio of mesotibia to mesofemur > 0.85, usually closer to one; abdomen without paired dorsal tubercles;* dorsum brown with few distinctive markings; sternum pale. Synonymized with *D. lata* (Jacobus and McCafferty, 2004) but re-elevated to species status by Funk et al (2008). Nymphs were collected by from Ball Creek, Clay County (Larry Eaton, DWQ) in 2012 and verified by BAU.

cornutella – nymphs 6.4-8.5 mm; *head with moderately long lateral frontoclypeal projections but less than half as long as the distance between them; median ocellar tubercle blunt to moderately sharp;* head mostly smooth (a very small roughened area at vertex of head may be seen on some specimens); femora with dense row of long, fine setae on posterior margin; *ratio of mesotibia to mesofemur < 0.85; abdomen without paired dorsal tubercles.* Collected in spring through early summer. Common. Synonymized with *D. lata* (Jacobus and McCafferty, 2004) but re-elevated to species status by Funk et al. (2008).

lata – nymphs 6-7 mm*; head smooth with short, flattened lateral frontoclypeal projections which are about as long as wide;* femora with few or no long, fine setae on posterior margin; *abdomen without paired dorsal tubercles although diverging low ridges may be present on 3 or 4-8, becoming successively more parallel in posterior segments;* dorsum brown with tergum 8 mostly pale; posterolateral projections on 4-8 and apices of femora pale; mature nymphs often with pale areas tinged with red; ventral surface light brown. Collected in February through July in the Mountains.

longicornis – nymphs 9-11 mm; *head with long lateral frontoclypeal projections, more than 1/2 as long as the distance between them;* head mostly smooth but may be inconspicuously roughened at vertex; *abdomen without paired dorsal tubercles;* dorsum brown with few distinctive markings; sternum pale; *apex of foretibia acute and sometimes curved*; *ratio of mesotibia to mesofemur > 0.85, usually closer to one*. Collected in spring through early summer. Rare. Mountains only. Originally described from NC. Synonymized with *D. lata* (Jacobus and McCafferty, 2004) but removed from synonymy by Funk et al. (2008). They suggest that *D. longicornis* may be a southern variant of *D. cornuta* but should remain at species status until further analysis has been done. Indeed, there is a fair amount of overlap between characters of *D. longicornis* and *D. cornuta*. Regardless, its status as a valid species remains unclear.

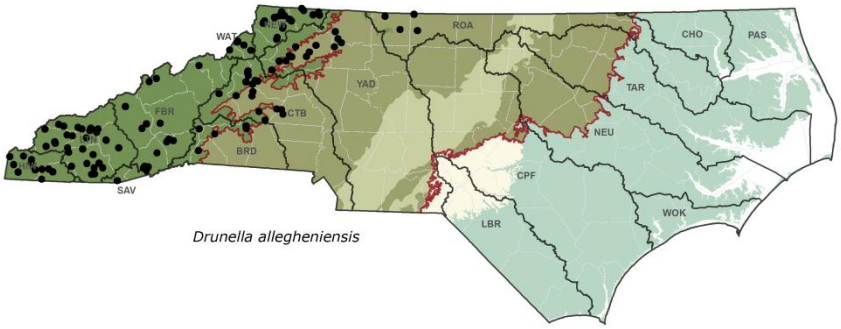
tuberculata – nymphs 7-9 mm; *head with long occipital tubercles not divergent apically; frons with dark transverse band interrupted medially, if present; small, blunt posteromedial tubercle on mesothorax; abdomen with long paired dorsal tubercles always well-developed on segments 5-7;* posterior edge of segments 1-7 with hair-like seta, absent between tubercles and indistinct on middle segments;, segments 8-9 with long hair, absent medially; dorsal surface brown to dark brown, segments 8 or 8-9 with extensive pale areas; ventral surface pale. Collected in spring and summer. Uncommon. Primarily a Mountain species although a disjunct population exists in the Cape Fear River near Erwin, Harnett County (B. Kondratieff and D. Lenat). Persistence of Harnett County population is unknown. Variants: some populations with occipital tubercles intermediate between *D. conestee* and *D. tuberculata* and/or with genal projections truncate and/or without anterior submarginal projections on mesothorax.

walkeri – nymphs 8-10 mm; *head roughened, with only small occipital tubercles and barely discernible lateral frontoclypeal projections; genae produced into sharp anterolateral projections; forefemur with long hair;* abdomen with paired dorsal tubercles always well-developed on segments 5-7; *body setose and stout,* pale to light brown, sometimes speckled. Collected in late winter through spring. Uncommon in the mountains with a disjunct population in Rockingham and Nash Counties.

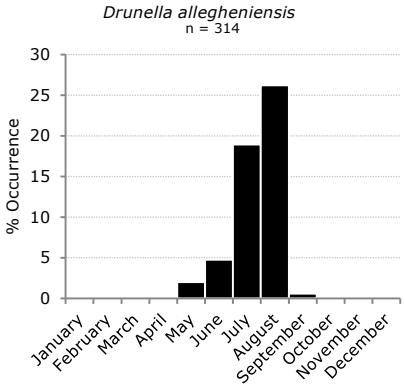
wayah – nymphs 6-7 mm; *head roughened, with only small occipital tubercles and barely discernible lateral frontoclypeal projections*; *genae produced into blunt anterolateral projections; forefemur without long hair;* abdomen with paired dorsal tubercles always well-developed on segments 5-7; body setose, brown with darker maculations and pales areas dorsally; legs banded. Collected during spring and summer in the Mountains. A disjunct population was collected from the Cape Fear River in Harnett County (B. Kondratieff and D. Lenat). Persistence of Harnett County population is unknown. Originally described from NC. Synonymized with *D. walkeri* (McCafferty, 1997).

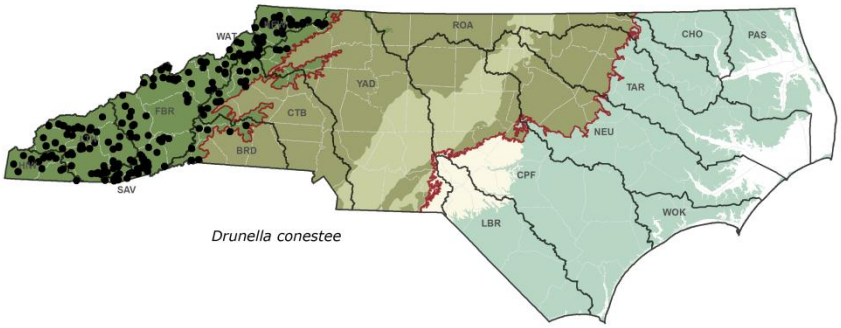
Notes: All *Drunella* species are highly intolerant and there are often 2-3 species co-occurring in clean rivers. McCafferty (1993) synonymized *D. conestee* with *D. tuberculata*, and McCafferty (1997) synonymized *D. wayah* with *D. walkeri.* Jacobus and McCafferty (2004) synonymized *D. cornuta*, *D. cornutella,* and *D. longicornis* with *D. lata*. NC BAU is currently not accepting these synonymies. Funk et al. (2008) re-elevated *D. cornuta* and *D. cornutella* to species status and suggested that *D. longicornis* persist as a valid species pending further investigations.

EPHEMERELLIDAE

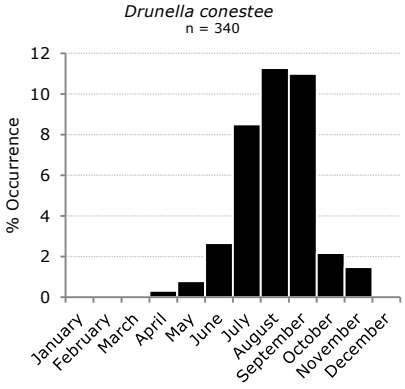


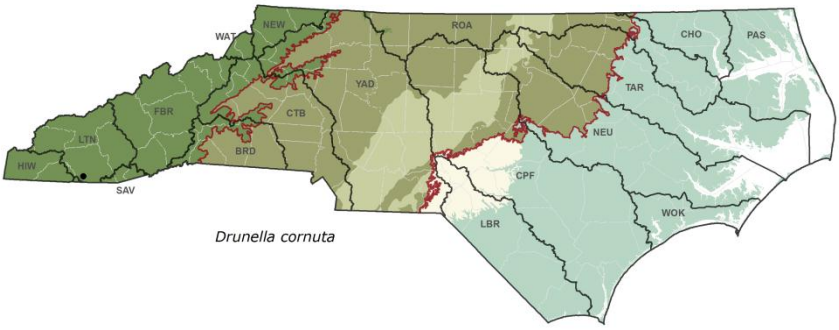
Drunella allegheniensis





Drunella conestee





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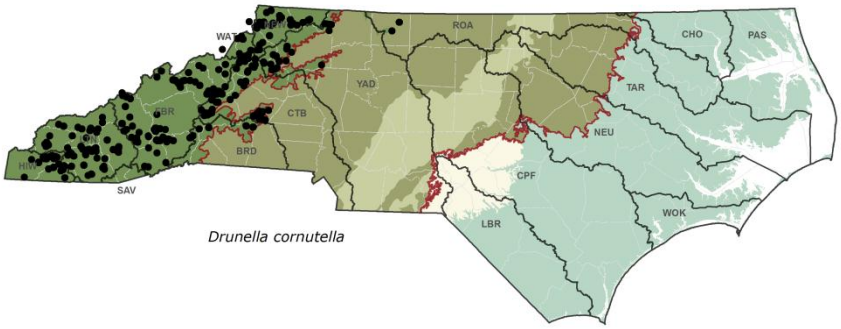

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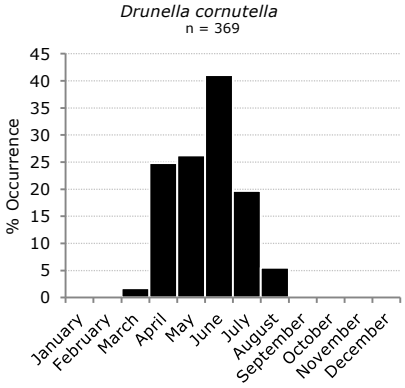

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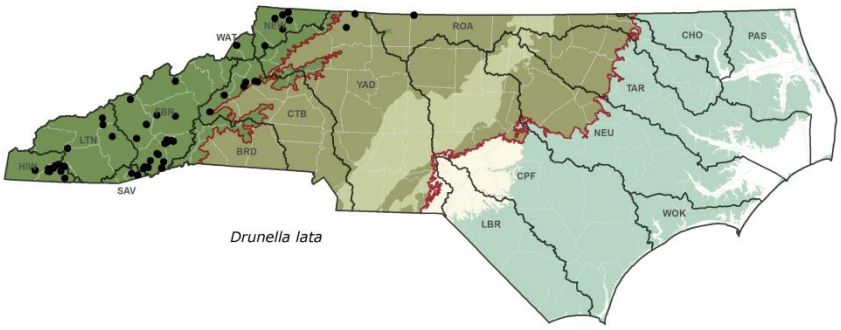

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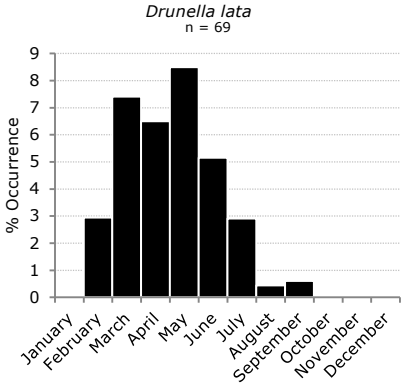

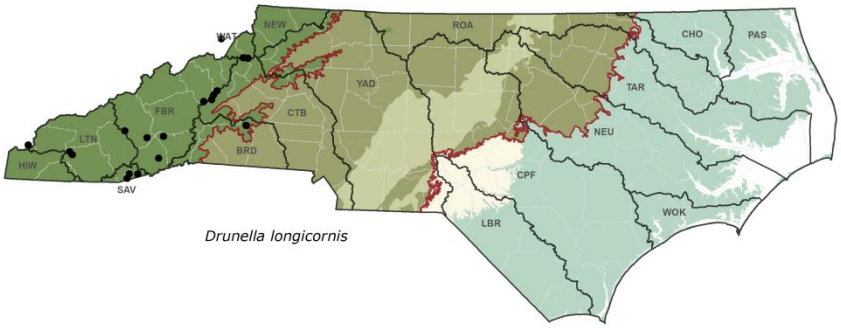

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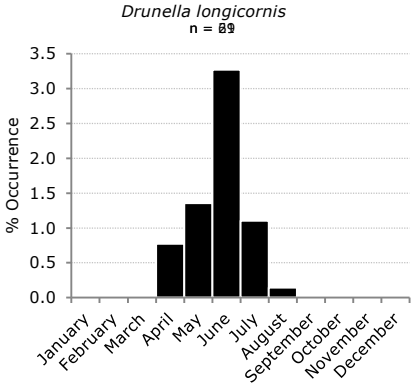

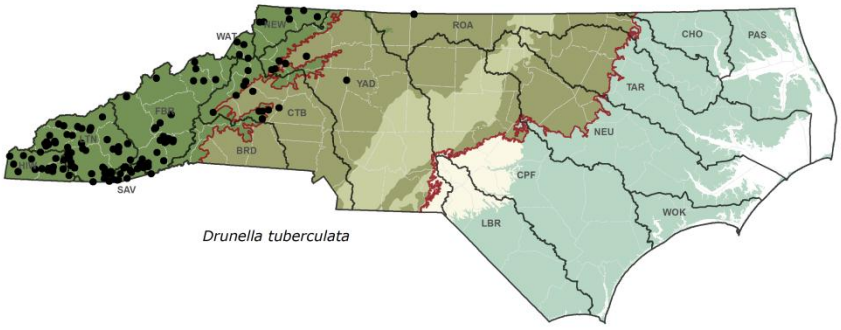

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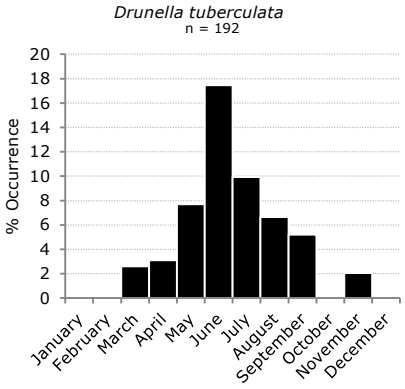

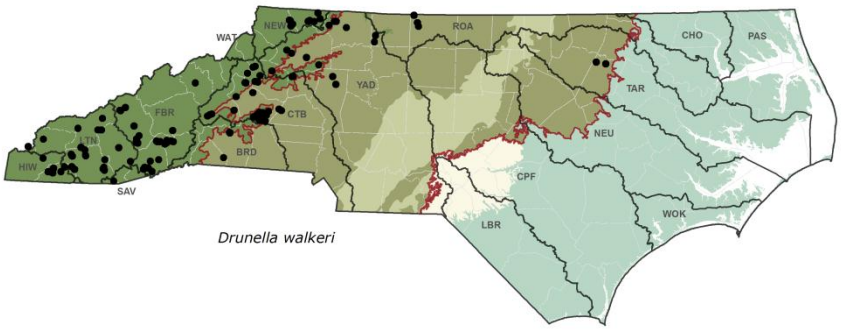

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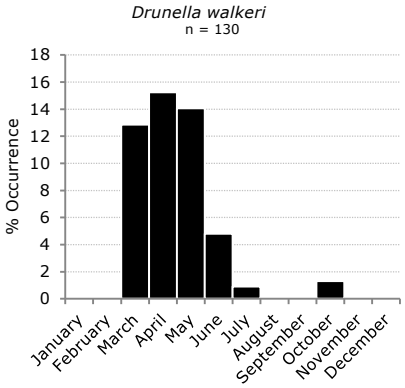

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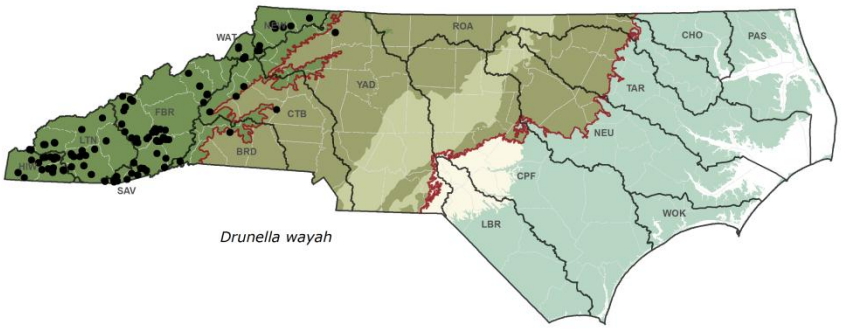

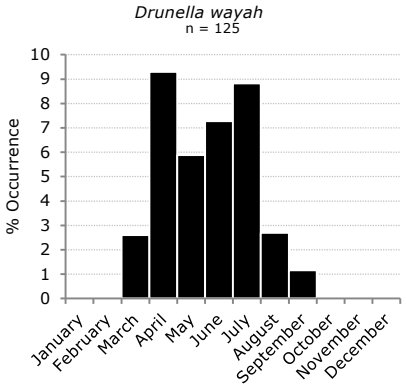

Taxonomic references:

nymphs:

⇨Allen, R. K. and G. F. Edmunds, Jr. 1962. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) V. The subgenus *Drunella* in North America. Miscellaneous Publications of the Entomological Society of America. 3: 147-179.

Funk, D. H., B. W. Sweeney, and J. K. Jackson. 2008. A taxonomic reassessment of the *Drunella lata* (Morgan) species complex (Ephemeroptera: Ephemerellidae) in northeastern North America. Journal of the North American Benthological Society 27(3): 647-663.

Jacobus, L. M. and W. P. McCafferty. 2004. Revisionary contributions to the genus *Drunella* (Ephemeroptera: Ephemerellidae). Journal of the New York Entomological Society 112 (2-3): 127-147.

McCafferty, W. P. 1993. Commentary on *Drunella tuberculata* and *Procloeon pennulatum* (Ephemeroptera: Ephemerellidae; Baetidae) in North Carolina. Entomological News 104(5): 235-239.

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adults:

⇨Allen, R. K. and G. F. Edmunds, Jr. 1962. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) V. The subgenus *Drunella* in North America. Miscellaneous Publications of the Entomological Society of America. 3: 147-179.

Funk, D. H., B. W. Sweeney, and J. K. Jackson. 2008. A taxonomic reassessment of the *Drunella lata* (Morgan) species complex (Ephemeroptera: Ephemerellidae) in northeastern North America. Journal of the North American Benthological Society 27(3): 647-663.

Ephemerella

Genus Diagnosis: *Maxillary palpi well developed;* abdominal segment 1 without filamentous gill; *lamellate gills present on abdominal terga 3-7 not operculate*; *ventral lamellae of gill 6 entire or only partially cleft;* abdominal terga with or without paired submedian tubercles; *caudal filaments with heavy interfacing intersegmental setae and without whorls of spines at apex.*

Habitat: Primarily lotic, in areas of fast flow in crevasses of hard substrates but some species in vegetation and root mats in edge areas where there is slow flow. Most are primarily collectors-gatherers, facultative scrapers or grazers (primary for *E. subvaria*).

Distribution and Occurrence: Collected mainly from the Mountains. See species accounts.

Species in NC: TAKE TO SPECIES

E. argo – nymphs 7-9 mm; *pronotum mostly yellow with dark lateral margins; brown anterior transverse band across yellowish thorax; tarsal claws with 6-9 denticles; abdomen mostly brown with terga 5, 6 and 10 yellow; posterolateral projections on abdominal segments 4-9; abdominal terga without tubercles or protuberances.* Collected in the late winter through spring from Coastal Plain (Roanoke Basin) and the Sand Hills. Rare. Synonymized with *E. excrucians* (Jacobus, 2003).

E. catawba – nymphs 7-9 mm; femora short, length less than 3 times the width, mostly unicolorous; forefemora with a few long, sometimes semi-spatulate subapical spines; *tarsal claws with 8-11 denticles, apical denticle usually larger than pre-apical ones;* dorsal tubercles absent on dorsum of the abdomen, although there may be some wave-like protuberances; *lateral margins of terga 3-9 with posterolateral projections (small or barely perceptible on 3), latter segments with large conspicuous serrations and with a few widely spaced stout setae;* silky intercalary setae on caudal filaments short and sparse to absent on outside margins of lateral filaments; *abdominal terga glabrous and lustrous, shiny;* abdomen typically unicolorous but may be mottled, may have pale patches mediad of gills; legs and caudal filaments variable but usually unbanded. Common spring through summer in the Mountains, extending into the western Piedmont. Records of *E. catawba* prior to 2004 are referred to as *E. catawba/dorothea* in BAU database.

E. crenula – nymphs 6-7 mm; *head covered with fine spicules; pronotum with a pair of low spiculate submedian tubercles;* fore-femora with a few apicodorsal spatulate spines; *tarsal claws with 4-6 denticles; abdominal terga with short, blunt, paired submedian tubercles on segments 3-8; short posterolateral projections on abdominal segments 4-9;* legs with dark tibial and tarsal bands; caudal filaments banded. The pronotal tubercle character is not in the Allen and Edwards (1964) key, but is in the larval description and is also figured. However, there are no other NC occurring *Ephemerella* with conspicuous pronotal tubercles (although *E. hispida* has a roughened pronotum). A spring species in the mountains, *E. crenula* is rarely collected. Synonymized with *E. excrucians* (Jacobus, 2003).

E. dorothea – nymphs 6-8 mm; tarsal claws more gradually curved than other *Ephemerella* species, with 6-9 denticles; *terga without dorsal tubercles but may have slightly developed, rather blunt, spiculate protuberances, body spines often spatulate; lateral margins of terga 4-9 with posterolateral projections; lateral margins with slight, small serrations with numerous stout setae; thorax and abdomen variable in pigmentation, light brown to dark brown, with or without pale speckles;* typically with paired posteromedial pale spots and sometimes with segments 5 and 6 pale mediad of gills; terga may have a thin, pale mediodorsal stripe in some nymphs; caudal filaments banded, silky intercalary setae long, dense, and present on outside margin of lateral filaments. Darker, unspeckled nymphs may be a subspecies or possibly a color variant of *E. dorothea* but DNA analysis and or/ adult associations are necessary to confirm. Occurs winter through spring in the Mountains to the Southeastern Plains, although records from lower altitudes may refer to *E. excrucians*. *Ephemerella dorothea* is a facultative species. Common. Records of *E. dorothea* prior to 2004 are referred to as *E. catawba/dorothea* in BAU database. See Notes.

(E. excrucians) – nymphs 6-7 mm; *tarsal claws strongly incurved, with 5-7 denticles; no dorsal abdominal tubercles; lateral margins of terga 4-9 with posterolateral projections, not strongly serrate and with numerous stout setae; legs and body uniformly brown; caudal filaments not banded.* Some BAU specimens may be erroneously identified as *E. dorothea* or *E. catawba.* Adults have been recorded from Buncombe County in 1997 (Kondratieff), Yancey County in 2008 (B. Kondratieff), and from GSMNP.

E. floripara – nymphs up to 7.5 mm; small maxillary palpi; tarsal claws with 6-10 denticles; *4-9 with posterolateral projections (weakly on 4); dorsal submedian tubercles weakly developed on terga 4 and 8, better developed on 6-7; head and body look iridescent due to dense covering of minute, clear spicules; distinctive broad median stripe on thorax and abdomen, narrows posteriorly.* Mature in mid-winter. Mountains only (mostly New River Basin) a distinct distribution in comparison with that of *E. invaria.* Additionally, individual *E. floripara* co-occurring with *E. invaria* tend to be larger in size. Recorded from GSMNP. Synonymized with *E. invaria* (Jacobus, 2003) but reinstated without explanation (McCafferty et al., 2010) although Alexander et al. (2009) suggest a lack of support for the synonymy. Listed by NC Natural Heritage Program as Significantly Rare (2012).

E. hispida – nymphs 8-12 mm; *pronotum irregular and furrowed with a complex pattern of spicules* (not in key, but in larval description); tarsal claws with 8-10 denticles; *abdomen with paired, moderately long, heavily spiculate, submedian tubercles on segments 1-9, weak to absent on 1; paired tubercles on terga 3 or 4-8 wide basally and originate from near the middle of the respective segment (best viewed laterally); lateral margins of terga 4-9 with posterolateral projections with the posterior segments with large conspicuous serrations and with a few widely spaced stout setae;* mature specimens brown with some darker brown markings; *caudal filaments brown and unbanded.* Could be confused with *E. rossi* except for size which is large for *Ephemerella.* Uncommon with two disjunct Mountain populations. Occurs fall through spring.

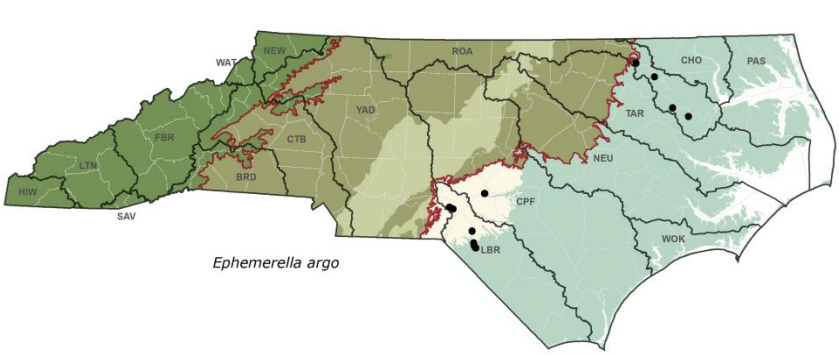
E. invaria gr. – nymphs 6-13 mm; *pale transverse stripe between eyes, may be interrupted medially;* tarsal claws with 5-10 denticles; *abdominal terga with short, sharp, paired submedian tubercles on segments 2-9, rarely on 2, sometimes barely discernible on segments 3 and 8, small on 4-7, rarely on 9;* posterolateral projections on abdominal segments 3 or 4-9 (variable to absent on 3); may have dot-dash pattern on pale ventral surface and speckling on last few segments. This are the most variable *Ephemerella* species in terms of size, color pattern, and size of tubercles. The abdominal tubercles may not be visible on smaller or immature nymphs. The overall described color pattern is similar to that of *E. dorothea*, although the BAU has specimens with other color patterns. Immature nymphs may key to *E. dorothea* although *E. invaria* appears to emerge earlier than *E. dorothea*, with peak abundance in March. *Ephemerella invaria* group occurs in the Mountains and Piedmont and includes *E. inconstans* and *E. rotunda.* See Notes.

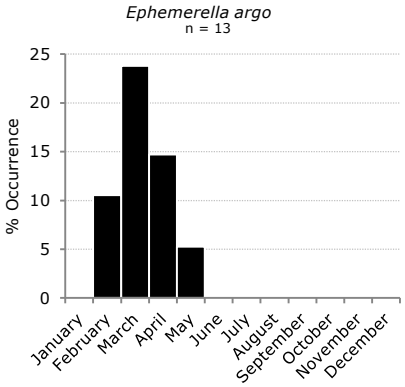
E. needhami – nymphs 7-8 mm; tarsal claws with 6-11 denticles; *paired submedian tubercles long and sharp on segments 1-8, not removed laterally; posterolateral projections on abdominal segments 3-9; wide longitudinal pale stripe from vertex of head through tergum 10 with dark lateral borders and sometimes with darker median stripe dividing wide pale stripe into two submedian stripes;* sterna1-8 with dot-dash pattern and short lateral longitudinally oriented dashes. Uncommonly collected from the Mountains and Piedmont during midwinter through early spring.

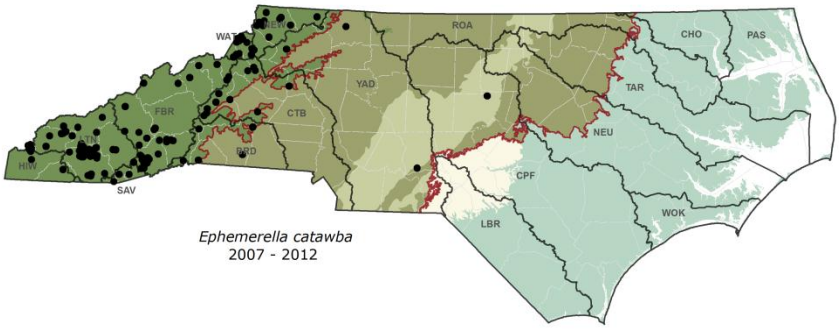
E. rossi *gr.* – nymphs 6-7.5 mm; *tarsal claws with 3-5 denticles; abdominal terga with short, blunt, paired, submedian tubercles on segment 4-9 and with paired submedian rows of spicules which widen anteriorly;* distance between tubercles decreases on each successive posterior segment; spicules not patchy; *posterolateral projections present on abdominal segments 4-9;* tergum 8 may have oblique pale stripes; caudal filaments unicolorous, unbanded. Mostly collected winter through spring from the Mountains only. Synonymized with *E. excrucians* (Jacobus, 2003).

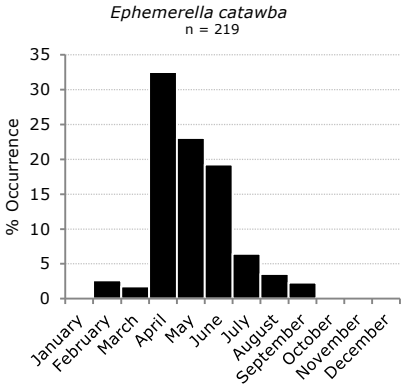
E. subvaria – nymphs 8.5-9.5 mm; tarsal claws with 4-6 denticles; *head with small submedian occipital tubercles; abdominal terga with moderately long, sharp paired submedian tubercles on segments 2-9;* lateral margins of terga 4-9 with posterolateral projections; *terga 5-7 usually pale but with dark tipped tubercles;* sterna get succeedingly darker and speckled; tibial and tarsal bands dark brown to black. Collected late summer through fall in the mountains only. Rare. Recorded from GSMNP.

Notes: *Ephemerella* is a very intolerant group of species. It should be mentioned that there are populations of *Ephemerella* specimens that key to *dorothea* in Allen and Edmunds (1964) based strictly on morphological characters (including size) but are, however, unspeckled (although they may have pale areas). These specimens most often co-occur with traditional *E. dorothea* and often present a continuum of coloration between speckled and unspeckled. These specimens are similar to the western *Ephemerella infrequens*. *Ephemerella infrequens* was downgraded to subspecies status of *E. dorothea* by Jacobus and McCafferty (2003) with the subspecies *dorothea dorothea* occurring in the eastern US and *dorothea infrequens* occurring only in the western US. Thus the BAU is considering these populations as *E. dorothea* variants. Also in Jacobus and McCafferty (2003), *Ephemerella argo*, *E. crenula*, and *E. rossi* were combined with *E. excrucians*; *E. floripara, E. inconstans* and *E. rotunda* were combined with *E. invaria*. *Ephemerella floripara* appears to have be reinstated in a subsequent paper (Jacobus and McCafferty, 2008). Additionally, *E. berneri* and *E. septentrionalis* have been elevated to generic status as *Tsalia berneri* and *Penelomax septentrionalis*, respectively (Jacobus and McCafferty 2008). The BAU is currently not recognizing the above synonymies. However, because *E. invaria, E. inconstans,* and *E. rotunda* are very difficult to separate, are closely related (Alexander et al., 2009) and exhibit high degrees of variation, the BAU designates this complex of species as "*E. invaria* group".









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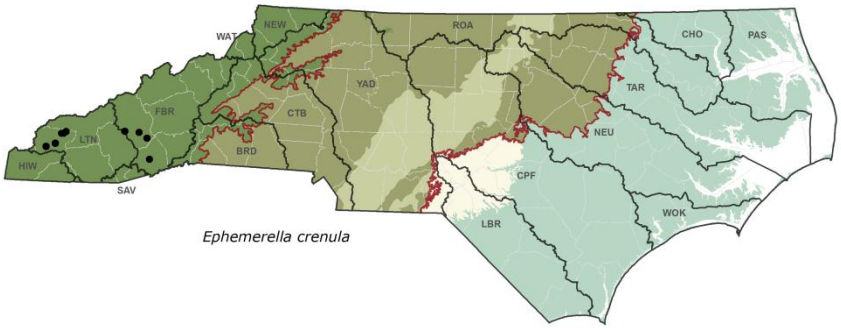

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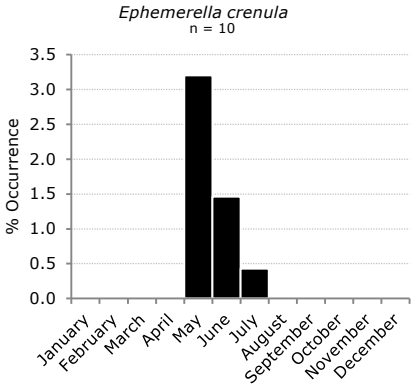

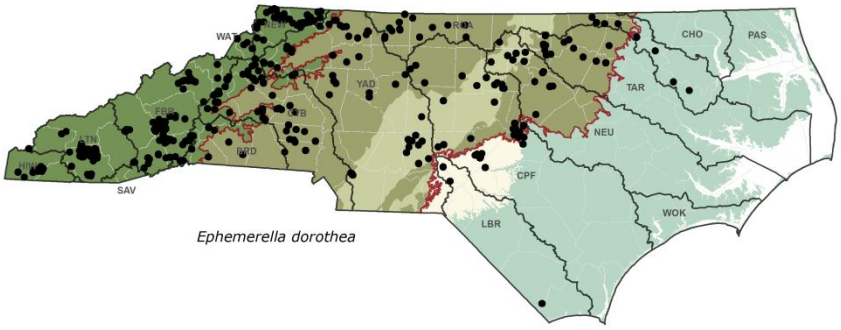

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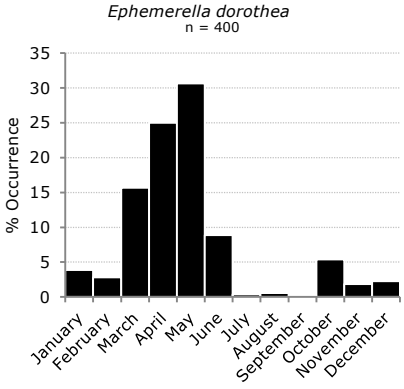

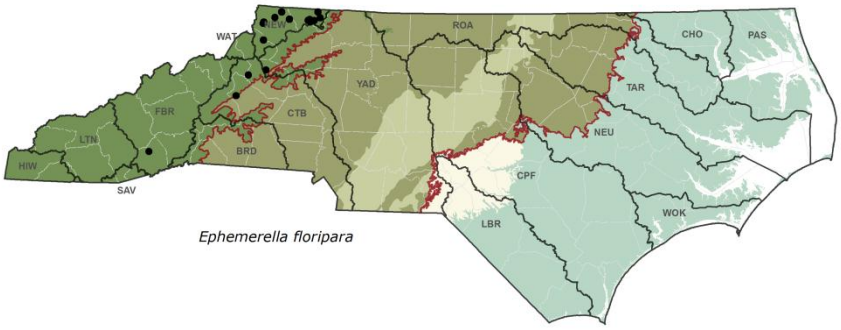

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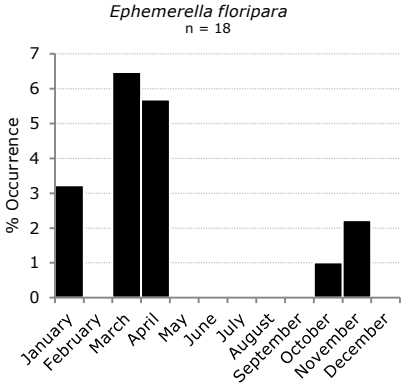
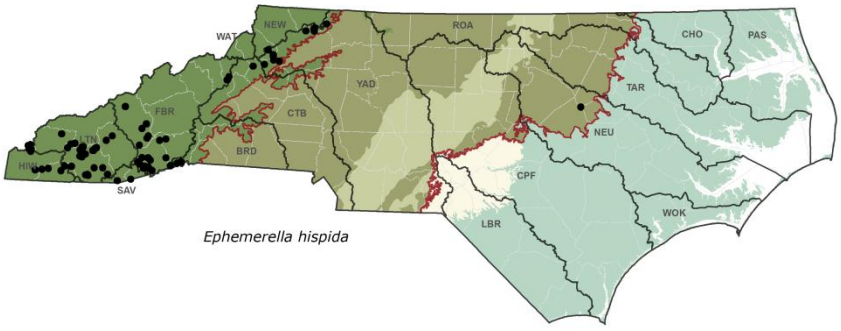
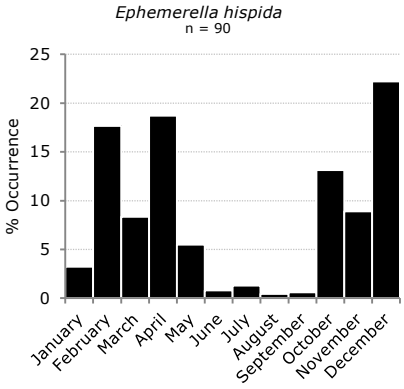




Ephemerella hispida



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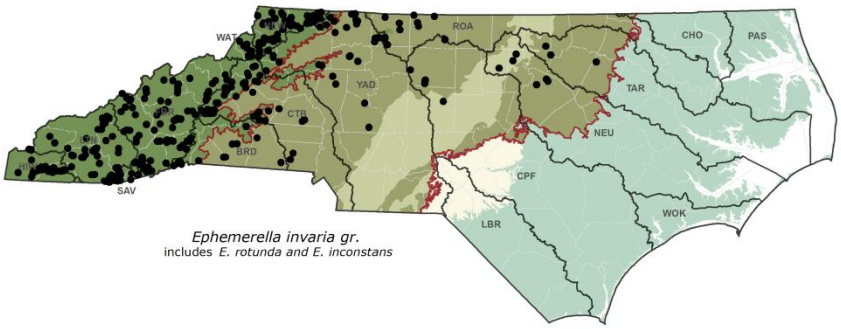
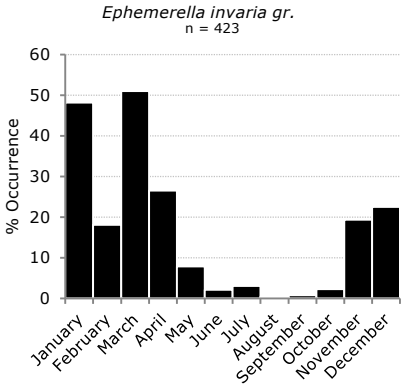
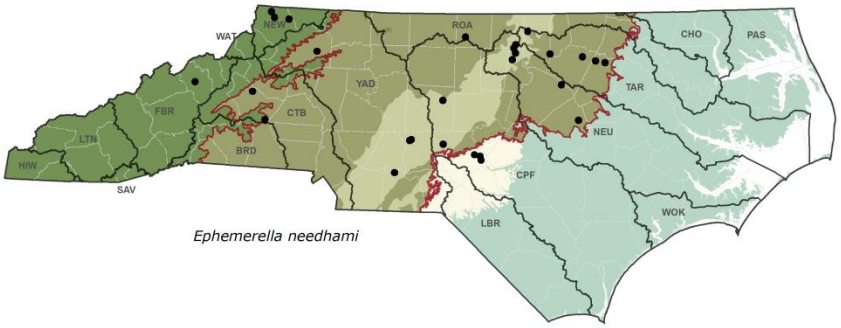
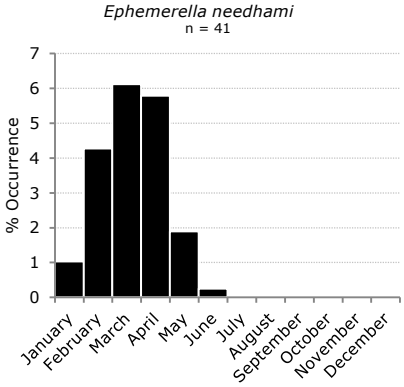


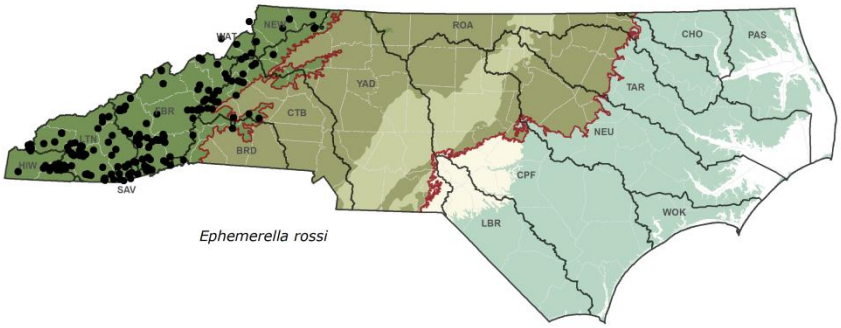
Ephemerella invaria gr.
includes *E. rotunda and E. inconstans*



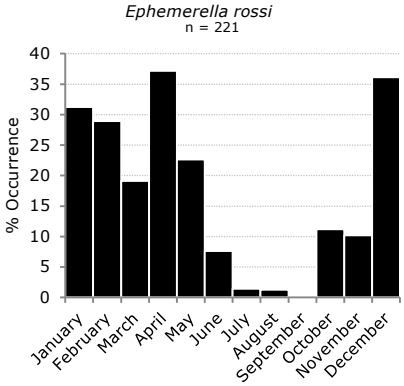


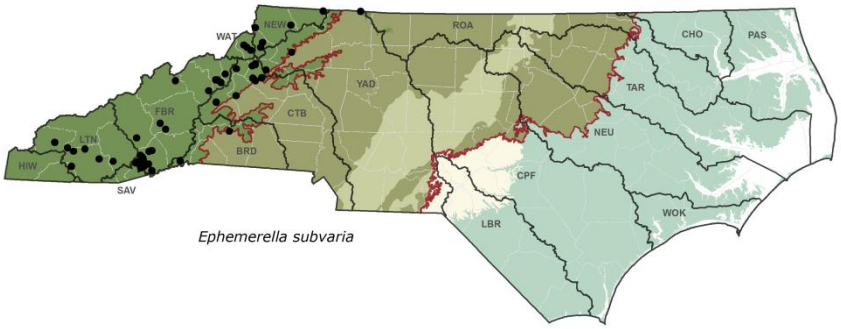
Ephemerella needhami



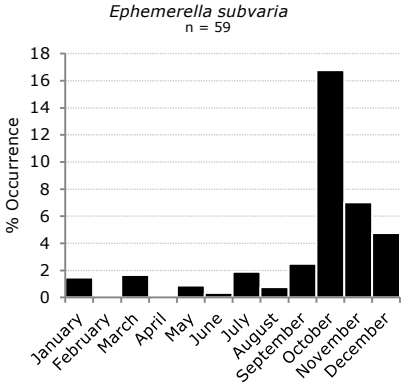


Ephemerella rossi





Ephemerella subvaria



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nymphs:

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⇨Allen, R. K. and G. F. Edmunds, Jr. 1964. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VIII. The subgenus *Ephemerella* in North America. Miscellaneous Publications of the Entomological Society of America 4: 243-282.

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adults:

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Jacobus, L. M. and W. P. McCafferty. 2008. Revision of Ephemerellidae genera. Transactions of the American Entomological Society 134(1-2): 185-274.

Eurylophella

Genus Diagnosis: *Maxillae without palpi;* claws with denticles; abdominal segment 1 with a filamentous gill; *gills on segment 4 operculate and largely covering the gills on 5-7; paired tubercles on abdominal segments 1-7;* abdominal segment 9 distinctly longer than segment 8.

Habitat: Lotic and lentic, areas of low flows (e.g. swamps and backwaters) to moderate flows, on a variety of substrates. Most eastern species are primarily collectors-gatherers, and possibly facultative scrapers or grazers (*E. verisimilis* primarily a scraper and *E. funeralis* a shredder).

Distribution and Occurrence: A widespread and common genus. See species accounts.

Species in NC: TAKE TO SPECIES

E. bicolor group: *0-2 very small dorsal subdivisions on the ventral lamella of gill 4*; submedian tubercles on terga 1-4 relatively short, stout and blunt; small to medium-sized species.

bicolor – nymphs 6.0-8.3 mm; female occipital tubercles distinct but small; *separation of the dorsal tubercles on segment 5 distinctly greater than on segment 4;* tubercles on 1-4 blunt and erect and those on 5-7 short, sharp and low-lying; posterolateral projections of segment 2 barely perceptible and small on segment 3. Common, widespread, and facultative, this species is least abundant during the summer. Many old *E. bicolor* records may be immatures of other species, based only on the size of the posterolateral projections.

macdunnoughi* – nymphs 6.9-8.9 mm; paired tubercles on terga 1-4 blunt and erect and those on 5-7 large, sharp and dorsally rounded; spines of hind margin of forefemora short, stout and blunt. Potentially collected during late winter and spring. Recorded from TN, VA, and WV

minimella – nymphs 5.9-7.7 mm; tubercles on terga 1-4 thinner, semi-acute and erect with those on segments 5-7 long, sharp, and semi-erect. Collected during late spring and early summer. Uncommon and limited to the mountains. Recorded from GSMNP.

verisimilis – nymphs 6.8-9.2 mm; this is the only species in the *bicolor* group with *well-developed occipital tubercles;* the dorsal tubercles are dark on segments 5-7 (between gills). Collected during winter through early summer. This is the most common *Eurylophella* in the Piedmont and Mountains.

E. funeralis group: *2-5 very small dorsal subdivisions on the lateral margin of the ventral lamella of gill 4 (some may be larger); posterolateral projections of segment 9 short with inner margins distinctly sinuate, apices acute and incurved and the outer margins of segment mostly straight and subparallel; segment 9 with well-developed submedian tubercles.* Large species.

funeralis – nymphs 8.1-10.3 mm; medium-sized occipital tubercles on both male and females; rows of submedian tubercles appear to diverge from segment 1 to segment 4 or 5, then converge slightly toward segment 7; *tubercles longer on segments 1-4 than any other Eurylophella species, even on very small specimens, and dorsally arched;* large dorsal tubercles are present on segment 9; posterolateral projections of segment 2 and 3 long. Some populations may be parthenogenetic. Collected during fall through spring. In NC, this distinct and intolerant species is largely confined to smaller Mountain and Piedmont streams. Recorded from GSMNP.

E. lutulenta group: *2-5 small dorsal subdivisions on the ventral lamella of gill 4; posterolateral projections of segment 9 long with inner margins straight;* submedian tubercles on terga 1 and 2 widely separated; *tubercles on terga 1-4 blunt and semi-erect.* Medium sized to large species.

aestiva – nymphs 6.4-8.1 mm; *occipital tubercles well developed in both sexes; posterolateral projections on segments 2 and 3 shorter but distinct;* entire body densely covered with small flattened, spicules with origins appearing as very small whitish dots (easier to see on darker specimens). This species has two distinct color patterns. Collected during spring and early summer. North Carolina is presently the southern limit for this species, with records for both the Mountain and Piedmont regions. Uncommon. Recorded from GSMNP.

enoensis – nymphs 8.3-10.5 mm; occipital tubercles medium sized in males to large in females; *tarsi with wide, dark, medial band; posterolateral projections on 2 and 3 long and thin* (longer and thinner than in *E. lutulenta*); without distinct and well developed ridges forming the bases of submedian tubercles on terga 6 and 7. Nymphs are collected fall through spring and are often larger in the fall than other species (except *E. lutulenta*). Some records may be keyed as *E. coxalis*. BAU records suggest that this species is primarily a Slate Belt species.

(lutulenta) – nymphs 9.3-11.7 mm; occipital tubercles small to non-existent in males and very small in females; posterolateral projections on 2 and 3 long; *terga 6 and 7 with distinct and well developed ridges forming the bases of submedian tubercles.* A typically lentic species and early emerger, nymphs should be collected fall through spring.

E. temporalis group: *dorsal subdivisions of the ventral lamella of gill 4 distinct and subequal to ventral subdivisions;* paired abdominal tubercles appear to converge between segments 2 and 7; *submedian tubercles on segment 7 narrowly spaced;* on mature specimens bands of spines on the dorsum of segment 8 originate near the tips of segment 7 tubercles and extend obliquely across dorsum of segment and onto the posterior margin near the posterolateral projections. *E. temporalis* group species are tolerant of slow-water habitats, including swamps and beaver ponds. Records of immatures of this group are referred to as *E. temporalis gr.* in the BAU database.

doris – nymphs 8.0-10.1 mm; *9 or more dorsal subdivisions in ventral lamella; occipital tubercles large in both sexes; paired submedian tubercles on terga 1-3 thicker and distinctly arched in lateral view; posterolateral projections on abdominal segments 2 and 3 usually longer*; *sublateral dashes on sterna blackish.* Common in Piedmont and Coastal Plain from April through July. Tolerant of pollution.

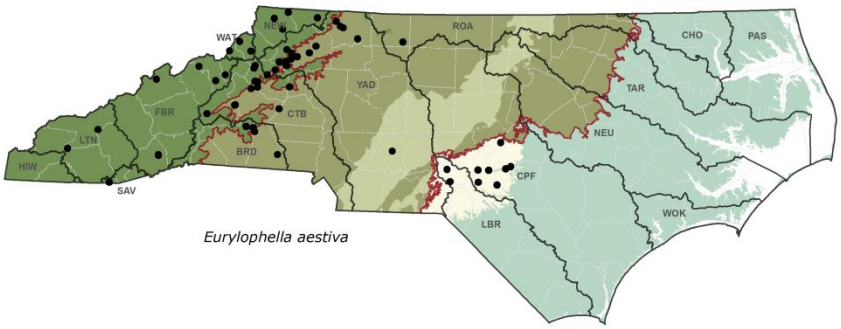
oviruptis – nymphs 8.0-9.7 mm; *6 dorsal subdivisions in ventral lamella;* occipital tubercles small; *submedian tubercles on segment 7 more widely spaced relative to those on segment 4; relative length of abdominal segments 5-7 shorter; paired submedian tubercles on terga 1-3 thicker and distinctly arched in lateral view; sublateral dashes on sterna brownish.* Parthenogenetic species. Often co-occurs with other species but will usually be distinctly larger and more developed than its congeners (i.e., *E. doris, E. prudentalis* and *E. verisimilis*) in Coastal Plain swamps due to early emergence. Described from NC swamp streams. "Swamp Thing".

prudentalis – nymphs 6.5-8.0 mm; *6 dorsal subdivisions in ventral lamella;* occipital tubercles small in females, almost imperceptible in males; *submedian tubercles on segment 7 narrowly spaced; relative length of abdominal segments 5-7 longer; paired submedian tubercles on terga 1-3 thin, pointed, and relatively straight in lateral view.* A Sand Hills and Coastal Plain species *E. prudentalis* nymphs occur late winter through spring. Many of the 25 BAU records have been misidentifications of recently described *E. oviruptis*.

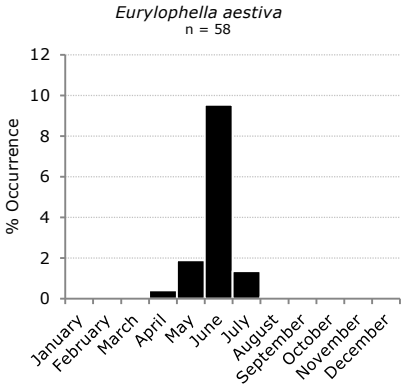
(temporalis) – nymphs 8.9-12 mm*; 9 or more dorsal subdivisions in ventral lamella;* occipital tubercles large in both sexes; paired submedian tubercles on terga 1-3 thicker and distinctly arched in lateral view; *posterolateral projections on abdominal segments 2 and 3 usually shorter than in E. doris.* A more northerly species, *E. temporalis* should not overlap with *E. doris*, a more southern species (Funk and Sweeney, 1994). However, *E. temporalis* has been recorded from FL, GA, NC, SC, TN, VA, and WV. It is unknown whether these records are of adults or nymphs, although it appears that many of these records (though not all) predate the Funk and Sweeney key. Therefore, BAU records of *E. temporalis* are still considered dubious until such time as either collections of adult *E. temporalis* in NC are confirmed or BAU nymphal specimens are taxonomically confirmed. New data was provided for SC (McCafferty and Meyer, 2008). It is also unknown whether McCafferty et al. (2010) verified the older southeastern records.

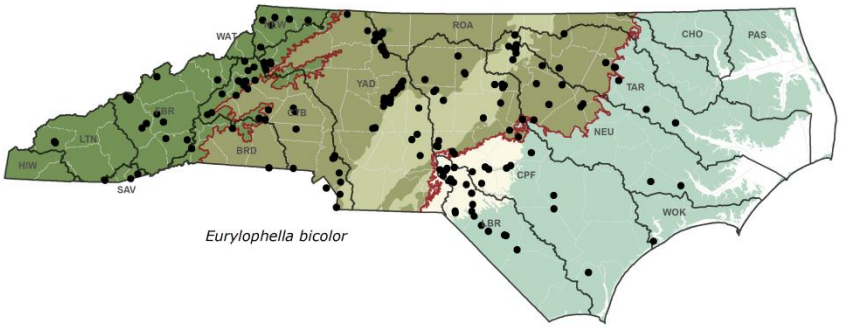
Notes: There are often 3-4 species co-occurring in NC swamp streams. Dorsal color pattern seems to be of little use, due to extreme variability in dorsal striping, the amount of speckling, as well as overall coloration patterns. Furthermore, mature nymphs may have distinct patterns that are not necessarily present on smaller nymphs. Emergence of NC species is approximately 2-4 weeks (3 in Piedmont) earlier than described in Funk and Sweeney (1994). The 61 BAU records for *Eurylophella coxalis*, revalidated as *Dentatella coxalis*, are most likely in error. Ten percent of the samples with *Eurylophella coxalis* identifications were checked for larval identity and, in every case, *Eurylophella aestiva* or *E. enoensis* was misidentified as *E. coxalis*. These identifications were based on keys which used misassociated larval material prior to the Funk and Sweeney revision. Burian (2002) synonymized *E. coxalis* with *Dentatella bartoni*. However, McCafferty et al. (2003) revalidated the genus *Dentatella* and further synonymized *E. coxalis* as *Dentatella coxalis* which is where it currently stands. *Dentatella coxalis* is restricted to Ontario, Quebec, and the some New England states and does not occur in NC.

EPHEMERELLIDAE

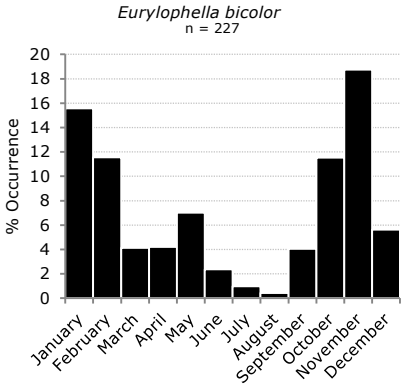


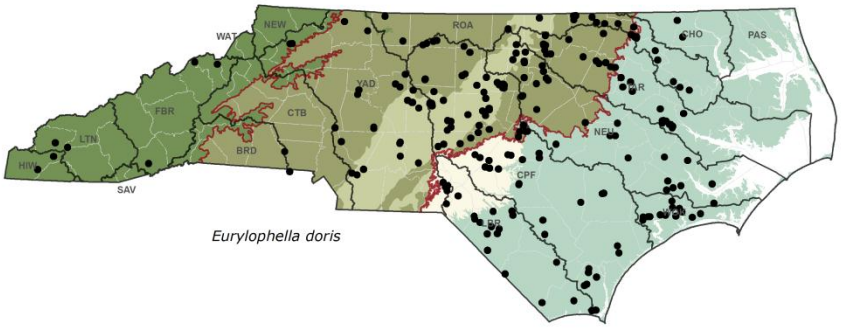
Eurylophella aestiva





Eurylophella bicolor





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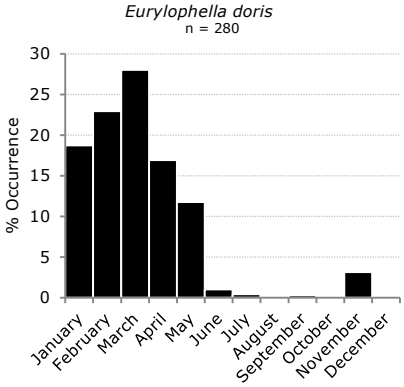

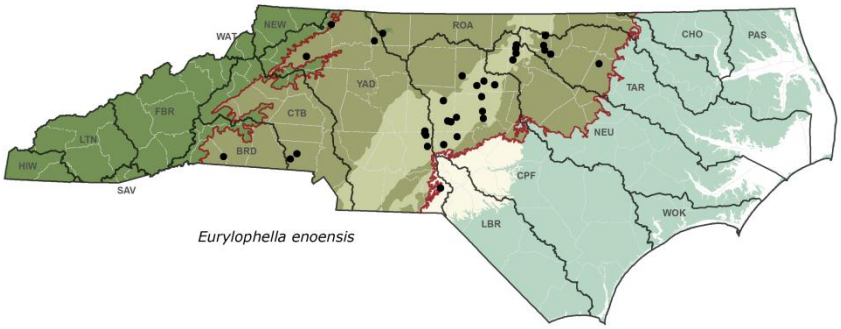

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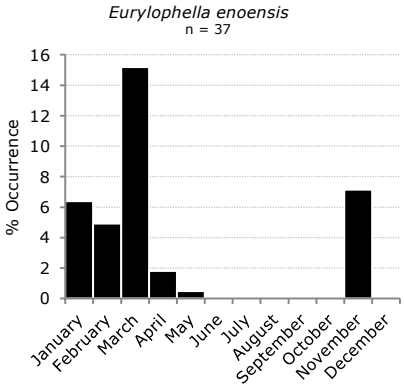
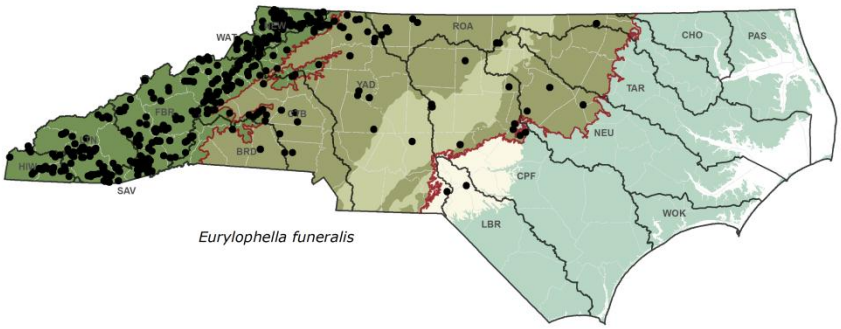
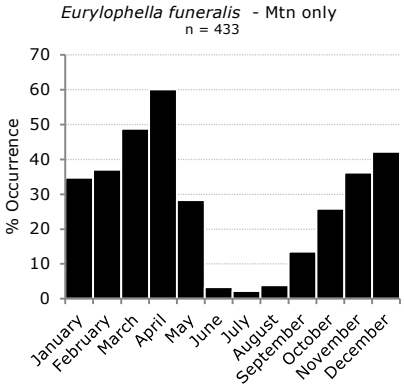
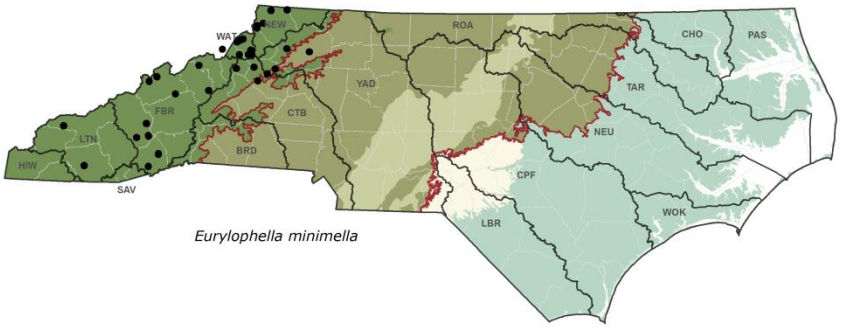


EPHEMERELLIDAE

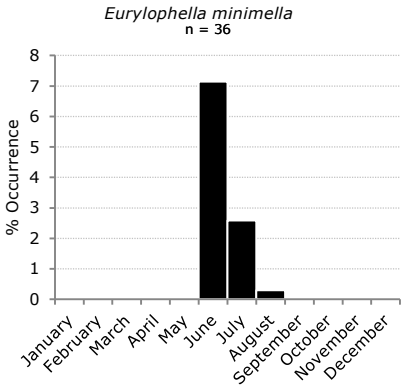


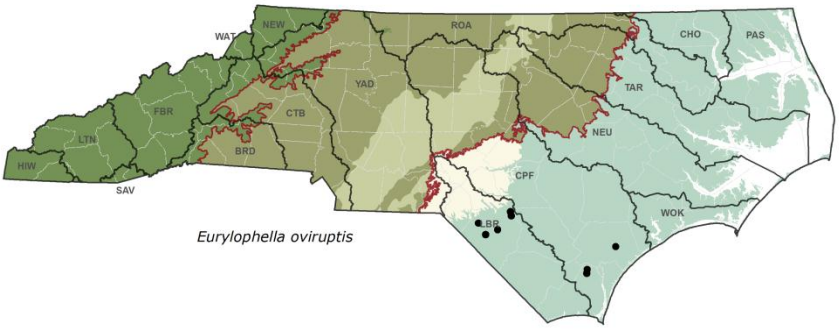
Eurylophella funeralis



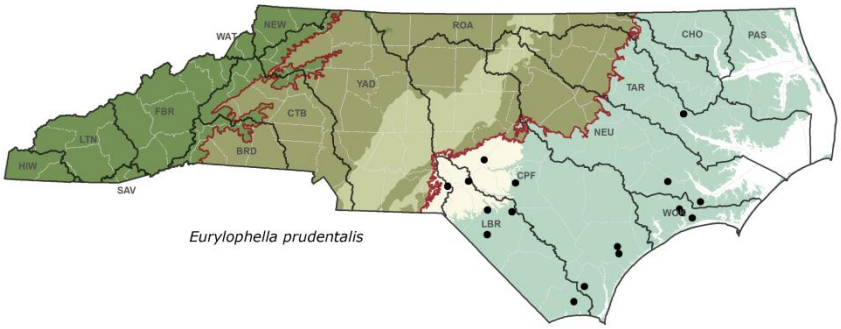


Eurylophella minimella

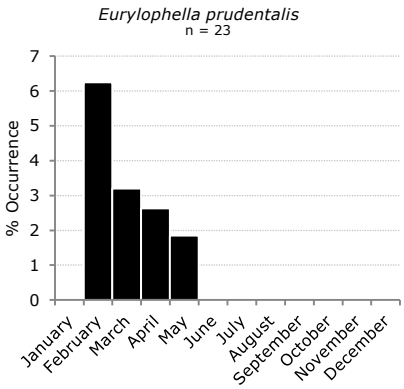


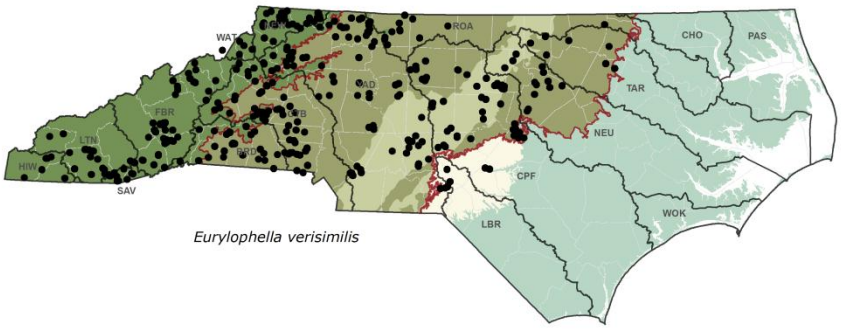


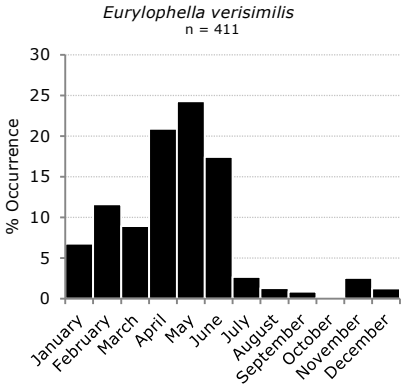
Eurylophella oviruptis



Eurylophella prudentalis







Taxonomic references:

nymphs:

Allen, R. K. and G. F. Edmunds, Jr. 1963. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae) VII. The subgenus *Eurylophella*. The Canadian Entomologist 95: 597-623.

Burian, S. K. 2002. Taxonomy of *Eurylophella coxalis* (McDunnough) with notes on larval habitat and behavior (Ephemeroptera: Ephemerellidae). Journal of the North American Benthological Society 21(4): 602-615.

⇨Funk, D. H. and B. W. Sweeney. 1994. The larvae of eastern North American *Eurylophella* Tiensuu (Ephemeroptera: Ephemerellidae). Transactions of the American Entomological Society 120: 209-286.

Funk, D. H., J. K. Jackson and B. W. Sweeney. 2008. A new parthenogenic mayfly (Ephemeroptera: Ephemerellidae: *Eurylophella* Tiensuu) oviposits by abdominal bursting in the subimago. Journal of the North American Benthological Society 27(2): 269–279.
(with emendation to Funk and Sweeney key)

McCafferty, W. P., L. M. Jacobus and T.-Q. Wang. 2003. Phylogenetics and the reconfirmation of *Dentatella* Allen (Ephemeroptera: Ephemerellidae). Proceedings of Entomological Society of Washington 105(3): 786-788.

adults:

Allen, R. K. and G. F. Edmunds, Jr. 1963. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae) VII. The subgenus *Eurylophella*. The Canadian Entomologist 95: 597-623.

Penelomax

Genus Diagnosis: Nymphs 9-10 mm; maxillary palpi well developed; abdominal segment 1 without filamentous gill; *lamellate gills present on abdominal terga 3-7 not operculate; abdominal terga 2-7 with a single, small posteromedian tubercle; legs very long and thin, femora almost as narrow as tibiae; caudal filaments with heavy intersegmental setae and without whorls of spines at apex*; legs with dark banding, dorsal surface dark laterally with two pale submedian stripes and a darker median stripe, finely speckled; ventrally brown, speckled, and darker posteriorly, with black dot-dash pattern and pale submedian spots along anterior edge of at least sterna 2-8 (may be indistinct in younger specimens).

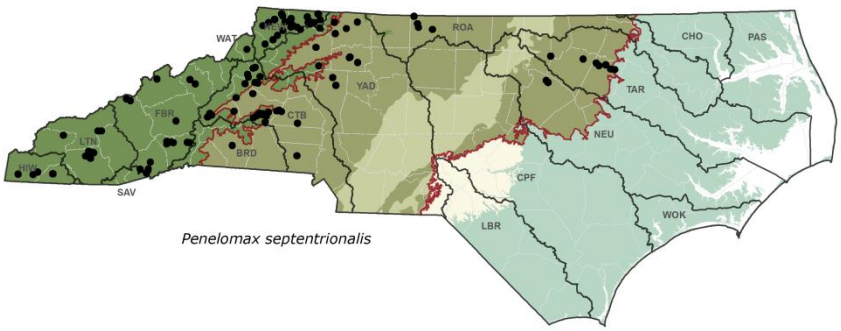
Habitat: Lotic, in edge habitat such as root mats or on hard substrates, in areas of good flow. Collectors-gatherers.

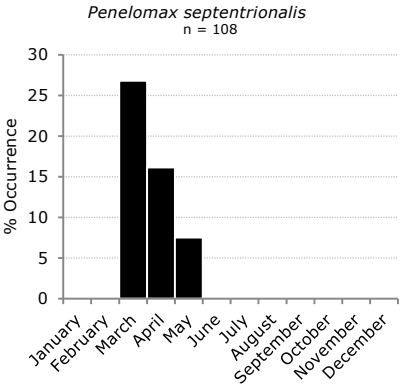
Distribution and Occurrence: Primarily a mountain species although a disjunct population exists in the headwaters of the Neuse and Tar rivers. Uncommon.

Species in NC: MONOTYPIC

septentrionalis – see Genus Diagnosis

Notes: A distinctive and intolerant ephemerellid, *Penelomax* is collected during the spring. Formerly *Ephemerella septentrionalis,* this species was elevated to generic status by Jacobus and McCafferty (2008).





Taxonomic references:

nymphs:

⇨Allen, R. K. and G. F. Edmunds, Jr. 1964. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VIII. The subgenus *Ephemerella* in North America. Miscellaneous Publications of the Entomological Society of America 4: 243-282.

Jacobus, L. M. and W. P. McCafferty. 2008. Revision of Ephemerellidae genera. Transactions of the American Entomological Society 134(1-2): 185-274.

adults:

Allen, R. K. and G. F. Edmunds, Jr. 1964. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VIII. The subgenus *Ephemerella* in North America. Miscellaneous Publications of the Entomological Society of America 4: 243-282.

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Serratella

Genus Diagnosis: *Maxillary palpi present, reduced;* tarsal claws with denticles; abdominal segment 1 without filamentous gill; some *abdominal terga with paired submedian tubercles; lamellate gills present on abdominal terga 3-7 not operculate; ventral lamellae of gill 6 deeply cleft; caudal filaments with sparse or no interfacing intersegmental setae on middle and basal segments, with whorls of spines at apex of each segment.*

Habitat: Primarily lotic, in areas of fast flow in crevasses of hard substrates, some species in vegetation and root mats in edge areas where flow is slower. Collectors-gatherers.

Distribution and Occurrence: Mountains and Piedmont only. See species accounts.

Species in NC: TAKE TO SPECIES

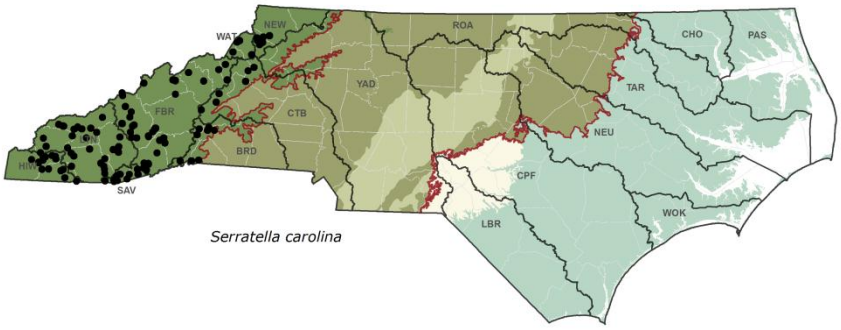
carolina – nymphs 4.5-5.0 mm; maxillary palpi one apparent segment; tarsal claws with 5-7 denticles; *occiput, pronotum, and abdominal terga 2-9 with paired, spiculate submedian tubercles, usually quite large* (may be imperceptible on 2); mesonotum with submedian and posteromedial elevations; *dorsally brown to dark brown; ventrally brown with brown sublateral dashes;* caudal filaments brown with pale apical bands, without setae. Adults unknown. Found in the mountains during the summer. Relatively common though very intolerant. Synonymized with *S. serrata* (Jacobus and McCafferty, 2003). Described from NC.

serrata – nymphs 5.0-6.0 mm; *head roughened with patches of spicules but without distinct tubercles;* maxillary palpi with three apparent segments; *pronotum with paired small submedian tubercles;* tarsal claws usually with 3-5 denticles; *paired submedian tubercles on terga 3-8, usually small but distinct on 4-7 and sometimes barely perceptible on 3 and 8, apically spiculate on middle segments*; body pale to light brown with various darker maculations and with terga 7-9 darker; *blackish sublateral dashes on at least segments 3-8; caudal filaments pale, short, and with intercalary hairs;* body relatively hairy overall. Fairly common and collected during summer only in the mountains and foothills with a population in northern Durham and Orange Counties. Recorded from GSMNP.

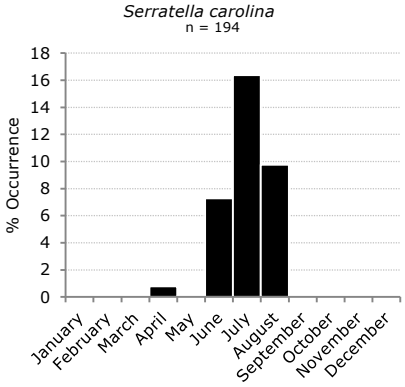
serratoides – nymphs 6.0-7.0 mm (males may be as small as 5.0 mm); maxillary palpi with three apparent segments; occiput and pronotum without submedian tubercles; tarsal claws usually with 5-8 denticles; *paired wave-like submedian tubercles on terga 3-7, usually small on segment 3; dark sublateral dashes and a transverse row of four black dots on each sternum, submedial pair posteriorly removed from anterior pair;* dorsal coloration variable but often dark with pale speckling on last few terga and sterna in some specimens; pre-emergent males may have pale transverse bar on frons, oblique pale stripes on pronotum and mesonotum as well as terga 5 and 6 pale, pale areas often tinged with red; caudal filaments usually dark with a pale submedial band and with apical segments darkened. Common in summer in the Mountains and Piedmont. Reinstated from *S. molita* in Jacobus and McCafferty (2007). Recorded from GSMNP.

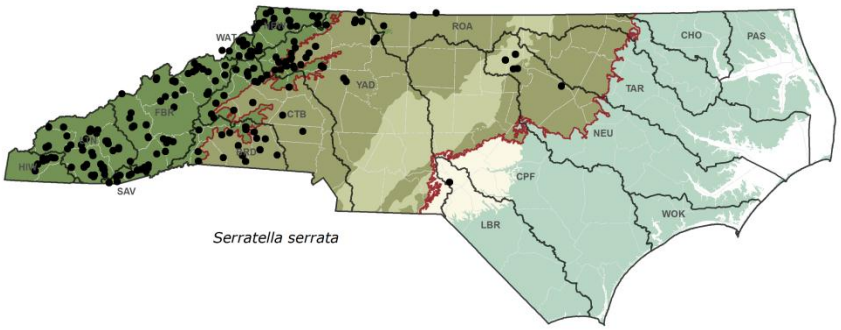
spiculosa – nymphs 4.0-4.6 mm; *head without tubercles and roughened with numerous spicules;* maxillary palpi with one apparent segment; *pronotum with paired submedian tubercles;* tarsal claws usually with 6-8 denticles; *paired submedian tubercles on terga 3-7, large and wide basally, often wave-like and spiculate apically*, dorsally brown to dark brown, with terga 5 and 6 paler, tergum 7 darkest; ventrally some specimens reddish brown and finely, with brownish sublateral dashes (?); *caudal filaments brown with pale apical bands, without setae.* Collected late spring through early summer. Mountains only, particularly in southwestern NC. Rare. Synonymized with *S. serrata* (Jacobus and McCafferty, 2003). Listed by NC Natural Heritage Program as Significantly Rare (2010).

Notes: Serratella species are very intolerant to intolerant. Jacobus and McCafferty (2003) synonymized *S. carolina* and *S. spiculosa* with *S. serrata*. However, many streams in NC contain 2-3 distinct groups with obvious morphological differences making apparent speciation relatively easy. Therefore, NC BAU is not currently accepting these synonymies. Also of note: the pictures labeled 11 and 12 in the Allen and Edmunds key (1963) are switched.

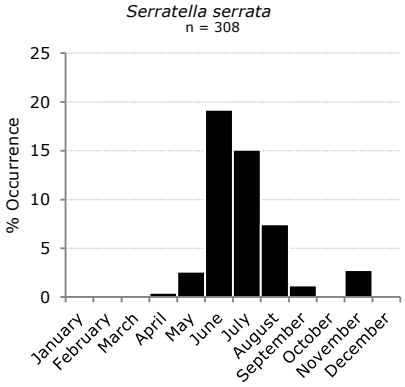


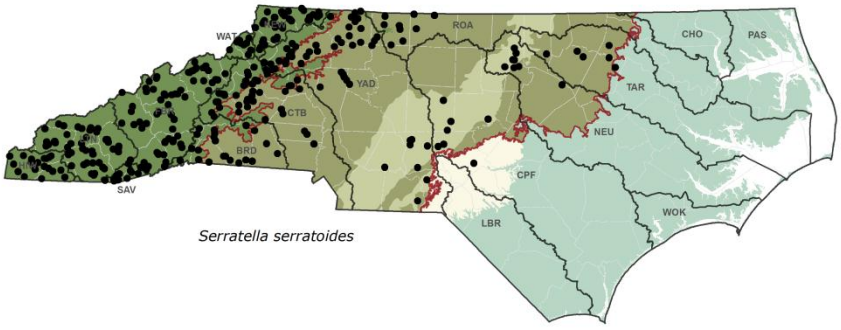
Serratella carolina



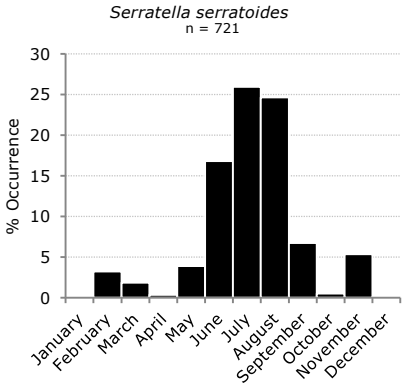


Serratella serrata

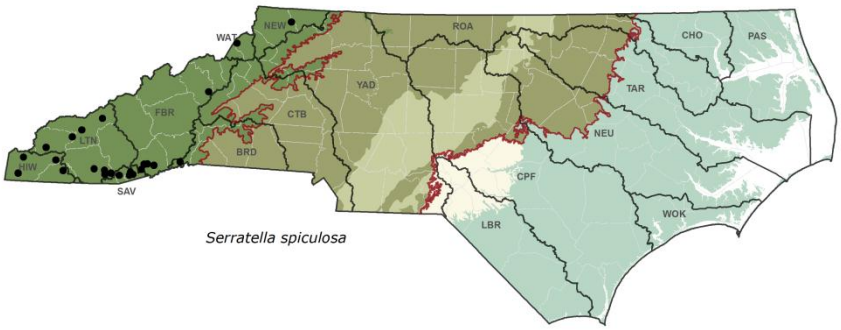


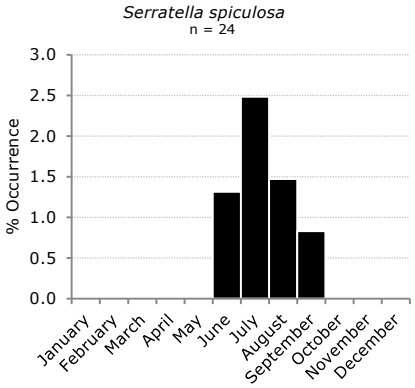


Serratella serratoides



EPHEMERELLIDAE





Taxonomic references:

nymphs:

⇨Allen, R. K. and G. F. Edmunds, Jr. 1963. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae) VI. The subgenus *Serratella* in North America. Annals of the Entomological Society of America 56: 583-600.

Berner, L. and R. K. Allen. 1961. Southeastern species of the mayfly subgenus *Serratella* (Ephemerella: Ephemerellidae). The Florida Entomologist 44: 149-158.

⇨Jacobus L. M. and W. P. McCafferty. 2000. Variability in the larvae of *Serratella serrata* (Ephemeroptera: Ephemerellidae). Entomological News 111(1): 39-44. (larval key adjustment)

Jacobus, L. M. and W. P. McCafferty. 2003. Revisionary contributions to North American *Ephemerella* and *Serratella* (Ephemeroptera: Ephemerellidae). Journal of the New York Entomological Society 111 (4): 174-193.

Jacobus, L. M. and W. P. McCafferty. 2007. Reinstatement of *Serratella serratoides* and status of *Ephemerella molita*. Proceedings of Entomological Society of Washington 109(3): 730-732.

Jacobus, L. M. and W. P. McCafferty. 2008. Revision of Ephemerellidae genera. Transactions of the American Entomological Society 134(1-2): 185-274.

adults:

Allen, R. K. and G. F. Edmunds, Jr. 1963. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae) VI. The subgenus *Serratella* in North America. Annals of the Entomological Society of America 56: 583-600.

Teloganopsis

Genus Diagnosis: *Maxillary palpi absent (T. deficiens) or reduced (other species); claws with a stout preapical denticle;* abdominal segment 1 without filamentous gill; lamellate gills present on abdominal terga 3-7 not operculate; *ventral lamellae of gill 6 deeply cleft; sparse or no intersegmental setae on apical segments of caudal filaments; caudal filaments with whorls of spines at apex of each segment.*

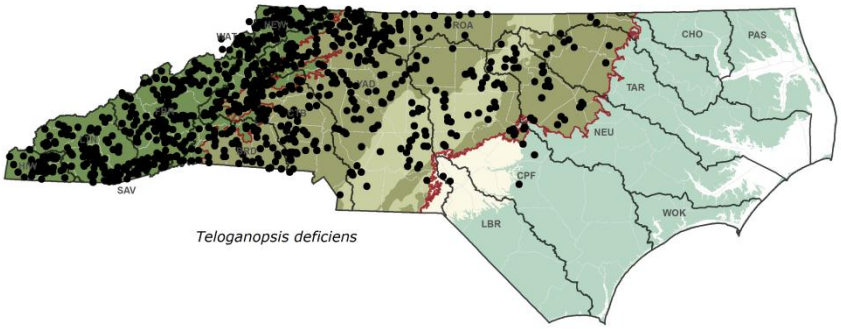
Habitat: Primarily lotic, in areas of fast flow in crevasses of hard substrates but some species in vegetation and root mats in edge areas where there is slow flow. Collectors-gatherers.

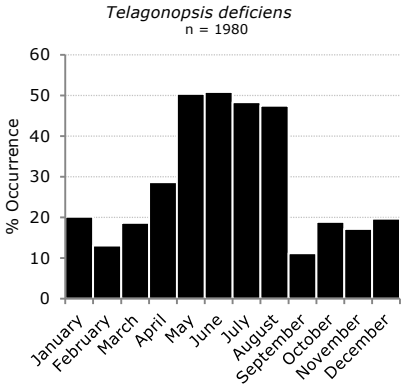
Distribution and Occurrence: Collected winter through summer in the Mountains and Piedmont. Very Common.

Species in NC: TAKE TO SPECIES

deficiens – nymphs 5-6 mm; *maxillary palpi absent; no paired tubercles on head, pronotum or abdominal terga;* tarsal claws with 8-10 denticles, *pre-apical denticles largest;* often dark but color variable, *with double pale dorsal stripes on pronotum, mesonotum and segments 1-5,* may be obscure on some specimens; sterna get progressively darker, sterna 1-7 or 8 with varyingly obscure pale medial spots, possibly coalescing with previous segments to form a pale longitudinal stripe; *each sterna 3-9 with pale lateral edges interrupted by a semicircular maculation;* caudal filaments usually pale with a darker medial band.

Notes: The double pale dorsal stripe and the pale, interrupted lateral edges make field identification straightforward. This species is intolerant. Jacobus and McCafferty (2003) transferred *Serratella deficiens* to *Teloganopsis* of which *T. deficiens* is the only species in the eastern US.





Taxonomic references:

nymphs:

⇨Allen, R. K. and G. F. Edmunds, Jr. 1963. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae) VI. The subgenus *Serratella* in North America. Annals of the Entomological Society of America 56: 583-600.

Berner, L. and R. K. Allen. 1961. Southeastern species of the mayfly subgenus *Serratella* (Ephemerella: Ephemerellidae). The Florida Entomologist 44: 149-158.

Jacobus, L. M. and W. P. McCafferty. 2008. Revision of Ephemerellidae genera. Transactions of the American Entomological Society 134(1-2): 185-274.

adults:

Allen, R. K. and G. F. Edmunds, Jr. 1963. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae) VI. The subgenus *Serratella* in North America. Annals of the Entomological Society of America 56: 583-600.

Tsalia

Genus Diagnosis: Nymphs 11-13 mm; maxillary palpi well developed; pronotum and mesonotum with paired tubercles and mesonotum with a large posteromedial tubercle; *tibiae stout, slightly arcuate;* abdominal segment 1 without filamentous gill; lamellate gills present on abdominal terga 3-7 not operculate; *abdominal terga with very distinctive and very long tubercles on 1-10 (longest on 4-9 barely perceptible on 1), tubercles slightly arched with axis divergent from medial line and darkened at least apically*; posterolateral projections on 3-9 long; caudal filaments with heavy intersegmental setae and without whorls of spines at apex; body brown, with anterior third of terga 2-8 darker.

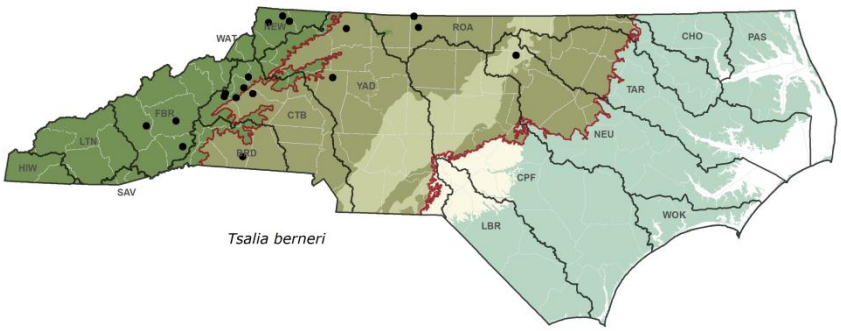
Habitat: Found in medium to large rivers during winter through mid-spring. Associated with *Podostemum ceratophyllum* (riverweed) and moderate to fast flows. Possibly collectors-gatherers.

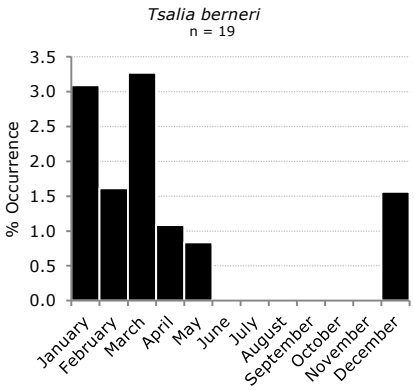
Distribution and Occurrence*:* Found in Mountains and northern Piedmont (Mayo River). Rare.

Species in NC: MONOTYPIC

berneri – see Genus Diagnosis

Notes: *Ephemerella berneri* was elevated to generic status as *Tsalia berneri* by Jacobus and McCafferty (2008). Listed by NC Natural Heritage Program as Significantly Rare (2012, as *Ephemerella berneri*). Listed as "vulnerable to extirpation" by Morse et al. (1997).





EPHEMERELLIDAE

Taxonomic references:

nymphs:

⇨Allen, R. K. and G. F. Edmunds, Jr. 1964. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VIII. The subgenus *Ephemerella* in North America. Miscellaneous Publications of the Entomological Society of America 4: 243-282.

Jacobus, L. M. and W. P. McCafferty. 2008. Revision of Ephemerellidae genera. Transactions of the American Entomological Society 134(1-2): 185-274.

Kondratieff, B. C., J. W. W. Foster, III, and J. R. Voshell, Jr. 1981. Description of the Adult of *Ephemerella berneri* Allen and Edmunds (Ephemeroptera: Ephemerellidae) with Biological Notes. 83(2): 300-303.

adults:

Allen, R. K. and G. F. Edmunds, Jr. 1964. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VIII. The subgenus *Ephemerella* in North America. Miscellaneous Publications of the Entomological Society of America 4: 243-282.

Jacobus, L. M. and W. P. McCafferty. 2008. Revision of Ephemerellidae genera. Transactions of the American Entomological Society 134(1-2): 185-274.

LEPTOHYPHIDAE

Asioplax

Genus Diagnosis: Nymphs 3.0-4.5 mm; *body dorsoventrally flattened; forefemora wide, three-quarters or subequal to length; forefemora with moderately long spines, margined with long setae;* hind wing pads absent; lamellate gills of second abdominal segment elongate and oval; posterior margins of terga 1-6 without spinules; *posterolateral projections of segment 7 and 8 longer than the median length of the respective tergum;* three caudal filaments.

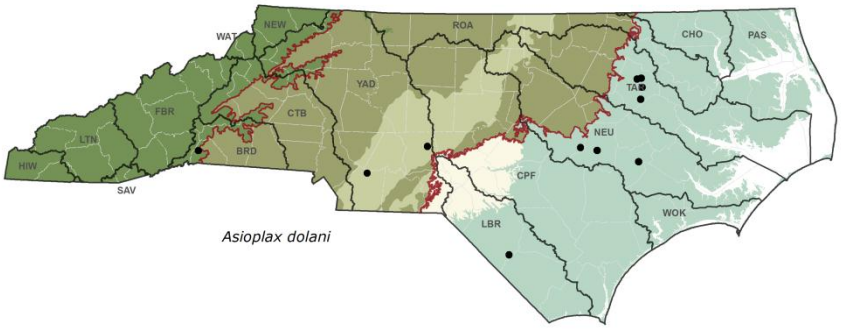
Habitat: Lotic, on silty wood and rocks in areas of slower flow. Collectors-gatherers.

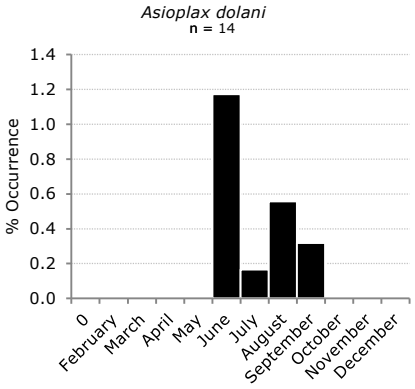
Distribution and Occurrence: Found in larger streams and rivers in the Slate Belt and Coastal Plain during the summer. Rare.

Species in NC: TAKE TO SPECIES

dolani – see Genus Diagnosis

Notes: *Asioplax dolani* is the only species in the southeastern US, with all others being southwestern in distribution. *Asioplax* can be confused with *Tricorythodes*, however its stout and very hairy body should prove to separate the two taxa. Formerly classified as *Leptohyphes*. Listed by NC Natural Heritage Program as Significantly Rare (2012).





Taxonomic references:

nymphs:

⇨Allen, R. K. 1978. The nymphs of North and Central American *Leptohyphes*. Entomological Society of America 71(4): 537-558.

Wiersema, N. A. and W. P. McCafferty. 2005. Contribution to the taxonomy of Asioplax (Ephemeroptera: Leptohyphidae: Tricorythodinae) in the New World. Entomological News 116(3): 147-158.

adults:

Wiersema, N. A. and W. P. McCafferty. 2005. Contribution to the taxonomy of Asioplax (Ephemeroptera: Leptohyphidae: Tricorythodinae) in the New World. Entomological News 116(3): 147-158.

Tricorythodes

Genus Diagnosis: Head not wider than pronotum; *width of forefemora less than two-thirds the length*; *forefemora with short spatulate setae on dorsal surface, not margined with long setae*; hind wing pads absent; *triangular to oval operculate gills on abdominal segment 2 do not meet medially*; posterior margins of terga 1-6 without spinules; three caudal filaments.

Habitat: Lotic, on a variety of substrates where silt collects, in areas of slower flow. Collectors-gatherers.

Distribution and Occurrence: A widespread and common genus. Collected mainly June through October.

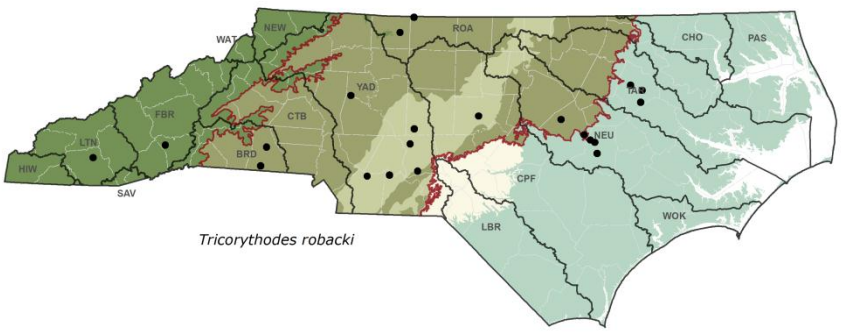
Species in NC: LEAVE AT GENUS except *robacki*

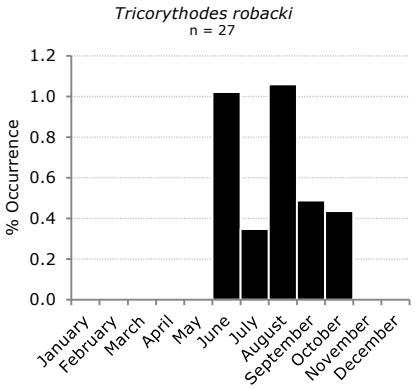
(allectus) – maxillary palpi two segmented; operculate gills triangulate with basomedial and posterior margins sub-angulate; long setae usually present at lateral edge of basomedial angle; posterolateral projections moderately developed; terga 2-9 usually partially pale medially or as longitudinal dashes or spots (McCafferty, unpublished); body hairy overall.

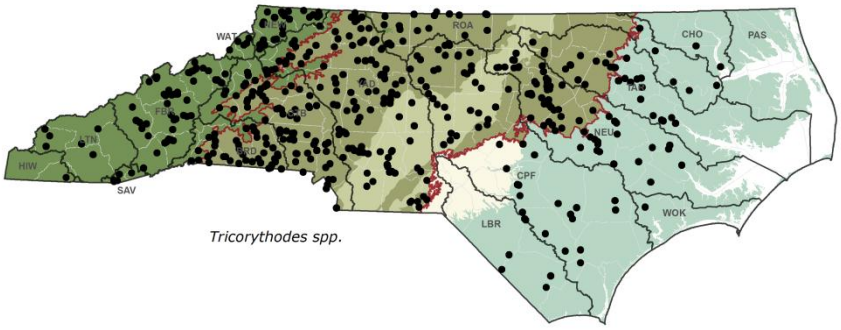
robacki – *nymphs* 3.0-4.0 mm; maxillary palpi one-segmented; femoral spines long and bifurcated; ventral margin of femora slightly concave; *gills more oval than other Tricorythodes, with basomedial margin rounded (not angulate) and lacking long setae;* abdominal terga 7 and 8 with well-developed posterolateral projections; posterolateral projections on tergum 9 apparently appressed; caudal filaments typically brownish, thick basally; *body not hairy overall and typically dark with uniform coloration.* Found in Piedmont and Coastal Plain streams. Listed as "vulnerable to extirpation" by Morse et al. (1997). A facultative species.

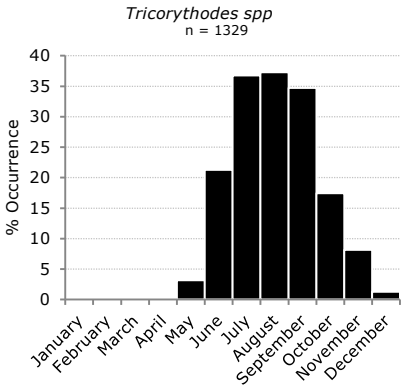
(stygiatus) – minute maxillary palpi three segmented (segment 2 very short); operculate gills triangulate with basomedial and posterior margins sub-angulate; long setae usually present at lateral edge of basomedial angle; posterolateral projections on segment 9 short; terga 2-9 usually dark medially and laterally, this color pattern only associated with NC specimens (McCafferty, unpublished); body hairy overall.

Notes: *Tricorythodes robacki* was previously *Leptohyphes robacki.* Also, *T. atratus* was synonymized with *T. allectus* (Alba-Tercedor and Flannagan, 1995). Color patterns of some nymphs may be unreliable in the Southeast as larvae for *T. allectus* and *T. stygiatus* were associated in northern regions, thus making speciation difficult.









Taxonomic references:

nymphs:

Alba-Tercedor, J. and J. Flannagan. 1995. Two new Canadian species of the genus *Tricorythodes* Ulmer, with additional studies on other North American species (Insecta, Ephemeroptera: Leptohyphidae). Canadian Journal of Zoology 73: 1588-1598.

Allen, R. K. 1978. The nymphs of North and Central American *Leptohyphes*. Entomological Society of America 71(4): 537-558.

Berner, L. 1946. New species of Florida mayflies (Ephemeroptera). The Florida Entomologist 28(4): 60-82. (description of *T. albilineatus*)

adults:

Alba-Tercedor, J. and J. Flannagan. 1995. Two new Canadian species of the genus *Tricorythodes* Ulmer, with additional studies on other North American species (Insecta, Ephemeroptera: Leptohyphidae). Canadian Journal of Zoology 73: 1588-1598.

Neoephemera

Genus Diagnosis: *Mesonotum with distinctly rounded anterolateral lobes*; hind wing pads present; hind legs long; femora and tibiae dorsally ridged; tibiae dark, tarsi with a wide dark medial band; *operculate gills on abdominal segment 2 fused medially, with a diagonal carina originating basomedially;* three caudal filaments.

Habitat: Lotic, in riffles or edge areas, often found in debris or vegetation and root mats in moderate to swift flows. Collectors-gatherers.

Distribution and Occurrence: A widespread and relatively common genus. See species accounts.

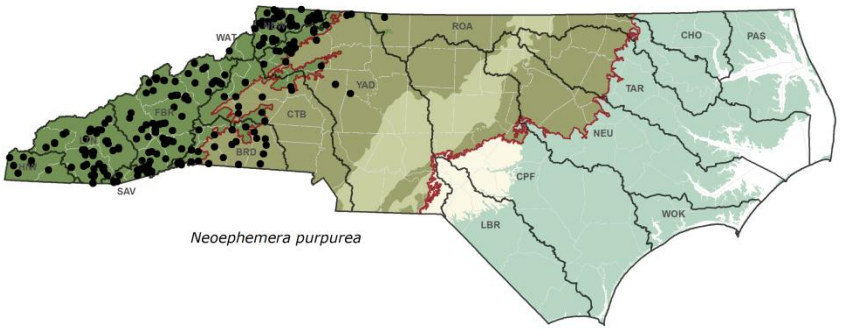
Species in NC: TAKE TO SPECIES

compressa* – nymphs 10.2 mm; without strongly produced anterolateral projections on pronotum; *anterolateral corners of mesonotum pointed; posterolateral spines of abdomen strongly produced.* Recorded from coastal plain regions of GA and VA. All 10 BAU records predate 1991, are from the Piedmont and Sand Hills, and are unverified. These records should be viewed with skepticism as there are no existing adult records of this species in NC.

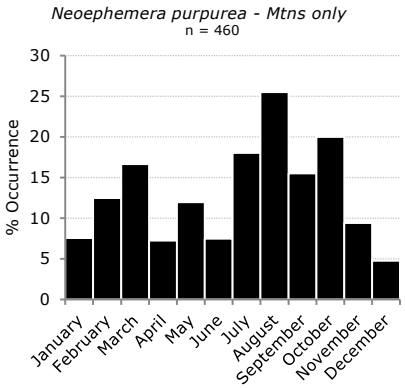
purpurea – nymphs 14.0-17.0 mm; *anterolateral projections of pronotum strongly produced;* anterolateral corners of mesonotum prominent and rounded; *posteromedian tubercles present on terga 6-8;* body dark brown; lateral margins of pronotum and anterolateral corner of mesonotum narrowly pale; tarsi with dark median band. Most common species in NC. Collected year-round in the mountains and foothills. Described from NC.

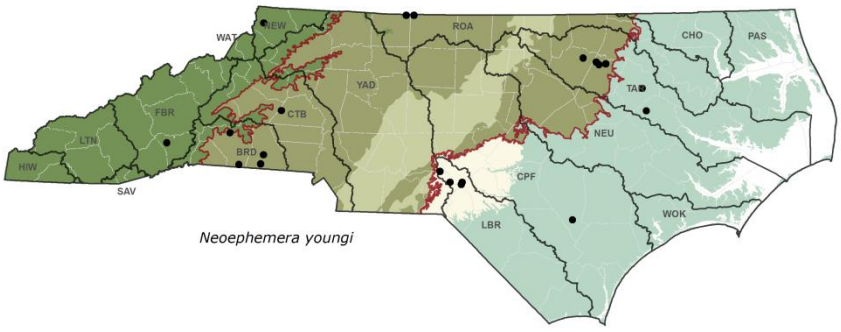
youngi – nymphs 8.1-11.0 mm; *anterolateral projections of pronotum not produced or barely so;* anterolateral corners of mesonotum not prominently rounded; *median spines absent on posterior margin of segments 7-8 and reduced on segment 6;* body brown, specked, and sometimes with apparent pale median stripe on terga 6-9; lateral margins of pronotum and anterolateral corner of mesonotum widely pale; apices of femora dark; tarsi not banded although apices are pale. Collected mostly from Piedmont, Sand Hills, and Coastal Plain from fall through spring. Rare.

Notes: *Neoephemera purpurea* is intolerant.

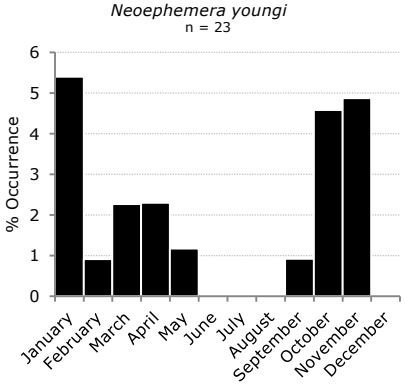


Neoephemera purpurea





Neoephemera youngi



Taxonomic references:

nymphs and adults:

Bae, Y. J. and W. P. McCafferty. 1998. Phylogenetic systematics and biogeography of the Neoephemeridae (Ephemeroptera: Pannota). Aquatic Insects 20(1): 35-68.

⇨Berner, L. 1956. The Genus *Neoephemera* in North America (Ephemeroptera: Neoephemeridae). Entomological Society of America 49: 33-42.

CAENIDAE

Amercaenis

Genus Diagnosis: *Outer margin of operculate gills fringed with short, bifurcate setae*; no tubercles on head; *inner margin of foretibia and tarsus densely covered with long setae*; *maxillary and labial palpi three-segmented, segment 3 twice as long as segment 2; labial palpi densely covered with long setae;* three caudal filaments.

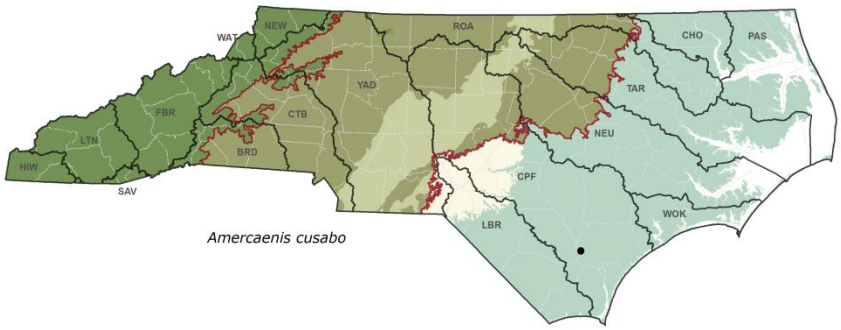
Habitat: Lotic, known from larger rivers in areas of slow flow and in silty depositional zones. Collectors-filterers.

Distribution and Occurrence: Extent unknown. See species account.

Species in NC: TAKE TO SPECIES

cusabo – nymph 4.2 mm; *segments 2 and 3 of labial palpi subequal in length; transverse row of setae on forefemora long and spatulate;* body appears broader and more depressed than that of *A. ridens*. Described from nymphs taken from the Black River, NC, *Amercaenis cusabo* is known only known only from one other river in NC: Pee Dee River, Anson County. Rare with only two DWQ records (both from Black River, Bladen County).

Notes: *Amercaenis cusabo* is the only species in NC. Unzicker and Carlson (1982) lists *Caenis ridens*, a junior synonym for *A. ridens,* as also occurring in either NC or SC. However, *A. ridens* is known only from Mississippi and Missouri River drainages and is disjunct geographically with *A. cusabo* (Provonsha and McCafferty 2006). *Amercaenis ridens* is also erroneously listed by NC Natural Heritage Program as Significantly Rare (2012) and as occurring in the Black River. That listing should refer to *A. cusabo* instead.



Taxonomic references:

nymphs and adults:

Provonsha, A. V. and W.P. McCafferty. 1985. *Amercaenis*: new Nearctic genus of Caenidae (Ephemeroptera). International Quarterly of Entomology. 1:1-17.

⇨Provonsha, A. V. 1990. A revision of the genus *Caenis* in North America (Ephemeroptera: Caenidae). Transactions of the American Entomological Society 116(4): 801-884.

⇨Provonsha AV, McCafferty WP. 2006. A second species of the North American mayfly genus *Amercaenis* Provonsha and McCafferty (Ephemeroptera: Caenidae). Journal of Insect Science 6:10; 1-6.

Brachycercus

Genus Diagnosis: Body broad at middle regions; *maxillary and labial palpi two-segmented;* head with three ocellar tubercles, one frontal and two occipital; legs slender, forelegs distinctly shorter than mid and hind legs; anterior margin of mesosternum flat, without bristles; *operculate gills meeting at midline, asymmetrical with posterolateral corner protruding further than posteromedial corner;* three caudal filaments.

Habitat: Lotic, on silty sand in areas with slow currents. May also occur in deeper waters. Collectors-gatherers.

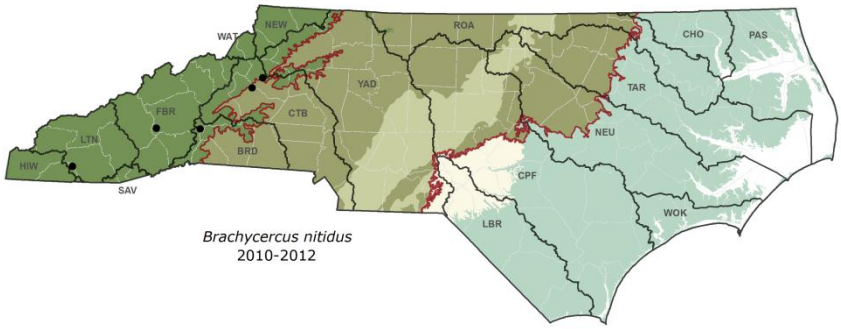
Distribution and Occurrence: Typically in Mountain streams. Collected mostly during summer.

Species in NC: TAKE TO SPECIES

nitidus – nymphs 7-9 mm; *anterolateral spines on pronotum; operculate gills asymmetrical with protruding edge at posterolateral corner;* tergum 10 brown, contrasting with paler abdomen.

Notes: Relatively intolerant. *Brachycercus* can be confused with *Sparbarus* but differences in gill symmetry will readily separate the two genera. Sun and McCafferty (2008) transferred *B. maculatus* to *Sparbarus* leaving *B. nitidus* as the only species in NC. Apparently, the Soldán key is based on misidentifications and, therefore, should not be used (Sun and McCafferty 2008). Collected from GSMNP.

CAENIDAE



Taxonomic references:

nymphs:

Soldán, T. A revision of the Caenidae with ocellar tubercles in the nymphal stage (Ephemeroptera). Acta Universitatis Carolinae-Biologica 1982-1984: 289-362.

⇨Sun, L, and W. P. McCafferty. 2008 Cladistics, classification and identification of the brachycaudal filamentsne mayflies (Insecta: Ephemeroptera: Caenidae). Zootaxa 1801: 1-239.

Caenis

Genus Diagnosis: Nymphs 2.6-6.8 mm; *maxillary and labial palpi three-segmented; head without tubercles;* inner margin of foretibia and tarsus with row of stout spines; *subquadrate operculate gills meeting at midline, not fused; outer margin of operculate gill fringed with long setae, with a diagonal carina originating basolaterally;* three caudal filaments.

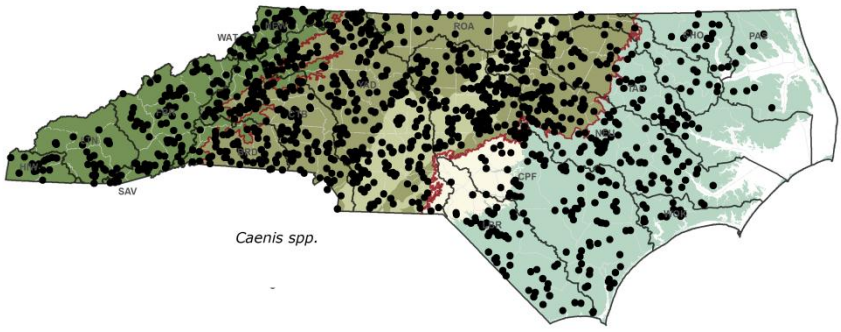
Habitat: Lentic and lotic, in depositional zones and areas with silt. Primarily collectors-gatherers, facultative scrapers or grazers.

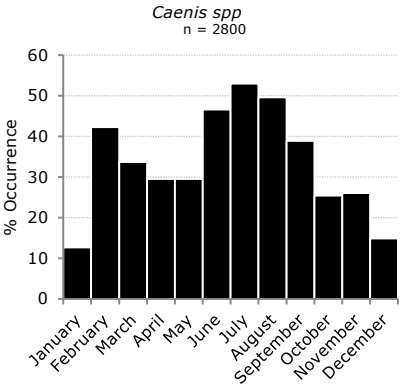
Distribution and Occurrence: Widespread. Collected year round but very common during the summer months.

Species in NC: LEAVE AT GENUS

(amica), (anceps), (diminuata), (hilaris), (latipennis), (macafferti), (punctata)

Notes: Noted nymphal sizes span range of different species. *Caenis* is tolerant as a group and at least seven species occur in NC. A taxonomically difficult genus, the nymphal key (Provonsha, 1990) uses features that are sometimes indistinct and/or variable. Specimens of *Caenis hilaris* from the Lumber River (Robeson County, 2011) exhibited a conspicuous and unique color pattern.





Taxonomic references:

nymphs and adults:

⇨Provonsha, A. V. 1990. A revision of the genus *Caenis* in North America (Ephemeroptera: Caenidae). Transactions of the American Entomological Society 116(4): 801-884.

Cercobrachys

Genus Diagnosis: Body broad at middle regions; *labrum ovate or nearly so, with lateral margins produced and rounded;* head with three ocellar tubercles, one frontal and two occipital; *anterior margin of mesosternum prominent with many long bristles (see Notes);* forelegs distinctly shorter than mid and hind legs; *foretarsi dorsal surface with well-ordered long setae; quadrate operculate gills meeting at midline and relatively symmetrical, appearing almost evenly rounded apically; posterolateral projection on segment 6 curved medially;* three caudal filaments.

Habitat: Lotic, on silty sand in areas with slow currents and may also occur in deeper waters. Collectors-gatherers.

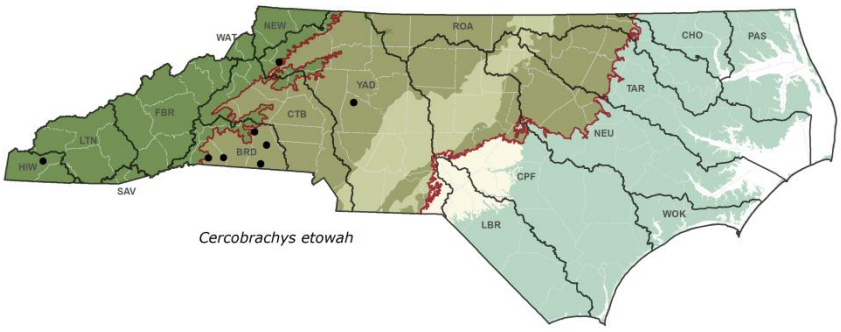
Distribution and Occurrence: Collected spring through early summer primarily in the Mountains and Piedmont.

Species in NC: TAKE TO SPECIES

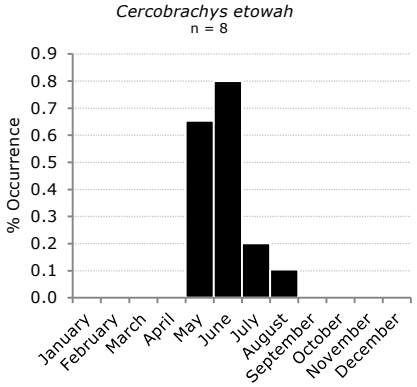
etowah – nymphs 4.5-6.8 mm; *galealacinia sickle-shaped, subequal to or longer than, 2.3 timer its basal width; median ocellar tubercle acutely pointed; ventral margin of foretarsi with very short stiff setae and long setae* that is subequal to or longer than 3X the width of foretarsi; *posterolateral projection of segment 5 reaching or almost reaching the apical margin of segment 6;* body pale yellowish; caudal filaments with basal segment darkened basally forming what appears to be a dark abdominal termination line. Listed by NC Natural Heritage Program as Significantly Rare (2012) but also listed as occurring only in the Tar River. However, there are no records from that locality, either BAU or published.

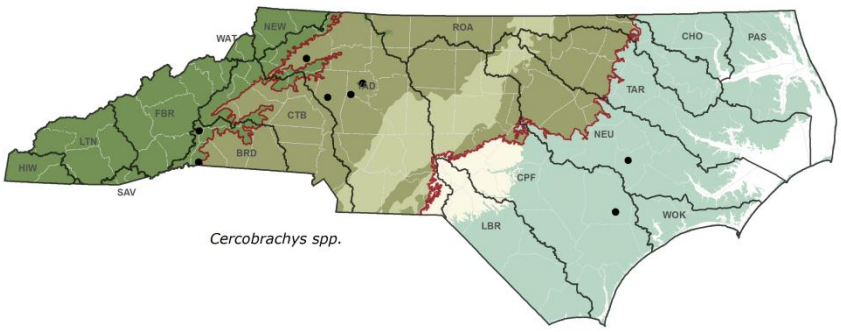
(pomeiok) – nymphs 5.7-5.9 mm; *galealacinia subtriangulate, subequal to or shorter than, 1.7 times its basal width; ventral margin of foretarsi with only long setae* that is 3 X the width of foretarsi or more; *posterolateral projection of segment 5 not approaching the apical margin of segment 6. Cercobrachys pomeiok* was described from the Tar River in Edgecombe County but BAU has no records. So far this species has only been recorded from NC and SC. A specimen from the Little River in South Carolina is in the BAU reference collection.

Notes: *Cercobrachys* is easy to confuse with *Brachycercus*. The Sun and McCafferty (2008) key is relatively easy to use. It appears the mesosternal bristles are no longer a primary character considering that *Brachycercus harrisella* also has these setae. However *B. harrisella* is a northern species and does not occur in NC, thus the mesosternal bristles are still useful in separating North Carolina *Cercobrachys* from the remaining brachycercine mayfly genera.

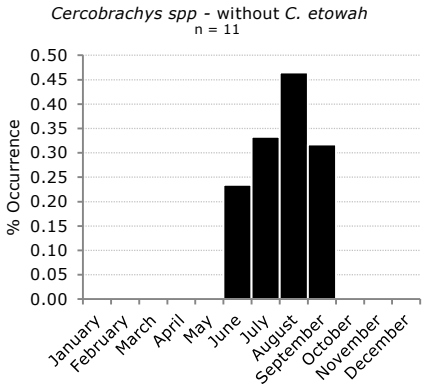


Cercobrachys etowah





Cercobrachys spp.



Taxonomic references:

nymphs and adults:

Soldán, T. A revision of the Caenidae with ocellar tubercles in the nymphal stage (Ephemeroptera). Acta Universitatis Carolinae-Biologica 1982-1984: 289-362.

⇨Sun, L, and W. P. McCafferty. 2008 Cladistics, classification and identification of the brachycaudal filamentsne mayflies (Insecta: Ephemeroptera: Caenidae). Zootaxa 1801: 1-239.

Sparbarus

Genus Diagnosis: Body broad at middle regions; *maxillary and labial palpi two-segmented;* head with three ocellar tubercles, one frontal and two occipital; forelegs distinctly shorter than mid and hind legs; anterior margin of mesosternum flat, without bristles; *operculate gills meeting at midline, generally symmetrical, without distinctive protruding posterolateral corner; posterolateral projection on segment 6 not curved medially;* three caudal filaments.

Habitat: Lotic, edge species, in silty areas. Collectors-gatherers.

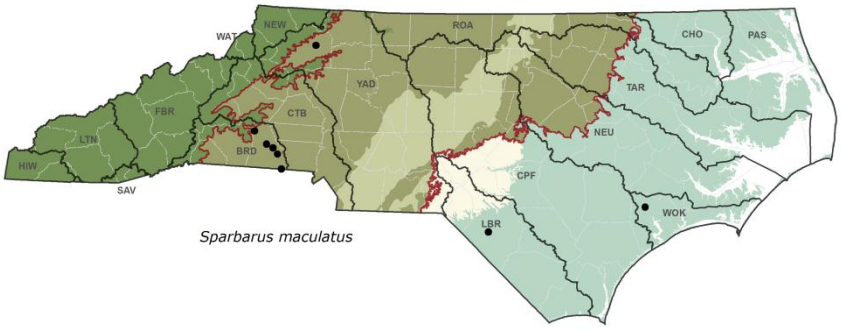
Distribution and Occurrence: Collected mostly in summer. See species accounts.

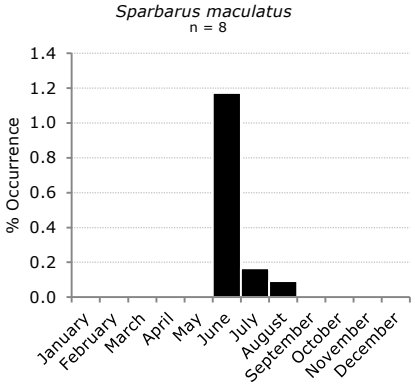
Species in NC: TAKE TO SPECIES

(lacustris) – nymphs 4.7-7.5 mm; *middle ocellar tubercle relatively elongate, about 1.5-2.0 times as long as basal width;* occiput with one or two transverse black bands posterior to lateral ocellar tubercles; *posterolateral projection on segment 2 moderately developed, length subequal to basal width and apically pointed.* Some specimens in the revised species description (Sun and McCafferty 2008) from the Chowan (1988) and Trent Rivers (1987).

maculatus – nymphs 4.0-6.4 mm; *middle ocellar tubercle short and triangulate, about as long as basal width;* occiput with one or two transverse black bands posterior to lateral ocellar tubercles; *posterolateral projection on segment 2 not developed, shorter than basal width and right-angled apically.* Recorded from Wilson Creek and the Linville River.

Notes: Relatively intolerant. Sparbarus can be confused with *Brachycercus.* A Provonsha identification of *B. maculatus* from Great Coharie Creek, Sampson County (August 1993) and material examined for the brachycercine mayfly revision is mostly from the NC Coastal Plain. Sun and McCafferty (2008) transferred *B. maculatus* to *Sparbarus* and also provide a species key that is easy to use. Based on information in Sun and McCafferty (2008), these two species should be easy to separate.





Taxonomic references:

nymphs:

Soldán, T. A revision of the Caenidae with ocellar tubercles in the nymphal stage (Ephemeroptera). Acta Universitatis Carolinae-Biologica 1982-1984: 289-362.

⇨Sun, L, and W. P. McCafferty. 2008 Cladistics, classification and identification of the brachycaudal filamentsne mayflies (Insecta: Ephemeroptera: Caenidae). Zootaxa 1801: 1-239.

Baetisca

Genus Diagnosis: Anterior margin of head with medial frontal projection or with anterolateral genal spines; *enlarged thoracic notum fused between wing pads and forming a shield or carapace-like projection which is extended to abdominal segment 6;* gills concealed beneath thoracic shield; three caudal filaments, short; body typically light brown with variable dark pigmentation.

Habitat: Lotic, partially buried, often in shallow sandy or gravelly riffles or in edge vegetation. Collectors-gatherers, facultative scrapers or grazers.

Distribution and Occurrence: A widespread and common genus. See species accounts.

Species in NC: TAKE TO SPECIES

becki – nymphs 6.0-7.5 mm; *genal spines absent; dorsal projections of mesonotal shield large, distinctly taller than medial hump; long, sharp lateral spines;* body pale with dark spots, lateral spines tipped with black. Collected late winter through spring. Half of the BAU records (5) are from Swift Creek in Tar River basin. Listed by NC Natural Heritage Program as Significantly Rare (2012).

berneri – nymphs 7.5-11.5 mm; *genal spines present; caudal filaments prominently banded with dark brown at base; body pale with variable speckling, an interrupted dorsomedial line on abdomen; ventral surface may be speckled and brown.* Collected winter through summer from the eastern Mountains, particularly in the New river basin. Uncommon and very intolerant.

carolina – nymphs 8.5-13.9 mm; *genal spines present; no banding on caudal filaments although distal half may be darker;* color pattern variable. Most common species in NC. Usually collected fall through spring in the Mountains and Piedmont (excluding the Slate Belt). Facultative.

gibbera – nymphs 6.3-12 mm; genal spines absent; dorsal projections of mesonotal shield weakly to moderately developed; mesonotal shield strongly flared with lateral margins almost straight diagonally; lateral spines of mesonotal shield as long as width at base. Collected during summer and early fall. Widespread but uncommon. Recorded from GSMNP.

lacustris* – nymphs 6.8-10.2 mm; *no genal spines; dorsal projections of mesonotal shield weakly to moderately developed; shield distinctly longer than wide;* sterna freckled with brown spots; brown spot on sterna next to coxae. Unverified specimens collected from Wilson Creek by outside agency. Recorded from TN, VA, and WV.

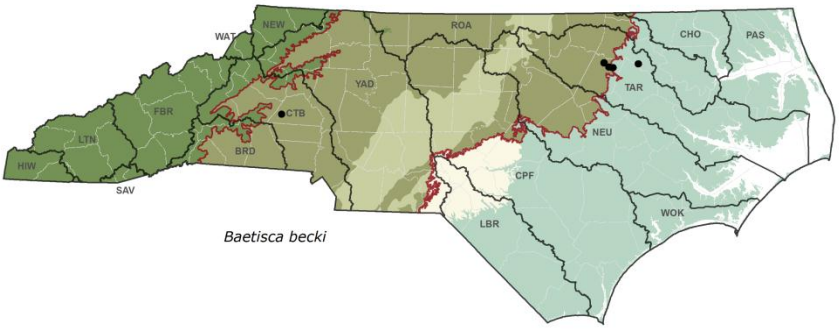
laurentina – nymphs 8.3-9.7 mm; *genal spines absent; well-developed dorsal projections on mesonotal shield taller than medial hump; lateral spines short; ventral aspect of mesonotal shield outlined with dark brown; frontal projection developed but not long; slender nymph.* Only one BAU record from the Trent River in Jones County (November 1990). Verified BAU reference specimen from Jacob Fork, Catawba County (November 1983). Inexplicably removed from the NC Natural Heritage Program Rare Animals list in 2008 and not re-instated. Possibly extirpated from NC.

obesa – nymphs 7.6-10.2 mm; *genal spines absent; well-developed dorsal projections on mesonotal shield taller than medial hump; lateral spines short; frontal projection well developed;* abdominal sterna 2-6 with prominent dark spots near lateral margin. Collected November through March. Only five BAU records (all from the Tar River). However, additional reference specimens are from the Black and Neuse Rivers. Listed by NC Natural Heritage Program as Significantly Rare (2012).

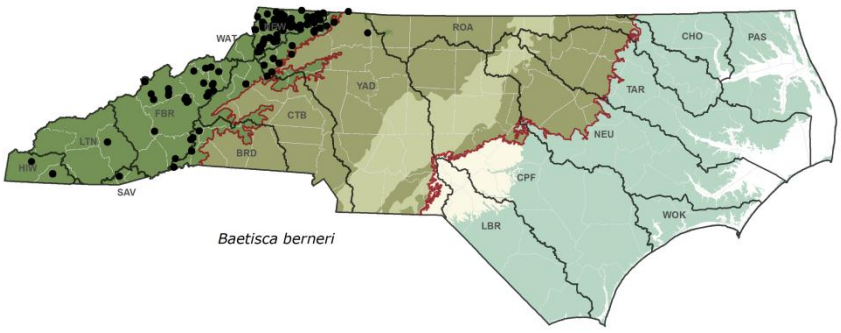
rogersi – nymphs 7.0-10.5 mm; *no genal spines; dorsal projections of mesonotal shield weakly to moderately developed; shield distinctly longer than wide; lateral margins of mesonotal spines serrate; posteromedial elevations of terga 7-9 well developed.* BAU has specimen photos of this species but no records. McCafferty et al. (2010) verified a specimen from Wilson Creek, Caldwell County (September 2002).

Notes: The pollution tolerances of *Baetisca* are known only for *B. berneri* and *B. carolina*. Most *Baetisca* species are highly variable in the coloration and pigmentation patterns. Often, the maculations are similar from species to species making morphological characters important for distinguishing between species. Leave small specimens at genus.

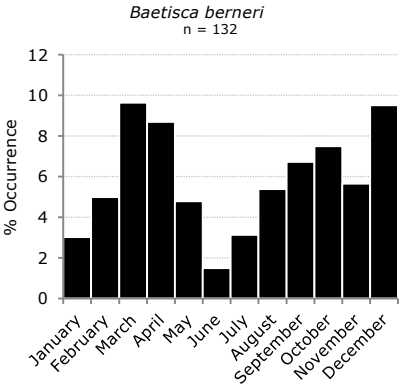
B A E T I S C I D A E

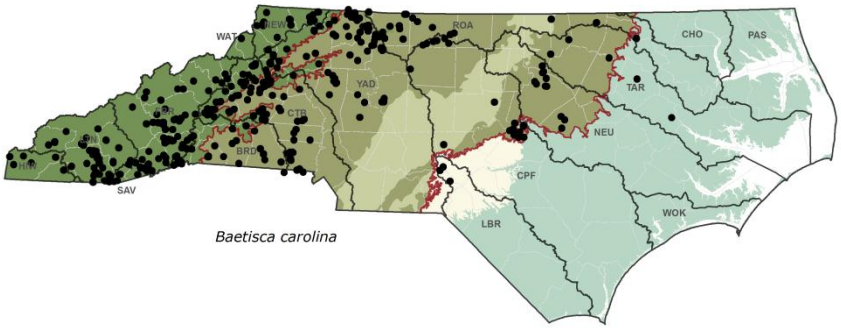


Baetisca becki

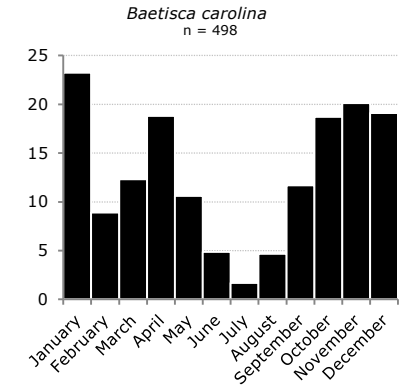


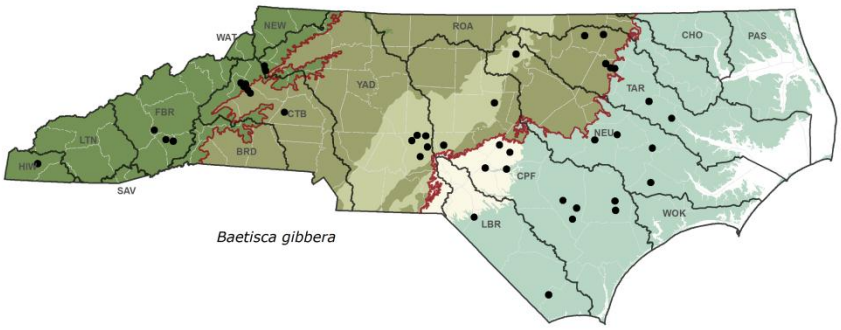
Baetisca berneri



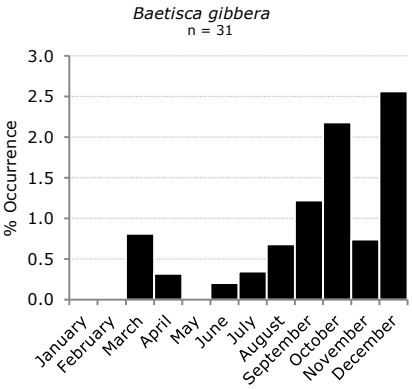


Baetisca carolina

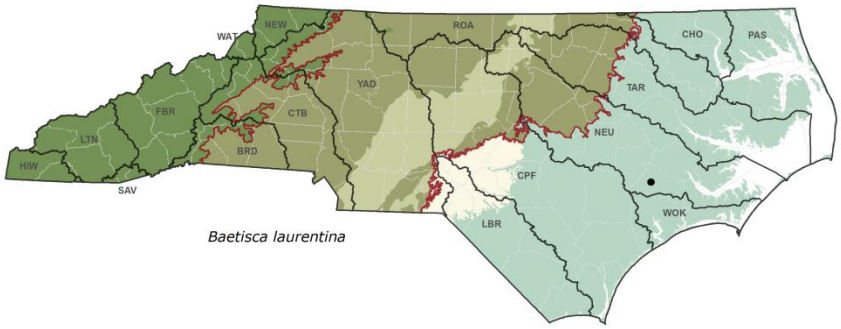




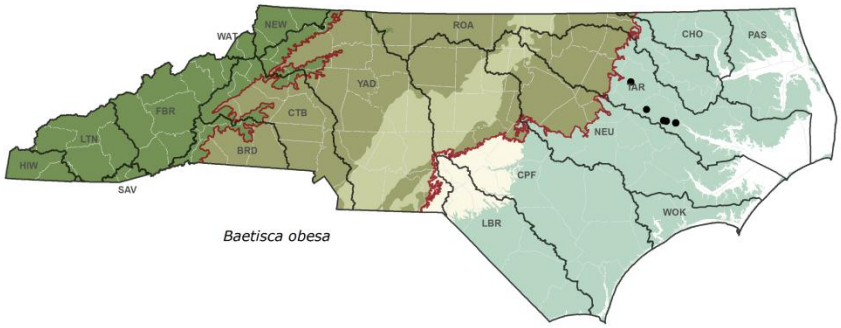
Baetisca gibbera



BAETISCIDAE



Baetisca laurentina



Baetisca obesa

Taxonomic references:

nymphs and adults:

⇨Pescador, M. L. and L. Berner. 1980. The Mayfly Family Baetiscidae (Ephemeroptera). Part II Biosystematics of the Genus *Baetisca*. Transactions American Entomological Society 107: 163-228.

Schneider, R. F. and L. Berner. 1963. A new southeastern species of *Baetisca* (Ephemeroptera: Baetiscidae). Florida Entomologist 46: 183-187. (description of *B. becki*)

Tarter, D. C and R. F. Kirchner. 1978. A new species of *Baetisca* from West Virginia (Ephemeroptera: Baetiscidae). Entomological News 89(9-10): 209-213. (description of *B. berneri*)

LEPTOPHLEBIIDAE

Choroterpes

Genus Diagnosis: Labrum is narrower than width of head, with dorsal setae in two transverse rows; maxillae with brush of hairs on apicolateral margin; *gills on segment 1 single and dorsal lamella on gills on 2-7 trilobed with median lobe ending in a single spatulate filament, highly tracheated;* three caudal filaments; body irregularly brown, terga with anterior pair of submedian pale triangular spots, may absent or be obscured on some segments.

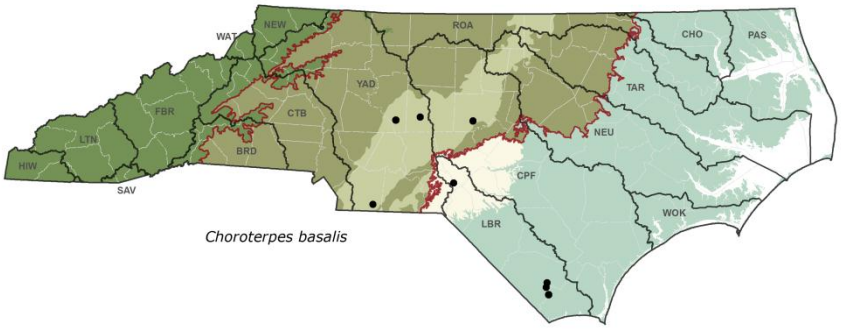
Habitat: Primarily lotic, in areas of slow currents on detritus, sticks, and logs. Collectors-gatherers, facultative scrapers or grazers.

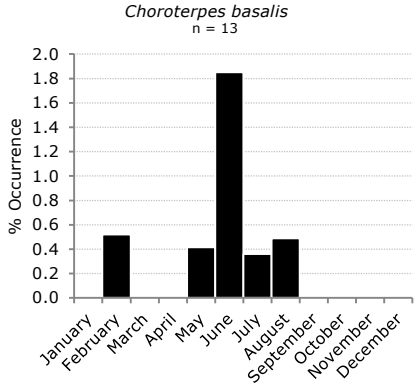
Distribution and Occurrence: Collected during the summer in the Piedmont and Coastal Plain. Rare.

Species in NC: TAKE TO SPECIES

basalis – nymphs 4.5-7.4 mm. See Genus Diagnosis.

Notes: *Choroterpes basalis* is the only species in southeastern US. Listed by NC Natural Heritage Program as Significantly Rare (2012). Burian (1995) synonymized *Choroterpes hubbelli* with *C. basalis.*





Taxonomic references:

nymphs:

Burian, S. K. 1995. Taxonomy of the eastern Nearctic species of *Choroterpes* Eaton (Ephemeroptera: Leptophlebiidae). Pages 433-533 in Corkum. L. D. and J. J. Ciborowski (eds), Current Directions in Research on Ephemeroptera. Canadian Scholars' Press, Toronto.

Habrophlebia

Genus Diagnosis: Labrum narrower than width of head; maxillae with brush of hairs on apicolateral margin; *abdominal gills on segments 2-7 with of clusters of narrow filaments originating from bifurcation about one-fourth to one-third distance from base*; three caudal filaments; body brown, males with terga 2-6 widely pale medially, pale areas roughly trapezoidal.

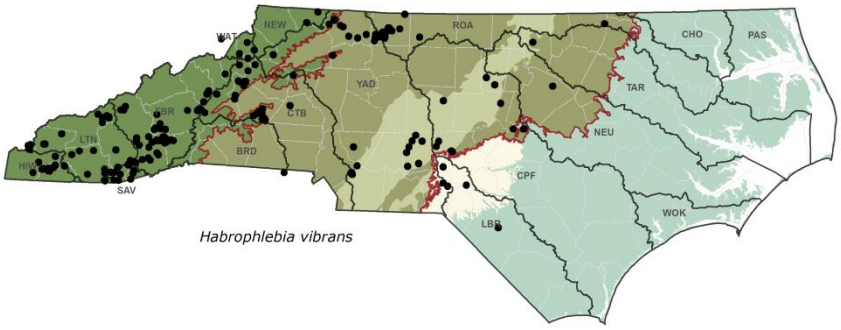
Habitat: Found in smaller streams in areas of gravel, possibly also in vegetation and on detritus, near banks. Trophic status remains unclear.

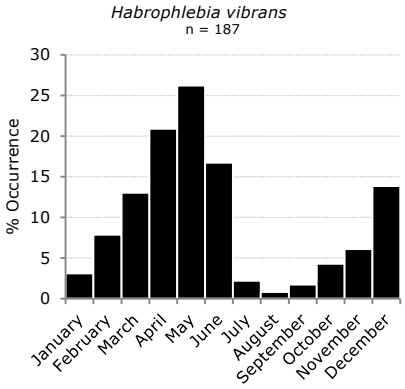
Distribution and Occurrence: Collected from Mountains, Piedmont (Sauratown and Uwharrie Mountains), and Sand Hills, mostly during winter through spring. Uncommon.

Species in NC: MONOTYPIC

vibrans – nymphs 4.5-7.4 mm. See Genus Diagnosis.

Notes: Very intolerant. Semivoltine in more northern latitudes but most likely univoltine in NC. Recorded from GSMNP.





Taxonomic references:

nymphs:

Berner, L. 1975. The mayfly family Leptophlebiidae in the southeastern United States. The Florida Entomologist 58: 137-156.

Lauzon, M. and P. P. Harper. 1986. Life history and production of the stream-dwelling mayfly *Habrophlebia vibrans* Needham (Ephemeroptera: Leptophlebiidae). Canadian Journal of Zoology 64:2038-2045.

Habrophlebiodes

Genus Diagnosis: Nymph 3.4-7.0 mm; *labrum narrower than width of head and with moderately deep V-shaped median emargination;* all abdominal gills similar; gills forked or bilamellate; *small row of spinules on posterior margins of terga 6 or 7-10 only, those on 8-10 long;* three caudal filaments; body irregularly brown, anterior margins of 2 or 3-7 with submedian pale triangles and a median pale streak either or all may be obscure; at least one species (*H. americana*) has a large, pale triangular to subtriangular spot on anterior portion of head.

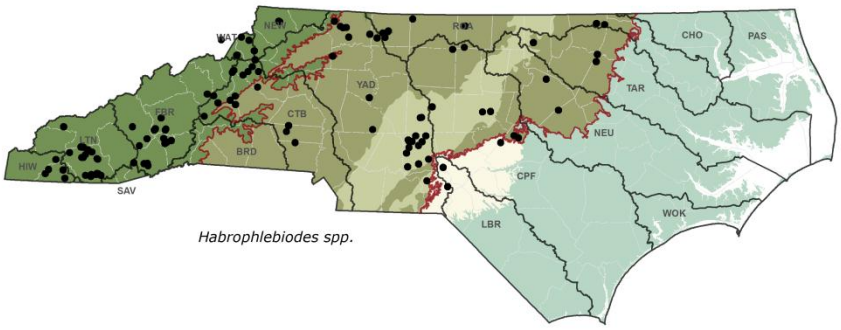
Habitat: Found in small to moderately sized streams, in areas of slow to moderately fast currents, among vegetation, root mats, and woody debris. Scrapers or grazer, collectors-gatherers.

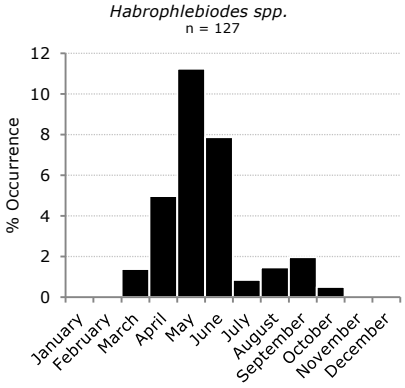
Distribution and Occurrence: Recorded from the Mountains and Piedmont during spring to early summer. Relatively uncommon.

Species in NC: LEAVE AT GENUS

americana, brunneipennis *, celeteria *

Notes: Facultative. Noted nymphal sizes span range of different species. The long clear spines on segment 9 and 10 are more easily seen from a lateral view. *Habrophlebiodes brunneipennis* has been recorded from GA and SC while *H. celeteria* has been recorded from TN and VA. There are possible misidentifications in BAU database as *Paraleptophlebia* as the two genera can be confused if care is not taken.





Taxonomic references:

nymphs and adults:

Berner, L. 1946. New species of Florida mayflies (Ephemeroptera). The Florida Entomologist 28(4): 60-82. (description of *H. brunneipennis*)

Berner, L. 1975. The mayfly family Leptophlebiidae in the southeastern United States. The Florida Entomologist 58: 137-156. (description of *H. celeteria*)

Leptophlebia

Genus Diagnosis: Labrum narrower than width of head; *gills on segment 1 slender and forked, much narrower than those on 2-7; gills of segments 2-7 bilamellate, each broad lamella of gills 2-7 end in single slender filament that may or may not be flanked by blunt lobes;* three caudal filaments.

Habitat: Lotic and lentic, in detritus and areas of slower flows (see Notes). Collectors-gatherers, facultative shredders.

Distribution and Occurrence: Widespread (except *bradleyi*). Collected fall through mid-spring.

Species in NC: LEAVE AT GENUS except *bradleyi*

bradleyi – nymphs 5.3-8.7 mm; *few to no spine-like setae along lateral margins of abdominal segments; gills 2-7 simple and bilamellate, not flanked by lobes; antennal scape and pedicel dark brown;* tarsal claws with single row of denticles and apex of claw elongate; legs distinctly banded with dark brown. Coastal Plain only, particularly swamps. A species with an early emergence, usually complete by the end of February.

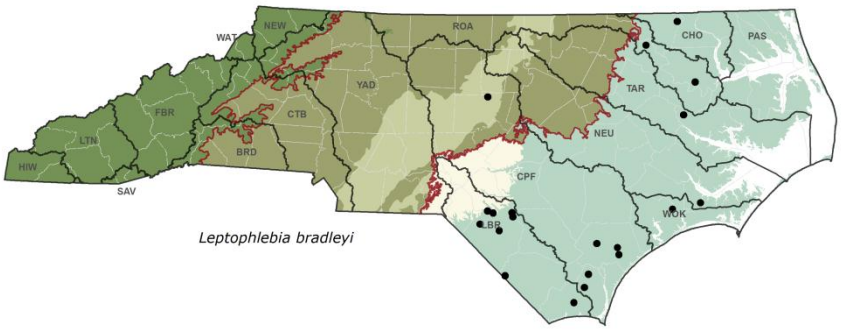
cupida – nymphs 8.9-13.2 mm; peg-like setae on palpifer (small basal segment of maxillary palp) usually in regular rows; many large spine-like setae along lateral margins of abdominal segments along with scattered long hair-like setae; legs not usually banded or with faint bands on tibiae and tarsi only. Note: need to slide mount mouthparts and legs to separate from *L. nebulosa* which still may not guarantee correct species identification.

intermedia – nymphs 9.5-14.4 mm; many large spine-like setae along lateral margins of abdominal segments along with scattered long hair-like setae; legs distinctly banded; large row of palmate setae on inner edge of forefemora; distinctly lobed gills on segments 2-6.

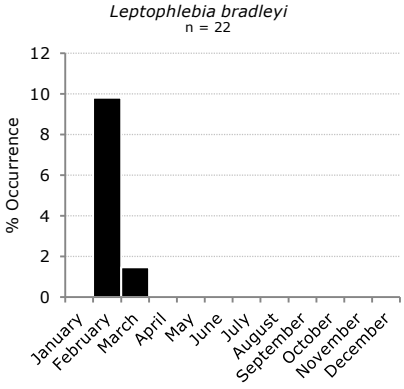
(johnsoni) – nymphs 6.8-8.4 mm; few to no spine-like setae along lateral margins of abdominal segments; gills 2-6 modified with lobes and bilamellate, segment 7 bilamellate but without lobes and lamellae make gradual change to slender filament; tarsal claws with primary and secondary rows of denticles, apex of claw not elongate; legs not distinctly banded. Slowest maturing nymphs and latest emerging species.

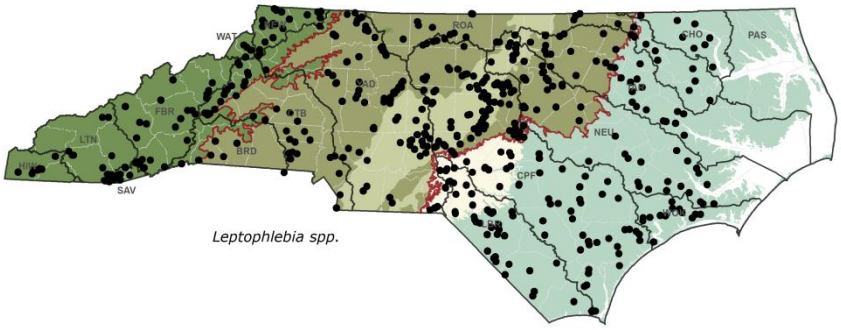
nebulosa – nymphs 7.1-12.5 mm; peg-like setae on palpifer (small basal segment of maxillary palp) usually in regular rows; many large spine-like setae along lateral margins of abdominal segments along with scattered long hair-like setae; legs usually faintly banded or with faint bands only on femora with more distinct bands on tibiae and tarsi. Note: need to slide mount mouthparts and legs to separate from *L. cupida* which still may not guarantee correct species identification. A specimen found in a lateral pool of Wilson Creek (March 2006) is attributed to DWQ (McCafferty et al., 2010) but BAU has no record of this sample date. This species has been recorded from TN and VA.

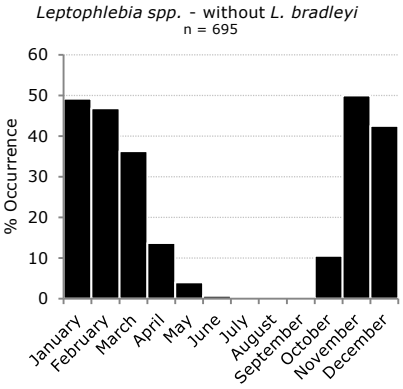
Notes: Burian (2001) does not guarantee species separation between *L. cupida* and *L. nebulosa* even at or near the pre-emergent stage. Slide mounts may need to be made for certain characters, such as labral and palpal setal analysis, to facilitate separation of nymphs. Also, early instars (particularly *L. bradleyi*) can be confused with *Paraleptophlebia* especially if the gills are missing. Burian (2001) placed *L. austrina* and *L. collina* as junior synonyms of *L. cupida* and also synonymized *L. grandis* with *L. intermedia*. *Leptophlebia* nymphs seasonally migrate from the stream channel to floodplain pools or flooded wetland areas in the late fall to winter or early spring (Hayden and Clifford, 1974). This may make collection problematic during the latter stages of nymphal development.



Leptophlebia bradleyi







Taxonomic references:

nymphs:

Berner, L. 1975. The mayfly family Leptophlebiidae in the southeastern United States. The Florida Entomologist 58: 137-156.

⇨Burian, S. K. 2001. A Revision of the genus *Leptophlebia* Westwood in North America (Ephemeroptera: Leptophlebia: Leptophlebiinae). Bulletin of the Ohio Biological Survey 13 (3): 1-80.

Edmunds, G. F. Jr. 1976. The Mayflies of North and Central America. University of Minnesota Press, Minneapolis.

Hayden, W. and H. F. Clifford. 1974. Seasonal movements of the mayfly *Leptophlebia cupida* (say) in a brown-water stream of Alberta, Canada. American Midland Naturalist 91:90-102

adults:

Burian, S. K. 2001. A revision of the genus *Leptophlebia* Westwood in North America (Ephemeroptera: Leptophlebia: Leptophlebiinae). Bulletin of the Ohio Biological Survey 13 (3): 1-80.

Paraleptophlebia

Genus Diagnosis: Nymph 4.5-8.0; *labrum narrower than width of head and with shallow median emargination; gill 1 similar in shape to remaining gills but smaller; gills 2-7 forked near base usually with conspicuous tracheation; row of small to minute spinules present on posterior margin of terga 1-10;* three caudal filaments.

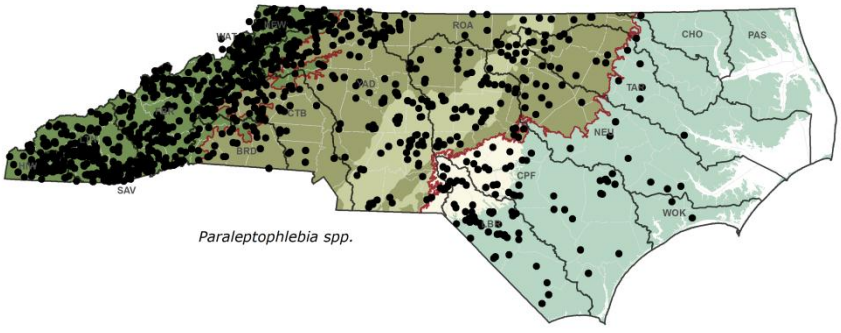
Habitat: Lotic, in slow to fast currents on many types of substrate. Mature nymphs migrate to slower waters. Collectors-gatherers, facultative shredders.

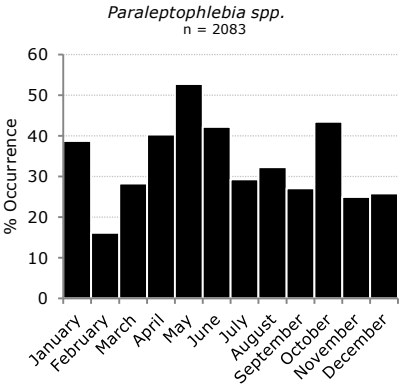
Distribution and Occurrence: Widespread and common. Collected throughout the year.

Species in NC: LEAVE AT GENUS

(adoptiva), (assimilis), (debilis), georgiana *, (guttata), jeanae *, kirchneri *, (moerens), (mollis), (swannanoa), (volitans)

Notes: Intolerant as a genus. Noted nymphal sizes span range of different species. It is possible to confuse *Paraleptophlebia* with *Habrophlebiodes* and immature *Leptophlebia.* With species descriptions from Randolph and McCafferty (1996), the Unzicker and Carlson (1982) key can be used to separate out nine potential NC species. Both *Paraleptophlebia assimilis* and *P. swannanoa* were described from North Carolina. Two species, *P. kirchneri* and *P. georgiana,* occur in TN and GA, respectively. *Paraleptophlebia georgiana* has not been reported since 1931 and is listed as "vulnerable to extirpation" by Morse et al. (1997). *Paraleptophlebia jeanae* is recorded from SC, TN, VA, and GSMNP and the nymphs to *P. kirchneri* are unknown.





LEPTOPHLEBIIDAE

Taxonomic references:

nymphs:

Berner, L. 1975. The mayfly family Leptophlebiidae in the southeastern United States. The Florida Entomologist 58: 137-156.

⇨Randolph, R. P. and W. P. McCafferty. 1996. First larval descriptions of two species of *Paraleptophlebia* (Ephemeroptera: Leptophlebiidae). Entomological news 107(4): 225-229. (descriptions for *P. assimilis* and *P. jeanae*).

⇨Unzicker, J. D. and P. H. Carlson. 1982. Ephemeroptera, Chapter 3 (97 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. 837 pp.

adults:

Harper, F. and P. P. Harper. 1986. An annotated key to the adult males of the northwestern Nearctic species of *Paraleptophlebia* Lestage (Ephemeroptera: Leptophlebiidae) with the description of a new species. Canadian Journal of Zoology 64: 1460-1468.

(Dolania)

Genus Diagnosis: Nymph 13 mm; head flattened; antennae originate ventrad; *anterolateral margins of head and pronotum with dense pad of long spines; legs highly modified: forelegs reduced, palp-like; hind legs long but with tibiae reduced, shorter in length than tarsi; tarsal claws absent; abdomen with dense setae along lateral margins; abdominal gills 2-7 ventral;* three caudal filaments; body yellowish-brown dorsally, pale ventrally.

Habitat: Occurs in clean, coarse, shifting sand in high quality waters with low pH and usually at depth. Nymphs burrow down in well-aerated sand to a depth of 10 to 30 cm. Predatory on chironomids.

Distribution and Occurrence: Coastal Plain only. Possibly extirpated. Nymphs emerge in April-May.

Species in NC: MONOTYPIC

(americana) – See Genus Description.

Notes: *Dolania americana* is one of the few mayflies that is semivoltine and spends up to one year in the egg stage. Collected in ponar samples from Black River in Sampson County in 1974 PSNC biologists, the nymphs have not been collected since and may have been extirpated from NC. However, the difficulty in the collection of the nymph may explain the dearth of records in North Carolina. Listed as "vulnerable to extirpation" by Morse et al. (1997). Listed by NC Natural Heritage Program as Significantly Rare (2012). Reference specimen in the possession of Trish McPherson (a.k.a P. L. Finn). In addition to the above NC record, which is a northern range extension, it is also recorded from AL, FL, GA, LA, and SC.

Taxonomic references:

nymphs:

Finn, P. L. and D. D. Herlong. 1980. New distributional record of *Dolania americana* (Ephemeroptera: Behningiidae). Entomological News 91(4): 102-104.

Hubbard, M. D. 1994. The mayfly family Behningiidae (Ephemeroptera: Ephemeroidea): Keys to the recent species with a catalog of the family. Great Lakes Entomologist 27(3): 161-168.

McCafferty, W. P. 1975. The Burrowing Mayflies (Ephemeroptera: Ephemeroidea) of the United States. Transactions of the American Entomological Society 101: 447-504.

adults:

Hubbard, M. D. 1994. The mayfly family Behningiidae (Ephemeroptera: Ephemeroidea): Keys to the recent species with a catalog of the family. Great Lakes Entomologist 27(3): 161-168.

Anthopotamus

Genus Diagnosis: Head and body somewhat flattened; *mandibular tusks without long setae but with dorsal and lateral spines;* pronotum with lateral edges semi-convex, produced and flattened, with the anterolateral corner variably produced into a spine; legs setose; hind tibiae unmodified, without terminal process; *gills forked and fringed, tracheated, held laterally;* three caudal filaments; body reddish brown to brown with varying pale areas; lateral edges of pronotum widely pale.

Habitat: Lotic. Typically a crevice dweller on rocks in riffles but can also be found burrowed into gravel and sand. Collectors-filterers.

Distribution and Occurrence: Mostly collected in the Mountains, usually summer through early winter.

Species in NC: TAKE TO SPECIES

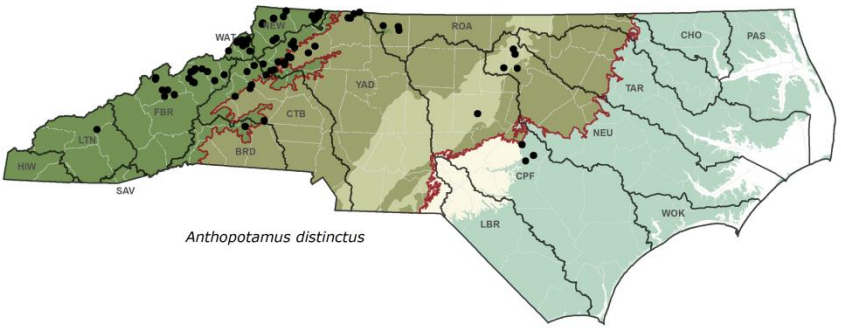
distinctus – nymphs 13.5-17.5 mm; mandibular tusks evenly attenuated; *lateral margins of pronotum moderately expanded, not produced into conspicuous spine like processes; foretibiae 1.2-1.5 times the length of the foretarsi, apical spine absent;* ground color of body reddish brown; *dark spots or splotches on wing pads;* terga 1-9 with row of three pale spots on both the anterior and posterior margins, the posterior submedial triangular spots sometimes confluent with anterior triangular spots on successive segment to form a pair of diamond shaped pale spots; these pale areas may coalesce in younger instars and appear as irregular transverse bands. Occurs in Mountain and Slate Belt streams. Most common *Anthopotamus* in NC.

myops – nymphs 13.5-17.0 mm; mandibular tusks evenly attenuated; *lateral margins of pronotum greatly expanded, with anterolateral corners as spine-like processes; foretibiae 1.5-1.9 times the length of the foretarsi, apical spine absent;* ground color of body brown; *wing pads without dark splotches;* diamond shaped pale spots present (formed by the anterior triangular spots on one segment merging with the posterior spots on the preceding segment); *pale mid-dorsal longitudinal stripe on abdomen.* A widespread taxon in the eastern US.

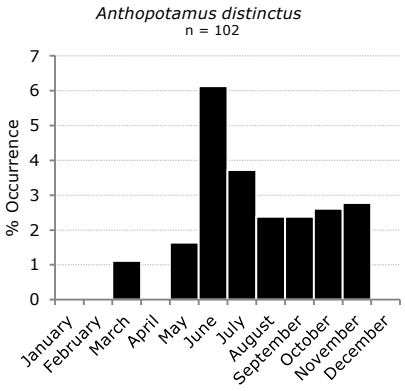
neglectus* – nymphs 10.3-10.7 mm; *mandibular tusks relatively short (0.7-0.8 times length of head) with base abruptly swollen;* lateral margins of pronotum greatly expanded, with strong anterolateral spine; foretibiae 1.4-1.6 times the length of the foretarsi, and with apical spine; color dark brown to purplish brown with late instars with distinct light markings similar to that of *A. distinctus*. Adults recorded from TN and VA.

verticis* – nymphs 10.0-11.0 mm; *mandibular tusks relatively long (0.9-1.3 times length of head) with base abruptly swollen and covered with spines;* lateral margins of pronotum greatly expanded, with strong anterolateral spine; foretibiae 1.4-1.5 times the length of the foretarsi, and *with apical spine;* head without pale markings; *abdomen brown to dark brown with interrupted mid-dorsal longitudinal pale stripe, often indistinct or even absent.* Recorded from GA, TN, and VA.

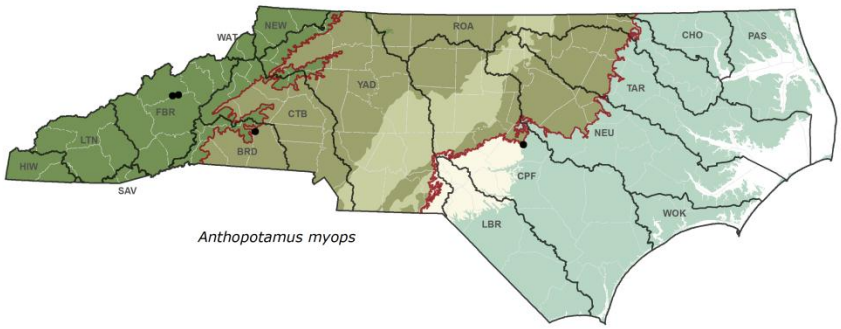
Notes: Typically intolerant. Nymphal lengths exclude tusks. The presence of splotches on the forewing pads is the easiest way to separate *A. distinctus* from *A. myops*. However, *A. myops* will almost always have a strong mid-dorsal pale stripe on the abdomen as well. Size differences will help separate out the other species which, as of yet not been recorded in NC, either as adults or larvae. Formerly *Potamanthus*.



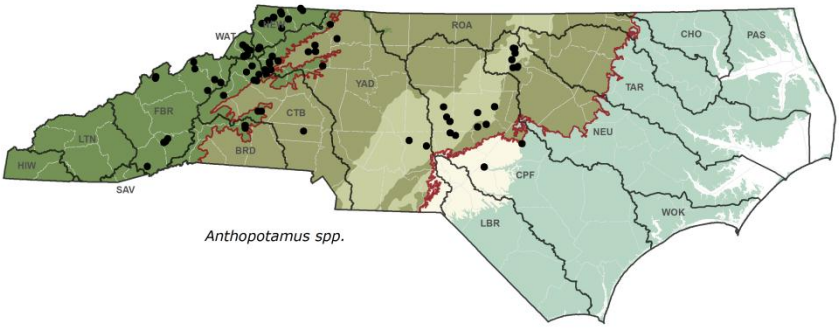
Anthopotamus distinctus



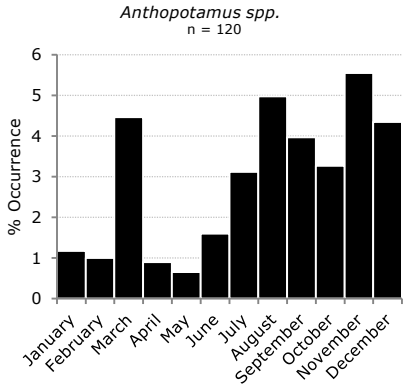
POTAMANTHIDAE



Anthopotamus myops



Anthopotamus spp.



Taxonomic references:

nymphs:

⇨Bae, Y. J. and W. P. McCafferty. 1991. Phylogenetic Systematics of the Potamanthidae (Ephemeroptera). Transactions of the American Entomological Society 117: 1-143.

Ide, F. P. 1935. Life history notes on *Ephoron*, *Potamanthus*, *Leptophlebia* and *Blasturus* with descriptions (Ephemeroptera). Canadian Entomologist 67(6): 113-125. (description of A. *verticis* – as *Potamanthus flaveola*)

McCafferty, W. P. 1975. The burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. Transactions of the American Entomological Society 101: 447-504.

McCafferty, W. P. and Y. J. Bae. 1990. *Anthopotamus*, a new genus for North American species previously known as *Potamanthus* (Ephemeroptera: Potamanthidae). Entomological News 101(4): 200-202.

adults:

Bae, Y. J. and W. P. McCafferty. 1991. Phylogenetic Systematics of the Potamanthidae (Ephemeroptera). Transactions of the American Entomological Society 117: 1-143.

EPHEMERIDAE

Ephemera

Genus Diagnosis: Nymphs large, 16-20 mm; *mandibular tusks divergent apically and curved upward in lateral view; frontal process of head distinctly bifurcate;* antennae with whorls of long setae along length; *ventral apex of hind tibia produced into an acute point;* small gills on abdominal segment 1 forked; abdominal gills held dorsally; three caudal filaments, usually curled.

Habitat: In areas of slow currents burrowed into deep sand or silt at edges of streams and lakes (primarily the littoral zone). Collectors-gatherers, facultative predators.

Distribution and Occurrence: A common genus in the mountains less so in the Piedmont. See species accounts.

Species in NC: LEAVE AT GENUS

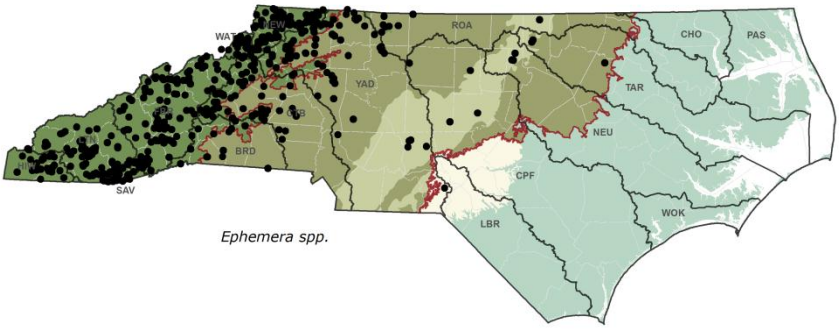
blanda – nymphs 18-20 mm; frontal process long, notch relatively deep, less than half the length of the entire process; *purplish-black curved markings at least on some terga and sterna; fore- and hind wing pads without dark blotches,* but sometimes shaded clouds apparent in forewing pad. Most commonly collected Ephemera. Collected winter through summer in the Mountains and Piedmont. Recorded from GSMNP. Described from NC.

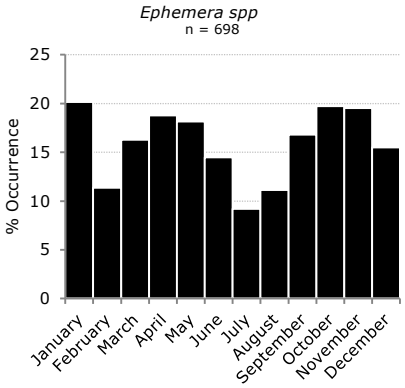
guttalata – nymphs up to 20 mm; frontal process long, notch deep, approximately half the length of the entire process; body brownish overall; *both fore- and hind wing pads heavily blotched with irregular dark spots; abdomen broad, generally lacking any distinct color pattern, both dorsally and ventrally.* Collected mostly during spring and summer. Mountains only. Uncommon. Recorded from GSMNP.

simulans – nymphs ?? mm; frontal process long slightly convergent in anterior half, notch shallow, about a third of the length of the entire process; *both fore- and hind wing pads blotched with irregular dark spots; dorsum of abdomen with dark curved submedial markings.* Collected during spring and summer in the mountains. A record from Cataloochee Creek (April 1990) was verified by McCafferty et al. (2010).

varia – nymphs ?? mm; frontal process relatively short, notch shallow, about a third of the length of the entire process; *pronotum with submedial dark lines not reaching anterior edge; forewing pad with dark blotches, hind wing pads without dark blotches; abdomen with dark, curved dorsal markings, longitudinal markings submedially on at least some sterna;* gills purplish. Collected mostly during winter and spring in the Mountains only. Recorded from GSMNP.

Notes: Intolerant. McCafferty (1975) key does not work well as intermediate forms with variable pigmentation are often collected. In addition, the size and shape of the frontal process appears to vary markedly within a species and is therefore not a reliable character. However, the depth of the medial emargination of the frontal process seems to vary less than the overall shape of the process in NC specimens examined.





Taxonomic references:

nymphs:

⇨McCafferty, W. P. 1975. The burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. Transactions of the American Entomological Society 101: 447-504.

Unzicker, J. D. and P. H. Carlson. 1982. Ephemeroptera, Chapter 3 (97 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.

Hexagenia

Genus Diagnosis: Nymphs large, 12-32 mm; *mandibular tusks subparallel to divergent apically, curved upward in lateral view, and without spination or spurs; frontal process rounded, conical or truncate;* antenna with whorls of long setae; ventral apex of hind tibiae produced into an acute point; small gills on abdominal segment 1 forked; abdominal gills held dorsally; three caudal filaments, usually curled.

Habitat: In areas of slow currents with a U-shaped burrow in deep silt or clay in both streams and lakes (littoral to profundal zone). Collectors-gatherers, filterers.

Distribution and Occurrence: A widespread and common genus. Collected year round. See species accounts.

Species in NC: LEAVE AT GENUS

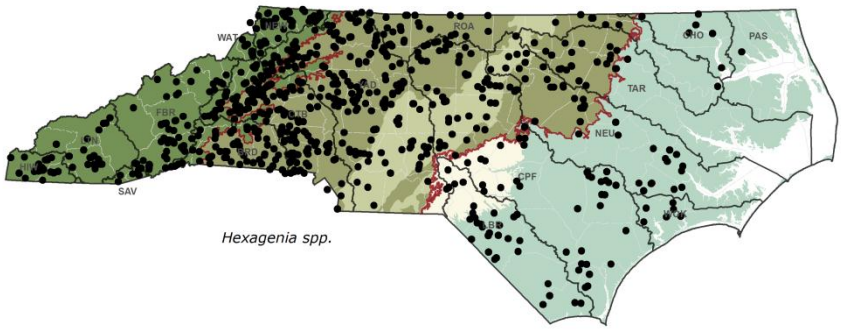
***(atrocaudata)* –** nymphs ?? mm; frontal process truncate and often slightly emarginate.

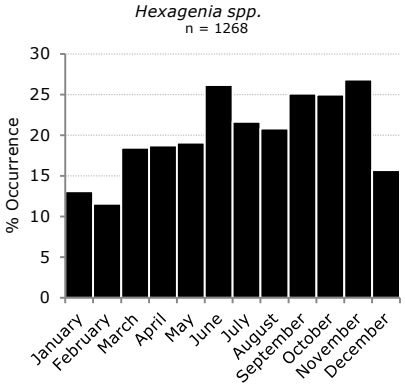
***bilineata* –** nymphs ?? mm; frontal process rounded to broadly conical; claw of second leg swollen; developing penes of male nymph angulate. This species may be semivoltine.

***limbata* –** nymphs ?? mm; frontal process evenly rounded; claw of second leg slender; developing penes of male nymph curved. This species may be semivoltine.

rigida* – nymphs ?? mm; frontal process narrowly conical; male nymphs with distinctive, nearly straight, developing penes. Recorded from GA, TN, and VA.

Notes: Facultative as a group. Speciation can be difficult as differences in the frontal process of different species can be slight and that variability in that character may make that character untenable. It appears the mesotarsal claw can be used to separate only two species, although there is some lack of confidence in that character. *Hexagenia munda* was synonymized with *H. limbata* (McCafferty, 1984). *Hexagenia bilineata* and *H. limbata* often co-occur.





Taxonomic references:

nymphs:

⇨McCafferty, W. P. 1975. The burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. Transactions of the American Entomological Society 101: 447-504.

McCafferty, W. P. 1984. The A new synonym in *Hexagenia* (Ephemeroptera: Ephemeridae). Proceedings of the Entomological Society of Washington 84(4): 789.

Litobrancha

Genus Diagnosis: *Mandibular tusks divergent apically and curved upward in lateral view; frontal process of head complete (not bifurcate), somewhat angulate with lateral margins slightly divergent from base;* antennae without whorls of long setae; *small gills on abdominal segment 1 single;* abdominal gills held vertically; three caudal filaments, usually curled; body light brown without conspicuous markings, frontal process widely dark basally and medially.

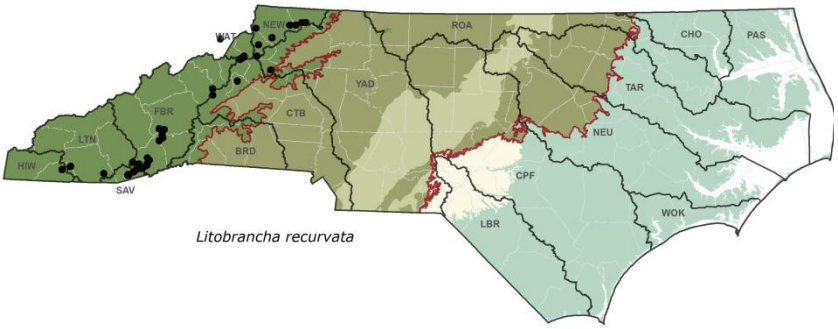
Habitat: Lotic, burrow on silty sand in moderate to fast cool waters. Trophic status uncertain but may be collectors-gatherers.

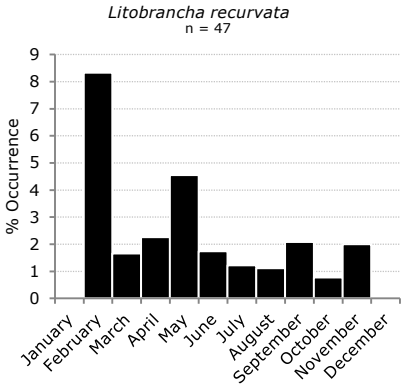
Distribution and Occurrence: Typically collected late winter through summer in mountain streams. Relatively rare.

Species in NC: MONOTYPIC

recurvata – See Genus Description.

Notes: Very intolerant. Listed as "vulnerable to extirpation" by Morse et al. (1997).





Taxonomic references:

nymphs:

⇨McCafferty, W. P. 1975. The burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. Transactions of the American Entomological Society 101: 447-504.

Ephoron

Genus Diagnosis: Head as wide or wider than pronotum; *tusks convergent in apical third with tubercles on upper surface, not curved upward in lateral view;* head with a rounded median frontal process; anterolateral corners of pronotum produced apically into a point*; foretibiae with long setal brushes both dorsally and ventrally; ventral apex of hind tibiae rounded;* abdominal gills held dorsally; gill on abdominal segment one singular and spatulate apically, not fringed; gills on 2-7 highly tracheated; three caudal filaments, usually curved; frons dark brown; abdomen brown, occasionally getting darker posteriorly.

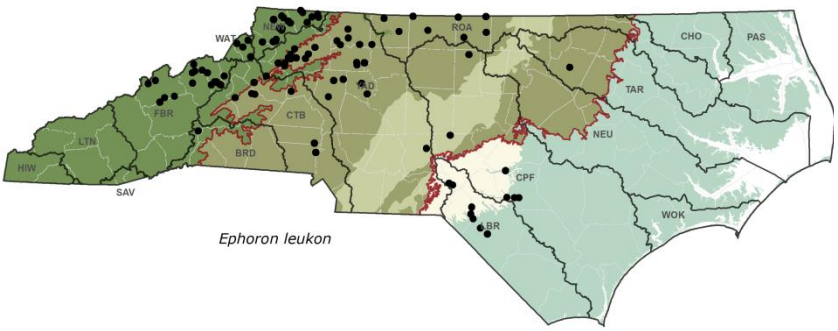
Habitat: Lotic, U-shaped burrows in sand, clay, or silt in shallow areas with slow to fast currents. Filterers, collectors-gatherers.

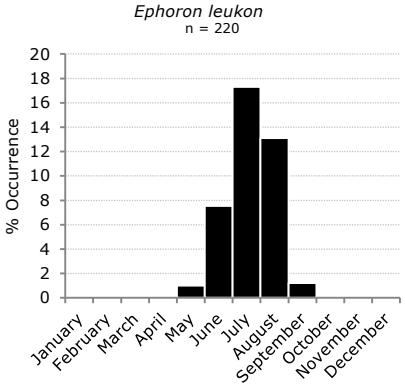
Distribution and Occurrence: Uncommon but widespread. Collected during the summer.

Species in NC: TAKE TO SPECIES

leukon – nymphs 12-21 mm.

Notes: *Ephoron leukon* is the only species in NC. Intolerant.





Taxonomic references:

nymphs:

⇨McCafferty, W. P. 1975. The burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. Transactions of the American Entomological Society 101: 447-504.

Tortopsis

Genus Diagnosis: *Tusks convergent, subparallel in basal two-thirds but abruptly narrowed in apical third and with a single, large subapical tubercle on inner surface (smaller spines may be present basally); no median frontal process;* abdominal gills held dorsally; *foretarsi flattened and broadly fused with foretibia; distal projection of foretibia-tarsus two-thirds the length of claw.*

Habitat: Larger rivers, in U-shaped burrows in clay banks. Trophic status unknown, possibly filterers and collector-gatherers.

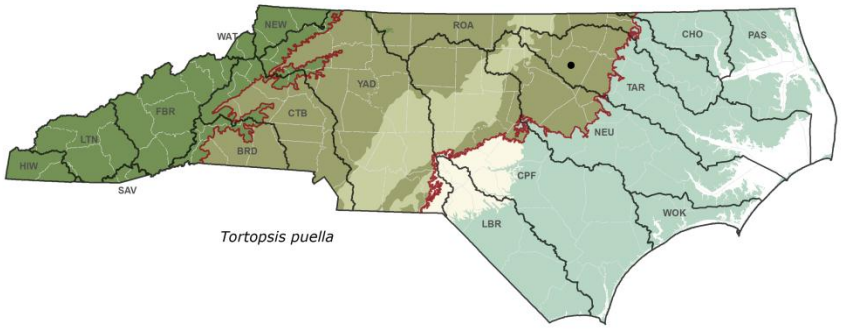
Distribution and Occurrence: Extent unknown. Rare. One BAU record from Tar River (1983).

Species in NC: TAKE TO SPECIES

puella – nymphs 19-35 mm. Collected only in the Tar and Black Rivers in NC. Listed by NC Natural Heritage Program as Significantly Rare (2012 – as *Tortopus*). BAU reference specimen from Pee Dee River on the NC/SC border collected by CP&L biologists. Formerly *Tortopus puella.*

Notes: Molineri (2010) combined *Tortopus puella* with a new genus *Tortopsis* based on phylogenetic analyses of both adults and nymphs. The two genera can be separated based on the number of subapical tubercles on the inner margin of the mandibular tusks; *Tortopus* has two, *Tortopsis* one. *Tortopsis puella* is most likely the only species in North Carolina. *Tortopsis primus* adults have not been collected from NC and is known only from AR and LA. McCafferty (1996) synonymized *T. incertus* with *T. puella*. *Tortopsis puella* nymphs burrow into soft banks making them difficult to collect.

POLYMITARCYIDAE



Taxonomic references:

nymphs:

⇨McCafferty, W. P. 1975. The burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. Transactions of the American Entomological Society 101: 447-504.

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Molineri, C. 2010. A cladistic revision of *Tortopus* Needham & Murphy with despcription of the new genus *Tortopsis* (Ephemeroptera: Polymitarcyidae).
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LITERATURE

General References

References pertinent to specific taxa may be found at the end of the each taxonomic treatment.

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LIST OF CONFIRMED SPECIES

Confirmed mayfly genera and species occurring in North Carolina with NCBI tolerance data. Taxa with fewer than 50 records, or with records that are historical, have no associated tolerance value. Tolerance values last updated in 2010.

Taxonomic Hierarchy			NCBI Tol. Value	Total No. BAU Records **	Notes
Family	Genus	Species			
Ameletidae					
	Ameletus		---	43	
		cryptostimulus Carle, 1978	---	12	
		lineatus Traver, 1932	2.4	395	
		tarteri Burrows, 1987			
		tertius McDunnough, 1938			Significantly Rare (NC NHP 2012)
		sp. 3 (undescribed)			
Baetidae					
	Acentrella		2.5	700	
		alachua (Berner, 1940)	3.0	88	
		barbarae Jacobus & McCafferty, 2006	---	19	described from GSMNP
		nadineae McCafferty, Waltz & Webb, 2009	1.9	237	
		parvula (McDunnough, 1932)	4.8	131	
		turbida (McDunnough, 1924)	2.0	411	
	Acerpenna				
		macdunnoughi (Ide, 1937)	---	32	
		pygmaea (Hagen, 1861)	3.7	595	
	Apobaetis				
		sp. 1 (+ cf. sp. 2) (undescribed)	---	1	2nd possible species (D. Lenat, Lumber R, Scotland Co, 2011) not confirmed
	Baetis		---	51	
		brunneicolor McDunnough, 1925	---	42	
		flavistriga McDunnough, 1921	6.8	2534	
		intercalaris McDunnough, 1921	5.0	3391	
		pluto McDunnough, 1925	3.4	2363	
		tricaudatus Dodds, 1923	1.5	1145	
	Baetopus				
		trishae Waltz, 2002	---	2	Significantly Rare (NC NHP 2012), described from NC
	Barbaetis				
		benfieldi Kennedy, 1985	---	10	Significantly Rare (NC NHP 2012) Vulnerable to extirpation (Morse et al., 1997)
	Callibaetis		9.2	184	
		floridanus Banks, 1900			
		fluctuans (Walsh, 1862)			
		pretiosus Banks, 1914			Vulnerable to extirpation (Morse et al., 1997)
	Camelobaetidius				
		musseri (Traver & Edmunds), 1968			location not confirmed (spec. lost)
	Centroptilum		3.8	127	records since 2007
		alamance (Traver, 1932)			described from NC
		album McDunnough, 1926			
		minor (McDunnough, 1926)	---	4‡	
		triangulifer (McDunnough, 1931)	---	20‡	
		sp A. undescribed			
	Diphetor				
		hageni (Eaton, 1885)	1.1	175	

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Family	Genus	Species			
	Heterocloeon		3.7	505	
		amplum (Traver, 1932)	3.4	402	
		curiosum (McDunnough, 1923)	2.1	261	
		petersi (Muller-Liebenau, 1974)	---	50	
	Iswaeon				
		anoka (Daggy, 1945)	4.4	162	
		davidi (Waltz & McCafferty, 2005)	---	25	
		rubrolaterale (McDunnough, 1931)			
	Labiobaetis		---	18	the 1232 pre-1997 records are suspect
		dardanus (McDunnough, 1923)	---	36	
		ephippiatus (Traver, 1935)	3.5	329	
		frondalis (McDunnough, 1925)	4.6	534	
		propinquus (Walsh, 1863)	5.8	2320	
	Paracloeodes		8.0	92	
		fleeki McCafferty & Lenat, 2004	---	26	
		minutus (Daggy, 1945)	---	35	
	Plauditus		---	28	
		bimaculatus (Berner, 1946)			included in BAU *P. dubius* group
		cestus (Provonsha & McCafferty, 1982)	4.6	86	
		cingulatus (McDunnough, 1931)	---	25‡	included in BAU *P. dubius* group
		dubius (Walsh, 1862)	2.2	1185	records are for *P. dubius* group
		gloveri McCafferty & Waltz, 1998	---	16	
		punctiventris (McDunnough, 1923)	---	203‡	included in BAU *P. dubius* group
		virilis (McDunnough, 1923)			included in BAU *P. dubius* group
	Procloeon		1.9	262	records since 2007
		fragile (McDunnough, 1923)			
		intermediale (McDunnough, 1931)			
		quaesitum (McDunnough, 1931)			Vulnerable to extirpation (Morse et al., 1997)
		rivulare (Traver, 1935)	---	21‡	Vulnerable to extirpation (Morse et al., 1997)
		rubropictum (McDunnough, 1923)	---	2‡	
		rufostrigatum (McDunnough, 1924)	---	7‡	
		simile (McDunnough, 1924)			
		viridoculare (Berner, 1940)	---	9‡	
		n. sp. (undescribed)	---	17‡	BAU "appalachia"
	Pseudocentroptiloides				
		usa Waltz & McCafferty, 1989	---	29	
Baetiscidae					
	Baetisca		3.2	176	
		becki Schneider & Berner, 1963	---	7	Significantly Rare (NC NHP 2012)
		berneri Tarter & Kirchner, 1978	1.4	142	
		carolina Traver, 1931	4.2	511	
		gibbera Berner, 1953	---	52	
		laurentina McDunnough, 1932	---	1	inexplicably removed from 2008 NC NHP list; extirpated?
		rogersi Berner, 1940			1 record: Wilson Cr, Caldwell Co., 2002 (D. Lenat, T. Morman)
		obesa (Say, 1839)	---	5	Significantly Rare (NC NHP 2012)

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Family	Genus	Species			
Behningiidae					
	Dolania				
		americana Edmunds & Traver, 1959			Significantly Rare (NC NHP 2010) Vulnerable to extirpation (Morse et al., 1997)
Caenidae					
	Amercaenis				
		cusabo Provonsha & McCafferty, 2006	---	2	Significantly Rare (NC NHP 2012) refers to *A. ridens* (not in NC), described from NC
	Brachycercus		2.1	353	pre-2010 records include *Sparbarus*
		nitidus (Traver, 1932)	---	8	
	Caenis		6.8	2912	
		amica Hagen, 1861			
		anceps Traver, 1935			
		diminuta Walker, 1853			
		hilaris (Say, 1839)			
		latipennis Banks, 1907			
		macafferti Provonsha, 1990			
		punctata McDunnough, 1931			
	Cercobrachys		---	11	
		etowah Soldán, 1986	---	9	Significantly Rare (NC NHP 2012) refers to Tar R only (?)
		pomeiok Sun & McCafferty, 2008			described from NC
	Sparbarus				
		lacustris (Needham, 1918)			
		maculatus (Berner, 1946)	---	8	
Ephemerellidae					
	Attenella				
		attenuata (McDunnough, 1925)	1.1	97	
		margarita (Needham, 1927)	---	2	Significantly Rare (NC NHP 2012)
	Dannella		---	18	
		lita (Burks, 1949)	---	73	
		provonshai (McCafferty, 1977)	---	8	
		simplex (McDunnough, 1925)	3.4	347	many records are suspect
	Drunella		---	35	
		allegheniensis (Traver, 1934)	0.3	324	
		conestee (Traver, 1932)	0.0	365	synonymy with *D. tuberculata* not accepted, described from NC
		cornuta (Morgan, 1911)			1 non-BAU (L. Eaton, Ball Cr, 2012)
		cornutella (McDonnough, 1931)	0.0	387	
		lata (Morgan, 1911)	0.0	71	
		longicornis (Traver, 1932)	---	22	
		tuberculata (Morgan, 1911)	0.0	195	
		walkeri (Eaton, 1884)	0.6	139	
		wayah (Traver, 1932)	0.0	128	synonymy with *D. walkeri* not accepted, described from NC

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Family	Genus	Species			
	Ephemerella		2.1	209	
		argo Burks, 1947	---	13	synonymy with *E excrucians* not accepted
		catawba Traver, 1932	0.0	238	940 pre-2004 records coded *catawba/dorothea*
		crenula Allen & Edmunds, 1965	---	11	synonymy with *E excrucians* not accepted
		dorothea Needham, 1908	3.3	433	
		excrucians Walsh, 1862			included in BAU *E. invaria* group
		floripara McCafferty, 1985	---	18	Significantly Rare (NC NHP 2012)
		hispida Allen & Edmunds, 1965	0.1	93	
		inconstans Traver, 1932			synonymy with *E invaria* not accepted
		invaria (Walker, 1853)	2.6	428	records are for *E. invaria* group
		needhami McDunnough, 1925	---	43	
		rossi Allen & Edmunds, 1965	0.0	226	records are for *E. rossi* group, synonymy with *E excrucians* not accepted
		rotunda Morgan, 1911	---	60‡	60 records included in BAU *E. invaria* group
		subvaria McDunnough, 1931	---	66	
	Eurylophella		4.0	738	
		aestiva (McDunnough, 1931)	---	62	
		bicolor (Clemens, 1913)	4.8	233	
		doris (Traver, 1934)	7.0	301	
		enoensis Funk, 1994	---	47	described from NC
		funeralis (McDunnough, 1925)	2.5	483	
		lutulenta (Clemens, 1913)			possibly not in NC
		minimella (McDunnough, 1931)	---	37	
		oviruptus Funk, Jackson & Sweeney, 2008	---	9	described from NC
		prudentalis (McDunnough, 1931)	---	23	
		temporalis (McDunnough, 1924)			possibly not in NC - old records predate 1994 revision
		verisimilis (McDunnough, 1930)	3.9	434	
	Penelomax				
		septentrionalis (McDunnough, 1925)	2.1	130	previously *Ephemerella septentrionalis*
	Serratella		---	9	
		carolina (Berner & Allen, 1961)	0.0	205	synonymy with *S. serrata* not accepted described from NC
		serrata (Morgan, 1911)	1.4	328	
		serratoides (McDunnough, 1931)	1.7	754	
		spiculosa (Berner & Allen, 1961)	---	24	synonymy with *S. serrata* not accepted
	Teloganopsis				
		deficiens (Morgan, 1911)	2.6	2093	
	Tsalia				
		berneri (Allen & Edmunds, 1958)	---	19	Significantly Rare (NC NHP 2012), Vulnerable to extirpation (Morse et al., 1997)

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Family	Genus	Species			
Ephemeridae					
	Ephemera		2.0	560	
		blanda Traver, 1932	---	109‡	described from NC
		guttulata Pictet, 1843	---	55‡	
		simulans Walker, 1853			
		varia Eaton, 1883	---	5‡	
	Hexagenia		4.4	1335	
		atrocaudata McDunnough, 1924			
		bilineata (Say, 1824)	---	7‡	
		limbata (Serville, 1829)	---	20‡	
	Litobrancha				
		recurvata (Morgan, 1913)	---	49	Vulnerable to extirpation (Morse et al., 1997)
Heptageniidae					
	Cinygmula				
		subaequalis (Banks, 1914)	0.0	173	
	Epeorus		1.6	549	
		dispar (Traver, 1933)	1.0	541	
		fragilis (Morgan, 1911)			
		pleuralis (Banks, 1910)	1.5	263	
		subpallidus (Traver, 1937)	---	22	
		vitreus (Walker, 1853)	1.2	1284	
		sp. 1 (undescribed)	---	8	
	Heptagenia		1.9	754	
		dolosa Traver, 1935			
		julia Traver, 1933	---	20	
		marginalis Banks, 1910	2.2	1461	
		pulla (Clemens, 1913)	2.2	83	
		townesi Traver, 1935			
	Leucrocuta		2.0	1764	
		aphrodite (McDunnough, 1926)	---	351‡	
		hebe (McDunnough, 1924)	---	11‡	
		juno (McDunnough, 1924)			
		maculipennis (Walsh, 1863)			
		thetis (Traver, 1935)			
	Maccaffertium		---	59	
		carlsoni (Lewis, 1974)	2.1	118	Vulnerable to extirpation (Morse et al., 1997)
		exiguum (Traver, 1933)	3.8	626	
		ithaca (Clemens & Leonard, 1924)	3.0	987	
		lenati (McCafferty, 1990)	2.5	113	
		mediopunctatum (McDunnough, 1926)	4.2	127	
		meririvulanum (Carle & Lewis, 1978)	0.5	263	
		mexicanum (McDunnough, 1924)	4.7	368	
		modestum (Banks, 1910)	5.7	5315	
		pudicum (Hagen, 1861)	2.1	1329	
		pulchellum (Walsh, 1862)	---	4	
		smithae (Traver, 1937)			

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Family	Genus	Species			
	Maccaffertium (cont.)				
		terminatum (Walsh, 1862)	4.4	284	
		vicarium (Walker, 1853)	1.5	69	
		wudigeum McCafferty and Lenat, 2010	---	4	described from NC Significantly Rare (NC NHP 2012)
	Macdunnoa				
		brunnea Flowers, 1982	---	15	Significantly Rare (NC NHP 2012)
	Nixe		---	52	
		inconspicua (McDunnough, 1924)	---	3‡	in BAU datase as *nr. inconspicua*
		perfida (McDunnough, 1926)			
		spinosa (Traver, 1933)			
	Rhithrogena		0.0	370	
		amica Traver, 1935	---	36	Significantly Rare (NC NHP 2012), Vulnerable to extirpation (Morse et al., 1997)
		exilis Traver, 1933	0.0	102	described from NC, Vulnerable to extirpation (Morse et al., 1997)
		fasciata Traver, 1933			described from NC
		fuscifrons Traver, 1933	---	44	described from NC, Vulnerable to extirpation (Morse et al., 1997)
		rubicunda Traver, 1937			described from NC, Vulnerable to extirpation (Morse et al., 1997)
		uhari Traver, 1933	0.0	72	described from NC
	Stenacron		---	28	
		carolina (Banks, 1914)	1.3	267	described from NC
		interpunctatum (Say, 1839)	6.4	2493	
		pallidum (Traver, 1933)	2.8	1979	
	Stenonema				
		femoratum (Say, 1823)	6.9	241	
Isonychiidae					
	Isonychia		3.6	3790	
		arida (Say, 1839)			
		bicolor (Walker, 1853)			
		georgiae McDunnough, 1931			Vulnerable to extirpation (Morse et al., 1997)
		hoffmani Kondratieff & Voshell, 1984			
		obscura Traver, 1932			
		sayi Burks, 1953			
		serrata Traver, 1932			
		sicca (Walsh, 1862)			
		similis Traver, 1932			
Leptohyphidae					
	Asioplax				
		dolani (Allen, 1967)	---	14	Significantly Rare (NC NHP 2012)
	Tricorythodes		5.0	1397	
		allectus (Needham, 1905)			
		robacki (Allen, 1967)	---	30	Vulnerable to extirpation (Morse et al., 1997)
		stygiatus McDunnough, 1931			

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Family	**Genus**	**Species**			
Leptophlebiidae					
	Choroterpes				
		basalis (Banks, 1900)	---	13	Significantly Rare (NC NHP 2012)
	Habrophlebia				
		vibrans Needham, 1907	0.3	238	
	Habrophlebiodes		---	152	
		americana (Banks, 1903)			
	Leptophlebia		6.0	701	
		bradleyi Needham, 1932	---	23	
		cupida (Say, 1823)	---	7‡	
		intermedia (Traver, 1932)	---	5‡	
		johnsoni McDunnough, 1924			
		nebulosa (Walker, 1853)			
	Paraleptophlebia		1.2	2180	
		adoptiva (McDunnough, 1929)			
		assimilis (Banks, 1914)			described from NC
		debilis (Walker, 1853)			
		guttata (McDunnough, 1924)			
		moerens (McDunnough, 1924)			
		mollis (Eaton, 1871)			
		swannanoa (Traver, 1932)			described from NC
		volitans (McDunnough, 1924)			
Metretopodidae					
	Siphloplectron		---	55	
		basale (Walker, 1853)			
		costalense Spieth, 1938			
		speciosum Traver, 1932			
Neoephemeridae					
	Neoephemera		---	20	10 pre-1991 *compressa* records suspect
		purpurea (Traver, 1931)	1.5	494	described from NC
		youngi Berner, 1953	---	30	
Oligoneuriidae					
	Homoeoneuria				
		cahabensis Pescador & Peters, 1980	---	12	Significantly Rare (NC NHP 2012)
Polymitarcyidae					
	Ephoron				
		leukon Williamson, 1802	1.5	228	
	Tortopsis				
		puella (Pictet, 1843)	---	1	Significantly Rare (NC NHP 2012-as *Tortopus),* record from Tar R (1983)
Potamanthidae					
	Anthopotamus		1.5	123	
		distinctus (Traver, 1935)	1.6	109	
		myops (Walsh, 1863)	---	9	

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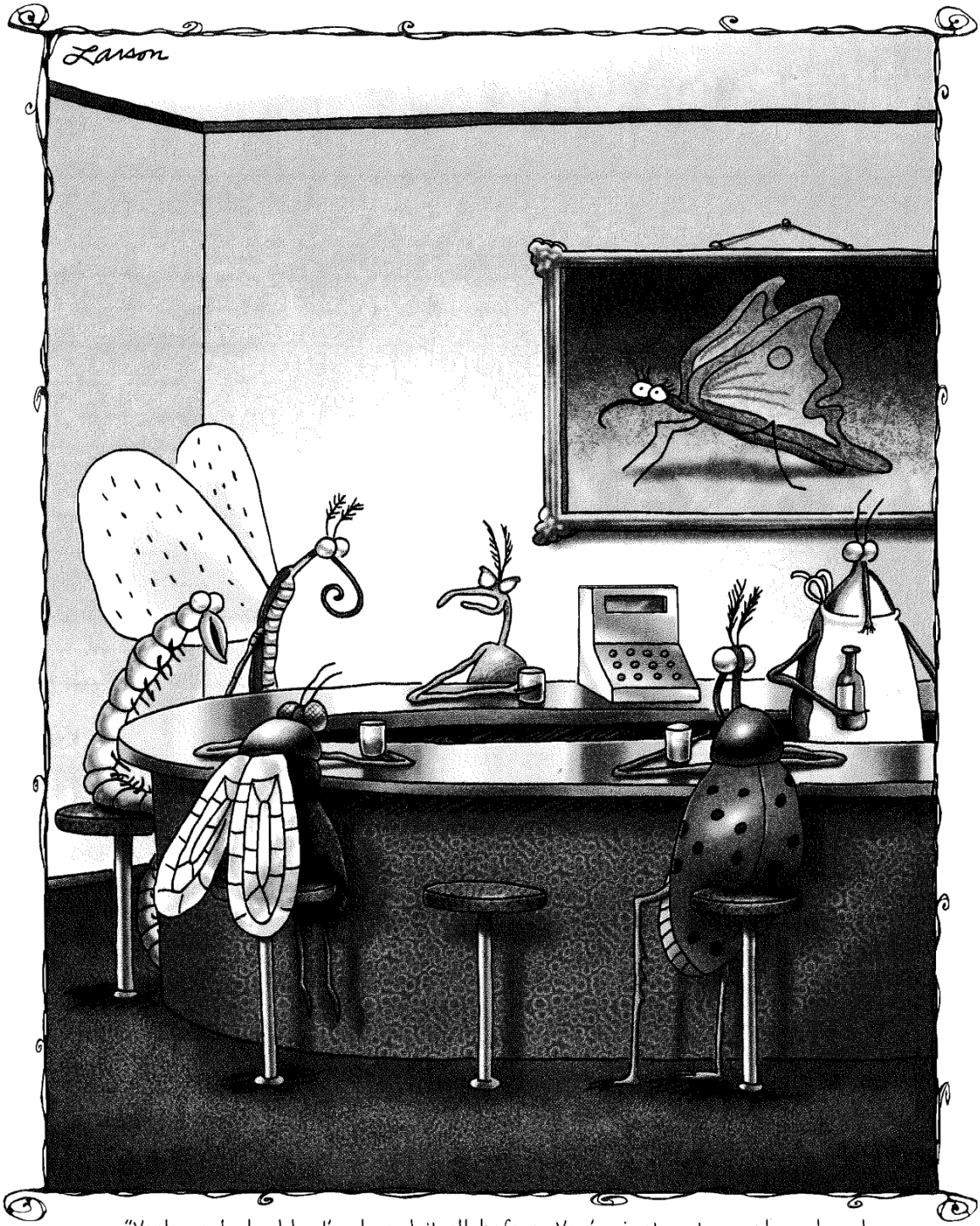
Family	Genus	Species			
Pseudironidae					
	Pseudiron				
		centralis McDunnough, 1931	---	2	2 additional records from non-benthic sampling, Significantly Rare (NC NHP 2012)
Siphlonuridae					
	Siphlonurus		6.0	67	
		decorus Traver, 1932			
		marginatus Traver, 1932			
		mirus (Eaton, 1885)			
		quebecensis (Provancher, 1878)			
		typicus (Eaton, 1885)			

* Total Records are through July 2013. ‡ Records are historical.



"Yeah, yeah, buddy, I've heard it all before: You've just metamorphosed and you've got 24 hours to find a mate and breed before you die. ... Well, buzz off!"