Mayflies Larval Habitats Guild
(Insecta: Ephemeroptera)

"A Mayfly" *Acanthametropus Pecatonica*
American Sand Burrowing Mayfly *Dolania Americana*
"A Mayfly" *Homoeoneuria dolani*

"A Mayfly" *Barbaetis benfieldi*
"A Mayfly" *Heterocloeon berneri*
"A Mayfly" *Tsalia berneri*

"A Mayfly" *Arthroplea bipunctata*
"A Mayfly" *Maccaffertium lenati*
"A Mayfly" *Siphlonurus decorus*

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South Carolina is home to 185 documented species of mayflies (Insecta: Ephemeroptera), making it one of the North American states or provinces with greatest species richness; it is arguably second only to neighboring North Carolina, which has at least 207 species (McCafferty 2001b; McCafferty & Meyer 2008; McCafferty et al. 2010). A few of South Carolina's mayflies should be considered species of conservation concern within the State. In several cases, the species are threatened throughout their global range; in other cases, only their South Carolina populations may be in jeopardy. Even if the latter case is true, the South Carolina populations historically may have represented important genetic reserves due to their being either isolated, or to their being on the periphery of the overall geographic distribution of the species.

During the species evaluation period of this project, it became apparent that South Carolina's rarest mayflies fell into three distinct larval habitat categories: (1) sand-bottomed streams, (2) streams with Hornleaf Riverweed, and (3) slow or stagnant waters. Each of these habitats faces significant threats.

Much training and experience is required to identify many small invertebrates to the species or even genus or family levels, and mayflies are no exception. Field identification is the unlikely exception for trained specialist. Descriptions and taxonomic discussions are not included except for general observations of form and likely locations these species may be encountered.

DESCRIPTION

The Ephemeroptera, or mayflies, are primitive insects that, along with the dragonflies (Odonata), are considered Paleopterous insects; as such, they are not able to fold their wings, as are all other modern insects. Mayflies are aquatic insects, with both the eggs and larvae residing in

freshwater. As such, mayflies are a major component of communities of invertebrates that live on or in the bottom substrates of streams and shallow zones of lake and ponds. Mayflies are unique among insects in that in their life cycle, they have a fully winged pre-adult stage known as a subimago as well as a fully winged adult stage. In all other winged insects, the fully winged condition is restricted to the reproductively mature adult stage. Both the subimago and adult stages do not feed and are terrestrial (aerial) rather than aquatic. The name of the order is based on the word “ephemeral” and is an allusion to the fact that most mayflies generally have a very short adult life span (less than an hour in some).

Eggs of mayflies are generally oval in shape and usually have a sticky covering or string-like attachment structure that helps them become attached to bottom substrates after being deposited on the surface of the water by females. The females of most mayfly species produce from 500 to 4,500 eggs. Larvae of mayflies demonstrate a large degree of diversity ranging from sleek minnow-like swimming forms, to extremely robust crawling forms, to highly flattened clinging forms. Compound eyes and antennae of mayflies are well developed. Mayfly mouthparts are on the underside of the head and show adaptations mainly for gathering small decaying material and diatoms, although some species have specializations for predation, filter feeding or scraping. Mayfly larvae have either 2 or usually 3 tails at the end of the abdomen. Both the subimagos and adults of mayflies are referred to as alates (bearing wings). The alates are fragile forms with vestigial, non-functioning mouthparts, small antennae, large compound eyes (more so in the males), and a pair of large, net-veined, more or less triangular-shaped forewings and a smaller pair of hindwings. The wings are held together directly above the body when at rest. Forelegs of male adults are very long and aid in holding the female from below when mating. The abdomen ends in either two or three well-developed, often very long tails. Differences are subtle between the subimago and adult stages. The subimago has duller wings and cuticle and, in males, the forelegs, eyes and genitalia are not as well developed as they are in adults. Mayflies generally have 1, 2 or 3 generations per year.

(1) Mayflies of Sand-bottomed Streams

Streams with shifting sands tend to have benthic macroinvertebrate communities that are low in diversity, but highly specialized in their morphologies and behaviors. In general, these habitats are neglected by biologists, due in part to their low diversity (McCafferty 1991), but also due to difficulties associated with working in deep, swift water, with an unstable bottom (Lillie 1995). However, macroinvertebrate denizens of these habitats have generally been under threat for many years (Peters & Peters 1977, McCafferty et al. 1990), and the psammophilous mayflies, in particular, “may be in serious jeopardy” (McCafferty 1991) due to threats from habitat alteration and pollution. For the conservation requirements of these species to be addressed properly, significant time and effort will need to be expended using specialized equipment and techniques. Until a comprehensive assessment can be done and new data collected on a broad scale, the following should be considered species of conservation concern.

***Acanthametropus pecatonica* (Burks, 1953) [Acanthametropodidae]**

POPULATION SIZE AND DISTRIBUTION

This species has been listed on the Wisconsin Endangered and Threatened Species List and has been considered endangered throughout its entire geographic distribution. Notably, it has been extirpated from parts of its range in Illinois and Wisconsin (Lillie 1995). Aside from these two states, the species is known only from single historical locations in Georgia and South Carolina (Edmunds et al. 1963, McCafferty 1991, McCafferty et al. 2010). In South Carolina, it is known only from the Savannah River in Barnwell County. The only confirmed South Carolina data records (as indicated by McCafferty 2001a) for this species are based on specimens taken at Mile 157 in May 1952 (McCafferty & Meyer, 2008). Edmunds et al. (1976) suggested that some differences may exist between the Southeast and Upper Midwest populations, but McCafferty (1991) considered them to be a single species. If the populations eventually prove to represent different species, then the outlook for the Southeastern variety will be even more dire. Morse et al. (1997) considered *A. pecatonica* to be a vulnerable Southeastern species, and previously it has been listed as such (USFWS 1994).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Lillie et al. (1987) and Lillie (1992, 1995) detailed the habitat and collection efforts in Wisconsin, where the species is found in late spring through middle summer in moderate- to large-sized, fairly rapid streams with rocky, but dominantly sandy, substrates. In particular, it has been found in rapidly shifting, fine silt and sand habitats, in currents of about 0.5 – 1.0 m/s (1.6-3.2 ft./sec.) at a depth of about 0.5-1.5 m (1.6-3.2 ft.). The species appears tolerant of warm and at least somewhat eutrophic conditions, as long as the dissolved oxygen levels remain relatively high; some of its streams receive wastewater treatment effluents upstream of the species' habitat. Difficulties associated with sampling the species' habitat contributes to its scarce collection. No data are available about the population density of the species, but it might be relatively abundant in the extremely localized, proper habitat conditions, even though no large number of specimens ever has been collected at a single time (Lillie 1995; D. Funk, pers. comm.). Although no data are available about the diet and feeding behavior of this species, its mouthpart morphology suggests it is a predator, perhaps on chironomid midge larvae like other species in its family (Edmunds and Koss 1972). Lillie (1995) recommended the highest protection possible for historical locales of this species until more research can be done.

CHALLENGES

As a riverine species, the challenges facing *Acanthametropus pecatonica* relate to the condition of South Carolina's large rivers. Throughout the world, large and great rivers have been severely modified by damming and dredging. Restoration of historic flow regimes is likely to have

positive benefits to many native river species. However, because of competing interests, this is not always possible.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments specifically for this species are known at this time.

CONSERVATION RECOMMENDATIONS

Encourage water use and conservation measures by industry, agriculture, and municipalities. Reduce river modification activities and pursue the feasibility of dam removal along medium and large rivers.

***Dolania americana* Edmunds & Traver, 1959 [Behningiidae]**
American Sand Burrowing Mayfly

This is an Eastern United States species that is known in South Carolina from only 2 waterbodies: the Savannah River and Upper Three Runs Creek (McCafferty, 2006; McCafferty and Meyer, 2008). It is primarily a species of the Southeast, but a disjunct population is known from Wisconsin (Jacobs 1990). This disjunct distribution pattern is similar to that seen for *Acanthametropus pecatonica*, mentioned previously (McCafferty 1991). Morse et al. (1997) considered this to be a vulnerable southeastern species, and it has been listed as such (USFWS 1994). No status updates are available since McCafferty (2006). For a more complete discussion of this species, see the separate American Sand Burrowing Mayfly species account.

***Homoeoneuria dolani* Edmunds, Berner and Traver, 1958 [Oligoneuriidae]**

POPULATION SIZE AND DISTRIBUTION

This species is a strictly Southeastern United States species (Pescador & Peters 1980, McCafferty & Meyer 2008). In South Carolina, this species is known only from the Savannah and South Saluda Rivers in Allendale, Barnwell, and Greenville Counties (Edmunds et al. 1958, Patrick et al. 1967; Brooks et al. 1979). Elsewhere, it is known from Florida and Georgia, with most of the Georgia records being from the Savannah River, and thus shared with adjacent South Carolina (Peters and Jones 1973; Brooks et al. 1979).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The larvae of this species are nearly transparent, and thus easily overlooked. They are filter-feeders and live in shallow burrows in sand-beds of swiftly-flowing streams, usually in deeper water, where the substrate is free of vegetation. The species probably has one generation per year, with an extended flight period from late spring through middle autumn. Adults swarm from midmorning until about noon on sunny days, about 1 m (3.3 ft.) above the water's surface (Berner and Pescador 1988).

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Encourage water use and conservation measures by industry, agriculture, and municipalities. Reduce river modification activities and pursue the feasibility of dam removal along medium and large rivers.

(2) Mayflies associated with Hornleaf Riverweed

Hornleaf Riverweed (*Podostemum ceratophyllum* Michaux) plays an important role in providing habitat structure for many aquatic macroinvertebrates (Hutchens et al. 2004). The riverweed may itself be an indicator of environmental health, being sensitive to landscape-level environmental changes (Meijer 1976, Argentina et al. 2010). Surely, the following mayflies are at least as sensitive. Protection of landscapes that drain into *Podostemum* streams may be warranted.

***Barbaetis benfieldi* Kennedy, 1985 (in Waltz et al. 1985) [Baetidae]**

POPULATION SIZE AND DISTRIBUTION

This is a species of clean, southeastern United States mountain streams, and it is the only species in its genus, representing an important component of regional and global phylogenetic diversity (Waltz et al. 1985, Beaty 2011). In South Carolina, it is known from three streams in Aiken (Cedar Cr.), Pickens (Cane Cr.) and York (Wildcat Cr.) Counties, with the most recent collections taken in 2000 (McCafferty and Meyer, 2008). Outside South Carolina, it has been reported only from North Carolina and Virginia (McCafferty et al. 2010), with it being considered endangered in Virginia (Kondratieff and Kirchner 1991). At least nine North Carolina populations have been found, all from far western, mountainous areas, with a concentration near the extreme northwestern tip of South Carolina (Lenat and Penrose 1987; E. Fleek and S. Beaty, pers. comm.). Morse et al. (1993, 1997) considered this species to be vulnerable, and it has been listed as significantly rare in North Carolina (NCDENR 2010).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Larvae are associated with Riverweed in stream riffles at a depth of about 0.5-2.5 m (1.6-8.2 ft.) where the flow is about 0.5 m/s (1.6 ft./s). Physical and chemical parameters vary widely,

including temperature, but dissolved oxygen is always near the saturation point which is typical of rapidly flowing streams. This species has one generation per year, with adults emerging from late April through middle May. This species drifts at night, with 10 individuals per 100 m^3 of water (10 individuals per 3,531 $ft.^3$) having been observed (Waltz et al. 1985).

CHALLENGES

As an aquatic insect this species faces the same challenges as other aquatic life occupying free-flowing streams. Urban sprawl is known to place considerable stress on certain organisms, and restoration is difficult once it has occurred.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments specifically for this species are known at this time.

CONSERVATION RECOMMENDATIONS

Encourage responsible landuse planning. Protect remaining large, undisturbed areas of land in the Piedmont and Mountains of South Carolina where this species may occur.

***Heterocloeon berneri* (Muller-Liebenau, 1974) [Baetidae]**

POPULATION SIZE AND DISTRIBUTION

This species is known only from the extreme southern Appalachians (Muller-Liebenau 1974; McCafferty and Meyer 2008). It is known in South Carolina from two streams (Flat Shoals R., Little R.) in Oconee County, with the most recent collections being from the former location in 2000 (McCafferty and Meyer, 2008). Elsewhere, it is only known from Cherokee and Lumpkin Counties in northern Georgia (Muller-Liebenau 1974, McCafferty et al. 2010), not far from the extreme northwestern tip of South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The larva of the species occurs in rapidly flowing warm water at a depth of about 15-65 cm (6-26 in.). It may be associated with crevices in rocks covered by Riverweed in streams with otherwise sandy and gravelly substrate. The species may not have sensitivity to slight siltation or even general turbidity. The ventral abdominal protuberances possibly serve as adhesive structures for life in swift currents (Muller-Liebenau, 1974).

CHALLENGES

While large tracts of undisturbed land occur in areas where this species is found, it may be particularly sensitive to increased sedimentation from forestry or construction activities.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments specifically for this species are known at this time.

CONSERVATION RECOMMENDATIONS

Encourage Best Management Practices (BMPs) related to landuse change and preservation of large tracts of land where the species may occur.

***Tsalia berneri* (Allen and Edmunds, 1958) [Ephemerellidae]**

POPULATION SIZE AND DISTRIBUTION

This is a strictly southern Appalachian species, and it is the only species in its genus, representing an important component of regional and global phylogenetic diversity (Jacobus and McCafferty 2008). This species is known in South Carolina from only the Little River in Oconee County, with the most recent specimens taken in 1997 (McCafferty and Meyer 2008). Elsewhere, it is known from scattered locations in Georgia, North Carolina, Tennessee, and Virginia (McCafferty et al. 2010). Morse et al. (1993, 1997) considered this species to be vulnerable, noting that little is known about its specific ecological requirements. The species is sometimes locally abundant in larger streams with densities of more than 200 individuals/square meter.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

This species is found in mats of Riverweed and watermoss (*Fontinalis* sp.), on root mats, and on rocks in riffle areas. Where it is found, the general stream substrate is composed of exposed bedrock, coarse pebbles and some cobbles. Water temperatures tend to be cool (ca. 12-15°C or 54-59°F). The species has been collected from streams below impoundments. Subimagos emerged in early afternoon to early evening (Kondratieff et al. 1981).

CHALLENGES

While large tracts of undisturbed land occur in areas where this species is found, it may be particularly sensitive to increased sedimentation from forestry or construction activities.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments specifically for this species are known at this time.

CONSERVATION RECOMMENDATIONS

Encourage Best Management Practices (BMPs) related to landuse change and preservation of large tracts of land where the species may occur.

(3) Mayflies of Slow or Stagnant Waters

South Carolina’s diverse wetlands are of particular conservation interest because they have continued to demonstrate a net loss in the state, even with construction of new wetlands and

mitigation efforts in place (Dahl 1999). Each of the following mayfly species requires additional study in South Carolina, but until much more is known, each should simply be considered a species of concern in the state.

***Arthroplea bipunctata* (McDunnough, 1924) [Arthropleidae]**

POPULATION SIZE AND DISTRIBUTION

This Holarctic species is relatively widespread throughout Canada and the Northeastern United States (including parts of the Upper Midwest), but it is primarily a far northern species (Burian and Gibbs 1991; Randolph and McCafferty 1998). Unzicker and Carlson (1982) and Pescador et al. (1999) listed the species for both North Carolina and South Carolina, but the North Carolina reports were not acknowledged by McCafferty et al. (2010), probably due to lack of substantiating data (McCafferty 2001a). Outside the Southeast, the nearest record is from northeast Ohio (McElravy and Foote 1975). The only South Carolina record (McCafferty 2001a) is from Boone Creek in Oconee County (Schultz 1973). This, and recently discovered voucher material from North Carolina (Jacobus and McCafferty, unpubl.), represent the only potentially verifiable Southeast data for the species (McCafferty et al. 2010). If the South Carolina report represents a bona fide record of the species, then it is the extreme southern limit of its distribution.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The genus is relatively easy to identify (Wang and McCafferty 1995). The larva occurs in stream overflow areas and backwaters with little or no flow, among coarse organic material (Myers et al. 2008), a habitat often neglected during field surveys of aquatic macroinvertebrates. Please note that some specialists are again including *Arthroplea* in the family Heptageniidae.

CHALLENGES

While large tracts of undisturbed land occur in areas where this species is found, it may be particularly sensitive to increased sedimentation from forestry or construction activities.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments specifically for this species are known at this time.

CONSERVATION RECOMMENDATIONS

Encourage Best Management Practices (BMPs) related to landuse change and preservation of large tracts of land where the species may occur.

***Maccaffertium lenati* (McCafferty, 1990) [Heptageniidae]**

POPULATION SIZE AND DISTRIBUTION

This species is a strictly Southeastern United States species (McCafferty 1990; Kondratieff et al. 2006). In South Carolina, this species is known only from the western front of the Piedmont, from a tributary of Watermelon Creek in Anderson County and from Lake Isaquenna in Pickens County, with the latter representing its most recent occurrence record, having been collected in 1987 (McCafferty and Meyer 2008). Elsewhere, it is known only from North Carolina from about 40 sites (Kondratieff et al. 2006; McCafferty et al. 2010).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The species appears to favor transition areas on the edges of the piedmont ecological region and thus may demonstrate a relatively narrow set of physiochemical habitat requirements. In the appropriate streams, the larva is found on large rocks in slow current, either near the head of a riffle or near the banks. Adults emerge in mid-May (Kondrateiff et al. 2006).

CHALLENGES

Increased development in the upper Piedmont in recent years continues to be a concern for aquatic organisms in this part of SC.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments specifically for this species are known at this time.

CONSERVATION RECOMMENDATIONS

Encourage Best Management Practices (BMPs) related to landuse change and preservation of large tracts of land where the species may occur.

***Siphlonurus decorus* Traver, 1932 [Siphlonuridae]**

POPULATION SIZE AND DISTRIBUTION

This Southeastern United States Coastal Plains species has not been reported for nearly 45 years (Berner, 1977). In South Carolina, this species is only known from Orangeburg County, based on adult material collected in the month of April (Berner 1977); no other data have been available until now [Orangeburg, N. Edisto River, 20-IV-1955, Hynes & Berner, one female adult, housed in the Florida A&M University collection, Tallahassee, Florida]. Elsewhere, it is known only from two swamps in North Carolina (Traver 1932).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The larva remains unknown, so specific habitat requirements are not determinable at this time. However, given the biology of the genus and this particular species' tentative association with

Coastal Plain swamps, it is likely that the larva will be found in stagnant or very slow flowing waters.

CHALLENGES

Obvious threats include wetland habitat destruction and alteration.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments specifically for this species are known at this time.

CONSERVATION RECOMMENDATIONS

Concerted efforts should be made to verify the continued existence of this species.

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