Contributions to the life history and knowledge of the ecology of mayflies (Ephemeroptera) from the New River, Virginia

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Abstract

Collections of macroinvertebrates made between 1976 and 1996 were used to establish distributional records for Ephemeroptera in the upper New River. Fifty species, 28 genera, and 13 families of Ephemeroptera are documented. The dominant species of mayflies were categorized into seasonal groups based on larval development patterns and adult emergence periods.

Keywords: life history, Ephemeroptera, drift.

Research Update on Ephemeroptera & Plecoptera
2003, E. Gaino (Ed.), University of Perugia, Perugia, Italy.

Introduction

Extensive inventories of aquatic insects occurring in North American temperate freshwaters has never been undertaken. The Nationwide Rivers Inventory estimated a total of 5,200,000 km of streams in the contiguous 48 states but only 2% are of sufficient quality to be worthy of federal protection status (Benke, 1990). It is reasonable to assume that man's increasing demands on water resources will continue to degrade surface waters.

The mayflies in a section of the upper New River were intensely studied over a twenty year period. The New River, a remaining segment of the prehistoric Teays River, is one of the oldest rivers in the world and is geologically older than the Appalachian Mountains through which it flows (Schoenbaum, 1979). Although most major river systems have had major alterations due to antropogenic activities within their drainage basins there are few such activities are present in our study area. The section of the New River upstream of the study area has been designated by the United States congress as a National Wild and Scenic River and a Natural Heritage River. The macroinvertebrate fauna of the Upper New River is diverse and includes many aquatic insects with a limited distribution (White and Brown, 1976; Kennedy and White, 1979; Waltz *et al.*, 1985). To date no detailed studies have been published concerning the distributions of mayflies in this ancient Appalachian river.

This paper presents information on the life histories of the mayfly species in a section of the upper New River. Documentation of mayfly diversity and distribution in the upper New River provides a baseline that will be useful in evaluating future changes and as a model for comparison to other streams in different geographical regions with similar hydraulic regimes.

Material and Methods

Site description:

The New River originates in the mountains of North Carolina and flows northward through Virginia and West Virginia until its confluence with the Gauley River to become the Kanawha River. The Kanawha River is a major tributary to the Ohio River. Collections of mayflies were made in an 50 km section of the upper New River in southwestern Virginia extending from near Fries (36.73214 N; -81.029175 W) upstream to the

Mouth of Wilson, Virginia (36.610193 N; -81.387261W).

The riffles in this region are formed from ridges of tilted bedrock strewn with sand, gravel and rock rubble. In addition, nearly all riffle areas are covered by an almost continuous mat of river weed, *Podostemum ceratophyllum* Michaux. These macrophyte mats contribute to the physical stability of the stream substrate and increase the complexity of the habitat available for macroinvertebrate colonization. Average yearly discharge at Fries, VA is 53.4 $m^3 sec^{-1}$.

Collection

Surveys of mayflies were made during 1976 - 1981 and 1986 - 1996. Sampling efforts during this period of time varied. The most intense sampling occurred during 1976 through 1977 during an aquatic insect drift study. Drifting aquatic insects, emerging adults and exuviae were collected with nets suspended from a bridge (County Route 721) 25, 50 and 75% of the distance across the river. Collections were made over a 24 hour period with drift nets (8 minimum samples per period) were made twice monthly, June - September 1976 and at least monthly October 1976 to May 1977, river conditions permitting. Each summer collection (June through August) consisted of two 24 hour series of samples taken within a 96 hour period.

Samples collected in drift samples were preserved in the field with 10% formalin and returned to the laboratory where exuviae, larvae, *subimago* and *imago* mayflies were removed. Mature larvae of many mayfly species were collected from the river and reared in the laboratory to aid in identification.

Mayfly larvae and exuviae collected in drift samples were categorized into developmental stages, based on wing pad development, following classifications established by Bretschk (1965). Exuviae were classified as either pre-emergent (shed exoskeleton of developing larvae prior to emergence), or emergent exuviae (exoskeletal remains from emerging subimagoes).

Morisita's Index was used to measure similarity of the mayfly communities collected in drift net samples taken in 1976 through 1977 (Morisita, 1959; Brower *et al.*, 1998). This community similarity index refers to the probability that individuals randomly drawn from each of two communities will belong to the same species, relative to the probability of randomly selecting a pair of individuals of the same species from one of the communities (Brower *et al*, 1998). The Morisita index of community similarity is

$$I_M = 2\Sigma x_i y_i/[(l_1 + l_2)N_1\ N_2]$$

where x_i is the number of individuals in species i in community 1 and N_1 is the total number of individuals in community 1. Likewise y_i is the number of individuals in species i in community 2 and N_2 is the total number of individuals in community 2. Using the same notation, l_1 and l_2 are defined as:

$$l_1 = \Sigma x_i(x_i -1)/N_1(N_1 -1)$$

and

$$l_2 = \Sigma y_i(y_i -1)/N_2(N_2 -1).$$

Morisita index values may range from 0 (no similarity) to approximately 1.0 (identical). This index has the desirable characteristic of having little influence by the size of samples (Wolda, 1981). Dendograms of the Morisita coefficient matrices were produced using the unweighted pair group method of cluster analysis (Pielou, 1984). Mayflies that were collected only once during the study were not included in this analysis.

During the years 1978 - 1981 and 1984 - 1996 imagoes and subimago mayflies were also collected from the study area with lights (blacklight and gasoline lantern) using white sheets of cloth. Larval mayflies were collected via D-frame kick nets. Collections made during this period were made at least annually, usually in May or June.

Results and Discussion

Some genera and their species collected from the New River are in need of revision (e.g. *Rhithrogena* (Heptageniidae), and *Tricorythodes* (Tricorythidae). Names applied to these genera are provisional.

A total of 13 families, 28 genera and 50 species of mayflies have been recorded from the upper New River (Table 1). This represents about 60% of all genera and 30% of the mayfly species known from Virginia (Kondratieff and Voshell, 1983). Undoubtedly, a number of factors have contributed to the total number of species occurring in this region. These factors include: 1) minimal anthropogenic activities in the drainage basin 2) frequency of sampling 3) diversification of sampling technique used to collect macroinvertebrates 4) geographical location of the river between northern and southern geographical regions 5) geological history of the river.

The mayflies of the New River may be categorized into seasonal groups based on larval developmental patterns and adult emergence periods observed during the drift net studies (Fig. 1).

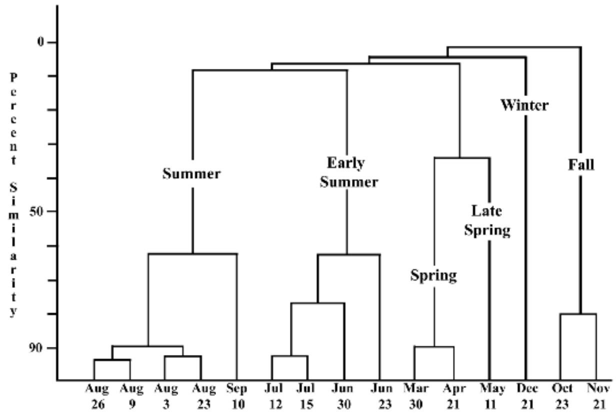

Fig. 1 - Mayfly community similarity in 1976 - 1977 as measured by Morisita's Index.

Spring (March - April): Spring samples were characterized by high densities of mature *Stenonema* larvae, representing, *S. ithaca, S. mediopunctatum, S. modestum* and mature *Ephemerella* larvae, primarily *E. berneri, E. needhami, E. invaria* and *E. dorothea.* Adults and emergent exuviae of these species of *Stenonema* and *Ephemerella* were also present during this period. The *Stenonema* emergence represented the spring generation of a probable bivoltine life cycle. *Ephemerella* species in this season all appeared to be univoltine with either egg or larval diapause until autumn or late winter. *Baetisca (Baetisca) carolina* emergent exuviae and subimago were collected in April. Emergence for this species continued through early May.

Late Spring (May): *Heterocloeon curiosum* and *Baetis intercalaris* larvae with darkened wing pads, emergent exuviae and subimagoes dominated the May drift collections. The spring emergence of *B. intercalaris* begins a surge of emergence which sporadically continues throughout the summer. The *H. curiosum* occurring during this season probably represent the first generation of a bivoltine life cycle.

Early summer (June - July): Mature larvae of *Isonychia bicolor* and *Stenonema terminatum* and emerging adults were present in samples during this season. The *I. bicolor* emergence peak represents the second generation of a bivoltine life cycle (Kondratieff and Voshell, 1984). *Stenonema terminatum* appears be univoltine in the New River with an extended emergence that begins in June. Late instar larva and emerging adults identified as *Eurylophella temporalis* also occurred during this season.

Table 1 - List of Ephemeroptera Collected in the New River Near Fries, Virginia, 1976 - 1981 and 1986 - 1996.

BAETIDAE

Acentrella TRAVER, 1932
Baetis intercalaris McDUNNOUGH, 1921
Baetis pluto (McDUNNOUGH, 1925)
Barbaetis benfieldi KENNEDY, 1985
Heterocloeon curiosum (McDUNNOUGH, 1923)
Heterocloeon petersi (MULLER - LIEBENAU, 1974)
Labiobaetis ephippiatus (TRAVER, 1935)
Plauditus dubius (WALSH, 1862)
Procloeon c.f. *rufrostrigatum* (McDUNNOUGH, 1924)

BAETISCIDAE

Baetisca berneri TARTER & KIRCHNER, 1978
Baetisca carolina TRAVER, 1937

CAENIDAE

Brachycercus nitidus (TRAVER, 1932)

EPHEMERELLIDAE

Dannella simplex (McDUNNOUGH, 1925)
Drunella alleghaniensis (TRAVER, 1934)
Drunella lata (MORGAN, 1911)
Drunella walkeri (EATON, 1884)
Drunella wayah (TRAVER, 1932)
Ephemerella berneri (ALLEN & EDMUNDS, 1958)
Ephemerella dorothea (NEEDHAM, 1908)
Ephemerella invaria (WALKER, 1853)
Ephemerella needhami (McDUNNOUGH, 1925)
Ephemerella septentrionalis (McDUNNOUGH, 1925)
Eurylophella bicolor (CLEMENS, 1913)
Eurylophella temporalis (McDUNNOUGH, 1924)
Serratella deficiens (MORGAN, 1911)
Serratella frisoni (McDUNNOUGH, 1927)
Serratella serratoides (McDUNNOUGH, 1931)

EPHEMERIDAE

Hexagenia atrocaudata McDUNNOUGH, 1924

HEPTAGENIIDAE

Epeorus EATON, 1881
Heptagenia c.f. *dolosa* TRAVER, 1935
Heptagenia marginalis BANKS, 1910
Leucrocuta c.f. *hebe* (McDUNNOUGH, 1924)
Rhithrogena c.f. *uhari* (TRAVER, 1933)
Stenacron floridense (LEWIS, 1974)
Stenacron interpunctatum (SAY, 1839)
Stenonema exiguum TRAVER, 1933
Stenonema ithaca (CLEMMENS & LEONARD, 1924)
Stenonema mediopunctatum (McDUNNOUGH, 1926)
Stenonema modestum (BANKS, 1910)
Stenonema pulchellum (WALSH, 1862)
Stenonema smithae (TRAVER, 1937)
Stenonema terminatum terminatum (WALSH, 1862)

ISONYCHIIDAE

Isonychia (Isonychia) bicolor (WALKER, 1853)
Isonychia (Prinoides) obscura TRAVER, 1932

NEOEPHERMERIDAE

Neoephemera purpurea (TRAVER, 1931)

OLIGONEURIIDAE

Homoeoneuria cahabensis PESCADOR & PETERS, 1980

POLYMITARCIDAE

Ephoron leukon WILLIAMSON, 1802

POTAMANTHIDAE

Anthopotamus distinctus (TRAVER, 1935)

PSEUDIRONIDAE

Pseudiron centralis McDUNNOUGH, 1931

TRICORYTHIDAE

Tricorythodes c.f. *stygiatus* (McDUNNOUGH, 1931)

Summer (August through early September): Mature larvae *B. intercalaris, H. curiosum, S. ithaca, S. mediopunctatum* and *S. modestum* were present during this period. Adults of these species were also collected in these samples and are thought to represent the emergence of the second generation of *H. curiosum*, *S. ithaca, S, mediopunctatum* and *S. modestum*. Emergence of *S. terminatum,* and *S. serratoides* was at a maximum during August. Maximum *B. nitidus, Hexagenia atrocaudata, Ephoron leukon* and *Tricorythodes stygiatus* emergence occurred through August.

Fall (October - November): Drift in the fall was characterized by mature, ready to emerge nymphs and emerging subimagoes representing *B. pluto* and *Plauditus dubius*. These larvae may have reached maturity too late to successfully emerge because of low air and water temperatures. Early instars of *Isonychia, Stenonema, Hexagenia, Ephoron, Ephemerella, Drunella* and *Serratella* also began to appear in the samples, indicating the beginning of the next generations of these species.

This study illustrates the importance of seasonal sampling to increase the probability of recording mayflies with restricted seasonal and spatial distributions. Once annual summer surveys would fail to record the diversified spring mayfly genera listed in this paper. Annual summer surveys for example would have recorded only 5 species of ephemerellids, a value reported to be the usual number of ephemerellid species found in a given reach of rivers in the Atlantic drainage (Vannote and Sweeney, 1980) rather than rich diversity (15 species) recorded in this study. This is an important consideration when designing environmental monitoring sampling strategies. Sampling protocols need to consider seasonal occurrence of species so that faunal compositional changes due to life history patterns can be separated from species elimination attributed to changes in water quality.

Knowledge of the existence of some mayfly species recorded in this study can be attributed to the use of drift nets in addition to kick nets. Rivers contain a mosaic of habitats and the use of a variety of collecting techniques during surveys will maximize the number of aquatic insects collected. The drift nets collected individuals from habitats not accessible to commonly used sampling techniques. For example the psammophilic mayflies, *Homoeoneuria* and *Pseudiron* were only collected in drift collections. As pointed out by Edmunds *et al.* (1976) microhabitats are impossible to determine from drift collections. However, once a species is recognized as existing in an aquatic system specialized sampling techniques can be implemented to sample and identify specific habitats.

Acknowledgments

I would like to thank B.C. Kondratieff, D. K. Morihara, R.D. Waltz, and Philip Lewis for their assistance with identification and confirmation of species. Dr. E. F. Benfield provided the opportunity to do this study. In addition he provided financial support during the early years of the project. Drs. J. Reese Voshell and B. Kondratieff read an early version of this manuscript and offered many helpful suggestions.

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