Journal of the Minnesota Academy of Science

Volume 45 | Number 3 Article 3

1979

Macroinvertebrate Populations In The Upper Mississippi River

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ABSTRACT—The macroinvertebrate community of the Mississippi River near Monticell, Minnesota, was examined for 22 months. Quantitative bottom fauna information was obtained by use of concrete block artificial substrate sampling units. Representative organisms were obtained from seven (7) orders, 15 families and 35 genera of benthic macroinvertebrates. All taxa collected displayed definite seasonal trends. The Orders Trichoptera, Diptera, and Ephemeroptera were the most abundant groups collected, Trichoptera (*Hydropsyche* and *Cheumatopsyche)* were the dominant members of the benthic population in both numbers and biomass. Midges and blackflies were the dominant Diptera. *Pseudocloeon, Stenonema,* and *Ephemerella* were the most frequently collected mayflies.

The invertebrates which live in, on, or near the bottom of running waters include representatives of almost every taxonomic group that occurs in freshwater. Several whole families of invertebrates are confined entirely to fast-flowing waters. Others reach maximum development in streams and rivers (Hynes, 1970).

Life is precarious in streams and rivers, and a fine degree of fitness is required for those plants and animals in a lotic environment. Constantly changing stream and river conditions offer a highly unstable and complicated environment. Man has accentuated this instability by activities such as industry and agriculture. In many trout streams and fast-flowing rivers, larger aquatic plants, important in the lentic environment, are practically precluded by currents. Thus, the biota under these circumstances is limited to species that are either strong swimmers or have special structural adaptations for clinging, such as the filter-feeding insects. The Mississippi River at Monticello, Minnesota, is a typical example of this habitat.

Relatively little work has been done with invertebrates in medium to large rivers (Hynes, 1970). Therefore, the objective of this study was to provide basic knowledge about the biology of a large river by determining the diversity and abundance of the macroinvertebrate benthic populations. A five mile section of the Mississippi River in Wright County, Minnesota, was the study area.

Non-traditional Methods Employed

Botom sampling in streams may be classified into two categories: grabs or dredges, and artificial substratum. Presently, samplers of the natural substrate are most popular because they are believed to give a more accurate representation of the bottom fauna than the artificial substrates. Traditional methods include the Ekman and Petersen grabs, dredges, cores and semi-open samplers of known area. The difficulty with these samplers is that they are non-operative in a rubble and boulder substrate or in deep, swift waters. Both of these conditions are characteristic of most large rivers. Therefore, artificial substrates, which are becoming more popular in lotic environments where it is difficult or impossible to use any of the traditional collecting methods, were used in this study.

Each sampling unit was a concrete block (adapted from Brit, 1955) with approximately three-tenths square meter surface area and roughened by sand blasting to provide sites for invertebrate attachment. The blocks were placed on the river bottom at the designated sampling location for a period of 30 days to allow colonization of the artificial substrates by the riverine species. At the end of the 30 day colonizing period, the blocks were returned to the surface and the captured invertebrates were removed. Laboratory analysis consisted of identifying, counting, and weighing the organisms to determine the average wet weight per organism and the toal weight per taxonomic group on the test substrate.

Sampling was initiated in February, 1969, and continued through November, 1970.

Eight quantitative invertebrate sampling transects composed of a total of 20 stations were estab lished to study the macroinvertebrate benthic environment. Each station was composed of four artificial substrate sampling units (Figure 1).

Transect 1 – composed of three sampling stations, 1C located in the middle of the river, 1L located midway between 1C and the east bank of the river, and 1R located midway between 1C and the west bank of the river. Twelve artificial substrate sampling units (the notation -C, -L, and -R was uniform throughout the study area and will have the same meaning as outlined above regardless of the transect involved).

Transect 2 – composed of two sampling stations, 2C and 2R. Eight artificial substrate sampling units.

Transect 3 – composed of four sampling stations, 3L, 3C, 3R, and 3E which was located midway between 3R and the west bank of the river. Sixteen artificial substrate sampling units.

Transect 4 – composed of three sampling stations, 4L, 4R, and 4E. Twelve artificial substrate sampling units.

Transect 5 – composed of one sampling station, 5C. Four artificial substrate sampling untis.

Transect 6 – composed of three sampling stations, 6L, 6C, and 6R. Twelve artificial substrate sampling units.

Transect 7 – composed of three sampling stations, 7L, 7C, and 7R. Twelve artificial substrate sampling units.

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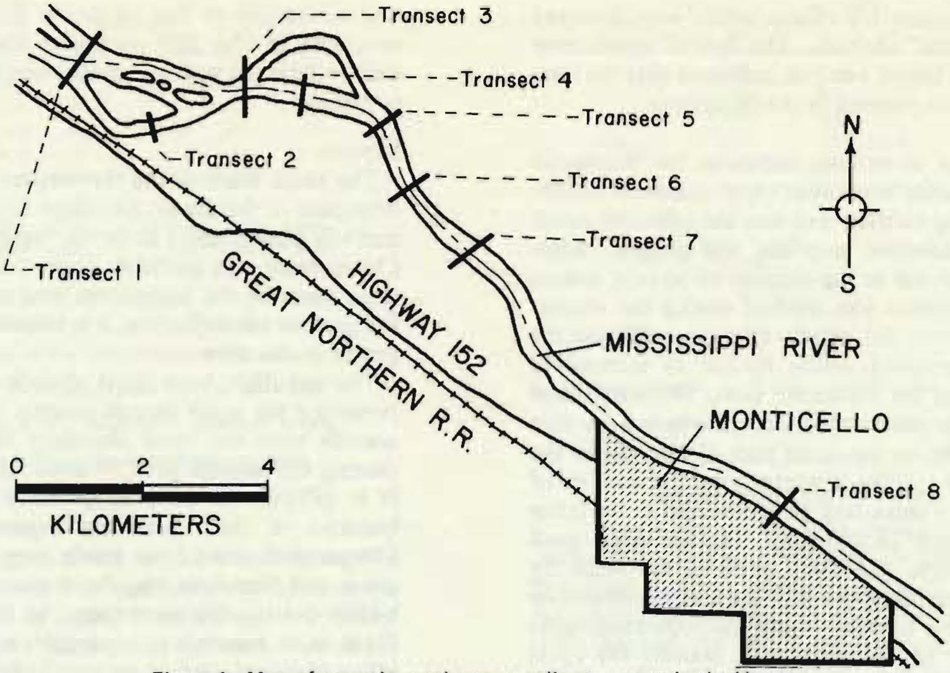

Figure 1. Map of macroinvertebrate sampling transects in the Upper Mississippi River near Monticello, Minnesota, during 1969 and 1970.

Transect 8 – composed of one sampling staion, 8C, with four artificial substrate sampling units.

Although seasonal variations occurred, current, depth, and temperature were not significantly different at the different sampling stations within sampling periods when compared in tests of differences (Steel and Torrie, 1960).

Benthic Fauna Composition

The genera of organisms collected were as follows (Nomenclature of Pennak, 1953, for all organisms except the chironomids and mayflies which are after Ward and Whipple, 1959).

Phylum Arthropoda
Class Insecta
Order Trichoptera
Family Hydropsychidae . *Cheumatopsyche sp.*, *Hydropsyche sp.*, *Macronemum sp.*
Family Philopotamidae . *Chimarrasp.*
Family Philopotamidae . *Chimarra sp.*
Family Psychomylidae . Unknown genera, *Psychomyia sp.*
Family Hydroptilidae . . Unknown genera
Order Ephemeroptera
Family Baetidae . . . . *Centroptilum sp.*, *Isonychia sp.*, *Pseudocloeon sp.*
Family Ephemerellidae . *Ephemerella sp.*
Family Heptageniidae . . *Cinygam sp.*, *Rhithrogena sp.*, *Stenonema sp.*
Family Leptophlebiidae . *Leptophlebia sp.*, *Paraleptophlebia sp.*
Family Potamanthidae . *Potamanthus sp.*
Family Tricorythidae . . *Tricorythodes sp.*
Order Plecoptera
Family Nemouridae . . *Taeniopteryx sp.*
Family Perlidae . . . . *Acroneuria sp.*, *Anacroneuria sp.*, *Atoperla sp.*, *Neoperla sp.*, *Paragnetina sp.*, *Perlesta sp.*, *Phasganophora sp.*
Family Perlodidae . . . *Isogenus sp.*, *Isoperla sp.*
Family Pteronarcidae . . *Pteronarcys sp.*
Order Coleoptera
Family Elmidae . . . . Unknown genera
Order Diptera
Family Chironomidae . . Tribe Chironomini
Family Simuliidae . . . *Simulium sp.*
Order Lepidoptera
Family Pyralididae . . . *Cataclysta sp.*
Phylum Mollusca
Class Gastropoda
Order Pulmonata
Family Ancylidae . . . *Ferrissia sp.*

Benthic Fauna Distribution

The Student's "T" test (Steel and Torrie, 1960) of the 1969 and 1970 data indicated, at the 95% level of confidence, that the macroinvertebrate population was quite stable throughout the sampling period with particular reference to longitudinal (i.e., from transect 1 through transect 8) and lateral (i.e., E, R, C, L) distribution of the three major groups of macroinvertebrates (Trichoptera, Ephemeroptera, and Diptera) collected by the artificial substrates (Table 1 and 2).

An analysis of the seasonal (between months) distribution of the above three groups revealed that each had a definite seasonal cycle. The Trichoptera and Ephemeroptera assumed major importance in the late spring, summer and early fall and dipterans were of primary importance in late fall, winter, and early spring (Figure 2). It seemed that the seasonal distribution of the organisms changed from month to month due to the changing seasons with their accompanying changes in water temperature, photoperiod, water depth, water current velocity, river discharge, etc. The analysis of longitudinal and lateral distribution took an average of these conditions through the 1969-70 sampling period and tended to eliminate the primary monthly effects which were detected in the "between months" analysis. The lack of significance in the logitudinal and lateral analysis indicated that the river was a homogeneous environment in the study area.

Seasonal dynamics

The peak abundance of aquatic insects in the Monticello study area occurred during September (approximately 10,000 organisms per sampling station) and was the principle result of an increase in caddisflies, mayflies, and midges. After this time, a rapid decrease in the number of aquatic insects occurred until a minimum was reached during the winter. The only exceptions were the mayfly *(Ephemerella)* and the midges (Tribe Chironomini) which tended to increase in population size beyond the September peak. However, these two groups, as with the other organisms, were only a fraction of the summer samples in the latter part of January or the first part of February. After a winter low, the number of insects increased until a secondary peak occurred in the latter part of April or the early part of May. This secondary peak was caused by the rapid short life cycle of the black fly *(Simulium)*. After this time, the aquatic macroinvertebrate population progressively increased until the population again peaked in September of the next year, starting the cycle anew. Population weights tended to be directly proportional to numbers and yielded the same generalized seasonal pattern.

Trichoptera

Caddisflies were represented by at least seven genera of insects and were the most abundant order of insects in the total collection for the two-year period. Of the total caddisflies, *Hydropsyche and Cheumatopsyche* were the most important in that they comprised 95 percent of the total two-year collection of trichopterans and approximately 45 percent of all the organisms collected (Figure 3). The second most abundant group of caddisflies were *Macronemum*, also a member of the family Hydropsychidae, although in comparison to the other caddisflies it was a very minor component of the population. The trends represented by the Order Trichoptera were really the trends of the representative members of the Family Hydropsychidae.

Sufficient specimens of the family Hydropsychidae were collected and weighed so that inferences about the life cycle of the group could be drawn. it appeared that members of *Hydropsyche, Cheumatopsyche,* and *Macronemum* collected in the study area were all univoltine with extended periods of ecdysis and eclosion. Reportings by local people in the area combined with the laboratory analysis seemed to indicate

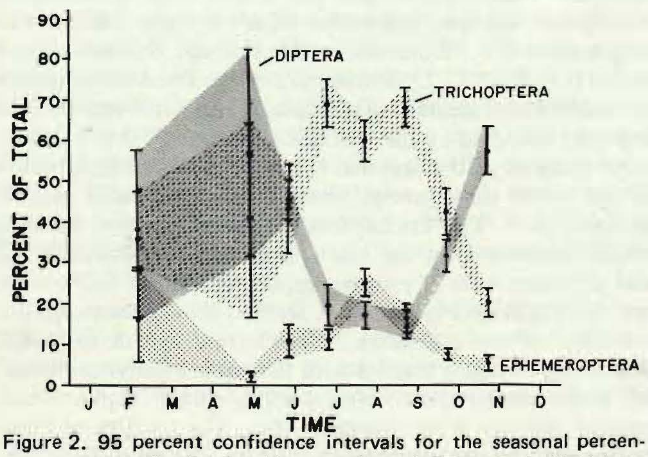

Figure 2. 95 percent confidence intervals for the seasonal percentage distribution (January through December) of Trichoptera, Diptera, and Ephemeroptera.

that emergence of this particular group of organisms began sometime in May and continued through the summer into early-middle fall with occasional unpredictable spurts of mass emergence.

Diptera

The order Diptera was represented by only two groups of organisms in this study, *Simulium* from the family Simuliidae and trib Chironomini from the family Chironomidae. Tribe Chironomini was probably composed of several genera but since none of the immatures were reared to the adult stage for positive identification, it is impossible to enumerate these genera at this time.

The simuliids were most abundant in the spring and represented the order almost entirely at that time. The chironomids were the most abundant in late summer and fall, causing the second peak of abundance shown by the order. It is difficult to draw conclusions about the possible life histories of these particular organisms because the tribe Chironomini was almost surely composed of more than one genus and *Simulium* may be an example of an organism with widely overlapping generations, as Hynes (1970) cited Simuliidae as an example of an aquatic insect which has the capability of completing its entire life cycle in a matter of six to eight weeks.

Ephemeroptera

The order Ephemeroptera was the third most important order represented in the study and had a yearly abundance of about one-tenth that of the orders Trichoptera and Diptera. The major component genera were *Pseudocloeon Stenonema,* and *Ephemerella. Pseudocloeon* and *Stenonema* set the trend for the order with the same life history pattern as had been shown by the order Trichoptera. *Pseudocloeon* appeared to be a multivoltine organism but without better winter sampling, it was impossible to establish whether it was

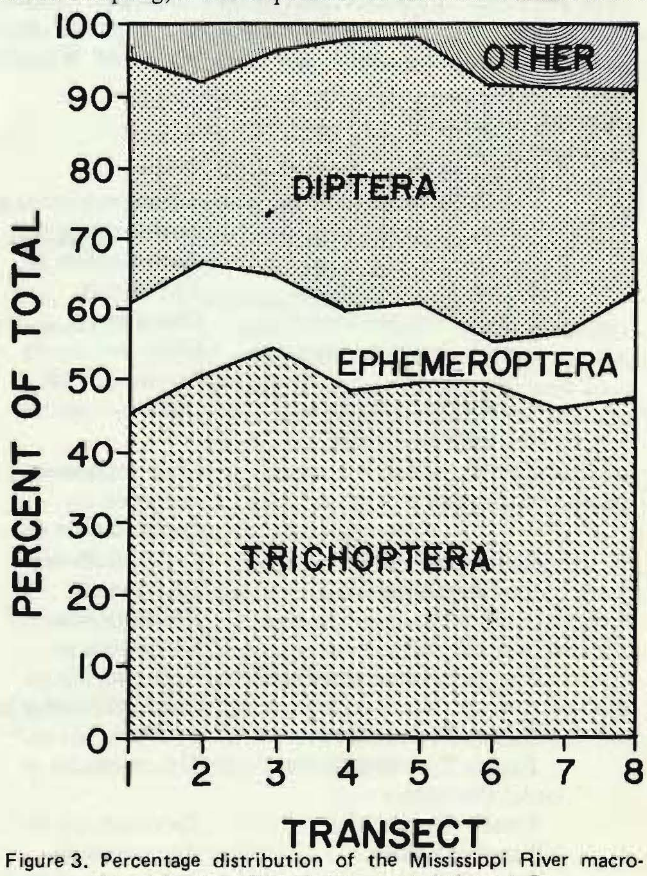

Figure 3. Percentage distribution of the Mississippi River macroinvertebrates collected at transects 1 through 8.

TRANSECT	TRICHOPTERA 1969	TRICHOPTERA 1970	EPHEMEROPTERA 1969	EPHEMEROPTERA 1970	DIPTERA 1969	DIPTERA 1970
1	46.02	44.70	17.01	12.90	35.90	33.74
2	48.27	53.33	19.01	11.67	21.99	28.81
3	49.05	60.22	9.65	10.86	36.67	25.15
4	43.78	52.58	11.05	12.48	42.41	32.09
5	54.22	46.76	9.65	12.27	34.63	37.75
6	52.07	47.60	8.60	8.71	32.39	39.32
7	42.61	50.12	8.63	12.34	37.99	30.27
8	45.41	50.45	12.09	15.80	32.80	25.27
OVERALL MEAN	47.67	50.72	11.96	12.13	34.35	31.55
$t_{cal.}$ 14, .05	1.374 N.S.		0.109 N.S.		1.001 N.S.	
$t_{tab.}$ 14, .05 = 1.761						

Table 1. Student's "T" test of the longitudinal distribution of Trichoptera, Ephemeroptera, and Diptera taken from the Mississippi River near Monticello, Minnesota during the years 1969 and 1970. Numbers recorded represent yearly average percent of the total for a specific transect for the respective year.

TRANSECT	TRICHOPTERA 1969	TRICHOPTERA 1970	EPHEMEROPTERA 1969	EPHEMEROPTERA 1970	DIPTERA 1969	DIPTERA 1970
E	35.60	45.18	16.07	16.60	38.20	30.29
R	45.44	50.64	15.66	10.31	32.30	33.94
C	51.60	50.15	14.49	11.95	31.57	32.69
L	41.46	47.77	11.02	13.28	41.26	32.42
YEARLY MEAN	43.53	48.44	14.31	13.04	35.83	32.34
$t_{cal.}$ 6, .05	1.137 N.S.		0.722 N.S.		1.422 N.S.	
$t_{tab.}$ 6, .05 = 1.943						

Table 2. Student's "T" test of the lateral distribution of Trichoptera, Ephemeroptera, and Diptera taken from the Mississippi River near Monticello, Minnesota during the years 1969 and 1970. Numbers recorded represent yearly average percent of the total collected at each station for the respective year.

bi-or trivoltine. This organism was not collected during the winter sampling period and if it was truly absent from the river during this period of time, it would be a bivoltine organism with two short summer cycles and two major periods of emergence. The first emergence occurred in the middle of summer and the second major emergence occured in the latter part of the fall. This theory was also supported by laboratory observations. During midsummer there was a definite bimodal size frequency distribution present with a large group of organisms nearly ready to emerge and a second large group of organisms which appeared to be very small and early in their development.

Stenonema appeared to be univoltine with a possible extended period of emergence similar to that of the caddisflies.

Finally, the genus *Ephemerella,* although it had a very small population, was the only group of organisms where an insect cohort could be followed. It was similar to *Ephemerella* as discussed by Crawford (1971), whereby *Ephemerella* was a univoltine organism with ecolosion occurring in the fall, and then a continual decrease in population numbers occurring as some of the individuals died, with ecdysis occurring in the following spring.

A simple ecological community discussed

On the basis of the small number of both plant and animal species present, the river segment of this study seemed to be a relatively simple ecological community. Odum (1959) reported that out of the numerous kinds of organisms generally present in a community, relatively few exert the major controlling influence by virtue of their numbers, size, or activities. Odum referred to these "key" organisms in the community as ecological dominants. It would appear the *Hydropsyche* and *Cheumatopsyche,* representing 44.5 percent of all macroinvertebrates collected during 1969 and 1970, were the ecological dominants of this Mississippi River benthos community.

The order Plecoptera, which is typically quite abundant in fast-flowing water, was well represented in terms of number of species but the total population size was very small when compared to the orders Trichoptera, Ephemeroptera, and Diptera. This would tend to indicate that the stoneflies (Plecopterans) were living in marginal conditions for their survival and additional stress on the river community may have drastic consequences for this group of organisms.

Significant differences in organism abundance were detected between months, and this would be expected as the river environment changed quite dramatically during the course of a year, with temperature probably the single most important variable. Macan (1957) felt that certain species of macroinvertebrates were absent from particular streams and rivers because the water warmed too rapidly between cold winter temperatures and summer thermal death temperatures. Additionally, Macan (1960b) stated that nymphs, such as *Rhithrogena semicolorata,* which had not emerged by the time the "upper limit of tolerance" temperatures arrived, were thermally killed. Macan (1960a) also believed that water temperature and not the particular size of various organisms was instrumental in triggering emergence from water to avoid thermal kill.

Since one major thrust of research was to evaluate thermal addition to a river environment, general comments can be made about the effects of temperature changes on the macroinvertebrate bottom fauna as observed during the sampling period. The fauna did appear to undergo a seasonal cycle of maximum abundance in the latter part of the summer to minimum abundance in winter. Specimens collected in the earlier parts of summer (May and June) tended to be larger sizes of invertebrates from a particular group which would soon be emerging. As new generations were produced, these were collected in the latter part of the summer, and were usually small individuals, probably first, second or third instar larvae. Whitney (1939) apparently referred to this phenomenon when he reported that small specimens were more resistant to higher temperatures, which occurred in late summer, than larger organisms. Thus, the particular seasonal cycles of the various organisms enable them to cope with the higher summer temperatures and exist in an area where they might otherwise have been eliminated. This adaptation is carried to an extreme by members of the genus *Ephemerella* which over-summer in the egg stage, and complete normal development during the fall and winter. In this case, emergence occurs in the spring and a new life cycle begins before the high temperatures of summer are reached. Here, the egg stage, being very small, is apparently thermally resistant and the organism subsequently can complete a life cycle in waters where normal summer water temperatures are high enough to kill larvae.

Finally, the same general seasonal cycle reported in this research was previously reported by Tebo and Hassler (1961) during their work with the Coweeta drainage basin of North Carolina.

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