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BOTTOM TYPE AS A FACTOR INFLUENCING THE LOCAL DISTRIBUTION OF MAYFLY NYMPHS

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During the fall and winter of 1938 the author conducted a brief study of the food habits of trout in Rattlesnake Creek, Missoula County, Montana. In the course of this investigation numerous bottom samples were taken, the final analysis of which yielded interesting but incomplete information concerning the distribution of several species of mayfly nymphs over part of the stream. It was apparent from these samples that the mayfly species composition of the fauna varied markedly over the comparatively short section of the stream studied, and marked changes were noted in the dominance of certain species within one particular area. The present study was carried out to determine more specifically the differences in species composition over this section of the stream, and to observe the conditions that might be associated with the known differences in relative numbers of the nymphs of several species.

THE AREA STUDIED AND METHODS

Rattlesnake Creek is a small spring-fed creek which retains a fairly uniform flow throughout the year. For a short period during the spring melting snows raise the water level considerably and the flow may be torrential for a short time. The water is clear except for this brief flood period, and low temperatures with high oxygenation obtain the year around. The fact that the stream is well shaded throughout most of its course helps in maintaining uniformly low temperatures. Preliminary chemical studies showed that oxygen and carbon dioxide content, and hydrogen-ion concentrations for any one period were practically the same over the limits of the stream studied. Although a small dam divides the study area, it appeared not to be a modifying factor. The portions of stream lying immediately below the dam showed an average temperature of from one to three degrees (C) higher, but aside from this no differences attributable to the dam were noted for the two areas.

The portion of the stream selected for study is clearly separable into two sections. One section (Region 1) extends from the point where the stream enters the Clark fork of the Columbia River to the small dam lying about two and one-half miles upstream. The creek bed in most of this region is broad with numerous shallow riffles. The bottom is composed of gravel and small stones with large rocks and boulders occurring only sparingly. Precipitated organic material is present over much of the stream bed in this area. Study in this portion of the stream was confined to a short area one-half mile in length below the dam. A short distance above the small dam (Region 2) the creek narrows down and a profound change is seen in the nature of its bed. Boulders and large rock fragments form the greater part of the bottom and only slight amounts of precipitated organic materials are present. Flat rock ledges in part of the creek bed and sheer rock walls contrast with the low soil banks of the lower part of the stream. Collections in this area were confined to a half-mile stretch immediately above the dam.

Because of the nature of some collecting sites exact quantitive measures were not attempted. The size of the sample taken was, however, kept as nearly uniform as possible. Samples were taken by churning a bottom area about 16 inches square and catching the dislodged insects in a net which was placed immediately below. All the nymphs taken in the collection were later identified and counted so that the relative numbers of each species could be determined. The type of bottom, stream depth, and position of insects in the habitat were recorded for each collection. The approximate velocity was taken by means of a small accoustic current meter. An equal number of collections were made in each region and in situations showing similar surface velocities.

RESULTS

Table 1 shows the 12 commonest species found, arranged in order of abundance as they occurred in the two regions studied. The relative numbers of each species as indicated is based on the per cent by total of all nymphs collected.

TABLE 1

The 12 Commonest Species Arranged in Order of Relative Abundance as They Occurred in Collections from Regions 1 and 2.

Region 1		Region 2	
Species	Abundance	Species	Abundance
Cinygmula sp.	A	*Ironopsis* sp.	A
Ephemerella inermis Eaton	C	*Ephemerella doddsi* Needh.	C
Ephemerella yosemite Trav.	C	*Rhithrogena doddsi* McD.	C
Ephemerella doddsi Needh.	P	*Ephemerella inermis* Eaton	C
Rhithrogena doddsi McD.	P	*Rhithrogena virilis* McD.	C
Leptophlebia adoptiva McD.	P	*Iron longimanus* Eaton	P
Baetis intermedius Dodds	P	*Cinygmula* sp.	P
Rhithrogena virilis McD.	P	*Ephemerella* sp.	P
Iron longimanus Eaton	P	*Baetis intermedius* Dodds	P
Ephemerella sp.	P	*Leptophlebia adoptiva* McD.	P
Baetis vagans McD.	P	*Baetis vagans* McD.	P
Ironopsis sp.	P	*Ephemerella yosemite* Trav.	*

A—Abundant. Averaging over 25% of all mayfly nymphs taken.
C—Common. Averaging 10 to 24% of all mayfly nymphs taken.
P—Present. Averaging less than 10% of all mayfly nymphs taken.
*—Not taken in this portion of the stream.

Several significant differences in the population composition of the two areas can be seen from Table 1. *Cinygmula* sp., which proved to be nearly twice as common as all the other species combined in region 1, is only seventh in order of abundance in region 2, and some collections made above this point indicated that the species becomes less common upstream. Similarly, *Ironopsis* sp., the commonest nymph found in region 2, was last in order of abundance in region 1. Another significant difference is seen in the relative numbers of *Ephemerella yosemite* Trav. taken. This nymph, which was consistently taken in the lower region, did not occur in collections from the upstream section. Other species were observed to be more common in one or another section of the stream but the differences were not so marked.

Analysis of collections further showed that the three species exhibiting the most pronounced differences in local numbers were also the most consistent in the "selection" of a given type of substratum. For instance, *Ephemerella yosemite* showed a decided "preference" for a rubble bottom, and reached the greatest concentrations in this situation when there was an overlay of organic material present. These requirements of bottom type were most commonly met with in region 1. *Cinygmula* sp. was taken most often over a bottom of intermediate sized rock and "avoided" the extremes of gravel and boulder bottoms. This nymph was the decided dominant in region 1 where the stream bed was principally of this nature. The nymph, *Ironopsis* sp., was observed to be the dominant form in the upper portion of the stream where flat-rock ledges made up much of the stream bed. With the exception of *Ephemerella doddsi* Needh., other members of this genus taken showed definite "preferences" for areas containing some organic debris although they were not completely restricted to this condition. The 12 commonest species taken, with notes on the conditions under which they occurred in greatest numbers, are given in Table 2.

TABLE 2

Observations of the Commoner Species Collected and Where They Were Found in Greatest Numbers.

Species	Preferred habitat (bottom type)	Position in habitat	Range of surface velocities (ft. per. sec.) over habitat in which found.
Cinygmula sp.	Rock-rubble. "Avoided" gravel and boulder bottoms.	Under stones.	0–8
Ironopsis sp.	Rock-boulder and rock ledges.	Mostly on underside of rocks. Moved freely over boulder surface.	0–8
Ephemerella yosemite Trav.	Rubble bottom in shallow riffle with organic debris.	On and under organic material.	0–5
Ephemerella doddsi Needh.	Deep rapids, smooth rocks and boulders, clean bottom.	Common on under side of rocks. Observed on sides and top of boulders.	0–8
Ephemerella inermis Eaton	Gravel-large rock when trash present.	In gravel and trash. Occasionally between rocks.	0–8
Ephemerella sp.	Gravel-large rock when trash present.	In gravel and trash. Occasionally between rocks.	0–8
Rhithrogena virilis McD.	Rubble beds around base of boulders.	Moved about quite freely. On and under stones.	0–8.5
Rhithrogena doddsi McD.	Rock-boulder.	On and under rocks. On sides of boulder near base.	0–8
Leptophlebia adoptiva McD.	Large rock.	Behind and under stones.	0–8
Iron longimanus Eaton	Stream's edge. Silt covered rocks.	On and under stones. Moves over stone surface.	0–8
Baetis intermedius Dodds	Stream's edge. Silt covered rocks. In swifter regions.	On and under stones. Occasionally on boulders.	0–8
Baetis vagans McD.	Large rocks.	Free ranging. Occasionally on boulders.	0–8

DISCUSSION

Students of lotic communities have generally considered the rate of flow of water to be of paramount importance in governing the distribution of aquatic organisms. Hora (1929) has stated: "Of the physical conditions that influence the ecological distribution of the torrential fauna, the principal one is the rate of flow of the current." The "morphological adaptations" of various mayfly nymphs to conditions of stream flow have been pointed out by Dodds and Hisaw (1924). It has since been demonstrated by Ide (1935) that over the course of a stream the distribution of mayflies is governed largely by temperature of the water. In this connection he further suggests that: "Within the limits set by temperatures are other limits set by the strength of current and the nature of the bottom." It can generally be concluded from his work that the general distribution of mayflies is limited primarily by temperature differences but local distribution may be affected by other physical or biological factors. The response of one species (*Chirotnetes albomanicatus* Needh.) to some of these factors has been studied in some detail by Clemens (1917). Clemens showed the importance of the bottom in controlling the rate of flow of the water and found that although the nymphs of *C. albomanicatus* were capable of sustaining themselves in a flow of 4.3 feet per second, they lived in a much diminished current. They were able to accomplish this by living beneath stones and rubble, a bottom type for which they showed a decided "preference" even when stream velocity was low enough to be of little consequence.

The present study clearly indicates the response of several species to certain conditions of bottom type and shows the importance of this factor in governing the local distribution of mayfly nymphs. Certain species were observed to "select" certain bottom types without respect to stream velocity, and this "preference" was further observed to be strong enough in several cases to limit some species to those portions of the stream in which certain requirements of bottom type could be met. The differences, between two sections of the stream, in the relative numbers of certain nymphs, showed a correlation with the type of bottom most characteristic of either section, and given species reached their greatest numbers in parts of the stream where the "preferred" substratum was general. In evaluating these apparent effects of bottom type it is appreciated that the type of bottom and flow of water are in a measure inseparable. In the final analysis the composition of the stream bottom is determined by the flow of the water which consequently must be considered the primary factor. Within small units of a stream, however, the direct effects of current and bottom type can be observed independently, and the present discussion refers to stream flow as such a force in the immediate environment of aquatic organisms.

Since the nature of the bottom can so profoundly affect the rate of flow of water it appears that stream flow, as such, would necessarily be of secondary importance to bottom-dwelling forms. An irregular bottom affords many places of greatly reduced velocity so that even where the surface speed may be torrential, species not "morphologically adapted" may inhabit these situations by avoiding the main force of the current. In this connection it might be pointed out that specimens of *Leptophlebia adoptiva* McD., an extremely fragile crawling form, were consistently taken in sites where the surface velocity was up to 8 feet per second, a feat which it was able to accomplish by keeping to the bottom and living beneath and behind the larger rocks. That this "preference" for larger rocks was not strictly a means of avoiding the current is, however, shown from the fact that this species was also common in this type of bottom in parts of the stream where the surface velocity was greatly diminished. No instance was observed where the distribution of any species within the stream bed appeared limited by the action of stream flow, as such. It was noted, however, that the position of many species in a given site was apparently determined by the stream velocity. Observations made on large boulders in torrential parts of the stream showed that the localization of various species on boulders was quite constant in many cases. For instance, in a surface velocity of 8 feet per second the top surface of a 20-inch boulder was most often observed inhabited by nymphs of *Ironopsis* sp., *Baetis intermedius* Dodds, and *Baetis bicaudatus* Dodds, the stream velocity at this point being from five to eight feet per second. These species often had a general distribution over the rock surface but were usually the only ones found on the tops of the boulders where the speed is greatest. Midway on the sides of the boulder where the stream speed measured from two to four feet per second, were found the species *Iron longimanus* Eaton and *Ephemerella doddsi* Needh. These two species could occasionally be seen near the surface of the boulder but on the downstream side where the current is reduced. *Baetis vagans* McD., a free ranging species, was observed in positions where the flow was up to four feet per second, and the nymph of *Rhithrogena doddsi* McD. when present on boulders, was usually confined to the lower sides where the current did not exceed two feet per second. Nymphs of the remaining species were most commonly taken on the smaller stones of the bottom and between and under the stones around the boulder. Nymphs of *Cinygmula* sp., and *Rhithrogena virilis* McD., were observed only on the bottom between and under stones, and *Ephemerella inermis* Eaton and *E. yosemite* Trav. were found to occupy the debris which usually gathers around the base of boulders. This zonation of species demonstrates the part stream speed may play in bringing about what might be termed vertical distribution due to the varying ability of different species to withstand current.

SUMMARY

In a study conducted to determine the factors responsible for limiting the local distribution of mayfly nymphs, it was found that:

1. Each of several species studied occurred in greatest concentrations in well defined types of stream bottom.

2. The requirements by several species of nymphs for a given type of substratum were so well defined as to exclude them from portions of the stream lacking in given bottom types. Limitations on the local distribution of these species was the observed result.

3. Stream flow, as such, appeared to be of no appreciable consequence in limiting local distribution, and most species were observed capable of inhabiting situations under a wide range of surface velocities wherever acceptable bottom types occurred.

4. Within a given site, stream flow appeared responsible for a vertical distribution of nymphs, due presumably to the different abilities of species to withstand current.

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