DRIFT OF STREAM INVERTEBRATES BELOW A CAVE SOURCE*

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Abstract

Stream invertebrate drift below the cave source of South Branch Creek, Minnesota, generally increased rapidly. Ephemeroptera and Trichoptera increased rapidly and then decreased at the lower stations (to 430 m) below the cave. Chironomidae drift, in high numbers but low biomass because of their small size, increased fairly rapidly and leveled out at the lowermost stations. Gastropods increased slowly below the cave, reached a maximum, then decreased somewhat at the lowermost station. Drifting oligochaetes, small in size but in very large numbers, increased more slowly below the cave and appeared not to have reached a maximum at the lowermost station. It was concluded that, in general, drift increases fairly rapidly below the stream origin and fluctuates in the upper reaches, probably reflecting benthic population abundance and local ecological conditions, before attaining equilibria downstream, rather than increasing linearly due to cumulative effects.

Introduction

The drift of stream invertebrates has received a great deal of study over the past 20 years. Of particular interest have been diel periodicities in drift with the probable involvement of circadian rhythms, possible upstream compensatory migrations, utilization of drifting organisms by predatory fish, and the relationship between drift rate and benthic invertebrate production. In these past two decades many intensive studies have been carried out in individual streams (e.g., Bailey, 1966; Elliott, 1967; Bishop & Hynes, 1969; Clifford, 1972; Bishop, 1973; Neveu & Échaubard, 1975; Cowell & Carew, 1976), and at least five general reviews of the subject have been published (Waters, 1969, 1972; Chaston, 1972; Bournaud & Thibault, 1973; Müller, 1974).

Drift, by its nature, is measured in some form of density, i.e., per unit volume of water, but the producing source of the organisms is measured by the standing stock or production rate per unit area of stream bottom. Whereas a number of investigations have attempted to correlate drift with standing stock or production (Waters, 1961; Dimond, 1967; Pearson & Kramer, 1972; Hildebrand, 1974; Waters & Hokenstrom, 1980), the functional relationship between the two concepts remains elusive. Involved is the distance of drift, but the few studies on this subject (Waters, 1965; McLay, 1970; Elliott, 1971) have not provided the kind of data that would elucidate the basic functional relationship. Unanswered problems that remain include a determination of the stream bottom area required, through production, to provide the observed drift; the substrate area or stream length upstream that is the effective source of drifting organisms; the pattern of drift development downstream from a stream's origin and possible cumulative effects downstream as drifting organisms pass through or over continuously producing substrate areas. One of these questions that would appear to provide a start in the above directions is the pattern of drift development downstream from a stream source – in effect, from point zero. The absolute beginning of a stream, however, is often difficult or impossible to identify. Alternative possibilities for studying the same question, some pioneering attempts at which have been published, include blocking the entire drift in a stream and measuring the drift downstream at successive points (Waters, 1965; Elliott, 1971), measuring drift at successive stations below an impoundment (Radford & Hartland-Rowe, 1971), or measuring drift below a spring or cave source.

The opportunity to do the last of the above was found in a stream in southeastern Minnesota, South Branch Creek. It is a stream typical of others in the karst topography of the 'driftless area' (parts of Wisconsin, Minnesota, Iowa, and Illinois), in which underground streams occur and emit from caves. The stream lies almost entirely in Forestville State Park, a unit of Minnesota's state park system, and thus is well protected from streambank erosion or other physical disturbance; however, it remains potential-

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ly susceptible to contamination from agricultural chemicals used in upland runoff sources.

The stream contains a self-sustaining population of the introduced brown trout (*Salmo trutta* Linnaeus). There is no road access available to the public, although public angling is permitted by foot access in the state park. It is managed as a wild trout sport fishery. The brown trout standing stock has been measured at about 150 kg/hectare, suggesting high productivity, and the stream is well considered by the angling public.

The present study is an initial part of a planned long-range project on production and trophic ecology of the brown trout population, including the relationships between trout production and feeding and invertebrate drift.

Description of study area

South Branch Creek originates from a cave (Fig. 1) in limestone formations in section 25, Range 12W, Town 102N, Fillmore County, southeastern Minnesota; it is also locally known as Canfield Creek. Waters from upland agricultural areas apparently drain through limestone fissures with little filtration; during and after storm events or springtime snow melt, turbid water containing large detrital particles emit from the cave source. The water is oxygenated at near air saturation. Under normal low-water conditions the stream water is with little color or turbidity (about 1 NTU). Small springs enter the stream throughout its course, and discharge increases rapidly; base-flow discharge is about 0.01 m^3/sec at the cave, and at the mouth discharge is normally about 0.20 m^3/sec. Water temperature remains relatively low in summer because of the subsurface drainage and subsequent springs, rarely over 10°C. Alkalinity at low water levels was about 260 mg/liter, but lower during times of higher runoff; pH was usually about 7.5; nitrate nitrogen usually was about 5-6 mg/liter.

Physiographically, the stream is composed of alternating long pools or sandy runs with short, steep riffles; the pools and runs are often heavily grown in with water cress (*Nasturtium* sp.). Bottom types include sand and fine gravel in the pools and runs, and flat, blocky cobbles of limestone in the riffles. Besides the brown trout, fishes include the slimy sculpin *(Cottus cognatus),* white sucker *(Catostomus commersoni),* longnose dace *(Rhinichthys cataractae),* and American brook lamprey *(Lampetra lamottei).* The creek is 2.5 km long and empties into South Branch of the Root River, which in turn is eventually tributary to the Mississippi River in Houston County, Minnesota.

A reach of stream 430 m long below the cave source was used for the study section. This section included several pools and short riffles, as described above, much water cress and several small springs. Mean width was 9 m. The gradient over this reach was 3.2 m/1000 m. Discharge at the cave mouth and all sampling stations, for both sampling dates, is given in Table 1. Other physical and chemical data were as described above.

Table 1. Discharge of South Branch Creek, Minnesota, below its cave source on the sampling dates, 1977 (m^3/sec).

Date	Distance downstream from cave (m)				
	0	16	75	235	430
20 Jul	0.025	0.051	0.081	0.129	0.136
15 Sep	0.007	0.015	0.023	0.044	0.050

Methods

Drift sampling was conducted on the dates of 19-20 July, 1977, and 14-15 September, 1977, each set covering a full 24 hr. Two drift nets were set at each of five stations, in such a manner as to intercept the main flow of the current and so that, as closely as could be judged at the time of setting, the two nets would sample an equal flow of the stream. The five stations were located at the cave mouth (Fig. 1) and 16, 75, 235, and 430 m downstream from the cave. The nets were constructed of 253-μm mesh Nitex, measured 15 cm wide at the mouth, 2 m long, and were set so as to intercept the water column from the bottom substrate to above water surface. Nets were set in the morning after full daylight and retrieved at the same time the following day; in July, day and night samples were obtained separately, with net changes at about sunset. No clogging so as to cause backwash occurred. Upon retrieval of all nets, sample material including invertebrates and other material collected were preserved in plastic sample bags in 10% Formalin for transport.

Following collection of the drift samples, data on water temperature, color, turbidity, total alkalinity, pH, dissolved oxygen, and nitrate nitrogen were taken at each station. Discharge of the entire stream and also through each individual drift net was measured with the use of a current meter. Gradient was measured (20 July 1977) with hand level and level rod.

In the laboratory, all aquatic invertebrates were manually separated from other debris and sorted into major taxonomic groups. These groups were counted, centrifuged in a fine screen to remove external water, and weighed on a balance to the nearest 0.1 mg to obtain wet weight. Caddisfly larvae were removed from their cases, and gastropods were decalcified with 0.1 N HCl, prior to weighing. For each station, separately from the contents of each net, the total drift from the entire stream was calculated by multiplying the sample weight by the ratio of stream discharge: net discharge. The drift was then expressed in terms of numbers or weight/day per m^3/sec, a term useful for comparison since it expresses daily drift per unit of stream discharge (Waters, 1972).

Results

Virtually no organisms drifted out of the cave. A fair number of chironomid larvae appeared in the nets set in the cave mouth, but these were very small and were presumed to have crawled into the net, perhaps through the mesh. An occasional gastropod and caddisfly larva also appeared in these nets, presumably by the same mode. No organisms which were considered true crenobionts were found.

Drift samples below the cave contained substantial numbers of specimens from several major taxa: Ephemeroptera, Trichoptera, Chironomidae, Muscidae, Gastropoda, and Oligochaeta. These groups formed the basis for

Fig. 1. Cave source of South Branch Creek, with drift nets set at cave mouth and first downstream station.

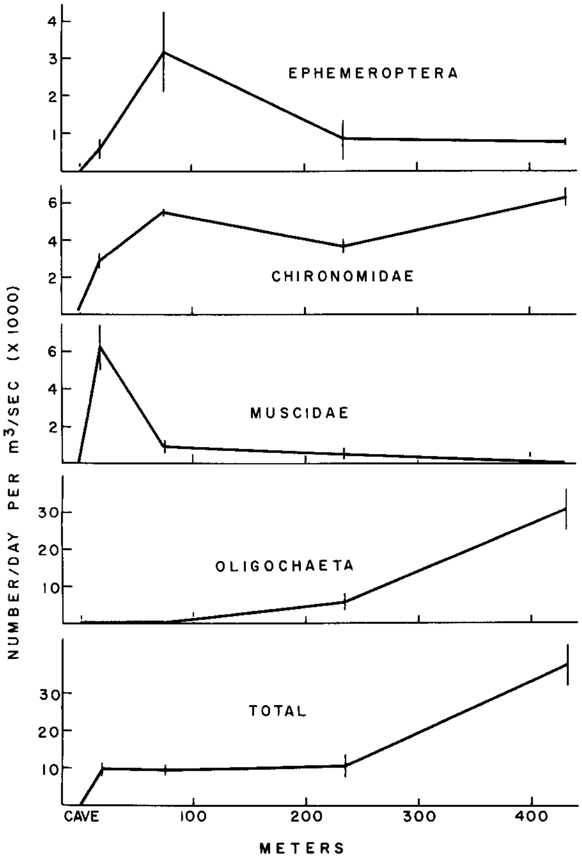

Fig. 2. Drift of invertebrates downstream from cave source, South Branch Creek, 19-20 July 1977 (1000's).

principal analysis (Figs. 2-5). Other taxa were present but not sufficiently in either numbers or biomass to enable an examination of drift development below the cave. These included occasional specimens of Isopoda, Corixidae, Turbellaria, several Coeloptera larvae, and several dipterans other than Chironomidae.

Ephemeroptera

The mayflies were represented only by *Ephemerella* in July, and by *Ephemerella* and *Baetis* in September (mostly the former). Drift by weight was relatively less in September, apparently because the September samples were made up of new generations. On both dates, *Ephemerella* drift increased rapidly below the cave to reach maxima at the second or third station (16 or 75 m), then decreased, and appeared fairly level in drift at the last two stations (235 and 430 m). In July, when day and night samples were separated, *Ephemerella* drift was substantially greater in the nighttime samples. Of the major groups, the mayflies were present in the drift in lowest numbers, but because of their relative larger size, not in the least weight.

Trichoptera

Caddisfly larvae of the genera *Brachycentrus, Microsema,* and *Glossosoma,* and unidentified Hydroptilidae constituted this group, primarily the first two. By far, these occurred in the September samples, with only an occasional specimen in July; presumably, this temporal distribution represented the seasonal development of new generations in the latter part of the summer. Somewhat similar to Ephemeroptera, the caddisfly drift reached a maximum fairly rapidly below the cave (75 m) and then decreased; the Trichoptera accounted for the highest numbers and greatest weight of all major groups in the reach of stream close to the cave but decreased to very low levels at the last station (430 m).

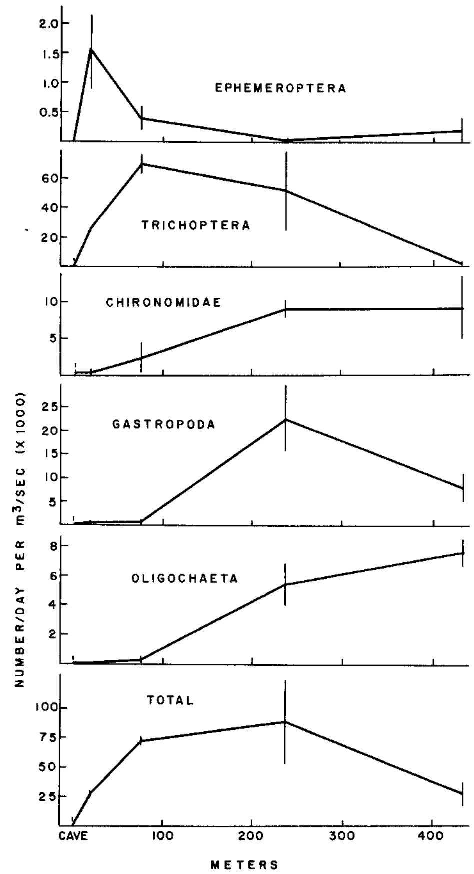

Fig. 3. Drift of invertebrates downstream from cave source, South Branch Creek, 14-15 September 1977 (1000's).

Chironomidae

Midge larvae occurred in high numbers but very low weight, reflecting their small size, in both the July and September samples. Drift increased fairly rapidly below the cave, reaching maxima in numbers at the second or third station (16 or 75 m), and then essentially leveling out to remain at high rates. Presumably this group included many species with several overlapping generations, so that the chironomids as a group comprised a substantial proportion of the drift at all seasons. In July, drift was highest in the nighttime samples.

Muscidae

The muscid larvae drift was somewhat of an anomaly, not having been reported previously in stream invertebrate drift in substantial quantities. Of the major groups, in July, these larvae constituted the highest proportion in both numbers and weight at the second station (16 m), and then decreased sharply. There was no indication of a day-night difference in July, and they were present only occasionally in September.

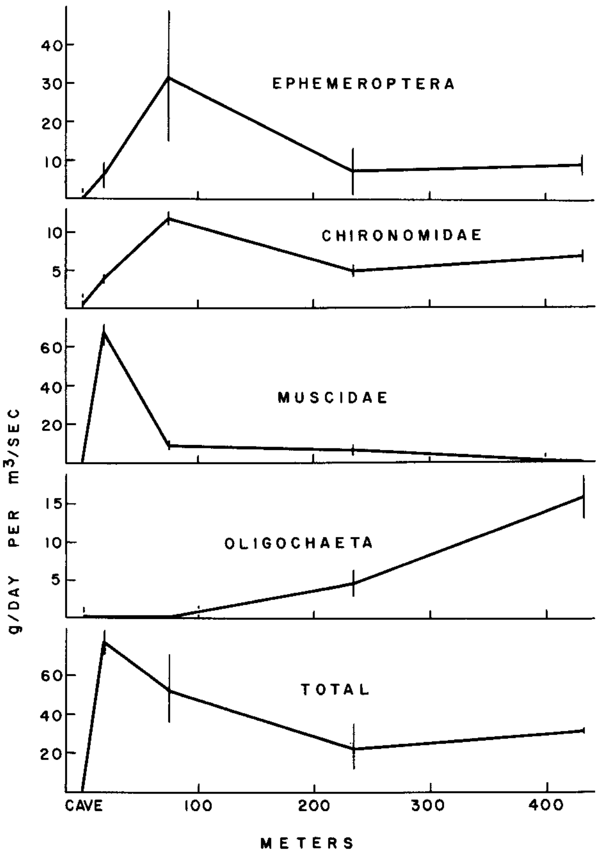

Fig. 4. Drift of invertebrates downstream from cave source, South Branch Creek, 19-20 July 1977 (g, wet weight).

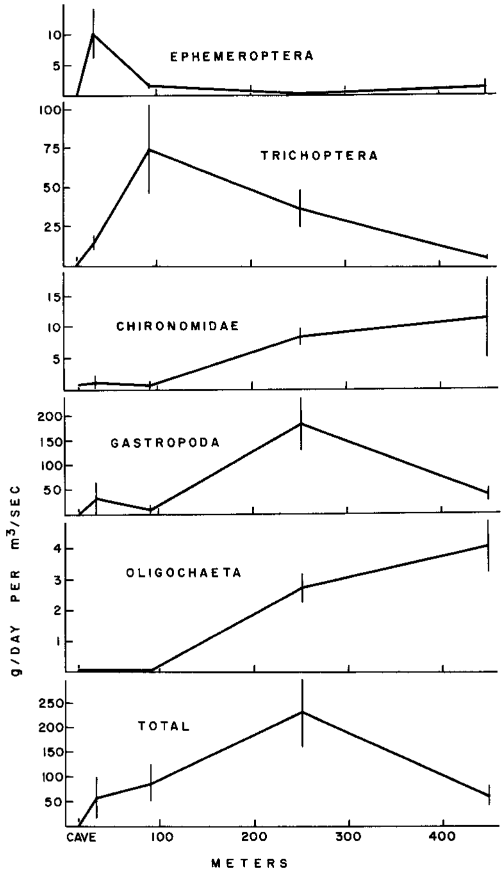

Fig. 5. Drift of invertebrates downstream from cave source, South Branch Creek, 14-15 September 1977 (g, wet weight).

Gastropoda

Snails were rarely present in July samples but constituted a substantial proportion of the drift in September when, because of their relatively large size, they were by far the major component by weight. They did not increase rapidly in the drift below the cave but rather reached a maximum at the fourth station (235 m), in both numbers and weight, and then decreased somewhat at the last station.

Oligochaeta

Aquatic earthworms were the most numerous of the major groups in both July and September, although of very small size, so that in weight they accounted for relatively small proportions of the total biomass at most stations. In July, there was a clearly higher drift at night than during the day. The oligochaete drift was low immediately below the cave and increased more slowly than others; of all major groups, this one was the only one that appeared not to have reached a maximum before the lowermost station, on both dates.

Discussion

The major conclusion that can be drawn from the results is that the drift of most taxa reached maxima or stable levels rather rapidly below the stream source. With the possible exception of the Oligochaeta, the drift of all major groups varied either with a rapid increase and subsequent decline to lower levels, or had increased to stable levels, by the distance of the lowermost station (430 m below the source). In terms of total weight, drift reached either stable levels or maxima before the lowermost station, most probably near the fourth station (235 m). In this case, and perhaps in other streams as well, there is an initial reach of stream in which benthic populations fluctuate and alternate according to local ecological conditions, favoring first one taxon and later others, until some equilibria are attained; in this case, at least, there does not appear a simple, gradual increase due to cumulative events. Whereas this effect may obtain farther downstream, in the initial reaches, at least, the drift (presumably reflecting benthic populations in both quality and quantity) fluctuates in accordance with local conditions. These conclusions would further suggest that the distance of drift may be fairly short, with such factors as predation by fish and other mortality having predominant effects upon drift, rather than a linear cumulative effect determining the levels of drift at successive points downstream from the source.

The subject of a diel periodicity in drift was little investigated in the present study, as it was not a basic objective of the work. However, in July, when the samples were taken separately for day and night, they indicated a predominance of drift during the night for all groups analyzed except Muscidae. This observation is in conformance with the general observation that most species exhibiting behavioral drift are night-active (Waters, 1972; Müller, 1974).

The presence of brown trout was observed essentially up to the cave mouth, and data from the Minnesota Department of Natural Resources fisheries surveys indicated good populations, including natural reproduction, throughout the stream length up to near the cave mouth (data from 1974, personal communication, Minnesota Department of Natural Resources). It would appear, therefore, that benthic invertebrate populations develop quickly after underground waters emit from the cave source, including drift.

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Summary

The drift of stream invertebrates was measured below the cave origin of South Branch Creek, Minnesota, in order to gain information on the rate of development of drift downstream from a stream source. South Branch Creek, an ultimate tributary of the upper Mississippi River, lies in the 'driftless area' of central U.S.A., wherein karst topography occurs; it originates from a cave from which waters from upland agricultural lands emit to form the initial source of the stream. Daily drift samples were collected in July and September, 1977, at the cave source and 16, 75, 235, and 430 m downstream from the cave. No crenobiont organisms were observed drifting from the cave.

Several major taxonomic groups were observed drifting in substantial quantities below the cave source; these were absent or represented by only occasional specimens at the cave mouth.

Ephemeroptera drift increased rapidly below the cave, then decreased to moderate levels at lowermost sampling stations. Trichoptera drift was essentially absent in July, but in September caddisfly larvae of presumably new generations drifted at high rates, developing fairly rapidly below the cave but decreasing to low levels at the stations farthest downstream. The drift of Chironomidae larvae occurred in high numbers but low biomass, because of their small size, on both July and September dates, increasing fairly rapidly below the cave and leveling out at high rates at the lowermost stations. Larvae of the dipteran

Muscidae drifted in high numbers and biomass below the cave in July, but they decreased rapidly downstream; they were barely present in September. Gastropoda were present in the drift only in the September samples; drift increased slowly below the cave, but it decreased somewhat at the lowermost station. Because of their relatively large size, the snails constituted the major biomass in September. The Oligochaeta was the most numerous of the major taxa at both sampling dates, although low in biomass because of their small size. The Oligochaeta was the only group that did not reach a maximum before the lowermost sampling station. In the July samples, when day and night samples were separated, all major groups exhibited higher drift at night than during daytime, except the Muscidae which showed no diel periodicity.

It was concluded generally that drift developed rapidly below the stream origin, reflecting benthic populations that probably also reached high abundance levels within short distances below the cave source. The levels of drift immediately below the source thus appeared to be responsive to local ecological factors rather than a linear cumulative effect.

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