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The macro-invertebrate fauna of a small Andean stream

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SUMMARY. The benthic fauna of a small headwater stream in the Amazon drainage in Ecuador was studied from August 1976 to July 1977. The sampling station was at an altitude of 3300 m in a typical paramo habitat of constant and cool temperatures. The fauna is dominated numerically by Hydracarina, Insecta, Copepoda and Oligochaeta. The major insect groups are Ephemeroptera, Plecoptera, Trichoptera, Elmidae (Coleoptera) and Chironomidae (Diptera). Benthos densities followed a bimodal pattern of rapid decreases and intervening gradual recoveries; similar patterns occur in most taxa, but are more pronounced in smaller animals such as Copepoda and Hydracarina. An analysis of the size-frequency distribution of three species of mayfly, two of stonefly and six of caddisfly suggest non-seasonal life-cycles except for *Anacroneuria* sp. Spates are thought to be the major factor regulating benthic densities in such non-seasonal environments.

Introduction

Tropical streams are still poorly known, taxonomically and ecologically. The pioneering studies of Marlier (1951, 1954) and Malaisse (1969), in the Congo, Starmühlner (1968), in Indonesia, and Ramanankasina (1969), in Madagascar, showed that low-altitude streams supported the usual biota distributed in a classic manner between lotic and lentic habitats. The more detailed investigations undertaken as part of onchocerciasis control programmes (Crisp, 1956; Hynes *et al.*, 1961; Hynes & Williams, 1962; Williams & Hynes, 1971) and trout introduction projects (Van Someren, 1952) provided the first data on the zonation of the fauna with altitude; indeed, Illies (1961, 1964) was able to recognize typical rhithron and potamon communities in Peruvian river systems, and similar observations were made on West Indian mountain streams (Hynes, 1971; Harrison & Rankin, 1976) and a Malayan river (Bishop, 1973). Nonetheless, nearly all detailed studies on tropical running waters were conducted on low altitude systems (Fittkau, 1964, 1975; Green, 1970; Petr, 1970; Hynes, 1975a,b; Stout & Vandermeer, 1975) or the lower reaches of mountain systems (Patrick, 1966); in fact, Rio Chama in Columbia (Hirigoyen, 1976) appears to be the only cold tropical stream for which detailed ecological information is available.

Thus, during an extended stay in Ecuador, the opportunity was taken by the senior author to visit regularly a small stream in the paramo and to follow through an annual cycle the dynamics and the composition of its benthic fauna.

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The stream

The stream we investigated flows into the broad Quinuas valley near a site known as Chirimachay in the Cordillera Cajas some 20 km northwest of

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Cuenca in Ecuador (Fig. 1). It arises from Laguna Verde Cocha, a small crater lake, at an altitude near 4000 m and extends for some 1200 m to its junction at an altitude of 3300 m with the main river of the valley, Rio Matadero (also known as Rio Tomebamba and Rio Llulluchas); this river is a tributary of Rio Santiago, itself a major headwater of the Amazon (Fig. 1, inset). The stream has a very high grade for most of its course, except in its lower reaches on the valley floor. The surrounding vegetation is typical of the paramo and dominated by grasses (*Stipa, Festuca, Calamagrostis, Antropogon* and *Paspalum*) and shrubs (*Gynoxis* and *Polylepis*) (Wolf, 1975). Air temperatures are cool throughout the year with an average of 8–9°C, rains are frequent but irregular in the order of 800–1000 mm a year and fog is common; there is no distinct seasonality.

The stream remains cool at all times (5–13°C) and its flow is rather constant (13–30 $l\ s^{-1}$). Selected chemical and physical characteristics of the water were determined: pH 7.7–8.5; dissolved oxygen 10–11 $mg\ l^{-1}$; alkalinity 95–100 $mg\ l^{-1}$ (as $CaCO_3$); nitrates 3–4 $mg\ l^{-1}$; sulphates 4–6 $mg\ l^{-1}$; colour 5–20 Pt units; turbidity 1–5 FTU. Most values fall within the usual ranges, except the high concentrations of silicates (35 $mg\ l^{-1}$) which result from the underlying quaternary volcanic deposits.

Stream vegetation is scarce and the substrate is composed mainly of gravel and cobbles. There are no fish in the stream, though introduced trout occurs in the main river; frogs and tadpoles are numerous.

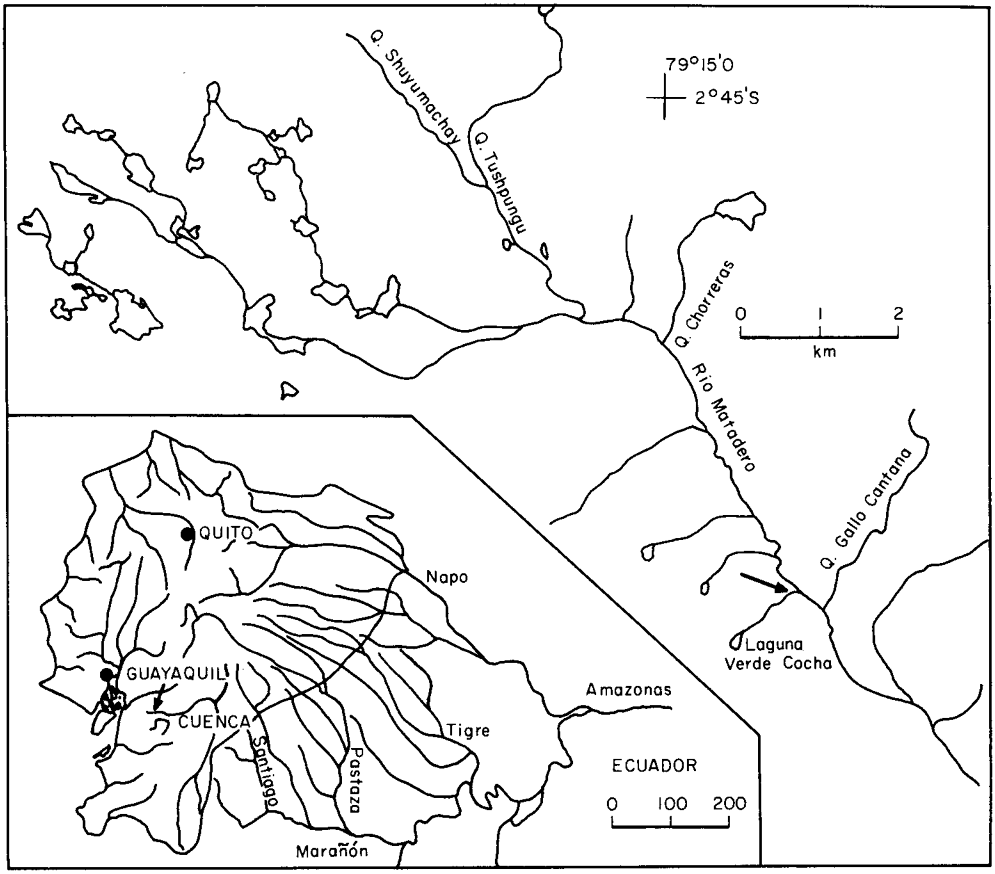

FIG. 1. Upper course of Rio Matadero. The position of the river in the Amazon basin is illustrated in the inset. The arrow marks the sampling site.

Methods

Samples were collected every month from August 1976 to July 1977 in the lower section of the stream. A bottom surface of *c.* 0.5 m^2 was disturbed with the foot and the dislodged material was collected in a dipnet (mesh size 0.2 mm) following the 'kick sample method' of Hynes (1961). Thus, semi-quantitative and comparable samples were secured for each month.

Representative specimens were deposited in the entomological collection of our institute.

Results

Composition of the fauna

Because of taxonomical problems, it was not always possible to identify our material precisely and our personal interests added a bias towards the insects. All discussions are based on numbers rather than on biomass, since many specimens were retained for taxonomic study.

The major components of the fauna are watermites (25%), insects (24%), oligochaetes (20%) and copepods (19%) (Table 1). The remaining groups are much scarcer: flatworms (3%), nematodes (2%), amphipods (2%), ostracods (2%), molluscs (0.2%) and leeches (0.07%). Terrestrial or riparian oligochaetes tend to appear sporadically in the benthos, especially following spates. Since three of the four dominant groups are very small animals, the insects—because of their greater size—constitute the predominant element of the fauna.

Despite the uniform conditions and the permanently cool temperatures, a wide variety of insects occur. As in most streams, the Diptera abound (64% of insects) followed in order by the Trichoptera (14%), the Coleoptera (13%), the Ephemeroptera (6%), the Plecoptera (3%) and the Odonata (0.02%).

Two families of Ephemeroptera, the Baetidae and the Leptophlebiidae, are present. *Baetis* is the most common genus (5% of insects) and is probably represented by two species. There is one species of *Baetodes* the larvae of which are identical to those of *B. serratus* Needham [by comparison with specimens from the type series, but they do not fit the redescription by Mayo (1968); we hesitate to call our material *serratus,* since the species is known only from Eastern Brazil (Needham & Murphy, 1924)]. The leptophlebiid larvae fit the description of *Atalonella* (Peters & Edmunds, 1972).

Two groups of Plecoptera occur in the stream: the common Andean *Claudioperla tigrina* (Klapálek) of the notogean family Gripopterygidae, as well as a species of *Anacroneuria* (Perlidae).

The Trichoptera are both abundant and diverse. The tiny Hydroptilidae are very abundant (6% of insects); the dominant forms are two undescribed species of *Oxyethira* and *Ochrotrichia (Metrichia)*; scattered larvae of *Neotrichia, Alisotrichia* and of what appears to be *Dibusa* were also collected. The Limnephi-

TABLE 1. Composition of the benthos

	Total number collected	Range in monthly samples	% of total
Platyhelminthes	1620	1–218	3.02
Nemathelminthes	1262	0–392	2.35
Annelida	11818	48–1929	22.01
Mollusca	124	0–33	0.23
Crustacea	12270	50–3135	22.85
Arachnida	13611	41–4502	25.35
Ephemeroptera	833	25–163	1.55
Odonata	2	0–1	0.004
Plecoptera	407	10–106	0.76
Trichoptera	1829	40–408	3.41
Coleoptera	1632	14–334	3.04
Diptera (Chironomidae)	7344	48–1198	13.68
Diptera (others)	940	20–201	1.75
Insecta	12987	205–2372	24.19
Total	53692	627–11265	

lidae rank second in number (4.8%), but clearly dominate when their large size is taken into account; there is only one species which agrees with Marlier's (1962, 1963) description of *Magellomyia illiesi* from Peru; this species is very common in the Cordillera and it may prove to be conspecific with other more southerly species, such as *Anomalocosmoecus subtropicalis* Schmid (1957). The larvae of four species of *Atopsyche* can be recognized, three of which were associated with adults and are still undescribed. *Nectopsyche* (Leptoceridae) larvae are common and two species can be distinguished, one much more abundant than the other. Other rare Trichoptera include larvae of *Phylloicus* (Calamoceratidae), *Diplectrona* (Hydropsychidae), *Helicopsyche* (Helicopsychidae) and small unidentifiable larvae of Brachycentridae.

The Coleoptera are numerous, particularly the Elmidae (12%), both as larvae and adults; Helodidae, Dytiscidae and Psephenidae occur as well, but their presence is sporadic.

Three groups of Diptera are clearly dominant: the Ceratopogonidae (2.1%), the Simuliidae (0.9%) and the Chironomidae (56%).

The prevalent species among the Ceratopogonidae belong to the *Bezzia-Palpomyia-Macropeza* group of Wirth (1962), the larvae of which are still indistinguishable.

The Simuliidae are represented by both Prosimuliini *(Gigantodax)* and Simuliini *(Simulium)*.

The Chironomidae are dominated by the Orthocladiinae (29% of insects) of which at least seventeen genera could be distinguished. The common species fit well into such cosmopolitan genera as *Cricotopus* (19%), *Limnophyes* (9%), *Psectrocladius* etc., but some of the rarer species are unknown to us and have been designated as gen. A, B etc. Similarly, in the Chironominae (19%, seven genera), the dominant species could be included in genera such as *Polypedilum* (0.08%), *Harnischia* (0.01%), *Pseudochironomus* (14%) and *Micropsectra* (4%). The Podonominae (7%, two genera) are relatively abundant as often occurs in neotropical mountain streams (Brundin, 1966). The Tanypodinae are much less so (1.3%) and contain only representatives of the widespread *Psectrotanypus* and *Zavrelimyia*. We have followed Roback's (1966) policy of inserting these species in existing genera when possible; however, the identifications, even at the genetic level, must be considered preliminary and serve to distinguish types of larvae within the samples.

Seasonal variations in the abundance of the major groups

Though our sampling is not quantitative in the strict sense, we feel that the samples are comparable one to the other and, thus, can reflect trends in density variations. These fluctuations are illustrated in Fig. 2. The total fauna follows a bimodal pattern of abundance during the year; in August, only 1000 specimens were collected (per 0.5 m^2) and similar results were obtained until November; the density of the fauna then increased constantly until February (11265 specimens); an important decrease followed in March with a gradual recovery in the subsequent months.

The bimodal pattern also occurs in each of the major taxa, particularly in Hydracarina, Copepoda and Nematoda. In Oligochaeta, Insecta and Amphipoda, the same bimodal fluctuation is apparent, but less pronounced (Fig. 2).

At the generic level, the situation tends to be somewhat obscured. For instance, in the mayflies *Baetis* and *Atalonella*, the bimodal pattern is present but a third smaller mode occurs as well in October. In Plecoptera, no clear pattern is evident, though in *Anacroneuria*, periods of maximal abundance are in October and in June. In other major groups of Trichoptera (*Oxyethira, Nectopsyche, Magellomyia, Atopsyche*), of Coleoptera (Elmidae) and of Diptera (*Psectrocladius, Podonomus, Cricotopus, Limnophyes, Pseudochironomus, Micropsectra*), the trimodal pattern seen in Ephemeroptera is also more or less well defined.

The relative composition of the fauna changes as well during the year. The insects represent an average of 24% of the total fauna; this percentage increases when the density of the total fauna is low (54% in October), which seems to indicate that insect densities are more stable than those of other elements of the fauna. The exceptionally low percentage of insects in February (16%) is due to an unusually large proportion of Copepoda in the fauna, of the order of 65%. In other groups, such as Oligochaeta, the percentages vary rather erratically. In Copepoda and Hydracarina, the percentages follow the same

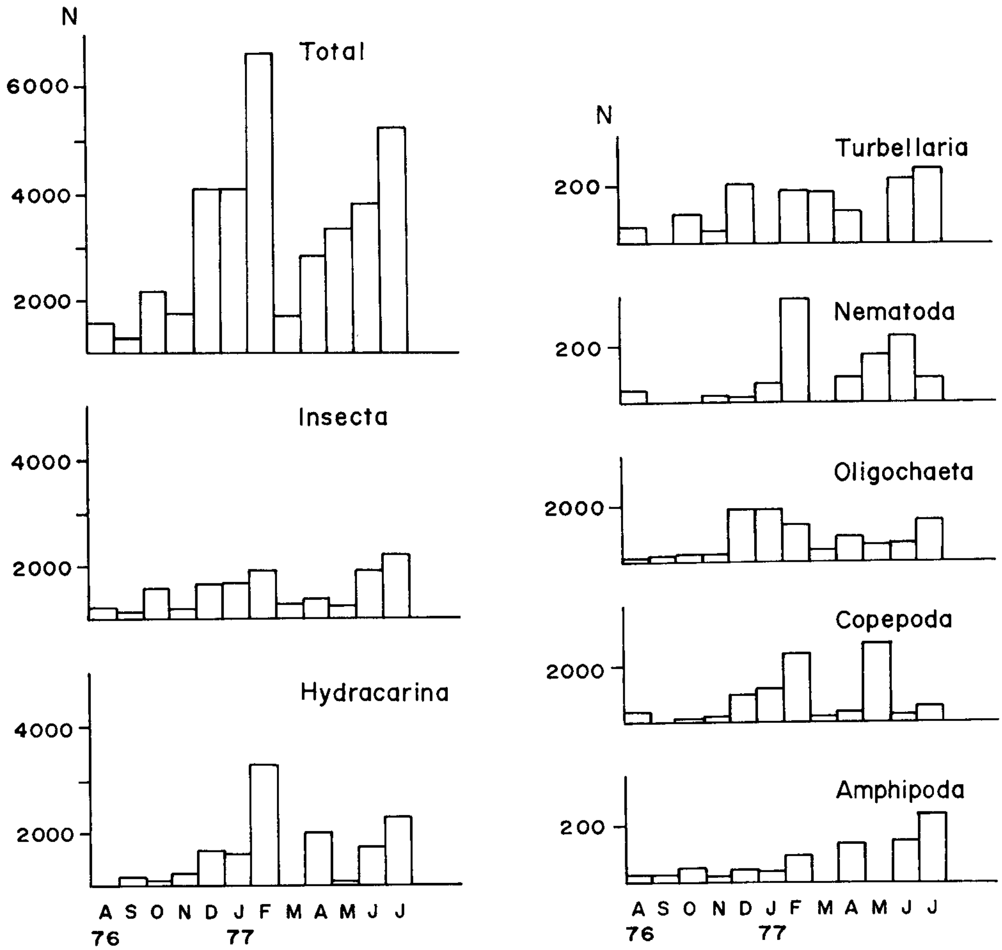

FIG. 2. Monthly variations in the density of the main groups of the benthos (number of animals collected at each sampling date, approximate numbers per 0.5 m^2).

patterns as the whole fauna, which indicates that these groups are in great part responsible for the overall bimodal pattern observed in the density of the benthos.

Size-frequency distribution of selected species

In order to assess the meaning of the annual density fluctuations of abundance, a study was conducted of the size-frequency distribution over the year of some of the common species, *Baetodes* sp., *Atalonella* sp., *Baetis* spp., *Claudioperla tigrina*, *Anacroneuria* sp., *Magellomyia illiesi*, *Nectopsyche* sp. A and three species of *Atopsyche*.

In most instances, there is little evident seasonality, immature stages of all sizes being present at all times of the year. A typical example, that of *Magellomyia illiesi*, is illustrated in Fig. 3. Perhaps the only exception is that of *Anacroneuria* sp. (Fig. 4) in which small nymphs occur mainly from August to November, the mid-instars from November to March and the late instars from March to July; a 1-year cycle could be surmised from such data.

It may be concluded that most of the species investigated are non-seasonal (adults and immatures of all instars occurring throughout the year). When seasonal patterns do occur, they tend to be imprecise; in these instances, emergence of adults is concentrated in the months April to October which are often the wettest of the year in the Cuenca area.

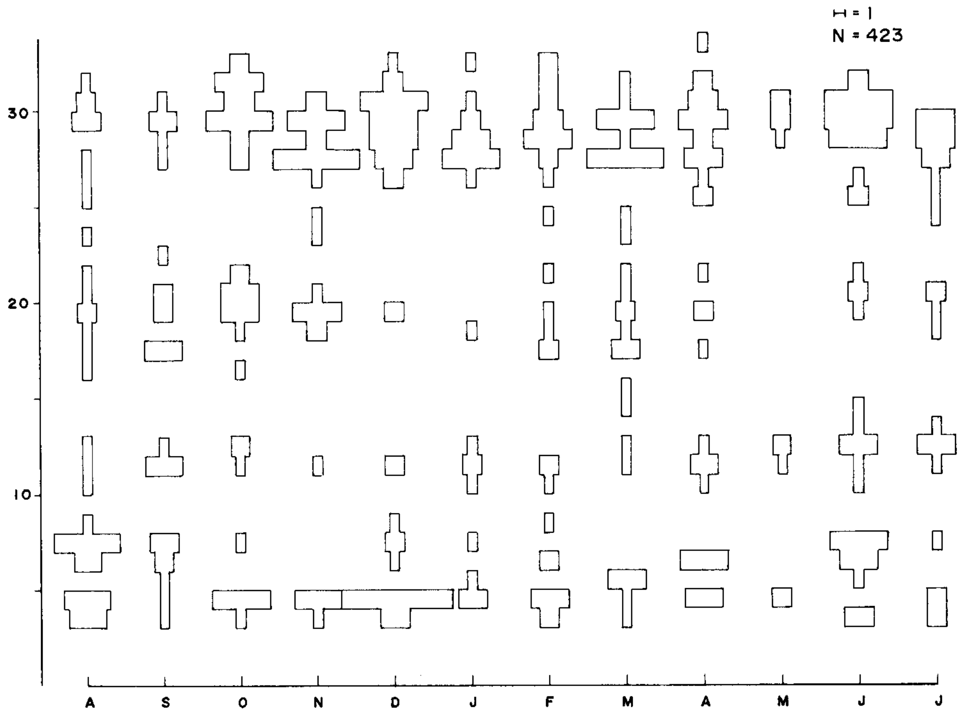

FIG. 3. Size-frequency distribution of head lengths (in micrometric units = 0.045 mm) of the larvae of *Magellomyia illiesi*.

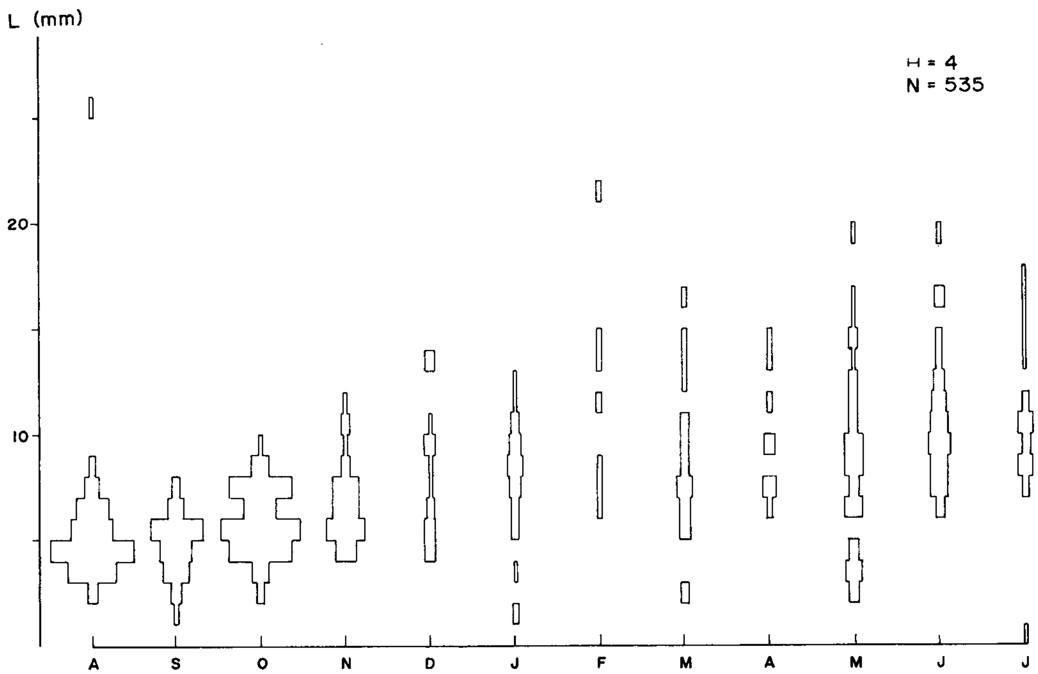

FIG. 4. Size-frequency distribution of body lengths (in mm) of the larvae of *Anacroneuria* sp.

Discussion

Despite the cold climatic conditions, the stream supports a moderately rich and diverse fauna. Hirigoyen (1976) who studied the Venezuelian Rio Chama at the same altitude found a very comparable fauna, though he gives no indications of benthic densities. The dominance is however different: Oligochaeta make up to 89% of the fauna, and this dwarfs the relative importance of the other groups. Perhaps the differences can be explained by a siltier substrate and the presence of carnivorous fish in Rio Chama. The lists of taxa are similar in both rivers, except that Blephariceridae are absent from our stream, and Mollusca, Plecoptera, and some Diptera (Ephydridae, Muscidae) are not mentioned by Hirigoyen. Among the insects, the Chironomidae are the most prevalent group, as is the case of other tropical streams (Fittkau, 1964; Williams & Hynes, 1971; Bishop, 1973; Hynes, 1975a), and indeed of nearly all streams.

Illies' (1964) study of Rio Huallaga in Peru is based on few specimens, but their identification is more precise. (Rio Huallaga flows towards the Amazon through Rio Marañon which also receives the water from our stream.) At an altitude of 3000 m, the faunas of both systems are very similar. The Ephemeroptera belong to the genera *Baetis* and *Atalophlebia* (a close relative of our *Atalonella*); the Plecoptera are the same; the Trichoptera bear many similarities (the dominance of *Magellomyia illiesi*, the abundance of Hydroptilidae, the presence of *Atopsyche* spp.). The Dryopidae are the major group in the Coleoptera. No study was undertaken of the Diptera.

During the Catherwood Expedition, Patrick (1966) studied extensively some headwater streams of the Amazon. The fauna of these rivers bears some general resemblance with that of our stream, but as collections were made mostly at lower altitudes (600 m), it is much more diverse: Lepidoptera, Heteroptera, Megaloptera, and warm-water Trichoptera were also collected; interestingly, the dominant mayfly families are the same, but there are more genera.

The variations in the densities of the benthos are not the same for all groups; the smaller invertebrates, such as Copepoda and Hydracarina, exhibit large fluctuations, whereas the larger insects appear to have more stable populations. Thus, the density fluctuations observed in the total fauna are caused mainly by changes in the populations of the tinier benthic invertebrates.

In temperate latitudes, density fluctuations are usually explained by the loss of organisms through flushing during the spring thaw or the summer emergence of insects. Under tropical climates, other factors must intervene: Hynes (1975a) observed a marked reduction in the benthos of a Ghanaan stream during the dry season because of the interruption of the flow. Petr (1970) noted greater densities in the Volta at the end of the dry season; the fauna was reduced by spates during the rainy season. Bishop (1973) explained fluctuations of densities in a Malayan river by the recurrence of floods which reduce the fauna; a gradual buildup follows until the next spate. As spates are irregular and unpredictable, so are the variations in the densities of the benthos. The bimodal pattern observed in our stream could be explained by such a mechanism; indeed, the great reduction in the density observed in March 1976 occurred after 3–4 months of heavy rain, when the soil must have been waterlogged and the stream more susceptible to overflowing. It should also ensue that the periods of greatest densities should occur after a prolonged dry period; this is not so in our stream and the maximum densities were observed in February after 3 months of heavier than average rainfall. The situation is not as straightforward as could be imagined.

The dominant role of spates is further supported by the fact that smaller invertebrates are subject to more severe fluctuations in numbers than larger ones. Perhaps the larger animals are more resistant to dislodging.

Most of the invertebrates are non-seasonal in their life-cycles and thus their period of emergence and recruitment extend over the whole year; at most, a few species exhibit limited seasonality and tend to concentrate emergence and/or recruitment in one half or so of the year instead of throughout the year. Corbet (1964), Petr (1970) and Bishop (1973) had made similar observations in warm tropical environments. This lack of synchronism in life-histories of most benthos dwellers in tropical areas eliminates life-cycle patterns as a major cause of the fluctuations of densities.

Tropical streams lack the cyclic dynamic processes common in temperate streams: the fluctuating temperatures, the changing photoperiods, and the regularly recurring flow patterns. Only in areas with dry and wet seasons are the streams controlled by a regularly recurring event. A close monitoring of non-seasonal lotic systems and the determination of the factors which regulate them in the absence of the obvious cues would greatly increase our comprehension of running water ecosystems.

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