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Life histories of two species of *Baetis* (Ephemeroptera: Baetidae) in a small North-East Indian Stream

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With 6 figures and 1 table in the text

Abstract

Life histories of two *Baetis* species were studied in the Umkhrah stream, Shillong, Northeastern India, for a one year period from October 1989 to September 1990. In spite of poorly synchronized nymphal development, three generations per year could be discerned for both the species. However, there was a marked overlap within and between generations, multiple cohorts, each in its own developmental phase, being present at any one time. Emergence and nymphal recruitment stopped during winter.

Introduction

Several species of the genus *Baetis* LEACH are important components of the ephemeropteran community in streams in and around Shillong city (Lat. 25° 34′ N; Long. 91° 52′ E; altitude ca. ∠ 1500 m a.s.l.), in the North-Eastern region of India, as revealed in a previous study on their distribution and seasonal abundance (Gupta & Michael 1992). However, little is known about the life history patterns, barring some preliminary observations (Gupta & Michael 1981). The main obstacle to such studies has been their poorly known taxonomy. Though species names could not be assigned to the two taxa in the present study, their nymphs and adults were associated, and it is reasonably certain that each of them represents a single species and not a complex of related species.

Little is known about the life histories of Ephemeroptera from other parts of India apart from Sivaramakrishnan & Job (1981), who showed them to have non-seasonal, asynchronous life histories. Life histories of ephemeropterans and other stream invertebrates from tropical and subtropical areas are usually non-seasonal and asynchronous (Petr 1970; Bishop 1973; Turcotte & Harper 1982). Poorly synchronized life histories have also been widely reported for most Australian and New Zealand stream invertebrates (Winter-

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BOURN 1974; TOWNS 1981, 1983), though a higher degree of synchrony is also known for several species (MARCHANT et al. 1984; YULE 1985; DEAN & CARTWRIGHT 1987). The objective of the present study was, therefore, to provide some baseline information about the life history patterns prevalent in a subtropical mountain stream in North-Eastern India.

Study sites

Collections were made at two stations on the Umkhrah stream, where it flows through the outlying areas of Shillong city (Fig. 1). *Baetis* sp. A was found at both the sites, while *Baetis* sp. B at Site II only.

Site I is located on the headwaters of Umkhrah stream, where it flows through abandoned pastures dotted with groves of Khasi Pine (*Pinus kesiya* Royle), the other plants present being small shrubs such as *Eupatorium* sp., *Lantana camara* and *Polygonum* sp., the latter growing chiefly along the stream margins. The average width and depth of the stream were 2.2 m and 18 cm, respectively. The collection site was a riffle with a substratum of pebbles and cobbles (ca. 10–60 cm in diameter).

Site II, also a riffle, but with occasional large boulders on the substratum besides pebbles and cobbles, is about 4 km downstream of Site I, after the stream has been joined by two tributaries. Here the stream flows through a deep gorge, with *Pinus kesiya, Pognotherum* sp., *Osbeckia* sp., *Eupatorium* sp., *Lantana camara, Arundinella* sp., *Bambusa* sp., and several species of ferns growing profusely on the hill slopes flanking the stream. Average width and depth are 4.9 m and 30 cm, respectively.

Material and Methods

Rainfall data for the study area were collected from a rain gauge nearby. Temperature readings were taken with a mercury bulb thermometer at the time of collection. Air temperature data were also collected from a local recording station. Current velocity was measured with a float and a stopwatch. Dissolved oxygen, total alkalinity, and nitrate contents of stream water were estimated using standard methods (GOLTERMAN et al. 1969), and pH and conductivity with a pH and conductivity meter, respectively. Nymphs of both species were collected by disturbing a 0.1 m^2 area of the substratum into a 30 × 30 cm net having a mesh size of 60 μm. Three such samples were collected on each sampling date, approximately at fortnightly intervals. The nymphs were preserved in 10% formalin and sorted under a dissecting microscope. Body length (excluding cerci) and head width were measured with a calibrated ocular micrometer. Emergence data were obtained by collecting adults with a light trap placed near the stream, also at fortnightly intervals. The approach of emergence could also be estimated from the occurrence of individuals with dark wing-pads in the population.

Results

Physical and chemical data

The monthly rainfall in the study area, the mean monthly rainfall for the period 1981–1990, the mean monthly maximum and minimum temperature in the study area, and water temperature at the time of sampling in sites I and II are presented in Fig. 2. The ranges of other physical and chemical variables are

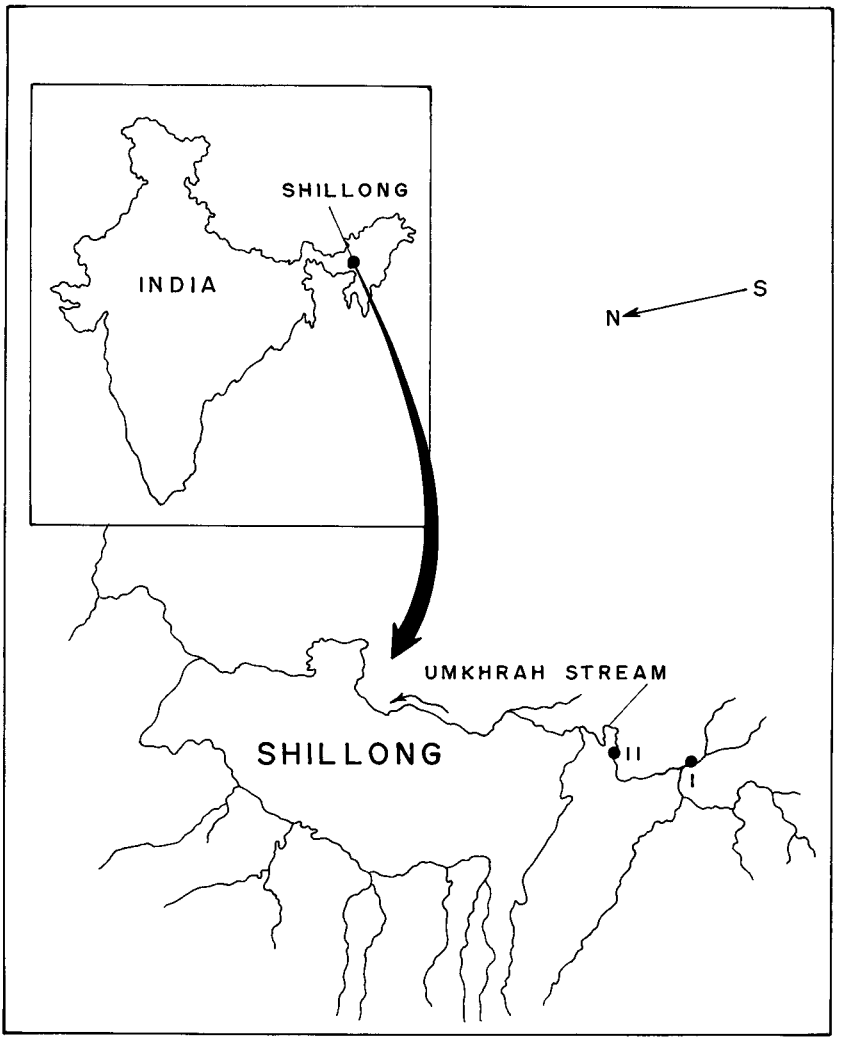

Fig. 1. Map of Shillong city and its outskirts showing the study sites. Small arrow indicates direction of stream flow.

given in Table 1. Monthly rainfall largely conformed to the long-term pattern, except that October and April were wetter than usual, and July and August drier. Higher diurnal ranges of air temperature were obtained during winter compared to the other months. Site I had slightly cooler water temperature and faster current speed than Site II. The stream water at both the sites had high dissolved oxygen, low alkalinity and moderate nitrate contents; pH was slightly acid and conductivity low.

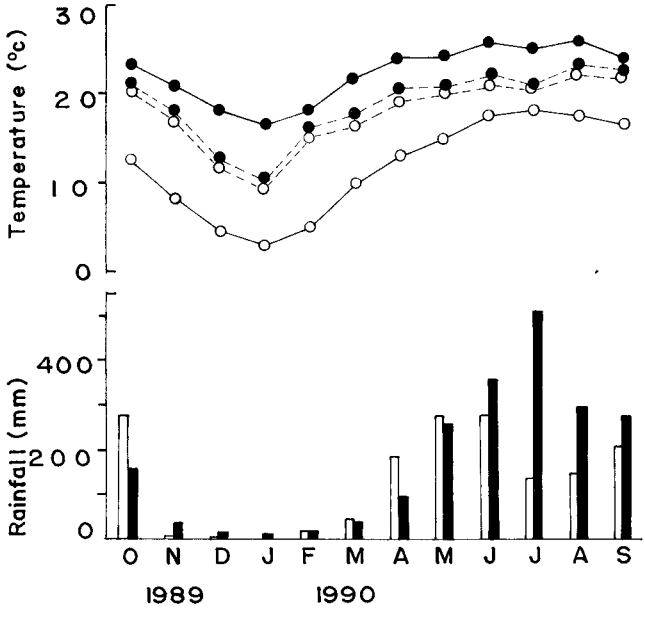

Fig. 2. Rainfall and temperature in the study area. ●——● = mean monthly maximum temperature, 1989–1990; ○——○ = mean monthly minimum temperature, 1989–1990; ●-----● = water temperature at Site I at the time of collection; ○-----○ = water temperature at Site II at the time of collection. Open column = monthly rainfall, 1989–1990. Closed column = mean monthly rainfall, 1981–1990.

Table 1. Ranges of some physical and chemical variables at the study sites.

Site	Current Velocity (cm sec^{-1})	pH	Conductivity ($\mu S\ cm^{-1}$)	Dissolved Oxygen (mg l^{-1})	Total Alkalinity (mg l^{-1})	Nitrate (mg l^{-1})
I	45–80	6.0–6.4	26.3–46.2	7.6–9.6	21.2–40.0	0.1 –0.37
II	35–75	6.0–6.5	30.5–57.8	7.2–9.0	26.0–44.0	0.42–1.85

Life history data

Baetis sp.A: The percentage size frequency distributions of this species at the two sites are depicted in Figs. 3 a and 3 b, while Figs. 4 a and 4 b present the mean head width of nymphs in different months. A wide size range of nymphs of this species was present for much of the year at both sites. Adults and mature nymphs were found almost throughout the year except from middle of December until late January. Very young nymphs with head width of about 0.2 mm were also present during much of the year except in December, January, June and August. Development lacked synchrony at both sites. Nevertheless, during the year at least three generations could be discerned, although with marked overlap between generations, and multiple cohorts, each

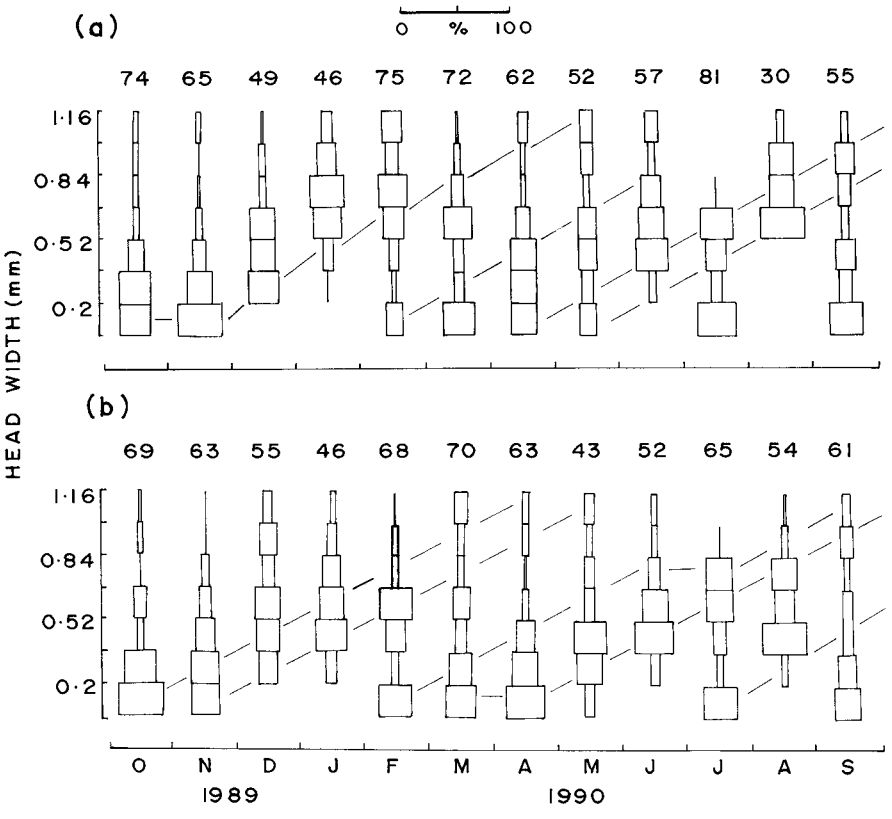

Fig. 3. (a) Size frequency (%) distributions of *Baetis* sp.A at Site I, Umkhrah stream. The mean number of individuals measured in each sample is given at the top of the figure. Lines indicate the growth of modal size-classes. (b) Size frequency (%) distributions of *Baetis* sp.A at Site II, Umkhrah stream. Labellings as in (a).

in a different developmental phase, being present at any time (Figs. 3 a, 3 b). The narrow ranges of mean head width values with considerable overlap of their confidence limits throughout the year signify that development is poorly synchronized (Figs. 4 a, 4 b).

Baetis sp.B: The percentage size frequency distribution (Fig. 5) as well as seasonal progression in mean size (Fig. 6) of this species at Site II indicate three generations per year, despite considerable overlap of generations and asynchronous development. Adults and mature nymphs were found throughout the year except during December and January, while the major nymphal recruitment periods were October, November, February–April and June. However, very few adults were trapped during July to September. Nymphal growth also was apparently slow during this period. Furthermore,

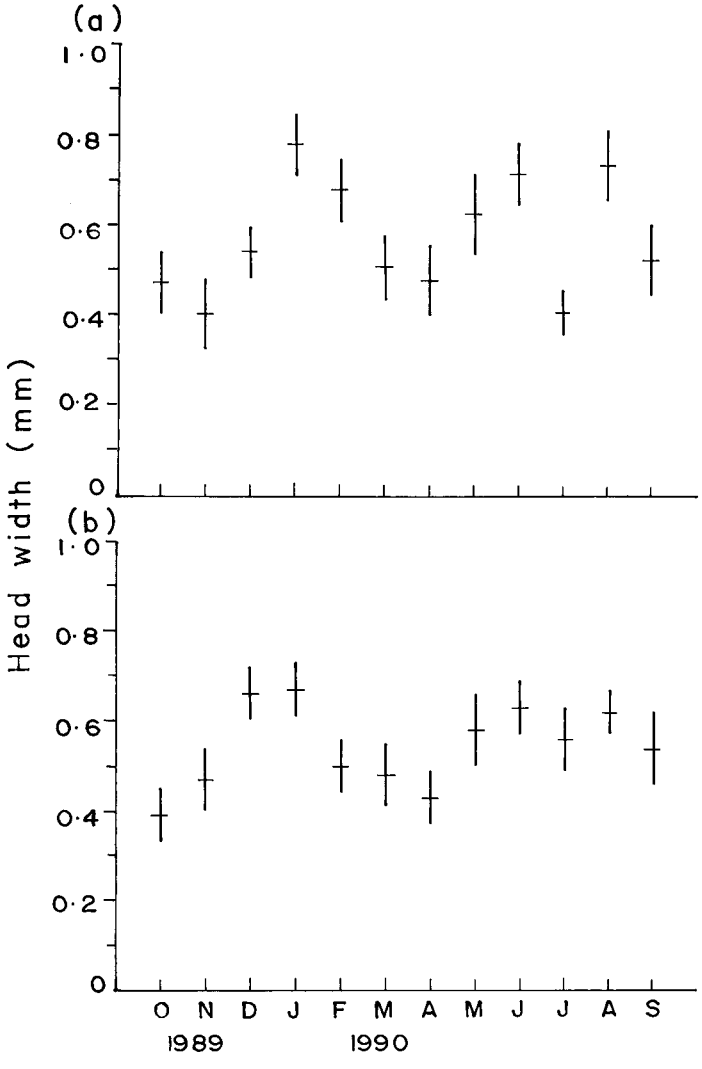

Fig. 4. (a) Seasonal head capsule growth of *Baetis* sp.A at Site I, Umkhrah stream. Horizontal line represents mean, and vertical line 95% confidence limit of the mean. (b) Seasonal head capsule growth of *Baetis* sp.A at Site II, Umkhrah stream. Conventions as in (a).

although this species also exhibited considerable cohort overlap, the lack of synchrony was less pronounced than in sp.A.

Discussion

One of the major features of the life histories of the two species of *Baetis* in the Umkhrah stream, Shillong, was the apparent lack of synchrony. This man-

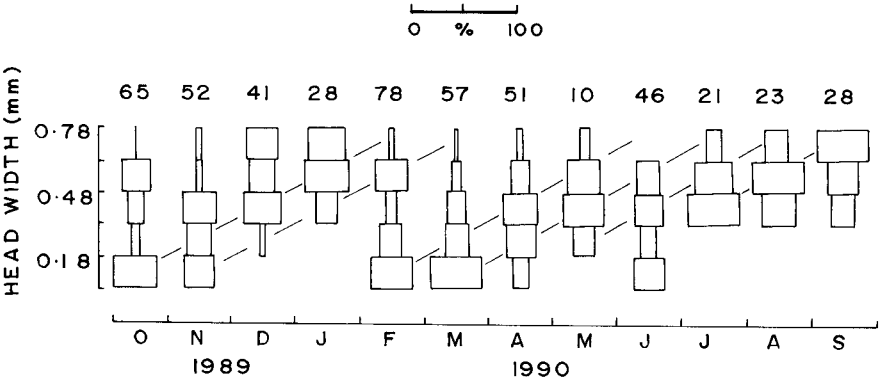

Fig. 5. Size frequency (%) distributions of *Baetis* sp.B at Site II, Umkhrah stream. Labellings as in Fig. 3 (a).

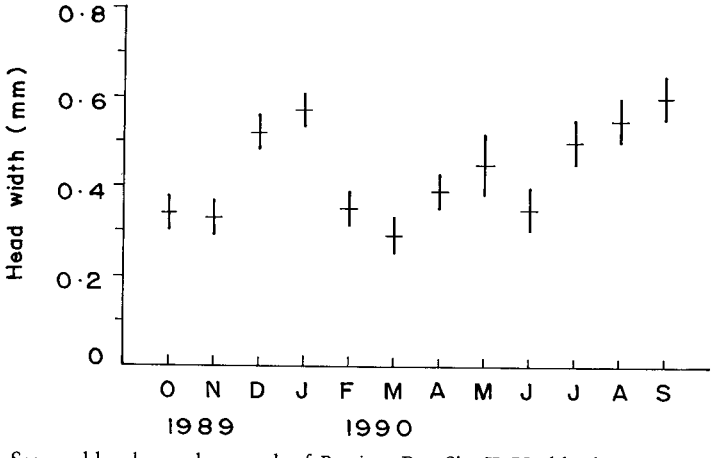

Fig. 6. Seasonal head capsule growth of *Baetis* sp.B at Site II, Umkhrah stream. Conventions as in Fig. 4 (a).

ifested itself in the extended emergence period of about 10 months, similarly extended periods of nymphal recruitment, and the occurrence of a large size range of nymphs at any time. It appears that multiple cohorts were present at both the study sites, each with a different developmental pattern. Though relatively little is known about the life histories of mayflies and other benthic invertebrates from tropical and subtropical streams (Petr 1970; Bishop 1973; Turcotte & Harper 1982; Dudgeon 1989), a pronounced lack of synchronized development appears to be an inherent feature observed in all the above investigations. In Australia and New Zealand too, where several studies have been conducted to elucidate the life histories of mayflies and other stream invertebrates, most revealed loosely synchronized larval development and extended periods of hatching and adult emergence (Winterbourn 1974; Towns

1981, 1983; CAMPBELL 1986), although a higher degree of synchrony could be observed for some species (MARCHANT et al. 1984; YULE 1985; DEAN & CARTWRIGHT 1987; BUNN 1988). BERNER (1950) also noted that mayflies in Florida, more so in its southern parts, exhibited largely non-seasonal and poorly synchronized life histories. Thus, such life histories appear to be characteristic of tropical and subtropical species in general (CLIFFORD et al. 1973). This is in marked contrast to the patterns found at the relatively high latitudes of Europe and N. America, where they are usually highly synchronized and strongly seasonal (LANDA 1968; MACAN 1970; CLIFFORD et al. 1973; SWEENEY & VANNOTE 1981).

Although the two species of *Baetis* in the Umkhrah stream, Shillong, have life histories which largely conform to the pattern observed for other tropical/subtropical species, they do exhibit certain features which are rather reminiscent of those found in moderate temperate areas. This mixture of subtropical and temperate features is probably brought about by the altitude of the study area which produces low temperatures during December–January accompanied by a wide range of diurnal temperature fluctuations during these two months. These in turn result in the cessation of emergence and nymphal recruitment during a brief period extending from middle of December to late January. More investigations in the mountain streams of Northeastern and Northwestern India would have to be conducted to find out whether such a "mixed" pattern is characteristic of stream invertebrate life histories in areas at altitudes around 1500 m, and a latitude north of 20 or 25° N. It is noteworthy that mayfly and other benthic invertebrate life histories in the mountain streams of peninsular India (lat. 10 to 12° N) (SIVARAMAKRISHNAN & JOB 1981), as well as in a high altitude tropical stream (TURCOTTE & HARPER 1982) were found to be totally asynchronous and non-seasonal. Nevertheless, even in "nonseasonal" tropical areas, natural environments exhibit some seasonality (MCELRAVY et al. 1982) and life cycles have to be temporally adjusted to align the timing of critical stages with appropriate environmental conditions. As can be seen from the physical data, Shillong experiences high rainfall during May to September/October, and as a result, the streams are often in high spate, carrying a heavy silt load. Again, this is also the period when water temperature frequently crosses 20 °C. Yet, despite the existence of a favourable temperature regime, nymphal recruitment is not continuous, the young nymphs being absent in June and August in case of *Baetis* sp.A, and in May and from July to September in case of sp.B. It is difficult to say at present whether this periodicity is linked to the spate frequency regime. There is also a possibility that the small nymphs could migrate to the hyporheic zone during spates.

However, it must be borne in mind that the present study deals only with two species of the genus *Baetis*. *Baetis* spp. are known to have fairly extended emergence and nymphal recruitment periods even in northern latitudes, up to

7 or 8 months for *Baetis rhodani* (PICTET) (MACAN 1970; BENGTSSON 1988), and about 6 months for other *Baetis* spp. (ILLIES 1968) in different parts of Europe. Hence, the life histories of mayfly species belonging to other families as well as of species belonging to other groups of invertebrates would have to be studied, preferably at different altitudes, before making any worthwhile generalizations regarding the life histories of benthic invertebrates in the streams of North-eastern India. Nevertheless, the present study does indicate that invertebrate life histories in the streams of this area, especially in those flowing above 1000/1500 m a.s.l., might present certain features of an environment somewhere between the tropical and the temperate. It might not be surprising, therefore, to come across a whole range of life history strategies in adaptation to the local conditions, which are likely to be different at different altitudes, as well as in streams having various degrees of riparian cover, both the factors in turn influencing the temperature regime and food availability.

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