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Seasonal abundance and diet of *Cloeon* sp. (Ephemeroptera: Baetidae) in a northeast Indian lake

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With 2 figures and 1 table in the text

Abstract

The mayfly, *Cloeon* sp. was studied in a small lake in Shillong, North Eastern India from April 1991 to March 1992 with respect to its seasonal abundance, life history and feeding habits. Nymphal density was largely governed by temperature and probably to some extent by predation and food availability. Nymphal development was poorly synchronized with rapid growth and continuous recruitment except in the winter months. The emergence of adults also ceased during December to February. Nymphs were herbivore-detritivores and exhibited a seasonal shift in the composition of their diet. Filamentous green algae and desmids were the dominant food materials during April to October, while during November to March, detritus and flagellates constituted the major items.

Introduction

Ecology of Indian Ephemeroptera still remains rather poorly documented. Of the few studies carried out till date, relatively more are on lotic (GUPTA & MICHAEL 1981, 1983, 1992; GUPTA 1993, SIVARAMAKRISHNAN & JOB 1981, SIVARAMAKRISHNAN & VENKATARAMAN 1990) than on lentic taxa (SIVARAMAKRISHNAN & VENKATARAMAN 1987, GUPTA et al. 1993 a, b). However, considering the fact that India abounds in tanks, ponds, small lakes, reservoirs and wetlands of various sizes, it is important that the ecology of their aquatic insect fauna including Ephemeroptera is studied in some detail. This paper describes the seasonal abundance, life history and food habits of a species of *Cloeon* (Ephemeroptera: Baetidae) which is a common inhabitant of lentic fresh water systems in and around Shillong in the north eastern region of India. Although no specific name could be assigned to this species, the nymphs and adults have been associated by rearing, and it is reasonably certain that the specimens collected rep-

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resent a single species (MÜLLER-LIEBENAU, personal communication). As two earlier investigations (GUPTA et al. 1993 a, b) outline the life cycle, instar analysis, growth, and influence of diet on growth, food retention time, and gill ventilation rates of nymphs of this species under laboratory conditions, the main objectives of the present study are to analyze the seasonal abundance patterns to evaluate field life history data in the light of laboratory based results obtained earlier, and to investigate the feeding habits of nymphs in the field.

Study site

Nymphs of *Cloeon* sp. were collected from Ward Lake, a small perennial water body in Shillong (Lat. 25° 34′ N Long. 91° 52′ E, alt. ca. 1500 m a.s.l.). Shillong receives an annual rainfall of about 2000 mm, most of which occurs during May to October. Collections were made from marginal weed beds formed mainly by *Hydrilla* sp. Beside *Cloeon* sp., larvae of *Crocothemis servilia* (DRURY) (Anisoptera: Libellulidae) and *Coenagrion* sp. (Zygoptera: Coenagrionidae), as well as juvenile and adults of *Agraptocorixa* sp. (Hemiptera: Corixidae) and *Anisops* sp. (Hemiptera: Notonectidae) are the other major aquatic insect taxa living in the weed beds.

Material and methods

Air temperature data for the study period were obtained from a local recording station. Air and water temperature readings were also taken with a mercury bulb thermometer at the time of collection of water and insect samples. Dissolved oxygen, total alkalinity and nitrate contents of lake water were estimated using standard methods (MICHAEL 1984), and pH and conductivity with a pH and a conductivity meter, respectively. Nymphs of *Cloeon* sp. and the other aquatic insects were collected by dragging a 25 × 25 cm net of 200 μm mesh through a 2 m long section of the weed bed and density finally expressed as numbers per unit sampling effort. Three replicate samples were collected at fortnightly intervals between April 1991 and March 1992. Nymphs were preserved in the field in 6 % formalin to prevent, as far as possible, digestion of food materials, and sorted in the laboratory under a dissecting binocular microscope. Body length (excluding antenna and cerci) and head width were measured with a calibrated ocular micrometer. Emergence data were obtained by collecting subimagines from the underside of leaves of the lake side vegetation and by rearing nymphs in the laboratory. The approach of emergence could also be estimated from the occurrence of individuals with dark wing pads in the population. For gut content analysis, 10 to 30 nymphs each of different size classes were dissected every month. The foregut contents of nymphs of a given size class were pooled and mixed with water of known volume in a tube. This suspension was then vigorously agitated and a 1 ml subsample transferred to a small counting cell fitted on a glass slide and examined under a microscope equipped with a squared ocular grid. Five to ten such subsamples were examined. The numbers of diatoms, desmids, flagellates, and cells of filamentous algae in each subsample as well as the number of squares in the grid occupied by detritus and mineral particles were counted. Length and width of common diatoms, desmids, flagellates and filamentous algal cells were measured separately and their approximate numbers fitting into a single grid (area 0.006 mm) were computed. All the food items were finally expressed in terms of grid area units. This method was a modification of similar earlier ones (BROWN 1961, HALL & PRITCHARD 1975, SHAPAS & HILSENHOFF 1976). Though the more refined and accurate method using millipore filters was not employed, the present level of accuracy was considered adequate for a general feeding habit determination study of this type.

Results

Physical and chemical data

The mean monthly maximum and minimum air temperatures, and water temperature at the time of sampling are presented in Fig. 1. The lake water had

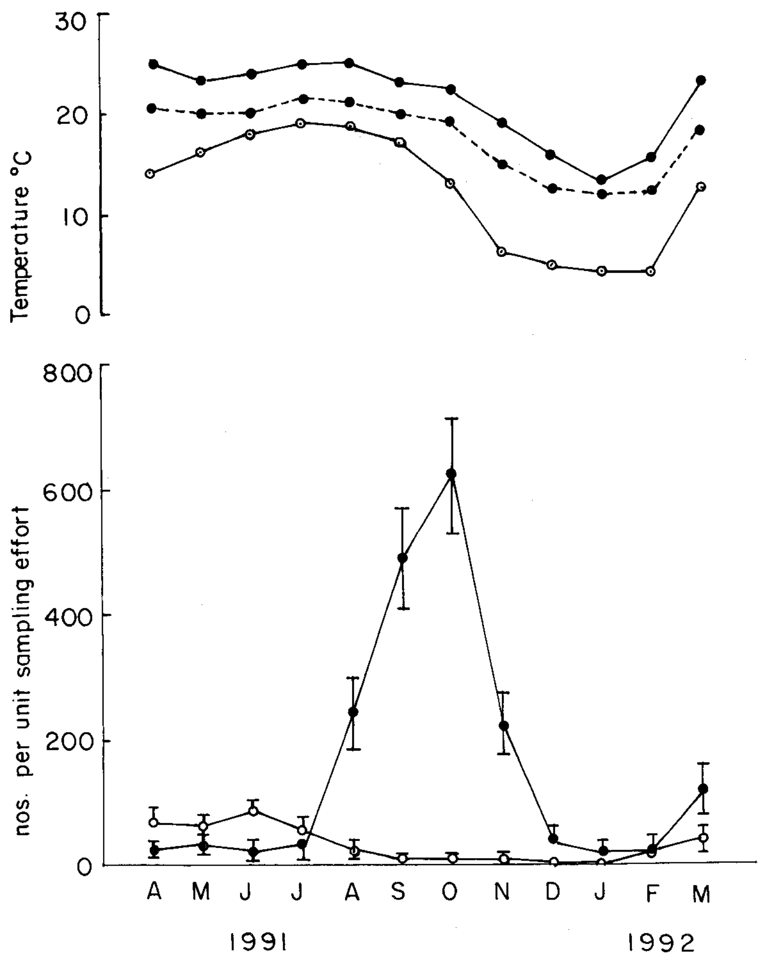

Fig. 1. Mean maximum and minimum air temperatures and water temperature (upper panel) and numbers (mean ± S.D.) of *Cloeon* sp. and *Crocothemis servilia* (lower panel) in Ward Lake, Shillong; ●——● mean monthly maximum temperature, ○——○ mean monthly minimum temperature, ●- - - - -● mean water temperature, ●——● number of *Cloeon* sp. nymphs and ○——○ number of *Crocothemis servilia* larvae. Vertical bars represent standard deviations of the mean.

slightly acid pH (5.9–6.5), low conductivity and alkalinity (57.8–91.2 $\mu S\,cm^{-1}$ and 25–45 $mg\,l^{-1}$, respectively), moderate nitrate (0.6–1.3 $mg\,l^{-1}$) and fairly high dissolved oxygen (6–7.2 $mg\,l^{-1}$).

Seasonal abundance and life history

Fig. 1 shows the seasonal abundance pattern of *Cloeon* and *Crocothemis servilia* nymphs. Density of *Cloeon* sp. was maximum in October, and minimum in February. Nymphs were also abundant in August, September and November, and to some extent in March. *Crocothemis servilia* nymphs were abundant during April to July with peak density in June.

The percentage size frequency distribution of *Cloeon* sp. is depicted in Fig. 2. Nymphs of all size classes were present during much of the year. Very young nymphs with head width of about 0.2 mm as well as mature nymphs and adults were found throughout the year except from late December to February.

Gut content analysis

Of a total of 16 taxa of desmids, diatoms, filamentous green algae, blue-green algae and flagellates found in the guts of *Cloeon* sp. nymphs, the most abundant were *Closterium* sp., *Gymnodinium* sp., and *Cosmarium* sp., followed by *Spirogyra* sp. and *Navicula* sp. The percentage abundance of different food items over the months are depicted in Table 1. As no significant difference could be observed between nymphs of different sizes, the results are not given separately. Desmids and filamentous green algae were abundant during

Table 1. Per cent abundance (mean ± S.D.) of food items in the gut of *Cloeon* sp. in different months.

Month	Mean % abundance ± S.D.				
	Green algae	Diatoms	Flagellates	Blue-green algae	Detritus
April 1991	23 ± 3.4	7.3±1.8	36.3±5.7	20.2±6.7	13.2±3
May	47 ± 8.4	2.3±2	25.9±6.3	2.8±1.1	22 ±6.9
June	38.7± 8.5	–	35.8±5.3	2.5±0.7	23 ±2.6
July	54.6±11.5	1.3±0.6	23.2±5.1	2.6±1.3	18.3±7
August	56.1±12.1	9.6±3.1	10.3±3.9	–	24 ±8.1
September	54.2± 9.3	11.1±4.2	12.4±2.1	–	22.3±3.5
October	46.9± 6.2	10.2±2.8	16.7±3.6	–	26.2±3.8
November	17.5± 4.2	7.1±2	33.2±6.6	–	42.2±8.3
December	19.0± 4.1	7.5±3.3	29.1±5.2	–	44.4±5.8
January 1992	16.3± 2.4	6.4±3.2	31.1±5.6	–	46.2±5.9
February	20.5± 3.7	3.6±2.6	26.4±4.1	14.1±3.3	35.4±5.5
March	17.2± 4.8	1.3±0.8	26 ±5	10.2±2.1	45.3±6.3

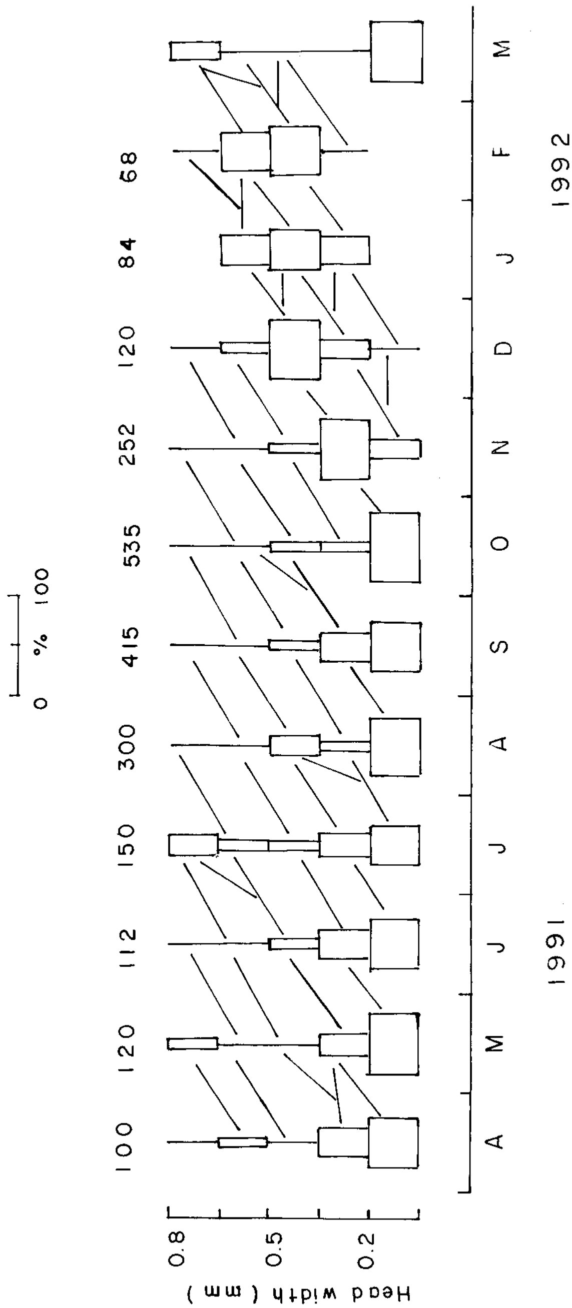

Fig. 2. Size frequency (%) distributions of *Cloeon* sp. in Ward Lake. The number of individuals measured is given at the top of the figure. Lines indicate the growth of modal size-classes.

May to October, especially July to September, while detritus gained importance as food during November to March. Flagellates were abundant during November to April. Cyanophyceae represented by *Oscillatoria* sp. were recorded during February to July only, while diatoms, though found in the gut almost throughout, could hardly be considered a major food items.

Discussion

Seasonal abundance patterns of *Cloeon* sp. nymphs revealed that population size was relatively small during April to July 1991 with a minor peak in March. Thereafter, from August onward, density built up steadily to reach a peak in October, after which it declined, although a sizeable population persisted in November (Fig. 1). Reduced density in December–February was most likely to have been caused by low temperature due to the high altitude of Shillong. Similar results were also found in the case of the running water Ephemeroptera of Shillong area (Gupta & Michael 1992), which, however, showed March–April to be a major period of population build up. In contrast, despite a higher temperature regime during April to July, nymphal density of *Cloeon* sp. did not record a concomitant increase. One plausible explanation for the lentic *Cloeon* sp. not experiencing an increased abundance during April–July could be increased predation pressure exerted on its population by carnivorous species, especially the larvae of the anisopteran *Crocothemis servilia,* whose numbers were relatively high during this period. However, no definite conclusion on the importance of predation governing population size of *Cloeon* sp. could be advanced at this stage, although predation has been shown to be a major factor controlling composition and abundance of lentic freshwater communities (Kjellberg 1972, Macan 1977, Brittain 1978, Savage 1986).

The life history of *Cloeon* sp. in Ward Lake was characterized by a pronounced lack of synchrony during the major part of the year. Emergence of adults as well as nymphal recruitment took place for 9–10 months except during late December till February. Nymphs of all size classes were present almost throughout the year, indicating that development was not synchronous. Such patterns are characteristic of most aquatic insect life histories in tropical and subtropical environments, although the bulk of the available information is on running water forms (Petr 1970, Bishop 1973, Sivaramakrishnan & Job 1981, Turcotte & Harper 1982). However, in a study on the life span of *Cloeon fluviatile* and *Tasmonocaenis* sp. in two tropical Australian billabongs, Marchant (1982) recorded nymphs of all size classes almost throughout the year, indicating continuous growth, emergence and reproduction. Nevertheless, our observations also indicate that growth of *Cloeon* sp. was relatively slow during November–March. An earlier study on lotic *Baetis* spp. from

Shillong also reported absence of emergence and nymphal recruitment during winter (GUPTA 1993), while, another (GUPTA et al. 1993 a) revealed that time taken by the nymphs of *Cloeon* sp. to complete the life cycle in the laboratory was distinctly shorter (25–46 days) during April–August than during November–December or February–March (50–62 days, and 49–53 days, respectively), and that growth rate was strongly influenced by temperature. BENKE & JACOBI (1986) observed that *Baetis, Stenonema* and *Trichorythodes* spp. needed 19, 41, and 31 days, respectively, to complete their development in a subtropical river in Georgia, U.S.A. Even in temperate latitudes in Britain and Scandinavia, *Cloeon dipterum* and *C. simile* were shown to have a rapid summer generation (BROWN 1961, MACAN 1961, KJELLBERG 1973, BRITTAIN 1974), while LICHTENBERG (1973) reported the existence of a summer generation of *C. dipterum* that required only 2 months to develop in an Austrian pond. Hence, in Shillong, with much warmer temperatures, it is natural for *Cloeon* sp. to have a multivoltine life history with continuous recruitment and emergence. However, with mean maximum air temperatures dropping below 17 °C during December–February, growth became relatively slow and more synchronized and emergence ceased. This blend of tropical and temperate patterns therefore, appears to be a characteristic feature of Ephemeroptera abundance and life histories in the subtropical mountain environment of Shillong (GUPTA & MICHAEL 1992, GUPTA 1993).

Gut content analysis of nymphs showed *Cloeon* sp. to be a herbivore-detritivore, and that there was a seasonal shift in the food items found in the gut from green algae during May–October to detritus and to some extent, flagellates, during November–March. However, the preponderance of a given food item was apparently linked to its availability, as it is known that mayflies shift from one diet to another in relation to available food and its nutritive value (NØST 1985). From June till around October, dense algal mats were observed to cover the *Hydrilla* strands, a microscopic examination of which revealed the predominance of *Spirogyra, Oedogonium, Closterium, Cosmarium, Staurastrum, Oscillatoria* and *Mougeotia* (GUPTA et al. 1993 b), and these were forms which constituted a major portion of the food of *Cloeon* sp. nymphs during this period. During winter, in contrast, the strands were coated with an amorphous, slimy, detrital material, which the nymphs fed upon, leading to a higher detrital content in their guts. Thus, availability of a particular food item in a given microhabitat was an important factor in determining the type of material ingested. Furthermore, preponderance of energy rich food of superior nutritional quality such as algae was also probably instrumental, along with temperature, in bringing about an increase in nymphal density during August–October. Several studies reveal that algae are a food of superior quality than detritus (CUMMINS & KLUG 1979, BIRD & KAUSHIK 1984, WEBB & MERRITT 1987) and our observations on growth of *Cloeon* sp. nymphs fed algae/

detritus also show that they grow and reach maturity faster on an algal diet (GUPTA et al. 1993 b). Thus it seems probable that several factors such as a higher temperature regime, abundance of energy-rich algal food and probably reduced predation pressure, were responsible for the population build up of *Cloeon* sp. nymphs during August–October, although more specific studies would have to be conducted to understand further the role of these factors, particularly predation.

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