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# Laboratory Studies on the Life Cycle and Growth of *Cloeon* sp. (Ephemeroptera: Baetidae) in Meghalaya State, India

by

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The number of nymphal instars in the life cycle of *Cloeon* sp. was found to vary from 10-14, though more than 50 percent of the nymphs emerged as subimagines in the tenth instar. The size range of different instars overlapped considerably. This could possibly be attributed either to a differential growth rate among nymphs or to sexual dimorphism or both. The species was found to be a multivoltine one with numerous overlapping generations in summer. However, growth slowed down in winter and the nymphs took a longer time to complete their life cycle. Temperature was found to be the most significant factor influencing growth under laboratory conditions.

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## INTRODUCTION

Nymphs of the mayfly genus *Cloeon* Leach (Ephemeroptera: Baetidae) are ubiquitous elements of aquatic insect communities of lentic freshwater habitats almost all over the world. The number of nymphal instars in the life cycle of certain species of this genus in Europe and N. America is known (Grandi, 1941; Degrange, 1959; Cianciaria, 1975), while considerable information is also available on their growth rates under both laboratory and field conditions (Kjellberg, 1973; Cianciaria, 1980; Sweeney and Vannote, 1981). In contrast, however, nothing is known on these aspects of their ecology from Indian waters. The main objective of the present investigation, therefore, was to rear the nymphs of *Cloeon* sp., a common and abundant species of mayfly occurring in the lentic freshwater systems of Meghalaya State, North-east India, and to find out the number of nymphal instars in its life cycle. Furthermore, while conducting a field-based study on the seasonal fluctuations in abundance and life cycle events of this species, we observed that growth slowed down considerably in winter. However, it was not possible to discern the role of temperature from field studies alone, as food availability could also play a major role. Another possible factor, photoperiod was improbable to be important in the case of this species, as we found its fluctuations to be independent of those of growth and abundance. This view is also supported by a study on the growth and emergence of a mayfly and a stonefly (Brittain, 1976a). Hence, nymphal growth was measured in the laboratory where excess food was given to the nymphs, but temperature was determined by environment temperature.

## MATERIALS AND METHODS

For procuring first instar nymphs of *Cloeon* sp., water was collected from the littoral areas of Ward Lake after thoroughly disturbing the weed beds. Any insect already present in this water was removed, and water kept in petridishes was scanned at hourly intervals to detect any first instar nymphs hatching from the egg masses apparently present there. This method was adopted based on our earlier observation that first instar nymphs of mayflies and dragonflies appeared in lake water kept in the laboratory, obviously hatching from eggs present therein. After hatching, nymphs were individually reared in petridishes in the laboratory where temperature was controlled by environment temperature. Air and water temperatures were recorded daily at 10 a.m. with a mercury-bulb thermometer having a 0.1° scale. Food and water were changed every two days. Food was supplied in the form of algal filaments.

In one set of experiments to determine the number of instars required to complete the life cycle, a batch of 22 first instar numphs was individually reared until the subimaginal stage. The presence of exuviae indicating an instar change was noted and measurements of body length (excluding antenna and cerci) were made from the exuviae after each moult. Furthermore, varying numbers of first instar nymphs were reared in different months to find out the range of duration of each instar as well as seasonal variations, if any, in the time taken by the nymphs to complete the life cycle.

In another experiment to study the growth rates of nymphs in different months, 20 animals of 1-2 mm size range were individually reared in each month. Measurements of body length were made at weekly intervals by placing live nymphs in a cavity slide in just a film of water to render them immobile. No mortality was seen to result from this practice. All measurements were made with the help of ocular and stage micrometers.

## RESULTS

The number of nymphal instars of *Cloeon* sp. reared in the laboratory varied from 10 to 14. The minimum number of instars required by any nymph to reach the subimago stage was ten. Furthermore, 54.5% of the nymphs completed the nymphal stages of their life cycle at the tenth instar, 27.3% at the eleventh, 9.1% at the twelfth, none at the thirteenth and 9.1% at the fourteenth instar. The nymphal body length ranged from 0.45 mm in the first to 5.0 mm in the eleventh instar. There was considerable overlap between successive instars (Table 1). The durations of the second and third instars were somewhat longer than that of the others (Table 2).

The mean body lengths at different instars reveal that the absolute length increment between instars one and two was less important than between instars two and ten. There was little increment, if any, during the last five instars (Fig. 1). The number of days taken by *Cloeon* sp. to complete the nymphal part of life cycle in the laboratory showed pronounced seasonal variations. During April to August, number of days required ranged between 25-46 days, during November to December between 50-62 days and during February to March between 49-53

Table 1. Size range of nymphs of *Cloeon* sp. at different instars.

| Instar No. | No. of animals | Body length (mm) | No. of subimagines emerging |
|---|---|---|---|
| I | 22 | 0.45 – 0.79 | – |
| II | 22 | 0.77 – 1.07 | – |
| III | 22 | 1.05 – 2.15 | – |
| IV | 22 | 1.2 – 3.5 | – |
| V | 22 | 1.4 – 3.9 | – |
| VI | 22 | 1.6 – 4.0 | – |
| VII | 22 | 1.65 – 4.4 | – |
| VIII | 22 | 2.0 – 4.6 | – |
| IX | 22 | 2.1 – 4.7 | – |
| X | 22 | 2.95 – 4.95 | 12 |
| XI | 10 | 3.5 – 5.0 | 6 |
| XII | 4 | 3.95 – 4.05 | 2 |
| XIII | 2 | 4.07 – 4.25 | – |
| XIV | 2 | 4.2 – 4.6 | 2 |

Table 2. Duration of nymphal instars of *Cloeon* sp. under laboratory conditions.

| Instar No. | Minimum-Maximum duration (in days) | Average duration (in days) |
|---|---|---|
| I | 1 – 3 | 2 ± 0.45 |
| II | 2 – 9 | 5 ± 2.93 |
| III | 2 – 7 | 4.3 ± 1.75 |
| IV | 2 – 5 | 2.5 ± 1.19 |
| V | 1 – 2 | 1.9 ± 0.35 |
| VI | 2 – 4 | 2.4 ± 0.92 |
| VII | 2 – 6 | 3.8 ± 1.39 |
| VIII | 3 – 5 | 3.2 ± 12.9 |
| IX | 2 – 4 | 2.8 ± 0.96 |
| X | 2 – 5 | 2.8 ± 1.23 |
| XI | 2 – 5 | 2.9 ± 1.39 |
| XII | 2 – 7 | 2.9 ± 1.9 |
| XIII | 3 – 5 | 3.7 ± 1.15 |
| XIV | 2 – 6 | 2.6 ± 1.49 |

days (Fig. 2). Growth rate in the laboratory was high during June to September, while during October to December and February to May it was relatively low, being less than 1 mm per week (Table 3). The correlation co-efficient between water temperature and laboratory growth rate revealed a significant relationship at $P = 0.001$.

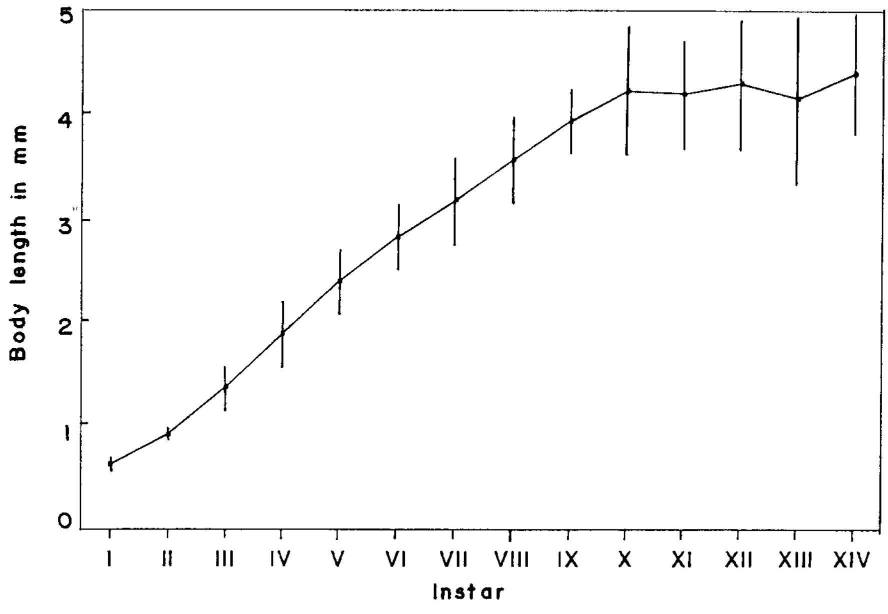


Fig. 1. Growth of *Cloeon* sp. in the laboratory. Mean body lengths are given ± 95% confidence limits.

## DISCUSSION

Studies on the life histories of various mayfly species reveal that ephemeropteran families usually have 12 to 19 instars (Murphy, 1922; Grandi, 1941; Degrange, 1959; Landa, 1969; Pescador and Peters, 1974), although Ide (1935) estimated between 30 to 45 instars for *Stenonema canadiense* (Walker). The total number of instars in *Cloeon* sp. varied from 10 to 14 only. Admittedly, nymphal growth under natural conditions could involve additional instars, the variations mainly resulting from a more varied diet and/or more severe fluctuations in temperature and other environmental parameters. In fact, Cianciaria (1975) showed that the number of nymphal instars in the life cycle of *Cloeon dipterum* (L.) could be varied by providing different types of food.

The present study reveals a fairly constant instar number for *Cloeon* sp., as more than 50% of the nymphs completed their life cycle in the tenth instar and another 27.3% in the eleventh. On the contrary, Degrange (1959) recorded 20 to 29 nymphal instars in C. *simile* Eaton, and demonstrated that the nymphs hatching from eggs of the same female and reared under identical conditions can have different numbers of moults. However, as mentioned earlier, the uniformity observed in *Cloeon* sp. could be due to rather constant regime of food and considerably milder temperature fluctuations experienced by the nymphs reared under

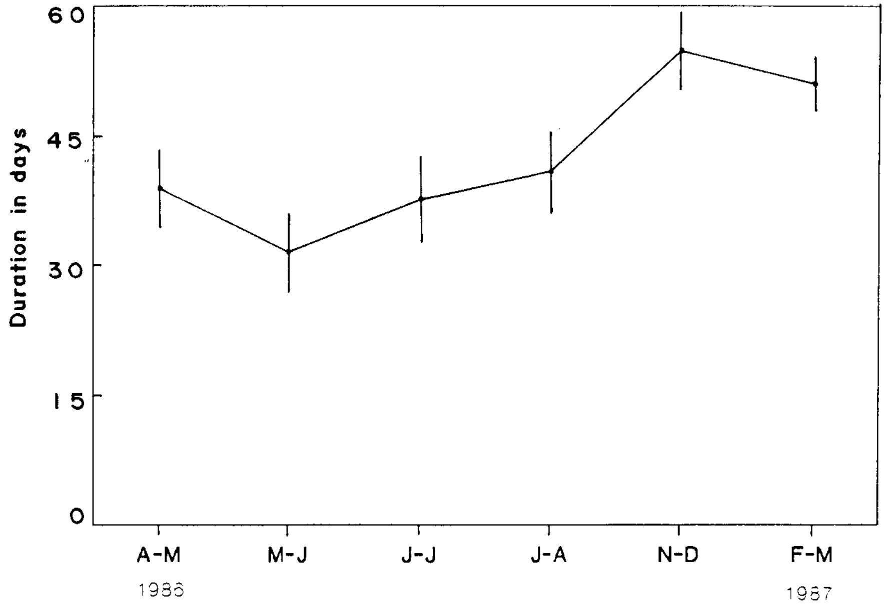


Fig. 2. Duration of nymphal development of *Cloeon* sp. in different months. Means ± standard deviations.

laboratory conditions. Temperature was nevertheless found to exert a profound influence on the duration of the nymphal developmental period of *Cloeon* sp. and this agrees well with the information available from some other earlier investigations (Brittain, 1972, 1976b, Kjellberg, 1973). Temperature was also found to be the principal factor influencing nymphal growth in the laboratory where excess food was supplied to the larvae.

The size range of different instars was found to overlap to a considerable extent. One explanation for this is that larger nymphs could sometimes be physiologically younger than smaller nymphs (Clifford, 1970), or nymphs of the same developmental stage may exhibit different growth rates as Hunt (1973) found in *Hexagenia limbata* Serville. Thus the physiologically younger nymphs which required additional instars after the tenth to complete their life cycle were smaller in size which resulted in the depression of the growth curve beyond tenth instar as observed in the present study. Further, sexual dimorphism is known to have profound influence on the size variation in aquatic insects (Svensson, 1977; Sweeney, 1978; Clifford et al., 1979; Ratte, 1979; Butler, 1982). The female nymphs of *Cloeon* sp. were distinguishable in the later instars as the males were smaller, more slender, and with turbinate eyes already distinguishable. Thus, variation in nymphal size, particularly in the later instars could be partly attributed to the above variations as well. Following hatching, the time taken by the

Table 3. Correlation coefficient and regression equation between monthly water temperature and laboratory growth rate in nymphs of *Cloeon* sp.

| Months | Mean water temp. in petridishes | Mean growth rate/week (in mm) |
|---|---|---|
| April '86 | 16.7 | 0.54 |
| May '86 | 17.2 | 0.64 |
| June '86 | 20.5 | 1.68 |
| July '86 | 18.9 | 1.3 |
| August '86 | 20.2 | 1.17 |
| September '86 | 17.7 | 1.0 |
| October '86 | 13.1 | 0.36 |
| December '86 | 9.7 | 0.23 |
| January '87 | – | – |
| February '87 | 11.7 | 0.29 |
| March '87 | 15.7 | 0.47 |

$r = 0.8775$; $y = 1.19529 + 0.12052x$
Significant at $P = 0.001$

nymphs of *Cloeon* sp. to complete their life cycle clearly designates them to be a multivoltine species with a large number of overlapping generations. This essentially reflects the impact of a subtropical temperature regime bringing about a much faster growth rate than is generally observed under temperate situations (Kjellberg, 1973; Brittain, 1976b). Nevertheless, the growth rate slowed down appreciably during October to May, and was particularly low during November to February, requiring an explanation. This was definitely due to the high altitude of the study area (ca 1500 m above s.l.) that simulates a temperate latitude in the winter months, as has also been observed in a field study conducted on Ephemeropteran larvae and other aquatic insects from this area (Gupta and Michael, 1983).

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