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# Influence of diet on growth, food retention time, and gill ventilation rate of nymphs of *Cloeon* sp. (Ephemeroptera: Baetidae)

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## Abstract

Early instar nymphs of the mayfly, *Cloeon* sp. were kept on an algal or a detrital diet at $20 \pm 1$ °C in the laboratory. A control group was not given any food. Nymphs kept on algae showed significantly ($P = 0.001$) higher growth both in terms of length and biomass than for those kept on detritus. None of the nymphs given algae or detritus died during the experiment, and 40 per cent of those fed algae and 20 per cent fed detritus reached maturity by the termination of the experiment. Food retention time as well as gill ventilation rate of nymphs feeding on algae were significantly ($P = 0.001$) higher than those feeding on detritus. It is probable that these two factors largely enabled the nymphs to survive as well as to grow and reach maturity, though relatively slowly, solely on a detrital diet. However, algae was clearly shown to be a superior food resource for *Cloeon* sp. nymphs.

## Introduction

Besides temperature, food is among the most important factors influencing growth and life cycle of aquatic invertebrates (Anderson & Cummins, 1979; Cummins & Klug, 1979; Sweeney, 1984; Sweeney & Vannote, 1984; Bird & Kaushik, 1984; Webb & Merritt, 1987). A previous study has already shown the influence of temperature on the growth of *Cloeon* sp. (Gupta *et al.*, 1992), while it is also known that (Gupta, 1981) this species of mayfly which is a common inhabitant of the lentic freshwater systems of shillong and its neighbouring areas in the North-Eastern region of India, is a herbivore-detritivore, feeding on algae and detritus. One objective of this study, therefore, was to determine the influence of a purely detrital or algal diet on the growth of *Cloeon* sp. nymphs under constant temperature conditions in the laboratory. Besides, considering that detritus is a poorer quality food than algae (Cummins & Klug, 1979), the other objective of the study was to find out whether nymphs compensated for this low nutritive value by processing a larger amount of detritus at a relatively low level of energy expenditure compared to algae to obtain sufficient nutrients for growth (Findlay & Tenore, 1982).

## Materials and methods

Early instar nymphs of *Cloeon* sp. collected from the field were either given no food or were fed a diet of algae or detritus. Algal mats were collected from Ward Lake, Shillong (Lat. 25° 34′ N; Long. 91° 52′ E; altitude 1500 m asl), while fine detritus (both inorganic and organic components) was collected from the lake bottom at shallow marginal areas, where they were particularly abundant at the base of the *Hydrilla* clumps. The detrital material was washed through a 500 $\mu$m sieve and the fraction that passed through was collected (Sutcliffe *et al.*, 1981). The detritus samples were then scanned under a microscope to detect the presence of algal cells, if any.

For feeding experiments with *Cloeon* sp., large petri dishes (120 mm in diameter × 20 mm deep) containing filtered Shillong tap water were used as feeding chambers. Five replicates, each with 10 specimens of *Cloeon* sp. were fed each diet in these chambers. The experiment was carried out at $20 \pm 1$ °C under continuous darkness for 40 days, from 21st August to 30th September 1988. The water in the feeding chambers was replaced at four day intervals with water containing fresh food to prevent food limitation. On these occasions, mortality was checked, and dead specimens, if any, removed. One group of five replicates having 10 specimens each was not given any food, while another group also of five replicates of 10 specimens each was sacrificed on the first day of the experiment. Their mean body length excluding cerci, measured using a dissecting microscope, and dry weight (oven dried at 75 °C for 24 h) served as reference points to determine growth that had occurred during the experiment. The body length and weight of specimens were determined at the termination of the experiment (Bird & Kaushik, 1984).

Yet another group of 4 replicates of 5 specimens each were also kept under similar conditions (continuous darkness and $20 \pm 1$ °C temperature). Of these, two replicates were given algae, and the other two given detritus as food. These specimens were fixed at regular intervals during the tenure of the experiment, and their gut contents analyzed. This was done to confirm that nymphs given a detrital diet did not ingest any algae.

In order to record the food retention time in gut and gill ventilation rate of nymphs feeding on algae or detritus, 20 nymphs of different size classes were used for each food item. They were kept without food in darkness at $20 \pm 1$ °C for 12 hours. A single nymph was taken at a time in a petri dish containing either algae or detritus. As the progress of each bolus of food was readily discernible under a dissecting microscope, method using charcoal powder (Ladle *et al.*, 1972) was not employed. The time taken by each bolus to travel down the gut till its egestion was recorded and termed here as food retention time. Gill ventilation rates of nymphs while they fed on algae/detritus were also recorded. Readings were taken in a room having an ambient air temperature of 20–22 °C at the time of recording. 5 readings were taken for each nymph, thus making a total of 100 for each food item.

Statistical analysis was done by one-way analysis of variance (ANOVA).

## Results

Survival of nymphs was 100 per cent both in case of an algal and a detrital diet. None of the nymphs not given any food survived. Forty per cent of the nymphs fed algae and twenty per cent fed detritus reached maturity, as evident from their dark wing pads. Initial values for length and biomass, based on the sacrificed nymphs, the length and biomass of nymphs fed algae or detritus at the termination of the experiment, as well as the food retention time and gill ventilation rates of nymphs feeding on algae or detritus, are given in Table 1. Nymphs fed algae registered significantly greater ($P = 0.001$) growth, both in terms of body length and biomass (mg dry weight) than those fed detritus. They exhibited higher ($P = 0.001$) food retention time and gill ventilation rates as well, while feeding on algae than on detritus.

Microscopic examination of the algal mat supplied as food revealed the presence of the following genera: *Spirogyra*, *Oedogonium*, *Oscillatoria*, *Cosmarium*, *Closterium*, *Staurastrum*, and *Mougeotia*. Among these, the first six were most abundant in the gut. The gut of nymphs fed detritus did not contain any algal cells. Microscopical exami-

*Table 1.* Mean ($\pm$ SD) growth, food retention time, and gill ventilation rates of *Cloeon* sp. nymphs fed algae/detritus.

| Treatment | Length (mm) | | Biomass (mg) | | Food retention time (seconds) | Gill ventilation rate (number minute$^{-1}$) |
|---|---|---|---|---|---|---|
| | Initial | Final | Initial | Final | | |
| Algae | $0.88 \pm 0.37$ | $3.59 \pm 0.88$** | $0.27 \pm 0.04$ | $2.79 \pm 0.12$** | $249.75 \pm 87.9$** | $55.76 \pm 14.8$** |
| Detritus | -do- | $3.26 \pm 0.64$ | -do- | $2.27 \pm 0.1$ | $87.41 \pm 41$ | $28.64 \pm 5.3$ |
| No food | -do- | * | -do- | * | * | * |

* – 100% mortality.
** – Significant at $P = 0.001$.

nation of detritus samples prior to their being given as food to nymphs, also did not reveal any algal contamination.

## Discussion

In the present study, growth of nymphs fed an algal diet was significantly higher than those fed detritus. This agrees well with the findings of several earlier workers that algae is a nutritionally superior food resource (Lamberti & Moore, 1984; Bird & Kaushik, 1984; Webb & Merritt, 1987), and that detritus, though its quality improves with microbial conditioning (Kaushik & Hynes, 1971), is nevertheless a poorer quality food than algae or animal tissue (Cummins & Klug, 1979).

However, the results of our study also reveal that nymphs could survive, grow and reach maturity, albeit relatively slowly, solely on detrital food. This has been possible because nymphs tend to compensate by consuming relatively large amounts of detritus to obtain sufficient nutrients for growth, and consequently have rapid ingestion-egestion rates, as shown in our study, and this is a view shared by a number of workers (Ladle *et al.*, 1972; Mulla & Lacey, 1976; Cummins & Klug, 1979; Findlay & Tenore, 1982). Furthermore, Brown's (1961) as well as our observations indicate that while algal feeding involves slow chewing actions of mouthparts, large amounts of fine detritus could be rapidly brushed up by the nymphs. Yet another factor responsible for the quick movement of detrital food through the gut could be the fine particle size of detritus (Wotton, 1978).

The low nutritive value of detritus also seems to be compensated by the fact that it involves less expenditure of energy as is indicated by the significantly lower gill ventilation rates of nymphs feeding on detritus than those feeding on algae. Assimilation of high-energy food such as algae is associated with increased metabolic activity which, in turn, results in a greater oxygen demand per unit weight per unit time. This is met by having higher ventilation rates to increase the average $\Delta pO_2$ (Wiley & Kohler, 1984).

Consumption of high energy algal food is also linked to the increased food retention time. As the nymph gets more energy per unit mass of algae than that of detritus, the feeding rate goes down during algal feeding, and resultantly, the food moves relatively slowly through the gut.

In conclusion, it could be said that detritus, in spite of it being a food resource of inferior nutritional value, could nevertheless enable the nymphs to survive during those periods of the year such as winter (December to February), when the density of algae in the lentic systems of Shillong is generally low (Thapa, 1981) and probably not adequate enough by itself as a food resource for the mayfly nymphs inhabiting these systems.

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