To
Mrs. Janice Peters
with kind regards
K. G. S
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Observations on feeding propensities, growth rate and fecundity in mayflies (Insecta: Ephemeroptera)

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Abstract. The relative importance of organic detritus and algae in promoting the growth and fecundity of some species of Baetidae is assessed on the basis of the nutritional differences among them. Taking into consideration the ephemeral aspect of adult life, an understanding of the relative importance of such substances as carbohydrate, protein and lipid in relation to their growth and fecundity is also examined.

Keywords. Feeding propensities; growth rate; fecundity; alga; detritus; mayflies.

1. Introduction

A basic facet of the structure and function of a freshwater ecosystem is the material cycling and energy flow. In turn, a significant portion of such cycling and flow involves the processing of various forms of organic matter by freshwater invertebrates, especially insects. This constitutes a basis for interest in trophic relations of aquatic insects (Cummins 1973). The nymphs of Ephemeroptera do not play the same part in the trophic structure of the communities in which they occur, and in view of this detailed knowledge of their feeding propensities is highly desirable.

The majority of mayfly nymphs are herbivorous, feeding on detritus and periphyton. The herbivorous mayflies fall into two main categories: collectors and scrapers (Edmunds 1978). Among the collectors, several genera are filter-feeders, with setae on the mouthparts or forelegs acting as filters. Within the Oligoneuridae, Leptophlebiidae, Siphlonuridae and the Heptageniidae, there are several genera that are probably filter-feeders (Wallace and Merritt 1980). By using their gills to produce a current of water through their burrows, several of the Ephemeridae and Polymitarcyidae may, at least for part of their food supply, be regarded as filter-feeders (Brittain 1982). Most mayflies, however, are fine-particle detritivores. These include many Siphlonurinae, Baetidae, Leptophlebiidae, Metretopodidae, Ephemerellidae, Caenidae and Baetiscidae, as well as some Heptageniidae (Edmunds 1978). The other major feeding group within the mayflies, the scrappers, utilize the periphyton present on mineral and organic surfaces. These include representatives of several mayfly families, notably the Baetidae, Heptageniidae, Leptophlebiidae and Caenidae (Edmunds *et al* 1976). Shredders are probably also represented among mayflies.

Earlier observations reveal that even within the detritivore/herbivore category, diet may change with season, habitat and stage of development. Seasonal differences are often a reflection of food availability (Brown 1961; McClure and Stewart 1976; Moore 1977), thus emphasizing the opportunistic nature of mayfly nutrition. However, within the range of food available, there is often evidence of selection (Brown 1961; Cianciara 1980). Food selection may clearly be advantageous, as growth may be influenced by different kinds of food (Anderson and Cummins 1979; Cianciara 1980; McCullough *et al* 1979).

Reproduction in insects is very closely related to nutritional factors, the qualitative and quantitative aspects of which have an impact not only on fecundity, but also on the rates of growth and development. Notable publications in this direction include those of Johansson (1958), Slansky (1980a, b), Ananthakrishnan *et al* (1982) and Raman and Sanjayan (1983). Whereas there are some investigations on feeding propensities (Brown 1960, 1961; Gupta and Michael 1981; Venkataraman 1984), food habits (Baekken 1981), trophic relations (Winterbourn 1974), food preference and dependence of growth on the type of food (Cianciara 1980) and nutritional dynamics (Zimmerman and Wissing 1980), work on the impact of nutrition on reproduction of mayflies is conspicuous by its absence. The present investigation aims at understanding and comparing the feeding propensities, growth rate and fecundity of two species of *Baetis* and one species of *Cloeon* available in and around Madurai, based on laboratory observations.

2. Material and methods

Early instar nymphs of *Baetis* sp. A and B were collected from Vaigai river near Thiruvedagam, 10 km west of Madurai. Early instar nymphs of *Cloeon* sp. were also collected from the temple tank of Thirumohur, 10 km north of Madurai. These nymphs were acclimated to the laboratory conditions (temperature 26 ± 1°C) for 24 h. Nymphs of constant length (approximately 2·0 mm), which are in the same physiological age were assorted. Twenty nymphs of each species were reared individually in separate petridishes of 9 cm diameter. Mortality was around 50% and dead nymphs were replaced by the nymphs of the same physiological age. A batch of 10 nymphs of each species was fed on crushed alga (*Spirogyra* sp.) and the remaining batch of 10 of each species on detritus collected from respective habitats. The two types of food (organic detritus and alga-*Spirogyra* sp.) used in the cultures were selected on account of abundant occurrence in the natural environment and of being well known from the literature (Brown 1960; Minshall 1967; Cianciara 1980). Food was supplied in excess. Filtered water brought from their natural habitats was used for rearing. A fresh supply of food was added every day when the water was changed. The head width and the body length of each nymph excluding antennae and cerci were measured after every moult. Since adult mayflies usually live for only a day or two and all the eggs are produced prior to the subimago stage (Clifford and Boerger 1974) total potential fecundity was determined accurately by counting the eggs in subimagos soon after emergence. The alga (*Spirogyra* sp.) and detritus were quantitatively analysed for proteins, carbohydrates and lipids by following the methods of Lowry *et al* (1951), Dubois *et al* (1956) and Kok (1971) respectively.

3. Results and discussion

It is evident from table 1 that *Baetis* sp. A and B grow faster in detritus than in alga (*Spirogyra* sp.) whereas it is vice versa in *Cloeon* sp. Apparently present observations indicate preference of detritus by the two species of *Baetis* under investigation and preference of alga by *Cloeon* sp. These are in conformity with the observations of some previous workers. Studies of Badcock (1949), Brown (1961) and Baekken (1981) on *Baetis rhodani* and of Gupta and Michael (1981) on *Baetis* sp. in Shillong,

Table 1. Growth rate of different species of mayflies fed on detritus and alga.

	Detritus		Alga	
	Body length (mm)	Head width (mm)	Body length (mm)	Head width (mm)
Baetis sp. A.	0·36 ± 0·08	0·15 ± 0·01	0·27 ± 0·08	0·10 ± 0·01
Baetis sp. B.	0·50 ± 0·05	0·14 ± 0·01	0·33 ± 0·03	0·09 ± 0·004
Cloeon sp.	0·20 ± 0·03	0·09 ± 0·01	0·66 ± 0·15	0·14 ± 0·01

Table 2. Quantitative profile of carbohydrate, protein and lipid as well as calorific values of different types of food.

	Carbohydrate (mg/100 mg)	Protein (mg/100 mg)	Lipid (mg/100 mg)	Calorific value (cal/mg)
Alga	5·1 ± 0·42	43·5 ± 6·3	11·2 ± 0·8	4,100
Detritus	1·09 ± 0·16	17·8 ± 0·35	8·2 ± 0·6	3,950

Meghalaya revealed them to be mainly detritivorous whereas Brown (1960) has shown that several species of algae were thoroughly and rapidly digested by *Cloeon dipterum* in the laboratory.

It is a well known fact that the type of food may have a substantial effect on the growth and fecundity of an organism. This is especially so in the nymphal span of mayflies whose adults are ephemeral and do not feed. Quantitative analysis of alga and detritus given as food for nymphs reveals that alga (*Spirogyra* sp.) is richer in carbohydrates, proteins and lipids when compared to detritus (table 2), though the calorific values of both types of food are approximate [*Spirogyra*—4,100 cal/mg, Ivanova (1958); detritus—3,950 cal/mg, Coffman *et al* (1971)]. When the nymphs of mayflies are feeding upon filamentous algae, the mandibles play a more important part in the collection of food than when this is fine detritus. Apparently the mandible tips of *Cloeon* sp. are more suitable for algal diet than those of *Baetis* spp. However, previous studies have shown little or no cellulose activity in mayflies (Monk 1976). Nevertheless, organic compounds leaked or secreted by the algae may be of nutritional importance (Cummins 1973).

The retarded growth of *Baetis* sp. A and B reared on algal diet in spite of its richness of nutrients may be correlated with their inability to consume large quantities of algae. The tip of the mandible of *Baetis* sp. A and B is more tapered than that of *Cloeon* sp. and the straight canines project towards the substratum rather than into the preoral cavity. Obviously the molar surfaces of *Baetis* spp. and of *Cloeon* sp. show constant differences in the details of their structure correlated with the nature of their respective diet though the feeding mechanisms of *Baetis* spp. and *Cloeon* sp. are adapted to allow the ingestion of a heterogenous diet in a variety of habitats as pointed out by Brown (1964).

It is also obvious from table 3 that the difference in fecundity of *Cloeon* sp. fed on alga and detritus is much more conspicuous than those observed in *Baetis* sp. A and B. Moreover, the quantity of food ingested also is of value in improving fecundity. Apparently it is the larger quantity of algae ingested by *Cloeon* sp. and the considerable quantity of detritus ingested by *Baetis* sp. A and B that might have

Table 3. Mean number of eggs/individual in different species of mayflies in relation to the type of food.

	Detritus	Alga
Baetis sp. A.	303 ± 1·41	245·5 ± 7·77
Baetis sp. B.	200 ± 2·82	151 ± 3·0
Cloeon sp.	101·5 ± 2·12	539·6 ± 33·2

resulted in increased fecundity of alga-fed *Cloeon* sp. and of detritus-fed *Baetis* sp. A and B in the present investigation.

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