BIOECOLOGICAL STUDIES ON THE BURROWING MAYFLY *EPHEMERA (AETHEPHEMERA) NADINAE* MCCAFFERTY AND EDMUNDS 1973 (EPHEMEROPTERA : EPHEMERIDAE) IN KURANGANI STREAM, WESTERN GHATS [1]

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(With three text-figures)

The life cycle pattern of *Ephemera nadinae* in Kurangani stream was interpreted from the developmental stage frequency histograms. It is basically multivoltine with asynchronous, overlapping generations or cohorts with continuous emergence. Food habits of *E. nadinae* were investigated. Detritus forms the major food. Meagre amount of minerals and plant tissues were noted in the gut, which might have been consumed with normal food incidentally. The emerging behaviour of subimagos was also studied. They emerge soon after sunset at about 1830 hrs throughout the year. Synchronous emergence of both sexes was recorded, with males outnumbering females. Subimagos emerge on the water surface. Longevity of the adults ranges from 24 to 48 hours. The average number of eggs/mm of body length in *E. nadinae* was 240 (r value = 0.9). The fecundity of *E. nadinae* is compared with co-existing species of lotic mayflies.

INTRODUCTION

Knowledge of ecology and life histories of all important groups of aquatic insects is essential in understanding the biological structure of fresh-water streams and lakes. Ecological studies on lotic systems in India with emphasis on Ephemeroptera are very few (Gupta 1980, Sivaramakrishnan and Job 1981, Venkataraman 1984, Kumar 1987). Though there are a number of studies on life cycles of ephemerids inhabiting temperate regions (Kuroda *et al.* 1984, Schloessor and Hiltunen 1984), there is a paucity of information on the life cycle patterns of tropical ephemerids including peninsular Indian forms. This study examines the life cycle pattern, feeding propensities, emergence and fecundity of *Ephemera nadinae*, a burrowing mayfly, in a third order stream in Kurangani village of the Cardamom hills of Western Ghats.

STUDY AREA

Kurangani (11° N, 77°50'E), the study area, is situated 116 km west of Madurai, Tamil Nadu. It lies on the north-eastern side of the Cardamom hills at an altitude of 650 m above m.s.l. This area is exposed to the effects of the south-west monsoon, the north-east monsoon and summer. For ecological studies, February through May are treated as summer, June through September as south-west monsoon period and October through January as north-east monsoon period.

MATERIAL AND METHODS

The study was conducted from February 1988 to January 1989. Three kick samples of ephemerids were collected from sandy regions of Kurangani stream. The sandy habitat was disturbed preferably by five horizontal and five vertical vigorous kicks strictly restricted to one square metre area. Nymphs thus collected were preserved in 70% alcohol and were sorted according to age-class. The plan of Clifford (1969) was followed and in the classification of stages, nymphs were grouped into four arbitrarily chosen developmental stages on the basis of appearance and the development of mesothoracic wing pads. Stage I nymphs lacked wing pads; stage II nymphs had wing pads that were shorter in length than the distance separating the two wing pads; the wing pad length of stage III nymphs was greater than the distance separating the fore wing pads. Stage IV nymphs had darkened wing pads.

Each stage represents several instars, with the exception of stage IV, which is the last nym-

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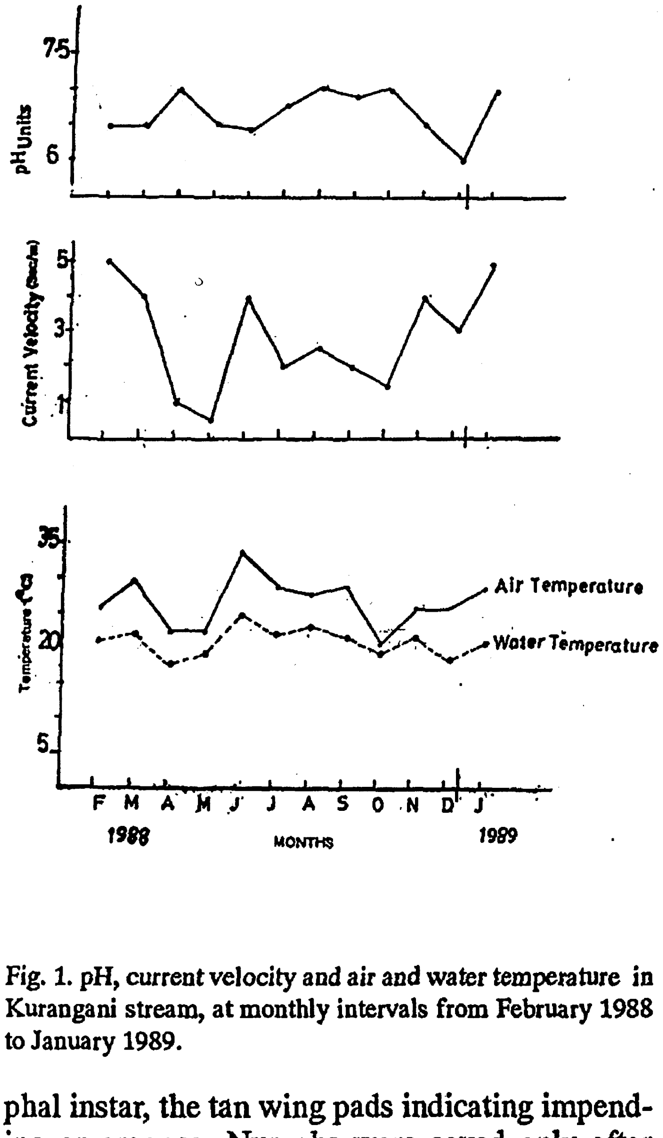

Fig. 1. pH, current velocity and air and water temperature in Kurangani stream, at monthly intervals from February 1988 to January 1989.

phal instar, the tan wing pads indicating impending emergence. Nymphs were sexed only after stage II on the basis of genitalia.

Physico-chemical parameters were recorded during collection time. During each visit atmospheric and water temperatures were recorded. Water velocity was determined by the cork floatation method. pH of water was noted with the help of BDH broad and narrow range pH indicator papers.

The method employed for food analysis is a combination of the methods followed by Minshall (1967) and Gupta and Michael (1981). Nymphs were collected at monthly intervals, fixed immediately in 70% alcohol, and later sorted in the laboratory. Five to ten nymphs of assorted varieties in every month were used for gut analysis. Stage IV nymphs were not used for gut analysis as they were almost ready to emerge and hardly ingested any food at the time. The foregut portion up to second abdominal segment was dissected and the contents were rolled out and teased. The suspension of the food material was transferred to Sedgewick rafter. The suspension was allowed to stand for some time to allow sediments to settle. The percentage composition was determined by counting the cells of Sedgewick rafter of different food materials. using a compound microscope.

Subimaginal emergence was monitored during south-west monsoon, north-east monsoon and summer periods. Monthly trips were made to Kurangani and light trapping was done with a 125 watt mercury vapour lamp powered by a portable generator. Light was switched on from 1800 to 2030 hrs and from 0500 to 0630 hrs. Subimagos were collected in subimaginal box cages (Edmunds *et al.* 1976). Longevity (emergence to imago-death interval) was determined in the subimaginal box cages at room temperature (28 ± 2°C) in the laboratory.

Fecundity is the total number of eggs produced by the female during her life span, regardless of the fate of the eggs. For meaningful comparison between species, the relationship between egg production of *E. nadinae* and body length was analysed. The eggs from the abdominal and thoracic body cavities of last instar (with darkened wing pad) nymphs of *E. nadinae* were removed to Sedgewick rafter and counted. The relationship between fecundity and body length was statistically analysed.

Results and Discussion

Life cycle pattern: The physico-chemical parameters like temperature, pH and water velocity of Kurangani stream are shown in Fig. 1. pH of the stream tended to decrease during southwest monsoon and to increase during summer. The atmospheric and water temperatures

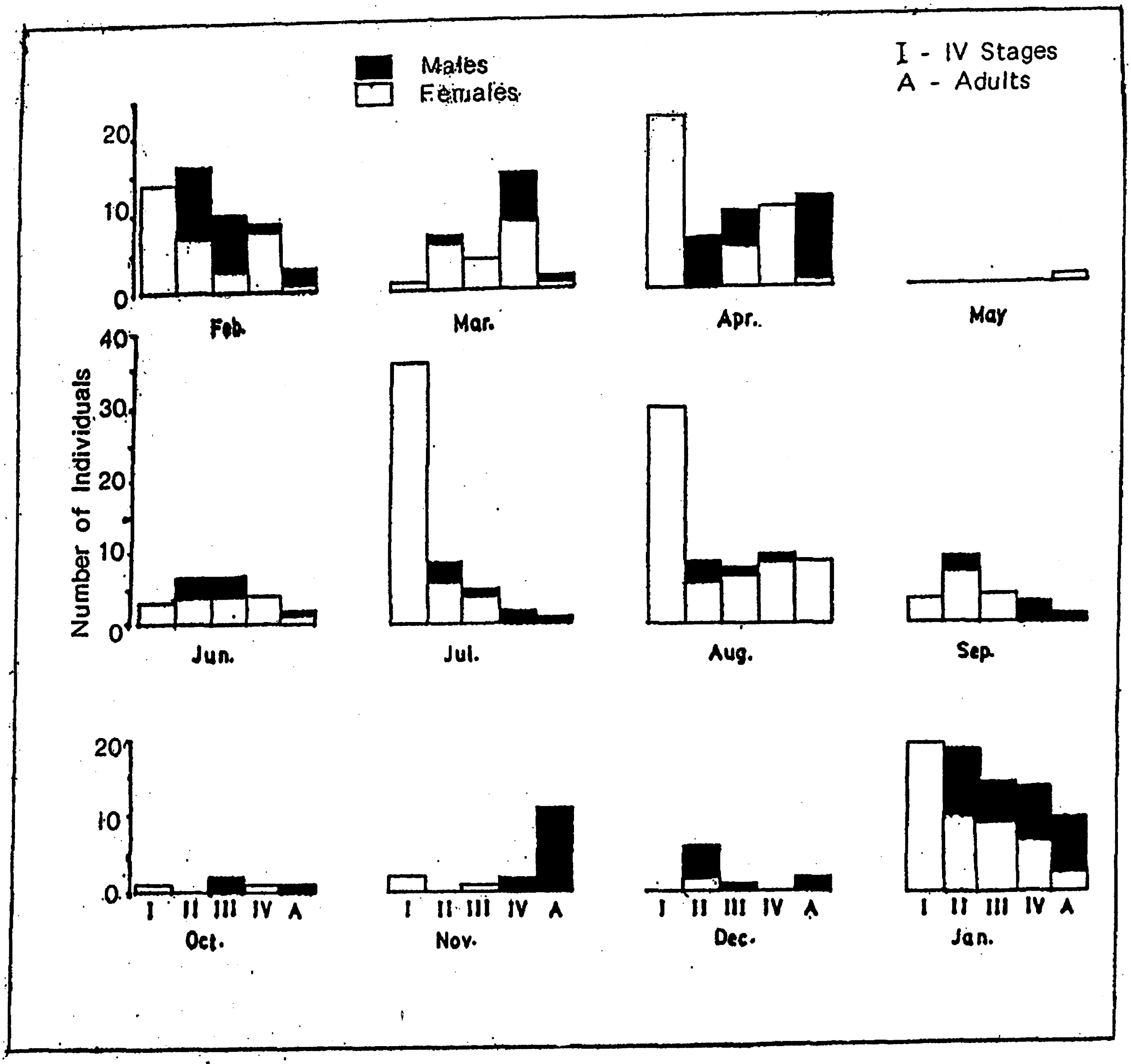

Fig. 2. Monthly changes in the distribution of *E. nadinae* adults and nymphs.
A – indicates months when emerging mayflies were found.

showed large fluctuations during different seasons.

Several factors are known to influence the distribution of aquatic insects. But important environmental factors likely to affect animal number within a very small segment of the stream are water velocity (Scott 1958, Ambuhl 1959, Jaag and Ambuhl 1964, Edington 1968), substratum (Rabeni and Minshall 1977, Shaw and Minshall 1980) and food (Egglishaw 1964, 1969; Williams and Hynes 1973).

The life cycle pattern of *E. nadinae* in Kurangani stream is interpreted from developmental stage frequency histograms (Fig. 2). It is basically multivoltine with asynchronous, overlapping generation or cohorts with continuous emergence. A cohort is a group of individuals that were born at the same time, or in practice born over a short period of time. Early instars of *E. nadinae* occur around July and this cohort continues up to November. Besides, the presence of two other cohorts which occur during January and April is suggested.

The life cycle patterns of ephemerids from temperate regions show agreement as well as deviation from the observed pattern. For instance, the life cycles of *E. japonica* and *E. orientalis* also have two or three cohorts in a year, suggesting multivoltine pattern, whereas *E. strigata* is evidently univoltine in having only one cohort (Kuroda *et al.* 1984). The life cycle of *Hexagenia limbata* of St. Marys river, Michigan, is composed of two non-synchronous emerging cohorts each with a two-year life span (Schloessor and Hiltunen 1984).

Feeding propensities: Mayfly nymphs do not play the same role in the trophic structure of the communities in which they occur. In view of this, knowledge of their feeding habits is desirable (Brown 1961). Studies on food habits of tropical and subtropical mayflies are very few (Sivaramakrishnan 1980, Gupta and Michael 1981, Venkataraman 1984). In the present investigation, detritus formed the major food. Studies by Venkataraman (1984) on nymphs of heptageniids of Palani hill streams reveal that they are algivores, whereas the same species and some leptophlebiids of Courtallam hill streams are detritivores (Sivaramakrishnan 1980).

The absence of canopy formation by forest trees on the banks of Kumbakkarai stream in Palani hills favours algal growth in rocky bottom. The limited vegetation near the bank may be correlated with minimal amount of allochthonous detritus. The condition in Courtallam hill streams is different, with poor access to direct sunlight over the stream due to canopy formation. Kurangani stream is in this respect similar to Courtallam streams. The statement that local conditions beget local results (Muttowski and Smith 1929) holds good for explaining the food habits of Ephemeroptera or even other groups of aquatic insects (Cummins 1973). Gut content analysis of *E. nadinae* revealed a meagre amount of minerals and plant tissues which might have been consumed with normal food incidentally.

Emergence: Emergence is probably a 'safety in numbers' strategy evolved to maximise survival from predation at one of the vulnerable periods in the life cycle of mayflies (Friesion *et al.* 1980). In the present investigation, *E. nadinae* emerged after sunset (around 1830 hrs throughout the year). Similar dusk emergence was observed by Takemon (1985) in *E. japonica*. He observed *E. strigata* to emerge in the afternoon. Synchronous emergence of both sexes of *E. nadinae* was recorded, with males outnumbering females. As against the male-biased emergence, female-biased emergence has been recorded in some tropical mayflies (Poyyamoli 1984, Venkataraman 1984).

Edmunds and Edmunds (1980) point out that apparently many of the activity patterns and adaptations of mayfly subimagos and imagos have formed in response to selection pressure from predators. Mayfly subimagos, being slow and clumsy fliers, are highly vulnerable to predation.

Nocturnal emergence observed in the present study may be attributed to the following reasons as suggested by Poyyamoli (1984) and Takemon (1985):

(1) The cuticle of newly emerged adults will be thin. As a result, they have to emerge during cooler hours, when evaporation is at its lowest. Night time in tropics is ideal.

(2) Nocturnal emergence helps these insects to escape from visual predators.

The emerging behaviour of *E. nadinae* of Kurangani stream was found to be of the water surface type and the behaviour is similar to *E. strigata* of Japan (Takemon 1985). However, nymphs of *E. japonica* after reaching the surface swam directly ahead along the surface with forelegs stretched forward until they came into contact with a partially submerged object such as a rock or plant. The longevity of adults (emer-

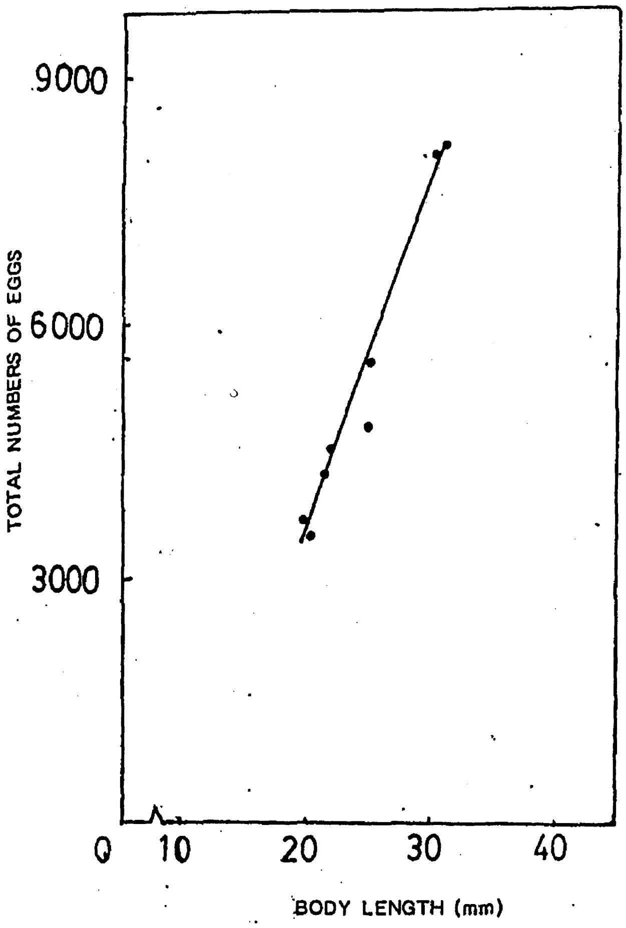

Fig. 3. Relationship between body length and number of eggs in *E. nadinae*.

gence to imago-death interval) of *E. nadinae* ranged from 24 to 48 hours.

Fecundity: The correlation between the number of eggs produced by *E. nadinae* and the body length is presented in Fig. 3. It confirms the general view that fecundity increases with increasing body length of the nymphs. However, Minshall (1967) found that beyond a size range (10.5 mm) the number of eggs decreased with increasing size of the individual. This apparent decline in egg number with increasing body size (up to 31 mm) has not been observed in the present study.

The average number of eggs/mm of body length in *E. nadinae* is 240 (r value = 0.9). The data of Clifford and Boerger (1974) for Bigory river mayflies of Canada, Hunt (1951) and Britt (1962) for Ephemerids and of Minshall (1967) and Venkataraman (1984) for Heptageniids would indicate 137-222 eggs/mm, 300-350 eggs/mm and 100-200 eggs/mm respectively.

Among the mayfly species, the burrowing Ephemeridae are the longest. But the rate of egg production is very high (1843 eggs/mm) only in Heptageniidae (Sridhar and Venkataraman 1989). The Ephemeridae are burrowing and sandy forms, whereas heptageniids are rheophilic and are restricted to torrential areas of rock-bottomed streams. This difference in ecological niche probably necessitates the production of more eggs to compensate for the loss of eggs being washed away (Sridhar and Venkataraman 1989).

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