To Dr. M. D. Hubbard with regards K. G. S

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STUDIES ON MAYFLY POPULATIONS OF COURTALLAM STREAMS

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INTRODUCTION

The taxonomic and ecological studies of aquatic insects have attracted the attention of many biologists because of importance of these insects in freshwater communities, their role in fisheries and their sensitivity to pollution. Mayflies are an excellent tool for studying environmental relationships and the importance of a favourable environment for all forms of aquatic life (Pescador and Peters, 1974).

Southern peninsular India abounds in numerous hill streams and the mayfly fauna of this habitat has received scanty attention by aquatic entomologists. Even the taxonomic literature of the species of lotic mayflies in South India is scanty excepting a few fragmentary reports by Demoulin (1955), Peters and Edmunds (1970), and Peters (1975). Whereas there is ample literature on the rithrolimnological studies of stream and small river systems of the high latitudes (Berg, 1943 ; Berg *et al.* 1948 ; Fjerdingstad, 1950 ; Allen, 1951 ; Illies, 1952 ; Albrecht, 1953 ; Harrison and Elsworth, 1958 ; Oliff, 1960 ; Allanson, 1961 ; Chutter, 1963 ; Minckley, 1963 ; Ulfstrand, 1968a and reviews by Macan 1961 ; Illies and Botosaneanu, 1963 ; Cummins, 1966 and Hynes, 1970), little work is yet done in equatorial regions. Recent comprehensive studies carried out in a small Malayan river, Sungai Gombak (Bishop, 1973) and investigations on Indian rivers (Venkateswarlu and Jayanti, 1968 and Venkateswarlu, 1969) and rivers of Sri Lanka (Costa and Fernando, 1967) are a few notable exceptions to the above statement.

This study is an initial attempt to investigate the species composition and the lifecycle pattern of the lotic mayflies of perennial and intermittent streams of Courtallam and to find out how the mayfly populations are maintained and repopulation is accomplished in small rock-bottomed streams that frequently go completely dry when the monsoon rains dwindle.

DESCRIPTION OF STUDY AREA

LOCATION :

Courtallam is situated in the Western ghats lying in the northern half of Tirunelveli District, Tamil Nadu between 8° 50′ and 9° 0′ northern latitudes and 77° 10′ and 77° 20′ eastern longitudes.

PHYSIOGRAPHY :

Courtallam is a hilly region whose height varies from 150 meters to 1500 meters with narrow valleys endowed with steep slopes.

TEMPERATURE:

The average temperature is 28°C and goes up to 32°C during March to May which is the hottest part of the year. The lowest temperature is felt during December.

RAINFALL :

During the monsoon the rains may at times be torrential, at times gentle and it may last for several days. The general rainfall of Courtallam ranges from 175-210 cms. per year. The rainfall is not evenly distributed throughout the year. During June to September and October to December, the hill gets the maximum rainfall from the Southwest monsoon and Northeast monsoon respectively.

DESCRIPTION OF STATIONS AND NOTES ON THEIR ECOLOGY

STATION I

This is located in the perennial stream (Fig. IA) between Shenbagadevi Falls and Main Falls. Mean elevation is 200m above M. S. L. The basic habitat consists of a series of rocky ledges overlain with large boulders and rubble. The substratum is rubble and gravel integrated with coarse sand in quieter water at the edges. The stream averages 15m wide. Maximum depth is 1.5m which drops 0.5 to 0.7m in summer.

Along the banks of the stream are thick strands of trees and shrubs whose leaves are the stream's principal source of organic detritus. Among the taller plants are *Givotia*, *Artocarpus* and *Syzigium*. Because of the leaf canopy over the stream formed by branched and leaning trees there is feeble exposure to direct sunlight even in midday. So fluctuation in day and night temperature is minimised.

The ecological study in this station was conducted from January 1977 to December 1977.

STATION II :

This is located in the intermittent stream (Fig. 1B) leading to Tiger Falls. Mean elevation is 180m above M. S. L. The substrate is a bedrock slab, covered with scattered bits of rubble. The stream

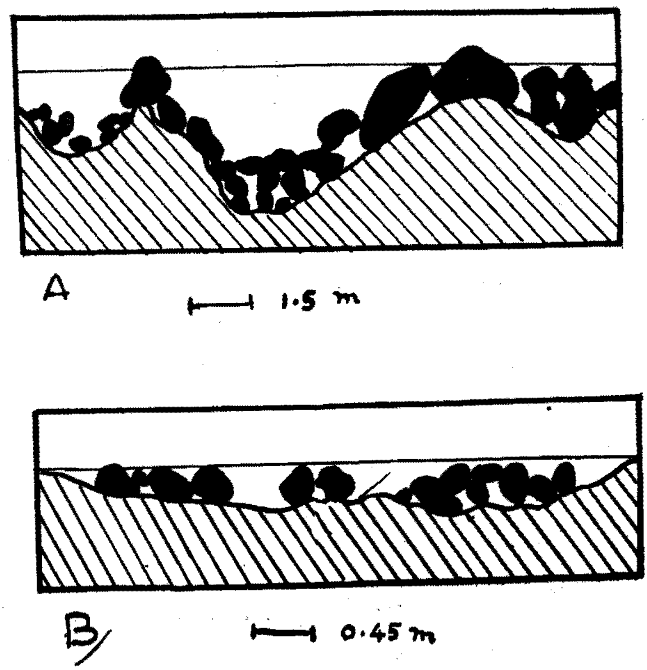


Fig. 1.A. Station I in perennial stream
B. Station II in intermittent stream.

averages 4.5 m wide. Average depth is 0.6m. The loose stones of the stream have little algal encrustation. The allocthonous leaf detritus form the principal source of food for the mayfly nymphs. The station is partly shady due to the thick growth of trees such as ***Pongamia***, *Kirganelia*, *Grewia*, *Careya*, *Zizyphus* etc. on the banks.

The ecological study in this station was conducted between September 1975 and December 1976.

MATERIAL AND METHODS

The technique adopted by Macan and Maudsley (1968) was used in sampling the nymphal populations. For a period of 5 minutes stones were picked up from the bottom by hand and examined for Ephemeroptera. The nymphs were gently collected by using fine brushes. Care was taken not to damage such delicate parts as tracheal gills. As the stones were picked up, a net was held underneath to obtain those nymphs that swam away when disturbed.

From the summation of the results of sampling the nymphal populations an abundance index was calculated for all the species in each locality. In view of overlapping life cycle and intermittent flow of some streams, maximum abundance rather than mean abundance formed the basis of the index. The abundance index for a locality was the maximum number of specimens of that species taken on any single occasion divided by the number of 1 metre square sampling areas (modified from Brittain, 1974). Actual values ranged from 0.5 to 35. To simplify the appreciation of the relative abundance between localities and as the methods are subject to certain amount of variation, the indices were grouped in the following four categories :

0.5-1.9	+	rare
2.0-9.9	++	common
10.0-30.0	+++	moderately abundant
above 30	++++	abundant

Mayfly life-history phenomena were interpreted by using the following procedure. Nymphs were counted. Each nymph was grouped into one of the four arbitrarily chosen developmental stages on the basis of appearance and development of the mesothorasic wing pads. Stage I nymphs lacked wing pads ; Stage II nymphs had wing pads, but their lengths were shorter than the distance separating the two wing pads ; the wing pad length of Stage III nymphs was greater than the distance separating the two wing pads. Stage IV nymphs had darkened wing pads. A more advanced developmental stage represents an older "physiological" age but because of environmental conditions not necessarily an older absolute age (Clifford, 1969). Each stage represents several instars with the exception of stage IV, which is the last nymphal instar, the tan wing pads indicating impending emergence.

Tests for dissolved oxygen were conducted by Winkler's method. Water temperatures were measured 7 cms. below the water surface by thermometer. Water velocity was determined by the cork floatation method. pH was noted with the help of broad range and narrow range pH papers. All the above observations were recorded whenever field trips were made in connection with ecological studies.

RESULTS AND DISCUSSION

A. DIVERSITY AND ABUNDANCE :

Comparison at gross level of the mayfly zoome of Courtallam streams with that of a temperate one namely Morgan's Creek, a small, springfed stony stream in Kentucky, USA reveals that species diversity

⊗ Gen. et. sp. nov. A, Gen. et. sp. nov. B,

of the families of mayflies is greater and the population of any particular species comparatively smaller in the former. For instance, only two heptagenids (*Epeorus pleuralis* and *Stenonema interpunctatum*), five baetids (*Baetis amplus*, *Baetis herodes*, *Baetis phoebus*, *Centoptilum rufostrigatum* and *Pseudocloeon carolina*) and one leptophlebiid (*Paraleptophlebia moerens*) were recorded in Morgan's Creek (Minshall, 1967). As many as five new leptophlebiids (*Choroterpes* (*Euthraulus*) sp., **Notophlebia*, *Thraulus* sp., and *Isca* sp.), three heptagenids (*Epeorus* sp., *Compsoneuriella* sp. and *Thalerosphyrus* sp.), one ephemerellid (*Teloganodes* sp.) and many baetids (the taxonomy of oriental Baetidae is practically not worked out) were recorded in station I in the perennial stream at Courtallam leading to Main Falls. In contrast to this species diversity in Courtallam streams, 1052 nymphs of *Epeorus pleuralis* were collected in 5 minute samples at Morgan's Creek from February 1963 to September 1964 (the mean abundance index is recalculated as 52.6), where as no individual species reach such great abundance in any station in the present study (Table I). The abundance index of Courtallam species rarely exceeds 30. Such a species diversity coupled with small populations of individual species was noted in various taxa of macroinvertebrates of the Malaysian river, Sungai Gombak (Bishop 1973). This may probably be one of the features of the tropical lotic ecosystems.

B. LIFE CYCLE PATTERN :

Life cycle pattern of Gen. et, sp. nov. A, and *Notophlebia* sp. nov., in Courtallam streams as revealed from developmental stage frequency histograms (Figs. 2 and 3) closely parallel those of Gombak river forms at Malaysia. The hatching was continuous and development asynchronous and independent of any cyclical pattern (Bishop, 1973).

Growth rates even at the almost uniform temperatures of the streams may however be governed to a degree by other extrinsic conditions, so that the time needed to complete development could be variable. Many tropical lentic aquatics require about four months for a complete cycle (Corbet, 1956), but in a changeable lotic system, the rate of growth may depend more on the availability of food than on time. Populations of nymphs extant during stable periods when both detritic and algal food are available undoubtedly develop at a more rapid pace than those hatched out into or subjected to denuded or improverished substrates following a period of spates (Bishop, 1973). This is analogous to the situation in temperate rivers where diet preferences and optimal growth periods are adjusted to the seasonal availability of food *i.e.*, algal grazers develop more rapidly in phototrophic periods of summer

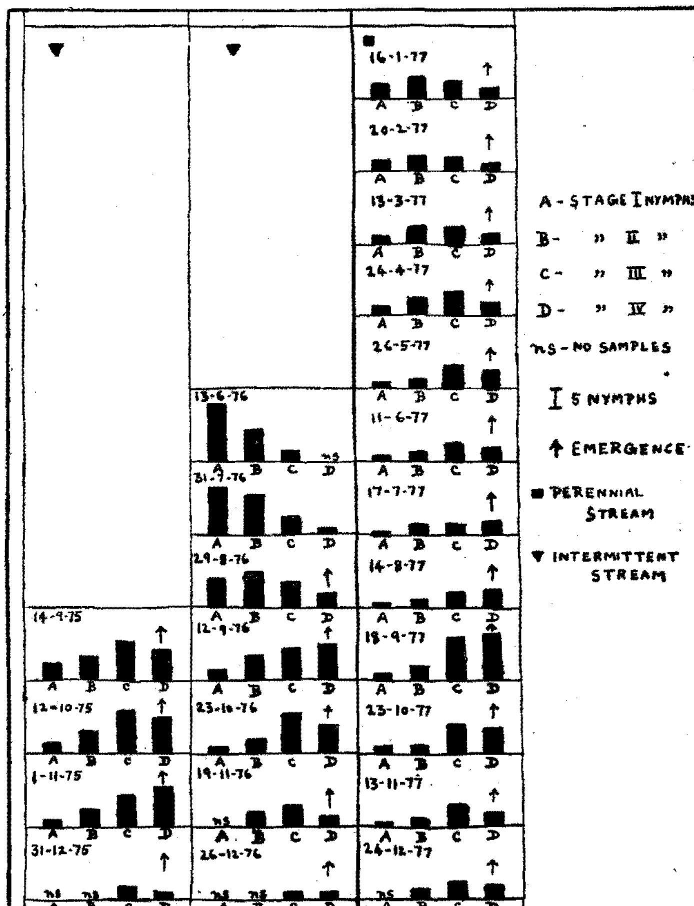
*The taxonomic descriptions of these new forms are to be published elsewhere.

Table I : Physical, Chemical and Faunistic parameters of investigated stations.

Station	Habitat	Water flow	Mean water velocity	Mean dissolved O_2 content	Water temperature range	pH	Mayfly fauna	*Abundance index (Maximum)	Associated forms
I (in perennial stream)	Rocky	Perennial	0.4 m per second	7.2 mg/l	22°-29°	6.5	Gen. et. sp. nov. A	+ + + +	Stoneflies
							Gen. et. sp. nov. B ~~*Edmundsula origanesansis*~~	+ + + +	
							Choropterpes (*Euthraulus*) sp.	+ +	
							Thraulus sp.	+	
							Notophlebia sp. nov.	+ + +	
							Isca sp.	+ +	
							Epeorus sp.	+ +	
							Cinygmina ~~*Compsoneuriella*~~ sp.	+ + +	
							Thalerosphyrus sp.	+	
							Teloganodes sp.	+ +	
							Baetidae	+ + +	
II (in intermittent stream)	Rocky	Intermittent	0.5 m per second	7.6 mg/l	22°-29°D	6.4	Gen. et. sp. nov. A	+++	Stoneflies
							Choroterpes (*Euthraulus*) sp.	+ +	
							Notophlebia sp. nov.	+ + +	
							Isca sp.	+ +	
							Epeorus sp.	+ +	
							Cinygmina ~~*Compsoneuriella*~~ sp.	+ + +	
							Thalerosphyrus sp.	+	
							Teloganodes sp.	+ +	
							Baetidae	+ + +	

*+ rare ; ++ common ; +++ moderately abundant ; ++++ abundant.

and detritivores in winter and early spring when leaf-fall materials are most abundant (Hynes, 1961 ; Ulfstrand, 1968a, b). Here, where light and leaf-fall are not seasonal, both categories of food vary in abundance altogether, in response to discharge conditions. In the present study, the development of gen. et. sp. nov. A, and *Notophlebia* sp. nov. was



Gen. et. sp. nov. A

Fig. 2. ~~Petersula courtallensis~~—age frequency histograms

found to be rapid in their bloom period in the intermittent stream (between September 1975 and November 1975). Maximum use of resources during this stable period enabled several generations to complete their life cycles. The emergence of the adults was also continuous.

Mayfly life cycles may be grouped according to Landa's (1968) classification which is abridged (Clifford, Robertson and Zelt, 1973 as follows :

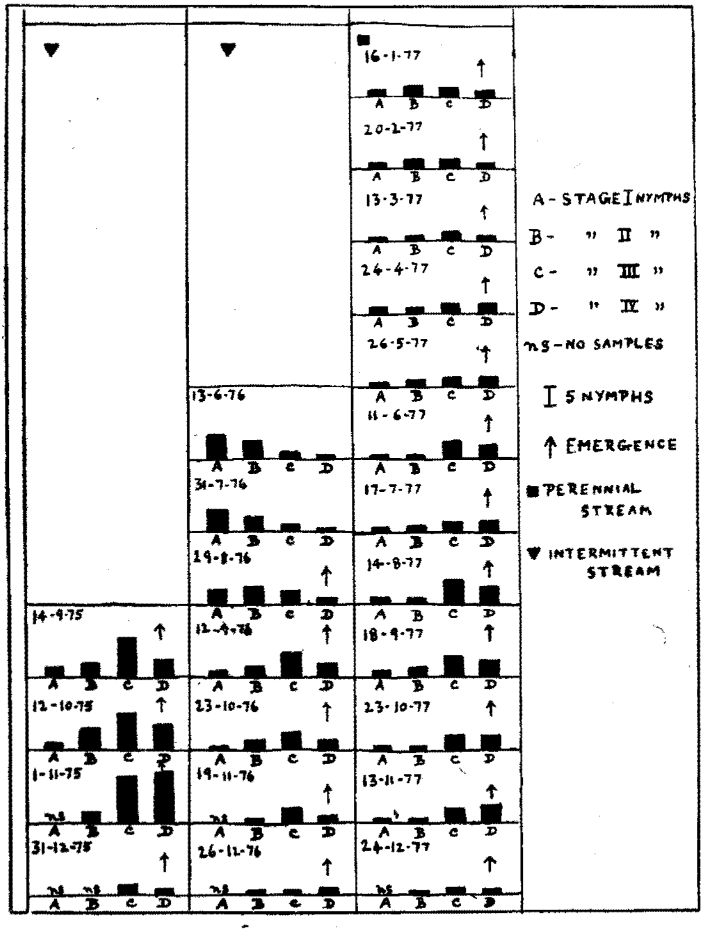


Fig. 3. *Notophlebia* sp. nov. age frequency histograms

A. One generation in a year.

A1 (winter species) Nymphs hatch in summer and autumn, continue to grow throughout the winter and emerge the following spring or summer.

A2 (summer species) Nymphs hatch, grow and emerge during a short period of summer, the eggs being in a supposedly diapause state for most of the year.

A3 (winter species) Nymphs hatch and grow in summer and autumn, but not in winter, growth resuming the following spring.

B. Two or more generations in a year.

C. One generation in two or more years.

D. Others.

The life cycle patterns of mayflies of different latitudes can fit into this scheme. The fauna of the moderate temperate regions can be characterized as having mainly nonoverlapping generations consisting of winter species with growth in winter as well as an abundance of summer species. In the cold temperate and subarctic regions of North America (*eg.* above latitude 42°), there is a tendency for the winter species with growth in the winter to give way to winter species without growth in the winter. (Clifford, Robertson and Zelt, 1973). In the tropics there is a preponderence of species with multivoltine cycles (B species, according to Landa's classification) and emergence is continuous and noncyclical. When emergence is cyclic in a tropical setup, it is found to be due to factors other than seasonally varying temperatures and photoperiods *ie.*, the lunar emergence rhythms of *Povilla adusta* Navás (Hartland-Rowe, 1958). The lifecycle pattern of the species occuring in the hill streams of Courtallam is basically multivoltine with overlapping generations and continuous emergence, characteristic of the tropical belt but the local influence of the two monsoons is especially felt in abruptly terminating the cycles in intermittent streams at the end of the monsoons due to dwindling discharge from the headwaters.

C. REPOPULATION BUILDUP IN INTERMITTENT STREAMS :

With the rise in temperature and arrest of northeast monsoon, the intermittent stream was reduced to isolated pools in February 1976 having the semblance of a typical lentic environment. These pools were inhabited by the lentic forms like *Cloeon dipterum* and mosquito larvae. In summer months the stream was practically dry. With the arrival of the southwest monsoon, the characteristic hillstream forms began to build up their population within a fortnight when the stream started flowing in June 1976.

The quick accomplishment of repopulation in such intermittent streams was investigated at this stage. The possibility of a few forms either in seepage itself or in water saturated air spaces above the seepage was completely ruled out because the stream bed comprised chiefly of exposed bedrock which did not permit the formation of interstitial spaces. The next alternative was to tide over the adverse environmental condition by the formation of diapause eggs, similar to the resting eggs (ephippia) of daphnids. Khoo (1968) recorded such diapause eggs of *Leptophlobia vespertina* in Windermere. During dry period, a few stones from the area were taken and placed in water brought from the perennial source for a few days to find out whether any juveniles attached to such stones in suspended animation could revive or whether any diapause eggs could hatch if at all present. The results were quite discouraging. The only other possibility *viz.*, the migration of nymphs into the streams via reestablished connections with permanent water bodies or via flight of adults was examined. This prompted the investigations at station I in a perennial source between Shenbagadevi Falls and Main Falls. Surprisingly enough nymphal populations of different species of mayflies were maintained throughout the year in the varied microhabitats available there. Moreover the facts that the intermittent stream under investigation received flow during monsoon seasons from the perennial 'stock reservoir' source just below Shenbagadevi Falls and that a few nymphs in advanced instars of different species were spotted in intermittent stream at station II even in the first collection at the onset of the monsoon (June 1976 and June 1977) reinforce the inevitable conclusion that repopulation is ~~only~~ mainly through migration of mature nymphs from perennial sources to the intermittent stream under investigation.

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