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Taxonomic Keys of Mayflies in the Palni and Cardamom Hills of Western Ghats, Southern India

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ABSTRACT

A key to ephemeropteran nymphs belonging to 8 families, 30 genera and 48 species from the Palni and Cardamom hills of the Western Ghats in Kerala and Tamil Nadu states is presented in this chapter. Sampling was done at 30 sites. Baetidae and Leptophlebiidae diversity was higher compared to Ephemeridae and Ephemerellidae. Mayflies endemic to the Palni and Cardamom hills include *Ephemerella (Aethephemerella) nadinae*, *Klugephlebia kodai* and *Indoganodes jobini*. This work serves as a taxonomic primer for doing further research on mayfly taxonomy, biology, biogeography and ecology and it will also aid Bio monitoring programs.

Keywords: Key; Baetidae; gills; setae; terga; endemism.

1. INTRODUCTION

Freshwater ecosystems are being subjected to anthropogenic disturbances throughout the world in recent times [1]. Benthic macro invertebrates are among the most important components of freshwater ecosystem; they are cosmopolitan in distribution and occur in several substrate types in freshwater environments [2]. The distribution of aquatic insects is influenced by their interactions of habitats, physico-chemical attributes, structural and hydrological characteristics and anthropogenic stress [3, 4].

Mayfly (Order: Ephemeroptera) larvae are living in fresh water habitats such as lakes, streams, ponds and rivers. Larvae of May fly commonly occurs in under stone, decaying leaf litters, wood logs, etc. The mayfly larvae are inhabited in water bodies while sub imagoes and imagoes are spending their life in terrestrial habitats. Larvae of mayfly size, shape and body plan are different from species to species and they are also slender, soft bodied creatures lacking wings and have feathery external gills along the sides or on the abdominal region. Their flattened head helps them to adhere to the rocks in fast flowing water. Larvae have 3 or 2 cerci in the terminal region of abdomen. Structure and location of gills on the larvae is essential characteristic feature for species identification.

Mayfly larvae act as an ecosystem servicer, nutrient cyler and bio indicator in fresh water bodies. These larvae are of different feeding categories such as grazers, scraper, filter feeder, predators, etc. Identification keys are very important for the identification and distribution of taxa. The main aims of this larval keys are for i) identification of new mayfly taxa, ii) collection of scientific data from this taxa and iii) identify the endemic fauna in Palni and Cardamom hills in the Western Ghats. Mayflies are recognized as potential bio indicators of good water quality and they have not widely been studied in the Indian subcontinent [5]. The reason for selecting Palni and Cardamom hills for the study is because they are the part of the Western Ghats which is one of the hot spots in the World. Nowadays, mayflies of these sites are facing more threat and extinctions because of human interference. This generic key will definitely be making awareness among budding scientist and conservation of these aquatic creatures.

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2. MATERIALS AND METHODS

2.1 Study Site

The present work was carried out from 2018-2019 in 30 streams of Palni and Cardamom hills (Table 1) of the Western Ghats in Southern India.

2.2 Sampling and Collection of Insects

Mayfly nymphs are collected using 1cm wide Kick-net, D-net and handpicking. All insects were picked and preserved in 80 percent ethanol and identified in the laboratory. Collected specimens were studied with the aid of a stereo microscope and identified with the help of a recent field guide [6] and appropriate taxonomic literature. Identification of all species was confirmed by the experts in this field.

Table 1. Details of the 30 Study sites

S. No	Name of the study site	Abbreviation	Stream order	Altitude (m)	Latitude (N°)	Longitude(E°)
1	Oothu	Ooth	3	1300	10°12'	77°26'
2	Perumalmalai	Peru	2	1400	10°18'	77°33'
3	Kurusadai	Kuru	2	1700	10°20'	77°28'
4	Ghandhi nagar	Gand	2	1600	10°18'	77°27'
5	Silver cascade	Silv	2	1700	10°12'	77°28'
6	Vattakanal	Vatt	2	1000	10°11'	77°25'
7	Fairy falls	Fair	3	290	10°13'	77°27'
8	Bear Shola falls	Bear	2	300	10°14'	77°27'
9	Fern hill falls	Fern	3	122	10°12'	77°20'
10	Pillar rock	Pill	1	2250	10°17'	77°28'
11	Near pillar rock	Near pill	1	2255	10°12'	77°30'
12	Pambar stream	Pamb	2	2248	10°13'	77°28'
13	Dhobikana	Dhob	3	2075	10°24'	77°24'
14	Gundar Falls	Gund	2	2200	10°14'	77°26'
15	Poomparai	Poom	2	2133	10°13'	78°16'
16	Kouchi	Kouc	2	2360	10°29'	77°30'
17	Kurangani up	Kura-up	2	2410	11°00'	77°50'
18	Kurangani down	Kura-down	2	2345	11°00'	77°45'
19	B. L. Rave	B.L.Rave	1	1250	10°11'	77°25'
20	Poonthampanai	Poon	1	1300	11°12'	77°26'
21	Santhamparai near bridge	San-bridge	2	1350	11°00'	77°52'
22	Santhamparai near SDA school	San-SDA	4	1400	11°13'	77°28'
23	Mattupetty Dam stream	Matt	2	1700	11°16'	77°29'
24	Anayirankal stream	Anai	2	1950	11°18'	77°31'
25	Aranmanaiparai	Aran	3	2050	11°21'	77°33'
26	Popparai	Popp	4	1785	11°44'	77°26'
27	Bodimettu	Bodi	2	1500	11°15'	77°24'
28	Thoovanam falls	Thuv	3	1550	11°15'	77°15'
29	Nayamakkadu falls	Naya	2	2197	11°20'	77°10'
30	Chinnakanal falls	Chin	1	1800	11°27'	77°30'

3. RESULTS AND DISCUSSION

3.1 Mayfly Diversity

A total of 1255 mayfly nymphs were collected during the period of 2018-2019 from the Palni and Cardamom hills comprising eight mayfly families, 30 genera and 48 species. Baetidae was the most diverse family with 17 species followed by Leptophlebiidae with 14 species. The lowest diversity

occurred in Ephemeridae and Ephemerellidae, each with one species. The highest numbers of nymphs collected were of *Choroerpes alagarensis* (Leptophlebiidae) and *Tenuibaetis frequentus* (Baetidae). *Potamanthellus ganges* (Neophemeridae) was the least collected species.

3.2 Endemism

Western Ghats is one of the most noted biodiversity hotspots of the world and its fauna exhibits a high level of endemism. Mayflies in the Palni and Cardamom hills show endemism to some extent, the mayflies that are endemic to the Palni and Cardamom hills are listed in Table 2.

Table 2. List of endemic taxa present in Palni and Cardamom hills

S. No	Family	Taxa
1	Ephemeridae	<i>Ephemerella (Aethephemerella) nadinae</i>
2	Leptophlebiidae	<i>Klugephlebia kodai</i>
3	Teloganodidae	<i>Indoganodes jobini</i>

Key to families of mayflies based on mature nymph of Palni and Cardamom hills:

1. Presence of seven simple gills including gill 1; lateral ocelli located above lateral areas of epicranial suture; ventral orientation of dorsal lobe on the apice of the femora.....**Baetidae**
-Gills variously developed, gill 1 either present or absent; lateral ocelli connecting with lateral branches of the epicranial suture or situated below the suture; no ventral orientation of dorsal lobe on the apice of the femora.....**2**
2. Mandibular tusks present, tusks curved outwards, inner edges convex; tibial extension on posterior area of legs**Ephemeridae**
-Mandibular tusks absent.....**3**
3. Gills absent on abdominal segment 2**Ephemerellidae**
-Gills present on abdominal segment 2.....**4**
4. Forewing pads freely extending beyond fusion to thorax for more than half their length; gill 2 not operculate.....**5**
- Forewing pads freely extending beyond fusion to thorax for less than half their length; gill 1 never operculate, operculate gills on abdominal segment 2 present or absent.....**6**
5. Head capsule mostly semi-circular and dorsoventrally flattened, gills 1-6 possessing plate-like dorsal lamella with a fibrilliform ventral portion, gill 7 lamellate without fibrilliform portion; no prominent brush of setae in the apicolateral margin of the maxilla**Heptageniidae**
-Head capsule mostly quadrangular or rectangular, gill 1 sometimes simple, unilamellate, lanceolate or filamentous and rudimentary; gills 2-7 bilamellate; prominent brush of dense setae in the apicolateral margin of the maxilla.....**Leptophlebiidae**
6. Gills on abdominal segment II meeting along the midline, median caudal filament covered with dense setae on outer and inner margins; the lateral filaments with setae only on the inner margins.....**Neophemeridae**
- Gill on abdominal segment II not as above.....**7**
7. Abdominal gills on segment II overlapping with setae or spatulate spines on posterior margin at midline and presence of Y-shaped ridges on the dorsum; terminal filament present or absent and abdomen wider than thorax; gill 1 always filamentous.....**Caenidae**
-Gill 1 present or absent and if it is present, it is filamentous; gill 2 operculate, semi-operculate, or not operculate; even if it is operculate, it is smaller than above and it is generally oval in shape; lack of Y-shaped ridges on dorsal surface and it is never overlapping, posterior margin of mesonotum with prominent V shaped notch and generally lobed basally**Teloganodidae**

Key to genera and known species of mayflies from family Ephemeridae:

1. Well-developed mandibular tusks; abdominal gill 1 with two lobes mostly of equal size.....*Ephemera*.....a
 - a. Mandibular tusks asymmetrical; right one is shorter (Fig. 1a).....subgenus:
Aethephemera.....i
 - i. Frontal process in the golden brown; tibia in the dorsal surface of prothoracic legs entirely spuriferous; Meta thoracic legs tibial process is densely covered with golden brown setae. (Fig. 1b).....*Ephemera (Aethephemera) nadinae*

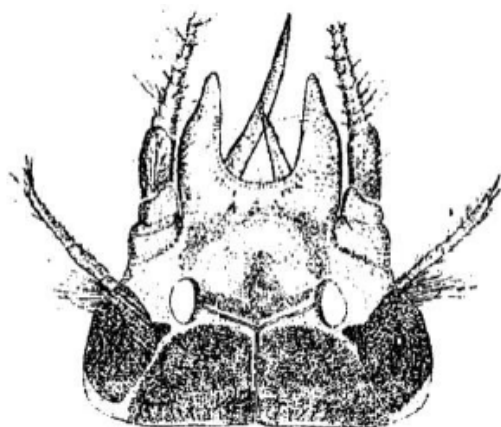


Fig. 1a.
 (after Balasubramanian et al. [7])

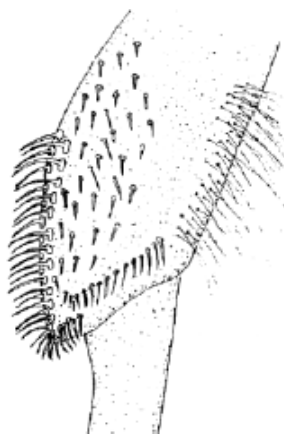


Fig. 1b.

Key to genera and known species of mayflies from family Ephemerellidae:

1. Gill III is enlarged and semi-operculate, covering the other gills (Fig. 2)
*Torleya*.....i
 - i. Head capsule distinctly have a row of spatulate setae along anterior margin; setae of median caudal filament recumbent and 2-3x the length of the filament segment.....*Torleya nepalica*

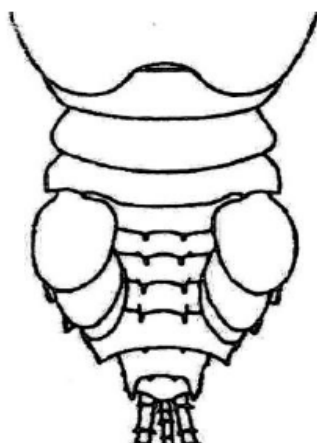


Fig. 2.