https://doi.org/10.33307/entomon.v46i4.638
ENTOMON 46(4): 279-284 (2021)
Article No. ent. 46401

Diversity and community structure of Ephemeroptera in freshwater stream of Megamalai hills, Tamil Nadu, India

S. Barathy*, T. Sivaruban#, Srinivasan Pandiarajan, Isack Rajasekaran and M. Bernath Rosi

Department of Zoology, Fatima College, Madurai-625018, Tamil Nadu, India; #PG and Research Department of Zoology, The American College (Autonomous), Madurai-625002, Tamil Nadu, India. Email: barathyruban@gmail.com

ABSTRACT: In the study on the diversity and community structure of Ephemeroptera in the freshwater stream of Chinnasuruli falls on Megamalai hills, a total of 523 specimens belonging to thirteen genera and five families were collected in six month periods. Of the five families, Teloganodidae and Leptophlebiidae exhibited high diversity and Caenidae showed low diversity. *Choroterpes alagarensis* (Leptophlebiidae) is the most dominant species. Diversity indices such as Shannon and Simpson indices showed that diversity was maximum in November and December and it was minimum in August and January. Canonical Correspondence Analysis revealed that rainfall, water flow, turbidity, and air temperature were the major stressors in affecting the Ephemeropteran community structure.

KEYWORDS: Mayflies, Shannon and Simpson indices, Canonical Correspondence Analysis

INTRODUCTION

Order Ephemeroptera commonly known as mayflies have larval stages in the aquatic environment and they inhabit the freshwater ecosystem. Mayfly nymphs mainly form the main part of the freshwater ecosystem. They change their abundance and diversity when habitats change or become depleted and are called bio-indicators of good water quality (Barathy *et al.,* 2020a). Along with Trichoptera and Plecoptera, mayflies are excellent biological indicators of water quality, due to their high level of sensitivity to pollution and anthropogenic effects (Rosenberg and Resh, 1993). Likewise, they play an important role in the nutrient cycle by degrading large amounts of organic matter in aquatic habitats, shaping an important part of the food chain and food web in freshwater habitats.

In recent years, numerous works were done in the taxonomic aspects and least known families in India like Tricorythidae, Teloganodidae, and Caenidae have been revealed (Sivaruban *et al.,* 2021; Srinivasan *et al.,* 2021a; Srinivasan *et al.,* 2021b) and some ecological works were carried out in both Western and Eastern Ghats of southern India (Barathy*et al.,* 2020b; Sivaruban *et al.,* 2020b; Srinivasan *et al.,* 2019) yet it stays fragmentary. As one of the biodiversity hotspots in the world, the Western Ghats occupy a variety of ecological niches and are unique in their ecological structure and functions. Megamalai is one of the high

* Author for correspondence

altitudinal places in Tamil Nadu and no studies were made formally in both taxonomy and ecological aspects in this eco-region. Therefore, the present study aims to evaluate the diversity and distribution of mayflies in correlation with physicochemical variables of water, as well as to provide information on the inventory of mayflies in the Megamalai region of Western Ghats.

MATERIALS AND METHODS

Chinnasuruli falls also known as "Cloud Land" falls is situated near Kombaithozhu Village of the Theni district of Southern Western Ghats of Tamil Nadu, India. The waterfalls originate from the Megamalai hills. The waterfalls cascade from the height of 190 feet. Coordinates: latitude 9°42'30" N and longitude 77°25'34" E. The present work was undertaken from August 2017 to January 2018. Water samples were collected from the stream and they were analyzed using APHA guidelines (APHA, 2005). Collection of benthic specimens was done using a 1m wide Kick-net (Burton and Sivaramakrishnan, 1993) with a mesh size of approximately 1 mm. All insects were picked and preserved in 80 percent ethyl alcohol. Collected samples were placed under a stereomicroscope (Magnus Pro) and identified with the help of field guides by Sivaramakrishnan *et al.* (1998) and Barathy *et al.* (2021).

Physico-chemical parameters of Chinnasuruli stream, water temperature (°C), air temperature (°C), water flow (m\s), water pH, dissolved oxygen (mg/l), total dissolved solids (ppt), turbidity (NTU), and mean monthly rainfall (mm) were taken for the period August – January.

The data analysis was done with the help of the PAST software (Version 4.2) to measure various diversity indices and Canonical Correspondence Analysis (CCA) was also analyzed (Hammer *et al.*, 2001).

RESULTS AND DISCUSSION

Sampling of Ephemeropteran larvae resulted in a total of 523 specimens belonging to 13 genera and five families (Table 1). Of the five families, Teloganodidae and Leptophlebiidae exhibited high diversity which includes five and four species respectively and encompassing 145 and 162 individuals respectively. On the other hand, Caenidae exhibits low diversity with only two species and encompassing 30 individuals. On the whole, *Choroterpes alagarensis* Dinakaran, Balachandran & Anbalagan, 2009 (Leptophlebiidae) is the most dominant species and it shows a wide range of tolerance to the physicochemical variables.

When diversity richness measured based on months indicated higher richness in October and November compared to other months. The richness was comparatively very low in these months and it is probably due to high temperature and low rainfall. Among alpha diversity indices, the Shannon-Weiner index and Simpson's index calculated to show that the Shannon index was higher in December (2.637) and lowest in August (2.415), while Simpson index was higher in November (0.9211) and lowest in August (0.8959). Results reveal that high rainfall months support more diverse taxa in contrast with non-rainy periods like August and January (Table 2). Similar results were observed by Sivaruban *et al.* (2020a) in the Gadana River.

Both water temperature and air temperature were higher in August and January compared to other months (Table 3). This also leads to a decline of low tolerant taxa in these months and supports high tolerant taxa like *Caenis* sp. The water flow velocity in Chinnasuruli stream during August was found to be 0.50 m/s which was low compared to other months and it lead to a decline of the rithral mayflies like *Epeorus* in August. Dissolved oxygen (DO) level stays normal in all the months and pH values stay similar in all months except there is a slight variation in August and January showing the water is slightly alkaline but falls within the normal range. Turbidity becomes a more vital component next to rainfall in this stream, as more turbid water was seen in August (0.30 NTU), this is due to low water flow and this subsequently leads to the low number of taxa. High rainfall was seen in September and October, during these months taxa richness becomes higher compared to non-rainy months.

Table 1. Ephemeroptera species recorded in the Chinnasuruli stream during different months

Family/ Species	Number collected						
	Aug	Sep	Oct	Nov	Dec	Jan	Total
Baetidae							
Baetis conservatus Müller-Liebenau & Hubbard, 1985	5	11	9	8	7	6	46
Tenuibaetis frequentus Muller-Liebenau & Hubbard, 1985	2	9	10	7	8	5	41
Acentrella vera Müller-Liebenau, 1982	0	7	6	9	5	4	31
Heptageniidae							
Afronurus kumbakkaraiensis Venkataraman & Sivaramakrishnan, 1990	1	1	2	3	1	0	8
Epeorus petersi Sivaruban, Venkataraman & Sivaramakrishnan, 2013	2	8	11	9	7	4	41
Thalerosphyrus flowersi Venkataraman & Sivamarakrishnan, 1987	1	2	6	4	4	2	19
Leptophlebiidae							
Choroterpes alagarensis Dinakaran, Balachandran & Anbalagan, 2009	11	14	18	16	12	7	78
Choroterpes nambiyarensis Selvakumar, Arunachalam & Sivaramakrishnan, 2013	4	12	12	11	8	4	51
Choroterpes sp.	2	3	5	7	3	1	21
Isca sp.	0	3	4	2	2	1	12
Teloganodidae							
Derlethina sp.	0	0	2	5	2	1	10
Dudgeodes palnius Selvakumar, Sivaramakrishnan & Jacobus, 2014	9	6	8	9	4	2	38
Dudgeodes sartorii Srinivasan, Sivaruban, Barathy & Isack 2021	5	7	9	11	6	1	39
Teloganodes kodai Sartori, 2008	7	9	6	7	6	4	39
Teloganodes sp.	2	1	3	6	5	2	19
Caenidae							
Caenis sp.	7	2	0	0	1	6	16
Clypeocaenis bisetosa Soldán, 1978	4	3	2	1	1	3	14
Total	62	98	113	115	82	53	523

Table 2. Diversity indices of Chinnasuruli stream during different months

Indices	Aug	Sep	Oct	Nov	Dec	Jan
Taxa_S	14	16	16	16	17	16
Individuals	62	98	113	115	82	53
Simpson index	0.8959	0.9107	0.915	0.9211	0.9191	0.9163
Shannon index	2.415	2.544	2.597	2.632	2.637	2.597

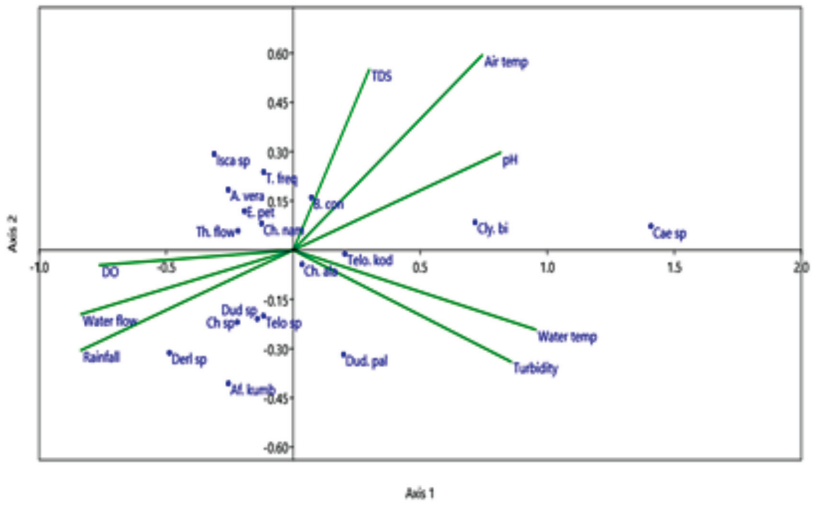

Fig. 1 Canonical Correlation Analysis (CCA) of Ephemeroptera in correlation with ecological attributes in Chinnasuruli stream.

(B. cons- *Baetis conservatus*, T. freq- *Tenuibaetis frequentus*, A. vera- *Acentrella vera,* Af. kum -*Afronurus kumbakkaraiensis*, E. pet- *Epeorus petersi,* Th flo- *Thalerosphyrus flowersi,* Ch. ala- *Choroterpes alagarensis*, Ch. nam- *Choroterpes nambiyarensis*, Ch sp- *Choroterpes* sp., Isca sp- *Isca* sp., Telo. kod- *Teloganodes kodai,* Telo sp- *Teloganodes* sp., Dud. Pal- *Dudgeodes palnius*, Dud sp- *Dudgeodes sartorii*, Derl sp- *Derlethina* sp., Cae sp- *Caenis* sp., Cly. bi- *Clypeocaenis bisetosa*)

Table 3. Physico-chemical parameters of Chinnasuruli stream during different months

Indices	Aug	Sep	Oct	Nov	Dec	Jan
Water temperature (°C)	22.4	21.1	20.7	20.5	20.5	21.4
Air temperature (°C)	27.5	27.6	27.2	27.0	27.2	27.8
Water flow (m\s)	0.50	0.52	0.74	0.72	0.68	0.54
Water pH	7.4	7.3	7.3	7.3	7.3	7.5
Dissolved oxygen (mg/l)	7.2	7.3	7.9	8.1	8.2	7.6
Total dissolved solids (ppt)	0.15	0.14	0.15	0.15	0.18	0.21
Turbidity (NTU)	0.30	0.21	0.16	0.15	0.15	0.19
Mean monthly rainfall (mm)	21.11	78.42	221.71	287.62	145.72	30.21

Canonical correspondence analysis (CCA) determines the correlation between EPT communities and environmental variables (TerBraak and Smilauer, 2002). CCA biplot reveals that taxa such as *Caenis* sp., *Baetis conservatus* Müller-Liebenau & Hubbard, 1985 and *Clypeocaenis bisetosa* Soldán, 1978 prefer high pH, air temperature, and total dissolved solids for their survival and they were inversely proportional to high rainfall, DO, and water flow (Fig. 1). High DO, rainfall, and water flow enhance the taxa like *Afronurus kumbakkaraiensis* Venkataraman & Sivaramakrishnan, 1990, *Choroterpes* sp., *Derlethina* sp. and *Dudgeodes* sp. and they were sensitive to attributes like pH, air temperature, and TDS. Taxa include *Tenuibaetis frequentus* Muller-Liebenau & Hubbard, 1985, *Acentrella vera* Müller-Liebenau, 1982, *Epeorus petersi* Sivaruban, Venkataraman & Sivaramakrishnan, 2013, *Thalerosphyrus flowersi* Venkataraman &

Table 4. Correlations of environmental gradients with the axes of CCA

Variables	Axis 1	Axis 2
Water temperature	0.954458	-0.24214*
Air temperature	0.743874	0.593868
Water flow	-0.83485*	-0.19507*
pH	0.81631	0.296973
DO	-0.7624*	-0.04579*
TDS	0.299409	0.549704
Turbidity	0.857756	-0.34013*
Rainfall	-0.83505*	-0.30507*

*indicates significant differences

Sivamarakrishnan, 1987, *C. nambiyarensis* Selvakumar, Arunachalam & Sivaramakrishnan, 2013 and *Isca* sp. gets affected by high levels of turbidity and water temperature whereas *C. alagarensis*, *Teloganodes kodai* Sartori, 2008 and *Dudgeodes palnius* Selvakumar, Sivaramakrishnan & Jacobus, 2014 gets nourished by high levels of turbidity and water temperature and *C. alagarensis* becomes the most diverse and tolerant taxa in the Chinnasuruli stream of Western Ghats. Rainfall, water flow, turbidity, and air temperature are vital in governing the diversity and distribution of mayfly larvae in Chinnasuruli stream (Table 4). Beyene *et al.* (2008) found that rainfall turns into a major element in governing the mayfly diversity and our results also show a closer resemblance to their findings. This study revealed that *C. alagarensis* is the most dominant taxon in the Chinnasuruli stream of the Western Ghats and environmental characteristics such as precipitation, water flow, turbidity, and air temperature are the main components in managing mayfly distribution.

REFERENCES

APHA (2005) Standard methods for the examination of water and wastewater. American Public Health Association. 21st Edition, Washington D.C.

Barathy S., Sivaruban T., Arunachalam M. and Srinivasan P. (2020a) Community structure of mayflies (Insecta: Ephemeroptera) in tropical streams of Western Ghats of Southern India. Aquatic Research 4(1): 21-37.

Barathy S., Sivaruban T. and Srinivasan P. (2020b) Distribution of mayflies in thirty streams of Western Ghats, Southern India. Journal of Insect Biodiversity 18(2): 50-62.

Barathy S., Sivaruban T. and Srinivasan P. (2021) Taxonomic Keys of Mayflies in the Palni and Cardamom Hills of Western Ghats, Southern India. Recent Research Advances in Biology 5: 128–154. https://doi.org/10.9734/bpi/rrab/v5/6233D

Beyene A., Legesse W., Triest L. and Kloos H. (2008) Urban impact on ecological integrity of nearby rivers in developing countries: the Borkena River in highland Ethiopia. Environmental Monitoring and Assessment 153: 146–161.

Burton T.M. and Sivaramakrisnan K.G. (1993) Composition of the insect community in the streams of the Silent Valley National Park in the Southern India. Journal of Tropical Ecology 34(1): 1-16.

Hammer O., Harper D.A.T. and Ryan P.D. (2001) PAST (Paleontological Statistics software package for education and data analysis). Palaeontologia Electronica 4(1): 9.

Rosenberg D.M. and Resh V.H. (1993) Freshwater biomonitoring and benthic macro invertebrates. Chapman and Hall, London. 9-488 pp.

Sivaramakrishnan K.G., Madhyastha N.A. and Subramanian K.A. (1998) Field guide to aquatic macroinvertebrates. Life Scape IISc, Bangalore. 8 pp.

Sivaruban T., Barathy S., Srinivasan P. and Isack R. (2020a) Temporal variation of mayfly community (Ephemeroptera) in response to ecological attributes in Gadana River, Tamilnadu, India. Entomon 45(2): 115-122.

Sivaruban T., Barathy S., Srinivasan P., Isack R. and Rosi B. (2020b) Impact of ecological attributes and feeding categorization of Ephemeroptera, Plecoptera and Trichoptera (EPT) insects in Kiliyur falls of Eastern Ghats, India. Entomon 45(3): 171-179.

Sivaruban T., Srinivasan P., Barathy S., Rosi M.B. and Isack R. (2021) A new species of *Sparsorythus* Sroka & Soldán, 2008 (Ephemeroptera: Tricorythidae) from Eastern Ghats of Southern India. Zootaxa 4915(2): 237-245.

Srinivasan P., Sivaruban T., Barathy S. and Isack R. (2021a) A new species of *Dudgeodes* Sartori, 2008 (Ephemeroptera: Teloganodidae) from Megamalai

hills of southern Western Ghats, India. Zootaxa 4990(3): 571-576.

Srinivasan P., Sivaruban T., Barathy S., Malzacher P. and Isack R. (2021b) A new charismatic *Caenis* Stephens, 1835 (Ephemeroptera: Caenidae) from Southern India. Zootaxa 4926(1): 105-116.

Srinivasan P., Sivaruban T., Isack R. and Barathy S. (2019) Bio-monitoring and Detection of Water Quality using Ephemeroptera, Plecoptera and Trichoptera (EPT) Complex in Karanthamalai Stream of Eastern Ghats. Indian Journal of Ecology 46(4): 818-822.

Terbraak C.J.F. and Smilauer P. (2002) CANOCO. Reference manual and CanoDraw for Windows user's guide: software for canonical community ordination (version 4.5). Ithaca, NY: Microcomputer Power.

(Received August 04, 2021; revised ms accepted October 04, 2021; printed December 31, 2021)