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Diversity and community structure of Ephemeroptera, Plecoptera and Trichoptera in Kolli hills of the Eastern Ghats, India

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ABSTRACT: The study describes the diversity and community structure of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa present in the Puliyancholai stream of the Kolli hills, Eastern Ghats. During the six months of study 397 specimens from 11 genera under seven families were collected. Ephemeroptera was the most dominant species followed by Trichoptera and Plecoptera. Various alpha biodiversity indices showed that the Simpson's index was maximum in October (0.878) and minimum in December (0.832). The Shannon-Weiner index was maximum in December (2.277) and minimum in January (2.151). Evenness index was most noteworthy in October (0.872) and it was least in December (0.725). Temperature, pH, calcium and magnesium are major stressors in governing the EPT community of Kolli hills, according to Canonical Correspondence Analysis (CCA). © 2022 Association for Advancement of Entomology

KEY WORDS: EPT taxa, biodiversity indices, Canonical Correspondence Analysis

Biodiversity refers to the variety of species, ecological variation, and genetic variation in a given ecosystem. Diversification is an important part of maintaining a healthy environment. Every species in an ecosystem plays an important function and is dependent on one another for their survival. Streams are physically diverse ecosystems that include a vast range of water habitats, ambient conditions, and biotic creatures. Anthropogenic activities have put the freshwater ecosystems under a variety of stresses. As a result of this, both the aquatic life and the human population are threatened. Freshwater benthic macro invertebrates such as Ephemeroptera, Plecoptera and Trichoptera (EPT) serve as the model organisms for meeting the ecological demands of the freshwater ecosystem (Beauchard *et al.,* 2003). Water flow, temperature, seasonality, altitude, pH, and dissolved oxygen are some of the ecological factors that influence the aquatic insect diversity and its community structure (Hodkinson and Jackson, 2005). Deterioration of freshwater is a case of concern mostly for the developing countries and it's a subject of debate, the study of aquatic organisms and their diversity can give us critical information regarding the water and ecosystem quality for the present and it will

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help us to do several actions to safeguard the freshwater ecosystems in the future if it is needed. In this context, an effort was made to start documenting the EPT fauna of the Puliyancholai stream, Kolli hills, Namakkal District, Tamil Nadu.

Sampling and collection of EPT taxa: Puliyancholai is located at the foot slopes of Kolli hills, Tamil Nadu. This region has rich green vegetation, trees, and Tamarind forests. It is located 241 km from Madurai and 76 km from Trichy District and latitude-longitude is 11°362' 01" N; 78°33' 03" E. The present study was carried out from October 2019 to March 2020 in Puliyancholai stream.

The random sampling was done from October 2019 to March 2020; it is because the falls is usually dry during other seasons. The nymphs of Ephemeroptera, Plecoptera, and Trichoptera were collected from the Puliyancholai stream of the southern Eastern Ghats. EPT complex was sampled by using a Kick-net (Burton and Sivaramakrishnan, 1993) with a mesh size of about 1mm and stored in ethyl alcohol (99.9%). EPT samples were examined under a stereomicroscope (Magnus Pro) and identified using standard taxonomic literature (Barathy *et al.,* 2021a). Water temperature, air temperature, pH, water flow, dissolved oxygen and turbidity were measured and analyzed using the APHA guidelines (APHA, 2005). PAST 4.0 version was used to analyze the data and calculate the Shannon, Simpson, and Evenness indices (Hammer *et al.,* 2001). Canonical Correspondence Analysis (CCA) was also done using the PAST software to find the relation between EPT insects and environmental attributes (Ter Braak and Smilauer, 2002).

Diversity and distribution of Puliyancholai stream: During six months, 397 EPT taxa were collected under 11 genera and 8 families. Baetidae, Caenidae, Hepatageniidae, Leptophlebiidae, Tricorythidae, Perlidae, Hydropsychidae and Stenopsychidae were families present in the Puliyancholai stream (Table 1). According to Selvakumar *et al.* (2012) the presence of *Baetis* sp., *Afronurus kumbakkaraiensis* Venkataraman and Sivaramakrishnan, 1989, *Epeorus petersi* Sivaruban, Venkataraman and Sivaramakrishnan, 2013 (Sivaruban *et al.,* 2013)*, Thalerosphyrus flowersi* Venkataraman and Sivaramakrishnan, 1987 and *Choroterpes alagarensis* Dinakaran, Balachandran and Anbalagan, 2009 are useful as bioindicators of forest conditions. Heptageniidae, Baetidae, and Tricorythidae were the more abundant and widespread in the present sites. Suhaila and Che Salmah (2010) stated that survival of *Baetis* sp. and *Thalerosphyrus* sp., was greater during the rainy season, confirming that these species were well suited to broad substrates and swift currents. Shannon Weiner's index ranges from 2.151 to 2.277 and was found to be maximum in December and October and least in January. According to Javaid and Ashok (2013), Shannon-Wiener diversity values ranging from 1 to 2 imply highly contaminated water. In this study, the majority of the diversity index values recorded from the study sites ranged above 2. As a result, it was found that the Puliyancholi stream was moderately polluted by anthropogenic activities. The Simpson index ranges from 0.832 to 0.878, with October being the most extreme and December being the least. In present study the Evenness index ranged from 0.725 to 0.872 indicating the uniform distribution of insects in the community (Table 2). In the present investigation, high air temperature (30^0C) and water temperature (26^0C) were recorded in February and March. Corbet (2004) reported that warm water has been shown to have low dissolved oxygen content. Barathy *et al.* (2021b) reported that high water and air temperatures lead to a decline of low tolerant taxa. Normal dissolved oxygen (DO) level in the freshwater streams was found to be 4.6 - 8.6 mg L^{-1} (Srinivasan *et al.,* 2019) and low DO reduces the EPT richness, whereas, high DO nourish the EPT taxa. Similar results were found in the present study sites, the DO was maximum (9.3) in December and minimum in January (7.3). Breitburg (2002) stated that oxygen concentrations in aquatic ecosystems changed periodically, with winter being greater than summer. The pH range of 6.5 to 8.0 offers acceptable protection for freshwater fish and bottom-dwelling macro invertebrates. The pH levels at the present study sites are in the acceptable range of 7.1 to 8.1 (Table 2). Alkalinity values of 20-200 mg L^{-1} are

Table 1. EPT taxa recorded in the Puliyancholai falls, India during 2019-2020

Order/ Family	Genus/species	Oct	Nov	Dec	Jan	Feb	Mar
Ephemeroptera/ Baetidae	*Acentrella vera* Müller-Liebenau, 1982	9	8	7	8	7	6
	Centroptella ghatensis Kluge, 2021	5	4	3	6	5	6
	Nigrobaetis paramakalyani Kubendran and Balasubramanian, 2015	6	4	5	5	6	6
	Labiobaetis sp.	5	5	5	4	6	5
Ephemeroptera/ Caenidae	*Caenis* sp.	3	2	2	3	2	3
Ephemeroptera/ Heptageniidae	*Afronurus kumbakkaraiensis* Venkataraman and Sivaramakrishnan, 1989	17	18	18	19	18	20
Ephemeroptera/ Leptophlebiidae	*Choroterpes alagarensis* Dinakaran, Balachandran and Anbalagan, 2009	8	6	9	10	8	9
Ephemeroptera/ Tricorythidae	*Sparsorythus sivaramakrishnani* Sivaruban, Srinivasan, Barathy, Bernarth-rosi and Isack, 2021	5	4	5	4	5	3
Plecoptera/ Perlidae	*Neoperla biseriata* Zwick, Anbalagan and Dinakaran, 2007	4	5	3	2	4	6
Trichoptera/ Hydropsychidae	*Hydropsyche* sp	0	2	2	1	3	2
Trichoptera/ Stenopsychidae	*Stenopsyche kodaikanalensis* Swegman, 1980	2	4	4	5	6	5

common in freshwater environments. In the present study sites, total alkalinity was highest (69) in February and lowest in October (41) which support the growth of EPT taxa. In the stream, the total hardness was elevated in January (49) and it was low in October (23). According to Bispo *et al.* (2006) a rapid increase in water flow promotes stream bed translocation, which results in the removal of insects and a decrease in their local abundance. In the present study, the highest water flow was recorded in October (0.65) and the lowest was recorded in March (0.92). According to Resende *et al.* (2021), high water flow intensity and frequency can cause rapid declines in aquatic biodiversity species richness and abundance. The results of the study areas show that the concentration of calcium was highest in November (59) and lowest in February (42). Magnesium is required by most forms of life, including aquatic organisms (Maret, 2016) because of their high enzymatic functions, these metals play an important metabolic role in the bodies of organisms, particularly in regulating aquatic insect homeostasis. In the present study, magnesium was maximum in February (7.6) and minimum in October (2.5). Turbidity was maximum in November (0.9) and minimum in October (0.5). According to Mahajan and Billore (2014), water transparency is inversely proportional to turbidity, which is caused by suspended particles and organic matter, planktons and other microscopic organisms.

CCA results: As per CCA analysis (Fig.1) various physicochemical parameters have influenced the diversity and distribution of the EPT community. The CCA biplot reveals that increasing water temperature characterized the distribution of the genera *Caenis sp*. and *Centroptella ghatensis* Kluge, 2021. High DO and pH support the growth of *A. kumbakkaraensis*. According to Sivaruban *et al.* (2020a) stoneflies and heptageniids prefer cool environments and require oxygen rich

Table 2. Diversity indices of EPT taxa and physico-chemical parameters of water sample in Puliyancholai stream, Eastern Ghats, India

Parameters	Oct	Nov	Dec	Jan	Feb	Mar
DO (mg L^{-1})	8.4	8.1	9.3	7.3	7.5	7.4
Calcium (mg L^{-1})	57	59	53	51	42	50
Magnesium (mg L^{-1})	2.5	3.2	4.0	7.5	7.6	4.7
pH	7.1	8.1	8.1	7.3	7.1	7.4
Total alkalinity (mg L^{-1})	41	53	52	69	67	66
TDS (mg L^{-1})	57	69	69	83	84	76
Total Hardness (mg L^{-1})	23	24	26	49	48	45
Turbidity (NTU)	0.5	0.9	0.8	0.7	0.8	0.7
Air temperature (^{0}C)	29	29	28	30	30	30
Water temperature (^{0}C)	26	25	25	27	28	28
Water flow (m S^{-1})	0.65	0.74	0.78	0.82	0.85	0.92
Simpson index (H)	0.878	0.849	0.832	0.876	0.874	0.876
Shannon index (1-D)	2.261	2.256	2.277	2.151	2.253	2.246
Evenness (E)	0.872	0.785	0.725	0.872	0.864	0.859

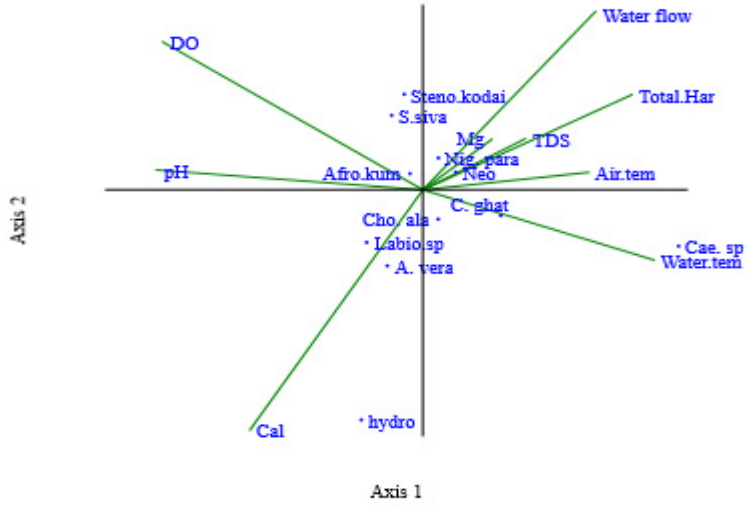

Fig. 1 Canonical correspondence analysis of Puliyancholai stream, India

(A.vera- *Acentrella vera*, Labio sp- *Labiobaetis* sp, Afro.kum- *Afronurus kumbakkarensis*, C.ghat- *Centroptella ghatensis*, Cae.sp- *Caenis* sp, Cho.ala- *Choroterpes alagarensis*, Nig. para- *Nigrobaetis paramakalyani*, Neo- *Neoperla* sp, Steno.kodai- *Stenopsyche kodaikanalensis*, S.siva- *Sparsorythus sivaramakrishnani*, hydro- *Hydropsyche* sp, DO- Dissolved Oxygen, cal-calcium, Mg- magnesium, Total.Har- total hardness, Water.tem- water temperature, Air.tem- air temperature)

environments to survive. High DO and water flow promote the growth of *Stenopsyche kodaikanalensis* Swegman and Coffman 1980 and *Sparsorythus sivaramakrishnani* Sivaruban, Srinivasan, Barathy, Bernarth-rosi and Isack, 2021 which are extremely sensitive to changes in the water temperature. The CCA results in the EPT community of Kiliyur falls, of Eastern Ghats, India showed that temperature, dissolved oxygen and rainfall turns into a major stressor (Sivaruban *et al.*, 2020b). *C. alagarensis*, *Labiobaetis* sp., *Acentrella vera* Müller-Liebenau, 1982 and *Hydropsyche* sp., prefers high level of calcium and are sensitive to high levels of air temperature, total hardness and TDS. High levels of water flow, TDS, total hardness, air temperature, and magnesium supports the growth of *Nigrobaetis paramakalyani* Kubendran and Balasubramanian,

2015 (Kubendran *et al.,* 2015) and *Neoperla biseriata* Zwick, Anbalagan and Dinakaran, 2007 while calcium was negatively related. The correlation coefficient between species and site scores is equal to the Eigen values associated with each axis. Thus, an Eigen value close to represents a high degree of correspondence between species and sites, whereas an Eigen value close to zero represents very little correspondence reported by Barman and Gupta (2015). The sum of all Canonical eigen values found in this study was axis 1 is 52.55 per cent and axis 2 is 22.82 per cent, indicating a high degree of correspondence of species with seasons.

This study revealed that *A. kumbakkaraiensis*, *S. sivaramakrishnani*, *C. alagarensis* and *A. vera* are the most dominant taxa in the Puliyancholai stream of the Eastern Ghats and environmental factors such as DO, pH, water flow, turbidity, air temperature, and water temperature are the major stressors governing EPT distribution, and the EPT's diversity decreased with the anthropogenic effect. This is comparable to that observed in previous studies that assessed the impact of anthropogenic pressures on aquatic insect biodiversity (Srinivasan *et al.,* 2019, Ligeiro *et al.,* 2013; Bijita and Susmita, 2015; Ramezani *et al.,* 2016). In the present study fewer genera were found due to anthropogenic activity.

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