https://doi.org10.33307/entomon.v45i3.548
ENTOMON 45(3): 171-180 (2020)
Article No. ent. 45302

Impact of ecological attributes and feeding categorization of Ephemeroptera, Plecoptera and Trichoptera (EPT) insects in Kiliyur falls of Eastern Ghats, India

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

PG and Research Department of Zoology, The American College (Autonomous), Madurai 625002, Tamil Nadu, India; # Department of Zoology, Fatima college, Madurai 625018, Tamil Nadu, India. Email: sivaruban270@gmail.com

ABSTRACT: Investigation on the diversity, ecology and trophic categorization of Ephemeroptera, Plecoptera and Trichoptera complex (EPT) was carried out in Kiliyur falls of the Eastern Ghats. An aggregate of 2,189 specimens belonging to 24 genera, 12 families and 3 orders were collected. Ephemeroptera was found to be high when compared to Plecoptera and Trichoptera. Baetidae was the most abundant taxa of all with presence of 5 genera and 6 species. Shannon-Weiner index and Simpson's index were calculated and it shows that Shannon-Weiner index was elevated in the August (2.882) and declines in January (2.744). Simpson's index was most noteworthy in December (0.9325) and it was least in January (0.9321). Canonical correlation analysis (CCA) shows that temperature, dissolved oxygen and rainfall turns into a major stressor in the EPT community of Kiliyur falls. Cluster analysis results prove that Baetidae and Caenidae shows comparative dispersion pattern as opposed to Teloganodidae and Perlidae. Functional feeding group (FFG) analysis shows that Kiliyur stream was overwhelmed by collectors followed by scrapers, predators and filter-feeders.

KEYWORDS: EPT complex insects, diversity, ecology, fresh water ecosystem

INTRODUCTION

Larval stages of Ephemeroptera, Plecoptera and Trichoptera are commonly known as EPT and they inhabit in freshwater streams (Allan, 1995) and they are viewed as satisfactory model organisms in addressing the ecological properties of the freshwater community (Beauchard *et al.*, 2003). The health of the freshwater ecosystem can be measure through collecting the freshwater macroinvertebrates because they normally imply the status of the particular habitat (Rosenberg and Resh, 1993; Wright and Burgin, 2009). Each taxa in the EPT complex reacts diversely to every pollutant present in the biological system and throughout time, they reacts to the contaminations contrastingly and fills in as bioindicator organisms (Bonada *et al.,* 2006; Odume and Muller, 2011). Earlier studies have shown promising results of EPT complex in biomonitoring studies by evaluating the connection between EPT taxa and ecological

* Author for correspondence

attributes (Hodkinson and Jackson, 2005; Silveira *et al.,* 2006; Milesi *et al.,* 2009).Various ecological factors include water flow, temperature, seasonality, altitude, pH and dissolved oxygen regulates the diversity and community structure of benthic macro invertebrates (Crisci-Bispo, 2007).

EPT insects develop uniquely in contrast to one environment to another biological system dependent on the habitat structure and food accessibility present in the specific habitat (Vannote *et al.,* 1980). Substrate present in the freshwater habitat becomes a major component in EPT complex because they form a source for feeding, deposition of eggs, shelter during physical disturbances (Stephanie *et al.,* 2000) and drought conditions (Fenoglio and Bosi, 2006). Functional feeding group (FFG) among benthic macro invertebrates can be studied based on the kind of food source utilized and the feeding mechanism involved (Cummins, 1973). These FFG encourages us to comprehend the different functions EPT insects perform inside freshwater environments and this helps in biomonitoring studies.

Most of the EPT organisms love pollution less environment and now a day due to anthropogenic impacts pollution becomes a significance issue in the freshwater habitat (Grzybowski and Gliñska-Lewczuk, 2019). This impacts downward dislodging in the development of local species and over the span of time, these are get supplanted by exotic and foreign species which will collapse the entire food chain of the freshwater ecosystem.

Normally, the studies on aquatic insects and its community structure is restricted only to the Western Ghats of Southern India, only limited studies were done in the Eastern Ghats (Srinivasan *et al.,* 2019). Kiliyur falls, which is one of the famous falls present in the Eastern Ghats of Southern India. It is part of the Salem district of Tamil Nadu; this part of region still remains unexplored in the light of ecology. So this work aims to study the diversity, distribution and functional feeding groups of EPT assemblages and how EPT insects responds to ecological factors in Kiliyur falls of the Eastern Ghats.

MATERIALS AND METHODS

Study area

Kiliyur Falls is situated in Shervaroyan slope of Salem district extends in the Eastern Ghats of Tamil Nadu, India. The waters flooding the Yercaud Lake fall into the Kiliyur Valley. It has the highest elevation of 4393 feet at a Latitude 11.7950° N and Longitude 78.2004° E. It receives an average annual rainfall of 1400 mm. EPT insects were collected from August 2017 to January 2018. Channel substrates of stream include bedrock, boulder, gravel, pebble and mostly covered with canopy cover. The sampling was done from August 2017 to January 2018; it is because the falls is usually dry during other seasons. Random sampling was made from three sites. Site I which is upstream, site II which is midstream and site III which is human inhabiting area where most people come and bath here. Each sampling site distinguishes at a distance of 1000 m. The EPT insects were collected by using 1m wide kick-net (Burton and Sivaramakrishnan, 1993) and surber sampling. The insects collected from the target habitats stored in 70% ethyl alcohol and labelled separately in the field for each sampling month.

Measuring water quality and habitat parameters

The physico-chemical parameters of stream water, habitat parameter, water flow, air temperature and water temperature were analysed for every month by using the guidelines of APHA (2005).

Specimen Identification

Using the stereomicroscope (Magnus MSZ-TR), the EPT insects were identified with the help of field guide by Sivaramakrishnan *et al.* (1998) and using other standard taxonomic literatures (Sivaramakrishnan *et al.,* 2009).

Data analysis

The biodiversity indices like Shannon- Weiner diversity and Simpson were calculated using the software PAST 4.2 (Hammer *et al.,* 2001). Canonical correspondence analysis (CCA) and cluster analysis were also done using the PAST software to find the relation between EPT insects and environmental attributes (Ter Braak and Smilauer, 2002).

Functional feeding group (FFG) analysis

Based on the feeding behaviour and ingested substances studies by gut content analysis (Merritt and Cummins, 1984), EPT complex were grouped into four categories: collectors, shredders, scrapers, and predators.

RESULTS AND DISCUSSION

Diversity and distribution of EPT in Kiliyur falls

Examining of EPT immatures from Kiliyur falls brought about an aggregate of 2,189 specimens belonging to 24 genera, 12 families and 3 orders (Table 2). A total of 1,721 Ephemeroptera specimens were collected including fifteen genera and six families. For Plecoptera, 99 specimens were collected having one genera and one family and for Trichoptera 369 specimens were collected belonging to five genera and five families. The Ephemeroptera richness is higher when compared to other orders and during diversity investigation for richness was comparatively very low in Plecoptera due to high temperature because stoneflies normally prefer cool environment for their survival. Among all families, Baetidae was the most abundant taxa with presence of 5 genera and 6 species. Among alpha diversity indices, Shannon-Weiner index and Simpson's index were determined. Shannon index values normally lies between 0.0 – 5.0 and very rarely it exceeds 4.5 (Kocatas, 1992). The values above 3.0 normally indicate that ecosystem is healthy. In Kiliyur falls, Shannon-Weiner index (Fig. 1) is elevated in the month of August (2.882) and declines in January (2.744). The Shannon index values of all the six months were under 3.0 and this shows that the ecosystem is not healthy and it is slightly broken, in future it is of great concern. Simpson's index (Fig. 2) was highest in December (0.9325) and it was lowest in January (0.9231). This supports the results of Shannon index also and the results portrays that during the high rainfall months like December and August, the index values were high and it supports more diverse EPT taxa and in the less rainy months like January, the index values were low and it does not bolster the EPT community.

In the investigation of months, January had high air (26ºC) and water temperature (23ºC) and this also results in least number of individuals in the month of January (Table 1). Temperature plays an important role in diversity, distribution and functioning of EPT taxa (Ward and Stanford, 1982; Minshall *et al.,* 1985). Minshall and Robinson (1998), recorded temperature becomes a stressor than other physico-chemical variables in governing the aquatic insects community. Along these lines temperature might be a significant factor impacting taxa richness (Jacobsen *et al*., 1997). Despite the fact that, rainfall level (Table 1) is most noteworthy in the long stretch of December, it bolsters the

Table 1. Physico-chemical parameter of Kiliyur falls

Physico-Chemical Parameters	AUG	SEP	OCT	NOV	DEC	JAN
Water temperature (Cº)	21.5 ± 0.8	21 ± 0.6	20.5 ± 0.5	20 ± 1.1	19 ± 0.8	23 ± 0.6
Air temperature (Cº)	25 ± 0.7	24 ± 0.6	22.5 ± 0.7	21 ± 0.9	21 ± 0.6	26 ± 0.5
Dissolved oxygen (mg/l)	5.7	6.3	6.6	7.5	8.2	5.7
pH	7.5	7.2	7.4	7.1	7.2	7
Water flow (m/s)	0.48	0.50	0.56	0.52	0.60	0.45
Mean monthly rainfall (mm)	187	143	156	148	260	164

Table 2. List of taxa present in Kiliyur falls in different months

Order	Family	Genus/ Species	Number of individuals					
			AUG	SEP	OCT	NOV	DEC	JAN
Ephemero ptera	Baetidae	*Baetis acceptus* (Müller-Liebenau & Hubbard 1985)	15	23	18	17	20	12
		Baetis conservatus (Müller-Liebenau & Hubbard 1985)	5	4	8	6	5	3
		Tenuibaetis frequentus (Müller-Liebenau & Hubbard 1985)	23	14	25	25	34	11
		Centroptella similis (Waltz & McCafferty 1987)	10	12	4	12	24	14
		Acentrella vera (Müller-Liebenau 1982)	5	4	5	7	9	8
		Procloeon regularum (Müller-Liebenau & Hubbard 1985)	36	32	36	25	34	22
	Caenidae	*Caenis* sp	5	5	4	6	5	3
		Clypeocaenis bisetosa (Soldán 1978)	3	0	5	5	4	8
	Heptageni idae	*Afronurus kumbakka-raiensis* (Venkataraman & Sivaramakrishnan, 1989)	14	18	15	13	20	12
		Epeorus petersi (Sivaruban, Barathy, Arunchalam, Venkataraman & Sivaramakrishnan, 2013)	28	34	18	32	38	25
		Thalerosphyrus flowersi (Venkataraman & Sivaramakrishnan, 1987)	8	6	12	15	18	6
	Leptophle biidae	*Choroterpes alagarensis* (Dinakaran, Balachandran & Anbalagan, 2009)	45	48	44	53	58	40
		Edmundsula lotica (Sivaramakrishnan, 1985)	12	12	12	12	3	0
		Indialis badia (Peters & Edmunds, 1970)	3	4	0	0	1	2
	Neoephe meridae	*Potamanthellus caenoides* (Ulmer 1939)	8	6	10	3	4	4
	Telogano didae	*Teloganodes kodai* (Sartori, 2008)	35	36	38	40	42	37
		Teloganodes sartorii (Selvakumar, Sivaramakrishnan & Jacobus, 2014)	23	26	23	28	32	25

Order	Family	Genus/ Species	Number of individuals					
			AUG	SEP	OCT	NOV	DEC	JAN
Plecoptera	Perlidae	*Neoperla* sp	8	6	8	14	12	2
		Neoperla biseriata (Zwick & Anbalagan, 2007)	7	7	5	12	14	4
Trichoptera	Rhyacophilidae	*Rhycophila* sp	5	3	2	0	6	0
	Philopotamidae	*Wormaldia* sp	1	3	0	0	5	0
	Stenopsychidae	*Stenopsyche kodaikanalensis* (Swegman & Coffman, 1980)	15	8	12	15	18	24
	Polycentropodidae	*Polycentropus* sp	12	13	11	12	12	12
	Hydropsychidae	*Hydropsyche* sp	24	32	36	33	30	25

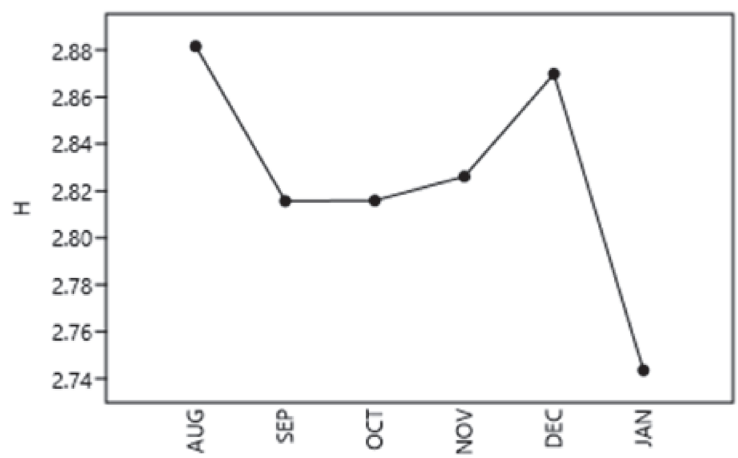

Fig. 1. Shannon_H index values of EPT insects in Kiliyur falls

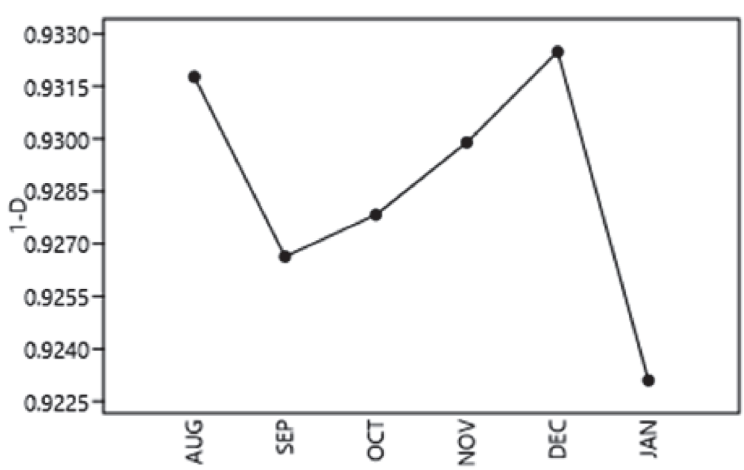

Fig. 2. Simpson_1-D index values of EPT insects in Kiliyur falls

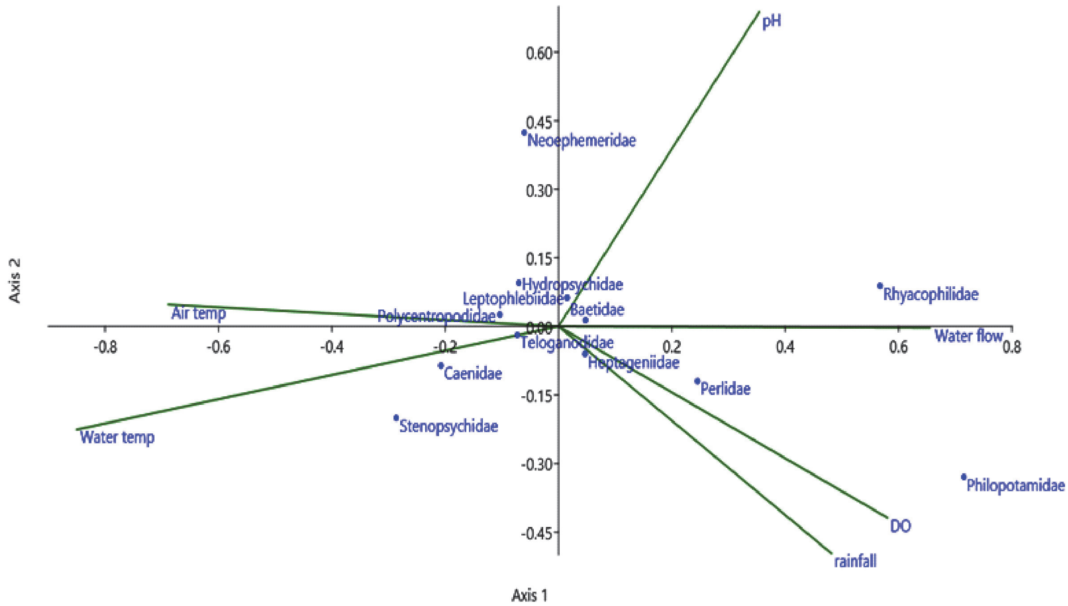

Fig. 3. Canonical Correlation Analysis (CCA) of EPT complex in correlation with ecological attributes

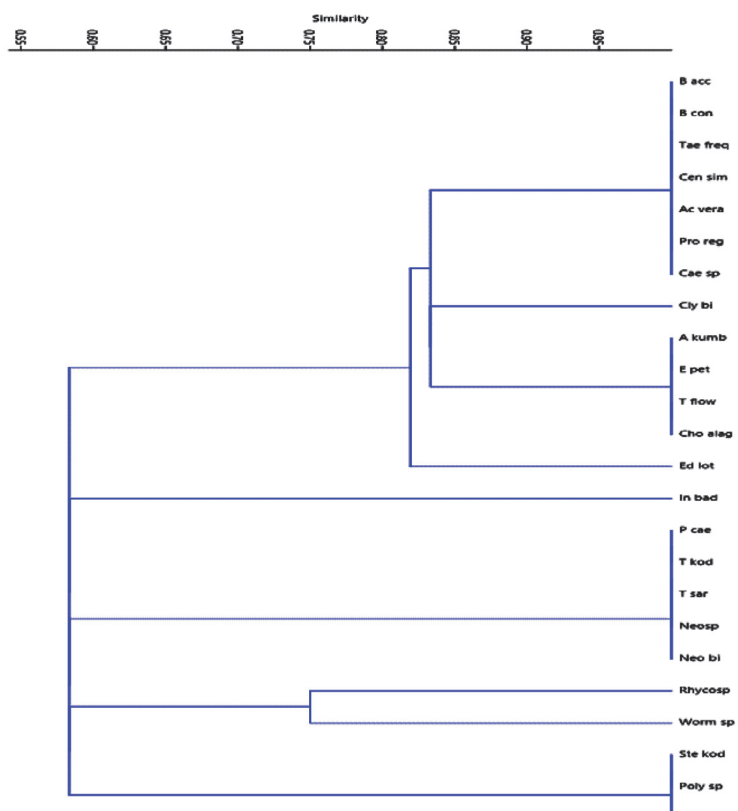

Fig. 4. Cluster analysis of EPT insects in Kiliyur falls

(B acc- *Baetis acceptus*, B con- *Baetis conservatus,* Te fre- *Tenuibaetis frequentus*, Ce sim- *Centroptella similis,* Ac ver- *Acentrella vera, Pro reg- Procloeon regularum,* A kum -*Afronurus kumbakkaraiensis* , Ep pet- *Epeorus petersi,* T flo- *Thalerosphyrus flowersi,* C ala- *Choroterpes alagarensis,* Ed lot- *Edmundsula lotica,* Ind bad- *Indialis badia*, P cae- *Potamanthellus caenoides*, T kod- *Teloganodes kodai,* T sar - *Teloganodes sartorii*, Cae sp- *Caenis* sp, Cly bi- *Clypeocaenis bisetosa*, Neo sp.- *Neoperla* sp, Neo bi- *Neoperla biseriata*, Rhyco sp- *Rhycophila* sp, Worm sp- *Wormaldia* sp, Ste kod- *Stenopsyche kodaikanalensis*, Poly sp- *Polycentropus* sp and Hydr- *Hydropsyche* sp) development of EPT community. Normal dissolved oxygen (DO) level in the fresh water streams was found to be 4.6 – 8.6 mg/l (Srinivasan *et al.,* 2019) and here it falls in 5.7 – 8.2 and it is of acceptable range. Low DO in the January reduces the EPT richness whereas high DO in the December supports high richness of EPT taxa. Hence this proves, EPT community gets affected by low DO and high temperature and it also supports the results of Gage *et al.* (2004). The other physico-chemical parameters fall within normal permissible limit in Kiliyur falls.

FFG analysis

In Kiliyur falls, collectors were seen as the prevalent group than the other functional feeding groups (Table 3). Collectors were (48.3%) dominated followed by scraper (31.5%). Predators (8.2%) and filter-feeders (12%) were the least occupied group. FFG analysis shows that Kiliyur stream is dominated by collectors followed by scraper, predator and filter-feeder. The functional feeding group results concur with the River Continuum Concept (RCC) (Vannote *et al.,* 1980) as the number of collectors tends to increase in mid reaches streams.

CCA analysis

CCA analysis (Fig. 3) predicts that various physico chemical parameters have influenced the diversity and distribution of the EPT community. The CCA biplot reveals that the distribution of families Caenidae, Teloganodidae and Stenopsychidae were characterized by increasing water temperature. High pH influences the diversity and distribution of Baetidae, Rhyacophilidae and Leptophlebiidae. High DO, rainfall and water flow which supports the growth of Heptageniidae and Perlidae and they are exceptionally sensitive to increasing levels of water temperature. This proves that stoneflies and heptageniids prefer cool environment for their survival and they also need oxygen rich environment for their survival. Polycentropodidae, Hydropsychidae and Neoephemeridae which gets upheld in the high air temperature and they were negative in relation with rainfall.

Cluster analysis

Cluster analysis results shows that four conspicuous clusters were formed (Fig. 4) of which family Baetidae and Caenidae of Ephemeroptera shows similar diversity and distribution pattern, in the second cluster family Heptageniidae and *Choroterpes alagarensis* of Ephemeroptera shows similar distribution over a period of time whereas in the third cluster family Teloganodidae of Ephemeroptera and Perlidae of Plecoptera shows similar pattern. In the fourth cluster, *Stenopsyche kodaikanalensis*, *Polycentropus* sp and *Hydropsyche* sp shows similarity in distribution. Taxa include *Edmundsula lotica*, *Indialis badia*, *Rhycophila* sp and *Wormaldia* sp shows novel distribution pattern.

It is concluded that, the greater part of EPT taxa present in Kiliyur falls were adversely related with temperature, rainfall and DO and it shows temperature, rainfall and DO turns into a major stressor in the EPT community of Kiliyur falls. Collectors were found to be the predominant group than the other functional feeding groups. CCA results prove that stoneflies and heptageniids prefer cool environment for their survival. Cluster analysis shows family Baetidae and Caenidae of

Table 3. Percentage of Trophic categorization of EPT complex in Kiliyur falls

Functional feeding groups	No. of individuals	Percentage
Collectors	1098	48.3%
Scrapers	716	31.5%
Predator	187	8.2%
Filter feeders	272	12%

Ephemeroptera shows similar distribution pattern contrast to Teloganodidae and Perlidae. So this work provides essential information about the diversity, distribution and community structure of EPT insects in Kiliyur falls and gives more knowledge about the EPT insects in less explored Eastern Ghats.

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(Received June 22, 2020; revised ms accepted August 06, 2020; printed September 30, 2020)