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Diversity and Distribution of Chironomidae Larvae in Relation to the Water Quality of Pampa River in the Perunad Area, Kerala, India

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Abstract

Chironomids are the most abundant bottom-dwelling benthic macroinvertebrates in the aquatic ecosystem. The present study determines the diversity and seasonal variation of Chironomid larvae about the water quality parameters of the Pampa river in the Perunad region of Kerala. The Chironomidae larvae and the water samples were collected during different seasons (Pre-monsoon, Monsoon, Post-monsoon) at three different sites for one year from February 2016 to January 2017. The water sample is analyzed for physico-chemical parameters such as temperature, pH, dissolved oxygen, electrical conductivity, chloride, nitrate, phosphate and sulphate. A total of 17 species under 15 genera and four subfamilies were identified. The Chironomidae larvae of Perunad area mainly consisted of Chironominae (48.60%), Tanipodinae (31.88%), Orthocladiinae (17.95%) and Diamesinae (1.54%). The maximum diversity was observed during pre-monsoon season and minimum at monsoon season. *Chironomus pulmosus* showed its highest abundance in all the seasons. The persistence of these Chironomidae larvae, mainly the *Chironomus* sp. previously ranked as 'pollution-tolerant' in the aquatic ecosystem indicates their ability to suffer both organic enrichment and contaminated habitats.

Keywords: Macroinvertebrates, Ecosystem, Pollution, Chironominae

1. Introduction

Water is the universal solvent and is the most precious natural resource for the survival of all living organisms, including human beings. During past decades, the river ecosystems face a series of threats due to human activities such as rapid industrialization, urbanization, industrial and sewage waste disposal which that results in the deterioration of water quality (Krishna and Kumar, 2014). Biological assessment is an evaluation of the quality of a water body by using biological organisms that spend all or part of their lives in that water body (Warwick, 1985) and those organisms whose characteristics reveal the status of the environment are called biological indicators. The biological assessment gives a long-term water quality status of the ecosystem (Rosenberg and Resh, 1993).

Chironomid larvae belong to the family of true flies (Insecta: Diptera), which constitute one of the most abundant bottom-dwelling macroinvertebrates in most of the aquatic ecosystems. The chironomid study (Ebrahimnezhad and Allahbakhshi, 2013) has special ecological importance because this group has a cosmopolitan distribution with a variety of aquatic habitat such as rivers, streams, ponds etc. Chironomid larvae are the most abundant insects in the freshwater ecosystem, and the families of Chironomidae are holometabolous; the life cycle consists of four stages such as egg, larvae, and pupae and the adult (Armitage 1995; Epler 2001; Coffman and Ferrington 1984). Most of the chironomids show adaptations to different ecosystems with extreme environmental situations related to high temperature, pH, organic matter content in the sediment and low dissolved oxygen. This paper determines the diversity and seasonal variation of Chironomidae larvae with the water quality parameters of the Pampa river in the Perunad region of Kerala.

2. Materials and Methods

This study was carried out on Perunad area of Pampa river. The study was conducted from February 2016 to January 2017. Water and chironomid larvae samples were collected from three sites during three seasons, namely, pre-monsoon (February to May) monsoon (June to September) and post-monsoon (October to January). The water sample is analyzed for physico-chemical parameters such as water temperature (T), pH, dissolved oxygen (DO) electrical conductivity (EC), chloride (Cl), nitrate, phosphate, and sulphate. All the analyses are carried out following standard methods (APHA, 2005). Sediment samples were taken using Van Veen grab with an area of 0.1 m^2 and sieved through 0.5 mm mesh sieve to separate the chironomid larva. The samples were preserved in 5% formalin solution. Permanent slides of chironomid larvae were prepared by following the method adopted from Epler (2001). The slide-mounted larvae were identified to the genus level using appropriate taxonomic keys (Merritt and Cummins, 1996; Epler, 2001; Cranston, 2004; Ahmad *et al.*, 2008).

Statistical Analysis

The correlation coefficient (r) between various physico-chemical parameters and Chironomidae larvae was evaluated by Karl Pearson coefficient of correlation analysis ($p < 0.05$) and Hierarchical Cluster analysis was performed to find the similarity groups of sampling sites by the software using SPSS 21.

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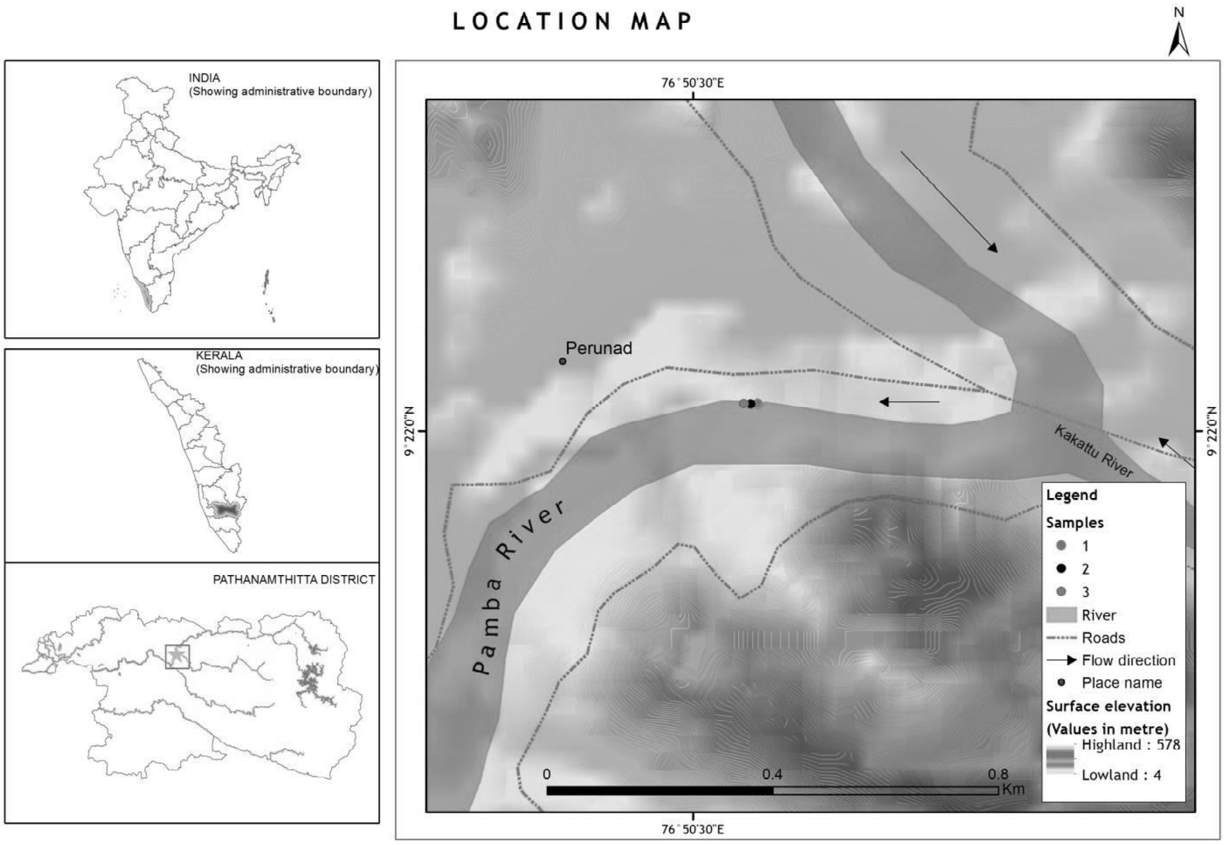

Fig. 1. Map showing the study area

3. Results

Environmental variables of water quality

Seasonal variations in environmental parameters are given in Table 1. All living organisms have an ideal temperature for their better survival. From the study highest mean temperature was recorded in pre-monsoon season (33±0.81) while the lowest mean value was recorded in monsoon season (27±1.88). pH is the measure of the intensity of acidity and alkalinity of the water and is one of the important factors that serve as a sign of pollution of the water body. Higher pH was recorded in monsoon season (6.70±0.04), and the lowest was in pre-monsoon season (6.50±0.04). The conductivity of an aquatic environment depends upon the concentration of ions present in the water. Conductivity was maximum in pre-monsoon season (44.5±2.08) and minimum in post-monsoon season (33.75±1.70). Dissolved oxygen is an important element for living organisms, and its fluctuation directly affects the aquatic ecosystem. Dissolved oxygen found maximum (6.60±0.36) in monsoon and minimum (5.40±0.27) during pre-monsoon season.

Chlorides are common components of all types of natural waters. The higher concentration of chloride value observed during the post-monsoon season (17.35±2.15) while it was observed minimum in monsoon season (11.5±1.29). In an aquatic ecosystem, nitrates are formed on biological oxidation of organic matter received from domestic sewage, agriculture run-off etc. Nitrate was maximum in monsoon season (0.42±0.04) and minimum in post-monsoon season (0.21±0.02). Phosphate is considered as the most important single constituent for biological productivity. Maximum Phosphate concentration was observed in the monsoon season (0.40±0.03) and minimum in post-monsoon season (0.20±0.02). Sulphate is a naturally occurring substance in water as a result of decomposition of leaves and other organic materials, and its concentration is increased due to human activities. Sulphate concentration was observed to the maximum value in pre-monsoon (11.10±1.50) and monsoon showed minimum value (5.30±1.44).

Species composition and diversity of Chironomid larvae

A total of 17 different species under 15 genera and four subfamilies were identified. The chironomid larvae of study area mainly consisted of Chironominae comprising 48.60% (5 genera, seven species) followed by Tanypodinae 31.88% (5 genera), Orthocladiinae 17.95% (4 genera) and Diamesinae 1.54% (1 genus) respectively. Chironominae was the most abundant subfamily which includes *Chironomus cloacalis*, *Chironomus pulmosus*, *Chironomus zealandicus*, *Microtendipes* sp., *Polypedilum* sp., *Riethia* sp. and *Tanytarsus* sp. followed by family Tanypodinae which includes *Ablabesmiya* sp., *Clinotanypus* sp., *Pentaneura* sp., *Psectrotanypus* sp. and *Zavrelimyia* sp. Family Orthocladiinae which includes *Cricotopus* sp., *Eukiefferiella* sp., *Hydrobaenus* sp. and *Parakiefferiella* sp. Family Diamesnae comprises only one species *Diamesa* sp. The highest densities of Chironomidae larvae observed during pre-monsoon season and the lowest densities recorded within the period of the monsoon (Fig. 2).

Table 1. Seasonal variation of water quality parameters of Pampa river in Perunad area

Physico chemical Parameters	Pre-monsoon Mean±SD	Monsoon Mean±SD	Post- monsoon Mean±SD
Temperature (^{0}C)	33±0.81	27±1.88	28.8±1.45
pH	6.50±0.04	6.70±0.04	6.56±0.03
Conductivity (µmhos/cm)	44.5±2.08	36.75±1.70	33.75±1.70
D.O (mg/l)	5.40±0.27	6.60±0.36	6.52±0.20
Chloride (mg/l)	16.5±1.29	11.5±1.29	17.35±2.15
Nitrate (mg/l)	0.25±0.01	0.42±0.04	0.21±0.02
Phosphate (mg/l)	0.30±0.01	0.40±0.03	0.20±0.02
Sulphate (mg/l)	11.10±1.50	5.30±1.44	7.32±0.58

Chironomid larvae and environmental variables

Pearson correlation analysis was performed to assess the relationship between environmental variables and Chironomidae larvae. Several significant correlations ($p < 0.05$) were found between water parameters and larvae (Tables 2-4). Of these *Tanytarsus* sp. and *Microtendipes* sp. showed a positive correlation with temperature, pH, DO and Conductivity. *Chironomus zealandicus* and *Zavrelimyia* sp. showed a negative correlation with chloride, nitrate, phosphate, and sulphate. Hierarchical clustering based on Ward linkage to figure out similarities between Chironomidae larvae in three seasons (Fig. 3). Taxonomic similarities between chironomid species in the study area figured out by using Hierarchical clustering based on the Ward linkage method (Fig. 3). From the dendrogram, at the base level, 3 clusters of species were observed in this study period. That is, Cluster 1 was formed of species such as *Parakiefferiella* sp., *Tanytarsus* sp., *Diamesa* sp., *Polypedilum* sp., *Cricotopus* sp., *Pentaneura* sp. and *Ablabesmiya sp.* which were showing their presence in the same way in this study area. Similarly, Cluster 2 formed of species namely *Eukiefferiella* sp., *Riethia* sp., *Chironomus cloacalis*, *Clinotanypus* sp., *Microtendipes* sp. and *Hydrobaenus* sp. which were identically showing their presence in the study area and Cluster 3 formed of species namely *Psectrotanypus* sp., *Zavrelimyia* sp., *Chironomus Zealandicus*, and *Chironomus pulmosus* which were showing their presence in the same manner in the study area (Fig. 3). In the next level of hierarchical clustering based on Ward linkage, Cluster 1 as before and Cluster 2 and 3 are being merged. This indicates that Cluster 2 and 3 are similar to each other than that of Cluster 1.

4. Discussion

During the study, the period temperature ranged from 27-33^{0}C. Temperature is a biologically important factor, which plays a vital role in the metabolic activities of the organism. The standard temperature for sustaining aquatic organisms varies between 28 ^{0}C to 30 ^{0}C (Weldermariam, 2013). pH of the study area was slightly acidic (6.5-6.7). Optimum pH range for the sustainable existence of aquatic organisms is pH 6.5-8.2. The pH of an aquatic ecosystem system is an important indicator of the water quality (Kumar et al. 2011). The conductivity of the study area ranges between 33.75 and 44.5 µmhos/cm. The electrical conductivity is a key to represent the total concentration of salts in the water body. Dissolved oxygen found

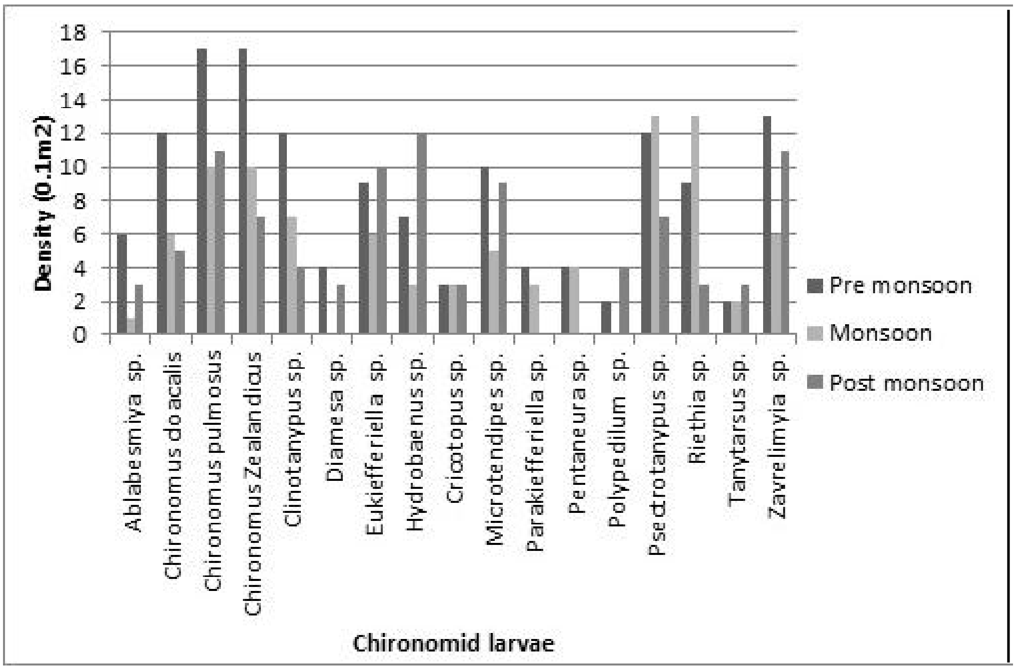

Fig. 2. Species composition of Chironomidae larvae during the study Period

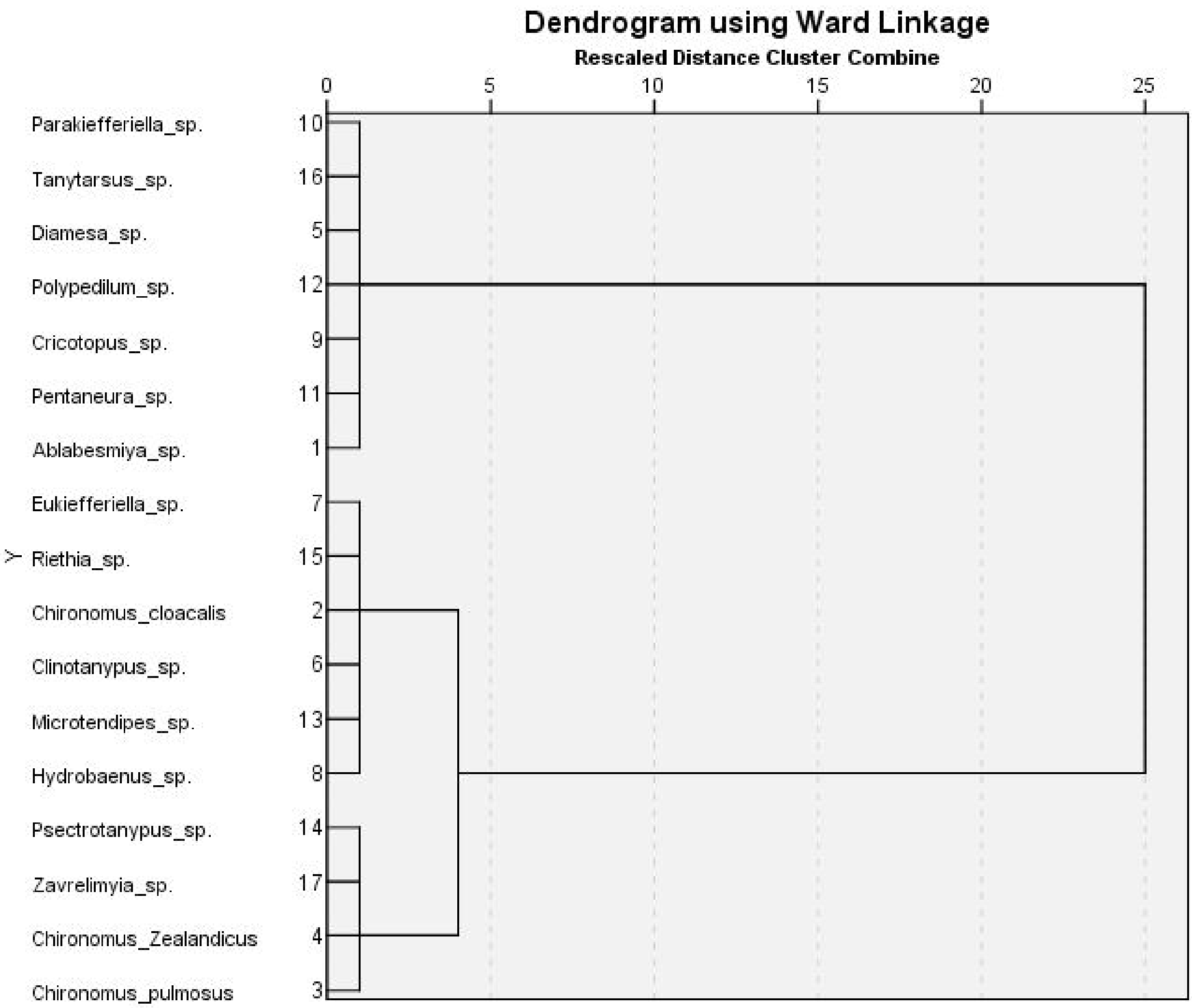

Fig. 3. Cluster analysis of the study area based on similarities between Chironomidae taxa

Table 2. Correlation between chironomid larvae and water quality parameters (Pre-monsoon)

	Temperature	pH	Conductivity	DO	Chloride	Nitrate	Phosphate	Sulphate
Ablabesmiya sp.	-.949*	0	-.800*	-.632*	0.4	-.949*	-.800*	.600*
Chironomus cloacalis	0	.949*	-0.316	0.5	-0.316	0	-0.316	-.949*
Chironomus pulmosus	0.316	0.2	0.2	-0.316	.600*	0.316	0.2	-0.4
Chironomus zealandicus	.833*	0.211	.632*	0.5	-0.211	.833*	.632*	-.738*
Clinotanypus sp.	.707*	-.894*	.894*	0	0	.707*	.894*	0.447
Diamesa sp.	0.333	-0.105	0.316	-0.5	.738*	0.333	0.316	-0.105
Eukiefferiella sp.	.632*	-.800*	.800*	-0.316	0.4	.632*	.800*	0.4
Hydrobaenus sp.	0	-.775*	0.258	0	-0.258	0	0.258	.775*
Cricotopus sp.	0.333	-0.105	0.316	-0.5	.738*	0.333	0.316	-0.105
Microtendipes sp.	-.707*	-0.447	-0.447	-.707*	0.447	-.707*	-0.447	.894*
Parakiefferiella sp.	0	.949*	-0.316	0.5	-0.316	0	-0.316	-.949*
Pentaneura sp.	0	0	0	-.707*	.894*	0	0	0
Polypedilum sp.	0	-.775*	0.258	0	-0.258	0	0.258	.775*
Psectrotanypus sp.	0	-.949*	0.316	-0.5	0.316	0	0.316	.949*
Riethia sp.	0.5	.632*	0.211	0.5	-0.211	0.5	0.211	-.949*
Tanytarsus sp.	.816*	-0.258	.775*	0	0.258	.816*	.775*	-0.258
Zavrelimyia sp.	0.316	-0.998*	.600*	-0.316	0.2	0.316	.600*	.800*

*Correlation is significant at the 0.05 level (2-tailed)

Table 3. Correlation between chironomid larvae and water quality parameters water (Monsoon)

	Temperature	pH	Conductivity	DO	Chloride	Nitrate	Phosphate	Sulphate
Ablabesmiya sp.	.775*	-.775*	-0.258	-.775*	.775*	-.775*	-.775*	.775*
Chironomus cloacalis	0.258	-0.258	.775*	-0.258	0.258	-0.258	0.258	0.258
Chironomus pulmosus	0.258	-0.258	.775*	-0.258	0.258	-0.258	.775*	0.258
Chironomus zealandicus	.800*	-.800*	-.600*	-.800*	.800*	-.800*	-.800*	.800*
Clinotanypus sp.	0.258	-0.258	.775*	-0.258	0.258	-0.258	0.258	0.258
Eukiefferiella sp.	0.4	-0.4	0.2	-0.4	0.4	-0.4	0.4	0.4
Hydrobaenus sp.	-0.258	0.258	-.775*	0.258	-0.258	0.258	-.775*	-0.258
Cricotopus sp.	0.316	-0.316	-0.105	-0.316	0.316	-0.316	-0.632	0.316
Microtendipes sp.	.738*	-.738*	.632*	-.738*	.738*	-.738*	0.316	.738*
Parakiefferiella sp.	0.211	-0.211	-.949*	-0.211	0.211	-0.211	-.738*	0.211
Pentaneura sp.	-0.316	0.316	.632*	0.316	-0.316	0.316	.949*	-0.316
Psectrotanypus sp.	0.4	-0.4	-.800*	-0.4	0.4	-0.4	-.600*	0.4
Riethia sp.	0.258	-0.258	.775*	-0.258	0.258	-0.258	.775*	0.258
Tanytarsus sp.	0.258	-0.258	.775*	-0.258	0.258	-0.258	.775*	0.258
Zavrelimyia sp.	.949*	-.949*	-0.316	-.949*	.949*	-.949*	-.632*	.949*

*Correlation is significant at the 0.05 level (2-tailed)

Table 4. Correlation between chironomid larvae and water quality parameters (Post monsoon)

	Temperature	pH	Conductivity	DO	Chloride	Nitrate	Phosphate	Sulphate
Ablabesmiya sp.	0.258	-.775*	-0.258	0	.775*	-.816*	-.775*	-0.258
Chironomus cloacalis	0.316	-.632*	0.316	0	.632*	-0.333	-.949*	0.316
Chironomus pulmosus	-0.105	-0.211	-.949*	0	0.211	-.778*	0.316	-.949*
Chironomus zealandicus	0	-0.4	0.4	0.316	.800*	-0.316	-.800*	0.2
Diamesa sp.	.738*	-.949*	-0.105	-0.5	0.316	-0.5	-.949*	0.211
Eukiefferiella sp.	0.316	-.632*	0.316	0	.632*	-0.333	-.949*	0.316
Hydrobaenus sp.	.949*	-.738*	0.105	-.833*	-0.316	0.056	-.738*	.632*
Cricotopus sp.	0.105	-.632*	-.738*	0	.632*	-0.998*	-0.316	-.738*
Microtendipes sp.	-.775*	.775*	.775*	.816*	0.258	0.544	0.258	0.258
Polypedilum sp.	-0.316	-0.316	-0.316	0.5	.949*	-.833*	-0.316	-.632*
Psectrotanypus sp.	0.316	-.632*	0.316	0	.632*	-0.333	-.949*	0.316
Riethia sp.	0.258	-0.258	.775*	0	0.258	0.272	-.775*	.775*
Tanytarsus sp.	-.949*	.949*	0.316	.833*	0.105	0.389	.738*	-0.211
Zavrelimyia sp.	-0.316	.632*	-0.316	0	-.632*	0.333	.949*	-0.316

*Correlation is significant at the 0.05 level (2-tailed)

minimum in pre-monsoon due to higher temperature and decomposition of organic matter and maximum in monsoon due to low temperature and microbial activity. A similar seasonal variation in DO was reported by Jitendra *et al.* (2008) in Yamuna River.

The maximum value of chloride was observed during pre-monsoon, and the minimum was recorded in monsoon. The maximum value of chloride during pre-monsoon season was mainly because of a decrease in water level in the river and minimum value of chlorides in monsoon which could be attributed to the dilution effect of heavy rains (Jindal and Sharma, 2011). The mean value of nitrate and phosphate was high during the monsoon season. This was may be due to runoff during rain which might have washed down nutrients into the water body (Sachidanandamurthy and Yajurvedi, 2006). Source of chloride in the water body is contributed by sewage, industrial wastes, fertilizers, and human as well as domestic waste (Rajaram *et al.*, 2013). Fluctuation in the values of nitrate, phosphate, and sulphate was observed in the present study. The wide spatial fluctuation of nitrate, Phosphate and sulphate values indicates the localized mode of contamination (Sujitha *et al.*, 2012).

The present study mainly consisted of four subfamilies such as Chironominae, Tanypodinae, Orthocladiinae, and Diamesinae under family Chironomidae and Chironominae was the most abundant among in these groups with seven species. Bhosale *et al.* (2012) found these four subfamilies during their study period. Family Chironomidae is an ecologically important, most abundant group of aquatic insects, and is generally distributed across the aquatic ecosystem worldwide (Armitage *et al.*, 1995). The most abundant species in this study area was *Chironomus pulmosus*, and its abundance indicated that the anthropogenic impact on the study area such as sewage disposal, industrial wastes, agricultural runoff etc. According to Bassirou *et al.* (2012), *Chironomus pulmosus* was considered as the only chironomid taxon that could be an important indicator to explain the anthropogenic effect in an aquatic ecosystem. This stress-resistant species was only observed in the area where the highest concentration of contaminants (Warwick, 1992).

Extensive variability of chironomid abundance was noticed during the study period. The highest density of Chironomidae larvae were found during pre-monsoon season and the lowest number within the period of the monsoon. Changes in the community structure of organisms are frequently related to variations in the flow of water (Gasith and Resh, 1999). During the study period species such as *Pentaneura* sp., *Cricotopus* sp., *Tanytarsus* sp., *Ablabesmiya* sp., *Microtendipes* sp., *Chironomus* sp. and *Polypedilum* sp. were found almost in all the seasons. These genera as indicators of various chemical conditions: *Pentaneura* sp. and *Tanytarsus* sp. mainly indicates the sewage enriched water. *Ablabesmiya* sp. generally exists in organically polluted and soft acidic water and *Microtendipes* sp., *Chironomus* sp. and *Polypedilum* sp. withstand average conditions for all these environmental factors (Rae, 1989).

The Chironomidae larvae have the ability to tolerant various organic and inorganic pollutants in rivers; occurrence and abundance of these organisms are effective indicators of river pollution (Wright and Burgin, 2009; Oliveira *et al.*, 2010). Biological assessment of water quality providing a healthier measure of the aquatic condition, and it supports the physico-chemical analysis of water. While physic- chemical parameters give the quality of water at the time of the sampling period, biological assessment represents a long-term result of water quality (Rosenberg and Resh, 1993). It can be concluded that Chironomidae constitutes an important benthic macroinvertebrates group which is a useful tool for monitoring freshwater ecosystems health. The diversity and ability to represent the level of pollution in the freshwater ecosystem is the selective characteristics features of this group. The most abundant Chironomidae larvae were *Chironomus pulmosus*, which indicates the river ecosystem at Perunad region of Kerala is disturbed.

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