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DIVERSITY OF AQUATIC INSECTS (EPHEMEROPTERA, PLECOPTERA AND TRICHOPTERA) IN KALLAR STREAM AND ITS TRIBUTARIES

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Abstract: This study was conducted to assess the diversity and distribution of aquatic insects in Kallar stream and its tributaries. Insects were collected on a monthly basis from January 2012 to December 2012. Four different sites (S1- Darpha-Kalungu, S2- Pottenchira, S3- Kaliyikkal and S4- Main Kallar) were selected for the insect's collection. Insects were sampled using standard entomological methods and the insect's identification was conducted in the laboratory in Department of Zoology, University of Kerala, Kariavattom. The results show that a total of 7441 individuals belonging to 3 orders, 16 families and 35 genera were collected during the study period. The maximum aquatic insect diversity were recorded from site 4 (2422 individuals), followed by site 1 (2089 individuals), site 2 (2040 individuals) and site 3 (890 individuals) respectively. Among the pollution sensitive groups, Ephemeroptera was the most dominant order with the highest number of individuals (50.69%) and are followed by Trichoptera (37.27%) and Plecoptera (12.04%). The most sensitive taxa like Perlidae, Heptagenidae, Lepidostomatidae, Polycentropodidae and Stenopsychidae are high in the main Kallar stream (S4) compared to the tributaries. Human intervention in the tributaries may be the reason for the low abundance of the pollution sensitive taxa when compared to the main Kallar stream. The biodiversity indices like Margalef's richness index, Shannon-Weiner diversity index and Simpson dominance index were found to be maximum in site 4 compared to other sites.

Key words: Biomonitoring, EPT, kick net, Biodiversity indices, Anthropogenic effects

INTRODUCTION

Aquatic insects spend at least a part of their lives in aquatic environments and they occur in all freshwater environments and a few in marine environments (Segers and Martens, 2005). They usually comprise from 70 to 90 % of the macro invertebrates in streams (Cushing and Allan, 2001). Aquatic insects, by their nature, maintain a relatively stable position in aquatic environment (Mc Cafferty and Provonsha, 1981) and express long-term changes in health and habitat quality rather than instantaneous conditions (Johnson *et al*., 1993). Their ubiquitous and sedentary nature facilitates their use as sensitive indicators of environmental changes in streams. They are made up of species that show broad ranges of pollution tolerances and thus providing strong information for interpreting cumulative effect of toxicants (Barbour *et al*., 1999). Several orders of insects, especially Ephereroptera, Plecoptera and Trichoptera (EPT) require high quality water for their existence. Thus their presence or absences, in conjugation with the numbers present at a particular location in a stream or river, have been used to develop several indices of water quality (Cushing and Allan, 2001). Biological monitoring of aquatic insects can provide important insights into the changes in water quality and habitat quality (Rosenberg and Resh, 1993). The greater importance of insects in the trophic structure of streams and rivers and biomonitoring in contrast with the scanty data available in the literature about their diversity and distribution indicates the need of studies in this subject. As Kallar is a typical tropical rainforest stream originating from the Western Ghats which is a freshwater biodiversity hotspot, it is relevant to study and document its aquatic insect diversity. The objectives of the present study are to assess the variation in diversity of Ephemeroptera, Plecoptera and Trichoptera (EPT) and to monitor the water quality of the selected sites using EPT.

MATERIALS AND METHODS

Study area

The study stream chosen are the typical tropical rainforest stream, Kallar, located near Ponmudi in Thiruvananthapuram district, Kerala, which forms the upper course of Vamanapuram River. It originates from Chemmunji Mottai, a mountain peak in the Western Ghats at an elevation of 1860 m above MSL. In this study four collection sites were selected in which three are the tributaries of Kallar stream and one is the main Kallar. The sites are chosen based on their location relative to forest area, habitat availability, land use pattern and human intervention. The selected sites are Darpha-Kalungu (S1), Pottanchira (S2), Kaliyikkal (S3) and main Kallar (S4). At each sampling locality, a stretch of 100 m area was chosen for collection of samples.

Field and laboratory methods

Samplings were done on monthly basis from January 2012 to December 2012. Aquatic insects were collected by using kick net (1 m^2 area, mesh size 200 µm) and D-frame net (mesh size 50 µm). The duration of each kick net operation was 5 minutes (Nagendran, 2007). The samples were placed in white trays for sorting and screening. The sorted invertebrates were collected without any damage using fine forceps and they were preserved in 70 % alcohol. Replicated sampling was carried out in each site. In the laboratory, the immature insects were sorted, identified and counted under stereoscopic microscope (Labomed CX Rlll) particularly the EPT. The collected samples were identified at genus level using available keys (Mc Cafferty and Provonsha, 1981; Morse *et al.*, 1984; Yule and Sen, 2004).

Statistical analysis

The biodiversity indices like Margalef's richness index, Shannon-Weiner diversity index and Simpson dominance index were calculated using the software PAST (2005).

RESULTS

A total of 7441 individuals belonging to 3 orders, 16 families and 35 genera were collected during the study period. Table 1 shows the overall composition and distribution of aquatic insect communities. The maximum intensity of aquatic insect were recorded from site 4 (2422 individuals), followed by site 1 (2089 individuals), site 2 (2040 individuals) and site 3 (890 individuals) respectively. Ephemeroptera was the most dominant order with the highest number of individuals (50.69%) and are followed by Trichoptera (37.27%) and Plecoptera (12.04%).

Ephemeroptera were numerically the most abundant order comprising of 3772 individuals belonging to 7 families and 14 genera. They were represented by Baetidae, Heptagenidae, Caenidae, Leptophlebidae, Potamanthidae, Tricorythidae and Ephemeridae. Leptophlebidae is the most abundant family in the selected sites and was represented by 2104 individuals, including 4 genera- Thraulodes, Choroterpes, Hebrophlebiodes and Leptophlebia. From this Thraulodes were the most dominant genera during the study period. The second largest family in Ephemeroptera is Heptagenidae and was represented by three genera (Epeorus, Thalerosphyrus and Heptagenia). Baetis and Platybaetis are the genera represented by the family Baetidae. Ephemeridae was represented by only one genus Ephemera and Tricorythidae by the genus Tricorythus. Caenidae was also represented by single genus *Caenis*. Potamanthidae was represented by 2 genera (*Potamanthus* and *Rhoenthanthus*). The abundance of *Ephemeroptera* was found to be maximum in site 1 and is followed by sites 2, 4 and 3 respectively.

Trichopterans were the second abundant order and were comprising of a total of 2773 individuals belonging to 8 families and 17 genera. They were represented by Calamoceratidae, Hydropsychidae, Lepidostomatidae, Philopotamidae, Polycentropodidae, Stenopsychidae, Xiphocentropodidae and Psychomiidae. Of these families, the most abundant is Hydropsychidae which was represented by a total of 2597 individuals belonging to 8 genera, namely Hydropsyche, Arctopsyche, Parapsyche, Diplectrona, Ceratopsyche, Cheumatopsyche, Psychomyia and Potamyla. Hydropsyche was the most dominant genera during the study period. Anisocentropus is the genus represented in the family Calamoceratidae. Lepidostomatidae was represented by two genus Lepidostoma and Neoseverinla. Polycentropodidae was repre-

Table 1. Details of insect genera collected from the study sites

Sl. No.	Genus	Site 1	Site 2	Site 3	Site 4
	Ephemeroptera				
	Baetidae				
1	Baetis	165	109	95	45
2	Platybaetis	12	37	14	16
	Caenidae				
3	Caenis	295	122	87	19
	Ephemeridae				
4	Ephemera	12	11	10	14
	Heptageniidae				
5	Epeorus	0	1	1	119
6	Thalerosphyrus	13	3	1	243
7	Heptagenia	6	6	2	200
	Leptophlebiidae				
8	Thraulodes	319	346	137	132
9	Leptophlebia	294	219	25	47
10	Choroterpes	22	11	16	9
11	Hebrophlebiodes	301	155	27	44
	Potamanthidae				
12	Potamanthus	6	0	0	2
13	Rhoenanthus	1	0	0	0
	Tricorythidae				
14	Tricorythus	0	0	0	1
	Plecoptera				
	Perlidae				
15	Neoperla	120	172	17	463
16	Tetropina	2	0	0	0
17	Acroneuria	1	6	4	110
18	Perlesta	0	0	0	1
	Trichoptera				
	Calamoceratidae				
19	Anisocentropus	2	0	0	0
	Hydropsychidae				
20	Hydropsyche	328	541	330	559
21	Cheumatopsyche	51	91	16	69
22	Arctopsyche	95	174	69	112
23	Parapsyche	26	11	26	44
24	Potamyla	5	4	4	4
25	Diplectrona	6	4	2	20
26	Ceratopsyche	2	0	1	1
27	Psychomyia	0	0	0	2
	Lepidostomatidae				
28	Neoseverinla	0	0	0	9
29	Lepidostoma	0	0	0	23
	Polycentropodidae				
30	Polycentropus	5	12	3	38
31	Nyctiophylax	0	1	0	5
	Psychomyeidae				
32	Tinodes	0	2	0	0
	Stenopsychidae				
33	Stenopsyche	0	0	0	34
	Xiphocentropodidae				
34	Xiphocentron	0	1	0	2
	Philopotamidae				
35	Dolophilodes	0	1	3	35
	Total	**2089**	**2040**	**890**	**2422**

sented with two genera (Polycentropus and Nyctiophylax). Psychomyeidae was represented with the genus Tinodes. Stenopsychidae was represented by only one genus Stenopsyche. Xiphocentropodidae was represented with the genus Xiphocentron and the Philopotamidae with Dolophilodes. The abundance of Trichoptera was found to be maximum in site 4 and is followed by site 2, site 1 and site 3 respectively.

Plecopterans were represented by only one family Perlidae which is the least dominant family during the study. It includes 4 genera namely Neoperla, Tetropina, Acroneuria and Perlesta. The abundance of Perlidae was found to be maximum in site 4 and is followed by site 2, site 1 and site 3 respectively.

Biological indices

The biological indices of aquatic insects at four sites were represented in Table 2. Shannon-Weiner diversity index for four sites were ranged from 2.103 to 2.541 and were found to be maximum at site 4 and minimum in site 3. Simpson dominance index also show similar relation in all four sites and is ranges from 0.808 to 0.880 and maximum is found in site 4 and minimum in site 3. Margalef's richness index show comparatively low value in site 1 and high in site 4, it ranges from 3.009 to 3.850.

Table 2. Biological indices of aquatic insects

Indices	Site 1	Site 2	Site 3	Site 4
Shannon Weiner index	2.305	2.248	2.103	2.541
Simpson Index	0.879	0.860	0.808	0.880
Margalef's richness index	3.009	3.018	3.092	3.850

DISCUSSION

Diversity is a structural character of an ecosystem (Bretschko, 1995). High diversity of aquatic insects aids for complex population interaction involving energy transfer, competition and niche apportionment (Brower *et al.*, 1990). It is generally expected that aquatic insects are diverse and abundant in streams and rivers with acceptable water quality. Such community structures are influenced by the changes in the water quality and habitat structure.

Species diversity pattern in selected streams of Western Ghats have been documented by many other workers (Anbalagan *et al.*, 2004; Subramanian and Sivaramakrishnan, 2005; Anbalagan and Dinakaran, 2006). In the present study 4 aquatic habitats were examined and each was exhibited a distinct pattern in species diversity, which emphasizes the uniqueness of these habitats. Hynes (1975) proposed that 'every stream is likely to be individual', moreover, each substrate type exhibits a very distinct community, and faunal similarity. The "individuality" of streams/ habitats and their substrate types has been challenged by anthropogenic impacts. The tributaries may serve as important point for recolonising the main channel after disturbances such as floods, droughts and pollution, and they are important habitats for the early life stages of fish and invertebrates (Bruns *et al.*, 1984; Rice *et al.*, 2001).

Indicator species are those taxa known to be particularly sensitive to specific environmental factors, so that changes in their incidence or abundance may directly reflect an environmental change (New, 1984). Data provided by indicator organisms can be used to estimate the degree of environmental impact and its potential dangers for other living organisms (Kovacs, 1992).

Bio monitoring using benthic macro invertebrates in running water is only a recent development in Indian fresh water biology (Gopal and Zutshi, 1998). Extensive data from USA and Europe have shown that methodology based on benthic macro invertebrates is most reliable due to several merits of these groups as bio indicators (Rosenberg and Resh, 1995). Among aquatic insects, Ephemeroptera, Plecoptera and Trichoptera (EPT), comprise rich assemblages in low and medium order stony cobble streams. These organisms are sensitive to environmental perturbations and occur in clean and well oxygenated waters. Therefore, EPT assemblages are frequently considered to be good indicators of water quality (Rosenberg and Resh, 1995). Specific families within these three EPT orders have been found to identify various levels of disturbance such as excess nutrients or sediment (Harrington and Born, 2000). Only 9.4% of the papers reported on the interactions of three orders such as Ephemeroptera, Plecoptera and Trichoptera, are especially important in the structure and function of running water ecosystems (Allan, 1995), EPT is prominently used for the measure of ecosystem health (Wallace and Jackson, 1996).

In the present study Ephemeroptera (50.69%) was the dominant group followed by Trichoptera (37.27%) and Plecoptera (12.04%). Ephemeroptera is one of the most abundant and common components of running water. They are often found in mid-stream, where substratum, food and oxygen are abundant. From the present study we observed 7 families and 14 genera of mayflies. Members of EPT are considered to be sensitive to environmental stress, thus their presence in high abundance shows a relatively clean environment. Therefore, EPT were found to be potential bio indicators for a clean ecosystem.

Among the orders of EPT, the diversity of Trichopteran family Hydropsychidae (genus: Hydropsychae) dominated the aquatic insects in the study area. The high proportional abundance of Hydropsychidae could be due to their feeding habits, they mainly feeds on the algae growing on cobbles and boulders. They cling to substrate and adapt to live in fast flowing waters. Jehamalar (2010) proposed that greater the number of Trichopterans, more the purity of water. In the case of Plecopterans we obtained only one family (Perlidae) and 4 genera (Neoperla, Tetropina, Acroneuria and Perlesta). The diversity of Plecopteran families is generally low in tropical Asian streams (Covich, 1988).

Lenat and Barbour (1994) reported that Ephemeroptera, Plecoptera and Trichoptera taxa (EPT taxa) are used as a suitable index which is sensitive to changes in stream water and /or substrate quality. The number of EPT taxa decreases with increasing human impacts. The greater richness of EPT taxa would have contributed to their wide distribution, together with less restrictive physiological requirements of these taxa. Brown and Brussock (1991) stated a non preference for mayfly habitats, which could be attributed to their adaptation to a wide range of current speeds and stream habitats. The taxa found within the orders Ephemeroptera, Plecoptera, and Trichoptera can imply specific conditions within the benthic habitat. Generally, habitats with higher counts of EPT insects have cleaner, cooler, and more oxygenated water. This study showed that all the selected sites supported relatively rich assemblage of EPT communities which indicate that the water quality is good to support these pollution sensitive taxa. From these, the most sensitive taxa like Perlidae, Heptagenidae, Lepidostomatidae, Polycentropodidae and Stenopsychidae are high in the main Kallar stream (S4) compared to tributaries. Human intervention in the tributaries may be the reason for the low abundance of the pollution sensitive taxa when compared to the main Kallar. But there are rapid development activities going on in and around the Kallar stream which include tourism, agriculture/plantation, deforestation and similar activities. So the present data can be considered as a benchmark and routine monitoring and continuous investigation are required to keep the stream healthy in future.

CONCLUSIONS

Aquatic insects are important elements in the ecological dynamics of lotic environment which plays an important role in the cycle of materials and in trophic transfers. They depend on water during a part of their lifecycles. These insects can exhibit a great breadth of genetic diversity and species richness, maintenance of which is essential for the functioning of stream ecosystem. The ubiquitous, sensitive and sedentary nature of the aquatic insects helps to use them on the bio monitoring of water quality and they have been used to assess the biological integrity of stream ecosystem. Among them, Ephemeroptera, Plecoptera and Trichoptera (EPT) are the organisms which are sensitive to environmental perturbation and occur in clean and well oxygenated water. EPT assemblages are frequently considered to be good indication of water quality. The objectives of the present study are to assess the variation in diversity of EPT and monitor the quality of the selected sites using them.

This study showed that all the selected sites supported relatively rich assemblage of EPT communities which indicate that the water quality is good to support these pollution sensitive taxa. From these, the most sensitive taxa like Perlidae, Heptagenidae, Lepidostomatidae, Polycentropodidae and Stenopsychidae are high in the main Kallar stream (S4) compared to the tributaries. In the tributaries many anthropogenic activities (deforestation, intensification of agriculture, increase of human settlement, soil erosion, and extraction of sand, pebbles and stones) are taking place, these factors having direct and indirect impact on the diversity of aquatic insects. So this may be the reason for the low abundance of the pollution sensitive taxa in the tributaries compared to the main Kallar stream. The conservation and management of the stream is very important for proper functioning of the ecosystem. So the present data can be considered as a benchmark and routine monitoring and continuous investigation are required to keep the stream healthy in future. The rapid bio assessment is being applied in many countries with success and optimizing time and resources in the sample methodologies. But we lack a thorough knowledge on the ecology of regional aquatic insects. Hence more comprehensive investigations are to be conducted to expand our knowledge on aquatic insect diversity in Western Ghats streams.

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