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Distribution and diversity of aquatic insects of Vellayani lake in Kerala

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Abstract

The diversity of insect fauna of Vellayani lake in Kerala was represented by 60 species classified under 37 families and 8 orders. Among the entomofauna collected from the lake, the order Coleoptera was diverse in number of genera (22). Shannon index was highest in station 2 (3.214) and lowest (2.839) in station 4. The higher richness index was also recorded in station 2 (6.331), though the lowest species richness was observed in Station 1 (5.205). The order Ephemeroptera is represented in Vellayani lake by the families Baetidae and Caenidae, which are considered as an indicator of water quality. Of the 15 metrices selected, taxa richness, Composition measures, Tolerance and Intolerance and Functional groups were also found out for all the stations. In the present study, the percentage of Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa richness and diversity remained high in Station 1, 2 and 3 but reduced drastically in stations 4 and 5. The high HBI value recorded at station 4 is due to the abundance of pollution tolerant taxa such as Chironomidae, Tabanidae, Culicidae and Anophilinae. The results of the study reveal greater diversity of aquatic entomofauna in Vellayani freshwater lake and suggest the possibility of using insects effectively for biomonitoring programmes.

Key words

Diversity, Insect fauna, Lake, EPT taxa, Hilsenhoff biotic index, Biomonitoring

Introduction

The aquatic insects perform several critical roles in ecosystem functioning by virtue of their numerical abundance, taxonomic diversity and trophic significance. Freshwater habitats from puddles to rivers to lakes, including both lentic and lotic habitats, are home to a greater biodiversity of insect fauna. Though aquatic insects make up only 3-5% of all insect species, they are taxonomically diverse (Daly *et al.,* 1998) and play a critical role in stability and maintenance of ecosystem, especially in nutrient dynamics. About 5,000 species of aquatic insects are estimated to inhabit inland wetlands of India, represented predominantly by mayflies (Ephemeroptera), dragonflies (Odonata) and caddiesflies (Trichoptera) (Subramanian and Sivaramakrishnan, 2007a). In addition to this significant ecosystem function, aquatic insects are very good indicators of human impact on the freshwater ecosystem.

Biomonitoring involves the use of indicators, indicator species or indicator communities to assess changes in the environment, generally changes due to anthropogenic causes. Aquatic insects are particularly suited for use in environmental impact assessment (EIA) and has a long tradition in water quality monitoring (Bonada *et al.,* 2005), act as reliable indicators, provide a spectrum of responses to disturbances at many levels of organization, ranging from organismal to population, community, and even ecosystem levels (Niemi and McDonald, 2004). The insect orders Ephemeroptera, Plecoptera, and Trichoptera are the pollution sensitive groups and are used extensively for aquatic insect biomonitoring programmes. The metrics prepared for biomonitoring programme consider species diversity is more sensitive to stress than total number of taxa, since the EPT taxa includes generally intolerant taxa. Many species require undisturbed habitats, thus a high number of EPT taxa indicates undisturbed streams and lakes with high habitat diversity and high species diversity (Barbour *et al.,* 1999; Subramanian and Sivaramakrishnan, 2007a and b).

Studies on the diversity and distribution of aquatic insects focused mainly on lotic ecosystems, while relatively very few works deal with the invertebrate fauna of lentic freshwater habitats, despite their great diversity and abundance in these systems. Aquatic Hemiptera of Pocharam Lake, Andhra Pradesh was studied for documenting diversity by Deepa and Rao (2007). Latha and Thanga (2010) reported the diversity and distribution pattern of benthic organims and macroinvertebrates of Veli lake and Kadinamkulam estuary, Kerala. The present study documents the diversity of aquatic entamofauna in Vellayani lake, Kerala and also emphazise the impacts of pollution by using bio-indicators of water quality.

Materials and Methods

Study area : Vellayani Lake, the second largest freshwater lake of Kerala, is located in the outskirts of Thiruvananthapuram city (8"24'09" - 8"26'30" N; 76°59'08"- 76°59'47" E) and has a water spread area of 450 ha. The lake is situated 29 m above msl, and the lake bed is 0.1 to 1.5 m below the msl. The length of the lake is about 3.15 km and at its maximum width is about 1000 m; depth of the lake varies from 2 to 6 m. Five different Stations chosen for collecting aquatic insects and larvae include Vellayani Pump House (Station 1), Vazhavila (Station 2), Kakkamoola (Station 3), Muttacadu (Station 4) and Venniyoor (Station 5).

Water quality parameters such as temperature, pH, conductivity, hardness, total alkalinity, total dissolved solids (TDS), dissolved oxygen, free carbon dioxide, nitrate, nitrite, sulphate and phosphate were analysed following APHA (2005).

Aquatic insects collection and taxonomy : Aquatic insects were collected using D-frame dipnet (0.3m width and 0.3m height) having mesh size 500 µ and Kicknet (1m x 1m) having mesh size 500 µ for a peroid of one year during April 2010 to March 2011. A random sampling of a 50 m reach was taken for collecting insect samples from each site. A total of 10 dippings or 10 kicking was carried out along the length of the sampling reach. The kicks or dips collected from this site was composited to obtain a single homogenous sample. The collected material was washed by running water through the nets two or three times to detach the insects/larvae adhered in the nets. The samples were then transferred to white trays in small quantities for hand-picking aquatic insects using forceps and fine brushes. The hand picked samples were then preserved in 95% ethyl alcohol and brought to the laboratory for further analysis. Before preserving, natural colour of insects was noted.

The collected samples were examined under a dissection or stereozoom microscope (4X and above) and identified using standared taxonomic keys. The family level identification was done following the manual of Subramanian and Sivaramakrishnan (2007b). The following keys were used for identification: Ephemeroptera (Dudgeon, 1999); Odonata, Plecoptera, Hemiptera, Megaloptera, Coleoptera, Diptera and Lepidoptera (Fraser, 1934; Dudgeon, 1999; Morse, *et al.,* 1994); Hemiptera (Thirumalai 1989, 1999) and Trichoptera (Wiggins, 1977 and 1996).

To evaluate the distribution and diversity of insects between sampling sites, community indices such as abundance, relative abundance, Shannon diversity index, Simpson dominance index, Margalef species richness index and evenness index were used (Magurran, 1988). The Hilsenhoff's Family Biotic Index (FBI) was calculated based on the Rapid Bioassessment Protocol methodology suggested by Plafkin *et al.* (1989) and APHA (2005) using the formula FBI= $[\sum (x_i)(t_i) / n]$

Where 't_i' is the tolerance value of a taxon, 'x_i' is the number of individuals within a taxon and n is the total number of individual in the collected sample. FBI indicates the effects of organic pollution and is based on species-specific tolerance levels. Taxa are assigned tolerance values ranging from zero to ten, where zero and ten represent the extremes for intolerance and tolerance respectively (Hilsenhoff, 1987). FBI not only includes the numbers of species and the distribution of individuals among species, but weighs abundance of each species according to its known ability to tolerate adverse water quality conditions, particularly organic inputs.

Results and Discussion

A total of 2,440 individuals representing 60 genera categorised under 37 families and 8 orders were collected from all the sampling sites in the present study. The aquatic entomofauna of Station 1 constituted 33 genera, 23 families and 8 orders, while 44 genera, 26 families and 7 orders were recorded from Station 2. The aquatic insect diversity in Station 3 was represented by 33 genera, 23 families and 7 orders. 36 genera classified under 23 families and 6 orders were recorded from Station 4. The insects recorded from Station 5 were included under 32 genera, 23 families and 7 orders. The Station wise abundance of aquatic insects in Vellayani lake revealed that the abundance of aquatic insects recorded was maximum (891) in Station 2 and minimum (308) in Station 4. The Station 1 and Station 3 showed somewhat equal distribution of fauna throughout the sampling periods.

The species diversity and percentage composition of various insect orders collected from Vellayani Lake is

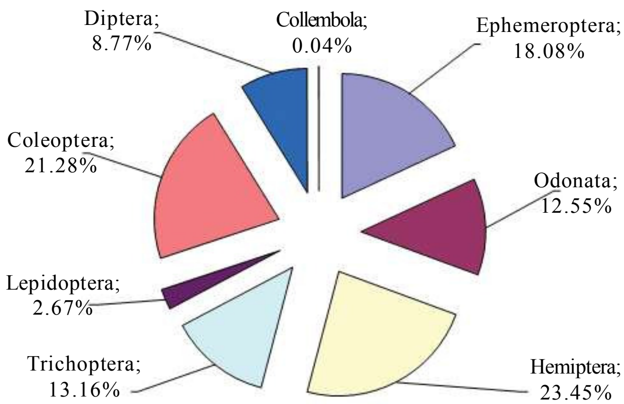

Fig. 1 : Composition of insect orders of Vellayani lake during a period of six months

shown in Fig. 1. Among the entamofauna collected the order Hemiptera was diverse in number of genera (17) comprising 23.45% of the total insect fauna. It was represented by 12 families viz., Corixidae, Nepidae, Belostomatidae, Notonectidae, Naucoridae, Pleidae, Helotrephidae, Hebridae, Mesovelidae, Hydrometridae, Vellidae and Gerridae. Of these, Belostomatidae was the most common family among Hemiptera in all Stations contributed by two genus *Belostoma sp.* and *Diplonychus sp.* This was followed by Nepidae which showed highest numerical abundance represented by two genus *Ranatra* and *Laccotrephes,* and was abundant in Station 2. Other members of this order among diverse families were *Naucoris* sp*., Distotrephes* sp*., Helotrephes* sp*., Paraplea* sp*., Micronecta* sp*., Anisops* sp*., Gerris* sp*., Mesovelia* sp*., Hebrus* sp*., Hydrometra* sp*., Velia* sp*., Microvelia* sp*.* and *Eurymetra* sp. Coleoptera was the most common group quantitatively representing 21.28% of the total aquatic insects in this lake. Khan and Ghosh (2001) in West Bengal and Johri *et al.* (2010) in Uttar Pradesh found Coleoptera to be the most common order quantitatively. The major aquatic Coleopteran was contributed by the families Hydrophylidae and Dytiscidae, represented by the genus *Sternolophus*, *Amphiops*, *Cybister* and *Hydrovatus*. Dytiscidae family generally inhabits leaf of bottom macrophytes of the clean freshwater and are predacious in nature. Hydrophylidae family on the contrary are water scavenger beetles and generally occur in shallower regions of the wetland with abundant macrophytes particularly emergent ones and feed mainly on detritus, algae and decaying vegetative matter (Khan and Ghosh, 2001). Other important insects recorded under this order were of the families Noteridae, Curculionidae, Hydrochidae, Elmidae, Heteroceridae, Chrysomelidae and Staphylinidae.

The order Ephemeroptera one of the intolerant/ sensitive group was represented in Vellayani lake by the families Baetidae and Caenidae which are considered as an indicator of water quality ecosystem health primarily because of its presence in both the polluted and unpolluted reaches of the lakes. The family Baetidae is contributed by two genus *Baetis* and *Cloeon* and was enormously found in Station 2 followed by Station 1 and Station 3. And the family Caenidae is contributed by only one genus *Caenis sp.* and it was found to be abundant in Station 3 and absent in Station 4. However, it appears too sensitive to pollution as numbers are significantly reduced at sites that regarded as disturbed sites (Station 4). The genera *Baetis sp.* and *Caenis sp.* from earlier studies have been reported to be tolerant top organic pollution (Timm, 1997; Menetrey *et al.,* 2008). However, in our study, *Caenis sp.* was not recorded at Station 4 along with very fewer numbers of *Baetis sp.* and few *Cleon sp*. A study conducted by Arimoro and Muller (2010) in a stream of Niger Delta showed that the overall composition and density of Ephemeroptera fauna varied both spatially and temporally in response to physico-chemical and biological factors of the environment. In the present study the Ephemeroptera taxa richness and diversity remain at a relatively high in the upper reaches of the Lake at Station 1, 2 and 3 but reduced drastically in lower reaches such as Station 4.

The trichoptera or Caddisflies were contributed by the genus *Polycentropus Leptocerus* and *Hydropsyche*. Among the Trichoptera taxa occurring in Vellayani lake *Polycentropus* was common throughout the study sites except at Station 4. These were most abundant in Station 2 and few in Station 4. The order Plecoptera is considered highly sensitive to environmental degradation (Fore *et al.,* 1996; Maxted *et al.,* 2000).

The Odonata was represented by the families Coenagrionidae and Libellulidae. The important members under Coenagrionidae were *Pseudagrion* and *Ceriagrion.* The nymphs of this family remain attached to macrophytes. *Acisoma*, *Brachythemis* and *Crocothemis* were the groups of Libellulidae*,* the naid of which is mud dwelling. The order Lepidoptera was represented by Pyralidae and Noctuidae constituting a total of 2.67% of insect groups in Vellayani lake. *Paraponyx sp. and Eoophyla sp.* coming under Pyralidae and *Bellura sp.* under Noctuidae were reported.

Dipterans were rich in numbers of species as well as in individual numbers. The order Diptera was contributed by 6 major families representing Culicidae, Ceratopogonidae, Chironomidae, Tabanidae, Sciomyzidae and Anophilinae. Larvae of most species can be considered aquatic in the broadest sense and they require a moist to wet environment within the tissues of living plants, amid decaying organic materials, as parasites or parasitoids of other animals, or in association with bodies of water (Courtney, 2009). *Anophiles, Chironomus* and *Culex* were recorded as the abundant species. Many of the dipterans inhabitat in heavily polluted water bodies with wide range of tolerance.

The species diversity indices are presented in Table 1. The highest Shannon index of diversity of 3.214 was recorded in Station 2 and lowest in Station 4 (2.839), indicating the presence of higher diversity of entomofauna in the lentic ecosystems. The diversity of insects in aquatic ecosystems tends to increase with increased nutrients and optimum environmental conditions favour their abundance in the habitat. Distribution of aquatic insects within a habitat is determined by intricate interplay between substrate, flow, turbulence and food availability. The high diversity of insect fauna in Vellayani lake is an indication of larger microhabitat diversity and better water quality conditions prevailing in the lake (Table 2).

In the present study, the evenness value was recorded low in almost all the Stations, indicating relatively even distribution of species in the lake. Species diversity and evenness were highest in almost all the Stations indicating good water quality. In the present investigation, species diversity index was always greater than one. The dominance recorded a lowest value of 0.051 in Station 2 and a highest of 0.077 in Station 1 and 4. The higher species richness index of 6.331 was also recorded in Station 2, though the lowest species richness of 5.205 was observed in Station 1.

In this study 15 candidate metrics were selected, representing taxa richness (Ephemeroptera richness, Plecoptera richness, Trichoptera richness), Composition measures (% of EPT and % of E), Tolerance or Intolerance measures (Number of intolerant taxa, % of tolerant organisms, and % of dominant taxa) functional feeding groups (Number of Clinger taxa and % of Clingers) (Table.3). The candidate metrices were chosen by receiving the literature for those that would be appropriate for lakes (Barbour *et al.,* 1999).

The percentage of EPT taxa formed 47.81% in Station 2, 30.28% in Station 3, 26.07% in Station 1, 23.44% in Station 5 and only 0.97% in Station 4 of the total insects collected. Ephemeroptera and Trichoptera were represented in this group (two intolerant groups). The tolerant organisms formed 11.45% in Station 2, 26.61% in Station 3, 25.0 % in Station 4, 22.85% in Station 5 and 16.67% in Station 1. The dominant taxa (Family Coenagrionidae) formed 20.09% in

Table 1 : Diversity of aquatic insects in five stations of Vellayani lake

Diversities	Stations					Total
	Station1	Station 2	Station 3	Station 4	Station 5	
No of individuals	468	891	436	308	337	2440
Dominance Index	0.077	0.051	0.066	0.077	0.067	0.047
Shannon index	2.854	3.214	2.964	2.839	2.924	3.347
Simpson Index	0.923	0.95	0.934	0.923	0.933	0.953
Evenness Index	0.526	0.566	0.587	0.499	0.582	0.474
Margalef	5.205	6.331	5.265	6.108	5.326	7.564

Table 2 : Summary of mean water quality parameters of Vellayani lake during a period from April to September 2010

Parameters	Stations				
	Station 1	Station 2	Station 3	Station 4	Station 5
Air Temperature (ºC)	26.83	28.08	30.33	29.33	29.08
Sediment temp (ºC)	29.60	31.00	32.17	31.25	31.58
Surface water temperature (ºC)	26.50	27.5	28.0	29.5	27.0
Bottom water temperature (ºC)	29.75	30.67	32.58	31.08	31.67
pH	6.93	7.33	7.65	6.53	7.88
Conductivity ($\mu S\ cm^{-1}$)	17.56	16.62	17.12	19.63	19.25
Hardness ($mg\ l^{-1}$)	32.33	31.33	32.33	36.00	35.17
Total alkalinity ($mg\ l^{-1}$)	30.00	24.38	23.50	26.67	26.15
TDS (mgl^{-1})	92.53	85.70	91.17	113.63	102.80
Dissolved O_2 ($mg\ l^{-1}$)	3.78	6.32	7.97	4.01	7.86
Free CO_2 ($mg\ l^{-1}$)	7.33	4.22	2.38	9.26	3.71
Nitrate ($\mu g\ ml^{-1}$)	0.23	0.27	0.31	0.35	0.27
Nitrite ($\mu g\ ml^{-1}$)	0.25	0.20	0.25	0.20	0.22
Sulfate ($\mu g\ ml^{-1}$)	0.74	0.58	0.34	0.38	0.42
Phosphate (μgml^{-1})	0.78	0.81	0.90	0.51	0.62
Total depth (cm)	36.00	41.17	40.17	42.50	38.33

Table 3 Tabulated metrices for insect samples collected from Vellayani Lake

Metrices	Station 1	Station 2	Station 3	Station 4	Station 5
Total number of taxa obtained	21	26	23	24	23
Number of EPT taxa	5	5	5	1	5
Ephemeroptera taxa	2	2	2	1	2
Plecoptera taxa	-	-	-	-	-
Trichoptera taxa	3	3	3	-	3
Percentage of EPT	26.07	47.81	30.28	0.97	23.44
Percentage of Ephemeroptera	24.36	17.62	25.23	0.97	16.91
Number of intolerant taxa	4	4	4	1	4
Percentage of tolerant organisms	16.67	11.45	26.61	25.0	22.85
Percentage of dominant taxa	20.09	15.38	17.20	16.23	15.73
Percentage of filterers	6.84	15.49	9.17	40.91	10.98
Percentage of grazers and scrapers	25.85	20.43	32.34	18.51	17.80
Number of clinger taxa	4	4	2	4	2
Percentage of clingers	21.15	28.956	21.33	2.27	16.02

Station 1, 15.38% (Family Leptoceridae) in Station 2, 17.21% (Family Baetidae) in Station 3, 16.23% Family Corixidae) in Station 4 and 15.73% (Family Baetidae) in Station 5 of the insect fauna. In the case of major functional groups among these insects, the percentage of clinger taxa was found to be low in Station 4 (2.27%) and high in Station 2 (28.96%). However, the percentage of filterers were high in Station 4 ie. 40.91%; it revealed the presence of highly tolerant dipteran taxa. Also, the percentage of grazers and scrapers were highest in Station 3 and lowest in Station 5.

In the present study the FBI of all the Stations showed a comparative significance in relation to water quality and aquatic insect diversity. The FBI of Station 2 could be taken as a reference site for comparing all the other (test) sites. In this study an inverse relationship of EPT and FBI of the lake was shown in Fig.2. Pollution sensitive groups (Ephemeroptera, Plecoptera, and Trichoptera or EPT taxa) were represented in the site by Ephemeroptera and Trichoptera which indicated the lake's health. High FBI values are associated with adverse impacts of organic pollution. Low FBI values indicate that the macro invertebrate community is not impacted by organic pollution. This indicated higher anthropogenic disturbance in Station 4, as this site is very close to dense human settlements located near the Kovalam tourist centre, and used extensively for general purposes such as cleaning of vehicles and dumping of solid wastes etc.

The FBI is used to indicate the amount of perturbations in an aquatic ecosystem, using insects as indicators. HBI value of 4.26-5.0 indicate good water quality, 5.01-5.75 indicate fair water quality, 5.76-6.50 indicate fairly poor water quality, a value 6.51-7.25 poor water quality, and 7.26- 10.0 indicates very poor water quality. Considering this, the water quality of Station 2 could be considered good and 1,3 could be considered fair, while that of Station 5 was fairly poor and that of Station 4, poor water quality.

The biodiversity of aquatic insect communities in a given ecosystem often reflect the environmental conditions. The sensitive species inhabiting the habitats because of the adverse of the environmental conditions are gradually eliminated and the tolerant species establish their colonies and grow in abundance (Rosenberg and Resh, 1993). The study shows the abundance of intolerant taxa comprising Ephemeroptera and Trichoptera, indicating relatively undisturbed condition of the lake in terms of water quality.

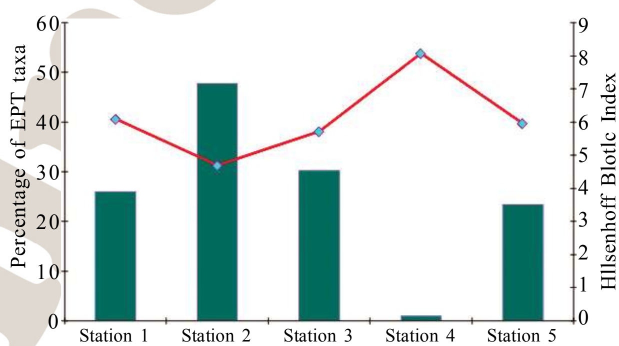

Fig. 2 : Spatial changes in Percentage of EPT taxa and Hilsenhoff Biotic Index of Vellayani lake

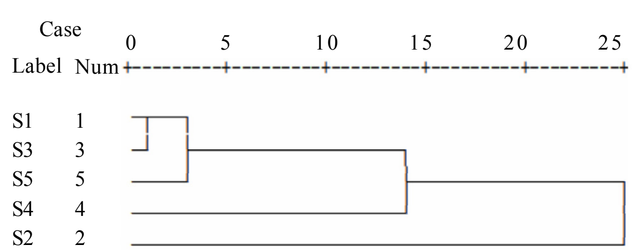

Fig. 3 : Dendrogram using Average Linkage (Between stations)

In present study a comparison of FBI throughout the Stations showed that the higher FBI value was found at site 4 indicating greater pollution due to the presence of highly tolerant taxa such as Chironomidae, Tabanidae, Culicidae, Anophilinae compared to other sites which shows less pollution. Based on the FBI we can compare the test site with reference site reaching the result that the more intolerant genera and species in each family predominate in clean waters, whereas the more tolerant genera species predominate in polluted systems. Fig.3 showed a simple hierarchical clustering based on Euclidien distance; it showed the possibility of three distinct groups. The fist group comprising Station 1, 3 and 5 are similar allowing only 12 percent variations within the cluster. Station 4 and Station 2 shows significant difference between them and from first cluster.

The structure and composition of biotic community is well reflected with altering water quality and are also shown in their distribution, diversity and abundance pattern of species (Kumar *et al.,* 2006). Most aquatic habitats with acceptable water quality and substrate conditions support diverse macroinvertebrates community. In which there is reasonably balanced distribution of species among the total number of individuals present. Such community responds to changing habitats and community structure such as invertebrate abundance and composition. However, many habitats, especially disturbed ones are dominated by few species (Sharma *et al*., 2004). Present study reveals greater abundance of insects in Station 2 compared with other Stations together with increasing taxa richness and composition. Identifying the diversity and community composition of a sample of macroinvertebrates in a selected wetland will help to determine the overall richness and abundance of the macroinvertebrate fauna within that wetland (Dodson, 2001).The high number of insect species compared to other living organisms also indicates that they are the most successful living things that ever live on earth. The results of the study revealed greater diversity of aquatic entomofauna in Vellayani freshwater lake with a possibility of pollution in lower reaches and suggest effectively for stringent biomonitoring programmes.

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