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Longitudinal distribution of EPT (Ephemeroptera, Plecoptera and Trichoptera) members in streams of Southern Western Ghats, India

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Abstract
A number of ecological theories and artificial models are developed for measuring the assessment of stream ecosystem, from the headwaters to the mouth of the stream, considering the variation in the physical and stream features of different stretches of the watercourse. We investigated the longitudinal variation of EPT (Ephemeroptera, Plecoptera and Trichoptera) members in streams. The present study was conducted in nine streams of southern Western Ghats. The EPT members were collected from different substrates in sampling sites. Result of this study indicates that nine species were collected from sampling sites under three insect orders. Of these, ephemeropterans occupied the greatest percentage than other insect orders. Among the environmental variables, elevation is a significant variable for the distribution of EPT members rather than other environmental variables given by PCA. Overall, elevation is determining factor for the distribution of EPT members rather than longitude.

Keywords: Aquatic insect, stream, longitude, environmental variables, Western Ghats

Introduction
Insects are the largest group of the phylum Arthropoda and they live throughout the world. Insects play an important role for pollination, bioindicators, nutrition, economic value, etc. Some group of insects complete their life cycle in the aquatic environment or have life stages that are closely associated with aquatic environments (Semiaquatic), known as aquatic insects. Although the vast majority of insects are living in terrestrial environment, but a small percentage is considered to be aquatic. Aquatic insects are integral components in the structure and function of both lentic and lotic waters and serve as the processing of organic matter, the cycling of nutrients, and as prey for aquatic, terrestrial, and aerial predators.
A total of 30 insect orders are known in the class of Insecta, of which seven orders have exclusively aquatic immature: Ephemeroptera, Trichoptera, Plecoptera, Odonata, Megaloptera, Diptera and Coleoptera. Of these, three orders Ephemeroptera, Trichoptera and Plecoptera (EPT) are widely distributed in all streams. They are used as an excellent bioindicators due to their sensitive survival and play an important role for leaf litter decomposition and food chain stream ecosystem. Many aquatic insect studies have been reported in South India: Anbalagan *et al.* [1], Pulugandi & Rajan [2], Mary *et al.* [3], Kubendran & Ramesh [4], Arumugam & Athikesavan [5], Raj *et al.* [6], but little information has been received on EPT complexes in India.
As the members of EPT are sensitive to water quality and habitat alterations, the present study was conducted in downstream of Western Ghats, in turn to assess the current status and stream integrity in the study area. Hence, the objective the present study was to investigate the longitudinal variation of EPT complexes in streams of Western Ghats, South India.

Materials and methods
Study area
The present study was conducted in 9 streams of southern Western Ghats. Western Ghats, north–south-running range of mountains or hills in western India that forms the crest of the western edge of the Deccan plateau parallel to the Malabar Coast of the Arabian Sea.

The Western Ghats are a biodiversity hot spot, a biologically rich but threatened region, and a UNESCO World Heritage site. They play a huge role in India's monsoon weather pattern. Many important streams and rivers originate in these areas and these streams are altered by human activities like dam construction, habitat changes, landscape changes, plantation, irrigation, etc. For this reason, assessment of sensitive taxa in streams is indispensable. Hence, the present study was conducted in streams flowing through Theni district (Figure 1 & 2). They are: Anaipillayar falls (site 1), Kottakudi river (site 2), Kurangani stream (site 3), Puliyuthuaruvi stream (site 4), Loveshore waterfalls (site 5), Suruli falls (site 6), KK patti river (site 7), Kambiyar (site 8) and Uthamapalayam river (site 9).

Sampling methods

Sampling was performed in July and August 2024 (South-west monsoon) from the submerged substrates of boulders, gravels and pebbles. We performed nine samplings in triplicates of each sites. Measurements of water temperature, pH, electrical conductivity, total dissolved solids and salinity were obtained with portable digital tester. Latitude and longitude of each site was noted with the help of GPS (Garmin, USA). Dissolved oxygen was measured by Winkler method in the laboratory. Stream width and average water depth were measured with the help of meter tape. The canopy cover is measured with visual method.

The EPT members were collected from submerged substrates and taken in a plastic vial containging 80% ethanol. The sampling was done by using forceps and brushes. Then, it brought to the laboratory and preserved at−4 °C until analysis. In the laboratory, samples were separated and identified up to genus level with standard identification manual.

Data analyses

The physical and chemical data and biological data were typed in MS-Excel and they were sorted out by site-wise. The average value, standard error, graphical representations were made in MS-Excel. Diversity analysis was performed for measuring diversity of EPT complexes. The environmental relationships and distribution of EPT members are estimated through multivariate analysis by using statistical software.

Results

Physical and chemical variables

In nine streams sampled, latitude ranged from 9.433 to 10.052 and longitude was 77.153 to 77.349. Elevation ranged from 384 to 1200 m. The low water temperature was 20.3 °C and highest was 24.3 °C. The parameters of pH was high in site 9, conductivity was high in site 8, total dissolved solids was high in site 3 and salinity was high in site 8. Stream width was high at site 8 and low at site 6. Stream depth was high at site 3. The diversified substrates were found between sampling sites. Riparian cover was ranged from 30 to 70% (Table 1).

Diversity and distribution

In total, 9 species were collected in 7 families under three insect orders. The highest individuals were collected at site 5 and lowest number of individuals were collected site 2 (Figure 3). *Baetis* occupied the highest of percentage (51%) than the other species (Figure 4). The order Ephemeroptera had high number of species (6) followed by Trichoptera (2) and Plecoptera (1). Of these, 86% was occupied by ephemeropteran individuals.

Diversity analysis indicates that the higher number of taxa was observed in site 1 and lower number of taxa was observed in site 5. Dominance index was high in site 5 and low in site 2. Simpson index was high in site 6 and low in site 4. The high value for Shannon and Evenness indices were found at site 6, respectively. The species richness index was high at site 2 and low in site 5 (Table 2).

Environmental relationships

A total of 14 environmental variables were taken for measuring relationship for taxa richness by using multivariate analysis of Principal component analysis (PCA). The eigen value for PC1 is 277271 and their variance is 99.5% and eigen value for PC2 is 782 and their variance is 0.28%. The PCA score revealed that elevation is an important variable for PC1 and conductivity is significant variable for PC2 (Table 3). The site 3, 7 and 9 are significant sites for the distribution of EPT members (Figure 5). Overall PCA resulted that elevation and conductivity are important variables rather than other environmental variables between sampling sites.

Discussion

In lotic ecosystems, community structure is determined by dynamic processes that determine the flow and transformation of energy and matter among different habitats [7]. A number of ecological theories and synthetic models have been developed for the description of these lotic environments, from the headwaters to the mouth of the stream, considering the variation in the physical and structural characteristics of different stretches of the watercourse. For this reason, the present study was carried out to estimate the relationship between environmental variables including longitude with the distribution of EPT members.

The distribution of communities in patches occurs mainly due to the intrinsic relationship between organisms and environmental parameters [8], and the majority of aquatic insects are adapted to specific conditions of luminosity and water flow velocity [9, 10]. In addition, they may use different substrates as microhabitats to obtain shelter and food [11]. The spatial arrangement of the zonation of functional processes found in a hydrographic network may determine which theory (River Continuum concept) the most applicable for the understanding of the distribution of Functional is feeding groups in a river basin. Likely, we observed very lower number of species (9 species) in sampling sites, since it may due to the downstream pattern or anthropogenic impact or environmental influences.

To estimate the environmental variables, the multivariate test of Principal component analysis was calculated. Result of PCA given that elevation is a significant variable rather than longitude and latitude and chemical parameter of conductivity was influenced with the distribution of EPT taxa richness. Mountain ranges provide an opportune landscape for identifying and understanding patterns of b-diversity, as environmental conditions change rapidly with elevation over a relatively small spatial scale. Consequently, compared to latitudinal gradients, elevational gradients enable the ability to partition the relative influence of habitat suitability and dispersal ability in shaping b-diversity patterns [12].

Table 1: Physico-chemical variables of nine streams in southern Western Ghats

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Latitude (N)	10.011	10.048	10.052	10.036	10.022	9.655	9.433	9.734	9.806
Longitude (E)	77.349	77.153	77.158	77.264	77.260	77.309	77.290	77.284	77.338
Elevation (m)	741	750	749	763	1200	454	457	462	384
Water temperature (°C)	24.3	22.3	20.3	22.6	23.6	24	22.5	24	22.6
pH	7.9	7.3	7.8	8.3	8.2	7.1	7	7.9	8.6
Conductivity (µ/Sec)	78	60	88.6	50.4	78.3	50.6	51.4	138	50.4
TDS (ppm)	47.3	42.7	49	39	41.3	37.2	35	63	36
Salinity (ppt)	29.2	20.3	30.3	54.3	53	29.6	28.4	66.5	28.7
Stream width (m)	5.6	6	7	7.6	7.3	4.2	5	10	7
Stream depth (cm)	20	29	36	16	10	11.6	11.5	5	5
Pebbles (%)	55	35	40	60	65	58	35	40	35
Boulders (%)	45	50	32	20	25	22	45	35	35
Sand (%)	10	15	18	20	10	20	20	25	30
Riparian Cover (%)	55	50	65	70	50	55	45	40	30

Table 2: Diversity indices for EPT members collected in nine streams

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Taxa_S	5	4	3	3	2	4	3	3	3
Dominance_D	0.3438	0.2653	0.375	0.7963	0.9524	0.2531	0.4184	0.38	0.551
Simpson_1-D	0.6563	0.7347	0.625	0.2037	0.04759	0.7469	0.5816	0.62	0.449
Shannon_H	1.257	1.352	1.04	0.4258	0.1147	1.38	0.98	1.03	0.7963
Evenness_e^H/S	0.7027	0.9661	0.9428	0.5103	0.5607	0.9938	0.8881	0.9334	0.7391
Margalef	1.259	1.542	0.9618	0.692	0.2693	1.038	0.7578	0.8686	0.7578

Table 3: Loading plot score for environmental variables and taxa richness given by PCA

	PC 1	PC 2
Latitude (N)	-197.89	-20.713
Longitude (E)	-8.7661	31.752
Elevation (m)	1888.5	-10.41
Water temperature (°C)	-161.46	-9.6698
pH	-203.74	-22.113
Conductivity (µ/Sec)	-22.686	79.304
Total dissolved solids (ppm)	-103.8	21.219
Salinity (ppt)	-116.03	14.653
Stream width (m)	-206.93	-20.77
Stream depth (cm)	-177.38	-26.243
Pebbles (%)	-86.523	-8.2747
Boulders (%)	-131.46	3.5248
Sand (%)	-178.46	-2.4787
Riparian Cover (%)	-76.761	-4.4756
No. of taxa	-216.64	-25.305

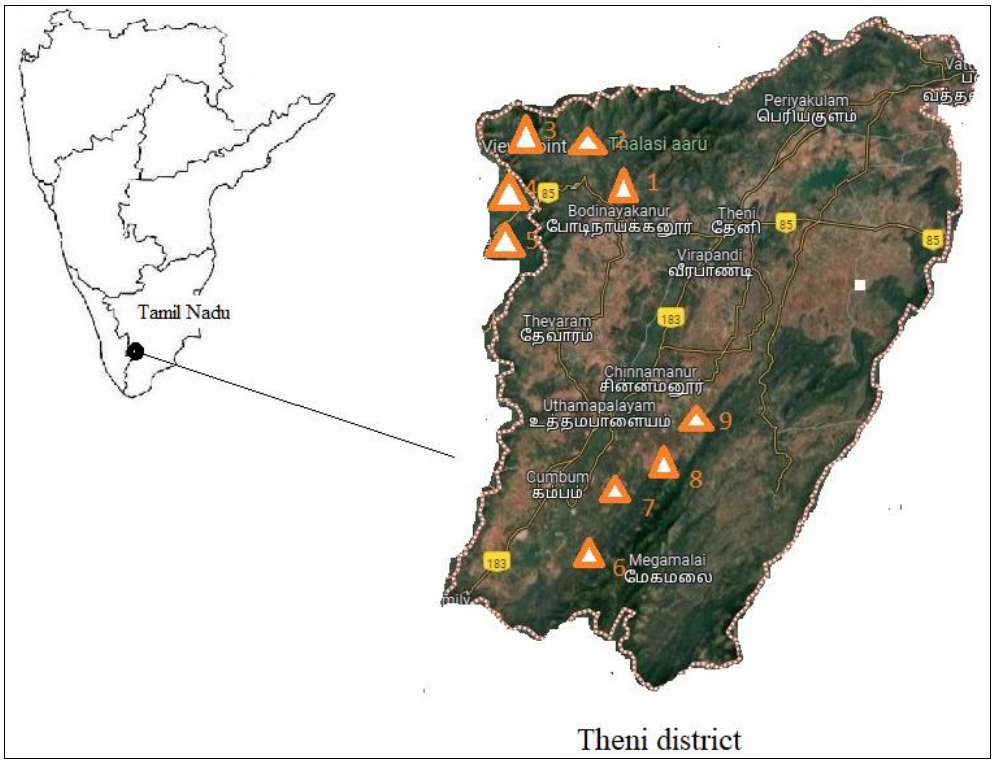

Fig 1: Map showing sampling sites in Western Ghats

Fig 2: Stream profile photographs of Western Ghats

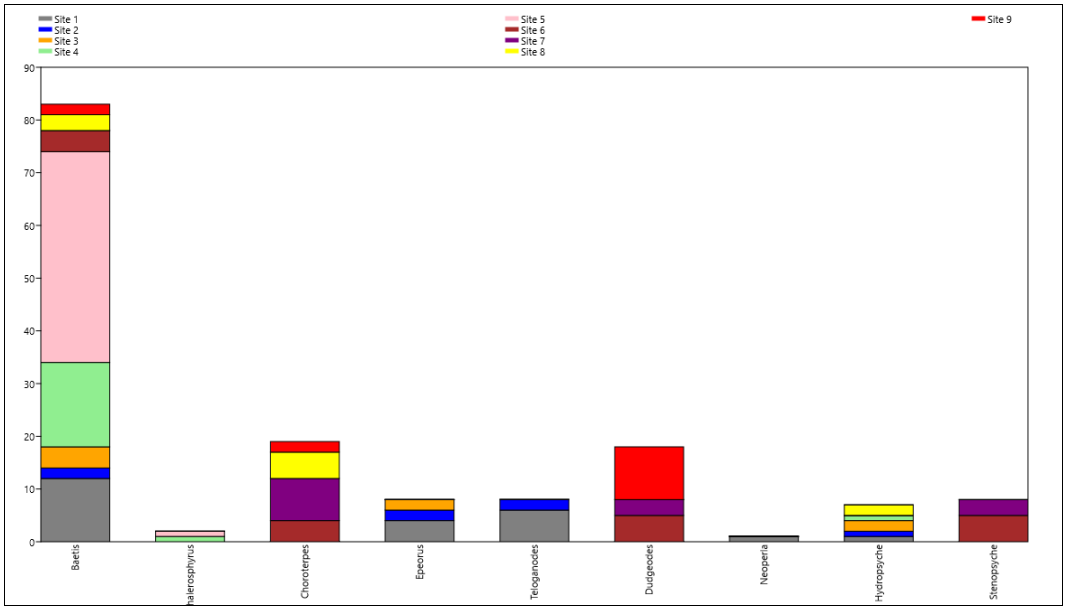

Fig 3: Stacked chart showing the distribution of EPT members in nine streams

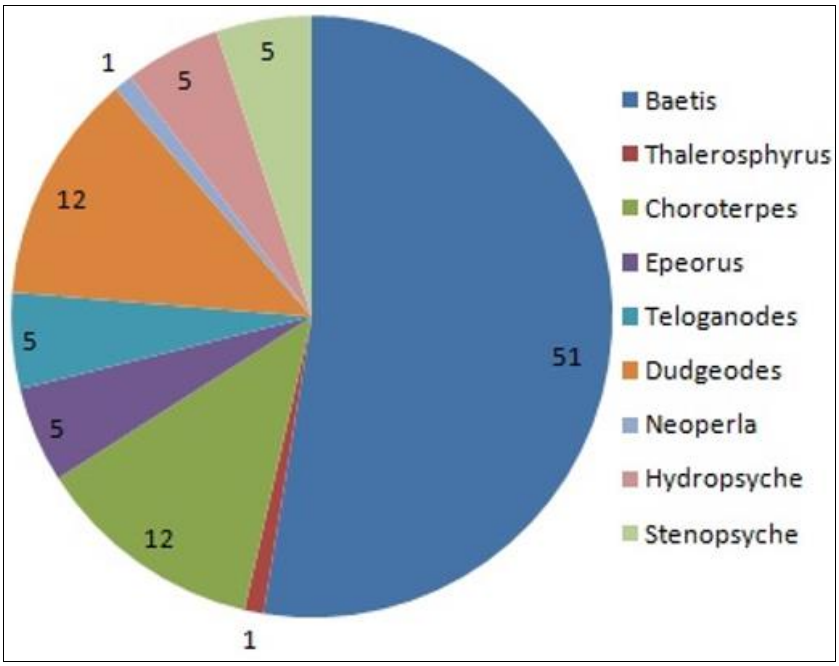

Fig 4: Percentage of EPT genera collected in nine streams

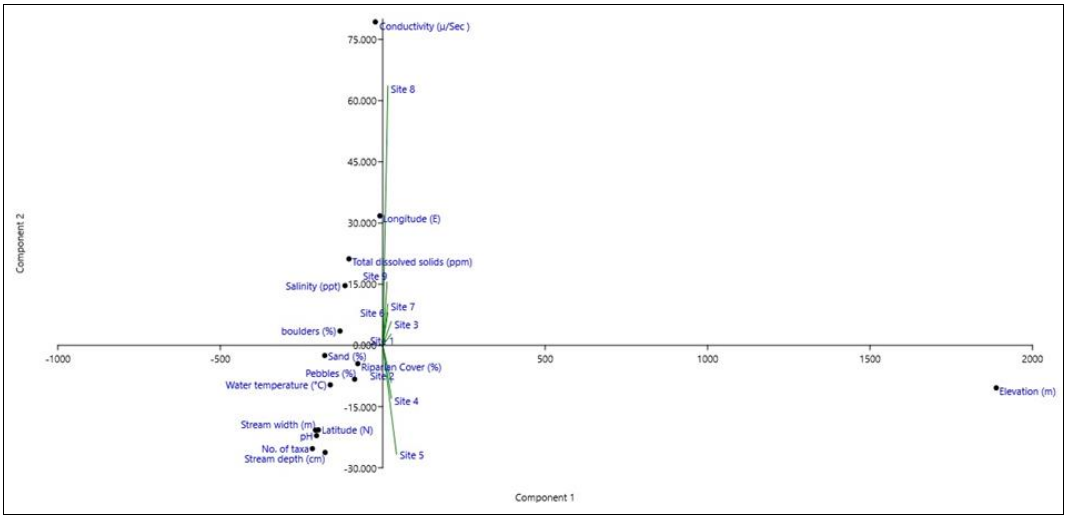

Fig 5: Principal component analysis between environmental variables and taxa richness of sampling sites.

Conclusion

Nine species were collected from sampling sites under three insect orders. Of which, ephemeropterans occupied the greatest percentage than other insect orders. The site 6 (Suruli falls) had the highest diversity of EPT members. Among the environmental variables, elevation is a significant variable for the distribution of EPT members rather than other environmental variables given by PCA. Hence, elevation is considered an important factor rather than longitude for the distribution of EPT members in sampling sites.

Conflict of interest

The author has no conflict of interest.

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