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# Feeding Patterns and Strategies of Ephemeroptera, Plecoptera and Trichoptera in Relation to Seasonality, Landscape Elements and Mesohabitats

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**Research Article**

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**Abstract**

We inspected functional feeding groups in relationship with seasonality, stream order, Land Scape Elements (LSE), and mesohabitat of Ephemeroptera, Plecoptera, and Trichoptera (EPT) based on gut content analysis and mouthparts in 27 streams of the Western Ghats and the Eastern Ghats. From the study, a total of 14,168 specimens were collected and identified. The composition of trophic categories showed a slight variation among the different seasons with the dominance of collectors. The results of the abundance of functional feeding groups of EPT across stream orders additionally showed the predominance of collectors and predators in-stream orders 1 and 2. Collectors and filter feeders dominate in-stream orders 3 and 4. By examining the LSE elements, it is found that collectors were higher in the streams flowing through areca nut and low in the streams flowing through natural vegetation. The distributions of functional feeding groups within the orders were also analyzed. Mesohabitat results showed scrapers were found to be predominant in riffles whereas collectors, predators, shredders, and filter feeders overwhelm in runs. ANOVA results showed that only mesohabitat was found to be significant. The results of the present study did not broadly concur with the predictions of the River Continuum Concept (RCC) because of the lack of thickly canopied headwater stream sites and the limitation of our study to only EPT taxa.

*Keywords*: Mesohabitat, EPT, land scape elements, macroinvertebrates, seasons

**Mevsimsellik, Peyzaj Elemanları ve Mezohabitatlara Göre Ephemeroptera, Plecoptera ve Trichoptera Beslenme Modelleri ve Stratejileri**

Batı Ghats ve Doğu Ghats'ın 27 deresindeki Fonksiyonel beslenme grupları, bağırsak içeriği analizine ve ağız kısımlarına dayanarak, mevsimsellik, akarsu düzeni, peyzaj elementleri (LSE)Ephemeroptera, Plecoptera ve Trichoptera mezohabitat (EPT) ile ilişkili olarak incelenmiştir. Çalışmadan toplam 14.168 örnek toplandı ve tanımlandı. Trofik kategorilerin bileşimi, toplayıcıların baskınlığı ile farklı mevsimler arasında hafif bir farklılık gösterdi. Akarsu düzenine göre EPT'nin fonksiyonel besleme gruplarının bolluğunun sonuçları, akarsu düzeni 1 ve 2'de toplayıcıların ve avcıların, 3 ve 4'de toplayıcılar ve filtre besleyicilerin baskın olduğunu gösterdi. LSE elementleri incelendiğinde, toplayıcıların areka cevizinden akan derelerde yüksek, doğal bitki örtüsü içinden akan akarsularda ise düşük olduğu görülmüştür. Fonksiyonel besleme gruplarının akarsu düzeni içindeki dağılımları da analiz edilmiştir. Mezohabitat sonuçları, kazıyıcıların çukurlardaki suda baskın olduğunu, toplayıcıların, yırtıcıların, öğütücülerin ve filtre besleyicilerin akan derelerde olduğunu gösterdi. ANOVA sonuçları, sadece mezohabitatın istatistiki açıdan anlamlı olduğunu gösterdi. Bu çalışmanın sonuçları, çalışmamızın sadece EPT taksonları ile sınırlı olması ve kalın bir şekilde örtülü su akışı alanlarının bulunmaması nedeniyle, Nehir Sürekliliği Konseptinin (RCC) tahminleriyle genel olarak uyuşmamaktadır.

*Anahtar Kelimeler:* Mesohabitat, EPT, peyzaj elemanları, makro omurgasızlar, mevsimler

## INTRODUCTION

The streams and other freshwater habitats mirror the physical and organic processes happening in the specific environment (Allan, 2004). Aquatic insects form assemblages that vary with their geographical location, according to historical biogeographical and ecological processes. Trophic categorization of aquatic insects is generally controlled by the species adaptation and taxonomical variations. The structure and functions of an aquatic habitat are maintained by the material cycling and energy flow. In turn, a significant position of such material cycling and energy flow involves the processing of various forms of organic matter by freshwater invertebrates, especially insects. The functional feeding group of aquatic insects can be classified into several functional feeding groups (FFGs) based on the trophic dynamics and mouthparts modification. Assessment of the mouthparts and adornment structures in the front legs is an initial phase in allocating an FFG. These are the parts utilized by the organisms to catch, control, and devour food resources (Merritt et al., 2008). Sharp and pointed teeth are attributes of predators and shredders. Mouthparts that look like plates or flat structures are a sign of a scraper. Collectors and filterers normally have an enormous number of hairs and setae or fan-like structures.

The aquatic production is directed by various intricate and dynamic biotic and abiotic factors, such as spatial and temporal variations in the overall productivities of environments (Chan et al., 2007) coupled by trophic trade (Wesner, 2010), predator-prey life history attributes (Baxter et al., 2005), highlights of the riparian ecotone, for example, limit penetrability (Cadenasso et al., 2003) and microhabitat multifaceted nature (Bates et al., 2007).

Aquatic insects are influenced by biotic and abiotic factors. Most examinations and calculated models relating to stream food networks have concentrated on the amount of every food web part and the development of vitality and materials from allochthonous and autochthonous food sources to benthic macroinvertebrates (Vannote et al., 1980). Benthic macroinvertebrates normally track the changes in the environment and they show dietary shift as a component of resource accessibility (Haapala et al., 2001). Hydromorphological changes are decided to be one of the most serious human-produced impacts influencing the uprightness of lotic ecosystems. The most well-known modifications are channel fixing and expulsion of riparian vegetation (Naiman and Décamps, 1997; Ward, 1998). A decrease of riparian vegetation can increment sunlight in the riparian zone and this leads to shifting of the changes in the functional feeding groups of the particular habitat. The effects of changes in land use and the expulsion of riparian vegetation on stream environments are well studied and understood (Allan and Castillo, 2007). Anthropogenic changes can bring about diminished diversity and distributions in aquatic insects and compel the appropriation of sensitive species.

Material cycles and energy flows of freshwater ecosystems are strongly influenced by the riparian zone, stream hydrology, and physicochemical parameters of water and substrate characteristics of streams. Ecological patterns and processes in aquatic ecosystems have been shown to vary at multiple spatial scales, between and within an aquatic habitat. Scrapers and collector-gatherers are abundant in the upper lotic habitat. Filter feeders are numerous in lower lotic habitats (Vilenica et al., 2018). Habitat and microhabitat distribution of trophic categories of insects of Western Ghats have been studied by Burton and Sivaramakrishnan (1993) and Subramanian and Sivaramakrishnan (2005).

This work intends to contemplate the trophic relationship of Ephemeroptera, Plecoptera, and Trichoptera in both the Western and the Eastern Ghats of Southern India. It also addresses the comparisons of trophic classifications with different seasons, landscape elements, and mesohabitats.

## MATERIALS and METHODS

### Study area

The study was carried out in 27 streams of the Western and the Eastern Ghats. The details of the study area were given in Table 1. Each site was selected after assessing the habitat heterogeneity, canopy cover, and riparian taxa.

### Sampling

All the streams in 27 sites are classified into four orders, three seasons, six landscape elements, and seven mesohabitats. The method of sampling was followed by kick net sampling (Burton and Sivaramakrishnan, 1993) and Surber sampling. The individuals were assigned to five functional feeding groups, namely predators, shredders, scrapers, collectors, and filter feeders (Merritt and Cummins, 1984) depending on their gut contents analysis and by the study of mouthparts morphology.

### Analysis of Data

An Analysis of Variance (One way–ANOVA) was performed by PAST software (Hammer et al., 2001).

### Classification of Stream orders

Twenty-seven sites were classified into 4 Stream orders. They are Stream order I, II, III, and IV. The stream orders were classified based on Strahler (1957).

**Table 1.** Characteristic features of sampling sites

| No | Sites | Abbreviation | Altitude (m) | Latitude and Longitude | Stream order |
|---|---|---|---|---|---|
| 1 | Kumbakkarai | Kumb | 400 | 10º18’ N 77º53’ E | Third |
| 2 | Sothuparai stream | Soth | 282 | 10º13’ N 77º46’ E | Fourth |
| 3 | Suruli | Suru | 450 | 09º65’N 77º30’ E | First |
| 4 | Kurangani falls | Kura | 650 | 11°04’N 77°50’ E | Second |
| 5 | Gadana Nathi | Gada | 360 | 08º48' N 77°19' E | Third |
| 6 | Iluppaiar | Ilup | 125 | 08º46' N 77°17' E | Second |
| 7 | Ramanadi | Rama | 310 | 08º47' N 77°23' E | Second |
| 8 | Chittar | Chit | 200 | 09°38' N 77°36' E | Third |
| 9 | Ayyanar falls | Ayya | 115 | 08º42' N 77°07' E | Second |
| 10 | Karuppar | Karu | 253 | 08º29' N 77º03’ E | First |
| 11 | Mundar | Mund | 155 | 08º30' N 77º07’ E | Third |
| 12 | Mothiramalai | Moyh | 139 | 08º18' N 77º29’ E | Second |
| 13 | Kumbar | Kumr | 211 | 08º29' N 77º01’ E | Second |
| 14 | Illanguruparai | Illa | 197 | 08º29' N 77º11’ E | Second |
| 15 | Kalikesam falls | Kali | 280 | 08º39' N 77º39’ E | Third |
| 16 | Kaippillai thodu-Kallar | Kaip | 48 | 08º71' N 77º12’ E | Third |
| 17 | Golden valley-Kallar | Gold | 176 | 08º72' N 77º12’ E | Second |
| 18 | Kallar | Kall | 165 | 08º70' N 77º10’ E | Third |
| 19 | Aranakuzhi – Kallar | Aran | 240 | 08º50’ N 77º35’ E | Second |
| 20 | Panivadi – Kallar | Pani | 300 | 08º33' N 77º19’ E | Second |
| 21 | Meenmutti | Meen | 610 | 08º71' N 77º14’ E | Third |
| 22 | Downstream- Kallar | Down | 155 | 08º42' N 77º14’ E | Fourth |
| 23 | Odamundurai odai-Karanthamalai | Odam | 470 | 10º30' N 78º17’ E | Second |
| 24 | Ayyan odai-Karanthamalai | Ayyn | 390 | 10º35 N 78º20’ E | First |
| 25 | Sirumalai | Siru | 550 | 10º24 N 77º95' E | Third |
| 26 | Bison vally- Alagar malai | Biso | 425 | 10º30' N 78º20’ E | First |
| 27 | Periaaruvi- Alagar malai | Peri | 500 | 10º50' N 78º30’ E | Second |

**Classification of Landscape Types**

Twenty-seven sites were classified into 6 Land Scape Element (LSE) types. They are Evergreen (EVG), Semi-evergreen (SEVG), Forestry plantation (FORP), Areca nut (ARE), Scrub (SCRUB), and Dry deciduous forest (DRY). The landscapes were classified according to Nagendra and Gadgil (1998) and Ghate et al. (1998).

**Seasonality classification**

All the samples collected during February to May, June to September, October to January are grouped as summer, south-west monsoon, and north-east monsoon collections respectively.

**Mesohabitat Descriptions**

Based on flow speed, depth, and substrate mesohabitat has been evolved by Vadas and Orth (1998), which were then characterized to EPT insects according to habitat associations in temperate streams (Ferro and Sites, 2007). Seven meso habitats were identified in the study and they were riffle, run, leaf pack, pool, no flowing, bank, and silt/mud.

## RESULTS and DISCUSSION

From the study, a total of 14,168 specimens were collected and identified. In the present investigation, twenty seven species of Ephemeroptera belonging to six families, two species of Plecoptera belonging to one family, and 20 genera of Trichoptera belonging to 12 families were identified. Plenitude of Plecoptera was limited only to two species; this may be due to the that the stoneflies ordinarily endure only in the cool headwaters as they are cold-water specialists and also due to the absence of rocky substrates in the 27 streams.

To characterize the functional feeding groups of EPT in different seasons, streams flowing through various stream orders, LSE types, and mesohabitats were examined utilizing the proportional abundance and log abundance in this study. The functional feeding groups of EPT taxa in 27 streams of the Western and the Eastern Ghats showed in Table 2. The composition of trophic categories indicates slight changes across various seasons (Figure 1). Different species of EPT insects present in six LSE types of the Western and the Eastern Ghats were presented in table 3. The proportional abundance of collectors is high in the stream moving through areca nut (ARE) and low in streams flowing through natural vegetation (Forested area). The scrapers were higher in streams flowing through the semi-evergreen area (57.9 %). The predators were at a high rate (17 %) and shredders were at a low rate (8.4 %) in streams coursing through scrub forests. The shredders were in high percentage in streams flowing through evergreen and semi-evergreen forests. The filter feeders were in high percentage in streams flowing through the dry deciduous forest (23.5 %). Only the influence of mesohabitats between groups and within groups was found to be significant based on ANOVA results. Statistically, P-value for functional feeding groups of EPT is significant (P= 0.0004) between and within the mesohabitats (Table 4). On all stream orders (Figure 2) collectors were more dominant when compared to other groups and shredders were of low rate (Table 5). Moreover, the distribution of functional feeding groups within the orders shows that Ephemeroptera generally prevailed by collectors followed by scrapers whereas in the order Plecoptera, they were predator transcendent because they were mostly predaceous, so it accounts for only one type of functional feeding group. Trichoptera, which were enriched with all the five functional feeding groups, in which the filter feeder was dominant among them and scrapers were least present feeding group (Figure 5).

However, in the present study, level of shredders was low (6 to 10 %) and this might be because of the low degrees of leaf litter in the streams. Stout (1989) recommended that shredders are hindered in tropical stations by the higher extent of poisonous dense tannins in the leaves of the tropical plants. Abdul and Che Salmah (2019) reported that the abundance of predators increments step by step in streams with a high measure of prey. Predators like stoneflies and some trichopterans can survive in cool headwaters. This might be ascribed to the slow decrease in predators in our study. The results of the present study agree with the results of other studies that have suggested that predictions of the River Continuum Concept do not apply strictly to streams from the tropics (Winterbourn et al., 1981).

The present study shows that the diversity and community structure of EPT insects change with riparian land-use patterns (Table 6). Taxa such as *Hydropsyche* sp., *Macronema* sp., *Tenuibaetis frequentus, Baetis ordinatus, Labiobaetis germinatus, Centroptella similis, Isca purpurea, Choroterpes alagarensis, Choroterpes nambiyarensis, Choroterpes nandini, Choroterpes petersi, Neoperla* sp were tolerant to disturbance inhabit streams flowing through human-influenced riparian land-use types.

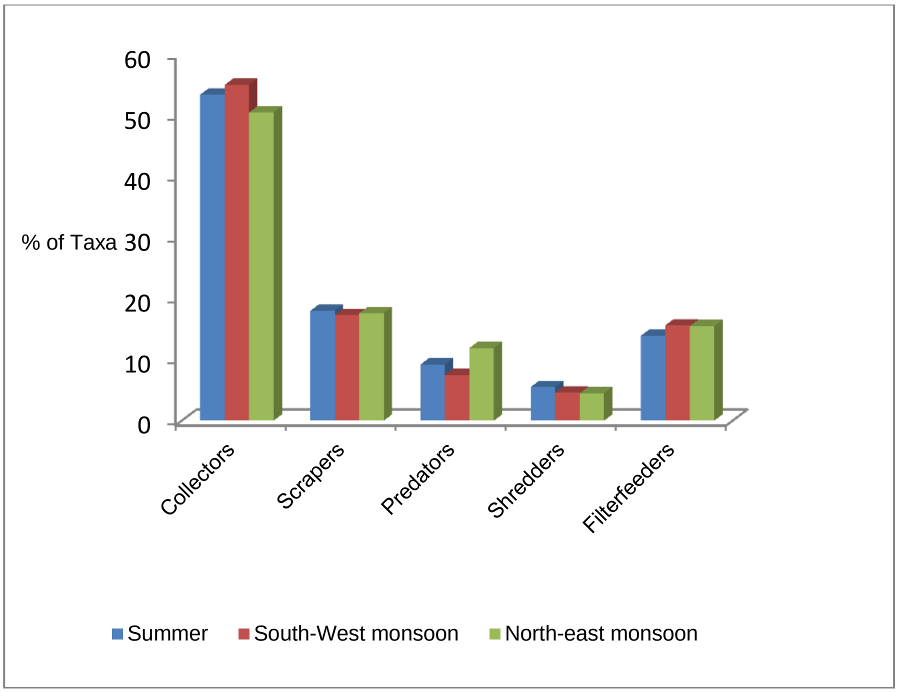


**Figure 1.** Percentage of Trophic categories in three seasons

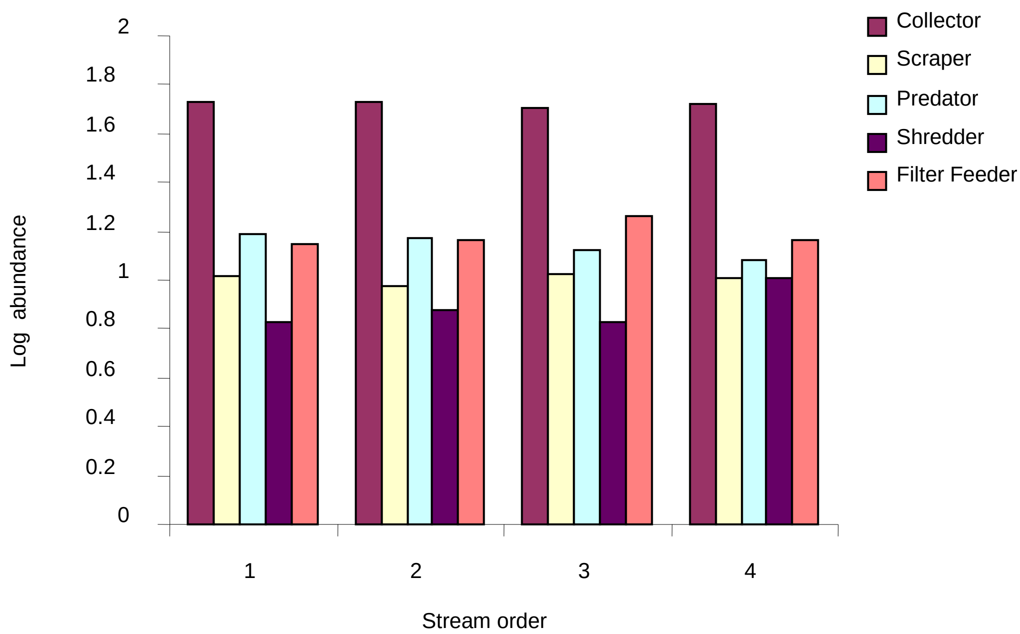


**Figure 2.** Log abundance of functional feeding groups of EPT across stream orders

**Table 2**. Trophic categorization of macroinvertebrates in 27 streams of Western and Eastern Ghats

| Order | Family | Genus and species | FFG assignment |
|---|---|---|---|
| **Ephemeroptera** | Baetidae | *Baetis conservatus* | Collectors |
| | | *Labiobaetis geminatus* | Collectors |
| | | *Centroptella similis* | Collectors |
| | | *Acentrella vera* | Collectors |
| | | *Tenuibaetis frequentus* | Collectors |
| | Caenidae | *Caenis* sp. | Collectors |
| | Leptophlebiidae | *Nathanella indica* | Collectors |
| | | *Notophlebia jobi* | Collectors |
| | | *Petersula courtallensis* | Scrapers |
| | | *Edmundsula lotica* | Scrapers |
| | | *Indialis badia* | Scrapers |
| | | *Isca purpurea* | Scrapers |
| | | *Thraulus* sp. | Scrapers |
| | | *Choroterpes alagarensis* | Scrapers |
| | | *Choroterpes nambiyarensis* | Scrapers |
| | | *Choroterpes nandini* | Scrapers |
| | | *Choroterpes petersi* | Scrapers |
| | Teloganodidae | *Teloganodes insignis* | Collectors |
| | | *Teloganodes dentata* | Collectors |
| | | *Teloganodes kodai* | Collectors |
| | | *Teloganodes sartorii* | Collectors |
| | | *Teloganodes sp.* | Collectors |
| | | *Indoganodes jobini* | Collectors |
| | Ephemeridae | *Ephemera nadinae* | Collectors |
| | Heptageniidae | *Epeorus petersi* | Scrapers |
| | | *Afronurus kumbakkaraiensis* | Scrapers |
| | | *Thalerosphyrus flowersi* | Scrapers |
| **Plecoptera** | Perlidae | *Neoperla biseriata* | Predators |
| | | *Neoperla nitida* | Predators |
| **Trichoptera** | Hydropsychidae | *Hydropsyche* sp. | Filter feeders |
| | | *Cheumatopsyche* sp. | Filter feeders |
| | | *Wormaldia* sp. | Collectors |
| | | *Leptocerus* sp. | Shredders |
| | | *Diplectrona* sp. | Filter feeders |
| | | *Potamyia* sp. | Filter feeders |
| | | *Macrostemum* sp. | Filter feeders |
| | | *Polymorphanisus* sp. | Filter feeders |
| | Helicopsychidae | *Helicopsyche* sp. | Scrapers |
| | Stenopsychidae | *Stenopsyche kodaikanalensis* | Filter feeders |
| | Polycentropodidae | *Rhyacophila* sp. | Predators |
| | | *Polycentropus* sp. | Predators |
| | | *Adicella* sp. | Collectors |
| | Dipseudopsidae | *Oecetis* sp. | Predators |
| | Ecnomidae | *Ecnomus* sp. | Predators |
| | Lepidostomatidae | *Goerodes* sp. | Shredders |
| | | *Lepidostoma* sp. | Shredders |
| | | *Setodes* sp. | Shredders |
| | Calamoceratidae | *Anisocentropus* sp. | Shredders |
| | Sericostomatidae | *Gumaga* sp. | Shredders |

**Table 3**. Distribution of EPT insects across landscape elements in 27 streams of Western and Eastern Ghats

| ORDER | FAMILY | SPECIES | EVG | S-EVG | SCRUB | ARE | FORP | DRY |
|---|---|---|---|---|---|---|---|---|
| EPHEMEROPTERA | Baetidae | *Baetis conservatus* | + | + | + | + | + | + |
| | | *Labiobaetis geminatus* | + | + | + | + | + | + |
| | | *Centroptella similis* | + | + | + | + | + | + |
| | | *Acentrella vera* | + | + | - | - | + | + |
| | | *Tenuibaetis frequentus* | + | + | + | + | + | + |
| | Heptageniidae | *Afronurus kumbakkaraiensis* | + | + | + | + | + | + |
| | | *Epeorus petersi* | - | + | - | + | + | - |
| | | *Thalerosphyrus flowersi* | + | + | + | + | - | - |
| | Leptophlebiidae | *Petersula courtallensis* | + | + | + | + | + | + |
| | | *Edmundsula lotica* | + | + | + | + | + | - |
| | | *Indialis badia* | + | + | - | + | + | - |
| | | *Isca purpurea* | + | + | + | + | + | - |
| | | *Nathanella indica* | + | + | - | + | + | - |
| | | *Notophlebia jobi* | + | + | - | + | + | + |
| | | *Choroterpes alagarensis* | + | + | + | + | + | + |
| | | *Choroterpes nambiyarensis* | + | + | + | + | + | + |
| | | *Choroterpes nandini* | + | + | - | + | + | - |
| | | *Choroterpes petersi* | + | + | - | + | + | - |
| | | *Thraulus* sp. | + | + | - | + | - | - |
| | Teloganodidae | *Teloganodes dentata* | + | + | + | + | + | + |
| | | *Teloganodes insignis* | - | - | - | + | - | - |
| | | *Teloganodes kodai* | + | + | + | + | + | + |
| | | *Teloganodes sartorii* | + | + | + | + | + | + |
| | | *Teloganodes indica* | + | + | + | + | + | + |
| | | *Indoganodes jobini* | + | + | - | + | + | - |
| | Ephemeridae | *Ephemera nadinae* | + | + | - | + | - | - |
| | Caenidae | *Caenis* sp. | + | + | + | + | + | + |
| PLECOPTEA | Perlidae | *Neoperla biseriata* | + | + | + | + | + | + |
| | | *Neoperla nitida* | - | - | - | - | + | - |
| TRICHOPTERA | Hydropsychidae | *Hydropsyche sp.* | + | + | + | + | + | + |
| | | *Cheumatopsyche* sp. | + | + | - | + | + | + |
| | | *Wormaldia* sp. | + | + | + | + | + | - |
| | | *Leptocerus* sp. | - | - | - | - | - | + |
| | | *Diplectrona* sp. | + | + | - | + | + | + |
| | | *Potamyia* sp. | + | + | - | + | + | + |
| | | *Macrostemum* sp. | + | - | - | - | - | + |
| | | *Polymorphanisus* sp. | + | + | - | + | + | + |
| | Helicopsychidae | *Helicopsyche* sp. | + | + | + | + | + | + |
| | Stenopsychidae | *Stenopsyche kodaikanalensis* | + | + | + | + | + | + |
| | Polycentropodidae | *Rhyacophila* sp. | + | + | + | + | + | + |
| | | *Polycentropus* sp. | + | + | - | + | - | + |
| | | *Adicella* sp. | + | + | + | + | + | + |
| | Dipseudopsidae | *Oecetis* sp. | + | + | + | + | + | + |
| | Ecnomidae | *Ecnomus* sp. | + | + | + | + | + | + |
| | Lepidostomatidae | *Goerodes* sp. | + | + | - | + | + | + |
| | | *Lepidostoma* sp. | - | + | - | - | - | + |
| | | *Setodes* sp. | + | + | - | + | + | - |
| | Calamoceratidae | *Anisocentropus* sp. | + | + | - | + | + | - |
| | Sericostomatidae | *Gumaga* sp. | + | + | - | + | + | + |

**Table 4.** Summary of nested analysis of variance test to examine the influence of stream orders, LSE, mesohabitats and seasons on total functional feeding groups

| Source of variation | | Df | SS | Mean Square | F | P-value | F crit |
|---|---|---|---|---|---|---|---|
| Stream orders | Between groups | 3 | 1.015 | 0.33 | 0.0237 | 0.994 (ns) | 3.490 |
| | Within Groups | 12 | 171.04 | 14.25 | | | |
| LSE | Between Groups | 5 | 0 | 0 | 0 | 1 (ns) | 2.620 |
| | Within Groups | 24 | 7952.12 | 331.33 | | | |
| Mesohabitats | Between Groups | 6 | 9718.61 | 1619.76 | 5.8635 | 0.0004* | 2.445 |
| | Within Groups | 28 | 7734.77 | 276.24 | | | |
| Seasons | Between Groups | 2 | 9.09E-13 | 4.54 E-13 | 1.24E-15 | 1 (ns) | 3.885 |
| | Within Groups | 12 | 4390.84 | 365.903 | | | |

* Significant (ns) Not significant

The taxa with high sensitivity to human disturbance such as *Helicopsyche sp.*, *Lepidostoma* sp. and *Anisocentropus* sp. are present in the streams with the natural riparian semievergreen and evergreen forests.

Prior investigations in Western Ghats streams reported fauna such as freshwater fishes and amphibians did not address how the riparian land use influences the diversity and community structure (Bhatta, 1997; Arunachalam, 2000). On the other hand, the present study and past investigation by Subramanian and Sivaramakrishnan (2005) show that the distribution and abundance of aquatic insect families and genera are extensively influenced by riparian land use.

Change in functional groups mirrors that human influence in the riparian zone alters the stream insect community structure and could be related to a change in the nature of the nutrient input into the streams. This change in functional groups of stream insects could fundamentally alter the stream ecosystem function. This, in turn, could directly affect the diversity and distribution of other fauna such as fishes that depend upon stream insects for their survival.

This examination likewise shows that the riparian land use-based approach to study the stream fauna could provide valuable insights into aspects of stream ecosystem function.

**Table 5.** Proportional abundance of functional feeding groups of EPT across stream orders

| Feeding groups | Stream orders | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| Collector | 53.5 | 53.3 | 50.8 | 52.9 |
| Scraper | 10.3 | 9.5 | 10.6 | 10.1 |
| Predator | 15.4 | 14.8 | 13.3 | 12.1 |
| Shredder | 6.7 | 7.6 | 6.7 | 10.1 |
| Filter feeder | 14 | 14.6 | 18.3 | 14.7 |

**Table 6.** Proportional abundance of functional feeding groups of EPT across LSE

| Feeding groups | LSE types | | | | | |
|---|---|---|---|---|---|---|
| | **EVG** | **SEVG** | **SCRUB** | **ARE** | **FORP** | **DRY** |
| Collector | 52.4 | 52.4 | 46.7 | 57.9 | 51.3 | 47.1 |
| Scraper | 10.9 | 11.9 | 4.4 | 10.1 | 8.4 | 7.8 |
| Predator | 12.6 | 13.9 | 17 | 12.3 | 16.3 | 16.4 |
| Shredder | 12.6 | 9.2 | 8.4 | 8.2 | 5.9 | 5.2 |
| Filter feeder | 15.7 | 13.6 | 19.3 | 10.5 | 18.1 | 23.5 |

**Table 7.** Proportional abundance of functional feeding groups of EPT across mesohabitats

| Feeding groups | Mesohabitats | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Riffle** | **Run** | **Leafpack** | **Pool** | **No flowing** | **Bank** | **Silt/Mud** |
| Collector | 7.3 | 12.5 | 0 | 0 | 2.3 | 4.1 | 0.4 |
| Scraper | 22.6 | 2 | 2 | 0 | 0 | 7.2 | 0 |
| Predator | 2 | 7.7 | 3 | 0.9 | 0 | 0 | 0 |
| Shredder | 0 | 6.5 | 0.7 | 0 | 1.95 | 0 | 0 |
| Filter feeder | 1 | 6.7 | 0 | 0 | 0.2 | 0 | 0 |

The proportional abundance of collectors (Table 6, Figure 3) is high in the stream flowing through areca nut and low in streams flowing through natural vegetation (forested area). The scrapers were higher in streams flowing through semi-evergreen areas (57.9 %). The predators were in a high percentage (17 %) and shredders were at a low percentage (8.4 %) in streams flowing through scrub forests. The shredders were in high percentage in streams flowing through evergreen and semi-evergreen forests. The filter feeders were higher in streams flowing through the dry deciduous forest (23.5 %).

The proportional log abundance of functional feeding groups in the streams flowing through different mesohabitats provides interesting results. (Table 7). Statistically, the P-value for functional feeding groups of EPT is significant (P = 0.0004) between and within the mesohabitats (Table 4).

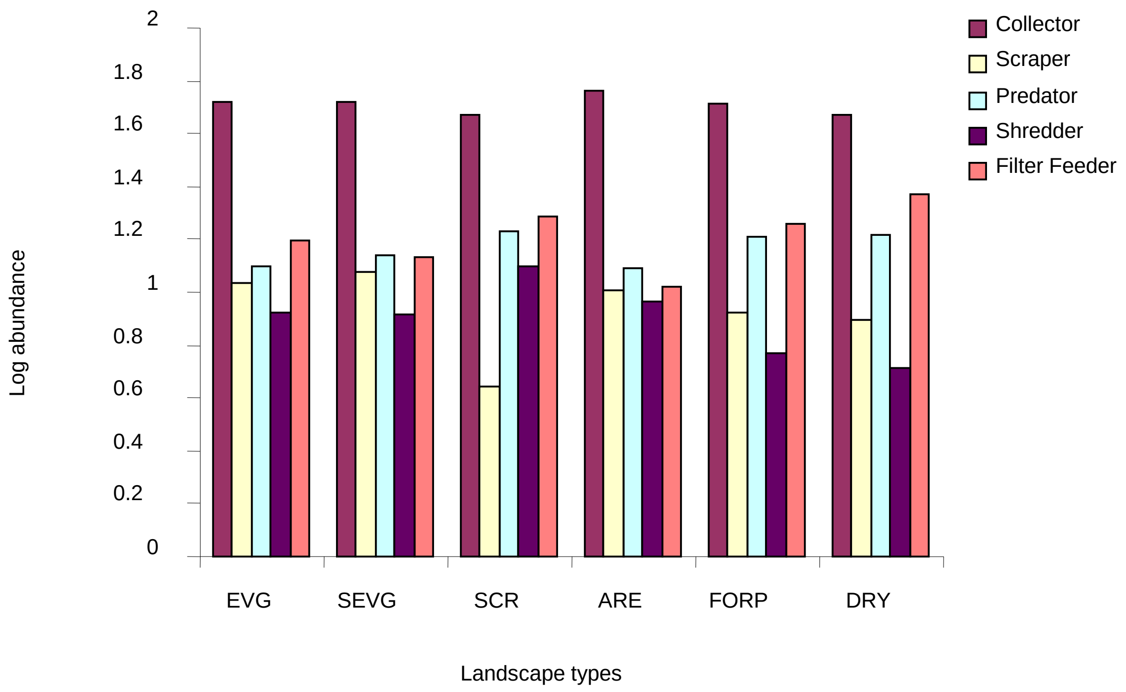


**Figure 3.** Log abundance of EPT across streams flowing through LSE types

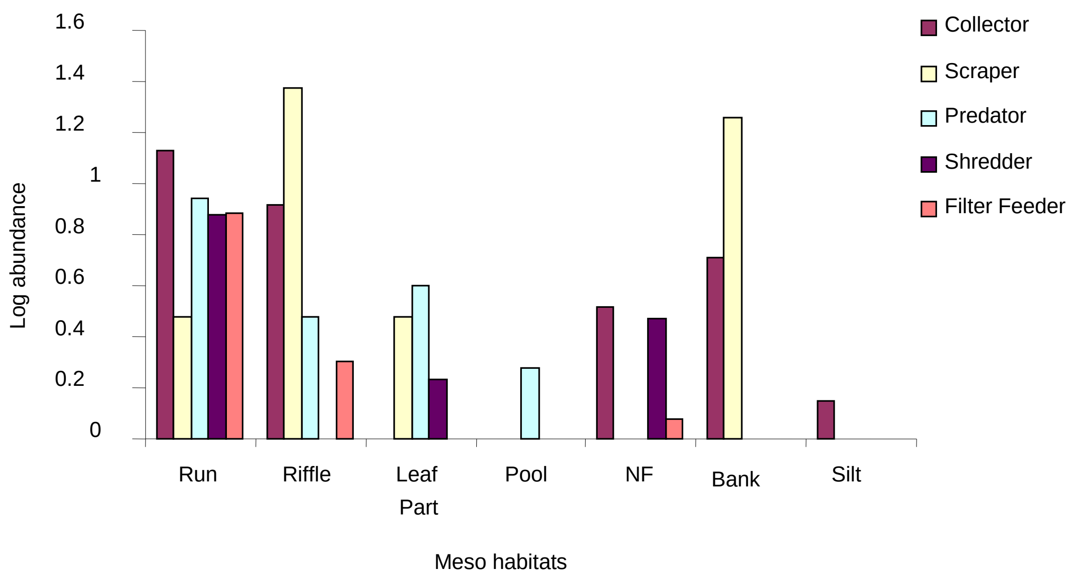


**Figure 4.** Log abundance of trophic categories of EPT across mesohabitats

The scrapers dominate in riffles whereas collectors, predators, shredders, and filter feeders dominate in runs. The richness of EPT was the highest in the riffles and the lowest in the pool with no flow (Ferro and Sites, 2007). Substrate type may influence species distribution; however, velocity and complex hydraulic characters also may be important (Sites and Willing, 1991). The high velocity and turbulence of a riffle increases aeration and provides an area where filterers can exploit the current and gather food with minimum energy expenditure (Merritt and Cummins, 1996). Additionally, the shallow water in riffles and runs increase the diversity of microhabitats of the bank and leaf pack which helps to protect EPT from predator fishes (Schlosser, 1987). Recent literature suggests that shredders are scarce in tropical streams (Dobson et al., 2003). Most of the common shredder taxa from temperate systems are lacking in the tropics. It has been suggested that shredding may be less important in tropical streams because there is an alternative decomposition pathway for leaves such as faster microbial processing due to higher temperatures (Irons et al., 1994) and because of the higher concentration of toxic compounds in leaves (Wantzen et al., 2002).

The collectors and scrapers decrease in abundance from the cascades to pools. Genus such as *Helicopsyche*, *Neoperla*, *Epeorus*, *Baetis*, and *Notophlebia* represents collectors and scrapers in the riffle and runs.

The River Continuum Concept (RCC) predicts that fine particulate organic matter (FPOM) in forested headwater streams is largely the result of upstream processing of leaf litter by shredders but such processing is likely to be carried out to a lesser extent by a few taxa of shredding insects besides macro crustaceans (prawns and crabs) and gastropods and mainly by Hyphomycetes fungi (personal observation) in investigated headwater streams of the Western and the Eastern Ghats.

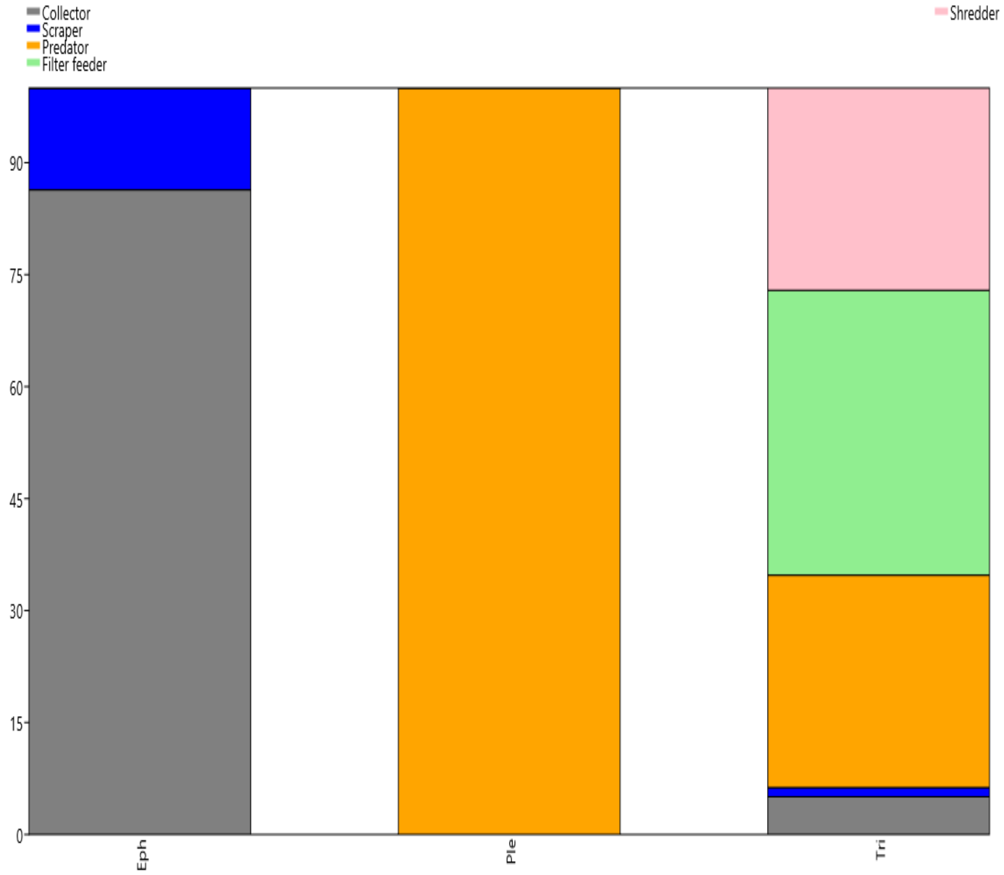


**Figure 5.** Percentage of functional feeding groups within the EPT orders (Eph- Ephemeroptera, Ple- Plecoptera, Tri- Trichoptera)

The result of the present study in the Western Ghats and the Eastern Ghats did not broadly agree with the predictions of RCC with regard to the dominance of insect shredders in headwater streams. Lack of thickly canopied headwater stream sites and restriction of our study to only EPT taxa are the probable reasons for the dominance of collectors and scrapers in investigated headwater sites, many of them with an autochthonous food source, and flowing through riffles and runs with meagre leaf litter retention.

On the whole, this work gives a lot of valuable information regarding the relationship of trophical categorization with seasonality, LSE types, and microhabitats. Compare to the Western Ghats, the

Eastern Ghats of Southern India have been less exposed in the light of taxonomy. So this work gives more information about the taxa of both the Western and the Eastern Ghats of Southern India.

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