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Original Article

Decomposition of three leaf litter species and associated aquatic insects in Kurangani stream of Western Ghats, South India

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Abstract

The structure and function of a freshwater ecosystem relied on the material cycling and energy flow. In turn, a significant portion of such cycling and flow involved the processing of various forms of organic matter by freshwater invertebrates, especially insects. This constituted interest in trophic relation of aquatic insects. The present study assessed that the influence of aquatic insects on decomposition of three leaf litter species in Kurangani stream, Theni district, Tamilnadu. The physico-chemical parameters and aquatic insects involved in leaf litter decomposition were sampled at two post monsoon periods such as South west post monsoon (August-October) and North east post monsoon (January-February) during 2011-2012. The average water temperature and pH were 21.8°C and 7.16 respectively. A total of 15 genera, 13 families and 5 orders of aquatic insects were collected during experimental period. Abundance of fresh water entomofauna associated with Bischofia javanica litter bags after 14 days was high (132 individuals/litter bags) in January 2012. Whereas abundance of aquatic insects associated with Clerodendron arboreum litter bags after 14 days was low (8 to 25 individuals/litter bags) in all studied month. Decomposition of Bischofia javanica and Pongamia pinnata was faster than Clerodendron arboreum and other combinations in August, January and February.

Keywords: - Aquatic insects, Leaf litter decomposition, Abundance, Southern Western Ghats.

1. Introduction

Tropical forests often are referred to as one of the most species diverse terrestrial ecosystems. Their immense biodiversity generates a variety of natural resources which sustain the livelihood of local communities. Leaves and wood from terrestrial vegetation that enter streams are significant sources of energy for stream communities and can provide important foods and habitat resources for macroinvertebrates. Forested streams depend on inputs of leaf litter as the primary source of energy for their detritus-based food webs (Webster and Benfield, 1986; Wallace et al., 1997). As leaf litter directly or indirectly falls into streams, it is colonized and decomposed by microbes and consumed by macroinvertebrate shredders. Leaf breakdown includes at least three distinct phases after entering a stream: leaching, conditioning and fragmentation (Petersen and Cummins, 1974). In the second of these stages, leaves undergo conditioning, which involves the colonization of leaf surfaces by micro-organisms (bacteria and fungi) that begin the decomposition process and increase the palatability of leaves to detritivorous macroinvertebrates. However, bacteria, fungi and macroinvertebrates are playing vital role in litter breakdown. These processes lead to the production of fine particulate organic matter (FPOM), which is consumed by macroinvertebrate collectors. The shredders and collectors are thus the major primary consumers, providing the main link between the organic inputs and predators in stream ecosystems.

The abundant literature on leaf litter breakdown in temperate streams contrasts with the scarce information available from tropical rivers (Anbalagan et al., 2012). Studies in low order tropical streams generally reported that rapid breakdown of leaf litter compared to temperate rivers. However, little is known about the absolute and relative importance of different decomposer types in the tropics (Dudgeon, 1982). Information on leaf litter dynamics in streams would be of practical importance towards our
comprehension of energetics of the tropical streams. So the present investigation consists of following objectives (i) To study the physico-chemical characteristics of Kurangani stream. (ii) To gain insights into the relative importance of macroinvertebrate decomposers (iii) To examine the assemblages of aquatic insects that colonized the leaf litter of three tree species during its breakdown.

2. Description of study area

Kurangani (77°.50’E longitudes and 11°.00’N latitudes), the study area is situated 116 kilometers from west of Madurai. It lies on the North eastern side of Cardamom hills at an altitude of 650 above Mean Sea Level (M.S.L.). This area is exposed to the vicissitudes of southwest monsoon, northeast monsoon and summer. The ecological and leaf litter decomposition studies were carried out during two post monsoon periods such as South west post monsoon (August-October) and North east post monsoon (January-February) during 2011-2012. The basic habit consists of series rocky ledges overlain with large boulders and rubbles. The substratum is rubble and gravel integrated with coarse sand in quieter water in the edges.

2.1. Riparian vegetation

Along the banks of the stream are thick stands of trees, shrubs, whose leaves are the stream’s principal source of organic detritus. Among the taller plants Bischofia javanica, Pongamia pinnata, Clerodendrum arboreum, Terminalia arjuna, Bombax sp, Mangifera indica and Lantana camera dominate the stream banks. Because of the leaf canopy cover, the stream formed by branched and leaning trees, there is a feeble exposure to direct sunlight even in midday. Most of the tree species lose leaves throughout the year, with increase in leaf litter fall in spring resulting from nutrient translocation of the vegetation.

3. Materials and methods

Physico-chemical parameters were measured based on the procedures suggested in APHA (1995). Water temperature and Air temperature were recorded by thermometer in the field. Water current of the stream was determined by cork floatation method. Stream depth and stream width were measured with the help of metal tap. Total solid, Total dissolved solid and Total suspended solid of stream water sample were also determined. pH was measured by using pH meter. Dissolved oxygen was estimated by using Micro. The aquatic insect samples were preserved in 80% Ethyl alcohol and stored in labeled vials. Collected samples were brought to laboratory and identified under stereobinocular microscope using standard taxonomic literature. Samples were assigned to family and genus using keys for that particular group. Following keys were used for identification; Ephemeroptera (Dudgeon, 1999); Odonata, Plecoptera, Hemitera, Megaloptera, Coleoptera, Diptera and Lepidoptera (Fraser, 1933-36; Morse et al., 1994); Trichoptera (Wiggins, 1975).

3.3. Assigning guilds

All the genera encountered during the study were assigned a habit and functional feeding group category based on the works of Merrit and Cummins (1996). The habit of a given taxon was determined the propensity and frequency of movement within the habitat. Based on mode of food acquisition and the nature of the food source, a taxon is assigned to a functional feeding group. Functional feeding groups and habits for each genus were combined and this was called the guild of the genera. The functional grouping reflects both convergent and parallel evolution leading to functionally similar organisms.
3.4. Data analysis
Observations of physical and chemical characters were recorded on each sampling date. The density, species richness were summarized as mean values.

4. Results and Discussion

4.1. Physico-chemical characteristics
The variation in physico-chemical parameters were analyzed from Kurangani stream, Western Ghats during August to October, 2011 and January to February, 2012 (Table 1 and Table 2). The third order Kurangani stream is clear and odourless. The sampling site had substrate index 6.15 which consists of 20% bed rocky, 25% boulders, 25% cobbles, 15% gravels, 10% sand integrated with 5% silts. Dinakaran and Anbalagan (2010) observed the average substrate index was 5.6, being lowest at Kallidai river (2.8) and highest at Palaruvi (7.6) from Southern Western Ghats. The stream averaged 5.3m wide. Maximum depth was 27 cm noted in January month and which drops 21 cm in August. The average water temperature was 21.8°C and Air temperature goes up to 25°C. The lowest water temperature (20°C) observed during month of January. Balasubramanian et al., (1992) reported that Air temperature and Water temperature showed large fluctuation because of different seasons in Kurangani stream of Cardamom hills. The average pH was 7.16. The dissolved oxygen of Kurangani stream ranged 6.5 to 8.3 (Table 2). While studying in tributaries of Kaveri (Mayflies) and Trichoptera (Caddisflies) were predominant, in all sampling litter bags, followed by Coleoptera and Diptera. Stoneflies and Mayflies contribute maximum viz., nearly half of total population while remaining orders have recorded with very few individuals. At family level, Perlidae, Hydropsychidae had contributed significantly to total shredder abundance. Perlidae also contributes maximum number of individuals followed by Leptophlebiidae and Baetidae. Genus Neoperla biseriata, Notophlebia jobi, and Caenis sp. were found to be high density followed by Baetis sp, Hydropsyche sp, Tipula, and Simulium sp. The taxa Neoperla biseriata and Caenis sp. were collected throughout the experimental period. In temperate streams, the most typical shredder taxa are gammarid amphipods, nemourid plecopterans, limnephilid and lepidostomatid trichopterans, and some tipulid dipterans (Graca, 2001). Their relative abundances were reported to range from 5% to 62% of the total macroinvertebrate abundance (Goncalves et al., 2006). In tropical streams, the most typical shredder taxa are replaced by crabs, shrimp, nemourid plecopterans, and leptocerid and calamocerid trichopterans (Pearson et al., 1989, Covish et al., 2003, Wantzen and Wagner, 2006) and they account for 0.2%-32.4% of the total macroinvertebrate assemblages (Dudgeon and Wu, 1999; Mathuria and Chauvet, 2002; Cheshire et al., 2005). Shredders were dominated by nemourid plecopterans with a few calamoceratid, lepidostomatid, and leptocerid trichopterans.

The subtropical stream thus exhibited similarities to both temperate and tropical streams. Shredders were mainly represented by nemourid plecopterans. Decomposition of three leaf litter studies in Kurangani stream, Tamilnadu showed little contrast in shredder dominance by perlid plecopterans and hydropsychid trichopterans. This is in consent with the suggestion of Kobayashi and Kagaya (2005) that shredders in fast-
flowing riffles were dominated by small-sized stoneflies. The dominant shredder taxa were similar to those in the riffle sections reported from boreal (Haapala et al., 2001), temperate (Short et al., 1980), and tropical (Dudgeon, 1982) regions, but differed from those from Neotropical (Mathurian and Chauvet, 2002; Wantzen and Wagner, 2006) and tropical Australian (Pearson et al., 1989) regions. In Neotropical and tropical Australian regions, shredders are dominated by large-sized caddisfly larvae, such as calamocerids and leptocerids, although those studies were conducted in riffle sections. Abundance of aquatic insects associated with Bischofia javanica litter bags after 14 days was high (132 individuals/litter bags) in January 2012. Whereas abundance of aquatic insects
Figure 1. Abundance of aquatic insects associated with different litter bags after 14 days at Kurangani during experimental period 2011-2012

Figure 2. Abundance of aquatic insects associated with different litter bags after 28 days at Kurangani during experimental period 2011-2012

associated with Clerodendron arboreum litter bags after 14 days was low (8 to 25 individuals/litter bags) in all studied months (Figure 1). The aquatic insects assemblage with Pongamia pinnata litter bags after 28 days was maximum (165 individuals/litter bags) in August 2011 (Figure 2). According to the shredder response model of Cummins et al., (1989), the 50% breakdown point should be when leaves are most palatable to shredders and, therefore, should be the period of maximum shredder...
colonization. This model applied to Schefflera octophylla and Ficus erecta for which shredder abundances reached maximum on day 23 and for Machilus thunbergii on day 58. But results of present study showed gradual increase in shredder abundance on 28th days of investigation. Breakdown rates of leaf litter in streams are influenced by the density and species richness of shredders (Short et al., 1980).

Collector-gatherer-scrappers dominated by Notophlebia jobi, Caenis sp, Baetis sp and Hydropsyche sp (Table 3). Wantzen and Wagner (2006) suggested that the number of macroinvertebrate collectors which possess generalized and opportunistic feeding strategies will increase in tropical streams containing leaves of tropical tree species which are recalcitrant and being disturbed by frequent spates which interfere with biotic leaf degradation. The collectors, which feed on Fine particulate organic matter (FPOM) did not directly participate in the rapid breakdown of the leaves and probably used the litter bags primarily as a habitat. The invertebrate richness, evenness and diversity were varied by harvest date on different types of leaves.

Anbalagan et al., (2012) examined the effect of two dominant leaf litter species of Pongamia pinnata and Syzygium cumini on the colonization of macroinvertebrate community in a tropical stream of south India. The rate of colonization of macroinvertebrates was higher in S. cumini than P. pinnata. Assemblages were composed of collector-filterers (38.3%), and to a lesser extent predators (36.5%) and collector-gatherers (23.4%). Of the 12 environmental variables, water temperature, pH and stream substrates were the significant predictors of macroinvertebrates assemblage colonization. The present study showed that decomposition of Bischofia javanica and Pongamia pinnata was faster than Clerodendrum arboreum and other combinations in August, January and February (Table 4). Pearson and Tobin (1989) suggested that the decomposition rates of leaf litters in streams reflect differences in the initial nutrient contents of the leaves as well as changes in nutrient levels associated with the decomposition process. Leaf litter of Schefflera octophylla and Ficus erecta contained high N concentrations, exhibited rapid breakdown, and supported higher colonization by shredders. The colonization of litter bags by shredders suggested that they have a preference for F. erecta over Machilus thunbergii. This preference is probably related to differences in leaf quality. The result indicated that leaves of F. erecta were probably more palatable to shredders than are those of M. thunbergii. Probably the leaves of Bischofia javanica might be more palatable to shredders and collectors when compared to Pongamia pinnata, Clerodendrum arboreum and other combinations.

5. Conclusion
The present study attempted that the influence of aquatic insects on decomposition of individual and combination of three freshly fallen leaves such as Bischofia javanica, Pongamia pinnata, Clerodendrum arboreum in Kurangani stream, Theni district, Tamilnadu. Leaf breakdown and associated aquatic insects differed among the leaves. The results revealed that decomposition of Bischofia javanica and Pongamia pinnata was faster than Clerodendrum arboreum and other combinations. In addition to aquatic insects, analysis of chemical composition of selected three leaves, colonized microbial decomposers would be useful to concisely understand of process of organic matter in stream ecosystem.

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7. References

Conflict of interest: None declared