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Macroinvertebrate colonization and breakdown of leaves in an astatic pond in south India

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Abstract: *Macroinvertebrate colonization and breakdown of Pongamia pinnata and Morinda tinctoria leaves were studied in an astatic pond in Madura College, Madurai. Morinda tinctoria leaves broke down faster than the leaves of P. pinnata. Breakdown capacities of astatic pond cannot be attributed to colonization of macroinvertebrates. Instead, microbial processing, and abiotic fragmentation are suggested as factors controlling breakdown rates. Tanypus sp (midge-larva) was abundant in leaf bags during the experimental period. This midge-larva appeared to use litter accumulations as a microhabitat that provided shelter and a rich supply of food in the form of organic matter. Their abundance and regular occurrence of two leaves suggest that midge larvae enhance leaf fragmentation and possibly mediate the incorporation of organic matter in pond sediments once the plant tissue is sufficiently macerated.*

Key words: *Colonization, Breakdown, Pongamia pinnata, Morinda tinctoria*
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Introduction

Macroinvertebrates comprise an ecologically important group of organisms in freshwater systems and provide a reliable indication of water health (Chessman, 1995; Duran and Suicmez, 2007), mode of primary production (Murphy, 1984), as well as the stability of the habitat (Death and Winterbourne, 1995) and other chemical factors of the water such as pH (Hamalainen and Huttunen, 1996). They are known to play a very important role in the processing and cycling of nutrients, as they belong to several specialist feeding groups such as filter-feeders, collectors, scrapers, shredders and predators (Dudgeon, 1999). The liming intervention should have encouraged the recovery of the benthic community, and leaf decomposition processes were employed to assess indirectly the effectiveness of the neutralization. Two aspects of leaf processes were considered: breakdown rates and leaf colonization by macro-invertebrates. These aspects of the decomposition process are not separate, since invertebrate activity regulates the rate of detritus processing (Petersen and Cummins, 1974; Menendez *et al*., 2001; Alvarez, 2006). This normally happens in unpolluted aquatic environments, although there is a significant reduction in the rate of breakdown processes in the bottom of lentic waters compared with streams (Webster and Simmonds, 1978; Alvarez, 2006). In fact, decay of vascular plant detritus results from several interactions between physical and chemical nature of specific leaves and the biotic and abiotic features of the environment (Petersen and Cummins, 1974; Reice, 1974; Webster and Benfield, 1986). The objective of the present study was to study the colonization of macroinvertebrates and breakdown of leaves of two plant species of astatic pond in south India.

Materials and Methods

Study area: The study was conducted in an astatic pond in the Madura College campus, Madurai (lat. 11°N, long. 77°50'E) between April and June 2005. Morphometric, physical and chemical characters of the pond are given in Table 1. Along the banks of the pond are thick stands of trees and shrubs, whose leaves are the pond's principal source of organic detritus. Dominant riparian tree species are *Pongamia pinnata* and *Morinda tinctoria*.

Experimental design: Freshly fallen leaves of two plant species (*Pongamia pinnata* and *Morinda tinctoria*) were collected from the study site. The collected leaves were dried at room temperature for two days and weighed into 13 g fresh mass and placed in nylon mesh bags with a mesh size of 10 mm (Petersen and Cummins, 1974). Twenty-one bags were randomly taken and were secured at the bottom of the pond. Three bags were taken from pond after every 2, 4, 8, 16, 24, 30 and 60 days and brought to the laboratory. Leaves were removed from the litterbags and individually rinsed to remove sediments and invertebrates. The macroinvertebrates associated with leaves were gently washed, then sorted according to taxon and functional role (Cummins, 1974) and enumerated.

Results and Discussion

Overall, 595 specimens representing 14 taxa were collected from leaf litter of two species (*P. pinnata* and *M. tinctoria*). Diptera were high percentage in *P. pinnata* and Gastropoda were high percentage in *Morinda tinctoria* than other taxonomic groups (Fig. 1). Diptera, the larvae of *Tanypus* sp were high numbers (n = 71) in *Pongamia pinnata* and Gastropoda (*Bithynia* sp, n= 158) were high numbers in *Morinda tinctoria* (Fig. 2). The results reflected that the importance of litter as a source of food and total densities of macroinvertebrates of major taxa were greater in leaf litter of *M. tinctoria*. Similar results have been reported in other studies where the colonization of palatable and non-palatable leaves has been compared in streams (Winterbourn, 1978; Dobson *et al*., 1992; Dudgeon and Wu, 1999).

Both taxa were frequently collected throughout the experimental period in leaf litter of both species. *Bithynia* sp, *Cloeon* sp, *Sminuthrides* sp, *Dero digitata* and *Orectochilus* sp were high in *P. pinnata* whereas *Tanypus* sp was high in *M. tinctoria* (Fig. 3). Colonization rate of macroinvertebrates was higher on *P. pinnata* than on *M. tinctoria*. Colonization of *Bithynia* sp was high (n = 142) on 4th day, scarce on 8th, 16 days and conspicuously absent on 24th, 30

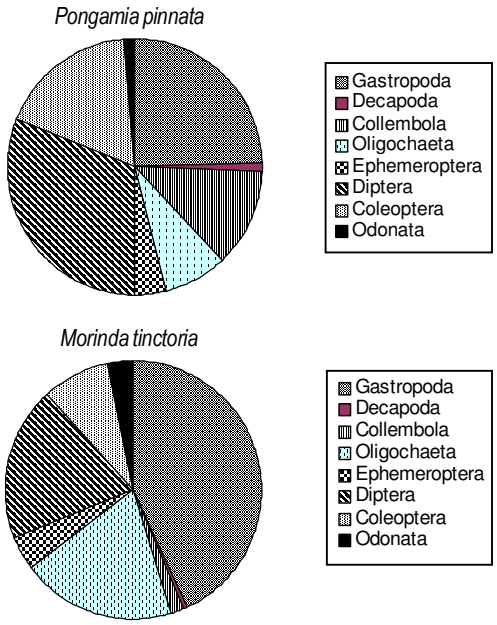

Fig. 1: Percentage of taxonomic groups inhabiting leaf litter

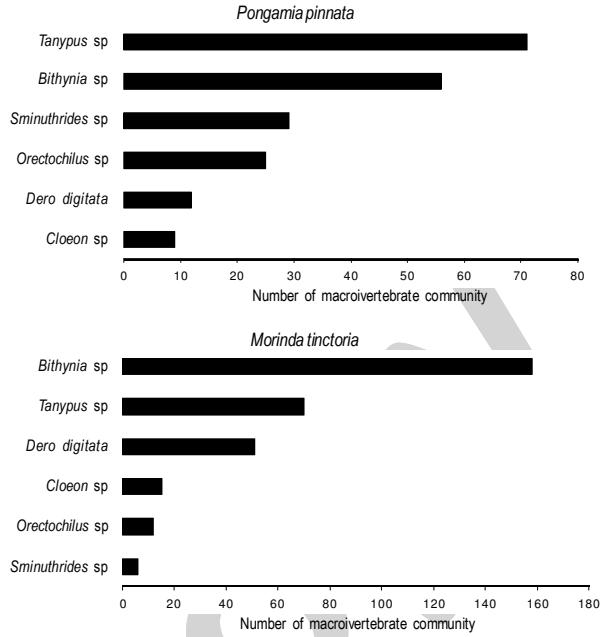

Fig. 2: The six most abundant taxa associated with leaf litter

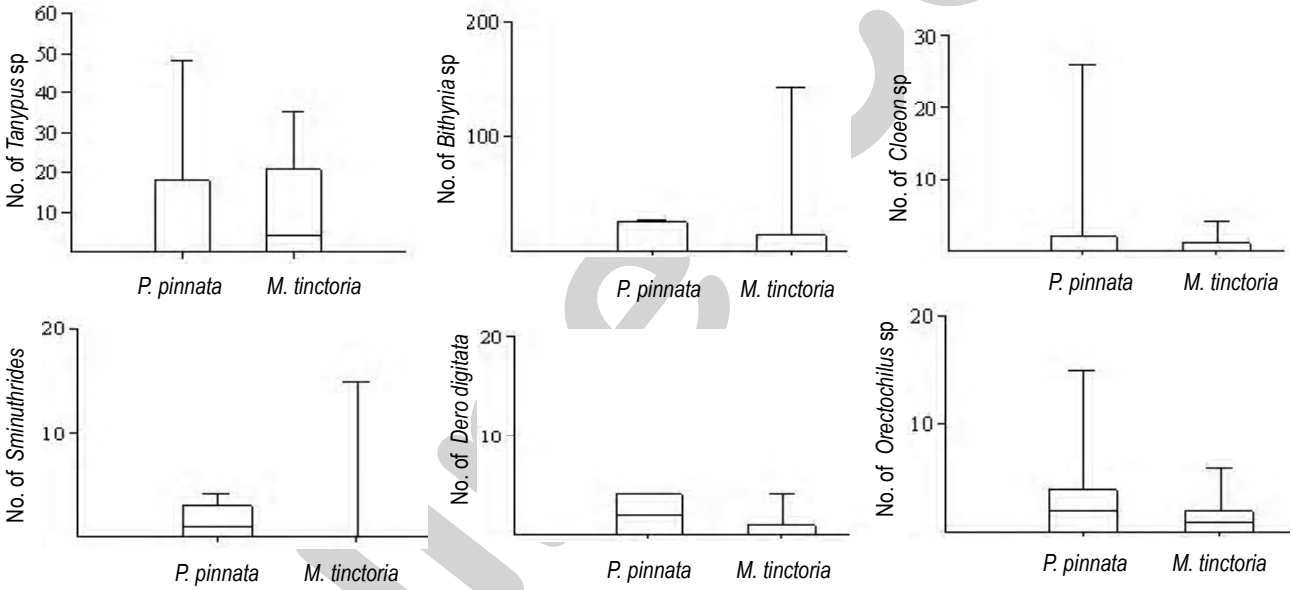

Fig. 3: Abundance of macroinvertebrates in two species of leaf litter during experimental period

and 60 days on *P. pinnata*. *Bithynia* sp colonization was abundant in 8th and 16th day and scarce in 2nd, 4th, 24th, 30 and 60 days on *M. tinctoria*. *Sminuthrides* sp was frequently found on all experimental days but abundant on 24th days in *P. pinnata*. *Tanypus* sp colonization started from 2nd day to 8th days in *P. pinnata* and in *M. tinctoria* was initiated from 4th day to 30 days. *Dero digitata* were found from 2nd day to 16th days and distinctly absent in both species (*P. pinnata* and *M. tinctoria*). In both species of leaves, *Orectochilus* sp was persistently found in throughout the experimental period. *Hydrovatus* sp was found only on 2nd and 4th days in *P. pinnata* whereas in *M. tinctoria* found on 4th, 8th, 16th and 30th days (Fig. 4). This indicates that *M. tinctoria* form a palatable litter, which served mainly as a food source and thus supported high densities of macroinvertebrates. Contrarily lower densities of macroinvertebrates associated with litter of *P. pinnata* indicated lesser palatability of its leaf and therefore may be useful as a substrate. This result reflects the fact that leaf litter in a tropical stream may serve as food or substrate for macroinvertebrates (Dudgeon and Wu, 1999). In tropical countries where many leaf types of varying palatability and defensive compounds are present (including a greater proportion of condensed tannins: Stout, 1989), the patch – specific response of faunal densities to changes in the total amounts of these compounds can be expected to be rather weak, and macroinvertebrate abundance is unlikely to correlate closely with litter biomass.

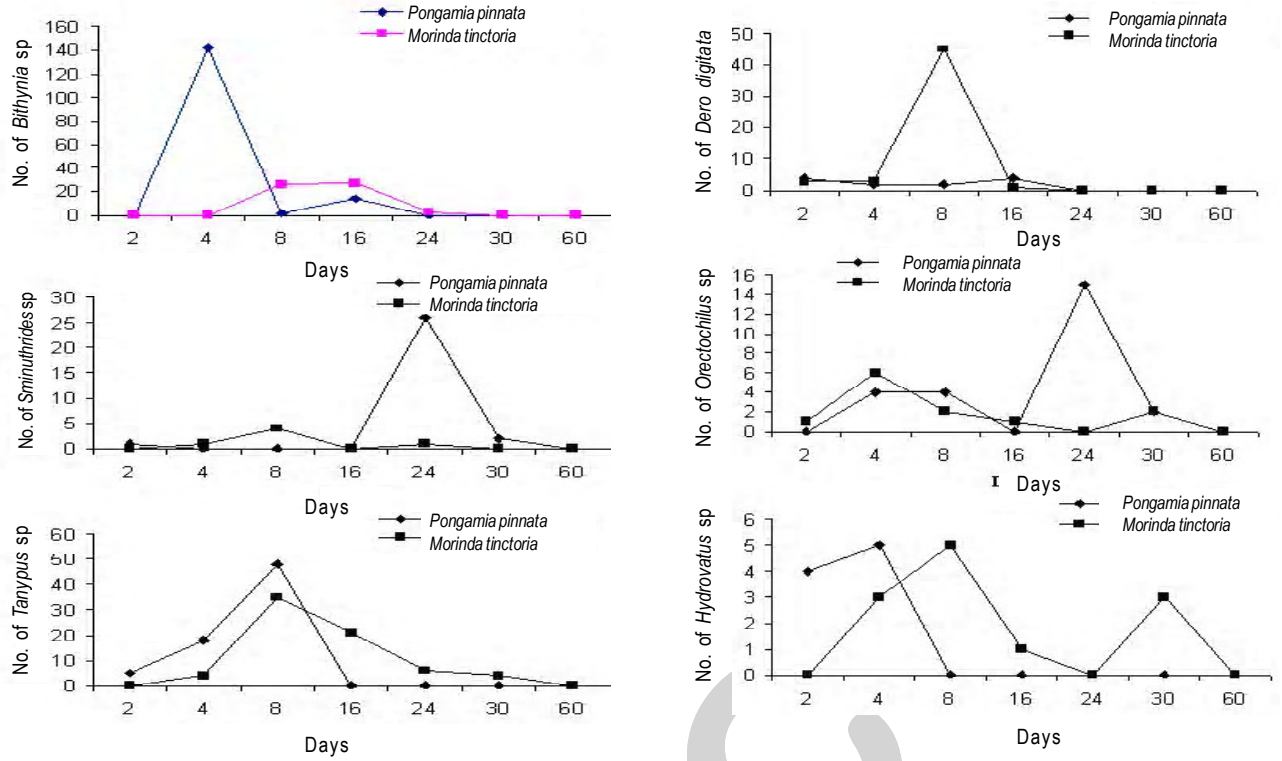

Fig. 4: Abundance of macroinvertebrates colonization in two leaves species

Leaves and other coarse particulate detritus are used as feed by macroinvertebrates (Cummins *et al*., 1989). In south India organic detritus enters the pond all through the year but a substantial proportion of the annual input from riparian trees at circumference pond occurs during April and May. Deciduous leaves are clearly a major food input to astatic ponds. The rate at which these leaves decompose and enter the food web depends on a number of factors and processes *viz.*, resistance to physical abrasion (by flow, sand and silt particles), chemical composition and susceptibility to chemical leaching, pond temperature following microbial activity and the feeding activity of aquatic macroinvertebrates. The present investigation shows considerable variability among species in the rate at which leaves leach and decompose once they have fallen into astatic pond. For example, *M. tinctoria* leaves lost about 30% of their mass after being submerged for 60 days in pond water, whereas *P. pinnata* leaves only lost about 20% during the same time period. Leaf weight loss during this experiment was probably due to microbial activity because leaves kept in sterile pond water for control purposes only lost about 4-9% of their mass during the same period. In the present study, *Bithynia* sp greatly reduced the decomposition time of *M. tinctoria* leaves by scraping at the end of the second week. In contrast, the larvae had little or no measurable effect on the rate of decomposition of *P. pinnata* leaves because they were not readily ingested.

In the guts of all examined specimens of *Bithynia* sp (30 specimens), *Cloeon* sp (15 specimens), *Sminuthrides* sp (14 specimens), *Tanypus* sp (35 specimens), *Dero digitata* (24 specimens), *Hydrovatus* sp (12 specimens), algae like *Oscillatoria, Anabena, Hydrodictyon* and diatoms, detritus particles, leaflets were found. Gut examination of macroivertebrates revealed that algae comprise huge quantity as compared to leaflets. Total dry weights of two species of leaf litter are listed in Table 2. The dry weight of *P. pinnata* was low (10-10.3 g) for first four days and reached maximum (14-14.2 g) between 8th and 24 days and abruptly decreased (5 g) on 30 and 60 days. The dry weight of *M. tinctoria* recorded gradual decline (from 12 g on 2nd day to 5 g on 60th day) during experimental period.

The dry weight of *P. pinnata* was higher than their initial mass in second and fourth weeks, probably due to the mass growth of algae *viz*., *Oscillatoria, Anabena*, diatoms *etc.* Numerous studies have implicated, the canopy and its effects on incidence levels of light that reach pond, as a major factor influencing benthic macroinvertebrates communities (Cummins, 1974; Minshall, 1978; Murphy *et al*., 1981; Hawkins *et al*., 1982; Feminella *et al*., 1989). In general, open canopies have been shown to have higher periphyton standing crops and primary production than more shaded area (Lyford and Gregory, 1975; Hawkins *et al*., 1982; Murphy, 1984; Power, 1984; Fuller *et al*., 1986). Other studies have shown that macroinvertebrate grazers benefit from improved food resources when more sunlight reaches the pond water and algal growth is stimulated (Murphy, 1984; Wallace and Gurtz, 1986; Perrin *et al*., 1987; Bilby and Bisson, 1991). In the present study, species of algal grazing mayfly *Cloeon* sp, *Hydrovatus* sp (Coleoptera) and *Bithynia* sp grew to significantly greater size. Hawkins *et al*. (1982) also found higher biomass of grazers in open versus shaded areas but found the densities of grazers to be actually lower in open areas. In contrast, Behmer and Hawkins (1986) found both higher biomass and densities for most grazers in the open sites. Although the

Table - 1: Physical parameters and water chemistry of the pond during experimental period

Parameter	Min.- Max.	Mean ± SD
Total surface area of pond (m)	23.56 – 24.62	24.00 ± 0.66
Water depth (cm)	49.5 – 52.3	50.68 ± 1.45
Water transparency (cm)	32.3 – 36.4	34.73 ± 2.15
Air temperature (°C)	33 – 35	34 ± 1
Water temperature (°C)	26 – 28	27.3 ± 1.15
pH	6.1 – 6.9	6.57 ± 0.41
Dissolved oxygen (mgl^{-1})	10.7 – 12.3	11.4 ± 0.82
Total dissolved solids (mgl^{-1})	35 – 41	38.6 ± 3.21
Alkalinity (mgl^{-1})	0.9 – 1.5	1.2 ± 0.3

Table - 2: Total dry weight of two species of leaf litter

Day	Total dry weight (g)	
	Pongamia pinnata	*Morinda tinctoria*
2	10.3	12
4	10	11
8	14.2	9
16	14	9
24	14	8
30	5	7
60	5	5

relationship between the density and biomass of grazers and the degree of shading has been studied but only a few works have measured macroinvertebrate production in relation to shading. The studies conducted by Allen (1951), Hopkins (1976), Wallace and Gurtz (1986), Behmer and Hawkins (1986) have all reported greater levels of secondary production in open versus shaded sites.

The present investigation are inconclusive but suggest that understanding the relationship between macroinvertebrate and litter in tropical astatic pond. Although pond ecosystem in south India have been subjected by humans to a vast array of perturbations (altered physical, chemical and biological characteristics), the most severe perturbation may have been the extensive removal of riparian trees from the boundaries of ponds and lakes. This litter input studies are needed for understanding the role of detritus in the food webs of astatic pond ecosystems.

References

Allen, K.R.: The Horokiwi stream. A study of a trout population. *New Zealand Mari. Fish. Bull.,* **10**, 1-238 (1951).

Alvarez, J.A. and E. Becares: Seasonal decomposition of *Typha latifolia* in the free-water surface constructed wetland. *Ecol. Eng.*, **1038**, 1-7 (2006).

Behmer, D.J. and C.P. Hawkins: Effects of overhead canopy on macroinvertebrate production in a Utah stream. *Freshwater Biol.*, **16**, 287-300 (1986).

Bilby, R.E. and P.A. Bisson: Allochthonous versus autochthonous organic matter contributions to the trophic support of fish populations in clear-cut and old growth forested streams. *Can. J. Fish. Aqua. Sci.*, **49**, 540-551 (1991).

Chessman, B.C.: Rapid river assessment using macroinvertebrates: A procedure based on habitat-specific family level identification and a biotic index. *Aust. J. Ecol.*, **20**, 122-129 (1995).

Cummins, K.W.: Structure and function of stream ecosystems. *Biosci.*, **24**, 631-641 (1974).

Cummins, K.W., M.A. Wilzbach, D.M. Gates, J.B. Perry and W.B. Taliaferro: Shredders and riparian vegetation. *Biosci.*, **39**, 24-30 (1989).

Death, R.C. and M.J. Winterbourn: Diversity patterns in stream benthic invertebrate communities: The influence of habitat stability. *Ecol.*, **76**, 1446-1460 (1995).

Dobson, M., A.G. Hildrew, A. Ibbotson and J. Garthwaite: Enhancing litter retention in streams: Do altered hydraulics and habitat area confound field experiments? *Freshwater Biol.*, **28**, 71-79 (1992).

Dudgeon, D.: Tropical Asian Streams: Zoobenthos, Ecology and Conservation. Hong Kong University Press, Hong Kong (1999).

Dudgeon, D. and K.K.Y. Wu: Leaf litter in tropical stream: Food or substrate for macroinvertebrates? *Arch. Hydrobiol.*, **146**, 65-82 (1999).

Duran, Mustafa and Menderes Suicmez: Utilization of both benthic macroinvertebrates and physico-chemical parameters for evaluating water quality of the stream Cekerek (Tokat, Turkey). *J. Environ. Biol.,* **28**, 231-236 (2007).

Feminella, J.W., M.E. Power and V.W. Resh: Periphyton responses to invertebrate grazing and riparian canopy in three northern California coastal streams. *Freshwater Biol.*, **22**, 445-457 (1989).

Fuller, R.L., J.L. Roelofs and T.J. Fry: The importance of algae to stream invertebrates. *J. Nor. Am. Benthol. Soci.*, **6**, 1-11 (1986).

Hamalainen, H. and P. Huttunen: Inferring the minimum pH of streams from macroinvertebrates using weighted averaging regression and calibration. *Freshwater Biol.*, **36**, 697-709 (1996).

Hawkins, C.P., M.L. Murphy and N.H. Anderson: Effects of canopy, substrate composition and gradient on the structure of macroinvertebrate communities in Cascade Range streams of oregon. *Ecol.*, **63**,1840-1856 (1982).

Hopkins, C.L.: Estimate of biological production in some stream invertebrates. *New Zealand J. Marine Freshwater Res.*, **10**, 629-640 (1976).

Lyford, J.H. and S.V. Gregory: The dynamics and structure of periphyton communities in three Cascade Mountain streams. *Int. Vereinigung fur Theoretische und Angewandte Limnologie: Verjamd imgen.*, **19**, 1610-1616 (1975).

Menendez, M., M. Martnez, O. Hernandez and F. Comin: Comparison of leaf decomposition in two Mediterranean rivers: A large eutrophic river and an oligotrophic stream (S. Catalonia, N.E. Spain). *Int. Rev. Hydrobiol.*, **86**, 475-486 (2001).

Minshall, G.W.: Autotrophy in stream ecosystem. *Biosci.*, **28**,767-771 (1978).

Murphy, M.L.: Primary production and grazing in freshwater and intertidal reaches of a coastal stream, southeast Alaska. *Limnol. Oceanogra.*, **29**, 805-815 (1984).

Murphy, M.L., C.P. Hawkins and N.H. Anderson: Effects of canopy modification and accumulated sediment on stream communities. *Transact. Am. Fish. Soc.*, **110**, 469-478 (1981).

Perrin, C.J., M.L. Bothwell and P.A. Slaney: Experimental enrichment of a coastal stream in British Columbia: Effects of organic and inorganic additions on autotrophic periphyton production. *Can. J. Fish. Aquat. Sci.*, **44**, 1247-1256 (1987).

Petersen, R.C. and K.W. Cummins: Leaf processing in a Woodland stream. *Freshwater Biol.*, **4**, 343-368 (1974).

Power, M.E.: Habitat quality and the distribution of algae-grazing catfish in a Panamanian stream. *J. Anim. Ecol.*, **5**, 357-374 (1984).

Reice, S.R.: Environmental patchiness and the breakdown of leaf litter in a woodland stream. *Ecol.*, **5**, 1271-1281 (1974).

Stout, R.J.: Effects of condensed tannins on leaf processing in mid-latitude and tropical streams: A theoretical approach. *Can. J. Fish. Aquat. Sci.*, **46**, 1097-1106 (1989).

Wallace, J.B. and M.E. Gurtz: Response of *Baetis mayflies* (Ephemeroptera) to catchment logging. *Am. Midli. Nat.*, **115**, 25-41 (1986).

Webster, J.R. and E.F. Benfield: Vascular plant breakdown in freshwater ecosystems. *Ann. Rev. Ecol. Syst.*, **17**, 567-594 (1986).

Webster, J.R. and G.M. Simmonds: Leaf breakdown and invertebrate colonization on a reservoir bottom. *Verh. Int.Ver. Limnol.*, **20**, 1587-1596 (1978).

Winterbourn, M.J.: An evaluation of the mesh bag method for studying leaf colonization by stream invertebrates. *Verh. Int. Ver. Limnol.*, **20**, 1557-1561 (1978).