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MACROINVERTEBRATE UTILIZATION OF LEAF DETRITUS IN A RIFFLE OF THE ILLINOIS RIVER, ARKANSAS

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ABSTRACT

Small (5 g) leaf packs were placed in a shallow riffle area of the Illinois River in western Benton County, Arkansas, and sequentially retrieved after various exposure times during the winter and spring of 1980. Oak leaves (*Quercus shumardii*) were utilized more rapidly (9.2% remaining after 91 days), followed by oak/sycamore (*Q. shumardii/Platanus occidentalis*) leaf packs (31.8% remaining after 91 days). Sycamore (*P. occidentalis*) was the slowest processed type (32.2% remaining after 91 days). The initial colonization by shredders as characteristic of northern U. S. streams did not occur in this study. Collector organisms were present in the leaf packs throughout the study. Predominant shredder organisms included stonefly nymphs (Plecoptera: *Nemoura* sp., *Allocapnia* sp., *Taeniopteryx* sp.) and caddisfly larvae (Trichoptera: *Pycnopsyche* sp., Limnephilidae). Predominant collector organisms included midge larvae and pupae (Diptera: Chironomidae) and mayfly nymphs (Ephemeroptera: *Leptophlebia* sp., *Ephemerella* sp., *Stenonema* sp.).

INTRODUCTION

Allochthonous input in the form of leaf litter is one of the most important sources of energy for macroinvertebrates in woodland streams (Minshall, 1967). This energy currency plays a major role in the stream ecosystems of the Ozark Region in northwestern Arkansas. Most of the small order streams of this area possess riparian vegetation which forms a canopy that overhangs a substantial portion of the stream.

Initial conditioning of leaf material begins with microbial invasion of the leaf surfaces and penetration into the matrix (Suberkropp and Klug, 1976). After this initial colonization shredder species begin to further process the leaf material and make available to collectors a high quality foodstuff (Cummins et al., 1973; Short and Maslin, 1977). Leaf material itself may serve as habitat for collector organisms through its coarse particulate organic matter (CPOM $>$ 1mm) component; associated fine particulate organic matter (FPOM $<$1mm) liberation from the action of other organisms may serve as food for collectors as well (Short et al., 1980).

Rates of processing of detrital material are believed to be the result of the interplay of several factors: temperature (Petersen and Cummins, 1974); physical fragmentation by water current (Benfield et al., 1977); pre-conditioning of leaves before entering the stream (Kaushik and Hynes, 1968); presence and kind of shredder activity (Short and Maslin, 1977); substrate particle size (Reice, 1974); and microbial and macroinvertebrate fauna present (Kaushik and Hynes, 1968; Anderson and Sedell, 1979). Leaf pack studies attempt to investigate rates of processing of leaves by means of models which approximate the leaf packs that occur under natural conditions.

Few studies, if any, of this type have been attempted in Ozark streams. In addition, very few studies have investigated the effect on processing rates of leaf packs composed of more than one species of leaves. Therefore, the present study was initiated. This study is one component of a series of investigations into the trophic dynamics of the Illinois River system.

STUDY SITE

The Illinois River which serves as a major drainage of the southwestern Ozarks Region in northwestern Arkansas and flows across the Springfield Plateau is a fifth order stream at the study site. Sub-climax oak-hickory forest and intermittent cleared pasture area border the stream. Sycamore (*P. occidentalis*) and shumard red oak (*Q. shumardii*) occur in great numbers along the stream banks as well. The stream channel is characterized by an alternating riffle and pool arrangement with rock substrate.

MATERIALS AND METHODS

Leaf processing rates were studied using 5 g leaf pack samples bound to bricks with monofilament nylon line as described by Petersen and Cummins (1974). Leaves of shumard red oak (*Q. shumardii*) and sycamore (*P. occidentalis*) were collected in January 1980. Oak leaves were collected from one tree prior to abscission. Sycamore leaves were collected from a grassy area under one tree and were selected against having touched soil. The leaves were air-dried in large containers for 7 days and weighed into 5 g packs consisting of oak, sycamore, and oak/sycamore configurations. The packs were bound onto bricks and placed in a riffle area of the stream on 18 January. Three leaf packs of each type were removed from the stream after 2, 7, 14, 21, 35, 49, 63, and 91 days. Samples were collected by removing the brick from the stream bed in one motion, releasing the leaf pack, and placing it in a plastic bag for transport to the laboratory. Samples were processed immediately upon return to the laboratory using tap water to rinse off sediment and silt deposited on the leaf packs while on the stream bed. Macroinvertebrates were hand-picked from the samples and placed in 75% ethanol for later analysis.

The intact leaves and small fragments were dried at 60°C for 48 hours, allowed to equilibrate in air and weighed. Macroinvertebrates were identified, enumerated, and weighed after drying at 60°C for 24 hours. No correction for mass loss due to preservation techniques have been made.

Fall-winter leaf processing has been thought to follow the exponential decay model proposed by Petersen and Cummins (1974): $Y_t = Y_0e^{-kt}$, where Y_t is the amount remaining after time t of the initial amount Y_0 and k is the loss rate or processing coefficient. Processing coefficients were calculated using linear regression.

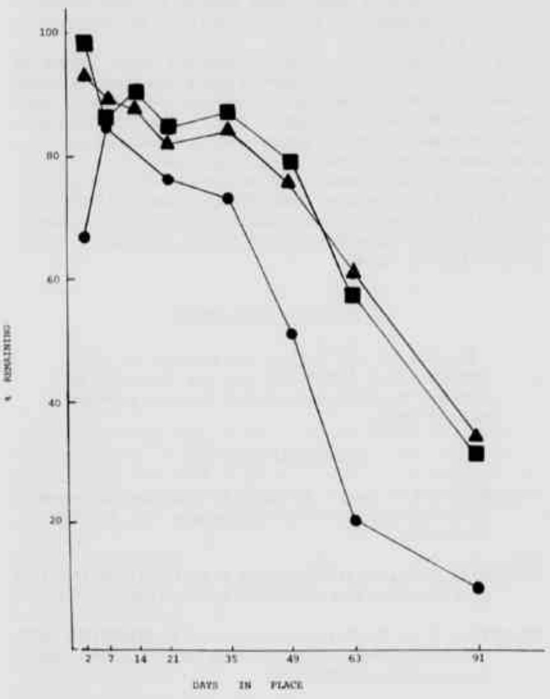
Macroinvertebrates were assigned to functional groups according to Merritt and Cummins (1978) and by visual observation of feeding habits in cases of trophic generalists.

RESULTS

Leaf Processing

Mass lost by the leaf packs through time is shown in Figure 1. Initial mass loss is thought to be from leaching and the subsequent gain in mass is due to initial colonization of the leaf packs by microbes and fungi. After weight loss due to leaching and subsequent microbial colonization, all three leaf types exhibited a linear rate of loss. Oak leaf packs demonstrated the most rapid processing. The sycamore and mixed oak/sycamore leaf packs were more slowly processed with no significant differences in rates of processing between the two. Processing coefficients (k) for oak, oak/sycamore, and sycamore leaf packs were 0.025, 0.012, and 0.011 respectively.

Figure 1. Loss in mass of leaf packs in the Illinois River, Arkansas, 18 January 1980 through 18 April 1980. ● = Oak; ■ = oak/Sycamore; ▲ = Sycamore.



Macroinvertebrates

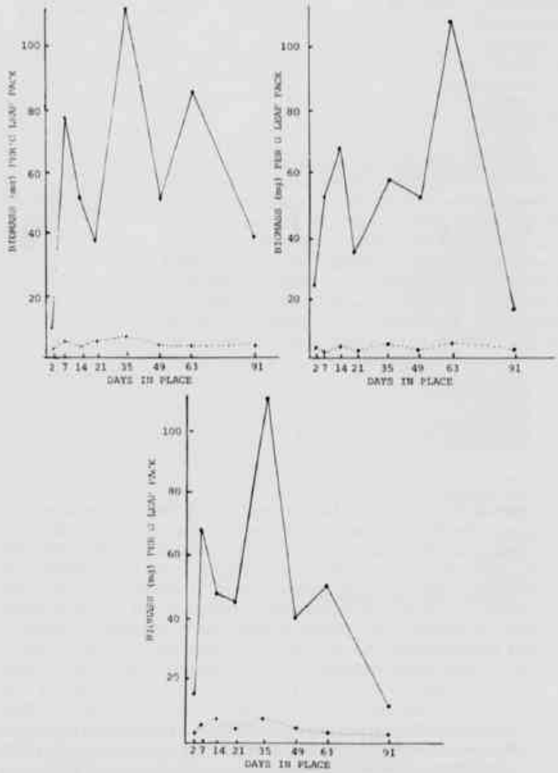
The major macroinvertebrate taxa are shown in the Table. The predominant shredders included stonefly nymphs (Plecoptera: *Nemoura* sp., *Allocapnia* sp., *Taeniopteryx* sp.) and caddisfly larvae (Trichoptera: *Pycnopsyche* sp., Limnephilidae). Collector organisms were represented by midge larvae and pupae (Diptera: Chironomidae) and mayfly nymphs (Ephemeroptera: *Leptophlebia* sp., *Ephemerella* sp., *Stenonema* sp.). Essentially the same macroinvertebrate fauna invaded the three different leaf types.

Table 1. Major macroinvertebrate taxa collected on leaf packs in the Illinois River, Arkansas. Functional group classification: C = collector; S = shredder; P = predator; O = other; + = presence.

Taxon	Functional Group	Oak/Sycamore	Sycamore	Oak
Ephemeroptera				
Leptophlebia sp.	C	+	+	+
Ephemerella sp.	C	+	+	+
Stenonema sp.	C	+	+	+
Baetis sp.	C	+	+	+
Isonychia sp.	C	+	+	+
Tricorythodes sp.	C	+	+	
Plecoptera				
Nemoura sp.	S	+	+	+
Allocapnia sp.	S	+	+	+
Taeniopteryx sp.	S	+		+
Strophopteryx sp.	C	+	+	+
Helopicus nalatus	P	+	+	+
Isoperla marlynia	P	+	+	+
Neoperla sp.	P	+	+	+
Perlesta sp.	P	+	+	
Acroneuria sp.	P	+		
Trichoptera				
Cheumatopsyche sp.	C	+	+	+
Hydropsyche sp.	C	+	+	+
Chimarra sp.	C		+	
Pycnopsyche sp.	S	+		
Helicopsyche sp.	C	+	+	
Limnephilidae	S	+	+	
Diptera				
Chironomidae	C	+	+	+
Simulium sp.	C	+	+	+
Isopoda				
Lirceus sp.	C/S	+	+	+
Decapoda				
Orconectes neglectus neglectus	C		+	
Total Number of Taxa		23	22	17

Densities of collectors far exceeded those of shredders (Figure 2) in all three leaf pack types. Collector organisms appeared responsible for initial colonization and biomass gain of macroinvertebrates per g leaf pack of the leaf packs. Within 7 days collectors showed high densities, reaching maximum densities at 35 days, after which a gradual decline occurred. Shredder densities did increase with time but never approached collector density values. Highest shredder density occurred around day 63, after collector densities had begun to decline. Biomass densities were calculated in addition to numbers and showed essentially the same results. One notable exception occurred on the day 63 sample in the sycamore leaf pack when shredder biomass (mg) per g leaf pack exceeded collector biomass by a factor of 7. This was accounted for by the presence of a large crayfish (*Orconectes neglectus neglectus*) collected from the sycamore pack.

Figure 2. Colonization of leaf packs in the Illinois River, Arkansas, according to functional group classification. ______ = Collectors, ... = Shredders.



DISCUSSION

Results of this study show that the leaf packs investigated are processed at a faster rate in the Ozarks Region of the Illinois River than in other studies using similar leaf types (Petersen and Cummins, 1974; Benefield et al., 1977; Benfield et al., 1979). The rates determined by this study were also faster than those obtained in a study in a slough area at the same study site (F. D. Petty and A. V. Brown, pers. comm.). This could be due to a temperature regime higher than those of other studies (X = 10°C). The method of assemblage of the leaf pack has been demonstrated to have considerable influence on processing rates (Benfield et al., 1979). Current velocity may have had some mechanical effects on leaf pack breakdown, as noted in other studies (Benfield et al., 1977), but with less severe influence on processing.

Oak leaf packs were processed more rapidly than oak/sycamore or sycamore leaf packs. This could be that oak leaves have been found to have high nitrogen levels, thus act as a higher quality food source (Suberkropp et al., 1976) and are preferred; however, numbers or biomass of organisms did not indicate this. Shumard red oak appears to be a more delicate leaf than ones used in other studies and may contribute to the faster processing rates as well. In the case of the mixed species pack, one might expect the processing rate to be intermediate to oak and sycamore types; however, the rate of processing of the mixed pack appears to be determined by the slowest leaf species present in the pack. Very few, if any, studies have investigated mixed species leaf packs and offer no basis for comparison of these results.

Collector organisms appeared most dominant among the macroinvertebrates collected from the leaf packs throughout the entire study. This is a similar situation to that of the Petty and Brown (pers. comm.) study in a slough at the same study site. Shredders occurred in lower densities than collectors, and the slower leaf packs contained higher shredder densities than the faster types. One explanation for this is that the method of collection of leaf packs and/or the leaf packs themselves excluded the larger shredder/processors. At the time of this study, there were many crayfish present in the riffle area; only one such organism was collected among the 81 samples taken. Non-collection of these organisms thought to be resonsible for the majority of the shredding activity could explain lower shredder densities in terms of numbers and biomass of the leaf pack types investigated. Alternatively, shredder organisms may not be as important in the breakdown of leaves in this stream since it also possesses some characteristics of pastureland streams. In some of these, shredder activities are less important to the breakdown of leaves than they are in woodland streams (Benfield et al., 1977).

The predominance of collector organisms could further be explained in terms of nutrient availability from all size classes of detritus present, as indicated by other studies (Egglishaw, 1964; Minshall, 1967; Short et al., 1980). Ward and Cummins (1979) indicated that food quality is of importance to collector species as well as shredder species. Thus, allochthonous input of fresh leaves, a high quality food, and their associated FPOM after conditioning, may serve as a better food source than FPOM of the substratum. Availability and quantity of FPOM from different leaf types of the Ozarks region should be further investigated to assess relative importance to the trophic dynamics of stream ecosystems in this region.

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