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Detritus processing and microfungal and animal associations in Arrone Stream (Rome, Italy)

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SEZIONE III

(Botanica, zoologia, fisiologia e patologia)

Ecologia. — *Detritus processing and microfungal and animal associations in Arrone Stream (Rome, Italy).* Nota di ELISA ANNA FANO (*), GIGLIOLA PUPPI (**) e M. GIUSEPPINA DOWGIALLO (***), presentata (****) dal Socio G. MONTALENTI.

RIASSUNTO. — Il processo di decomposizione di foglie di leccio (*Quercus ilex* L.) immerse in acqua è stato seguito nel torrente Arrone (Roma, Italia) per 100 giorni, in due diverse località e periodi stagionali. La decomposizione era valutata come perdita in peso secco privo di ceneri e contenuto in C, N e P.

La velocità di decomposizione è risultata essere in rapporto alle caratteristiche fisico-chimiche delle località in esame, varianti con la stagione, alla struttura ed efficienza delle associazioni microfungine ed animali. È possibile osservare una successione nei gruppi fungini, il cui comportamento e frequenza relativa è influenzato dalla stagione.

La composizione delle associazioni animali è collegata sia alle caratteristiche chimico-fisiche della zona di studio, sia alle sue caratteristiche sedimentologiche, la più alta ricchezza in specie, diversità, « evenness » e varietà risultando associate alla maggiore diversità del substrato.

INTRODUCTION

The importance of allochthonous plant detritus as an energy source in running water is generally acknowledged (Cummins, 1974; 1979; Minshall, 1978; Fano *et al.*, 1981), although a different ratio between autotrophy and heterotrophy of the river ecosystem may be observed according to the order of the river (Minshall, 1978; Cummins, 1979; Vannote *et al.*, 1980).

Once having reached the water body, the allochthonous detritus, composed mainly by leaves, undergoes leaching during the first 24-48 hours of immersion (Petersen and Cummins, 1974); after that, microbial colonization takes place, the organisms involved being mainly fungi (Suberkropp *et al.*, 1976); these attack particulate organic matter (POM) and, by transforming it, make plant substances available to benthic organisms (Fano *et al.*, 1981, 1982).

The aim of this work, part of a more complex research on the energetics of running waters, is to elucidate the decomposition pattern of holm (*Quercus ilex* L.) leaves immersed in two sites of the Arrone stream, differing for physico-chemical, geomorphological and sedimentological characters.

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Study sites

The research was carried out in a stream, Arrone, emissary of the Bracciano Lake (Rome, Italy). Two sites were chosen, one upstream Galeria, the other downstream Testa di Lepre.

Physico-chemical and sedimentological characters of the two sites during the experiments are reported in Table I. The two areas differ in their geology, as at Galeria the stream flows in a bed of pyroclastic rocks belonging to the vol-

Table I.

Chemical-physical and morphological feature of two sites of Arrone stream in two experimental periods.

SS = spring-summer; AW = autumn-winter.

	Galeria upstream		*Testa di Lepre* downstream	
	SS	AW	SS	AW
Depth (cm)	30–50	40–50	40–65	35–45
Current velocity (m/s)	0.18–0.60	0.25–0.54	0.42–0.89	0.45–0.70
Temperature (°C) . .	13–17.5	11.5–18	11.5–19	7–19
pH	6.4–6.7	6.1–6.4	6.0–6.7	6.1–6.7
O_2 dissolved (ppm) .	9.5–11.2	8.8–13.0	8.1–10.5	9.4–11.9
Alkalinity (mg $CaCO_3$/l) . . .	65–207	223.5–250	250–275	245–272
Granulometry (φ) . .	— 1/0	— 1/0	0/+ 1	+ 1/+ 2

canic system of the Monti Sabatini, whereas at Testa di Lepre Plio-Pleistocene sands and clays prevail (Corda, *et al.*, 1978, De Rita, *et al.*, 1983).

The aspect of the two stretches of the stream is quite different: at Galeria river banks are 7-8 m high, and the water is whirling, due to the presence of boulders and tree-trunks that interrupt the stream; riffles are also present. At Testa di Lepre the river bed is wider, with low banks and the flow of the stream is free.

As for the texture of the bottom, at Galeria fine gravel prevails throughout the year, whereas at Testa di Lepre coarse sand is prevalent in spring-summer and medium-sized sand in autumn-winter.

The vegetation of the site is also different: at Galeria holms prevail in the area around the stream, alders, willows and maples being present along the river banks; the trees form a canopy over the stream. At Testa di Lepre on the contrary, the water flows in an open area, covered by herbs and grass with few alders and willows along the banks.

MATERIALS AND METHOD

Holm leaf bags (1 cm mesh) were immersed on the bed of the river, fastened to the banks, at the beginning of each experimental period (March, 14, 1983, and September, 28, 1983).

Sampling was made after 14, 28, 42, 70 and 100 days of immersion; in the second experiment samples were also collected after 7 days. At each sampling date, for each site, depth, stream flow and temperature on the bottom were recorded. Water samples were also collected and carried in refrigerated bags to the laboratory, where the dissolved O_2, pH and alkalinity were measured.

For each sampling date and site, seven leaf bags were collected, placed separately in polyethylene bags, and carried to the laboratory, where they were immediately processed. After washing with tap water to remove mud, the animals were collected from each bag and then identified by taxon and counted. The leaves of five bags were then oven-dried (60 °C for three days), part of these (two bags) were then burnt in a muffle at 600 °C for 6 hours to determine the ash-free dry weight (AFDW), and part (three bags) powdered in a mortar and analysed for organic C (method of Anne modified), total N (Kjeldhal) and total P (Rapp, 1971). Two bags were used for fungal analyses; these were carried

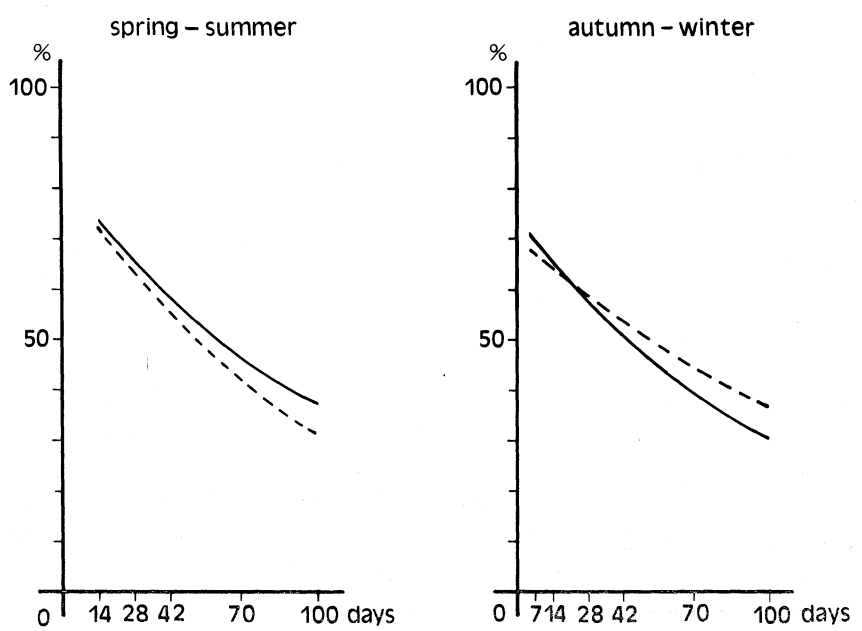

Fig. 1. – Correlation between percent of ash-free dry weight remaining and days of leaf packs of *Quercus ilex* placed in two sites of Arrone stream (Italy).

Galeria upstream ————
Testa di Lepre downstream – – – – –

Galeria spring–summer	$y = 82.6604e^{-0,0081x}$	$r = -0.9312$	$p < .01$
Testa di Lepre SS	$y = 83.4733e^{-0,0098x}$	$r = -0.9403$	$p < .01$
Galeria autumn–winter	$y = 7.39506e^{-0,0089x}$	$r = -0.9001$	$p < .01$
Testa di Lepre AW	$y = 70.1626e^{-0,0064x}$	$r = -0.8878$	$p < .01$

out by plating on malt agar leaf disks, 5.5 mm in diameter, previously rinsed with six changes of sterile water (Puppi, 1983).

Results

Detritus processing, expressed as change with time of AFDW, fits on a negative exponential curve (fig. 1). Significative differences between sites and seasons were not observed, decomposition rate resulting highest at Testa di Lepre in spring-summer (30.5% of AFDW remained after 100 days), followed, in decreasing order, by Galeria autumn-winter (31.0%), Galeria spring-summer (38.9%) and Testa di Lepre autumn-winter (40.7%). The time in days needed for the 1% only of the leaf material to be left, appears so to be: 450.9 at Testa di Lepre spring-summer, 486.2 at Galeria autumn-winter, 541.9 at Galeria spring-summer, and 664.1 at Testa di Lepre autumn-winter.

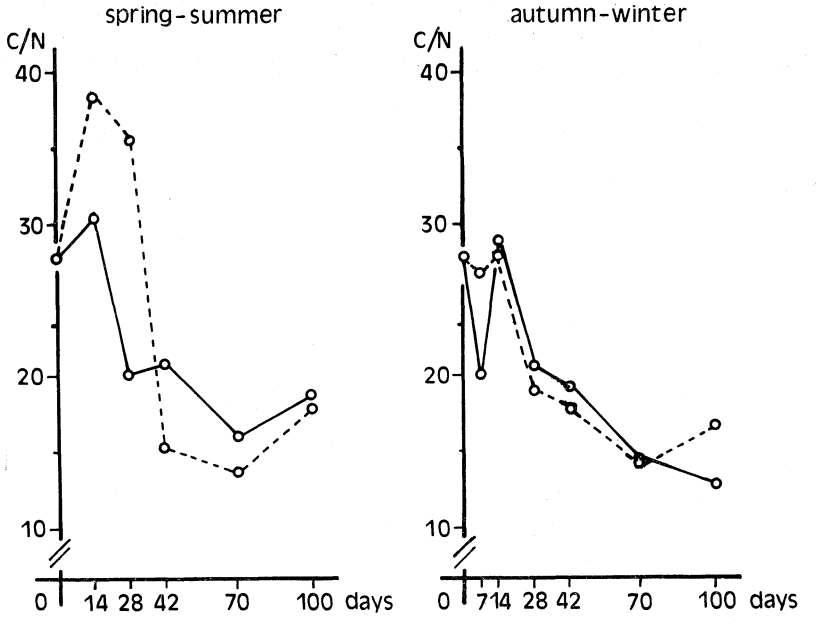

Fig. 2. - Variations of C/N ratio in leaf packs of *Quercus ilex* placed in two sites of Arrone stream (Italy).

Galeria upstream ————
Testa di Lepre downstream - - - - -

The process of decay is also made apparent by changes in the chemical components observed: C, N, P, organic matter and C/N ratio. Percentage content of total organic C decreases with time, the same trend being of course followed by organic matter. Total nitrogen and phosphorus on the contrary increase during decomposition. Graphs (figg. 2 and 3) represent the observed

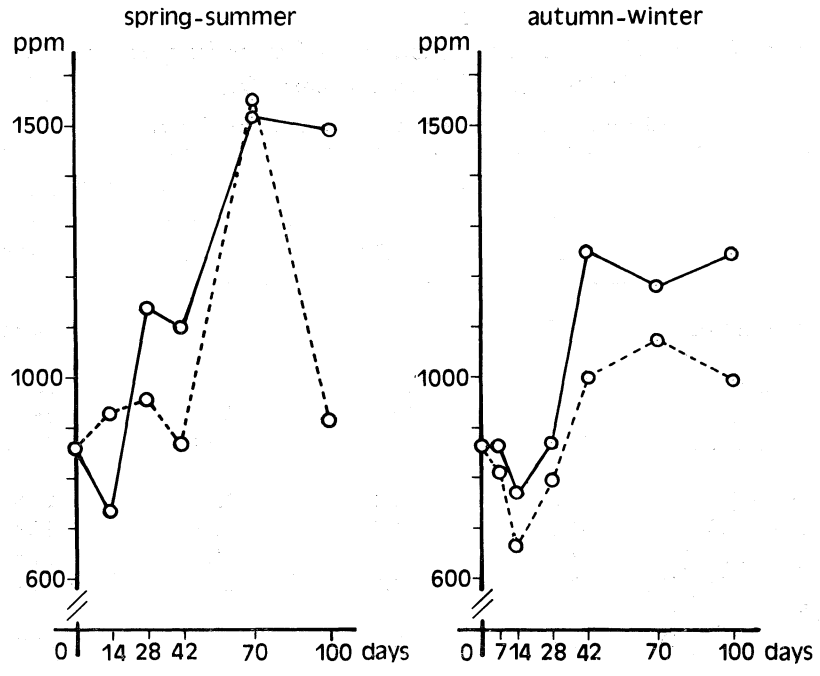

Fig. 3. – Variations of total content of Phosphorus in leaf packs of *Quercus ilex* placed in two sites of Arrone stream (Italy).
Galeria upstream _____
Testa di Lepre downstream - - - - -

value of C/N ratio and total P, respectively. Observing in detail the changes in each component, the same order in decomposition rate as the one obtained from decrease in AFDW may be noted.

The main features of fungal associations are shown in Table II; it may be noted that the colonization index is higher in autumn-winter, while evenness and richness in species are higher in spring-summer. Percentage frequencies of fungal groups vary according to site and season. Graphs in fig. 4 show the behaviour of the different fungal groups during decomposition.

Observing the results for animal associations on leaf bags in the two sites and seasons (Table III), it may be noted that the relative number of animals per bag is always higher in spring-summer than in autumn-winter, and at Testa di Lepre with respect to Galeria. Diversity, expressed by the Shannon index, is highest at Galeria in spring-summer, followed by Galeria autumn-winter, Testa di Lepre autumn-winter, and Testa di Lepre spring-summer. A different composition of animal associations in each site and season may also be observed (fig. 5).

DISCUSSION

From the analysis of the data concerning changes in AFDW it may be observed that the leaf material experimented (*Quercus ilex*) seems to be decomposed

TABLE II.

Features of microfungal associations and percentage frequencies of taxonomical groups in two sites of Arrone stream (Italy).

SS = spring–summer; AW = autumn–winter,

	Galeria		Testa di Lepre	
	SS	AW	SS	AW
Colonization index .	0.546	0.735	0.556	0.688
Species richness . . .	12.9	11.3	16.5	13.4
No of species	22	23	28	28
Evenness	0.800	0.760	0.840	0.710
Oomycetes (%) . . .	22.6	20.4	22.4	14.8
Zygomycetes (%) . .	44.6	31.6	23.3	47.8
Hyphomycetes *a*) (%)	13.4	31.7	21.5	16.6
b) (%)	12.7	3.1	25.6	5.9
Aquatic hyphomycetes (%)	6.7	13.3	7.1	14.9

Hyphomycetes *a*) = typical leaf and soil fungi.
Hyphomycetes *b*) = species possibly active also in water.

at slow rate (sensu Petersen and Cummins, 1974), as was also demonstrated for *Quercus cerris* L. leaves (Fano *et al.*, 1981), while *Quercus alba* has been demonstrated at medium rate of decomposition (Wallace *et al.*, 1982).

Decomposition rate cannot be univocally related to site or season and in fact at Testa di Lepre leaves were decomposed at the highest rate in spring-

TABLE III.

Features of animal associations in two sites of Arrone stream (Italy).

SS = spring–summer; AW = autumn–winter.

	Galeria		Testa di Lepre	
	SS	AW	SS	AW
No of taxa	16	14	13	12
Diversity	1.716	1.665	0.333	1.454
Evenness	1.425	1.453	0.300	1.347
Variety	4.702	4.758	0.859	3.662
Density (No of animals/pack)	61.96	20.77	99.08	31.50

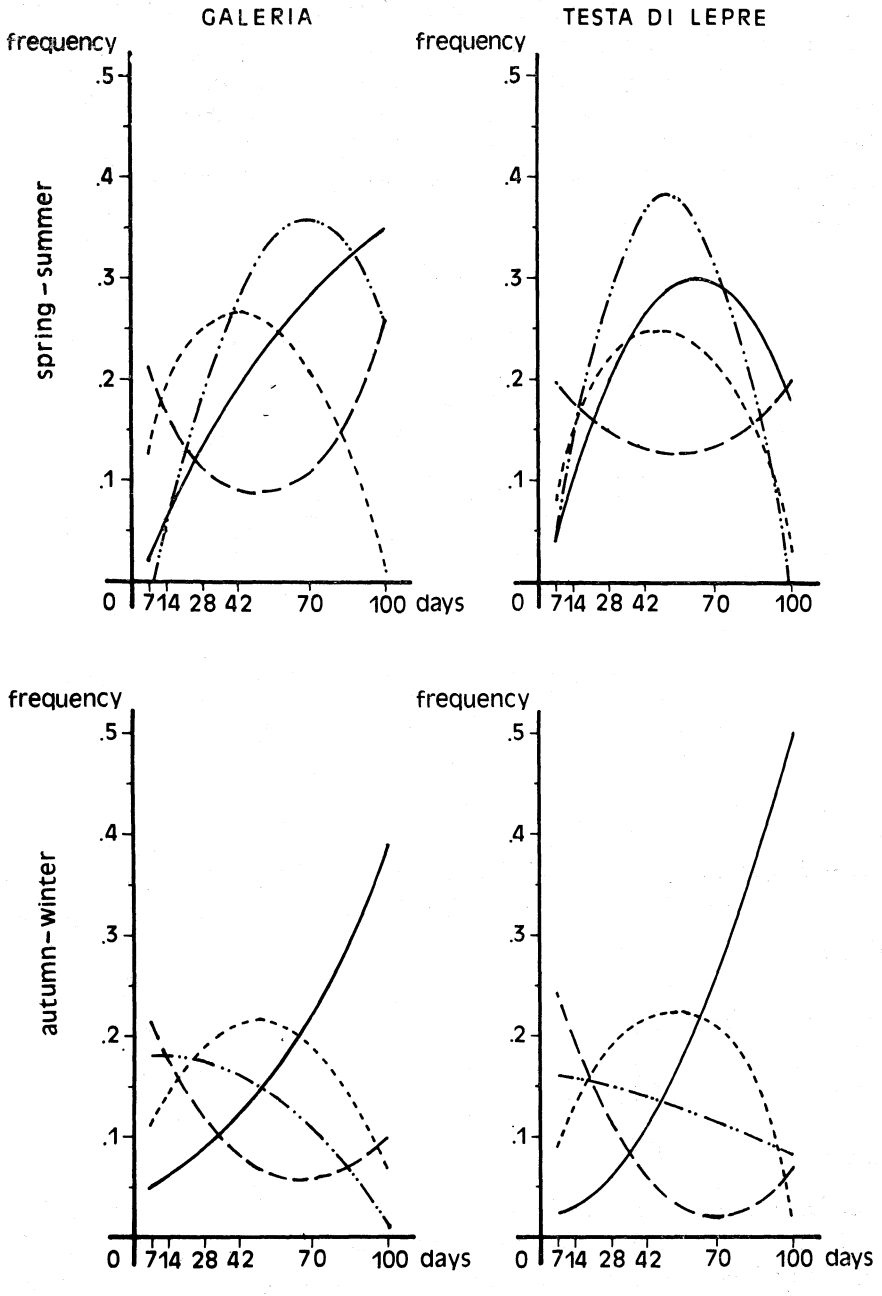

Fig. 4. – Behaviour of microfungal associations (No of colonies identified of single taxonomical group/total No of colonies identified) on leaf packs of *Quercus ilex* placed in two sites of Arrone stream (Italy).

Oomycetes ————
Zygomycetes – – – – –
Hyphomycetes — — — — —
Aquatic Hyphomycetes — . . — . . — . . —

summer and at the lowest rate in autumn-winter whereas at Galeria the highest rate is observed in autumn-winter and the lowest in spring-summer.

Decomposition rate seems therefore affected by chemical properties of the study sites (alkalinity) according to the results of Egglishaw (1964). In fact the highest value of decomposition rate is observed at Testa di Lepre in spring-summer when the highest value of alkalinity (mean = 263.12 mg $CaCO_3$/1) is recorded.

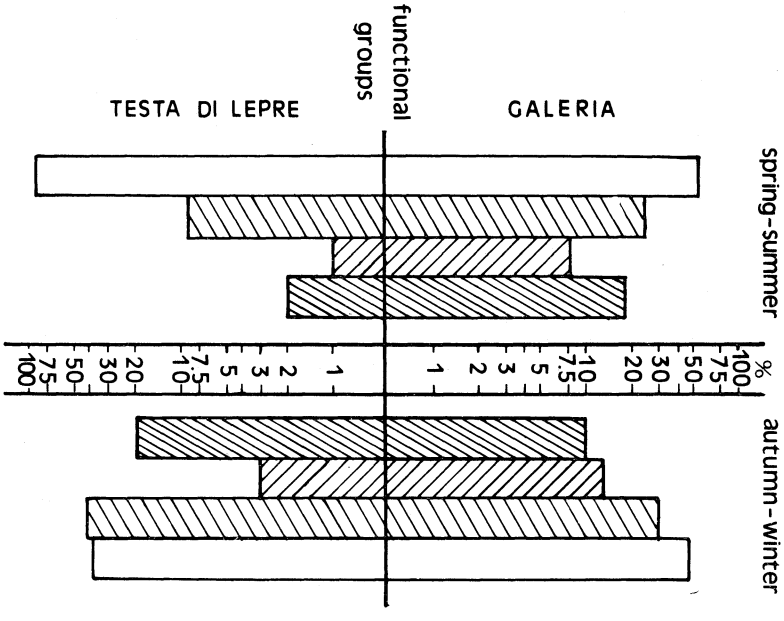

Fig. 5. – Frequencies percentage of detritivorous functional groups on leaf packs of *Quercus ilex* placed in two sites of Arrone stream (Italy).

Shredders

Scrapers and Grazers

Predators

Collectors

As for changes in chemical components of leaves, it may be noted that nitrogen and phosphorus content, after a first decrease seemingly due to leaching, progressively increases with the proceeding of decomposition. C/N ratio increases at first, decreasing then to a minimum value that is reached at Testa di Lepre after 70 days in both the experiments and at Galeria after 70 days in spring-summer and after 100 days in autumn-winter. Observing the C/N ratio at the 70th day, an order of decomposition rates may be noted similar to that obtained from the data of loss of AFDW. Our results are in agreement with the findings of other Authors (Willoughby, 1974; Meyer, 1980; Killingbeck *et al.*, 1982). They all report similar trends for C, N and P during decompo-

sition, although the extent of changes observed is different, being mainly related to the kind of leaves examined.

Data on fungi show that the colonization index is higher in autumn-winter whereas evenness is higher in spring-summer for each site, although lower at Galeria. Since colonization index appears to be unrelated to decomposition rate, this could suggest that in spring-summer leaves are colonized, although to a lesser extent, by more efficient and evenly distributed species. Richness in species, as stated, is lower in the Galeria site and this could imply the presence of more specialized strains. As for the frequency of the major taxonomical groups, hyphomycetes which are possibly active in aquatic environments are more frequent in spring-summer and in Testa di Lepre site whereas aquatic hyphomycetes are more common in autumn-winter. The more interesting findings however, concern the dynamics of the different groups during leaf decomposition. Oomycetes progressively increase with time in autumn-winter but in spring-summer their frequency shows a decline at the end of the study period. Zygomycetes increase during the first stages of decomposition, decreasing with the proceeding of leaf decay. " Terrestrial " hyphomycetes decrease, as is to be expected, in the first period of immersion; in later stages however, their frequency increases again, mainly due to species possibly active also in aquatic environments. Such behaviour is particularly evident in the first experiment (spring-summer). These findings confirm the importance of temperature in determining fungal associations in water (Barlocher and Kendrick, 1974; Puppi, 1983) and in influencing successional patterns.

Concerning animal associations, species richness, diversity, evenness and variety are higher at Galeria, associated with a greater diversity of the substratum, as pointed out by other Authors (Reice, 1977; Cummins, 1979; Vannote *et al.*, 1980). Density on the contrary is always higher at Testa di Lepre, these data being due mainly to the presence of Amphipoda (*Gammarus*), which are dominant in the site, representing 90% of the animal associations in spring-summer and 65% in autumn-winter. Therefore, decomposition rate and diversity and/or density appear to be unrelated (Reice, 1978; Fano *et al.*, 1981). As for functional groups (sensu Cummins, 1974), shredders, actual agents of decomposition (Cummins and Klug, 1979; Cummins *et al.*, 1981) are dominant in spring-summer, reaching the maximum value at Testa di Lepre. As may be noted from the Table III, the composition of animal associations varies according both to physico-chemical features of the site, and to sedimentological characteristics (Fano *et al.*, 1981). It is clearly evident that corresponding to the greater abundance of shredders, in the site and season considered, the higher decomposition rate is observed.

From the data here reported it may be concluded that the decompositional pattern of allochtonous plant detritus in running water, as regards the loss of AFDW and changes in the main chemical components (C, N, P), is dependent both on abiotic features of the environment and on the efficiency of microfungal associations colonizing detritus and on functional groups of benthic animals.

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