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Role of macroinvertebrates and microfungi in the transfer of ^{32}P along detritus food chains in rivers

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SEZIONE III

(Botanica, zoologia, fisiologia e patologia)

Ecologia. — *Role of macroinvertebrates and microfungi in the transfer of* ^{32}P *along detritus food chains in rivers.* Nota (*) di LORETO ROSSI e PETER CALOW, presentata dal Socio G. MONTALENTI.

RIASSUNTO. — Viene descritto l'uso di un isotopo del fosforo (^{32}P) per lo studio di trasferimenti di questo elemento lungo le catene alimentari a base detrito, costituite da microfunghi, detritivori e loro predatori invertebrati. Il nostro scopo non era solo quello di usare il ^{32}P come tracciante per capire la dinamica del fosforo ma anche considerare il ruolo dei microfunghi, dei detritivori e dei predatori nella ciclizzazione del radioisotopo.

Gli esperimenti sono stati condotti *in situ*, in un fiume scozzese (River Kelvin, Glasgow). Sacchi di rete plastificata (maglia = 0.1 mm) sono stati usati per manipolare la comunità in studio. Cinque pacchi di foglie di ontano, ciascuno inoculato con una singola specie fungina, sono stati introdotti in ogni sacco ma uno solo dei pacchi era inoculato con un fungo marcato per ciascun sacco. I sacchi, preparati in coppie, furono riempiti con materiale marcescente e la naturale fauna associata. Da un sacco di ogni coppia furono però esclusi i predatori (Tricladida e Hirudinea). Ogni prova sperimentale consisteva quindi, di 10 sacchi. 5 per avere tutti i funghi marcati per 2 per avere assenza e presenza di predatori. Dopo 7 gg. di permanenza nel fiume, fu determinata l'attività del ^{32}P negli animali colonizzatori dei pacchi e nei pacchi stessi, tramite la tecnica di scintillazione su liquido.

I risultati ottenuti mostrano ruoli differenti tra i vari microfunghi per il trasferimento del ^{32}P ai livelli trofici successivi e ciò sembra strettamente collegato alle nicchie trofiche dei detritivori. Inoltre, le vie ed i tassi di trasferimento del ^{32}P risultano modificati dalla predazione. Questa appare molto importante nel mediare la coesistenza dei detritivori attraverso la riduzione delle reciproche sovrapposizioni.

INTRODUCTION

Phosphorus is a major factor limiting the productivity of freshwater ecosystems and relatively high concentrations of ^{32}P can be found in the organisms involved in detritus systems [1]. In fact, the supply and transfer of this element in freshwater depends crucially on the transport of material through the detritus food chains [1]. Micro–organisms, microfungi in particular, and macro–organisms are involved as prey/predator systems in the detritus food web, but their specific rôles in P–transfer are not fully understood [2].

(*) Pervenuta all'Accademia il 16 luglio 1984.

On he other hand, the trophic niches of detritivores are strongly affected by competition as well as predation and these control coexistence equilibria of species in these ecosystems [3]. Hence, the recycling rate in P from detrital sediments could depend on the mechanisms of regulation of detritivorous populations as well as on their food requirements.

In the present paper, we describe the fate of ^{32}P utilized by individual microfungal species present on natural detritus in a lotic ecosystem. We have two main aims, namely: *a*) to establish the involvement of microfungi, detritivores and invertebrate predators in ^{32}P transfer along detritus food chains; *b*) to determine the rôle of invertebrate predation on coexistence of detritivores and on P-dynamics.

Materials and Methods

The experiments were carried out *in situ* in a Scottish river (R. Kelvin, Glasgow). Five major species of fungi, initially isolated from natural litter in the river, were used: *Aspergillus niger*, *Cladosporium herbarum*, *Pytium proliferum*, *Penicillium cyclopium*, *Mucor mucedo*. The detritivores were the isopod, *Asellus aquaticus* and the pulmonate snail, *Lymnaea peregra*, both of which are known to eat fungi on leaf litter and both of which were the most abundant macroinvertebrate species in the River Kelvin at the time of experiments (July-October). The predators were *Dendrocoelum lacteum* (Platyhelminthes, Tricladida) and *Erpobdella octoculata* (Annelida, Hirudinea) natural predators in the river at the time of study. The experiments were performed in enclosures ($20 \times 60 \times 80$ cm), where the abundance of predators could be manipulated. Five alder leaf packs (4.5 g dry weight), each incubated for 15 days with a single species of fungus, were added to every enclosure, but only one leaf pack was labelled with ^{32}P per enclosure. These leaf packs were labelled during their incubation with fungi in Erlenmeyer flasks containing 1.88 μCi/ml of ^{32}P as H_3PO_4. The enclosures were replicated in pairs but one of the pair contained no predators. Hence, 10 enclosures were used for each experiment; 5 to account for labelling all the fungi times 2 to account for presence and absence of predators. These were left in the shallow water of the river for 7 days, after which all animals that had colonised the leaf packs were manually separated and ^{32}P activity was monitored in the animals and in the packs themselves using liquid scintillation techniques. Samples of animals and leaf packs were oven dried before radioassay (60 °C per 24 h) and weighed to determine the Activity Density (AD) and Trophic Transfer Index (TTI) [4].

Results and Discussion

Each of the five species of fungi took up radiophosphorus to different extents from the incubation media (Table I) and this was probably due to them having different growth rates on alder leaf litter. AD ranged from 0.176 μCi/g

TABLE I

Labelled fungus and detritivores with their predators in enclosures.

P = predators present; NP = predators excluded. Nc = mean numbers of animals sampled on leaf packs in each enclosure; %L = % labelled animals; AD = mean activity density as μCi/g d.w.; TTI = trophic transfer index °. » = significant heterogeneity within distribution; * = significant difference between distributions joined by bar ($p < 0.05$); ns = not significant. χ^2-test.

Enclosures		A	B	C	D	E
Labelled fungi on leaf-packs		*Aspergillus niger*	*Cladosporium herbarum*	*Pytium proliferum*	*Penicillium cyclopium*	*Mucor mucedo*
		AD » 0.018	0.044	0.068	0.108	0.176
Asellus aquaticus	P	Nc ns 66	49	65	51	54 ns
		%L » 18	29	68	58	22 *
		AD » 3.3	4.1	2.4	3.1	6.1 *
		TTI » 183	93	35	29	37 *
	NP	Nc ns 54	52	62	67	76 —
		%L » 62	83	94	96	69 —
		AD » 13.2	14.1	21.1	30.1	28.3 —
		TTI » 733	320	310	279	161 —
Lymnaea peregra	P	Nc ns 25	18	30	24	27 ns
		%L » 76	62	—	18	74 *
		AD » 2.3	2.0	—	1.9	4.4 *
		TTI » 129	46	—	17	25 *
	NP	Nc » 18	23	21	26	15 —
		%L » 69	62	—	22	76 —
		AD » 1.9	1.5	—	1.9	4.1 —
		TTI » 105	33	—	17	23 —
Predators	P	Nc ns 15	14	16	17	10
		%L » 16	72	23	61	85
		AD » 0.01	0.18	0.01	0.32	1.00
		TTI » <.01	0.06	<.01	0.13	0.19

° = AD consumers/AD resources.

d.w. for *Mucor mucedo* to 0.018 μCi/g d.w. for *Aspergillus niger*; these species being respectively most and least abundant in the natural habitat at the time of the experiments. The AD and TTI of *A. aquaticus* were always greater than equivalent values for *L. peregra* (Table I). There was significant hetero-

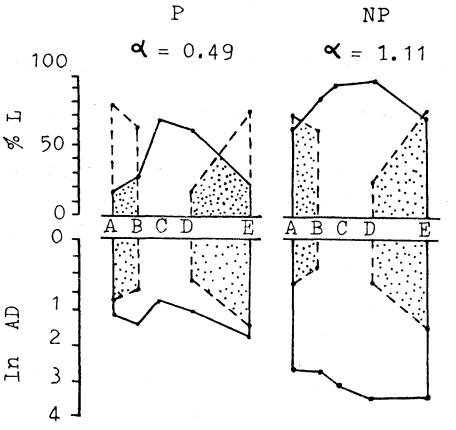

Fig. 1. – Trophic preferences (%L) and uptake of ^{32}P (lnAD), of native *A. aquaticus* (—) and *L. peregra* (– – –) with respect to 5 labelled fungi. The fungi (capital letters as in Table I) are ranked in according to AD of leaf packs. P = predators present; NP = predators excluded; α = coefficient of interspecific competition; the shaded areas are the food niche overlaps.

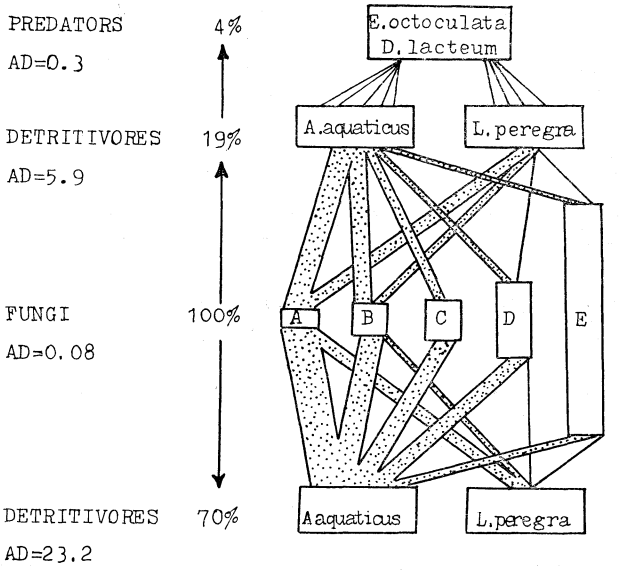

Fig. 2. – Transfer of ^{32}P along detritus food chains with predators present (upper) or excluded (lower) in R. Kelvin. The width of the lines indicate the extent of trophic transfer from food sources. AD = mean of ADs in the trophic level.

geneity in the % L of detritivores exposed to different labelled fungi (fig. 1) and this could be ascribed to differences in trophic preferences (trophic niches). The presence of predators caused a significant reduction in %L, AD and TTI of *A. aquaticus* (Table I). This was due to reductions in the trophic niche breadth and possibly in turn to restrictions in the mobility of the prey. Predators had less effect on *L. peregra*; mainly an increase in AD and TTI but no consistent effect on %L (Table I). There was a significant correlation between the ADs of the predators and those of *A. aquaticus* ($r = 0.92$, $p < 0.05$) but not those of *L. peregra* ($r = 0.02$ n.s.). Hence, through their effects on the detritivores and particularly on *A. aquaticus*, predators influenced the quantity and pattern of phosphorus transfer through the system (fig. 2). However, by reducing overlap in trophic niches (α, 1.11 $\rightarrow$ 0.49) the predators contributed to stable coexistence between detritivores. These results, support the model developed by Levin [5] about the mechanisms of coexistence in natural ecosystems and encourage further researches involving the use of radioisotopes to study the trophic niches of animals in detritus systems.

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