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EFFECT OF PREDATION ON SOIL MESOFAUNA: AN EXPERIMENTAL STUDY

1. Introduction

In hydrobiology studies involving biomanipulations have increased in recent years. Often these consist of changes in the nutrient levels /mostly phosphorus/ in water bodies, that are induced by manipulating the number of predators /Lynch and Shapiro 1981, Wright and Shapiro 1984, Gliwicz 1986/. It has been found that an increase in the standing crop of predatory fish indicates the series of responses. First the density of planktivorous fish declines. This is followed by an increase in large-sized, filter feeding zooplankton /cladocerans/ which effectively reduces the phytoplankton. With less phytoplankton phosphorus is stored in bottom sediments, resulting in a lower concentration in water.

These studies show that predation affects not only the numbers and composition of prey populations, but also the functioning of more distant trophic levels, including the size and composition of primary producers, and the nutrients upon which they depend.

The simplicity of aquatic ecosystems, especially in the pelagic zone makes studies of trophic relationships much easier than in most terrestrial systems.

It has been shown in soil ecosystems, that when rates of decomposition are low the biomass of predators is high in proportion to the total biomass of soil organisms. It is difficult to tell if this is an effect of low rates of decomposition or rather the cause.

I present results of an experiment that compares soil cores with no searching by predatory arthropods, with control cores having normal predator activity.

The effect of reduced predator access on density of soil mesofauna, abundance of microflora, and the rate of decomposition of plant material were examined.

Soil cores /surface area of 78 cm^2, 15 cm deep/ taken in a meadow were immediatly put into isolators and returned to original places so that their natural structure was not disturbed /40 cores of each treatment per plot/.

Two types of isolators were used. One was made of a dense nylon mesh screen that excluded macrofauna /E = predator excluded, close soil cores/ and the second type was made of the same screen but with openings cut, so that macrofauna could enter /P = predator present, open soil cores/.

The experiment was carried out over two growing seasons, from May to November, on drained fens managed as meadows, in the Biebrza valley. In the first year, the experiment was conducted on one meadow, in the second year it was replicated on three meadows. To facilitate comparisons, all the experimental soil cores were taken from the same meadow.

On five occassions in the first year, small pitfall traps made of glasstubes were inserted into the cores for a 2-3 day period to record numbers and species composition of the animals entering the isolators. In addition, Barber pitfall traps were placed near the isolators in both years.

To estimate the density of microarthropods 10 cm^2 samples were taken from the cores. Collembola and Acarina were extracted with Tullgren funnels. Macrofauna was extracted from whole experimental cores with a Kempson extractor.

To measure rates of decomposition 5 g dry grass litter were placed in nylon bags on the surface of soil cores. Mesofauna /Enchytraeidae, larval Diptera/ were extracted from the litter with wet funnels /O'Connor type/, and numbers of microflora were estimated using plate counts.

When the experiment ended, the soil from isolators was analysed for carbon content /Tiurin method/ and humus /Kononova and Bielchikova method/.

2. Results

2.1. Predators

I found significant differences in the intensity of predator searching between open /P/ and closed /E/ isolators /Tab. 1/. The number of predatory arthropods in the glass tube pitfall traps was over 20 times higher in the open /P/ isolators. Spiders were the dominant group accounting for 72.6 % of the predators. The other groups included Staphylinidae /8.4 %/, Carabidae /13 %/ and Formicidae /6 %/. In the Barber traps, the proportion of spiders was oven higher /86.9 %/.

Tab. 1. Locomotory activity and density of Araneae in soil cores located at Wizna fen.

	E Predator excluded	P Predator present
Mean number ± SE per trap per day	0.05 ± 0.04	1.56 ± 0.28
Mean number ± SE per core	0.0	0.38 ± 0.12

Dominant species: Pardosa palustris /L./, Erigone atra Bl., Oedothorax fuscus /Bl./, Oe. retusus /Westr./.

2.2. Mesofauna from the litter bags and soil

The density of mesofauna was higher in the isolators without predators /E/ /Tab. 2/. If these differences in

Tab. 2. Mean density ± SE of mesofauna in soil cores

Location	Type of isolator	Months VI	IX	X	XI
Wizna	E	54.67±15.64	110.24±21.82	57.13±13.21	54.60±14.39
	P	26.61± 7.95	90.70±22.61	50.90±13.39	41.80± 8.48
Lipniki	E	42.73±11.70	103.85±29.01	106.40±25.03	40.40±20.80
	P	40.06±12.19	97.23±22.01	57.00±22.54	35.80±9.96
Dolistowo	E	35.05±6.51	0.83±0.46	-	-
	P	18.34±2.94	0.33±0.30	-	-

E - predators excluded, P - predators present

mesofauna numbers were an effect of predation, three predictions can be made.

Differences in numbers of individuals between the two isolator types should:

1. depend on the density of mesofauna in closed isolators,
2. depend on the intensity of searching by predators,
3. not occur in the experimental series from which predators were removed.

ad. 1. Ratios of predator excluded to predator present densities /E/P/ were used, to characterize the rate of change occurring in open isolators as compared with closed ones. To analyse the effect of mesofauna density on this rate of change the E/P ratio was compared between the maximum and minimum density of individuals /Tab. 3/.

Tab. 3. E/P ratio of mesofauna at maximum and minimum density in E soil cores

Group	Maximum density in E	E/P	Minimum density in E	E/P
Enchytraeidae	42.1	2.76xx	1.29	1.50
Acarina	58.9	2.05xx	4.0	0.63
Sminthuridae	7.2	1.84	0.20	0.10
Entomobryidae	50.9	3.85xxx	1.29	0.88
Diptera /larvae/	35.0	6.59xx	0.86	0.22xx

Differences tested by t test. Levels of significance: x $p < 0.05$, xx $p < 0.01$, xxx $p < 0.001$

After reaching peak numbers, the density in open isolators declined at the highest rate. In all those cases the E/P ratio was greater than 1, and the density was significantly higher in the predator excluded isolators /Tab. 3/. Only for Sminthuridae a group in which maximum numbers were low, were differences between E and P not significant.

At minimum densities numbers of mesofauna were not significantly larger in isolators E, and only in one case was E/P greater than 1 /Tab. 3/.

ad. 2. Analysis of the relationship between the rate of change /E/P ratio/ and the intensity of searching by predators is complicated by the fact that the locomotory activity of predators is negatively correlated with prey density. When feeding conditions are good locomotory activity of predators is reduced /Grüm 1971, Kaczmarek 1978/. Thus, to analyse the effect of searching on the rate of change in open isolators, prey density should be kept constant. For this reason only the most frequent range of densities was considered /16-40 individuals per isolator/, all extreme densities being excluded. Acarina and Collembola were selected for this analysis and considered jointly as one group. In addition, I analysed Acarina separately. The relationship between the intensity of searching by predators and the E/P ratio /Kendall rank correlation coefficient/was significant /Siegel 1956/ in both cases /Fig. 1/.

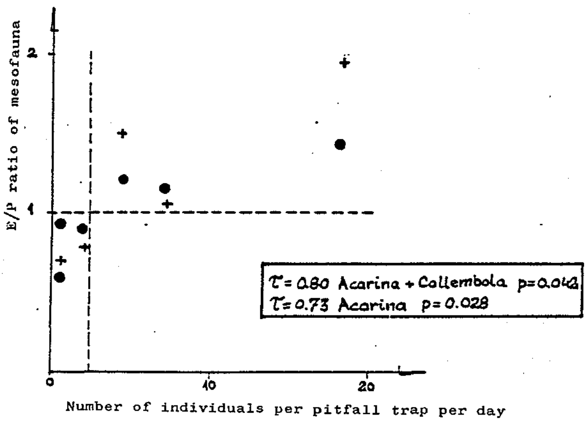

Fig. 1 Relationship between locomotory activity of predators and E/p ratio of mesofauna

E - number of individuals in predator excluding soil cores
P - number in soil cores with predators present
● - Acarina
\+ - Acarina and Collembola

I found that at low intensities of predator searching, /0.7 - 2.0 ind. per Barber trap per day/ the E/P ratio was <1, and when the locomotory activity increased, the E/P ratio tended to be higher /Fig. 1/.

ad. 3. In an analogous experiment carried out several years earlier, permanent glass-tube pitfall traps were inserted in two series of isolators to catch predators. In the series with these traps no characteristic differences in numbers of mesofauna were observed between open and closed isolators. If numbers in closed isolators are taken as 100 %, then they were 38 % in the open series without traps and 105 % in the open series with traps /Kajak and Jakubczyk 1976/.

This analysis of conditions in which the density of mesofauna in open isolators declines provides evidence that differences in numbers were caused by the exclusion of predators entering the open isolators.

Tab. 4. Density of Collembola in soil cores

Species	E predators excluded	P predators present	E/P
Isotoma viridis Bourl.	2.45 ± 0.90	0.51 ± 0.11	4.80^x
Isotoma notabilis Schöff.	0.60 ± 0.25	0.05 ± 0.23	12.0^x
Sphaeridia pumilis /Krausb./	1.48 ± 0.90	0.42 ± 0.17	3.44
Folsomia quadrioculata /Tullb./	1.66 ± 0.40	0.74 ± 0.20	2.24
Ceratophysella armata /Nic./	0.75 ± 0.27	0.37 ± 0.14	2.03
Sminthuridae juv.	0.54 ± 0.27	0.31 ± 0.18	1.74^x
Hypogastrula manubrialis /Tullb./	0.90 ± 0.43	0.02 ± 0.02	45.0
Onychiurus armatus /Tullb./	3.45 ± 1.04	2.51 ± 0.59	1.37

x $p < 0.05$

The species composition and the body size distribution of Collembola were analysed in detail to find out whether the predation accounts for changes in the proportions of different size classes. I compared the size distribution in the E isolators to size distribution of individuals removed by predators /E-P/. However, no significant differences were found /χ^2 = 0.019, p $>$ 0.05/. All dominant Collembola species, independent of their body sizes, were characterized by E/P $>$ 1 /Tab. 4/.

2.3. Microflora abundance and the rate of litter disappearance

The next step was an analysis of the consequences of reduced density of mesofauna on other components of the ecosystem such as numbers of microflora and the rate of decomposition. Differences in the abundance of microflora were not identical in the 3 meadows. On the Wizna fen, all the analysed microflora groups were more abundant in closed isolators. On the other meadows, similar differences occurred in the groups of ammonifying bacteria and cellulolytic microorganisms, but this was not the case for the other groups of microflora.

It turned out that with higher E/P of mesofauna, there were grater differences in numbers of microflora, between experimental and control soil cores.

When the E/P ratio of the mesofauna was $<$1, the E/P ratio of microflora was close to 1. With increasing E/P ratios of mesofauna E/P of microflora increased also. Thus when mesofauna is reduced, differences in microflora abundance increased between the two isolator types. The relationship between the E/P ratio of mesofauna and the E/P ratio of microflora abundance is significant /Fig. 2/.

I also found that the plant litter was decomposed at a lower rate in isolators available to predators. On two sites /Wizna, Lipniki/ more litter and organic /not mineralized/ nitrogen remained at the end of the experiment in isolators P as compared with those closed to predators.

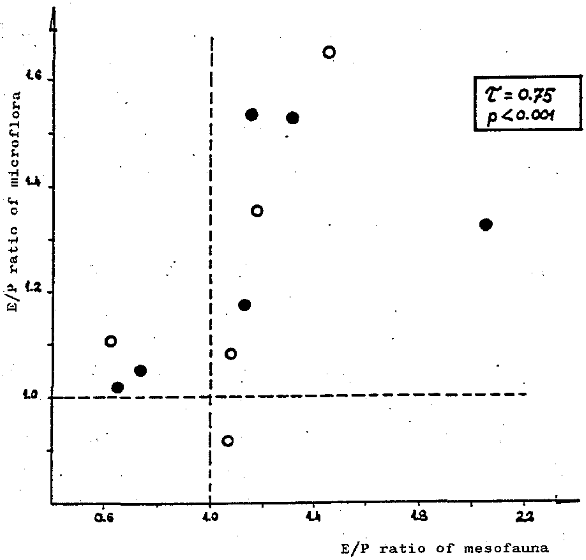

Fig. 2 Relationship between ratio of mesofauna and microflora

E - number of individuals in predator excluding soil cores
P - number of individuals in soil cores with predators present
o - total mesofauna and microflora
● - Acarina and ammonyfying bacteria

The analysis of the amount of litter and nitrogen remainimg in the bags also shows that the E/P ratio of the mesofauna is correlated with an increasing amount of undecomposed plant material / τ = 0.80, $p < 0.01$/. Also the content of humus in the soil was significantly higher at the end of the experiment in the cores available to predatory arthropods / $p < 0.05$/.

3. Conclusions

The results of this experiment indicate that predatory epigean arthropods can reduce numbers of soil mesosaprophages. This reduction is followed by a series of consequences. These involve a decrease in numbers of microflora /ammonifying bacteria, cellulolytic microorganisms/, a reduced rate of organic decomposition, and a small increase in the humus content in the soil.

The rate of reduction in the density of mesosaprophages increases with increasing density and frequency of searching by predators.

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