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Effects of irrigation on the protozoan fauna of a spruce forest

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Synopsis

Mit einer direkten Zählmethode wurde im Herbst 1985 die Auswirkung von Bewässerung auf die Mikrofauna eines Fichtenwaldbodens unter Freilandbedingungen untersucht. Die Bewässerung führte in 0-3 cm Bodentiefe zu einer beträchtlichen Abnahme der Abundanz der aktiven Ciliaten. Die Artenzahl stieg jedoch, ebenso wie bei den Testaceen. Deutliche Unterschiede im Artenspektrum waren weder bei den Ciliaten noch bei den Testaceen nachweisbar. Die Abundanz der Testaceen und der Rotatorien erhöhte sich nur geringfügig, während jene der Nematoden stark anstieg ($p < 0.01$). In der Bodentiefe von 3-9 cm unterschied sich der Wassergehalt der Versuchsfläche kaum von dem der Kontrollfläche. Dementsprechend fanden sich auch in der Besiedlung keine wesentlichen Unterschiede. Diese Ergebnisse deuten darauf hin, daß der Bodenwassergehalt im Fichtenwald-Ökosystem kein primär limitierender Faktor für die Abundanz der Protozoen und Rotatorien ist. Allerdings treten mit zunehmender Bodenfeuchte mehr Arten von aktiven Ciliaten und belebten Testaceen auf.

Ciliates, irrigation, nematodes, rotatorians, spruce forest soil, testaceans.

1. Introduction

Soil humidity is widely believed to control the abundance and species composition of terrestrial protozoa. Experimental data, however, are weak and conflicting and concern mainly naked amoebas and flagellates (FOISSNER 1987). In addition, most studies have been done with rather unreliable culture techniques. Therefore, we performed an irrigation experiment under field conditions and estimated the microfauna (ciliates, testaceans, nematodes, and rotatorians) with a direct counting method.

2. Material and methods

The two plots investigated, each 15 m^2 in size, are situated close to each other in a spruce forest (age of the trees about 100 years) near Aigen (Upper Austria), 860 m above sea level. The 0-3 cm layer consists of fresh and slightly decomposed needles (L- and F-layer), the 3-9 cm horizon is raw humus (H-layer). One plot served as untreated control, receiving only natural rain, the second plot was irrigated every 4th day at a rate of about 25 l/m^2. Spring water (not chlorinated) from a nearby water supply station was used. Whenever it rained the night before watering, an adequate amount of water was subtracted from the subsequent irrigation to get a more constant soil moisture level.

6 hours, 1 day and 3 days after each irrigation, 5 subsamples from 0-3 and 3-9 cm depth of each plot were randomly taken. After mixing each subsample, 0.1 g fresh soil was suspended in a soil extract of a few ml and immediately investigated under the microscope at 40x magnification for active ciliates, nematodes and rotatorians. For testaceans, 0.5 g soil (0.1 g of each of the 5 subsamples) was stained with phenolic anilinblue. After a series of dilutions, 0.005 g soil was examined at 100x magnification. The study was carried out between September and early November 1985. The 3-9 cm layer was investigated only during the first 10 days of the study.

The experimental data were tested for differences with an analysis of variance (ANOVA, type 1) or with the U-test of Mann-Whitney (KÖHLER et al. 1984).

3. Results

The moisture content in the 0-3 cm layer of the irrigated plot was on the average about 9% higher than in the control ($p < 0.05$). Surprisingly, the irrigation led to a considerable decrease of active ciliates in this horizon ($p < 0.1$, Tab. 1). This was already evident after the first irrigation, which was carried out after 5 days of dryness ($p < 0.1$; 422 active ciliates/g dry mass, soil moisture 37.3% compared with 612 individuals, soil moisture 28.8% in the control; $n = 3$). There was, however, no difference at $p < 0.1$ between the single sample dates (H-test of Kruskal-Wallis, KÖHLER et al. 1984) which is probably due to the high standard deviations. Irrigation slightly increased the abundance of testaceans and rotatorians ($p > 0.2$) but a marked effect was evident only on nematode numbers ($p < 0.01$, Tab. 1). The species number of the ciliates ($p < 0.005$) and living testaceans ($p < 0.1$) increased with irrigation (Tab. 1). Cluster analysis of the ciliate and testacean species comprising the irrigated communities showed no distinct differences to the control.

In 3-9 cm soil depth, the moisture content of the irrigated plot and the control were not essentially different ($p > 0.1$). Likewise, there were no conspicuous differences in the microfauna (Tab. 1).

Tab. 1: Summary of data (arithmetic mean ± standard deviation). Values followed by the same letter affix are not different. Abundances are given as individuals/g dry mass of soil.

Parameters	Soil depth (cm)	Irrigated	Control	n	Test
Soil moisture	0-3	50.0^a ±9.9	41.3^b ±12.6	15	ANOVA ($p<0.05$)
(% wet mass of air-dried soil)	3-9	48.8^a ±4.3	44.7^a ±5.9	8	ANOVA ($0.2>p>0.1$)
Ciliates					
abundance	0-3	311^a ±141	489^b ±258	15	U-test ($0.05<p<0.1$)
	3-9	10^a ±10	14^a ±24	8	U-test ($p>0.2$)
species number	0-3	12.8^a ±4.5	8.4^b ±3.3	15	ANOVA ($p<0.005$)
	3-9	2.4^a ±2.1	1.6^a ±1.9	8	U-test ($p>0.2$)
Testaceans					
abundance					
living	0-3	22203^a ±7040	17908^a ±3175	4	ANOVA ($p>0.2$)
empty tests	0-3	361720^a ±17204	319081^a ±58390	4	ANOVA ($p>0.2$)
species number					
living	0-3	11.5^a ±1.3	9.8^b ±1.0	4	ANOVA ($0.05<p<0.1$)
total	0-3	18.0^a ±0.0	19.8^a ±2.2	4	U-test ($p>0.2$)
Nematode abundance	0-3	1197^a ±349	824^b ±349	15	ANOVA ($p<0.01$)
	3-9	308^a ±80	391^a ±173	8	ANOVA ($p>0.2$)
Rotatorian abundance	0-3	227^a ±88	181^a ±122	15	ANOVA ($p>0.2$)
	3-9	38^a ±25	31^a ±18	8	U-test ($p>0.2$)

4. Discussion

The marked decrease in the abundance of the active ciliates in the upper layer of the watered site contrasts laboratory and field experiments of SZABO et al. (1964) and DETCHEVA (1972) who reported increasing ciliate numbers with increasing soil moisture. Despite the high amount of water irrigated, washing out of a greater number of active ciliates into underlying layers is very unlikely because no increase was observed in 3-9 cm depth. The difference to the study of DETCHEVA (1972) could have methodological reasons because a rather unreliable culture method had been used there for abundance estimation.

Testacean abundance showed no marked response to increased humidity in 0-3 cm depth which is probably caused by an insufficient number of samples. This is, however, not too unexpected, if one considers the results of LOUSIER (1974a, b). Generally, he found an increased number of testaceans in a very dry aspen woodland after irrigation, but numbers of total living individuals were different from the control only in about half of the tested areas.

The nematode numbers increased by about 45% ($p < 0.01$) in the 0-3 cm horizon of the watered plot suggesting that they prefer a higher soil humidity.

These results indicate that the soil moisture content in the spruce forest ecosystem is not the main limiting factor for the abundance of protozoa and rotatorians. However, the species number of the active ciliates and living testaceans increased in the irrigated plot suggesting that certain species need a higher soil moisture content which occurs generally only for short periods after rainfall.

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