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Springtails (Collembola, Hexapoda) inhabiting algae with different degrees of waste product contamination

Summary

The study was carried out in July 2009 in Murmansk (68°57' N; 33°03'E) and involved algae that had washed up at the edge of the intertidal zone of Kola Bay. Two areas of algae were selected for this study: uncontaminated (algae I) and algae contaminated with waste products (algae II). The material was collected using a frame with an area of 100 cm^2. A total of 40 samples were taken. The abundance of the springtails was almost three times lower in the contaminated algae than in the uncontaminated algae, whereas the species diversity of the springtail communities was much higher in the contaminated algae. The littoral species *Hypogastrura viatica* was the dominant species in the uncontaminated algae, and that in the contaminated algae was the cosmopolitan species *Folsomia quadriuculata*. It appears that the contamination of the algae with waste products can promote the intensification of competition among springtails and between springtails and other saprophagous invertebrates.

Key words: algae, springtails, waste products

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1. Introduction

Springtails, grazing bacteria, and fungi modify their growth and thus indirectly influence mineralization and humification processes (Lussenhope 1981). Springtails belong to one of the most important groups of invertebrates that inhabit subpolar and polar areas (Babenko 2012). Despite the abundant literature about Arctic areas, relatively few studies have referred to springtails, especially those inhabiting washed up algae (Sveum 1986, Urban-Malinga, Burska 2009).

The aim of this study was to inventory the local springtails inhabiting the algae at the edge of the intertidal zone and to compare the collembolan communities of the uncontaminated algae with those of the algae contaminated with waste products.

2. Methods

The study was carried out in July 2009, in Kola Bay, in Murmansk (68°57'N; 33°03'E). The climate of the region is rather mild because of the Gulf Stream. The warmest month is July, with an average temperature of approximately 2–14°C, and the coldest month is February, with an average temperature of approximately 10°C (Koroleva 1994). The annual average precipitation ranges from 400–500 mm (Żurek 2009). There is snow cover from October until the end of April. During the study period, the weather was very changeable, with temperatures ranging from 10°C to as high as 25°C (authors' measurements); additionally, there was short-term rainfall. Murman is surrounded by boreal forest, which changes to birch forests to the north and tundra on the coast.

The study involved the algae washed up at the edge of the intertidal zone of Kola Bay. Two areas that differed in the degree of contamination with waste products – such as food debris, pieces of wood and plastic waste, and fishing nets – were selected for study. The first area was characterized by a relatively low contamination of algae, located in the suburbs, in the place poorly visited by people (uncontaminated algae – algae I), whereas the second area was located near the port, and the contamination of algae with waste such as food debris, pieces of wood, and plastic containers was high (contaminated algae – algae II).

The material for this study was collected using a frame with an area of 100 cm^2. During each sampling, 20 samples were taken from each study site, for a total of 40 samples. The springtails were extracted in a modified Tullgren's apparatus, and the species were determined using Fjelberg's keys (1994, 1998, 2007).

To compare the numbers of springtails, the nonparametric Wilcoxon matched pairs test was used because of the non-normal distribution, even after logarithmic transformation.

The species diversity of the springtail communities was measured using the Shannon-Weaver index (1963), and the statistical significance of the index values was estimated using the Hutcheson test (1970).

3. Results and discussion

The densities of the collembolan communities of the two study areas were significantly different (p=0.02). In the case of the algae contaminated with waste products, the abundance of the springtails was almost three times lower than the abundance in the uncontaminated algae (Table 1)

Table 1. Dominance structure (% of the total number of individuals), density (thousands ind. m^{-2}), standard deviation (SD) and species diversity (value of Shannon-Wiener H' index) of the springtail communities in the studied sites (algae I – uncontaminated algae, algae II – algae contaminated with waste products).

No	Species	Algae I	Algae II
1.	*Hypogastrura viatica*	55.2	10.0
2.	*Friesea mirabilis*	0	2.3
3.	*Micranurida pygmea*	4.0	0
4.	*Anurida granaria*	0	3.8
5.	*Neanura muscorum*	3.4	0
6.	*Xenylodes armatus*	0.6	1.5
7.	*Oligaphorura ursi*	0	1.5

8.	*Protaphorura bicampata*	5.5	10.8
9.	*Tetracanthella arctica*	0.6	0
10.	*Folsomia quadrioculata*	29.6	45.4
11.	*Isomiella minor*	0	2.3
12.	*Pseudisotoma sensibilis*	0	3.1
13.	*Parisotoma notabilis*	0	3.1
14.	*Isotoma anglicana*	1.1	10.0
15.	*Lepidocyrtus lignorum*	0	5.4
16.	*Sminthurinus concolor*	0	0.8
	Density (thousands ind.m^{-2})	19.4[1]	7.8
	SD	17.3	7.6
	Value of H' index	1.73[2]	2.73

[1] statistical significance $p = 0.02$, [2] statistical significance $p < 0.0001$

Springtails are saprophagous and feed on dead organic matter, bacteria, fungi, or algae and plant food (Bødvarson 1970, Butcher *et al*. 1971, Sveum 1986, Gunn Cherrett 1993, Zwart *et al*. 1994, Chauvat, Wolters 2014). Thus, it was expected that there would be a higher number of springtails in the algae contaminated with waste products because the waste could be an additional source of food for these arthropods. The large amount of organic matter in the contaminated algae can promote the growth of bacteria and fungi, which in turn increases the number of springtails. Researchers have emphasized the relationship between Collembola and microflora and fungi (including Usher *et al*. 1982, Bardgett *et al*. 1993). For example, Sveum (1996) found that the grazing of Collembola could influence bacterial activity. Chauvat and Wolters (2014) showed that overgrazing by springtails may reduce both the biomass and growth of fungi. Consequently, limiting the growth of bacteria and fungi can lead to a decrease in the number of collembolans. Perhaps in the algae contaminated with waste products, the potentially large amount of food was reduced due to the excessive use by springtails, which could have caused the decrease in their numbers.

It is likely that the competition for food could affect the number of springtails. Huhta *et al.* (1988) showed the effect of springtails on other soil organisms. The possibility cannot be ruled out that the competition for resources was stronger in the contaminated algae because the springtails were competing not only with each other but also with other saprophagous species. This heightened competition for food could have caused a decrease springtails density, which could have contributed to their lower numbers in the contaminated algae.

The decrease of the density of springtails in the contaminated algae could also be the result of increased predator activity. It is known that predator activity is connected with environmental heterogeneity. It is likely that the contamination of the algae with waste products could contribute to increase the diversity of the environment and could thus contribute to the activity of predators.

The springtail community of the uncontaminated algae was composed almost entirely of one littoral species, *Hypogastrura viatica* (Table 1). In contrast, the springtail community of the algae contaminated with the waste products was dominated by the cosmopolitan species *Folsomia quadrioculata* (Table 1). Both species feed on, among others, the microflora that inhabit algae (Sveum 1996, Cole *et al.* 2004). Sveum (1996) showed the effect of *Hypogastrura viatica* on the growth of the microflora inhabiting algae. Cole *et al.* (2004) observed the reduction of the microbial biomass when high densities of *Folsomia quadrioculata* were present. It seems that both species could compete with each other and that the cosmopolitan *Folsomia quadrioculata*, which easily adapts to changing environmental conditions, could displace the littoral *Hypogastrura viatica*.

Of course, the species composition of the springtail communities inhabiting the algae could be the result not only of the contamination of the algae with the waste products competition or species plasticity but also of their passive dispersion, mainly by wind, because the Murmansk region is characterized by strong winds (Babenko 2012).

In contrast to their number, the species diversity of springtails was higher in the contaminated algae than in the uncontaminated (Table 1). In this study, the species diversity of springtail communities inhabiting the algae could be associated with the heterogeneity of the environment. It is suggested that the heterogeneity of the environment and the availability of food have a positive effect on the species diversity of the springtails (Anderson 1978, Sgardelis, Margaris 1993). The algae contaminated with waste products was not only a source of food but also provided a varied environment for the springtails.

In conclusion, it appears likely that the contamination of algae with waste products may

- Influence the springtails' density and diversity
- Modify species composition. Littoral species are replaced by cosmopolitan species, which are widely distributed and easily adapt to the environmental conditions.

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