

Status of collembolans (Collembola) on Surtsey, Iceland, in 1995 and first encounter of earthworms (Lumbricidae) in 1993

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ABSTRACT

The distribution of collembolans was studied in plots of five different plant successional stages outside and inside the gull colony on Surtsey in 1995. Six species of collembolans were found, three of them new to the island. The dominant species were *Mesaphorura macrochaeta* outside the colony and *Hypogastrura purpureescens* inside it. In sparsely vegetated areas outside the gull colony 0 - 935 individuals m⁻² of collembolans were found on the average but in the more developed grass swards inside the colony the density was much higher or 17,680 - 74,724 individuals m⁻². The total C and N levels of the soil in the gull colony were higher than in plots outside the colony. The gull colony on Surtsey with its nutrient enrichment has had an impact on the development of the soil fauna.

In 1993 the first earthworms were found on Surtsey when two juveniles of the species *Lumbricus castaneus* (Sav.) were extracted from soil samples taken in the gull colony. In spite of a thorough search and sampling on the island in 1995 earthworms were not reencountered.

INTRODUCTION

Colonization of soil fauna has not been closely studied on Surtsey but detailed surveys of the occurrence of mites and collembolans were made by Lindroth *et al.* (1973), Bødvarsson (1982) and Ólafsson (1978). In the first ten years after the formation of the island collembolans were found at and near the coastline but when vegetation development began upon the island the collembolans were also found there (Bødvarsson 1982). In 1986 and the following years a distinct gull colony was formed on a lava terrain on the southern part of the island. The formation of the gull colony was a turning point in plant colonization and influenced the development of the ecosystem due to enrichment of the soil by the gulls (Fridriksson 1994, Magnússon *et al.* 1996).

Collembolans together with the mites, enchytraeids and nematodes constitute the soil meso-

fauna. Collembolans live in the air-filled pore system of the soil and cannot make their own burrows like larger soil animals (macrofauna) as earthworms. Collembolans and earthworms also inhabit the litter layer at the soil surface.

The aim of the study, which was carried out in 1995, was to describe the collembolans at five different plant successional stages on Surtsey and to see if gulls were having an impact on the soil fauna. A second aim was to investigate if earthworms found on the island in 1993 had managed to survive.

STUDY AREA

The soil fauna was investigated by taking soil samples from 5 plots, 3 x 3 m in size, in the vicinity of permanent vegetation study plots (Magnússon *et al.* 1996) on the southern part of the island (Fig. 1). The sampling was carried out on July 19, 1995.

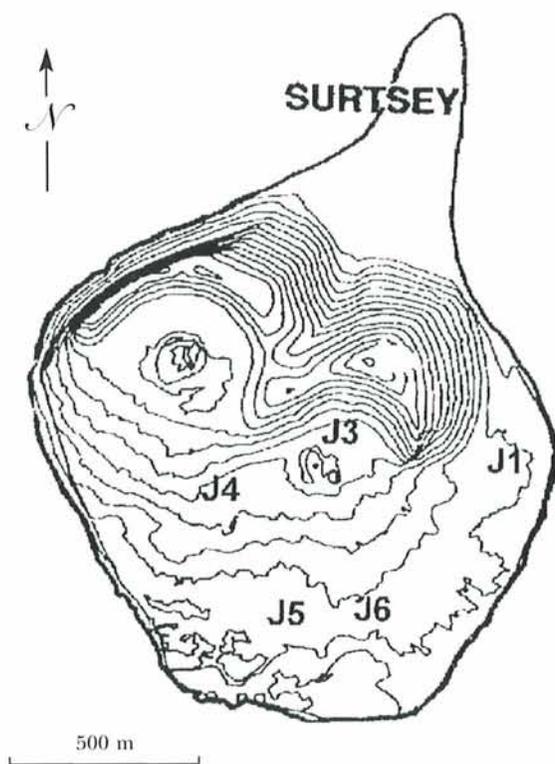


Figure 1. Location of the soil fauna plots on Surtsey.

Unvegetated reference plot (J4).

The plot was considered as a base-line reference. The plot was on mostly unvegetated sand. Only 4-5 seedlings of *Honkenya peploides* were found within the plot. The plot was approximately 200 m northwest of the permanent plot no. 11 in the crater area.

Honkenya plot (J3).

The plot was grown with developed *Honkenya peploides* colony on sand. The plot was 36° and 12 m northeast of permanent plot no. 12 in the crater area.

Honkenya-Leymus plot (J1).

The plot was grown with developed *Honkenya peploides* colony and *Leymus arenarius* on sand. The plot was 160° and 27 m south of permanent plot no. 13 on the easternmost part of the island.

Young gull colony plot (J5).

The vegetation was dominated by *Honkenya peploides*, *Poa pratensis*, *Puccinellia retroflexa*, *Cochlearia officinalis* and *Stellaria media*. The plot was 318° and 22 m south of permanent plot no.1

within the gull colony on the southern part of the island.

Old gull colony plot (J6).

Vegetation association of *Puccinellia retroflexa* and *Poa annua*. Compact layer of roots and plant residues on top of a flat lava terrain. The plot was 54° and 21 m south of permanent plot no. 6 in the old gull colony on the southern part of the island.

METHODS

Soil fauna sampling

Ten random soil samples were taken in each plot with a soil corer (7 cm diameter) down to 5 cm depth. Within 3 days the collembolans and mites were extracted from the soil separately in a modified Macfadyen high gradient extractor kept running for 8 days, during which time temperature was increased from 10 to 60°C (Sigurdardóttir 1990). Total number of collembolans was determined. A small subsample of specimens from different samplings and plots was sent to Dr Arne Fjellberg, Norway who identified them to species. The aim was strictly to ascertain which species were dominant in the plots and no attempt was made to find difference in species composition between plots. Extracted mites were sent to Dr Peter Gjelstrup, the Natural History Museum, Aarhus, Denmark. Enchytraeids were also extracted from the soil samples but not identified to species.

In the annual expedition of plant ecologists to Surtsey, soil samples were taken in the gull colony with a soil corer (7 cm diameter) down to 5 cm depth, on August 15, 1993. Earthworms were extracted from the soil separately in a modified Macfadyen high gradient extractor as described above.

Soil sampling

Three random samples were taken in plot J1, J5 and J6 with a soil corer (7 cm diameter) down to 5 cm depth and mixed for each plot. The samples were sieved through 2 mm mesh and dried at 40°C. Organic carbon content (% C) and nitrogen (%N) content was determined.

RESULTS

Collembolans

Five species of collembolans were found in the plots on Surtsey in 1995 and one species in *Racomitrium*-moss in the crater Gamli Surtur on Surtsey. Four of these six species have not been

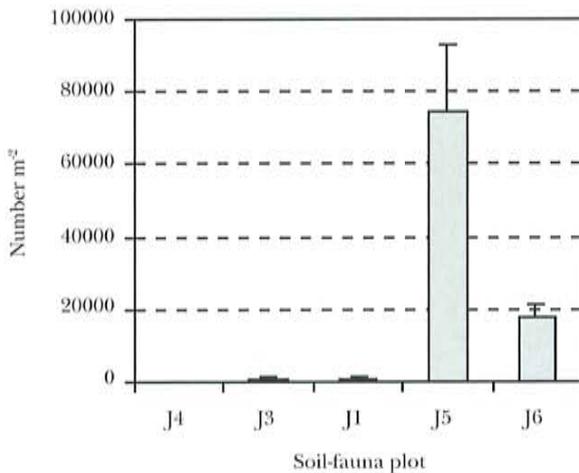


Figure 2. Number of collembolans per square meter found in plots of different plant successional stages outside and inside the gull colony on Surtsey in 1995 (mean SD). J1= *Honkenya-Leymus* plot, J3= *Honkenya* plot, J5= Young gull colony plot with *Honkenya* and grasses and J6= Old gull colony plot with a dense grass sward. No collembolans were found in the unvegetated reference plot, J4.

found previously on the island. The dominant species in the plots outside the gull colony were *Mesaphorura macrochaeta* and *Hypogastrura purpurescens* in the plots inside the colony (Fjellberg 1980). Four of the species listed in Table 1 were also found in samples taken by Gjelstrup (2000) on the same expedition, who found two additional species in the plots.

Abundance of collembola is summarized in Fig. 2. There was a great difference in the average number of collembolans inside and outside the gull colony.

No collembolans were found in the unvegetated reference plot J4, but in plot J3 and J1 a

density of 806-936 individuals m⁻² was found. Within the gull colony, on the other hand, the density was 74,724 and 17,680 individuals m⁻² in plots J5 and J6 respectively. Enchytraeidae were found in all plots except the unvegetated reference plot, J4.

Earthworms

In soil samples taken in the gull colony in 1993, earthworms were found for the first time on Surtsey. Two approximately 3 cm long juvenile individuals of the species *Lumbricus castaneus* (Sav.). This species is usually found in the litter layer and soils with high organic content (Sims & Gerard 1985). No earthworms were found on Surtsey in July 1995 in spite of a thorough search and sampling of the same area.

Soil fertility

Soil samples taken in the fauna plots in 1995 and in the permanent vegetation study plots in 1998 revealed that the total C and N levels in the gull colony were much higher than in plots outside the colony (Table 2).

DISCUSSION

The numbers of collembolans in the gull colony were considerably higher compared to the plots outside the colony where the soil was not as developed, has lesser microbial activity and vegetation cover (Magnússon 1992, Frederiksen *et al.* 2000, Magnússon & Magnússon 2000). The gulls no doubt enrich the soil and vegetation by depositing droppings that have high content of nutrients (Sobey & Kenworthy 1979). The abundance of collembolans in the colony is surprisingly high considering the

Table 1. Collembola species found on Surtsey in 1995. J1= *Honkenya-Leymus* plot, J3= *Honkenya* plot, J5= Young gull colony plot with *Honkenya* and grasses and J6= Old gull colony plot with a dense grass sward. No collembola were found in the unvegetated reference plot, J4.

Species	Plots outside the gull colony		Plots inside the gull colony		<i>Racomitrium</i> in Gamli Surtur crater
	J3	J1	J5	J6	
<i>Ceratophysella succinea</i> [§]	X	X			
<i>Hypogastrura purpurescens</i> [§]		X	X [†]	X [†]	
<i>Mesaphorura macrochaeta</i> [§]	X [†]	X [†]			
<i>Isotoma anglicana</i> [§]		X	X	X	
<i>Isotoma notabilis</i>		X	X	X	
<i>Folsomia brevicauda</i>					X

[§] Species of Collembola not found previously on Surtsey.

[†] Dominant species.

Table 2. Chemical properties of soil outside and inside gull colony (sampling depth 5 cm and 10 cm*).

Plot	C%	N%
Outside gull colony:		
Plant plot 11* (near J4)	< 0.105	< 0.004
Plant plot 12* (near J3)	< 0.105	< 0.004
<i>Honkenya Leymus</i> , J1	< 0.105	0.07
Inside gull colony:		
Young gull colony, J5	0.5	0.34
Old gull colony, J6	3	1.62

* Results from Magnússon & Magnússon 2000.

young age of the island and can be compared to numbers of collembolans extracted from grasslands in southern Iceland (Sigurdardóttir 1998). The low numbers of collembolans in plots outside the bird colony is comparable to numbers found in eroded areas in Iceland with sparse vegetation cover (Sigurdardóttir 1990, Sigurdardóttir unpublished).

There is no simple answer to the question how the earthworm, *Lumbricus castaneus*, in the gull colony was dispersed to Surtsey. Most likely they were dispersed by birds from the other islands or from the mainland of Iceland. Earthworms will not survive going through the digestive tract of gulls and it is doubtful that they have dispersed directly to the island as juvenile or adult individuals. On the other hand it is potential that gulls have carried earthworm cocoons, clinging to dirt on their feet or feathers, with them to the island. The gull species (*Larus fuscus* and *L. argentus*) most abundant in the gull colony on Surtsey are frequently seen in grasslands, hayfield and heathland in Iceland foraging on insects and earthworms (Magnússon & Magnússon 2000). *Lumbricus castaneus* has also been found on Heimaey on the Westman Islands (Lindroth *et al.* 1973) and in Skaftafell in southern Iceland (Fig. 3). Altogether eleven earthworm species have been found in Iceland (Sigurdardóttir 1994). Enchytraeides were found in all plots but the unvegetated reference plot, J4 and were first discovered on Surtsey in 1972 (Ólafsson 1978). The Macfadyen high gradient extractor method does not ensure a detailed assessment of numbers of enchytraeides so no attempt was made to find difference in number between plots.

Collembolans and earthworms are part of the decomposition food web and their consumption of dead plant material leads to fragmentation,



Figure 3. *Lumbricus castaneus* found in Skaftafell in Southern Iceland.

thereby increasing the availability of this material to microorganisms. Their activity leads to release of nutrients into the soil where they become available to plants and microorganisms. It is obvious that the gull colony on Surtsey, with its nutrient rich habitat, has had an impact on the soil fauna that has managed to disperse and to develop on the island. In this fragile environment the soil fauna will no doubt change considerably through time. It is of interest here that slugs were found for the first time on Surtsey in 1998 and they were also present in 1999. The slugs were found in a dense grass sward in the gull colony. Identification to species has not been carried out, but the specimens found on Surtsey are similar to slugs commonly found in moist grassland and gardens in southern Iceland (Magnússon & Magnússon, personal communication).

Many questions concerning development and succession of the soil formation and soil fauna on Surtsey and its possible interaction with the vegetation and gull colony development still remains a challenging subjects for future research.

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