Soil mites and collembolans on Surtsey, Iceland, 32 years after the eruption

PETER GJELSTRUP
The Natural History Museum, Aarhus, Denmark.

ABSTRACT

This paper represents a field study of mites and collembolans on the 32 year old eruptive island Surtsey, 30 km south of Iceland. The data were collected in July 1995. Five squares, each 3x3 m^2 were investigated, representing different successional communities on the island. Mites were the most numerous soil arthropods followed by collembolans. 80,000-240,000 mites and 68,000-97,000 collembolans per m^2 were found in and close to a gull *(Larus argentatus)* colony, dominated by the grasses *Puccinellia retroflexa*, the common meadow grass (*Poa pratensis*) and the plant common scurvy-grass *(Cochlearia officinalis)*. In a pioneer community dominated by the sea purlane *(Honkenya peploides)* and the sea lyme grass *(Leymus arenaria)* about 190,000 mites and 10,000 collembolans per m^2 were collected. Oribatid mites (Oribatida) were unexpectedly represented on Surtsey with 22 species, two of the species may have arrived from North America (Nearctic). All other species found on Surtsey most likely have spread from Iceland or Western Europe.

INTRODUCTION

Lindroth *et al.* (1973) listed the mites found on Surtsey in the period from 1963-1970, (see Table 1). A survey of the occurrence of collembolans found on Surtsey in the period from 1963-1978 was made by Bödvarsson (1982). The first registration of mites on Surtsey was in 1965 and it was found on a Orthocladiin midge (fly). The first Oribatid mite (Oribatida) was found in 1966 on driftwood. The first collembolans were found on the shore in 1967 and apparently they had floated to the island on the sea. New mites and collembolans arrived each year. Most of the firstly appearing mites were found on flies and in connection with the little hut on Surtsey, whereas all collembolans collected in the period from 1965-1972 were found in connection with the shore. However, in 1976 collembolans were for the first time found in mossy vegetation on the southern lava fields far from the shore (Bödvarsson 1982).

Lindroth *et al.* (1973) and Bödvarsson (1982) found 16 species of mites and 16 species of collembolans on Surtsey. Mites most likely have arrived to the island by flies, birds, driftwood, the wind (in stormy weather) or even by man, whereas collembolans may have arrived either by the sea, the birds or the wind. However, a permanent soil fauna was not observed. Therefore it was a big challenge to investigate the soil fauna on Surtsey in July 1995.

METHODS

The soil fauna was investigated by taking soil samples from 5 squares 3x3 m in different successional plant communities and later extracted in a modified MacFadyan apparatus. The samples in this paper were collected by the author. However, mites from samples collected by the icelandic Hólmfrídur Sigurdardóttir are also included in the results.

Samples collected by the author were handled as follows:

Ten samples each 5.6 cm in diameter (24.62 cm^2) and to a depth of 8 cm (if possible) were taken from a mini-grid, 30 x 45 cm, thrown back into each of the 3x3m grid by chance. From 10 fixed positions in the mini-grid, soil samples were taken (see Figs 1 and 2).

The samples were extracted in a modified high gradient MacFadyan (Gjelstrup & Patersen, 1987) apparatus a month later in the Mols-laboratory, The Natural History Museum, Aarhus, Denmark.

Samples were collected at different other locations on the island and the results are included in the results (Tables 2-6). 80 samples were taken on Surtsey in 1995.

Samples collected by Hólmfrídur Sigurdardóttir were handled as follows:

Ten samples, 7 cm in diameter (38.46 cm^2), and to a depth of 5 cm were taken from different fixed squares (30x30 cm) in each of the 3x3 m^2 areas. The samples were extracted in a modified MacFadyan apparatus a week later in Reykjavik, Iceland.

The mites from these samples were included in this paper (see Table 1-5). In another paper Sigurdardóttir (2000) publishes the results on the collembolans from her samples.

In the old bird colony (J6) it was sometimes difficult to take samples to a depth of 5-8 cm because of the lava just beneath the grass.

The main localities investigated:

J1: A *Honkenya-Leymus* community growing on loose tephra sand in the eastern part of the island, 120 m from the eastern coast line (Figs 1–2). Here *Honkenya* appeared for the first time in 1967. (The mites from this square, collected by Hólmfrídur Sigurdardóttir were lost when sent by post from Iceland to Denmark).

J3: *Honkenya peploides* community growing on loose tephra sand on the rather steep eastern slope of the island. Here *Honkenya* appeared in 1974 (Hólmfrídur Sigurdardóttir coll.).

J4: Control area with bare and loose tephra sand about 300 m from the southern coast line (Hólmfrídur Sigurdardóttir coll).

J5: Young bird colony established in the southern lava field in 1986, 250 m from the southern coast line. The plant community was dominated by *Honkenya peploides, Poa pratensis, Puccinellia retroflexa, Cochlearia officinalis* and the Common Chickweed (*Stellaria media*). (Hólmfrídur Sigurdardóttir coll. included).

Figure 1. Collection sub-area in J1. Samples were taken in the mini-grid squares to the right of string marked with white tape. Surtsey, July 1995.

J6: Old bird colony (with breeding birds since 1985) is situated in the middle of the southern lava field about 200 m from the southern coast line. The plant community here was dominated by *Poa pratensis* and *Puccinellia retroflexa* (Hólmfrídur Sigurdardóttir coll. included).

Besides a special area east of the old gull colony was investigated:

J6 E: A community with vegetation of *Cochlearia officinalis* and different grasses.

The above mentioned 3x3 m squares except J6 E are permanently marked. Therefore it will be possible to follow the succession of soil arthropods in those areas in the following years.

RESULTS

Mites- earlier arrivals

The 16 mite species found on Surtsey in the period from 1963-1970 (Lindroth *et al.* 1973) are listed in Table 1. In the period from 1971-1976 918 specimens of mites have been collected, but not determined to species level (Ólafsson 1978).

Oribatida (Oribatid mites)

From 1963-1970 only 1 species of Oribatid mite *Oribotritia faeroensis* was found on Surtsey (Table 1). In 1995, however, Oribatid mites were found in most places with vegetation including in the main squares as seen from Table 2.

Table 1. Mites found on Surtsey 1963-1970.

	1965	1966	1967	1968	1969	1970	way of transport
Thinoseius spinosus	5		>1,000				I
Oribotritia faeroensis *		11					D
Myianoetus digiferus ***		many		8		52	I
Ixodes ricinus #			1				B
Myianoetes vesparum ***			281				I
Pygmephorus mesembrianae **				20	27		I
Tyrophagus dimidiatus ***				27		1	H
Dendrolaelaps oudemansi				14			H
Haemogamasus nidi					1	1	H D?
Ixodes uriae #						2	B
Caloglyphus reglei ***						1	I
Machrocheles matrius						1	I
Arctoseius cetratus						many	H
Halolaelaps suecicus						12	H
Cocceupodes clavifrons **						5	H
Rhagidia sp.**						1	H
Protereunetes agilis **						53	H
	5	21	1,306	70	4	148	1,554

Gamasida (6)
* Oribatida (1)
** Actinedida (4)
*** Acaridida (4)
# Ixodida (2)

I: spread by insects (6)
B: spread by birds (2)
D: spread by driftwood (1)
H: possibly spread by man - found under boards near the hut or in or under the hut (8)

Table 2. Oribatid mites from different communities on Surtsey, July 1995.

	J1	J5	J6	J6 E	J3F	J5F	J6F	J4F	Ex
Hypochthonius rufulus *	4								
Liochthonius lapponicus *	33	41			4	28	6		12
Lichthonius muscorum *			8	1					28
Liochthonius propinquus **	1			227					257
Eniochthonius minutissimus **		1							
Hermannia sp. nov. *** (~*pseudonodosa*, Alaska)			3	300	18		23	6	2,309
Tectocepheus velatus	10	7							
Suctobelba subcornigera	2		1						
Suctobelba sarekensis *			1						
Suctobelba acutidens	1								3
Quadroppia quadricarinata	1				27				1
Quadroppia sp. nov. *** (~*illinoiensis*, USA)				2					
Oppiella nova *		1							
Oppiella splendens *					85				106
Oppiella subpectinata *	1								
*Autogneta longilamellata***			1						
Ameronothrus lineatus			2		1	69		71	
*Ameronothrus nigrofemoratus**									1
Zygoribatula exilis *		2							
Chamobates cuspidatus **			2						
Ophidiotrichus connexus **		1							
Achipteria coleoptratus	1								
Total number	54	53	18	530	135	28	98	6	
Species	9	6	7	4	5	1	3	1	

*: Found for the first time on the Westman Islands (16).
**: Species new to Iceland (7)
***: Species new to science (2)
~: Closely related to

J1: *Honkenya-Leymus* 1970
J5: bird colony, young
J6: bird colony, old
J6 E: East of the old bird colony
Ex: Found elsewhere on Surtsey, 1995

J1F: (Hólmfrídur Sigurdardóttir coll.)
J5F: (Hólmfrídur Sigurdardóttir coll.)
J6F: (Hólmfrídur Sigurdardóttir coll.)
J4F: Control area, tephra without vegetation (Hólmfrídur Sigurdardóttir coll.)

Table 3. Actinedida mites found in different communities, Surtsey, July 1995.

	J1	J5	J6	J6 E	J3F	J5F	J6F	J4F	Ex
*Tarsonemus fusarii***	4,410	945	1,675	1,515					3,174
Nanorchestes arboriger								3	4
Rhagidia mordax		1			4	4	2		1
Penthalodes ovalis		1				9			
*Petrobia apicalis***	3								
Bdella sp	2								4
Neomolgus littoralis									>50
Anystis sp.**	4								
Bakerdania sp. nov. ***							2		
Total	4,419	947	1,675	1515	4	13	4	3	3,233
Number of species	4	3	1	1	1	2	2	1	

Abbreviations as in Table 2

More than 3700 Oribatid mites were found representing 22 different species, which all are new to Surtsey. 5 species belong to Oribatei Inferiores (species 1-5), 11 species to Oribatei Superiores (sp. 6-18) and 4 species to Oribatei Pterogasterina (sp. 19-22). Two of the species seem to be new to science, 7 of the species new to Iceland, and 16 species new to the Westman islands.

By far the most numerous and widespread Oribatid mite species on Surtsey in 1995 were *Hermannia* sp nov. followed by *Liochthonius lapponicus* and *Liochthonis propinquus*. Most of the other species were found in very few specimens. Outside the 5 main squares investigated only 8 of the 22 oribatid mite species were found, and only one species *Ameronothrus nigrofemoratus* was found in green algae growing at two nests of the Fulmar (*Fulmarus glacialis*) on the volcano cone Surtur 1. Unexpectedly Oribatid mites were also found in soil samples from the control area without vegetation (J4) collected by Hólmfríður Sigurðardóttir. 9 species were found in the pioneer square J1 dominated by *Honkenya* and *Elymus*. In or close to the bird colony 4-7 species were found in each square, and in all 15 species were found. Oribatid mites were not found under driftwood or close to the sea. *Hermannia* sp. nov. to science were numerous in patches with single specimens of *Puccinellia pratensis* growing in the lava field close to the southern coast line of Surtsey and in many other places investigated including the zero plot J1 without vegetation at all. Most Oribatid mites are mycophagous mites or bacteria feeders.

Figure 2. Collection site J1 3x3 m with *Honkenya peploides* and *Leymus arenaria*, Surtsey, July 1995.

Actinedida (Prostigmatic mites).

From 1963-1970, 4 species were found on Surtsey (Table 1). None of them, however, were found in 1995 although 3 of the species, *Cocceupodes clavifrons*, *Rhagidia* sp. and *Protereunetes agilis* are soil living mites. In 1995 *Tarsonemus fusarii* was by far the most numerous species on Surtsey (more than 11,000 specimens collected, see Table 3). This mite species may feed on tissue of plants and/or may be a fungus feeder (Cooreman 1941). *T. fusarii* was especially numerous in the pioner community J1 with *Honkenya* and *Elymus*. Many of the other Actinedid mites found are predaceous mites eating other soil organism. One species, *Nanorchestes arboriger* is phycophagous and may consume microalgae, and *Petrobia apicalis* and *Bakerdania* sp. nov. are phytophagous.

Neomolgus littoralis were numerous on the shore, whereas the rest of the species are soil living species.

Table 4. Acaridida mites found on Surtsey, July 1995.

	J1	J5	J6	J6 E	J3F	J5F	J6F	J4F	Ex
Tyrophagus similis		127	120	1742	5	454	73		379
*Schwiebia cavernicola***	163		16	56					
Histiostoma feroniarum	33	584	50	1518	1	1,087	291		213
H. (hypopus)						852		2	
Total	196	711	186	3,316	6	2,393	364	2	
Number of species	2	2	3	3	2	2	2	1	

Abbreviations as in Table 2

Acaridida (Astigmatic mites, mites of stored products)

From 1963 - 1970, 4 species were found on Surtsey, see Table 1. Only 1 species, *Tyrophagus dimidiatus* may live in the soil. This species (= *Tyrophagus similis*, Table 4) was numerous in many of the soil samples investigated in 1995, but a new species *Histiostoma feroniarum* often dominated. The latter was mainly numerous in the bird colonies. *H. feroniarum* was found on Heimaey in 1967 by Lindroth *et al.* (1968).

A species new to Iceland, *Schwiebea cavernicola* was found in some of the samples from the gull colonies but dominated in the pioneer area J1. This species may be the same species as *Schwiebea talpa*, mentioned from northern Iceland (Hudges 1961).

The Acaridid mites found on Surtsey are supposed to be mycophagous or detritus feeders. Species of the family Anoetidae, to which the genus *Histiostoma* (Table 4) and *Myanoetus* (Table 1) belong, however, are bacteria feeders. Many acaridid mite species have a highly mobile second instar (hypopus) with suckers adapted to attach on other animals including insects, which then act as vectors (Table 1, Table 4).

On Surtsey Acaridid mites were especially numerous in and close to the gull colonies, localities J5, J6 and J6 E.

Gamasida (Mesostigmatic mites)

Gamasid mites were the first mites to be found on Surtsey in 1965. The species found in 1995 are soil living species. In 1995 about 2000 specimens were found, many being subadults and difficult to determine to species level. The most dominating and widespread species seems to be *Eviphis ostrinus* and *Zercon triangularis*, species new to Surtsey. In 1966-1968, however, both species were found on Heimaey and other islands south of Iceland (Lindroth *et al.* 1973).

The other species were found in few specimens. Gamasid mites were especially found in or close to the gull colonies J5, J6 and J6E.

Gamasid mites are predaceous and some species attach themselves to insects and in this way may be spread (especially *Thinoseius*, Table 1, and *Eviphis* Table 5).

Table 5. Gamasida mites found on Surtsey, July 1995.

	J1	J5	J6	J6 E	J3F	J5F	J6F	J4F	Ex
Eviphis ostrinus	5	250	854	631	8	406	94	5	602
Zercon triangularis		1	55			42	39		38
Actoseius sp. nov. ***									
~ cetratus					5				8
Eugamasus kraepelina			2						2
Halolaelaps sp. nov.***									
~ porulus				1					
Parasitus halophilus	1								
Total	6	251	917	638	13	453	133	5	
Species	2	2	3	2	2	2	2	1	

Abbreviations as in Table 2

Table 6. Collembolans per m² found on Surtsey, July 1995.

	J1	J5	J6	J6 E	Ex
*Ceratophysella succinea**	2,397				n
*Hypogastrura purpurescens**		55,448	58,332	90,951	n
*Mesaphorura macrochaeta**	6,134	2,397	5,037	4,875	n
Isotoma notabilis	1,503	14,014	2,437	609	n
*Isotoma anglicana**	130	325	1,137	934	n
*Isotomiella minor**		81			n
*Pseudisotoma sensibilis**		41			n
Onychiurus duplopunctatus#					78
	10,033	72,956	67,797	97,369	

EX: Other localities. *: new to Surtsey. n: not counted.
Found under driftwood.

Collembola (Collembolans)

16 species of collembolans were found on Surtsey in the period from 1963-1978 (Bödvarsson 1982). In 1995, 7 species were found in the soil samples investigated, and 1 species on driftwood on the northern sea shore. The occurrence of collembolans per m² in the different areas are calculated in Table 6. Six of the eight species are new to Surtsey.

The dominating species in the gull colonies were *Hypogastrura purpurescens*, *Mesaphorura macrochaeta* and *Isotoma notabilis*. In the pioneer plant community J1 with *Honkenya peploides* and *Leymus arenarius*, *Mesaphorura macrochatea* and *Ceratophysella succinea*, new species to the fauna of Surtsey, dominated.

The distribution of soil mites and collembolans

When investigating soil animals on a young island as Surtsey, it is interesting to see how aggregated the animals are distributed. In Fig. 3 a Box Plot has been made for the number of mites and collembolans found in samples from the investigated areas. The boxes in Fig. 3 indicate where the central 50% of the values falls and the vertical line the median. Extreme values are indicated by a "o" and less extreme values with an asterix.

Fig. 3 illustrates that in and close to the birds colonies the central 50% values are high and rather close to each other. In samples from the pioneer areas J4 and J3 many zero-values were included in the results. Fig. 3 also illustrates that extremely high numbers of animals were found in some of the samples from the bird colony. Thus the soil fauna may be much aggregated or patchy in distribution even in the bird colony with dense vegetation of grasses.

Total number of mites and collembolans per m² in the different sampling areas

The total number of mites and collembolans per m² found in the plant communities have been calculated in Table 7. From the table it is seen, that mites are the most numerous group. Actinedid mites are dominating followed by acaridid and/or gamasid mites.

DISCUSSION

Tyrophagus dimidiatus (=*T. similis*) and *Halolaelaps cetratus* were found on Surtsey already in

Table 7. Mites and collembolans per m² in different plant communities, Surtsey, July 1995.

	J1	J5	J6	J6 E	J3F	J5F	J6F	J4F
Oribatida	2,194	2,153	731	21,529	3,510	728	2,548	156
Actinedida	179,506	38,468	68,041	61,541	104	338	52	78
Acaridida	7,962	28,882	7,556	134,700	156	62,212	9,463	52
Gamasida	203	10,155	37,006	25,673	208	11,647	3,406	130
Total mites/m²	189,846	79,658	113,334	243,443	3,978	74,925	15,469	416
Collembola/m²	10,033	72,956	67,797	97,369	806*	74,702*	17,680*	0*
Total/m²	199,879	152,614	181,131	340,813	4,784	149,627	33,149	416

*: values from Hólmfridur Sigurdardóttir (2000)

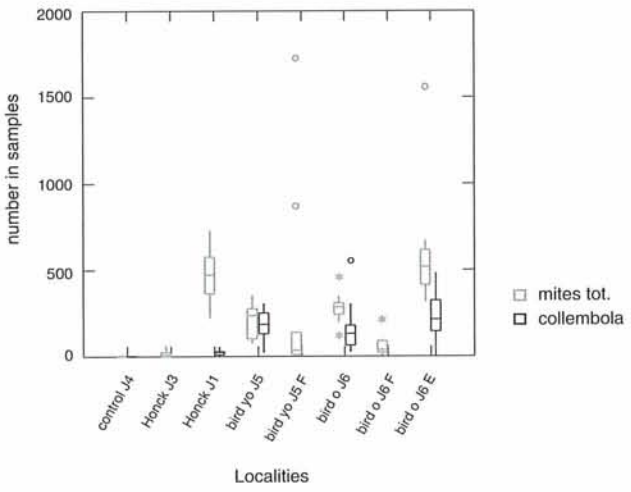

Figure 3. Box plot showing numbers of specimens of Mites and Collembolans in samples from main localities, Yo=young bird colony, o=old bird colony, Honk = *Honkenya,* Control J4=control area.

1968 and 1970 (Lindroth *et al.* 1973). The latter species may be the same as *Halolaelaps* sp. nov. in this paper. Only *T. similis* was common and widespread in 1995. Of the 16 species of collembolans found in the period from 1963-1978 (Bödvarsson 1982) only *Isotoma notabilis* was common and widespread in 1995. This confirm Bödvarsson (1982) saying that "a permanent colonization is as yet extremely doubtful".

In 1995, however, a new soil fauna was found, dominated by the Actinedid mites *Tarsonemus fusarii*, the Acaridid mite *Tyrophagus similis* and *Histiostoma feroniarum*, the Gamasid mite *Eviphis ostrinus*, the Oribatid mite *Hermannia* sp.nov. and the collembolans *Hypogastrura purpurescens*, *Mesaphorura machrochaeta* and *Ceratophysella succinea.* Especially *Eviphis ostrinus* and *Histiostoma feroniarum* may easily be spead by insects. In all 40 species of mites and 8 species of collembolans were found. 38 of the mite species and 6 species of the collembolans are new to Surtsey. Most species were found in small numbers and probably will not survive on the island.

The number of individuals per m^2 is very high considering Surtsey as a young island, and the number of mites were exceptionally high for pioneer communities. In comparison with these results samples from Dyrhólaey, southern Iceland, 1995 a pioneer plant community with *Honkenya peploides* and *Leymus arenara* as found on Surtsey only revealed few specimens of mites and collembolans (Gjelstrup, unpublished).

As illustrated in this paper a numerous and well established fauna of some mite and collembolan species existed on Surtsey in 1995, 32 years after the eruption. However, the combination of species may change in the future until more stable and diverse plant communities evolve. It is concluded, that many species of soil living animals easily spread to Surtsey.

The respiration of the soil arthropods may be of interest in future studies. The soil respiration was measured on Surtsey by Magnússon (1992). Also the nutrient cycling and nutrient mobilization is influenced by the soil fauna. (see also Henriksson & Henriksson 1974, 1982, Frederiksen *et al.* 2000).

Future investigations should focus on the development of the food-chains of soil animals. It would also be of interest to follow the vertical distribution of animals and if this distribution of the fauna follows the roots of the plants into the tephra material. The fauna may survive deeply in the tephra soil when the climatic conditions close to the soil surface are too extreme.

ACKNOWLEDGEMENTS

I am most gratefull to the Surtsey Research Society, Iceland, who made it possible for me to visit Surtsey in 1995, to the Icelandic Coast Guard, who handled the helicopter to Surtsey, to the Carlsberg Foundation, Copenhagen, who supported the journey financially, to Hólmfrídur Sigurdardóttir, Iceland, who collected mites in some of the main plant communities investigated, to Henning Petersen, the Mols laboratory, Denmark, for verification of the collembola species found, and to Dr Sturla Fridriksson, Borgthór Magnússon, Hólmfrídur Sigurdardottir, Iceland, Helle Bisgaard Frederiksen, Denmark and Lisa L. Poole, Gloucester, for valuable assistance and companionship during the stay on the island.

References

Athias-Henriot, C. 1980. Terrestrial Parasitiformes Gamasida I. The Zoology of Iceland III, 57d: 1-38.

Bödvarsson, H. 1982. The Collembola of Surtsey, Iceland. Surtsey Res. Progr. Rep. 9: 63-67.

Cooreman, J. 1941. Un tarsonemide mycophage nuveau (Acarien). Bull. Mus. Hist. nat. Belgique XVII, 20: 1-7.

Fjellberg, A. 1998. The Collembola of Fennoscandia and Denmark. Part I: Poduromorpha. Fauna Ent. Scand. 35: 1-184.

Frederiksen, H.B., A.L. Petersen & S. Christensen 2000. Substrate induced respiration and the microbial growth in soil during the primary succession on Surtsey, Iceland. Surtsey Res. 11: 29-35.

Gjelstrup, P. & H. Petersen 1989. Jordens mider og springhalen. Natur og Museum 36, 4: 1-32.

Henriksson, L.E. & E. Henriksson 1974. Studies on the nitrogen cycle of Surtsey in 1972. Surtsey Res. Progr.Rep. 7: 36-44.
Henriksson, L.E. & E. Henriksson 1982. Concerning the biological nitrogen fixation on Surtsey. Surtsey Res. Progr. Rep. 9: 9-12.
Hudges, A.M. 1961. Terrestrial Acarina III. Acaridae. The Zoology of Iceland III, 57c: 1-12.
Gjelstrup P. & T. Solhøy 1994. Oribatid mites (Acari). The Zoology of Iceland III, 57e: 1-78.
Lindroth, C.H., H. Anderson & H. Bödvarsson 1966. Report on the Surtsey investigation in 1965. Terrestrial invertebrates. Surtsey Res. Progr. Rep. 2: 15-17.
Lindroth, C.H., H. Anderson, H. Bödvarsson & S. H. Richter 1968. Preliminary Report on the Surtsey Investigation in 1967. Terrestrial invertebrates. Surtsey Res. Progr. Rep. 4: 77-82.
Lindroth, C.H., H. Anderson, H. Bödvarsson, B. Pejler & S. H. Richter 1972. Preliminary report on the Surtsey investigation in 1969 and 1970. Terrestrial invertebrates. Surtsey Res. Progr. Rep. 6: 78-81.
Lindroth, C.H., H. Anderson, H. Bödvarsson & S.H. Richter 1973. Surtsey, Iceland. The development of a new fauna 1963-1970. Terrestrial invertebrates. Ent. Scand. Suppl. 5: 1-280.
Magnússon, B. 1992. Soil respiration on the volcanic island Surtsey, Iceland in 1987 in relation to vegetation. Surtsey Res. Progr. Rep. 10: 9-16.
Marshall,V.G., R.M. Reeves & R.A. Norton 1987. Catalogue of the Oribatida (Acari) of continental United States and Canada. Mem. Entom. Soc. Can., 139: 1-418.
Ólafsson, E. 1978. The development of the land-arthropod fauna on Surtsey, Iceland, during 1971-1976 with notes on terrestrial Oligochaeta. Surtsey Res. Progr. Rep. 8: 41-46.
Sigurdardóttir, H. 2000. Status of collembolans (Collembola) on Surtsey in 1995 and first encounter of earthworms (Lumbricidae) in 1993. Surtsey Res. 11: 51-55.
Woas, S. 1981. Zur Taxonomie und Phylogenie der Hermanniidae Sellnick 1928 (Acari, Oribatei). Andrias 1, Karlsruhe, 7-100