

New records of *Enchytraeidae* (*Oligochaeta*) from Spitsbergen, Svalbard.

Tone Birkemoe & Klara Dózsa-Farkas

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During a survey of soil-inhabiting enchytraeids at Spitsbergen, Svalbard, two species, *Mesenchytraeus argentatus* and *Bryodrilus parvus*, not previously recorded from the island were found. Additionally, one species was recorded from a new locality at considerable distance from previous records. At present a total of 28 species are known from Spitsbergen, of which 13 species was found in the this study. *Enchytraeus liefdeensis* is synonymised with *Enchytraeus kincaidi* on the basis of the specimen found during this study.

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Introduction

Several expeditions have collected Enchytraeidae from Spitsbergen, the largest island of Svalbard archipelago reaching from 76°30' N to 80°00' N. Nurminen (1967) summarised all records from this island (Michaelsen 1900, Ude 1902, Stephenson 1922, 1924, 1925, Nurminen 1965, 1966) and no work on enchytraeids including identification to species level has been published from Spitsbergen since then. The present investigation was undertaken to increase our knowledge about the Enchytraeidae fauna on Spitsbergen and to get acquainted with the species composition in certain habitats as a basis for later studies.

Study area, material and methods

Soil samples were collected from several localities around Kongsfjorden, Adventdalen, Bjørndalen and Grumant in August 1993

(**Figure 1**). The material also includes enchytraeids collected in June 1993 from Adventdalen. Most of the enchytraeids were extracted using O'Connor's (1962) wet funnel technique within a week after collection. The extracted enchytraeids were kept in boxes containing a small amount of soil at 1 °C. In addition, soil samples from location 1 and 7 (see description below) were kept intact until the day before identification of enchytraeids. These soil samples were kept at 1°C until extraction. The quantity of soil (measured as area on the surface) extracted from the different localities were approximately the following: Loc. 1: 480 cm², loc. 3: 480 cm² outside and 480 cm² inside fence, loc. 4: 160 cm², loc. 5: 500 cm², loc. 6: 500 cm², loc. 7: 480 cm². The organic soil layer was 3-6 cm deep. The sampling effort at location 2 could not be measured by surface area, and is best described as "two handfuls". The worms were identified alive under a microscope in October 1993.

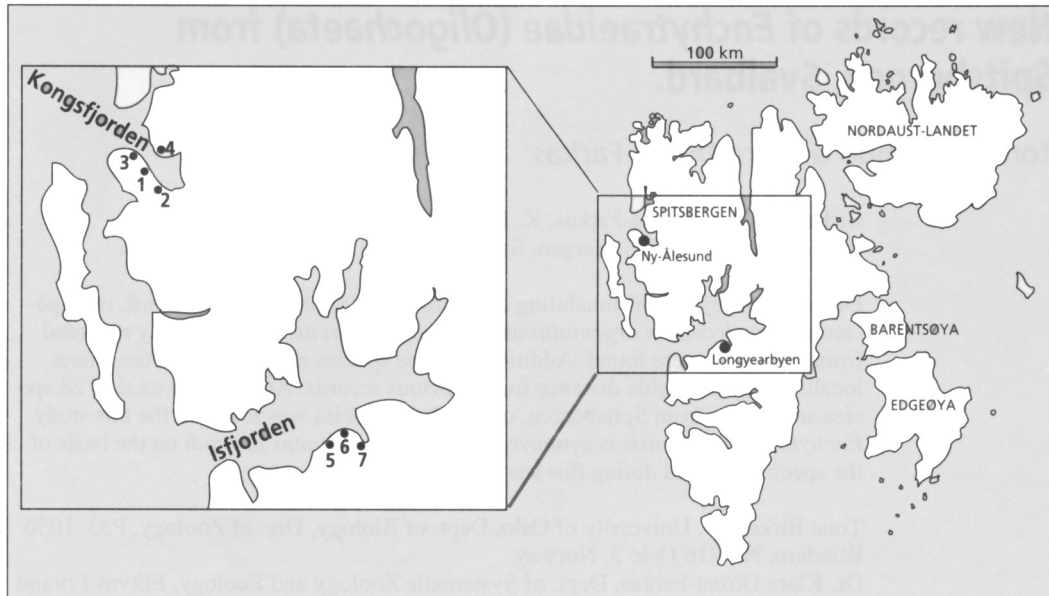


Figure 1
Sampling localities at Spitsbergen, Svalbard.

Description of localities:

Locality 1: By Kongsfjorden, very close to Ny-Ålesund. The vegetation is a *Cassiope tetragona-Dryas octopetala* vegetation type with 50-100 % coverage (Brattbakk 1981). The bedrock is Carboniferous-Permian sandstone (Winsnes 1988). The habitat is moist during the spring, but becomes rather dry during the summer.

Locality 2: Inner part of Kongsfjorden, under a bird cliff with kittiwakes (*Rissa tridactyla* (L.)). The enchytraeids were found in a "compost" of bird excrements, mosses, vascular plants and nest materials. The habitat is moist throughout the year and includes a very high level of nutrients.

Locality 3: Stuphallet, outer part of Kongsfjorden. This locality is subdivided into two different parts; one inside a fence (without reindeer) and one outside. The fence was put up in 1978 at the same time as 15 reindeers

were released at Brøggerhalvøya (Wegener et al. 1992). Since then, the reindeer population has increased exponentially reaching 360 animals in 1993 (Thorbjørn Severinsen pers. comm.), resulting in heavy grazing. Consequently, the vegetation inside the fence is different from outside. Lichens dominate inside while the outside is more dominated by mosses. For a complete description of the vegetation differences see Wegener et al. (1992). Soil samples were taken inside the fence and approximately 10 meter outside the fence. (These samples were taken as part of a course in Arctic Biology arranged by the University of Oslo.)

Locality 4: Blomstrand Island in Kongsfjorden. The soil cores were taken from a heath very similar to the *Cassiope tetragona-Dryas octopetala* vegetation type close to Ny-Ålesund (locality 1). The bedrock which is a Precambrian limestone (Hjelle 1993) is very nutritious.

Locality 5: Grumantbyen, by Isfjorden. Tall grass, mainly *Poa alpina* (L.) and a 30-50 % coverage of mosses. The only area at Spitsbergen where an outdoor population of mice (*Microtus epiroticus* (Ondrias)) exists.

Locality 6: Bjørndalen, by Isfjorden. Tall grass, mainly *Poa alpina* and a 50-60 % coverage of mosses.

Locality 7: Adventdalen, by Isfjorden, ca 10 km south-east of Longyearbyen. The habitat is wet and has a high coverage of mosses and the grasses *Alopecurus alpinus*. (Sm.) and *Lutzula arcuata* ssp. *arcuata* (Swartz). *Equisetum arvense* ssp. *boreale* (Bong.) and *Salix polaris* (Wahlenb.) occur frequently.

Results

A total of 13 species were found, 2 of which have not previously been recorded from Spitsbergen. Location 7 was the most species rich site, including 11 out of 13 species

(Table 1). Only *Enchytraeus kincaidi* (Eisen, 1904) was found in location 2, which was also the only place where this species occurred. *Henlea similis* (Nielsen & Christensen, 1959) and *Bryodrilus ehlersi* (Ude, 1892) occurred in 6 out of 7 localities, and are the two most widespread species in the present study. The list below includes all records from the summer of 1993:

Bryodrilus ehlersi Ude, 1892

Adventdalen, loc. 7; Ny-Ålesund, loc. 1; Blomstrand Island, loc. 4; Bjørndalen, loc. 6, Grumant, loc. 5; Stuphallet, inside the fence, loc. 3.

Apparently, all specimens belong to the subspecies *B. e. glandulosa* (Dózsa-Farkas 1990); the specimens had an irregularly shaped seminal vesicle, secondary septal glands and four oesophageal diverticula that did not (or only vaguely) contract. However, the specimens lacked the gland at the opening of the spermatheca, which is also a characteristic of *B. e. glandulosa*. The segment number

Table 1. Species occurrence in different localities of the present study.

	locality							
	1	2	3a	3b	4	5	6	7
<i>Bryodrilus ehlersi</i>	x		x		x	x	x	x
<i>Bryodrilus parvus</i>					x			
<i>Cernosvitoviella</i> sp.								x
<i>Cognettia</i> sp.								x
<i>Enchytraeus kincaidi</i>		x						
<i>Henlea heleotropha</i>								x
<i>Henlea perpusilla</i>	x		x			x	x	x
<i>Henlea similis</i>	x		x	x	x	x	x	x
<i>Henlea ventriculosa</i>						x	x	x
<i>Marionina argentea</i>			x					x
<i>Mesenchytraeus argentatus</i>	x							x
<i>Mesenchytraeus flavus</i>	x						x	x
<i>Mesenchytraeus</i> sp.	x							x

a inside fence, b outside fence

(33-40) is less than described for *B. ehlersi ehlersi* and *B. ehlersi glandulosa*. Nurminen (1965) also found a low number of segments in *B. ehlersi ehlersi* from Spitsbergen.

The subspecies *Bryodrilus ehlersi glandulosa* was described from a *Sphagnum* bog in Hungary (Dózsa-Farkas 1990). The author mentions the possibility of this subspecies having evolved from a population surviving as a relict species in this very small area. The specimen from the present material, however, makes this suggestion doubtful.

Bryodrilus parvus Nurminen, 1970

Blomstrand Island, loc. 4.

The specimens closely resemble the subspecies *Bryodrilus parvus kananaskis* described by Dash (1970) from the Rocky mountains in

Canada, but as the number of segments (27-28) is within the range of *B. parvus parvus* it is uncertain if it can be grouped with the Rocky mountain subspecies. The 1. and 2. septal glands (in segment IV and V) have ventral lobes, a character which was also found in *B. parvus kananaskis* (although in segment V and VI). The dorsal vessel originates in XII and not in XIII as in *B. parvus kananaskis*. Origin of the dorsal vessel was not mentioned in Nurminens (1970) description of *B. parvus parvus*. The synonymy of the two subspecies suggested by Nurminen (1973a) and formalised by Dózsa-Farkas (1992) agrees with the variation found in the present material.

Cernosvitoviella sp.

Adventdalen, loc. 7

Altogether 11 specimens were found. Several of them had spermatheca and seminal funnel and appeared to be mature. Unfortunately, no eggs were observed. Setae 2, 3 - 2; 2, 4 - 3, about 4 mm long and number of segments in the range of 23-25. First nephridium in VI/VII. The lymphocytes were oval and white. Seminal vesicle present. Spermatheca and sperm funnel are shown in **Figure 2**.

Cognettia sp.

Adventdalen, loc. 7

Only a few immature specimens were found.

Enchytraeus kincaidi Eisen, 1904

descr. Coats and Ellis, 1981 and Erseus, 1990.

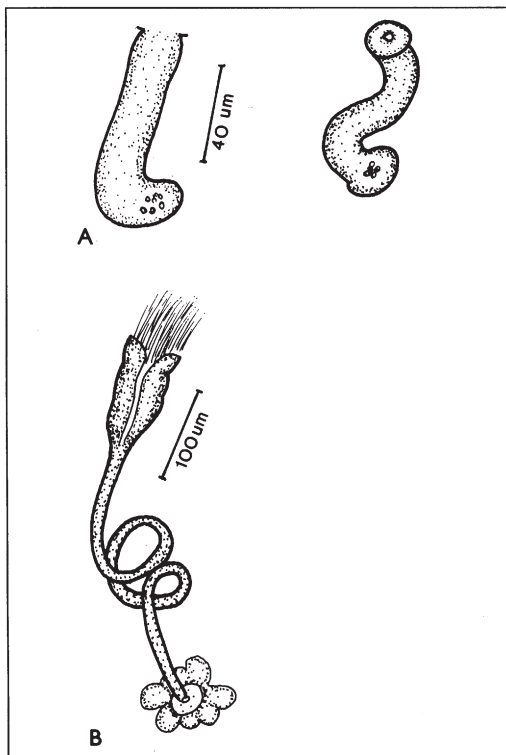
Enchytraeus kincaidi Eisen, 1904

Enchytraeus alaskae Eisen, 1904

Enchytraeus modestus Eisen, 1904

Figure 2

Cernosvitoviella sp. A. Spermatheca, B. Sperm funnel.



Marionina modesta Nielsen & Christensen, 1959 ?

Enchytraeus saxicola Eisen, 1904 ?

Enchytraeus citrinus Eisen, 1904

Enchytraeus cryptosetosus Tynen, 1969, Shurova, 1979, Nakamura, 1983 *Enchytraeus kinkaidi* Nakamura, 1983

Enchytraeus liefdeensis Stephenson, 1924, Nurminen, 1965

Inner part of Kongsfiorden, loc. 2.

Medium-sized, length 10-19 mm, width 0,70 mm, 35-45 segments. Setae straight with ental hook, equal length within bundle: 2-2: 3-2, 3. Brain about twice as long as wide, with refractile cell aggregations (**Figure 3A, B**). Lymphocytes discoid, nucleate, granulate 20-25 mm long. Peptonephridia are paired and unbranched (**Figure 3D**). Three pairs primary pharyngeal glands with ventral lobes, all broadly united dorsally. Dorsal vessel arising in XIII (XIII/XIV), blood yellow. Anteseptal of nephridium consists of a funnel only, the duct being terminal (**Figure 3C**).

Clitellum extending over XII-XIII, gland cells large, irregularly scattered. Ventrally the gland cells are smaller and light. Seminal vesicle large in X. Sperm funnel cylindrical and 6-7 times as long as wide in the well developed specimens (**Figure 3G, H**). The male pores complex (**Figure 3I, J**), with a small "primary" penial bulb and some pre and post "secondary" bulb or papilla. The ampulla of the spermatheca with a single, large diverticulum of irregular outline. The ental duct is short, wide and connected to the gut. The ectal duct with a small rosette of glands at the orifice. The ectal duct widening gradually to the ampulla (Fig. 3E, F). Four to six or more eggs present at a time in mature specimens.

Coates & Ellis (1981) have synonymised the 5 species mentioned above. We have identified our species found in Spitsbergen with

Enchytraeus kincaidi. (Stephenson 1924) described the species *E. liefdeensis* from specimens originating from Spitsbergen. On the basis of his classifications carried out with enchytraeids also collected at Spitsbergen, Nurminen (1965) augmented the species *E. liefdeensis*. Studying our specimens and the literature as well as the description and red-descriptions of *E. kincaidi*, we are convinced that *E. liefdeensis* has to be a synonym of the species *E. kincaidi*. Studies of the Enchytraeidae material described here and of animals living in our cultures show, that the little unimportant differences between the synonymies can vary with the sexual state (maturity) of the different specimens. For example, in a well developed stage (with eggs) the sperm funnel is 7 times longer than wide, whereas in specimens being immediately before or after reproduction this proportion can decrease to 2. The typical shape of spermatheca can also vary with the maturity stage. We have found a small difference in the location of the dorsal vessel, it originates in segment XIII or XIII/XIV in our animals, while it originates in XIV-XVI in the description of *E. kincaidi*.

***Henlea heleotropha* Stephenson, 1922**

Adventdalen, loc. 7

***Henlea perpusilla* Friend, 1911**

Adventdalen, loc. 7; Ny-Ålesund, loc. 1; Bjørndalen, loc. 6; Grumant, loc. 5; Stuphallet, inside fence, loc. 3.

***Henlea similis* Nielsen & Christensen, 1959**

Adventdalen, loc. 7; Ny-Ålesund, loc. 1; Bjørndalen, loc. 6; Grumant, loc. 5; Stuphallet, inside and outside the fence, loc. 3, Blomstrand Island, loc. 4.

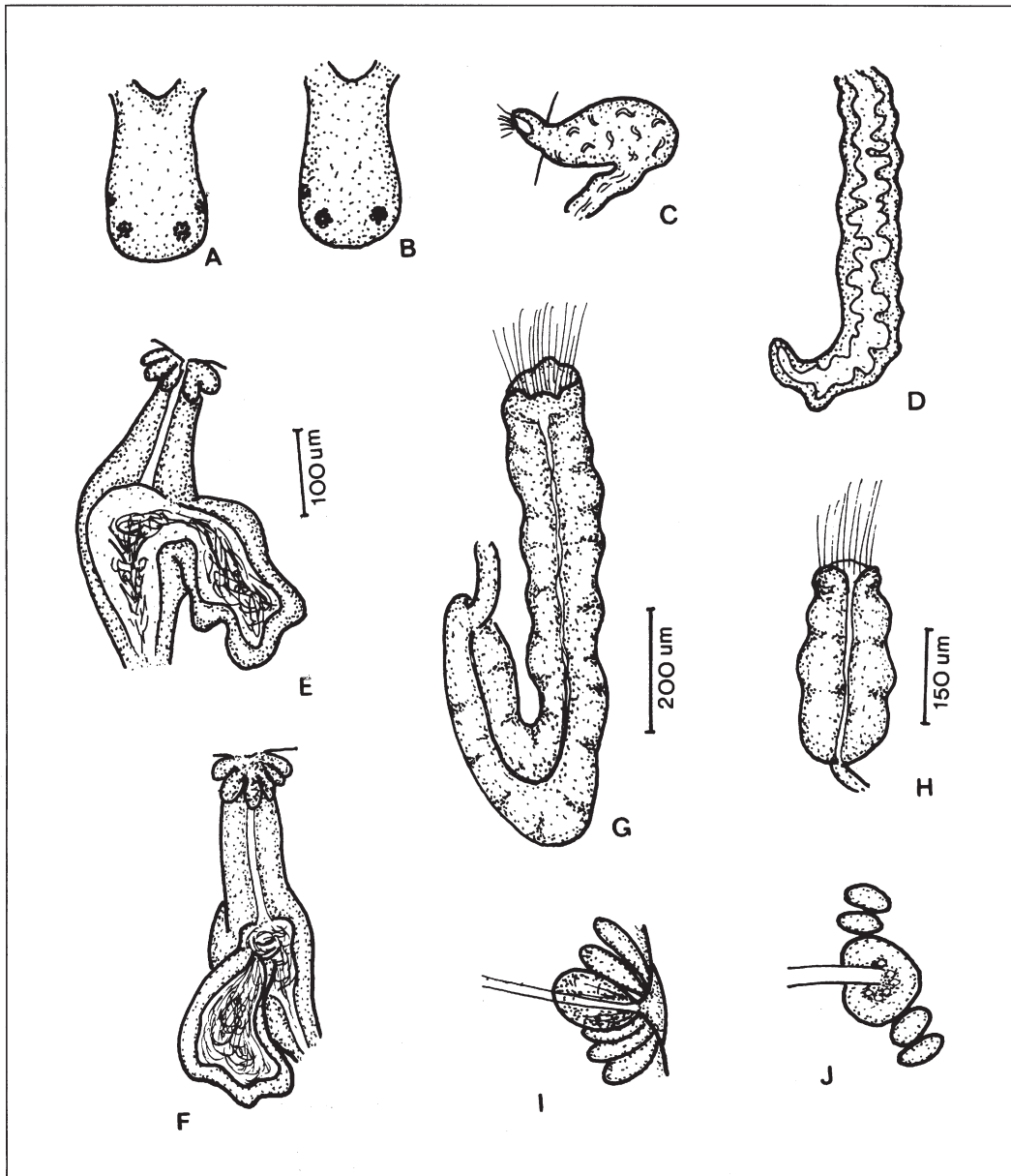


Figure 3
Enchytraeus kincaidi. A, B. Brain, C. Nephridia, D. Peptonephridia, E, F. Spermatheca, G, H. Sperm funnel, I, J. Male pore.

Several specimens had a dorsal vessel originating in the very last part of seg. VIII and when pulsating, extending into segment IX.

***Henlea ventriculosa* (Udekem, 1854)**

Adventdalen, loc. 7; Bjørndalen, loc. 6; Grumant, loc. 5.

***Marionina argentea* (Michaelsen, 1889)**

Adventdalen, loc. 7; Stuphallet, inside the fence; loc. 3.

***Mesenchytraeus argentatus* Nurminen, 1973**

Adventdalen, loc. 7; Ny-Ålesund, loc. 1

Several specimen were found. They differed from Nurminen's description (1973a) by the following characters: the lymphocytes were roundish or oval not spindle-shaped, the number of setae was higher at the dorsal side; 2, 4, 5 - 3: 4, 5, 6 - 3, 4 not 2, 3 -2, 3: 5, 6, 7 - 3, 4, and the number of segments was fewer; 27-28 not 29-32.

***Mesenchytraeus flavus* (Levinsen, 1884)**

Adventdalen, loc. 7; Bjørndalen, loc. 6; Ny-Ålesund, loc.1.

***Mesenchytraeus* sp.**

Adventdalen, loc. 7; Ny-Ålesund, loc. 1.

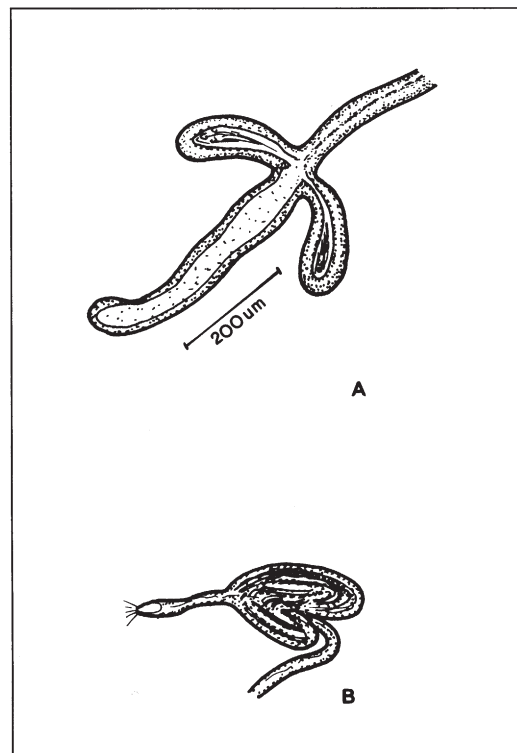
Two immature specimens were found. The setae: 2, 3 - 2, 3: 3, 4, 5 ,6, 7 - 6, 4 ,5, 3, the dorsal vessel originates in XVIII-XXI, the blood being red. They were large worms (18,5 mm and 26,3 mm), intensely orange/red (coloured by the chloragencells), having

Figure 4
Mesenchytraeus sp. A. Spermatheca,
B. Nephridia.

small, transparent lymphocytes and spermatheca with ampulla that where not attached to the oesophagus (**Figure 4A**). The nephridia **Figure 4B**, seminal vesicle lobed to XIX. Cutaneous glands small, yellowish, 4-5 rows.

Discussion

Nurminen (1966) reported an immature *Mesenchytraeus* species with white lymphocytes from Spitsbergen. In a later publication (Nurminen 1973a) he suggests that this immature specimen could have been *Mesenchytraeus argentatus*. The present findings of *M. argentatus* support Nurminen's assumption. The species has previously only been reported from Canada (Nurminen 1973a) and Spitsbergen (present study) and is likely to have a northern distribution. On



Spitsbergen the species occurred both close to Ny-Ålesund in the rather dry *Cassiope tetragona-Dryas octopetala* heath and in Adventdalen in wet soil dominated by grass and mosses. Thus, the species probably has a wide distribution on Spitsbergen.

Bryodrilus parvus has not previously been reported from Spitsbergen. It was described from Greenland and has been found in the Arctic archipelago of Canada (Nurminen 1973a), on Iceland (Nurminen 1973b) and in the Kananaskis region in Northwest Canada (Dash 1970, Dash & Cragg 1972). Therefore, this species also appears to have a northern distribution.

Enchytraeus kincaidi has not been reported from Spitsbergen before, but as previously mentioned, *E. liefdeensis* should be synonymised with *E. kincaidi*. *E. liefdeensis* was described from Spitsbergen by Stephenson (1924), so this is not the first record of *E. kincaidi* from Spitsbergen.

The Enchytraeidae-fauna of Spitsbergen has been studied most extensively around Isfjorden and in the Kongsfjorden area (Stephenson 1922, 1924, 1925, Nurminen 1965, 1966). In spite of this, (*Mesenchytraeus flavus*) has not been recorded from the Kongsfjorden area previous to the present study (Table 2). At present, the total Enchytraeidae fauna at Spitsbergen includes 28 species (Table 2). Only eight out of 28 species (Table 2) have been found both in Kongsfjorden and Isfjorden area as well as in other localities.

It is impossible to draw any overall conclusions of the species richness at the localities investigated in the present study. There are two main reasons for this: 1) The sampling effort varied considerably between the locations. 2) None of the animals were identified immediately after the soil samples were tak-

en. The main part of the enchytraeids lived in unnatural high numbers in cultures for three months before being identified, and the species composition could thus have changed. Only worms from two locations were left in intact soil until identification.

Equal sampling effort was used in the localities outside and inside the fence at Stuphallet. The enchytraeids were counted straight after extraction as a part of another research project, comparing collembola, mite, enchytraeid and nematode populations inside and outside the fence (Anunsen et al. 1993). Anunsen et al. found that the enchytraeids occurred in significantly higher numbers outside compared to inside the fence. The present study indicates that one species dominates totally outside the fence compared to 4 species inside the fence. Biotic or abiotic changes in the soil caused by grazing, differences in nutrient availability caused by reindeer faeces or differences that existed in the soil before the reindeer fence was put up could all be important to explain this pattern. Both species composition and total density of enchytraeids are expected to reflect such differences in habitat quality, which may be influenced by reindeer grazing.

Acknowledgement

We wish to thank Terje Visnes who collected the soil samples from Bjørndalen and Grumantbyen and kindly handed the Enchytraeidae over to us. We also wish to thank professor Lauritz Sømme for valuable help in field research as comments on the manuscript. The study was partly financed by a grant to one of us (Tone Birkemoe) from the Norwegian Research Council.

Table 2. The distribution of the Enchytraeidae species recorded from Spitsbergen. Records: S= Stephenson (1922, 1924, 1925), N=Nurminen (1965, 1966) and + = the present study.

	Isfjorden area		Kongsfjorden area		other localities
<i>Bryodrilus ehlersi</i>	+	(N)	+	(N)	(N)
<i>Bryodrilus parvus</i>			+		
<i>Cernosvitoviella immota</i>		(N)			
<i>Cognettia sphagnetorum</i>					(N)
<i>Enchytraeus albidus</i>		(S)(N)			(S)
<i>Enchytraeus kincaidi</i>		(N)	+	(N)	(N)(S)
<i>Fridericia bulboides</i>		(N)			
<i>Fridericia bulbosa</i>		(N)			
<i>Fridericia leydigi</i> *					
<i>Henlea heleotropha</i>	+	(N)	+	(N)	(S)
<i>Henlea nasuta</i>					(N)
<i>Henlea perpusilla</i>	+	(N)	+	(N)	(N)
<i>Henlea similis</i>	+	(N)	+	(N)	(N)
<i>Henlea ventriculosa</i>	+	(N)			(N)
<i>Lumbricillus eltoni</i>					(S)
<i>Lumbricillus arenarius</i> ¹					(N)
<i>Lumbricillus muscicolus</i>					(S)
<i>Lumbricillus bülowi</i> ²		(N)			(N)
<i>Lumbricillus pagensteecheri</i> *		(S)(N)		(N)	(S)(N)
<i>Lumbricillus reynoldsoni</i>		(N)		(N)	(N)
<i>Lumbricillus rivalis</i>		(N)			(N)
<i>Lumbricillus semifuscus</i>		(N)			
<i>Marionina argentea</i>	+	(N)			(N)
<i>Marionina crymodes</i>		(S)			
<i>Marionina libra</i>				(N)	
<i>Mesenchytraeus argentatus</i>	+		+		
<i>Mesenchytraeus eltoni</i>		(S)			(S)
<i>Mesenchytraeus flavus</i>	+	(N)	+		(N)

* recorded by Michalsen (1900) and Ude (1902), but no place name at Spitsbergen are given.

1. Syn. *L. magdalenae* (Nurminen 1965), according to list of Enchytraeidae synonyma (Dózsa-Farkas 1992).

2. Syn. *L. nielseni* (Nurminen 1965), according to list of Enchytraeidae synonyma (Dózsa-Farkas 1992).

Sammendrag

Nye funn av Enchytraeidae (Oligochaeta) fra Spitsbergen, Svalbard.

Tone Birkemoe & Klara Dózsa-Farkas

En undersøkelse av Enchytraeidae faunaen rundt Kongsfjorden og områder nære Longyearbyen ble foretatt sommeren 1993. Målet var å

øke kunnskapen om utbredelsen til denne dyregruppen samt finne artssammensetningen i utvalgte habitater med tanke på senere studier.

To arter som hittil ikke har vært rapportert fra Svalbard ble funnet (*Mesenchytraeus argentatus* og *Bryodrilus parvus*). I tillegg til dette ble *Mesenchytraeus flavus* registrert ved Kongsfjorden, et område som ligger langt fra tidligere funnsteder. Faunaen av enchytraeid-

er på Spitsbergen omfatter nå totalt 28 arter, hvorav 13 ble funnet i denne undersøkelsen. *Enchytraeus liefdeensis* har blitt synonymisert med *Enchytraeus kincaidi* på bakgrunn av individer fra dette studiet.

En sammenligning av Enchytraeidae-faunaen innenfor og utenfor et reingjerde indikerer at en art dominerer utenfor gjerdet der vegetasjonen er beitet av rein. mens jorden innenfor er mere artsrik. En tidligere undersøkelse fant et signifikant større antall av enchytraeider utenfor det samme gjerde i forhold til innenfor. Det er derimot ikke grunnlag for å trekke noen konklusjoner om sammenhengen mellom disse resultatene og reinbeiting.

References

- Anunsen, I. W., Birkemoe, T., Nielsen, L., Sickel, H. & Sømme, L. 1993. Sammenlignende undersøkelse av reinens beiteeffekt på jordbunnsfaunaen. Prosjektoppgaver i BIO 390: 41-53. Department of Biology, University of Oslo.
- Brattbakk, I. 1981. Ny-Ålesund, Brøggerhalvøya, Svalbard. Vegetasjonskart 1: 10 000. Norske Videnskapelige Selskap, Trondheim.
- Coates, K. & Ellis, D.V. 1981. Taxonomy and distribution of marine *Enchytraeidae* (*Oligochaeta*) in British Columbia. *Can. J. Zool.* 59: 2129-2150.
- Dash, M. C. 1970. A taxonomic study of *Enchytraeidae* (*Oligochaeta*) from Rocky Mountains forest soils of the Kananaskis region of Alberta, Canada. *Can. J. Zool.* 48: 1429-1435.
- Dash, M.C. & Cragg, J.B. 1972. Ecology of *Enchytraeidae* (*Oligochaeta*) in Canadian Rocky Mountain soils. *Pedobiologia.* 12: 323-335.
- Dózsa-Farkas, K. 1990. New Enchytraeid species from *Sphagnum*-bogs in Hungary (*Oligochaeta*). *Acta Zool. Hung.* 36: 265-274.
- Dózsa-Farkas, K. 1992. List of Enchytraeid Synonyma. Newsletter on Enchytraeidae. 3: 16-35.
- Hjelle, A. 1993. Svalbard geologi. Polarhåndbok nr. 6, Norsk Polarinstitutt.
- Michaelsen, W. 1900. *Oligochaeta*. *Das Tierreich.* 10:1-575.
- Nurminen, M. 1965. *Enchytraeid* and *Lumbricid* records (*Oligochaeta*) from Spitsbergen. *Ann. Zool. Fenn.* 2: 1-10.
- Nurminen, M. 1966. Further notes on the Enchytraeids (*Oligochaeta*) of Spitsbergen. *Ann. Zool. Fenn.* 3: 68-69.
- Nurminen, M. 1967. Faunistic notes on North-European enchytraeids (*Oligochaeta*). *Ann. Zool. Fenn.* 4: 567-587.
- Nurminen, M. 1973a. *Enchytraeidae* (*Oligochaeta*) from the Arctic archipelago of Canada. *Ann. Zool. Fenn.* 10: 403-411.
- Nurminen, M. 1973b. *Enchytraeidae* (*Oligochaeta*) of Island. *Ann. Zool. Fenn.* 10: 412-413.
- O'Connor, F. B. 1962. The extraction of enchytraeidae from soil, 278-285 in: Murphy, P.W. (ed.) *Progress in Soil Biology*. Butterworths, London.
- Stephenson, J. 1922. The *Oligochaeta* of the Oxford University Spitsbergen expedition. *Proc. Zool. Soc. Lond.* 1922: 1109-1138.
- Stephenson, J. 1924. On some *Oligochaete* worms from Spitsbergen. Results of the Merton College expedition to Spitzbergen, 1923. *Ann. Mag. Nat. Hist.* 13: 210-216.
- Stephenson, J. 1925. The *Oligochaeta* of Spitsbergen and Bear Island: Some additions and summary. *Proc. Zool. Soc. Lond.* 1925: 1293-1322.
- Ude, H. 1902. Die arktischen Enchyträden und Lumbriciden, sowie die geographische Verbreitung dieser Familien. *Fauna Arctica.* 2:1-34.
- Wegener, C., Hansen, M. & Bryhn Jacobsen, L. 1992. Effekter av reinbeite ved Kongsfjorden, Svalbard. *Meddelelser fra Norsk Polarinstitutt.* 121: 32-54.
- Winsnes, T. S. 1988. Bedrock map of Svalbard and Jan Mayen. Norsk Polarinstitutt.