

Freshwater tardigrades from Hopen, Svalbard (76°31'N)

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Seventeen species of Tardigrada were found in submerged mosses of 17 freshwater bodies from the S-E part of the island of Hopen (Svalbard). Fourteen species are new records for Hopen; *Pseudechiniscus islandicus* was not previously reported from Svalbard. The most frequently and numerous encountered species were *Isohypsibius granulifer*, *Hypsibius dujardini*, *Dactylobiotus dispar*, *Macrobiotus dianeae* and *Amphibolus weglarskae*.

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INTRODUCTION

Hopen 76°31'N, 25°01'E) is a high arctic island of the Svalbard archipelago located in the Barents Sea, S-SE of the island Edgeøya. The only published records on the tardigrade fauna of Hopen are by Richard (1898), who reported *Macrobiotus macronyx* (species dubia) and Richters (1911a) who found *Testechiniscus spitsbergensis* (Scourfield), *Diphascon belgicae* Richters, *D. recamieri* Richters, *D. stappersi* Richters, *Hypsibius arcticus* (Murray), *Macrobiotus areolatus* Murray, *M. echinogenitus* Richters and *M. hufelandi* Schultze (nomenclature updated by the authors).

The present paper deals with the tardigrade species found in submerged mosses from freshwater habitats, sampled during a biological expedition of Antwerpen University.

MATERIAL AND METHODS

The island of Hopen is a narrow strip, about 37 km long and 0.9-1.8 km wide, which consists of a series of plateau-shaped mountains of 200-370 m high and separated by seven saddles right across the island. The sub-

strate consists of sandstone and shales (Winsnes & Worsley 1981). The island is normally surrounded by ice for about 10 months of the year. It has a tundra climate with mean annual temperature below freezing point (Steffensen 1969). Monthly mean temperatures are below freezing-point, except during the period July-September (0.9-2.2 °C). During our stay (06 September 1985), the air temperature varied between 0.5 and 0.8 °C (11.30 a.m.-16.30 a.m.).

The seventeen water bodies sampled in this study were from the south-eastern part of the island (Figure 1). Three of them are located in a stretch of coastal lowland (Heniesalen- Koefoedodden), 10 lie in the saddle behind the radio-station (Husdalen) and 4 are from a mountain plateau (Werenskioldfjellet). All of them are shallow (<0.5 m in maximum depth) and freeze to the bottom.

Some details about the water bodies:

N° 1: small puddle near lowland at Bekkeskardet, ca. 2 m from high tide level, 1 m diameter, depth 5 cm, substratum muddy with gravel, manured by birds; total hardness >7-14°dH (125-250 mg CaCO₃ l⁻¹).

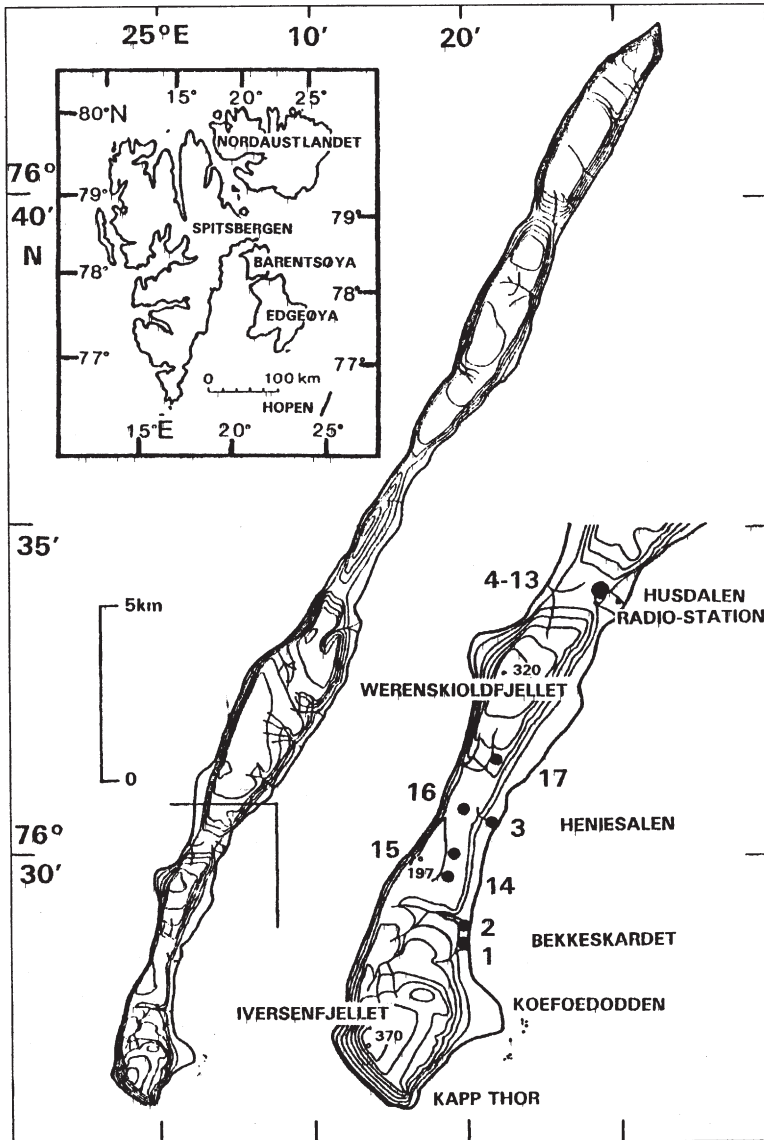


Figure 1

Map of Hopen with sampling area and localities investigated (1-17).

- N° 2: puddle in lowland behind raised beach ridge near Bekkeskardet, ca. 40 m from high tide level, 10 m x 3 m, depth 5-10 cm, substratum muddy, manured by birds; total hardness >7-14°dH.
- N° 3: drainage area behind raised beach ridge near Heniesalen, 10 m from high tide level; total hardness <3°dH (<50 mg CaCO₃ l⁻¹).

- N° 4: Husdalen, pool, 2 m diam., depth 5-10 cm, manured by birds; total hardness >7-14°dH.
- N° 5: Husdalen, pool, 5 m x 3 m, depth 15 cm, manured by birds; total hardness <3°dH.
- N° 6: Husdalen, pool, 7 m x 5 m, depth 20-30 cm; manured by birds; total hardness <3°dH.
- N° 7: Husdalen, pool, 10 m x 5 m, depth 20-30 cm, manured by birds; total hardness <3°dH.

- N° 8: Husdalen, pool, 8 m x 4 m, depth 10 cm, manured by birds; total hardness < 3°dH, pH 7.5, conductivity 461 μScm^{-1} (25 °C).
- N° 9: Husdalen, pool, 7 m x 4 m, depth 10-15 cm, manured by birds; total hardness < 3°dH.
- N° 10: Husdalen, pool, 7 m x 3 m, depth 10-15 cm, manured by birds; total hardness < 3°dH.
- N° 11: Husdalen, pool, 7 m x 3 m, depth 10-15 cm, manured by birds; total hardness < 3°dH.
- N° 12: Husdalen, pool, 5 m x 3 m, depth 10-15 cm, manured by birds; total hardness < 3°dH.
- N° 13: Husdalen, small pool behind radio-station, 3 m x 1 m, depth 15-20 cm; total hardness > 4-7°dH (>70-125 mg $\text{CaCO}_3 \text{ l}^{-1}$).
- N° 14: Werenskioldfjellet mountain plateau, small puddle, 40 cm x 40 cm, depth 5 cm; total hardness < 3°dH.
- N° 15: Werenskioldfjellet mountain plateau, puddle 10 m x 5 m, depth 2-5 cm, substratum muddy; total hardness < 3°dH.
- N° 16: Werenskioldfjellet mountain plateau, puddle, 5 m x 3 m, depth 2-5 cm, substratum muddy; total hardness < 3°dH.
- N° 17: Werenskioldfjellet mountain plateau, puddle, 5 m x 5 m, depth 2-5 cm, substratum muddy; total hardness < 3°dH.

Qualitative sampling was done by squeezing submerged mosses from the margins of the water bodies. The samples were preserved immediately in 5 % formaldehyde.

The occurrence of the species in high arctic freshwater bodies was assessed by calculating their constancy, *i.e.* the ratio of the number of water bodies with the investigated species, to the number of all water bodies sampled. All samples compiled in Van Rompu & De Smet (1991a) were included.

General zoogeographical and ecological remarks were mainly taken from Ramazzotti & Maucci (1983), Dastych (1988) and McInnes (1994).

RESULTS AND DISCUSSION

All the samples contained tardigrades. Table 1 details the species and number of specimens at each of the

localities sampled. The 17 samples yielded 17 species belonging to nine genera and four families.

Annotated species list

Amphibolus weglarskæ (Dastych, 1972)

Length 352-767 μm .

Hygrophilous and alcalciphilous, cold-stenotherm. Distribution insufficiently known; the species is apparently holarctic (e.g. Italy, Poland, Norway, Svalbard, Greenland, Canada: Vancouver and Devon Island, Japan). This is probably an arctic boreo-alpine element. Its constancy in high arctic water bodies is 22 %.

Svalbard records : Bjørnøya (Van Rompu & de Smet 1988), Barentsøya (Van Rompu & De Smet 1991a).

Dactylobiotus dispar (Murray, 1907)

Length 253-1070 μm .

This is a cosmopolitan and hydrophilous species. Its constancy in high arctic water bodies is 33 %.

Svalbard records: Barentsøya (Van Rompu & De Smet 1991a), Prins Karls Forland (Murray 1907 sub *Macrobiotus dispar*), Spitsbergen (Klekowski & Opaliński 1986, 1989).

Diphascon pingue (Marcus, 1936)

Length 207-290 μm .

The specimens from Hopen showed microplacoids and a septulum, and were accordingly identified as *D. pingue* (Pilato & Binda 1977, Dastych 1984).

D. pingue is a widespread and hydrophilous species. It was found in 17 % of the freshwater bodies examined so far.

Svalbard records : Barentsøya (Van Rompu & De Smet 1991a), Bjørnøya (Van Rompu & De Smet 1988, variety A sub *Diphascon alpinum* Murr.), Edgeøya (De Smet *et al.* 1988 variety A sub *D. alpinum* Murr.), Prins Karls Forland ? (Murray 1907 sub *D. alpinum* Murr.), Spitsbergen (Dastych 1985, Weglarska 1965 sub *Hypsibius (D.) alpinus* Murr.).

Diphascon recamieri Richters, 1911

Length 202-257 μm .

D. recamieri is considered as a hydrophilous, cold-stenotherm and alcalciphilous species. It is an arctic-alpine element with mainly holarctic distribution; it has also been recorded from the alpine zone in Argentina.

Table 1. Numbers of specimens in each tardigrade species found at the different localities.

Locality	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Freq.	N. ind.
HETEROTARDIGRADA																			
Echiniscidae																			
<i>*Pseudechiniscus islandicus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	2
<i>*Pseudechiniscus suillus</i>	-	-	-	-	-	2	1	-	-	-	-	1	1	1	-	1	33	7	40
<i>Testechiniscus spitsbergensis</i>	-	-	-	-	-	-	-	-	-	-	1	-	2	1	-	-	1	4	5
EUTARDIGRADA																			
Macrobiotidae																			
<i>*Dactylobiotus dispar</i>	2	-	1	26	1	14	70	63	73	35	3	10	6	-	10	64	81	15	459
<i>*Macrobiotus crenulatus</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	2
<i>*Macrobiotus dianeae</i>	-	-	-	16	-	2	1	-	-	-	-	-	-	-	-	-	74	4	93
<i>Macrobiotus echinogenitus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	4	2	8
<i>*Macrobiotus harmsworthi</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	6	3	8
Eohypsibiidae																			
<i>*Amphibolus weglarskae</i>	2	-	-	22	1	7	-	1	1	-	-	-	-	44	-	-	46	8	124
Hypsibiidae																			
<i>*Diphascon pingue</i>	-	-	-	2	1	2	-	-	1	-	-	-	1	-	-	1	2	7	10
<i>Diphascon recamieri</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	1	2	8
<i>*Diphascon scoticum</i>	-	-	-	1	1	-	1	1	-	-	-	-	-	11	-	-	3	6	18
<i>*Hypsibius dujardini</i>	20	2	95	23	18	5	23	10	22	47	15	22	22	77	14	5	36	17	456
<i>*Isohypsibius granulifer</i>	21	-	191	106	75	690	467	608	594	341	81	645	98	18	52	373	17	16	4377
<i>*Isohypsibius papillifer</i>	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
<i>*Isohypsibius elegans</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
<i>*Mesocrista spitsbergensis</i>	-	-	-	-	-	8	1	-	1	-	1	1	-	-	4	6	45	8	67
Number of species	5	2	3	7	6	8	7	5	7	3	5	6	6	7	5	8	14		
Number of individuals	46	3	287	196	97	730	564	683	693	423	101	680	130	159	84	452	351		5679

* species new to Hopen

The species is frequently found in cryoconite holes on glaciers (Dastych 1985, De Smet & Van Rompu 1994). Svalbard records : Hopen (Richters 1911a), Spitsbergen (Weglarska 1965, Dastych 1985, De Smet & Van Rompu 1994).

***Diphascon scoticum* Murray, 1905**

Length 233-347 µm.

This is an euryhygric and cosmopolitan species, preferring mesocalciphilous habitats. It shows a constancy of 13 % in high arctic freshwater bodies.

Svalbard records : Barentsøya (Van Rompu & De Smet 1991a), Prins Karls Forland (Murray 1907), Spitsbergen (Murray 1907, Richters 1911a, Weglarska 1965, Dastych 1985).

***Hypsibius dujardini* (Doyère, 1840)**

Length 172-457 µm.

This species is aquatic and hygrophilous, alcalciphilous and cosmopolitan. *Hypsibius dujardini* is with a constancy of 86 % one of the most frequently encountered species in high arctic freshwater bodies.

Svalbard records : Barentsøya (Van Rompu & De Smet 1991a), Bjørnøya (Van Rompu & De Smet 1988), Edgeøya (De Smet *et al.* 1988), Spitsbergen (? Von Goes 1862, Richters 1911a, Weglarska 1965, Dastych 1985, De Smet *et al.* 1987).

Isohypsibius elegans (Binda and Pilato, 1971) (figure 2a-e)

Length 370 μm .

Dorsal surface with 10 transverse rows of poorly developed gibbositities; there are 3 gibbositities in the first row, 2 in the second, 4 in the third to the ninth and one in the tenth row. Gibbositities oval-shaped in anterior half, becoming more conical and prominent posteriorly. Cuticle with more or less regularly distributed small granules dorsally increasing in dimensions caudally. Bucco-pharyngeal apparatus with wide buccal tube (length 38 μm , diameter 5.6 μm) and oval bulbous (length 47 μm , diameter 38 μm) with large apophyses. Two macroplacoids, the first twice as long as the second, with distinct constriction near mid-length. Microplacoids absent. Eyes present. Double claws large, inner and outer claw only slightly different in size and shape, with small accessory spines on primary branches. Lunulae present. A large cuticular bar

(length 10.8 μm , width 1.2 μm) at the bases of internal claws I-III; outer side of bar delicately curled.

This species has been found in Europe, Russia, Africa and Australia. It is considered as an eucalciphilous element.

Svalbard record : Spitsbergen (Dastych 1985).

Isohypsibius granulifer Thulin, 1928

Length 168-555 μm ; embryo 160 μm , embryonated eggs 76-100 x 94-102 μm .

This is a hydrophilous and cosmopolitan species. It was the dominant species in the cryoconite holes studied by De Smet & Van Rompu (1994). Together with *Hypsibius dujardini* it is the most frequently found species in high arctic freshwater bodies (constancy 86 %). Svalbard records: Barentsøya (Van Rompu & De Smet 1991a), Bjørnøya (Van Rompu & De Smet 1988), Edgeøya (De Smet *et al.* 1988), Spitsbergen (? Dastych 1985, De Smet & Van Rompu 1994).

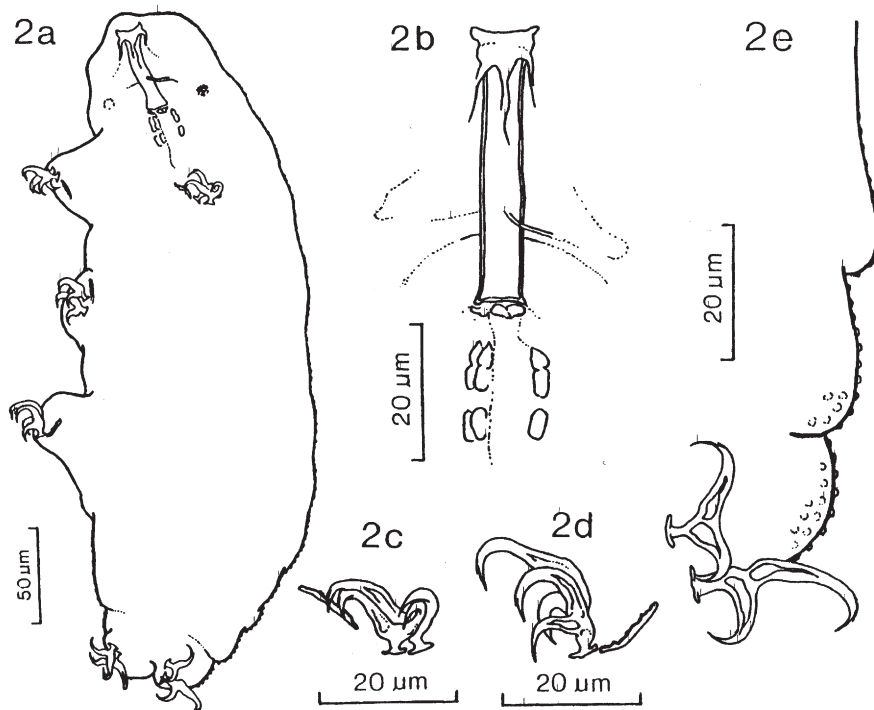


Figure 2

Isohypsibius elegans : a habitus, b buccal apparatus, c double claw of leg I with cuticular bar, d double claw of leg III with cuticular bar, e double claw of leg IV and detail of cuticle.

Isohypsius papillifer (Murray, 1905)

Length 210 µm.

The specimen displayed papillae with up to four small, stiff hairs on their tops. These hair-like structures have been demonstrated in the species on several occasions (Van Rompu & De Smet 1988, 1991a, b, 1992, 1996). Similar structures are also commonly found (Dastych 1990) in the probably closely related *I. sattleri* (Richters).

This is a hygrophilous and cosmopolitan species. Its constancy in high arctic freshwater bodies amounts to 16 %.

Svalbard records : Barentsøya (Van Rompu & De Smet 1991a), Bjørnøya (Van Rompu & De Smet 1988), Spitsbergen (Richters 1911a).

Macrobotus crenulatus Richters, 1904 (figure 3a-g)

Length 315-393 µm.

Medium sized animals. Dorsal and ventral cuticle with mostly rounded or elliptic pores of variable dimensions. The two close-set elliptic pores dorsally of the mouth cavity were not seen. Double claws of the *hufelandi*-

type, with large lunulae; each lunula with ca. 12 pointed teeth. Oval pharyngeal bulb (length 26 µm, diameter 23 µm) with large apophyses, two macroplacoids and a large microplacoid; the first macroplacoid constricted in the middle, and nearly twice as long as the second. Buccal tube : length 34 µm, diameter 2.4 µm.

This species has only been reported from the Holarctic (Europe, Russia, N. America).

Svalbard records : Prins Karls Forland (Murray 1907), Spitsbergen (Richters 1904).

Macrobotus dianeae Kristensen, 1982

Length 205-535 mm.

This is probably a hygrophilous species with arctic-temperate distribution (Greenland, Svalbard, Canada : N.W.T. Devon and Little Cornwallis Island, Belgium, Tanzania : Kilimanjaro). Its constancy in high arctic water bodies is 27 %.

Svalbard record : Barentsøya (Van Rompu & De Smet 1991a).

Macrobotus echinogenitus Richters, 1904

Length 193-440 µm.

This is a common, euryhygric, eucalciphilous and eurythermic species with cosmopolitan distribution. Its constancy in high arctic water bodies is 6 %.

Svalbard records : Barentsøya (Van Rompu & De Smet 1991a), Bjørnøya (Richters 1911b), Edgeøya (De Smet *et al.* 1988), Hopen (Richters 1911a), Prins Karls Forland (Murray 1907), Spitsbergen (Richters 1904, 1911a, Weglarska 1965, Dastych 1985; Klekowski & Opaliński 1986, 1989).

Macrobotus harmsworthi Murray, 1907

Length 150-570 µm.

This is an euryhygric and eurythermic species with cosmopolitan distribution. Its constancy in high arctic water bodies amounts to 6 %.

Svalbard records: Kong Ludvigøyanne (Richters 1911b), Prins Karls Forland (Murray 1907), Spitsbergen (Richters 1903 (sub *M. echinogenitus*), 1911a, Weglarska 1965, Dastych 1985, Klekowski & Opaliński 1986, 1989).

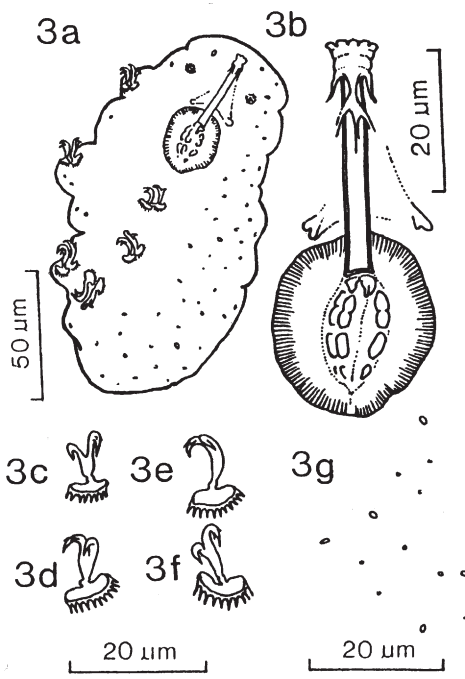


Figure 3

Macrobotus crenulatus: a habitus, b buccal apparatus, c inner claw of leg I, d outer claw of leg III, e-f outer and inner claw of leg IV, g detail of cuticle.

***Mesocrista spitzbergensis* (Richters, 1903)**

Length 190-625 μm .

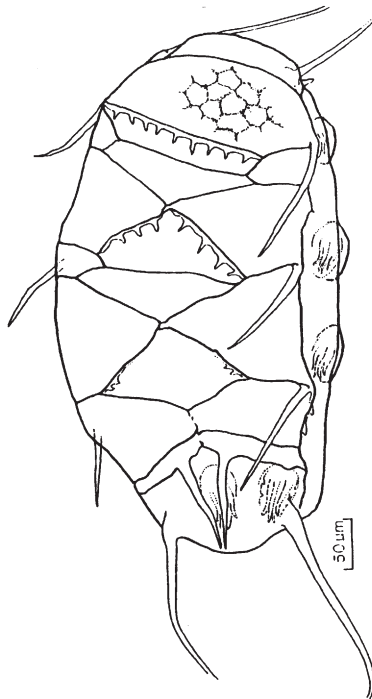
This species has been found in many locations throughout the Holarctic. Its constancy in high arctic water bodies is 17 %.

Svalbard records: Bjørnøya (Van Rompu & De Smet 1988), Edgeøya (De Smet *et al.* 1988), Prins Karls Forland (Murray 1907), Spitsbergen (Richters 1903, 1904, Weglarska 1965, Dastych 1985).

***Pseudechiniscus islandicus* (Richters, 1904) (figure 4)**

Length 520 μm .

Large animals. The cuticular sculpturing of the dorsal plates consists of rows of small spots in a more or less irregular reticulate pattern of 5-6-edged facets. Median plate 1 and 2 divided in two pieces; median plate 3 undivided. Lateral cirri A and E very long, appendages B, C and D short and spiniform. Caudal margin of paired pseudosegmental plate III' dorsally with 2 long, robust spines. Lateral margins of caudal plate with 2 small spines; caudal margins of scapular plate I and paired segmental plates II and III with a series of spi-



nes. Spines of dentate collar of legs IV small. Internal claws with small secondary basal spur.

This species is regarded as a mountainous species by Ramazzotti & Maucci (1983). It has been reported from Switzerland, Scotland, Shetland and Faroe Isles, and Greenland. This is the first record of it from Svalbard.

***Pseudechiniscus suillus* (Ehrenberg, 1853)**

Length 172-203 μm .

This is a cosmopolitan and common species, usually reported from mosses on rocks and soil. Its constancy in high arctic freshwater bodies is 17 %.

Svalbard records: Barentsøya (De Smet & Van Rompu 1991a) Prins Karls Forland (Murray 1907 sub *Echiniscus mutabilis* Murr.), Spitsbergen (Richters 1911a sub *Echiniscus suillus* Ehrbg., Weglarska 1965, Dastych 1985).

***Testechiniscus spitsbergensis* (Scourfield, 1897)**

Length of adults 273-315 μm ; juveniles 142-317 μm .

This is an euryhygric and polycalciphilous species with holarctic distribution. It shows a constancy of 13 % in high arctic water bodies.

Svalbard records: Barentsøya (Van Rompu & De Smet 1991a), Bjørnøya (Richters 1911b), Hopen (Richters 1911a), Ryke Yseøyane (Richters 1904), Spitsbergen (Scourfield 1897, Richters 1903, 1904, 1911a, Bryce 1922, Weglarska 1965, Dastych 1985).

General remarks

A total of 5679 specimens attributable to 17 species in 9 genera of tardigrades was collected during this study. The species composition and abundance of the species (Table 1) was relatively dissimilar for the different samples. One sample yielded 14 of the total of 17 species found, and one had 2. The remainder varied between 3 and 8 species. Three of the species were very frequent: *Hypsibius dujardini* occurred in all samples, *Isohypsibius granulifer* was found in 16 and *Dactylobiotus dispar* was observed in 15 of the 17 samples. The frequency of occurrence of the remainder of the species varied from 1 to 8. The majority or 77 % of all speci-

Figure 4

Pseudechiniscus islandicus: habitus.

mens identified were of *Isohypsibius granulifer*; the total number of the two other most numerous species, e.g. *Dactylobiotus dispar* and *Hypsibius dujardini*, accounted for 8% each. The relative share of each of the other species was less than 1.2 %.

Among the species observed, only 3 belong to the Heterotardigrada (*Pseudechiniscus islandicus*, *P. suillus*, *Testechiniscus spitsbergensis*). It is well known that, in contrast with terrestrial and marine environments, Eutardigrada rather than Heterotardigrada predominate in freshwater habitats (e.g. Nelson 1991, Bertolani 1982). The present findings for Hopen and other arctic localities confirm this rule. Of the 34 taxa reported from high arctic freshwater habitats so far (Dastych 1985, De Smet *et al.* 1987, 1988, Mihelčič 1971, Van Rompu & De Smet 1988, 1991, Weglarska 1970, Weglarska & Kuc 1980) only four e.g. *Echiniscus blumi*, *Pseudechiniscus islandicus*, *P. suillus* and *Testechiniscus spitsbergensis*, are heterotardigrades.

The majority (11) of the species found are widespread or cosmopolitan, whereas the distribution (as far as known) of the remainder five species is considered to be holarctic. Fourteen species are new to Hopen (marked with an asterisk in Table 1), and one species, *Pseudechiniscus islandicus*, is new to Svalbard.

The most frequently occurring species in the different water bodies sampled at Hopen, were also most frequently found in other arctic waters (Van Rompu & De Smet 1991). After adding the data for Hopen to these previous results, it follows that the five species with the highest constancy in high arctic water bodies are *Isohypsibius granulifer* (86%), *Hypsibius dujardini* (86%), *Dactylobiotus dispar* (33%), *Macrobotus dianeae* (27%) and *Amphibolus weglarskae* (22%).

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