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SHORT NOTE

The first record of a rare marine tardigrade, *Halobiotus crispae* Kristensen, 1982 (Eutardigrada: Hypsibiidae), from the Svalbard Archipelago

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Abstract A rare marine tardigrade *Halobiotus crispae* Kristensen, 1982 was found abundant in intertidal flats at Josephbukta, Bellsund fiord, West Spitsbergen. This is the first record of this species from the Svalbard Archipelago. So far, the species has been found only in seven other localities in the northern hemisphere (between 56° and 69°N). The present record greatly extends the known geographical range to the north and also indicates a much wider distribution of the species than formerly reported. Moreover, a potential indicative character of this species and of the study area in monitoring climatic changes is discussed.

Keywords *Halobiotus crispae* · Tardigrada · New record · Spitsbergen · Intertidal flats · Climate change

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Introduction

Halobiotus crispae Kristensen, 1982 is a marine eutardigrade that belongs to the family Hypsibiidae. The species was originally described from Nipissat Bay, Disko Island, West Greenland by Kristensen (1982). During latter regular sampling for marine tardigrades around the world, it was also found in six additional localities in the northern hemisphere (Møbjerg et al. 2007; Fig. 1). The species occurs in intertidal and subtidal habitats to the depths of eight meters, where it dwells on filamentous algae that cover small stones and mussels or in silt and mud (Kristensen 1982; Eibye-Jacobsen 1997; Møbjerg et al. 2007). One of the important characteristics of this species is cyclomorphosis, i.e. the seasonal cyclic changes in morphology and physiology (Kristensen 1982; Møbjerg et al. 2007; Halberg et al. 2009a). Although the existence of cyclomorphosis has been suggested for other tardigrades, *H. crispae* remains the only tardigrade species for which cyclomorphosis has been recognised and described in detail (Møbjerg et al. 2007). Hence, *H. crispae* has often been sampled and used as a model organism in numerous studies of tardigrade biology, morphology and ultrastructure (Kristensen 1982; Møbjerg and Dahl 1996; Eibye-Jacobsen 1997, 2001; Møbjerg et al. 2007; Halberg et al. 2009a, b).

Intertidal and subtidal marine ecosystems are the most susceptible to climatic irregularities, ranging from

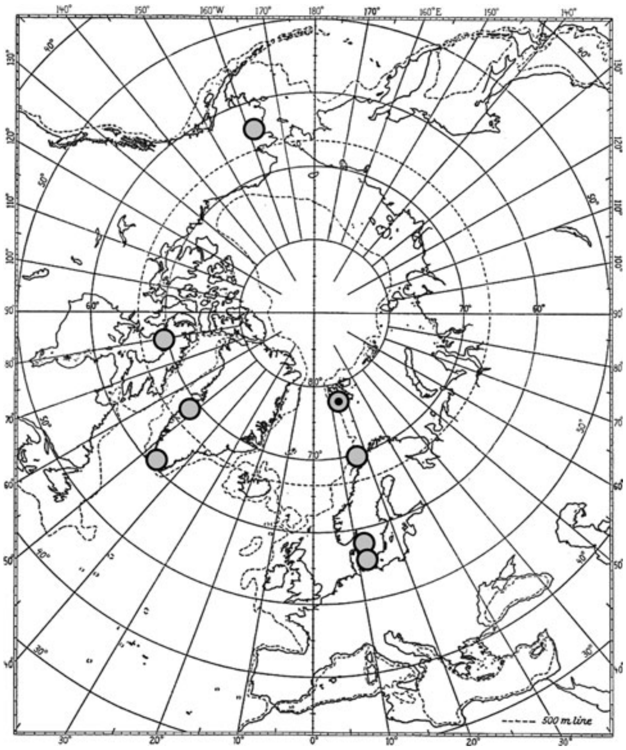


Fig. 1 Map with all known localities (including the present record, marked with a *black dot* in the centre) from which *Halobiotus crispae* was collected (after Møbjerg et al. 2007)

overheating, high UV radiation to drying, freezing, siltation and abrasion during low tides. Because of that, they can be used as models for studying the biological effects of climate changes (Węsławski et al. 2010). Due to the recent climatic changes and increased interest in biodiversity studies, a number of surveys were performed in intertidal and subtidal habitats around Svalbard. However, these studies focused mainly on macrofauna (see Węsławski et al. 1993, 2010 and cited literature therein) while largely ignoring meiofauna. Only very few studies (Szymelfenig et al. 1995; Węsławski et al. 1997; Włodarska-Kowalczuk et al. 1999; Veit-Köhler et al. 2008) examined meiofauna and reported tardigrades. Unfortunately, in these studies, tardigrades were considered only as a taxonomic group. In consequence, virtually nothing is known about marine tardigrades inhabiting coastal waters around Svalbard. For that reason, in summer 2010, during a survey of intertidal flats at Josephbukta (Bellsund fiord, Svalbard), several fine sediment samples were collected to investigate the tardigrade fauna of the region. In this note, we provide the first record of *Halobiotus crispae* from Svalbard (Arctic). This finding greatly extends the known geographic distribution of this model tardigrade species.

Materials and methods

Josephbukta (77°31′50″N, 14°37′50″E) is a small bay located in the south branch of the Bellsund fiord, West Spitsbergen (Fig. 2). It consists of two distinct parts, the muddy intertidal flat and the main oval basin ca. 600 m in diameter, with a steep bottom and depths ranging from 2 to 50 m. The intertidal flat is sheltered from the Bellsund fiord by a sandy–gravely spit formed by the marginal moraine of the Renardbreen Glacier. In the beginning of the twentieth century, which was also the end of the Little Ice Age, Josephbukta was completely covered by the Renardbreen Glacier. It became ice-free due to climatic changes and strong recession of the glacier in years 1936–60. Since then, this area was considerably affected by various morphogenetic factors, such as littoral, glacial, fluvioglacial and fluvial processes. The coastline and the bay were also strongly affected by marine processes, such as waving,

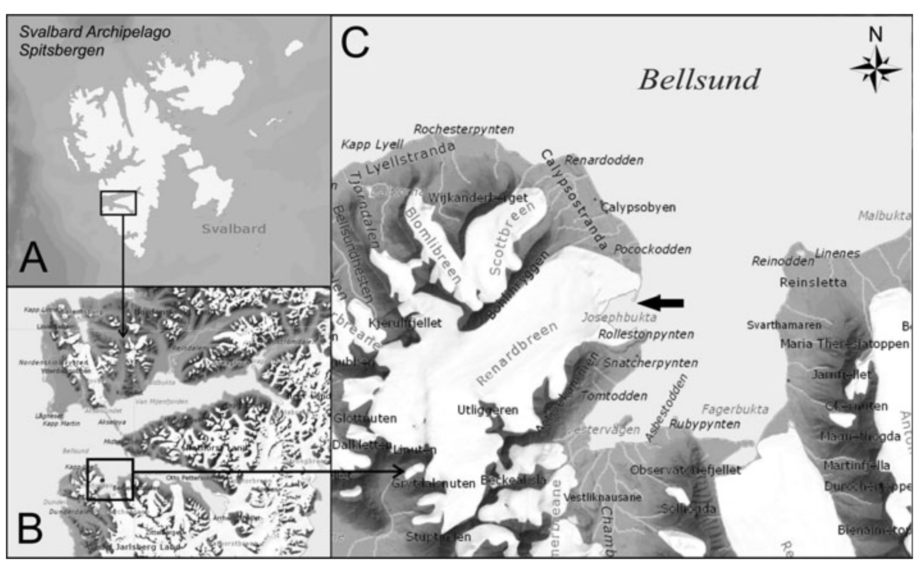


Fig. 2 Map of the investigation area: (**a**) Svalbard Archipelago (**b**) Bellsund Fiord, West Spitsbergen, (**c**) Josephbukta (based on maps from Norsk Polarinstitute, reprinted with permission)

tides and long-shore currents. At present, due to a strong recession of the Renardbreen Glacier and due to disappearance of the fluvioglacial processes, the marine processes are now the major factors affecting costal environments of the Josephbukta area (Zagórski 2007 and cited literature therein).

During the summer of 2010, fine sediment samples from the Josephbukta intertidal flats were collected to investigate micro-biota of this environment. For tardigrade examination, ten fine sediment samples, 10 cm^3 each, were collected. Sampling points were chosen approximately every 100 m, on a profile running across the whole flat from the low to high tide water levels. Temperature and salinity of the upper layer of sediment were measured with electronic field reader. The recorded temperature was 5.1°C, and salinity ranged between 22 and 23 PSU. The samples were collected on the 1 July 2010, during the low tide. The upper layer (down to 5 mm deep) of the exposed sediment surface was collected with a spatula and preserved immediately after collection in a 4% neutral formaldehyde solution. Then, the collected samples were shipped to Poland for analysis. In the laboratory, approximately 10% of each sample was processed for tardigrade extraction. Tardigrades were extracted under a stereomicroscope at $40\times$ magnification and then mounted on microscope slides in Hoyer's medium. The slides were analysed under a phase contrast microscope (Olympus BX 51) associated with a digital camera. Animals and their traits were measured only if their orientations were suitable. The material is preserved in the collection of the second author at the Department of Animal Taxonomy and Ecology, A. Mickiewicz University, Poznań, Poland.

Results and discussion

The total of 268 specimens of *Halobiotus crispae* Kristensen, 1982 were extracted from the processed sediment samples. All the extracted specimens were in the active stage, which, among other things, is characterised by fully developed bucco-pharyngeal apparatus (Kristensen 1982; Møbjerg et al. 2007). No specimens in other cyclomorphic stages were found in the examined material. Currently, there are three species attributed to the genus *Halobiotus* (*H. crispae* Kristensen, 1982, *H. arcturulius* Crisp and Kristensen, 1983 and *H. stenostomus* (Richters, 1908)). All these species are extremely similar morphologically and therefore difficult to differentiate one from another. Moreover, they also occupy similar habitats in the northern hemisphere and their geographical distributions largely overlap. In the samples examined in this study, *H. crispae* was the only tardigrade species. The morphology (Figs. 3, 4, 5, 6) and measurements of all the examined specimens correspond well with the

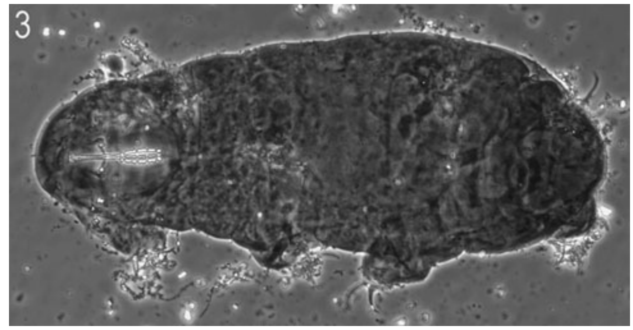
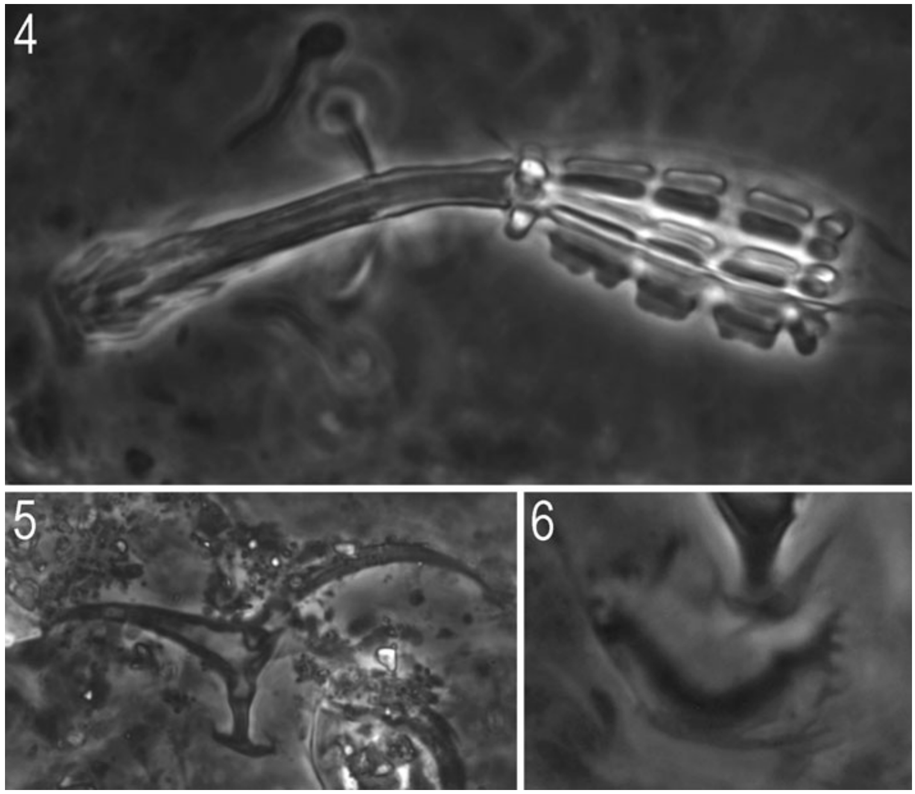


Fig. 3 *Halobiotus crispae* collected from Spitsbergen; habitus

original description of this species given by Kristensen (1982). Up to now only *H. arcturulius* was recorded from high Arctic localities (Crisp and Kristensen 1983; Mokievsky 1992). However, *C. crispae* is distinct from the latter species mainly in having a reticular sculpture on the dorsal side of the body.

Although the species is well known and has often been sampled (see Kristensen 1982; Møbjerg and Dahl 1996; Eibye-Jacobsen 1997, 2001; Møbjerg et al. 2007; Halberg et al. 2009a, b), the knowledge of its distribution seems to be only fragmentary. Since the discovery of an *H. crispae* population at Nipissat Bay, Disko Island, West Greenland (Kristensen 1982), this species has been reported from only seven other localities in the northern hemisphere, all located between 56° and 69°N (Møbjerg et al. 2007; Fig. 1). The present record from Svalbard at 77°N expands the range northward by a considerable extent.

The west coast of Svalbard is strongly influenced by warm waters of the West Spitsbergen Current (Berge et al. 2005). In consequence, it is characterised by ameliorated climatic conditions. In the intertidal flats along the West Spitsbergen coast, water temperature may reach over 10°C, whereas temperature of waters along the east coast even during summer season is usually below 0°C (Węsławski et al. 1993). Such high temperatures make the conditions in intertidal flats located at the coast of West Spitsbergen similar to Subarctic waters. Literature data demonstrate that some littoral and shallow-water benthic fauna may be easily rafted from the south to the Svalbard archipelago (on kelps and floating litter) and a northward expansion of some species has been observed over the last decades (Węsławski et al. 1997; Berge et al. 2005; Węsławski et al. 2010). In its southern localities, *H. crispae* is often found in association with the blue mussel *Mytilus edulis* (Kristensen 1982; Eibye-Jacobsen 1997; Møbjerg et al. 2007). There is no information on occurrence of this thermophilous mollusc in Bellsund but its appearance, related to current climate warming, has been recently documented in the nearby Isfjord (Berge et al. 2005). It is therefore possible that the occurrence of *H. crispae* at such high latitude could result



Figs. 4–6 *Halobiotus crispae* collected from Spitsbergen; **4** buccal apparatus, **5** external claw II, **6** cuticular thickening under external claw III

from more favourable climatic conditions of the investigated area and warm waters of the West Spitsbergen Current, which transported this tardigrade species from more southern localities.

In the previous surveys around the Svalbard archipelago, tardigrades were recorded only infrequently (in 2–7% of samples) and in very low numbers, with the maximum abundance ranging 0.8–2.5 specimens per 10 cm^2 (Szymelfenig et al. 1995; Węsławski et al. 1997; Włodarska-Kowalczuk et al. 1999; Veit-Köhler et al. 2008). Literature data indicate strong patchiness and variability in the Arctic intertidal meiofaunal abundance (e.g. Szymelfenig et al. 1995; Urban-Malinga et al. 2005). Therefore, due to the relatively low number and small volume of our samples, exact abundance of tardigrades for the locality surveyed in this study was not calculated. However, very high numbers of the extracted specimens and their presence in all examined samples indicate that their abundance can be even two orders of magnitude higher than the maximum densities reported for tardigrades from other localities around the Svalbard archipelago. In all these studies, tardigrade abundance was estimated from sediment samples collected to the depth of 3–5 cm, whereas in our study, only the upper layer of sediments (to 5 mm deep) was collected. Mokievsky (1992), in his studies of Svalbard intertidal meiofauna, has shown that the first centimetre of sediment comprises 70–90% of all organisms and in case of some taxonomic groups even all specimens are found only to this shallow depth. Therefore, it is possible that the sampling design used by previous workers could contribute to the reported lower numbers. Investigations of the vertical distribution of tardigrades in marine sediments are needed to test this hypothesis.

It has been documented, however, that recent increases in the sea water temperature around Svalbard not only led to the expansion of new species but also significantly increased the abundance of zoobenthos (Węsławski et al. 2010). It is therefore likely that such exceptionally large quantities of *H. crispae* could be related to the favourable climatic conditions of the investigated locality. Accordingly, due to their ameliorated conditions, intertidal flats at Josephbukta potentially possess an indicative character and may thus be used as model ecosystems for predicting the biological effects of the climatic changes and warming of the Svalbard shores. To better understand the extent and nature of biodiversity changes related to the current climatic amelioration, re-examination of tardigrade specimens collected during previous studies and/or collection of new samples from around Svalbard to provide baseline data for this poorly investigated taxon is needed.

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