# NEW DATA ABOUT MOSSES ON THE SVALBARD GLACIERS


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Rapid melting and retreat of glaciers in the Arctic is a cause of sustainable long-term existence of ablation zone on them. Sometimes these areas are the habitats of some mosses partly due to good availability of water and cryoconite substratum. 14 species were found in this unusual habitat on Alaska and Iceland: *Andreaea rupestris* Hedw., *Ceratodon purpureus* (Hedw.) Brid., *Ditrichum flexicaule* (Schwaegr.) Hampe, *Pohlia nutans* (Hedw.) Lindb., *Polytrichum juniperinum* Hedw. (Benninghoff, 1955*), Racomitrium fasciculare* (Hedw.) Brid. (=*Codriophorus fascicularis* (Hedw.) Bendarek-Ochyra et Ochyra) (Shacklette, 1966), *Drepanocladus berggrenii* (C.Jens.) Broth. (Heusser, 1972), *Racomitrium crispulum* var. *rupestre* (Hook. f. & Wils.) Dix., *Holodontium pumilum* (Mitt.) Broth., *Dicranoweisia brevistea* Card. (Seki, 1974), *Grimmia* sp. *Codriophorus fascicularis* (Hedw.) Bendarek-Ochyra & Ochyra (*R. fasciculare* (Hedw.) Brid.), *Niphotrichum ericoides* (Brid.) Bendarek-Ochyra & Ochyra (*R. ericoides* (Brid.) Brid. (Porter et al., 2008), *Pohlia filum* (Schimp.) Mertensson, *Sanionia uncinata* (Hedw.) Loeske, *Codriophorus fascicularis* (Dickson, Johnson, 2015, in print). Due to spheroidal and cylindric shape of moss cushions they were named "jökla mýs", that means "glacier mice" (Eythórsson, 1951).

Fig. 2. Glacier Bertil (Bertilbreen) near Pyramiden (Svalbard)

**In Svalbard** moss populations were found on 9 glaciers.
**In 2007** B.R.Mavlyudov collected one specimen on Bertilbreen *(Paludella squarrosa* (Hedw.) Brid.) and some specimens on Austre Grønfjordbreen (*Ceratodon purpureus* (Hedw.) Brid., *Warnstorfia sarmentosa* (Wahlenb.) Hedenäs, *Sanionia uncinata* (Hedw.) Loeske, *Hygrohypnella polare* (Lindb.) Ignatov & Ignatova.).
**In 2009** populations of two latter species were studied in more detail: the arrangement of moss polsters on ice, structure of the spherical cushions, anatomical features of the leaves, some ecological and biological characteristics of species that help them live in unfavorable conditions on the glaciers (Belkina, Mavlyudov, 2011).

**In 2012**, during re-examination of the populations a few individuals of *Bryum cryophilum* Mårtensson and some plants of *Sanionia uncinata* were found among *H. polare* shoots in some large cushions. Therefore the next stage of cushion succession had begun – emergence of a di- and multi-species community. A similar process was observed earlier on the bone of a mammal that was lying on the same glacier. *Ceratodon purpureus* settled in center of almost spherical cushion of *Sanionia uncinata* on the both butt-ends of the bone (Belkina, Likhachev, Mavlyudov, 2013). An important role of mosses ("glacier mice") as a habitat for invertebrates, basidiomycete fungus and even vascular plants (seedlings yet) in their colonization of glacier surface was pointed out by some researchers (Coulson et al., 2012; Dickson, Johnson, 2015).

## MATERIALS AND METHODS

In August **2013,** during floristic field exploration of Pyramiden environs we visited Bertile Glacier (**Bertilbreen**, Billefjord) and registered colony of mosses on glacier tongue in ablation zone.
40 samples of moss polsters and globular lumps of cryoconite were gathered from ice. Only a few samples could be identificated in the field. Other samples were studied in laboratory: extracted from cryoconite balls, washed from fine-earth deposits and examined under a microscope.
In laboratory 10 lumps of cryoconite without any leaves or stems on their surface was study under microscope.

*(**Cryoconite** is windblown dust consisting of mineral fine earth enriched with organic substances and particles. It is deposited and builds up on glaciers surface. Dark clusters of cryoconite absorb solar radiation causing the melting of snow or ice beneath them and creating cryoconite holes. Over time cryoconite deposits become comact and form rounded lumps.)*


Fig. 1. Map of Svalbard.
1-9 ▲ – the localities, where mosses on glaciers ice were found.
Glaciers:
1 – Austre Grønfjordbreen,
2 – Vestre Grønfjordbreen,
3 – Tavlebreen,
4 – **Bertilbreen**,
5 – Svenbrepen,
6 – Cambridgebreen,
7 – Mittag-Lefflerbreen,
8 – Elfenbeinbreen,
9 – Murraybreen.

## RESULTS

**1.** Large cushions (about 5-10 cm in diameter) were lying on a flat surface and towered above the ice. They looked like those on Austre Grønfjordbreen. But smaller tufts (less than 5 cm) differed: they were inside little cavities in the ice or in holes and they were almost completely wrapped cryoconite round them. There were many little presumably moss-free clasts on ice.
The size of samples varied from 0.5 till 5 cm, and we pinched off a small pieces from larger polsters.

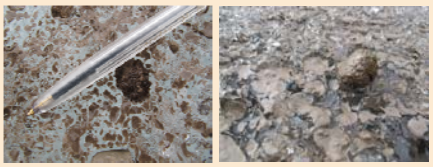


Fig. 3. Moss polsters and cryoconite holes

**2.** Populations of two species are on Bertilbreen - ***Hygrohypnella polare*** and ***Schistidium* cf. *abrupticostatum*** Sull. et Lesq.
Tufts of both species were placed on ice mixed together. Courtains of the first species were larger and located mostly upslope. Cushions of the second species were more numerous, smaller and almost completely enveloped in the cryoconite. They were lying down the slope of the glacier tongue, in little ice hollows.
No any concentric layers inside the ball have been found.

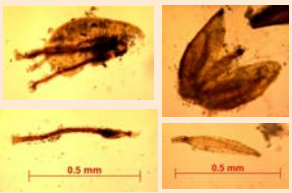
Fig. 4. Cushions of *Schistidium*

Fig. Cushion of *Hygrohypnella polare*

Fig. 5. Moss "balls" and cryoconite lumps

Fig. 6. Cushion of *Schistidium* washed from fine-earth deposits

Many plants of *Schistidium* had gametangia – archegonia (a) and antheridia (b) arranged in synoecium. '




***a*** ***b***

Fig. 7. Archegonia (*a*) and anteridia (*b*) of *Schistidium*

Inside of one of the cryoconite ball a single instance of ***Philonotis* sp**. was found in good condition.
From clast one a little tuft of the ***Pohlia* cf. *wahlenbergii*** (F.Weber & D.Mohr) Andrews was extracted.
We **couldn't confirm the presence of *Paludella squarrosa*** (Hedw.) Brid. on Bertilbreen, it was not found in 2013.

**3**. A study of 10 "bare"cryoconite lumps under a microscope revealed the following:.
a) Inside three of them (0.5-2 cm in diameter) mosses was not at all.
b) In other (0.5-2 cm) we found few or many thread-like structures - **protonemata**, or exactly, **caulonema** (Glime, 2007).

They are brownish and have slanting cross walls.

Caulonema forms short branches, consisting of 1-several widened green cells with chloroplasts.

On other parts of the caulonema a few buds with leaves of *Schistidium* are developing.

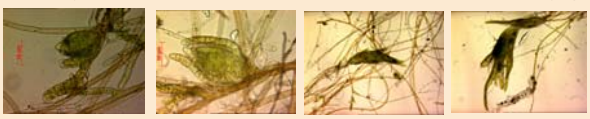


Fig. 8. Buds on the different stages of development

Also fragments of adult plants of this species were found in some globules. There were many protonemata around them. Sometimes the threads originated from vegetative parts of plants – leaf costa or stem. In these cases it is not differs from rhizoids.
Some long unbranched protonemata can be found near adult plants (along the stem) in well-developed cushions of *Schistidium*.

Fig. 9. Protonemata originated from leaf costa

## DISCUSSION

1) The lumps of cryoconite are full of developing protonemata (caulonema) of *Schistidium* moss. It is interesting that caulonema and, probably, chloronema grow and differentiate in deficiency of light.
2) *Schistidium* plants can form gametangia, but they can't develop sporophytes. In 2009 on Austre Grønfjordbreen some plants *Sanionia uncinata* had antheridia and none had sporophytes. The same situation was described for moss populations on glaciers in Alaska and Iceland.
3) Benninghoff (1955) assumed that reproduction of cushions is a result of growth and the subsequent splitting into pieces. A cause of disruption is a limit of tensile strength of moss stem. This way we registered on Austre Grønfjordbreen and Tavlebreen.

Fig. 10. Disruption of moss polsters on Tavle Glacier (photo by B.Mavlyudov)

Benninghoff (1955) pointed also, that sometimes "polsters develop from a young plant in the vegetative phase or from a fragment of an olderplant". They branch, grow and form flat and then round polsters.
According to our data, new cushions can appear due to developing young plants from protonemata inside globules of cryoconite. It may arise from small fragments of plants trapped in substratum or it appears as a result of spore germination. But the way of penetration of the fragments or spores into cryoconite remains uncertain. They might come from surrounding territory or from melting ice of glaciers. The spores can remain viable after long-term presence in the ice or permafrost (Troitsky et al., 2012; Roads et al., 2014).

## SUMMARY

❖Populations of the two species – *Hygrohypnella polare* and *Schistidium* cf. *abrupticostatum*, - there are on ice of Bertilbreen for at least 6 years. Some mosses-hygrophytes (*Philonotis* sp., *Pohlia* cf. *wahlenbergii*) can remain alive inside cryoconite globs for uncertainly long time.
❖The structure of cushions on Bertilebreen differ from those on Austre Grønfjordbreen. There is not any concentric layers in moss polsters coated with cryoconite cover.
❖*Schistidium* plants can form gametangia, but they can't develop sporophytes. In 2009 on Austre Grønfjordbreen it was observed the same situation with *Sanionia uncinata*.
❖On glacier new *Schistidium* cushions may arise through the development of shoots from protonemata. It may originate from the vegetative organs of plants, and probably from spores inside cryoconite lump. Caulonema can grow and produce buds in low-light conditions.


## LITERATURE

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