

## Bryophytes of the Larsemann Hills (Princess Elizabeth Land, Antarctica)

L. E. Kurbatova, M. P. Andreev

Komarov Botanical Institute, Professora Popova Str., 2, St. Petersburg, 197376, Russia; korablik-l@mail.ru, kurbatovale@binran.ru; andreevmp@yandex.ru

**Abstract.** The bryoflora of Larsemann Hills oasis (Princess Elizabeth Land, Antarctica) was investigated. Six moss species and one liverwort, *Cephaloziella varians*, were recorded during field studies over the period 2009–2014. *Bryum archangelicum* Bruch et Schimp. is new for Princess Elizabeth Land and three species [*B. archangelicum*, *Bryoerythrophyllum antarcticum* (L. I. Saviz et Smirnova) P. Sollman and *Syntrichia sarconeurum* Ochyra et R. H. Zander] are new for Larsemann Hills. Representative specimens are listed and data on habitats and associated species provided. The most common mosses in the area are *Bryum pseudotriquetrum* and *Coscinodon lawianus*. *Bryum pseudotriquetrum* was found for the first time in Larsemann Hills at the bottom of lakes.

**Keywords:** bryophytes, flora, Larsemann Hills, Princess Elizabeth Land, Antarctica.

## Мохообразные оазиса Холмы Ларсеманн (Земля Принцессы Елизаветы, Антарктика)

Л. Е. Курбатова, М. П. Андреев

Ботанический институт им. В. Л. Комарова РАН, ул. Профессора Попова, д. 2, Санкт-Петербург, 197376, Россия; korablik-l@mail.ru, kurbatovale@binran.ru; andreevmp@yandex.ru

**Резюме.** Проведено детальное исследование бриофлоры оазиса Холмы Ларсеманн (Земля Принцессы Елизаветы, Антарктика). По результатам исследований 2009–2014 гг. выявлено 6 видов мхов и печеночник *Cephaloziella varians*. Три вида [*Bryoerythrophyllum antarcticum* (L. I. Saviz et Smirnova) P. Sollman, *Bryum archangelicum* Bruch et Schimp. и *Syntrichia sarconeurum* Ochyra et R. H. Zander] отмечены для оазиса впервые, из них *Bryum archangelicum* впервые указывается для Земли Принцессы Елизаветы. Для каждого вида приведены репрезентативные образцы, местообитания и сопутствующие виды. Выявлено, что наиболее распространенными видами в оазисе являются *Bryum pseudotriquetrum* и *Coscinodon lawianus*. Впервые найдены мхи (*Bryum pseudotriquetrum*) в озерах оазиса Холмы Ларсеманна.

**Ключевые слова:** мохообразные, флора, Холмы Ларсеманна, Земля Принцессы Елизаветы, Антарктика.

This paper continues a series of publications on the cryptogamic flora of insufficiently explored Antarctic areas (Andreev, Kurbatova, 2008; Andreev, 2013; Kurbatova *et al.*, 2014).

The Larsemann Hills oasis is located in the eastern part of the Antarctic continent on the south-eastern coast of Prydz Bay of the Commonwealth Sea, Princess Elizabeth Land (69°30' S, 76°20' E) (Larsemann Hills..., 2014). The Larsemann Hills area was first charted by a Norwegian expedition led by Lars Christensen in 1935, but over the following 50 years no human activity of a significant or sustained nature occurred. Since 1986, the area has seen rapid and on-going development of infrastructure. Currently, there are three year-round research stations: Russian (Progress), Chinese (Zhongshan), Indian (Bharati), as well as a former Australian, now Romanian, summer research base (Law-Racovitza Base).

The Larsemann Hills oasis is an ice-free area covering 40 km<sup>2</sup>, consisting of two major peninsulas (Stornes and Broknes), 4 minor peninsulas, and approximately 130 near shore islands (Larsemann Hills..., 2014) (Fig.). Jagged hills and rocky ranges rising to 162 m (Blundell Peak), dissected by steep-sided fjords and valleys characterise the major peninsulas.

Larsemann Hills contains more than 150 lakes, ranging from shallow ponds to large basins, and from fresh, to slightly saline water (Larsemann Hills..., 2014). Offshore islands are likely to be roches moutonnées, isolated by the current sea level.

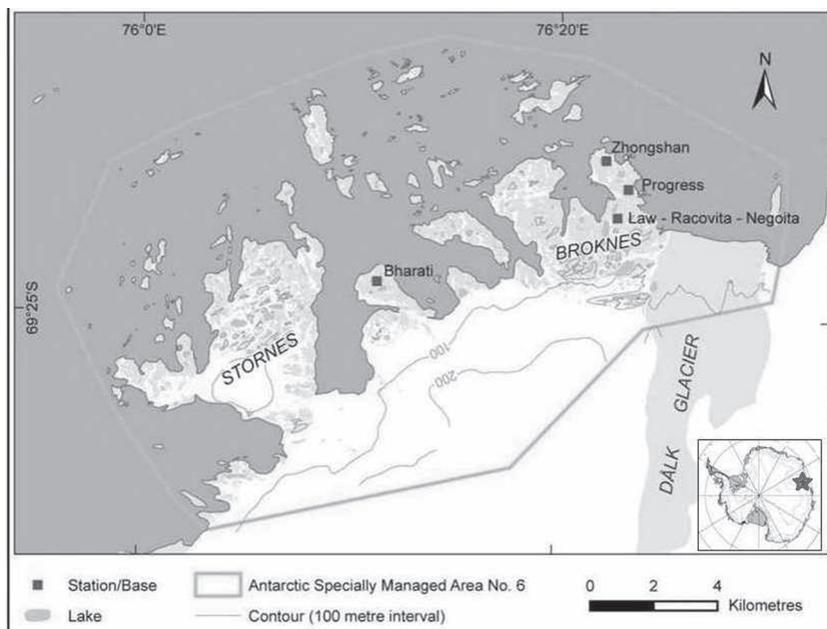


Fig. The study area in the Antarctic and a map of the oasis Larsemann Hills.

Bedrock exposures in the Larsemann Hills are composed of Palaeozoic supracrustal volcanogenic and sedimentary rocks, underlain by the Proterozoic orthogneiss basement (Larsemann Hills..., 2014). Surface sediments are common in depressions, as a sand, blown-in particles, screes and alluvium. Very thin soils (less than 10 cm deep) occur in association with scattered isolated vegetation patches. A permafrost layer exists 20–70 cm below the surface.

The climate of Larsemann Hills, because of orographic features, is milder compared with neighboring coastal oases (Larsemann Hills..., 2014). The mean annual temperature is 9.8 °C, July being the coldest, and December, the warmest months. Mean monthly winter temperatures lie between –15 °C and –18 °C. Daytime air temperatures from December to February frequently exceed 4 °C and can exceed 10 °C, with the mean monthly temperature slightly above 0 °C. The mean annual wind speed is 6.7 m/sec., with easterly winds prevailing. Precipitation is unlikely to exceed 250 mm water equivalent annually, occurring mainly as snow, and in summer very rarely as rain.

The relatively mild microclimate and presence of fresh water in summer provide favourable conditions for bird nesting, for marine fauna, terrestrial microfauna and cryptogamic vegetation development.

The Larsemann Hills territory has been visited on numerous occasions by Russian, Australian, and Chinese scientists. Nevertheless, very little published data on the bryophytes of the area exists. In the fundamental work on Antarctic mosses (Ochyra *et al.*, 2008) only two moss species collected by R. Lewis-Smith are mentioned — *Bryum pseudotriquetrum* (Hedw.) P. Gaertn., B. Mey. et Scherb. and *Coscinodon lawianus* (J. H. Willis) Ochyra.

In the «Larsemann Hills, East Antarctica: Antarctic Specially Managed Area Management Plan» (2014), seven species of bryophytes are mentioned without any indication of habitats and specimens: *Bryum pseudotriquetrum* (also as *Bryum algens* Cardot), *Schistidium antarctici* (Cardot) L. I. Savicz et Smirnova as *Grimmia antarctici* Cardot, *Coscinodon lawianus* as *Grimmia lawiana* J. H. Willis, *Ceratodon pupureus*, *Sarconeurum glaciale*, *Bryum argenteum* Hedw and *Cephaloziella exiliflora* (Taylor) Douin. The list was probably compiled on the basis of publications devoted to the bryoflora of the neighbouring oasis Vestfold Hills and adjacent territories (Seppelt, 1984, 1986), but without reference to collections from Larsemann Hill.

A detailed bryofloristic investigation of Stornes and Broknes peninsulas was conducted by L. E. Kurbatova during the summer seasons 2009–2012. As a result, the bryoflora, habitats and features of the moss vegeta-

tion were explored. Material collected in the oasis by M. P. Andreev in 2013–2014 has added substantially to data on the distribution of certain species.

Seven bryophytes currently known from Larsemann Hills on the basis of herbarium specimens and reliable literature references are presented below in alphabetical order. Latin names follow «Illustrated moss flora of Antarctica» (Ochyra *et al.*, 2008). The frequency of occurrence and integrated description of habitats in the area are provided for each species.

The frequency of occurrence was evaluated using the following scale: frequently — more than 15 localities, occasionally — from 6 to 15 localities, rare — fewer than 5 localities. Five representative specimens with exact coordinates, dates, name of collector and specimen number are given for every species. All localities are provided for rare species collected from less than 6 localities.

**Bryoerythrophyllum antarcticum** (L. I. Saviz et Smirnova) P. Sollman — occasionally. Broknes Pen.: 69°24.177' S, 76°21.556' E, alt. 50 m, 17.12.2009, Kurbatova, P014-2 (LE); 69°22.795' S, 76°19.336' E, alt. 44 m, 19.12.2009, Kurbatova, P029-2 (LE); 69°23.387' S, 76°22.042' E, alt. 20 m, Kurbatova, P007 (LE); 69°23.048' S, 76°18.870' E, alt. 59 m, 19.12.2009, Kurbatova, P030-1 (LE). Stornes Pen.: 69°24.630' S, 76°07.660' E, alt. 53 m, 24.12.2009, Kurbatova, P050 (LE).

*B. antarcticum* grows in the oasis on wet sand of lake and stream banks, normally together with *Bryum pseudotriquetrum*, rarely as a pure mat or in mixed communities together with lichens and cyanobacteria.

In Continental Antarctic *Bryoerythrophyllum antarcticum* is only known from the Eastern part of the Antarctic — in Vestfold Hills (Princess Elizabeth Land) and in Bunger Hills (Queen Mary Land) (Sollman, 2015). This is the first record of this Antarctic endemic in Larsemann Hills.

**Bryum archangelicum** Bruch et Schimp. — rare. Broknes Pen., NW bank of Progress Lake, on lakeside rocks, 69°24.075' S, 76°22.923' E, alt. 17 m, 17.12.2009, Kurbatova, P015-2a (LE).

*B. archangelicum* was recorded in Larsemann Hills on the ground in rock crevices, as sole species, poorly developed.

*B. archangelicum* was first recorded for Princess Elizabeth Land. Its nearest known locations in continental Antarctic are in Thala Hills (Oasis Molodyozhnyi, Enderby Land) (Kurbatova *et al.*, 2014). This bipolar species is common in Antarctic Peninsula area, but rather rare in the continental Antarctic (Ochyra *et al.*, 2008; Kurbatova *et al.*, 2014).

**B. pseudotriquetrum** (Hedw.) P. Gaertn., B. Mey. et Scherb. (= *Bryum algens* Cardot) — frequently. Broknes Pen.: 69°23.871' S,

76°19.362' E, alt. 60 m, 18.12.2009, Kurbatova, S358-1 (LE); 69°23.289' S, 76°21.183' E, alt. 7 m, 20.12.2009, Kurbatova, P036-1 (LE); 69°23.698' S, 76°21.680' E, alt. 27 m, 14.03.2012, Kurbatova, P 406-1 (LE). Stornes Pen.: 69°24.670' S, 76°08.147' E, alt. 45 m, 24.12.2009, Kurbatova, P055-a (LE); 69°24.630' S, 76°07.660' E, alt. 53 m, 24.12.2009, Kurbatova, P050-1 (LE).

*B. pseudotriquetrum* is the most abundant moss in Larsemann Hills, normally growing on sand and screes in wet habitats on lake and stream banks, and in seepages from snow-beds. It rarely occurs on sand deposited on rock ledges and on the ground in rock crevices. It was twice recorded on bird bones. In addition, certain *B. pseudotriquetrum* shoots were found on the surface of bottom sediments at a depth of 34 m (Lake Progress, 69°24' S, 76°22.923' E, 17.12.2009, Vershinin, P009-a). This species was previously recorded from deep water continental Antarctic lakes (Li *et al.*, 2009), including the neighbouring Vestfold and Amery oases. New for Larsemann Hill lakes.

*B. pseudotriquetrum* accounts for the biggest moss communities in the oasis, specifically occurring along lake banks and moist depressions. Moss mats can reach 3–4 cm in depth and cover an area extending 1–2 m<sup>2</sup>.

This bipolar species is widely distributed in the Antarctic, recorded in all its regions (Ochyra *et al.*, 2008).

**Ceratodon purpureus** (Hedw.) Brid. — rare. Broknes Pen., NW bank of Lake Scandrett, rocks of western exposition, 69°23.464' S, 76°22.096' E, alt. 20 m, 14.03.2012, Kurbatova, S357-1 (LE).

This cosmopolitan species was recorded previously in all Antarctic regions. One of the most widespread species occurring in the continental oases (Ochyra *et al.*, 2008). However, in the Larsemann Hills territory, *C. purpureus* was found only once — on the ground in deep rock crevices.

**Cephaloziella varians** (Gottsche) Steph. (= *Cephaloziella exiliflora* (Taylor) Douin) — rare. Broknes Pen.: NW bank of Lake Scandrett, low rocks of western exposition, on the ground in deep rock crevices, 69°23.464' S, 76°22.096' E, alt. 25 m, 14.03.2012, Kurbatova, P 408-1 (LE); northern slope of Gentnel Peak, on rock ledge in snow-bed seepage, on sand, 69°23.200' S, 76°18.547' E, alt. 60 m, 19.12.2009, Kurbatova, P032-2 (LE). Stornes Pen.: unnamed lake in the north-eastern part of the peninsula, on sand and between stones on the bank, 69°24.589' S, 76°07.858' E, alt. 63 m, 24.12.2009, Kurbatova, P051-2 (LE).

In Larsemann Hills, *C. varians* is known from some localities on Broknes and Stornes peninsulas. It mainly forms pure mats up to 5–10 cm in diam. on lake banks just near the shore line. Mats of this liverwort are

frequently partly covered by black bryophilous lichens and/or cyanobacteria. Only once was *C. varians* collected in the depression of a rock ledge together with *Coscinodon lawianus*.

Liverworts are very rare in continental Antarctic, represented by this single species recorded in the coastal oases of Princess Elisabeth Land, Wilkes Land, and southern part of Victoria Land (Bednarek-Ochyra *et al.*, 2000). In accordance with «The liverwort flora of Antarctica» the Antarctic specimens of *Cephaloziella exiliflora* should be referred as *C. varians*.

**Coscinodon lawianus** (J. H. Willis) Ochyra ( $\equiv$  *Grimmia lawiana* J. H. Willis) — frequently. Broknes Pen.: 69°22.437' S, 76°18.331' E, alt. 44 m, 22.03.2011, Kurbatova, S351-1 (LE); 69°24.210' S, 76°21.306' E, alt. 93 m, 17.12.2009, Kurbatova, P015-a1 (LE); 69°23.940' S, 76°19.812' E, alt. 40 m, 22.03.2011, Kurbatova, S356-1 (LE); 69°23.360' S, 76°22.419' E, alt. 20 m, 16.12.2009, Kurbatova, P006-1 (LE); 69°24.462' S, 76°20.084' E, alt. 122 m, 15.02.2014, Andreev, 1410802 (LE).

*C. lawianus* is the second most frequently occurring bryophyte in the oasis. It grows on sand in different habitats: rock ledges, alluvial deposits, along snow-bed margins and lake banks, rarely on the ground in rock crevices. In Larsemann Hills, *C. lawianus* forms pure mats up to 10–15 cm in diam., rarely together with *Bryum pseudotriquetrum*.

*C. lawianus* is endemic to the Antarctic, particularly continental oases and rather rare in western and maritime Antarctic regions (Ochyra *et al.*, 2008).

**Syntrichia sarconeurum** Ochyra et R. H. Zander — occasionally. Broknes Pen.: 69°24.283' S, 76°20.311' E, alt. 57 m, 14.03.2012, Kurbatova, P 398-1 (LE); 69°23.483' S, 76°20.056' E, alt. 80 m, 18.01.2014, Andreev, 144909 (LE); 69°22.818' S, 76°17.082' E, alt. 86 m, 03.02.2014, Andreev, 149005 (LE); 69°22.725' S, 76°19.830' E, alt. 57 m, 03.02.2014, Andreev, 149407 (LE). Stinear Pen.: 69°24.302' S, 76°18.268' E, alt. 50 m, 12.02.2014, Andreev, 1410401 (LE).

*S. sarconeurum* occurs in the territory of the oasis occasionally on the ground in rock cracks, rarely on sand on rock ledges, not lower than 50 m alt. This is the first record of this Antarctic endemic in Larsemann Hills. In the Antarctic, *S. sarconeurum* occurs in oases and on nunatacks around the whole continent and on offshore islands (Ochyra *et al.*, 2008).

Bryophytes occupy very small areas in the Larsemann Hills oasis, preferring lake and stream banks, snow-bed seepages, rock depressions and water-filled hollows on ledges. Moss communities typically include 1–3 species not exceeding a cover of 2 m<sup>2</sup>. Mosses grow either as convex hemispherical cushions, or more frequently as flat mats almost complete-

ly buried in sand. In most cases marginal shoots of the cushions are alive, green and partly covered by sand whereas median shoots of the cushions are dead and covered by bryophilous lichens. Remarkably, the best developed and undamaged by fungi and lichens mats were found on bird bones and remains.

The most common moss species in Larsemann Hills are *Bryum pseudotriquetrum* and *Coscinodon lawianus*. These mosses occur in all available habitats, often forming single species associations: (i) on sloping lake and stream banks; (ii) in nival habitats and on rock ledges.

Associations involving 2–3 species can also occur, where, together with the first two mentioned mosses, *Bryoerythrophyllum antarcticum* may also participate. Besides mosses such communities can also include some lichen species, on lake banks — cyanobacteria and very rarely the liverwort — *Cephaloziella varians*.

Other mosses are rather rare in the Larsemann Hills oasis. The bryoflora of the adjacent big Vestfold oasis amounts to five moss species [including *Henediella heimii* (Hedw.) R. H. Zander, which in Larsemann Hills has not yet been found] and the liverwort *Cephaloziella varians* (Seppeld, 1986; Ochyra *et al.*, 2008). Based on the data of the Vestfold oasis, the bryoflora of Larsemann Hills is typical for this region of the Antarctic in respect of species number and taxonomical composition. However, the possibility of new taxa being discovered on the territory of the oasis should not be excluded as indicated in the «Management Plan...» (Larsemann Hills..., 2014). Examples include *Bryum argenteum* and *Schistidium antarctici*, species which remained undiscovered during the 2009–2014 field work.

Further bryological investigations of numerous islands and peninsulas, and, additionally, more distantly situated nunatacks, could well enlarge the Larsemann Hills bryophyte list. The nearest bryologically investigated territory is Landing Cliff (Sunny Bay, Prydz Bay, Commonwealth Sea 69°44.9' S, 73°42' E). Mosses were collected there in 2009 near the Russian geological field base Druzhnaya-4. Although lichen communities predominate there, three moss species were recorded: *Coscinodon lawianus*, *Bryum pseudotriquetrum* and *Syntrichia sarconeurum*, the first being most abundant. It forms moss cushions on north-facing rocks near Lake Basovoye, and was found on the southern slopes of Landing Cliff and adjacent rock outcrops along Prydz Bay. *Bryum pseudotriquetrum* was noted along streams in depressions between rock ridges.

The authors are greatly indebted to the season's leaders of the of 55 and 56 RAE L. S. Alekseev and V. A. Kuchin, the leader of the station

Progress of the 59 RAE V. M. Vinogradov, for friendly logistical support and invaluable field assistance. We thank K. E. Vershinin, scientist of the Limnological Institute of the Siberian Branch of the Russian Academy of Sciences, other colleagues, RAE participants and comrades. Dr. O. W. Purvis is greatly thanked for language assistance.

### References

- Andreev M. P. 2013. Lichenes of the oasis Molodyozhnyi and adjacent areas (Enderby Land, Antarctic). *Novosti Sist. Nizsh. Rast.* 47: 167–178. (In Russ. with Engl. abstract).
- Andreev M. P., Kurbatova L. E. 2008. New data of the lichens and bryophytes of the Pacific Antarctic. *Novosti Sist. Nizsh. Rast.* 42: 142–152. (In Russ. with Engl. abstract).
- Bednarek-Ochyra H., Vaña J., Ochyra R., Lewis Smith R. I. 2000. The liverwort flora of Antarctica. Cracow: 236 p.
- Kurbatova L. E., Andreev M. P., Dolgikh A. V. 2014. Bryophytes of the oasis Molodyozhnyi (Enderby Land, Antarctica). *Novosti Sist. Nizsh. Rast.* 48: 365–373. (In Russ. with Engl. abstract).
- Larsemann Hills, East Antarctica: Antarctic Specially Managed Area Management Plan. 2014. *ATCM XXXVII Final Report. 2.* Buenos Aires: 277–309. [http://www.ats.aq/documents/ATCM37/fr/ATCM37\\_fr002\\_e.pdf](http://www.ats.aq/documents/ATCM37/fr/ATCM37_fr002_e.pdf) (In Engl.), [http://www.ats.aq/documents/ATCM37/fr/ATCM37\\_fr002\\_r.pdf](http://www.ats.aq/documents/ATCM37/fr/ATCM37_fr002_r.pdf) (In Russ.).
- Li S.-P., Ochyra R., Wu P.-C., Seppelt R. D., Cai M. H., Wang H.-Y. 2009. *Drepanocladus longifolius* (Amblystegiaceae), an addition to the moss flora of King Georg Island, South Shetland Islands, with review of Antarctic benthic mosses. *Polar Biol.* 32: 1415–1425.
- Ochyra R., Lewis Smith R. I., Bednarek-Ochyra H. 2008. *Illustrated moss flora of Antarctica.* Cambridge: 685 p.
- Seppelt R. D. Bryophytes of the Vestfold Hills. 1986. *Antarctic oasis; terrestrial environments and history of the Vestfold Hills.* Sydney: 221–245.
- Seppelt R. D. 1984. The bryoflora of the Vestfold Hills and Ingrid Christensen Coast, Antarctica. *ANARE Res. Notes.* 20: 1–30.
- Sollman P. 2015. The genus *Bryoerythrophyllum* (Musci, Pottiaceae) in Antarctica. *Polish Bot. J.* 60(1): 19–25.

### Литература

- [Andreev] Андреев М. П. 2013. Лишайники оазиса Молодежный и близлежащих территорий (Земля Эндерби, Антарктида). *Новости сист. низш. раст.* 47: 167–178.
- [Andreev, Kurbatova] Андреев М. П., Курбатова Л. Е. 2008. Новые данные о мхах и лишайниках тихоокеанского сектора Антарктиды. *Новости сист. низш. раст.* 42: 142–152.
- Bednarek-Ochyra H., Vaña J., Ochyra R., Lewis Smith R. I. 2000. The liverwort flora of Antarctica. Cracow: 236 p.

- [Kurbatova *et al.*] Курбатова Л. Е., Андреев М. П., Долгих А. В. 2014. Мхи оазиса Молодежный (Земля Эндерби, Антарктика). *Новостям сист. низш. раст.* 48: 365–373.
- Larsemann Hills, East Antarctica: Antarctic Specially Managed Area Management Plan. 2014. *ATCM XXXVII Final Report. 2.* Buenos Aires: 277–309. [http://www.ats.aq/documents/ATCM37/fr/ATCM37\\_fr002\\_e.pdf](http://www.ats.aq/documents/ATCM37/fr/ATCM37_fr002_e.pdf) (In Engl.), [http://www.ats.aq/documents/ATCM37/fr/ATCM37\\_fr002\\_r.pdf](http://www.ats.aq/documents/ATCM37/fr/ATCM37_fr002_r.pdf) (In Russ.).
- Li S.-P., Ochyra R., Wu P.-C., Seppelt R. D., Cai M. H., Wang H.-Y. 2009. *Drepanocladus longifolius* (Amblystegiaceae), an addition to the moss flora of King Georg Island, South Shetland Islands, with review of Antarctic benthic mosses. *Polar Biol.* 32:1415–1425.
- Ochyra R., Lewis Smith R. I., Bednarek-Ochyra H. 2008. *Illustrated moss flora of Antarctica.* Cambridge: 685 p.
- Seppelt R. D. Bryophytes of the Vestfold Hills. 1986. *Antarctic oasis; terrestrial environments and history of the Vestfold Hills.* Sydney: 221–245.
- Seppelt R. D. 1984. The bryoflora of the Vestfold Hills and Ingrid Christensen Coast, Antarctica. *ANARE Res. Notes.* 20: 1–30.
- Sollman P. 2015. The genus *Bryoerythrophyllum* (Musci, Pottiaceae) in Antarctica. *Polish Bot. J.* 60(1): 19–25.