

ON THE DISTRIBUTION AND VARIABILITY OF *BUCEGIA ROMANICA* RADIAN
О РАСПРОСТРАНЕНИИ И ВАРИАБЕЛЬНОСТИ *BUCEGIA ROMANICA* RADIAN

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Abstract

Bucegia romanica Radian (Marchantiaceae) is reported for the first time from Svalbard significantly extending the previously known range. The level of ITS1-2 nrDNA, *trnL*-F and *trnG*-intron cpDNA nucleotide sequence variability from European and Svalbard populations is quite low and any significant morphological differences between specimens are not revealed. Characters differentiating *Bucegia romanica* from similar the at first glance *Preissia quadrata* (Scop.) Nees and *Asterella lindenberghiana* (Corda ex Nees) Arnell as well as ecology of the species in Svalbard and worldwide are discussed. The global distribution of the species is reviewed and mapped.

Резюме

Bucegia romanica Radian (Marchantiaceae) впервые приводится для Шпицбергена, что значительно расширяет известный ранее ареал вида. Показано, что дивергенция между географически удаленными популяциями по нуклеотидным последовательностям ITS1-2 ядерной, *trnL*-F и интрона *trnG*-хлоропластной ДНК незначительна. Заметных морфологических различий между европейскими и шпицбергенскими популяциями выявить не удалось. Обсуждаются отличия вида от габитуально сходных *Preissia quadrata* (Scop.) Nees и *Asterella lindenberghiana* (Corda ex Nees) Arnell. Приводятся фотографии внешнего облика и срезов *B. romanica*, обсуждается экология и распространение вида.

KEYWORDS: *Bucegia romanica*, ITS1-2, *trnL*-F, *trnG*-intron, ecology, distribution, Europe, Russia, Svalbard, hepatics, Marchantiaceae

INTRODUCTION

Bucegia Radian is the monotypic genus that was described by Radian (1903) from Bucegi Massif, Cerbului Valley (Carpathian Mts, Romania) as *B. romanica* Radian. So far the species is known from Carpathian Mts (Müller, 1906-1911; Schumacker & Váňa, 2005; Ștefănuț, 2008), several localities in Western North America (Schofield, 2002) and Arctic and Northern Russia (Konstantinova, Bakalin et al., 2009).

During the study of hepatics collected by Konstantinova and Savchenko in Svalbard we found several specimens that were provisionally referred to *Bucegia*. At first we supposed that the Svalbard specimens represent a new species or variety of *Bucegia romanica*, but after careful study we determined that all specimens from Svalbard fit well in *Bucegia romanica*. Nevertheless our data expands knowledge on both distribution and variability of this poorly known species and we consider it useful to publish the results obtained.

MATERIAL AND METHODS

Specimens of *Bucegia romanica* were collected by Konstantinova and Savchenko in the course of study

of hepatics of Svalbard both on the most northern island Nordaustlandet and on West Spitsbergen. In total 7 specimens from Svalbard were referred to this species.

Our DNA analysis involved six specimens of *Bucegia romanica*: two of them were gathered in Europe: Bucegi (near the type locality) and Făgăraș Mts in Romania, one specimen originated from Carpathian Mts (Ukraine), and three were collected on Svalbard (Norway). Additionally we tested three specimens of *Preissia quadrata* (Scop.) Nees from different regions of the European part of Russia. Three DNA loci – ITS1-2 nrDNA, *trnL*-F and *trnG*-intron cpDNA – were sequenced for each specimen. *Marchantia polymorpha* L. was chosen as outgroup and DNA sequences for it were downloaded from GenBank. Thus, all three genera classified in the family Marchantiaceae Lindl. (Crandall-Stotler et al., 2009) were tested in this study. All analyzed specimens are listed in Table 1, including GenBank accession numbers and voucher details.

Nomenclature follows Konstantinova, Bakalin et al. (2009). Synonyms that are generally accepted are given in parentheses.

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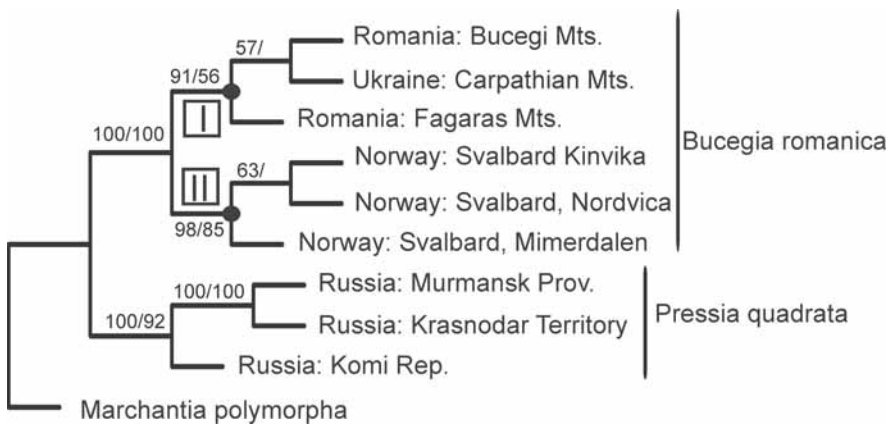


Fig. 1. Maximum parsimony phylogenetic tree for the family Marchantiaceae Lindl. based on combined dataset ITS1-2+trnL-F+trnG-intron. Bootstrap support values more than 50% are indicated from MP/ML analyses.

DNA isolation, PCR amplification and DNA sequencing followed protocols described in Konstantinova & Vilnet (2011).

Phylogenetic analysis. Three datasets, ITS1-2, trnL-F, trnG-intron, were automatically aligned in BioEdit 7.0.1 (Hall, 1999) with ClustalW option and then manually corrected. The preliminary phylogenetic analyses revealed a lack of incongruence between ITS1-2, trnL-F and trnG-intron and subsequently three datasets were combined. All positions of the final alignment were included in the phylogenetic analysis, lacking parts of sequences were coded as missing.

The combined dataset was analyzed by the maximum likelihood method (ML) with PhyML (Guindon et al., 2010) and the maximum parsimony method (MP) with TNT (Goloboff et al., 2003). The program ModelGenerator (Keane et al., 2004) determined that the GTR+I+G model was the best-fit evolutionary model of nucleotide substitutions. This model was used in ML analysis and the heterogeneity rate among sites was modelled using a gamma distribution with four rate categories. Bootstrap support (BS) for individual nodes was assessed using a resampling procedure with 300 replicates. According to

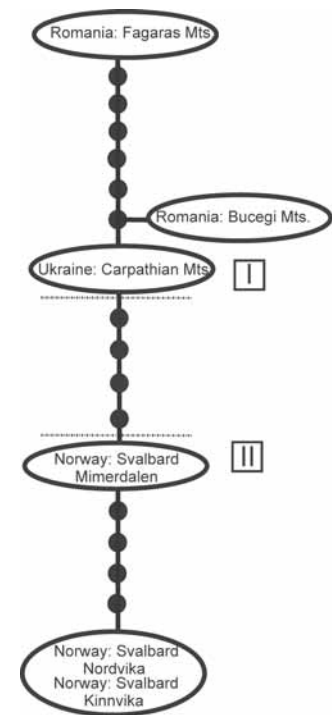


Fig. 2. The haplotypes network for *Bucesgia romanica* specimens constructed from combined dataset ITS1-2+trnL-F+trnG-intron. Missing haplotypes are marked by black dots.

stopping frequency criterion (FC) for bootstrapping procedure (Pattengale et al., 2010) for our dataset even 250 replicates were enough for reaching BS convergence with Pearson average $\phi_{100} = 0.997271$ realized in RAxML v7.2.6 (Stamatakis, 2006).

The MP analysis involved a New Technology Search with a search for the minimum-length tree by one reiteration and 1000 bootstrap resamplings; the default settings were used for other parameters, indels were taken into account by a modified complex coding algorithm in SeqState (Müller, 2005).

The infraspecific variability of *Bucesgia romanica* was evaluated as the *p*-distances for ITS1-2, trnL-F and trnG-intron calculated in Mega 5.1 (Tamura et al., 2011) using the pairwise deletion option for counting gaps.

Table 1. The list of taxa, specimens vouchers and GenBank accession numbers for studied samples. The nucleotide sequence data for *Marchantia polymorpha* were downloaded from GenBank.

Taxon	Specimen voucher	GenBank accession number		
		ITS1-2	trnL-F	trnG-intron
<i>Bucesgia romanica</i>	Norway: Svalbard Kinnvika, Konstantinova & Savchenko, K20/1-10 (KPABG)	KJ195815	KJ195821	KJ195804
	Norway: Svalbard Nordvika, Konstantinova & Savchenko, K152/1-07 (KPABG)	KJ195817	KJ195823	KJ195806
	Norway: Svalbard Mimerdalen, Konstantinova & Savchenko, K41/2-08 (KPABG)	KJ195816	KJ195822	KJ195805
	Romania: Bucegi Massif, S. Ștefănuț, B4322 (BUCA, dupl. KPABG)	KJ195812	KJ195825	KJ195807
	Romania: Fagaras Mts., S. Ștefănuț, B4321 (BUCA, dupl. KPABG)	KJ195813	KJ195824	KJ195808
	Ukraine: Carpathian Mts., D. Zerov, 495 (KW, dupl. KPABG)	ITS1 KJ195814		
<i>Preissia quadrata</i>	Russia: Komi Rep., M. Dulin, 113625 (KPABG)	ITS2 KJ195803	KJ195826	KJ195802
	Russia: Krasnodar Territory, Fisht Mts., Konstantinova & Savchenko, K416/5-12 (KPABG)	KJ195818	KJ195827	KJ195809
	Russia: Murmansk Prov., Khibiny Mts., Konstantinova, 18347 (KPABG)	KJ195820	KJ195829	KJ195811
<i>Marchantia polymorpha</i>		KJ195819	KJ195828	KJ195810
		AY342318	NC001319	NC001319

Table 2. The characteristic of produced ITS1-2, *trnL*-F, *trnG*-intron nucleotide alignments

	Total sites		Conservative sites		Variable sites		Parsimony-informative sites	
	base pairs	base pairs	%	base pairs	%	base pairs	%	
all ITS+trnL regions	2772	1725	62.23	889	32.07	194	7.00	
ITS1-2	1716	857	49.94	745	43.41	145	8.45	
<i>trnL</i> -F	435	404	92.87	27	6.21	12	2.76	
<i>trnG</i> -intron	621	464	74.72	117	18.84	37	5.96	

Genealogical relationships between *Bucegia romanica* haplotypes were evaluated in TCS (Clement et al. 2000) based on analysis of the combined data matrix ITS1-2+*trnL*-F+*trnG*-intron with exclusion of outgroup taxa, gaps were treated as missing data.

RESULTS

The nucleotide sequences of ITS1-2, *trnL*-F and *trnG*-intron were obtained for nine specimens. The parameters of produced alignments for each studied loci and combined dataset are shown in Table 2. The *trnL*-F appears to be the most conservative loci in the studied taxa, whereas both ITS regions are highly variable and difficult to align.

The MP analysis of combined ITS1-2+*trnL*-F+*trnG*-intron dataset yielded a single tree with a length of 1701 steps, with CI= 0.980249 and RI= 0.952020 calculated in Mega 5.1. The arithmetic means of Log likelihood obtained in ML calculation for combined dataset was -7579.77299.

The tree topologies obtained by the two methods are highly congruent, thus on Fig. 1 the MP tree is shown with indication of bootstrap support (BS) values calculated both in MP and ML analyses. The specimens from genera *Bucegia* and *Preissia* composed their own robustly separated clades. The specimens of *Bucegia romanica* were split into two subclades according to their geographical distribution. The subclade I (BS=91% in MP and BS=56% in ML) contains accessions from Europe, but the two Romanian specimens are separated from each other by the Ukrainian one. The subclade II (BS=98% in MP and BS=85% in ML) includes all three specimens from Svalbard.

In Romania, *Bucegia romanica* is distributed in alpine zone, mostly on calcareous substrates, with some exceptions. In Făgăraș Mts, where calcareous substrates occur, *Bucegia romanica* also colonize crystalline schists, that can be an explanation for the genetic diversification of Făgăraș specimens beside Bucegi and Ukraine specimens.

The results of infraspecific and infrageneric *p*-distance calculations are shown in Table 3. The minute nucleotide variation in ITS1-2 (0.23% and 0.04%) and absence of variation in both *trnL*-F and *trnG*-intron were detected in East Europe and Svalbard populations of *Bucegia romanica*. The *p*-distance between these populations is 0.28% for ITS1-2, 0.1% for *trnL*-F and 0.3% for *trnG*-intron, whereas the level of infraspecific variation in the phylogenetically related *Preissia quadrata* is more significant (1.8% for ITS1-2, 0.24% for *trnL*-F and 6.4% for *trnG*-intron).

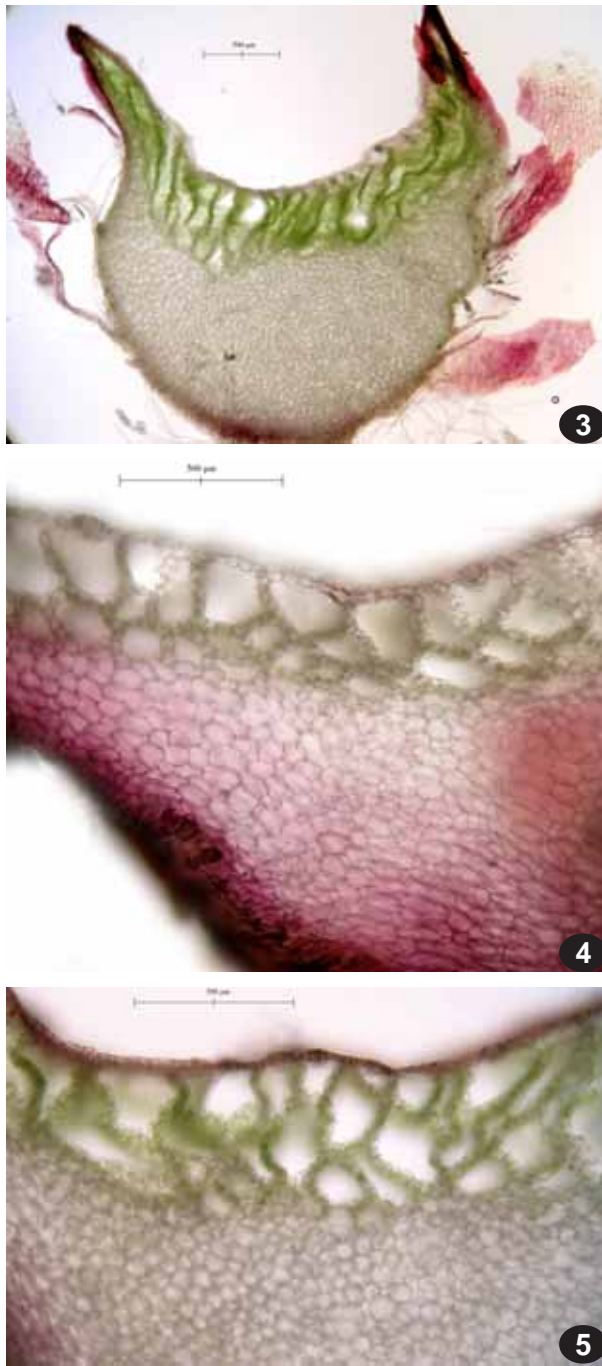
TCS analysis of combined dataset produced a network with separation of two haplotype groups (I and II) with specimen distribution corresponding to East Europe and Svalbard populations. The network demonstrated phylogenetic isolation between obtained haplotype groups by four missing haplotypes (Fig. 2). In Europe, the most diverged haplotype belongs to a specimen from Făgăraș Mts which is separated from the two others by six missing haplotypes. In the Svalbard population two haplotypes were found: specimens from Nordvika Bay and Kinvika Bay (closely allied territories, see map) possess a common haplotype, whereas specimen from Mimerdalen differs from them by four missing haplotypes.

DISCUSSION

Taxonomic relationship. Schuster (1984) placed *Bucegia* together with the subantarctic *Neohodgsonia* Perss. in the separate subfamily Bucegioideae, but that is not supported by molecular data. Study of complex thaloid liverworts based on LSU nrDNA nucleotide sequence of 27 genera provided by Boisselier-Dubayle et al. (2002) resolved *Bucegia romanica* and *Preissia quadrata* in one clade with high bootstrap support (98%) in sister relation to the multiply sampled genus *Marchantia* L., whereas *Neohodgsonia* was placed in the first diverged phylum of all Marchantiidae, and the genus *Dumortiera* was found in a more derived clade. Later Long (2006) placed *Neohodgsonia* in the separate order Neohodgsoniales

Table 3. The values of *p*-distances, calculated from ITS1-2, *trnL*-F, *trnG*-intron nucleotide sequences within and between studied species. BR EE – *Bucegia romanica* from East Europe, BR S – *Bucegia romanica* from Svalbard, PQ – *Preissia quadrata*, MP – *Marchantia polymorpha*.

Groups	Value of within group <i>p</i> -distances, %			Value of between groups <i>p</i> -distances, ITS1-2/ <i>trnL</i> -F/ <i>trnG</i> %			
	ITS1-2	<i>trnL</i> -F	<i>trnG</i> -intron	BR EE	BR S	PQ	MP
BR EE	0.23	0	0.1	–			
BR S	0.04	0	0	0.28/0.1/0.3	–		
PQ	1.8	0.24	6.4	10.8/2.9/6.6	11.1/2.8/6.8	–	
MP	n/c	n/c	n/c	47.4/5.6/11.2	44.1/5.7/10.9	36.9/4/14.5	–



Figs. 3-5. Transverse section of *Bucegia romanica* thallus: 3: from Bucegi Massif, Romania; 4-5: from Svalbard, Nordaustlandet, Norway (Photos of A. Manole).

D.G. Long, and *Dumortiera* was kept in Marchantiales in the separate family Dumortieraceae D.G. Long. This solution was accepted by Crandall-Stotler et al. (2009) and in more recent studies.

Description and differentiation. *Bucegia romanica* is a relatively large thallose hepatic ca. 3.5-10 mm wide and 7-20(-50) mm long, but its length does not exceed 5-8 mm width in Svalbard. Thalli are green with rose-purplish to dark brown (in Svalbard) secondary pigmentation of margins and ventral side. Most studied specimens from Svalbard have thalli that are red brown to dark brown

on dorsal side. Thalli flat with elevated sides, V-shaped in cross section. Dorsal epidermis of thin-walled cells, without trigones and oil-cells. Aerenchyma layer is rather thick, usually more than 0.25-0.35(-0.4) of the maximum thallus height and consists of (1-)2-3(-4) layers of large and empty (without any filaments) air-chambers (Figs. 3-5). Pores barrel-shaped, surrounded by 5 superimposed cell rings with (3-)4(-5) cells in each ring. Ventral tissue without oil cells and sclerenchyma cells, often colourless even if the thallus is with red-dark brown dorsal side. Ventral scales in 2 rows, red-violet to blackish violet, but often with colourless margin, large, 1.5-2.4 mm (over 3/4 of a half of ventral thallus) with one linear, oblong, often very short appendage and numerous slime hairs on margin. Cells of ventral scales thin walled, without trigones, large, 36-50×75-100 µm. Dioicous. Female disk conic, to 4-5 mm in diameter, 2-3 mm high, with 3-5 wide lobes. Male receptacles with disk almost circular, not lobed. Spores brown, 45-50 µm, tetrahedral.

At first glance *Bucegia romanica* (Figs. 6, 7) is similar to the very common and much more widespread arctic-boreomontane *Preissia quadrata* (Fig. 8) due to similar barrel-shaped pores and stalked male and female receptacles. Both species have similar shape, size and color of thalli as well and because of this are often confused. In the field, these species can be distinguished from other thallose liverworts by the verrucose-like side of dorsal thallus, that can be seen without a lens. This is due to the barrel-like pores that are visible like small verruca on the dorsal side of thallus. The color of *Preissia* and *Bucegia* thalli is similar, from yellow-green, green to red-violet and red-brown, in arctic often blackish red but never dark-green, like *Marchantia polymorpha*. *Marchantia* sometimes has a thallus with dark line in midrib region, that is missing on *Preissia* and *Bucegia*. Thallus bearing cup-shaped gemma-receptacles are never present on *Preissia* and *Bucegia* thalli, but are quite characteristic for *Marchantia*.

When sterile, *Preissia quadrata* and *Bucegia romanica* could be not be easily distinguished in the field, but if an oblique sectioning of thallus is made, spongiose-like structure can be seen with lens on the dorsal side of *Bucegia* thallus, because of hollow air-chambers layers. Such spongiose-like structure is not seen on the dorsal side of the *Preissia* thallus because this species has only one layer of air-chambers and the air-chambers are not hollow: they are filled with uniseriate chlorophyllose filaments growing from the air-chamber floor.

When female receptacles are present, *Bucegia* can be easily distinguished from *Preissia* in the field by the shape of the carpocephalum. The female receptacle of *Bucegia* is conic and has a hemispheric apex (Fig. 6), while the female receptacle of *Preissia* is convex and has four more or less distinct ridges across it.

Further distinctions include: 1) absence of oil cells and sclerenchyma cells in cross section of thalli while in *P. quadrata* they occur, at least scattered; 2) mostly tri-



Figs. 6-8. Plant habit of *Bucegia romanica* (6-7) with archegoniophore (6) and male receptacles (7), and *Preissia quadrata* (8) with archegoniophore. All from Bucegi Massif, Romania (photos of Ștefănuț: 6-7: 14.VII.2008 and 8: 20.VI.2007; note that some plants in Fig. 6 belong to *Peltolepis quadrata*).

angular cross section of thallus, usually without long and narrow flanks that are quite characteristic for *Preissia*; 3) male disk without translucent irregular margin. As it was shown above, these genera are also clearly distinguished molecularly.

From the somewhat similar arcticmontane *Asterella lindenbergiana* (Corda ex Nees) Arnell *Bucegia* differs in: 1) barrel shaped pores vs. simple ones in *A. lindenbergiana*; 2) dioicous sexual condition vs. paroicous or autoicous in *A. lindenbergiana*; 3) stalked male receptacles vs. sessile ones in *A. lindenbergiana*; 4) lacking oil cells in ventral scales vs. presence of scattered oil cells in *A. lindenbergiana*; 5) absence of specific smell vs. a smell of rotten fish of *A. lindenbergiana* in fresh condition.

Sometimes (for example in specimens from Wrangel Island) *Asterella lindenbergiana* and *Bucegia romanica* are mixed in the same samples that sometimes leads to confusion.

Variation. The number of layers of air chambers. It is often stressed (even in keys, see Schljakov, 1982) that *Bucegia* has 3-4 layers of chambers whereas *Preissia* has only one. However, in drawing in Müller (1906: fig. 180) only one layer of chambers could be seen in *Bucegia*. In material from Svalbard the number of air chamber layers vary from one (often) to 2 or 3, and chambers are large and elongated (at least chambers of the upper layer) contrary to *Preissia* with small and mostly isodiametric chambers. In *Bucegia*, the air chamber layer comprises ca. 1/3 of the height of the thallus (in the middle) whereas in *Preissia quadrata* it never exceeds 1/4 of the height of the thallus.

Shape of transersal section of thallus is quite peculiar in *Bucegia romanica*. It is mostly V-shaped (triangular) and similar to that of *Asterella lindenbergiana* whereas in *Preissia quadrata* it is U-shaped, often with long narrow flanks. In Svalbard *Bucegia* sometimes has U-shaped cross-section, but flanks are always very short (Fig. 3).

Size and color of thallus. In collections from Svalbard the width of *Bucegia romanica* thalli varies from 4-5 (in Nordaustlandet) to 7-8 mm (in western Spitsbergen). The dorsal side of plants from Nordaustlandet is

mostly red-brown to dark brown. In both localities in western Spitsbergen dorsal surface of studied plants is light green with red-colored margins.

KEY FOR THE GENERA OF MARCHANTIACEAE

Key for sterile plants

1. Air-chambers in (1-)2-4(-5) layers, without chlorophyllose filaments *Bucegia*
— Air-chambers in one layer, with chlorophyllose filaments 2
2. Ventral scales in 4 or 6 rows, oil cells present both in ventral tissues and ventral scales, gemmae cups on dorsal side of thallus often present (sometimes absent) *Marchantia*
— Ventral scales in 2 rows, oil cells in ventral scales absent, gemmae cups never present *Preissia*

Key for fertile plants

1. Plants monoicous, heteroicous or dioicous .. *Preissia*
— Plants dioicous 2
2. Female receptacle with terete lobes *Marchantia*
— Female receptacle without terete lobes 3
3. Conic female receptacle with hemispheric apex *Bucegia*
— Convex female receptacle without hemispheric apex *Preissia*

Key for *Bucegia* and *Preissia* in the field (sterile plants)

1. Thallus with large laminal scales, 3/4 of ventral thallus, scales in 2 rows; no sclerocytes or mucilage cavities in thallus *Bucegia*
— Thallus with vestigial laminal scales, less than 1/2 of ventral thallus, scales in more than 2 rows; frequent sclerocytes and mucilage cavities in thallus *Preissia*

Key for *Bucegia* and *Preissia* in the field (fertile plants)

1. Female receptacle conic with hemispheric apex, plants dioicous *Bucegia*
— Female receptacle convex, with 4 more and less distinct ridges across, plants dioicous, sometime heteroicous (subsp. *quadrata*) or autoicous (subsp. *hyperborea*) *Preissia*

DISTRIBUTION AND ECOLOGY

The species has clearly arcticmontane distribution.

In Svalbard *Bucegia romanica* has been collected in eight localities (Fig. 9). Most of them are situated on Nordaustlandet, including three localities on the west coast of Murchison Fjorden and two on the coast of Innvika Bay; one is located on Barents Island and two on West Spitsbergen Island in Mimerdalen (Billefjorden) and Agardhdalen. In all localities on Nordaustlandet and Barents Island the species was collected in coastal areas on clayish moist soil, often on banks of small, sometimes dried rivulets or in deep narrow crevices among dead mosses. In Western Spitsbergen *Bucegia romanica* was found in the innermost areas on steep solifluction slopes to the streams on moist clay. The species grows mostly as single plants on bare soil. The most common associates of *Bucegia romanica* are *Schljakovianthus quadrilobus* (Lindb.) Konstant. & Vilnet (*Orthocaulis quadrilobus*), *Blepharostoma trichophyllum* var. *brevirete* (L.) Dumort., *Cephaloziella varians* (Gottsche) Steph. and other Ca-tolerant species. It is evident that the species is much more common in Svalbard, but has been overlooked because of its resemblance with *Preissia quadrata*, which is very common in archipelago.

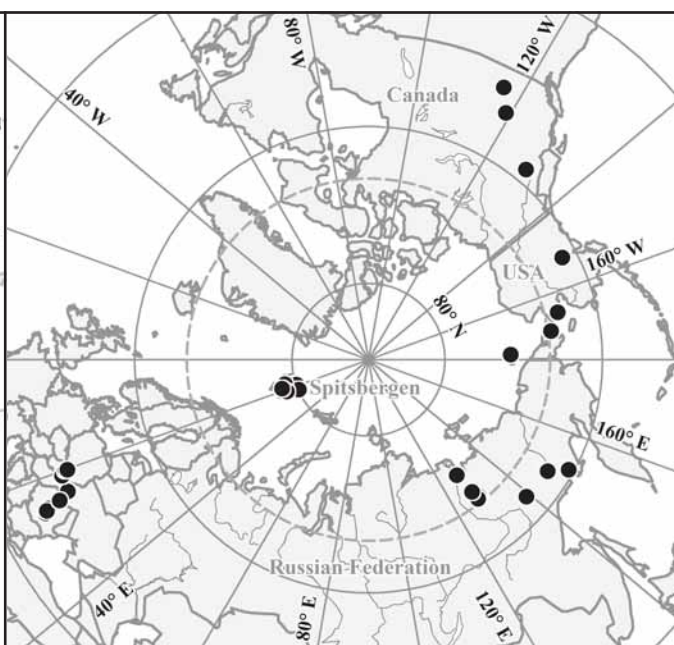
In Europe (Fig. 10) *Bucegia* has been reported from Romania: Bucegi Massif (Radian, 1903), Făgăraș Mts (Ștefureac, 1949), Piatra Craiului Mts (Ștefureac, 1951), and Rodnei Mts (Ștefureac, 1983). Recent distribution of *Bucegia romanica* in Romania is mapped by Ștefănuț (2008). In Slovakia and Poland the species occurs in Tatra Mts (Schiffner, 1908a,b, 1911; Górski et al., 2011). Distribution in Slovakia is compiled by Duda & Váňa (1990) and improved later by Blackburn et al. (1997). The species was provisionally reported by Zerov (1964) for the Ukrainian Carpathians. It was recently confirmed for Ukraine by Borovichev et al. (2014).

Bucegia was firstly recorded for Russia by Schljakov (1973) based on a specimen collected by Katenin in the Lower Lena River (Fig. 10). The species was subsequently gathered several times in Chukotka Province by Afonina where the species was recorded for Krause Cape (Abramova et al., 1985; Afonina & Duda, 1993) and Wrangel Island (Afonina, 2000). *Bucegia romanica* was later found in Republic of Sakha (Yakutia): Suntar-Khayta Ridge (Sofronova, 2001), the Orulgan Sis Resource Reserve, left bank of Khabol River and in Sulda-Tekeekit River Basin (Sofronova & Sofronov, 2012) and Orulgan Ridge, the upper Eningan-Toloon River (Ivanova & Sofronova, 2013). The species was recently collected in Magadan Province (Konstantinova & Bakalin, 2014).

In North America (Fig. 10) the species is known as very rare from the west, particularly from Rocky Mts of British Columbia, Alberta (Haynes, 1915; Evans, 1917) and Alaska (Potemkin, 1995; Schofield, 2002).

Specimens examined: (new localities in Svalbard have more habitat details).

Svalbard. Nordaustlandet. Murchison Fjorden: numerous rivulets on east facing slope Hoppebukta, on mossy bank of rivulet (80°2'38"N – 18°33'23"W, 81 m alt.), on moist loam near small rock, Konstantinova & Savchenko K9/2-10 (KPABG); and east coast of Kinnvika bukta at the edge of first marine terrace (80°2'51"N – 18°15'32"W), 6 m alt., on wall of the deep mossy cut, mixed with *Sauteria alpina* (Nees) Nees, Konstantinova & Savchenko K20/1-10 (as *Preissia quadrata*, KPABG); Murchison Fjorden, Nordvika Bay: mountain terrace with numerous rivulets and moist spots covered by bryophytes, (80°2'58"N – 18°54'29"W), 32 m alt., between protuberance some thalli on loam, with *Schljakovianthus quadrilobus*, *Blepharostoma trichophyllum* var. *brevirete*, *Leiocolea badensis*, Konstantinova & Savchenko K152/1-07 (KPABG); Prins Oscars Land, Fotherby fjorden, Invika Bay, right bank of Ringasdalen (80°06'45"N – 23°03'52"W), 4 m alt.: solifluction slope on and between small protuberants, several thalli associated with *Schljakovianthus quadrilobus*, *Cephaloziella varians*, *Blepharostoma trichophyllum* var. *brevirete*, Konstantinova & Savchenko K370/2-11 (KPABG), and several thalli with young male receptacles, associated with *Blepharostoma trichophyllum* var. *brevirete*, Konstantinova & Savchenko K370/8-11 (KPABG); rocks at the bottom of solifluction slope, in micro depression, on moist soil in cracks of crust of bryophytes with dominance of *Tritomaria quinque-dentata* (Huds.) H.Buch and admixture of *Blepharostoma trichophyllum* var. *brevirete*, *Nardia geoscyphus* (De Not.) Lindb., *Cephaloziella varians*, *Anthelia juratzkana* (Limpr.) Trevis., Konstantinova & Savchenko K371/3-11 (KPABG). **West Spitsbergen.** Billefjorden, upper part of Mimerdalen, northern slopes under glacier Jotunfonna, steep south-west facing slopes with large rocks and bare soil (78°38'02"N – 16°06'46"W), 176 m alt., on moist loam under rock, Konstantinova & Savchenko K41/2-08 (KPABG); Agardhdalen, valley of Eistradalen at the bottom of south slope of Holmgardfjellet (78°06'12"N – 18°22'21"W), 32 m alt., separate thalli with young male receptacles on bare detritous ground, associated with *Schljakovianthus quadrilobus*, Konstantinova & Savchenko K99/1,2-10 (KPABG). **Barentsrya Island.** Frankenhavna, coastal valley, on banks of dry rivulet (78°35'14"N – 21°06'49"W), 5 m alt., some stems with separate thalli with young male receptacles, with *Lophozia polaris*, *Blepharostoma trichophyllum* var. *brevirete*, Savchenko C353/1a-11 (KPABG). **Russia. Chukotka Province:** Wrangel Island, Somnitel'naya Bay, 1.IX.1985, T.G. Polozova s.n. (LE, duplicate in KPABG 109392), mixed with *Asterella lindenbergiana*; surroundings of Lavrentia Settlement, on detritous slope, O.M. Afonina s.n. (LE, duplicate in KPABG 105918); Lavrentia Bay, Krause Cape, rocky slope with cliffs, on fine earth, 28.VIII.1975, O.M. Afonina s.n. (LE, 3 specimens); **Magadan Province**, upper course of Kolyma River, Bakalin Mag-44-28-11 (VLA); Ol'skoye Basalt Plateau in upper course of Ola River Bakalin Mag-57-5-11 (VLA); **Ukraine:** Carpathian Mts., D.K. Zerov 111688 (duplicate in KPABG). **Romania:** Bucegi Massif: Bătrâna Peak towards Omu Peak, 21.VII.1897, K. Loitlesberger 1171/H (BP); Bucșoiu Peak, 30.VIII.1911 A. Degen 1176/H, 1177/H (BP); Omu Peak, 31.VIII.1911 A. Degen 1174/H (BP), Mălăiești Valley, 1.IX.1911 A. Degen 1175/H (BP), 30.VIII.1911, A. Degen, 1173/H (BP), Bucșoiu Mountain, 6.X.1962, Á. Boros, sub *Peltolepis grandis*, 31001/H (BP), Cerbului Valley, 2300 m a.s.l., 3.IX.1955, T. Pócs, 10358/H, 30979/H (BP), Brâna

Figs. 9. Distribution of *Bucegia romanica* in Svalbard.Fig. 10. Global distribution of *Bucegia romanica*.

Caprelor and Bucșoiu, 30.VIII.1917, A.D. Vlădescu 1172/H (BP), Bucegi Massif, Ștefănuț B4322 (BUCA); Făgăraș Mts.: Ștefănuț B4321 (BUCA); Făgăraș Mountains Podragu Valley, L. Vajda 25526/H (BP); Piatra Craiului Mountains, Marele Grohotiș, 1998, Ștefănuț B933 (BUCA), Brâna Caprelor, 23.V.2002, O. Pop B2827 (BUCA), Diana, 23.V.2002, O. Pop B2873 (BUCA); **Slovakia**: Cervené Mountains, in Kresarica Mountain, 1956, Vezda 30973/H (BP), Boloské Tatry, Siroké Mountain, 1800 m a.s.l., 10.VIII.1951, J. Smarda 30974/H (BP), Liptovské Mountain, 1900 m a.s.l., 14.IX.1966, J. Duda 30976/H (BP); **Poland**: Wysokie Tatry, Dolina Pieciu Staow Polskich, 2100 m a.s.l., 10.IX.1958, J. Szweykowski 30980/H (BP), Poland Tatra, 1700-2100 m a.s.l., 25.VI.1959, Á. Boros 30981/H (BP); idem, Kopa Krolowa Mala, 1400-1500 m a.s.l., 22.VI.1959, Á. Boros 30982/H (BP); idem, infra jugum Zawrat, 1700-2100 m a.s.l., 25.VI.1959, Á. Boros 30983/H (BP), idem, Turnia Mountain, 1300-1500 m a.s.l., 24.VI.1959, Á. Boros 30985/H, 30986/H (BP); **Canada**: Cassiar Mountains, Glacial Lake (58°20'N - 129°30'W), 17.VII.1981, W.B. Schofield, L.S. Donovan & C.P. Siens 76435 (UBC), idem, 58°20' N - 129°50' W, 21.VII.1981, W.B. Schofield, L.S. Donovan & C.P. Siens 76706 (UBC), on S. slope of Mt. Bosworth, 51°27'53"N - 116°20'01"W, 9.VII.1913, A.H. Brikman 822 (UBC), Caw Ridge, ca. 15 mi. N of Grande Cache (54°00'N - 119°02'W), 31.VII.1975, A. Ceska & O Ceska B163702 (UBC).

Specimens incorrectly determined as *Bucegia romanica* and proved to be other species: **Canada**: *Preissia quadrata*, Cassiar Mountains, Glacial Lake (58°20'N - 129°30'W), 22.VII.1981, W.B. Schofield, L.S. Donovan & C.P. Siens 76764 (UBC); **USA**: *Asterella lindenberiana*, Idaho, Fisher Creek Saddle West, 2287 a.s.l., 45°09'N - 116°07'W, 8.IX.1999, W.B. Schofield & J. Harpel 113888 (UBC). **USA**: *Preissia quadrata*, Alaska, Brooks Range, Gates of the Arctic National Park: Noatak River drainage, on ridge west of 12 Mile Slough, 29.VII.2004, E. Laeger 2332, rev. J. Shevock, 2014, 21786 (UC).

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