Arctoa (2016) **25**: *177–182*
doi: 10.15298/arctoa.25.16

SPHAGNUM MOSSES IN VEGETATION COVER OF HIGHLANDS IN THE SUB-POLAR URAL, KHANTY-MANSIYSK AUTONOMOUS DISTRICT

СФАГНОВЫЕ МХИ В РАСТИТЕЛЬНОМ ПОКРОВЕ ВЫСОКОГОРИЙ ПРИПОЛЯРНОГО УРАЛА, ХАНТЫ-МАНСИЙСКИЙ АВТОНОМНЫЙ ОКРУГ

Elena D. Lapshina[1], Maria G. Noskova[2,3] & Yulia V. Skuchas[4]

Елена Д. Лапшина[1], Мария Г. Носкова[2,3], Юлия В. Скучас[4]

Abstract

Species diversity of *Sphagnum* was studied in the mountain highlands (areas above a timber-line) in the Sub-Polar Urals within the Khanty-Mansiysk Autonomous District (64°27’ – 64°35’ N; 59°35’ – 59°46’ E). This work was conducted in 2013 and 2015 and revealed 19 species. Their distribution along the altitudinal profile from 300 m alt. in the upper forest belt to 1200 m in mountain tundra belt has been studied. Only one species, *S. compactum*, was found to occur mostly in the mountain tundra belt, although with a low abundance. The most common and widespread species above timber-line were found to be *S. girgensohnii* and *S. russowii,* which grow in a wide range of habitats. Several primarily bog species, including *S. fuscum, S. balticum, S. capillifolium, S. lindbergii, S. teres,* and *S. contortum* are confined in the highlands of the Sub-Polar Urals to the dwarf shrub-sedge-*Sphagnum* mires, concentrating there in less than 1% of total in surveyed area. A number of species of *Sphagnum* occur in a wider variety of the vegetation types, while three species, *S. fallax*, *S. flexuosum* and *S. jensenii* grow up to the tree-line, but never exceed it in th study area. The altitudinal distribution and frequency of *Sphagnum* species in the Sub-Polar Urals and other mountains of the Northern Eurasia are compared.

Резюме

Изучено видовое разнообразие сфагновых мхов в высокогорьях (на территориях выше границы леса) на Приполярном Урале в пределах Ханты-Мансийского национального округа (64°27’ – 64°35’ N; 59°35’ – 59°46’ E). Полевые исследования проводились в 2013 и 2015 гг. и позволили выявить 19 видов. Было изучено их распределение по высотному профилю от 300 м над ур. м., в верхней части лесного пояса, до 1200 м в поясе горных тундр. Только один вид, *S. compactum*, оказался приуроченным преимущественно к поясу горных тундр, хотя он встречался там с невысоким обилием. Самыми массовыми и широко распространенными видами рода в высокогорьях являются *S. girgensohnii* и *S. russowii,* они растут в широком спектре местообитаний. Несколько преимущественно болотных видов, таких как *S. fuscum, S. balticum, S. capillifolium, S. lindbergii, S. teres* и *S. contortum* в высокогорьях Приполярного Урала встречаются исключительно на кустарничково-осоково-сфагновых болотах, которые занимают здесь не более 1% от всей территории. Ряд других видов *Sphagnum* встречается в более широком спектре растительных сообществ, а три вида, *Sphagnum fallax*, *S. flexuosum* и *S. jensenii* распространены в лесном поясе, вплоть до его верхней границы, но не заходят в высокогорья. Встречаемость и фитоценотическая активность видов *Sphagnum* на Приполярном Урале сравнивается с таковыми в других горных системах Северной Евразии.

Keywords: *Sphagnum*, highlands, altitudinal distribution

Introduction

Sub-Polar Urals (SPU) is the widest and most elevated part of the ancient Ural Mountains. The mountain range here is up to 150 km wide (at 65° N), and some peaks are higher than 1800 m above sea level. Being hard to access, SPU as a whole and especially its highlands are poorly studied for the biodiversity, including bryophytes. The highlands are defined here as above the upper limit of close forests regardless of the altitude elevation; vegetation is affected there by severe conditions,

[1] – Yugra State University, 16 Chekhov St., Khanty-Mansiysk, 628012 Russia – Россия 628012, г. Ханты-Мансийск, ул. Чехова, д. 16, Югорский государственный университет; e-mail: e_lapshina@ugrasu.ru
[2] – St. Petersburg University, 7/9 Universitetskaya Nab., St. Petersburg, 199034 Russia – Россия 199034, Санкт-Петербург, Университетская наб. 7/9, Санкт-Петербургский университет
[3] – Komarov Botanical Institute RAS, 2 Popov St., 197376 St. Petersburg – Россия 197376, Санкт-Петербург, ул. Проф. Попова 2, Ботанический институт им. В.Л. Комарова; e-mail: maria.noskova@mail.ru
[4] – Museum of Nature and Man, 11 Mira St., Khanty-Mansiysk, 628012 Russia – Россия 628012, г. Ханты-Мансийск, ул. Мира 11, Музей природы и человека; e-mail: jskuchas@umuseum.ru

and forests are substituted by other vegetation types, such as subalpine ('sub-goltsy') open forests and shrubs, subalpine meadows, and mountain tundra. An extensive areas near the top have primarily rock fields.

The upper limit of closed mountain forest is situated at 400–450 m a.s.l., and above this altitude a subalpine vegetation occurs. It is represented by larch-dominated open woodlands, secondary low birch forests, alder tickets and subalpine meadows. Since 500–600 m, mountain tundra forms the belt, which is succeeded by rock fields with only scattered and fragmentary vegetation at the level above 800–900 m. However, due to the highly dissected relief, location of the upper limit of the subalpine wood communities is very variable in the SPU. They may occur up to 650 m a.s.l. in deep valleys and on steep slopes.

Previous exploration of this area was mainly conducted on the forested mountain slopes and on neighboring water-logged plain lands, both on the west and east slopes (Lapshina *et al*., 2015). The data on *Sphagnum* from numerous publications (Pohle, 1915; Ivanovsky, 1917; Zinserling, 1935; Ghaze, 1930; Sochava, 1930; Gorchakovsky, 1958, 1975; Kuvaev, 1970) were summarized by Dyachenko (1995); in total, 27 species were recorded in this area.

The aims of our study were to determine the species composition of *Sphagnum* on the eastern macroslope of SPU, with special emphasis on vegetation of higher elevations, above the tree line, and to estimate the occurrence and abundance of *Sphagnum* species in different habitat types.

MATERIAL AND METHODS

Field surveys were carried out in 2013 and 2015 at mount Ner-Oyka and in the upper course of the Puiva River (64°27' – 64°35' N; 59°35' – 59°46' E), in the altitudinal range of 380 to 1200 m above sea level.

In two chosen key sites, 176 vegetation relevés were done, attempting to cover most types of vegetation and habitats, and to reveal species diversity. *Sphagnum* species were found in 62 studied plots (35% of the whole amount). A preliminary species lists and their abundance have been drafted *in situ*. Identification of most specimens was checked later in the laboratory, excepting for easily recognizable species, such as *S. fuscum, S. squarrosum, S. compactum*, *etc*. All herbarium samples collected during the field work are stored in the herbarium of the Yugra State University (YSU) and M. Noskova's private collection in St.-Petersburg, and duplicates were delivered to the Museum of Nature and Man in Khanty-Mansiysk.

For the analysis of species distribution patterns and their frequencies, the diversity of habitats in the SPU highlands and upper forest belt was structured into 14 large categories (groups). *Sphagnum* mosses were found in ten of them (Table 1). Habitats, in which *Sphagnum* species were not found, include young karst sinkholes, calcareous rock remnants, subalpine meadows, and disturbed habitats (roads, waste rock heaps, abandoned settlements).

For the comparison of the altitudinal distribution of *Sphagnum* species in SPU and in other mountain regions of North Asia, we used published data with sufficiently detailed information regarding altitudinal distribution and/or occurrence in the vegetation types above tree line. Their frequency of occurrence were scored by five grade scale (Table 2).

RESULTS

In total, 218 *Sphagnum* specimens were collected and identified under microscope; the whole set includes 300 records.

In these collections, 19 *Sphagnum* species were identified (Table 1). Among them, *Sphagnum fallax, S. flexuosum* and *S. jensenii* were collected only within the forest belt, in meso-oligotrophic sedge-*Sphagnum* mire, situated in the Puiva River valley at 390 m a.s.l. The rest 16 species were found above the tree line, in smaller or greater amounts.

Rock outcrops and rock fields (kurumniks) (Table 1, column 1). *Sphagnum* species are rare in rock fields and grow mostly on soil under big rocks, on fine earth filling flat moist recesses, at groundwater outcrops between rocks, or sometimes spread on rock surfaces on steep slopes to the narrow creek canyons, where air is very humid. The most frequent is *S. girgensohnii*; it forms pure extensive mats, rarely with admixture of *S. russowii*. On wet soil under rocks, small tufts of *S. aongstroemii* and *S. squarrosum* were found, while *S. compactum* grew on dry moss litter between rocks of rock field. *S. lindbergii* was once observed at the bottom of rock field, at the edge of late snow bed, between rocks, in water running from melting snow.

Tundra vegetation. *Sphagnum* species are absent in most tundra sites, except for few ones. We studied 19 dwarf shrub-lichen-moss and herbaceous-green moss tundra communities, and *Sphagnum* mosses were noted in only three of them (Table 1, column 2). Thus, mountain tundra vegetation, which occupies no less than 70% of the study area, is poor in Sphagna. Only two species, *S. girgenshonii* and *S. compactum*, occurred in tundra itself, both being quite rare. They were found in moderately drained sites in dwarf shrub-lichen-moss and herb-moss tundra. The former species formed small cushions directly on mineral soil, and the latter one grew in flat patches up to one meter in diameter.

Late snowmelt sites and nival meadows. *Sphagnum* avoids sites with late snowmelt (Table 1, column 3), where only not abundant (1–3%) *Sphagnum girgeshonii* and *S. russowii* were observed once as an admixture to liverworts *Neoorthocaulis floerkei, Lophozia wenzelii* and green mosses *Kiaeria starkei* and *Ologotrichum hercinicum*.

Bogged dwarf shrub-moss tundra. Species diversity and abundance of Sphagna sharply rise in boggy dwarf

Table 1. Number of relevés) of *Sphagnum* species in the highlands of the SPU eastern slope. Altitudinal belts: I – mountain tundra and subalpine (sub-goltsy), II – upper forest belt. Habitat types: 1 – siliceous rock outcrops and stone fields (kurumniks); 2 – lichen, herbaceous, and dwarf shrub-moss tundra; 3 – late snowmelt sites and nival meadows; 4 – bogged dwarf shrub-moss tundra; 5 – dwarf shrub-sedge-*Sphagnum* mires; 6 – fens and paludified willow carrs at groundwater outcrops; 7 – alder thickets and open larch woodland; 8 – banks of rivulets and streams: 8-t – in highland areas, 8-f – in closed mountain forest belt; 9 – mountain boreal forest including wet and paludified forests in river valleys; 10 – transitional *Sphagnum* mires.

Altitudinal belts	I (highland area)								II (forest)		
Habitat types	1	2	3	4	5	6	7	8-t	8-f	9	10
number of relevés	20	19	6	6	14	6	8	25	5	11	5
relevés with *Sphagna*,	6	3	1	6	14	5	2	4	1	8	5
%	30	16	17	100	100	83	25	16	20	73	100
S. compactum	2	2			1						
S. girgensohnii	6	2	1	5	6	1	2	1	1	4	3
S. russowii	2		1	4	10				1	2	2
S. aongstroemii	2			3	5	1					
S. angustifolium				3	8	1					3
S. balticum					6						
S. fuscum					5						
S. capillifolium					4					1	
S. lindbergii	1				8						1
S. teres					5						1
S. contortum					1						
S. majus					1						1
S. warnstorfii					3	5		1	1	2	
S. squarrosum	1					1		2		1	
S. riparium								1			3
S. fimbriatum								1	1		1
S. fallax											2
S. flexuosum											1
S. jensenii											1

shrub-moss tundra communities, represented in tundra belt (Table 1, column 4). Such type of tundra develops in shallow depressions and on poorly insolated north-facing slopes. Mosses form here a layer up to 15–20 cm thick. First stage of *Sphagnum* expansion includes *S. girgensohnii,* occurring as an admixture to other mosses, and *S. aongstroemii,* forming pure tufts in small depressions. On further stages, as can be assumed from higher *Sphagnum* abundance, *S. russowii* and *S. angustifolium* appear. Total cover of Sphagna in boggy tundra is up to 20–40%.

Dwarf shrub-sedge-*Sphagnum* mires. The highest diversity of *Sphagnum* mosses (13 species) was detected in high-mountain dwarf shrub-sedge-*Sphagnum* mires (Table 1, column 5). These mires varied in size, from several square meters to 1–2 ha, however, in total occupying not more than 1% of the territory. *Sphagnum* mosses cover was up to 95% of the surface of such mires. Various combinations of *Sphagnum* species dominated there, *i.e.*, *Sphagnum russowii, S. capillifolium, S. angustifolium* and *S. warnstorfii*, often with a notable contribution of *S. balticum, S. fuscum, S. teres* and *S. girgensohnii*. *Sphagnum aongstroemii* was quite common at early stages of mire development. In the course of microrelief differentiation, hollows are formed, where *Sphagnum lindbergii* gained the absolute dominance. Rarely *Sphagnum contortum* and *S. majus* were also observed in these high-mountain mires.

Fens and waterlogged willow carrs. *Sphagnum warnstorfii* was the only fairly constantly present species of this genus in mineral-rich fens and waterlogged willow carrs. It grew on peat and peat-mineral soil at groundwater outcrops (Table 1, column 6); however, its cover rarely exceeded 10–20%. Its occasional and non-abundant companions were *S. squarrosum, S. girgensohnii* and *S. aongstroemii.*

Alder thickets and larch open forests. Woody communities close to the tree line in subalpine belt were most poor in Sphagna. The only species constantly present there, though in small quantity, was *Sphagnum girgensohnii* (Table 1, column 7). It grew in small pure tufts in the ground layer and on mossy rocks, among *Hylocomium splendens, Pleurozium schreberii, Rhytidiadelphus squarrosus* and *Sciuro-hypnum reflexum*. The diversity of *Sphagnum* species noticeably increased in the mountain forest belt, especially in wet conditions in waterlogged forests in river valleys (Table 1, column 9).

Banks of rivulets and streams in highlands did not have a distinctive species diversity of *Sphagnum* mosses compared to those in forest belt (Table 1, columns 8-t and 8-f). Most *Sphagnum* species, which were found on the banks of rivulets and streams, occurred up to the upper bounds of the mountain tundra belt. The exception was *Sphagnum riparium*, which did not exceed the sub-goltsy belt. Species composition depended on the type of sub-

Table 2. Altitudinal distribution and frequency of *Sphagnum* species in mountains of Northern Eurasia (arranged from West to East): **Lav**: Lavana-Tundra mountains, Murmansk Province (Likhachev & Belkina, 1999); **Khi**: Khibiny Mountains (Schljakov, 1961); **NU**: North Urals, Vishera Nature Reserve (Ignatova *et al*., 1996); **SPU**: Sub-Polar Urals (present paper); **PU**: Polar Urals (Ghaze, 1930; Czernyadjeva, 1994); **Put**: Putorana Plateau (Czernyadjeva, 1990, 1992); **Say**: Sayan Mountains (Bardunov, 1974); **Alt**: Altai (Ignatov, 1994); **M-Kh**: Mus-Khaya Mountain, Yakutia (Ignatova *et al.*, 2011); **Kam**: Kamchatka Peninsula (Czernyadjeva, 2012). Frequency is indicated as: **com** – common, **fr** – frequent; **sp** – sporadic, **rr** – rare, **un** – unique, + – present with unknown frequency. Frequency of species found only in the forest belt is given in parentheses.

	Lav	**Khi**	**NU**	**SPU**	**PU**	**Put**	**Say**	**Alt**	**M-Kh**	**Kam**
Species, total	**21**	**21**	**22**	**20**	**17**	**15**	**20**	**25**	**13**	**31**
In highlands	**15**	**16**	**8**	**17**	**14**	**8**	**14**	**22**	**10**	**20**
Species of the whole altitudinal profile, including upper highlands										
S. girgensohnii	sp	com	com	com	fr	sp	fr	fr	(rr)	com
S. warnstorfii	com	com	fr	fr	com	fr	fr	com	un	com
S. russowii	sp	fr	fr	com	fr	+	sp	fr	–	com
S.compactum	sp	fr	sp	sp	–	sp	sp	rr	(un)	com
S. aongstroemii	(un)	–	(un)	fr	fr	–	un	rr	sp	–
S. rubellum	–	–	(un)	–	fr	–	un	sp	sp	sp
S. fimbriatum	sp	un	–	rr	–	(+)	–	rr	sp	fr
S. squarrosum	sp	sp	sp	sp	(fr)	+	(sp)	sp	–	(sp)
Species of forest and subalpine belts, and low part of highlands										
S. capillifolium	fr	fr	sp	sp	fr	+	fr	com	–	com
S. fuscum fr	sp	(rr)	sp	rr	(sp)	fr	fr	sp	fr	
S. angustifolium	sp	fr	-	fr	fr	(+)	sp	fr	–	fr
S. balticum	–	rr	(sp)	sp	rr	rr	sp	sp	sp	sp
S. teres	rr	fr	(un)	sp	rr	fr	fr	(sp)	–	com
S. lindbergii	fr	fr	(rr)	sp	sp	–	–	un	–	sp
S. platyphyllum	sp	un	–	–	–	–	–	fr	–	(sp)
S. subsecundum	fr	un	(rr)	–	–	–	–	sp	–	sp
S. contortum	–	(un)	–	un	un	(+)	–	un	–	rr
S. jensenii	rr	sp	(sp)	(un)	–	–	–	rr	–	sp
S. centrale	(sp)	(sp)	un	–	–	–	un	rr	un	sp
S. lenense	–	–	–	+	fr	(+)	–	–	fr	–
Species mostly limited by forest and low part of subalpine belt										
S. riparium	–	(sp)	(sp)	un	(fr)	(+)	un	rr	–	–
S. magellanicum	(un)	(rr)	(fr)	–	–	(+)	rr	rr	–	(sp)
S. fallax	(un)	–	(rr)	(rr)	–	–	(sp)	rr	–	rr
S. flexuosum	–	–	fr	(un)	–	–	(un)	fr	–	(rr)
S. majus	–	–	(rr)	un	–	–	–	–	–	(rr)
S. subfulvum	un	(un)	–	–	–	–	–	–	rr	–
Species limited by forest belt										
S. papillosum	(un)	–	(un)	–	–	–	–	–	–	(sp)
S. obtusum	–	–	–	–	+	–	–	–	(un)	(rr)
S wulfianum	–	–	(un)	–	(un)	–	(sp)	–	–	–
S. cuspidatum	–	–	–	–	–	–	(sp)	–	–	(un)
S. palustre	–	–	–	–	–	–	–	(un)	–	un
S. quinguefarium	–	un	–	–	–	–	(un)	(rr)	–	–

Besides, single mountain moss floras contain: **Lav** – *Sphagnum subnitens*, (rr); **Put** – *S. orientale*, +; **M-Kh** – *S. tundrae*, un; **Kam** – *S. inundatum*, rr; *S. tundrae*, un; *S. tenellum*, (un); *S. pulchrum*, (un); *S. inexpectatum*, (un).

strate: *S. fimbriatum* and *S. girgensohnii* grew directly on mineral soil, while *S. riparium, S. squarrosum* and *S. warnstorfii* were found on peaty banks of water courses.

In addition to nineteen *Sphagnum* species in our collections, eight other species have been reported for the SPU by Dyachenko (1995). Among them, *S. magellanicum, S. papillosum* and *S. cuspidatum* apparently do not occur in high mountain areas, being always restricted to the plains. Another two species, *Sphagnum wulfianum* and *S. obtusum*, collected in 1924 and 1926 by B.N. Gorodkov and V.B. Sochava at the tree line in the Polar Urals (Ghaze, 1930), are generally unusual for highlands, and hardly at all reach beyond the forest belt in mountain systems of Northern Eurasia. However, their occurrence in the SPU forest belt is quite expected.

Sphagnum lenense is rather common in Polar Urals, where it was observed in open moss-dominated mires in the mountain tundra belt (Ghaze, 1930; Kuvaev, 1970); however, its southern distribution limits are in the northernmost part of Sub-Polar Urals, and it did not occur in our surveys.

Presence of some other *Sphagnum* species above tree line in SPU is quite possible; these are *Sphagnum jensenii, S. flexuosum* (both detected by us only in the upper part of the forest belt) and *S. centrale*; the latter species was reported from the mountain tundra and the forest belt of the North Urals (Ignatova *et al*., 1996). All three species are occasionally found in the highlands in many Eurasian mountain systems.

Discussion

Our data are generally in good agreement with the patterns of altitudinal and ecological-phytocoenotic distribution of species in adjacent parts of the North and Polar Urals and in other mountain systems of Northern Eurasia (Table 2). The total number of *Sphagnum* species varies among individual mountain systems from 13 to 31, being 20–22 species in average. The number of species is the lowest under the harsh conditions of ultracontinental climate (Mt. Mus-Khaya, Yakutia, cf. Ignatova *et al.*, 2011). Mountains of Kamchatka are the richest in *Sphagnum* species, apparently due to the high diversity of habitats and high level of bryological exploration (Czernyadjeva, 2012). Average number of *Sphagnum* species within high mountain vegetation belt ranges within 10–20 species, constituting from 60 to 90% of the total species diversity of *Sphagnum* in the area; though it depends on the covering of these highlands by bryological studies. The respective value in the SPU is over 80%.

The species featuring the widest altitudinal amplitude and occurrence in the greatest number of habitats in SPU highlands is *Sphagnum girgensohnii*, which is also the most frequent species there, and extremely diverse morphologically. It is the only highest-climbing representative of the genus, which is typical for the alpine belt in European mountains (Dierssen, 2001), whereas the bulk of other species are limited to the forest belt or the lower sub-alpine belt (Gerdol & Bragazza, 1994). *Sphagnum girgensohnii*, along with *S. warnstorfii*, is noted for high frequency of occurrence in nearly all high mountain moss floras of Northern Asia (Table 2). The exception is the local flora of Mus-Khaya Mountain in Yakutia (Ignatova *et al.,* 2011), where these species are practically absent. Remarkably, *S. warnstorfii* in SPU highlands falls somewhat behind *S. russowii* in terms of the range of habitats and frequency of occurrence, probably because of the obvious prevalence of siliceous rocks over very locally appearing calcareous rocks in this area.

Sphagnum species occur in different types of habitats in the mountain tundra belt, although some species are relatively infrequent, *i.e.*, *Sphagnum compactum, S. aongstroemii, S. rubellum, S. squarrosum,* and *S. fimbriatum*.

Distribution of *S. fuscum, S. balticum, S. capillifolium, S. lindbergii, S. teres* and *S. contortum* in SPU highlands, like in other mountain systems of northern Eurasia, is associated, predominantly or exclusively, with mountain peat mires (Schljakov, 1961; Bardunov, 1974; Gerdol & Bragazza, 1994; Chenyadjeva, 2012). The frequency of peat mires declines rapidly in mountain tundra belt, apparently due to severe climate conditions, which become too cold and dry for the development of at least some types of mires. Thus most *Sphagnum* species closely connected with peat mires are restricted to the forest and subalpine belts, and to the lower part of tundra belt. According to our observations, the ecological-phytocoenotic amplitude of *S. angustifolium* and *S. aongstroemii* is somewhat wider, so they have higher frequency. We collected all species mentioned above at much higher altitudes in SPU highlands than it was reported previously: a majority of species grew up to 920–960 m a. s. l., *S. lindbergii* – to 900 m, and *S. contortum* – to 630 m. Furthermore, some species previously known only from plains and lower parts of the forest belt, were found in highlands: *S. fallax*, *S. flexuosum, S. jensenii* and *S. majus* were collected in the sedge-*Sphagnum* mire close to the tree line, at 390 m a.s.l.; S. *squarrosum* and *S. riparium* grew in a waterlogged willow carr in the upper part of the sub-goltsy belt, at 530 m a.s.l.; some other species were detected even from the upper part of the mountain tundra belt, including *S. fimbriatum* growing along stream bank at 790 m*, S. majus* in a *Sphagnum* mire at 900 m, and *S. squarrosum* on fine earth substratum in a large-boulder stone river, at 980 m a.s.l.

The species diversity of *Sphagnum* mosses in the highlands of the SPU eastern slope is most similar to that in the Vishersky Nature Reserve, which is situated on the western slope of North Urals (Table 2). The higher proportion of species limited in distribution to the forest belt in Vishersky Reserve can be explained by the fact that high mountain habitats were less studied than the forest belt (Ignatova *et al*., 1996).

Compared to the Polar Urals, some species reach higher elevations in SPU mountains, which is quite explicable. Thus, *Sphagnum teres* and S. *lindbergii* do not get higher than larch open woodland of the sub-goltsy belt in the Polar Urals, but they are sporadically present all along the altitudinal profile in the SPU, up to the upper limits of the mountain tundra belt. *Sphagnum squarrosum* and *S. riparium* occur in the sub-goltsy belt and higher in the SPU, but do not reach further than the forest belt in the Polar Urals. Such species as *Sphagnum fallax* and *S. flexuosum,* being present in the upper part of the forest belt in the SPU, were not found in the Polar Urals (Table 2). On the other hand, *Sphagnum lenense* and *S. rubellum* are quite frequent in the highlands of Polar Urals, but the former species is very rare and the latter one has not been found in the mountains of Sub-Polar Urals.

The collected data can be used in further studies of the moss flora and in environmental monitoring of Sub-Polar Urals highlands based on identification of trends in the altitudinal distribution and phytocoenotic activity of *Sphagnum* mosses under the impact of global climate warming.

ACKNOWLEDGEMENTS

Authors are sincerely grateful to Dr. M. Ignatov for valuable comments and improving the English. We also cordially thank the administration of the Museum of Nature and Men of Khanty-Mansiysk Autonomous District for the organization and support of the field trip.

LITERATURE CITED

[BARDUNOV, L.V.] БАРДУНОВ Л.В. 1974. Листостебельные мхи Алтая и Саян. – [Leaf mosses of the Altai and Sayan] *Новосибирск, Наука* [*Novisibisk, Nauka*], *168 pp.*

[CZERNYADJEVA, I.V.] ЧЕРНЯДЬЕВА И.В. 1990. Бриофлора северо-запада плато Путорана. – [The bryophyte flora of north-western of Putorana plateau] *Новости Систематики Низших Растений* [*Novosti Sistematiki Nizshikh Rastenij*] **27**: *153–157.*

[CZERNYADJEVA, I.V.] ЧЕРНЯДЬЕВА И.В. 1992. Анализ активности видов бриофлоры северо- запада плато Путорана. – [Analysis of species activity in bryoflora of North-West of Putorana Plateau] *Новости Систематики Низших Растений* [*Novosti Sistematiki Nizshikh Rastenij*] **28**: *161–165.*

[CZERNYADJEVA, I.V.] ЧЕРНЯДЬЕВА И.В. 1994. Флора листостебельных мхов окрестностей стационара "Собь" (Полярный Урал). – [Moss flora of vicinity "Sob" Station (Polar Ural)] *Arctoa* **3**: *133–138.*

[CZERNYADJEVA, I.V.] ЧЕРНЯДЬЕВА И.В. 2012. Мхи полуострова Камчатка. – [Mosses of Kamchatka Peninsula] *СПб: Изд-во СПбГЭТУ «ЛЭТИ»* [*St. Petersburg: Publishing house of ETU*], *459 pp.*

DIERSSEN, K. 2001. Distribution, ecological amplitude and phytosociological characterization of European bryophytes. – *Bryophytorum Bibliotheca* **56**: *1–289.*

[DYACHENKO, A.P.] ДЬЯЧЕНКО А.П. 1995. История изучения флоры листостебельных мхов Приполярного Урала. – [History of the studies of moss flora in the Subarctic Urals] *Arctoa* **4**: *17–22.*

[GHAZE, O.F.] ГАЗЕ О.Ф. 1930. Список сфагновых мхов, собранных Б. Н. Городковым в Западной Сибири и Б. Н. Городковым и В. Б. Сочавой на Полярном Урале. – [The list of peat mosses collected by B.N. Gorodkov in the western Siberia by B.N. Gorodkov and V.B. Soczava in the Polar Urals] *Труды Ботанического Музея АН СССР* [*Trudy Botanicheskogo Museya Akademii Nauk USSR*] **22**: *207–213.*

GERDOL, R. & L. BRAGAZZA. 1994. The distribution of *Sphagnum* species along an elevational gradient in the southern Alps (Italy). – *Botanica Helvetica* **104**: *93–101.*

[GORCHAKOVSKY, P.L.] ГОРЧАКОВСКИЙ П.Л. 1958. Растительность хребта Сабля на Приполярном Урале. – [Vegetation of Sablja range at the Subarctic Urals] *Растительность крайнего севера СССР и ее освоение* [*Rastitelnost krainego severa SSSR i ee osvoenije*] **3**: *95–127.*

[GORCHAKOVSKY, P.L.] ГОРЧАКОВСКИЙ П.Л. 1975. Растительный мир высокогорий Урала. – [Vegetation of the high-mountain Urals' regions] *М., Наука* [*Moscow, Nauka*], *283 pp.*

[IGNATOV, M.S.] ИГНАТОВ М.С. 1994. Мохообразные Алтая. I. Район исследования и история его бриологического изучения. – [Bryophytes of Altai Mountains. I. Study area and history of its bryological exploration] *Arctoa* **3**: *13–27.*

[IGNATOVA, E.A., M.S. IGNATOV & A.G. BEZGODOV] ИГНАТОВА Е.А., М.С. ИГНАТОВ, А.Г. БЕЗГОДОВ. 1996. Мхи Вишерского заповедника (Пермская область, Северный Урал). – [Mosses of the Vishera State Reserve (Perm Province, Northern Ural Mountains)]. – *Arctoa* **6**: *7–20.*

[IGNATOVA, E.A., E.I. IVANOVA, O.V. IVANOV & M.S. IGNATOV] ИГНАТОВА Е.А., Е.И. ИВАНОВА, О.В. ИВАНОВ, М.С. ИГНАТОВ. 2011. Мхи горы Мус-Хая (Якутия, Азиатская Россия). – [Mosses of the Mus-Khaya Mountain (Yakutia, Asiatic Russia)] *Arctoa* **20**: *211–226.*

[IVANOVSKY, V.] ИВАНОВСКИЙ В. 1917. Список мхов, собранных Б.Н. Городковым в бассейне р. Северной Сосьвы Березовского уезда Тобольской губернии. – [List of the mosses collected by B. N. Gorodkov at Severnaja Sosva river's basin (Berezovsky district, Tobolsk province)] *Ежегодник Тобольского губернского музея, год 26* [*Ezhegodnik Tobolskogo gubernskogo muzeja, god 26*] **28**(2): *1–12.*

[KUVAEV, V.B.] КУВАЕВ В.Б. 1970. Лишайники и мхи Приполярного Урала и прилегающих равнин. – [Lichens and mosses on the Sub-Polar Urals and adjoined plains] *Труды Института экологии растений и животных, Уральский филиал АН СССР* [*Trudy Instituta Ecologii Rastenij i Zhyvotnykh, Uralskiy filial Akademii Nauk USSR*] **70**: *61–92.*

[LAPSHINA, E.D., E.A. IGNATOVA, M.S. IGNATOV & YU.V. SKUCHAS] ЛАПШИНА Е.Д., Е.А. ИГНАТОВА, М.С. ИГНАТОВ, Ю.В. СКУЧАС. 2015. К изучению бриофлоры высокогорий Приполярного Урала (Ханты-Мансийский автономный округ). – [Contributions to the knowledge of moss flora of the Subpolar Ural mountains highland (Khanty-Mansi Autonomous District)] *Материалы Международной бриологической конференции, посвященной 100-летию со дня рождения А.Л. Абрамовой (Санкт-Петербург, 12-16 октября 2015 г.)* [*Proceedings of the International Bryological Conference Devoted to the 100-th Anniversary of A.L. Abramova (Saint Petersburg, October 12-16, 2015)*] *Санкт-Петербург: Изд-во СПбГЭТУ «ЛЭТИ»* [*St. Petersburg: Publishing house of ETU*]: *96–100.*

[LIKHACHEV, A.YU. & O.A. BELKINA] ЛИХАЧЕВ А.Ю., О.А. БЕЛКИНА. 1999. Листостебельные мхи горного массива Лаванатундра (Мурманская область, Россия). – [Mosses of Lavana-Tundra Mountains (Murmansk Province, Russia)] *Arctoa* **8**: *5–16.*

[POHLE, R.R.] ПОЛЕ Р.Р. 1915. Материалы для познания растительности северной России. I. К флоре мхов северной России. – [Contributions to the vegetation of northern Russia. I. On the moss flora of northern Russia] *Труды Императорского Ботанического сада* [*Trudy Imperatorskogo Botanicheskogo Sada*] **33**(un): *I–VIII, 1–148.*

[SCHLJAKOV, R.N.] ШЛЯКОВ Р.Н. 1961. Флора листостебельных мхов Хибинских гор. – [Moss flora of Khibiny Mountains] *Мурманск, Мурманское кн. изд-во* [*Murmansk, Murmansk Kn. Izd.*], *251 pp.*

[SOCZAVA, V.B.] СОЧАВА В.Б. 1930. Пределы лесов в горах Ляпинского Урала. – [The forests' limits in Ljapin Ural mountains] *Труды Бот. Музея АН СССР* [*Trudy Botanicheskogo Museya Akademii Nauk. USSR*] **22**: *1–48*.

[ZINZERLING, YU.D.] ЦИНЗЕРЛИНГ Ю.Д. 1935. Очерк растительности массива Сабля. – [An overview of vegetation of Sablja Mountain Range] *Труды ледниковых экспедиций. Вып. 4. Урал. Приполярные районы* [*Trudy lednikovykh expeditsij. Vol.4. Ural. Pripolyarnyje rajony*]: *75–86.*