

ON THE MOSS FLORA OF KHANGALASSKY DISTRICT
(REPUBLIC OF SAKHA/YAKUTIA, EAST SIBERIA)

К ФЛОРЕ МХОВ ХАНГАЛАССКОГО УЛУСА
(РЕСПУБЛИКА САХА/ЯКУТИЯ, ВОСТОЧНАЯ СИБИРЬ)

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Abstract

New and previously known data on the moss flora of Khangalassky District are summarized. The list of mosses includes 232 species, 59 of them are newly recorded for this territory. Territory of the district is situated in Central Yakutia, along the middle course of Lena River. There is the Nature park “Lena Pillars” known by vertical limestone cliffs up to 100 m high stretching for ca. 80 km along the right bank of Lena River. They host a number of species with generally more southern distribution, e.g., *Anomodon minor*, *Brachythecium buchananii*, *Fabronia ciliaris*, *Homalia trichomanoides*, *Homomallium incurvatum*, *Leucodon sciuroides*, *Entodon schleicheri*, *Oxyrrhynchium hians*, *Philonotis falcata*, *Plagiomnium acutum*, *Trachycystis ussuriensis*, etc. A unique combination of habitats provides environments for co-existence side-by-side of hygrophilous, mesic, and xeric moss species. New localities of some rare species were revealed. *Indusiella thianschanica* and *Jaffueliobryum latifolium*, previously known only in one locality near Labyja Creek mouth, were found on dry cliffs and dry rock outcrops on the left bank of Lena River. *Myrinia rotundifolia*, known from few localities in the north of Yakutia and in Taimyr, appeared to be abundant on moist rock ledges just near the water on the left bank of Lena River. *Fissidens arcticus* was collected several times on rock ledges covered with soil along the river and on soil in *Salix* thickets on the river island. Rare epigeic species, *Pterygoneurum kozlovii* and *Hennediella heimii*, were collected in the eastern part of the district, on cryogenic hills (boolgunnyakhs) covered by low grass meadow.

Резюме

Обобщены ранее известные и новые данные по бриофлоре Хангаласского улуса. Список мхов насчитывает 232 вида, 59 из них приводятся впервые для его территории. Территория улуса расположена в Центральной Якутии, в среднем течении р. Лена, где находится природный парк “Ленские Столбы”, известный благодаря высоким, до 100 м, отвесным известняковым скалам, тянущимся на 80 км по правому берегу. Здесь были найдены многие виды, имеющие в целом более южное распространение: *Anomodon minor*, *Brachythecium buchananii*, *Fabronia ciliaris*, *Homalia trichomanoides*, *Homomallium incurvatum*, *Leucodon sciuroides*, *Entodon schleicheri*, *Oxyrrhynchium hians*, *Philonotis falcata*, *Plagiomnium acutum*, *Trachycystis ussuriensis* и др. Уникальное сочетание природных условий обуславливает произрастание в непосредственной близости друг от друга болотных, мезофильных лесных и ксерофильных степных видов. Для некоторых редких видов выявлены новые местонахождения. *Indusiella thianschanica* и *Jaffueliobryum latifolium*, собранные ранее только на скалах в устье р. Лабыйа, были найдены на сухих скалах и скальных выходах на левом берегу Лены. *Myrinia rotundifolia*, известная из немногих местонахождений на севере Якутии и на Таймыре, найдена в большом количестве на сырых скальных плитах у самой воды по берегу р. Лены, на левом берегу. На почве, покрывающей полочки скал по берегам Лены, а также на почве в ивняках со свидиной на острове посреди Лены нередко произрастает *Fissidens arcticus*. На почве на низкотравных лужайках, покрывающих бугры пучения (булгунняхы) в восточной части улуса собраны редкие в Якутии *Pterygoneurum kozlovii* и *Hennediella heimii*.

KEYWORDS: moss flora, Yakutia, Russia, rare species

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INTRODUCTION

Yakutia is a largest administrative unit of Russia, stretching from 55 to 77° N. Bryophyte flora of its Arctic and mountain areas is very diverse and attracted more attention of bryologists. The central lowland part of Yakutia is more monotonous, thus its moss flora was studied only in a few places. Special bryological studies in Khangalassky District concentrated mostly in the area of Lenskie Stolby (Lena Pillars) Nature Park, notable by a marvelous limestone column-shaped cliffs along the right bank of Lena River, some being over 100 m high (Bopposova & Krivoshapkin, 2007; Fedorov *et al.*, 2007; Krivoshapkin *et al.*, 2001). Otherwise, various small collections gathered in the course of geobotanical projects accumulated in SASY herbarium. A special bryological expeditions in 2015–2016 added some more studied localities and enriched an amount of specimens up to 3000. Thus we are presenting here the list of mosses the district, aiming also to exclude doubtful and erroneous identifications, quite numerous in Dicranaceae, Rhabdoweisiaceae, Brachytheciaceae and Grimmiaceae, which were a subject of special revisions in last decades, resulting in description of new species or resurrection previously synonymized taxa.

STUDY AREA

Khangalassky District is situated in the central part of Yakutia, in the valley of Lena River in its middle course, covering ca. 24680 km² (Fig. 1). Being a lowland, its altitudes are ranging insufficiently from ca. 100 m, the level of Lena River, to 200–300(–400) m in surrounding areas, where the studies were carried out. Contemporary valleys of the rivers Lena, Sinyaya and Buotama have a flood-valleys and two fluvial terraces with a relative elevations of watersheds rarely exceeding 100 m. The soils are mainly sandy, at places loamy, and in the latter cryogenic lakes and ‘boolgunyakhs’ (Yakutian name for frost mounds) are expressed (Elovskaya & Konorovsky, 1978). Boolgunyakhs reach several meter high in the study area, and their eroded sides provide a suitable habitat for some rare bryophytes. Ancient alluvial plain (formed in pleistocene) often has numerous flooded and dry shallow cryogenic depressions (‘alases’ in Yakutian). Being surrounded by the forest, they have meadow to swampy vegetation, commonly surrounding a lake in the middle, formed as a result of permafrost melt (Bosikov, 1991). Importantly, after draining of these lakes, soil becomes saline. Alases provide a space for hay meadows and pastures, so they are very important for agriculture in Yakutia.

A moderately steep sandy or loamy slopes to rivers are interrupted by bedrock outcrops, including limestone, marl, dolomite and schist. “Lenskie Stolby”, or “Lena Pillars” are especially conspicuous. They are formed by strongly weathered Cambrian limestones, standing at ca. 80 km along the right bank of Lena River. Similar rocks, although not so high and forming more wall-like outcrops occur along Sinayaya and Butoma rivers, and at places on the left bank of Lena River.

The climate in Khangalassky District is severely continental, with great amplitude of seasonal temperature and low precipitation rate, falling mainly in warm season. Continentality is raising in SW–NE direction (from Olyokminsk meteorostation to Yakutsk meteorostation, at the border of Khangalassky District) (Table 1). These climatic differences define a border for some southern species, while relic tundra-steppe landscapes and permafrost-dependent alases and boolgunnyakhs appear in the eastern part of the district.

The Khangalassky District occurs in the middle taiga subzone (Norin, 1987). Larch forests are prevailing, and pine forests have a scattered distribution. Mesic grass and sedge meadows occur in alases, while open slopes to rivers represent xeric steppes, with *Stipa*, *Agropyron* and *Festuca*, species of Limoniaceae and succulents, e.g. *Orostachys spinosa* (L.) Sweet. Drift sands, or “tukulans” (in Yakutian) with scattered psammophytic vegetation are also characteristic for the district.

Larix cajanderi Mayr. forests occupy ca. 80% of the forested area (Timofeev, 2001). Larch forests are mainly of the *Vaccinium vitis-idea* type. Mosses are not abundant, being represented mostly by *Rhytidium rugosum*, *Aulacomnium turgidum*, *Polytrichum strictum*, *P. piliferum* and *P. juniperinum*, and only in somewhat wetter places *Hylocomium splendens*, *Pleurozium schreberi*, *Aulacomnium palustre* and *Tomentypnum nitens* may occur, sometimes with admixture of *Dicranum polysetum*, *D. bardunovii*, *D. elongatum*, *Climacium dendroides*, *Abietinella abietina*, *Sanionia uncinata* and *Ceratodon purpureus*.

Pine (*Pinus sylvestris* L.) forests cover only 3.5 % of forested area, being mostly confined to dry upper parts of slopes. Mosses are poorly developed there, being represented by *Rhytidium rugosum*, *Abietinella abietina*, *Polytrichum piliferum* and *P. juniperinum*.

Spruce, birch, poplar and aspen forests, together with dwarf birch and alder thickets occupy 8% of the forested

Table 1. Meteorological data (Annual meteorological reports, 1987–1990)

Meteorostations	Mean annual temperature, °C	Maximal air temperature, °C	Minimal air temperature, °C	Mean air temperature, of January, °C	Mean air temperature of July, °C	Annual precipitation, mm	Number of days with snow cover	Maximal height of snow cover, cm
Olyokminsk	–5,6	33,6	–49,9	–30,8	18,5	232	117	66
Isit'	–7,7	33,2	–51,1	–36,5	17,7	257	122	46
Pokrovsk	–9,4	33,4	–56,6	–42,0	18,4	211	118	42
Yakutsk	–9,3	34,0	–52,8	–41,7	19,2	191	119	46

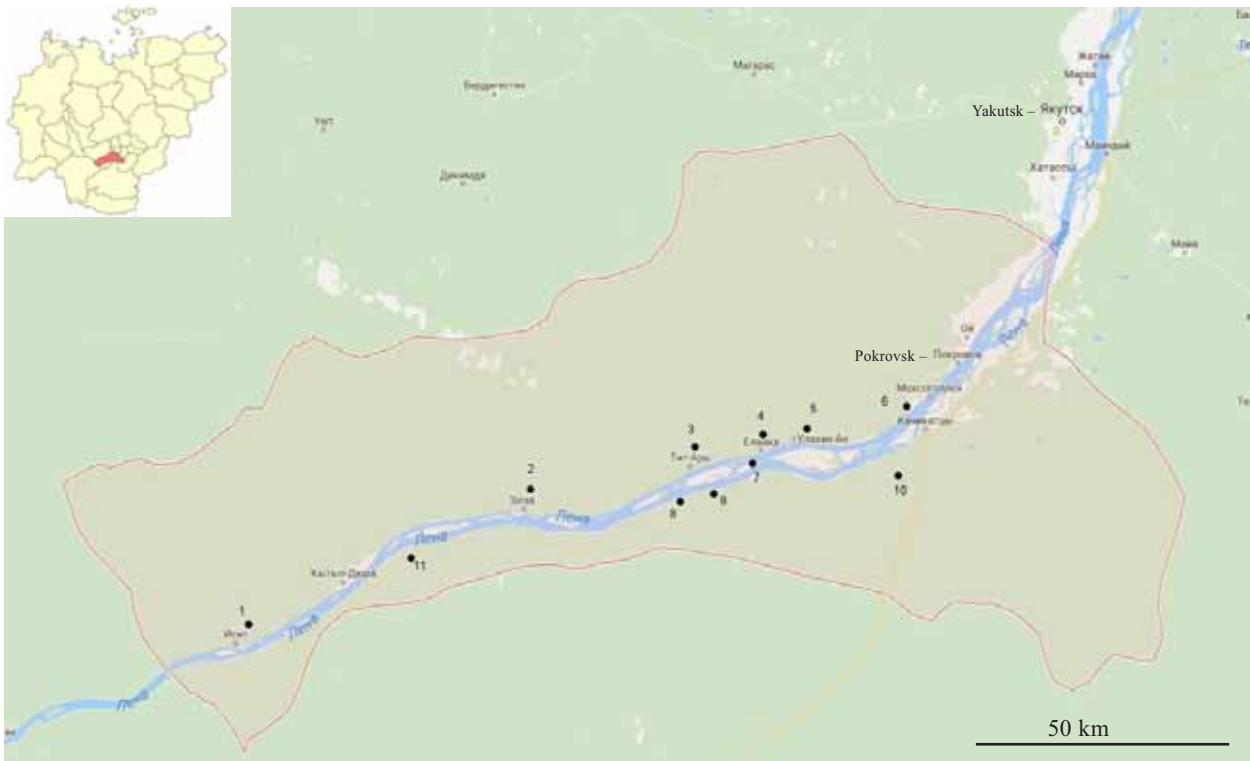


Fig. 1. Collecting localities in Khangalassky ulus (at 60°45'45.29" – 61°46'40.01"N, 125°01'45.25" – 129°32'18.49"E):
№ Locality

№ Locality	Collectors and years of collecting	Lat	Long
<i>Left bank of Lena River</i>			
1. Surroundings of Isit' Settlement	Isakova, 2015	60°48'	125°18'
2. Lower course of Sinyaya River, Nature Park "Lena Pillars"	Ivanova, 2000	61°10'	126°54'
3. Lower course of Ulakhan Keteme Creek	Ignatov, Ignatova and Ivanova, 2016	61°16'	127°50'
4. Surroundings of Elanka Village	Ignatov, Ignatova and Ivanova, 2016	61°16'	128°06'
5. Surroundings of Ulakhan-An Settlement	Ignatov, Ignatova and Ivanova, 2016	61°18'	128°14'
6. Surroundings of Boolgunnyakhtakh Settlement	Ignatov, Ignatova and Ivanova, 2016	61°18'	128°39'
7. Kharjalakh Island on Lena River (opposite Elanka Village)	Ignatov, Ignatova and Ivanova, 2016	61°14'	128°01'
<i>Right bank of Lena River</i>			
8. Near the mouth of Labyja Creek, Nature Park "Lena Pillars"	Krivoshapkin, 1999-2000; Ignatov, 2000	61°06'	127°21'
9. From the mouth of Labyja Creek to the end of pillars, Nature Park "Lena Pillars"	Ignatov, Ignatova and Ivanova, 2016	61°06'	127°25'
10. Lower course of Buotama River, Nature Park "Lena Pillars"	Ivanova, 1998-2001	61°06'	128°45'
11. From Churan-baza site to the mouth of Labyja Creek, Nature Park "Lena Pillars"	Ivanova, 2001	60°53'	125°46'

area. However, being more wet, they are the more interesting in terms of bryophyte diversity.

Spruce (*Picea obovata* Ledeb.) forests in flood valleys of smaller rivers and creeks often have continuous moss floor cover of *Hylocomium splendens*, *Rhytidadelphus triquetrus*, *Pleurozium schreberi*, *Aulacomnium palustre*, *Tomentypnum nitens* and *Ptilium crista-castrensis*. A somewhat drier places within this carpet are occupied by *Aulacomnium turgidum*, *Sanionia uncinata*, *Abietinella abietina* and *Rhytidium rugosum*. Lower branches of spruce trees host *Ortotrichum elegans* and *Pylaisia polyantha*.

On steep river banks pioneer mosses, *i.e.*, *Funaria hygrometrica*, *Leptobryum pyriforme* and *Ceratodon purpureus* are abundant; few plants of *Bryobrittonia lon-*

gipes and *Physcomitrella patens* were also collected in this type of habitat. Hygrophilous mosses from families *Mniaceae*, *Calliergonaceae*, *Scorpidiaceae*, *Pylaisiaceae* and *Amblystegiaceae* cover wet sites near water courses.

On south-faced steep slopes of Lena and Buotama Rivers a unique type of vegetation, *i.e.* petrophytous steppes, is represented. In such steppe sites near mouth of Labyja Creek several xerophilous species were found: *Pterygoneurum subsessile* grows in large quantity on bare soil; spots of *Bryum argenteum* are frequent, and more rarely *Pterygoneurum ovatum*, *Stegonia latifolia* and *Jaffueliobryum latifolium* were recorded on open rocky substrates (Krivoshapkin *et al.*, 2001; Ivanova, 2001).

Drift sands ("tukulans", Saarys Kumakha) are situated along the right bank of Lena River near the mouth

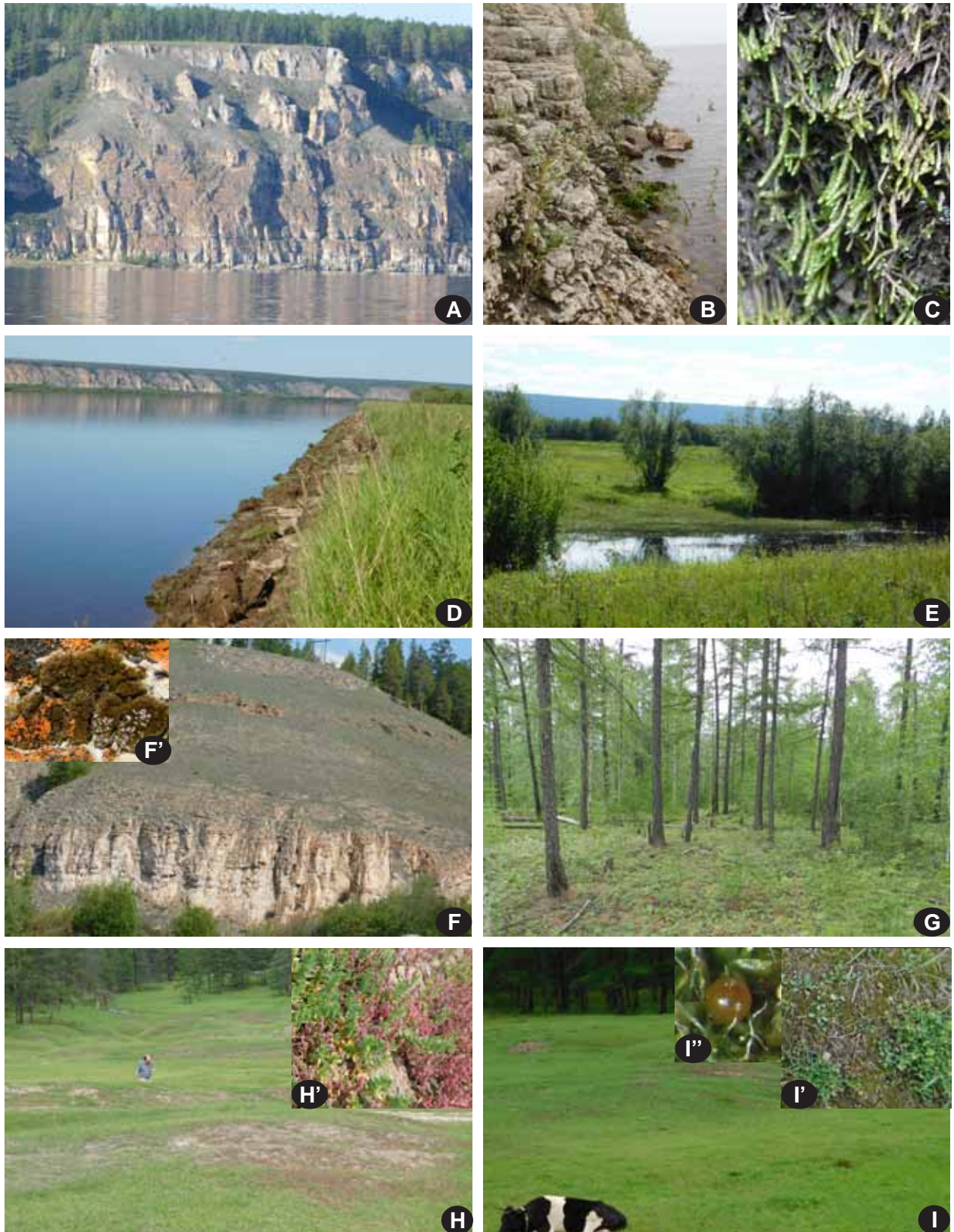


Fig. 2. Common types of some moss habitats, all at left bank of Lena (localities 4-7 in Table 1): A (arrow point B-C): clifly bank of Lena River with *Indusiella* on cliff faces and *Myrinia rotundifolia* at cliff base, on frequently flooded rocks (close up B and C); D: Lena River clifly bank, view from island, where island bank is a place where *Physcomitrella* and *Bryobrittonia* were found; E: meadows in island (poor in bryophyte, but with *Fissidens arcticus* locality, on soil under shrubs); F: Most common type of *Larix* forest, poor in bryophytes; H-I: pastures with low boogunnyakhs, with halophytic plants (H': *Glaux*, *Suaeda*; I: *Lepidium ruderales*, I': *Pterygoneurum kozlovii*, *Henediella heimii*, *Aloina rigida*. I': close up of *Pterygoneurum kozlovii*).

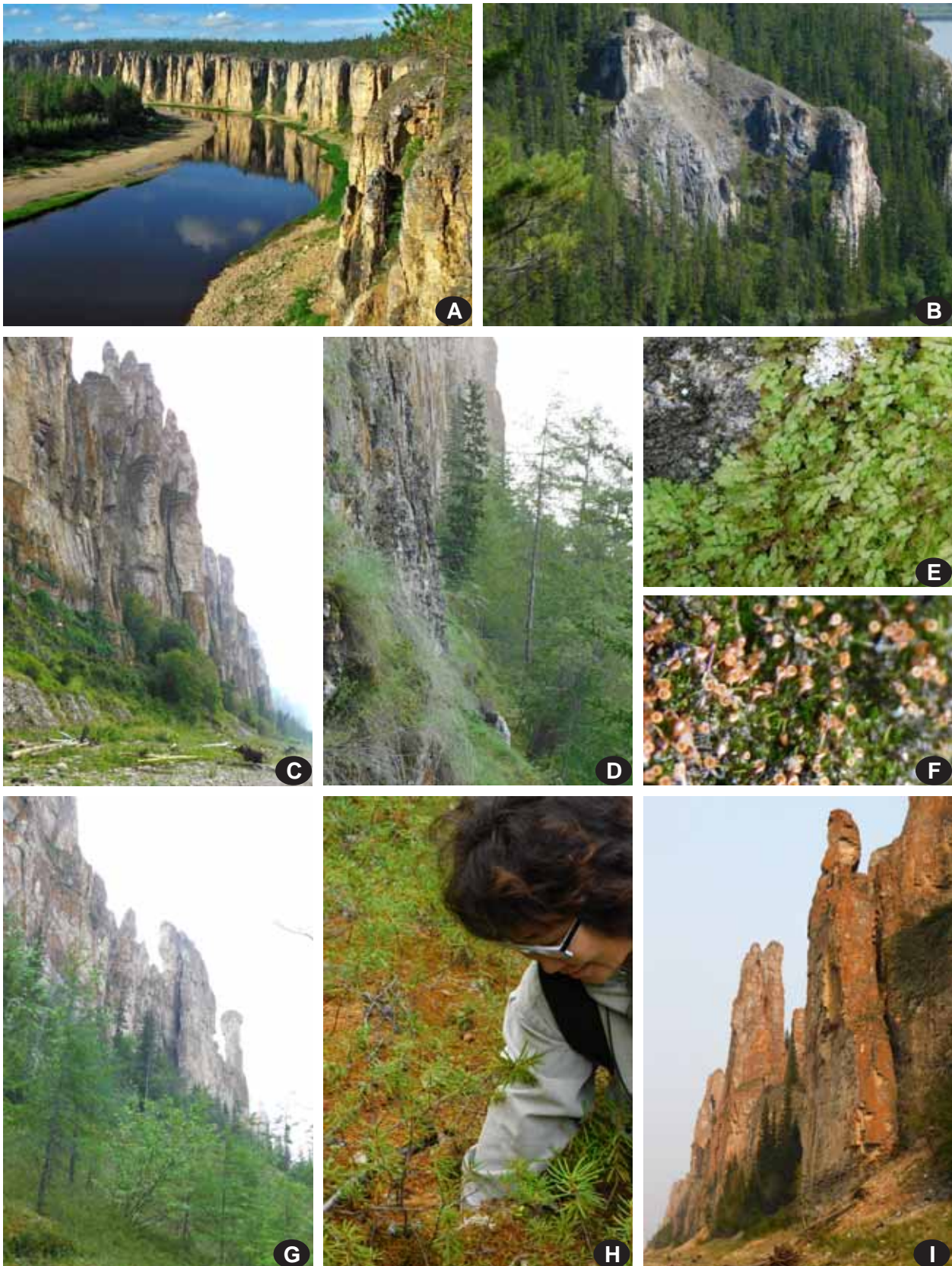


Fig. 3. Common types of some moss habitats, A: Sinyaya River (loc. 2); B: Ulakhan Keteme Creek (loc. 3); C–I right bank of Lena, Lenskie Stolby (loc. 9 in Table 1): A: clifly bank of Sinyaya River; B: cliff in forest on slope to Ulakhan Keteme Creek (*Seligeria doniana* locality); C, D, G, I: cliffs with various vegetation at their bases: G corresponds to H: the slope is composed of *Sphagnum girgenshohnii* (Asian brownish phenotype), also H shows also depth of ice (ca. 30 cm in the end of August); E–F: common species at cliff base: E: *Cyrtomnium hymenophylloides* and *Distichium capillaceum*; F: *Seligeria tristichoides*.

of river Buotama. Mosses were found only in small pine grove among sands, represented by *Ceratodon purpureus* and some species of *Pohlia*.

Bryophyte flora of calcareous cliffs, or “pillars”, is unique. Mosses grow in crevices, cracks and small hollows in cliff walls. Moss composition is more diverse on north-faced Lena pillars. Cliffs near Labyja Creek mouth are covered by *Rhytidium rugosum*, *Abietinella abietina*, *Stereodon vaucheri* and *Hypnum cupressiforme* in more or less shaded sites. In dry crevices and niches *Bryum argenteum*, *Encalypta rhamnifolia* and *Bryoerythrophyllum*

recurvirostre often occur, *Anomodon minor*, *Molendia sendthneriana* and *Gymnostomum aeruginosum* are also rather frequent. In moist and shady places with seeping water *Hymenostylium recurvirostrum* and *Trichostomum crispulum* grow, and wet niches between rocks are occupied by *Distichium capillaceum*, *Myurella julacea*, *M. sibirica*, *Neckera oligocarpa*, etc. (Krivoshapkin *et al.*, 2001; Ivanova, 2007). See also discussion section below.

In the following list nomenclature follows Ignatov, Afonina, Ignatova *et al.* (2006) with some recent updates. Numbers of localities correspond to Fig. 1.

Table 2: Distribution of species by localities shown in Fig. 1: fr – frequent; sp – sporadic; r – rare; un – unique.

	1	2	3	4	5	6	7	8	9	10	11
<i>Abietinella abietina</i>	sp	sp	sp	sp	sp	sp		fr	r	sp	sp
<i>Aloina rigida</i>				sp	sp	sp					
<i>Amblystegium serpens</i>				sp	sp		sp	sp	sp		
<i>Anomobryum concinnatum</i>							r				
<i>Anomodon minor</i>		r	r	r				fr	sp		
<i>Aulacomnium acuminatum</i>			r					sp	sp	r	
<i>A. palustre</i>	sp	sp						fr	sp	sp	sp
<i>A. turgidum</i>	sp	sp			fr		r	fr		sp	sp
<i>Barbula convoluta</i>				r			r	r			
<i>B. unguiculata</i>				r		r	r			un	
<i>Brachytheciastrum trachypodium</i>		fr	sp				sp	fr	un		
<i>Brachythecium boreale</i>		un	sp	r					r		
<i>B. buchananii</i>			r	r					sp		
<i>B. cirrosum</i>								r	r	sp	
<i>B. erythrorrhizon</i>				r			r	r	r		
<i>B. jacuticum</i>				r					sp		
<i>B. mildeanum</i>	r	r		r			sp	sp		r	
<i>B. rotaeantum</i>		un	r	sp			r	r			
<i>B. salebrosum</i>	r			r	r			fr			
<i>B. turgidum</i>								r			
<i>Bryobrittonia longipes</i>							r	sp	r		
<i>Bryoerythrophyllum recurvirostrum</i>	sp	r					fr	sp		r	
<i>Bryum algovicum</i>		un									
<i>B. amblyodon</i>				r					sp		
<i>B. arcticum</i>								r			
<i>B. argenteum</i>	r	r		r				fr			
<i>B. caespiticium</i>								r			
<i>B. creberrimum</i>								r	r		
<i>B. kunzei</i>			r	r							
<i>B. moravicum</i>									un		
<i>B. pallens</i>		un						r			
<i>B. pseudotriquetrum</i>	r	r	r				r	fr	fr		
<i>B. sibiricum</i>									r		
<i>B. turbinatum</i>								un			
<i>Calliergon cordifolium</i>								r			un
<i>C. giganteum</i>		sp	un					fr	r	sp	
<i>Calliergonella cuspidata</i>									un	sp	
<i>C. lindbergii</i>	r	sp	sp				sp	fr	sp	sp	
<i>Campyliadelphus chrysophyllus</i>		r					r		sp		
<i>Campylidium sommerfeltii</i>		r						r	sp		
<i>Campylium polygamum</i>										un	
<i>C. protensum</i>								sp		sp	
<i>C. stellatum</i>	r	sp			r			fr	r	sp	
<i>Ceratodon purpureus</i>	sp	sp	r	r	sp		r	fr	sp	sp	
<i>Cinclidium cf. minutifolium</i>								un			
<i>Claopodium pellucinerve</i>								un			
<i>Climacium dendroides</i>		r	r					fr	r	r	

	1	2	3	4	5	6	7	8	9	10	11
<i>Conardia compacta</i>									un	un	
<i>Cratoneuron filicinum</i>		r	sp					r	sp		
<i>Ctenidium molluscum</i>								r			
<i>Cyrtomnium hymenophylloides</i>		fr	fr					fr	fr		sp
<i>Dichodontium pellucidum</i>			un						un		
<i>Dicranella grevilleana</i>											
<i>D. schreberiana</i>								un			
<i>D. varia</i>									r		
<i>Dicranum acutifolium</i>		r						un	un		
<i>D. bardunovii</i>		fr	sp		fr				fr		r
<i>D. dispersum</i>									un		
<i>D. elongatum</i>		sp			fr			r	r	sp	sp
<i>D. flexicaule</i>	r	r						sp			sp
<i>D. fragilifolium</i>	r	r						sp	fr	sp	
<i>D. montanum</i>									r		
<i>D. polysetum</i>		r			sp			fr		sp	
<i>D. undulatum</i>	r	sp			sp			fr	sp	sp	
<i>Didymodon cordatus</i>								un			
<i>D. fallax</i>								r			
<i>D. ferrugineus</i>			r					r	sp	r	
<i>D. cf. glaucus</i>				un							
<i>D. icmadophilus</i>			r	sp		r		sp	fr	sp	sp
<i>D. cf. rigidulus</i>										r	
<i>D. validus</i>		r	fr	fr				sp	fr	sp	
<i>Distichium capillaceum</i>	sp	fr	fr	r				fr	fr	sp	
<i>Ditrichum pusillum</i>									un		
<i>Drepanium recurvatum</i>	r							sp	un	r	
<i>Drepanocladus aduncus</i>	r	sp			sp	r		sp	r	sp	
<i>D. longifolius</i>					un						
<i>D. polygamus</i>				un				r	un		
<i>Encalypta pilifera</i>											
<i>E. procera</i>		r	r					sp	sp		
<i>E. rhamnoides</i>		sp	sp					fr	sp	sp	r
<i>E. trachymitria</i>				un					un		
<i>Entodon concinnus</i>		un	un					fr	sp		
<i>E. schleicheri</i>								r			
<i>Entosthodon pulchellus</i>				un				r		un	
<i>Eurhynchiastrum pulchellum</i>	r	sp	r	r			sp	fr	fr	r	
<i>Fabronia ciliaris</i>								un			
<i>Fissidens arcticus</i>				r			sp				
<i>F. bryoides</i>								r			
<i>Flexitrichum flexicaule</i>	r	sp						r	sp		
<i>F. gracile</i>									un		
<i>Fontinalis hypnoides</i>			un							r	
<i>Funaria hygrometrica</i>	sp	sp					sp		r		
<i>Funaria polaris</i>										un	
<i>Grimmia anodon</i>				sp				r	un		
<i>G. longirostris</i>			sp	sp				sp		sp	
<i>G. teretinervis</i>		un						un			
<i>G. tergestina</i>			sp	sp				r			
<i>Gymnostomum aeruginosum</i>		r	sp	fr				fr	fr		
<i>Helodium blandowii</i>						r		un			
<i>Henediella heimii</i>						un					
<i>Homalia trichomanoides</i>								sp			
<i>Homomallium incurvatum</i>			un								
<i>Hygroamblystegium tenax</i>								r			
<i>Hygrohypnella ochracea</i>								sp			
<i>Hygrohypnum luridum</i>			un				un	sp	sp		un
<i>Hylocomium splendens</i>	sp	sp						fr	fr	fr	sp
<i>Hymenostylium recurvirostrum</i>		sp	sp					sp	sp		
<i>Hypnum cupressiforme</i>								fr		sp	
<i>Indusiella thianschanica</i>				r				r			
<i>Isopterygiopsis pulchella</i>	r	r						r			

	1	2	3	4	5	6	7	8	9	10	11
<i>Jaffuelobryum latifolium</i>			r	sp				r			
<i>Leptobryum pyriforme</i>	r					un	r	fr	sp		sp
<i>Leptodictyum riparium</i>			un				sp	r			
<i>Leskea polycarpa</i>							sp	fr		r	
<i>Leucodon sciuroides</i>								un			
<i>Microbryum davallianum</i>										un	
<i>Mnium blyttii</i>								r	sp	r	r
<i>M. lycopodioides</i>	un								r	un	
<i>M. marginatum</i>								sp			
<i>M. stellare</i>	r							r			
<i>M. thomsonii</i>		r	sp					sp	sp		r
<i>Molendoa sendtneriana</i>		r	sp					fr	sp		sp
<i>Myrinia pulvinata</i>								fr			
<i>M. rotundifolia</i>				sp						sp	
<i>Myurella acuminata</i>		un									
<i>M. julacea</i>	r	r	r					fr	r	sp	
<i>M. sibirica</i>		sp	sp					fr	sp	sp	
<i>M. tenerrima</i>	un							un			
<i>Myuroclada longiramea</i>								r	un		
<i>M. maximowiczii</i>		r	r	sp			sp	sp		r	
<i>Neckera besseri</i>		un						fr			
<i>N. oligocarpa</i>		r	r	sp				fr	sp	sp	
<i>Ochyraea alpestris</i>								un			
<i>Oncophorus elongatus</i>	r	r			r			sp			
<i>Orthothecium strictum</i>		sp	fr					r	sp	r	
<i>Orthotrichum anomalum</i>		sp	sp	sp				sp	sp	r	
<i>O. elegans</i>	r			r			r	fr	r		r
<i>O. obtusifolium</i>							r	sp	r		r
<i>O. pellucidum</i>									un		
<i>Oxyrrhynchium hians</i>								un			
<i>Pahudella squarrosa</i>		un									
<i>Philonotis falcata</i>											un
<i>P. tomentella</i>		un						un	r	un	
<i>Physcomitrella patens</i>							un				
<i>Plagiomnium acutum</i>								un			
<i>P. confertidens</i>								r	un		
<i>P. curvatulum</i>				un				sp	r	un	r
<i>P. cuspidatum</i>								r			r
<i>P. ellipticum</i>	r	r					sp	fr	r	sp	sp
<i>P. rostratum</i>			un				r	un			r
<i>Plagiopus oederianum</i>		un									
<i>Plagiothecium laetum</i>		un			r			r	r	un	
<i>Platydictya acuminata</i>		un									
<i>P. jungermannioides</i>	un			sp				un	fr		
<i>Platygyrium repens</i>								r			
<i>Pleurozium schreberi</i>	sp							fr	sp	sp	r
<i>Pohlia cruda</i>	r	r						fr	sp	r	
<i>P. lescuriana</i>							un				
<i>P. nutans</i>	r				r			fr	sp	sp	r
<i>P. wahlenbergii</i>							r	r	r	un	
<i>Polytrichum commune</i>										r	
<i>P. juniperinum</i>	r	sp						sp		sp	
<i>P. piliferum</i>	sp							fr		sp	
<i>P. strictum</i>	r		r		sp			fr		sp	
<i>Pseudoleskeella catenulata</i>		r		r				r		un	
<i>P. rupestris</i>			r					r	sp		
<i>P. tectorum</i>			r	sp				sp	r	r	
<i>Pterygoneurum kozlovii</i>					r						
<i>P. ovatum</i>		un			sp	r		un			
<i>P. subsessile</i>			r	sp	sp	r		r			
<i>Ptilium crista-castrensis</i>	r							fr	sp	sp	
<i>Pylaisia polyantha</i>	sp	sp	r	r	sp		sp	fr		r	
<i>P. selwynii</i>									un		

	1	2	3	4	5	6	7	8	9	10	11
<i>Rhytiadelphus triquetrus</i>		r	r					fr	sp		
<i>Rhytidium rugosum</i>	sp	r				r		fr	sp	sp	sp
<i>Sanionia uncinata</i>	sp	sp	r	r	fr			fr	sp	fr	sp
<i>Schistidium dupretii</i>										r	
<i>S. marginale</i>										un	un
<i>S. platyphyllum</i>			un						un		
<i>S. pulchrum</i>		un	sp	r					sp		
<i>S. scabripilum</i>										r	
<i>S. sordidum</i>			un								
<i>S. submuticum</i> subsp. <i>arcticum</i>			un	un					r	r	
<i>Scorpidium revolvens</i>								r			
<i>Seligeria brevifolia</i>									un		
<i>S. diversifolia</i>			r								
<i>S. donniana</i>			un								
<i>S. tristichoides</i>	un	un	sp					r	sp		
<i>Sphagnum angustifolium</i>		sp						sp		sp	
<i>S. balticum</i>								sp		sp	
<i>S. capillifolium</i>									sp		
<i>S. fimbriatum</i>		un						r		sp	
<i>S. fuscum</i>		r								r	
<i>S. girgensohnii</i>									fr	r	r
<i>S. magellanicum</i>									r	r	
<i>S. obtusum</i>										r	
<i>S. orientale</i>										r	
<i>S. russowii</i>		un						r		r	
<i>S. squarrosum</i>		r						sp		r	
<i>S. teres</i>								r		r	
<i>S. warnstorffii</i>								r			
<i>Splachnum luteum</i>	r	un									
<i>S. sphaericum</i>	un									r	
<i>S. sp.</i>								un			
<i>Stegonia latifolia</i>								un			
<i>Stereodon hamulosus</i>								un			
<i>S. holmenii</i>	r								r		
<i>S. plicatulus</i>	r				r						
<i>S. subimponens</i>		r	un							r	
<i>S. vaucheri</i>		sp	fr	fr				fr	fr	sp	r
<i>Straminergon stramineum</i>								sp		r	
<i>Syntrichia caninervis</i>			sp	fr							
<i>S. pagorum</i>								un			
<i>S. ruralis</i>	r	r	sp	r	r			fr	sp	r	r
<i>Tetraphis pellucida</i>								un		r	
<i>Tetraplodon mnioides</i>			un							r	
<i>Thuidium assimile</i>	r		r					fr	fr		r
<i>Timmia bavarica</i>		r	sp				sp	sp	sp		r
<i>T. comata</i>		sp	r				r	r	sp	un	r
<i>T. megapolitana</i>							r	fr	un		
<i>T. sibirica</i>								r			un
<i>Tomentypnum nitens</i>	sp	sp	r		sp			fr	sp	sp	sp
<i>Tortella fragilis</i>	r		un					r			
<i>T. tortuosa</i>	r							r			
<i>Tortula aestiva</i>				r				un			
<i>T. cernua</i>						sp				un	
<i>T. mucronifolia</i>	un			un				sp		un	un
<i>T. obtusifolia</i>			r	r				r	sp	un	
<i>Trachycystis ussuriensis</i>								un			
<i>Trichostomum crispulum</i>		un						sp	sp		r
<i>Warnstorfia exannulata</i>								sp			
<i>W. fluitans</i>		un									
<i>W. pseudostraminea</i>		un									
<i>Zygodon sibiricus</i>			r						r		r

EXCLUDED SPECIES

Amblystegium varium (Hedw.) Lindb., *Bardunovia baicalensis* Ignatov & Ochyra, *Brachytheciastrum velutinum* (Hedw.) Ignatov & Huttunen, *Brachythecium campestre* (Müll. Hal.) Schimp., *Bryhnia novae-angliae* (Sull. & Lesq.) Grout, *Campylidium hispidulum* (Brid.) Ochyra, *Cinclidium cf. latifolium* Lindb., *Dicranum fuscescens* Turner, *Drepanocladus sendtneri* (Schimp.) Warnst., *Entosthodon muhlenbergii* (Turn.) Fife (= *Funaria muhlenbergii* Turn.), *Grimmia funalis* (Schwägr.) Bruch & Schimp., *G. montana* Bruch & Schimp., *G. ovalis* (Hedw.) Lindb., *Hygrohypnella duriuscula* (De Not.) Ignatov & Ignatova, *Oncophorus wahlenbergii* Brid. (all available specimens were reidentified as *O. elongatus*), *Orthotrichum speciosum* Nees, *Philonotis fontana* (Hedw.) Brid., *Schistidium apocarpum* (Hedw.) Bruch & Schimp., *S. strictum* (Turner) Loeske ex Mårtensson.

DISCUSSION

In general, forest and meadow vegetation (Fig 2 E, G) are very poor in bryophytes, as *Larix* forests are usually too dry and meadows on islands and in flood valleys along oxbows have too dense grass-herbaceous vegetation. However, a number of habitat types are rich and interesting in bryophytes, comprising several phytogeographically noteworthy groups.

(1) **Southern elements** are concentrated in the Lenskie Stolby area (Fig. 3, C–I). They include species growing on more or less shaded calcareous cliffs (*Anomodon minor*, *Didymodon cordatus*, *Homomallium incurvatum*, *Homalia trichomanoides*, *Conardia compacta*), open cliffs (*Brachythecium buchananii*, *Fabronia ciliaris*, *Leucodon sciuroides*), tree trunks (*Entodon schleicheri*, *Platygyrium repens*, *Pylaisia selwynii*, *Zygodon sibiricus*), rotten logs (*Plagiomnium acutum*), soil (*Claopodium pellucinerve*, *Philonotis falcata*, *Myuroclada longiramea*, *M. maximowiczii*, *Oxyrrhynchium hians*, *Plagiomnium confertidens*, *Trachycystis ussuriensis*). Some species, e.g. *Brachythecium rivulare*, *Dicranum montanum* and *Tetraxis pellucida* might look odd in this group of southern species, as in, e.g., Norway and northern European Russia and even in the northern West Siberia they grow in much more northern areas. However, the permafrost zone is special in their almost total lacking and in this particular longitudinal sector their localities are the most northern.

Most of the above mentioned species occur in mountains of South Siberia (Altai, Sayans and southern Transbaikalia), Russian Far East and mountains of northern Mongolia. Their closest localities are at hundreds kilometers to the south from the Lenskie Stolby. High concentration of these southern elements in a limited area likely indicates a relic status of their populations here. Noteworthy is that 3/4 of them are dioicous, which is in contrast with mostly monoicous species penetrating to the north along Bureya River in the Russian Far East (Ignatov *et al.*, 2000). The latter fact was interpreted as

an indication of a recent expansion, whereas the case of Lenskie Stolby is different. We interpret it as a refugium, where a great variety of microhabitats provide a space for relic species: there are expanded labyrinths among cliffs that extend over 80 km along the N-facing slope of right bank of Lena River.

(2) **Northern species** of the study area are few and scattered, but most of them (marked by *) also occur in Lenskie Stolby area: *Bryum sibiricum**, *Cinclidium cf. minutifolium**, *Funaria polaris**, *Mnium blyttii**, *Fissidens arcticus*, *Schistidium sordidum*.

The most unexpected was the finding of *Myrinia rotundifolia*, endemic species of Yakutia and neighboring parts of Southern Taimyr. It was found in a relatively great quantity along a cliffy left bank of Lena River, which is unpassable at an average water level, and is rather regularly covered by flooding water (Fig. 2A–C).

(3) **Xeric elements** include *Entosthodon pulchellus*, *Grimmia anodon*, *G. teretinervis*, *G. tergestina*, *Indusiella thianschanica*, *Jaffueliobryum latifolium*, *Microbryum davallianum*, *Pterygoneurum ovatum*, *P. subsessile*, *Syntrichia caninervis*, and *S. pagorum*.

Some of them, e.g., *Indusiella* and *Jaffueliobryum*, were previously known from single collections in Lenskie Stolby, but their population on the left (south-exposed) bank of Lena River appeared to be bigger, especially of the latter species (Fig. 2F). Habitats of *Indusiella* are more difficult to explore (Fig. 2A), as it grows mostly on vertical cliffs, which bases are under water, not allowing their exploration from the river bar. However, on several reachable cliffs we collected it in a number of places.

Microbryum davallianum is a very rare species in Russia: it is known from few localities in the Caucasus, one finding in European Russia, and one collection from Anabar Plateau (Fedosov *et al.*, 2011). It was collected on fine soil in crack of xeric cliff along Buotama River, with *Entosthodon pulchellus* and *Tortula cernua*. The second closest known locality of this species is in Inner Mongolian Province of China (collections in MHA), although it can be overlooked by collectors due to a small size of plants.

The locality of *Didymodon cordatus* is the northernmost in Russia; this species sporadically occurs in xeric places in southern Siberia (Altai, Transbaikalia), Russian Far East and the Caucasus. Distribution of *Philonotis falcata* is similar. The latter species was earlier found in Yakutia in two localities in Tomponsky District.

(4) **Xeric-saline mosses** were collected in several boggy places. These are *Aloina rigida*, *Tortula cernua*, *Hennediella heimii*, *Pterygoneurum kozlovii*, *P. ovatum*, and *P. subsessile*. Especially interesting are findings of *P. kozlovii*, which we were able to find in several suitable places, although not in all inspected ones (Fig. 2H–I). *Aloina* and other *Pterygoneurum* species are always common in such habitats, while *Tortula cernua* and *Hennediella*

heimii were found one time each. *P. kozlovii* was previously found in Yakutia on steppe slopes along Indigirka River and near Yakutsk. It is likely that this xeric complex is rather well represented on boolginyakh; it is also noteworthy that *Tortula acaulon* var. *pilifera* (Schreb. ex Hedw.) R.H. Zander, one of the most common species on steppe slopes in Eastern Yakutia and also known on boolginyakh, has never been collected in Khangalassky District.

(5) *Eastern species*, e.g., those common in Yakutia and not penetrating much to the west include *Aulacomnium acuminatum*, *Brachythecium boreale*, *B. jacuticum* and *Dicranum bardunovii*. Three latter species were described only recently. All of them are not rare, at least in some places, although only *Dicranum bardunovii* is a really frequent in the area.

(6) *Western species*, contrary to the eastern ones, are all rare or very rare. *Physcomitrella patens* was found only in one place, on soil bank on island on Lena River: just one plant was collected, and we failed to find more during one hour of intentional search (Fig. 2D). The species is sporadic, but occasionally locally abundant in European Russia and West Siberia, but it was reported only once east of Yenisey River, on Aldan River, and also only one sporophyte was seen (Ignatov *et al.*, 2001). Yearly multiply floods in permafrost area are likely the reason why this species avoids it, while along big rivers of West Siberia it is locally abundant, because floods usually happen there only once per year.

Tortula aestiva was found in two places. Being ubiquitous in Europe, this species is already rare in West Siberia, and further to the East it is known from solitary localities in Anabar Plateau, on the island in Baikal Lake, and in Kamchatka. Similarly, *Ctenidium* is common in West Europe and the Caucasus and absent already in the Middle European Russia, while in Asia its localities are few and scattered; in the Lenskie Stolby area it was found only once in one canyon.

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