



# Mire vegetation in the lower Indigirka River basin (southern tundra subzone, Yakutia)

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## ABSTRACT

The vegetation of mires and its syntaxonomic diversity were studied in the Berylyokh River basin, a left tributary of the lower Indigirka River (southern tundra subzone, Allakhovskii District, Republic of Sakha (Yakutia), Russia), following the principles of the Braun-Blanquet approach. Based on 280 phytosociological relevés, a phytocoenotic characteristic of 10 associations, 10 subassociations, 12 variants and 2 community types was provided. These units were assigned to three alliances (*Caricion stantis* Matveyeva 1994, *Salici fusciscentis*–*Sphagnion squarrosi* **all. nov.** and *Scheuchzerion palustris* Nordhagen ex Tx. 1937) within the class *Scheuchzerio*–*Caricetea nigrae* Tx. 1937 and two alliances (*Sphagnion lenenses* Lapshina 2022 and *Rubo chamaemori*–*Dicranion elongati* Lavrinenko et al. 2015) within the class *Oxycocco*–*Sphagnetes* Br.-Bl. et Tx. ex Westhoff et al. 1946. Among them, nine associations (one provisionally) and eight subassociations are described as new. A new alliance, *Salici fusciscentis*–*Sphagnion squarrosi* **all. nov.**, is proposed to encompass sedge-*Sphagnum* and low willow-*Sphagnum* communities dominated by mesotrophic and mesooligotrophic species of *Sphagnum* in the complex mire systems of the Asian part of Russia. Ordination of the identified syntaxa using t-distributed stochastic neighbor embedding (t-SNE), supplemented by cluster analysis, was performed to assess the degree of similarity between the distinguished syntaxa.

**Keywords:** vegetation, flat-palsa and rim-polygonal mires, Braun-Blanquet approach, southern tundra subzone, Yana-Indigirka lowland, northeast of Yakutia

## РЕЗЮМЕ

Лапшина Е.Д., Филиппов И.В. Растительность болот в бассейне нижнего течения р. Индигирки (подзона южных тундр, Якутия). Изучена растительность болот и выявлено ее синтаксономическое разнообразие в бассейне р. Берелёх, левого притока р. Индигирка в ее нижнем течении (подзона южных тундр, Аллаховский р-он, Республика Саха (Якутия) в соответствии с принципами школы Браун-Бланке. На основе 280 геоботанических описаний дана фитоценотическая характеристика 10 ассоциаций, 10 субассоциаций, 12 вариантов и 2 типов сообществ, которые отнесены к 3 союзам (*Caricion stantis* Matveyeva 1994, *Salici fusciscentis*–*Sphagnion squarrosi* **all. nov.** и *Scheuchzerion palustris* Nordhagen ex Tx. 1937) класса *Scheuchzerio*–*Caricetea nigrae* Tx. 1937) и 2 союзам (*Sphagnion lenenses* Lapshina 2022 и *Rubo chamaemori*–*Dicranion elongati* Lavrinenko et al. 2015) класса *Oxycocco*–*Sphagnetes* Br.-Bl. et Tx. ex Westhoff et al. 1946. Из них 9 ассоциаций (одна предварительная) и 8 субассоциаций описаны как новые. Выделен новый союз *Salici fusciscentis*–*Sphagnion squarrosi*, объединяющий осоково-сфагновые и низко ивово-сфагновые сообщества с доминированием мезотрофных и мезоолиготрофных сфагновых мхов тундровых болот комплексного строения в азиатской части России. Проведена ординация выделенных синтаксонов методом t-SNE, дополненная кластерным анализом, для оценки степени сходства между отдельными синтаксонами.

**Ключевые слова:** растительность, бугристые и валиково-полигональные болота, классификация Браун-Бланке, подзона южных тундр, Яно-Индигирская низменность, северо-восток Якутии

The first data on the vegetation of the tundra zone in Yakutia in the lower Indigirka River basin were provided by Sheludyakova (1938) and Tyrtikov (1958). A general overview and brief description of mires near the settlements of Chokurdakh and Polyarny were later given by Boch (1975). More comprehensive information on the vegetation of the tundra zone in Yakutia, including mire ecosystems, is presented in the monograph by Perfil'yeva et al. (1991), where five classes and twelve groups of hydrophilic sedge and sedge-moss mire communities are described based upon dominant approach. Communities of relatively well-

drained palsa mires with dwarf birch-moss and tussock dwarf shrub-cottongrass-*Sphagnum* vegetation are considered as part of tundra vegetation. However, such general reviews and dominant classifications, lacking full published relevés, provide only limited information on the species composition and structure of plant communities, thus restricting their use in comparative phytocoenotic and biogeographical analyses.

Within the Braun-Blanquet ecological-floristic classification system, the vegetation of mires in the tundra zone was more or less comprehensively described for

northern European Russia (Lavrinenko & Lavrinenko 2015, Lavrinenko et al. 2016), Western Siberia (Telyatnikov et al. 2019b, 2021, Lapshina et al. 2021, 2022, 2023) and the Taymyr Peninsula (Matveyeva 1994, 1998, Zankha 2007, Lavrinenko et al. 2022). In contrast, information on the mire vegetation of the tundra zone in Yakutia remains extremely limited, with only few mire syntaxa mentioned in general descriptions of the region's tundra vegetation.

In the lower reaches of the Kolyma River, the association *Cardamino pratensis*–*Calthetum arcticae* Troeva et Telyatnikov (Telyatnikov et al. 2014) was described, along with two subassociations within previously known associations (*Sphagno*–*Eriophoretum vaginati* Walker et al. 1994 and *Meesio triquetris*–*Caricetum stantis* Matveyeva 1994) originally identified in Alaska and the Taymyr Peninsula, respectively. On rim-polygonal and tundra-mire complexes in the southern tundra subzone in the lower Indigirka River basin, the distinctive ass. *Carici rariflorae*–*Sphagnetum warnstorffii* was described, comprising transitional communities occurring at the contact zones between rims and hollows, occupying very limited areas (Telyatnikov et al. 2015). In the Kolyma River valley, sedge-dominated communities with *Carex aquatilis* subsp. *stantis* was recorded and assigned to the association *Caricetum stantis* Barrett et Krajina, 1972 (Telyatnikov et al. 2014).

The objective of the present study is to investigate the phytocoenotic diversity, to develop a vegetation classification of mires within the southern tundra subzone in northern Yakutia and to provide a description of the identified syntaxa.

## MATERIAL AND METHODS

### Study area

The study area is located in the northeastern part of Yakutia, within the southern tundra subzone, in the Yana-Indigirka Lowland. This lowland represents an extensive accumulative plain, 50–80 m above sea level, composed of loose Tertiary and Quaternary loess-like loams. The surface is dissected by shallow but wide river valleys with river terraces rising 6–10 m and numerous lake depressions. The major part of the surveyed area is occupied by rim-polygonal mires exhibiting a well-developed polygonal structure (Fig. 1A–C). These mires were formed on low river terraces and in the expansive basins of drained thermokarst lakes of various ages, known in Siberia as 'khasyrei' (local Yakutian name – 'alas'), shaping the overall landscape appearance. Outside the river valleys and at later stages of khasyrei development, flat-palsa and flat-palsa-hollow mires are widespread (Fig. 1D). These often form complex mire systems in combination with rim-polygonal mires.

Flat areas and lakeside depressions alternate with elevated landforms in the form of low ridges and hills, known as 'yedomas' (Popov, 1969). These support zonal *Dryas*-green moss and dwarf shrub-lichen-moss tundras (Fig. 1E) with abundant low shrubs (*Betula nana* subsp. *exilis*, *Salix glauca*) and hypoarctic dwarf shrubs (*Vaccinium vitis-idaea* subsp. *minus*, *V. uliginosum* subsp. *microphyllum*, *Ledum palustre* subsp. *decumbens*). Gentle slopes and poorly

drained flat hilltops are occupied by tussock cottongrass (*Eriophorum vaginatum*) tundras (Fig. 1F). The base of slopes and flat depressions develop cottongrass-*Sphagnum* bogs (*Sphagnum lenense*, *S. balticum*). Occasionally, isolated dome-shaped hills – 'bulgunnyakhs' or hydrolaccoliths – occur, up to 25–50 m in height and 100–300 m in width, towering above the surrounding waterlogged tundra.

The climate of the region is characterized by long, cold winter and short, cool summer. According to data from the Chokurdakh weather station (1939–2021), the mean annual temperature is  $-13^{\circ}\text{C}$  (Fig. 2). Winter begins in October and lasts until mid-May, with average January temperature of  $-34^{\circ}\text{C}$ . Snow cover is 30–35 cm in depth. Summers are overcast, with very short frost-free period of 45–51 days. Average July temperatures range from 8 to  $12^{\circ}\text{C}$ . Annual precipitation totals 150–250 mm, with 55–60 % during the winter months. Permafrost is continuous throughout the area (Yershov et al. 1989). The active layer thickness varies from 0.2 to 1.8 m.

### Sampling and data analysis

Fieldwork was conducted in the southern part of the Kytalyk National Park (Allaikhovskii District, Republic of Sakha (Yakutia)) within the Berelyokh River basin, a left tributary of the Indigirka River. The study focused on mire vegetation along the river valley and in adjacent interfluvial and elevated areas over stretch of approximately 200 km, from the upper to the lower ranger stations of the National Park, west of the settlement of Chokurdakh.

During the fieldwork from 8 to 21 July 2023 280 phytosociological relevés were performed across three key study sites: (I) Okean-Syane near the upper ranger station, (II) Omuk-Sane in the middle reaches of the river and (III) the Base Station in the lower reaches. Additional vegetation surveys were carried out along the segments between the main study sites (Fig. 3).

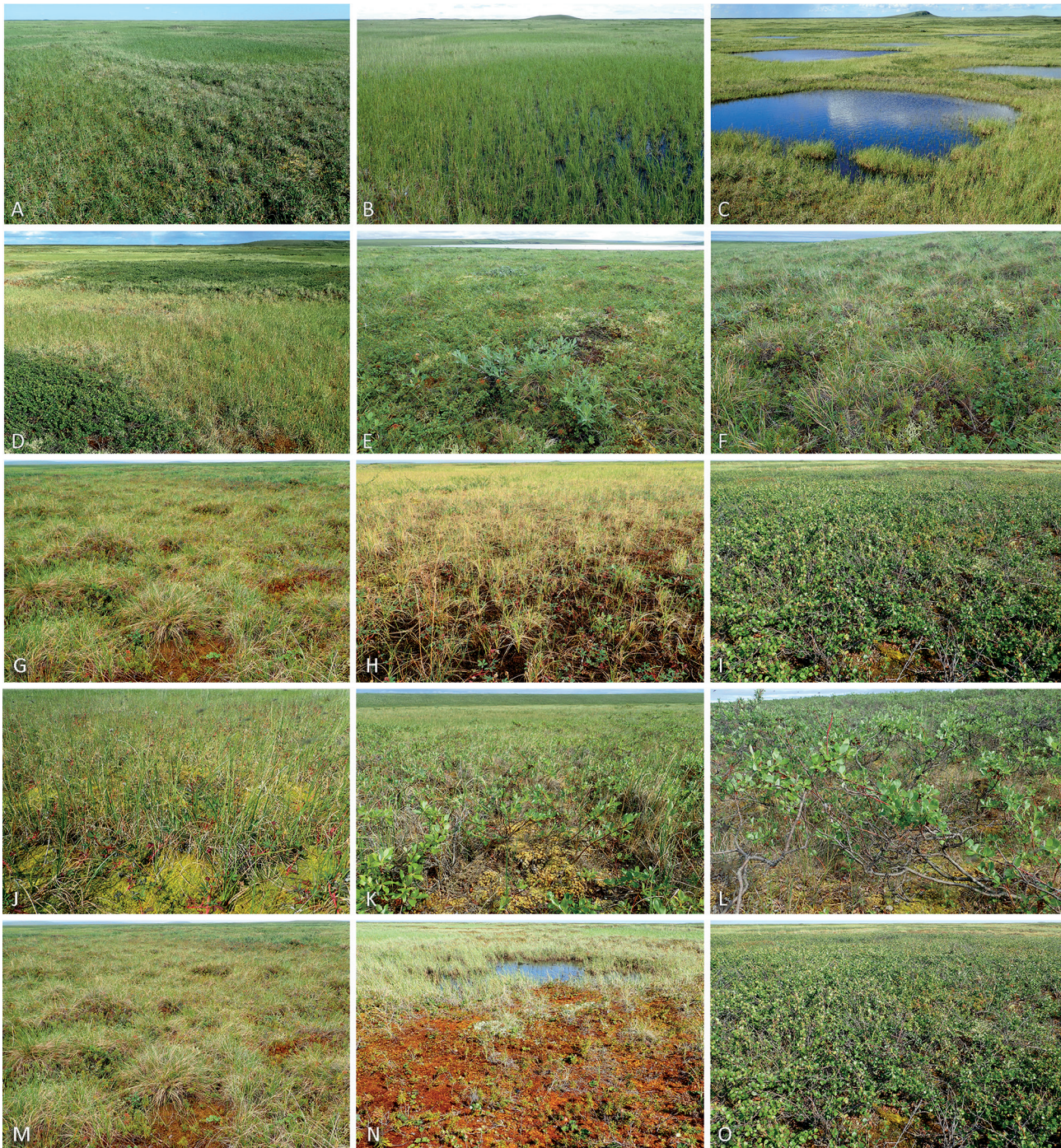
Vegetation surveys were conducted on  $5 \times 5$  m sample plots, recording all vascular plants, bryophytes and terricolous lichens wherever possible, along with estimates of their percentage cover. Data on the occurrence of rare moss species and the diversity, distribution and habitat specificity of liverworts were published previously (Konstantinova et al. 2024b, Lapshina et al. 2024).

An Integrated Botanical Information System, IBIS 7.2 (Zverev 2007), was used for preliminary sorting of relevés and developing the vegetation classification.

Species abundance in phytocoenotic tables is presented in percentage cover scores (Mirkin & Naumova 1998): r – solitary, + – less than 1 %, 1 – 1–5 %, 2a – 6–13 %, 2b – 14–25 %, 3 – 26–50 %, 4 – 51–75 %, 5 – 76–100 %. Species constancy in tables is given using following percentage scale (%): R – <10; I – 10–20 %; II – 20–40 %; III – 41–60 %; IV – 61–80 %; V – 81–100 %. Species with constancy classes V and IV were classified as highly constant.

The vegetation classification was carried out following the principles of the Braun-Blanquet approach (Westhoff & van der Maarel 1978).

The concept of diagnostic species was used for syntaxon delimitation, including selective species (occurring in some



**Figure 1** Main types of tundra stands and mire landscapes in the southern tundra subzone in the northeastern Yakutia: A – rim-polygonal mire complex with relative drained rims (on the front) and low-centered sedge-moss polygons; B – rim-polygonal mire with waterlogged sedge communities in polygons (ass. *Ranunculo pallasii*–*Caricetum stantis*); C – rim-lake polygonal mire; D – flat-palsa mire complex with frozen peat mound and sedge-*Sphagnum* moss hollows; E – zonal low shrub-lichen-moss tundra; F – tussock cottongrass-moss tundra; G–L: photos of described mire communities of the class *Scheuchzerio*–*Caricetea nigrae* in the southern tundra subzone in the northeastern Yakutia (G – *Hamatocauli vernicosi*–*Caricetum stantis* typicum; H – *Meesio triquetri*–*Caricetum chordorrhizae*; I – *Sphagno orientalis*–*Caricetum stantis*; J – *Sphagno obtusi*–*Caricetum stantis*; K – *Salici fuscrescentis*–*Sphagnetum squarrosi* typicum; L – *Salici fuscrescentis*–*Sphagnetum squarrosi sphagnetosum fimbriati*); M–O: photos of described mire communities of the class *Oxycocco*–*Sphagnetea* in the southern tundra subzone in the northeastern Yakutia (M – *Ledo decumbentis*–*Eriophoretum vaginati* typicum; N – *Ledo decumbentis*–*Eriophoretum vaginati sphagnetosum lenenses*; O – *Dicrano laevidentis*–*Betuletum exilis*)

syntaxa but with highest constancy in one) and preferential species (equally constant in some syntaxa but more abundant in one). Diagnostic species of associations and sub-associations represent differential species combinations, where these species are characteristic of the syntaxon if occur together, although individually, each species may not

be differentiating (diagnostic) (Matveyeva 2006, Lavrinenko & Lavrinenko 2015, Lavrinenko et al. 2016).

The names of syntaxa, the name of the taxon from the highest dominant layer was placed second (ICPN, Art. 10b). In cases where the vascular plant cover was low (25 % or less) – a common feature of most mire communities – the

second element of the name refers to the dominant species (edificator) of the moss layer, which determines the habitat conditions, structure and external appearance of the mire communities.

The nomenclature of the described syntaxa follows the International Code of Phytosociological Nomenclature (ICPN) (Theurillat et al. 2021).

For statistical analysis, the t-SNE method (t-Distributed Stochastic Neighbor Embedding) was used, which allows for the visual representation of high-dimensional feature spaces as compact clusters on a two-dimensional plane (van der Maaten & Hinton 2008). Hierarchical clustering was employed to determine the degree of similarity between identified phytocoenons and to visualize their structure as a dendrogram.

The nomenclature of the species follows generally Sekretareva (2004) for vascular plants, Hodgetts et al. (2020) for bryophytes and Santesson et al. (2004) for lichens.

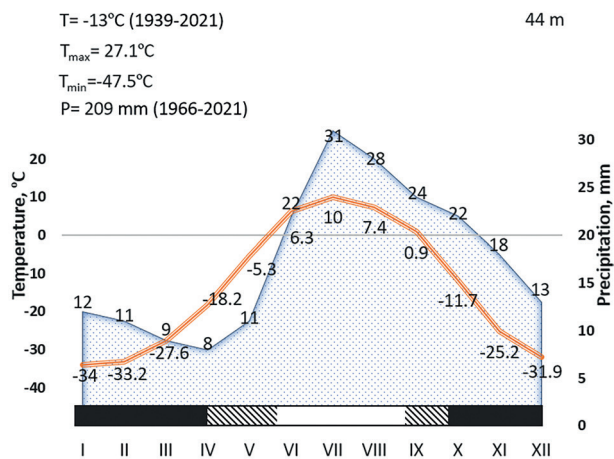


Figure 2 Climadiagram according to the Chokurdakh weather station (data archive meteo.ru: <http://aisori-m.meteo.ru/>)

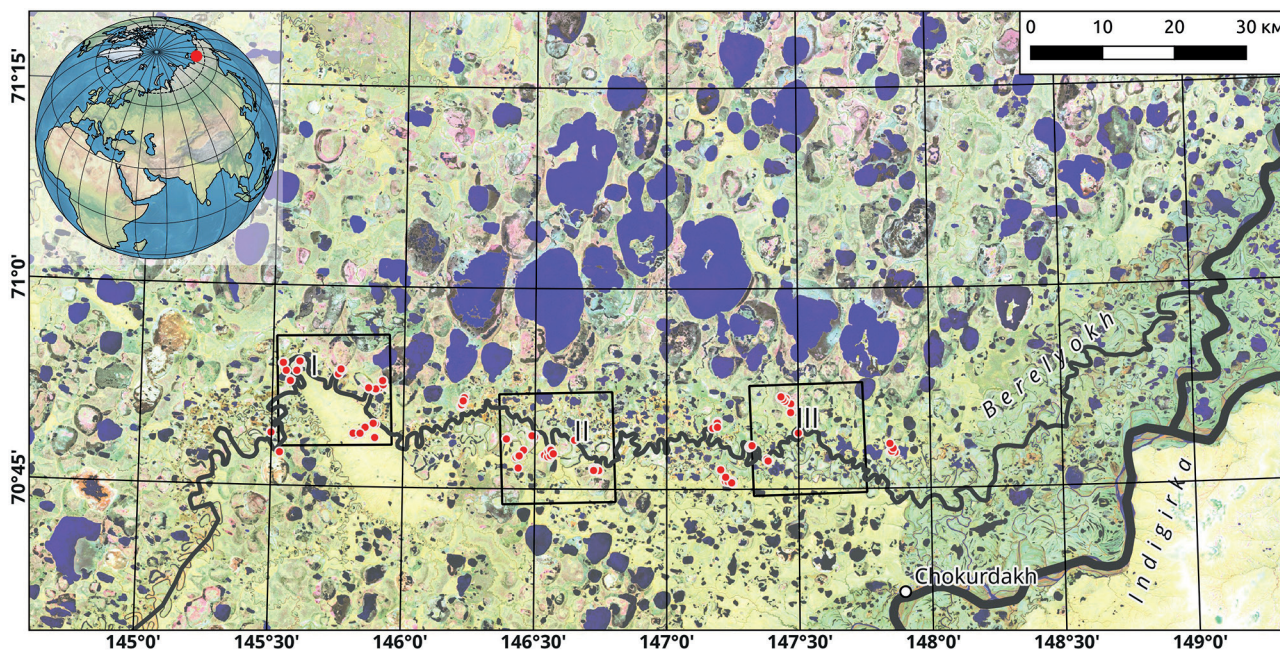


Figure 3 Key study areas: I – Okean-Syane near the upper ranger station, II – Omuk-Sane in the middle reaches of the river, III – the Base Station in the lower reaches area. Sites of relevés (red points)

## RESULTS

Mires in northeastern Yakutia, within the Yana-Indigirka Lowland, cover approximately 70 % of the area. The full diversity of mire habitat types and their associated plant communities in the study region can be classified into several groups according to the type of water-mineral supply and the degree of moisture.

### Moderate-rich minerotrophic fens

1. Herb-sedge-hypnum communities dominated by *Hamatocaulis vernicosus*, *Campyllum stellatum*, *Calliergon* spp.) on floodplain mires under conditions of more or less regular inundation by river waters.
2. Sedge (*Carex aquatilis* subsp. *stans*) and sedge (*Carex chondrorrhiza*, *C. aquatilis* subsp. *stans*)-hypnum moss communities dominated by *Scorpidium revolvens*, *Meesia triquetra*, *Cinclidium* spp. on waterlogged polygons of rim-polygonal mires and lakeside floating mats across the bottoms of numerous drained thermokarst lake basins (khasyreis) and low river terraces.

### Transitional mineral-poor minerotrophic mires

3. Sedge (*Carex aquatilis* subsp. *stans*)-*Sphagnum* communities (dominated by *Sphagnum orientale*) on waterlogged polygons of rim-polygonal mires along the bottoms of ancient khasyreis on second floodplain terraces.
4. Sedge (*Carex aquatilis* subsp. *stans*)-*Sphagnum* communities dominated by *Sphagnum obtusum* in waterlogged hollows of rim-polygonal and flat-palsa mires, occurring within the oldest drained thermokarst lake basins (khasyreis) and on high river terraces.
5. Low willow (*Salix pulchra*, *S. fuscescens*)-*Sphagnum* communities dominated by *Sphagnum squarrosum* on frozen ridges and better-drained sections of rim-polygonal mires within drained thermokarst lake basins (khasyreis) on flat river terraces.
6. *Sphagnum* (cf. *Sphagnum fimbriatum*)-willow (*Salix pulchra*) communities of hanging mires along temporary

streams in ravines on the slopes of high moraine ridges and uplands.

#### Raised (ombrotrophic) bogs with atmospheric water supply

7. Cottongrass (*Eriophorum vaginatum*)-*Sphagnum* (*Sphagnum lenense*, *S. balticum*) bogs on poorly drained concave slopes and at the bases of elevated landforms (yedomas).
8. Dwarf birch (*Betula nana* subsp. *exilis*)-green moss (*Polytrichum strictum*, *Dicranum* spp.) communities of frozen peat mounds in flat-palsa mires.

As a result of the tabular processing of mire vegetation relevés in the tundra zone in Yakutia, conducted according to the principles of the Braun-Blanquet approach, 10 associations with subassociations and variants were identified. The original relevés are presented in diagnostic tables (Tables 1–7) and summarized in synoptic table (Table 8).

To visualize the classification results, an ordination of all syntaxa was performed using t-distributed stochastic neighbor embedding (t-SNE), which effectively separates and displays clusters as groups of points in a two-dimensional space. Hierarchical clustering was additionally applied to assess the degree of similarity between syntaxa.

Descriptions of the identified syntaxa are provided below.

#### Vegetation of sedge-moss and willow-sedge-moss mires of the class Scheuchzerio-Caricetea nigrae

Sedge and sedge-hypnum moss communities of moderately rich minerotrophic mires

##### **Hamatocaulis vernicosi-Caricetum stantis** ass. nov. (Table 1, rel. 1–21; Table 8, syntaxa 1–2; Figs 1G, 4, 5, clusters 1.1, 1.2)

**Holotypus:** relevé 9 (author's number – 108E23kt) in Table 1, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 14.07.2023, author E.D. Lapshina.

The association encompasses sedge-forb-hypnum moss communities of floodplain mires subject to periodic inundation or flooding by river waters in valleys of the southern tundra subzone in Yakutia.

**Diagnostic species:** *Campylium stellatum*, *Cinclidium latifolium*, *Bryum pseudotriquetrum*, *Hamatocaulis vernicosus*, *Polemonium acutiflorum*, *Saxifraga cernua*, *S. hirculus*.

**Structure and composition.** The herb layer is dense (30–90 %, occasionally 15–25 %). The upper sublayer (up to 30 cm tall) is dominated by *Carex aquatilis* subsp. *stans*. Scattered plants of *Pedicularis sudetica*, *Polemonium acutiflorum* and *Rumex arcticus* are present. The lower sublayer (10–20 cm tall) consists of *Comarum palustre*, *Minuartia stricta*, *Saxifraga hirculus*, *S. cernua*, *S. foliolosa* and, more rarely, *Saxifraga hieracifolia*, *S. radiata* and *Valeriana capitata*. Low willows (*Salix reptans*, *S. fuscescens*, *S. pulchra*) are occasionally present in some communities. The moss layer is typically dominated by *Hamatocaulis vernicosus*, accompanied with high constancy by *Campylium stellatum*, *Cinclidium latifolium*, *Meesia triquetra*, *Pseudocalliergon brevifolium* and *Scorpidium revolvens*.

The number of species per sample plot is 26–38, in association 92, including 11 (12 %) highly constant.

**Distribution and ecology.** Communities of this association occur in floodplain and lakeshore mires that are regularly or episodically flooded by river and snowmelt waters. The water level ranges from 0 to 7(10) cm below the moss surface. The depth of seasonal frozen peat thawing is 25–30 cm.

Based on differences in species richness and habitat conditions, two subassociations were distinguished: typicum and calamagrostietosum neglecti.

##### **Hamatocaulis vernicosi-Caricetum stantis typicum** subass. nov. (Table 1, rel. 7–21; Table 8, syntaxon 2; Figs 1G, 4, 5, cluster 1.2)

**Holotypus:** relevé 9 (author's number – 108E23kt) in Table 1, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 14.07.2023, author E.D. Lapshina.

**Diagnostic species:** *Bistorta vivipara*, *Calliergon richardsonii*, *Carex marina*, *Minuartia stricta*, *Pedicularis scpectrum-carolinum*, *Salix reptans*.

**Structure and composition.** The well-developed herb-shrub layer (20–30 cm tall) is dominated by *Carex aquatilis* subsp. *stans* along with characteristic set of herbaceous species. Low shrubs (*Salix reptans*, with occasional presence of *S. fuscescens* and rarely *S. pulchra*) contribute noticeably, with cover ranging from 5–25 %, occasionally up to 40 %.

The continuous moss layer is dominated by *Hamatocaulis vernicosus*, accompanied with high constancy of *Cinclidium latifolium*, *Meesia triquetra*, *Pseudocalliergon brevifolium*, *Scorpidium revolvens* and *Calliergon richardsonii*.

Species richness in communities is comparable to that of the overall association. In total, 81 species were recorded within the subassociation, including 13 (16 %) highly constant.

**Distribution and ecology.** This subassociation occupies the central parts of floodplain mires with weakly expressed polygonal structure. The sites are subject to periodic water-logging but are not inundated during spring floods. The communities occur in water-saturated centers of polygons of 10–15 m in diameter. The surface is slightly undulating, formed by soft carpet of hypnoid mosses (5–10 cm high) interspersed with standing water. The depth of seasonal frozen peat thawing is 25–30 cm.

##### **Hamatocaulis vernicosi-Caricetum stantis calamagrostietosum neglecti** subass. nov. (Table 1, rel. 1–6; Table 8, syntaxon 1; Figs 4, 5, cluster 1.1)

**Holotypus:** relevé 2 (author's number – 092E23kt) in Table 1, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 14.07.2023, author E.D. Lapshina.

**Diagnostic species:** *Aulacomnium palustre*, *Brachythecium boreale*, *B. mildeanum*, *Calamagrostis neglecta*, *Calliergon cordifolium*, *C. giganteum* subsp. *sibiricum*, *Chryso-splenium sibiricum*, *Drepanocladus polygamus*, *Peltigera leucophlebia*, *Plagiomnium curvatum*, *Stellaria ciliatosepala*, *Warnstorfia pseudostraminea*.

**Structure and composition.** The dense herbaceous layer (50–90 % cover) is dominated by *Carex aquatilis* subsp. *stans* (up to 30 cm), with a notable presence of *Calamagrostis neglecta* (up to 20 %). *Comarum palustre* (10–20 %) dominates the lower herb layer, accompanied with high constancy by *Chryso-splenium sibiricum*, *Epilobium palustre* and *Stellaria ciliatosepala*. Shrub willows are absent. The moss layer is well developed (70–90 %), dominated by *Hamatocaulis vernicosus* and consistently accompanied by flood-tolerant species such as *Aulacomnium palustre*, *Brachythecium mildeanum*, *Calliergon cordifolium*, *C. giganteum* subsp. *sibiricum*, *Drepanocladus polygamus* and *Warnstorfia pseudostraminea*.

The number of species per sample plot is 27–32 (mean 30), in subassociation 57, including 24 (42 %) highly constant.

**Distribution and ecology.** Communities occur near rivers and flood channels in river valleys. The vegetation cover is homogeneous. The depth of seasonal frozen peat thawing is 30 cm.



Table 1. Continued.

Relevé nr. in the table	1	2*	3	4	5	6	7	8	9*	10	12	11	13	14	15	16	17	18	19	20	21	22	23	24	25	26*	27	28	1a	1b	1	3	
<i>Petasites frigidus</i>	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	I	.
<i>Drepanocladus aduncus</i>	+	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	I	.	
<i>Mesoptychia sablbergii</i>	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	R	R	.	
<i>Poa arctica</i>	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	.	.	.	
<i>Polytrichastrum longisetum</i>	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	R	.	.	
<i>Aulacomnium turgidum</i>	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	R	R	.	.	
<i>Juncus triglumis</i>	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I	R	R	.	
<i>Sphagnum squarrosum</i>	.	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	R	R	.	
<i>Marchantia polymorpha</i> subsp. <i>ruderalis</i>	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I	R	R	.	
<i>Sphagnum orientale</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	R	R	R	I	
<i>Utricularia vulgaris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	R	R	R	I	
<i>Luzula wahlenbergii</i>	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	R	R	.	
<i>Sanionia uncinata</i>	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	R	R	.	
<i>Pseudocalliergon trifarium</i>	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I	R	R	.	
<i>Cephalozella uncinata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	II	
<i>Cephalozella</i> sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	II	

**Note.** Species found in one relevé with abundance (indicated in brackets): *Arctous alpina* (10 r), *Breidleria pratensis* (8 +), *Cephalozia bicuspida* (24 r), *Cinclidium minutifolium* (14 +), *Equisetum arvense* (1 +), *Eriophorum medium* (9 1), *Gastrolychnis apetala* (18 +), *Gymnocolea borealis* (21 r), *Helodium blandowii* (8 +), *Myurella tenerima* (20 r), *Plagiomnium ellipticum* (13 1), *Plagiothecium berggrenianum* (5 +), *Poa alpigena* (13 r), *Pohlia nutans* (4 r), *Polytrichum jensenii* (27 +), *Pyrola rotundifolia* (7 +), *Rubus arcticus* (12 +), *Scapania irrigua* (24 +), *S. paludicola* (8 +), *Schljakovia kuzneana* (8 +), *Scorpidium scorpioides* (25 +), *Sphagnum obtusum* (22 2a), *S. talbotianum* (8 +), *Stellaria crassifolia* (2 +), *Utricularia intermedia* (27 +), *Sarmentypnum exannulatum* (22 +), *S. sarmentosum* (21 +).

**Dates and localities:** 1 – 14.07.2023, 70.79998, 146.55988; 2 – 14.07.2023, 70.79998, 146.55988; 3 – 14.07.2023, 70.79978, 146.55966; 4 – 14.07.2023, 70.79958, 146.55977; 5 – 14.07.2023, 70.79898, 146.55891; 6 – 14.07.2023, 70.79947, 146.55855; 7 – 14.07.2023, 70.79868, 146.56059; 8 – 19.07.2023, 70.75969, 147.23039; 9 – 14.07.2023, 70.79741, 146.55049; 10 – 19.07.2023, 70.75829, 147.24536; 11 – 14.07.2023, 70.79185, 146.55905; 12 – 19.07.2023, 70.75998, 147.24863; 13 – 14.07.2023, 70.79417, 146.56980; 14 – 19.07.2023, 70.76038, 147.24753; 15 – 14.07.2023, 70.79868, 146.56059; 16 – 14.07.2023, 70.79859, 146.55757; 17 – 14.07.2023, 70.79775, 146.55896; 18 – 14.07.2023, 70.79527, 146.56061; 19 – 14.07.2023, 70.79859, 146.55757; 20 – 14.07.2023, 70.79453, 146.56126; 21 – 19.07.2023, 70.75962, 147.23175; 22 – 10.07.2023, 70.90272, 145.53704; 23 – 17.07.2023, 70.83445, 147.19319; 24 – 12.07.2023, 70.87865, 145.92097; 25 – 17.07.2023, 70.83322, 147.19167; 26 – 09.07.2023, 70.89476, 145.59377; 27 – 13.07.2023, 70.86236, 146.22891; 28 – 12.07.2023, 70.88288, 145.91726.

**Authors:** E.D. Lapshina – rel. 1, 2, 4, 5, 9, 10, 14, 16–21; I.V. Filippov – rel. 3, 6–8, 11–13, 15, 22–28. Here and in Tables 2, 4, 5, 7 nomenclature types (holotypus) are indicated by a gray fill and an asterisk.

**Note.** Physiognomically, the communities resemble the ass. Carici stantis–Salicetum reptantis Zanolka 2003 described on Taymyr (Zanolka 2003) and later reported from the East European tundra (Lavrinenko et al. 2016). However, among the diagnostic species of this association, only *Bryum pseudotriquetrum* and *Saxifraga hirculus* are present in the Yakutian communities. Of the 24 constant species reported for Carici stantis–Salicetum reptantis, only six were recorded in at least one of the two sub-associations newly described in Yakutia. The shared species mainly belong to the Caricion stantis alliance and the class Scheuchzerio–Caricetea nigrae, which are widespread in tundra mires.

**Ranunculo pallasi–Carietum stantis ass. nov.** (Table 1, rel. 23–28; Table 8, syntaxon 7; Figs 1B, 4, 5, cluster 4)

**Holotypus:** relevé 26 (author's number – 006F23kt) in Table 1, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 09.07.2023, author I.V. Filippov.

The association encompasses species-poor, waterlogged *Carex aquatilis* subsp. *stans* communities in deep hollows of flat-palsa mires and low-centered polygons of rim-polygonal mires, less frequently in peat floodplain mires in the tundra zone in Asian Russia.

**Diagnostic species:** *Carex aquatilis* subsp. *stans* (dom.), *Eriophorum russeolum*, *Hamatocaulis lapponicus*, *Ranunculus pallasi*.

**Structure and composition.** The herb layer (30–40 cm) is dominated by *Carex aquatilis* subsp. *stans*, with variable cover (20–80 %). Lower sublayer (around 20 cm) is formed by *Carex chordorrhiza* and *Comarum palustre*, with *Eriophorum russeolum* low abundance but high constancy and less frequent *Ranunculus pallasi*. The moss layer is poorly developed (1–10 %, rarely up to 20 %) or absent. When present, it is composed of *Bryum neodamense*, *Cinclidium subrotundum*, *Hamatocaulis lapponicus*, *Meesia triquetra* and *Scorpidium revolvens*.

The number of species per sample plot is 6–17 (mean 11), in association 29, including 6 (21 %) highly constant.

**Distribution and ecology.** This association is widespread across the tundra zone in the Asian part of Russia. In Yakutia, it occupies deep hollows in palsa bogs and the centers of waterlogged concave polygons in polygonal mires. The nanorelief is either absent or formed by loose *Carex* tussocks up to 15 cm high. The water level is above the surface. The depth of seasonal frozen peat thawing is about 80 cm.

#### Community type *Eriophorum angustifolium*

(Table 1, rel. 22)

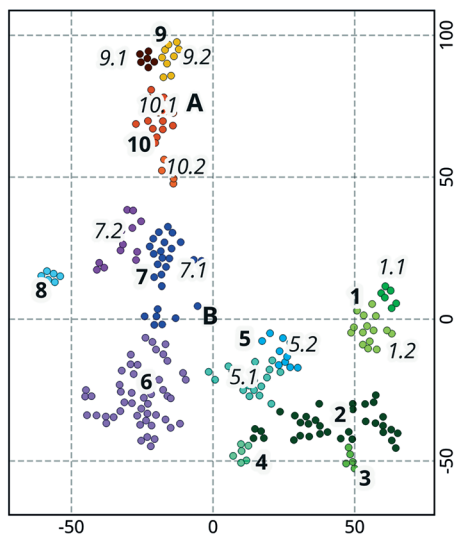
The community is low in species (typically about 5 species), moderately dense (10–40 %) layer of *Eriophorum angustifolium* (30–40 cm) and poorly developed or often absent moss layer. Only one relevé was done, although within the study area visually it occurs sporadically in deep thermokarst depressions and in the centers of low-centered polygons within rim-polygonal and flat-palsa-hollow mire complexes, where it occupies small areas.

#### **Ranunculi pallasi–Caricetum chordorrhizae ass. prov.** (Table 2, rel. 1–5; Table 8, syntaxon 6; Figs 4, 5, cluster 3)

The association encompasses sedge-hypnum moss communities of long-flooded (waterlogged) hollows in peat mound-hollow mire complex, with poor species set and dominance of *Meesia triquetra* in the moss layer.

**Diagnostic species:** *Aneura pinguis*, *Meesia triquetra* (dom.), *Scapania paludicola*, *Saxifraga cernua*, *S. foliolosa*, *Ranunculus pallasi*.

**Structure and composition.** The herb layer (30–70 %) is co-dominated by two sedge species – *Carex aquatilis* subsp. *stans* (20–30 cm) and *C. chordorrhiza* (15 cm) in varying proportions, with *Epilobium palustre*, *Saxifraga cernua*, *S. foliolosa* and *Ranunculus pallasi* with low abundance but high constancy. Shrubs are absent. The moss layer is dominated by *Meesia triquetra* (50–70 %) with constant minor presence of



**Figure 4** Ordination of the described syntaxa performed in the relative axes by non-linear mapping of the multidimensional feature space onto the 2D-plane by the t-SNE method. A – class Scheuchzerio–Caricetum nigrae. 1 – Hamatocauli vernicosi–Caricetum stantis: 1.1 – subass. calamagrostietosum neglecti, 1.2 – subass. typicum; 2 – Meesio triquetri–Caricetum chordorrhizae; 3 – Ranunculo pallasi–Caricetum stantis; 4 – Ranunculo pallasi–Caricetum stantis; 5 – Sphagno orientalis–Caricetum stantis: subass. typicum, 5.2 – subass. meesietosum triquetrae; 6 – Sphagno obtusi–Caricetum stantis; 7 – Salici fusciscentis–Sphagnetum squarrosum: 7.1 – subass. typicum, 7.2 – subass. sphagnetosum fimbriati; 8 – Sphagno fimbriati–Salicetum pulchrae; B – class Oxycooco–Sphagnetea. 9 – Ledo decumbentis–Eriophoretum vaginati: 9.1 – subass. sphagnetosum lenenses, 9.2 – subass. typicum; 10 – Dicrano laevidentis–Betuletum exilis: 10.1 – subass. ledetosum decumbentis, 10.2 – subass. typicum

*Aneura pinguis*, *Bryum neodamense*, *Cinclidium subrotundum* and *Scapania paludicola*. Notably absent are many moss species character of the alliance Caricion stantis.

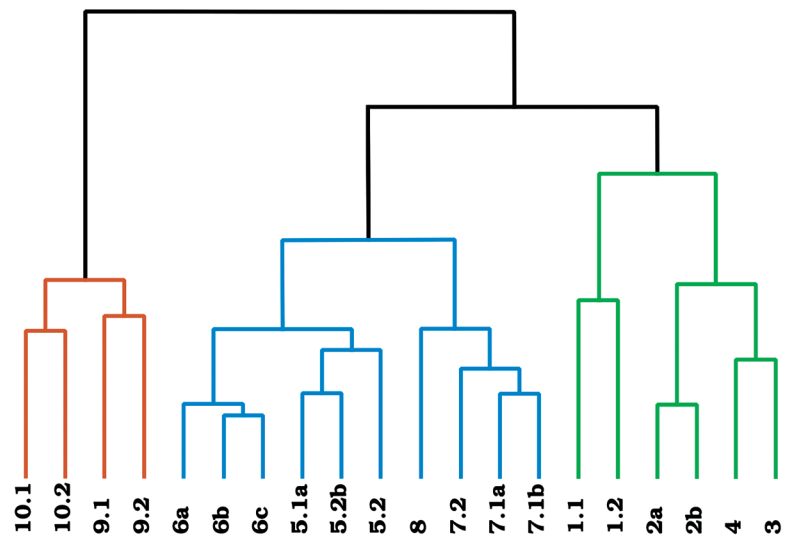
The number of species per sample plot is 11–17 (mean 15), in association 25, including 11 (44 %) highly constant.

**Distribution and ecology.** The communities were described in flat depressions between frozen peat mounds within flat-palsa-hollow mire occupying extensive drained thermokarst lake basins (khasyreis). The flat hollows experience regular, prolonged flooding from adjacent lake.

**Note.** These communities are formed under habitat conditions that is reflected in structural and floristic differences from all other sedge-hypnum moss communities in the study area. However, being found in the only one mire complex, they are established as new association provisionally.

**Meesio triquetri–Caricetum chordorrhizae** ass. nov. (Table 2, rel. 6–39; Table 8, syntaxa 3–5; Figs 1H, 4, 5, clusters 2a, 2b)

The association encompasses sedge-hypnum moss communities of waterlogged polygons in rim-polygonal mires and lakeside floating mats across the bottoms of drained thermokarst lake basins (khasyreis) in the southern tundra subzone in Yakutia.



**Figure 5** The similarity of syntaxa of the in the southern tundra subzone in the northeastern Yakutia, established by the Completelinkage clustering (Squared Euclidean distances). Syntaxa: 1.1 – Hamatocauli vernicosi–Caricetum stantis calamagrostietosum neglecti, 1.2 – Hamatocauli vernicosi–Caricetum stantis typicum; 2a – Meesio triquetri–Caricetum chordorrhizae var. *Sphagnum orientale*; 2b – Meesio triquetri–Caricetum chordorrhizae var. *Sphagnum orientale*; 3 – Ranunculo pallasi–Caricetum stantis; 4 – Ranunculo pallasi–Caricetum stantis; 5.1a – Sphagno orientalis–Caricetum stantis typicum var. *typica*, 5.1b – Sphagno orientalis–Caricetum stantis typicum var. *Sphagnum obtusum*, 5.2 – Sphagno orientalis–Caricetum stantis meesietosum triquetrae; 6a – Sphagno obtusi–Caricetum stantis var. *typica*, 6b – Sphagno obtusi–Caricetum stantis var. *Comarum palustre*, 6c – Sphagno obtusi–Caricetum stantis var. *Sphagnum squarrosum*; 7.1 – Salici fusciscentis–Sphagnetum squarrosum typicum 7.1a – Salici fusciscentis–Sphagnetum squarrosum typicum var. *Sphagnum obtusum*, 7.1b – Salici fusciscentis–Sphagnetum squarrosum typicum var. *typica*; 7.2 – Salici fusciscentis–Sphagnetum squarrosum sphagnetosum fimbriati; 8 – Sphagno fimbriati–Salicetum pulchrae; 9.1 – Ledo decumbentis–Eriophoretum vaginati sphagnetosum lenenses, 9.2 – Ledo decumbentis–Eriophoretum vaginati typicum; 10.1 – Dicrano laevidntis–Betuletum exilis ledetosum decumbentis, 10.2 – Dicrano laevidntis–Betuletum exilis typicum

**Holotypus:** relevé 16 (author's number – 091E23kt) in Table 1, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 13.07.2023, author E.D. Lapshina.

**Diagnostic species:** *Aneura pinguis*, *Carex chordorrhiza*, *Meesia triquetra*, *Pseudocalliergon brevifolium*, *Salix fusciscentis*, *Scorpidium revolvens* (dom.), *S. scorpioides*, *Sphagnum orientale*.

**Structure and composition.** The total cover of herb layer varies widely (5–90 %). The sparse upper sublayer (30 cm) is formed by *Carex aquatilis* subsp. *stans*, *Eriophorum angustifolium*, *E. russeolum*, *Pedicularis sudetica*, *Rumex arcticus*, *Saxifraga foliolosa*, with *S. radiata* in low abundance. The denser lower (15–20 cm) sublayer is formed by *Carex chordorrhiza* and *Comarum palustre*. Low *Salix fusciscentis* shrubs (15–20 cm) frequently form noticeable admixture (3–30 %). The moss layer (30–100 %) is dominated by *Scorpidium revolvens* and *Meesia triquetra*, with constant admixtures of *Pseudocalliergon brevifolium*, *Cinclidium subrotundum*, *Sphagnum orientale* and liverworts *Aneura pinguis* and *Mesoptichia rutheana*. Reduced moss cover is associated with high water level and the presence of open water on the surface.

The number of species per sample plot in 11–28 (mean 19), in association 75, including 8 (11 %) highly constant.

**Distribution and ecology.** The communities are widespread in the southern tundra subzone in Yakutia, where



**Table 2.** Continued.

*uncinata* (25 +), *Chiloscyphus pallescens* (27 +), *Drepanocladus polygamus* (19 +), *Eriophorum medium* (28 +), *Gastrolychnis apetala* (37 r), *Hamatocaulis lapponicus* (36 +), *Luzula nivalis* (21 +), *Oncophorus integerrimus* (23 +), *O. wahlenbergii* (37 +, 39 +), *Poblia bulbifera* (38 r), *P. nutans* (12 r), *Pseudocalliergon trifarium* (37 +), *Salix phylicifolia* (23 1), *Scapania degenii* (32 +), *Schljakovia kuzneana* (24 +), *Sphagnum obtusum* (17 +), *Utricularia minor* (24 +), *U. vulgaris* (37 r).

**Dates and localities:** 1 – 12.07.2023, 70.88258, 145.91960; 2 – 12.07.2023, 70.88258, 145.91960; 3 – 12.07.2023, 70.88258, 145.91960; 4 – 12.07.2023, 70.88277, 145.91820; 5 – 12.07.2023, 70.88288, 145.91726; 6 – 13.07.2023, 70.85175, 146.21793; 7 – 15.07.2023, 70.79127, 146.44047; 8 – 13.07.2023, 70.85202, 146.21921; 9 – 13.07.2023, 70.85305, 146.21829; 10 – 13.07.2023, 70.85767, 146.22670; 11 – 13.07.2023, 70.86306, 146.23012; 12 – 13.07.2023, 70.85202, 146.21921; 13 – 16.07.2023, 70.77528, 146.72394; 14 – 21.07.2023, 70.79603, 147.85303; 15 – 13.07.2023, 70.85175, 146.21793; 16 – 13.07.2023, 70.85909, 146.22586; 17 – 16.07.2023, 70.77365, 146.72286; 18 – 13.07.2023, 70.85409, 146.22050; 19 – 13.07.2023, 70.85473, 146.22247; 20 – 18.07.2023, 70.80443, 147.32313; 21 – 12.07.2023, 70.87760, 145.92038; 22 – 16.07.2023, 70.77303, 146.72231; 23 – 21.07.2023, 70.79613, 147.85092; 24 – 16.07.2023, 70.77528, 146.72394; 25 – 18.07.2023, 70.86210, 147.44966; 26 – 18.07.2023, 70.85970, 147.44914; 27 – 17.07.2023, 70.83246, 147.19301; 28 – 16.07.2023, 70.77596, 146.72403; 29 – 13.07.2023, 70.85761, 146.22646; 30 – 16.07.2023, 70.77596, 146.72403; 31 – 17.07.2023, 70.83291, 147.19183; 32 – 18.07.2023, 70.85951, 147.44875; 33 – 13.07.2023, 70.85928, 146.22827; 34 – 18.07.2023, 70.84542, 147.47054; 35 – 18.07.2023, 70.86294, 147.45332; 36 – 15.07.2023, 70.79127, 146.44047; 37 – 19.07.2023, 70.75829, 147.24536; 38 – 09.07.2023, 70.89417, 145.59306; 39 – 21.07.2023, 70.79620, 147.85213;

**Authors:** E.D. Lapshina – rel. 1–4, 6, 9–11, 15, 16, 18, 21–23, 25–28, 30, 31, 37–39; I.V. Filippov – rel. 5, 7, 8, 12–14, 17, 19, 20, 24, 29, 32–36.

they occur in waterlogged polygons of rim-polygonal mires, hollows of flat-palsa-hollow mire complexes and lakeside floating mats across numerous drained thermokarst lake basins (khasyreis). The surface is flat or slightly undulating, formed by continuous carpet of hypnoid mosses with frequent of open water. The depth of seasonal frozen peat thawing is 30–40 cm.

Based on the species set of the moss layer within the association three variants were distinguished: *typica*, *Sphagnum orientale* and *Scorpidium scorpioides*. The variant *typica* (Table 2, relevés 6–26) corresponds to the diagnostic characteristics of the subassociation.

The variant *Sphagnum orientale* (Table 2, rel. 27–35) differs by the notable *Sphagnum orientale* presence, with its cover 5–25 %.

The variant *Scorpidium scorpioides* (Table 2, relevés 36–39) is characterized by the high presence and high abundance (30–50 %) of *Scorpidium scorpioides*.

**Note.** Species-poor composition, together with the high presence of *Carex chordorrhiza* in the herb layer and *Scorpidium scorpioides* in the moss one, shows affinity with communities of the ass. *Scorpidio scorpioidis*–*Caricetum chordorrhizae* Osvald ex Lapshina 2021 (Lapshina et al. 2021). However, the limited number of relevés and the transitional nature of these communities, are the reasons to classify them as variant within wider distributed association.

### **Sedge-Sphagnum and low willow-Sphagnum communities of mineral-poor minerotrophic mires**

**Sphagno orientalis–Caricetum stantis** ass. nov. (Table 3, rel. 1–27; Table 8, syntaxa 8–10; Figs 11, 4, 5, clusters 5.1a, 5.1b, 5.2)

The association encompasses sedge-*Sphagnum* and sedge-hypnum-*Sphagnum* communities in waterlogged polygons in rim-polygonal mires, dominated by *Sphagnum orientale*, across old drained thermokarst lake basins (khasyreis) outside of river floodplains in the southern tundra subzone in Yakutia.

**Holotypus:** relevé 6 (author's number – 151E23kt) in Table 3, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 18.07.2023, author E.D. Lapshina.

**Diagnostic species:** *Carex chordorrhiza*, *Eriophorum russeolum*, *Salix fuscescens*, *Sphagnum orientale* (dom.).

**Structure and composition.** The total cover of the herb layer varies from 20 to 80 %, while shrub cover ranges from 1 to 25 % or may be absent. The upper layer (30 cm) is dominated by *Carex aquatilis* subsp. *stans* (5–70 %), with minor presence of tall herbs such as *Pedicularis sudetica* and

*Rumex arcticus*. The second layer (15–20 cm) is composed of *Carex chordorrhiza*, *Comarum palustre* and *Eriophorum russeolum*. More or less distinct lower layer, when present, is formed by short (5 cm) shoots of *Salix fuscescens* (0.5–25 %). The continuous moss layer is dominated by *Sphagnum orientale* (50–100 %), with *S. obtusum* and *Mesia triquetra* in some communities.

The number of species per sample plot is 5–24 (mean 13), in association 65, including 7 (11 %) highly constant.

**Distribution and ecology.** The communities are widely distributed across waterlogged low-centered polygons in rim-polygonal mires in the southern tundra subzone in Yakutia. The surface is undulating or covered with small hummocks (up to 5 cm high), formed by mosses at the base of sedge stems. The water level is 1–4 cm below the moss surface. Peat depth is 30–40 cm. The depth of seasonal frozen layer thawing is the same.

Two subassociations are distinguished within this association.

**Sphagno orientalis–Caricetum stantis typicum** subass. nov. (Table 3, rel. 1–17; Table 8, syntaxa 8–9; Figs 11, 4, 5, clusters 5.1a, 5.1b)

**Holotypus:** relevé 6 (author's number – 151E23kt) in Table 3, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 18.07.2023, author E.D. Lapshina.

**Diagnostic species:** same as in the association.

**Structure and composition.** The herb-shrub layer is similar to that of the association. The continuous carpet of moss layer forms *Sphagnum orientale*, with variable participation of *S. obtusum* (up to 30 %, commonly not more than 5 %).

The number of species per sample plot in 6–17 (mean 10), in subassociation 42, including 7 (19 %) highly constant.

**Distribution and ecology.** Same as the association.

Within the subassociation 2 variants were identified: *typica* and *Sphagnum obtusum*.

The variant *typica* (Table 3, rel. 1–8) represents the typical communities of the subassociation.

The variant *Sphagnum obtusum* (Table 3, rel. 9–17) is characterized by the high constancy and high (20–40 %) presence of *Sphagnum obtusum* in moss layer.

**Sphagno orientalis–Caricetum stantis meesietosum triquetrae** subass. nov. (Table 3, rel. 18–27; Table 8, syntaxon 10; Figs 4, 5, clusters 5.2)

**Holotypus:** relevé 23 (author's number – 162E23kt) in Table 3, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 18.07.2023, author E.D. Lapshina.

**Table 3.** Sedge-*Sphagnum* (*S. orientale*) polygon communities in rim-polygonal mires. 1–27 – ass. *Sphagno orientalis*–*Caricetum stantis*: 1–17 – subass. *typicum*: 1–8 – var. *typica* (1a), 9–17 – var. *Sphagnum obtusum* (1b); 18–27 – subass. *meesietosum triquetrae* (2).

Association	<i>Sphagno orientalis</i> – <i>Caricetum stantis</i> (1)																											Constancy				
Subassociation	<i>typicum</i>																	<i>meesietosum triquetrae</i> (2)														
Variant	<i>typica</i> (1a)								<i>Sphagnum obtusum</i> (1b)									–														
Plant cover, % – shrubs herbs mosses Number of species Relevé nr. by author	0	1	0	5	0	1	1	0	10	0	20	5	0	0	1	0	20	5	5	35	0	4	25	10	20	0	20					
Relevé nr. in the table	1	2	3	4	5	6*	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23*	24	25	26	27	1a	1b	2	1	
<b>Diagnostic species of the ass. <i>Sphagno orientalis</i>–<i>Caricetum stantis</i></b>																																
<i>Sphagnum orientale</i>	4	3	5	5	5	5	5	5	3	4	3	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	V	V	V	V
<i>Carex chordorrhiza</i>	+	+	1	2a	1	1	1	1	2b	1	2b	1	3	2b	2b	1	2b	·	3	2a	3	1	2a	2b	1	1	+	V	V	V	V	
<i>Salix fuscescens</i>	+	+	+	+	+	+	+	+	+	+	2b	1	1	·	+	2b	1	1	3	+	1	2b	2a	2b	+	2b	IV	IV	V	V		
<i>Eriophorum russeolum</i>	+	+	+	+	·	·	1	·	·	·	1	·	1	+	+	·	·	·	·	1	+	+	·	·	·	·	IV	IV	II	III		
<b>Diagnostic species of the var. <i>Sphagnum obtusum</i></b>																																
<i>Sphagnum obtusum</i>	·	1	1	1	·	+	+	·	3	3	3	3	2b	2b	2b	2b	2b	+	1	·	·	·	·	·	·	+	·	IV	V	II	IV	
<b>Diagnostic species of the subass. <i>Sphagno orientalis</i>–<i>Caricetum stantis</i> <i>meesietosum triquetrae</i> and the <i>Caricion stantis</i></b>																																
<i>Meesia triquetra</i>	+	·	·	·	1	·	+	·	+	·	·	+	·	·	1	·	+	3	2b	2b	2b	2a	2a	2a	1	+	1	II	III	V	IV	
<i>Scorpidium revolvens</i>	·	+	·	·	·	·	1	·	·	·	·	+	·	·	·	·	2b	1	+	2a	2b	2a	2a	·	+	1	II	II	IV	III		
<i>Pedicularis sudetica</i>	·	+	·	+	·	+	·	·	·	1	·	·	·	·	·	·	+	1	1	+	+	+	+	·	·	·	II	II	IV	III		
<i>Pseudocalliergon brevifolium</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	+	+	+	1	·	·	·	·	·	·	III	I		
<i>Hamatocaulis vernicosus</i>	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	1	1	1	·	·	+	·	·	·	III	II		
<i>Aneura pinguis</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	+	+	+	+	1	+	·	·	III	II		
<i>Scapania paludicola</i>	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	+	+	·	·	·	+	+	+	·	+	I	I	III	II		
<b>Diagnostic species of the <i>Caricion stantis</i></b>																																
<i>Carex aquatilis</i> subsp. <i>stans</i>	3	3	3	3	3	2b	2b	2b	2b	4	2b	2b	2b	3	3	2b	2b	1	1	1	2b	3	1	1	2b	4	2a	V	V	V	V	
<i>Sphagnum squarrosum</i>	·	+	1	·	·	·	·	·	2b	1	·	2b	·	2a	·	·	·	1	·	·	·	·	·	1	+	·	II	III	II	II		
<i>Cinclidium subrotundum</i>	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	+	+	·	·	·	·	·	2a	2a	1	·	·	III	II		
<i>Polytrichum jensenii</i>	+	·	·	·	+	·	·	·	+	·	1	·	·	·	·	·	·	1	+	·	·	·	·	2a	1	·	II	II	II	II		
<i>Rumex arcticus</i>	·	·	·	·	·	+	·	+	·	·	·	·	r	1	·	+	·	·	·	+	·	·	·	·	·	·	I	III	I	II		
<i>Mesoptychia rutheana</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+	·	+	·	·	I	R		
<i>Cinclidium latifolium</i>	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	I	·	I	R		
<b>Diagnostic species of the ass. <i>Scheuchzerio</i>–<i>Caricetea nigrae</i></b>																																
<i>Comarum palustre</i>	3	1	1	·	1	2b	+	+	+	·	+	+	2b	+	3	·	2a	1	2b	·	·	+	+	2a	2b	2a	1	IV	IV	IV	IV	
<i>Warnstorfia fluitans</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	r	·	·	·	·	·	·	+	·	·	·	II	I		
<i>Eriophorum angustifolium</i>	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	I	·	I	I		
<i>Epilobium palustre</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	+	·	·	I	I		
<b>Other species</b>																																
<i>Aulacomnium turgidum</i>	·	·	·	·	·	+	·	·	·	·	+	+	+	·	·	1	·	·	1	·	+	1	1	1	+	+	I	III	III	II		
<i>Pedicularis pennellii</i>	·	·	·	+	·	+	·	·	·	·	+	+	+	·	·	·	·	·	+	·	·	·	·	·	·	·	II	II	I	I		
<i>Luzula wahlenbergii</i>	·	·	·	+	·	+	·	·	·	·	+	·	·	·	·	·	+	·	+	·	·	·	·	·	·	·	II	I	II	I		
<i>Saxifraga foliolosa</i>	·	·	·	1	·	·	·	·	·	·	+	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	I	I	II	I		
<i>Saxifraga cernua</i>	·	·	·	+	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	I	I	II	I		
<i>Calliergon richardsonii</i>	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·	·	·	·	·	1	·	·	·	I	II		
<i>Bistorta vivipara</i>	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+	+	·	·	·	·	·	·	·	·	I	II		
<i>Cephalozia uncinata</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	r	·	·	·	·	r	·	·	·	+	·	·	I	II		
<i>Hieracium pauciflorum</i>	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	II	I		
<i>Arctagrostis latifolia</i>	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	II	I	·	I		
<i>Bryum pseudotriquetrum</i>	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	I	I		
<i>Bryum neodamense</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	r	·	·	·	·	I	I		
<i>Calamagrostis holmii</i>	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	+	+	+	+	·	·	I	I		
<i>Cephalozia</i> sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I	I		
<i>Saxifraga radiata</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	I	R		
<i>Ranunculus pallasii</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	I	R		
<i>Campylium stellatum</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	1	·	·	I	R		
<i>Salix pulchra</i>	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	I	R		
<i>Betula nana</i> subsp. <i>excilis</i>	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	I	·	I	R		
<i>Salix reptans</i>	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	·	I	·	I	R		
<i>Rudolpha fasciniifera</i>	·	·	·	·	·	·	·	·	·	+	·	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	II	·		

**Note.** Species found in one relevé with abundance (indicated in brackets): *Andromeda polifolia* subsp. *pumila* (24 1), *Blepharostoma brevirete* (18 r), *Calamagrostis purpurea* (27 +), *Calliba arctica* (7 r), *Cephalozia divaricata* (25 +), *C. varians* (20 r), *Drepanocladus polygamus* (25 r), *Eriophorum medium* (20 +), *Juncus triglumis* (20 1), *Loeskygnum badium* (20 +), *Peltigera* sp. (20 r), *Polemonium acutiflorum* (26 +), *Scapania irrigua* var. *rufescens* (23 r), *Schljakovianthus quadrilobus* (20 1), *Sphagnum aongstroemii* (9 +), *S. girgensohnii* (9 1), *S. perfoliatum* (12 2a), *S. tesorum* (9 1), *Stellaria ciliatosepala* (27 +), *Sarmentypnum sarmentosum* (19 +).

**Dates and localities:** 1 – 12.07.2023, 70.87229, 145.89302; 2 – 09.07.2023, 70.89325, 145.55047; 3 – 10.07.2023, 70.89633, 145.75894; 4 – 18.07.2023, 70.86488, 147.43565; 5 – 15.07.2023, 70.79182, 146.43938; 6 – 18.07.2023, 70.86378, 147.44835; 7 – 18.07.2023, 70.86344, 147.44910; 8 – 18.07.2023, 70.85639, 147.47113; 9 – 09.07.2023, 70.89451, 145.59435; 10 – 12.07.2023, 70.87357, 145.86537; 11 – 10.07.2023, 70.90218, 145.53795; 12 – 11.07.2023, 70.81666, 145.83578; 13 – 20.07.2023, 70.80460, 147.32123; 14 – 11.07.2023, 70.81666, 145.83578; 15 – 09.07.2023, 70.89325, 145.55047; 16 – 10.07.2023, 70.90298, 145.53897; 17 – 09.07.2023, 70.89353, 145.59073; 18 – 18.07.2023, 70.84611, 147.47066; 19 – 20.07.2023, 70.80415, 147.32201; 20 – 16.07.2023, 70.77615, 146.72318; 21 – 15.07.2023, 70.79182, 146.43938; 22 – 15.07.2023, 70.79148, 146.43826; 23 – 18.07.2023, 70.84599, 147.46989; 24 – 16.07.2023, 70.77360, 146.74229; 25 – 17.07.2023, 70.83392, 147.19009; 26 – 21.07.2023, 70.79665, 147.85365; 27 – 17.07.2023, 70.83322, 147.19167.

**Authors:** E.D. Lapshina – rel. 1-11, 13-16, 18-26; I.V. Filippov – rel. 12, 17, 27.







The variant *Sphagnum squarrosum* (Table 4, rel. 35–48) is characterized by significant (20–25 %) cover of *Sphagnum squarrosum* in moss layer.

**Salici fuscescentis–Sphagnetum squarrosum** **ass. nov.** (Table 5, rel. 1–40; Table 8, syntaxa 14–16; Figs 1K–L, 4, 5, clusters 7.1a, 7.1b, 7.2)

Low willow-*Sphagnum* communities (*S. squarrosum*) occur on frozen peat rims and relatively drained areas of rim-polygonal mires within old drained thermokarst lake basins (khasyreis) outside of river valleys in the southern tundra subzone in Yakutia.

**Holotypus:** relevé 19 (author's number – 114F23kt) in Table 5, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 20.07.2023, author I.V. Filippov.

**Diagnostic species:** *Aulacomnium turgidum*, *Calamagrostis holmii*, *Pyrola rotundifolia*, *Salix fuscescens*, *S. pulchra*, *Ranunculus lapponicus*, *Sphagnum squarrosum* (dom.), *S. talbotianum*.

**Structure and composition.** The cover of shrubs and herbs varies widely (1–40 %). The upper sublayer (20–30 cm) consists of *Carex aquatilis* subsp. *stans*, tall herbs (*Arctagrostis latifolia*, *Pedicularis sudetica*, *Polemonium acutiflorum*, *Rumex arcticus*) and *Salix pulchra* shrubs (1–20 %, occasionally absent), with rare dwarf birch shrubs (up to 40 cm height). The lower sublayer (5–15 cm) is formed by *Salix fuscescens* shoots (1–25 %) and low herbs such as *Calamagrostis holmii*, *Comarum palustre*, *Pyrola rotundifolia*, *Ranunculus lapponicus*. The continuous moss layer (85–90 %) is dominated by *Sphagnum squarrosum*, often with presence of *S. obtusum*.

The number of species per sample plot is 8–26 (mean 14), in association 53, including 8 (15 %) highly constant.

**Distribution and ecology.** The communities are developed on peat rims 2–4 m wide or on more extensive, slightly elevated and relatively dry areas within sedge-*Sphagnum* rim-polygonal mires. The surface is slightly undulating, with stunted sedges and dry, partially decayed sphagna. The peat layer is up to 60 cm thick. The depth of seasonal frozen peat thawing is 15–20 cm.

Based on differences in species richness and habitat conditions, two subassociations are distinguished within this association.

**Salici fuscescentis–Sphagnetum squarrosum** **typicum subass. nov.** (Table 5, rel. 1–26; Table 8, syntaxa 14–15; Figs 1K, 4, 5, clusters 7.1a, 7.1b)

**Holotypus:** relevé 19 (author's number – 114F23kt) in Table 5, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 20.07.2023, author I.V. Filippov.

**Diagnostic species:** same as in the association.

**Structure and composition.** The herb-shrub layer is the same as in the association. The continuous carpet in moss layer is formed by *Sphagnum squarrosum*. In less drained conditions, there is noticeable admixture of *S. obtusum* (5–30 %). *Polytrichum jensenii* occurs with low abundance but relatively high constancy, while other species are rare and scarce.

The number of species per sample plot is 8–24 (mean 14), in subassociation 48, including 10 (21 %) highly constant.

**Distribution and ecology.** These communities are developed at the early stages of permafrost heaving, where the rise of the permafrost level causes the surface of the continuous moss carpet to be elevated up to 5–10 (15) cm above the surrounding polygons and hollows, leading to drying (which further reduces peat thawing). The depth of seasonal frozen peat thawing is 15–20 cm. The communities appear to be relatively stable over time and are

widespread in the southern part of the tundra zone in Yakutia, occurring in sedge-*Sphagnum* mires with a more or less clearly developed polygonal structure.

Two variants are distinguished within the subassociation.

The variant *typica* (Table 5, rel. 15–26) represents the typical communities of the subassociation.

The variant *Sphagnum obtusum* (Table 5, relevés 1–14) is distinguished by higher constancy and greater abundance of *Sphagnum obtusum* (5–30 %) in moss layer. The communities are associated with slightly wetter conditions and are characterized by lower frequency of such diagnostic species as *Calamagrostis holmii*, *Pyrola rotundifolia* and *Ranunculus lapponicus*. Higher abundance of *Comarum palustre* and sporadic occurrences of *Luzula wahlenbergii* are in the herb layer.

**Salici fuscescentis–Sphagnetum squarrosum** **sphagnetosum fimbriati subass. nov.** (Table 5, rel. 27–40; Table 8, syntaxon 16; Figs 1L, 4, 5, cluster 7.2)

**Holotypus:** relevé 27 (author's number – 120F23kt) in Table 5, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 20.07.2023, author I.V. Filippov.

**Diagnostic species:** *Hylocomium splendens*, *Sphagnum arcticum*, *S. fimbriatum*, *S. teres*.

**Structure and composition.** The shrub-herb layer is well-developed, with shrubs ranging 10–45 % and herbs 5–20 %. The upper sublayer (30–40(50) cm) is commonly dominated by *Salix pulchra* (20–40 %), occasionally with minor presence of *Betula nana* subsp. *exilis* (1–3 %) and herb species (*Arctagrostis latifolia*, *Carex aquatilis* subsp. *stans*, *Pedicularis sudetica*). The lower sublayer (5–20 cm) is formed by *Salix fuscescens* low shrubs (1–30 %, 5–15 cm height) and herbs (*Calamagrostis holmii*, *Pyrola rotundifolia*, *Ranunculus lapponicus*). The continuous moss layer (85–100 %) is species-rich, dominated by *Sphagnum squarrosum* but with significant sporadic presence (20–40 %) of *Aulacomnium turgidum*, *Hylocomium splendens*, *Sphagnum arcticum*, *S. fimbriatum*, *S. talbotianum* and *S. teres*.

The number of species per sample plot is 11–26 (mean 17), in subassociation 45, including 11 (24 %) highly constant.

**Distribution and ecology.** The communities occur on relatively elevated rims (15–20 cm) in rim-polygonal mires and also occupy the periphery of mire complexes within river-drained zone 20–25 m wide between riparian willow scrubs and the open mire. The surface is flat or slightly undulating. The depth of seasonal frozen peat thawing is 20–30 cm.

**Sphagno fimbriati–Salicetum pulchrae** **ass. nov.** (Table 5, rel. 41–46; Table 8, syntaxon 17; Figs 4, 5, cluster 8)

*Sphagnum* (*S. cf. fimbriatum*)-willow (*Salix pulchra*) communities of hanging mires along temporary watercourses in ravines on the slopes of high moraine ridges and uplands in the southern part of the tundra zone in Yakutia.

**Holotypus:** relevé 41 (author's number – 024F23kt) in Table 5, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 11.07.2023, author I.V. Filippov.

**Diagnostic species:** *Salix pulchra* (dom.), *Sphagnum squarrosum*, *S. cf. fimbriatum* (dom.), *S. teres*, *Straminergon stramineum*, *Pseudobryum cinclidioides*.

**Structure and composition.** The shrub layer is formed by *Salix pulchra*. Dense fragments with willow (50–70 cm height) cover ranging from 70–80 % alternate with relatively open parts (5–10 m across), where willow abundance is 15–30 % and shrub height is 15–30 cm. *Betula nana* subsp. *exilis* grows sparsely (up to 1 % cover) but with high constancy. Herb cover varies between 5 and 40 %. The upper herb sublayer (about 20 cm) is dominated by *Carex aquatilis*

**Table 6.** Dwarf shrub-cottongrass-*Sphagnum* bogs of the ass. Ledo decumbentis–Eriophoretum vaginati in comparison with zonal dwarf shrub-lichen-moss tundras and dwarf shrub-cottongrass tundras. Zonal tundras on elevated landforms (edomas): 1–2 – low shrub-green moss-lichen tundra; 3 – dwarf shrub-green moss tundra; 4–8 – tussock cottongrass (*Eriophorum vaginatum*) tundra on poorly drained mineral soils. 9–25 – ass. Ledo decumbentis–Eriophoretum vaginati: 9–19 – subass. typicum (1a): 9–18 – var. Aconogonon tripterocarpum, 19 – var. typica; 20–25 – subass. sphagnetosum lenenses (1b).

Association/Community	Tundra			Cottongrass tundra				Ledo decumbentis–Eriophoretum vaginati (1)																			Constancy					
	–			–				typicum (1a)									sphagnetosum lenense (1b)															
<b>Cover, % – shrubs</b>	25	10	30	50	20	60	20	20	80	20	5	25	10	20	20	25	5	20	20	20	25	10	10	20	10	1						
<b>herbs</b>	15	15	25	40	25	20	25	60	25	65	15	25	20	55	25	15	55	70	40	15	50	5	20	15	25							
<b>mosses</b>	80	90	90	90	60	95	100	70	80	90	90	100	95	95	90	95	60	80	80	100	100	100	100	100	100							
<b>Number of species</b>	51	46	41	39	43	38	40	46	22	39	26	24	22	41	30	22	31	34	22	16	19	14	16	10	10							
<b>Relevé nr. by author</b>	169E23kt	104F23kt	018F23kt	039E23kt	083F23kt	189E23kt	123F23kt	137E23kt	043E23kt	057E23kt	029F23kt	074F23kt	027F23kt	058E23kt	069F23kt	028F23kt	118E23kt	124F23kt	168E23kt	034F23kt	068E23kt	072E23kt	030F23kt	160E23kt	091F23kt							
<b>Relevé nr. in the table</b>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	1a			1b	1		
<b>Species of zonal low shrub-lichen-moss tundra</b>																																
<i>Cladonia</i> spp.	2b	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			.	R	.	.
<i>Achoriphragma nudicaule</i>	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.
<i>Tofieldia coccinea</i>	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.
<i>Myurella julacea</i>	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
<i>Distichium capillaceum</i>	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
<i>Cephalozia varians</i>	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
<i>Lophozia silvicola</i>	+	+	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
<i>Luzula confusa</i>	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
<i>Pedicularis capitata</i>	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
<i>Cassiope tetragona</i>	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
<i>Petasites frigidus</i>	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
<b>Species of zonal dwarf shrub-lichen-moss tundra and dwarf shrub-cottongrass tundra</b>																																
<i>Tomentypnum nitens</i>	3	1	+	2a	1	2b	+	3	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	II			
<i>Dryas punctata</i>	1	+	+	1	+	2a	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
<i>Saxifraga nelsoniana</i>	+	+	+	1	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
<i>Valeriana capitata</i>	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
<i>Vaccinium uliginosum</i> subsp. <i>microphyllum</i>	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R			
<i>Rhytidium rugosum</i>	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
<i>Plagiobuccium berggrenianum</i>	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
<i>Samonia uncinata</i>	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	I			
<i>Carex bigelowii</i> subsp. <i>arctisibirica</i>	1	1	+	1	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R			
<i>Salix glauca</i>	+	+	1	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
<i>Dicranum acutifolium</i>	1	1	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
<i>Arctous alpina</i>	+	+	+	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R			
<i>Poblia nutans</i>	r	r	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	I			
<i>Stellaria ciliatosepala</i>	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
<i>Gowardia nigricans</i>	+	1	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R			
<i>Peltigera aphiosa</i>	+	+	+	1	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	I			
<b>Species of tundra communities entering cotton grass–Sphagnum bogs</b>																																
<i>Hylacomium splendens</i>	2b	1	3	3	1	2b	3	2b	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	.	III			
<i>Salix pulchra</i>	1	1	1	1	2a	+	1	1	+	1	1	+	1	1	+	1	+	1	+	+	+	+	+	+	+	+	V	I	IV			
<i>Cetraria islandica</i>	+	1	+	+	+	1	2a	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	I	III			
<i>Sphenobolus minutus</i>	1	1	+	+	+	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	.	III			
<i>Stereodon holmenii</i>	1	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	.	III			
<i>Dactylina arctica</i>	+	1	1	1	.	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	II	III			
<i>Arctagrostis latifolia</i>	1	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.	II			
<i>Lophozia murmanica</i>	+	.	+	.	.	r	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.	II			
<i>Ptilidium ciliare</i>	.	1	.	.	1	2b	+	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.	II			
<b>Diagnostic species of the ass. Ledo decumbentis–Eriophoretum vaginati and the alliance Sphagnion lenense</b>																																
<i>Eriophorum vaginatum</i>	.	+	+	2b	2b	2b	2b	3	2a	3	2b	2a	2b	3	2b	2b	3	3	2b	1	1	1	1	.	.	.	V	IV	V			
<i>Sphagnum lenense</i>	.	.	.	1	.	.	.	.	4	4	3	4	5	4	3	4	3	3	4	5	4	5	5	5	5	5	V	V	V			
<i>Sphagnum balticum</i>	.	.	.	.	.	.	.	.	+	2a	2b	.	2a	2b	.	2a	1	2b	2b	.	2b	2a	1	1	.	V	IV	V				
<i>Sphagnum capillifolium</i>	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	2b	1	+	+	1	.	1	.	.	IV	III	III				
<b>Diagnostic species of the var. Aconogonon tripterocarpum and Carex aquatilis subsp. stans</b>																																
<i>Aconogonon tripterocarpum</i>	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	.	III			
<i>Carex aquatilis</i> subsp. <i>stans</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	IV	II			
<b>Diagnostic species of the Rubo chamaemori–Dicranion elongati and Rubo chamaemori–Cladonietalia arbusculae</b>																																
<i>Rubus chamaemorus</i>	.	.	.	.	.	.	.	.	2b	.	+	2a	+	.	.	.	.	2b	1	2b	1	2b	2b	2b	2b	III	V	IV				
<i>Ledum palustre</i> subsp. <i>decumbens</i>	2a	1	2b	2a	2a	3	1	2a	5	2a	+	2b	1	2a	2b	+	2a	2b	2b	2b	2b	2a	2b	2a	2a	V	V	V				
<i>Vaccinium vitis-idaea</i> subsp. <i>minus</i>	.	1	1	2b	2a	2b	1	2b	2b	2a	1	1	1	2a	1	1	2b	2b	1	1	3	1	+	1	+	V	V	V				
<i>Flavocetraria cucullata</i>	.	2b	+	2a	+	2a	2b	+	2b	+	1	2b	1	+	2b	+	+	1	+	2b	.	1	1	+	1	V	V	V				
<i>Aulacomnium turgidum</i>	1	2b	2a	1	2b	2a	1	1	1	1	1	+	+	1	+	1	+	1	+	1	+	+	1	.	+	V	V	V				
<i>Dicranum elongatum</i>	1	1	2a	2b	2a	2b	1	1	2a	.	+	2a	.	+	1	.	2a	2a	1	.	.	.	.	.	.	IV	.	III				
<i>Dicranum laevigatum</i>	1	1	+	1	.	1	.	1	1	+	+	+	+	+	1	+	2a	+	1	.	+	+	+	.	.	V	III	V				
<i>Orthocaulis binsteadii</i>	.	.	+	+	1	1	+	+	1	+	+	1	+	+	1	+	2b	2b	1	+	+	.	+	r	.	V	IV	V				
<b>Other species</b>																																
<i>Betula nana</i> subsp. <i>exilis</i>	2b	1	1	2b	2a	3	1	1	+	2a	+	1	1	2a	1	1	2b	+	1	1	1	+	1	.	.	V	IV	V				
<i>Calamagrostis holmii</i>	+	.	1	+	+	.	.	.	+	+	.	+	.	.	+	.	1	+	r	+	+	.	r	r	+	IV	V	IV				
<i>Polytrichum strictum</i>	.	.	.	.	.	+	+	1	.	.	.	.	.	+	1	.	+	+	1	.	1	1	1	+	+	III	V	III				
<i>Aulacomnium palustre</i>	.	.	.	1	+	2a	+	1	.	r	.	.	.	.	1	.	.	+	+	.	.	.	.	.	.	III	II	III				
<i>Luzula nivalis</i>	+	+	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	II	.	II				
<i>Blepharostoma brevirete</i>	.	.	.	.	.	.	.	+	.	r	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	II	.	II				
<i>Pedicularis labradorica</i>	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	II	.	I				
<i>Calypogeia muelleriana</i>	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	I				
<i>Pseudotritomaria heterophylla</i>	r	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	I				
<i>Empetrum subbolarcticum</i>	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	I				

Table 6. Continued.

Relevé nr. in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	1a	1b	1	
<i>Schljakovia kuzneziana</i>	.	.	.	.	+	.	.	2a	.	r	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I	.	I
<i>Solenostoma</i> sp.	.	.	.	.	.	.	.	r	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	I	.	I
<i>Sphagnum tesorum</i>	.	.	+	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I	.	I
<i>Tritomania quinqueidentata</i>	.	.	.	.	+	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R
<i>Plagiothecium svalbardense</i>	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	R	.	R
<i>Dicranella subulata</i>	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	I	.	I
<i>Cephalozia pleniceps</i>	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	R	.	R
<i>Sphagnum aongstroemii</i>	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	II	.	I
<i>Polytrichum jensenii</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	+	.	.	.	.	.	.	II	I	I
<i>Sphagnum arcticum</i>	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	II	.	I
<i>Scapania parvifolia</i>	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	II	.	I
<i>Cephalozia bicuspadata</i>	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	II	.	I
<i>Straminergon stramineum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	+	+	.	.	.	.	.	.	.	II	.	I
<i>Bistorta officinalis</i>	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Equisetum arvense</i>	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Riccardia latifrons</i>	.	.	.	.	r	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Scapania paludicola</i>	.	.	.	.	+	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R
<i>Schistochloopsis grandiretis</i>	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R
<i>Sphagnum concinnum</i>	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	R	.	R
<i>Blepharostoma trichophyllum</i>	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	I	.	I
<i>Solenostoma sphaerocarpon</i>	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	I	.	I
<i>Pleurozium schreberi</i>	.	.	.	.	.	.	.	.	.	r	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I	.	I
<i>Diplophyllum</i> sp.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	I	.	I
<i>Sphenolobus minutus</i> subsp. <i>grandis</i>	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	I	.	I
<i>Tephrosia integrifolia</i>	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	I	.	I
<i>Salix fuscescens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	R	I	I
<i>Pedicularis sudetica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	III	I
<i>Eriophorum angustifolium</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	II	I

**Note.** Species found in on relevé with abundance (indicated in brackets): *Aloina brevirostris* (1 r), *Andromeda polifolia* subsp. *pumila* (25 +), *Anthelia juratzkiana* (8 r), *Arnella jennica* (1 r), *Bryum algovicum* (1 r), *Bryum amblyodon* (1 r), *Bryum pseudotriquetrum* (5 +), *Bryum* sp. (1 r), *Calyptogeia sphagnicola* (21 r), *Cladonia amaurocraea* (12 +), *Delphinium cheilanthum* (6 +), *Flavocetraria nivalis* (2 +), *Leiocolea collaris* (5 r), *Lophozia* sp. (18 r), *L. guttulata* (7 +), *L. ventricosa* subsp. *longiflora* (18 r), *L. wenzelii* (2 +), *Lophozia polaris* (8 r), *Marsipella sprucei* (10 r), *Meesia minor* (1 r), *Nardia geoscophus* (8 r), *Orthilia obtusata* (2 +), *Pedicularis* sp. (6 +), *Solenostoma hyalinum* (10 r), *Poa alpigena* (3 +), *P. arctica* (1 +), *Poblia prolifera* (1 r), *Polytrichum hyperboreum* (2 +), *Saxifraga foliolosa* (11 +), *Schistochloopsis incisa* (8 +), *Schljakovianthus quadrilobus* (5 +), *Sphaerophorus globosus* (3 +), *Sphagnum angustifolium* (9 r), *S. fimbriatum* (18 +), *S. jensenii* (9 +), *S. talbotianum* (18 1), *Stereodon* sp. (7 +), *S. subimponens* (1 r), *Tetraplodon mnioides* (14 +), *Tomentypnum involutum* (8 r), *Warnstorfia fluitans* (14 +).

**Dates and localities:** 1 – 19.07.2023, 70.76471, 147.21767; 2 – 19.07.2023, 70.76498, 147.22009; 3 – 10.07.2023, 70.89393, 145.75137; 4 – 10.07.2023, 70.89383, 145.75050; 5 – 17.07.2023, 70.82636, 147.17443; 6 – 21.07.2023, 70.79806, 147.85907; 7 – 21.07.2023, 70.79840, 147.85861; 8 – 17.07.2023, 70.82639, 147.17346; 9 – 10.07.2023, 70.89552, 145.76089; 10 – 11.07.2023, 70.81434, 145.81543; 11 – 11.07.2023, 70.81658, 145.80952; 12 – 16.07.2023, 70.77601, 146.73433; 13 – 11.07.2023, 70.81448, 145.81407; 14 – 11.07.2023, 70.81419, 145.81346; 15 – 15.07.2023, 70.79839, 146.45679; 16 – 11.07.2023, 70.81448, 145.81407; 17 – 15.07.2023, 70.79839, 146.45679; 18 – 16.07.2023, 70.77608, 146.43721; 19 – 19.07.2023, 70.76134, 147.22525; 20 – 12.07.2023, 70.87433, 145.90989; 21 – 12.07.2023, 70.87344, 145.90633; 22 – 12.07.2023, 70.87348, 145.90805; 23 – 12.07.2023, 70.87433, 145.90989; 24 – 18.07.2023, 70.85578, 147.47279; 25 – 16.07.2023, 70.86387, 147.43254.

**Authors:** E.D. Lapshina – rel. 1, 4, 6, 8–10, 14, 17–19, 21, 22, 24; I.V. Filippov – rel. 2, 3, 5, 7, 11–13, 15, 16, 20, 23, 25.

subsp. *stans* (0.5–20 %), while the lower one is formed by *Comarum palustre*, *Calamagrostis holmii* and *Stellaria crassifolia*.

The number of species per sample plot is 11–18 (mean 14), in association 30, including 11 (37 %) highly constant.

**Distribution and ecology.** The communities are developed on slopes and terraced ledges in the upper reaches of V-shaped valleys of small streams and temporary watercourses on morainic hills and elevations (yedomas). On flat or gently sloping mire surfaces, nanorelief is absent. On steeper sites, it is formed by large rounded hummocks of *Sphagnum* mosses, between which water flows during snowmelt. Peat depth, determined from exposure along the bank of temporary watercourse, is 1.5–2 m. Under undisturbed moss layer, the depth of seasonal frozen peat thawing is 20–30 cm.

### Sedge-*Sphagnum* communities of oligotrophic hollows in flat-palsa mires

Only two relevés of this category were made in study area in hollows of the flat-palsa mire complex.

**Community type** *Carex aquatilis* subsp. *stans*–*Sphagnum balticum* (Table 4, rel. 49–50)

**Diagnostic species:** *Carex aquatilis* subsp. *stans*, *Sphagnum balticum* (dom.).

**Structure and composition.** The sparse (10–15 %) herb layer 15–20 cm tall, is formed by *Carex aquatilis* subsp. *stans*, *Eriophorum angustifolium* and *E. russeolum*, *Betula nana* subsp. *exilis* and low abundant (0.5–3 %) *Ledum palustre* subsp. *de-*

*cumbens*. The continuous carpet of moss layer is dominated by *Sphagnum balticum*.

**Distribution and ecology.** Communities dominated by *Carex aquatilis* subsp. *stans* and *Sphagnum balticum* are not widely distributed across the mires in the Eurasian tundra zone. These communities were not recorded in the tundra zone in the European Russia (Lavrinenko 2016), Western Siberia (Lapshina et al. 2021, 2022, Telyatnikov et al. 2014, 2015, 2019a, b, 2021), or on the Taymyr Peninsula (Matveyeva 1994, 1998). In the southern tundra subzone in Yakutia, this community type was described twice in a flat-palsa-hollow mire within extensive mire system. The water level is about 5 cm below the surface of the moss carpet. The depth of seasonal frozen peat thawing is about 30 cm.

**Note.** Close associations are *Carici stantis*–*Sphagnetum lindbergii* Lavrinenko et al. 2016, *Carici rariflorae*–*Sphagnetum baltici* (Andreev, 1932) Lavrinenko et al. 2016 and *Carici rotundatae*–*Sphagnetum baltici* Lapshina et al. 2022.

### Vegetation of frozen cottongrass mires and dry peat mounds of the class Oxyocco–Sphagnetea: *Eriophorum-Sphagnum* communities

**Ledo decumbentis–Eriophoretum vaginatis** Lapshina in Lavrinenko et al. 2022 (Table 6, rel. 9–25; Table 8, syntaxa 18–19; Figs 1M–N, 4, 5, clusters 9.1, 9.2)

The association includes tussock dwarf shrub-cottongrass-*Sphagnum* communities dominated by *Eriophorum vaginatum*

Table 7. Dwarf birch (*Betula exilis*)-green moss (*Polytrichum strictum*, *Dicranum* spp.) frozen peat mounds (palsa). Ass. Dicrano laevidentis–Betuletum exilis: 1–6 subsp. typicum (1a), 7–22 – subass. ledetosum decumbentis (1b).

Associations	Dicrano laevidentis–Betuletum exilis (1)																						Constancy			
	typicum (1a)						ledetosum decumbentis (1b)																			
Cover, % – shrubs	50	85	70	60	40	80	70	85	90	85	95	90	40	90	40	70	60	60	50	90	70	30	V	V	V	
herbs	10	5	15	5	5	5	3	0	0	0	0	3	1	0	1	10	15	20	60	1	15	30				
mosses	80	95	80	100	100	90	100	100	100	95	100	95	90	100	70	90	100	90	90	70	85	90				
Number of species	20	19	18	24	19	29	19	18	21	13	20	27	19	14	22	19	21	15	24	23	23	21				
Relevé nr. by author	0091F23kt	1051E23kt	0121F23kt	1161E23kt	105a23kt	0221E23kt	0581F23kt	1461E23kt	0701E23kt	1031E23kt	0711E23kt	1261E23kt	0891F23kt	045a23kt	0921F23kt	0761F23kt	1571E23kt	0821F23kt	0211F23kt	1251E23kt	0351F23kt	0331F23kt	1	1a	1b	
Relevé nr. in the table	1*	2	3	4	5	6	7	8	9	10	11*	12	13	14	15	16	17	18	19	20	21	22	1	1a	1b	
<b>Diagnostic species of the ass. Dicrano laevidentis–Betuletum exilis</b>																										
<i>Betula nana</i> subsp. <i>exilis</i>	3	4	4	2a	2b	3	3	5	5	5	4	5	2b	2b	2a	3	3	3	2a	4	4	3	V	V	V	
<i>Salix pulchra</i>	1	2a	+	3	2b	.	2b	+	+	1	+	+	1	.	1	1	1	+	+	.	+	.	V	V	V	
<i>Polytrichum strictum</i>	2a	2b	2a	2a	2b	2b	2a	+	2a	3	2a	2a	1	2a	1	+	1	+	1	1	1	1	V	V	V	
<i>Dicranum laevidens</i>	2b	2b	+	3	1	3	1	3	4	2b	2b	3	+	1	+	1	3	2b	1	3	3	3	V	V	V	
<i>Dicranum elongatum</i>	2a	3	1	1	3	.	3	2a	2a	3	3	2b	3	4	3	3	2a	3	1	3	3	2b	V	V	V	
<b>Diagnostic species of the subass. typicum</b>																										
<i>Tomentypnum nitens</i>	1	+	3	+	+	r	.	.	.	.	.	+	.	.	.	1	.	.	+	.	.	.	V	I	III	
<i>Pyrola rotundifolia</i>	+	+	.	1	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	R	II	
<i>Salix fuscescens</i>	1	.	1	.	+	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.	I	
<i>Pedicularis labradorica</i>	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.	.	
<i>Luzula wahlenbergii</i>	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.	I	
<i>Sphagnum squarrosum</i>	1	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.	I	
<i>Sphagnum aongstroemii</i>	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	III	I	I	
<i>Samolium uncinatum</i>	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	I	II	
<b>Diagnostic species of the subass. ledetosum decumbentis</b>																										
<i>Ledum palustre</i> subsp. <i>decumbens</i>	+	.	.	.	.	+	1	1	1	+	3	1	2b	5	2b	3	3	3	3	2b	2a	1	II	V	V	
<i>Flavocetraria cucullata</i>	.	.	.	.	.	+	2a	1	1	1	2a	1	3	2b	1	+	4	2a	2b	+	2a	2b	.	V	IV	
<i>Orthocaulis binsteadii</i>	.	.	.	.	.	+	+	+	1	1	1	1	1	1	1	1	1	1	1	+	+	+	I	V	IV	
<i>Cladonia amanuocraea</i>	.	.	.	.	+	.	+	+	1	1	+	+	+	2b	+	+	.	+	+	1	1	1	I	IV	III	
<i>Ptilidium ciliare</i>	.	.	.	.	.	+	2a	+	+	+	+	+	+	+	+	+	+	+	+	1	1	1	I	IV	III	
<i>Sphenobolus minutus</i>	.	.	.	.	.	.	.	2a	.	1	+	+	+	+	+	+	+	+	+	+	+	+	I	III	II	
<i>Vaccinium vitis-idaea</i> subsp. <i>minus</i>	.	1	.	+	.	.	+	.	+	+	.	.	r	.	+	2a	2b	2b	3	2b	2b	3	II	IV	IV	
<b>Other species</b>																										
<i>Aulacomnium palustre</i>	1	2b	1	3	.	2b	3	2b	1	2b	2a	2b	.	.	+	.	1	+	+	2a	+	1	V	V	V	
<i>Aulacomnium turgidum</i>	2b	.	r	+	2b	2b	+	+	+	+	1	1	1	+	1	2a	+	.	+	1	+	+	V	V	V	
<i>Calamagrostis holmii</i>	2a	+	2b	1	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	V	V	V	
<i>Peltigera aphthosa</i>	+	r	+	.	.	.	.	.	+	1	1	1	.	.	.	+	+	+	.	.	.	.	IV	III	III	
<i>Arctagrostis latifolia</i>	.	+	.	1	1	.	+	+	+	.	+	+	.	.	+	+	.	.	+	.	.	.	III	III	III	
<i>Plagiobacium berggrenianum</i>	.	+	+	.	.	+	+	+	+	r	+	+	+	+	+	.	.	.	.	+	.	.	III	II	III	
<i>Eriophorum vaginatum</i>	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	+	1	.	.	.	r	I	III	II	
<i>Stereodon holmii</i>	.	+	.	+	.	+	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	III	II	II	
<i>Hylacomium splendens</i>	.	.	.	2a	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	II	II	II	
<i>Carex aquatilis</i> subsp. <i>stans</i>	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	II	.	I	
<i>Sphagnum talbotianum</i>	1	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	II	.	I	
<i>Sphagnum obtusum</i>	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	I	
<i>Pedicularis sudetica</i>	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	R	
<i>Dicranum acutifolium</i>	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	R	
<i>Pedicularis lapponica</i>	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	R	
<i>Tephrosia integrifolia</i>	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	R	
<i>Lophozia silvicola</i>	.	+	.	.	.	.	+	+	.	.	.	.	.	.	+	.	+	.	+	+	+	+	I	III	II	
<i>Cladonia</i> sp.	.	.	.	.	1	.	+	.	.	+	.	.	.	1	r	+	.	+	.	.	.	1	I	III	II	
<i>Cladonia cornuta</i>	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	I	II	II
<i>Dactylina arctica</i>	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	+	+	+	I	II	II	
<i>Cetraria islandica</i>	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	1	.	.	+	+	+	.	II	II	
<i>Lophozia murmanica</i>	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	II	II	
<i>Poblia nutans</i>	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	I	II	II	
<i>Tritomaria quinqueidentata</i>	.	.	.	+	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	I	
<i>Blepharostoma brevirete</i>	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	I	R	R	
<i>Tetraplodon mnioides</i>	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	I	R	R	
<i>Sphagnum capillifolium</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	I	R	
<i>Aconogonon tripterocarpon</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	I	R	
<i>Plagiobacium svalbardense</i>	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	R	
<i>Lophozia</i> sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	I	R	

**Note.** Species found in one relevé with abundance (indicated in brackets): *Blepharostoma trichophyllum* (13 +), *Calyptogea muelleriana* (11 r), *Cetraria* sp. (17 +), *Cladonia gracilis* (22 r), *Dicranum* sp. (9 +), *Lophozia polaris* (6 r), *Orthilia obtusata* (15 +), *Petasites frigidus* (4 1), *Plagiobacila arctica* (6 +), *Poa arctica* (5 +), *Polytrichum hyperboreum* (6 +), *P. jensenii* (12 +), *Riccardia latifrons* (6 r), *Rubus chamaemorus* (21 +), *Salix glauca* (21 1), *Scapania paludicola* (6 r), *Seljakovia kunzeana* (8 +), *Sphagnum arcticum* (1 +), *S. beringiense* (9 +), *S. fimbriatum* (3 +), *S. lenense* (19 3), *Stellaria ciliatosepala* (5 +), *Tritomaria exsectiformis* (12 r), *Valeriana capitata* (4 +).

**Dates and localities:** 1 – 10.07.2023, 70.90343, 145.54166; 2 – 14.07.2023, 70.79199, 146.53749; 3 – 10.07.2023, 70.90272, 145.53704; 4 – 14.07.2023, 70.81335, 146.39667; 5 – 14.07.2023, 70.81409, 146.39665; 6 – 10.07.2023, 70.90218, 145.53795; 7 – 14.07.2023, 70.79148, 146.53196; 8 – 18.07.2023, 70.86470, 147.43307; 9 – 12.07.2023, 70.87348, 145.90805; 10 – 14.07.2023, 70.78948, 146.55696; 11 – 12.07.2023, 70.87348, 145.90805; 12 – 16.07.2023, 70.77658, 146.72211; 13 – 18.07.2023, 70.86387, 147.43254; 14 – 10.07.2023, 70.89511, 145.76421; 15 – 18.07.2023, 70.86294, 147.45332; 16 – 16.07.2023, 70.77634, 146.72178; 17 – 18.07.2023, 70.86470, 147.43307; 18 – 16.07.2023, 70.77187, 146.74164; 19 – 10.07.2023, 70.89523, 145.76148; 20 – 16.07.2023, 70.77583, 146.73709; 21 – 12.07.2023, 70.87349, 145.90702; 22 – 12.07.2023, 70.87349, 145.90702.

**Authors:** E.D. Lapshina – rel. 2, 4–6, 8–12, 14, 17, 20; I.V. Filippov – rel. 1, 3, 7, 13, 15, 16, 18, 19, 21, 22.

on poorly drained concave slopes and footslopes of elevated landforms (yedomas), as well as dwarf shrub-cloudberry-*Sphagnum* communities on flat frozen surfaces and low peat mounds within flat-palsa complexes in the tundra zone in the Asian part of Russia.

**Diagnostic species:** *Ledum palustre* subsp. *decumbens*, *Eriophorum vaginatum*, *Sphagnum balticum*, *S. capillifolium*, *S. lenense* (dom.).

**Structure and composition.** The upper dwarf shrub layer (up to 15 cm) is formed by *Ledum palustre* subsp. *decumbens*, with *Betula nana* subsp. *exilis*. Dominants in the lower herb-dwarf shrub layer are *Eriophorum vaginatum* (15–40 %) and *Vaccinium vitis-idaea* subsp. *minus* (5–15 %). The continuous moss layer is primarily formed by *Sphagnum lenense*, with occasional presence of *S. balticum* and, more rare, *S. capillifolium*. Green mosses *Aulacomnium turgidum*, *Dicranum elongatum*, *D. laevidens*, *Polytrichum strictum* and the liverwort *Orthocaulis binsteadii* are low abundant but with high or moderate constancy.

The number of species per sample plot is 10–41 (mean 23), in association 67, including 14 (23 %) highly constant.

**Distribution and ecology.** The association was described in the southern tundra subzone in the northern West Siberia (Lavrinenko et al. 2022). It is also widely distributed in the southern tundra subzone in the Taymyr Peninsula (Konstantinova et al. 2023) and in the northern Yakutia. Communities are developed in poorly drained sites in the lower parts of gentle slopes of hills and on low flat peat mounds within polygonal and flat-palsa mires.

Cottongrass tussocks are small and flat (20–30 cm in diameter, 5 cm high). The soils are peaty, with peat layer thickness from 0.5 to 1.0 m. The depth of seasonal frozen peat thawing is 20–25 cm.

Two subassociations are distinguished within this association.

#### **Ledo decumbentis–Eriophoretum vaginati typicum** (Table 6, rel. 9–19; Table 8, syntaxon 19; Figs 1M, 4, 5, cluster 9.2)

**Diagnostic species:** the same as in association.

**Structure and composition.** The upper layer (15 cm) is formed by *Ledum palustre* subsp. *decumbens* and *Betula nana* subsp. *exilis* with highly constant but low abundant *Salix pulchra*. A character feature is the constant presence, in low abundance, of green mosses *Dicranum elongatum*, *Hylocomium splendens*, *Stereodon holmenii* and liverworts *Lophozia murmanica*, *Ptilidium ciliare*, *Sphenolobus minutus* in the ground layer as well as lichens *Cetraria islandica*, *Dactylina arctica*, *Flavocetraria cucullata* – species typical of zonal and cottongrass tundra stands (Table 6).

The number of species per sample plot is 22–41 (mean 28), in subassociation 67, including 19 (28 %) highly constant.

**Distribution and ecology.** The subassociation is widely distributed in the southern part of the tundra zone in the Asian part of Russia, where it occurs on gently concave surfaces and at the footslopes of hills.

Variants typical of *Aconogonon tripterocarpaceum* are identified within the subassociation.

The variant typical (Table 6, rel. 19) are typical communities of the subassociation.

The variant *Aconogonon tripterocarpaceum* (Table 6, rel. 9–18) with the presence of the variant name species predominates in the study area.

#### **Ledo decumbentis–Eriophoretum vaginati sphagnetosum lenenses** Lapshina et al. 2023 (Table 6, rel. 20–25; Table 8, syntaxon 18; Figs 1N, 4, 5, cluster 9.1)

The subassociation was first described in the Yamalo-Nenets Autonomous Okrug in the northern part of Western Siberia (Lapshina et al. 2023) and, according to our obser-

vations, also occurs in the southern Taymyr Peninsula. The detection of these communities in the southern tundra subzone in Yakutia significantly extends the known range of the subassociation in the Asian part of Russia.

The subassociation includes dwarf-shrub (*Ledum palustre* subsp. *decumbens*)-cloudberry-*Sphagnum* communities dominated by *Sphagnum lenense*, occurring on frozen low peat mounds in flat-palsa mires and polygonal mire complexes.

**Diagnostic species:** *Rubus chamaemorus* (dom.), *Sphagnum lenense* (dom.).

**Structure and composition.** Floristically weakly differentiated but easily recognizable in the field, these communities are distinguished due to the bright reddish-orange color of the continuous *Sphagnum lenense* carpet (Fig. 1N). The herb-dwarf shrub layer (15–50 %) is formed by *Ledum palustre* subsp. *decumbens* and *Rubus chamaemorus* (3–5 cm), with a more or less noticeable (0.5–15 %) presence of *Vaccinium vitis-idaea* subsp. *minus*. Scattered shrubs of *Betula nana* subsp. *exilis* and less frequently sedge *Carex aquatilis* subsp. *stans* 10–15(20) cm in height, rise above the herb-dwarf shrub layer. *Eriophorum vaginatum* is low abundant (0.5–5 %) or absent. The continuous moss layer is formed by *Sphagnum lenense*, often with *S. balticum* and minor amount of *Aulacomnium turgidum* and *Flavocetraria cucullata*.

The number of species per sample plot is 10–19 (mean 14), in subassociation 23, including 13 (57 %) highly constant.

The species richness in the subassociation and communities in the southern tundra subzone in Yakutia is generally lower than in Western Siberia (Lapshina et al. 2023), although the number of constant species is the same.

**Distribution and ecology.** The communities occur on flat and slightly convex peat mounds (20–25 cm above the level of wet hollows) in flat-palsa mires, often forming periphery around higher dry peat mounds, as well as on flat-centered frozen polygons of polygonal mire complexes in the southern tundra subzone in Western Siberia, the Taymyr Peninsula and Yakutia. The surface is flat or slightly undulating. The depth of seasonal frozen peat thawing is 15–20 cm.

#### **Vegetation of frozen cottongrass mires and dry peat mounds of the class Oxycocco–Sphagnetea: dwarf birch-green moss communities**

##### **Dicrano laevidentis–Betuletum exilis** ass. nov. (Table 7, rel. 1–22; Table 8, syntaxa 20–21; Figs 1O, 4, 5, clusters 10.1, 10.2)

Dwarf birch-green moss communities of frozen peat mounds in flat-palsa mires, dominated by *Dicranum* spp. and *Polytrichum strictum* in the moss layer, in the tundra zone in the Asian part of Russia.

**Holotypus:** relevé 1 (author's number – 009F23kt) in Table 7, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 10.07.2023, author I.V. Filippov.

**Diagnostic species:** *Aulacomnium palustre*, *Betula nana* subsp. *exilis* (dom.), *Dicranum elongatum* (dom.), *D. laevidens* (dom.), *Peltigera aptosa*, *Polytrichum strictum* (dom.), *Salix pulchra*.

**Structure and composition.** Floristically poorly differentiated communities, but easily recognizable in the field by a dense (60–90 %) low layer of dwarf birch *Betula nana* subsp. *exilis* (10–15(20) cm), often with noticeable presence of willows (*Salix fuscescens*, *S. pulchra*). Dwarf shrub *Ledum palustre* subsp. *decumbens* sometimes being dominant, is accompanied by *Vaccinium vitis-idaea* subsp. *minus* (2–3 cm). Herbs are scarce, with total cover up to 5 %. The ground layer is formed by dense sod of green mosses, primarily *Dicranum elongatum*, *D. laevidens* and *Polytrichum strictum*.

**Table 8.** Synoptic table. Associations of mire vegetation in the lower Indigirka River basin (southern tundra subzone, Yakutia): 1–2 – *Hamatocauli vernicosi*–*Caricetum stantis*, 3–5 – *Meesio triquetri*–*Caricetum chordorrhizae*, 6 – *Ranunculo pallasi*–*Caricetum chordorrhizae*, 7 – *Ranunculo pallasi*–*Caricetum stantis*, 8–10 – *Sphagno orientalis*–*Caricetum stantis*, 11–13 – *Sphagno obtusi*–*Caricetum stantis*, 14–16 – *Salici fuscescentis*–*Sphagnetum squarrosi*, 17 – *Sphagno fimbriati*–*Salicetum pulchrae*, 18–19 – *Ledo decumbentis*–*Eriophoretum vaginati*, 20–21 – *Dicrano laevidentis*–*Betuletum exilis*.

Clusters number in the Fig. 7	1.1.	1.2.	2a	2b	2c	3	4	5.1a	5.1b	5.2.	6a	6b	6c	7.1a	7.1b	7.2.	8	9.1.	9.2.	10.1.	10.2.
Syntaxon nr. in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
<b>Diagnosis species of the ass. <i>Hamatocauli vernicosi</i>–<i>Caricetum stantis</i></b>																					
<i>Hamatocaulis vernicosus</i>	V	IV	II	II	1	.	I	I	.	III	.	.	.	.	.	.	.	.	.	.	.
<i>Campylopus stellatum</i>	V	V	I	.	2	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.
<i>Saxifraga birculus</i>	V	V	I	I	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cinclidium latifolium</i>	IV	V	II	II	2	.	.	I	.	I	.	.	.	.	.	.	.	.	.	.	.
<i>Polemonium acutiflorum</i>	V	III	.	.	.	.	.	.	.	.	.	.	.	II	III	II	.	.	.	.	.
<i>Saxifraga cernua</i>	V	III	II	I	.	IV	.	I	I	II	r	I	II	II	I	r	I	.	.	.	.
<i>Bryum pseudotriquetrum</i>	V	III	II	II	2	I	II	.	I	I	.	.	.	.	.	.	.	.	.	.	.
<b>Diagnosis species of the subass. <i>Hamatocauli vernicosi</i>–<i>Caricetum stantis calamagrostietosum neglecti</i></b>																					
<i>Calamagrostis neglecta</i>	V	r	r	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Stellaria palustris</i>	V	II	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Brachythecium mildeanum</i>	V	II	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Calliergon giganteum</i> subsp. <i>sibiricum</i>	V	II	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Peltigera leucophlebia</i>	IV	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Plagiommium curvatulum</i>	V	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Chrysosplenium sibiricum</i>	IV	II	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Calliergon cordifolium</i>	IV	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Brachythecium boreale</i>	IV	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Warnstorfia pseudostraminea</i>	IV	II	.	.	.	.	.	.	.	.	.	.	II	.	.	II	.	.	.	.	.
<i>Drepanocladus polygamus</i>	III	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<b>Diagnosis species of the subass. <i>Hamatocauli vernicosi</i>–<i>Caricetum stantis typicum</i></b>																					
<i>Salix reptans</i>	.	IV	.	.	.	.	.	I	.	II	.	.	.	.	.	.	.	.	.	.	.
<i>Calliergon richardsonii</i>	I	IV	I	II	1	.	.	.	I	II	.	.	.	.	.	.	.	.	.	.	.
<i>Bistorta vivipara</i>	.	IV	I	II	1	.	.	I	.	II	.	.	r	r	.	.	.	.	.	.	.
<i>Carex marina</i>	I	III	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Minuartia stricta</i>	II	III	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Pedicularis sceptrum-carolinum</i>	II	III	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<b>Diagnosis species of the ass. <i>Meesio triquetri</i>–<i>Caricetum chordorrhizae</i></b>																					
<i>Pseudocalliergon brevifolium</i>	III	V	IV	IV	2	.	.	.	.	III	.	.	.	.	.	.	.	.	.	.	.
<i>Saxifraga radiata</i>	III	II	II	II	1	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.
<i>Scorpidium scorpioides</i>	.	.	III	I	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<b>Diagnosis species of the ass. <i>Ranunculo pallasi</i>–<i>Caricetum chordorrhizae</i></b>																					
<i>Saxifraga foliolosa</i>	III	III	III	II	1	V	II	I	I	II	I	I	.	II	.	.	I	.	.	.	.
<i>Scapania paludicola</i>	.	.	III	II	.	V	.	I	I	III	.	.	.	.	.	.	II	.	r	.	.
<b>Diagnosis species of the ass. <i>Ranunculo pallasi</i>–<i>Caricetum stantis</i></b>																					
<i>Ranunculus pallasi</i>	.	.	I	I	1	V	V	.	.	I	.	.	.	.	.	.	.	.	.	.	.
<i>Hamatocaulis lapponicus</i>	.	.	.	.	1	III	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<b>Diagnosis species of the ass. <i>Sphagno orientalis</i>–<i>Caricetum stantis</i></b>																					
<i>Sphagnum orientale</i>	.	r	IV	V	3	I	I	V	V	V	.	II	II	II	II	r	I	.	.	.	.
<i>Salix fuscescens</i>	.	III	III	IV	.	.	.	IV	IV	V	III	IV	V	V	V	IV	II	.	r	.	IV
<b>Diagnosis species of the ass. <i>Sphagno obtusi</i>–<i>Caricetum stantis</i></b>																					
<i>Sphagnum obtusum</i>	.	r	.	.	.	.	.	IV	V	II	V	V	V	V	III	II	IV	.	.	.	II
<i>Eriophorum russeolum</i>	.	I	II	II	3	I	IV	IV	IV	II	V	IV	V	II	.	.	.	.	.	.	.
<b>Diagnosis species of the ass. <i>Salici fuscescentis</i>–<i>Sphagnetum squarrosi</i></b>																					
<i>Sphagnum squarrosus</i>	I	r	I	I	.	.	II	III	II	I	IV	V	V	V	V	V	V	.	.	.	III
<i>Polytrichum jensenii</i>	.	.	III	II	.	.	II	II	II	I	II	II	II	IV	IV	III	II	.	II	.	II
<i>Sphagnum talbotianum</i>	.	.	.	.	.	.	.	.	.	.	r	II	II	III	II	IV	III	.	.	.	II
<i>Ranunculus lapponicus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	II	III	V	.	.	.	.	II
<i>Pyrola rotundifolia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	II	III	IV	.	.	.	r	V
<i>Sphagnum arcticum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	III	.	.	II	.	.
<b>Diagnosis species of the ass. <i>Sphagno fimbriati</i>–<i>Salicetum pulchrae</i></b>																					
<i>Sphagnum fimbriatum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	I	r	IV	V	.	.	.	.
<i>Sphagnum teres</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	r	I	II	V	.	.	.	.
<i>Straminergon stramineum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	II	V	.	II	.	.
<i>Pseudobryum cinclidioides</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	IV	.	.	.	.
<b>Diagnosis species of the <i>Caricion stantis</i></b>																					
<i>Meesia triquetra</i>	V	V	V	V	4	V	III	II	III	V	.	r	.	.	.	.	.	.	.	.	.
<i>Aneura pinguis</i>	I	II	IV	IV	3	V	II	.	.	III	.	.	.	.	.	.	.	.	.	.	.
<i>Bryum neodamense</i>	.	II	IV	I	1	IV	IV	.	I	I	.	.	.	.	.	.	.	.	.	.	.
<i>Scorpidium revolvens</i>	III	V	V	V	3	.	IV	II	II	IV	.	.	.	.	.	.	.	.	.	.	.
<i>Mesoptychia rutheana</i>	.	III	II	III	1	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.
<i>Carex aquatilis</i> subsp. <i>stans</i>	V	V	V	V	4	V	V	V	V	V	V	V	V	V	V	IV	V	IV	r	.	II
<i>Pedicularis sudetica</i>	.	IV	II	V	1	.	II	II	IV	II	III	II	III	IV	IV	IV	I	.	.	.	II
<i>Cinclidium subrotundum</i>	IV	I	IV	III	1	III	III	.	III	II	r	I	r	r	r	.	.	.	.	.	.
<i>Rumex arcticus</i>	II	III	II	III	1	.	.	I	III	I	r	II	II	II	IV	r	.	.	.	.	.
<i>Caltha arctica</i>	.	II	r	II	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<b>Diagnosis species of the <i>Scheuchzerio</i>–<i>Caricetea nigrae</i></b>																					
<i>Comarum palustre</i>	V	IV	IV	III	2	III	III	IV	IV	IV	IV	V	V	IV	IV	II	III	.	.	.	.
<i>Carex chordorrhiza</i>	.	II	V	V	4	V	V	IV	V	V	II	II	II	.	r	.	.	.	.	.	.
<i>Eriophorum angustifolium</i>	V	II	I	II	1	.	III	I	.	I	IV	III	III	II	I	r	.	.	.	.	.
<i>Epilobium palustre</i>	V	II	III	II	1	V	III	.	I	I	.	.	.	.	.	.	.	.	.	.	.
<b>Species common to associations drainage habitat of the classes <i>Scheuchzerio</i>–<i>Caricetea</i> and <i>Oxycocco</i>–<i>Sphagnetea</i></b>																					
<i>Salix pulchra</i>	.	III	.	.	.	.	.	I	I	.	I	.	.	III	V	V	V	I	V	V	V
<i>Calamagrostis holmii</i>	.	II	I	I	.	.	.	.	I	I	r	III	r	IV	V	V	IV	V	IV	V	V
<i>Aulacomnium turgidum</i>	I	r	II	II	1	.	.	I	III	III	I	III	IV	IV	V	V	IV	V	V	V	V
<b>Diagnosis species of the ass. <i>Ledo decumbentis</i>–<i>Eriophoretum vaginati</i> and subass. <i>sphagnetosum lenense</i></b>																					
<i>Eriophorum vaginatum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	V	III	I

Table 8. Continued.

Syntaxon nr. in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
<i>Sphagnum lenense</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	V	.	.	
<i>Sphagnum balticum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	V	.	.	
<i>Rubus chamaemorus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	III	.	.	
<i>Sphagnum capillifolium</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	IV	I	.	
<b>Diagnosis species of the ass. Ledo decumbentis–Eriophoretum vaginati subass. typicum</b>																						
<i>Aconogonon tripterocarpon</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	I	.	
<i>Hylacomium splendens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	III	.	IV	II	II	II	
<i>Cetraria islandica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	IV	II	II	
<i>Stereodon bolmenii</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	II	III	
<i>Sphenolobus minutus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	III	.	
<i>Lophozia murmanica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	II	.	
<i>Dactylina arctica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	III	II	.	
<b>Diagnosis species of the ass. Dicrano laevidentis–Betuletum exilis</b>																						
<i>Dicranum elongatum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	V	V	
<i>Aulacomnium palustre</i>	V	II	.	.	1	.	.	.	.	.	.	I	.	II	.	r	III	II	III	V	V	
<i>Peltigera aphthosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	III	IV	
<b>Diagnosis species of the subass. Dicrano laevidentis–Betuletum exilis ledetosum decumbentis</b>																						
<i>Cladonia amaurocraea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	I	
<i>Ptilidium ciliare</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	IV	I	
<i>Lophozia silvicola</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	I	
<i>Cladonia sp.</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	III	I	
<b>Diagnosis species of the subass. Dicrano laevidentis–Betuletum exilis typicum</b>																						
<i>Tomentypnum nitens</i>	.	I	.	.	.	.	.	.	.	.	.	.	.	I	II	III	I	.	II	I	V	
<i>Sanionia uncinata</i>	I	r	.	.	.	.	.	.	.	.	.	.	.	I	.	II	.	.	I	I	III	
<i>Plagiothecium berggrenianum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	II	III	
<i>Pedicularis labradorica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	I	r	r	.	.	II	.	III	
<i>Sphagnum aongstroemii</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	I	r	I	.	.	II	I	III	
<b>Diagnosis species of the Rubo chamaemori–Dicranion elongati and Rubo chamaemori–Cladonietalia arbusculae</b>																						
<i>Betula nana</i> subsp. <i>exilis</i>	.	II	.	.	.	.	.	I	.	I	II	I	II	III	r	III	V	IV	V	V	V	
<i>Ledum palustre</i> subsp. <i>decumbens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	I	.	V	V	V	II
<i>Polytrichum strictum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	.	V	III	V	V
<i>Dicranum laevidens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	I	r	I	.	.	III	V	V	V
<i>Orthocaulis binsteadii</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	V	V	I
<i>Vaccinium vitis-idaea</i> subsp. <i>minus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	V	IV	II
<i>Flavocetraria cucullata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	V	V	.
<b>Other species</b>																						
<i>Luzula wahlenbergii</i>	.	I	II	III	1	II	.	II	I	II	II	r	II	III	.	.	.	.	.	.	III	
<i>Arctagrostis latifolia</i>	III	II	.	.	.	.	I	II	I	.	r	II	II	II	III	III	.	.	III	III	III	
<i>Hierochloa pauciflora</i>	I	II	I	II	.	.	.	II	I	I	r	II	II	II	r	I	.	.	.	.	.	
<i>Cephalozia</i> sp.	.	.	II	II	1	III	II	.	I	I	.	.	.	.	.	.	.	.	.	.	.	
<i>Cephalozia uncinata</i>	.	.	r	.	.	.	II	.	I	II	.	.	.	r	.	II	.	.	.	.	.	
<i>Poblia nutans</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	II	I	.	II	II	I	
<i>Brachythecium turgidum</i>	III	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Brachythecium udum</i>	III	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

The number of species per sample plot is 13–29 (mean 20), in association 73, including 12 (16 %) highly constant.

**Distribution and ecology.** The communities are widespread in mires across the northern Yakutia, where they are common on convex frozen dry peat mounds, 30–35 (up to 60) cm high and 5–20 m in diameter, among flat waterlogged sedge-*Sphagnum* hollows within palsa-hollow (Fig. 1D) and palsa-hollow-polygonal mire complexes.

The surface of the frozen peat mounds is segmented by shallow grooves or deep frost cracks (up to 20 cm) into convex fragments 20–50 cm in diameter. The depth of seasonal frozen peat thawing is 20–30 cm.

**Note.** Communities, similar in terms of ecology and physiognomy, were previously reported from the Avam tundra in the southern Taymyr Peninsula (Konstantinova et al. 2023).

Based on differences in habitat conditions and species composition, two subassociations have been distinguished.

**Dicrano laevidentis–Betuletum exilis typicum subass. nov.** (Table 7, rel. 1–6; Table 8, syntaxon 21; Figs 1O, 4, 5, cluster 10.2)

**Holotypus:** relevé 1 (author's number – 009F23kt) in Table 7, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 10.07.2023, author I.V. Filippov.

**Diagnostic species:** *Luzula wahlenbergii*, *Pedicularis labradorica*, *Plagiothecium berggrenianum*, *Pyrola rotundifolia*, *Salix fuscescens*, *Sanionia uncinata*, *Sphagnum aongstroemii*, *Tomentypnum nitens*.

**Structure and composition.** Dense (40–85 %) low shrub layer (10–15 cm) is formed by *Betula nana* subsp. *exilis* and willow species (*Salix pulchra*, *S. fuscescens*). Herbs are sparse, with occasional occurrence of *Calamagrostis bolmii*, *Luzula wahlenbergii*, *Pedicularis labradorica* and *Pyrola rotundifolia*. The moss layer is dominated by *Dicranum elongatum*, *D. laevidens* and *Polytrichum strictum*, with small amount of *Aulacomnium palustre*, *A. turgidum*, *Sanionia uncinata*, *Sphagnum aongstroemii*, *S. squarrosum* and *Tomentypnum nitens*. Among lichens, only *Peltigera aphthosa* is highly constant.

The number of species per sample plot 18–29 (mean 22), in subassociation 52, including 12 (23 %) highly constant.

**Distribution and ecology.** This subassociation represents advanced stage of permafrost-induced peat mound development, characterized by slightly convex or dome-shaped surfaces up 40–60 (occasionally up to 80) cm in height. The combination of well-warmed upper peat layers and long-term frozen peat at the depth 20–25 cm maintains optimal soil moisture during the summer, leading to significant decomposition of the peat.

**Dicrano laevidentis–Betuletum exilis ledetosum decumbentis subass. nov.** (Table 7, rel. 7–22; Table 8, syntaxon 20; Figs 4, 5, cluster 10.1)

**Holotypus:** relevé 11 (author's number – 071E23kt) in Table 7, Republic of Sakha (Yakutia), Allaikhovskii District, Berelyokh River basin within the Yana-Indigirka Lowland, 12.07.2023, author E.D. Lapshina.

**Diagnostic species:** *Cladonia amaurocraea*, *Ledum palustre* subsp. *decumbens*, *Lophozia silvicola*, *Ptilidium ciliare*. Differential species comparing to the typical association include character taxa of the alliance and order the Rubo chamaemori–Cladonietalia arbusculae Lapshina et al. 2023: *Flavocetraria cucullata*, *Orthocaulis binsteadii* and *Vaccinium vitis-idaea* subsp. *minus*.

**Structure and composition.** Communities are characterized by the high constancy and often dominance of *Ledum palustre* subsp. *decumbens* within the dense, low shrub layer of *Betula nana* subsp. *exilis*. *Vaccinium vitis-idaea* subsp. *minus* (2–3 cm) is also highly constant and may be abundant. The herb layer is poorly developed, with total cover less than 0.5–3 %. The ground layer is dominated by green mosses, with consistent presence and cover between 1–5 % up to 60 % of lichens (*Cladonia* spp., *Dactylina arctica*, *Flavocetraria cucullata*, *Peltigera aphthosa*). Also constant are liverworts *Orthocaulis binsteadii*, *Ptilidium ciliare* and *Sphenobolus minutus*.

The number of species per sample plot is 13–27 (mean 20), in subassociation 52, including 14 (27 %) highly constant.

**Distribution and ecology.** The communities are typically developed on lower, flat to slightly convex frozen peat mounds, 30–40 cm above the surrounding wet depressions. The depth of seasonal frozen peat thawing is 25–30 cm.

**Note.** Physiognomically similar communities, with moss layers dominated by *Dicranum elongatum* and *Polytrichum strictum*, were previously described under the name *Betulo nanae*–*Dicranetum elongati* [Art. 2b, ICPN] in the southern tundra subzone in the Taymyr Peninsula (Zanokha 2007). However, the species composition of communities in the northern Yakutia differs substantially from those described earlier.

## DISCUSSION

Within the framework of the ecological-floristic classification, the phytocoenotic diversity of mire vegetation in the lower Indigirka River basin (southern tundra subzone in Yakutia) is represented by 10 associations, 10 subassociations, 12 variants and 2 community types within the classes Scheuchzerio–Caricetea nigrae and Oxycocco–Sphagneteta. Nine associations and eight subassociations are established as new, primarily due to the previously limited study of the area and the relatively high diversity of mire types.

### Prodromus of the mire vegetation in the lower Indigirka River Basin

#### Class

##### Order

##### Alliance / Suballiance

##### Association / Community type

##### Subassociations

##### Variant

Scheuchzerio–Caricetea Tx. 1937

Caricetalia nigrae Koch 1926

Caricion stantis Matveyeva 1994

Hamatocauli vernicosi–Caricetum stantis **ass. nov.**

typicum **subass. nov.**

calamagrostietosum neglecti **subass. nov.**

Ranunculo pallasi–Caricetum stantis **ass. nov.**

Community type *Eriophorum angustifolium*

Ranunculo pallasi–Caricetum chordorrhizae **ass. prov.**

Meesio triquetro–Caricetum chordorrhizae **ass. nov.**

typica

Sphagnum orientale

Scorpidium scorpioides

Salici fuscescentis–Sphagnion squarroso **all. nov.**

Sphagno orientalis–Caricetum stantis **ass. nov.**

typicum **subass. nov.**

typica

Sphagnum obtusum

meesietosum triquetri

Sphagno obtusi–Caricetum stantis **ass. nov.**

typica

Comarum paluste

Sphagnum squarrosum

Salici fuscescentis–Sphagnetum squarroso **ass. nov.**

typicum **subass. nov.**

typica

Sphagnum obtusum

sphagnetosum fimbriati **subass. nov.**

Sphagno fimbriati–Salicetum pulchrae **ass. nov.**

Scheuchzerietalia palustris Nordhagen ex Tx. 1937

Scheuchzerion palustris Nordhagen ex Tx. 1937

Caricion rariflorae Lavrinenko, Matveyeva et Lavrinenko 2016

Community type *Carex aquatilis* subsp. *stans*–*Sphagnum balticum*

Oxycocco–Sphagneteta Br.–Bl. et Tx. ex Westhoff et al. 1946

Rubo chamaemori–Cladonietalia arbusculae Lapshina et al. 2023

Sphagnion lenenses Lapshina 2023

Ledo decumbentis–Eriophoretum vaginati Lapshina in Lavrinenko et al. 2022

typicum

typica

Aconogonon tripterocarpum

sphagnetosum lenenses Lapshina et al. 2023

Rubo chamaemori–Dicranion elongati Lavrinenko O. et Lavrinenko I. 2015

Dicrano laevidentis–Betuletum exilis **ass. nov.**

typicum **subass. nov.**

ledetosum decumbentis **subass. nov.**

The ecological-floristic classification of mire vegetation in the region, developed in accordance with the principles of the Braun-Blanquet approach, largely corresponds to the preliminary assessment of mire typological diversity based on habitat conditions and general physiognomy. This correspondence is clearly demonstrated by the synoptic table (Table 8) and the cluster dendrogram of the identified syntaxa (Fig. 5), where three distinct clusters are distinguished.

Two of the clusters include all communities belonging to the class Scheuchzerio–Caricetea nigrae. The first group (Fig. 5, clusters 1–4) encompasses sedge and sedge-hypnum communities of the alliance Caricion stantis, which was suggested by Kholod (2007) to be placed within the order Caricetalia nigrae. This alliance was established in the Taymyr Peninsula and proposed for moss-rich mire communities in low-centred polygons of polygonal mires, around lakes and in wide flat or U-shaped stream valleys (Matveyeva 1994, 1998). Diagnostic species: *Caltha arctica*, *Calliergon giganteum* s. l., *Carex aquatilis* subsp. *stans*, *Drepanocladus arcticus*, *Dupontia fisheri*, *Hamatocaulis ver-*

*nicosus*, *Mesitptychia rutheana*, *Pedicularis sudetica* (Matveyeva 1994). We also consider *Cinclidium latifolium*, *C. subrotundum*, *Meesia triquetra*, *Rumex arcticus* and *Scorpidium revolvens* are worth to be added to this group.

Initially, the ass. *Meesio triquetris*–*Caricetum stantis* Matveyeva 1994, the nomenclatural type of the alliance, comprises all sedge-moss communities occurring in depressions with moist soils persisting throughout the entire growing season across the tundra zone in the Taymyr Peninsula. As a result, the diagnostic species of the association include the majority of species that regularly occur in waterlogged habitats throughout the tundra zone and characterize the alliance as a whole.

In the tundra mires in Yakutia, we describe the new ass. *Meesio triquetri*–*Caricetum chordorrhizae* **ass. nov.**, with three variants (Table 8, syntaxa 3–5; Fig. 5, clusters 2a, 2b). These communities are widespread and typically occur on low-centred polygons in rim-polygonal mires across numerous drained thermokarst lake basins (khasyreis) and along the margins of lakes on low river terraces. Ecologically and floristically, the new association is closely related to the previously described *Meesio triquetris*–*Caricetum stantis* Matveyeva 1994 in the Taymyr Peninsula. However, the similarity primarily reflects shared diagnostic species at the alliance level, while the full species set differs substantially.

More distinct floristic differences are in the ass. *Hamatocauli vernicosi*–*Caricetum stantis* **ass. nov.** (Table 8, syntaxa 1–2; Fig. 5, clusters 1.1, 1.2), whose communities establish in river floodplains under regular short-term flooding (subass. *calamagrostietosum neglecti*) or inundation by floodwaters (subass. *typicum*) and the ass. *Ranunculo pallasi*–*Caricetum chordorrhizae* **ass. prov.** (Table 8, syntaxon 6; Fig. 5, cluster 3), described in the periodically flooded hollows within *palsa*-hollow mire complex near the large lake within the drained thermokarst lake basin (khasyrei) and characterized by reduced species richness.

The ass. *Ranunculo pallasi*–*Caricetum stantis* **ass. nov.** (Table 8, syntaxon 7; Fig. 5, cluster 4) also belongs to this group of syntaxa. These communities develop in thermokarst depressions, deep waterlogged hollows and concave polygons of tundra mires, but they never cover extensive areas.

The second cluster of syntaxa (Fig. 5, clusters 5–8) comprises two physiognomically distinct groups of communities.

The first group includes associations *Sphagno orientalis*–*Caricetum stantis* **ass. nov.** (Table 8, syntaxa 8–10; Fig. 5, clusters 5.1a, 5.1b, 5.2) and *Sphagno obtusi*–*Caricetum stantis* **ass. nov.** (Table 8, syntaxa 11–13; Fig. 5, clusters 6a, 6b, 6c). These associations encompass mesotrophic and meso-oligotrophic sedge-*Sphagnum* communities that are developed in waterlogged polygons and hollows in rim-polygonal and flat-*palsa* mires. Both associations are widespread throughout the study region.

The second group consists of low willow-*Sphagnum* (*S. squarrosum*, *S. fimbriatum* cf.) communities of the ass. *Salici fuscescentis*–*Sphagnetum squarrosum* **ass. nov.**, represented by two subassociations and two variants (Table 8, syntaxa 14–16; Fig. 5, clusters 7.1a, 7.1b, 7.2). These communities occupy rims and relatively well-drained sites with seasonally thawed peat layer no deeper than 15–

20 cm in rim-polygonal mires. Although being widespread, they cover relatively small areas, as rims and drained sites generally account for no more than 30 % of the surface area of rim-polygonal mires.

Close to these communities is the comparatively rare ass. *Sphagno fimbriati*–*Salicetum pulchrae* **ass. nov.** (Fig. 5, cluster 8), which occurs exclusively on hanging mires at the sources of intermittent streams on the slopes of elevated landforms (*yedomas*).

The syntaxa of the second block occupy an intermediate position between the typical sedge-hypnum moss communities of the alliance *Caricion stantis*, occurring in wet hollows and shallow depressions of minerotrophic tundra mires and the vegetation of comparatively dry peat mounds of the class *Oxycocco*–*Sphagnetea*. They share with the former the constant presence of diagnostic species of the *Caricion stantis* – *Carex aquatilis* subsp. *stans*, *Cinclidium subrotundum*, *Pedicularis sudetica* and *Rumex arcticus* – as well as character species of the class *Scheuchzerio*–*Caricetea nigrae* – *Carex chordorrhiza*, *Comarum palustre*, *Epilobium palustre* and *Eriophorum angustifolium*. In contrast, only few widespread non-bog species – *Aulacomnium turgidum*, *Calamagrostis holmii*, *Salix fuscescens* and *S. pulchra* – shared with communities of the class *Oxycocco*–*Sphagnetea* show wide ecological amplitude (Table 8).

Distinctive feature of the *Sphagnum*-dominated communities of tundra mires within the class *Scheuchzerio*–*Caricetea nigrae* is the dominance of mesotrophic and meso-oligotrophic *Sphagnum* species, namely, *S. orientale*, *S. fimbriatum*, *S. squarrosum* and *S. obtusum*. These are regularly accompanied, though with lower constancy on relatively well-drained frozen sites, by *Sphagnum talbotianum*, *S. teres*, *S. girgensohnii*, *S. concinnum*, *S. olafii* and *S. arcticum*, none of which occur in the ombrotrophic communities of the class *Oxycocco*–*Sphagnetea*. Altogether, this confirms the clear affiliation of these communities with the class *Scheuchzerio*–*Caricetea nigrae*.

More difficulties arose in determining the place of the newly described associations of tundra mires, dominated by mesotrophic and meso-oligotrophic *Sphagnum* species, to the higher units of the subordinate level (alliance and order). Assigning these communities to the alliance *Caricion stantis* would result in highly heterogeneous group in both ecological and phytocoenotic terms.

Given their clear differences in habitat conditions, structure and species set from the typical sedge-hypnum communities traditionally included within the alliance *Caricion stantis*, we propose to place these in new alliance *Salici fuscescentis*–*Sphagnion squarrosum* **all. nov.** Due to the comparatively sparse shrub layer of low willows (with cover usually up to 25 %, rarely more) and the minor abundance of herbs, we place the dominant moss species, which determines the structure and physiognomy of these communities, in the second position in the alliance name.

#### **Salici fuscescentis**–**Sphagnion squarrosum** **all. nov.**

**Holotypus:** The nomenclatural type of the alliance is the ass. *Salici fuscescentis*–*Sphagnetum squarrosum* (Table 5, relevés 1–40, this study).

The alliance comprises sedge-*Sphagnum* and low willow-*Sphagnum* communities occurring on weakly concave polygons, rims, low ridges and relatively drained areas dominated by mesotrophic and meso-oligotrophic *Sphagnum* species. These communities are found in rim-polygonal mires and tundra-mire complexes in the southern tundra subzone in Asian Russia (Taymyr Peninsula and Yakutia).

**Diagnostic species:** *Salix fuscescens*, *Sphagnum squarrosum*, *S. concinnum*, *S. cf. fimbriatum*, *S. obtusum*, *S. orientale*, *S. talbotianum*, *S. teres*.

At the current stage of the tundra mire vegetation knowledge, the alliance includes the ass. *Salici fusciscentis*–*Sphagnetum squarrosum* **ass. nov.** with two subassociations (typicum and *sphagnetosum fimbriati*), as well as three additional associations: *Sphagno orientalis*–*Caricetum stantis* **ass. nov.** with two subassociations (typicum and *meesietosum triquetri*), *Sphagno obtusi*–*Caricetum stantis* **ass. nov.** (with three variants) and *Salici pulchrae*–*Sphagnetum fimbriati* **ass. nov.** In the future these associations may be assigned to different alliances within new circumpolar order that will unite the mire vegetation of the class *Scheuchzerio*–*Caricetea nigrae* in the tundra zone in Eurasia and North America.

Unlike minerotrophic mire vegetation, ombrotrophic hollow communities dominated by *Sphagnum* with exclusively atmospheric precipitation, belonging to the alliance *Scheuchzerion palustris* (suballiance *Caricenion rariflorae*) of the monotypic order *Scheuchzerietalia palustris*, class *Scheuchzerio*–*Caricetea nigrae* (Mucina et al. 2016), are extremely rare in the southern tundra subzone in Yakutia. Within the study area, this suballiance is so far represented by only two relevés, considered as community types, which are not shown in the cluster dendrogram and in the synoptic table.

The third cluster identified in the synoptic table and cluster dendrogram (Table 8, syntaxa 18–21; Fig. 5, clusters 9–10) corresponds to the class *Oxycocco*–*Sphagnetea*. In the southern tundra subzone in Yakutia, communities of this class occur on tussock dwarf shrub-cottongrass-*Sphagnum* bogs with peat layers 20–40 cm thick and on frozen peat mounds elevated 30–60 cm above adjacent waterlogged hollow surfaces in flat-palsa mires.

Two associations of this class were recorded in the study area, each assigned to different alliance – *Sphagnion lenenses* and *Rubo chamaemori*–*Dicranion elongati* – within the recently established order *Rubo chamaemori*–*Cladonietalia arbusculae* (Lapshina et al. 2023).

The alliance *Sphagnion lenenses* includes oligotrophic dwarf shrub-cloudberry-*Sphagnum* and dwarf-shrub-cottongrass-*Sphagnum* bogs dominated by *Sphagnum lenense* and *S. balticum*. Diagnostic species: *Aulacomnium turgidum*, *Dicranum laevidens*, *Eriophorum vaginatum*, *Orthocaulis binsteadii*, *Sphagnum balticum*, *S. lenense*.

In Yakutia, it is represented by the ass. *Ledo decumbentis*–*Eriophoretum vaginati* with two subassociations (Table 8, syntaxa 18–19; Fig. 5, clusters 9.1, 9.2). The communities of the subass. *sphagnetosum lenenses* show consistent physiognomy across northern West Siberia, southern Taymyr Peninsula and the southern

tundra subzone in Yakutia, occurring sporadically on low frozen *Sphagnum* mounds or along the margins of larger peat mounds in flat-palsa mires.

It is more difficult to identify dwarf shrub-cottongrass-*Sphagnum* communities of the subass. *Ledo decumbentis*–*Eriophoretum vaginati* typicum and to differentiate them from tussock cottongrass stands on clay soils within zonal vegetation of the class *Carici arctisibiricae*–*Hylocomietea alaskani* Matveyeva et Lavrinenko 2023 (Table 6, syntaxa 4–8), widespread across the tundra zone in Asia and Alaska.

For such zonal tundra stands on the uplands of Alaska, the ass. *Sphagno*–*Eriophoretum vaginati* Walker M., Walker D. et Auerbach 1994 (Walker et al. 1994) [Art. 3g ICPN] was described. Unlike cottongrass stands on interfluvial sites, cottongrass-*Sphagnum* bogs are developed on peat soils and are characterized by continuous cover of oligotrophic *Sphagnum* mosses (*S. lenense*, *S. balticum*), consistent presence of *Rubus chamaemorus* and the absence of most species typical of zonal cottongrass and dwarf shrub-lichen-moss tundra stands (Table 6, syntaxa 9–19). Only few zonal tundra moss and lichen species extend into the cottongrass-*Sphagnum* bogs.

The syntaxonomic position of the new ass. *Dicrano laevidentis*–*Betuletum exilis* **ass. nov.**, including two subassociations (typicum and *ledetosum decumbentis*) (Table 8, syntaxa 20–21; Fig. 5, clusters 10.1, 10.2), remains somewhat uncertain. This association comprises dwarf birch-green moss (*Dicranum* spp., *Polytrichum strictum*) communities occurring on dry peat mounds within flat-palsa mire complexes.

At the current stage, we assign these communities to the alliance *Rubo chamaemori*–*Dicranion elongati*, due to presence of some diagnostic species of this alliance and the order *Rubo chamaemori*–*Cladonietalia arbusculae*.

The alliance *Rubo chamaemori*–*Dicranion elongati* includes oligotrophic dwarf shrub-cloudberry-moss (*Dicranum* spp., *Polytrichum strictum*) and dwarf birch-moss-lichen communities of palsa and polygonal mires in the southern tundra subzone in Eurasia (Lavrinenko & Lavrinenko 2015). Diagnostic species: *Andromeda polifolia* subsp. *pumila*, *Betula nana*, *Cetraria islandica*, *Cladonia arbuscula*, *Dicranum elongatum*, *Empetrum hermaphroditum*, *Flavocetraria nivalis*, *Ledum palustre* subsp. *decumbens*, *Polytrichum strictum*, *Rubus chamaemorus*, *Vaccinium vitis-idaea* subsp. *minus*, *V. uliginosum* subsp. *microphyllum*.

The ass. *Dicrano laevidentis*–*Betuletum exilis* **ass. nov.** is characterized by the absence of oligotrophic *Sphagnum* species and *Rubus chamaemorus* and the presence of tundra herbs, mosses and liverworts non typical for mire vegetation (Table 8, syntaxa 20–21).

Similar peat mound communities, lacking the main diagnostic features (presence of *Sphagnum* species), previously were assigned either to the alliance *Rubo chamaemori*–*Dicranion elongati* (Lavrinenko & Lavrinenko 2015) or to the class *Oxycocco*–*Sphagnetea* without alliance placement (Zanokha 2007), awaiting further clarification as more data becomes available.

The full set of relevés was ordinated in multidimensional space using t-distributed stochastic neighbor embedding (t-SNE) (Fig. 4). A dendrogram based on hierarchical clustering was constructed to assess the similarity among the syntaxa, revealing three major community groups (Fig. 5).

The first two clusters encompass all syntaxa of the class Scheuchzerio–Caricetea nigrae. They include typical sedge-hypnum moss communities of the alliance Caricion stantis in its original concept (Matveyeva 1994, 1998), as well as sedge-*Sphagnum* communities (*Sphagnum obtusum*, *S. orientale*) of waterlogged hollows and low willow-*Sphagnum* communities (*S. squarrosum*, *S. fimbriatum* agg.) on rims and in relatively drained sites with depth of seasonal frozen peat thawing 15–20 cm, assigned to the newly proposed alliance Salici fuscescentis–Sphagnion squarrosum **all. nov.**

Communities of both alliances are widespread in the region, occupying most of the areas of rim-polygonal and partially flat-palsa mires.

A third cluster comprises vegetation of the class Oxycocco–Sphagnetea, including frozen cottongrass-*Sphagnum* bogs of the alliance Sphagnion lenenses found at the footslopes, flat depressions among zonal tundra stands and on low peat mounds of flat-palsa bogs. Dwarf birch-green moss communities on dry frozen peat mounds, preliminarily assigned to the alliance Rubo chamaemori–Dicranion elongati, are also included in this cluster.

## CONCLUSIONS

The mire vegetation of the southern tundra subzone in the lower Indigirka River basin (Yakutia) was classified based on 280 relevés. We distinguished 10 associations, 10 subsociations, 12 variants and 2 community types, assigned to three alliances (Caricion stantis, Salici fuscescentis–Sphagnion squarrosum and Scheuchzerion palustris) within the class Scheuchzerio–Caricetea nigrae and two alliances (Sphagnion lenenses and Rubo chamaemori–Dicranion elongati) within the class Oxycocco–Sphagnetea. Nine associations (one provisionally) and eight subsociations are newly described. New alliance, Salici fuscescentis–Sphagnion squarrosum, is established to encompass sedge-*Sphagnum* and low willow-*Sphagnum* communities dominated by mesotrophic and mesooligotrophic species (*Sphagnum* cf. *fimbriatum*, *S. obtusum*, *S. orientale*, *S. squarrosum*) on rim-polygonal mires and tundra-mire complexes in the southern tundra subzone in Asian Russia.

The syntaxonomic position of dwarf birch-green moss communities of dry frozen peat mounds within the class Oxycocco–Sphagnetea is discussed. These communities are distinguished by the absence of *Sphagnum* mosses – a key diagnostic feature of the class. In future, as more data are accumulated, the structure of higher syntaxonomic units of tundra mire vegetation at the level of alliances and orders may be revised and refined.

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