Species composition of mosses of wetland ecosystems of the Bolonsky Reserve

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Abstract. This paper presents the data on the moss species diversity in wetlands of the Bolonsky State Nature Reserve. The spectrum includes 45 species from 18 genera, 15 families and 5 orders belonging to Polytrichopsida, Bryopsida and Sphagnopsida classes. The Polytrichopsida class includes 3 species, Bryopsida – 19 species and Sphagnopsida – 23 species. The most numerous in species composition was the Sphagnaceae family.

1. Introduction
Mosses play an important role in the composition and functioning of the vegetation cover in wetland ecosystems; they are often dominants of the ground cover and edificators of various phytocenoses. Therefore, the identification of the species composition of the moss flora enables to more accurately identify the state of wetland ecosystems and further take measures for their protection and restoration.

The material for this study was mosses collected during field works in 2017–2020 in the eastern part of the Bolonsky nature reserve (between the Simmi and Amur rivers). The Bolonsky reserve is located in the northeastern part of the Middle Amur lowland within two municipal districts of Khabarovsk Territory – Amur and Nanay. Its territory belongs to the basin of the Bolon lake and covers mainly the lower part of the Simmi river basin, as well as part of the lake coast.

This is the lowest part of the plain with prevailing absolute heights from 22 to 26 m and elevations on average no more than 3 m. The territory is characterized by a combination of a low floodplain, inter-floodplain graded spaces and rises. 80% of the territory is occupied by mires and wet meadows. Water-logged reed and sedge-reed meadows, eutrophic sedge-reed and sedge fens are widespread here [1, 2, 3].

The nature of the relief is determined by the accumulative activity of the Amur river, with which the lake is connected [2, 4].

Another important factor that contributes to waterlogging of the upper horizons of the soil cover and bogging of this territory is the climate and its monsoon nature. In winter periods, characterized by low temperatures and a small snow cover (about 50 mm of precipitation in the cold half of the year), there is a strong freezing of soils – up to 2 m and deeper. Thawing continues until mid-June, and in mires until early August. In some areas, the permafrost may persist during the entire warm period.

One of the serious anthropogenic factors affecting the state of the plant communities of the wetlands in the reserve is periodic fires that contribute to the depletion of the biological diversity of ecosystems, as a result of which some species may disappear before they are identified here. Therefore, the purpose...
of this study was to identify the floristic diversity of bryophytes most vulnerable to anthropogenic impact of wetland ecosystems.

2. Materials and Methods
To identify the floristic diversity of wetland ecosystems and identify the boundaries (contours) of phytocenoses, the route method of geobotanical descriptions according to pre-planned transects in key areas was used (Fig. 1). The boundaries of phytocenoses were fixed using a GPS navigator Etrex vista HCx by recording the exact geographic coordinates. A detailed geobotanical description was done within the boundaries of the contours of each phytocenosis, indicating the floristic composition and projective cover for each layer and species.

![Figure 1. Field research routes, 2017–2020](image)

Cameral processing of floristic materials included processing of herbarium specimens with the subsequent generalization of observations, compilation and refinement of floristic lists.

In the process of working and describing specific wetland facies, the author collected difficult-to-identify groups of plants, rare and interesting species. In total, more than 200 herbarium specimens of higher plants and bryophytes have been collected. The species of vascular plants and moss-like plants were identified in laboratory conditions using the comparative anatomical and morphological method. A number of bryophyte specimens were tested Dr. Biol. M. S. Ignatov (Main Botanical Garden of the RAS named after N. V. Tsitsin).

The names of species of various taxonomic groups of plants are given in accordance with the modern academic data for these groups [5, 6].

3. Results and Discussion
In the vegetation cover of the floodplain boggy reed and sedge-reed meadows, which occupy a significant area, there is a slight presence of hypnum mosses Warnstorffia fluitans, Climacium dendroides and Leptodictyum riparium.

On sedge and sedge-reed fens, represented by flowing hollows on the floodplain or runoff hollows on low terraces above the floodplain, the projective cover of mosses does not exceed 25%. Here, on the sides of hummocks and in inter-hummock depressions, eutrophic species of sphagnum mosses dominate: S. squarossum or S. subsecundum. The eutrophic-mesotrophic S. palustre, S. contortum and the
mesotrophic *S. jensenii*, *S. flexuosum* are much less common. *Aulacomnium palustre* and *Polytrichum strictum* are common on hummocks.

In the ground cover of a sedge-reed fen, located on the high floodplain of the estuarine part of the Khylga river – a small tributary of the lake in the northeastern part of the reserve, *Sasaokaea aomoriensis* patches were found [7]. This species has long been considered endemic to Japan, where it was recorded on the islands of Kyushu and Honshu [8, 9]. Recently, the species was also found on Jeju (South Korea) and Taiwan islands [10]. In Russia it’s only known location is in the south of Primorsk Territory on Furugelm island in the Peter the Great Bay [11]. Due to the extremely limited range of this species, it is necessary to further study and take into account its habitats on the territory of the Bolonsky Reserve and study its ecology.

Sphagnum-dwarf-shrub-sedge and sphagnum-dwarf-shrub-cotton-grass fens are found on terraces above the floodplain in more watered areas of inter-rise spaces. Here, mosses cover up to 60% of the surface. The moss layer of sedge-sphagnum phytocenoses is dominated by hydrophilic eutrophic species *S. inundatum*, *S. subsecundum*, *S. platyphyllum*, and eutrophic-mesotrophic *S. palustre* and *S. contortum*. *S. imbricatum* and *S. divinum* are less common. In the ground cover of shrub-cotton grass-sphagnum phytocenoses, mesotrophic *S. flexuosum* is predominant; *S. subsecundum*, *S. fallax*, *S. palustre*, *S. jensenii* are much less common.

Bogbean (quaking) mires are represented in heavily watered runoff hollows, cauldrons, along the channels of intra-boggy watercourses and occupy an insignificant area on the territory of the reserve. The moss cover here covers up to 40–50% of the area and consists mainly of hypnum mosses: *Campylium stellatum* and *Drepanocladus polygamus* with a total cover of at least 25–30%. Of the sphagnum mosses, *S. inundatum* prevails here (up to 15%). *S. jensenii* and *S. flexuosum* are much less common.

Ridge-hollow mire complexes with alternation of wide flooded hollows (30–100 m wide) and elevated ridges (10–20 m wide, 300–500 m long, no higher than 25–40 cm) are common in runoff hollows in the upper and middle reaches of the Selgon river. On the ridges, the moss layer with a projective cover of 40–60% is represented mainly by sphagnum mosses dominated by *Sphagnum divinum* in mixed sods with *Sphagnum subfulvum*, *Sphagnum centrale*, *Aulacomnium palustre*, and *Polytrichum commune*. *S. fuscum* is found along the highest edge of the ridges. Along the rim of the ridges, the synusia of *Sphagnum inundatum*, *Sphagnum palustre*, and *Pohlia nutans* were noted at low levels. *Ceratodon purpureus* was noted on the burned-out areas. In the hollows, there are forb-sedge communities without mosses.

Below is a list of leafy mosses of the Bolonsky State Reserves. The names of the species are given in accordance with the “Flora of mosses in the middle part of European Russia” [3, 4].

**POLYTRICHOPSIDA** Ochyra, Żarnowiec & Bednarek-Ochyra.
**POLYTRICHALES** M. Fleisch

**Polytrichaceae** Schwägr.
1. *Polytrichum commune* Hedw.
2. *Polytrichum juniperinum* Hedw.
3. *Polytrichum strictum* Menzies ex Brid.

**BRYOPSIDA** Horan.
**HYPNALES** Dumort.

**Climaciaceae** Kindb.
4. *Climacium dendroides* (Hedw.) F. Weber & D. Mohr
5. *Warnstorfia fluitans* (Hedw.) Loeske
6. *Warstorfia exannulata*

**Brachitheciaeae** Schimp.
7. *Brachythecium mildeanum* (Schimp.) Schimp.
8. *Brachythecium rivulare* Schimp.
9. *Myuroclada maximowiczii* (G.G. Borschh.) Steere & W.B. Schofield
Pylaiisaeae Schimp.
10. Calliergonella cuspidata (Hedw.) Loeske

Amblystegiaceae G. Roth.
11. Campylium stellatum (Hedw.) C.E.O. Jensen
12. Drepanoclados aduncus (Hedw.) Warnst.
13. Leptodictyum riparium (Hedw.) Warnst.
14. Drepanoclados polygnus

Leskeaceae Schimp.
15. Sasaokaea aomoriensis (Paris) Kanda

Thuidiaceae Schimp.
16. Helodium blandowii (Web. Et Mohr.) Warnst.

BRYALES Limpr.

Bryaceae Schwagr.
17. Bryum creberrimum Taylor

Mielichhoferiaceae Schimp.
18. Pohlia nutans (Hedw.) Lindb.

Aulacomniaceae Schimp.
19. Aulacomnium palustre (Hedw.) Schwägr.

Mniaceae Schwägr.
20. Plagiommium cuspidatum (Hedw.) T.J. Kop.

DICRANALES H.Philib. ex M.Fleisch.

Ditrichaceae Limpr.
21. Ceratodon purpureus (Hedw.) Brid.

Dicranaceae Schimp.
22. Dicranella sp.

SPHAGNOPSIDA Schimp.
SPHAGNALES C. Martius

Sphagnaceae Martynov

Section Sphagnum
23. Sphagnum centrale C.E.O. Jensen
24. Sphagnum divinum Flatberg & Hassel
25. Sphagnum imbricatum Hornsch. ex Russow
26. Sphagnum palustre L.

Section Cuspidata
27. Sphagnum angustifolium (C. Jens. ex Russ.) C. Jens.
28. Sphagnum balticum (Russ.) Russ. ex C. Jens
29. Sphagnum cuspidatum Ehr. ex Hoffm.
30. Sphagnum cuspidatum Ehrh. ex Hoffm.
31. Sphagnum fallax H. Klinggr.
32. Sphagnum flexuosum Dozy & Molk.
33. Sphagnum jensenii H. Lindb.
34. Sphagnum obtusum Warnst.
35. Sphagnum riparium Ångström

Section Subsecunda
36. Sphagnum platyphyllum (Lindb.) Warnst.
37. Sphagnum inundatum Russow
38. Sphagnum subsecundum Nees.
39. *Sphagnum contortum* Schultz
40. *Sphagnum denticulatum* Brid.

Section Acutifolia
41. *Sphagnum fimbriatum* Wilson
42. *Sphagnum subfulvum* Sjoers
43. *Sphagnum fuscum* (Schimp.) Klinggr.
44. *Sphagnum capillifolium* (Ehrh. Hedw.

Section Squarrosa
45. *Sphagnum squarrosum* Crome

4. Conclusion
Thus, the species list of mosses of the vegetation cover of wetland ecosystems of the reserve is represented by 45 species of leafy mosses belonging to 18 genera, 15 families, 5 orders, and 3 classes of *Polytrichopsida*, *Bryopsida*, and *Sphagnopsida*. The *Polytrichopsida* class includes 3 species, *Bryopsida* – 19 species, and *Sphagnopsida* – 23 species. The most numerous in terms of species composition turned out to be the *Sphagnaceae* family (23 species).

It should be noted that fires on the territory of the reserve cause significant damage to the most vulnerable component of the vegetation cover of the reserve’s wetlands – the moss layer. The sods of sphagnum mosses are especially susceptible to the pyrogenic influence. On the wetlands effected by the fire, rare regenerations of sphagnum mosses were observed only in the flooded inter-hummock depressions. The impact of fires on the wetland phytocenoses of the reserve leads to the degradation of the moss cover and the loss of non-dominant species, stimulates the growth of bushes and shrubs, which ultimately results in a significant change in the structure and functioning of wetland ecosystems.

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References
[1] Anisimov V M 1973 Typology of mires in the North-Eastern part of the Middle Amur lowland. *Issues of the geography of the Far East* (Khabarovsk: Printing house No. 1 of the Regional Printing Office) 14 pp 67–72
[2] Prozorov Yu S 1985 *Patterns of development, classification and use of mire biogeocenoses* (Moscow: Nauka)
[3] Prozorov Yu S and Popov A A 1962 Soils of mari of the Middle Amur lowland and their genesis *Proceedings of the 1st Siberian Conference of Soil Scientists* pp 274–83
[4] Makhinov A N 2006 *Modern relief formation under conditions of alluvial accumulation* (Vladivostok: Dalnauka)
[5] Ignatov M S and Ignatova E A 2003 *Moss flora of the middle part of European Russia* (Moscow: KMK Scientific Publishing Association)
[6] Ignatov M S and Ignatova E A 2004 *Moss flora of the middle part of European Russia* (Moscow: KMK Scientific Publishing Association)
[7] Kuptsova V A et al. 2018 Finding *Sasaokaea aomoriensis* (Leskeaceae, Bryophyta) in the Bolonsky Nature Reserve (Russian Far East) *Russ. Bot. J*. 103(2) pp 249–55
[8] Noguchi A 1961 Notes on Japanese *Musci J. Jap. Bot.* 36(4) pp 113–7
[9] Noguchi A 1991 *Illustrated moss flora of Japan* Pt. 4. (Japan, Nichinan: Hattori Botanical Laboratory) pp 743–1012
[10] Yoon Y J, Tan B C and Sun B Y 2015. Seven new records of overlooked South Korean moss species *Hattoria* 6 pp 57–61

[11] Gorobets K V 2004 *The flora of leafy mosses of the Murav’ov-Amursky Peninsula and the islands of the Peter the Great Bay (Primorsk Territory)* Author’s abstract. Vladivostok