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On the bryophyte diversity of black alder forests in the Republic of Bashkortostan (the Southern Urals region)

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Abstract. The bryophyte composition of monodominant black alder forests was studied in the Republic of Bashkortostan (the Southern Urals region). Fifty-six moss species and fifteen liverworts were recorded. The annotated species list with precise locations is provided. The bryophyte richness of studied communities is not very high because of waterlogging regime of habitats and rarity of these communities in the region. Forests occurring in habitats with short inundation time (mostly at small rivers and lake shores) are more than double rich in bryophytes, then communities located in river valleys with wide floodplain and in karst depressions, where staying water preserves for a long time during growing season. In investigated black alder forests, rare relict species (*Helodium blandowii*, *Tomentypnum nitens*, *Riccardia latifrons*, *Pseudobryum cinclidioides*) grow in small isolated populations at the southern limit of the species range. It is essential to improve the protection of these rare ecosystems in the future.

1. Introduction

Black alder (*Alnus glutinosa* (L.) Gaertn.) is native to most of Europe being a common species in forests along river and lake shores as well as in waterlogged sites at the edges of mires. In Russia, the northern limit of black alder range occurs across the northern and middle taiga along imaginary line from Petrozavodsk to Perm (Republic of Karelia, Arkhangelsk Region, Komi Republic). The southern border coincides with the steppe zone in Russia (the Republic of Kalmykia, Volgograd, Saratov and Orenburg Regions) and in the Northern Kazakhstan. The eastern border of range reaches the Trans-Urals and Western Siberia up to lower stream of Tobol River (Kurgan and Tymen Regions) [1]. Eastwards, in the Omsk Region, this species was early listed in the regional Red Data book, but currently is probably extinct [2].

In the Republic of Bashkortostan, *Alnus glutinosa* grow near the eastern border of range being much less common tree species than *Alnus incana* (L.) Moench. Monodominant black alder forests are quite rare, however, this species may be found as admixture in the understory of paludified birch forests in middle mountains of the Southern Urals, in the Ufa Plateau and the Bashkir Trans-Urals [3].

In the last decades, particular attention was paid to study of the bryophyte diversity in the forests of the Southern Urals where about 70 % of all bryophytes known in the republic were revealed. At the same time, little is known about bryophyte diversity in the paludified forests except data on vegetation of two nature protected areas [4, 5]. The paper with brief characteristic of the syntaxonomical position and habitat features of the Southern Urals forests belonging to the class *Alnetea glutinosae* Br.-Bl. et



R. Tx. ex Westhoff et al. 1946 did not cover in any detail the information on bryophyte richness in these communities [6].

This paper aimed to reveal and discuss bryophyte composition of black alder forests in the Republic of Bashkortostan.

2. Methods and Materials

Field work was carried out during 2013-2016. About 350 bryophyte specimens were sampled in black alder dominated forests.

In each stand, from one to five 400 m² plots were positioned to collect bryophytes from different habitat niches, i.e. the bark of living trees, roots of trees, the decaying wood, peat and mineral soil.

The specimens were identified with the microscopes Olympus CX31 and Altami SPM 0880. The nomenclature of species follows the last checklist of bryophytes of Europe [7].

The study area has continental climate with short warm summers and moderately cold winters. The average annual temperature varies from +0,5 - +3.5 °C, the frost-free period is 55–120 days in the plain areas and 50–80 days in the mountains. The average annual precipitation is 350–500 mm in the plains and 600–700 mm in the Southern Urals [8].

The collection sites are numbered as follow:

The Bashkir Fore-Urals:

1. Davlekanovsky district, 2 km NE from Kuryatmasovo Village. 54.2595 N, 54.5973 E, Alt 220 m Asl;
2. Mishkinskiy district, 1.5 km SE from Yandyganovo village. 55.3979 N, 55.9826E; Alt 100 m Asl;
3. Duvanskiy district, 2 km N from Arkaulovo Village. 55.4194 N, 57.9328 E. Alt 280 m Asl;
4. Iglinskiy district, 1.5 km S from Kaltymanovo village. 54.6943 N, 56.3940 E. Alt 160 m Asl;
5. Arkhangelskiy district, 2 km SW from Orlovka Village. 54.3215N, 56.5537E. Alt 100 m Asl;
6. Arkhangelskiy district, 5 km NE from Mikhailovka Village. 54.6308N, 57.1511E. Alt 140 m Asl.

The Bashkir Trans-Urals:

7. Abzelilovskiy district, 6.5 km SW from Khalilovo Village. 53.0332 N, 58.4538 E, Alt 440 m Asl;
8. Abzelilovskiy district, 2 km W from Khalilovo Village. 53.0538 N, 58.5245 E, Alt 400 m Asl;
9. Abzelilovskiy district, 2.5 km NE from Zelenaya polyana Village. 53.6218 N, 58.6507 E, Alt 440 m Asl;
10. Baimakskiy district, 0.5 km W from Turkmenevo-2 Village. 52.8561 N, 58.4817 E. Alt 420 m Asl.

3. Results and Discussion

In surveyed black alder forests 15 liverworts and 56 mosses were revealed. The list presents all species annotated with occurrence in the collection sites cited earlier.

Liverworts:

Adelanthaceae Grolle: *Syzygiella autumnalis* (DC.) K.Feldberg, Váňa, Hentschel et Heinrichs – 2.

Aneuraceae H.Klinggr.: *Riccardia latifrons* (Lindb.) Lindb. – 2.

Blepharostomataceae W.Frey&M.Stech: *Blepharostoma trichophyllum* (L.) Dumort. – 3.

Cephaloziaceae Mig.: *Cephalozia bicuspidata* (L.) Dumort. – 2;

Fuscocephaloziopsis connivens (Dicks.) Váňa et L.Söderstr. – 2;

Fuscocephaloziopsis lunulifolia (Dumort.) Váňa et L.Söderstr. – 2.

Geocalyceae H.Klinggr.: *Geocalyx graveolens* (Schrad.) Nees – 2.

Jungermanniaceae Rchb.: *Liochlaena subulata* (A.Evans) Schljakov – 2.

Lophocoleaceae Vanden Berghen: *Chiloscyphus pallescens* (Ehrh.) Dumort. – 7, 8;

Chiloscyphus polyanthos (L.) Corda – 1, 2, 7, 8;

Lophocolea heterophylla (Schrad.) Dumort. – 2, 3, 7, 9, 10;

- Lophocolea minor* Nees – 3, 7.
- Marchantiaceae* Lindl.: *Marchantia polymorpha* L. – 2.
- Pelliaceae* H.Klinggr.: *Apollia endiviifolia* (Dicks.) Nebel & D. Quandt. – 2.
- Ptilidiaceae* H.Klinggr.: *Ptilidium pulcherrimum* (Weber) Vain. – 4.
- Mosses:
- Amblystegiaceae* G. Roth: *Amblystegium serpens* (Hedw.) Schimp. – 1-10;
Campyliadelphus chrysophyllus (Brid.) R.S.Chopra – 2;
Campylium stellatum (Hedw.) Lange & C.E.O.Jensen – 2, 3, 8, 9, 10;
Campylophyllopsis sommerfeltii (Myrin) Ochyra – 2;
Cratoneuron filicinum (Hedw.) Spruce – 7;
Drepanocladus aduncus (Hedw.) Warnst. – 1-4, 7-9;
Drepanocladus polygamus (Schimp.) Hedenäs – 9,10;
Hygroamblystegium humile (P.Beauv.) Vanderp., Goffinet&Hedenäs – 1, 7, 9;
Hygroamblystegium varium (Hedw.) Mönk. – 8;
Leptodictyum riparium (Hedw.) Warnst. – 2;
Pseudoamblystegium subtile (Hedw.) Vanderp. & Hedenäs – 1;
Tomentypnum nitens (Hedw.) Loeske – 2.
- Aulacomniaceae* Schimp.: *Aulacomnium palustre* (Hedw.) Schwägr. – 2, 5, 7-10.
- Brachytheciaceae* Schimp.: *Brachythecium mildeanum* (Schimp.) Schimp. 2, 3, 7, 8, 10;
Brachythecium rivulare Schimp. – 3, 5, 7, 9;
Brachythecium salebrosum (Hoffm. ex F.Weber & D.Mohr) Schimp. – 1-3, 5, 9;
Sciuro-hypnum reflexum (Starke) Ignatov & Huttunen – 1, 2.
- Bryaceae* Schwägr.: *Ptychostomum moravicum* (Podp.) Ros & Mazimpaka – 1, 2, 7, 8, 10;
Ptychostomum pseudotriquetrum (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen – 1-10.
- Callicladiaceae* Jan Kučera & Ignatov: *Callicladium haldanianum* (Greville) H.A.Crum – 2-4.
- Calliergonaceae* Vanderp., Hedenäs, C. J. Cox & A. J. Shaw: *Calliergon cordifolium* (Hedw.) Kindb. – 7;
Calliergon giganteum (Schimp.) Kindb. – 4;
Sarmentypnum exannulatum (Schimp.) Hedenäs – 4.
- Climaciaceae* Kindb.: *Climacium dendroides* (Hedw.) F.Weber & D.Mohr – 3-5, 7, 9.
- Dicranaceae* Schimp.: *Dicranum montanum* Hedw. – 3;
Dicranum scoparium Hedw. – 2, 3.
- Distichiaceae* Schimp.: *Distichium inclinatum* (Hedw.) Bruch & Schimp. – 3.
- Ditrichaceae* Limpr.: *Ceratodon purpureus* (Hedw.) Brid. – 3, 7.
- Fissidentaceae* Schimp.: *Fissidens adianthoides* Hedw. – 10.
- Hylocomiaceae* M.Fleisch.: *Pleurozium schreberi* (Willd. ex Brid.) Mitt. – 1, 2.
- Jocheniaceae* Jan Kučera & Ignatov: *Jochenia pallescens* (Hedw.) Hedenäs, Schlesak&D.Quandt – 1-4, 7-10.
- Leskeaceae* Schimp.: *Leskea polycarpa* Hedw. – 2.
- Meesiaceae* Schimp.: *Leptobryum pyriforme* (Hedw.) Wilson – 2, 3, 7-9.
- Mniaceae* Schwägr.: *Mnium stellar* Hedw. – 3;
Plagiomnium cuspidatum (Hedw.) T. J. Kop. – 5-9;
Plagiomnium ellipticum (Brid.) T. J. Kop. – 2-4, 6, 9, 10;
Plagiomnium medium (Bruch & Schimp.) T. J. Kop. – 10;
Plagiomnium rostratum (Schrad.) T. J. Kop. – 2, 3, 10;
Pohlia nutans (Hedw.) Lindb. – 2, 3, 5-10;
Pseudobryum cinclidioides (Huebener) T. J. Kop. – 7;
Rhizomnium magnifolium (Horik.) T.J.Kop. – 9;
Rhizomnium punctatum (Hedw.) T. J. Kop. – 7.
- Plagiotheciaceae* M. Fleisch.: *Plagiothecium cavifolium* (Brid.) Z. Iwats. – 2;

- Plagiothecium denticulatum* (Hedw.) Schimp. – 2, 5, 6-10;
Plagiothecium laetum Schimp. – 2, 3, 6, 9.
Pylaisiaceae Schimp.: *Calliergonella cuspidata* (Hedw.) Loeske – 3, 6, 7-10;
Calliergonella lindbergii (Mitt.) Hedenäs – 4;
Ptilium crista-castrensis (Hedw.) De Not. – 2;
Pylaisia polyantha (Hedw.) Schimp. – 1-3, 6, 8, 9.
Scorpidiaceae Ignatov & Ignatova: *Sanionia uncinata* (Hedw.) Loeske – 1-3.
Sphagnaceae Dumort.: *Sphagnum capillifolium* (Ehrh.) Hedw. – 2, 4;
Sphagnum fimbriatum Wilson – 4;
Sphagnum squarrosum Crome – 4, 5, 9;
Sphagnum teres (Schimp.) Ångstr. – 2.
Stereodontaceae Hedenäs, Schlesak & D.Quandt: *Stereodon pratensis* (W.D.J.Koch ex Spruce) Warnst. – 2, 3, 7, 8.
Thuidiaceae Schimp.: *Helodium blandowii* (F.Weber&D.Mohr) Warnst. – 2, 9.

The bryophyte richness of investigated communities is similar to data on bryophyte flora of black alder forests from North-West of Russia, i.e. in the Republic of Karelia (56 mosses) [9] and Finland (72 bryophytes) [10], but significantly lower than in black alder swamps in Poland (124 species) [11] and Sweden (171 species) [12]. These differences may be explained by smaller data set and continental climate of study area.

Investigated forests are characterized by dominance of black alder, whereas other trees and shrubs (*Alnus incana* (L.) Moench, *Betula pubescens* Ehrh., *Prunus padus* L., *Frangula alnus* Mill., *Viburnum opulus* L., *Sorbus aucuparia* L., *Ribes nigrum* L., etc.) have low constancy and abundance. The crown cover varies from 40 to 75 % accounting on average for 55%. The height of trees is 12-25 m and the mean diameter of their trunks is 15 cm. The shrub layer is not dense, and its cover is 1–5 %. The herb cover can vary greatly (50–80%) depending mainly on the duration of waterlogging.

The ground bryophyte cover is not high and usually does not exceed 3–5 %. Flooding can physically or physiologically damage the bryophytes [12]. Bryophytes mostly grow on dead wood and bases of tree trunks, in the upper parts of sedge tussocks, at the edge of the stagnant water and at the banks of the streams.

All studied forest communities may be roughly divided into two main groups distinguishing in hydrological properties of habitats and species composition. The first group consists of communities where stagnant water preserves during almost all summer, and such species as *Thelypteris palustris* (A. Grey) Schott, *Carex pseudocyperus* L., *Calla palustris* L., *Equisetum fluviatile* L., *Galium palustre* L., *Comarum palustre* L. are common. Most of these forests were described in river valleys with wide floodplain and in mires forming within karst depressions. Bryophyte diversity of these communities is comparatively low (27 species).

Communities belonging to the second group are characterized by relatively short inundation time and usually occur at small rivers and lake shores. The herb layer is often dominated by *Filipendula ulmaria* (L.) Maxim. and contains as admixture such species as *Phragmites australis* (Cav.) Trin. ex Steud., *Carex cespitosa* L., *Carex rostrata* Stokes, *Urtica dioica* L., etc. These forests are quite rich in bryophytes (67 species).

The comparative analyses found that the proportion of epixylic and epiphytic species is about 40 %, and ground species – 60 % in the bryophyte composition of all investigated forests as well as both community groups. In terms of growth forms, the bryophytes are Dendroids (1.4 % of all bryophytes revealed in investigated forests), Rough Mats (21.1%), Smooth Mats (26.8 %), Thalloid Mats (4.2%), Turfs (32.4%) and Wefts (14.1 %). Bryophytes growing on the rotten wood and bark of trees are mainly represented by Mats, whereas ground species – by Turfs and Wefts growth forms.

The range of biogeographic elements includes temperate (15.5%), boreo-temperate (45.1%), boreal (15.5%), boreo-montane (14.1%) and boreo-arctic-montane (9.8%) species. Considering that investigated forests are located within zone of broad-leaved forests in the Bashkir Fore-Urals and

within forest-steppe and steppe zones in the Bashkir Trans-Urals, the high proportion of bryophyte species with boreal ranges is of interest for the purpose of biodiversity protection in study area.

Such species listed in European Red List of bryophytes as Near Threatened [13], i.e. *Helodium blandowii* and *Tomentypnum nitens* were found in two locations. The first habitat (collection site 2) is within nature protected area in the Mishkinsky district. The second habitat located in the Abzelilovskiy district (collection site 9) needs of protection. In Europe, *Helodium blandowii* is considered as a glacial relict and its occurrence south from Fennoscandia is scattered and rare [14]. Other species rare for the Southern Urals (*Riccardia latifrons* and *Pseudobryum cinclidioides*) are also associated with black alder forests. In the Republic of Bashkortostan, all these species are relicts and presented by small and isolated subpopulations growing near the southern limit of ranges.

4. Conclusion

The bryophyte richness of the Southern Urals monodominant black alder forests is not very high because of waterlogging regime of habitats and rarity of these communities in the region. Despite of insignificant projective cover of ground bryophytes which rarely exceed 5%, the number of ground species is significant (the ratio to number of epixylic and epiphytic species is 3:2). Forests occurring in habitats with short inundation time are more than double rich in bryophytes, then communities where staying water preserves for a long time during growing season. The most important factor in a conservation of black alder forests is the hydrology. Even small changes in hydrology can radically change the habitat conditions for drought sensitive species [12]. As black alders forests are quite small sized and fragmented in the Southern Urals, the human impact and climate change may cause damage for these ecosystems in the future.

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