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SYNUSIAL STRUCTURE OF MOSSES OF SWAMP COMMUNITIES IN THE TYUMENSKIY STATE NATURAL FEDERAL-CLASS RESERVE

SUMMARY. The synusial structure of mosses of four swamp communities in the Tyumenskiy Reserve is presented (projective cover, species composition, growth form, etc.). On the swamp with Carex, Oxycoccus, and Sphagnum, 6 types of synusiae relating to the epigeal biotopical row are registered. The spectrum of growth forms includes whorled-branch turfs, tall turfs, and pinnate-branch wefts. On the swamp with Betula nana, Eriophorum, and Sphagnum, 3 types of synusiae relating to the epigeal biotopical row and 1 synusia of the epixylous biotopic row are registered. The spectrum of growth forms includes whorled-branch turfs and tall turfs in the epigeal biotopical row, as well as short turfs of the epixylous synusia. On the swamp with Chamaedaphne, Ledum, Eriophorum, and Sphagnum, 5 types of synusiae relating to the epigeal biotopical row are registered. The spectrum of growth forms includes whorled-branch turfs, tall turfs and compact mats. On the swamp with Petasites frigidulus, Carex, and green mosses, 5 types of epigeal synusiae are registered. The spectrum of growth forms includes compact mats, tall turfs and short turfs. The growth form of mosses in synusiae is determined by the type of mineral nutrition of the swamp, species composition, and cross-impact of mosses.

KEY WORDS. Synusiae, synusial structure, mosses, Tyumenskiy Reserve.

The study of structural elements of plant communities is important for stating the regularities of wildlife, alongside the problem of studying species diversity. In the structure of a community, its most significant processes and phenomena are reflected.

One of the targets of the plant formation study is to elicit synusiae and to find out laws of their combinations, since synusiae are significant structural elements in a plant formation, demonstrating the general expression of all elementary, single-cover forms of life with more or less homogeneous composition, ecologically and structurally insulated groups of plants that generally comprise complex plant formations [1].

Studying synusiae of different communities helps to learn the structure and the character of relationships between different ecological groups, to find out basic laws of synusiae distribution in econiches, to determine the degree of their use, and to outline the direction of sere changes in a community. By the composition of synusiae as structural groups of plants which are the most homogeneous in ecological and plant formation aspects, one can estimate the degree of similarity and dissimilarity between compared communities and their place in the classification system [2]. Many researchers underline high sensitivity of the bryophytic component to air pollution and recreational load [3-5], this allows to use moss synusiae as bioindicators of the condition of the environment and plant communities.

The data on the composition and structure of moss synusiae can be the basic one for monitoring and comparative analysis of vegetation condition in reference

communities (particularly in reserves) and in plant communities under anthropogenic transformation.

The purpose of our research is to study the species composition and structure of moss synusiae of swamp plant communities in the *Tyumensky* State Natural Federal-Class Reserve (hereinafter referred to as the Reserve).

The Reserve is located in the Nizhetavdinsky District (the south of the Tyumen Region), in the sub-taiga sub-zone of the forest climatic zone. The Reserve was founded in 1958; its mission is to conserve the unique flora and fauna formed in sub-taiga forests, an area marginal to southern taiga, as well as to protect the *Tarmansky* Lake system. Its area is 53,600 ha.

The relief of the Reserve is a gently undulating plain with relative pitches of 60-85 m, with a great number of lakes, especially in its eastern part, and swamps. The soils are mainly marshy sod-gley, sod-podzolic, and gray-forest. Lakes occupy 7% of the Reserve area. The lakesides are gently sloping, margined with watery forest tracts and areas of riam, sedge-tussok and shrabby-grass swamps. The Akhmanka River, a left tributary of the Tura River crosses the Reserve territory. The climate is temperate continental. The annual average temperature is -18°C in January and +18°C in July. The annual precipitation is 400 mm [6]. The vegetation is characterized with a patchwork of forest and swamp communities, including upland meadow areas that are rich in grasses. There are mainly secondary small-leaved forests where *Betula pendula* Roth. and *Populus tremula* L. dominate, complex pinewoods (*Pinus sylvestris* L.) with a touch of other coniferous species (*Picea obovata* Ledeb., *Abies sibirica* Ledeb., *Pinus sibirica* (Rupr.) Mayr) and deciduous species (*Betula pendula*, *Populus tremula*), as well as hardwoods (with *Picea obovata* and *Abies sibirica* dominating). They cover 48% of the Reserve area. Swamps of different types occupy 34% of its area. In the northern part of the Reserve, sphagnous riams (raised bogs) with low shrubs (*Ledum palustre* L., *Chamaedaphne calyculata* (L.) Moench, *Andromeda polyfolia* L., in some areas *Oxicoccus palustris* Pers), dominate. As for grasses, sedgy species (*Eriophorum vaginatum* L., *Carex globularis* L) dominate. In the central and southern parts, there are mainly bush-and-grass swamps, the dominants are low shrubs and trees *Populus tremula*, *Betula pubescens* Ehrh., *B. nana* L., *B. humilis* Schrank, *Salix pentandra* L., *S. cinerea* L., *S. lapponum* L., *S. rosmarinifolia* L., *Ledum palustre*, *Oxicoccus palustris*. In the grass-and-moss cover, there are *Carex cinerea* Pollich, *C. paupercula* Michx., *Eriophorum vaginatum*, *Calamagrostis langsdorfii* (Link) Trin., *Comarum palustre* L., and sphagna of different species [7].

The synusia structure of the moss cover was studied in 2004 and 2011, the field-routing method was applied, sample plots of 1 m^2 were laid. The exact position data of the sample plots were adjusted with *Garmin GPS 76* Global Positioning System.

When moss synusiae were described, sheets registering the form of nano- and micro-relief, the synusia area, and its height were filled; the species composition and the projective cover of each species within the sampling area were taken into account; the growth form was specified. The growth form was given using the classification by Gimingham and Robertson [8]: large (Cu) and small (cu) cushions; tall (T) and short (t) turfs, open (o) and whorled-branch (Wh) turfs; dendroids (D); compact (M) and thready (tr) mats; spreading-branch (Sp) and pinnate-branch (Pi) wefts. The synusiae positions were mapped by stob-sketching [9], with sketch maps plotted to a scale of 1 in 100 and 1 in 50. The frequency of occurrence (P) was

calculated for each type of synusia in a certain community. The frequency of occurrence is treated as the ratio of the number of record plots with the given group to the total number of record plots laid in the community under study. The synusiae were named according to their species composition, assuming the dominant principle. In case of polydominance, the first word in a name is the species having larger value than the average projective cover.

On the swamp with *Carex, Oxycoccus* and *Sphagnum* (Fig. 1), 6 types of synusiae relating to the epigeal biotopical row were registered. The sampling area was laid 10.5 km to the south-east of Bukhtal Village in close vicinity to the floating bog on the mossy bank of Lake Ishimbay (57°28.150' N, 65°20.300' E). The *Ishimbay* Lake-Swamp Complex, a prototype of plant formation on a mossy bank in the late stages of swamping a fresh lake with rare species of flora and fauna, is a state regional-class reserve. The relief is small-tussock, with the average height of 0.1 m. The soil is peat-bog. The total projective cover is 100%. The projective cover of the tree layer (*Betula pendula* and *Pinus sylvestris*) does not exceed 5%. The projective cover of the bush layer (*Salix cinerea* and *Betula* nana) is 5%. The low shrub layer is exemplified by *Ledum palustre, Andromeda polyfolia,* and *Oxicoccus palustris;* the grass layer is exemplified by *Carex pseudocyperus* L., *Dactylorhiza russowii* (Klinge) Holub, *Comarum palustre, Drosera rotundifolia* L., *Menyanthes trifoliata* L., *Scheuchzeria palustris* L., and *Thelypteris palustris* Schott.

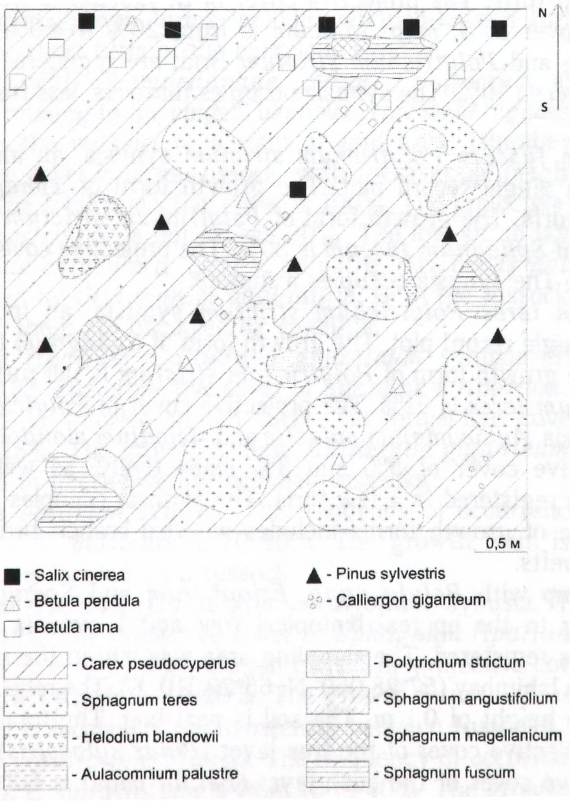

Fig. 1. Sketch map of a swamp with Carex, Oxycoccus, and Sphagnum

1. *Sphagnum teres* synusia. The frequency of occurrence is P=0.36. The growth form of the dominating species (*S. teres* (Schimp.) Aongstr.) is whorled-branch turfs. The projective cover of *S. teres* is from 95 to 100%. It occupies tussocks and space between them, forming continuous moss cover in the shape of a carpet. In the synusia, *Aulacomnium palustre* (Hedw.) Schwaegr. and *Calliergon giganteum* (Schimp.) Kindb. are registered, their projective cover does not exceed 2%. *Sphagnum teres* is an aedificator of certain associations of low-lying and intermediate swamps [10].

2. *Helodium blandowii* synusia, an independent group represented by a single record plot. The growth form of the dominating species (*H. blandowii* (F.Weber et D.Mohr) Warnst.) is pinnate-branch wefts. The projective cover of *H. blandowii* is 90%. It is located on a tussock. In the synusia, *Sphagnum teres* и *Aulacomnium palustre* (on the tussock bottom) are registered, with the projective cover of 7% and 3% respectively.

3. *Sphagnum angustifolium–S. magellanicum* synusia, an independent group represented by a single record plot. The growth form of *S. angustifolium* (C.E.O. Jensen ex Russow) C.E.O. Jensen Brid. and *S. magellanicum* Brid. is whorled-branch turfs. The projective cover of *S. angustifolium* is 70%. The projective cover of *S. magellanicum* is 30%. It is located on a tussock.

4. *Sphagnum fuscum–S. magellanicum* synusia. The frequency of occurrence is P=0.27. The growth form of *S. fuscum* (Schimp.) H.Klinggr. и *S. magellanicum* is whorled-branch turfs. The projective cover of *S. fuscum* is from 40% to 70%. The projective cover of *S. magellanicum* is from 20% to 60%. In the synusia, *S. angustifolium* and *Polytrichum strictum* Brid. are registered, their projective cover does not exceed 10%. The synusia occupies tussocks, less frequently it occurs in microlowering.

5. *Sphagnum fuscum–Polytrichum strictum* synusia, an independent group represented by a single record plot. The growth form of *Sphagnum fuscum* is whorled-branch turfs. The growth form of *Polytrichum strictum* is tall turfs. The projective cover of *Sphagnum fuscum* is 80%. The projective cover of *Polytrichum strictum* is 20%. The synusia occupies a tussock.

6. *Sphagnum teres–Polytrichum strictum* synusia, an independent group presented by a single record plot. The growth form of *Sphagnum teres* is whorled-branch turfs. The growth form of *Polytrichum strictum* is tall turfs. The projective cover of *Sphagnum teres* is 61%. The projective cover of *Polytrichum strictum* is 30%. In the synusia, *Aulacomnium palustre* and *Helodium blandowii* are registered, with the projective cover of 5% and 3% respectively, as well as *Sphagnum angustifolium* is registered in a few turfs. The synusia occupies a tussock.

The spectrum of growth forms includes whorled-branch turfs, tall turfs, and pinnate-branch wefts.

On the swamp with *Betula nana, Eriophorum* and *Sphagnum*, 3 types of synusiae relating to the epigeal biotopical row and 1 synusia of the epixylous biotopical row are registered. The sampling area was laid in the middle part of the riam around Lake Ishimbay (57°28.050' N, 65°20.310' E). The relief is small-tussock, with the average height of 0.1 m. The soil is peat-bog. The total projective cover is 100%. The projective cover of the tree layer (*Pinus sylvestris*) does not exceed 5%. The projective cover of the bush layer (*Betula* nana) is 50%. The low shrub layer is exemplified by *Chamaedaphne calyculata, Andromeda polyfolia,*

Vaccinium uliginosum L., *Oxicoccus palustris;* the grass layer is exemplified by *Eriophorum vaginatum, Menyanthes trifoliata, Equisetum hiemale* L., *Drosera rotundifolia, Dactylorhiza russowii.*

1. *Sphagnum balticum–Straminergon stramineum* synusia. The frequency of occurrence is P=0.53. The growth form of *Sphagnum balticum* (Russow) C.E.O. Jensen is whorled-branch turfs. The growth form of *Straminergon stramineum* (Dicks. ex Brid.) Hedenaes is tall turfs. The projective cover of *Sphagnum balticum* is from 85 to 90%. The projective cover of *Straminergon stramineum* is from 10 to 15%. The synusia occupies a tussock where *Sphagnum balticum* occurs on the tussock top and sides and *Straminergon stramineum* grows only in microlowering.

2. *Sphagnum angustifolium–S. magellanicum* synusia. The frequency of occurrence is P=0.33. The growth form of *S. angustifolium* and *S. magellanicum* is whorled-branch turfs. The projective cover of *S. magellanicum* is 70%. The projective cover of *S. angustifolium* is 30%. The synusia is located on a tussock.

3. *Sphagnum fuscum* synusia, an independent group represented by a single record plot. The growth form of *Sphagnum fuscum* is whorled-branch turfs. The projective cover is 90%. The synusia is located in microlowering.

4. *Pohlia nutans* synusia, an independent group represented by a single record plot. The growth form of *P. nutans* (Hedw.) Lindb. is short turfs. The projective cover is 20%. The synusia is located epixylously on a dry pine. In the synusia, a touch of *Pleurozium schreberi* (Brid.) Mitt. is also registered.

The spectrum of growth forms includes whorled-branch turfs in the epigeal biotopical row and short turfs of the epixylous synusia.

On the swamp with *Chamaedaphne, Ledum, Eriophorum,* and *Sphagnum*, 5 types of synusiae relating to the epigeal biotopical row were registered. The sampling area was laid on the outskirt of a riam around Lake Ishimbay (57°27.960' N, 65°20.210' E). The relief is large-tussock, with the average height of 0.25 m. The soil is peat-bog. The total projective cover is 100%. The projective cover of the tree layer (*Pinus sylvestris*) does not exceed 30%. The low-shrub layer is exemplified by *Chamaedaphne calyculata, Ledum palustre, Oxicoccus palustris,* the grass layer is exemplified by *Eriophorum vaginatum.* Both the tussocks and the microlowering between them are occupied by sphagna.

1. *Sphagnum riparium–Calliergon giganteum* synusia. The frequency of occurrence is P=0.33. The projective cover of *Sphagnum riparium* Aongstr. is 70%. The growth form is whorled-branch turfs. The projective cover of *Calliergon giganteum* is 10-15%. The growth form of *Calliergon giganteum* is tall turfs. The synusia is located in microlowering between tussocks.

2. *Sphagnum balticum* synusia. The frequency of occurrence is P=0.21. The projective cover of *S. balticum* is 70-80%. The growth form is whorled-branch turfs. The synusia is located on a tussock.

3. *Sphagnum riparium–Calliergon cordifolium* synusia. The frequency of occurrence is P=0.14. The projective cover of *Sphagnum riparium* Aongstr. is 50-70%. The growth form is whorled-branch turfs. The projective cover of *Calliergon cordifolium* (Hedw.) Kindb. is 15-20%. The growth form of *C. cordifolium* is tall turfs. The synusia is located in microlowering between tussocks.

4. *Calliergon cordifolium* synusia. The frequency of occurrence is P=0.14. The projective cover of *C. cordifolium* is from 10 to 40%. The growth form is compact mats. It occupies space between tussocks.

5. *Sphagnum magellanicum–S. balticum* synusia. The frequency of occurrence is P=0.14. The projective cover of *S. magellanicum* is 60-70%. The growth form of *S. magellanicum* and *S balticum* is whorled-branch turfs. The synusia is located in a microlowering between tussocks. *S. angustifolium* and *S. warnstorfii* Russow are registered, their projective cover does not exceed 5%.

The spectrum of growth forms includes whorled-branch turfs, tall turfs, and compact mats.

On the swamp with *Petasites frigidulus* (L.) Fries, *Carex* and green mosses, 5 types of epigeal synusiae were registered. The sampling area was laid 13.5 km to the south-east of Bukhtal Village (57°26.365' N, 65°20.647' E). The relief is horizontal. The soil is peat-bog. The total projective cover is 100%. The grass layer is exemplified by p. *Carex, Petasites frigidulus, Comarum palustre.*

1. *Drepanocladus aduncus* synusia. The frequency of occurrence is P=0.33. The growth form of *D. aduncus* (Hedw.) Warnst. is compact mats. The projective cover is from 35% to 100%.

2. *Bryum pseudotriquetrum–Plagiomnium ellipticum–Drepanocladus aduncus* synusia, an independent group represented by a single record plot. The growth form of *Bryum pseudotriquetrum* (Hedw.) P. Gaertn. is short turfs. The growth form of *Plagiomnium ellipticum* (Brid.) T.J. Kop. is tall turfs. The growth form of *Drepanocladus aduncus* is compact mats. The projective cover of *Bryum pseudotriquetrum* is 40%. The projective cover of *Bryum pseudotriquetrum* is 40%. The projective cover of *Plagiomnium ellipticum* is 35%. The projective cover of *Drepanocladus aduncus* is 20%.

3. *Plagiomnium ellipticum–Drepanocladus aduncus* synusia. The frequency of occurrence is P=0.43. The projective cover of *Plagiomnium ellipticum* is from 30 to 45%. The projective cover of *Drepanocladus aduncus* is from 30 to 75%. The growth form of *Plagiomnium ellipticum* is tall turfs. The growth form of *Drepanocladus aduncus* is compact mats.

4. *Plagiomnium ellipticum* synusia, an independent group represented by a single record plot. The projective cover is 100%. The growth form is tall turfs.

5. *Brachythecium mildeanum* synusia. The frequency of occurrence is P=0.17. The growth form of *B. mildeanum* (Schimp.) Schimp. is compact mats. The projective cover is 40%.

The spectrum of growth forms includes compact mats, tall turfs, and short turfs.

As a result of our works in the territory of the Reserve, 4 main swamp communities were distinguished (the community with *Carex, Oxycoccus,* and *Sphagnum;* the community with *Betula nana, Eriophorum,* and *Sphagnum;* the community with *Chamaedaphne, Ledum, Eriophorum,* and *Sphagnum*; and the community with *Petasites frigidulus, Carex,* and green mosses).

In oligotrophic and meso-oligotrophic swamps, mosses with whorled-branch turfs dominate. This growth form seems optimal for dominants of these plant communities, as it occurs on tussocks, between tussocks, and on the horizontal areas.

In the swamps which are richer in mineral substances, compact mats dominate. Less frequent are tall turfs, even less frequent are short turfs. The latter are peculiar not to the epigeal biotopical row, but to the epixylous one.

Thus, the growth form dominating in synusiae of a certain swamp community largely depends on the composition of mosses comprising it, which in its turn is determined by the level of the swamp mineral nutrition. Moreover, there is cross-impact of species growing together: in the swamp with *Betula nana, Eriophorum,* and *Sphagnum,* the species of *Calliergon giganteum* and *C. cordifolium* growing in a single-species turfs form compact mats, whereas those growing together with *Sphagna* form tall turfs.

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