Comparison of taxonomic composition of phytoplankton of the floodplain lakes of the buffer zone of the Prisursky State Nature Reserve

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Abstract. The data on the phytoplankton composition in the floodplain lakes of the Prisursky State Nature Reserve buffer zone in summer are presented for the first time. During two years of study, 219 taxa of algae (rank below genus) were registered in the phytoplankton. The representatives of the phyla Chlorophyta, Cyanophyta, and Euglenophyta played a dominant role. The larger the lake area, the highest was the species richness of algae. The algal planktonic flora of the lakes characterized by a high species richness had the highest similarity. In small water bodies, specific phytoplankton communities were developed.

1. Introduction
It is well known that the biological diversity is a prerequisite for the sustainability of any ecosystem. In general, steady decline of the biodiversity is currently observed under increasing anthropogenic load on the biosphere. Meantime, the loss of poorly studied groups of organisms cannot be estimated, so most of them may disappear, remaining unknown to science [1]. Therefore, assessing the true biological diversity of ecosystems, taking into account both macro- and microorganisms, is one of the most important tasks.

The protected areas of different kinds are established to protect natural territories in order to preserve biological diversity and to maintain natural complexes and objects in their natural state [2]. Accordingly, it is necessary to have an idea of the true biological diversity of these sites for establishing a new conservation area.

The study aims to assess the species richness of the algal flora of the floodplain lakes in the buffer zone of the Prisursky State Nature Reserve and to compare its development in different lakes.

2. Materials and methods
About three hundred water bodies of the 100-m² area and more are located in the buffer zone of the Prisursky State Nature Reserve and belong to the floodplain of the Sura River [3].

The studies of the planktonic algal flora in these water bodies are extremely scarce, when a single lake was examined during the winter period of 2004. In July 2018-2019, the phytoplankton communities of the buffer zone was surveyed as part of the program aiming to assess the settlement of the Russian desman Desmana moschata in the Prisursky State Nature Reserve. Samples were taken
from the water surface, preserved with a 4% formalin solution, and processed according to standard hydrobiological methods [4]. The dominant species were assigned as comprising 10% or more of the total abundance/biomass.

A comparative description of the phytoplankton communities in six lakes (figure 1) is presented; some morphological and hydrological characteristics of the lakes are given (table 1).

**Figure 1.** Location of the floodplain lakes of the Prisursky State Nature Reserve: (1) Bolshoe Shchuchye, (2) Maloe Shchuchye, (3) Lisa, (4) Chebak, (5) Bashkirskoe, (6) Bazarskoe.

**Table 1.** Some morphological and hydrological characteristics of the floodplain lakes of buffer zone of the Prisursky State Nature Reserve, according to [5].

| Characteristics       | Bolshoe Shchuchye | Maloe Shchuchye | Lisa | Chebak | Bashkirskoe | Bazarskoe |
|-----------------------|-------------------|-----------------|------|--------|-------------|-----------|
| Depth (m)             |                   |                 |      |        |             |           |
| - average             | 3.0               | 1.5             | 1.2  | 2.5    | 1.3         | 1.14      |
| - maximum             | 11.4              | 3.8             | 2.8  | 5.1    | 3.0         | 4.1       |
| Area (ha)             | 06.02.20          | 02.07.20        | 12.04.20 | 09.04.20 | 10          | 13.02.20  |
| Water exchange        |                   |                 |      |        |             |           |
| - flow-through        |                   |                 |      |        |             |           |
| - through             |                   |                 |      |        |             |           |
| Water supply          | mixed             | mixed           | mixed| mixed  | mixed       | mixed     |
| Transparency (m)      | 1.1               | 0.7             | 0.4  | 0.35   | 0.6         | 0.4       |

*spring period only.
3. Results and discussions
The planktonic algal flora in the floodplain lakes of the reserve in the summer period was characterized by a high species richness. In total, 219 taxa of algae have been registered (rank below genus) (table 2). As in most of fresh water bodies, green algae (phylum Chlorophyta) were characterized by the greatest species richness, comprising 44% of the total number of species and intraspecific taxa, followed by Bacillariophyta (14% of the species richness), Cyanophyta (14%), Euglenophyta (9%), Chryzophyta (5%), Dinophyta (5%), Xanthophyta (3.5%), Cryptophyta (3%), Streptophyta (2%), and Raphidophyta (0.5%).

| Phylum          | Bolshoe Shchuchye | Maloe Shchuchye | Lisa | Chebak | Bashkirskoe | Bazarskoe | Total |
|-----------------|-------------------|-----------------|------|--------|-------------|-----------|-------|
| Cyanophyta      | 11                | 4               | 17   | 11     | 15          | 22        | 31    |
| Chryzophyta     | 7                 | 3               | 4    | 3      | 5           | 5         | 10    |
| Bacillariophyta | 7                 | 8               | 13   | 9      | 23          | 16        | 31    |
| Xanthophyta     | 2                 | 0               | 4    | 1      | 4           | 7         | 8     |
| Cryptophyta     | 2                 | 3               | 6    | 4      | 5           | 6         | 7     |
| Dinophyta       | 6                 | 3               | 7    | 3      | 3           | 7         | 10    |
| Euglenophyta    | 11                | 8               | 11   | 4      | 13          | 7         | 21    |
| Raphidophyta    | 0                 | 0               | 0    | 1      | 0           | 0         | 1     |
| Chlorophyta     | 37                | 18              | 51   | 35     | 56          | 75        | 95    |
| Streptophyta    | 3                 | 1               | 1    | 1      | 1           | 3         | 5     |
| **Total**       | **86**            | **48**          | **114** | **72** | **125**     | **148**   | **219** |

The greatest species richness was observed in the largest of the studied lakes, namely, the Lake Bazarskoe, the Lake Bashkirskoe, and the Lake Lisa. The phytoplankton community of each lake comprised more than 100 taxa of algae with a rank below genus. The lowest number of species and intraspecific taxa of algae was observed in the smallest of the studied lakes, i.e. the Lake Maloe Shchuchye. In all reservoirs, Chlorophyta was represented by the highest number of taxa, followed by Cyanophyta (in large lakes) or Euglenophyta (in small lakes). It is known that Euglenophyta algae prefer shallow, organic-rich reservoirs.

The Lake Chebak was the only lake where a representative of the phylum Raphydophyta, *Gonyostomum semen* (Ehr.) Diesing, has been found. This species develops in the water bodies characterized by pronounced water colour in the summer and is considered invasive in boreal lakes [6].

The similarity of planktonic algal flora in the lakes did not exceed 55% when comparing between the years of study.

A comparative analysis of the taxonomic composition of algal flora evidenced that the lakes with the maximum number of species had the greatest similarity (Table 3). This may be due to large number of ecotopes. In the lakes with a smaller area, environmental conditions are more similar, so each lake is characterized by a rather specific algal flora.
Table 3. Species similarity coefficient (%) of algal flora of the floodplain lakes of the buffer zone of the Prisursky State Nature Reserve

| Lake          | Bolshoe Shchuchye | Maloe Shchuchye | Lisa    | Chebak | Baschkirskoe | Bazarskoe |
|---------------|-------------------|-----------------|---------|--------|--------------|-----------|
| Bolshoe Shchuchye | 100               | 42              | 46      | 52     | 51           | 53        |
| Maloe Shchuchye  | 100               | 37              | 40      | 30     | 33           |           |
| Lisa           | 100               |                 | 51      | 57     | 72           |           |
| Baschkirskoe   | 100               |                 |         | 48     | 49           |           |
| Bazarskoe      |                   |                 |         |        | 100          | 64        |

It is a common fact that biocenoses distinguished with trivial richness and even contribution of each species to assemblage evolution quantitative level (abundance, biomass) are organized in favorable conditions. Shannon-Weaver index is a generic variety criteria. An ecological system with the index higher than 3 is considered stable.

In all the studied reservoirs, the Shannon-Weaver index was quite high both in terms of abundance and biomass: in the Lake Bazarskoe, it ranged 4.3-3.8; in the Lake Bashkirskoe, 3.1-3.8; the Lake Lisa, 4.0-4.7; the Lake Bolshoe Shchuchye, 4.1-2.6; the Lake Maloe Shchuchye, 3.8-3.6; and in the Lake Chebak, 3.9-3.6.

The complex of dominant algae species comprised the representatives of different phyla (Table 4). Representatives of the phyla Cyanophyta and Chlorophyta dominated most often in the phytoplankton communities. Different species of algae of phylum Cyanophyta are characterized by different optimal ranges of nitrogen content in the water. In this regard, their succession may be traced when considering the lake eutrophication. Thus, the species of the genus *Anabaena* are able to fix nitrogen, so they need very low content of this element in the water [7, 8]. *Microcystis* develops mainly in reservoirs where ammonium form of nitrogen dominates; the species of the genera *Planktolyngbia* and *Pseudoanabaena* can grow in the eutrophic environment, consuming amino acids [9]. The dominant complex of algae species in the lakes of the Prisursky State Nature Reserve comprises mainly the representatives of the genus *Anabaena*. This allows us to assume that the nitrogen content in these water bodies is low.

The algae dominating by biomass were mainly presented by the representatives of phyla able to perform heterotrophic nutrition, namely, Euglenophyta and Dinophyta. *Trachelomnas volvocina* Ehr. was the dominant species of Euglenophyta. Representatives of the genus *Trachelomnas* develop in small humic water bodies, where iron and manganese compounds are released as a result of the reduction reaction [10, 11]. In addition, the representatives of these algae phyla are moving quite actively, which allows them to maximize the use of the resources.

It should be noted that the composition of the dominant complexes of algae species differed in all lakes in 2018 and 2019.
Table 4. Dominant species of algae in the floodplain lakes of the Prisursky State Nature Reserve in summer; the relative abundance/biomass (%) is indicated in the brackets

| Lake               | Dominants by abundance          | Dominants by biomass          | Year |
|--------------------|---------------------------------|--------------------------------|------|
| Bolshoe Shchuchye  | Anabaena spiroides Kleb. (24), Aulacoseira alpigena (Grun.) Krammer (17), Aphanizomenon flos-aquae (L.) Ralfs (17) | Anabaena spiroides (34), Aulacoseira alpigena (11) | 2018 |
|                    | Crucigenia tetrapedia (Kirchn.) W. et G. S. West (26) | Ceratium hirundinella (O. F. Müll.) Schr. t. furcoides (Zederb.) Bachm. (79) | 2019 |
| Maloe Shchuchye    | Planktolyngbia limnetica (Lemmermann) Komářká-Legnerová et Croberg (37), Eudorina elegans Ehr. (10) | Peridinipsis oculatum (Stein) Bourrelly (16), Eudorina elegans (14) | 2018 |
|                    | Crucigenia tetrapedia (16), Moniraphydium arcuatum (Korsch.) Hind. (15), Anabaena flos-aquae Bréb. (12), Monoraphydium contortum (Thur.) Kom.-Legn. (11) | Peridinium umbonatum Stein (28), Peridinium oculatum (27), Trachelomonas volvocina Ehr. (12) | 2019 |
| Lisa               | Microcystis aeruginosa (Kütz.) Kütz. (22), Microcystis pulvorea (Wood) Forti emend. Enlk. (21), Pseudoanabaena limnetica (Lemmermann) Komárek (12) | Trachelomonas volvocina (16), Microcystis aeruginosa (12) | 2018 |
|                    | Stephanodiscus hantzschii Ehr. (20), Dictysphaerium subsolitariurn von Goor (16) | Stephanodiscus hantzschii (62), Trachelomonas volvocina (11) | 2019 |
| Chebak             | Anabaena variabilis Kütz. (21), Anabaena flos-aquae (16), Anabaena planctonica Brunnth. (16), Microcystis aeruginosa (12) | Didymocystis planctonica Korsch. (15), Dictysphaerium subsolitariurn (11), Anabaena planctonica (10) | 2018 |
|                    | Synedra pulhella (Ralfs) Kütz. (25), Peridinipsis oculatum (21), Anabaena planctonica (14), Anabaena flos-aquae (10) | Peridiniosps oculatum (31), Pandorina morum (Müll.) Bory (12) | 2019 |
| Bazerskoe          | Anabaena sigmoidea Nyg. (17), Planktolyngbia limnetica (16), Crucigenia tetrapedia (10) | Ceratium hirundinella (O. F. Müll.) Schr. (42), | 2018 |
|                    | Microcystis pulvorea (32) | Trachelomonas volvocina (37), Staurastrum boreale W. et G. S. West (11) | 2019 |
| Bashkirske         | Aphanocapsa grevillei (Berkeley) Raben. (39), Microcystis pulvorea (17) | Tetraedriella gigas (Pasch.) Ded.-Sheg. (25), Anabaenopsis elenkinii V. Miller (16) | 2018 |
|                    | Microcystis pulvorea (65) | Trachelomonas volvocina (34), Peridiniosps oculatum (Stein) Bourrelly (19), Phacus hispidulus var. glabrus Defl. (17) | 2019 |

4. Conclusion
The summer phytoplankton communities of the floodplain lakes in the buffer zone of the Prisursky State Nature Reserve are characterized by high species richness. 219 taxa of algae with rank below genus have been registered.
The representatives of the phyla Chlorophyta, Cyanophyta, and Euglenophyta formed the basis of the algal flora. Reservoirs with a larger area were characterized by a higher species richness of algae.

The highest similarity of phytoplankton flora was observed between the lakes with high species richness.

*Gonyostomum semen*, a representative of the phylum Raphidophyta, an invasive species in the boreal lakes, has been recorded in the Lake Chebak.

The complexes of the dominant algae species were different both in particular lakes and in different years.

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