Species Diversity of Lichens on the Territory of the Burabay National Park (Republic of Kazakhstan)

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Article

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Abstract

The article provides an analysis of the distribution of lichen species across 11 test sites laid on the territory of the Burabay National Park in 2018–2019. The total area of the Burabay National Park is 129.3 thousand hectares, where more than 700 vascular plants grow. It was formed in 2000 in the northern part of the Republic of Kazakhstan in order to preserve the unique natural complex and use it for recreational, scientific and cultural purposes. It is part of the Shchuchinsko-Borovskaya resort area. Geographically, it is an island-type ring structure, which is an oasis surrounded by expanses of steppes. On the territory of the Burabay National Park there are multiple large lakes: Borovoe, Shuchye, Maloe and Bolshoe Chebachye, Maybalyk, Katarkol. To identify the full species composition of lichens, all types of substrates were examined on the test areas: the surface of trunks and branches of trees of different species and conditions (live, dry, dead wood), rotting wood, soil, stones. 44 species of lichens belonging to 9 families and 19 genera have been identified in the vicinity of the National Park. The taxonomic composition of lichenobiota is as follows: Peltigeraceae (3 species), Teloschistaceae (3), Lecideaceae (3), Physciaceae (5), Parmeliaceae (14), Cladoniaceae (13). The families Dermatocarpaceae, Verrucariaceae, and Lecanoraceae include one species each. The largest number of species of the National Park Burabay are represented by epiphytes.

Introduction

Currently, in the context of a significant transformation of the environment, the role of specially protected natural areas in the conservation and maintenance of the main types of natural landscapes, communities and biodiversity is becoming increasingly relevant (Gray et al., 2016; Berteaux et al., 2018). Lichens are an integral component of boreal ecosystems, known for their high sensitivity to habitat conditions (Nash, 2008). For the lichens, the type of substrate, the combination of environmental factors, and the duration of the violation play a major role in their sensitivity themselves. (Ellis, 2012). Under certain environmental conditions, lichens form a high diversity biomass, and can be indicators of the degree of ecosystem disturbance (Coppins & Coppins, 2005, 2006; Boch et al., 2016).

Lichenological studies in specially protected natural areas traditionally arouse great interest among specialists due to the high preservation of natural communities and their significant role in maintaining a unique variety of species, including those that are rare and subject to protection (Dymytrova et al., 2014). The species diversity of lichens can serve as an effective indicator for biomonitoring the state of ecosystems of natural reserves (Khastini et al., 2019), be used in assessing the scale of dynamic processes associated with both global and regional factors (McMullin et al., 2016; Brzeziecki, 2017), as well as for forecasting the state of ecosystems and developing effective measures for their protection (Waser et al., 2007; Zhang et al., 2016).

There are 29 geobotanical zones on the territory of Kazakhstan, including several floristic areas located on the territory of Northern Kazakhstan. The Burabay National Park is the fifth geobotanical area, which has the status of an environmental and scientific institution, and is included in the system of specially
protected natural territories (SPNA) of republican significance, designed to preserve biological and landscape diversity. The total area of the Burabay National Park is 129.3 thousand ha, where more than 700 vascular plants grow, many of which need protection (Khrustaleva et al., 2012; Sultangazina et al., 2014).

The territory of the Burabay National Park is part of the Shchuchinsk-Borovskaya resort area. Geographically, it is an island-type ring structure, which is an oasis surrounded by expanses of steppes. The unique combination of pine forests with large lakes provides a unique microclimate. The climate of the district is sharply continental, with hot summers and harsh winters with little snow, softened by the influence of hills, reservoirs and forests. Geomorphologically, the territory is the most elevated part of the northern outskirts of the Kazakh Uplands. The mountainous terrain is most pronounced in the western part. Here the Kokshetau mountain range stretches in an arc, bounded on all sides by large lakes. In the northern part, the ridge reaches the highest altitude (Mount Kokshetau (Sinyukha) – 947.6 m above sea level), further south are the mountains Burabay and Zheke-Batyr, respectively, with heights of 690 and 826.2 m. In the southern part of the ridge, the height of the mountains decreases to 400–500 m. On the territory of the Burabay National Park there are multiple large lakes: Borovoe, Shuchye, Maloe and Bolshoe Chebachye, Maybalyk and Katarkol (Sultangazina et al., 2012a).

One of the most important tasks of our time is the study and preservation of biodiversity. The study of lichens on the territory of Kazakhstan was carried out sporadically by florists and geobotanists. Without knowledge of the species composition of lichen flora, it is impossible to preserve them and rationalize the use of lichens as one of the most important components of ecosystems.

The purpose of the study

Conducting a complete survey of the lichen flora of the surroundings of the National Park Burabay for the first time, and establishing the taxonomic affiliation of the species. This would provide a baseline for further studies in the taxonomy of lichens all territory of Kazakhstan.

Material And Methods Of Research

The collection of materials was carried out in the spring and summer of 2018–2019 on the territory of the Burabay National Park in natural plant communities. When performing the work, the random route method was used. For the most complete accounting of lichens, the studied area was divided into squares. In each square, all possible localities of lichens were examined: bark of woody plants, soil, rocky substrate, etc.

The occurrence of epiphleoid lichens was taken into account at trial sites:

- Plot 1 – Akylbay Forestry District;
- Plot 2 – Katarkol Forestry District;
- Plot 3 – Surroundings of Bolshoe Chebachye Lake;
• Plot 4 – Surroundings of Lake Maloe Chebachye;
• Plot 5 – Surroundings of Lake Shchuchye;
• Plot 6 – Barmashy Forestry District;
• Plot 7 – Zolotoborskoe Forestry District;
• Plot 8 – Polyana Abylai Khan;
• Plot 9 – The territory of the Baldauren educational and wellness center;
• Plot 10 – Priozernoye Forestry District;
• Plot 11 – Forestry District "Peaceful".

In the course of the work, the collection of material was carried out, which was labeled and identified in the form of a herbarium collection. The material in the herbarium was identified using a comparative morphological method and a number of determinants. The nomenclature of taxa is given according to the latest reports of lichens in Austria (Hafellner et al., 2001), Norway and Sweden (Santesson, 2004), Canada and the USA (Esslinger, 1997), and for cetrarioid lichens – according to T. Randlane, A. Saag (Urbanavicius et al., 2004).

Vegetation was described according to the methodological techniques and approaches adopted in phytocenology and widely used in geobotanical studies.

The collected material is stored in the herbarium of the Department of General Biology and Genetics of the Faculty of Natural Sciences of the L.N. Gumilev Eurasian National University.

**Research Results And Their Discussion**

As a result of the study of the species diversity of lichens in the vicinity of the Burabay National Park, 44 species of lichens belonging to 9 families and 19 genera were identified. The results of the study are shown in the Table 1:
Table 1
Species composition of lichens in the Burabay National Park

<table>
<thead>
<tr>
<th>Genus</th>
<th>Species</th>
<th>Life form</th>
<th>Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family <em>Dermatocarpaceae</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Dermatocarpon</td>
<td><em>Dermatocarpon aquaticum</em> (Weiss.) Zahlbr.</td>
<td>scale</td>
<td>stones submerged in water</td>
</tr>
<tr>
<td>Family <em>Verrucariaceae</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Verrucaria</td>
<td><em>Verrucaria nigrescens</em> (Ach.) Pers.</td>
<td>scale</td>
<td>stones</td>
</tr>
<tr>
<td>Family <em>Peltigeraceae</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Peltigera</td>
<td><em>Peltigera spuria</em> (Ach.) DC.</td>
<td>leafy</td>
<td>soil</td>
</tr>
<tr>
<td></td>
<td><em>Peltigera canina</em> (L.) Willd.</td>
<td>leafy</td>
<td>soil/stumps</td>
</tr>
<tr>
<td></td>
<td><em>Peltigera rufescens</em> (Weis.) Humb.</td>
<td>scale</td>
<td>stones</td>
</tr>
<tr>
<td>Family <em>Lecideaceae</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Psora</td>
<td><em>Hypocenomyce scalaris</em> (Ach. ex Lilj.) M. Choisy (Psora streata)</td>
<td>scale</td>
<td>bark/stones</td>
</tr>
<tr>
<td>5. Rhizocarpon</td>
<td><em>Rhizocarpon geographicum</em> (L.) DC.</td>
<td>scale</td>
<td>stones</td>
</tr>
<tr>
<td>6. Lecidea</td>
<td><em>Lecidea glomerulosa</em> Steud.</td>
<td>scale</td>
<td>bark</td>
</tr>
<tr>
<td>Family <em>Cladoniaceae</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Cladonia</td>
<td><em>Cladonia fimbriata</em> (L.) Fr.</td>
<td>bushy</td>
<td>mossy stumps</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia gracilis</em> (L.) Willd.</td>
<td>bushy</td>
<td>soil</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia sylvatica</em> (L.) Hoffm.</td>
<td>bushy</td>
<td>soil</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia rangiferina</em> (L.)</td>
<td>bushy</td>
<td>stumps/soil</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia coccifera</em> (L.) Willd.</td>
<td>bushy</td>
<td>soil</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia alpicola</em> (Flot.) Vain.</td>
<td>bushy</td>
<td>soil</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia verticillata</em> (Hoffm.) Schaer.</td>
<td>bushy</td>
<td>sandy</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia deformis</em> (L.)</td>
<td>bushy</td>
<td>forest litter/stumps</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia crispate</em> (Ach.) Flot.</td>
<td>bushy</td>
<td>mossy stumps</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia comuta</em> (L.) Hoffm.</td>
<td>bushy</td>
<td>mossy stumps</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia tenuis</em> (F I k.) Harm.</td>
<td>bushy</td>
<td>soil/stumps</td>
</tr>
<tr>
<td></td>
<td><em>Cladonia coniocraea</em> (Flk.) Spreng.</td>
<td>bushy</td>
<td>tree trunk</td>
</tr>
<tr>
<td>Genus</td>
<td>Species</td>
<td>Life form</td>
<td>Substrate</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------------------</td>
<td>-----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Cladonia</td>
<td>Cladonia alpestris (L.) Rabenh.</td>
<td>bushy</td>
<td>sand soil</td>
</tr>
</tbody>
</table>

**Family Lecanoraceae**

8. Haematomma
   *Haematomma ventosum* (L.)
   limestone

**Family Parmeliaceae**

9. Parmellia
   *Parmelia vegans* Nyl.
   leafy
   soil

   *Parmelia sulcata* Taylor
   leafy
   tree trunk

   *Parmelia caperata* (L.) Ach.
   Leafy
   bark

   *Parmelia acetabulum* (Neck.) Duby.
   Leafy
   bark

   *Parmelia saxatilis* Linds.
   Scale
   stones

   *Parmelia olivacea* (L.) Ach.
   Scale
   stones

10. Hypogymnia
    *Hypogymnia physodes* (L.) Nyl.
    Leafy
    bark

11. Evernia
    *Evernia prunastri* (L.) Ach.
    Bushy
    bark

    *Evernia thamnodes* (Flot.) Arnold.
    (син.: *Letharia thamnodes* (Flot.) Arnold.)

12. Xanthoparmelia
    *Xanthoparmelia conspersa* (Ehrh.) Ach.
    Leafy
    stones

13. Parmeliopsis
    *Parmeliopsis hyperopta* (Ach.) Vain.
    Leafy
    bark

    *Parmeliopsis pallescens* (Hoffm.) Hillm.
    Leafy
    bark

14. Cetraria
    *Cetraria glauca* (L.) Ach.
    Leafy
    bark

    *Cetraria pinastri* (Scop) S.F. Gray.
    Leafy
    bark

**Family Teloschistaceae**

15. Caloplaca
    *Caloplaca murorum* (Hoffm.) Th. Fr.
    Scale
    stones

    *Caloplaca aurantiaca* (Lightf.) Th. Fr.
    Scale
    bark

16. Xantoria
    *Xantoria candelaria* (L.) Th. Fr.
    Leafy
    bark

**Family Physciaceae**

17. Physcia
    *Physcia aipolia* (Ehrh.) Furnr.
    Leafy
    bark

    *Physcia stellaris* (L.) Nyl.
    Leafy
    bark
<table>
<thead>
<tr>
<th>Genus</th>
<th>Species</th>
<th>Life form</th>
<th>Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. Gasparrinia</td>
<td><em>Gasparrinia elegans</em> (Link.) Stein</td>
<td>scale</td>
<td>stones</td>
</tr>
<tr>
<td>19. Gyrophora</td>
<td><em>Gyrophora murina</em> (Ach.)</td>
<td>leafy</td>
<td>stones</td>
</tr>
<tr>
<td></td>
<td><em>Gyrophora polyphylla</em> (L.) Funck.</td>
<td>Leafy</td>
<td>stones</td>
</tr>
</tbody>
</table>

The system given in the 10th edition of the Dictionary of the Fungi (Anisworth et al., 2008) is taken as a basis. The nomenclature of taxa is given by the Index Fungorum. In the new version of the system, lichens and fungi close to them are assigned to 5 classes of Ascomycota and one class of Basidiomycota. Systematically, all identified lichens belong to the class of marsupials (*Ascolichenes*), two subclasses (*Pyrenocarpaceae, Gymnocarpaceae*) and can be presented in the following taxonomic order:

Kingdom – Real mushrooms (*Fungi* (*Mycota, Mycetalia*)

Sub-kingdom - Higher mushrooms (*Dikarya*)

Department – Marsupial mushrooms (*Ascomycota* (Berk.) Caval.-Sm. (1998))


Class Marsupial lichens – *Ascolichenes*

Subclass Pyrenocarpaceae – *Pyrenocarpaceae*

Order Pyrenocarpaceae – *Pyrenocarpales*

Family Verrucariaceae – *Verrucariaceae*, genus *Verrucaria*.

The family Dermatocarpaceae – *Dermatocarpaceae*, genus *Dermatocarpon*.

Gymnocarpaceae Subclass – *Gymnocarpaceae*

The Order Round – Fruited - *Cyclocarpales*

Peltigeraceae family - *Peltigeraceae*, genus *Peltigera*.

Lecideaceae family – *Lecideaceae*, genera: Lecidea; Psora; Rhizocarpon.

Family Cladoniaceae – *Cladoniaceae*, genera: Cladonia; Thamnolia.


The Parmelia family – *Parmeliaceae*, genera: Parmelia; Parmeliopsis; Cetraria; Hypogymnia; Evernia.

Teloschistaceae family - *Teloschistaceae*, genera: Caloplaca; Xanthoria.
The Fisciaceae family – Physciaceae, genera: Gasparrinia; Gyrophora; Physcia.

The average number of births per family is 2.11. The Parmeliaceae family (6 genera), Lecideaceae and Physciaceae (3 genera each) are the leaders in the number of genera. The Teloschistaceae family is represented by two genera. There are 5 families represented by one genus (Cladoniaceae, Dermatocarpaceae, Lecanoraceae, Peltigeraceae, Verrucariaceae). Its high position in the flora of the Parmeliaceae family brings it closer to the boreal flora of the Holarctic (Golubkova, 1983). However the specific features in the area include the presence of the Verrucariaceae family, which is characteristic of the flora of the arid regions of the Holarctic. Thus, the floral spectrum of lichens of the studied region combines features characteristic of the arid and boreal lichenoflora of the Holarctic, which indicates the heterogeneity of the lichenoflora of the region, to a certain extent corresponding to its geographical location.

The average number of species in a genus is 2.32. 2 out of 19 genera combining 19 species (43.2% of the total number) are characterized by an above-average indicator. These are the genus Cladonia (13 species) and the genus Parmellia (6 species).

The most numerous in terms of species diversity was the family Parmeliaceae – 14 species (31.8%). The second place belongs to the Cladoniaceae family – 13 (29.5% of the total number of species). The Physciaceae family is represented by five species (11.4%), the Lecideaceae, Peltigeraceae and Teloschistaceae families are represented by three species (6.8% each). The remaining families are represented by single species; they account for 6.8% of the detected species.

Based on the relative role of the leading families and genera in the flora, the territory of the Burabay National Park can be characterized as boreal with pronounced arid features.

Despite the fact that most researchers distinguish four main groups of lichens in relation to the substrate (epiphytic, epilitic, epigeic, epicylic), in relation to other habitat conditions (soil specificity, waterlogging, features of biological residues, etc.), this classification can be expanded by highlighting the following ecological and substrate groups (Oxner, 1974; Plant life..., 1977; Merkulova, 2006): 1) epilitic (stones, rocks); 2) epiphytic (bark of trunks of woody plants and shrubs); 3) epigeal (soil, soil sediments); 4) epigeic-epilitic (sandstones, poor soils); 5) epigeic-calcifilic (on limestone); 6) eurysubstrate (on two or more substrates); 7) epiphytic-epicylic (on rotting wood, wet mossy stumps); 8) epibriophytic (on mosses); 9) epilichenophilic (on other lichens); 10) epicyl (exposed wood (trunks without bark); 11) epiphytoreliquites (on dead mosses, plant remains (forest litter); 12) amphibites (on rocks or other substrates, most of the time submerged in water).

In accordance with this, 9 ecological and substrate groups of lichens can be allocated for the lichen flora of the surroundings of the Burabay National Park:

1) epilitic (10 taxa; 22.7%);

2) epiphytic (14 taxa; 31.8%);
3) epigeic (6 taxa; 13.6%);
4) epigenic-epilitic (2 taxa; 4.6%);
5) epigeino-calcifilic (1 taxon; 2.3%);
6) eury substrate (5 taxa; 11.4%);
7) epicylic (2 taxa; 4.5%);
8) epiphyto-epicyl (3 taxa; 6.8%);
9) the amphibian ecological-substrate group is represented by the lichen Dermatocarpon aquaticum (Weiss.) Zahlbr. (2.3%).

In relation to the substrate, the species diversity of lichens decreases in a row: on soil > on bark > on Stone. Thus, lichens belonging to the epiphytic and epigeic groups (in total) predominate in the studied territory; their total number is 26 species (59.1%).

The biomorphological structure of lichens is the result of long-term evolutionary changes in the process of adaptation to environmental conditions. In sharply continental, arid, Arctic and high-altitude areas, scale lichens predominate; in humid temperate and tropical climatic zones - leafy; more northern and sufficiently mesophilic landscapes are characterized by the dominance of bushy lichens. Of the 44 lichen species of the Burabay National Park, 11 species belong to scale life forms, 17 – to leafy, and 16 – to bushy. This distribution of life forms is most likely due to the location of the research area in a warm temperate moderately humid forest-steppe zone.

Of the 44 lichen species found in the Burabay National Park, 1 species is included in the Red Book of Kazakhstan – Cladonia rangiferina (L.) (Red Book..., 1981; Sultangazina et al., 2012b; Sultangazina et al., 2014; Khrustaleva et al., 2012).

Conclusion

44 species of lichens belonging to 9 families and 19 genera were identified in the vicinity of the Burabay National Park (Republic of Kazakhstan) in 2018–2019. The taxonomic composition of lichenobiota is as follows: Peltigeraceae (3 species), Teloschistaceae (3), Lecideaceae (3), Physciaceae (5), Parmeliaceae (14), Cladoniaceae (13). The families Dermatocarpaceae, Verrucariaceae, Lecanoraceae include one species each. This position of the families in the lichenoflora of the studied region indicates a combination of features characteristic of the arid and boreal lichenoflora of the Holarctic. Epiphytes are represented by the largest number of species in the Burabay National Park (14). Of the 44 lichen species, 11 species belong to scale life forms, 17 – to leafy, and 16 – to bushy. This distribution of life forms is due to the location of the research area in a warm temperate moderately humid forest-steppe zone. One
of the discovered and studied species is included in the Red Book of Kazakhstan – *Cladonia rangiferina* (L.).

**Declarations**

**Acknowledgements**

The authors would like to thank Dr. Batiash Silybayeva (ABU, Kazakhstan) and Dr. Nurzia Karipbaeva (AIU, Kazakhstan) for suggestions, comments, and for helping write this article.

**Availability of data and materials**

The collected material is stored in the herbarium of the Faculty of Natural Sciences of the L.N. Gumilyov Eurasian National University. Data not already included in the manuscript won’t be available on-line, however it can be privately made available on-request from the corresponding author provided approval is granted from the L.N. Gumilyov Eurasian National University.

The collection sites in the Burabay National Park were not in a restricted area and do not require any special permission for entry and collection of plant material according to national legislation. All appropriate general permissions or permits for the collection of plant material and their storage in the herbarium are held by the L.N. Gumilyov Eurasian National University. All relevant institutional, national, and international guidelines and legislation has been adhered to.

**Ethical Approval**

I declare that the results and/or discussion reported in this paper do not relate human and/ or animal studies.

**Competing interests**

I declare that the authors have no competing interests as defined by Clarivate, or other interests that might be perceived to influence the results and/or discussion reported in this paper and interests of a financial or personal nature.

**Authors’ contributions**

Bukabayeva Zh. did all fieldwork. The taxonomy of lichens and writing of the manuscript was done by all authors. All authors reviewed the manuscript.

**Funding**

I declare that the results and/or discussion reported in this paper didn’t have any founding.

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References


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