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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

LICHENS AND MOSSES OF THE KORCHAY STATE NATURE RESERVE AND THEIR INDICATION CHARACTERISTICS

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INTRODUCTION

Relevance and degree of development of the topic. One of the most important issues that allows for the protection of flora and the determination of a plan of action to preserve it in its current natural environment is the determination of the current range of flora[1]. As a result of multidisciplinary experiments conducted at the international level on the protection of rare species, it has been determined that the most effective form of protection for flora in the current natural condition is the preservation of their habitats in specially protected natural areas[2]. The most fundamental problem of preserving the stability of the natural environment is determining the historical development paths of natural plant communities. The basis for maintaining the sustainability of coenoses is the protection and monitoring of their biodiversity.

In accordance with Article 6 of the United Nations Convention on "Biological Diversity", the "National Strategy of the Republic of Azerbaijan on Conservation and Sustainable Use of Biodiversity for 2017-2020" was approved by the Decree of the President of the Republic of Azerbaijan dated October 3, 2016[3]. In order to resolve a number of important issues arising from this Decree, one of the main goals has been to identify ecosystems with biological diversity in the regions of the republic and assess them for preservation in natural environmental conditions.

Mosses are an integral part of natural plant ecosystems and regulate the material-energy exchange of various biocenoses. Also, mosses are successfully used as bioindicators in nature conservation, as they are sensitive components of phytocenoses to environmental

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[1] Ibadullayeva, S.J., Huseynova, I.M. An Overview of the Plant Diversity of Azerbaijan. In: Öztürk, M., Altay, V., Efe, R. (eds) Biodiversity, Conservation and Sustainability in Asia. Springer, Cham. –2021, –p. 431–478.

[2] Bayramova, A.A. Azərbaycanın qərb bölgəsinin xüsusi mühafizə olunan təbiət ərazilərinin flora biomüxtəlifliyi / A.A. Bayramova, – Bakı: Elm, - 2013, -327 s.

[3] Azərbaycan Respublikasında bioloji müxtəlifliyin qorunmasına və davamlı istifadəsinə dair 2017–2020-ci illər üçün Milli Strategiya // Azərbaycan Respublikası Prezidentinin 3 oktyabr 2016-cı il tarixli sərəncamı ilə təsdiq edilmişdir. – Bakı: –2016, – s. 20 s.

factors[4, 5, 6].

Mosses and lichens are not only indicators of changes in the environment, but also closely participate in the processes occurring in these phytocenoses, creating a special ecological environment. Mosses and lichens provide a diagnosis of anthropogenic changes in the environment and dynamic processes occurring in natural communities. According to famous bryologists, "*Mosses are a page of geological history that cannot be read in other plants*"[7]. Despite the abundance of scientific literature on the study of plant communities and the dynamics of their individual components[8, 9], this information on lichens and mosses is relatively scarce. In this regard, the issues of the structure, dynamics, and regeneration of mosses and lichens are still relevant today.

Since lichens are biologically very sensitive organisms to anthropogenic impacts, they have long been included in the list of test objects within the ecological monitoring network, as an elementary typological unit of various synusia (microcommunities). The reliability of the indication properties of epiphytic lichens has already been proven[10].

The fact that lichnes are relatively ecologically plastic living organisms creates broad opportunities for their distribution in various natural and climatic zones. Lichens play an important role in the

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[4] Каманина, И.З. Изучение поверхности мхов-биомониторов в условии разной техногенной нагрузки/ И.З.Каманина, С.П.Каплина, И.И.Виноградов (и др.) //Научное обозрение, Биологические науки. - 2021, N4, - с.5-12.

[5] Safonov, A.I. Phytoindicational monitoring in Donetsk // Наука. Мысль. -2016. № 4. –p.59-71.

[6] Баишева, Э.З. Мохообразные – индикаторы биологически ценных лесов Республики Башкортостан // - УФА: Известия Уфимского научного центра РАН. -2015, №4(1). -с.8–11.

[7] Бархалов, Ш.О. Листоватые и кустистые лишайники Азербайджана / Ш.О.Бархалов, – Баку: – 1969. – 307 с.

[8] Novruzov, V.S. Fitosenologiyanın əsasları / V.S.Novruzov. – Bakı: Elm, – 2010, – 306 s.

[9] Федченко, Б.А. Флора Азиатской России. Вып. 13. Мхи. Ч. 2 / Б.А.Федченко. - Москва: Высшая школа, – 2017. – 905 с.

[10] Алвердиева, С.М. Конспект лишайников Азербайджана / С.М.Алвердиева, В.С. Новрузов, – Баку: Элм, – 2014, – 240 с.

emergence, formation, and dynamics of many new plant communities, especially vegetation on bare rocks. The study of the lichen flora of various regions of the Earth is relevant not only from the point of view of the problem of efficient use and protection of natural resources, but is also very important for solving many theoretical issues of the history of the formation, development, distribution and ecology of modern vegetation. Especially in ecosystems existing in mountainous areas, lichens have a very high species diversity and play the role of ecological monitoring to explain the mechanism of successions. In addition to being an integral part of the biosphere, lichens are also closely involved in the emergence and formation of vegetation cover in the existing area. A comprehensive study of the biodiversity of the lichens of a specific area is also very important for revealing the bioecological characterristics and application possibilities of the species, for the efficient use of vegetation cover, and for the protection of the gene pool.

Considering the role of mosses and lichens in the emergence and formation of the vegetation cover of the Korchay State Nature Reserve, as well as in explaining the mechanism of successions, their species composition, distribution patterns, botanical-geographical characteristics and indication properties were studied.

Object and subject of research. The object of research is the lichens and mosses of the Korchay State Nature Reserve. The subject of the research is the study of mosses and lichens using modern and classical methods, as well as the identification of species that are toxitolerant and sensitive to atmospheric pollutants.

Purpose and objectives of the research. It consists of studying the species composition, distribution patterns, botanical-geographical characteristics, ecological-cenotic properties of the mosses and lichens of the Korchay State Nature Reserve, and clarifying the possibilities of their use in biological monitoring.

In order to achieve the main goal set, it is considered important to fulfill the following tasks:

- Inventory and study of species composition of mosses and lichens in Korchay State Nature Reserve;
- Determining the distribution patterns of mosses and lichens;

- Providing the classification and botanical-geographical characteristics of mosses and lichens;
- Investigating the possibilities of using mosses and lichens as indicators of environmental conditions;
- Geographical elements of mosses and lichens and their life forms;
- Ecological-cenotic classification of mosses and lichens and their synusial structure;
- Development of a system of actions for the protection of rare species of moss and lichens.

Research methods. Comparative morphological, biomorphological, biogeographical, bioecological and other methods were used in the implementation of research.

The main provisions put forward for defense:

1. The formation of the mosses and lichens of the Korchay State Nature Reserve is related to complex factors and is the result of the historical development of the flora of the area.

2. The richness of mosses and lichens reflects the tolerance of the vegetation cover of the Korchay State Nature Reserve.

3. The species diversity and structure of lichens and mosses are determined by the age of trees and shrubs, the slope inclination, the degree of herbaceous competition in the soil, and alterations in the hydrothermal regime of the area.

Scientific novelty of the research. For the first time, a complete inventory of the mosses and lichens of the Korchay State Nature Reserve was conducted, and the botanical and geographical characteristics of 47 lichens belonging to 17 families and 33 genera, as well as 38 moss species belonging to 14 families and 26 genera, were provided. In biological monitoring, lichens such as *Cladonia cornuta* (L.) Hoffm. and *Physcia stellaris* (L.) Nyl., mosses such as *Brachythecium mildeanum* (Schimp.) Schimp. ex Milde and *Hylocomium splendens* (Hedw.) Schimp. were recommended. The analysis of lichens was conducted according to the geographical elements of nemoral, montane, euryholarctic, hypo-arctic-montane, boreal, xerocontinental, and multiregional, and the analysis of mosses according to the geographical elements of boreal, arid, euryholarctic,

montane and multiregional. As a result of the analysis of geoelements, the origin and formation of the moss and lichen flora of the study area have been revealed for the first time. Based on the data obtained, 5 ecological-cenotic complexes of mosses were distinguished: xerophytes, mesophytes, mesoxerophytes, hygrophytes, and hydrophytes. For the first time, as a result of studying the species composition and ecological-cenotic characteristics of the mosses and lichens of the reserve, comparative monitoring was conducted with the mosses and lichen flora of industrial centers close to the reserve (the cities of Mingachevir and Yevlakh).

Theoretical and practical significance of the research: The results obtained can be used in developing an action plan for the protection of rare species of moss and lichen, in monitoring areas bordering the reserve, and in compiling new editions of the "Red Book" of Azerbaijan. It can be used to develop a system of significant protective actions at the local and national levels. The collected herbarium materials can be used in conducting practical classes in biology and chemistry-biology specialties. Information on the coenopopulation status of species and their ecology is useful for developing a system of conservation measures. A conspectus developed on lichens and mosses can be considered a baseline for compiling determination keys and floras

Studying the regular changes in the species diversity of epiphytic lichens and mosses in areas most exposed to anthropogenic impacts can be successfully used to assess the restoration potential of ecosystems, as well as in planning the region's desert and semi-desert policy. It is also possible to conduct long-term biomonitoring observations on anthropogenic changes in natural environmental conditions in the Korchay Reserve based on the polytolerance indices.

Studying the species composition of mosses and lichens in the Korchay State Nature Reserve is a scientific basis for investigating the patterns of their distribution in existing ecosystems and conducting many large-scale monitoring studies.

Approbation and application. The materials of the dissertation have been discussed at a number of international conferences: “Current Problems of Modern Natural Sciences” (Ganja, 2017),

“Current Problems of Modern Natural and Economic Sciences” (Ganja, 2018), “Current Problems of Modern Natural and Economic Sciences” (Ganja, 2019), 4th Republican Scientific Conference of doctoral and master's students on the topic "Unity of Education, Research, and. Innovation" (Nakhchivan, 2022), X All-Russian Scientific and Practical Conference on "Biodiversity and Rational Use of Natural Resources" (Makhachkala, 2022), "International scientific conference "Current Problems of Modern Natural and Economic Sciences" dedicated to the 100th anniversary of the birth of National Leader Heydar Aliyev”.

Eight scientific articles and four theses related to the dissertation (3 articles in international databases: Web of Science, AGRIS, RSCI) were published in refereed and indexed journals.

Name of the organization where the dissertation was carried out: The dissertation was carried out at the Department of Botany of Ganja State University.

Structure and scope of the dissertation: The dissertation comprises 163 pages and consists of an introduction, 8 chapters, conclusions, industrial proposals, and a bibliography of 166 references (including 65 in English). The dissertation consists of 200984 characters (introduction - 11047 characters, chapter I - 11500 characters, chapter II - 13571 characters, chapter III - 5415 characters, chapter IV - 57278 characters, chapter V - 72780 characters, chapter VI - 4858 characters, chapter VII - 21343 characters, conclusions - 2702 characters, proposals - 490 characters). The dissertation features 8 tables, 30 figures, and 2 figure-maps.

GENERAL CHARACTERISTICS OF THE WORK

CHAPTER I. NATURAL-GEOGRAPHICAL CONDITIONS OF THE KORCHAY STATE NATURE RESERVE

The chapter provides a brief description of the natural conditions of the Korchay State Nature Reserve: geographical location, relief, soil, water supply, climate, and vegetation.

The Bozdag Range is located within the coordinates of – 45°50′ north latitude and 46°45′ east longitude. Its absolute height is 520 m and its length is about 150 km. The geographical relief of the area

consists of semi-desert, steppe, dry steppe, vast plains, hills, and medium and low mountain ranges - the Bozdag ranges. The Bozdag range is located in the northern and foothill slopes and steppe plain landscape. The geographical relief of the Bozdag massif is distinguished by its uniqueness. Thus, the Bozdag massif consists of medium mountain ranges and foothill slopes, semi-desert, steppe plains, small hills, the Korchay valley, the Bozdag mountain ranges stretching from west to east (150 km), and the Tugai forests along the banks of the Kura River. The low and medium mountain ranges of the Bozdag massif, stretching from west to east, cover a large area. The area is surrounded by the Mingachevir reservoir to the north and the Korchay river valley, the left large tributary of the Kurakchay, to the south. The map of the Korchay State Nature Reserve is shown in the figure below (Fig. 1).

Figure 1. Territory of Korchay State Nature Reserve

CHAPTER II. LITERATURE REVIEW

The chapter provides information about the history of studying mosses and lichens of the Korchay State Nature Reserve. The moss flora of the area has been almost completely unstudied. It is also clear from the literature that the mosses and lichens of the Korchay State Nature Reserve have not been extensively and systematically studied until our research.

CHAPTER III. RESEARCH MATERIAL AND METHODS

Lichens and mosses were taken as the objects of research. Lichens and mosses were selected as biological indicators due to their sensitivity to anthropogenic factors, environmental influences, and also based on H.H. Trass's Poleotolerance Index (IP).

The research was conducted in 2018-2022 under route and stationary, semi-stationary, and laboratory conditions. The nomenclature of taxa is given based on modern catalogs. At the same time, floristic, floristic-systematic, areological, botanical-geographical, phytocenological, and statistical methods were taken into account.

The atmospheric purity of the reserve area was calculated based on H.H. Trass's[11] Poleotolerance Index (PI), and a species sensitivity scale was established (the frequency of occurrence for each species was determined using a five-point scale: 1 point for 0–20%; 2 points for 21–40%; 3 points for 41–60%; 4 points for 61–80%; and 5 points for 81–100%).

The research area varies in terms of its geographical location and topography. However, the reserve area has a general character as a whole, along with specific features due to the nature of its vegetation cover. The life forms and ecological groups of lichens and mosses, the frequency of occurrence of species, as well as their general distribution patterns and dominant synusia depending on the type of substrate, were determined, and the structure of the sample plots in the reserve was comparatively analyzed by us.

[11]Трасс, Х.Х. Классы полеотолерантности лишайников и экологический мониторинг // Проблемы экологического мониторинга и моделирования экосистем, − Л.: − 1985. т.7, − с. 122.

The basis of the dissertation is 47 herbarium specimens of lichens and 38 mosses collected from the research area.

The taxonomic structure of the lichen flora of the Korchay State Nature Reserve is presented according to O.Erikson[12]. For the identification of species, “Determinants of Lichens of the USSR” [13], “Flora of Lichens of the Caucasus” [14], as well as for the determination of ranges, classical catalogs and relevant literature were used[15, 16]. The systematics of mosses has been modified taking into account the systems of M.P. Andreyeva[17] and M.S. Ignatov[18]. "Determinant of Leafy Mosses of Central Siberia"[19], "A conspectus of the Moss Flora of the MPR"[20] and "Leafy Mosses of the Caucasus Nature Reserve" [21]and other literature were used in the definition of mosses. Relevant literature has been developed on individual genera and species. The classification also takes into account the “International Code of Botanical Nomenclature” [22].

Geographic analysis of the lichen flora of the Korchay State Nature Reserve was carried out on the basis of zonal and regional principles

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[12] Outline of Ascomycota / Eriksson, O. [eds.] – Myconet, − 2006. v. 9. − p.1-89.

[13]Абрамов, И.И. Определитель лишайников СССР: [в 5 томах] / И.И. Абрамов, Н.С.Голубкова, – Ленинград: "Наука", − т.1, 1971, − 410 с.

[14] Бархалов, Ш.О. Флора лишайников Кавказа / Ш.О.Бархалов, - Баку: -1983.-338 с.

[15] Santesson, R. The lichens and lichenocolous fungi of Sweden and Norway. − 2003. − 240 p.

[16] Urbanavichus, G., Ismailov, I. The lichen flora of Gunib plateau, inner-mountain Dagestan (North-East Caucasus, Russia). / Turk J Bot. – 2013. – p. 753-768.

[17]Андреев, М.П. Флора лишайников России / М.П.Андреев, Д.Е. Гимельбрант [и др.], Вестник РФФИ, − 2013, − 235 с.

[18] Игнатов, М.С. Флора мхов средней части Европейской России / М.С.Игнатов, Е.А.Игнатова, − Москва: − 2004. т. 2, − с.245-248.

[19] Вардунов, Л.В. Определитель листостебельных мхов Центральной Сибири / Л.В. Вардунов, − М.: − 1969. − 270 с.

[20] Абрамова, А.Л. Конспект флоры мхов Монголской Народной Республики / А.Л.Абрамова, И.И.Абрамов [и др.] – Л: Наука, – 1983, – 221с.

[21] Акатова, Т.В. Листостебельные мхи Кавказского заповедника (Западный Кавказ, Россия). // Arctoa, - 2003, т.11, - с.179-204.

[22] International Code of Botanical Nomenclature. – Leninqrad: -1975; –Sidney: -1983; –Saint Louis: -1999; –Vienna: -2005.

according to T.N. Klakotskaya[23], N.V. Malysheva [24], V.S. Novruzov[25] etc.

Since the characteristics of life forms are an integral part of the ecological analysis of flora, a biomorphological analysis of the lichen flora of the KSNR was carried out according to Gabitov[26]. Within the 3 morphological types, many forms were discovered according to the nature of the thallus. Thus, *Arthonia* Ach. and *Pertusaria* DC. belong to the endophloid form, *Verrucaria* Shrad. and *Glypholecia* Nyl. to the endolith form group, *Lepraria* Ach. belongs to the leprous (powdery) form and other types of forms.

CHAPTER IV. ANALYSIS OF THE TAXONOMIC STRUCTURE OF THE LICHEN AND MOSS FLORA

4.1. Taxonomic spectrum

4.1.1. Analysis of the lichen flora. All of the lichen present in the area belong to the *Ascomycota* division. It was determined that the lichen flora of the study area consists of 47 species belonging to 17 families and 33 genera. All of the species shown are shown for the first time for the reserve area. The main places in terms of species richness are occupied by the families *Cladoniaceae* Zenker. (6 species), *Lecanoraceae* Körb. (6 species), *Parmeliaceae* Zenker. (6 species), *Teloschistaceae* Zahlbr. (5 species), *Physciaceae* Zahlbr. (4 species) and *Ramalinaceae* C.Agardh. (4 species). Other families do not have a wide variety of species, and are represented by 1 or 2 species.

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[23] Клакоцкая, Т.Н. Мохообразные НП “Припятский” (эволюционный аспект, таксономия, экология, география, жизненные стратегии) / Т.Н.Клакоцкая, Ж.М.Петрикова, А.В.Углянец. − Минск: Белор-кий Дом печ., − 2015. − 181 с.

[24] Малышева, Н.В. Лишайники городов Европейской России. I. Таксономический анализ // Ботан. журн., − 2016. т. 91. №12. − с.834-841.

[25] Новрузов, В.С. Флорогенетический анализ лишайников Большого Кавказа и вопросы их охраны / В.С. Новрузов, − Баку: Элм, − 1990. − 324 с.

[26] Габитова, С.М., Баишева, Э.З. Экологический анализ бриофлоры эвтрофных болот Башкирского Зауралья // Известия Самарского научного центра РАН., − 2015, т. 17, №6. − с.57–62.

The chapter analyzes the taxonomic composition of the lichen flora of the Korchay State Nature Reserve.

A biomorphological analysis of the lichen flora of the Korchay State Nature Reserve was conducted, and [27, 28] within 3 morphological types, many forms (endolithic, endophloid, leprous-powdery, granular-warty, rosette) were characterized according to the nature of the thallus[29]. The taxonomic composition of the lichens of the Korchay State Nature Reserve is presented in Figure 2.

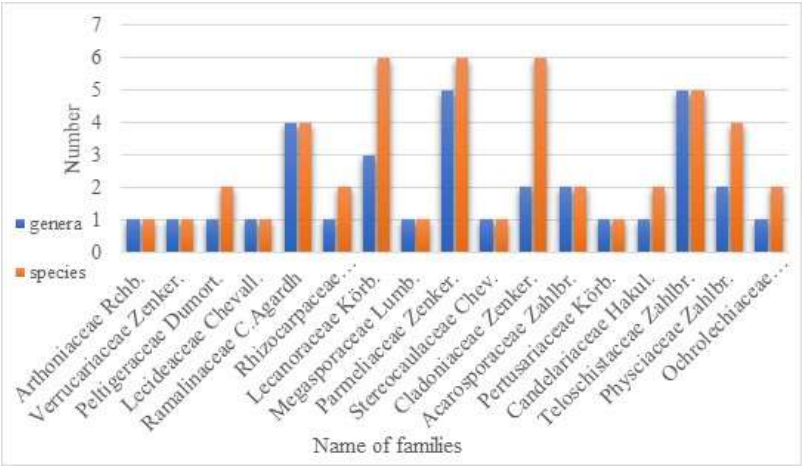

Figure 2. Taxonomic composition of lichens of the Korchay State Nature Reserve

4.1.2. Analysis of moss flora. Considering the role of mosses in the formation of the valley's vegetation cover in the area, the

[27] Alekberov, F.F. The mosses flora of Korchay State Nature reserve // Bulletin of Science and Practice. − 2022, v.8, n. 11, − s. 28-31.

[28] Алекперова, Ф.Ф., Новрузов, В.С. Пустынные степные лишайники Корчайского государственного заповедника Азербайджана // Биоразнообразие и рациональное использование природных ресурсов. Материалы докладов X Всероссийской научно-практической конференции, с международным участием. −Махачкала: 21-22 апреля, −2022. − s.53-56.

[29] Ələkbərov, F.F., Abbasov, İ.M., Yusifov, C.A. Korçay Dövlət Təbiət Qoruğunun arid ekosistemlərinin şibyə florası // Beynəlxalq elmi konfransın materialları "Müasir Təbiət və İqtisad elmlərinin aktual problemləri", − Gəncə: − 2018, №2, − s.136-137.

mosses of the Korchay State Nature Reserve were studied. Studying the moss flora of the reserve can provide valuable material on the history of the development of the region's flora, as well as the evolution and systematics of mosses. Research reveals that the moss flora of the area is closely associated with various centers of speciation, particularly boreal and Mediterranean elements. Their cenotic role depends on the level of occurrence in the area.

Along with studying the species composition of mosses, it was considered appropriate to investigate their role in various biogeocoenoses based on ecological factors. As a result of our field research materials and literature data processing, 38 moss species belonging to 14 families and 26 genera were identified in the Korchay State Nature Reserve (Fig. 3). The main places in terms of species richness are occupied by the families *Pottiaceae* Hampe (7 species), *Brachytheciaceae* (6 species), *Amblystegiaceae* Kindb. (4 species), *Dicranaceae* Schimp. (4 species) and *Grimmiaceae* Ach. (3 species). Other families are represented by 1 or 2 species.

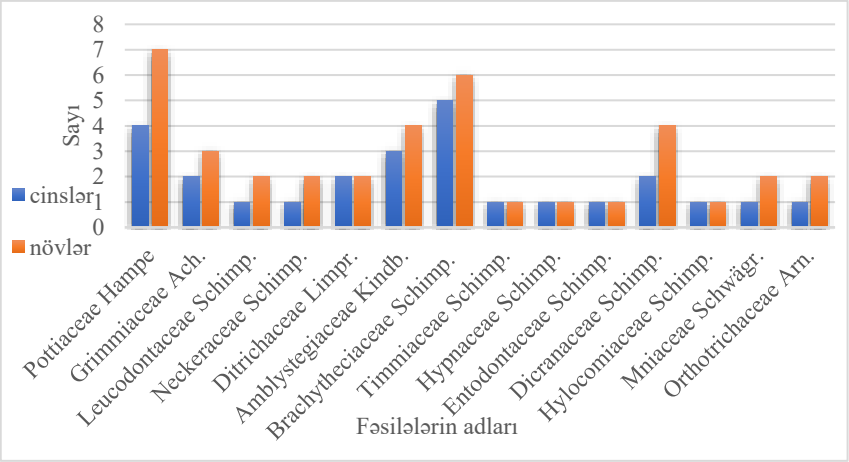

Figure 3. Taxonomic composition of mosses of Korchay State Nature Reserve

Analysis of the moss flora present in the area at the genus level shows that the 15 genera in the flora do not have a wide species diversity, but consist of only one species.

4.2. Geographical analysis

4.2.1. Geographical analysis of the lichens. In addition to the taxonomic composition, one of the main conditions for studying the flora of any area is to determine the origin of species. This problem can be solved through geographical analysis and research of the modern range. In the Korchay State Nature Reserve, 47 species of lichens belonging to 17 families and 33 genera are distributed. The species were analyzed according to geographical elements and 7 geoelements were identified. In general, the systematic structure of the mosses and lichens of the Korchay reserve mainly reflects the zonal characteristics of the flora. Furthermore, regional characteristics are also pronounced, which is attributed to the heterogeneous nature of the area[30]. The lichen flora as a whole is of nemoral-xerocontinental (arid) character. Boreal (15.0%), Euryholarctic (10.7%), and hypoarctic-montane (10.7%) species also play a certain role in the flora[31] (Fig. 4.).

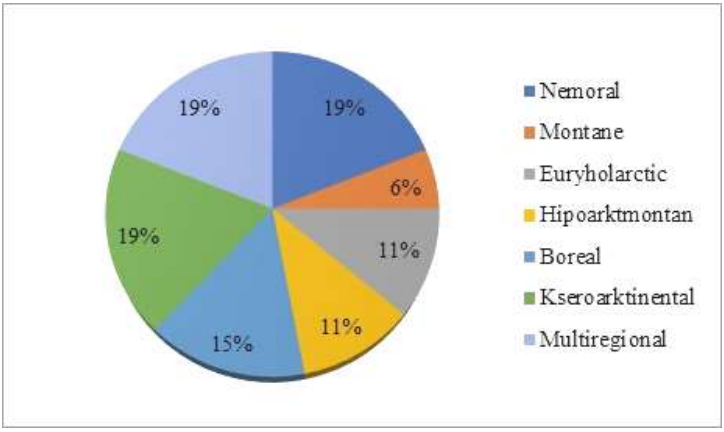

Figure 4. Geographical analysis of the lichens

[30] Novruzov, V.S., Ələkbərov, F.F., Fətəliyeva N.Q. Korçay Dövlət Təbiət Qoruğunda şibyələrin yayılması və coğrafi təhlili // Ümummilli lider Heydər Əliyevin anadan olmasının 100 illiyinə həsr olunmuş "Müasir Təbiət və İqtisad elmlərinin aktual problemləri", − Gəncə: 05-06 may, − 2023, 3-cü hissə, − s. 9-12.

[31] Alekberov, F.F. Botanical-geographical characteristics of lichens and mosses of Korchay State Nature reserve // Bulletin of Science and Practice. – 2023. v. 9, n. 1, − p.76-80.

4.2.2. Geographical analysis of the mosses. In the Korchay State Nature Reserve, 38 moss species belonging to 14 families and 26 genera are distributed. As a result of geographical analysis of moss flora, 5 geoelements were discovered. The moss flora is dominated by boreal (15 species) and arid species (9 species). Other elements are represented by fewer species (Euryholarctic - 6, Montane and Multiregional - 4). Based on the above, the moss flora is mainly characterized by arid-boreal, Mediterranean, and multiregional types.

The moss flora is generally boreal (39.5%) and arid (23.7%) in character. Euryholarctic (15.8%), montane and multiregional species (10.5%) also play a certain role in the flora (Fig. 5.).

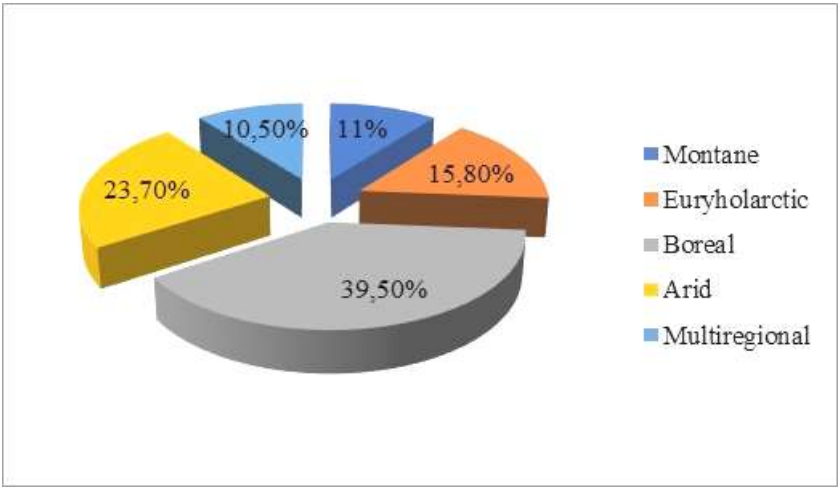

Figure 5. Geographic analysis of moss flora

4.3. Analysis of relicts. Relicts can provide valuable insights for clarifying the flora from ancient times and determining evolutionary pathways that shaped the modern state of the vegetation cover of any area. The scarcity of paleobotanical data does not allow to determine the history of emergence and formation of the mosses of the study area. Therefore, the development history and distribution patterns of the moss flora of the Korchay basin were studied based on floristic data.

According to the nature of its distribution, bioecological and systematic characteristics, the 3rd period relict lichen species of the study area are: *Aspicilia calcarea* (L.) Mudd., *Bacidia rosella* (Pers.) De Not., *Glypholecia scabra* (Pers.) Mull., *Gyalolechia flavovirescens* (Wulfen) Søchting, Fröden., *Lecanora conferta* (Duby ex Fr.) Grognot., *L. dispersa* (Pers.) Sommerf., *Lecidea lapicida* Ach., *Rhizocarpon expallescens* Th.Fr., *R. petraeum* (Wulfen) A. Mass., *Rhizoplaca melanopthalma* (DC) Leu. and *Toninia candida* (Web.) Th.Fr.

Species of lichens like *Acarospora bicolor* (Vain.), *Ochrolechia pallescens* (L.) A. Massal., *O. arborea* (Kreyer) Almb., *Pertusaria constricta* Erichs. and *Verrucaria floerkeana* Dall. are relicts of the Pleistocene glaciation.

Due to its biological characteristics and distribution *Barbula alpicola* C.Müll. Hal. and *Grimmia anodon* Bruch. are relict moss species. Relict complexes of mosses have been preserved in the area, mainly in carbonate rocks.

In the Bozdag range, climatic conditions vary along vertical zonation, and relicts are more abundant in refugiums. Usually, the species *Brachythecium mildeanum* (Schimp.) Schimp., *Dicranum polysetum* Sw., *Entodon orthocarpus* (Brid.) Lindb., *Eurhynchium speciosum* (Brid.) Jur., *Pottia lanceolata* (Hedw.) Müll. Hal., *Pohlia crudoides* (Sull) Broth., *Tortula subulata* Hedw. and *Hypnum imponens* Hedw. are found as III-period relicts in the refugiums of the temperate climate zone.

As a result of research, it was discovered that the mosses and lichens of the Korchay reserve were formed mainly due to the relicts of the Tertiary and Quaternary periods. Migration and speciation have further accelerated these processes. In total, 26 relict lichen and moss species (16 lichen and 10 moss species, respectively) were identified for the research area, as listed above.

4.4. Alternating life forms of lichens and mosses. As a result of the research conducted, it has been determined that there is a certain relationship between life forms and life strategy. The moss species *Amblystegium serpens* (Hedw.) Schimp. and *Brachythecium mildeanum* (Schimp.) Schimp., which are included in the boreal ele-

ment, have a carpet-like shape and tend to expand horizontally, which increases their tolerance to competition. This type of thallus is also ecologically plastic and can transition from an epigeic life form to epilithic and epixylic life forms under stress conditions in a technogenic regime. In some mosses, *Tortula subulata* Hedw., *Orthotrichum tenellum* Bruch. ex Brid. and *Dicranum acutifolium* (Lindb. & Arnell) C.E.O. Jensen transform into a smooth carpet-like form to increase resistance to trampling by animals. To retain moisture in cold and dry climates, *Entodon orthocarpus* (Brid.) Lindb., *Grimmia anodon* Bruch. and *G. pulvinata* (Hedw.) Sm. develop a pulviniform shape.

Although the crustose lichens develop much more slowly than other shaped species, this shape makes them more tolerant to adverse environmental conditions.

CHAPTER V. BIOECOLOGICAL, ECOLOGICAL-COENOTIC AND INDICATION CHARACTERISTICS OF LICHENS AND MOSSES

The lichen and moss flora of the Korchay State Nature Reserve exhibits a regular distribution pattern depending on the altitudinal gradient. Like other plant communities, the distribution of mosses and lichens has its own specific characteristics. When considering the formation of mosses and lichens, as well as the history of the development of flowering plants and the geomorphological development of the relief, it becomes clear that their geographical distribution and development are closely related to the environment. In general, the emergence and formation of the lichen flora on Earth dates back to the first half of the Cretaceous period, while the remains of ancient plants in the Lesser Caucasus region date back to the end of the Cretaceous period.

5.1. Bioecological groups of lichens and mosses. The spectrum of life forms depends on the growing areas of the species. The ecosystems studied are divided into several ecological-substrate groups based on their adaptation to different substrates. Epiphytic lichens and mosses are found on all substrates throughout the entire territory of the Korchay State Nature Reserve. Lichens and mosses

grow on a wide variety of substrates in the research area - tree bark, stones, soil, wood, and stumps. In this regard, lichens and mosses are divided into the following ecological groups: epixylic – 2; epiphytic– 21; epilithic– 13; epigeic– 9 species.

Each ecological group is characterized by a certain ecological regime. In most cases, lichens and mosses adapt to a specific substrate, but when environmental conditions are unfavorable, species can migrate to other substrates. Epiphytic species are also found on various substrates, depending on conditions[32] (Fig. 6).

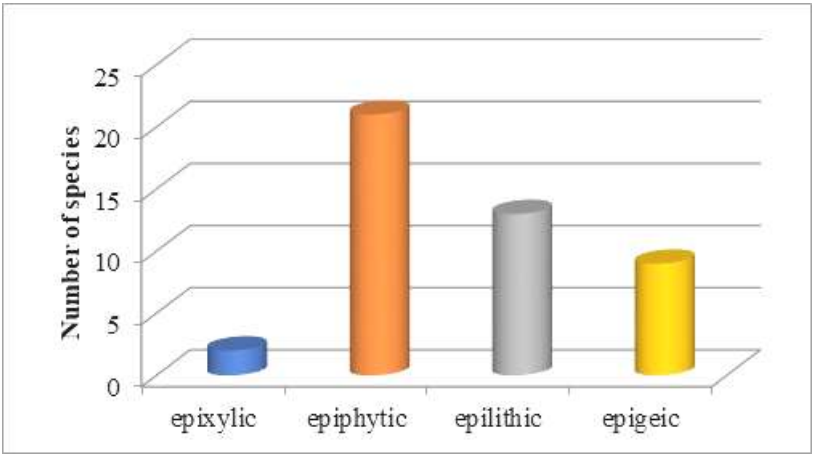

Figure 6. Ecological groups of lichens and mosses

5.2. Ecological-coenotic characteristics of lichens and mosses. Drawing upon the conceptions of H.Trass, we view the concept of synusia as "a single-layered specific community that occurs within the phytocenosis, reflects the characteristic features of microcommunity, and has a unique specific structure".

[32] Ələkbərov, F.F., Tağıyeva, N., Fətəliyeva, N. Korçay vadisi mamırlarının ekoloji-senotik xüsusiyyətləri // Doktorant və magistrantların IV Respublika elmi konfransının materialları "Təhsil, Tədqiqat və İnnovasiyaların vəhdəti", −Naxçıvan: 29 aprel, −2022, − s. 419-421.

The synusia typical for the research area are given in Table 1. Taking lichens and mosses as the syntaxonomic basis for the synusia, 3 unions (plant associations) and 13 societes (plant communities) were identified within the Korchay Reserve. A number of rare relict species were observed within the identified synusia. Therefore, for the conservation of rare species, it is recommended transitioning from autecological analysis to the synecological analysis of synusia. In unique ecotopes where they occur, the reserve regime should be strengthened and permanent control over populations should be ensured.

Table 1

Synusia typical of the research area

Taxa	Sinuses
Union	*Amblystegium serpens – Pottia lanceolata*
Sosiet	*Dicranum scoparium – Neckera complanata*
	Hylocomium splendens – Grimmia anodon
	Amblystegium serpens – Grimmia pulvinata
	Orthodicranum anomalum – Brachythecium mildeanum
	Dicranum scoparium – Hylocomium splendens
Union	*Brachythecium mildeanum – Xanthoria parietina*
Sosiet	*Brachythecium mildeanum — Cladonia fimbriata*
	Amblystegium serpens – Cladina rangiferina
	Dicranum scoparium – Flavoparmelia soredians
	Pottia bryoides – Lecanora dispersa
Union	*Cladonia cornuta – Lecanora dispersa*
Sosiet	*Cladonia fimbriata – Xanthoria parietina*
	Physcia stellaris – Toninia candida
	Cladina rangiferina – Aspicilia calcarea
	Physcia stellaris – Evernia prunastri

Epiphytic life forms in the synusia characterize the climatic conditions of the region as a whole. While in the Korchay reserve, 55% of the life forms of the lichens are crustose, 28% are leafy, and 17% are fruticose, in the Tugai forest the majority of life forms are

crustose (54%), with only 34% having leafy life forms. The impact of anthropogenic factors on epiphytic synusia in the reserve manifests itself through species that are sensitive to atmospheric pollutants[33].

The analysis of the reserve's bryoflora according to ecological conditions is presented in Table 2.

Table 2

Analysis of the reserve's bryoflora by ecological groups

№	Ecological groups	Distribution conditions	Number of species	General by number %
1.	Hydrophytes	In water basins and swamps	2	5.3
2.	Mesophytes	In damp and shady places	8	21
3.	Mesoxerophytes	In places with low humidity and high drought	11	29
4.	Xerophytes	In drought, on southern slopes	12	31.6
5	Hygrophytes	In coastal areas	5	13.1

The moss species common in the reserve include 8 mesophytic species, 11 mesoxerophytic species, 12 xerophytic species, and 7 hydrophytic and hygrophytic species.

5.3. Indication properties of lichens and mosses. Following long-term monitoring in nature reserves, it is essential to re-evaluate species diversity of mosses. The moss species *Trichostomum crispulum* Bruch. is considered an indicator of changing humidity. The thallus of the species *Flavoplaca citrina* (Hoffm.) Arup has branched cracks. Changes occur in cracks depending on climatic conditions. Thus, certain changes occur in those cracks depending on humidity and temperature[34].

[33] Bayramova, A.A., Ələkbərov, F.F. Korçay vadisi mamırlarının bioekoloji və sinuzial xüsusiyyətləri // Odlar yurdu Universitetinin Xəbərləri, − Bakı: − 2022, − s.109-114.

[34] Ələkbərov, F.F., Nəbiyev, R.Q. Şibyələrin bioindikasiya xüsusiyyətləri // Beynəlxalq elmi konfransın materialları "Müasir Təbiət və İqtisad Elmlərinin Aktual Problemləri", − Gəncə: 03-04 may, −2019, − s. 78-80.

Based on the poleotolerance scale, it is possible to determine the concentration of various pollutants in the atmospheric air according to the composition of lichens. Due to these characteristics, the lichens are used as an ecological monitoring network (Fig. 7-8).

Figure 7. Mosses as an ecological monitoring network

Figure 8. Lichens as an ecological monitoring network

Among the species of lichens found in the Korchay State Nature Reserve, *Polycauliona polycarpa* (Hoffm.) Frödén et al., *Physcia adscendens* H.Olivier., *P. caesia* (Hoffm.) Fürnr., *Xanthoria parietina* (L.) Th. Fr. and moss species *Leptodictyum riparium* (Hedw.) Warnst. are

nitrophilous species. These nitrophilous species form relatively large populations, mainly in areas where birds nest. The ecological activity and the breadth of the spectrum of occurrence of *Caloplaca decipiens, Cladonia fimbriata, Lecanora glabrata, Pleurosticta acetabulum* species are close to those of the cities Mingachevir and Yevlakh. Species such as *Xanthoria parietina, Parmelia laevigata, Physcia adscendens, P. caesia, P. stellaris* and *Candelariella aurella* are recommended for bioindication, and *Caloplaca decipiens, Cladonia fimbriata, Lecanora glabrata* and *Pleurosticta acetabulum*for anthropogenic changes in ecological conditions in phytocenoses.

To use plants as indicators, it is first necessary to clarify the signs of indication. For this, the signs must be precise and clear. If these aspects are not taken into account, the indication may give incorrect results. Tolerance (sustainability) markers should be identified for individual vegetation types within each zone. For example, the vegetation cover of the western region of Azerbaijan, which has an arid climate, undergoes seasonal changes depending on the seasons of the year.

Lichens can be considered the most perfect indicator for determining soil type. Thus, *Toninia candida* is the best indicator for clayey and clay-mixed, weakly alkaline soils. *Candelariella aurella* is an indicator of calcareous and carbonate soils. Light chestnut-colored clay-carbonate soils are a permanent habitat for the species *Parmelia laevigata*.

Currently, the term indication is often repeated in various fields: soil indication (pedo-indication), mountain rocks (meto-indication), glacial indication (copo-indication), salinization (halo-indication), human activity (anthro-indication), plant indication (phyto-indication). Recently, another indication has emerged - lichen indication. The lichen indication method has many prospects. By growing in habitats where other plants cannot survive, lichens actively participate in soil formation, which is crucial for the development of the regional flora. Regardless of the seasons of the year, the color variation in their thalli does not manifest itself sharply. In response to environmental changes, stable taxonomic characters develop within them. Therefore, lichens can be used as indicators in all seasons of

the year. Without employing economically costly and labor-intensive methods, this approach makes it possible to pre-forecast even the areas suitable for various sectors of agriculture.

In recent decades, due to the rapid development of industry and the sharp changes in the ecological situation in our Republic, the possibility of using more reliable and also relatively cost-effective, efficient environmental monitoring methods for organizing long-term permanent control and forecasting over natural environmental components on a regional scale has begun to be studied.

As indicated, the Korchay reserve was designated as an ecological testing ground because it meets the requirements of international biological programs, and the scope of influence of anthropogenic anomalies within the agroecosystems of Mingachevir and Yevlakh districts was determined based on test species.

CHAPTER VI. COMPARATIVE CHARACTERISTICS OF THE LICHEN AND MOSS FLORA OF THE KORCHAY STATE RESERVE WITH THE FLORAS OF OTHER REGIONS

It is possible to reach certain scientific conclusions by selecting species that are sensitive to the emergence, formation, and indication of the flora of a specific area and comparing them with the flora of neighboring areas. According to many researchers, in order to determine general botanical geographical relationships, it is essential to consider not only the number of species, genera, and families, but also their comparison with the floras of various adjacent territories. For this purpose, comparing the lichen and moss flora of the reserve with species found in areas near the reserve is a valuable source of material for determining the formation of species[35].

For this purpose, the geographical distribution of lichens and mosses of the Korchay reserve was compared with the lichen and mosses flora of the Mingachevir, Ganja, Yevlakh and Goygol areas. These areas were chosen because they border the Korchay reserve.

[35]Alekberov, F.F., Isayeva, F.M. Lichenobıota of urboecosystems and clustering problems // Sylwan journal, − 2019, v. 163, is. 4., − s. 34-37.

Undoubtedly, although these areas differ from one another in terms of scale and level of study, they are highly favorable for determining the pathways of flora migration. Analyses of individual families and genera indicate that the relationships between the compared areas are not the same. Thus, the lichen flora of Mingachevir is characterized by 12 species, and the moss flora by 9 species. The lichen flora of Ganja is characterized by 5 species, and the moss flora by 5 species. The lichen flora of Yevlakh is characterized by 11 species, and the moss flora by 8 species. The comparison of the lichens and mosses of Goygol National Park is more characteristic. Thus, Goygol National Park is represented by 7 species of lichens and 6 species of mosses[36].

A comparative analysis of the lichen and moss flora of the reserve with the lichen and moss flora of other areas shows that, at the species level, they are relatively closer to the lichen and moss flora of Mingachevir and Yevlakh territories. The diversity in flora is due to the different climatic conditions in the area and also to the geographical adaptation of species.

The species adapted to the border zones of the reserve with Mingachevir–which are exposed to anthropogenic anomalies–include *Candelariella aurella, Cladonia coniocraea, C.fimbriata, Peltigera canina, Physcia adscendens, P.caesia, P.stellaris, Pleurosticta acetabulum, Xanthoria parietina* and etc.

CHAPTER VII. MONITORING THE COENOPOPULATIONS OF RARE LICHENS AND MOSSES AND THE CONSERVATION OF THE GENE POOL

Studying the species diversity of lichens and mosses in the Korchay State Nature Reserve and analyzing their distribution patterns enables for the identification of rare species. Rare species include species with only 3-5 occurrence locations. Species in need of protection were selected and a list was compiled by us. These lichen species include *Bacidia rosella* (Pers.) De Not., *Flavoparmelia caperata* (L.)

[36] Ələkbərov, F.F., Novruzov, V.S. Korçay Dövlət Təbiət Qoruğunun şibyə florası // − Gəncə: Azərbaycan Respublikası Elm və Təhsil Nazirliyi Azərbaycan Texnologiya Universitetinin Elmi Xəbərləri, − 2022, − s. 52-56.

Hale., *Lecanora allophana* Ach.Nyl., *Melanelixia glabra* (Schaer.) O. Blanco et al., *Ochrolechia pallescens* (L.) A. Massal., *Parmelia laevigata* Sm. Ach., *Pertusaria constricta* Erichs., *Glypholecia scabra* (Pers.) Mull., moss species - *Timmia bavarica* Hessl., *Camptothecium lutescens* (Philibert) Bertsch., *Dicranum acutifolium* (Lindb. of Arn) C.E.O.Jensen, *D. polysetum* Sw., *Eurhynchium speciosum* (Brid.) Jur. and *Orthotrichum tenellum* Bruch. ex Brid. [37].

The populations of the *Rhynchostegium murale* (Hedw.) Schimp. species, which are found in the calcareous rocks of the Bozdag area, in humid and shady places, are not stable in all their occurrences and disappear as soon as the humidity regime changes. Monitoring their populations, discovering new occurrence sites, and establishing a conservation regime in their habitats are considered appropriate.

The habitats of the relicts distributed across the Bozdag ridge belong to interglacial and post-glacial relicts. Post-glacial relicts are widespread in ravines, steep slopes, alkaline soils, and steppe phytocenoses with disturbed grass cover. Relict moss complexes are mainly preserved in carbonate rocks.

Based on the frequency of species occurrence, the lichen and moss flora of the research area are classified into 3 categories according to their degree of rarity:

Category I (CR B2ab) – those Critically Endangered. From lichens *Parmelia laevigata* Sm. Ach., *Pertusaria constricta* Erichsen, *Melanelixia glabra* (Schaer.) O. Blanco et al., mosses *Timmia bavarica* Hessl., *Dicranum acutifolium* (Lindb. & Arnell) C.E.O.Jensen and *Eurhynchium speciosum* (Brid.) Jur. belong to this category.

Category II (EN) – the endangered limit. These include the lichen species *Gyalolechia flavovirescens* (Wulfen) Søchting et al., *Peltigera aphthosa* (L.) Willd., *P. canina* (L.) Ach., *Lecania triseptata* Boom & Moniri., and moss species *Entodon orthocarpus* (Brid.) Lindb., *Pohlia crudoides* (Sull) Broth., *Hygroamblystegium*

[37]Гасымова, А.Г., Алекперова, Ф.Ф. Мониторинг и охрана генофонда в сенопопуляциях редких лишайников, мхов // Естественные и технические науки, − 2024, №12(199), − s.148-151.

humile (P.Beauv.) Vanderp., Hedenäs & Goffinet, *Hypnum imponens* Hedw. and *Trichostomum crispulum* Bruch. The destruction of the habitats of such species may lead to the extinction of the species itself. It is important to organize constant control over their populations.

Category III (VU D2) – Vulnerable From lichens, *Bacidia rosella* (Pers.) De Not., *Glypholecia scabra* (Pers.) Müll. Arg., *Flavoparmelia caperata* (L.) Hale., *Lecanora allophana* Ach. Nyl., *Ochrolechia pallescens* (L.) A. Massal., mosses *Camptothecium lutescens* (Philibert) Bertsch, *Dicranum polysetum* Sw. and *Orthotrichum tenellum* Bruch. ex Brid. belong to this category.

CONCLUSIONS

1. For the first time, 47 lichen species belonging to 17 families and 33 genera and 38 moss species belonging to 14 families and 26 genera were discovered in the Korchay State Nature Reserve. In terms of species richness, the leading positions within the lichen flora are occupied by the families *Parmeliaceae* Zenker. (6 species), *Cladoniaceae* Zenker. (6 species), *Lecanoraceae* Körb. (6 species), *Teloschistaceae* Zahlbr. (5 species), *Physciaceae* Zahlbr. (4 species), *Ramalinaceae* C.Agardh (4 species) and within the moss flora - *Pottiaceae* Hampe. (7 species), *Brachytheciaceae* Schimp. (6 species), *Dicranaceae* Schimp. (4 species), *Amblystegiaceae* Kindb. (4 species), *Grimmiaceae* Ach. (3 species). Other families are represented by 1-2 species.
2. Among the 17 lichen families that make up the systematic structure, *Arthoniaceae* Rchb., *Verrucariaceae* Zenker, *Lecideaceae* Chevall., *Megasporaceae* Lumbsch, *Stereocaulaceae* Chevall., *Pertusariaceae* Körb. and among 14 moss families *Timmiaceae* Schimp, *Hypnaceae* Schimp., *Entodontaceae* Schimp., *Hylocomiaceae* Schimp. are represented by only one genus and one species. Overall, the average number of species in families in the research area is 8.6, the average number of genera in families is 2.2, and the average number of species in genera is 3.9.

3. It was determined that the lichens and mosses of the reserve area are divided into 4 life forms (epixylic, epigeic, epiphytic, and epilithic) based on their growing substrate, and into 5 ecological groups (xerophytes, mesophytes, mesoxerophytes, hygrophytes, and hydrophytes) according to their moisture supply.
4. The lichen and moss flora of the research area was divided into 3 categories based on their degree of rarity, and it was determined that 6 species belong to Category I (Critically Endangered – CR B2ab), 9 species to Category II (Endangered – EN), and 8 species to Category III (Vulnerable – VU D2)."
5. The lichen and moss flora are not genetically heterogeneous, but consists of geographical elements belonging to different floristic provinces. The moss flora as a whole is of boreal (39.5%) - arid (23.7%) character. Euryholarctic (15.8%), montane and multiregional species (10.5% each) also play a role in the flora. The lichen flora as a whole is of nemoral-xerocontinental (arid) character. Boreal (15.0%), euryholarctic (10.7%), and hypo-arctic-montane (10.7%) species also play a role in the flora.
6. Based on the biological diversity of species in the test objects in the bio-testing grounds and the existing ecosystem, it was determined that, based on their occurrence level, *Acarospora bicolor* (Vain.) Zahlbr, *Lecanora dispersa* (Pers.) Sommerf, *Lepraria incana* (L.) Ach., *Bacidia rosella* (Pers.) De Not., *Physcia adscendens* H. Olivier., *P. stellaris* (L.) Nyl., *Rhizoplaca melanopthalma* (DC) Leu. toksitolerant, *Anaptychia ciliaris* (L.) Körb., *Flavoparmelia caperata* (L.) Hale, *Ramalina farinacea* (L.) Ach. and etc. are lichens sensitive to atmospheric pollutants; *Amblystegium subtilis* (Hedw) Schimp., *A. serpens* (Hedw) Schimp., *Timmia bavarica* Hessl. toksitolerant, *Brachythecium mildeanum* (Schimp.) Schimp., *Dicranum acutifolium* (Lindb & Arnell) C.E.O.Jensen., *Eurhynchium zetterstedtii* Hedw., *Pohlia annotina* (Hedw.) Lindb., *Tortula subulata* Hedw. are mosses sensitive to atmospheric pollutants.

PROPOSALS AND RECOMMENDATIONS

1. It is proposed to use toxitolerant lichens and moss species as bio-

logical test objects for continuous monitoring of atmospheric pollution on the border of the Mingachevir reservoir.
2. It is recommended to effectively protect rare and endangered species of lichen and moss species in the reserve regyme, organize continuous monitoring of their populations, and include them in the "Red Books".
3. The reserve regime should be strengthened in the unique ecotopes where relicts are found in the Korchay State Nature Reserve.

List of published scientific works on the topic of the dissertation

1. Ələkbərov, F.F., Bayramova, A.A. Korçay Dövlət Təbiət Qoruğu şibyə florasına dair // Beynəlxalq konfransın materialları "Müasir Təbiət Elmlərinin Aktual problemləri", − Gəncə: − 2017, − s.121-123.
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4. Alekberov, F.F., Isayeva, F.M. Lichenobıota of urboecosystems and clustering problems // Sylwan journal, − 2019, v. 163, is. 4., − s. 34-37.
5. Ələkbərov, F.F., Tağıyeva, N., Fətəliyeva, N. Korçay vadisi mamırlarının ekoloji-senotik xüsusiyyətləri // Doktorant və magistrantların IV Respublika elmi konfransının materialları "Təhsil, Tədqiqat və İnnovasiyaların vəhdəti", −Naxçıvan: 29 aprel, −2022, − s. 419-421.
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8. Novruzov, V.S., Alekberov, F.F. Lichens and mosses in Bozdag mountain range, opportunities of their use for monitoring // Acta Botanica Caucasica, – 2022, v. 1, no1, – p. 28-31.
9. Алекперова, Ф.Ф., Новрузов, В.С. Пустынные степные лишайники Корчайского государственного заповедника Азербайджана // Биоразнообразие и рациональное использование природных ресурсов. Материалы докладов X Всероссийской научно-практической конференции, с международным участием. –Махачкала: 21-22 апреля, –2022. – s.53-56.
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