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Research Article

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Study of lichen species growing in the "eastern part" of Kazakh small mountain hills

The rapid development of industry at the present stage, the accumulation of harmful waste, and the emergence of large settlements—all these anthropogenic factors cause climate change around the world. In this regard, it is known that a decrease in atmospheric moisture has a significant impact on the expansion of desert areas. The above-mentioned global changes directly affect living organisms on Earth and alter the species composition of both flora and fauna. Therefore, scientists must pay special attention to the natural changes occurring in local flora. In this study, lichens were chosen as the object of research, as they form an essential part of the local flora, inhabit various biomes, and are resistant to climatic changes due to their structural features. In recent years, scientific publications on the plant flora of Kazakhstan have included lichenological studies providing data on the biological characteristics, ecology, and indicator value of species growing in specific regions. However, there are no dedicated studies covering the lichen species found in the flora of the Chingistau, Kalbatau, Kokentau, and Abraly mountains, which belong to the eastern part of the Kazakh Small Hills. In the present study, a comparative analysis of the species composition was carried out, since the mountain ranges collectively known as the Small Hills of the East are located far from each other. As a result, 11 species belonging to 5 genera and grouped into 6 families were identified as growing across all these hills.

Keywords: Kazakh small hills, epilyticlichen, epigeallichen, indiffent lichen, Drude scale

Introduction

The "eastern part" of the Kazakh small hills occupies the southwestern part of the land sections of the Abay region. This territory is distinguished by a strongly sliced low-mountainous, small-hilly terrain. The Chingis Mountains occupy a large area, stretching from northwest to southeast [1]. Most of all, small hills in the eastern part of Kazakhstan are located connecting the territories of two large regions of Kazakhstan. The part that includes the Abraly mountains, the eastern part of Saryarka includes small hills located on the territory of the Karaganda region, Karkaraly district and Abay district [2].

In connection with the topic of the research work, the importance of the emergence of various types of lichens, based on the diversity of photo—and mycobiontes in the symbioses of lichens in rocks, is shown in the research works of foreign scientists. Lichens are sensitive to climate change and have been found to be at risk of extinction in the highlands. Temperature and precipitation, the effects of the altitude gradient change the structure and phylogenetic diversity of lichen associations [3–5]. In addition, data are presented on the structure of lichen thalli and their changes depending on climatic conditions. It has been established that a certain lichen consists of several groups of algae and also fungi, including ascomycetes and two phylogenetic basidiomycetes [6–8]. The frequency of occurrence and distribution of lichens is determined by considering their functional features. Changes in the external morphology of lichens are considered to be related to its level of hydration and the course of photosynthetic activity. The vast majority of lichens are adapted to grow in the high latitudes of the mountains, in temperate and subtropical zones [9].

In recent years, research work on lichenology in Kazakhstan shows data on the species of lichens distributed in the small hilly, mountainous areas of central Kazakhstan and their relationship with the environment [10–12].

On the rocks of small hilly mountain slopes, the main plant associations, painted in different colors, are formed by lichens. In some domestic works, it is given that among the vegetation cover in the Kazakh small

hills, lichens belonging to the genus Cladonia, Alectoria, Peltigera are found from the lower plants [2]. In literary sources, the biology, ecology and types of lichens that need protection are studied in the biomes of the Burabay Park [13-14].

In addition, among the published scientific works in accordance with the plant flora of Kazakhstan, one can find General Data related to the distribution, morphological and environmental characteristics of lichen species. But, in particular, due to the species of lichen growing in the mountains of Chingistau, Kalbatau, Kokentau, Abraly, which belong to the small hills and low mountains of Abay region, information is very rare. These mountains are known as the spurs of the Tarbagatai and Saryarka mountains of the East, which are located on the territory of the Abay region at a certain distance from each other. The species of higher plants that grow in the study areas are very inhospitable in the mountain belts. This is due to the fact that the soil cover is gravel, and the moisture content is very small, there are often associations of real xerophytic plants. As the dominant plant species characteristic of all research areas, plant species such as Festuca, Artemisia, Stipa, Spiraea, Juniperus, Allium, Orostachys and others grow. In accordance with the main goal of the research work, the above-mentioned species of lichen growing on small hills and low mountains were studied. In the regions surveyed, the route expedition was carried out in different seasons of 2024-2025.The lichenological study was carried out using geobotanical methods.

Experimental

Identification of lichen species settled in the mountains of Abraly ($49^0$10N $77^0$25E), Kokentau (Semeytau) ($50^0$10N $79^0$43E), Kalbatau ($49^0$22N $81^0$29|30E) and Chingistau ($48^0$52N $79^0$15E), grouping into systematical taxa and meeting with the environment communication research was carried out.

a) **b)** **c)** **d)**

Figure 1. Map-scheme of the regions where the route expedition to the small mountain hills of Abay region was carried out a) Abraly mountains b) Chingistau c) Kokentau (Semeytau) d) Kalbatau

Among the geobotanicalmethods, the determination of quantitative indicators of species in plant associations living in research areas is of great importance. To determine the number of lichens settled at the research sites, the number, density and variety of lichens within 1 м^2 of wooden Squaresticks were evaluated in advance. In the study, indicators were obtained depending on the variety, number and covering projection of lichens within 1 м^2 Squaresticks in the mountains of Abraly, Chingistau, Kalbatau, Kokentau. To determine the quantitative and covering projection in the research areas, the obtained Squaresticks were carried out by throwing them randomly (10–15 times with a repetition) at the research sites. The accuracy of the numerical values obtained from the test sites directly depends on the repeated implementation of the experiment. This is because it must be taken into account that the types of epilytic lichen have their own characteristics in the research methods compared to epiphytic and epigeal lichen. Especially in some cases, factors such as the surface shapes of different rocks (steep, rocky) and the growth of lichen individuals settled on them, covering each other, cause difficulties in determining their quantitative indicator. To find quantitative indicators of very rare (Sol), rare (Sp), often (Cop) very numerous (Soc) species of lichens, the Drude scale was used as a geobotanical method [15].

Determination of the types of lichen taken as samples was carried out using the 3-volume determinant of E.I. Andreeva “Flora of spore plants of Kazakhstan” [16]. Identification of lichens collected during the route expedition was carried out using the “Low vacuum raster electron microscope (rem)” JSM-6390 LV JEOL (Japan). In connection with the research work, collections of collected types of lichens were created.

Results and Discussion

The route expedition was carried out in the last months of autumn, spring and summer. The GIS map of the regions where the route expedition was conducted was taken, and latitude and longitude indicators were given (map).

As shown on the map, certain points of the small hills of the East were taken. During the guided expedition on the Chingistau, Kalbatau, Kokentau and Abraly mountains, which are part of the Kazakh small and low-lying mountain ranges, the collected types of lichen were identified and classified into systematic groups. The identified species were analyzed depending on the form of life, ecology and frequency of occurrence (Tab. 1).

Table 1

Biology and ecological features of lichen species settled in the small hills of Abay region

№	Genus	Frequency of meetings	Lifeform	Ecology
Family *– Verrucariaceae*				
1	*Genus Verrucaria* *Species V.nigrescens*	(Cop)	scale lichens	epilytic
Family *–Acarosporaceae*				
2	*Genus Acarospora* *Species A. chlorophana*	(Sol)	scale lichens	epilytic
Family *– Caloplacaceae*				
3	*Genus Caloplaca* *Species C. viridirufa*	(Sol)	scale lichens	epilytic
4	*Genus Caloplaca* *Species C. decipiens*	(Sp)	scale lichens	epilytic
Family *– Lecanoraceae*				
5	*Genus Placolecanora* *Species P. alphoplaca*	(Sol)	scale lichens	epilytic
6	*Genus Lecanora* *Species L. allophana*	(Sp)	scale lichens	epilytic
7	*Genus Lecanora* *Species L. frustulosa*	(Sp)	scale lichens	epilytic
Family *– Parmeliaceae*				
8	*Genus Parmelia* *Species P. tominii*	(Cop)	leafylichens	epilytic
9	*Genus Parmelia* *Species P. conspersa*	(Sp)	leafylichens	epilytic
10	*Genus Parmelia* *Species P. vagans*	(Soc)	leafylichens	epigeal
11	*Genus Parmelia* *Species P. sulcata*	(Sol)	leafylichens	indiffent

Of the 11 species identified depending on the Life Form, 4 species were grouped into leafy lichens and 7 species of scaly (sometimes small-leaved) lichens. Due to their ecology, 9 out of 11 species were classified as epilytic lichen, 1 as epigeal, and one species as indifferent species (Tab. 1). In the course of the study, the settlement of lichens at different heights of the mountains was directly related to the mountain slopes. In comparison with the slopes of the mountains, epilytic lichen species are most often settled on sunny slopes, where there is plenty of sunlight. In addition, the lichens that settled on the sunny side of the mountain differed due to their morphological structures and colors. For example, species such as Acarospora chlorophana, Caloplaca viridirufa, Caloplaca decipiens, Lecanora Allophana, which have different frequency of occurrence, and most importantly, have a beautiful bright color. And on the negative surfaces of the mountain, it was noticed that lichen species Verrucaria nigrescens, Lecanora frustulosa, Parmelia tominii, Parmelia conspersa often grow in black and gray color.

Table 2

Indicators of lichen species settled in small and low Kazakh mountains, depending on the quantitative and covering projection

№	Lichen species	Chingistau		Kalbatau		Kokentau		Abraly mountains		Average indicators of all types of lichens	
		Ranks	coverprojection %	Ranks	coverprojection %	Ranks	coverprojection %	Ranks	coverprojection %	Ranks	coverprojection %
1	*Verrucaria nigrescens*	1, 8	2,2	6,1	3,1	22,2	20,4	24,9	25	13,8	12,7
2	*Acarospora chlorophana*	-	-	1,8	1,7	2,5	0,5	10,6	2,2	3,7	1,1
3	*Caloplaca viridirufa*	-	-	4,1	2,1	-	-	-	-	1,0	0,5
4	*Caloplaca decipiens*	2,2	2,0	4	1,6	8,2	1,8	12,9	8,2	6,8	3,4
5	*Lecanora allophana*	1,4	0,8	13,5	5,3	5,6	3,4	6,3	4,5	6,7	3,5
6	*Lecanora frustulosa*	2,9	2,7	2	1,5	2,5	0,9	19	9,5	6,6	3,7
7	*Parmelia tominii*	1,3	1,3	27,7	11,5	12	6	21,7	10	15,7	7,2
8	*Parmelia conspersa*	6,8	2,7	3,5	2,6	8	3,7	2,1	3	5,1	3
9	*Parmelia vagans*	55,1	47,2	76,4	45,4	2	1,1	-	-	33,4	23,4
10	*Placolecanora alphoplaca*	1,8	2,7	-	-	4,1	2,7	-	-	1,5	1,3
11	*Parmelia sulcata*	0,3	0,1	-	-	-	-	-	-	0,07	0,02

In terms of the number of identified lichen species grows in Chingistau (9), Kalbatau (9), Kokentau (9), and Abraly mountains (7). Due to the covering projection, the species Parmelia vagans showed greater values in the Chingistau and Kalbatau mountains (47.2 % and 45.4 %). In the process of comparing their averages with the diversity of lichens settled in the mountains obtained in each study, it was found that, depending on the number and covering projection, the dominant species are Parmelia vagans, Parmelia tominii and Verrucaria nigrescens. In addition, in the course of the study, the species Parmelia sulcata, Caloplaca viridirufa and Placolecanora alphoplaca, which are very small in number and have a very low incidence, were classified as very rare species (Tab. 2, Diagrams 1-2).

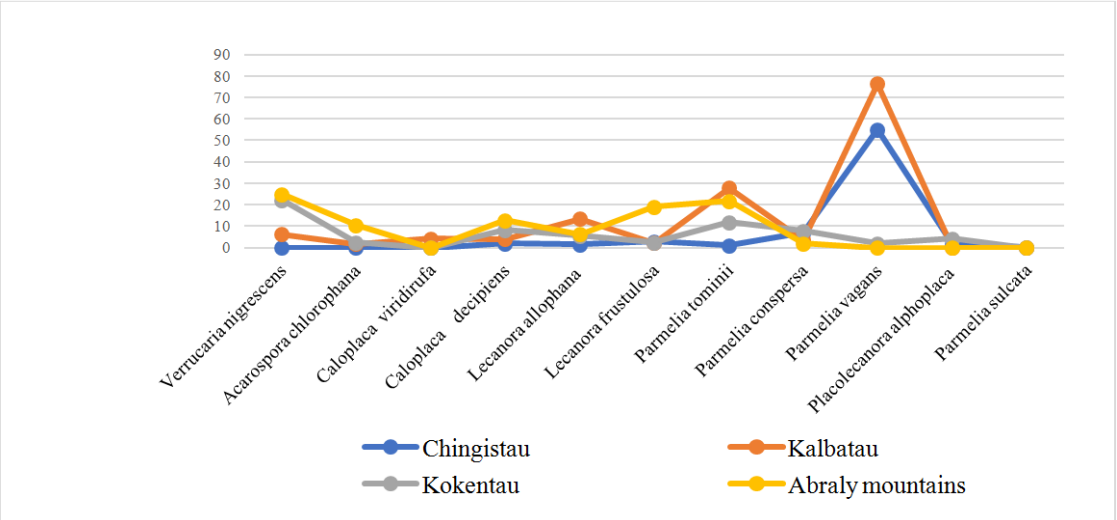


Diagram-1. Quantitative indicators of lichen species settled in Kazakh small mountain ranges

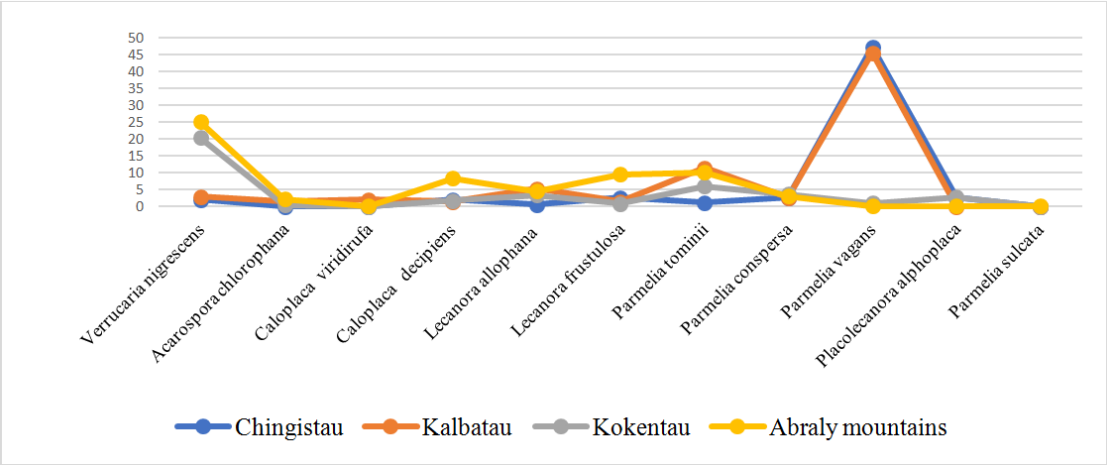
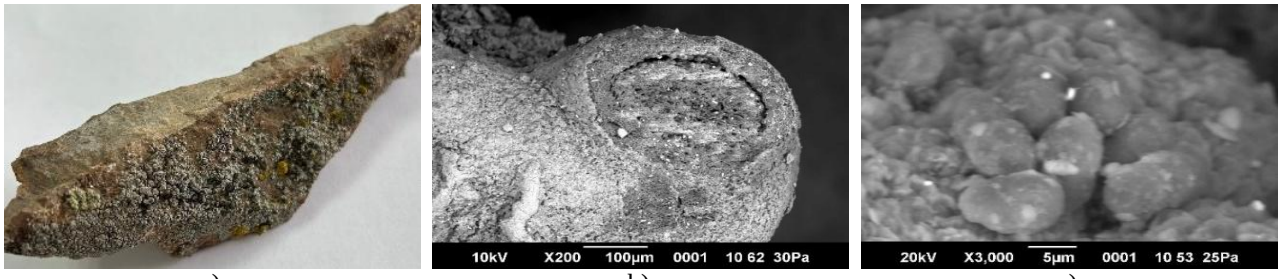


Diagram-2. Indicators of lichen species settled in Kazakh small mountain ranges depending on the covering projection

The following is a morphological brief description based on the settlement of lichens on substrates and photo images obtained under a scanning microscope.

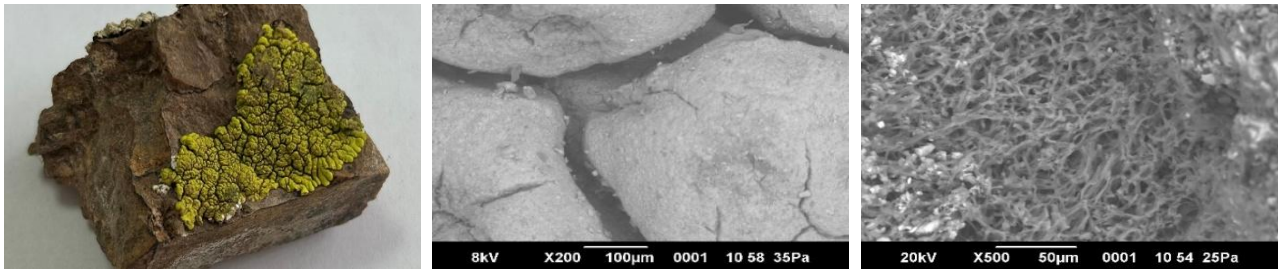
1. *Verrucariaceae*–Verrucaria nigrescens—frequent, scalylichen. Belongs to the epilytic type, adapted to growth in the stone. The lichen thallus is brownish-gray in color, very thin, the underside of the thallus is black. Many perithecia, black in color, are located inside the thallus, penetrating it. The spores are of different shapes, arranged in several rows. Pycnidium are formed by spreading over the lichen in the form of a black dot.



a) b) c)

Figure 2. a) General view of the lichen Verrucaria nigrescens settled on the stone surface;
b) Aseparate perithecia and a black pycnidium part of the species;
c) Manifestation of lichen spores formed in the peritoneum

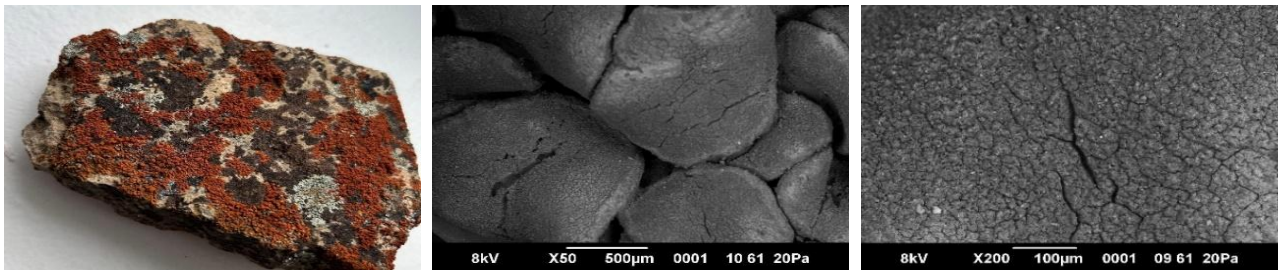
2. *Acarosporaceae*–Acarospora chlorophana—very rare, epilyticlichen. The surface of the thallus is uniformly scaly, thin. The areoles are smooth, slightly fleshy, light yellow-green in color. In close contact with each other, in the form of a whole coating, sometimes separated, scattered among other types of lichen is formed. The middle layer of the thallus is white, dense, the undercoat is black, clearly noticeable.



a) b) c)

Figure 3. a) The period when the species Acarospora chlorophana grew in the substrate;
b) Angular formation of apothecium disks; c) View of the corepart of the lichen

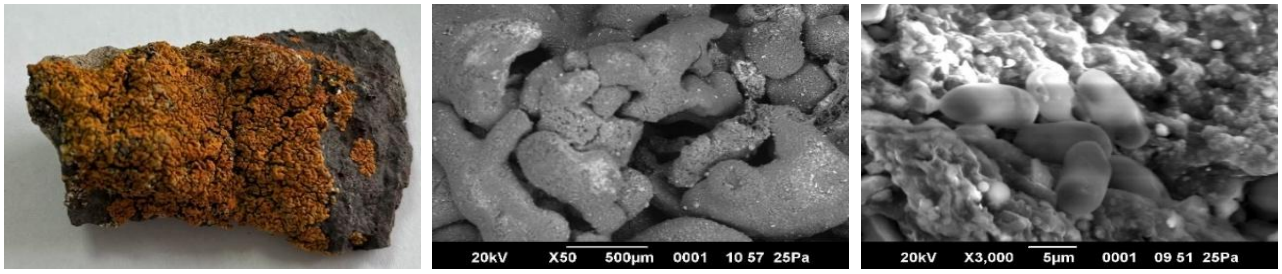
3. *Caloplacaceae*–Caloplaca viridirufa—very rare, scaly lichen. The color is dark red or red-brown, with epilytic lichens settling on the surface of the stones.The thallus on the surface of the stone is formed by a thin, hard sticking. The apothecia is located in large numbers in the middle part of the thallus, forming singly, but in close contact with each other. The apothecia is oval or round in shape, with a whole edge. Eight ascospores are formed in the ascus.



a) b) c)

Figure 4. a) Location of the species Caloplaca viridirufa in the stone;
b) Representation of apotheias of different shapes; c) The surface part of the individual apothecary

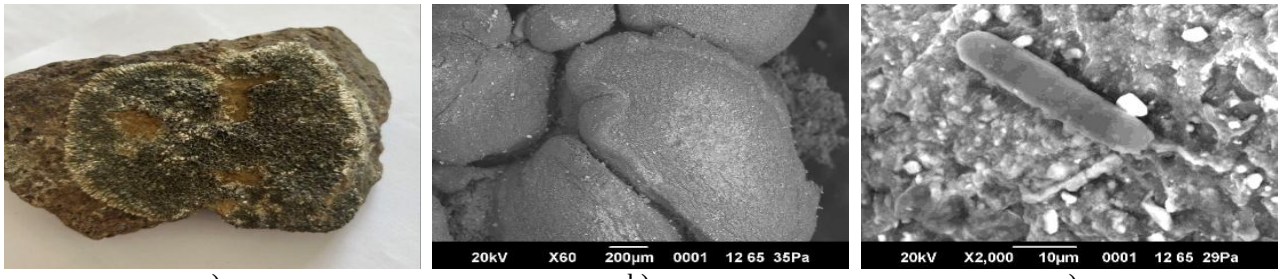
4. *Caloplacaceae*–Caloplaca decipiens (Gasparrinia decipiens)—the most common is epilytic, scaly lichen. The surface of the thallus is rough, in the form of grains. The color of the surface layer is orange-red. Flatshape, color orange-yellow. The undercoat of the thallus is dark gray in color, not clearly noticeable. The incipient apothecia is sessile and sparsely located. The edges of the apothecia disks are intact but, branched. The spores are two-celled, bipolar, and consist of 8 elliptical spores.



a) b) c)

Figure 5. a) Caloplaca decipiens lichen species; b) Manifestation of the apothecia part of the lichen; c) Elliptical spores

5. *Lecanoraceae*–Placolecanora (Lobothallia) alphoplaca—the extreme edges of the areoles of different shapes and sizes are clearly formed, the surface part of the thallus is rough. The color of the thallus is white-gray, in the middle part there are groups of black apotheosis.The shapes of the apothecia are convex and formed in a protruding state. 4 or 8 spores are located in special pockets.

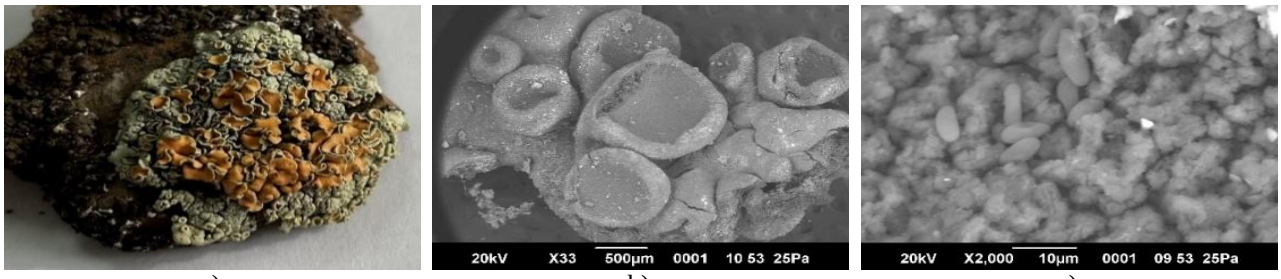


a) b) c)

Figure 6. a) General view of the species Placolecanora (Lobothallia) alphoplaca;
b) The middle part of the convex apothecia part; c) The stage of formation of 8 ellipse-shaped spores

6. *Lecanoraceae*–Lecanora allophana—rare, epilyticlichen. This species is known as an epiphytic species, which grows not only on stone surfaces, but also clinging to forest trees in certain regions of Kazakh-

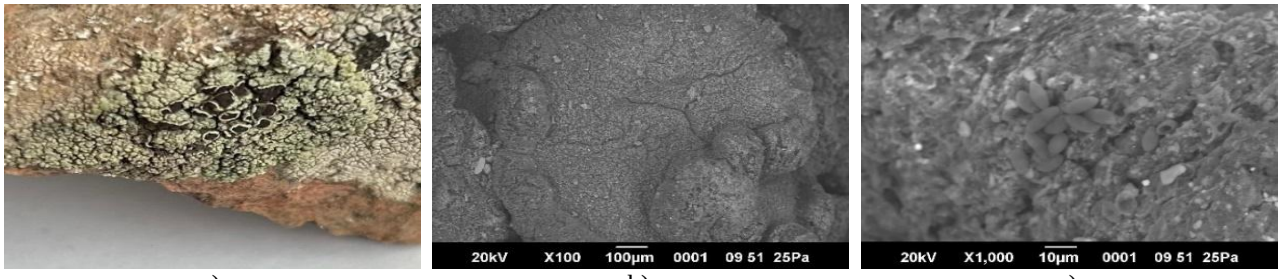
stan. The scaly color of lichens thallus is light gray or pale green. In the middle part, the color is pale yellow, and the edges are pale green, numerous apothecia are formed as a whole or singly. Apothecia are located on the substrate with short ridzines.



a) b) c)

Figure 7. a) General view of the epilytic species Lecanora Allophana;
b)Convex edge apothecarypart; c) The period of formation of ellipse-shaped spores

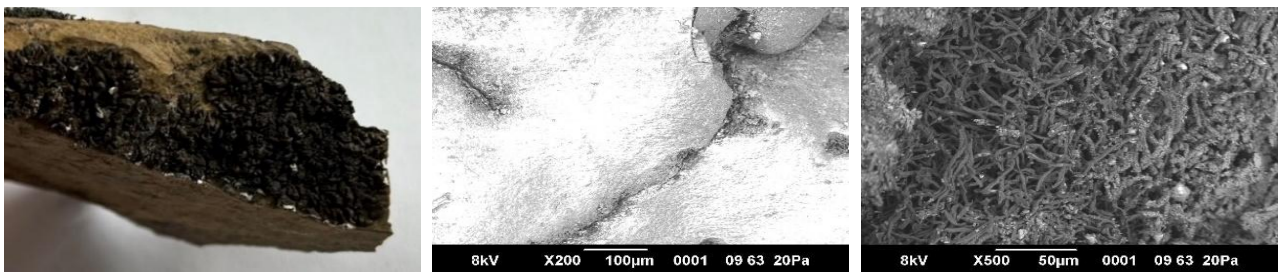
7. *Lecanoraceae*–Lecanora frustulosa—the meetingvest is rarelye pilytic lichen. The surface of the thallus is scaly, the color is greenish-yellow or greenish-gray, the underside is black. While the extreme thalli on the surface of the Stone are formed in an elevated form, tightly adjacent to each other, the thalli of the middle apothecia part are formed, forming a relatively thin layer. The apothecia of the settled black color is numerous, arranged in groups. The apothecia discs are rounded, with jagged edges, and then the flesh changes to a lush state.The shapes of the unicellular colorless spores are ovoid.



a) b) c)

Figure 8. a) Species Lecanora frustulosa with black apothecia;
b) Expression of apothecia with sliced edges; c) The stage of spore formation of the lichen Lecanora frustulosa

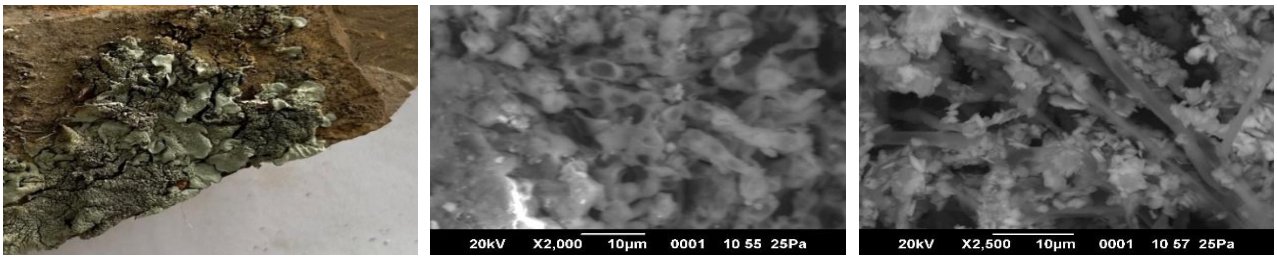
8. *Parmeliaceae*–Parmelia tominii—in the study areas, meetings were frequent. Lichen thallus consists of short ridzines that are not tightly attached to the substrate, of various shapes, the surface is brownish-black in color, with folds, the underside is white, reaching the edge of the thallus. There are no soredia and Isidis. The edges are formed with fleshy thalli tightly touching and covering each other. Thalli located at the edgesare arranged dichotomously or radially branched. The disks of their apothecia, scattered or grouped, are flat, brown in color.



a) b) c)

Figure 9. a) Appearance of lichen Parmelia tominii on the substrate;
b) The apotheos is of the disc is not obvious; c) The lower ridzinal section of the lichen

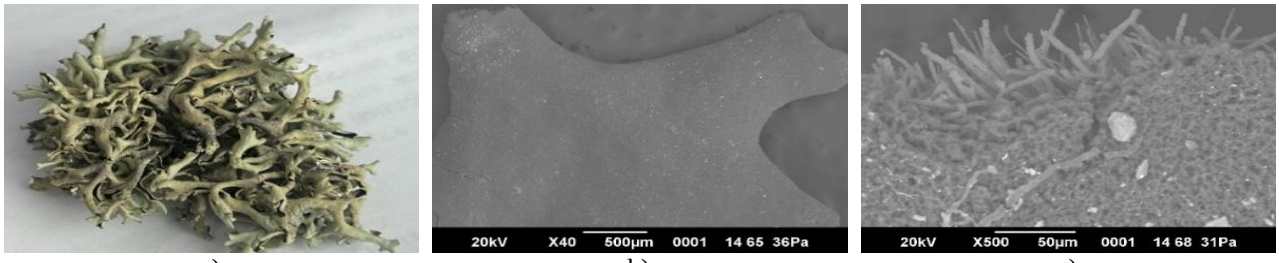
9. *Parmeliaceae*–Parmelia conspersa—rare in research areas. In the middle parts, leaf-shaped thalli are formed by sticking to the surface of the stone, while the extreme edges are loosely raised. The petals of the thallus, cut off from the part, are collected in a dense touch with a wavy spin. The surface is greenish-gray in color, with a large number of isidiums formed on the periphery. Apothecia of black-brown color is formed in a raised form on a set or short-term leg. The middle part of the thallus is whitish, loose, formed by filaments. There are many pycnidis in the form of black spots, spread all over their thallus.



a) b) c)

Figure 10. a) Parmeliaconspersa; b) Section of the apothecary thallus; c) Reflection of isidia formed in groups

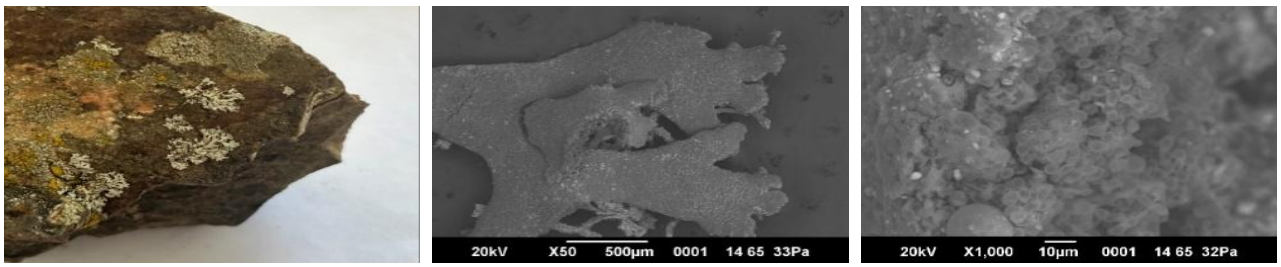
10. *Parmeliaceae*–Parmelia vagans—lichen has been identified as an epigeal species that grows in research areas. The meeting is high. The thallus is loosely arranged on a deciduous substrate, with dichotomous or dorsoventrally branched marginal edges wrapped in a tube and formed by the edges pointing downwards. The surface of the thallus is yellowish-green, the surface is smooth. Soredium, isidium, and apotheosis do not exist.



a) b) c)

Figure 11. a) Parmelia vagans; b) Sectionof the edges of the thallus;
c) Manifestation of the anatomical structure of the thallus

11. *Parmeliaceae*–Parmeliasulcata—indiffent (in the bark of a stone and woody plant), very rare, leaf-shaped lichen with sliced edges. Tightly attached to the substrate, the upper surface of the thallus is bluish-gray in color, arranged in groups. Docked apothecias are rarely formed. Soredia of whitish or greenish color are located covering the surface of the thallus as a whole. Pycnidis are formed at the ends of the slicked edges of the obtuse shape of the lichen thallus. Reproduction is carried out by pycnoconidiums.



a) b) c)

Figure 12. a) Indiffent Parmeliasulcata, which grew scattered on the surface of the stone lichen;
b) Part of the lichen thallus with pycnidia formed along the edges;
c) Soredium appearance, formed as a whole in the surface part of the lichen thallus

The study examined 11 species of lichens growing in the region, combined into 6 genus in 5 families.

Conclusion

Identification of lichen species settled in the mountains of Abraly ($49^0$10N $77^0$25E), Kokentau (Semeytau) ($50^0$10N $79^0$43E), Kalbatau ($49^0$22N $81^0$29|30E) and Chingistau ($48^0$52N $79^0$15E), occupying the eastern part of the Kazakhs hills, belonging to the territory of Abay region, along with the determination of quantitative indicators and covering projects, environmental and biological features were considered.

Of the 11 species, united in 5 identified families, 6 genus, 9 were identified as epilytic lichens growing on the surface of the stone, one species as epigeal, and one species as indifferent (settled on different substrates).

It was found that despite the remoteness of the Abraly, Kokentau (Semeytau), Kalbatau and Chingistau mountains, belonging to the eastern small hills and low mountains of the Kazakhs, lichen species Verrucaria nigrescens, Caloplaca decipiens, Lecanora allophana, Lecanora frustulosa, Parmelia tominii, Parmelia conspersa grow in all mountains. According to the Drude scale, the species Parmelia sulcata, Caloplaca viridirufa, Acarospora chlorophana, Placolecanora alphoplaca were attributed to lichens that are small in number and have a very low incidence.

Author contribution

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript. CRediT: **Zhumaniyazova A.Zh**. — performed the experimental part of the article, analyzed the results. **Bukabayeva Zh.T**. — substantiated the relevance of the topic, conducted a literary review, determined the direction of research, participated in writing annotations and keywords; **Silybayeva B.M. —** laid the theoretical basis of the study, conducted a comparative analysis of scientific works and revealed the scientific novelty of the research problem; **Kunanbayeva N.S**. — prepared diagrams and tables, drew up illustrative materials; **Anuarbekova A.N**. — edited the scientific text, brought it in line with the requirements of the international publication. She made linguistic and stylistic adjustments and ensured the preparation of the article for publication.

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Қазақтың ұсақ тау шоқыларының «шығыс бөлігінде» өсетін қына түрлерін зерттеу

Қазіргі кезеңдегі индустрияның қарқынды дамуы, зиянды қалдық заттардың үйіндісінің артуы, ірі елдімекендердің пайда болуы және т.б. антропогендік факторлардың әсерлері дүниежүзінде климаттың өзгеруін туғызуда. Осыған байланысты атмосфералық ылғалдың азаюы шөл және шөлейтті аймақтардың көлемінің артуына әсері жоғары екендігі белгілі. Жоғарыда аталған жаһандық өзгерістер, жер бетіндегі тірі организмдерге тікелей әсер ете отырып, кез келген флора мен фаунаның түрлік құрамын өзгерістерге ұшыратады. Осыған орай, қазіргі уақытта ғалымдардың жергілікті флорадағы туындаған табиғи өзгерістерге ерекше көңіл бөлуі қажет. Зерттеу жұмысында жергілікті флораның негізгі бір бөлігін құрайтын, әртүрлі биомдарда қоныстанған, өзінің құрылыс ерекшеліктерімен сыртқы ортаның климаттық өзгерістеріне төзімді қына түрлері зерттеу объектісі ретінде қарастырылды. Соңғы жылдарда Қазақстанның өсімдіктер флорасына сәйкес, лихенологиялық жарияланған ғылыми зерттеулерде белгілі бір жерлерде өсетін түрлердің биологиялық ерекшеліктері, экологиясы және индикациялауда қолдануға байланысты деректерді кездестіруге болады. Қазақтың ұсақ тау шоқылырының «шығыс бөлігіне» жататын Шыңғыстау, Қалбатау, Көкентау және Абралы тауларының флорасында кездесетін қына түрлерін қамтитын нақтылы зерттеу жұмыстары жоқ. Зерттеу жұмысында зерттеу объектісі ретінде қарастырылған шығыстың ұсақ тау шоқылары ретінде жалпы атаумен берілген таулар бір-бірінен алыс қашықтықта орналасқандықтан түрлік құрамына байланысты салыстырмалы түрде талдау жасалынды. Барлық ұсақ шоқылы тауларда өсетін 5 тұқымдасқа жататын, 6 туысқа біріктірілген 11 түр анықталды.

Кілт сөздер: Қазақтың ұсақ шоқылары, эпилитті қыналар, эпигейлі қыналар, индиффентті қыналар, Друде шкаласы

Ә.Ж. Жұманиязова, Б.М. Силыбаева, Ж.Т. Букабаева,
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Изучение видов лишайников, произрастающих в «восточной части» Казахских мелкосопочников

Динамичное развитие промышленности на современном этапе, увеличение количества вредных отходов, появление крупных населенных пунктов и, в том числе, воздействие антропогенных факторов вызывает изменение климата во всем мире. В связи с этим известно, что уменьшение атмосферной влаги оказывает большое влияние на увеличение размеров пустынных и полупустынных зон. Вышеупомянутые глобальные изменения, оказывая непосредственное влияние на живые организмы на Земле, вызывают изменения видового состава любой флоры и фауны. В связи с этим в настоящее время ученым необходимо уделять особое внимание естественным изменениям, происходящим в местной флоре. В исследовательской работе объектом исследования рассматривались виды лишайника, составляющие основную часть местной флоры, обитающие в различных биомах, устойчивые к климатическим изменениям внешней среды, со своими особенностями строения. В последние годы, согласно флоре растений Казахстана, в лихенологически опубликованных научных исследованиях можно встретить данные, связанные с биологическими особенностями, экологией и использованием в инди-

кации видов, произрастающих в определенных местах. Нет конкретных исследований, включающих виды лишайника, встречающиеся во флоре гор Абралы, Чингистау, Калбатау, Кокентау, относящихся к мелкому горному хребту востока. В исследовательской работе был проведен сравнительный анализ, связанный с видовым составом, поскольку горы, названные общим названием как небольшие горные холмы востока, рассматриваемые как объект исследования, расположены на большом расстоянии друг от друга. Было идентифицировано 11 видов, объединенных в 7 родов, принадлежащих к 5 семействам, произрастающим во всех небольших холмистых горах.

Ключевые слова: Казахские мелкосопочники, эпилитные лишайники, эпигейные лишайники, индиффентные лишайники, шкала Друде

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