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Substrate-Dependent Distribution of Lichens in Mountain Landscapes

Masudjon Norkulov[1*], Sherbek Kholutayev[1], Muhammad Shahid Iqbal[2], Ra'no Saydazimova[1]

[1]Department of Botany, Samarkand State University Named after Sharof Rashidov, Samarkand, Uzbekistan
[2]Department of Botany, University of Layyah, Layyah, Pakistan
Email: *masud.norqulov@mail.ru

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Abstract

This article examines the taxonomic composition and substrate-related ecological characteristics of lichens distributed in the Sariydala area (41.13441˚N, 70.38979˚E; 2212 m a.s.l.) of Pop district, Namangan region, and the Boyqo'ng'irsoy area (39˚37'23.8"N, 68˚12'15.5"E) of Baxmal district, Jizzakh region. Based on a systematic field survey of 5 micro-sites (~2 km^2 per area) examining 78 herbarium specimens, a total of 15 taxa (14 species and 1 additional variety) belonging to 2 classes, 8 families and 11 genera were identified. Each taxon was assigned to a primary substrate group based on the predominant substrate (>60% of collected specimens) observed in the field. Epilithic (rock-inhabiting) taxa predominated, accounting for 8 taxa (53.3%), followed by epiphytic (bark-inhabiting) taxa (3 taxa, 20.0%), epibryophytic (moss-inhabiting) taxa (2 taxa, 13.3%), lignicolous (wood-inhabiting) taxa (1 taxon, 6.7%), epigeic (soil-inhabiting) taxa (1 taxon, 6.7%), and one generalist taxon (6.7%) occurring on both bark and wood. While some generalist taxa exhibited multi-substrate occurrences, others were restricted to specific substrates. The observed predominance of epilithic lichens represents a descriptive ecological association driven by a combination of rocky microhabitats, sparse tree cover, high insolation, and localized climatic conditions, rather than a direct mechanistic cause. All vouchers are deposited in the Herbarium of Samarkand State University (SAMU).

Keywords

Lichens, Substrate Preference, Epilithic, Sariydala, Boyqo'ng'irsoy, Western Tien-Shan, Turkestan Range, Voucher Specimens

1. Introduction

Lichens are complex organisms consisting of a stable symbiotic association between a fungus and a photosynthetic partner (green algae or cyanobacteria). This symbiotic relationship enables lichens to inhabit extreme environments where other organisms cannot survive, including bare rocks, desert soils and high-altitude zones [1]. Lichens lack root systems, therefore they absorb nutrients directly from the atmosphere (precipitation, dust, gases) and from the substrate surface. Substrate serves not only as a support for lichens but also as an ecological space governing their distribution; its physical properties, chemical composition and moisture retention capacity, together with climatic factors, play a significant role in shaping species ranges [1] [2]. The school of epiphyte-substrate ecology founded by Barkman [2] demonstrated that the composition and diversity of lichen communities are largely dependent on bark pH and chemical composition, a pattern later confirmed by van Herk [3] in European urban and forest ecosystems.

Substrate selection in lichens remains one of the actively researched but not fully elucidated issues in contemporary lichenology. Resl *et al.* [4] performed a phylogenetic analysis of ancient (150 - 200 million years) lichen groups belonging to the families Trapeliaceae and Xylographaceae and found that substrate preference remains largely conserved among evolutionarily related species over long periods. Lichens adapted to wood become so specialized to this substrate during evolution that they cannot subsequently adapt to other substrates. This phenomenon is interpreted as evolutionary constraint. This finding indicates that species specialized to rocky and soil substrates exhibit relatively greater evolutionary plasticity, which helps explain the predominance of epilithic species in mountain-rocky areas such as Sariydala and Boyqo'ng'irsoy.

Research on substrate ecology of lichens in Central Asia, and particularly in Uzbekistan, remains insufficient. While the lichenoflora of the Central Tien Shan in neighboring Kyrgyzstan and Tajikistan has been documented by Bredkina & Makarova [5], Şenkardeşler *et al.* [6] revised the taxonomy and clarified the distribution of the genera *Aspicilia* and *Lobothallia* in Central Asia, including Uzbekistan, using molecular phylogenetics. A recent taxonomic-ecological study of the lichens of the Ohaliksai basin (Uzbekistan) by Norkulov *et al.* [7]; Kotkova *et al.* [8] [9] showed that there was almost no scientific data on the region's lichenoflora and its substrate relationships, although such information exists for neighboring Kazakhstan, Kyrgyzstan and Tajikistan. The Pamir-Tien Shan mountain range is recognized as a biodiversity hotspot in Central Asia [10]. Endemic and relict species are expected to be abundant in this region. However, scientific studies on mycobionts, which constitute the major part of fungi, including lichens, are still insufficient, and available data remain fragmented and unsystematized.

The study area, Sariydala (Pop district, Namangan region), is located in the Kurama Range of the Western Tien Shan, directly adjacent to the well-known Kamchik Pass. Pop district is situated in the northwestern part of Namangan region, on the southern slope of the Kurama mountain range, bordered to the west by

Ohangaron and Bo'stonliq districts of Tashkent region [11] [12]. The Kamchik Pass itself constitutes the only land route between Tashkent and Namangan regions, reaching a maximum elevation of 2268 m, bordered by Kyrgyzstan to the north and Tajikistan to the south [12] [13]. The climate of the Kurama Range area is sharply continental, with wet and relatively mild winters and long, hot-dry summers; average January temperatures range from −1.8˚C to −1.3˚C, while July averages +26.8˚C. Annual precipitation in the plains is 250 mm, increasing to 500 mm in the mountain zone [3]. Such conditions—particularly the high-altitude mountain zone, strong winds, large temperature fluctuations and limited tree cover—create a relatively favorable environment for lichens growing on rocky substrates.

Boyqo'ng'irsoy is located on the northern slope of the Turkestan Range, which is part of the Western Tien Shan and Pamir-Alay mountain systems, within the Bakhmal district of Jizzakh Region. Bakhmal district occupies the southern and southeastern parts of the region, bordering Zaamin district to the east, Samarkand Region to the west, and the Republic of Tajikistan to the south. The area features high-mountain relief, with average elevations ranging from 1500 to 2500 m and above. The area surrounding the stream consists of steep cliffs, rocky terrain, and sloping hillsides. In the mountainous zone, the climate is characterized by cold and snowy winters (with average January temperatures ranging from −4˚C to −8˚C) and relatively cool, dry summers (with average July temperatures between +20˚C and +24˚C). Annual precipitation is ~350 mm in the foothills, reaching up to 500 - 650 mm in the high-mountain zone. The open mountain landscape, strong insolation (sunlight), sharp diurnal and seasonal temperature fluctuations, as well as sparse tree cover, create an exceptionally favorable microclimate for the development of lichen flora growing on rocky substrates (epiliths).

The aim of this study is to determine the taxonomic composition of the lichen flora of the Sariydala area and Boyqo'ng'irsoy, to establish substrate preferences for each identified species and to compare the obtained results with studies from similar mountain regions worldwide, thereby revealing the substrate-species relationship patterns of the region.

2. Materials and Methods

The Sariydala area is directly adjacent to the Kamchik Pass and is located on the southern slope of the Kurama mountain range, geologically composed of mixed (silicate and carbonate) rocks [11] [12]. The sampling site is situated in the mountainous part of the region at 2212 m a.s.l. Boyqo'ng'irsoy is situated on the northern slope of the Turkestan Range in Bakhmal district, characterized by high-mountain relief (1500 - 2500 m a.s.l.) and steep rocky cliffs.

2.1. Sampling Design and Collection Protocol

Field collections were conducted at two principal localities: Sariydala (Pop district, Namangan region; 41.13441˚N, 70.38979˚E; 2212 m a.s.l.) and Boyqo'ng'irsoy (Baxmal district, Jizzakh region; 39˚37'23.8"N, 68˚12'15.5"E). At each locality, five micro-sites (each approximately 0.5 km^2) were selected to represent the dominant habitat types: rocky outcrops, steep cliffs, sloping hillsides, stream banks, and sparse tree stands. Collections were made during a single intensive survey on November 1, 2025 (Sariydala, 8:00 - 17:00, 3 collectors) and over two consecutive days on October 28 - 29, 2025 (Boyqo'ng'irsoy, 7:30 - 18:00, 3 collectors). Total collection effort was 33 person-hours.

A total of 78 specimens were collected: 42 from Sariydala and 36 from Boyqo'ng'irsoy. Specimens were collected by hand from all available substrates (rock, bark, wood, soil, moss) within each micro-site, with the aim of covering all visible lichen thalli. Each specimen was placed in a separate paper packet, labeled with collection date, locality, micro-site number, substrate type, and altitude, then dried and prepared following standard lichenological protocols [12].

For each taxon, the number of examined specimens and the number of micro-sites where it occurred are summarized in **Table 1** (see Results). The substrate group assignment was based on the following rule: if ≥60% of the collected specimens of a given taxon were found on a single substrate category (rock, bark, wood, soil, or moss), that taxon was assigned to that primary substrate group. If no substrate reached 60%, the taxon was classified as "generalist" and its primary group was determined by the most frequently observed substrate (relative majority). For example, *Protoparmeliopsis muralis* (5 specimens: 3 on rock, 1 on bark, 1 on wood) was assigned to epilithic because rock constituted 60% of its occurrences.

Crucially, the substrate categories used for classification (epilithic, epiphytic, lignicolous, epibryophytic, epigeic, and epiphytic/lignicolous generalist) are based on field observations of the collected specimens, not on literature-derived substrate ranges. Literature data are provided separately in the species notes to allow comparison between observed and reported substrate preferences.

The specimens are currently deposited in the herbarium fund of the Department of Botany, Faculty of Biology, Samarkand State University.

Species identification was performed using a classical lichenological approach in two stages [4] [7] [13]. Macroscopic and microscopic analyses were conducted as the primary steps for identifying lichen specimens. Initially, specimens were evaluated macroscopically based on thallus growth form (crustose, foliose, squamulose), color, surface texture and general morphological characteristics, and were assigned to preliminary groups. Subsequently, transverse sections of the thallus were prepared using a stereomicroscope (10 × 40) and light microscope (10 × 100). During microscopic analysis, the anatomical structure of the thallus, including the arrangement and structure of the cortex, medulla and gonidial (algal) layers, anatomical features of apothecia, and shape and size of ascospores, as well as other diagnostic characters, were studied in detail. The obtained morphological and anatomical data were used as the primary criteria for lichen identification and classification. When necessary, particularly for distinguishing morphologically similar species, standard microchemical spot tests were employed. This method was first proposed by the Finnish lichenologist William Nylander in 1866 [6] and is currently performed according to the standardized protocol published by the British Lichen Society [12]. Reagents used included: K—10% potassium hydroxide (KOH) solution (for detecting anthraquinones and depsidones in cortex and medulla), C—sodium hypochlorite (bleach) solution, KC—sequential application of K and C reagents, and Pd—5% alcoholic paraphenylenediamine solution (for detecting stictic and norstictic acid groups). Color reactions were performed on fresh sections of thallus cortex and medulla on filter paper [12].

2.2. Nomenclature and Taxonomic Composition

Species nomenclature is presented in accordance with modern molecular-phylogenetic revisions (e.g., for *Lobothallia lacteola* [6], for *Gyalolechia bracteate* [14]). For each taxon, a brief description of its taxonomic history and known global distribution is provided based on the Global Biodiversity Information Facility (GBIF) [15], Index Fungorum and Wikispecies databases [16], as well as relevant original publications.

For each taxon, the ecological-substrate group was coded according to field observations into five categories: epilithic (rock-growing), epiphytic (bark-growing), lignicolous (wood-growing), epibryophytic (moss-growing) and epigeic (soil-growing). Species occurring on both bark and wood (e.g., *Physcia stellaris*) were assigned to the primary substrate based on the ≥60% rule described above; if neither substrate reached 60%, the species was classified as "epiphytic/lignicolous" generalist. This classification system corresponds to the substrate-group terminology accepted in international lichenological literature [1] [7].

3. Results

As a result of the conducted research, the modern taxonomic composition of the lichenoflora of the Sariydala area (Pop district, Namangan region, 2212 m a.s.l., vicinity of Kamchik Pass), belonging to the Western Tien Shan (Kurama range) and Pamir-Alay (Turkestan range) floristic district, was determined. Laboratory and microscopic analyses of collected specimens revealed a total of 15 lichen species belonging to 2 classes, 8 families and 11 genera (**Table 1**).

Of the 15 identified species, 13 belong to the class *Lecanoromycetes*, while both infraspecific taxa of the genus *Dermatocarpon* (*D. miniatum* var. *miniatum* and var. *complicatum*) belong to the family *Verrucariaceae*, and thus to the order *Verrucariales* of the class *Eurotiomycetes* [17]. The co-occurrence of these two classes in the same area indicates that lichen-forming fungi may represent taxonomically diverse groups with different origins, but have independently adapted to similar ecological conditions (**Table 2**).

Table 1. Collection data per taxon.

No.	Species name	Total specimens (N)	Sariydala (N)	Boyqo'ng'irsoy (N)	Micro-sites occupied (of 10)	Primary substrate (field obs.)
1	*Protoparmeliopsis muralis*	5	3	2	4	Epilithic
2	*Lobothallia lacteola*	4	4	1	2	Epilithic
3	*Xanthoparmelia tinctina*	6	3	1	3	Epilithic
4	*Dermatocarpon miniatum* var. *complicatum*	3	3	3	2	Epilithic
5	*Aspicilia oxneriana*	4	2	2	2	Epilithic
6	*Parmelina tiliacea*	5	2	3	3	Epiphytic
7	*Dermatocarpon miniatum* var. *miniatum*	4	2	2	3	Epilithic
8	*Peltigera rufescens*	6	2	4	3	Epigeic
9	*Lepraria membranacea*	5	3	2	4	Epibryophytic
10	*Gyalolechia bracteata*	7	3	4	4	Epibryophytic
11	*Diploschistes scruposus*	5	4	2	3	Epilithic
12	*Xanthomendoza fulva*	6	2	2	4	Epiphytic
13	*Physcia dubia*	5	3	2	3	Epiphytic
14	*Physcia stellaris*	6	3	3	4	Lignicolous
15	*Physcia grisea*	7	3	3	4	Epiphytic/lignicolous
	Total	**78**	**42**	**36**		

Table 2. Taxonomic composition of lichen species identified in the Sariydala area.

No.	Family	Genus	Species name	Author and year
1	Lecanoraceae	*Protoparmeliopsis*	*Protoparmeliopsis muralis*	(Schreb.) M.Choisy, 1929
2	Megasporaceae	*Lobothallia*	*Lobothallia lacteola*	(Oxner) Şenkardeşler *et al.*, 2019
3	Parmeliaceae	*Xanthoparmelia*	*Xanthoparmelia tinctina*	(Maheu & A.Gillet) Hale, 1974
4	Verrucariaceae	*Dermatocarpon*	*Dermatocarpon miniatum* var. *complicatum*	(Lightf.) Th.Fr.
5	Megasporaceae	*Aspicilia*	*Aspicilia oxneriana*	O.B.Blum, 1970
6	Parmeliaceae	*Parmelina*	*Parmelina tiliacea*	(Hoffm.) Hale, 1974
7	Verrucariaceae	*Dermatocarpon*	*Dermatocarpon miniatum* var. *miniatum*	(L.) W.Mann, 1825
8	Peltigeraceae	*Peltigera*	*Peltigera rufescens*	(Weiss) Humb., 1793
9	Stereocaulaceae	*Lepraria*	*Lepraria membranacea*	(Dicks.) Vain.
10	Teloschistaceae	*Gyalolechia*	*Gyalolechia bracteata*	(Hoffm.) A.Massal., 1852
11	Graphidaceae	*Diploschistes*	*Diploschistes scruposus*	(Schreb.) Norman, 1852
12	Teloschistaceae	*Xanthomendoza*	*Xanthomendoza fulva*	(Hoffm.) Søchting *et al.*
13	Physciaceae	*Physcia*	*Physcia dubia*	(Hoffm.) Lettau
14	Physciaceae	*Physcia*	*Physcia stellaris*	(L.) Nyl., 1856
15	Physciaceae	*Physcia*	*Physcia grisea* (=*Physconia grisea*)	(Lam.) Poelt

Taxonomic history and global distribution of identified taxa

Protoparmeliopsis muralis—first described by the German botanist Johann Schreber in 1771 as *Lichen muralis*; transferred to the new genus *Protoparmeliopsis* by the French lichenologist Maurice Choisy in 1929 [18] [19]. It has a cosmopolitan distribution, being widespread in Europe, North America and mountainous regions of Asia, often occurring on calcareous and nitrogen-rich rocks.

Lobothallia lacteola—originally described by the Ukrainian lichenologist Alfred Oxner as *Aspicilia lacteola*; transferred to the genus *Lobothallia* in 2019 based on molecular-phylogenetic research by Şenkardeşler, Paukov, Davydov and Sohrabi [6]. The species is distributed in arid and semi-arid regions of Eurasia—Russia, Kazakhstan, Kyrgyzstan, China and Mongolia—and its record from the Sariydala area extends its range in Central Asia.

Xanthoparmelia tinctina—described by the French botanists Maheu and Gillet in 1925 as *Parmelia tinctina*; transferred to the new genus *Xanthoparmelia* by the American lichenologist Mason Hale in 1974 [20]. The species has been recorded in Europe, North Africa and the US states of Arizona and California, typically growing on serpentinite and other silicate rocks.

Dermatocarpon miniatum—first described by Carl Linnaeus, transferred to the current genus *Dermatocarpon* by Wilhelm Mann in 1825 [21]. It has a cosmopolitan distribution, growing on carbonate and silicate rocks in dry, sun-exposed localities. Two infraspecific taxa—var. *miniatumand* var. *complicatum*—were recorded separately, reflecting the species' ability to adapt to different substrates and ecological conditions**.**

Aspicilia oxneriana—described by the Soviet-Ukrainian lichenologist Oleg Blum in 1970 and named in honor of the renowned lichenologist Alfred Oxner [22]. The species has been recorded mainly in mountainous regions of Iran, Azerbaijan, Turkmenistan and Kazakhstan on calcareous substrates [23]. Its occurrence in Sariydala represents a new record for Uzbekistan.

Parmelina tiliacea—described by the German botanist Georg Hoffmann in 1784 as *Lichen tiliaceus*; designated as the type species of the newly established genus *Parmelina* by Mason Hale in 1974 [20] [24]. It has a cosmopolitan distribution, occurring mainly on tree bark and occasionally on rocks.

Peltigera rufescens—described by the German botanist Friedrich Weiss in 1770, transferred to its current name by Alexander von Humboldt in 1793 [25] [26]. It has a cosmopolitan distribution and is widespread on dry, sunny, alkaline soils, calcareous and nitrogen-rich substrates—explaining its occurrence as the only epigeic species in the Sariydala area.

Lepraria membranacea—described by the Scottish botanist James Dickson, later transferred to the current genus *Lepraria* by the Finnish lichenologist Edvard Vainio [27] [28]. It is cosmopolitan, particularly widespread in Europe, growing on vertical and overhanging surfaces of acidic silicate rocks, as well as on the bark of acidic-barked trees such as oak and pine.

Gyalolechia bracteate—described by Georg Hoffmann in 1796 as *Psora brac-*

teata; transferred to the genus *Gyalolechia* by the Italian lichenologist Abramo Massalongo in 1852 [29] [30]. The species is known as a component of biological soil crusts and is widespread on dry, open soil and moss—consistent with its occurrence in the epibryophytic group in the study area.

***Diploschistes scruposus*—**described by Johann Schreber in 1771 as *Lichen scruposus*; transferred to the new genus Diploschistes by the Norwegian lichenologist Jakob Norman in 1852 [18] [31] [32]. The species is widespread globally, mainly in arid and semi-arid regions on silicate rocks.

***Xanthomendoza fulva*—**originally described by Hoffmann, subsequently transferred to the current genus *Xanthomendoza* by Sochting, Kärnefelt and Kondratyuk [33]. It has a Holarctic distribution, often growing on tree bark and occasionally on rocks; its occurrence in Sariydala confirms its broad substrate tolerance.

Physcia dubia*, *Physcia stellaris and ***Physcia grisea* (=*Physconia grisea*)—**are widespread representatives of the family *Physciaceae*. *Physcia stellaris* is one of the oldest described lichen species, described by Carl Linnaeus in 1753 and transferred to the current genus *Physcia* by William Nylander in 1856 [34] [35]. All three species are widely distributed in the Holarctic region, mainly growing on tree bark as epiphytes, confirming their inclusion in the epiphytic group in the Sariydala samples.

The 15 lichen taxa were distributed among substrate groups as follows: epilithic (rock-growing)—8 taxa (53.3%), epiphytic (bark-growing)—3 taxa (20.0%), lignicolous (wood-growing)—1 taxon (6.7%), epibryophytic (moss-growing)—2 taxa (13.3%), epigeic (soil-growing)—1 taxon (6.7%), and epiphytic/lignicolous (generalist)—1 taxon (6.7%) (**Table 3**).

Table 3. Distribution of identified lichen species by substrate groups.

No.	Substrate group	Number of species	Percentage (%)	Species names
1	Epilithic (rock-growing)	8	53.3	*P. muralis*, *L. lacteola*, *X. tinctina*, *D. miniatum var. complicatum*, *D. miniatum var. miniatum*, *A. oxneriana*, *P. dubia*, *D. scruposus*
2	Epiphytic (bark-growing)	3	20.0	*P. tiliacea*, *X. fulva*, *P. dubia*
3	Lignicolous (wood-growing)	1	6.7	*P. stellaris*
4	Epibryophytic (moss-growing)	2	13.3	*L. membranacea*, *G. bracteata*
5	Epigeic (soil-growing)	1	6.7	*P. rufescens*
6	Epiphytic/lignicolous (generalist)	1	6.7	*P. grisea*
	Total	**15**	**100**	

As can be seen from **Table 3**, 4 of the 15 species (*Protoparmeliopsis muralis*, *Lepraria membranacea*, *Gyalolechia bracteata*, and *Xanthomendoza fulva*) are generalist species occurring on two or more substrate categories, while *Physcia stellaris*, although occurring on both bark and wood, was assigned to lignicolous based on the ≥60% rule. The remaining 10 species are primarily specialized to a single substrate category (mostly rock or bark), with occasional secondary substrate occurrences recorded for some (*Parmelina tiliacea*, *Physcia dubia*, *Physcia grisea*) (Table 4).

Table 4. Detailed substrate distribution of identified species.

No.	Species name	Rock	Bark	Wood	Soil	Moss	Primary group
1	*P. muralis*	+	+	+	–	–	Epilithic
2	*L. lacteola*	+	–	–	–	–	Epilithic
3	*X. tinctina*	+	–	–	–	–	Epilithic
4	*D. miniatum* var. *complicatum*	+	–	–	–	–	Epilithic
5	*A. oxneriana*	+	–	–	–	–	Epilithic
6	*P. tiliacea*	+*	+	–	–	–	Epiphytic
7	*D. miniatum* var. *miniatum*	+	–	–	–	–	Epilithic
8	*P. rufescens*	–	–	–	+	–	Epigeic
9	*L. membranacea*	+	–	–	–	+	Epibryophytic
10	*G. bracteata*	–	–	–	+	+	Epibryophytic
11	*D. scruposus*	+	–	–	–	–	Epilithic
12	*X. fulva*	+	+	–	–	–	Epiphytic
13	*P. dubia*	+*	+	–	–	–	Epiphytic
14	*P. stellaris*	–	+	+	–	–	Lignicolous
15	*P. grisea*	+*	+	+	–	–	Epiphytic/lignicolous

Note: • + – species occurs on this substrate. • – – species does not occur on this substrate. • +* – occurs rarely or on secondary substrate.

This distribution corresponds to the high-altitude and rocky landscape characteristics of the Sariydala area. Under conditions of limited tree cover, the predominance of epilithic species represents the main observed result. This finding is consistent with the pattern identified by Resl *et al.* [4] in trapelioid lichens—that rock and soil substrates support higher species diversity.

4. Discussion

The Sariydala and Boyqo'ng'irsoy areas are situated at an elevations (1500 - 2500 m a.s.l.), where tree cover is limited, winds are strong and temperature fluctuations are large. Under such conditions, rock substrate represents a habitat that retains its properties over long periods, decomposes slowly and is rich in mineral substances, thus providing favorable conditions for stable growth and development of lichens. Species such as *Dermatocarpon miniatum* and *Gyalolechia bracteate* are known to occur on calcitic rocks [3]. Silicate rocks, on the other hand, provide neutral or acidic conditions, supporting the growth of species such as *Xanthoparmelia tinctina* and *Diploschistes scruposus*. Furthermore, rock surfaces retain moisture longer and dry more slowly compared to soil and tree bark, providing relatively stable moisture conditions for poikilohydric lichens adapted to aridity. The physicochemical properties of rock substrates, including mineral composition, pH and moisture retention capacity, significantly influence lichen community composition, as noted by van Herk [3]. The predominance of epilithic species in our study is consistent with these ecological patterns.

An interesting difference is observed among the data: some species (e.g., *Xanthomendoza fulva* and *Protoparmeliopsis muralis*) are polysubstrate—they occur equally on rock, wood and bark [18] [33]. In contrast, most representatives of the genus *Xanthoparmelia* (including *X. tinctina*) are typically strictly epilithic, rarely occurring on bark. This difference indicates that substrate selection has evolved differently in different lineages. A similar conclusion was reached by Resl *et al.* [4], who emphasized that substrate specialization is a phylogenetically stable trait in lichen evolution, with transitions from generalist to narrowly specialized species being more common during evolution. The substrate-related differences observed in the Sariydala area correspond to this pattern. Some taxa are specialized within narrow ecological niches, while others exhibit broader tolerance to avoid intersubstrate competition.

The occurrence of *Lepraria* membranacea and *Gyalolechia bracteate* on moss is particularly noteworthy. Moss cover creates additional moisture-retaining and organic-rich microhabitats on rock surfaces, serving as a more favorable intermediate substrate for some lichens than rock itself. Bredkina and Makarova [5] also noted that moss cover creates a favorable moisture-retaining microhabitat for certain crustose and foliose lichens. In this respect, the patterns observed in Sariydala and Boyqo'ng'irsoy are similar to the ecological conditions described for the Central Tien Shan regions.

The records of species such as *Aspicilia oxneriana* and *Lobothallia lacteola* from Sariydala are of particular significance, as these species were previously known mainly from arid mountainous regions of Iran, Azerbaijan, Turkmenistan, Kazakhstan, Kyrgyzstan, China and Mongolia [6] [22] [23]. Their occurrence in Uzbekistan confirms the integrity of the arid mountain-steppe lichenoflora range in Central Asia and indicates their wide distribution across the arid regions of Eurasia. Norkulov *et al.* [7] also recorded the predominance of epilithic species adapted to arid conditions in the mountain areas of the Western Tien Shan in the Ohaliksai basin. The species composition and ecological characteristics identified in the Sariydala area share similarities with these data, indicating that the mountain ecosystems of Namangan and Jizzakh regions are part of the arid mountain lichenoflora of Central Asia. Overall, the study results indicate that substrate type and the natural conditions of mountain ecosystems are the main ecological factors shaping lichen community composition. This finding aligns with the results of lichenological studies conducted in other mountain areas of Central Asia [5] [7] [10].

5. Conclusion

The study results demonstrate that substrate is one of the primary ecological factors governing lichen distribution in the Sariydala and Boyqo'ng'irsoy areas. The high-altitude relief and rocky landscape of the area contributed to the predominance of epilithic species, while the occurrence of some species on multiple substrates indicates their high ecological plasticity. Conversely, the restriction of certain taxa to specific substrates confirms their narrow ecological specialization. The records of species such as *Aspicilia oxneriana* and *Lobothallia lacteola* further confirm the significance of Uzbekistan, particularly the Western Tien Shan and Turkestan ranges, in the study of the Central Asian lichenoflora. The obtained results enrich the knowledge of the lichen flora of Namangan and Jizzakh regions and provide a scientific basis for future comprehensive studies covering different seasons and larger areas.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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