Distribution and Diversity of Lichens Species at Selected Sites within Sulaymaniyah Province, Iraq

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Abstract
The objectives of this research are to study the distribution, diversity, and relative dominance of lichen species on rock and tree bark at a few sites in Sulaymaniyah. A fifteen species of lichens were observed, with an obvious difference in occurrence and abundance of the two substrate types. The findings showed that the distribution and diversity of lichen communities on rocks was more balanced with Circinaria calcarea having the highest relative dominance of 12.5% and several species with moderate contributions. Lichen community on tree bark, in contrast, had a high dominance pattern with Physcia stellaris contributing to 47.1%, which demonstrated its high adaptability to the conditions of the bark.

These variations were closely linked to the environmental conditions especially substrate pH. The rock substrates were mainly alkaline, more favorable to a wider variety of calcicolous species, whereas tree bark conditions were acidic and reduced the diversity of species and increased the domination of a limited number of tolerant taxa. Also, climatic conditions like temperature and relative humidity helped in determining the distribution of lichens as they affected the environment and the suitability of growth. This interplay between environmental variables and substrate properties were important in shaping lichen community structure.

Keywords: Lichens, Distribution, Diversity, Air physicochemical factors, Sulaymaniyah .

Aims And Background

The traditional definition of lichens is a symbiotic association between a fungus (mycobiont) and a photosynthetic alga (photobiont). They are non-vascular macro-organisms and four primary morphological types of them include crustose, foliose, squamulose, and fruticose [1]. Lichens are one of the most successful types of symbiosis and of great ecological significance. It is approximated that out of all known fungal species some 17 percent can form lichens and they cover about 8 percent of the land on Earth. Lichens thrive in a wide range of environments from humid forests to arid deserts and high-altitude areas, including some harsh habitats where other organisms cannot survive [2]. This symbiosis allows lichens to colonize bare surfaces such as rocks, soils, and tree bark. In these habitats, lichens play a role in the succession of ecosystems by contributing to soil formation through rock fragmentation and dust trapping, which enables the subsequent settlement of other organisms. Furthermore, lichens are important global environmental indicators due to their high sensitivity to environmental changes [3]. Due to the environmental importance of lichens in shaping the structure and composition of biological communities in the study area, the aim is to study the diversity and distribution of lichen communities within the Sulaymaniyah Governorate, and the impact of some environmental factors on their presence.

EXPERIMENTAL

Study Area

The study area is located within Sulaymaniyah Province /Kurdistan Region, bordered by Turkey to the north and Syria to the west (Figure 1). It is surrounded by several mountain ranges, including Azmer Mountain, Goyija Mountain, and Qaiwan Mountain to the northeast, Baranan Mountain to the south, and the Tasluja Hills to the west. The province is located at approximately 35°33′40″ N latitude and 45°26′24″ E longitude, covering an area of about 20,143.91 km². The climate of Sulaymaniyah is characterized as semi-arid, with hot and dry summers and cold, wet winters. However, summer temperatures are relatively moderated due to the mountainous topography of the region [4, 5]. Sedimentary rocks dominate the geology of the Sulaymaniyah Province, with limestone and calcareous shale being common, especially in the mountain ranges and raised terrains [6]. The vegetation cover of the natural vegetation on the hills and mountainous regions is predominantly oak forests and shrublands [7, 8].

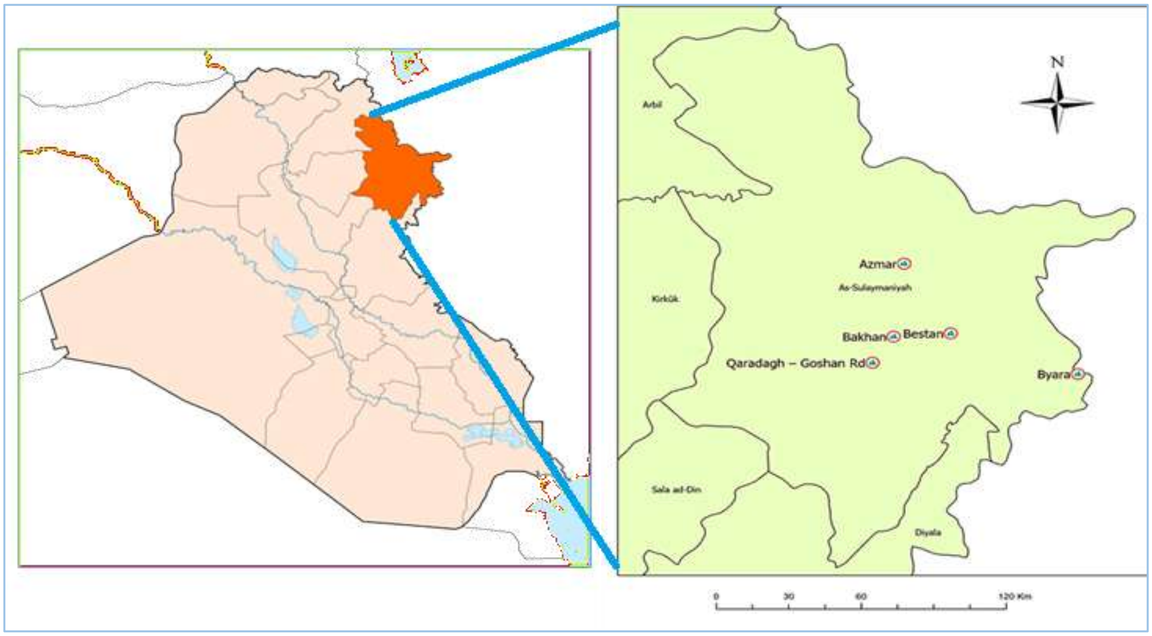

Figure 1: Map of the study sites within Sulaymaniyah Province

Table 1: Coordinates of the selected study

Sites	Coordinates
Site 1: Bakhan	35˚36′15″ N, 45˚43′12″ E
Site 2: Qaradagh	35˚26′61″ N, 45˚35′23″ E
Site 3: Azmar	35˚62′72″ N, 45˚46′99″ E
Site 4: Bestan sur	35˚37′33″ N, 45˚64′29″ E
Site 5: Byara	35˚22′46″ N, 46˚11′58″ E

Sample Collection

At every sampling site, the lichen samples were collected on various substrates, such as rocks and tree bark. Sulaymaniyah Province was chosen as a sampling location and sampling was done in March and April 2025 (Spring season), October and November 2025 (Autumn season) in five sites selected. Lichen samples were collected manually using simple tools from roadside areas approximately 1 km away from main roads at the study sites. Depending on their type and size, samples were stored either in clean paper bags/envelopes or polyethylene containers until transportation to the laboratory for subsequent identification and classification. The collection of saxicolous and Corticolous lichens followed the method described by Nayaka [9]

, which involves selecting mature specimens containing reproductive structures (such as apothecia, soredia, or isidia), as these facilitate taxonomic identification in the laboratory. Lichens were carefully detached using a sharp knife, fingers, or forceps.

Methods

Laboratory analyses, including Physicochemical and biological tests of the collected samples, were conducted at the ecology and pollution Laboratory, Biology Department, College of Science, Tikrit University. Air temperature and relative humidity were measured using a digital humidity sensor (multi-hygrometer), which provides real-time data on both temperature and humidity. The recorded values were expressed as percentages (%) [10]. The pH of tree bark was determined by mixing a portion of the bark sample with distilled water at a ratio of 1:1 or 2:1. The suspension was prepared by carefully shaking the mixture, and the pH of the suspension prepared was recorded with calibrated pH meter to have accurate values [11]. The pH of the rock was determined by making a suspension of ground rock samples with either distilled or deionized water in the ratio of 1:1 or 2:1. The suspension was swirled and left to settle and then the pH of the suspension was measured with a pH meter. The approach gives a clue on geochemical interactions and weathering capability of rocks. [12]. Morphological characteristics of lichen samples were examined under a microscope for identification based on thallus morphology (thallus color, growth form, size, and the presence of distinctive structures such as lobes, isidia and soredia (powdery propagules), following the method described by Nayaka [9]. Identification and taxonomic keys by following [13, 14].

Statistical analysis

The Statistical Package for the Social Sciences (SPSS), version 24, was used to perform Analysis of Variance (ANOVA) to determine the presence or absence of significant differences in the studied variables, according to temporal (between months) and spatial (among study sites) variations were assessed at a significance level of $P \leq 0.05$.

Results And Discussion

The distribution and occurrence of lichen species in the studied sites are strongly influenced by several environmental factors, particularly substrate type, pH, moisture availability, Air temperature and microclimatic conditions [15].
Tables 2 and 3 show a significant variation in air temperature and relative humidity between the studied sites and seasons, which influenced the distribution and occurrence of lichen species. Air temperature ranged 20-35 °C during the study period, with higher values recorded in spring (April–May) and relatively moderate values during autumn (October–November). Despite these fluctuations, the temperature range across all sites remained within limits generally suitable for lichen survival and metabolic activity. Other species are more at home in open, sunny places, especially on rocks, and others in the shade or semi-shade of a tree canopy. The combination of these environmental conditions produces a series of ecological niches and different lichen species coexist or in some instances the deepest adapted species prevail.

Table 2. Monthly and Spatial Variations in Air Temperature (°C) in the Study Area

Season	Sites / Months	Site 1 Bakhan	Site 2 Qaradagh	Site 3 Azmar	Site 4 Bestan sur	Site 5 Byara
Spring	April	22a	28a	24a	32b	20a
	May	25a	30b	25a	31b	35c
Autumn	October	22a	25a	24a	27a	22a
	November	25a	30b	25a	28a	23b

Table 3. Monthly and Spatial Variations in humidity % in the Study Area

Season	Sites / Months	Site 1 Bakhan	Site 2 Qaradagh	Site 3 Azmar	Site 4 Bestan sur	Site 5 Byara
Spring	April	52%c	25%a	25%a	45%b	55%c
	May	40%b	37%b	42%c	37%a	46%b
Autumn	October	30%a	35%b	38%b	37%a	50%c
	November	28%a	32%b	28%a	37%a	47%c

Another important variable influencing the distribution of lichen is the availability of moisture, relative humidity exhibited a greater difference between sites, with a range of 25 to 55 percent. The spring recorded higher humidity values especially in locations like Bakhan and Byara and lower values were reported in areas with lower humidity like Azmar and Qaradagh (Table 3). These variations in moisture availability influenced more the distribution of lichens than when temperature alone was used. More humid or more water-retentive sites (e.g. shaded habitats, the structure of the bark or the porosity of rocks) are likely to harbor greater lichen diversity and abundance. The season also has an impact on the activity of lichens since temperature and rainfall variations between autumn and spring can alter metabolic rates, development, and reproduction [16].
In all the environmental factors that were studied, Duncan test indicated significant differences in the time periods among all the different groups, with the months of the various groups varying at a certain level of significance ($P \leq 0.05$). Conversely, no significant spatial differences in temperature were observed among sites, whereas humidity and pH had obvious differences, which implies that these factors play vital roles in distinguishing between the analyzed environments.
The pH is also vital in defining the lichens composition as there are certain types of lichens that are sensitive to acidic or alkaline environments or neutral [17]. The lichens that grew on the rocks in the current study were mostly related to alkaline substrates, particularly the calcareous and dolomitic rocks, with pH values of moderately to highly alkaline (Table 4). These environments are favorable to calcicolous species, such as Circinaria calcaran or Caloplaca saxicola that thrive well in mineral-rich soil and high pH [18]. Though pH of tree bark was mostly acidic and moderately acidic, depending on host tree species (Table 5). This acidity played a big role in the composition of the lichen and the species that thrived more in the acid conditions were corticolous species, which had the highest relative dominance [19].
The reduced diversity on bark when compared to rocks could be explained by the decreased pH range and the more selective character of a bark as a substrate. Pinus and Quercus trees were probably the cause of this trend because they have variations in their bark chemistry, texture and water retention [20].

Table 4: Lichen species on rocks in Sulaymaniyah at the studied sites

Sites	Rock type	value pH (Spring)	value pH (Autumn)	Chemical properties of the rock	Lichens species
Site 1 Bakhan	---	---	---	---	---
Site 2		7.7	8.0		Caloplaca saxicola

Qaradagh	Calcareous rocks			moderately alkaline	Circinaria caesiocinerea
					Circinaria calcarea
					Physcia stellaris
					Lecanora campestris
					Protoparmeliopsis muralis
Site 3 Azmar	Hard calcareous rocks	8.0	8.3	Highly alkaline	Circinaria calcarea
					Caloplaca saxicola
					Circinaria caesiocinerea
					Varicellaria lacteala
					Lecanora chlarotera
					Caloplaca cerina
					Variospora flavescens
					Herteliana gage
	Dolomite	8.2	8.5	Highly alkaline	Circinaria calcarea
					Protoparmeliopsis muralis
Site 4 Bestan sur	---	---	---	---	---
Site 5 Byara	Silicate metamorphic rocks	6.7	7.0	Slightly acidic to neutral	Rhizoplaca chrysoleuca
					Rhizocarpon reductum
					Variospora thallincola
					Variospora flavescens
					Lecanora chlarotera

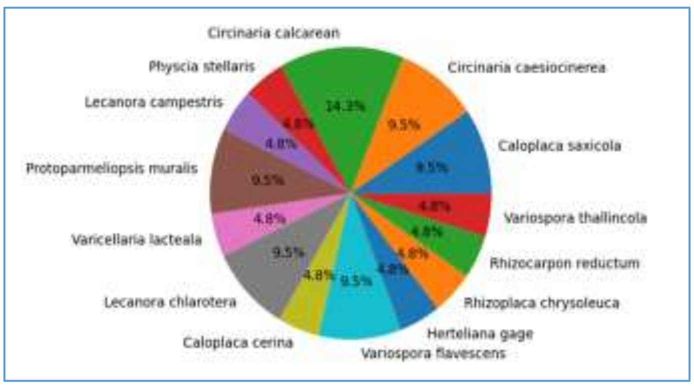

Figure 2. Distribution of Lichen Types on Rocks at Selected Sites in Sulaymaniyah

Table 5: Lichen species on tree bark in in Sulaymaniyah at the studied sites

Sites	**Plant species**	**pH** (Spring)		**value pH (Autumn)**		**Lichens species**
		May	April	November	October	
Site 1 Bakhan	Pinus sp.	3.9	4.2	4.6	4.9	Protoparmeliopsis muralis
	Quercus sp.	4.6	5.4	5.0	5.8	Physcia stellaris
						Myriolecis antiqua
						Protoparmeliopsis muralis
	Platanus orientalis	5.9	6.3	6.6	7.1	Physcia stellaris
Site 2 Qaradagh	Pinus sp.	3.8	4.3	4.5	4.9	Physcia stellaris
						Protoparmeliopsis muralis
						Rhizocarpon reductum
	Pinus brutia	3.8	4.2	4.5	4.8	Physcia stellaris
Site 3 Azmar	Acer monspessulanum	5.5	6.1	6.4	7.0	Physcia stellaris
						Lecanora chlarotera
						Rhizoplaca chrysoleuca
	Quercus lusitanica	4.3	4.7	5.0	5.4	Physcia stellaris
Site 4 Bestan sur	Quercus brantii	4.5	5.4	5.1	5.8	Physcia stellaris
						Rhizoplaca chrysoleuca
						Protoparmeliopsis muralis

Site 5 Byara	Quercus brantii	4.3	4.6	5.1	5.3	Protoparmeliopsis muralis
						Physcia stellaris

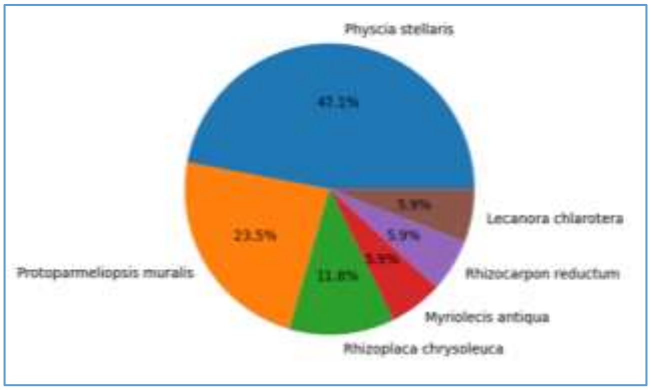

Figure 3. Distribution of Lichen Types on tree bark at Selected Sites in Sulaymaniyah

The results showed relative dominance revealed clear differences in lichen community structure between rock substrates and tree bark across the studied sites in Sulaymaniyah. In Table 4 and Figure 2 show rocks, lichen species distribution appeared relatively heterogeneous, with Circinaria calcarea showing the highest relative dominance (12.5%), followed by several species such as Caloplaca saxicola, Circinaria caesiocinerea, Protoparmeliopsis muralis, Lecanora chlarotera, and Variospora flavescens, each contributing moderately (8.3%). This trend indicates a fairly differentiated and less competitive community form, which is probably caused by heterogeneity of substrates, especially, the prevalence of alkaline pH calcareous and dolomitic rocks. These environments are also known to be conducive to the growth of calcicolous lichens, particularly Circinaria and Caloplaca species, which are well acclimated to high PH, and mineral-rich substrates [21].

Table 5 and Figure 3 indicate that lichen communities were heterogeneously distributed on the bark with Physcia stellaris being dominant (47.1%), then Protoparmeliopsis muralis (23.5%), and other species were lowly represented (≤11.8%). This high dominance tendency can be attributed to the effect of the bark characteristics like acidity, texture and moisture content. The pH of the tree bark recorded was acidic to moderately acidic, which is especially conducive to lichens such as Physcia stellaris that are nitrophilous and corticolous. Its enormous dominance indicates that it can withstand environmental stress more and perhaps specialized to compete more competitively during variable microclimatic conditions [22, 19].

Comparisons between the two substrates reveal that the rock habitats accommodate more species evenness as compared to the tree bark habitats, which are dominated by species. This distinction can be explained by the differences in the stability of the substrate, the presence of nutrients, and the conditions of the microenvironment. More stable and chemically distinct niches are found in rocks, and particularly silicate metamorphic and calcareous rocks, which facilitate the coexistence of species [21]. Conversely, tree bark is a more dynamic substrate and changes seasonally, depending on the chemistry of the bark and the host tree species and, therefore, may restrict species diversity and select a limited number of well-adapted taxa [23].

Conclusion

These findings underscore the role played by the type of substrate and environmental conditions in regulating the diversity and distribution of lichens, thereby justifying the use of lichens as a good bioindicators of the environment. Several lichen species were observed, and it was evident that the presence and abundance of these species differed between the two substrate types (rock and bark). Relative dominance Analysis showed that there were clear variations in the lichen community structure between rocky and tree bark substrates at the sites at Sulaymaniyah under study. Homogeneity of species is more present in rocky habitats whereas tree bark habitats are dominated by some species. This disparity can be explained by differences in the stability of the substrate, nutrient availability and microenvironmental conditions.

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Authors' Declaration

-Conflicts of Interest: none

-We hereby confirm:

All the Figures and Tables in the manuscript are ours. Any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.

-No animal studies are present in the manuscript.

-No human studies are present in the manuscript.
-Ethical Clearance: The project was approved by the local ethical committee at Tikrit University.

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