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Understanding Lichen Ecology using Detailed PCA in Temperate – Alpine Gradient of Uttarakhand, India

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Abstract The paper presents classification of lichen regions from temperate (Loharkhet) to alpine zones (Pindari Glacier) using Principal Component Analysis (PCA) of growth forms and habitat preferences of lichens in Himalayas. The study is based on published literature, preserved lichen specimens at lichen herbarium in National Botanical Research Institute, Lucknow, India, and lichen collections from the valley. Varied growth forms of lichens are observed such as foliose, crustose, fruticose, squamulose, and leprose. Habitat preferences of lichens are corticolous, saxicolous, terricolous, and muscicolous. Some lichens exhibit a range of habitat preferences like corticolous-saxicolous-terricolous-muscicolous, corticolous-terricolous-muscicolous, corticolous-saxicolous-terricolous, saxicolous-terricolous, corticolous-terricolous, corticolous-saxicolous, terricolous-muscicolous, and terricolous-lignicolous. These two different features, growth form and habitat preferences are used to run PCA to see their role in distribution of lichens across different altitudinal variations and whether it can be used to categorize the region into different types. As the region is under continuous anthropogenic pressure and lichens are highly sensitive to changes in environmental conditions where they exist, this classification can be of help in conservation of the region on the basis of priority areas.

Keywords Bageshwar, Ecological Traits, Lichen Forms, PCA, Pindari Glacier

1. Introduction

Lichens are known to constitute the major part of floristic diversity in high terrains of Uttarakhand Himalayas. They prefer different substratum such as on rock, soil, tree bark, and even mosses and leaves and attain different forms such as crust like, foliar like, and fruit like. Mishra [1] in a study in Uttarakhand reported 630 species of lichens of which more than 67% preferred bark and around 30% preferred rock substratum. Crustose and foliose represented the dominant growth forms with around 42% and 39% respectively. Mishra and Saini [2] reported 429 species of corticolous lichens in Uttarakhand, where 88% of all lichens exhibited either foliose or crustose form, and fruiticose, squamulose, and leprose represented 8%, 3%, and 1% respectively. They observed that varied substratum provided by different tree species helped species richness of lichens. Although the region has been explored earlier for floristic studies of various plant groups, high-altitude glacier valleys have been neglected for the extensive exploration of cryptogams especially lichens. Pindari Glacier valley is situated in Bageshwar district of Uttarakhand at an altitude that ranges from 1700 m to 3660 m. The valley lies at about 30°15.30 "N latitude and 79°13' – 80°2" E longitude and forms the southeast part of NandaDevi Biosphere Reserve. The unique topography, wide altitudinal range, and varied climatic conditions favor the diverse flora and fauna in the region. Lichens are excellent indicator of forest ecosystem and climatic conditions. A number of studies regarding lichens as excellent indicators of environmental changes are available

[3]. It is comparatively easier to observe the changes in growth forms, habitat types, and morphology of lichens, for estimating environmental conditions, than to measure environmental parameters of an ecosystem using conventional instruments, as they are not cost effective and also difficult to carry in high terrain. Clair et al. [4] observed in a study in Uinta mountains, in USA that lichen community structure is related with factors such as rock cover where they are growing, sheep grazing which helps in its dispersion, and timing of snow melt, an abiotic factor. Joshi et al. [5] argued change in lichen communities with change in forest while reporting 44 species within 2 km^2 area in Uttarakhand. Diversity of morphological forms being indicators of habitat and climatic conditions provides more adaptability to lichens [6].

Oksanen [7] used principal component analysis (PCA), varimax, quartimax, and oblique rotation to study lichen rich habitats in Finland, and observed that lichen-rich forests show less distinct but greater variation, with some frequently abundant lichens such as *Cladonia* sp., *Lecidea* sp., and *Cladonia stellaris*. These species also represent two ends of ecological succession. Application of PCA in studies of lichens is being done in many different ways. Recently, Kuusinen et al. [8] observed that the first three principal components explained 97% of variance in the reflectance spectra of lichens, which they used as input variables in hierarchical clustering analysis. They noted that the taxonomical difference and structure and chemical composition of lichens which is related with phylogeny may result in variation in lichen spectra. Osyczka and Kubiak [9] studied the relationship of trees and lichens association in Poland and presented it with the help of PCA biplot. They suggested that habitat conditions affect the tree bark character which is related with lichen species richness. The lichens together with other cryptogams play important roles in the functioning of healthy ecosystems, by providing food, shelter and other resources for a wide range of species. The present study therefore attempts to understand the ecology of lichens in Bageshwar district of Uttarakhand using in-depth principal component analysis.

2. Materials and Methods

2. 1. Survey and Collection of Lichens

A total of five localities, i.e., Loharkhet, Dhakuri, Khati, Dwali, and Phurkia and enroute zero-point to Pindari Glacier, were surveyed exhaustively for their lichen diversity that correspond to different levels of anthropogenic pressures. The study was conducted during the month of May. Eight hundred specimens of lichens were collected during various field trips in the study area from lower to higher altitude from Loharkhet to Pindari Glacier in district Bageshwar of Uttarakhand state of India (Figure 1). The fruticose lichen samples hanging on the trees or branches and from trunk were picked by hand while lichens tightly attached to barks and rocks were collected using hammer and chisel. Details on habitat and ecology are also noted down. After proper packaging, the lichens are preserved in the herbarium in National Botanical Research Institute, Lucknow. Lichen specimens of the region collected earlier are also taken into consideration, including collection by Dr. D. D. Awasthi (AWAS) [10].

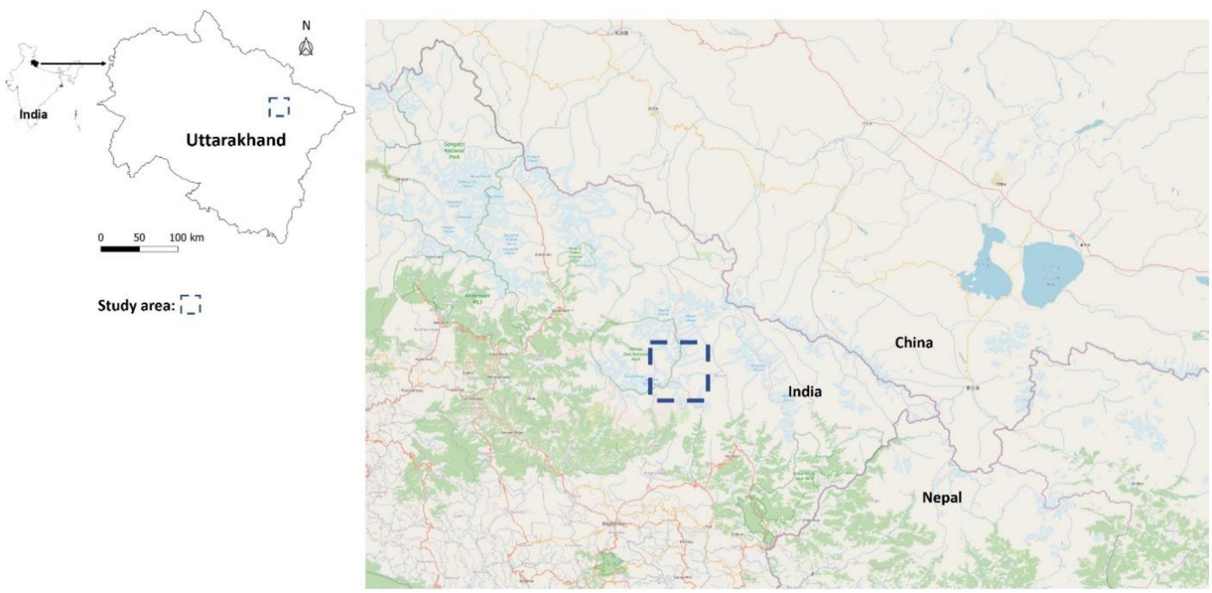

Figure 1. Study area showing the Bageshwar region in Uttarakhand

2.2. Identification

Dissecting binocular microscope and compound microscope are used to study the external morphology and thallus and apothecial anatomy, respectively, by cutting thin hand sections mounted in water or cotton blue. The chemistry was done by applying chemical reagents (K, Pd, C, KC, I) on thallus and medulla resulting in colour change, and thin layer chromatography (TLC) was performed. The morphology and anatomy of lichens were studied under two different microscopes. The colour spot tests were done using aqueous potassium hydroxide, Steiner's paraphenylenediamine and aqueous calcium hypochlorite. The solvent system used for thin layer chromatography was 180Toluene: 60Dioxane: 8Acetic acid.

The identification (of unidentified lichen specimens) along with the correct nomenclature according to recent classification resulted in exclusion or inclusion of certain lichen taxa from the study area. Some lichen species are merged, synonymised or transferred into other genera or species. Literatures cited for lichen identification were Walker and James [12], Orange et al. [13], Awasthi [14, 15, 16, 17].

2.3. Analysis

PCA, developed by Pearson [11] allows the identification of groups of variables that are interrelated via phenomena that cannot be directly observed. This is accomplished by assuming that any observed variables are correlated with a small number of underlying phenomena, which cannot be measured directly. PCA is an automated and systematic examination of correlations among manifest variables, aimed at identifying underlying latent principal components [18]. In the present study, PCA is used to see any pattern exhibited by lichens manifested through their growth forms and through their habitat types and to see whether there exist any similarities and variability of local environmental conditions among different places.

3. Results and Discussion

3.1. Lichens

The Pindari region exhibits luxuriant growth of coniferous and oak trees both as in mixed or isolated forest patches at elevations between 1800-2500 m. Common vegetations at around 3000 m elevation are *Taxus baccata, Lonicera alpigena, Rosa sericea*, etc., while *Juniperus* and *Cotoneaster* are observed at around 3500 m. Some common lichens found at around 2500 m are *Bulbothrix meizospora*, *B. sensibilis*, *Canoparmelia texana* (all on trees), *Cladonia cartilagenia* (on soil) *Dermatocarpon vellereum*, and *Parmotrema praesorediosum* (on rock). Lichens which were observed at around 3500 m elevation are *Aspicilia dwaliensis*, *Caloplaca ochroplaca*, *C. pachychelia*, *Lecanora garovaglii*, *Lobothallia praeradiosa* (all on rocks), and *Lobaria kurokawae* (on soil).

The boulder fields along the river sometimes provide suitable habitat for species of lichen genera *Stereocaulon* and *Cladonia*, in shady moist places. The moraines with pebbles along the river coming out from glaciers snout provide habitat for the growth of some species of lichen genera *Peltigera*, *Leptogium* and *Collema*. Species such as *Peltigera* and *Lobaria* prefer humid soil environment under shady areas of boulders, whereas species such as *Caloplaca* and *Acarospora* prefer exposed regions on rock. The pebbles, moraines and rocks in the summits of glacier in Pindari glacier valley provide a suitable substratum for the growth of *Caloplaca* sp., *Lobothallia praeradiosa*, *Rhizocarpon geographicum* and *Lecanora subimmersa* species.

3.2. Alpine Region of Pindari and Lichen Adaptability

The prevailing conditions in the alpine region limit the growth of most of the plant groups except lichens and mosses. Lichens have some morphological and physiological properties that enable them to grow even in extreme conditions of cold. Plant species occurring in extreme environment of Pindari glacier exhibit peculiar adaptation features. Lichens of the area have little access to soil moisture, but due to lack of effective cuticle they are able to absorb water throughout much of their surface. However, this results in rapid water loss during dry conditions and in compensation the cytoplasm is desiccation-tolerant. The plant becomes inactive when it dries, but resumes normal metabolism rapidly on remoistening. The plants are able to utilize short periods of favorable conditions whenever they occur. The rate of drying and the length of active periods are influenced by the spatial organization of individuals within the colony, leading to correlation between growth-forms and habitat. Poikilohydricity may also enhance frost resistance, by conferring tolerance of cytoplasmic dehydration resulting from extracellular ice formation [19].

Lichen genera such as *Aspicilia* and members of the family Acarosporaceae and Porpidiaceae, growing on rocks, are closely appressed to or grow within the substrate. Foliose and fruitcose taxa appear compact and tiny in comparison to their normal shape. Most of the lichens in these areas have yellow, red, brown or black pigments, in their upper cortex, which protect the photobiont from the illumination intensity of the habitats. Pigmentation has been interpreted as being a protection against irradiation and UV radiation [20, 21]. Poikilohydricity and shelter strategies are frequently interconnected, and when combined with cell mobility and development of complex life cycles, afford considerable potential for the survival of lichens in alpine zone. Lichens of the alpine area in Pindari region maintain the stability by balancing the water conditions. The phenotype plasticity of thallus plays a major role in the survival of lichens in the cold climate of the glacier. Some foliose (*Phaeophyscia hispidula* (Ach.) Moberg and *Heterdermia microphylla* (Kurok.) Skorepa) and fruticose (*Usnea robusta* Stirt. and *Ramalina sinensis* Jatta) lichens are bushy, compact, and tiny unlike the growth form in lower regions. The pendulous form of *Usnea* enables avoiding heavy soaking of rainwater. Lichen genera *Porpidia*, *Diploschistes* and *Endocarpon* are found to be confined to gaps between boulders or crevices in the rock, thus retaining moisture for longer duration and avoiding blowing wind. *Lobaria kurokawae*, *L. retigera*, *Peltigera rufescens* and *P. canina* that prefer to grow among mosses which provide mechanical support to these lichen taxa and facilitate trapping of diaspores and helping in the colonization of species. As cyanophilous lichens are not able to take up water from the air, the moraines with pebbles along the riverbank provide suitable habitat for the growth of some cyanophycean species of lichen genera *Leptogium* and *Collema*.

3.3. Classification Using Principal Component Analysis

Principal component analysis is used to study the factors contributing to maximum variations of species richness in different elevations. Responses to the lichen species diversity structure on the basis of 19 variables were used as prior communality estimates for PCA, after which an orthogonal rotation was performed (Table 1).

Table 1. Total variation explained for 19 components; Extraction method-PCA

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative%
1	7.815	41.131	41.131
2	4.297	22.615	63.747
3	2.205	11.605	75.352
4	1.834	9.655	85.007
5	1.277	6.721	91.728
6	0.610	3.212	94.940
7	0.441	2.320	97.260
8	0.329	1.732	98.992
9	0.152	0.802	99.794
10	0.039	0.206	100.000
11	3.24E-016	1.71E-015	100.000
12	1.44E-016	7.60E-016	100.000
13	4.63E-018	2.44E-017	100.000
14	-4.17E-017	-2.20E-016	100.000
15	-1.33E-016	-7.01E-016	100.000
16	-3.68E-016	-1.94E-015	100.000
17	-4.44E-016	-2.34E-015	100.000
18	-5.83E-016	-3.07E-015	100.000
19	-9.97E-016	-5.25E-015	100.000

Table 2 shows five factors having significant contribution to the lichen species richness of the Pindari region. To reduce the number, only those components are considered whose eigenvalue is more than 1 (based on Chatfield and Collins [22]).

Table 2. Rotated component matrix for 19 variables; Extraction method: PCA

Variable	Component				
	1	2	3	4	5
Uo	0.252	-0.046	0.956	-0.002	-0.064
Lep	0.181	-0.056	-0.147	-0.078	0.946
Sq	0.229	0.942	-0.087	0.060	-0.055
Cr	0.693	0.257	0.570	0.150	0.048
Fo	0.860	0.236	0.355	0.007	-0.007
Fr	0.384	0.098	-0.098	0.875	-0.087
P	0.252	-0.046	0.956	-0.002	-0.064
C	0.847	-0.190	0.237	0.395	-0.080
S	0.286	0.833	0.375	0.105	0.015
T	-0.108	0.660	-0.012	0.659	0.231
M	-0.401	-0.141	0.068	0.161	0.848
TL	-0.244	0.771	-0.040	0.294	-0.192
TM	-0.144	0.950	-0.036	0.056	-0.042
CS	0.852	-0.146	0.258	0.103	-0.110
CT	0.592	0.313	-0.091	0.539	0.374
ST	0.259	0.338	0.461	0.693	0.038
CST	0.916	0.153	0.213	0.208	0.071
CTM	0.907	-0.204	0.116	0.048	-0.057
CSTM	0.713	0.586	-0.123	0.109	-0.042

(Uo-Unorganised, Lep-Leprose, Sq-Squamulose, Cr-Crustose, Fo-Foliose, Fr-Fruticose, P-Parisitic, C-Corticolous, S-Saxicolous, T-Terricolous, M-Muscicolous, TL-Terricolous Lignicolous, TM-Terricolous Muscicolous, CS-Corticolous Saxicolous, CT-Corticolous Terricolous, ST-Saxicolous Terricolous, CST-Corticolous Saxicolous Terricolous, CTM-Corticolous Terricolous Muscicolous, CSTM-Corticolous Saxicolous Terricolous Muscicolous)

The first five components total to 91.7% of all variances, indicating that these components have significant impacts and control on the species richness of lichens [23]. Communalities in Table 3 show that variances of all the variables have been described well.

Table 3. Description of variances of all 19 variables

Variable	Initial	Extraction
Uo	1.000	0.983
Lep	1.000	0.959
Sq	1.000	0.954
Cr	1.000	0.896
Fo	1.000	0.922
Fr	1.000	0.940
P	1.000	0.983
C	1.000	0.972
S	1.000	0.927
T	1.000	0.936
M	1.000	0.930
TL	1.000	0.779
TM	1.000	0.929
CS	1.000	0.836
CT	1.000	0.887
ST	1.000	0.876
CST	1.000	0.957
CTM	1.000	0.883
CSTM	1.000	0.881

Table 4 shows the variable contributions to principal factors. The percentage of the total variance is more than 0.7 for all the 19 variables. The first component gives information about the variation in foliose growth form, and habitat preferences like corticolous, corticolous-saxicolous, corticolous-saxicolous-terricolous, and corticolous-terricolous-muscicolous. It can be observed that corticolous (growing on trees) lichens have a significant role in the overall lichens diversity. Besides this, the lichens which have two and above habitat preferences also have its importance in overall species richness. In the second component, squamulose growth form is important. Saxicolous lichens and combination of soil- dead-wood and soil- mosses are also important as habitat preference. In the third component, the unorganized lichens in which thallus is not fully developed and the parasitic lichens are of importance. In the fourth component, the fruticose growth form is of significance and lichen with habitat preference of rock and soil are of importance. In the fifth component, the leprose growth form is important. The lichens which grow on mosses show high correlation. From the rotation of components, it is clear that the first component emphasizes on foliose growth form while the second component lay more emphasis on squamulose growth form. Regarding the habitat preferences, the analysis reveals the important role of bark and rock loving lichens in enhancing lichen species richness. Similarly, lichens with varied preferences (bark-rock-soil; bark-soil-moss) also have a significant role having very high values (> 0.9). The second component implies that lichens with combined habitat preferences of soil-moss has the highest value (0.95), followed by only rock loving lichens (0.833) and combined preference of soil-dead wood (0.771).

Table 4. Variable contributions to principal factors in the study

Variable	Factor 1	Factor 2
Uo	0.035274	0.034624
Lep	0.000095	0.000714
Sq	0.033193	0.131718
Cr	0.102659	0.005102
Fo	0.103018	0.010419
Fr	0.046208	0.008007
P	0.035274	0.034624
C	0.086801	0.045556
S	0.061683	0.065852
T	0.016882	0.143392
M	0.012053	0.001905
TL	0.003708	0.158288
TM	0.006921	0.181967
CS	0.072675	0.055416
CT	0.066970	0.011579
ST	0.066918	0.014602
CST	0.110096	0.010395
CTM	0.063707	0.066200
CSTM	0.075867	0.019639

It can be observed (Table 5) that there are significant correlations of some of the lichen growth forms with their habitat preferences. Fruticose lichens show a significant positive correlation with corticolous habitat followed by combined preferences of bark- soil and rock- soil substrate. Foliose lichens are positively correlated with a number of substrates such as bark, bark-rock, bark-rock-soil, bark-soil-mosses, and bark-soil-rock-mosses.

Table 5. Correlation between Growth Form-Habitat in the study

		Habitat												
		P	**C**	**S**	**T**	**M**	**TL**	**TM**	**CS**	**CT**	**ST**	**CST**	**CTM**	**CSTM**
Growth Form	**Uo**	**1.00**	0.45	0.38	-0.10	-0.10	-0.15	-0.10	0.46	0.06	0.48	0.41	0.35	0.04
	Lep	-0.15	0.05	-0.08	0.12	**0.67**	-0.22	-0.15	0.02	0.42	-0.07	0.19	0.04	0.05
	Sq	-0.04	0.01	**0.83**	**0.61**	-0.28	**0.64**	**0.90**	0.06	0.51	0.35	0.33	0.01	**0.70**
	Cr	**0.68**	**0.75**	**0.69**	0.20	-0.24	0.04	0.14	**0.73**	0.54	0.56	**0.86**	0.60	0.52
	Fo	0.54	**0.78**	0.52	0.09	-0.34	0.06	0.02	**0.79**	0.50	0.54	**0.92**	**0.77**	**0.77**
	Fr	0.01	**0.62**	0.30	0.56	-0.11	0.16	0.16	0.40	**0.75**	**0.64**	0.50	0.38	0.39
Bold correlations are significant at p < 0.05														

Table 6. Correlation of Growth Form-Habitat with the altitude in the study

Uo	Lep	Sq	Cr	Fo	Fr	P	C	S	T	M	TL	TM	CS	CT	ST	CST	CTM	CSTM
-0.14	0.1	0.21	-0.39	-0.43	-0.14	-0.14	-0.53	0.04	0.35	0.29	0.43	0.42	-0.71	-0.01	0.14	-0.53	-0.66	-0.11
Bold correlations are significant at p < .05																		

Crustose lichens exhibit their inclination towards bark, bark-rock, bark-rock-soil, bark-soil-mosses, and bark-soil-rock-mosses. Squamulose, which is an intermediate form between crustose and foliose, shows its inclination towards rock, soil, soil-dead wood, soil-mosses, and bark-soil-rock-mosses. Leprose growth form with a level higher than unorganized lichen shows its positive correlation with only mosses. It is quite interesting to see that the first stage of lichen growth form i.e. unorganized lichens prefers only to be parasitic and do not tend to exhibit any liking towards any other substrate. It can be observed that altitude has a significant negative correlation with combined habitat preferences of bark-rock and bark-soil-moss (Table 6).

The cluster analysis (Figure 2) indicates that different sites of varied altitudes exhibit certain similarities on the basis of growth form and habitat preferences. Dhakuri, Dwali-Phurkia route, Loharkhet (altitude-2683m, 2972m, 1760m); Dwali, Pindari Glacier, Phurkia, Khati (altitude-2734m, 3660m, 3210m, 2210m) and Dhakuri-Khati route, Khati-Dwali route (altitude-2446.5m, 2472m) exhibit are accommodated in a single cluster that indicates the high range of similarities amongst each other. On the other hand, Loharkhet-Dhakuri (2221.5m) and Phurkia-Pindari Glacier route (3435m) are less similar to others as both forms separate linkage (Fig.2 & 3). Sites 3, 8, and 1 (2683m, 2972m, and 1760m) are placed together in the center; sites 7, 11, 9, and 5 (2734m, 3660m, 3210m, and 2210m) are placed together at the right side; and sites 4 and 6 (2446.5m and 2472m) are placed together on the left side.

From Figure 3 it can be observed that lichen species richness of sites 1,5,7,9, and 11 are characterized more by factor 1 on which the dominant role is played by CST, CR, and Fo. Similarly, lichen species richness of sites 8, 9, 10 are characterized by factor 2 on which the dominant role is played by Sq, and T (Table 4). First component among the two principal components out of the 19 variables which seems to have a significant role (Table 3) in the lichen species richness of the 11 sites of the study area at different altitudes are more pronounced and stable habitats like bark, soil, and rock and more advanced foliose growth form; and the second principal component seems to be relatively more unstable habitat preferences like mosses and ligneous, and lower level squamulose growth form. These two components are responsible for the present lichen species composition of the study area spread across an altitude from 1760 m to 3660 m.

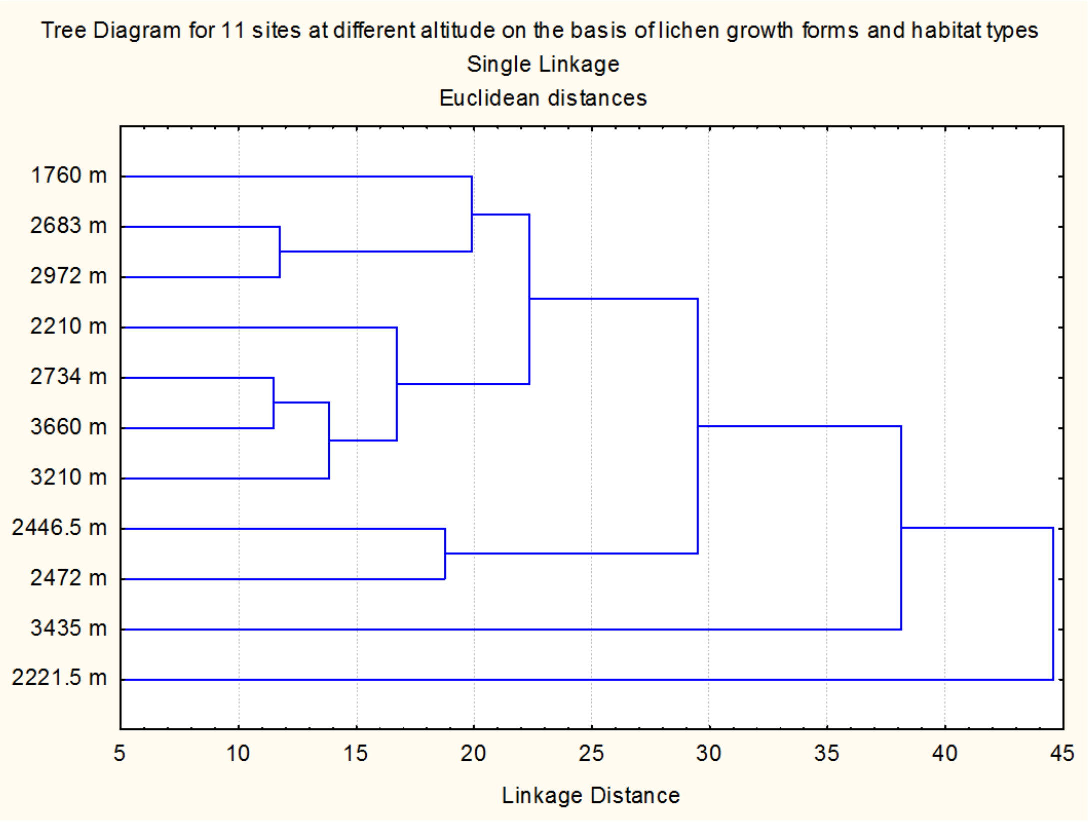

Figure 2. Cluster analysis of 11 sites on the basis of growth form and habitat in the study

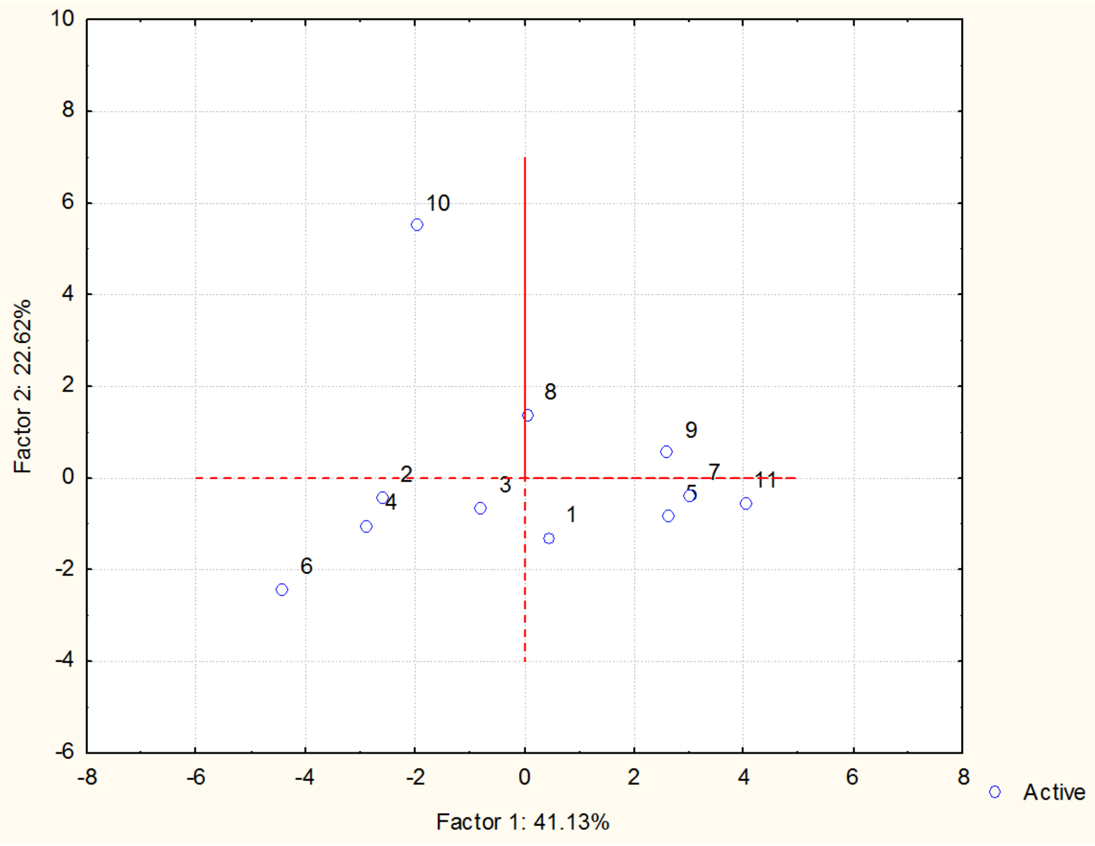

Figure 3. Projection of the 11 sites on the basis of 19 variables in the study

Mishra and Upreti [24] reported 361 species of lichens from Bageshwar region of Uttarakhand where lichens on trees were dominant as compared with rocks and soil. Joshi et al. [25] recorded 283 species of lichens from temperate and alpine regions of Uttarakhand. Foliose species dominated with 41%, followed by crustose, fruticose, squamulose, and leprose with 37%, 18%, 3%, and 1% respectively. They observed that around 46% of the species grew only on bark where as 28% and 7% of all lichens preferred only rock or only soil respectively. Similarly, while 7% of all species preferred both bark and rock, 4% preferred either rock and soil combined or bark and soil combined, and 4% preferred three surfaces together; bark, rock, and soil. Only 1% of all species preferred all four substrata together; bark, rock, soil, and even mosses. In a detailed study of Uttarakhand lichens, Upreti et al. [26] recorded 541 species. In this study it was observed that half of all species preferred tree bark where as 23% preferred rock, and 9% preferred soil. While there were three species observed on mosses, only one species was found growing on leaf. Species which preferred two substrata were 5% (bark and rock), 4% (bark and soil), 2% (rock and soil), and 1% (soil and moss). 14 species preferred three substrata (bark, rock, and soil) while 3 to 4 species each preferred either bark, rock, moss, or bark, soil, moss, or soil, rock, moss. Gupta et al. [6] reported that growth forms and substrate determine lichen groups in studied sites in Uttarakhand. They used PCA to summarize the compositional differences between sites and calculated Pearson's correlation coefficients to compare temperature, relative humidity and altitude on one hand and growth forms on the other hand. Gupta et al. [27] observed crustose, fruticose, and foliose lichens in Uttarakhand in a study at an altitude beyond 3000 m. The lichens were found mostly on soil, rock, or mosses, but not on bark. Rai et al. [28] studied lichen association with habitat and elevation using PCA in Uttarakhand and observed a gradient of lichen habitat subsets with less variability in growth forms with altitude. Substratum specialization by lichens are its ecological trait and there may be specialist (restricted to one substratum), intermediate type (preferring two or three substrata), and generalist (growing on more than three substrata) [29]. While growth forms of lichens are its vegetative traits, only generalists exhibited a clear trend along the land-use gradient in a study in eight different European countries [29]. Substrate preferences of lichens, which are often related to the differences in lichen communities in different land use category, may help deriving complex diversity patterns [30]. In a study in Romania where the authors observed 240 species of lichen, 36% were specialists, over 51% were intermediates, and 13% were generalists.

4. Conclusions

The Pindari Himalayan region ranging from temperate to alpine has been categorized according to the ecological variables of lichens using PCA. The technique helped in manifesting the latent variables which otherwise might not be possible by measuring only growth forms and habitat types individually. It is observed that some sites having varied altitudinal ranges show similarity in environmental conditions on the basis of lichen biomonitoring. It has been observed that the lichens from one locality to another exhibit maximum diversity as compared to the lichens in and around inhabited localities. The region exhibits dense floristic composition in between localities while the forests around localities are thinned out. The high anthropogenic activities in and around villages are more in comparison to the forest's sites between two localities. Lichens are collected as non-timber forest produce either for own consumption or for selling in the market through middle-men. In addition to collection of lichens from the forest floor, people are also relying on lopping of trees and pruning of twigs and wood. There is a huge demand because of its medicinal properties and other usages. Collection of lichens by local inhabitants and people from other regions is drastically changing the natural community structure of lichens. Studies are also indicating towards changing climatic conditions and its impact on lichen ecology in the region.

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