Sumerianz Journal of Scientific Research, 2020, Vol. 3, No. 9, pp. 109-117
ISSN(e): 2617-6955, ISSN(p): 2617-765X
Website: https://www.sumerianz.com

Original Article Open Access

Study of Lichen Diversity in Shankaracharya Forest

Sabeeqa Samad
P.G. Department of Environmental Science, S. P. College Campus, Cluster University Srinagar, Kashmir

Shahid Ahmad Wani
P.G. Department of Environmental Science, S. P. College Campus, Cluster University Srinagar, Kashmir

Basharat Mushtaq*
P.G. Department of Environmental Science, S. P. College Campus, Cluster University Srinagar, Kashmir

Article History
Received: July 20, 2020
Revised: August 25, 2020
Accepted: August 29, 2020
Published: September 1, 2020

Abstract

An assessment had been carried out in Shankaracharya forest ecosystem Srinagar, to explore the lichen diversity of the region. A total of 19 lichen species were found during the study period belonging to the 9 families and 14 genera. Among the growth forms Foliose was the most frequently encountered lichen from with 14 species followed by Crustose with 4 species and Fruticose with 1 species. The lichens were found to be growing on different substratum; trees, dead wood, rocks and moss with the epiphytic lichens as dominating type. Lichen diversity values (LDV) were generated based on recorded epiphytic, Lignicolous and treemoss lichens. Mean LDV was recorded highest for epiphytic lichens (891.10) followed by Lignicolous lichens (730.00) and treemoss lichens (486.66).While as frequency, density and abundance was measured in Saxicolous and Rockmoss lichens. The maximum mean density of 8.60 and minimum values of 0.33 was depicted by *Candelaria conclor* and *Xanthoria parietina* respectively among Saxicolous lichens. While in case of Rockmoss lichens, *Candelaria conclor* recorded high mean density (8.77) and the least was recorded for *Physconia distorta* (1.77).

Keywords: Lichen diversity; Shankeracharya forest; LDV; Rockmass and tree trunk.

1. Introduction

The term `lichen` was introduced in 300 B.C. by Theophrastus, the father of Botany, primarily to represent the superficial growth of lichens on the bark of olive trees [1]. Lichens are composite organisms formed by the symbiotic association of algae and fungi. Owing to their desiccation resistant property, survival under extreme temperature and nutrient accumulating efficacy, lichens occur in a wide range of habitats [2]. The primary photobiont, (green-algal or cyanobacterial partner) fixes carbon for both partners [3]. Cyanobacteria also convert nitrogen gas into forms used to build proteins, nucleic acids and other essential molecules [4]. On the basis of substratum lichens grow upon, they are grouped as, Epiphytic/Corticolous lichens (lichens growing on tree trunks and barks), Lignicolous (growing on dead wood), ramicolous (lichens inhabiting twigs), Terricolous (lichens growing on soil), humicolous (lichens growing on humus), Saxicolous (lichens growing on rocks) and Folicolous (lichens growing on evergreen leaves) [1]. Morphologically, lichens are growing in 3 different growth forms, which are crustose (used to grow attached to the substratum) followed by foliose (used to grow like leafy and slackly attached to the substratum) and lastly fruticose (used to grow like bushes which is hanging or upright growing on substratum) [5]. Lichens are of great significance. In nature, lichens play an important role as pioneer organisms. The role of lichens as biological weathering agents in the development of soils was formally considered in a geological context only, but recent researchers have shown that these organisms are capable of biodeteriorating stone substrates within a relatively short time-scale [6]. Some lichens fix nitrogen for soil. They are the first colonizers of bare rocks and prevent erosion by stabilizing the soil [7]. Lichens along with cyanobacteria contribute a significant role for forest nitrogen fixation and also have various industrial applications [8]. When abundant lichens and bryophytes growing on trees intercept and hold moisture moderating humidity and temperature within the canopy. They also capture and slowly release the nutrients from rain, dew, fog, air borne fine particles and gases which might otherwise be lost or unavailable. Climate change and biodiversity can be tracked and indicated by monitoring lichen community composition. Climate strongly influences lichen community composition i.e. which lichens are present. A few lichens tolerate large fluctuations in climate, but most require more specific regimes. Girdhar, *et al.* [9]. Lichens also contribute to the biological diversity. It is estimated that there are about 25,000 lichen species throughout the world [10]. A colourful diversity of lichens can be found on soils, rocks, trees, wood, etc. Various squirrels, chipmunks, voles, Pikas, mice and bats use leafy and hairy lichens for insulation or in nest building. Deer, elk, moose, caribow, mice, bats, butterflies, spiders, etc eat lichens. Some insects e.g. moths, hide from predators by mimicking common bark lichens .A variety of fungi, algae and bacteria grow on or parasitize lichens; some are very specific to particular species. Humans also use lichens. Lichens with their metabolites are also having numerous biological activities such as antimicrobial, antiprotozoal, antiviral, antiproliferative, anti-inflammatory, analgesic, antipyretic, antitermite, antioxidant, cytotoxic, enzyme inhibitory, insecticidal, wound healing, antitumor and in the ecological roles as well as enzyme inhibitory [11].

*Corresponding Author

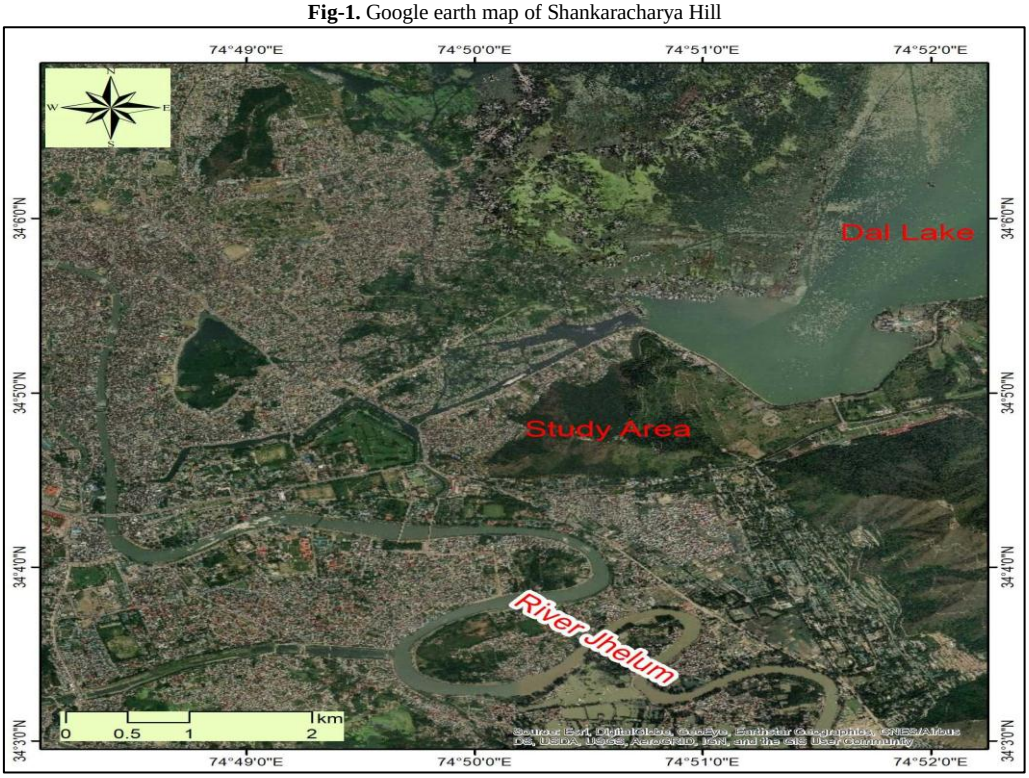
Owing to the tremendous potential of lichens, many studies related to lichens have been carried out in different parts of India, including Jammu and Kashmir. From time to time the Union Territory of Jammu and Kashmir was well surveyed for collection of higher plants, particularly angiosperms, however, lichens have received little attention. Recently, scantly workers on lichen diversity had been documented so far such as, Priyadarshini [12], Sheikh, *et al.* [13], Haq, *et al.* [14]. However, no exhaustive exploration for the collection and identification of lichen species of Shankaracharya forest ecosystem has been done so for. Moreover, increasing urbanization in and around the Shankaracharya forest has drastic effects on vegetation in general, and on lichen species, in particular. Hence, It is in this context that the present study was undertaken to explore the lichen flora diversity of Shankaracharya forest ecosystem.

1.1. Study Area

The present study was carried out on Shankaracharya Hill, in Zabarwan range, Srinagar. The geographical co-ordinates of the Hill are 34º04′35.56″ and 34º05′25.08″ N latitude and 74º50′03.16″ and 74º51′08.63″ E longitude, covering an area of approximately 138.35 ha. It represents one of the extension tail tips of Zabarwan Range in Srinagar and lies in South-East of Srinagar at a distance of about 4.5 Km from clock tower, Lal Chowk and 17.5 Km from Dachigam National Park. Average height of the hill is nearly 300 m i.e., from 1572 to 1880m above mean sea level. It bears a prevailing northerly trend and shows a gradual increase in its height till it merges with the majestic snow-clad water Way Mountains in the South-East.

The study area was divided into three plots ; Lower plot (from foothill upto the road length of 1.5 kms), Middle plot (from 1.5kms of road length to 3.5kms of road length) and Higher plot(from 3.5 kms of road length to 5.5kms of road length).The samples were collected on monthly basis from all the three plots and for each plot 3 trees, 2 rocks ,2 woods , 2 mosses were taken for surveying lichens .

Fig-1. Google earth map of Shankaracharya Hill



2. Materials and Methods

2.1. Corticolous (Epiphytic), Lignicolous and Treemoss Lichens

Trees with girths more than 40 cm and showing no evidence of damage or interference by humans or animals were selected for sampling

Lichen diversity was surveyed on selected trees using surveying grids consisting of four quardrat segments of 50 cm in height and 10cm in width .Surveying quardrat was attached vertically to the trunk placing the quardrat segments on the North ,East ,South and West side of the trunk and 1-2 meter above the ground. Each quardrat segment was subdivided into five quardrat squares 10 x10 cm and the presence of species was recorded in each quardrat square. In case of lignicolous lichens, the grids was placed linearly on the wood log and were counted from i to iv [15].

2.2. Calculation of Lichen Diversity Values (LDV)

The European guideline developed by Asta, *et al.* [16], Asta, *et al.* [17] was used to assess the lichen diversity in Shankaracharya hill. LDV for each sample plot was calculated following procedures of Asta, *et al.* [16], Asta, *et al.* [17]. Within each sample plot; a sum of frequencies of lichen species at aspect of each tree (1)/dead wood/tree moss

was calculated .Thus for each tree /dead wood /tree moss there were four sum of frequencies (SF1) on North (SF1n), East (SF1e), South(SF1s)and West(S1w) side of the trunk .Then the mean of the sums of the frequencies (MSF) for each aspect (North East South West) in each sample plot was calculated according to following equation:

$$MSF_n = \frac{SFIn+SF2n+SF3n+SF4n}{N}$$

Where:

MSF_n = Mean of the sums of the frequencies of all trees/dead woods /tree mosses of sample plot at a given aspect (e.g. North)

SF1n = sum of frequencies of all the species found at one aspect tree1/dead wood1/tree moss1 (e.g. North)

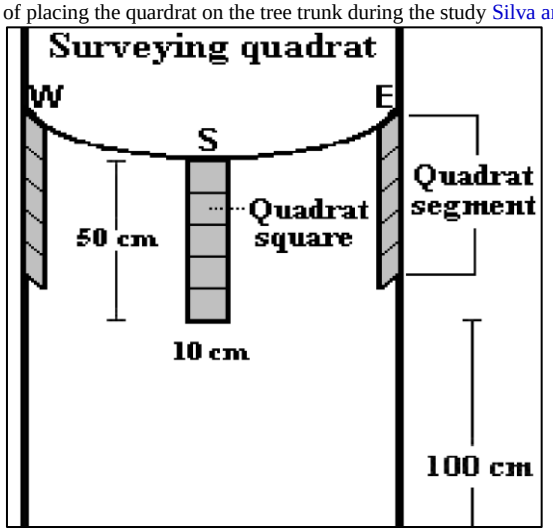
n, e ,s ,w = North ,East, South, West, (For lignicolous lichens, n, e, s, w will be replaced by I, ii, iii, iv respectively)

N = number of trees/ dead woods/tree mosses surveyed in sample plot

Then the Lichen Diversity Value (LDV) of a sample plot was calculated as the sum of the MSF of all the aspects:

$$LDV = MSFe + MSFw + MSFn + MSFs$$

Figure-2. Location of placing the quardrat on the tree trunk during the study Silva and Senanayake [15]



2.3. Saxicolous and Rockmoss Lichens

Lichen composition on the rocks and rock moss was recorded by quardrat method [18].Two rocks for saxicolous lichens and one rock for rock moss lichens were taken for each plot to record the species. Four quardrats of size 25x25 sq.m per rock were marked with the help of white chalk at various points of the rock to determine the diversity. Lichen vegetation of the selected rocks was carried out and the data on vegetation was subjected for percentage frequency, density and abundance which was obtained by actual count method [18]. The lichen vegetation analysis can be done by using following formulas:

Percentage frequency:

$$Frequency(\%) = \frac{Total\ number\ of\ quardrats\ in\ which\ specied\ occured}{Total\ number\ of\ quardrats\ studied}\ X\ 100$$

Density:

$$Density = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quardrats}{Total\ number\ of\ quardrats\ studied}$$

Abundance:

$$Abundance = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quardrats}{Total\ number\ of\ quardrats\ in\ which\ species\ has\ occured}$$

Data collected during the study period was carefully analysed, compiled and interpreted.

2.4. Collection of Lichens

Foliose lichens were collected with part of the substrate to prevent any damage to the thallus and rhizines. Crustose lichens were cut off by taking sufficient bark from the trees. Ordinary poly bags were used as temporary pockets to collect the lichens specimens.

2.5. Lichen Identification

The species were identified using standard works by Awasthi [19, 20] and Singh, *et al.* [21].

3. Results and Discussion

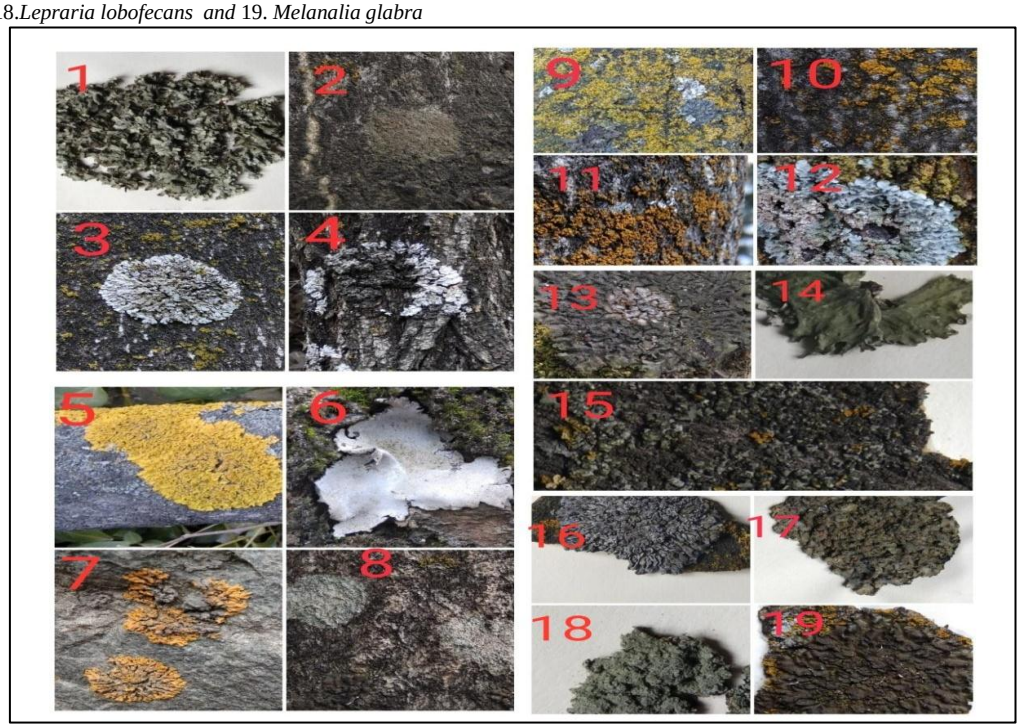
3.1. Species Composition

A total of 19 lichen species were found during the study period (Table 1) belonging to the 9 families and 14 genera, dominated by growth form foliose (14species), followed by crustose (4 species) and fruticose (1 species). The lichens were found to be growing on different substratum; trees, dead wood, rocks and moss with the epiphytic lichens as dominating type. The family Parmeliaceae was found as dominating family with 5 species followed by Physiaceae (4 species), Teloschistaceae (3 species), Ramalinaceae (2 species), Chrysotrichaceae, Lecanoraceae, Lecinimperfecti, Candelariaceae and Verrucariaceae (1 species each).

Table-1. Species composition of lichens collected during the study

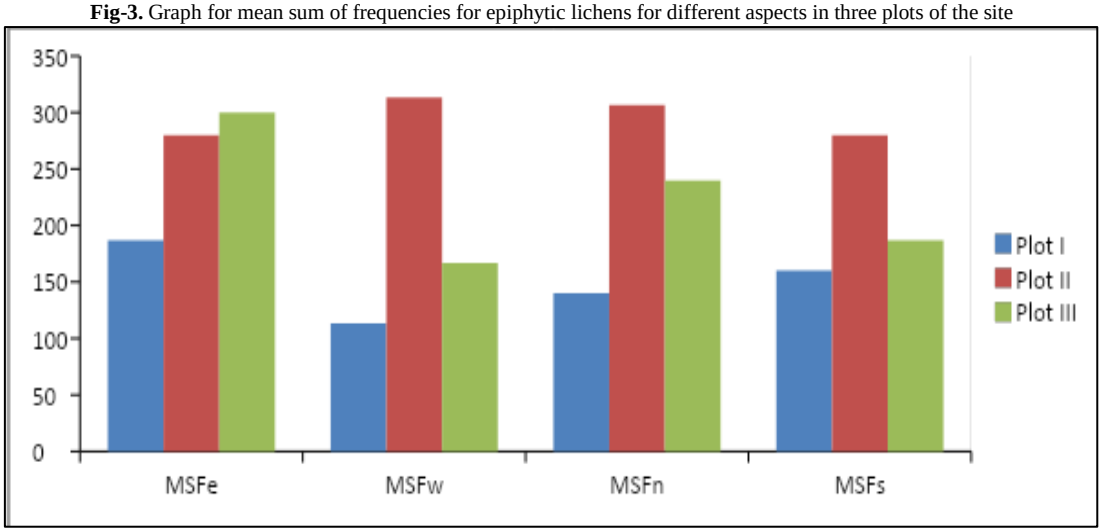
S. No.	Species	Family	Growth form	Substrate type
1	*Parmelia tiliacea*	Parmeliaceae	Foliose	Lignicolous
2	*Xanthoria parietina*	Teloschistaceae	Foliose	Lignicolous, Saxicolous, Epiphytic
3	*Crysothrix candelaris*	Chrysotrichaceae	Crustose	Epiphytic
4	*Punctilia nutralis*	Parmeliaceae	Foliose	Lignicolous, Epiphytic, Muscicolous
5	*Melanalia glabra*	Parmeliaceae	Foliose	Lignicolous, Epiphytic
6	*Melanalia disjuncta*	Parmeliaceae	Foliose	Epiphytic, Muscicolous
7	*Leconora tropica*	Lecanoraceae	Crustose	Saxicolous, Epiphytic
8	*Phyllopsora corallina*	Ramalinaceae	Crustose	Lignicolous, Saxicolous, Epiphytic, Muscicolous
9	*Lepraria lobofecans*	Lecinimperfecti	Crustose	Epiphytic
10	*Parmelia sulcata*	Parmeliaceae	Foliose	Epiphytic
11	*Physconia distorta*	Physiaceae	Foliose	Lignicolous, Epiphytic Saxicolous, Muscicolous
12	*Pheophysia orbicularis*	Physiaceae	Foliose	Lignicolous,
13	*Hyperphyscia adglutinata*	Physiaceae	Foliose	Lignicolous, Epiphytic, Muscicolous
14	*Candelaria conclor*	Candelariaceae	Foliose	Lignicolous, Epiphytic Saxicolous, Muscicolous
15	*Dermatocarpon vellerum*	Verrucariaceae	Foliose	Saxicolous, Muscicolous
16	*Physconia disjuncta*	Physiaceae	Foliose	Lignicolous
17	*Ramalina sinensis jatta*	Ramalinaceae	Fruticose	Epiphytic
18	*Xanthoria fallax*	Teloschistaceae	Foliose	Lignicolous, Epiphytic
19	*Xanthoria elegans*	Teloschistaceae	Foliose	Saxicolous

Photo-1. Photos of lichens: 1.*Parmelia tiliacea*, 2.*Phyllopsora corallina*, 3.*Physconiadistorta* 4.*Parmelia sulcata*, 5.*Xanthoria parietina*, 6.*Dermatocarpon vellerum* , 7.*Xanthoria parietina*, 8.*Leconora tropica*, 9.*Candilaria conclor*, 10.*Xanthoria fallax* ,11.*Crysothrix candilaris* , 12.*Punctilia nutralis*, 13.*Melanalia disjuncta*, 14.*Ramalina sinensis jatta*, 15. *Hyperphyscia adglutinata*, 16.*Physconia disjuncta* , 17.*Pheophysia orbicularis*, 18.*Lepraria lobofecans and* 19. *Melanalia glabra*



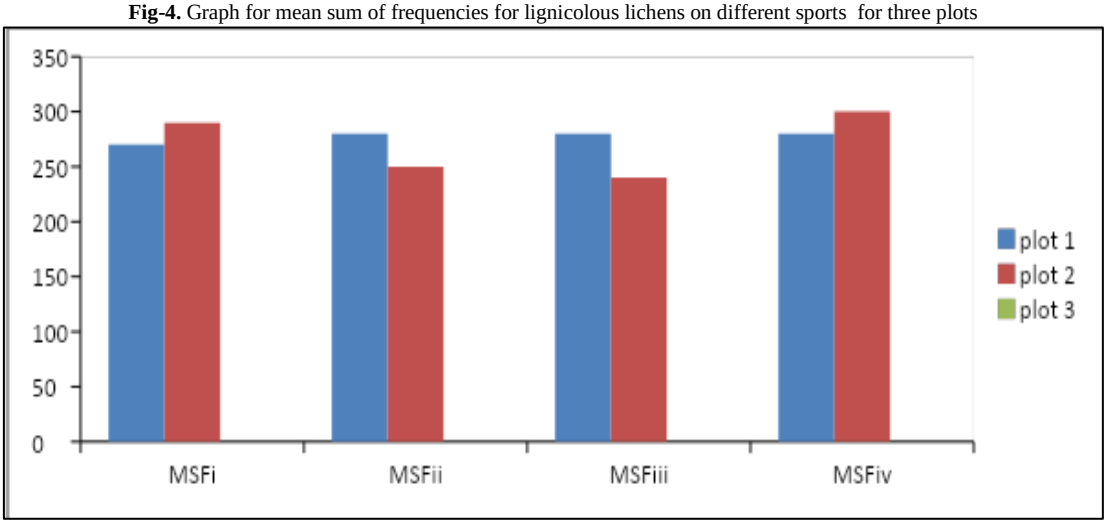
3.2. Graphical Representation

Fig-3. Graph for mean sum of frequencies for epiphytic lichens for different aspects in three plots of the site



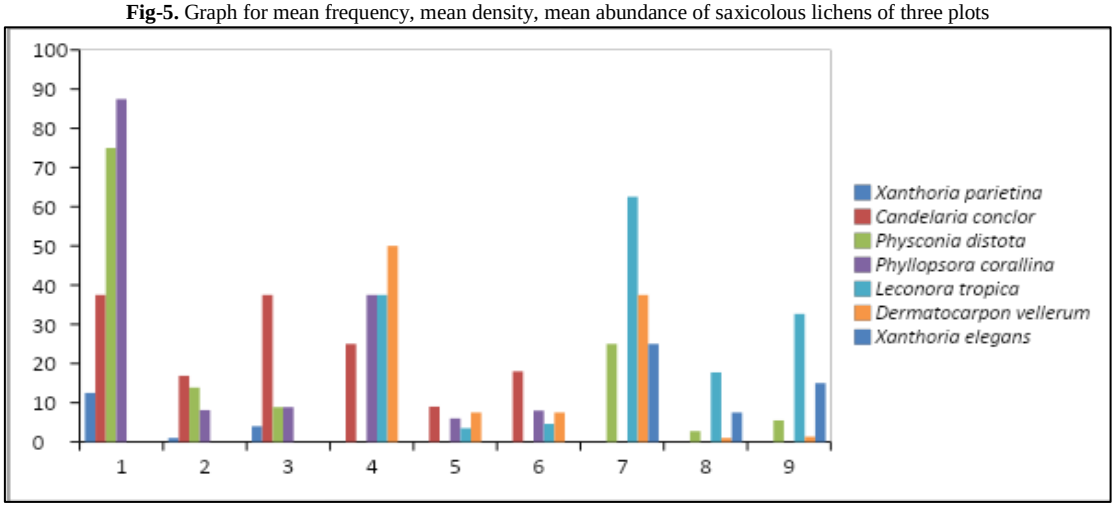
It was recorded in the present investigation that among the three plots, MSF values for epiphytic lichens were highest in plot II i.e., 280.00 (MSFe and MSFs), 313.33 (MSFw) and 306.66 (MSFn), followed by plot III i.e., 300.00 (MSFe), 166.66 (MSFw), 240.00 (MSFn) and 186.66 (MSFs) and then by plot I i.e., 186.66(MSFe), 113,33(MSFw), 140.00(MSFn) and 160.00(MSFs)(fig 3). Further, it was recorded that MSF value in plot II was highest for the lichens on west side (313.33), followed by north (306.66), south and east (280 each).

Fig-4. Graph for mean sum of frequencies for lignicolous lichens on different sports for three plots



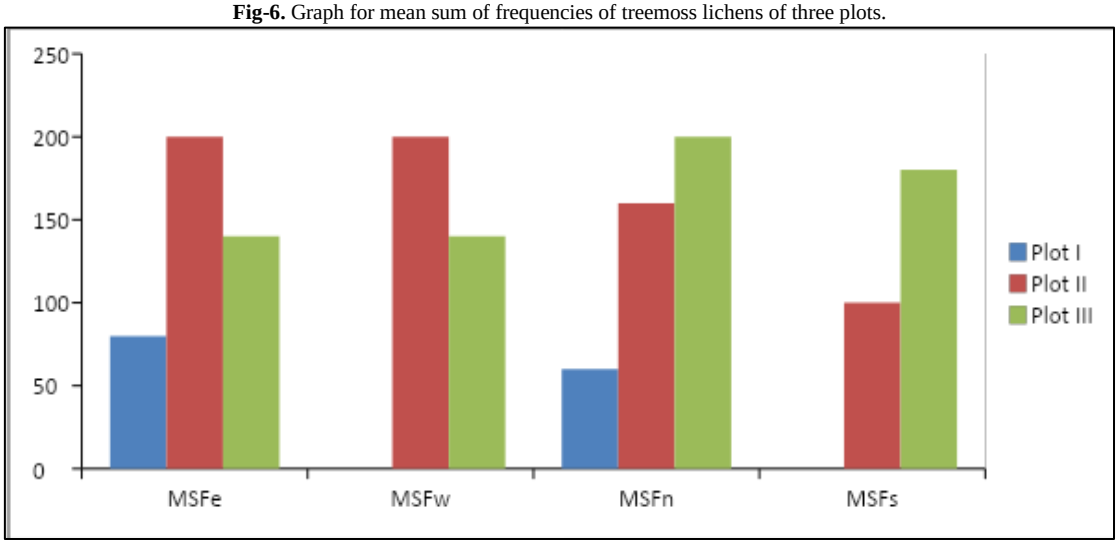
It was recorded in the present study that MSF values of lignicolous lichens were highest for plot II, i.e, 290 (MSFi), 250 (MSFii), 240 (MSFiii) and 300 (MSFiv),followed by plot I i.e.,270(MSFi), 280 (MSFii, MSFiii, and MSFiv).However MSF values were recorded 0 for plot III (Fig 4).Further, MSF values were recorded higher on spots i and iv of selected wood in plot II while at spots ii and iii, MSF values were recorded highest for plot I.

Fig-5. Graph for mean frequency, mean density, mean abundance of saxicolous lichens of three plots



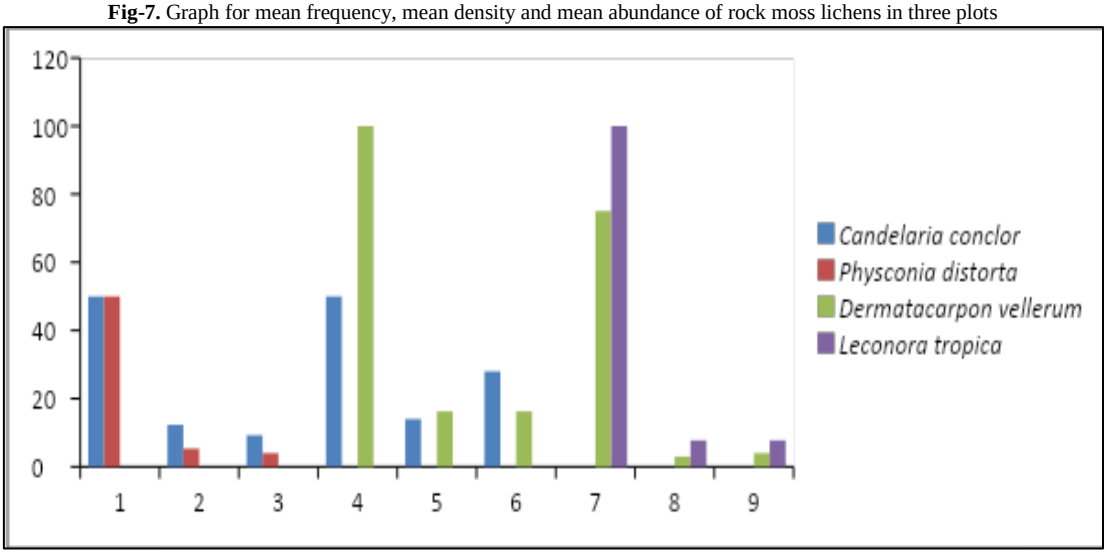
In the present study it was recorded that, for the saxicolous lichens MF value was highest for *Phyllopsora corallina* (87.5) in plot I followed by *Leconora tropica* (62.5) in plot III and *Dermatocarpon vellerum* (50.00) in plot II.MD values were recorded highest for *Leconora tropica* (17.75) in plot III followed by *Candelaria conclor* in plot I (16.87) and plot II (9.00).MA values were recorded highest for the *Candelaria conclor* (37.5) in plot I followed by *Leconora tropica* (32.66) in plot III and *Candelaria conclor* (18.00) in plot II (Fig 5)

Fig-6. Graph for mean sum of frequencies of treemoss lichens of three plots.



In the present investigation, it was recorded that MSF values of tree moss lichens were highest for plot II i.e., 200 (MSFe), 200 (MSFw), 160 (MSFn) and 100 (MSFs)followed by plot III i.e., 140 (MSFe), 140 (MSFw), 200 (MSFn) and 180 (MSFs) and then by plot I i.e.,80 (MSFe) and 60 (MSFn). Further, it was recorded that MSF values on east and west sides in plot II and on the north side on plot III were same i.e.200. However, on west and south sides in plot I, MSF was recorded as 0 (Fig 6).

Fig-7. Graph for mean frequency, mean density and mean abundance of rock moss lichens in three plots



It was recorded in the present study that among the Rockmoss lichens found in the study area, the mean was found highest for *Leconora tropica* (100) in plot III and *Dermatocarpon vellerum* (100) in plot II, followed by *Physconia distorta* and *Candelaria conclor* (50 each) in plot I. Mean was recorded highest for *Dermatocarpon vellerum* (16.25) and *Candelaria conclor* (14.00) in plot II, followed by Candelaria conclor (12.33) in plot I and *Leconora tropica* (7.75) in plot III. Mean was recorded highest for *Dermatocarpon vellerum* (16.25) and Candelaria conclor (12.00) in plot II followed by *Candelaria conclor* (9.25) in plot I and *Leconora tropica* (7.75) in plot III (Fig 7).

3.3. Mean values of Three Plots

Table-2. Variation in LDV of three lichen types

Lichen type	Plots			Mean LDV
	I	II	III	
Epiphytic	600	1180	893	891
Lignicolous	1110	1080	0	730
Tree moss	140	660	660	487

During the present investigation, the observed three lichen types such as epiphytic, lignicolous and treemoss lichens showed marked variations in values of LDV at different plots (Table 2). The range values of LDV of epiphytic lichens depicted maximum value of 1180 at plot II with 600 minimum LDV at plot I. However, Lignicolous lichens recorded highest LDV (1110) at plot I and lowest (0) at plot III. While as Tree moss lichens showed equal LDV values (660) each at plot II and plot III with least LDV of 140 at plot I. On the basis of mean LDV of different lichen types the epiphytic lichens was found dominant (891), followed by lignicolous (730) and least treemoss lichens (487).

Table-3. Variation in mean frequencies (MF)**,** mean densities (MD, and mean abundances (MA) of saxicolous and rockmoss lichens of three plots

Species		MF	MD	MA
Xanthoria parietina	**Saxicolous lichens**	4.16	0.33	1.33
Candelaria conclor		20.83	8.60	18.5
Physconia distorta		33.33	5.54	8.00
Phyllopsora corallina		41.66	4.70	5.60
Leconora tropica		0.20	7.08	12.42
Dermatocarpon vellerum		29.16	2.80	2.94
Xanthoria elegans		8.30	2.50	5.00
Candelaria conclor	**Rockmoss lichens**	33.33	8.77	12.41
Physconia distorta		16.66	1.77	1.30
Dermatocarpon vellerum		58.30	6.41	6.75
Leconora tropica		33.33	2.58	2.58

The present study revealed marked differences in mean frequencies, mean densities and mean abundances in Saxicolous and rockmoss lichens in three plots (Table 3). Among saxicolous lichens MD values depicted highest value of 8.60 for Candelaria conclor and lowest value of 0.33 for Xanthoria Parietina. However, among rockmoss lichens MD values depicted highest value of 8.77 for Candelaria Conclor and the lowest value of 1.77 for Physconia distorta. Among the common species found between saxicolous and rockmoss lichens, Candelaria conclor showed highest MD value of 8.77 on rockmoss and lowest value of 8.60 on rock. While as Physconia distorta and Leconora tropica showed the highest MD values of 5.54 and 7.08 respectively on the rock and lowest MD values of 1.77 and 2.80 respectively on rockmoss. On the basis of mean density of different lichens saxicolous lichens are found to be dominant over rockmoss lichens.

4. Discussion

Among the different types of lichens found in the Shankaracharya forest, the epiphytic lichens were the dominating ones (Table 1). Dominance of epiphytic lichens simply indicates high abundance of trees for lichen growth compared to other substrates present there. Among different growth forms found on the site fruticose lichens were found least compared to other two forms. Since the forests are usually dense, fruticose lichens may not get the advantage of being able to utilize light from all the directions whereas many foliose and flat lichens (crustose) maximize the harvest of more or less unidirectional light in shady positions in dense forests and on low canopy branches [22]

The present study recorded mean sum of frequencies (MSF) of epiphytic lichens highest for plot II i.e., 280.00 (MSFe and MSFs), 313.33 (MSFw) and 306.66 (MSFn), (Fig 3).Since the plot II of the study area was highly dominated by *Ailanthus altissima*, the highest MSF values of epiphytic lichens on it indicates that this tree supports luxuriant lichen diversity compared to the trees in other plots. The bark of Ailanthus altissima is soft and retains relatively good amount of moisture compared *Morus alba ,Cedrus deodara, populas tremula* etc in other plots where the bark is hard to retain the excess moisture which is one the essential factor to support the lichen growth. Armstrong [23], has also mentioned in his studies substrate texture, as one of the essential factors associated with lichen growth. Further, MSF values of epiphytic lichens of plot I was recorded highest on West side (313.33), followed by north, while east and south sides had the same and low MSF values (280.00). The highest MSF value on the west side of the trees in plot I indicates high moisture retention from that side as compared to other sides which increased photosynthesis and in turn enhanced the growth of lichens. Akhkha [24], has also reported in his research that water plays an important role in all physiological processes in plants including photosynthesis. While as the reverse was the case for east and south sides which are adjacent to each other and are facing almost same light and hence same moisture conditions.

The present investigation recorded highest MSF values for lignicolous lichens in plot II i.e., 290 (MSFi), 250 (MSFii), 240 (MSFiii) and 300 (MSFiv), (Fig 4).This indicates the abundance of deadwood in plot. Further, the study recorded 0 MSF values for lignicolous lichens in plot III indicating absence of these lichens in that plot. This may be due to presence of *Pinus* and *Cedrus* species of trees that highly dominated the plot and are not easily subjected to natural damage by wind or heavy snow so that these would have been converted into dead wood as compared to other trees like; *Ailanthus altissima* or *Morus alba* etc that usually break down and support the growth of lignicolous lichens.

In the present study, among saxicolous lichens of the three plots, we recorded highest mean density (MD) for *Candelaria conclor* i.e., 16.87 in plot I and 9.00 in plot II while as the third plot showed the highest MD value for *Leconora tropica* i.e., 17.75 (Fig 5). The high MD value of *Leconora tropica* in plot III indicates that the plot bears

mostly dry and exposed rocks. The study of Agarwal, 1988 also reveals that on dry, exposed rocks, saxicolous lichen species like *Acarospora*, *Calaplaca*, *Leconora* etc. grow luxuriantly.

The present investigation recorded the highest mean sum of frequencies of muscicolous lichens for plot II i.e., 200 (MSFe), 200 (MSFw), 160 (MSFn) and 100 (MSFs) compared to other two plots (Fig 6). Plot II is highly dominated with *Ailanthus altissima*, the bark of which retains good amount of moisture. Moisture supports the growth of moss in turn influencing the growth of muscicolous lichens. Mean sum of frequencies for muscicolous lichens on west and south sides in plot I were found to be 0 indicating high light intensity on that sides which prevents the growth of moss thereby effecting the growth of muscicolous lichens on these sides. Stalfelt [25], has also reported in his studies that high light intensity has detrimental effect on forest moss.

In the present study, among the rockmoss lichens the highest MD value was recorded by *Candelaria conclor* in plot I (12.33), *Dermatocarpon vellerum* in plot II (16.25) and *Leconora tropica* in Plot III (7.75), (Fig 7). The highest MD value of *Candelaria conclor* on plot I indicates that the plot contains more of those rocks which face adequate light. This can be related to the studies of [26] that higher and more lightened walls are inhibited by lichens; *Pyxine cocoes, P. petricola and Candelaria conclor*. The highest MD value of *Dermatocarpon vellerum* in plot II indicates good amount of moisture in the moss bearing rocks which in turn favours the growth of *Dermatocarpon vellerum.* Harada [27], has also reported in his studies that many *Dermatocarpon* species are typical elements of lichen communities on either seeping rocks, or in streams and on lake margins. The high MD value of *Leconora tropica* in plot III indicates that the plot bears mostly dry rocks. The study of Agarwal [28] also reveals that on dry, exposed rocks, saxicolous lichen species like *Acarospora*, *Calaplaca*, *Leconora* etc. grow luxuriantly.

Among the epiphytic, lignicolous and treemoss lichens of the three plots, the present investigation recorded the highest mean LDV for epiphytic lichens (891) followed by lignicolous lichens (730) and treemoss lichens (487) (Table 2). The highest mean LDV value for epiphytic lichens simply reveals the abundance of trees in the site compared to the dead wood and moss as substrate for lichens. However, In spite of having abundance of trees in the site, mean LDV of treemoss lichens was recorded lower than lignicolous lichens as the moss on the trees was limited and confined, limiting in turn the diversity and distribution treemoss lichens.

It was recorded in the present study that *Candelaria conclor* had the highest MD value of 8.60 among saxicolous lichens as well among the rockmoss lichens (8.77), (Table 3). This indicates that the site bears dry and exposed rocks more, favoring the growth of *Candelaria conclor*. This can be related to the studies of Singh and Dhawan [26] that higher and more lightened walls are inhibited by lichens; *Pyxine cocoes, P. petricola and Candelaria conclor*. Further, the study recorded saxicolous lichens as the dominating over the rockmoss lichens. This indicates the site bears more exposed rocks that face adequate light than those containing moss, which is also supported by the studies of Singh and Dhawan [26].

5. Conclusion

A good diversity of lichens was present on the Shankaracharya hill growing on different substrates dominated by corticolous/ epiphytic lichens which is supported by floristic diversity of trees on the hill, including *Ailanthus altissima*, Populas tremula, *Morus alba*, *Acacia nilotica*, many species of pinus, etc. Here, the lichens are also growing on dead wood (lignicolous), rocks (saxicolous) and moss (muscicolous).In addition to the floristic diversity and other substrata present on the hill, lichen growth is also influenced by sulpher emissions from tourist vehicles as the site is a famous tourist spot for Shankeracharya shrine, located at the top of the hill.

Acknowledgement

We would like to acknowledge P.G. Department of Environmental Sciences, S.P. College Campus, Cluster University, Srinagar Kashmir for providing the opportunity of this work and support to complete the project.

References

[1] Nayaka, S., 2005. "Studying lichens (lichen collection, preservation and identification method For beginners). Western ghats biodiversity information system." Available: http://wgbis.ces.iisc.ernet.in/biodiversity/bio-iden/lichens.htm

[2] Kumar, J., Rai, H., Khare, R., Upreti, D. K., Dhar, P., Tayade, A. B., Chaurasia, O. P., and Srivastava, R. B., 2014. "Elevational controls of lichen communities in Zanskar valley, Ladakh, a Trans Himalayan cold desert." *Tropical Plant Research*, vol. 1, pp. 48–54.

[3] Søchting, U., 2015. *Lichens in miehe g, pendry c (eds) nepal: An introduction to the natural history, ecology and human environment of the himalayas*. Edinburgh: Royal Botanic Garden Edinburgh. p. 191.

[4] Negi, H. and Upreti, D. K., 2000. "Species diversity and relative abundance of lichens in Rumbak catchment of Hemis National Park in Ladakh." *Curr. Sci.*, vol. 78, pp. 1105-1112.

[5] Gaurav, K. M. and Upreti, D. K., 2016. "Diversity and distribution of macro-lichen in Kumaun Himalaya, Uttarakhand." *Int. J. Adv. Res.*, vol. 4, pp. 912 - 925.

[6] Uppadhyay, V., Ingle, K. K., Trivedi, S., and Upreti, D. K., 2016. "Diversity and distribution of lichens from monuments of Gwalior division, Madya Pradesh with special reference to the rock porosity and lichen growth." *Tropical Plant Research*, vol. 3, pp. 384-389.

[7] McMullin, R. T. and Wiersma, Y. F., 2019. "Out with OLD growth, in with ecological contiNEWity: new perspectives on forest conservation." *Frontiers in Ecology and the Environment*, Available: http://doi:10.1002/fee.2016.

[8] Debnath, R., Khare, R., Gogoi, L., Upreti, D. K., and Rout, J., 2018. "New additions of the macrolichens to the lichen flora of Arunachal Pradesh, India in easter himalayas." *Studies in Fungi*, vol. 3, pp. 100-114.

[9] Girdhar, C., Rai, I., Talukdar, G., and Rawat, G., 2018. "Monitoring lichens as climate change Indicators in Indian Himalayan region (IRH)." Available: Doi:10.13140/RG.2.2.25055.97445

[10] Chapman, A., 2009. *Numbers of living species in Australia and the world*. Australian Biological Resources Study (ABRS).

[11] Rajan, V. P., Gunasekaran, S., Ramanathan, S., Murugaiyah, V., Samsudin, M., and Din, L., 2016. "Biological activities of 4 Parmotrema species of Malaysian origin and their chemical constituents." *J. Appl. Pharmaceut Sci.*, vol. 6, pp. 36-43.

[12] Priyadarshini, 2006. *Ecological and taxonomic studiesof lichens of Kalidhar forest range*. Jammu, : MPhil.diss.University of Jammu (J and K).

[13] Sheikh, M. A., Upreti, D. K., and Raina, A. K., 2006. "Lichen diversity in Jammu and Kashmir, India." *Geophytology*, vol. 36, pp. 4-14.

[14] Haq, M., Reshi, Z. A., Nayaka, S., and Sheikh, M. A., 2013. "New additions to the lichen biota of Jammu and Kashmir, India." *Phytotaxonomy*, vol. 13, pp. 84-87.

[15] Silva, D. and Senanayake, S. P., 2015. "Assessment of epiphytic lichen diversity in pine plantations and adjacent secondary forest in Peacock Hill, Pussellawa, Sri Lanka." *International Journal of Modern Botany*, vol. 5, pp. 29-37.

[16] Asta, J., Erhardt, W., Ferretti, M., Fornasier, F., Kirschbaum, U., Nimis, P. L., Purvis, O. W., Pirintsos, S., Scheidegger, C., *et al.*, 2002a. *European guideline for mapping lichen diversity as an indicator of environmental stress*. London, England: British Lichen Society.

[17] Asta, J., Erhardt, W., Ferretti, M., Fornasier, F., Kirschbaum, U., Nimis, P. L., Purvis, O. W., Pirintsos, S., Scheidegger, C., *et al.*, 2002b. "Mapping lichen diversity as an indicator of environmental quality." In *Monitoring with lichens –monitoring lichens (eds. P.L. Nimis, C. Scheidegger and P.A. Wolseley). NATO Science Series, IV, Kluwer Academic Publishers, Dordrecht, Netherlands.* pp. 273-279.

[18] Misra, R., 1968. *Ecology work book*. Calcutta: Oxford and TBH, Publishing co. p. 244.

[19] Awasthi, D. D., 1988. "A key to macro lichens of India and Nepal." *Journ Hattori Bot Lab*, vol. 65, pp. 207-302.

[20] Awasthi, D. D., 1991. *A key to micro lichens of India* vol. 40. Nepal and Sri Lanka: Biblioth Lichenol. pp. 1-336.

[21] Singh, Arya, M., and Vishwakarma, S. K., 2019. "Advancements in methods used for identification of lichens." *International Journal of Current Microbiology and Applied Sciences*, vol. 8, pp. 1450 – 1460.

[22] Gauslaa, Y., Palmqvist, K., Solhaug, K. A., Hilmo, O., Holien, H., Nybakken, L., and Ohlson, M., 2009. "Sizedependent growth in two old-growth associated macrolichen species." *New Phytologist*, vol. 18, pp. 683–692.

[23] Armstrong, R. A., 2015. *The influence of environmental factors on the growth of lichens in the field*. Recent advances in Lichenology, pp. 1-18

[24] Akhkha, A., 2009. "The effect of water stress on photosynthesis, respiration and relative chlorophyll of the desert plant calotropis procera." *Biosciences, Biotechnology Research Asia*, vol. 6, pp. 653– 658.

[25] Stalfelt, M. G., 1937. "Der gasaustausch des moose. Planta 27:30 – 60.Singh a, s dhawan 1991 interesting observation on stone weathering of an indian monument by lichens." *Geophytology*, vol. 21, pp. 119-123.

[26] Singh and Dhawan, S., 1991. "Interesting observation on stone weathering of an Indian monument by lichens." *Geophytology*, vol. 21, pp. 119-123.

[27] Harada, H., 1993. "A taxonomical study on Dermatocarpon and its allied genera (Lichens, Verrucariaceae)." *Natural History Research*, vol. 2, pp. 113-152.

[28] Agarwal, S. K., 1998. *perspectives in environment*. APH Publishing.