ISSN (Online): 2349-1183; ISSN (Print): 2349-9265
TROPICAL PLANT RESEARCH
The Journal of the Society for Tropical Plant Research
9(3): 133–138, 2022
DOI: 10.22271/tpr.2022.v9.i3.019

Research article

Lichen - rock interaction in a temperate environment: A case study from a Panzipora area, Kashmir, India

Asma Hussan Wani[1,2], Mukhtar Shiekh[3] and C. P. Kushwaha[1]*

[1]School of Applied Sciences, Shri Venkateshwara University, Amroha-244236, Uttar Pradesh, India
[2]Department of Environmental Studies, Amar Singh College, Gogjibagh, Srinagar-190008, Jammu and Kashmir, India
[3]Govt. Boys Higher Secondary, Khrew, Pulwama-191103, Jammu and Kashmir, India

*Corresponding Author: kushwahacp@gmail.com [Accepted: 30 November 2022]

Abstract: The diversity of Saxicolous lichens with their rock strata has been investigated in the rural area of Kashmir to enrich the lichen inventory in the region. The study also focuses on the quantification of the regional distribution of lichens. A total of 32 lichens belonging to 10 families and 15 genera, with each species having an average 60–70% of consistency, were found occurring on the sedimentary rocks. The diversity and relationship of particular lichen groups (e.g. *Nitrophytic*, *Acidophytic*, *Neutrophytic*) with growth forms (e.g. crustose, foliose, fructicose) and substratum, and with environmental variables in the habitat suggest that Lichens can act as an indicator of environmental quality in the given area. The significant variability in the spatiotemporal patterns of lichen diversity and growth indicates the crucial role of microhabitat conditions and associated micro-environmental conditions, which in turn drive the biodiversity of saxicolous lichens in the region.
Keywords: Lichens - Saxicolous - Panzipora - Kashmir.

[Cite as: Wani AH, Shiekh M & Kushwaha CP (2022) Lichen - rock interaction in a temperate environment: A case study from a Panzipora area, Kashmir, India. *Tropical Plant Research* 9(3): 133–138]

INTRODUCTION

The collaborative association between taxonomically and physiologically diverse forms of fungi, algae and/or cyanobacteria (Hawksworth *et al.* 1995, Nash 1996) results in Eco physiologically resourceful reorganization, stemming into the emergence of pioneering and innovative Lichen. Such association is adaptable to extreme climatic conditions in which this symbiotic bonding seems to protect the partners. This particular tying seems to have evolved in response to diversified microhabitats with heterogeneous microclimatic conditions which appear unfavourable to fungi and algae in isolation. This symbiosis seems to have evolved around 400–600 million years (Yuan *et al*. 2005). Devoid of roots and cuticle, lichens meet their nutrient, mineral and water requirements from the air and expertly extract nutrients (P, Mg, Ca, K, Su and Fe) from recalcitrant surfaces (Richardson 1975). A wise selection of photobiont, the water holding structures, and ability to stand osmotic stress are few survival strategies (Rundel 1988, Richardson 2002). This perhaps helps them to get well adjusted to intense light, extreme desiccation and harsh conditions. Apart from this, such adaptations also help them in the changing environmental scenarios in which normal life forms are almost absent, which are unsuitable normally for life forms. Apart from addition to overall biodiversity, lichens also play various important roles in all types of ecosystems (Wani & Rahim 2020).

Although versatile kinds of reversionary works on Indian lichens and henceforth Jammu & Kashmir (J&K) already stand established there, but ecological studies are yet ignored to a greater or lesser extent. J&K, despite being called as hotspot of lichen diversity, bears diverse kinds of species, yet very little information is available from rural areas. In spite of having several lichen inventories for a few sites of Kashmir, no documentation of Saxicolous lichen has been done till date and hence published, accordingly, the present investigation has been carried out predominantly on rock strata of area (preferably sedimentary ones) to document the diversity of Saxicolous lichen.

Received: 05 July 2022
Published: 31 December 2022
https://doi.org/10.22271/tpr.2022.v9.i3.019

MATERIALS AND METHODS

Study area

The present investigation has been carried out around the Panzipora which is a quite remote village and hidden from the common eye. The hamlet lies on enroute to Arizal. This area is mostly agricultural having a good frequency of orchards (Fig. 1). The survey site had *Malus domestica* Borkh. and *Juglens* sps. plantation and seemed free from any direct polluting source. Thus the stimulus behind the survey in this particular area was our attempt to contribute to lichen inventory, especially from rural areas. Also, the ecology and diversity of lichens would provide us with an idea about the status of the local environment in the area.

Figure 1. Satellite imagery showing study site - Panzipora.

Material and methods

Lichens growing on Sedimentary rocks were collected with the help of hammer, chisel and knife. Foliose lichens which are often lightly allied on to the rock surface need to be separated precisely and collected using a knife while taking care of all the attachments (rhizines) to stay intact with thallus body. During the lichen collection, the details of locality and substratum have also been recorded. While still at their natural place of occurrence (*i.e.* rocks) records have been maintained in form of pictures. The literary work of Awasthi (1988, 1991 & 2000), Upreti (1988), Divakar (2001) and Nayaka (2004) was consulted for identification of collected lichen specimens. The morphology of the Lichen taxa has been studied under a stereo-zoom binocular microscope. Anatomical details of the thallus and fruiting bodies have been studied in free-hand sections with water as a mounting medium under a compound microscope. Usage of certain reagents like calcium hypochlorite (C) (Aqueous), potassium hydroxide (Aqueous) and Steiner's para phenylenediamine was frequently employed to carry out colour spot tests. Thin Layer Chromatography has been performed for authentic identification of the lichen substances in solvent system A (Toluene, 180 ml: 1-4 Dioxane, 60 ml: Acetic acid, 8 ml) following Walker & James (1980).

RESULTS AND DISCUSSION

All the rocks were juxtaposed with lichens with seldom any uncolonised rock in between. Sedimentary rocks appear to be deeply colonized by Lichens. The luxuriant growth imparted rocks orange, grayish, greenish and brownish colour variations. There are some significant factors among the rocks responsible for selection by multi-substrate species as almost 32 different species occurred on same boulder type (Table 1). *Xanthoria parietina* (L.) Th. Fr has ability to fix with rock substratum by adherence of a single cell wall from the lower cortex (Egipsy *et al*. 2002) Some of the species found here are typically seen on acid substrates although presence of *Lecanora campestris* (Schaer.) Hue, *Caloplaca*, *Physcia* sps. and *Xanthoria parietina* indicate nutrient enrichment probably derived from bird excrement (probably rich in N_2, P and Ca), road dust, biomass burning and use of nitrogenous fertilizers (area is predominantly under horticulture use with abundance of *Malus* and *Juglens* sps) (Egipsy *et al*. 2002).

Table 1. Various Saxicolous Lichens and their growth forms collected from Panzipora area.

S.N.	Species Name	Family	Growth form	Substratum
1	*Aspicilia alphoplaca* (Wahlenb. in Ach.) Poelt & Leuck.	Megasporaceae	Foliose	Saxicolous
2	*Aspicilia calcarea* (L.) Sommerf	Megasporaceae	Crustose	Saxicolous
3	*Aspicillia contorta* (Hoffm.) Krempelh	Megasporaceae	Crustose	Saxicolous
4	*Caloplaca saxicola* (Hoffm.) Norden	Teloschistaceae	Crustose	Saxicolous
5	*Caloplaca* sp.	Teloschistaceae	Crustose	Saxicolous
6	*Candelariella aurella* (Hoffm.) Zahlbr	Candelariaceae	Crustose	Saxicolous
7	*Dermatocarpon miniatom* (L.) W. Mann.	Verrucariaceae	Foliose	Saxicolous
8	*Dermatocarpon vellereum* Zschacke	Verrucariaceae	Foliose	Saxicolous
9	*Diploschistes* sp.	Thelotremataceae	Crustose	Saxicolous
10	*Hypogymnia physodes* (L.) Nyl	Parmeliaceae	Foliose	Saxicolous
11	*Lecanora campestris* (Schaer.) Hue	Lecanoraceae	Crustose	Saxicolous
12	*Lecanora frustulosa* (Dieks.) Ach.	Lecanoraceae	Crustose	Saxicolous
13	*Lecanora garovaglii* (Körb.) Zahlbr.	Lecanoraceae	Crustose	Saxicolous
14	*Lecanora indica* Zahlbr	Lecanoraceae	Crustose	Saxicolous
15	*Lecanora muralis* (Schreb.) Rabenh	Lecanoraceae	Crustose	Saxicolous
16	*Lecanora muralis* var. *muralis* (Schreb.) Rabenh. em. Poelt	Lecanoraceae	Crustose	Saxicolous
17	*Melanelia disjuncta* (Erichsen) Essl	Parmeliaceae	Foliose	Saxicolous
18	*Phylliscum indicum* Upreti	Lichinaceae	Crustose	Saxicolous
19	*Physcia* sp. 1	Physciaceae	Foliose	Saxicolous
20	*Physcia* sp. 2	Physciaceae	Foliose	Saxicolous
21	*Physconia distorta* (With.) Laundon	Physciaceae	Foliose	Saxicolous
22	Physconia sp.	Physciaceae	Foliose	Saxicolous
23	*Porpidia macrocarpa* (DC.) Hertel & Knoph in Hertel	Porpidiaceae	Crustose	Saxicolous
24	*Rhizoplaca chrysolenca* (Sm.) Zopf.	Lecanoraceae	Foliose	Saxicolous
25	*Xanthoparmelia conspersa* (Ach.) Hale	Parmeliaceae	Foliose	Saxicolous
26	*Xanthoparmelia mexicana* (Gyeln.) Hale	Parmeliaceae	Foliose	Saxicolous
27	*Xanthoparmelia tinctina* (Maheu & Gillet) Hale	Parmeliaceae	Foliose	Saxicolous
28	*Xanthoria elegans* (Link) Th. Fr	Teloschistaceae	Foliose	Saxicolous
29	*Xanthoria fulva* (Hoffm.) Poelt & Petutschnig	Teloschistaceae	Foliose	Saxicolous, Corticolous
30	*Xanthoria parietina* (L.) Th. Fr.	Teloschistaceae	Foliose	Corticolous
31	*Xanthoria* sp. 1	Teloschistaceae	Foliose	Saxicolous
32	*Xanthoria* sp. 2	Teloschistaceae	Foliose	Saxicolous

The Saxicolous lichen species seem to be affected by an increase in shading and litter accumulation from surrounding vegetation. Saxicolous lichens, comprising of 32 species, seem to have successfully established on bare rocks with each species having a consistency of 60–70% and even more. Noticeable is that fraction of crustose and foliose types is almost equal (46% and 54%, respectively). The mean area of thallus of most frequent species reaches several cms. Nitrophilous species like *Xanthoria elegans* (Link) Th. Fr and *Caloplaca* sp. colonization covered 50–80% of rock surfaces. In future, the covered rock surface may rapidly exceed further. On observation we realized certain species as *Lecanora garovaglii* (Körb.) Zahlbr., *Xanthoparmelia conspersa* (Ach.) Hale, *Physconia distorta* (With.) Laundon, etc. displaying large thalli size which might point towards the young age of species (Fig. 2). These species seemed to grow nicely in this area, with frequent water flow and in exposed habitats. Another thing that we could comprehend is that summer temperature appeared to be one of the factor favoring Lichen establishment even in areas having much anthropogenic pressures (as is evident here). High relative humidity (60-70%) enables stable moisture content which seems to provide enough water and minerals for lichen establishment. Fine-scale studies pointed out the importance of altitude, slope, exposure, nutrient enrichment by birds, geochemical rock composition, snow cover and surface microtopography, especially in the case of saxicolous lichens (Bjelland 2009). The water and nutrient budget are being overblown by topographical variables at any place (Horsch 2003) and acts as a boon for lichens. Concerning height and direction of the substratum no gradient or preference has been observed.

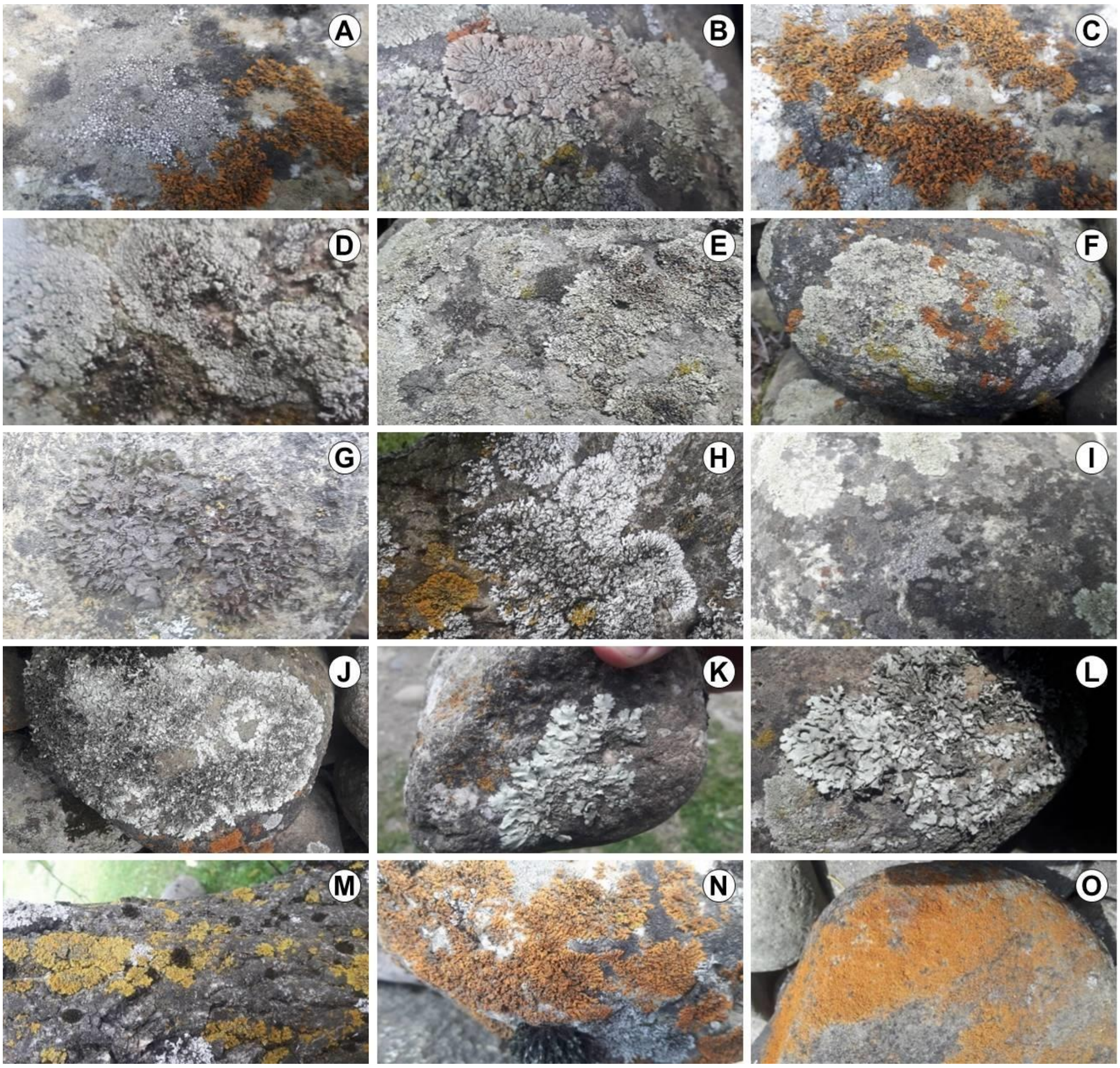

Figure 2. Predominant Saxicolous Lichens in the Panzipora area of Kashmir: **A**, *Aspicillia contorta (Hoffm.) Krempelh*; **B**, *Aspicilia alphoplaca* (Wahlenb. in Ach.) Poelt & Leuck; **C**, *Caloplaca saxicola* (Hoffm.) Norden; **D**, *Lecanora campestris* (Schaer.) Hue; **E**, *Lecanora garovaglii* (Körb.) Zahlbr; **F**, *Lecanora muralis* (Schreb.) Rabenh; **G**, *Melanelia disjuncta* (Erichsen) Essl.; (Egipsy,V.S. et al. 2002, *Physconia distorta* (With.) Laundon; **I**, *Porpidia macrocarpa* (DC.) Hertel & Knoph in Hertel; **J**, *Xanthoparmelia conspersa* (Ach.) Hale; **K**, *Xanthoparmelia mexicana* (Gyeln.) Hale; **L**, *Xanthoparmelia tinctina* (Maheu & Gillet) Hale; **M**, *Xanthoria elegans* (Link) Th; **N**, *Xanthoria parietina* (L.) Th. Fr.; **O**, *Xanthoria* sp. 1.

Generally, Crustose forms show wider tolerance to environmental conditions including the extremities. However, in the present investigation, predominance of Foliose forms have been recorded. Such mushrooming of particular growth form may be attributed to high Nitrogen supplements available in the air, which can also give insight for air quality of site. The complete prevalence of Nitrophilous groups and foliose growth forms can befit in understanding the environmental quality of a given area.

Eutrophication erupting out of elevated Nitrogen enrichment conditions seems to affect Lichen diversity negatively by causing the emergence and dissemination of a particular lichen group and the related growth forms. Nitrogen stress can decelerate the growth of Acidophiles and associated lichens growth forms. Increased Nitrogen concentrations have been reported to reduce the Chlorophyll A content and ergosterol in non-nitrophilous Lichens (Gaio-Oliveira *et al.* 2004) through its direct effect on integrity of fungal cell membrane apart from affecting the symbiotic balance of Lichen thalli (Wang *et al.* 2019).

The structure and functioning of Lichens showed a strong correlation with both micro- and macro-climatic variables of the regions. Lichens have also been reported to modify the immediate environmental conditions (Barnier *et al.* 2011, Porada *et al.* 2016).

CONCLUSIONS

Lichen diversity and extent of colonization provide an insight of prevailing environmental conditions and also help in the robust interpretation of environmental quality. Based on lichen diversity, the area under observation could be quantified into air quality zones which can prove of great help in depicting state of health and hence quality of the environment in the given ecological region. Various factors such as air pollutants, site management, availability and specificity of substrate, favorable climatic conditions, anthropogenic activities (i.e. disturbances, cutting and trimming of strands, biomass burning) play considerable role in the determination of Lichen diversity resulting into high or low diversity counts. The low lichens presence indicates the risk area. There is urgent need for the increased awareness and knowledge to tap huge beneficial potential of lichens.

ACKNOWLEDGEMENTS

I would like to acknowledge my thanks to Principal, Amar Singh College, for providing me necessary lab facilities to carry out my research. Afterwards I am immensely thankful to my mentors, My Mother and Husband Mr. Ashiq Hussain Shah whose encouragement, willpower and immense trust on my abilities, helps me to cope up with all the challenges during my research period and would reinvigorate my enthusiasm and raise my spirits whenever I felt like giving up.

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