Lichen colonization on nylon net houses in Surya-kunj Nature Interpretation site, Kosi-Katarmal, Almora, Uttarakhand

The Surya-kunj Nature Interpretation and Learning Centre (NILC) of G.B. Pant Institute of Himalayan Environment and Development (GBPIHED), Kosi-Katarmal, Almora, Uttarakhand, represents an *ex situ* conservation site for representative Himalayan flora. The site is spread over an area of about 27 ha, and ranges between 1100 and 1250 m elevation. Over the last 25 years or so, Surya-kunj has come up as an excellent site showcasing the potential of *ex situ* mechanisms for: (i) conservation of floristic diversity, (ii) restoration of degraded hill slopes and (iii) availability of new habitats that have helped in natural establishment of various floral and faunal groups. Among the non-flowering plants colonization of lichens (such as *Bacidia* De Not., *Buellia* De Not., *Candelaria* A. Massal., *Caloplaca* Th. Fr., *Canoparmelia* Elix & Hale, *Chrysothrix* Mont., *Cladonia* P. Browne, *Dirinaria* (Tuck.) Clem., *Graphis* Adans., *Heterodermia* Trevis., *Hyperphyscia* Müll. Arg., *Lecanora* Ach., *Lepraria* Ach., *Parmotrema* A. Massal., *Phaeophyscia* Moberg, *Punctelia* Krog, *Pyxine* Fr., *Ramalina* Ach., *Usnea* Dill. ex Adans. and *Xanthoparmelia* (Vain.) Hale) on various trees in different sites of Surya-kunj have been the subject of study.

Besides the natural habitats, the Surya-kunj NILC uses glasshouses, net houses and the nylon shade net houses for acclimatization and hardening of tissue culture and seed-raised juvenile plants of rare, endangered and threatened (RET) species, especially the endemic medicinal plants. Some of these nylon net houses in Surya-kunj are nearly 12 years old. Interestingly, such old net houses have proved to be a suitable substrate for lichens to colonize. The luxuriant growth of lichens which formed a colourful mosaic on the nylon net (Figure 1) attracted the present authors to study their diversity and uniqueness in comparison to lichens on natural substrates in neighbouring sites.

Lichens are ubiquitous in nature and have a wide habitat preference ranging from stone, soil, bark, leaves, twigs and man-made materials such as concrete, mortar, bricks, tarmac, glass, metals and even plastics. Lichens that prefer plastic as a habitat are referred to as plasticolous. In general, across the globe plasticolous lichens have not been worked out well and so far only few publications are available on them[1–5]. Recently, the utility of plastic cover slips as a substratum for *in situ* study of lichen developmental stages has been established with respect to a neotropical foliicolous lichen community and European temperate corticolous community[6]. Further, this technique has proven to be quite useful regarding foliicolous lichens as these lichens are adapted to grow on the leaf surface and readily colonize smooth artificial substrata such as plastic[1,2,6,7].

The present study forms a part of ongoing inventorization of lichen diversity in Surya-kunj area that follows standard methods and approaches. The lichen specimens were collected in August 2013 and 23 January 2014 from the 12-year-old nylon nets (net house) in Surya-kunj NILC. The collected specimens were processed and deposited in the herbarium of Kumaun University (ALM), Uttarakhand. Morphological characters of thallus, reproductive structures, colour, size and shape were examined under stereo-zoom dissecting microscope (SZM-2LED OPTIKA). Thin hand-cut sections were made for studying the anatomy of

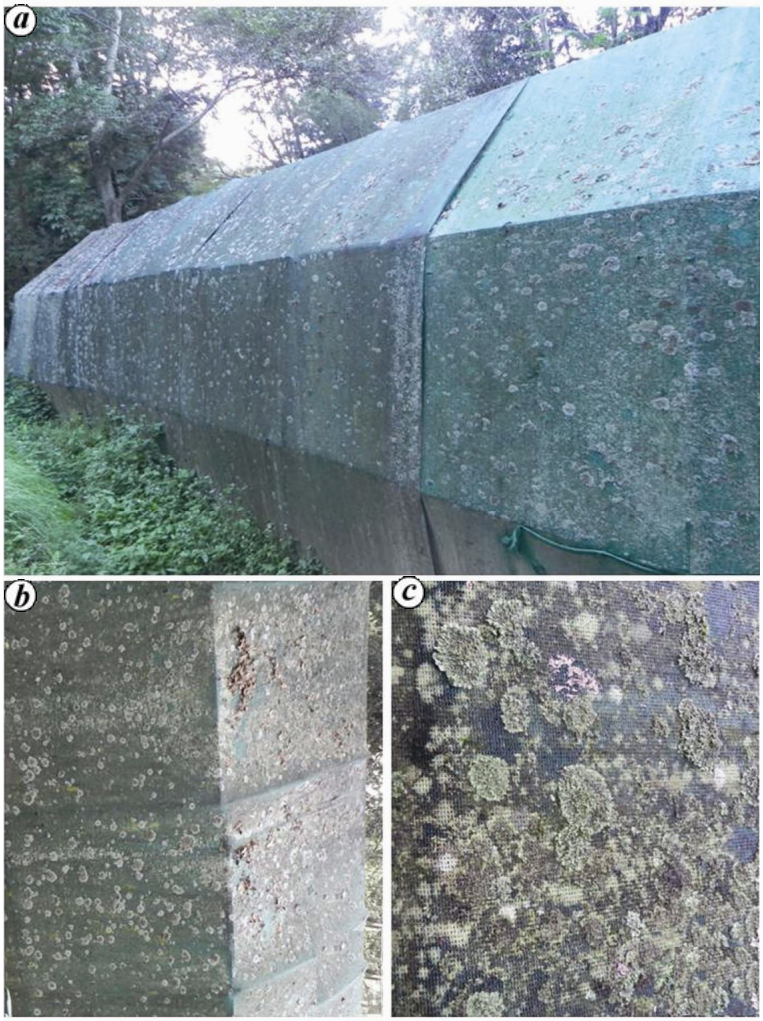

Figure 1 ***a–c.*** Lichen colonies on nylon net house at Surya-kunj Nature Interpretation and Learning Centre, GBPIHED, Almora.

Table 1. Lichenized fungi colonizing nylon net in GBPIHED, Almora

Lichen taxa	Family	Habitat			
		S	C	T	M
Anisomeridium sp.	Monoblastiaceae	?	?	?	?
Bacidia sp.	Ramalinaceae	?	?	?	?
Caloplaca sp.	Teloschistaceae	?	?	?	?
Caloplaca flavovirescens (Wulfen) Dalla Torre & Sarnth.	Teloschistaceae	+	–	–	–
Caloplaca subsoluta (Nyl.) Zahlbr.	Teloschistaceae	+	–	–	–
Candelaria concolor (Dicks.) Stein.	Candelariaceae	+	+	–	–
Canoparmelia crozalsiana (de Lesd.) Elix & Hale	Parmeliaceae	+	+	–	–
Collema leptaleum var. *biliosum* (Mont.) Degel.	Collemataceae	–	+	–	–
Collema pulcellum var. *subnigrescens* (Müll. Arg.) Degel.	Collemataceae	+	+	–	–
Heterodermia comosa (Eschw.) Follmann & Redón	Physciaceae	–	+	–	–
Heterodermia firmula (Nyl.) Trevis.	Physciaceae	+	+	+	–
Heterodermia japonica (M. Satô) Swinscow & Krog	Physciaceae	+	+	+	–
Heterodermia obscurata (Nyl.) Trevis.	Physciaceae	+	+	+	–
Heterodermia pseudospeciosa (Kurok.) W.L. Culb.	Physciaceae	+	+	+	–
Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt	Physciaceae	+	+	–	–
Lecanora sp. 1	Lecanoraceae	?	?	?	?
Lecanora sp. 2	Lecanoraceae	?	?	?	?
Lepraria sp.	Stereocaulaceae	?	?	?	?
Myelochroa aurulenta (Tuck.) Elix & Hale	Parmeliaceae	+	+	–	–
Parmotrema austrosinense (Zahlbr.) Hale	Parmeliaceae	+	+	–	–
Parmotrema crinitum (Ach.) M. Choisy	Parmeliaceae	–	+	+	–
Parmotrema reticulatum (Taylor) M. Choisy	Parmeliaceae	+	+	+	–
Phaeophyscia hispidula (Ach.) Moberg	Physciaceae	+	+	+	+
Phyllopsora sp.	Ramalinaceae	?	?	?	?
Physcia dilatata Nyl.	Physciaceae	+	+	–	–
Punctelia borreri (Sm.) Krog	Parmeliaceae	+	+	–	–
Punctelia rudecta (Ach.) Krog	Parmeliaceae	+	+	–	–
Punctelia subrudecta (Zahlbr.) Hale	Parmeliaceae	+	+	–	–
Ramalina conduplicans Vain.	Ramalinaceae	+	+	–	–
Xanthoparmelia mexicana (Gyeln.) Hale	Parmeliaceae	+	+	–	–

S, Saxicolous; C, Corticolous; T, Terricolous; M, Muscicolous.

thalli and fruiting bodies and examined under compound microscope (B-150DB OPTIKA). Colour spot test reactions were carried out on thalli and reproductive bodies using routine reagents K, C and Pd. Thin layer chromatography (TLC) was performed as described by Orange *et al.*[8]. The identification of lichens was based on the published literature[9–11].

A total of 30 lichen species were found colonizing both sides of the net house facing the east and west directions, except *Caloplaca* sp. 1, *Caloplaca flavovirescens*, *Caloplaca subsoluta*, *Collema leptaleum* var. *biliosum*, *Collema pulcellum* var. *subnigrescens* and *Ramalina conduplicans*, which were found growing in the westward direction only (Table 1). The dominance of Physciaceae members along with Teloschistacean taxa on the net indicates heavy atmospheric pollution which the site is facing, as it is located on the Almora–Ranikhet motor road. Also, the presence of few patches of cyanolichens on the nylon net indicates moist environmental condition of that place.

Earlier, occurrence of three lichen species [*Hyperphyscia adglutinata* (Flörke) H. Mayrhofer & Poelt, *Parmotrema austrosinense* (Zahlbr.) Hale and *Punctelia subrudecta* (Zahlbr.) Hale] on a plastic net house in a similar locality (different shade house) has been reported[5]. Therefore, of the 30 species recorded presently, 3 were common with the previous records (*H. adglutinata*, *P. austrosinense* and *P. subrudecta*).

In another study, species like *Heterodermia firmula* and *Phaeophyscia hispidula* belonging to the family Physciaceae, have been reported to colonize plastic nets in Nepal Himalaya[3]. While analysing available reports on plasticolous lichens, it was noticed that some of the species have never been seen before inhabiting plastic net houses or any substratum made of plastic. In the present study, a total of 22 lichen species, i.e. *Caloplaca* sp. 1, *Caloplaca flavovirescens*, *Caloplaca subsoluta*, *Candelaria concolor*, *Canoparmelia crozalsiana*, *Collema leptaleum* var. *biliosum*, *Collema pulcellum* var. *subnigrescens*, *Heterodermia comosa*, *Heterodermia japonica*, *Heterodermia obscurata*, *Heterodermia pseudospeciosa*, *Lecanora* sp. 1 and 2, *Lepraria* sp., *Myelochroa aurulenta*, *Parmotrema crinitum*, *Parmotrema reticulatum*, *Physcia dilatata*, *Puncteila borreri*, *Puncteila rudecta*, *Ramalina conduplicans* and *Xanthoparmelia mexicana* were found colonizing plastic. Besides, the plasticolous habitat of these species in India contrasts with the predominantly described habitat for all these species across the globe – an ecological difference which needs special attention.

The appearance of fertile stages of foliose and fruticose lichens on the nylon net indicates that this substratum is suitable for complete development of the thallus. Production of mature ascocarps

by several species is consistent with the results obtained in colonization experiments with opaque plastic leaves surveyed after 24 months exposure within a Costa Rican rainforest[2,12] and 21 months exposure within a neotropical foliicolous lichen community and in an European temperate corticolous community[6]. This could, in general, be attributed to the loose texture, along with damp and moist microclimate, of these nets which provides a favourable substratum for lichens to colonize[1,3,13,14].

This characteristic of lichens to grow on an artificial substratum exhibits their ability to thrive against the destruction of natural habitats by colonizing on alternative substrates, especially of anthropogenic origin[1]. The present study, which exhibits diversity and luxuriant growth of lichens on nylon nets, beyond their natural substrate, further corroborates this statement. In case these old nets remain undisturbed, there is every possibility that other lichen species, growing in the vicinity of the net house, viz. *Buellia*, *Chrysothrix*, *Cladonia*, *Graphis* and *Usnea*, may also find an opportunity to colonize these nylon nets in the near future. Besides, such artificial substratum may prove effective in studying non-foliicolous lichen ontogeny in certain well-chosen habitats, as there have been numerous reports of crustose and foliose lichens colonizing synthetic substrata, including rubber, plastic and painted metal, often on vertical surfaces, in temperate environments[3,15–18].

Considering the above, it would be interesting to monitor the future colonization/succession pattern of lichens on these nylon nets. The use of this type of material will also permit observation of developmental stages, a variety of reproductive strategies operating within the lichen community, and fungal–algal interactions directly under light microscopy[6,19–21]. In this context, we recommend that these shade houses, especially the existing shade nets, should be maintained without causing any damage to them. Long-term studies need to be commissioned to monitor the temporal changes in diversity and abundance of lichens. This study further highlights the importance of such artificial substratum towards promoting lichen diversity and its conservation. In particular, the research and educational institutions may consider using this substratum for effective learning of selected lichen species.

The present study also recommends that the macro- and micro-lichens key must be updated, since at certain places the species have been differentiated just based on their substratum preference, which has resulted in a dilemma whether to treat these plasticolous lichens as saxicolous or corticolous. For instance, *Caloplaca* sp. encountered in the present study may be either *C. bassiae* (Willd. ex Ach.) Zahlbr. or *C. subbassiae* Y. Joshi & Upreti – the most prominent difference between these two species is their habitat preference. The former is corticolous, while the latter is saxicolous; hence where to place this plasticolous specimen needs to be answered. Similar was the case with *Bacidia* and *Lecanora* species. This paper further justifies that lichens have the ability to colonize any sort of substratum; hence, in the upcoming generic keys, special attention needs to be paid to important diagnostic characters rather than habitat for identifying lichens, because any species which is right now growing on a particular substrate may in the near future be able to colonize another substrate.

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YOGESH JOSHI[1,*]
GEETANJALI BHAKUNI[1]
DEEPA BISHT[1]
MANISH TRIPATHI[1]
KAPIL BISHT[1]
SHASHI UPADHYAY[1]
KRISHNA CHANDRA[1]
RANBEER S. RAWAL[2]

[1]*Lichenology Division, Department of Botany, S.S.J. Campus, Kumaun University, Almora 263 601, India*
[2]*G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India*
**For correspondence.*
e-mail: dryogeshcalo@gmail.com