

Need for creation of lichen gardens and sanctuaries in India

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The habitat loss, increasing air pollution, changes in the microclimatic conditions and uncontrolled harvest have become the major detrimental factors for lichen diversity in India. Propagation of lichens by means of tissue culture method proved to be uneconomical and their re-introduction into the field has been unsuccessful. Hence declaring lichen-rich areas as 'lichen sanctuaries', enriching the existing botanical gardens with lichens and creating lichen gardens would be effective methods to conserve them in their natural habitats. Such sanctuaries and gardens would be unique in the world; apart from conservation, they also serve as educational and recreational sites.

The fast pace of urbanization and industrialization in recent years is responsible for a perceptible decline in the vast ranges of forest areas in different parts of the world. The rate of decline in the Indian Himalayas is quite fast compared to that in other areas. The leading factors for the loss of biodiversity in the Himalayan region are the agricultural practices, urbanization, construction of roads and buildings on hills, mineral exploration, hydroelectric projects, and excessive use of firewood. In the last few decades large tracts of forest cover have been depleted in and around the human settlements in the Himalayas.

In India, the lichens are still in use as medicine, spice, dye and incense material. The easily accessible areas of the Himalayas are exhaustively exploited for collection of commonly occurring lichens for commercial exploitation. Information regarding the commercial, ethnobotanical utilization and use of lichens in Ayurvedic and Unani systems of medicine in India is well documented¹⁻⁵. Upreti⁶ has discussed in detail, the different factors responsible for the loss of lichen diversity in India. The disappearance of sensitive lichen species due to changes in microclimatic conditions and air pollution is evident in the recent studies conducted in the cities of Bangalore and Kolkata^{7,8}.

Use of herbal drugs in recent years has created an increasing demand for medicinal herbs. The medicinal plants in the easily accessible areas in nature are being exploited exhaustively. Several local and outside traders are indulging in the indiscriminate collection of these plants, that sometimes no propagules are left in nature for regeneration. Lichens are promising source of several biologically active secondary metabolites with antibiotic, antimycobacterial, antiviral, anti-inflammatory, analgesic, antipyretic, antiproliferative and cytotoxic activities^{9,10}.

However, lichens are slow-growing organisms and take several years to get established in nature. Lichens that use to occur as thick growth on tree trunks in the lower temperate regions, have now become scanty due to uncontrolled harvest. Hundreds of bags of lichens are being exported from different foothill areas of the Himalayas⁵.

A number of areas have been declared as National Parks, Wildlife Sanctuaries and Biosphere Reserves in recent years for the protection of wildlife; however, cryptogams such as lichens are still treated as waste or non-timber forest product. In alpine regions, junipers, rhododendrons and other shrubs which represent a growth of over hundred years are destroyed by the tourists for bonfires and lichens growing on them are also destroyed unknowingly.

Lichen resources in contrast to other natural resources in India are exploited at fast rate and there are no efforts to replenish them. Apart from creating awareness among common people, it is also important to undertake serious conservation measures to improve the lichen resources of the country. *In vitro* culture of lichen symbionts or resynthesis of whole thallus in bulk quantities appears to be an alternative to prevent decline of the lichen population under natural conditions. In recent years, highly efficient methods have been established for the cultivation of isolated symbionts and the lichen tissue itself¹¹⁻¹³. Mycobionts grow faster in *in vitro* culture and have the ability to produce the same secondary metabolites as in composite thallus. Apobiotically and axenically grown mycobionts can replace naturally grown thalli to meet the demand of large quantities of biologically active lichen substances¹⁴. Also, the development of bioreactors for

cultures and genetic manipulation would facilitate large-scale production of lichen metabolites¹⁰. In India several lichens have been successfully *in vitro*-cultured and standardized for their physiological conditions¹⁵⁻²². However, it should be noted that multiplying lichens by means of tissue culture method is uneconomical, time-consuming and has also proved to be unsuccessful in several cases²³. Unlike other plants, success rate of re-introducing cultured lichen thallus into the field is also low. Hence, *in situ* conservation by declaring lichen-rich areas as 'lichen sanctuaries', enriching the existing botanical gardens with lichens and creating lichen gardens would certainly be effective methods to protect lichen populations in their natural habitat.

Enriching botanical gardens with lichens

Arvidson²⁴ has discussed in detail the importance of botanical gardens for lichens in the Asian tropics. In certain areas of the world, botanical gardens are the best place for lichenological studies as they have well-developed lichen flora. The cultivation of the cryptogams, particularly the indigenous ones, are possible in different available habitats of both the tropical and temperate areas. Several factors which favour a diverse lichen vegetation in botanical gardens are the long ecological continuity, variety of habitats, less polluted pockets in the centre of the garden, and presence of rare and endangered plants that provide an opportunity for many lichen taxa to colonize.

Many botanical gardens already function as genetic banks for vascular plants, but in the case of non-vascular plants such functions are not known. For *in situ* conservation of threatened lichens,

transplantation of symbiotic propagules and thallus fragments was found to be a successful approach²⁵. Lichens could be transported to gardens from the nearby areas having similar climate conditions.

Declaration of lichen sanctuaries in India

The botanical gardens cannot possibly save all kinds of lichens. To rescue a rainforest species, one probably needs a rainforest. The natural habitats are, of course, the most suitable and they should be preserved as far as possible²⁴.

Divakar and Upreti²⁶ recommended declaration of some habitats as 'lichen sanctuaries' in India, which includes Amarkantak area, in the Amarkantak–Achanakmar Biosphere Reserve (AABR); Nilgiri and Palni Hills in the Nilgiri Biosphere Reserve; Saryu Valley, Nain Singh Top area en route to Milam Glacier; Chopta–Tunganath Peak in the Nanda Devi Biosphere Reserve and Ropa, Shilt, Dhela, Khanauti, Sangar, Daweridhar and Ukhal areas in the Great Himalayan National Park (GHNP; Figure 1). However, these localities are already protected under different National Parks and Biosphere Reserves.

Being home to some 1200 lichen species, the Himalayan region is a biodiversity hotspot of lichens. The varied geology, topography, climate and diversity of phorophytes provide a diverse habitat for luxuriant growth of a number of lichens in the area. Large tracts of NW Himalaya have not yet been affected by atmospheric and water pollution. Hence, there is great scope to declare many forested sites as lichen sanctuaries. *Shorea robusta* or 'sal' is the major vegetation in the tropical region, especially in Central India and covers about 13.3% of the total forest area of the country. Satya *et al.*²⁷ recorded a total of 64 lichen species growing on *S. robusta* trees in India. Apart from AABR, there are a few other forested areas in Central India that have the potential to be declared as lichen sanctuaries. Similarly, the Western Ghats is a hotspot of lichen diversity²⁸ and a total of 949 species have been reported from the region, while NE Himalayas has interesting lichen flora and rich diversity of foliicolous lichens²⁹. The lichen-rich sites in India, which need protection against the threat due to heavy anthropogenic activities and declaration as lichen sanctuaries are shown in Figure 1.

Creating lichen gardens

If the natural habitats of a threatened species are likely to be destroyed, transplantation of the lichen must be a possibility. The transplant should, of course, be moved primarily to a similar natural habitat, but, if none exists, a botanical garden is an alternative to be considered. The Indian subcontinent has a wide range of climatic conditions. Thus creation of a garden in the country is widely influenced by the climatic conditions also. The making of a lichen garden in India may be covered under two major climates, namely temperate and tropical.

Lichen gardens in temperate areas of India

To create lichen gardens in temperate climate is easy, as most of the lichens

prefer to grow under such conditions. Lichens belonging to genera *Cladonia*, *Lecanora*, *Ramalina*, *Usnea* and parmelioid and physiod groups are abundant in such climate. The site selected should have shady, moist areas together with open canopies, which allow more sunlight and wind to enter the site, thus providing diverse habitats for many lichens to colonize.

Most of the lichens have strategies for reproducing asexually. The vegetative propagules of lichens such as isidia and soredia, readily break away from the parent plant and form new plants. This ability of lichens to reproduce easily by asexual division is especially useful for the lichen garden.

Stones and boulders bearing lichens [most of the saxicolous taxa such as *Acarospora*, *Aspicilia*, *Buellia*, *Caloplaca*, *Dermatocarpon*, *Endocarpon*, *Lecanora* (Placodioid group), *Rhizoplaca*,

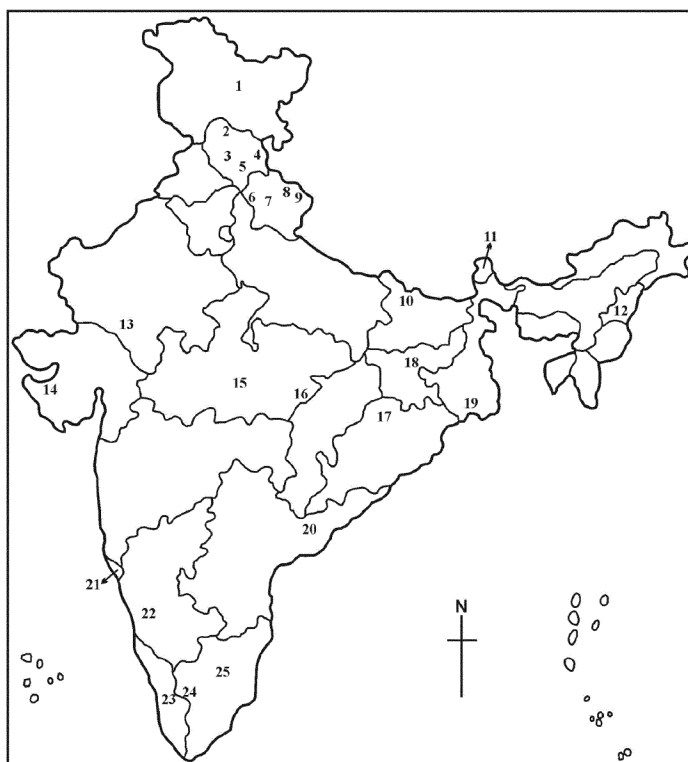


Figure 1. Map of India showing lichen-rich areas to be declared as 'lichen sanctuaries'. 1, Khardungla Pass and Hemis National Park; 2, Darcha and Baralacha; 3, Hatu Peak (Narkanda) and Sungri (Rohru); 4, Chitkul Forest; 5, Great Himalayan National Park; 6, Jim Corbett Tiger Reserve and Deoban Forest; 7, Chaubatia (Ranikhet) and Mussoorie Hills; 8, Saryu Valley, Nain Singh Top (Milam Glacier); 9, Chopta–Tunganath Peak; 10, Dawn Hills; 11, Tiger Hills; 12, Phek; 13, Mt. Abu; 14, Pirotan Islands; 15, Pachmarhi Wildlife Sanctuary; 16, Amarkantak–Achanakmar Biosphere Reserve; 17, Jharsuguda; 18, Naterhat Forest; 19, Sundarbans Biosphere Reserve; 20, Mahendra Giri Forest area; 21, Bhagwan Mahavir Wildlife Sanctuary; 22, Jog Falls Forest area; 23, Myladumpara Forest area; 24, Nilgiri and Palni Hills; 25, Shevaroy and Pappanasam Hills.

Rhizocarpon and *Staurothele*] are the best materials for starting lichen gardens in temperate regions. Similarly, the terricolous lichens growing over soil, mostly species of *Cladonia*, *Phaeophyscia* and *Lepraria*, are easy to transplant in the gardens.

Substrates with lichens from nearby areas should be removed along with the substratum and should be placed in the garden according to the needs of the climatic condition of a particular genus. Lichen taxa from the substrate should be removed carefully to ensure minimal damage to the thalli. To avoid mechanical damage to the thallus, dry period/sunny days are best for its removal. Following removal of the thalli from the substrate, the specimens should be placed in a shady, cool place until transplantation.

The corticolous taxa may be transplanted on similar trees in the garden. The thallus lobes or whole lichen thallus can be affixed on trunks of the similar trees with the help of small nets or glue. New propagules of the lichen thallus can be obtained on the trunks of the trees by rubbing sorediate and isidiate thalloid lichens. For successful transplantation of lichens, taxa growing naturally under similar climatic conditions of the garden can be selected.

Lichen garden in tropical areas of India

The moist tropical regions, particularly the coastal Indian region, the Western Ghats and eastern Himalayas have excellent climate for creation of a lichen garden comprising graphidaceous, thelotremataceous and pyrenocarpaceous lichens. The site selected should be moist enough, a more or less open canopy and should have both smooth and rough barked trees. The smooth bark with plenty of water content allows many graphidaceous, pyrenocarpaceous and thelotremataceous lichens to colonize, while the rough bark that retains moisture for longer periods and also anchors vegetative propagules of many

lichen taxa more effectively, is good for many foliose and fruticose lichens.

Conclusion

It is clear from the above discussion that to efficiently and effectively accomplish conservation of lichens in India, there is a need for creation of 'lichen gardens' in all the phytogeographical regions of the country, or at least in all the five major zones (north, east, west, central and south), and also declaration of some sites as lichen sanctuaries. Lichen gardens, apart from conservation, also serve as centres for education and recreation. Lichens also provide an aesthetic sense to the garden. A successful garden, especially in temperate areas, may act as a resource for medicinally important lichens and can be sustainably harvested. Gardens or sanctuaries especially dedicated to conservation of lichens are nil or rare in the world and such an attempt in India is highly desirable.

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