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Research article

Diversity and distribution of lichens from the monuments of Gwalior division, Madhya Pradesh with special reference to rock porosity and lichen growth

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Abstract: The present study reports the diversity and distribution of lichens growing on historical monuments of Gwalior division. Result revealed the occurrence of 28 lichen species belonging to 16 genera and 9 families. The members of the lichen family Physciaceae, Teloschistaceae and Verrucariaceae dominate the lichen diversity on monuments as represented by 5 species each of the families, followed by members of Peltulaceae and Lecanoraceae. Among the different growth forms, crustose exhibits their luxuriant growth, followed by squamulose and foliose on various monuments. Substrate preference for lichen colonization is apparent by occurrence of maximum diversity of lichens represented by 27 species on sandstone, followed by concrete, igneous granite, calcareous and clay represented by 7, 6, 5 and 2 species respectively. The rock porosity was calculated to measure water holding capacity and the correlation between rock porosity and lichen growth were studied which shows that the squamulose growth form lichen *Endocarpon rosettum* and *Endocarpon subrosettum* with thick medullary zone, grows on rocks having maximum water holding capacity of 43% each followed by *Phylliscum indicum* and *Endocarpon nanum* growing on rocks with 23% and 16.5% water holding capacities respectively.
Keywords: Lichen distribution - Monuments - Gwalior division - Rock porosity.

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INTRODUCTION

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 (Kumar & Kumar 1999, Kumar *et al.*2014). Lichens have an ability to grow on any substrate of perennial nature. In nature they play important role in soil formation and grow as pioneer organism. The role of lichens as biological weathering agents in the development of soils was formerly considered in a geological context only, but recent researches have shown that these organisms are capable of biodeteriorating stone substrata within a relatively short time-scale. Biodeterioration of stone monuments may be classified into three categories: biophysical, biochemical and aesthetic deterioration (Allsopp & Seal 1986, Caneva *et al.* 1991). The characteristics of lichens and their deterioration on stone have been studied by several authors worldwide (Paine *et al.* 1933, Jones & Wilson 1985, Giacobini *et al.* 1985; Sabbioni & Monte del 1987, Seaward 1988). James *et al.* (1977) observed numerous distinct lichen communities on hard limestone from British Islets.

The distribution of lichens growing on historic monuments of different regions of India was enumerated in number of studies (Ayub 2005, Singh & Upreti 1991, Chatterjee *et al.* 1995, Singh *et al.* 1999, Saxena *et al.* 2004). Although, some work exploring the lichen diversity on the monuments of central India has already been done (Jain 2001, Upreti 2002, Upreti *et al.* 2004, Bajpai *et al.* 2008), but one of the monument rich Gwalior has

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not been explored well. Thus, the present study was conducted to know the diversity and distribution of lichens growing on the monuments of Gwalior division.

MATERIALS AND METHODS

Study area

The Gwalior division is an administrative subdivision of Madhya Pradesh state in Central India. It includes districts of Ashoknagar, Datia, Guna, Gwalior and Shivpuri. The Gwalior division is a home to a number of forts, castles, temples and historical and religious monuments. The monuments in the study are having varied construction material such as calcareous, clay, igneous granite and sandstone. Some monuments were constructed with concrete as well. Being alkaline nature of most of the construction materials it provides an excellent substratum for a large number of lichens to colonize together with other group of plants.

Sample collection and Identification

The study is based on the collection of lichens from more than 25 Monuments situated in five districts of Gwalior division, Madhya Pradesh (Table 1). More than 200 samples were collected during August 2012 to October 2014. The sample collections were made from the abandoned monuments and nearby rocks to avoid the destruction of protected monuments.

Table 1. Localities survey for collection of lichens.

S.No.	District	Monuments and nearby area
1	Ashoknagar	Kila kothi, Chanderi fort; Khuni Darwaja, Chanderi fort;, Kati Ghati; Digambar Jain mandir; Jageshwari Mata mandir; Near Graveyard, Chanderi; Thubon village
2	Datia	Pancham kavi ki pahadi; Chiviya for ki mata; Veer Singh palace; Karam Sagar dam; Dong Karera village; Udnu ki pahadi; 5 Km from Datia towards Shivpuri
3	Guna	Bajrang garh fort; Gader ki Gufa; Beesbhuji temple
4	Gwalior	Chaturbhuj temple, Gwalior fort; Gujri mahal, Gwalior fort; Tansen ki dargah; Devkho; Gupteshwar temple
5	Shivpuri	Narwar fort; Survaya fort; Atal Sagar dam; Bhadaiya kund;10 Km from Shivpuri to Jhansi highway

Though Gwalior division has rich diversity of a number of historical monuments, however Jain (2001) enumerated few lichens and algae from a single monument of the district. Thus the present study is aimed to investigate the lichen diversity on most of the monuments of the Gwalior division comprising of five districts. The information regarding correlation between lichen diversity and the rock types will be significant for conservators of the monuments to adopt appropriate conservational and management strategies.

The samples were identified morphologically, anatomically and chemically. The external morphology of the thallus was observed under a stereo-zoom microscope. The anatomical structures were studied under a compound microscope. For chemical spot tests, the usual reagents K (5% potassium hydroxide), C (aqueous solution of Calcium hypochlorite), and PD (para-phenylenediamine) were used. Thin Layer Chromatography was performed in solvent system C following Orange *et al.* (2001). The samples were identified up to their species level and authenticated following literature of Awasthi (1991, 2007). The identified specimens are preserved in herbarium of CSIR- National Botanical Research Institute (LWG).

Determination of porosity of rocks

The known volume (1–3 gm) of monumental rock samples are taken in glass bowl. This bowl already contains distilled water 100 cc volume. These rock saturated by capillary action of water at room temperature for 24 hours, till a thin film of water on the top surface of the rock was consequently seen. This saturated sample was weight and dried in an oven at 105ºC for 24 hours, till constant weight was established. Then the rock samples are removed and weight. Water holding capacity was calculated as wet minus dry weight and specified as percentage water content related to dry weight.

RESULTS AND DISCUSSION

The study revealed occurrence of 28 species belonging to 16 genera and 10 families from the Gwalior division (Table 2). The crust forming lichens exhibit their dominance in the area represented by 17 species followed by squamulose, foliose and leprose growth forms with 8, 2 and 1 species respectively. The monument

in Ashoknagar district exhibit the maximum dominance of lichens represented by 27 species followed by Guna and Shivpuri with 14 and 7 species respectively, while Datia and Gwalior district represented by 6 species each. Out of the 10 families of lichens, members of family Physciaceae and Teloschistaceae exhibit their dominance followed by the members of families Peltulaceae, Lichinaceae and Lecanoraceae (Table 2). The most common lichen genera growing on different monuments are *Caloplaca*, *Peltula*, *Amandinea* and *Endocarpon*.

Table 2. Distribution of lichens on various monuments of Gwalior division.

	Lichen taxa	GF	Localities in study sites					Substratum
			1	2	3	4	5	
Lecanoraceae								
1	*Lecanora cenisia* Ach.	C	1					Sandstone
2	*Lecanora pseudistera* Nyl.	C	1					Sandstone
3	*Lecidella stigmatea* (Ach.) Hertel & Leuckert	C	1					Sandstone
Lichinaceae								
4	*Anema decipiens* (A. Massal.) Forssell	C					1	Sandstone, Igneous granite
5	*Phylliscum indicum* Upreti	S	3	2	2	4	1	Sandstone, Calcareous, Concrete
Parmeliaceae								
6	*Parmotrema praesorediosum* (Nyl.) Hale	F	1		1			Sandstone, Concrete
Peltulaceae								
7	*Peltula euploca* (Ach.) Poelt in Pisut	S	1	6	1		4	Sandstone, Igneous granite, Concrete
8	*Peltula obscurans* (Nyl.) Gyeln.	S	1		1		1	Sandstone, Igneous granite
9	*Peltula patellata* (Bagl.) Swinscow & Krog	S	3	2	1	1	3	Sandstone, Igneous granite, Concrete
10	*Peltula placodizans* (Zahlbr.) Wetmore	S	2	5	1	2	3	Sandstone, Clay, Igneous granite, Concrete
Physciaceae								
11	*Amandinea Montana* (H. Magn.) Marbach	C	1					Sandstone
12	*Amandinea subduplicata* (Vain.) Marbach	C	2					Sandstone
13	*Amandinea submontana* Marbach	C	2					Sandstone
14	*Buellia indica* S.R. Singh & D.D. Awasthi	C	1					Sandstone
15	*Dirinaria confluens* (Fr.) D.D. Awasthi	F	2		1			Sandstone
Ramalinaceae								
16	*Bacidia arnoldiana* Körb	C	1					Sandstone
Stereocaulaceae								
17	*Lepraria lobificans* Nyl.	L	1		1			Sandstone
Teloschistaceae								
18	*Caloplaca cupulifera* (Vain.) Zahlbr.	C	2					Sandstone
19	*Caloplaca pseudopoliotera* Y. Joshi & Upreti	C	5					Sandstone
20	*Caloplaca subpoliotera* Y. Joshi &Upreti	C	1	2	1		1	Sandstone, Igneous granite
21	*Caloplaca subsoluta (Nyl.) Zahlbr.*	C	3		1			Sandstone, Calcareous
22	*Caloplaca tropica* Y. Joshi &Upreti	C	2					Sandstone
Thelenellaceae								
23	*Thelenella luridella* (Nyl.) H. Mayrhofer	C	2					Sandstone
Verrucariaceae								
24	*Endocarpon nanum* Ajay Singh &Upreti	S	3		1			Sandstone, Calcareous
25	*Endocarpon rosettum* Ajay Singh &Upreti	S	2		1			Sandstone, Calcareous
26	*Endocarpon subrosettum* Ajay Singh &Upreti	S	1	1	3	1		Sandstone, Calcareous, Clay, Concrete
27	*Staurothele fissa* (Taylor) Zwackh	C	1		2	1		Sandstone, Concrete
28	*Verrucaria coerulea* (Ramond)	C	4			1		Sandstone

Note: GF, Growth forms; 1, Ashoknagar; 2, Datia; 3, Guna; 4, Gwalior; 5, Shivpuri.

The lichens were uniformly found growing on different rock types including Calcareous, Clay, Concrete, Igneous granite and Sandstone. The sandstone is the major rock type used as a construction material for the monuments throughout the division exhibit growth of most of the lichens The correlation between rock porosity and the type of lichen growth have been studied which determined by water holding capacity method. Since water holding capacity is directly proportional to the porosity of rock, which controls the availability of water and hence influences the growth of lichens on monuments. The correlation between water uptake capacity of

rocks and the type of lichen growth in Bhimbetka rock shelter have been studied by Upreti *et al.* (2006) and suggested that the leprose lichens with thin medullary crust over rock have less water intake capacity, whereas crustose lichens colonize on rocks having moderate water holding capacity. Among the foliose lichens, the taxa with thin thallus grow on rocks having maximum water holding capacity.

In the present study among the different growth forms, squamulose lichen *Endocarpon rosettum* and *Endocarpon subrosettum* with thick medullary zone, exhibit the maximum water holding capacity of 43% each followed by *Phylliscum indicum* and *Endocarpon nanum* with 23% and 16.5% respectively. *Caloplaca subsoluta* and *Caloplaca tropica*, crustose lichens have the maximum water holding capacity of 28% each followed by species of lichen genus *Amandinea*, *Bacidia*, *Buellia* and *Lecidella* with 10% each. The foliose lichen *Dirinaria confluens* and *Parmotrema praesorediosum* with thick thallus showed 10% water holding capacity. The only leprose lichen found in the area *Lepraria lobificans* with a thin medullary crust spreading over rocks have the lowest water holding capacity of 5%. Some common lichens of the study area have also been shown in figure 1.

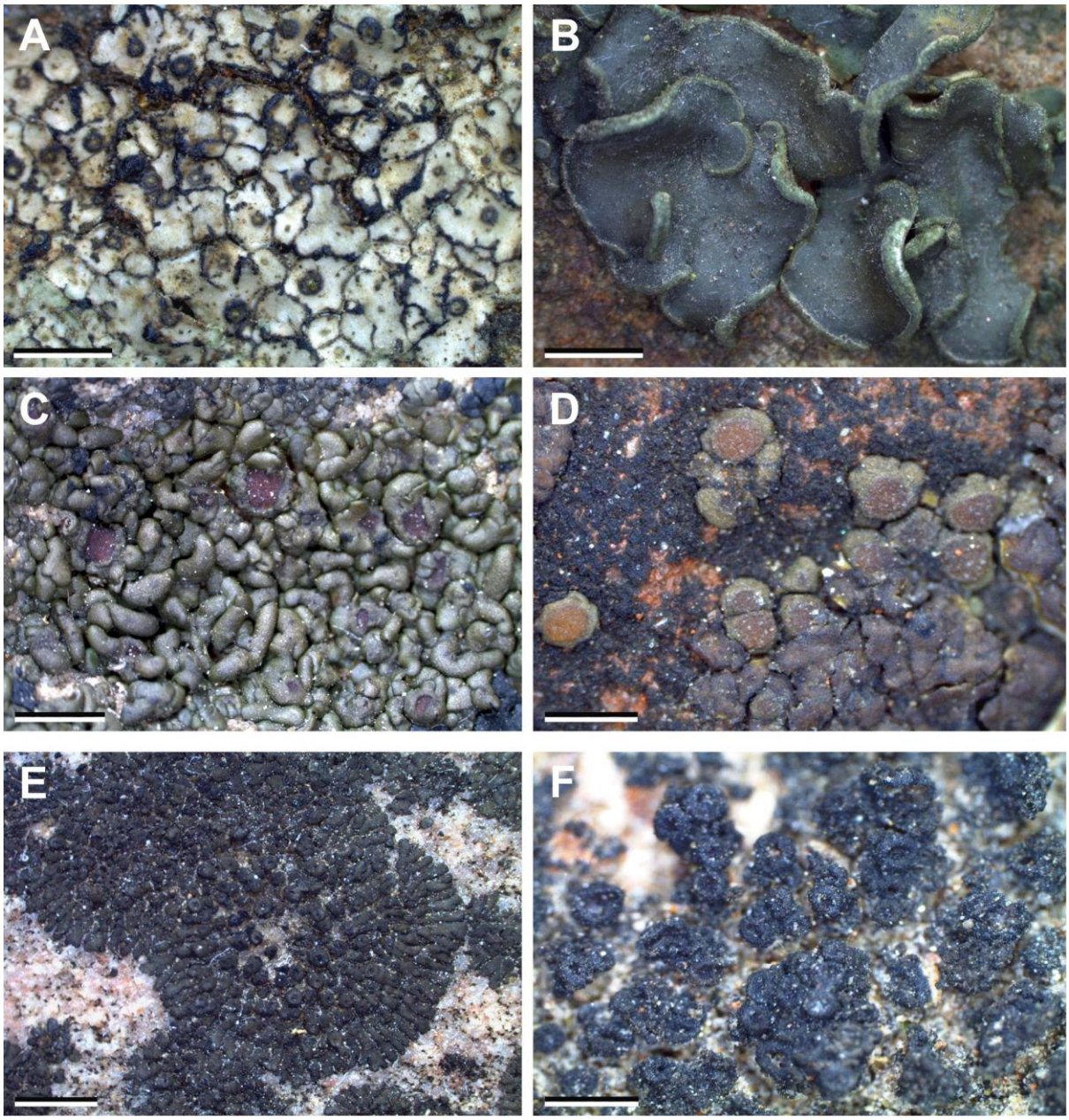

Figure 1. Some common lichen species reported from the study area: **A,** *Endocarpon subrosettum* Ajay Singh & Upreti; **B,** *Peltula euploca* (Ach.) Poelt in Pisut; **C,** *Peltula obscurans* (Nyl.) Gyeln.; **D,** *Peltula patellata* (Bagl.) Swinscow & Krog; **E,** *Peltula placodizans* (Zahlbr.) Wetmore; **F,** *Phylliscum indicum* Upreti. **[**Scale bars: A–F = 2 mm]

It is clear from the study that the anatomical characters play vital role in determining the water holding capacity. Within different type of rocks, Calcareous rock showed the maximum water holding capacity ranging from 10–43% followed by Concrete and Sandstone with the range between 5–35% and 3–28% respectively. Concrete rocks exhibit 35% and Clay showed range between 3–23% water holding capacity while the Igneous granite exhibit the range between 5–10% (Fig. 2). The chemical composition and physical form of the rock also play role in the water holding capacity. As calcareous rocks are rich in calcium salts, which has a tendency to absorb moisture and retain it for longer period of time, while igneous rock solidified magma has little or no tendency to absorb moisture. The non-porous rocks and the rocks with large pores have very less water holding capacity as in both types the water absorption rate is very low. However, the rocks with smaller pores have high water holding capacity because of its capillary action and lesser surface exposure of water to the air.

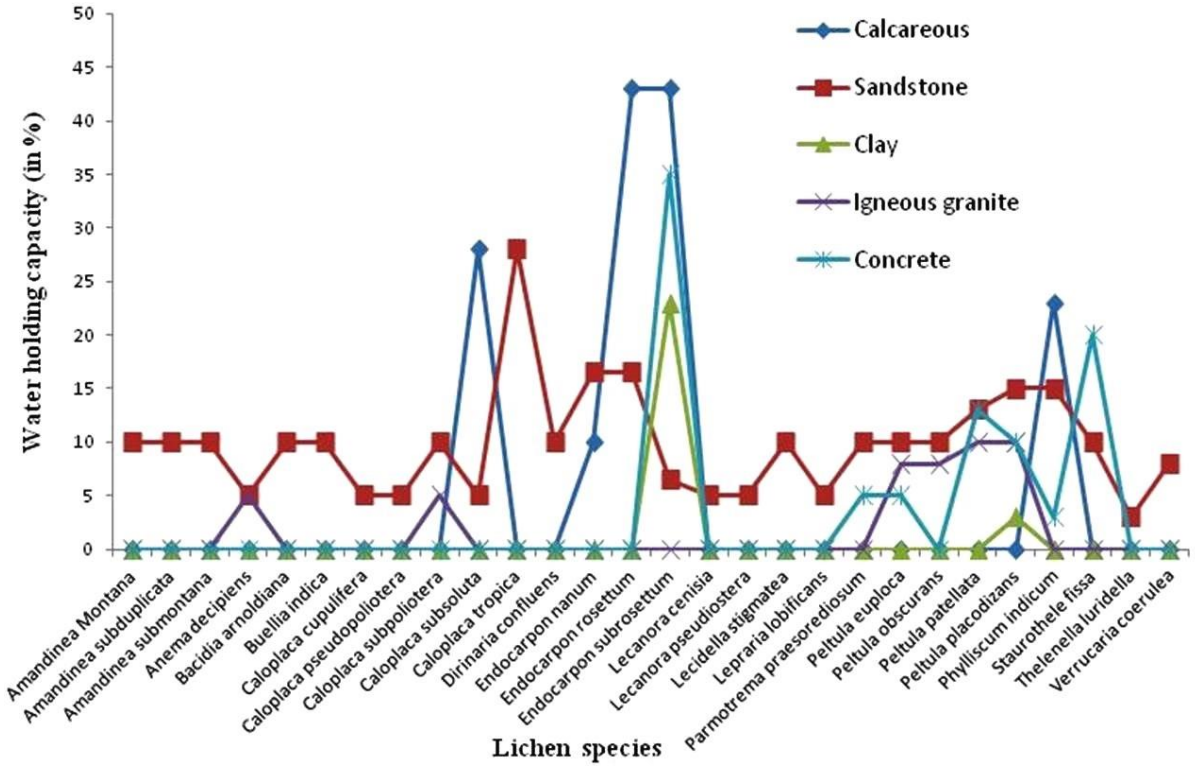

Figure 2. Graph shows water holding capacity of lichen species, correlated with different types of rock substratum.

In dry conditions lichen metabolism reduces water and nutritional needs to the minimum, and as a consequence lichens are able to withstand xeric conditions for prolonged periods. Bare and exposed monument surfaces therefore provide ideal, competition-free situations for lichen invasion and establishment as pioneers of the bio-succession. Besides, many micro-environmental or microclimatic conditions develop in mosaic habitats on account of conditions that create their own modified versions of the general lichen-flora supported by prevailing macroclimate of the area. The present study will be helpful in conducting future bio-monitoring studies and to the conservators for adopting conservation practices for the monuments in Gwalior division.

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