

## Full Length Research Paper

## Distribution of Lichens on few ancient monuments of Sonitpur district, Assam, North East India

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This preliminary investigation describes the diversity and distribution of lichens from the different archaeological monuments of Sonitpur district, located in the Eastern Himalayan region of India, which is a part of Indo-Burma biodiversity hotspot. It is a land of natural beauty and rich cultural heritage and it is well reflected in the number of archaeological sites and monuments of ancient time at this region. Enumerations of 38 species of lichen belonging to 21 genera and 15 families have been reported from the archaeological monuments of Sonitpur district. 6 species are new records for this state. Members of Physciaceae showed higher dominance with 11 species followed by Teloschistaceae with 4 species and Lecanoraceae and Verrucariaceae each containing 3 species, respectively. *Cryptothecia subnidulans* is the most widespread species, reported from 7 study sites.

**Key words:** Diversity, Eastern Himalayan, heritage, hot spot, species.

### INTRODUCTION

Lichens are a stable self-supporting association of a mycobiont and a phycobiont in which the mycobiont is the inhabitant (Hawksworth, 1988). They are known to occur on various substrates including barren rocks, mainly for their resistance to desiccation at extreme temperature and efficiency in accumulating nutrients (Martin, 1985; Chaffer, 1972; Seaward, 1979, 1988). As the earliest colonizers of terrestrial habitats on the earth, lichens are amongst the most successful forms of symbiosis (Galloway, 1994). These symbiotic thallophytic hardy plants can grow and thrive under extreme conditions and

can withstand xeric conditions which other plants find unfavourable for their growth and survival. The colonisation of monuments by lichens is a universal and well established fact and is greatly influenced by climatic and micro-climatic condition (mainly temperature and relative humidity), type of substratum, architectural design as well as the anthropogenic disturbances. Bare and exposed monuments, ruins of ancient archaeological sites provide an ideal place for invasion and colonisation of different groups of lichens. The colonization of lichens on building material and biodeterioration are usually

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**Table 1.** List of study sites with their coordinates.

S/N	Study Site	Coordinates	Type of material	Periods of construction
1	Temple Ruins of Bamuni Hill	26° 37' 01" N 92° 48' 57" E	Rock, Brick	10th to 12th century AD
2	Temple ruins of Da-Parbatia	26° 37' 52" N 92° 45' 27" E	Rock, Brick	6th century AD
3	Ruins of Singri Hill	26° 36' 53" N 92° 29' 55" E	Rock	11th to 12th century AD
4	Rock inscription on the Bhomoraguri hill	26° 36' 41" N 92° 51' 13" E	Rock	18th century AD
5	Garh DouL	26° 38' 46" N 92° 46' 19" E	Brick	7th and 8th century AD
6	Sakraswari on the island Umatumuni	26° 39' 42" N 93° 10' 36" E	Rock	18th century AD
7	Biswanath Siva Linga	26° 39' 41" N 93° 10' 20" E	Rock	17th century AD
8	Bamgaon ruin	26° 73' 73" N 93° 16' 34" E	Brick	7th and 8th century AD
9	Bordol Temple	26° 39' 35" N 93° 10' 19" E	Rock, Brick	17th century AD
10	Dhandi Ruin	26° 51' 90" N 93° 41' 55" E	Brick	18th century AD
11	Basudev DouL	26° 51' 46" N 93° 45' 15" E	Rock, Brick	16th century AD
12	Nandikeshar Dewaloya	26° 73' 80" N 92° 91' 43" E	Rock, Brick	16th century AD
13	Mahabhairab Temple	26° 64' 41" N 92° 79' 64" E	Rock	10 <sup>th</sup> century AD
14	Sculptures of Chummery Compound	26° 61' 84" N 92° 79' 49" E	Rock	10th to 12th centuries AD

linked to environmental conditions (Bajpai et al., 2012). The lichens on Indian monuments were previously described and reported in several literatures (Upreti, 2002; Upreti et al., 2004; Bajpai, 2008; Bajpai et al., 2008; Singh and Upreti, 1991; Chatterjee et al., 1995; Singh et al., 1999).

Sonitpur district of Assam is located on the Northern bank of River Brahmaputra, covering an area of about 5324 km<sup>2</sup> expanding from Singri to Hawajan, Sonitpur district with a large expanse of land lying scattered numerous archaeological remains showing a glorious civilisation in this region as old as six century A.D. There are many central government as well as state protected archaeological sites and monuments within the Sonitpur district which include remain of temple, rock inscription, sculptures, structural remains of ancient period and a few temples of Ahom destiny which are covered by enormous groups of lichens (Table 1). Despite harbouring rich lichen diversity, these monuments are not being explored. The aim of the current study was to explore the distribution and diversity of lichen's colonisation in the hitherto monuments of Sonitpur district.

## MATERIALS AND METHODS

Lichens were carefully removed and collected from the monuments by avoiding any damage to these monuments. They were immediately wrapped in tissue paper and then transferred to lichen herbarium packets. The collected specimens were investigated morphologically, anatomically and chemically in the laboratory. The colour tests were performed with the following reagents; K (5% potassium hydroxide), C (aqueous solution of calcium hypochlorite), P (paraphenylene diamine) and I (iodine solution). Lichen's substances were identified with thin layer chromatography (TLC) in solvent system A (toluene : dioxane : acetic acid; 180:60:8 ml). The lichen's substances were identified with the help of table given by Orange et al. (2001). The identities of different specimen were confirmed by matching them with well identified specimen preserved in the herbarium of CSIR-NBRI, Lucknow. The nomenclature and classification of lichens were updated following Lumbsch and Huhndorf (2007).

## RESULTS AND DISCUSSION

The different monuments of Sonitpur district harbour many lichen species and represented by 38 species belonging to 21 genera under 15 families (Table 2, Figure 1).

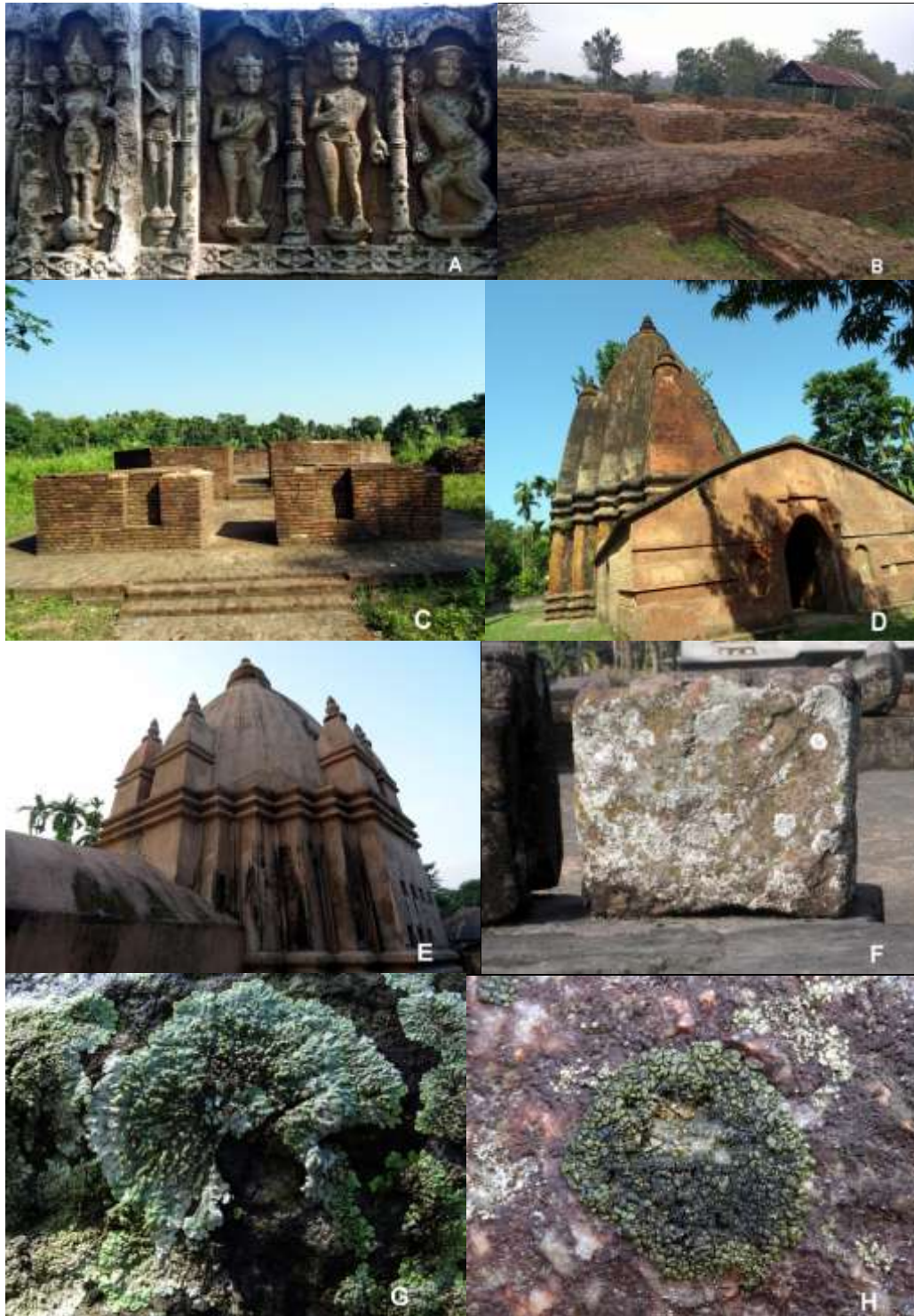
**Table 2.** List of lichens from the historical monuments of Sonitpur district, Assam.

Species name	Family	Type	*Study site	Secondary metabolites
<i>Bacidea rubella</i> (Hoffm.) Massal.	Bacidiaceae	Crustose	3	No secondary metabolites
<i>Caloplaca bassiae</i> (Wild. Ex Ach.) Zahlbr.	Teloschistaceae	Crustose	1,13,14	Parietin
<i>C. cinnabariana</i> (Ach.) Zahlbr.	Teloschistaceae	Crustose	6	Parietin, Xanthorin
<i>C. cupillifera</i> (Vain.) Zahlbr.	Teloschistaceae	Crustose	1	Parietin
<i>C. subsoluta</i> (Nyl.) Zahlbr	Teloschistaceae	Crustose	7,11	Parietin
<i>Cryptothecia scripta</i> G.Thor	Arthoniaceae	Crustose	11	Gyrophoric acid
<i>C. subnidulans</i> Stirton.	Arthoniaceae	Crustose	1,2,5,7,10,11,12	Gyrophoric acid
<i>Chrysothrix candelaris</i> (L.) J.R. Laundon	Chrysothricaceae	Leprose	3	Calycin
<i>C. chlorine</i> (Ach.) J.R. Laundon	Chrysothricaceae	Leprose	4,12,14	Calycin, Vulpinic acid
<i>Dirinaria aegialita</i> (Afz.in Ach.) Moore	Physciaceae	Foliose	1,4, 14	Divaricatic acid
<i>D. applanata</i> (Fee) D.D.Awasthi	Physciaceae	Foliose	2,10	Divaricatic acid
<i>D. confluens</i> (Fr.)D.D.Awasthi	Physciaceae	Foliose	1,2,6	Atranorin, Divaricatic acid
<i>D. consimilis</i> (Stirton) D.D.Awasthi	Physciaceae	Foliose	1, 12,14	Atranorin, Sekikaic acid
<i>Endocarpon</i> sp.	Verrucariaceae	Squamulose	1,5,8	No secondary metabolites
<i>Heterodermia diademata</i> (Taylor) D.D. Awasthi.	Physiaceae	Foliose	9	Atranorin, Zeorin
<i>H. microphylla</i> (Kurok) Skorepa.	Physiaceae	Foliose	3	Zeorin
<i>Lecanora pseudistera</i> Nyl.	Lecanoraceae	Crustose	1,3	Atranorin, 2-0-methylperlatolic acid
<i>L. subimmersa</i> (Fee) Vain.	Lecanoraceae	Crustose	1,14	Atranorin, Zeorin
<i>Lecanora</i> sp.	Lecanoraceae	Crustose	2,14	Atranorin, gangaleodin
<i>Lepraria coriensis</i> (Hue) Sipman	Stereocaulaceae	Leprose	14	Atranorin, Constipatic Acid
<i>Micarea</i> sp.	Pilocarpaceae	Crustose	5	Gyrophoric acid
<i>Mycobilimbia hunana</i> (Zahlbr.) Awasthi	Porpidiaceae	Crustose	1,5,8	Atranorin
<i>Parmotrema presorediasum</i> (Nyl.) Hale	Parmeliaceae	Foliose	1,3	Atranorin
<i>P. reticulatum</i> (Taylor) Choisy	Parmeliaceae	Foliose	9	Salazinic acid
<i>P. saccatilobum</i> (Taylor) Hale	Parmeliaceae	Foliose	7,10,11,14	Atranorin, protocetraric acid
<i>P. tinctorum</i> (Despr.ex Nyl.) Hale	Parmeliaceae	Foliose	1,12	Atranorin, Lecanoric acid
<i>Peltula obscurans</i> (Nyl.) Gyelnik	Peltulaceae	Squamulose	4	No secondary metabolites
<i>P. tortuosa</i> (Nees) Wetmore	Peltulaceae	Squamulose	3	No secondary metabolites
<i>Phyllopsora furfuracea</i> (Pers.) Zahlbr.	Ramalinaceae	Squamulose	2	Furfuraceic acid
<i>Physia dimidiata</i> (Arn.) Nyl.	Physiaceae	Foliose	2	Atranorin
<i>Porina</i> sp.	Porinaceae	Crustose	14	No secondary metabolites
<i>Pyxine cocoes</i> (Sw.) Nyl.	Physciaceae	Foliose	1,10,11	Lichenoxanthane, Triterpene
<i>P. meissnerina</i> Nyl.	Physciaceae	Foliose	6,14	Triterpenoides
<i>P. subcinerea</i> Stirt.	Physciaceae	Foliose	1,11	Lichenoxanthane
<i>Rinodina oxydata</i> (A.Massal.) A.Massal	Physciaceae	Crustose	1,2,4,11,14	Atranorin
<i>Staurothele</i> sp.	Verrucariaceae	Crustose	3	No secondary metabolites
<i>Trapelia</i> sp.	Trapeliaceae	Crustose	1	No secondary metabolites
<i>Verrucaria</i> sp.	Verrucariaceae	Crustose	5	No secondary metabolites

\*1. Temple Ruins of Bamuni Hill, 2. Temple ruins of Da-Parbatia, 3. Ruins of Singri Hill, 4. Rock inscription on the Bhomoraguri hill, 5. Garh Dou, 6. Sakraswari on the island Umatumuni, 7. Biswanath Siva Linga, 8. Bamgaon ruin, 9. Bordol Temple, 10. Dhandi Ruin, 11. Basudev Dou, 12. Nandikeswar Dewaloya 13. Mahabhairab Temple 14. Sculptures of Chummary compound.

Among the different growth forms, crustose lichens exhibit the maximum diversity with 17 (44.73%) species followed by foliose lichen with 13 (34.21%) species. 4 species of squamulose lichens (10.52%) and 3 species of leprose (7.89%) are also reported. Physciaceae dominates with 4 genera and 11 species. (Figure 2) *Cryptothecia subnidulans* is the most common and well distributed species reported from 7 study sites followed

by *Parmotrema saccatilobum* and *Rinodina oxydata* each from 4 study sites, respectively. The ruins of Bamuni hills exhibited the maximum diversity of lichens represented by 16 species followed by Sculptures of Chummary Compound with 11 species and Temple ruins of Da-Parbatia with 7 species respectively. Two lichen genera, *Caloplaca* and *Dirinaria* with 4 species each, dominants the study areas and grows luxuriantly in different

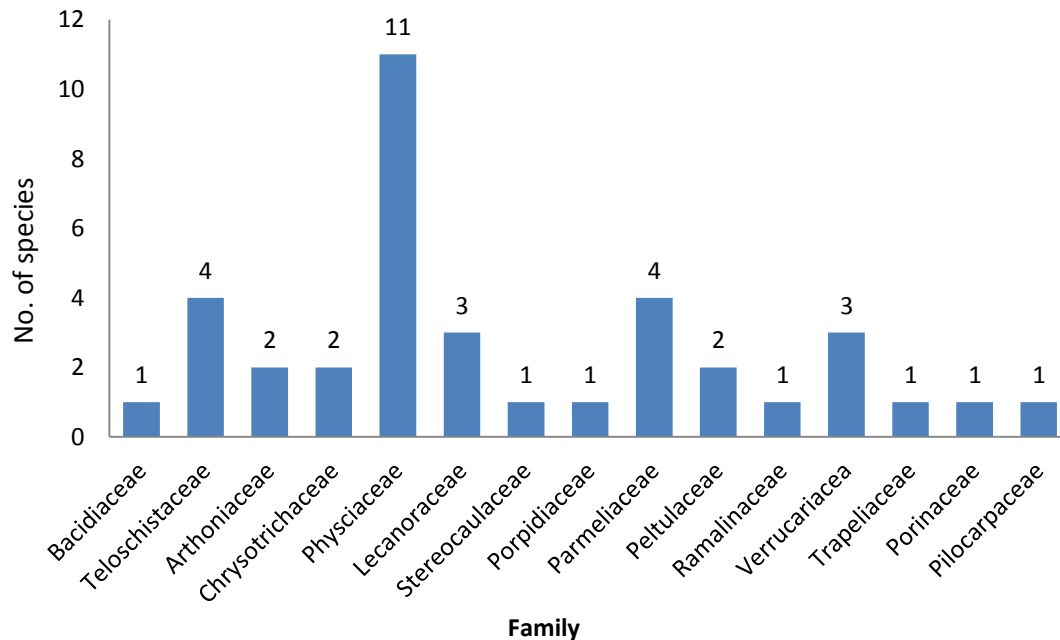


**Figure 1.** (A) Sculptures of Chummery Compound, (B) Garh Dou, (C) Bamgaon ruin, (D) Basudev Temple, (E) Bordle temple, (F) Da-Parbatia, (G) *Pyxine meissnerina*, (H) *Peltula tortusa*.

substrata in different conditions.

Due to lack of anthropogenic activities and lack of maintenances in terms of remedial measure, the different ruins exhibit high lichen diversity as compared to the

other maintained sites. The geographical location, microclimatic condition and the presence of porous, rough and exposed rocks of Bamuni Hills provide ideal condition for the colonization of different groups of



**Figure 2.** Representation of different lichen families in the monuments of Sonitpur district.

lichens. On the other hand, Biswanath Siva Linga, Bamgaon ruin and Bordol Temple are well maintained by both local authorities as well as by ASI, resulting in decreasing lichen's diversity. The excessive use of iron brushes for eradication of lichens resulted in the formation of irregularity of rock's surface morphology at several sites which in turn physically deteriorate the monument. These irregular lines are clearly seen in the different substrata of ruins of Da-Parbatia. In Bordol Temple, recent renovation work by lime concrete finishing to the mandapa and lime surkhi plastering to the cracks as well as on the exterior old decayed plaster of the monument were executed. During the renovation process *P. reticulatum* and *Heterodermia diademata* were completely eliminated from the Bordol Temple.

The lower strata of these monuments hardly receive strong light during the day time and remain shaded and moist, show dominance of some moisture loving species, *Mycobilimbia hunana*. In these strata of Garaha Dol brick built ruin *Mycobilimbia hunana* grows luxuriantly and occupy the whole strata. As the height from the base of the plinth increase the moisture content start to decrease and comparatively more exposed to sunlight and wind and shows dominance of genera *Cryptothecia*, *Caloplaca*, *Lecanora* and *Parmotrema*. The middle and the uppermost strata of the monument mainly composed of rock made vertical walls firmly joint by lime plaster and lime surkhi plastering to the exterior surface facing different directions and expose to different degrees of light, wind and moisture. The middle strata hold more and dense lichen's diversity and comprise different lichen's community. The uppermost stratum receives maximum

amount of sunlight during the day time and provide xeric habitat for lichen genera, *Endocarpon* and *Peltula*. *Cryptothecia subnidulans* and *Dirinaria confluens* also grows abundantly in these faces. Presence of large woody vascular plant vegetation around and near these monuments also changes the microclimatic conditions of these faces, alter the niche and promote the growth of shade loving lichens genera *Heterodermia*, *Physia* and *Chrysothrix*. Shading tends to alter the microclimatic condition by reducing the hot day temperature, proving shade and slowing down the moisture evaporation process. In the roofs and terraces lichen genera, *Endocarpon*, *Dirinaria*, *Peltula* and *Cryptothecia* show abundance in the exposed horizontal floor of ruins of Da-Parbatia species of *Cryptothecia*, *Caloplaca*, *Dirinaria* and *Lecanora* grows abundantly. *Physia* and *Heterodermia* mostly occur in the vertical walls in association with *Cryptothecia*.

On the brick made monuments of Garhadol and Bamgaon ruin *Endocarpon pallidum* and *Mycobilimbia hunana* shows their dominance. *Cryptothecia subnidulans*, *D. consimilis* and *Pyxine meissnerina* are also found to grow in different brick made monuments.

Seasonal variation influences the visibility, texture, contrast of colours and appearance of fruiting bodies of the lichens on the monuments. During monsoon season, with increase in atmospheric humidity and abundant rainfall, species of *Endocarpon* and *Peltula* assume their natural characteristic colour, swell up and attain their normal dimension, and grow vigorously in different substrata. *Endocarpon* exhibits preference to colonize more rapidly in the monsoon season in the bricks.

## Conclusion

The present investigation supports the lichen richness in the archaeological sites of Sonitpur district of Assam. Most of the archaeological monuments are constructed with sandstone and brick firmly cemented by lime plaster, which in turn provide an excellent substratum for colonization of different groups of lichens together with mosses and other vascular plants. This North East part of India is shared by well distributed and heavy rainfall that supports an excellent condition for the rapid growth and distribution of lichens. This present enumeration of lichens and their distribution pattern will act as baseline data which will be helpful in future for conducting bio-monitoring as well as bio-deterioration studies in this area of investigation area.

## Conflict of Interests

The authors have not declared any conflict of interests.

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