

Lichen Diversity at Alang-Sosiya Shipyard, West Coast, India

Bhasker Punjani^{1*}, Jayesh Raval², Dalip K. Upreti³

¹P.G. Center in Botany, Smt. S.M. Panchal Science College, Sabarkantha, Talod-383 215, Gujarat, India

²P.G. Center in Botany, Mehsana Urban Institute of Sciences, Ganpat University, Kherva-384012, Gujarat, India

³Lichenology Laboratory, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow-226001, Uttar Pradesh, India

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*Corresponding author:

e-mail: blpunjani1958@gmail.com

ABSTRACT

The Alang-Sosiya Shipyard area [also known as ASSBRY (Alang-Sosiya Ship Breaking and Recycling Yard)] is located in the west coast of India, Bhavnagar district of Gujarat state. A total of 56 lichen specimens were collected, which revealed the occurrence of 20 species under 14 genera belonging to nine families. There are 13 species considered as new records for Gujarat state. Among the recorded families, Physciaceae dominated with four species, followed by Verrucariaceae, Lichinaceae and Peltulaceae, each with three species. The dominant genera were *Endocarpon* and *Peltula*, each with three species. The species' growth forms included a maximum of 60% crustose, 25% foliose, and the remaining 15% with squamulose types. Concerning habitats, saxicolous consisted of 65% and corticolous of 35% of species. The enumeration of lichens recorded will act as baseline data to be utilized in the future for carrying out bio-monitoring studies, together with bioprospecting of a few lichen species growing luxuriantly in the area under study.

INTRODUCTION

Lichen is a self-sustaining ecosystem formed by the interaction of an exhabitant fungus and an extracellular arrangement of one or more photosynthetic partners and an indeterminate number of other microscopic organisms (Hawksworth and Grube 2020). The fungal partner (mycobiont), which in most of the cases belongs to phylum Ascomycota and rarely to Basidiomycota. The photosynthetic partner (photobiont) may be Cyanophyceae and/or Chlorophyceae members. Under diverse climatic conditions and on diverse substrates, lichens can grow. Lichens are the significant components of Indian biota and at comprise over 2,900 species which is 14.8% of the world's known species (19,500 spp.) under phylum Ascomycota, of which about 540 (over 18%) species are endemic to Indian boundaries (<https://bsi.gov.in/page/en/lichens>). About 49 species are recorded from Gujarat state with special reference to coastal habitats of Gujarat state and islands of Marine Protected Area, Jamnagar district, Gujarat (Nayaka et al. 2010; Nayaka et al. 2013; Ingle et al. 2014, 2017). A total of 79 species were recorded for Gujarat state by Nayaka (2015) while assessing the diversity of mangrove lichens in Gujarat with special reference to coastal habitats, of which 15 species were mentioned from Bhavnagar district. However, Alang-Sosiya Shipyard was not explored for lichen diversity so far. Hence, an attempt has been made to record and prepare a checklist of the lichen diversity for Alang-Sosiya Shipyard located on the west coast of India.

The field trips were arranged during the year 2015-2017 to Alang-Sosiya Ship Breaking and Recycling Yard (ASSBRY) in short Alang-Sosiya Shipyard. Alang (21°23'N; 72°10'E) and Sosiya (21°26'N; 72°12'E) are located 50 km in a southeast direction from Bhavnagar, Gujarat, India. Established in 1982, ASSBRY is the world's largest ship-breaking zone on the North-west of Gulf of Khambhat or Kambay. ASSBRY spreads over about 14 km stretch on the coast. The coast is mostly rocky with boulders and overlaying silt-clay in the southern region (Figure 1).

The study area lies within a semi-arid, drought-prone coastal zone of saline soils. The area has an average annual rainfall of 558 mm; the mean maximum and minimum temperatures are 34.2°C and 21.9°C, respectively. The natural vegetation is classified as semi-arid scrub forest. *Prosopis juliflora* (Sw.) DC locally called "*Gando baval*" is an exotic small tree that grows abundantly in the study area. The area falls under the central Indian region of lichenogeographical regions of India (Singh and Sinha 1997).

MATERIALS AND METHODS

The present study is based on the observations of 56 lichen specimens collected from the study area. All the collected samples were air dried, mounted on herbarium sheets with the help of quick-fix. They were examined for their morphology, anatomy, and chemistry. The morphological characters of lichen specimens were studied under MICROS

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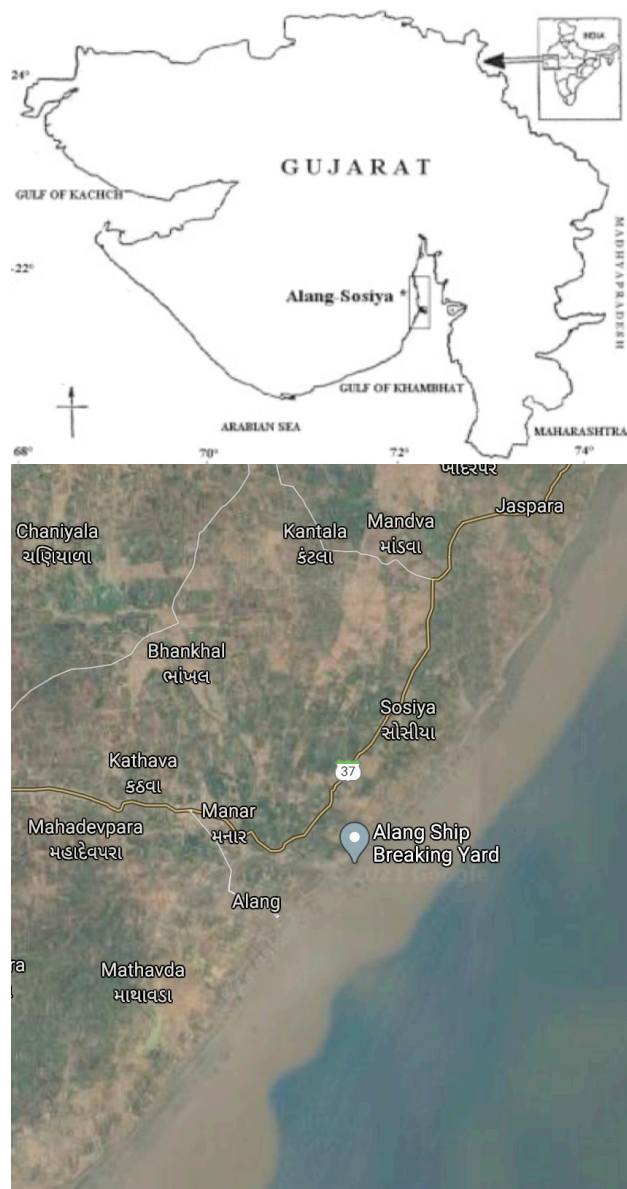


Figure 1: Location of the study area in Gujarat state

LADYBIRD MZ 1240 Zoom Stereo Microscope. The anatomy of lichen thallus and ascomata were examined under OLYMPUS MLX-B PLUS light microscope and Leica TM DM 500 optical microscope. Hand-cut sections of thalli and ascomata were studied in distilled water, and KOH mounts. The color spot tests of the thalli were tested with 5% KOH (K), undiluted commercial bleach (C), and 0.5 g of *p*-phenylenediamine diluted in 5 ml of ethanol (P). Thin Layer Chromatography (TLC) was performed in solvent systems A & C on silica gel pre-coated 60F₂₅₄ aluminium sheets 20 × 20 cm size following Orange et al. (2001). The specimens were identified up to species level following the literature of Awasthi (1991, 2007), Ertz and

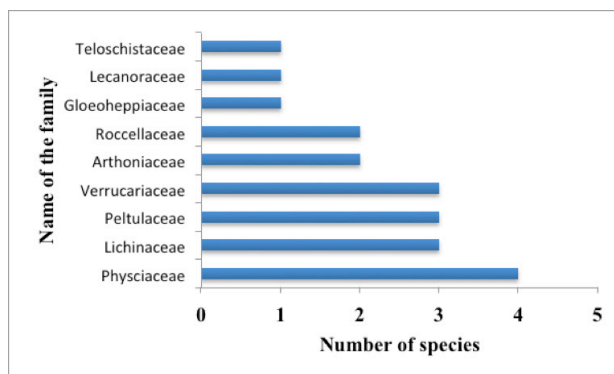


Figure 2: Number of species in the families

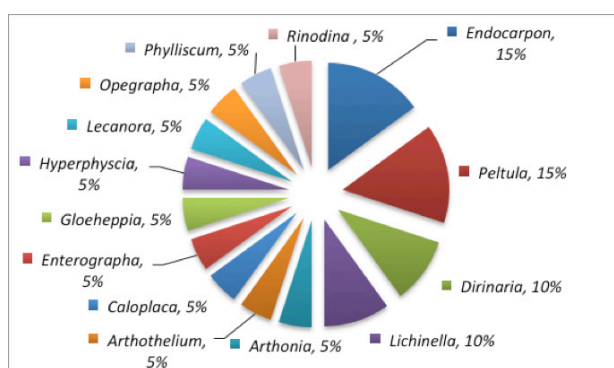


Figure 3: Percentage of species in the genera

Diederich (2007), and Ertz (2009). The nomenclature is updated following www.mycobank.org, and classification was updated following Lücking et al. (2017). The identified specimens are preserved in the Department of Botany, Smt S M Panchal Science College, Talod, Gujarat. A set of voucher specimens are deposited in the herbarium of CSIR-National Botanical Research Institute, Lucknow (LWG).

RESULTS AND DISCUSSION

The study revealed the occurrence of 20 species within 14 genera belonging to nine families along Alang-Sosiya Shipyard area (Table 1). The family Physciaceae represented four species followed by Verrucariaceae, Lichinaceae, and Peltulaceae, each with three species; Arthoniaceae and Roccellaceae each with two species and Teloschistaceae, Gloeoheppiaceae and Lecanoraceae each represented one species (Figure 2). The dominant genera *Endocarpon* and *Peltula* represented three species each, followed by *Dirinaria* with two species. Hence, these three genera contribute 40% of the total number of species. On the other hand, *Arthonia*, *Arthothelium*, *Caloplaca*, *Enterographa*, *Gloeoheppia*, *Hyperphyscia*, *Lecanora*, *Lichinella*, *Thallinocarpon*, *Pseudoschismatomma*, *Phyllicum*, and *Rinodina* represented one species each, and these 12 genera contribute rest of the 60% (Figure 3).

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Table 1: List of lichens with new records, location, growth forms and herbarium number in Alang-Sosiya Shipyard area.

Sl. No.	Name of Taxa/Family	New records for Gujarat	Habitat	Latitude/ Longitude	Growth form	LWG Accession No
1	<i>Arthonia</i> sp./ Arthoniaceae	Yes	Corticolous	N 21°29'23.3"/ E 72°14'74.2"	Crustose	58554
2	<i>Arthothelium chiodectoides</i> (Nyl.) Zahlbr./ Arthoniaceae	Yes	Corticolous	N 21°24'56.5"/ E 72°09'65.7"	Crustose	58555
3	<i>Caloplaca cupulifera</i> (Vain.) Zahlbr./ Teloschistaceae		Saxicolous	N 21°22'98.1"/ E 72°09'84.5"	Crustose	58556
4	<i>Dirinaria confluens</i> (Fr.) D.D. Awasthi/ Physciaceae		Saxicolous	N 21°22'98.1"/ E 72°09'84.5"	Foliose	58557
5	<i>Dirinaria confusa</i> D.D. Awasthi/ Physciaceae	Yes	Corticolous	N 22°22'34.7"/ E 41°03'71.5"	Foliose	58558
6	<i>Enterographa pallidella</i> (Nyl.) Redinger/ Roccellaceae		Corticolous	N 21°22'94.5"/ E 72°09'91.4"	Crustose	58559
7	<i>Endocarpon pallidum</i> Ach./ Verrucariaceae	Yes	Saxicolous	N 21°26'83.6"/ E 72°13'51.3"	Squamulose	58560
8	<i>Endocarpon rosettum</i> Ajay Singh & Upreti/ Verrucariaceae	Yes	Saxicolous	N 21°22'32.1"/ E 72°09'91.3"	Squamulose	58561
9	<i>Endocarpon subrosettum</i> Ajay Singh & Upreti/ Verrucariaceae	Yes	Saxicolous	N 21°22'94.5"/ E 72°09'91.6"	Squamulose	58562
10	<i>Gloeoheppia turgida</i> (Ach.) Gyeln./ Gloeoheppiaceae		Saxicolous	N 21°22'98.1"/ E 72°09'84.5"	Crustose	58563
11	<i>Hyperphyscia adglutinata</i> (Flörke) Mayrhofer & Poelt/ Physciaceae	Yes	Saxicolous	N 21°24'56.5"/ E 72°09'65.7"	Foliose	58564
12	<i>Lecanora achroa</i> Nyl./ Lecanoraceae		Corticolous	N 21°22'94.5"/ E 72°09'91.6"	Crustose	58565
13	<i>Lichinella flexa</i> Henssen, Büdel & T.H. Nash/ Lichinaceae	Yes	Saxicolous	N 22°22'34.7"/ E 41°03'71.5"	Foliose	58566
14	<i>Thallinocarpon nigritellum</i> (Lettau) P.M. Jørg./ Lichinaceae	Yes	Saxicolous	N 22°22'34.7"/ E 41°03'71.5"	Foliose	58567
15	<i>Pseudoschismatomma rufescens</i> (Pers.) Ertz & Tehler/ Roccellaceae	Yes	Corticolous	N 21°22'94.5"/ E 72°09'91.4"	Crustose	58568
16	<i>Peltula euploca</i> (Ach.) Poelt ex Ozenda & Clsuzade/ Peltulaceae		Saxicolous	N 21°22'98.1"/ E 72°09'84.5"	Crustose	58569
17	<i>Peltula patellata</i> (Bagl.) Swinscow & Krog/ Peltulaceae	Yes	Saxicolous	N 22°22'34.7"/ E 41°03'71.5"	Crustose	58570
18	<i>Peltula zahlbruckneri</i> (Hasse) Wetmore/ Peltulaceae	Yes	Saxicolous	N 21°22'90.1"/ E 72°09'85.6"	Crustose	58571
19	<i>Phylliscum indicum</i> Upreti/ Lichinaceae		Saxicolous	N 21°22'98.1"/ E 72°09'84.6"	Crustose	58572
20	<i>Rinodina sophodes</i> (Ach.) A. Massal./ Physciaceae	Yes	Corticolous	N 22°22'94.5"/ E 72°09'91.4"	Crustose	58573

Out of the total recorded genera, *Arthonia*, *Arthothelium*, *Caloplaca*, *Enterographa*, *Gloeoheppia*, *Lecanora*, *Pseudoschismatomma*, *Peltula*, *Phyllicum* and *Rinodina* have crustose growth form, contributing 60% with 12 species. Whereas *Dirinaria*, *Hyperphyscia* and *Lichinella* and *Thallinocarpon* have foliose form, contributed 25% with five species, and only single genus *Endocarpon* is a squamulose with three species contributed 15% to the total (Figure 4).

The substratum for the growth of lichens at study area included coastal rocks, *Azadirachta indica* A. Juss., *Ficus benghalensis* L., *Mangifera indica* L. and *Manilkara hexandra* (Roxb.) Dubard. Accordingly, saxicolous lichens on coastal rocks dominated in the area represented by 13 species (65%) and corticolous by seven species (35%) (Figure 5). Although the study area consisted of *Prosopis juliflora* as major vegetation forming natural forest, its bark did not support the growth of lichens. The mangroves at the area under study were moderately dense and grew in the creek area. It occupied around 0.26 ha area. The height reported was 10-15 m, while the circumference at breast height (CBH) ranged from 20-50 cm. *Avicennia marina* (Forssk.) Vierh. was the only mangrove species found at ASSBRY, which did not host any lichens.

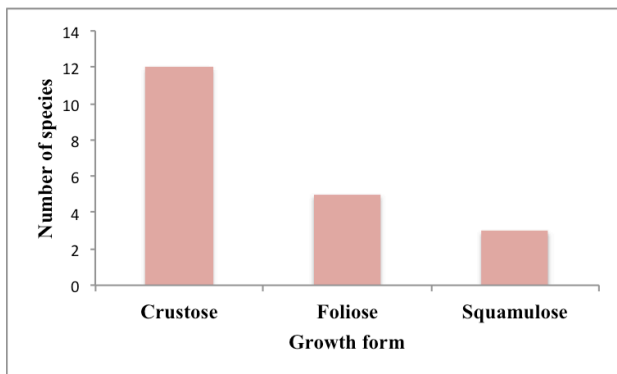


Figure 4: Growth forms of the species

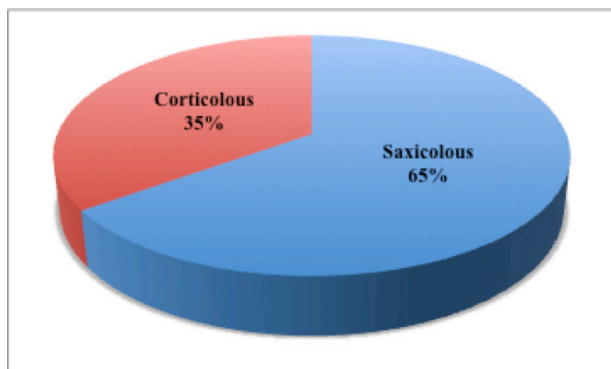


Figure 5: Habitat occupied by lichen species

The uniqueness of lichen mycota in Alang-Sosiya Shipyard area of coastal belts lies in the dominance of the crustose lichens except for very few foliose and squamulose lichens. The dry and arid climatic condition of the coastal area is suitable for growth of mostly crustose lichens (Nayaka et al. 2013). Further, the lichen species *Endocarpon pallidum* Ach., *Endocarpon rosettum* Ajay Singh & Upreti and, *Endocarpon subrosettum* Ajay Singh & Upreti belonging to Verrucariaceae are typical elements of arid areas (Shukla et al. 2014). Four cyanolichen species such as *Lichinella flexa* Henssen, Büdel & T.H. Nash, *Thallinocarpon nigritellum* (Lettau) P.M. Jørg., and *Phyllicum indicum* Upreti belonging to family Lichinaceae, and *Gloeoheppia turgida* (Ach.) Gyeln. of family Gloeoheppiaceae were found in the present study. The cyanolichens are sensitive to acidification from air pollution (Cameron and Richardson 2006). These pollution-sensitive lichens in ASSBRY indicate that the area has good air quality. The proposed pollution-sensitive indicator species for Nova Scotia are almost all cyanolichens (Cameron et al. 2007), which is consistent with studies in Europe and North America that indicate that cyanolichens are particularly sensitive to acid rain, sulphur dioxide, and nitrogen oxides (Gilbert 1986; Hallingback 1989; Hawksworth and Rose 1970; Sigal and Johnston 1986). The cyanolichens are especially affected because nitrogen fixation, essential for their survival, is more sensitive to acid rain than photosynthesis (Gries 1996).

Members of the family Physciaceae such as *Dirinaria confluens* (Fr.) D.D. Awasthi, *D. confusa* D. D. Awasthi, *Hyperphyscia adglutinata* (Flörke) H. Mayrhofer & Poelt, and *Rinodina sophodes* (Ach.) A. Massal, as they survive in an unfavorable environment is considered to be toxic tolerant. Hence, it may also be considered as an indicator for pollution. It is also considered as 'early alarming devices' for the deteriorating air quality in the area (Hussan et al. 2013).

CONCLUSION

The current study being the first report of lichens from Alang-Sosiya Shipyard area, will be very helpful as baseline data for the future. The lichens being sensitive to the microclimatic condition, can be used as biomonitors keeping in view of anthropogenic disturbances in the area. The study area is largely occupied by ship-breaking activities. The area has one of the largest ship-breaking facilities in Asia; it results in all kinds of pollution, leading to a severe change in lichen biodiversity. It is proposed that the same study should be undertaken after ten years to check the lichen diversity of the area with respect to air pollution, as lichens are reliable bio-indicators.

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