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Diversity of Saxicolous Lichens across the Marine Protected Area, West coast, Gujarat

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ABSTRACT

From 2015 to 2018, extensive surveys were conducted in the Marine National Park and Sanctuary (MNPS) of the Gulf of Kachchh, Gujarat, India, focusing on saxicolous lichens in coastal habitats. The MNPS may be collectively called marine protected area (MPA). A total of 138 samples were collected, with 83 from coastal areas and 55 from islands, resulting in the identification of 32 lichen species across 19 genera and 11 families. Notably, *Phylliscum indicum* was found on both natural and artificial substrates. The study added 17 new saxicolous species to the state's records and highlighted the unique lichen communities in these coastal environments. The findings provide a baseline for future bio-monitoring, serve as bioindicators for conservation, and suggest potential applications in medicine and industry, particularly in monitoring atmospheric heavy metal contamination.

INTRODUCTION

Lichens are symbiotic organisms composed of a fungus (mycobiont) and a photobiont, typically an alga or cyanobacterium. Saxicolous lichens grow on rocks and similar man-made surfaces like concrete. The coastal habitats of the MNPS in Gujarat present unique ecosystems influenced by extreme climatic conditions, such as high winds, temperature fluctuations, and nutrient-poor soils.

Out of a total 32 lichen taxa recorded in the present study, a concise list of 15 lichens reported earlier from Gujarat is provided with relevant literature citations. *Dirina indica* Upreti and Nayaka (Tehler et al. 2013; Nayaka et al. 2013; Nayaka 2015; Punjani et al. 2021a), *Dirinaria aegialita* (Afzel. ex Ach.) B.J. Moore (Nayaka 2015), *Dirinaria confluens* (Fr.) D.D. Awasthi (Punjani et al. 2021b), *Dirinaria consimilis* (Stirt.) D.D. Awasthi (Nayaka 2015), *Endocarpon pallidum* Ach. (Punjani et al. 2021b), *Endocarpon subrosettum* Ajay Singh and Upreti (Punjani et al. 2021b), *Gloeoheppia turgida* (Ach.) Gyein (Nayaka et al. 2013; Nayaka 2015; Punjani et al. 2021b), *Peltula euploca* (Ach.) Poelt (Singh and Sinha 2010; Tehler et al. 2013; Nayaka et al. 2013; Nayaka 2015; Punjani et al. 2021b), *Peltula obscurans* (Nyl.) Gyeln. (Nayaka 2015; Punjani et al. 2021a), *Peltula patellata* (Bagl.) Swinscow and Krog (Punjani et al. 2021b), *Peltula zahlbrucknerii* (Hasse) Wetmore (Nayaka 2015; Punjani et al. 2021a, b), *Phylliscum indicum* Upreti (Nayaka et al. 2013; Ingle et al. 2014; Nayaka 2015; Punjani et al. 2021a, b), *Phylliscum testudineum* Henssen (Nayaka et al. 2013; Ingle et al. 2014; Nayaka 2015; Punjani et al. 2021a), *Physcia convexlla* Moberg (Nayaka 2015) and *Roccella montagnei* Bél. em. D.D. Awasthi (Singh and Sinha 2010; Nayaka et al. 2013; Tehler et al. 2013; Ingle et al. 2014; Nayaka 2015). However, the saxicolous lichen communities in the MNPS have not been thoroughly explored. This study aims to assess the diversity and distribution of lichens on stony substrates within the coastal areas and islands of MNPS for the first time.

Study Area

The MNPS is situated in the intertidal zone of the Gulf of Kachchh (GoK), Gujarat, India, between 22° 15' N and 23° 00' N latitude and 69° 00' E and 70° 33' E longitude. It spans parts of Morbi, Jamnagar, and Devbhumi Dwarka districts (Fig 1) and includes 42 islands, 20 of which have mangroves. Only two islands are inhabited; Beyt Dwarka is an important temple and pilgrim site, while Ajad supports a small farming community. Many of the islands, such as Chusna, Pirotan, Ajad and Beyt Dwarka, are pir and dargah sites (traditional religious sites) having annual pilgrimages and fairs.

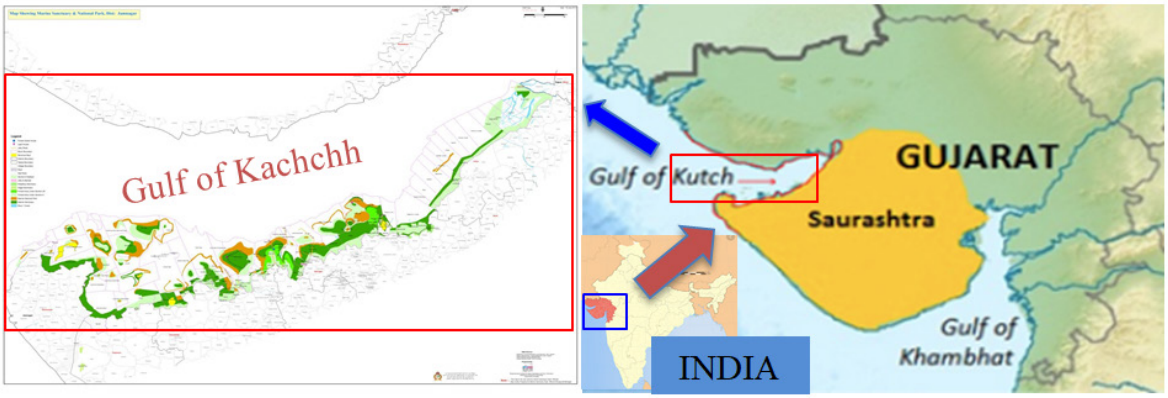

Fig 1: Map showing location of study area-MPA, Gujarat, India

The MNPS covers 457.92 sq km, comprising 162.89 sq km of the Marine National Park and 295.03 sq km of the Sanctuary, and is divided into three zones: eastern, central, and western. Biogeographically, it falls under Zone 4 (Semi-Arid) and Zone 8 (Coastal) (Rodgers and Panwar 1988). The vegetation (Champion and Seth 1968) is classified as Littoral and Swamp Forests (Type 4B) and Northern Tropical Thorn Forests (Type 6B), with predominant rock types in coastal belts including calcareous, igneous (basalt), and sedimentary (limestone), alongside bauxite and laterite minerals.

MATERIALS AND METHODS

This study involved collecting 138 lichen samples from 2015 to 2018 across four zones: eastern coastal, central coastal, western coastal, and various islands. Samples were air-dried and mounted on herbarium sheets. Morphological examinations were conducted using a MICROS LADYBIRD MZ 1240 Zoom Stereo Microscope, while anatomical studies utilized an OLYMPUS MLX-B PLUS light microscope and a Leica TM DM 500 optical microscope. Hand-cut sections were analyzed in distilled water and KOH mounts, and color spot tests were performed with 5% KOH, bleach, and p-phenylenediamine in ethanol. Thin Layer Chromatography (TLC) was carried out on silica gel sheets using solvent systems A and C (Orange et al. 2001). Identification was based on established literature (Awasthi 1991, 2007; Ertz and Diederich 2007; Ertz 2009), with species names confirmed via Index Fungorum and nomenclature updated through MycoBank. The classification was updated following Lücking et al. (2017). Specimens are preserved at Smt. S M Panchal Science College, Talod, Gujarat, with voucher specimens deposited at the CSIR-National Botanical Research Institute, Lucknow (LWG).

RESULTS AND DISCUSSION

A total of 138 saxicolous lichen specimens were collected from 31 localities within the MPA. The investigation identified 32 species across all surveyed sites, representing 19 genera and 11 families of Ascomycota. Table 1 shows saxicolous lichen taxa with growth form, presence in the major zone and rock type. Notably, 17 species are new records for Gujarat state. Detailed zone-wise data on the number of species surveyed, specimens collected, and counts of families, genera, and species is provided in Table 2.

Out of the recorded 32 saxicolous lichens in the present study, 17 lichens, such as, *Amandinea subduplicata* (Vain) Marbach, *Anema decipiens* (Massal.) Forss., *Dirina paradoxa* (Fee) Tehler, *Endocarpon nanum* A. Singh and Upreti, *Lecanographa farinulenta* (Müll.Arg) Egea and Torrente, *Lecanographa hypothallina* (Zahlbr) Egea and Torrent, *Lichinella cribellifera* (Nyl.) P. P. Moreno and Egea, *Lichinella flexa* Henssen and T. H. Nash, *Lichinella nigritella* (Lettau) Moreno and Egea, *Peltula africana* (Jatta) Swinscow and Krög, *Pertusaria indica* Preeti Srivast and D.D Awasthi, *Polymeridium microsporum* (Makhija and Patw.) Aptroot, *Pyxine reticulata* (Vain.) Vain., *Schismatomma galactinum* (Leight.) Zahlbr., *Trapelia coarctata* (Turner) M. Choisy, *Trapeliopsis granulosa* (Hoffm.) Lumbsch and *Zahlbrucknerella indica* Awasthi and S. Singh are new to Gujarat (Fig 2).

The Lichinaceae family was the most represented, with seven species, followed by Peltulaceae and Physciaceae, each with five species. Roccellaceae had four species, Verrucariaceae three, and Lecanographaceae and Trapeliaceae each contributed two species. The remaining families-Caliciaceae, Gloeoheppiaceae, Pertusariaceae, and Trypetheliaceae-each had one species. Overall, Lichinaceae

Table 1: Showing a list of saxicolous lichen taxa in MPA showing growth form, presence in the major zone (P) and type of rock (Y)

S. No.	Lichen taxa/Family	Habit/Growth form	Major zone		Rock Type			
			Coastal Area	Island	Basalt	Bauxite	Laterite	Lime Stone
1	*Amandinea subduplicata* (Vain) Marbach/ Caliciaceae	Crustose	P		Y			
2	*Anema decipiens* (Massal.) Forss./ Lichinaceae	Squamulose	P		Y			Y
3	*Dirina indica* Upreti and Nayaka/ Roccellaceae	Crustose		P	Y			
4	*Dirina paradoxa* (Fee) Tehler/ Roccellaceae	Crustose		P			Y	Y
5	*Dirinaria aegialita* (Afzel. ex Ach.) B.J. Moore/ Physciaceae	Foliose to placodioid	P	P	Y			
6	*Dirinaria confluens* (Fr.) D.D. Awasthi/ Physciaceae	Folios to placodioid	P		Y			
7	*Dirinaria consimilis* (Stirt.) D.D. Awasthi/ Physciaceae	Folios to placodioid	P	P	Y			Y
8	*Endocarpon nanum* A.Singh and Upreti. Verrucariaceae	Squamulose		P				Y
9	*Endocarpon pallidum* Ach./ Verrucariaceae	Squamulose	P		Y			
10	*Endocarpon subrosettum* Ajay Singh and Upreti/ Verrucariaceae	Squamulose		P	Y			
11	*Gloeoheppia turgida* (Ach.) Gyein./ Gloeoheppiaceae	Squamulose to moderately peltate	P	P	Y			Y
12	*Lecanographa farinulenta* (Müll.Arg) Egea and Torrente/ Lecanographaceae	Crustose		P				Y
13	*Lecanographa hypothallina* (Zahlbr) Egea and Torrent/ Lecanographaceae	Crustose	P	P	Y			Y
14	*Lichinella cribellifera* (Nyl.) P.P Moreno and Egea/ Lichinaceae	Foliose to Fruticose	P		Y			
15	*Lichinella flexa* Henssen and T. H. Nash/ Lichinaceae	Foliose to Fruticose	P		Y			
16	*Lichinella nigritella* (Lettau) Moreno and Egea/ Lichinaceae	Foliose to Fruticose	P	P	Y			Y
17	*Peltula africana* (Jatta) Swinscow and Krog/ Peltulaceae	Squamulose	P		Y			
18	*Peltula euploca* (Ach.) Poelt/ Peltulaceae	Squamulose	P	P	Y		Y	Y
19	*Peltula obscurans* (Nyl.) Gyeln./ Peltulaceae	Squamulose	P	P	Y	Y		
20	*Peltula patellata* (Bagl.) Swinscow and Krog/ Peltulaceae	Squamulose	P		Y			Y
21	*Peltula zahlbrucknerii* (Hasse) Wetmore/ Peltulaceae	Squamulose	P		Y			

S. No.	Lichen taxa/Family	Habit/Growth form	Major zone		Rock Type			
			Coastal Area	Island	Basalt	Bauxite	Laterite	Lime Stone
22	*Pertusaria indica* Preeti Srivast and D.D Awasthi/ Pertusariaceae	Crustose		P				
23	*Phylliscum indicum* Upreti/ Lichinaceae	Crustose	P	P	Y	Y	Y	Y
24	*Phylliscum testudineum* Henssen/ Lichinaceae	Crustose	P	P	Y		Y	Y
25	*Physcia convexlla* Moberg/ Physciaceae	Foliose	P					Y
26	*Polymeridium microsporum* (Makhija and patw.) Aptroot Trypetheliaceae	Crustose	P					
27	*Pyxine reticulata* (Vain.) Vain./ Physciaceae	Foliose		P	Y			
28	*Roccella montagnei* Bél/ Roccellaceae	Fruticose	P	P	Y		Y	
29	*Schismatomma galactinum* (Leight.) Zahlbr./ Roccellaceae	Crustose	P		Y			
30	*Trapelia coarctata* (Turner) M. Choisy/ Trapeliaceae	Crustose	P					Y
31	*Trapeliopsis granulosa* (Hoffm.) Lumbsch/ Trapeliaceae	Squamulose		P	Y			
32	*Zahlbrucknerella indica* Awasthi and S. Singh/ Lichinaceae	Subfruticose	P	P	Y			Y

Table 2: Showing zone-wise saxicolous lichen diversity recorded in MPA

Zone	No. of sites surveyed	No. of specimens collected	No. of families	No. of genera	No. of species
Eastern Zone	3	9	4	6	6
Central Zone	8	29	3	5	8
Western Zone	11	47	9	14	22
Coastal area (Total)	22	85	10	15	24
Islands	9	53	9	13	19
MPA (Total)	31	138	11	19	32

accounted for 22% of the total species identified in this study (Fig 3).

Among the dominant genera, *Peltula* represented five species, contributing 16% to the total species count. *Dirinaria*, *Endocarpon*, and *Lichinella* each had three species (9%). *Dirina*, *Lecanographa* and *Phylliscum* contributed two species each (6%). The remaining twelve genera-*Amandinea*, *Anema*, *Gloeoheppia*, *Pertusaria*, *Physcia*, *Polymeridium*, *Pyxine*, *Roccella*, *Schismatomma*, *Trapelia*, *Trapeliopsis* and *Zahlbrucknerella*-each had one species (3%) (Fig 4).

Based on occurrence in the major zones, out of the total species recorded, 41% (13 species) were found only in the coastal belt, 25% (8 species) only on the islands, and 34% (11 species) were common to both areas (Fig 5). This distribution suggests that the coastal belt and islands each contribute a significant portion to the total species diversity, with a considerable overlap between the two zones.

In terms of growth forms, crustose lichens were the most dominant, making up 34% of the total species. Squamulose followed at 31%. Foliose to fruticose and to placodioid forms, each accounted for 10%. Foliose made

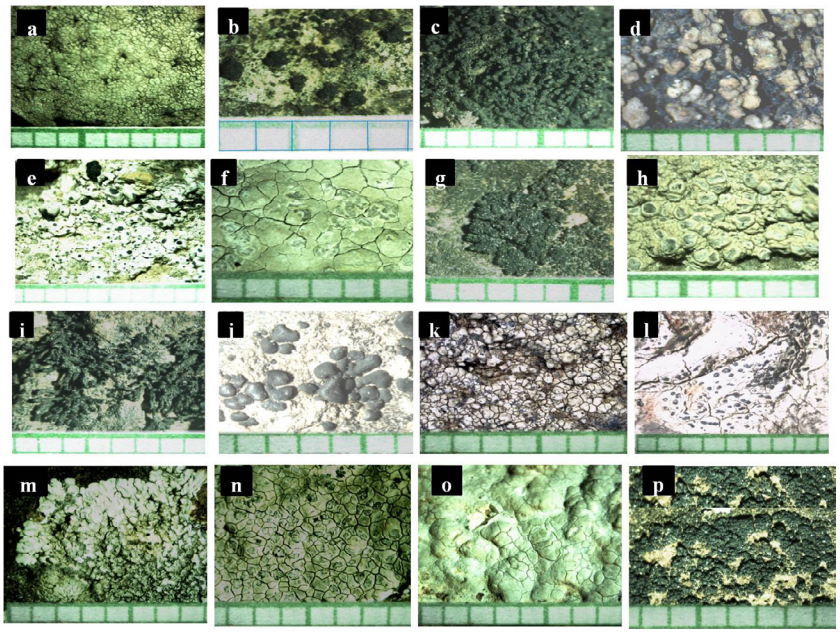

Fig 2: Showing saxicolous lichens-new records to Gujarat state-collected from MPA ***a.*** *Amandinea subduplicata*, **b.** *Anema decipiens*, **c.** *Dirina paradoxa,* **d.** *Endocarpon nanum,* **e.** *Lecanographa farinulenta,* **f.** *Lecanographa hypothallina,* **g.** *Lichinella cribellifera,* **h.** *Lichinella flexa,* **i.** *Lichinella nigritella,* **j.** *Peltula Africana,* **k.** *Pertusaria indica,* **l**. *Polymeridium microsporum,* **m.** *Pyxine reticulata,* **n.** *Schismatomma galactinum,* **o.** *Trapelia coarctata,* **p.** *Zahlbrucknerella indica.*

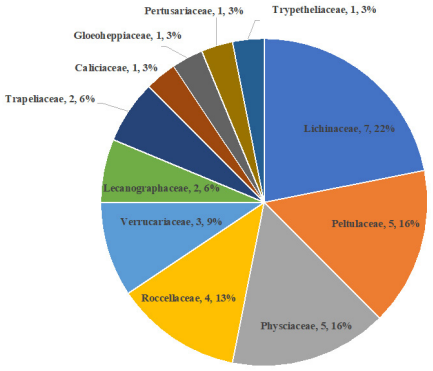

Fig 3: Showing number of species followed by percentage to the family

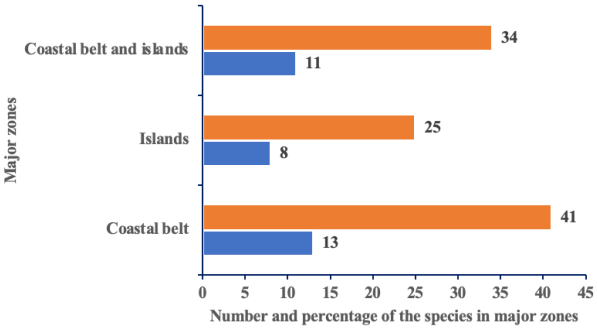

Fig 5: Showing number and percentage of the species in major zones of the MPA

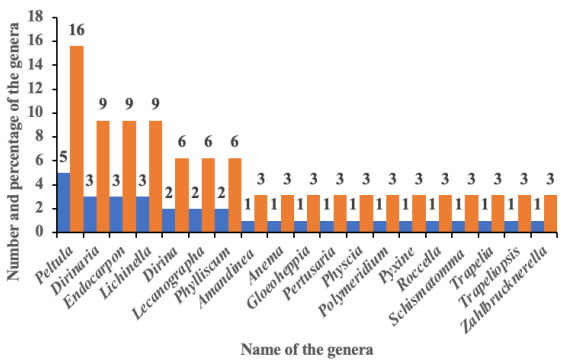

Fig 4: Showing number and percentage of the genera

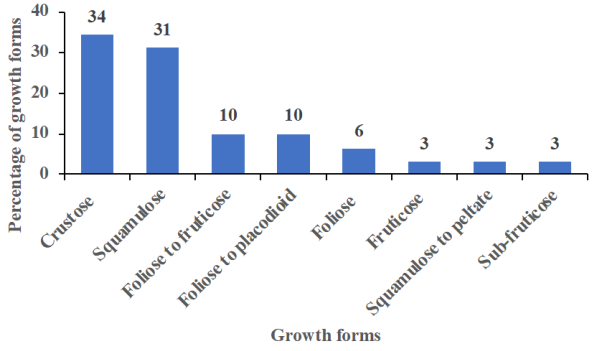

Fig 6: Showing percentage of growth forms to the species of MPA

up 6%, while fruticose, moderately peltate squamulose, and sub-fruticose forms each represented 3% (Fig 6).

CONCLUSION

This study highlights the unique saxicolous lichen diversity in the semi-arid coastal habitats of Gujarat, influenced by harsh climatic conditions and limited resources. It serves as the first report on saxicolous lichens in the state, offering a baseline for future bio-monitoring, as lichens are sensitive to air pollution and climate change. Pollution-sensitive species like *Dirina indica* can be used for pollution monitoring, while pollution-tolerant species such as *Dirinaria*, *Phylliscum* and *Peltula* can help study environmental resilience. The present study opens some of the interesting areas such as ecological differences governing the distribution of lichen in coastal areas and islands in GoK. The study suggests repeating this research in ten years to assess changes in environmental quality and encourage further exploration of lichen diversity across Gujarat.

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