

Study on distribution of *Roccella montagnei* B el., across the Marine National Park and Sanctuary in Gulf of Kachchh, West Coast, India

Bhasker Punjani¹, Jayesh Raval¹, Sanjeeva Nayaka² and Dalip Kumar Upreti²

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

²Lichenology Laboratory, CSIR-National Botanical Research Institute, Lucknow-226 001, Uttar Pradesh, India

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*Corresponding author:

e-mail: blpunjani1958@gmail.com

ABSTRACT

Several field explorations were undertaken during 2015–2018 to study the distribution of *Roccella montagnei* B el., across the Marine National Park and Sanctuary in Gujarat. *R. montagnei* is the only fruticose lichen of family Roccellaceae recorded from MNPS area. A total of 108 specimens were collected from bark and rocks. The epiphytic lichens were recorded from 17 species of plants. The study revealed that *Ceriops tagal*, a mangrove plant and *Salvadora persica*, a mangrove associated plant found to be the major substratum for the lichens followed by *Rhizophora mucronata*. Out of the 19 islands surveyed *R. montagnei* is recorded from 15 islands of which Bhens bid and Bhaidar showed luxuriant growth. The information gathered in the study will act as baseline data and useful for future ecological and biomonitoring studies in the National Park. The abundant growth of *R. montagnei* in the study area can serve as resource for the bioprospecting and identification of secondary metabolites.

INTRODUCTION

Lichens of India are being studied since 1753 AD. Linnaeus mentioned the occurrence of Lichen *fuciformis* L. (= *Roccella fuciformis* (L.) DC) from India, in his masterpiece 'Species Plantarum' (Nayaka and Upreti 2005). Awasthi (1965) opined that *R. fuciformis* does not occur in India and correct identity should be *Roccella montagnei* B el. It is the most widespread of all *Roccella* species ranging from Australia, around the Indian Ocean and further on along the west coast of Africa up north to the Cape Verde Islands. Globally it was reported from New Caledonia, Northern Australia, Philippines and Indonesia (Java, Sumatra). In India it was collected from the coastal line 30–35 km inwards from various states such as Andhra Pradesh, Karnataka, Kerala, Maharashtra, Odisha, Pondicherry, Tamil Nadu and West Bengal (Tehler et al. 2010). In a study carried out by Sethy et al. (2012) it was observed that members of family Roccellaceae were completely lacking in Andaman islands except for *R. montagnei* which was also the only fruticose lichen recorded. It is one of the most common, widely distributed and abundant lichens in Gujarat state found growing on barks of mangroves and mangroves associated plants as well on some rocks in the coastal areas of Gulf of Kachchh (GoK).

Thallus of the lichen *R. montagnei* was used as a source of a natural dye for colouring the royal fabrics during historical

times. The orcinol group of secondary compounds of the lichen was found important as a dying agent. Currently, the interests on natural dyes from lichens are reviving and the natural thallus of *R. montagnei* is considered as a potential resource of dyes (Shukla et al. 2014). *R. montagnei* contains wide array of secondary metabolites including roccelic acid, erythrinand lecanoric acid. It is popularly known as 'litmus lichen' as it is utilized for preparation of acid-base indicator used as a litmus paper (Nash 2008). Further the natural thallus extracts of *R. montagnei* showed antibacterial and antifungal activity against many of human pathogens. Recently *R. montagnei* is also used as larvicidal activity against filarial vector (Balaji et al. 2006, 2007).

The uniqueness of lichen biota of Marine National Park and Sanctuary (MNPS) in Gujarat is the dominance of lichen family Roccellaceae (Ingle et al. 2014). It is observed that that family is represented by 14 species of which *R. montagnei* was recorded as only fruticose lichen (Nayaka et al. 2010, 2013). The lichens of Gujarat remained poorly studied as compared to Angiosperms. No one has made any attempt to study the distribution of *R. montagnei* in marine protected areas of Gujarat. Hence, for the first time the present study was carried out on distribution of *R. montagnei* using first hand data collected during three years of explorations in different localities in coastal belt and islands of MNPS.



Fig 1: Map showing location of Marine National Park and Sanctuary, GoK, Gujarat, India

Study area

Among the Indian maritime states, Gujarat state has the longest coastline extending 1600 km. The present study was carried out in the GoK, Gujarat. The GoK is situated at western coast of India and located between 22°15' N and 23°40' N Latitudes and 68°20' E and 70°40' E Longitudes. Biogeographically, the area falls in the semi arid and west coast zones according to classification of Rodgers and Panwar (1988). The Southern margin of the GoK is fringed by 42 islands and several coastal areas having coral reefs, mangroves and mudflats that fall in 3 districts viz., Jamnagar, Devbhumi-Dwarka and Morbi.

MNPS was the first declared as Marine Sanctuary in 1980 and later established as Marine National Park in 1982 under the Wildlife (Protection) Act, 1972. The area falls under the Morbi, Jamnagar and Devbhumi-Dwarka districts of Gujarat. The MNPS is situated in the intertidal zone of the Northern Saurashtra. The MNPS covers an area of 620.81 km², which includes 148.90 km² areas of islands and 309.02 km² of intertidal zones along the coast form marine sanctuary and, the national park covers an area of 162.89 km² (Singh et al. 2004).

There are several temples on some islands like Beyt Dwarka while many mosques in islands like Patha Pir, Pirotan, Mitha chusana, Ashaba Pir and Q Tapu (Q island). There are two Birds Sanctuary located in the study area. First one, Khijadiya Birds Sanctuary that is unique for salt water and fresh water ecosystems with the variety of habitat types and it is residence of several migratory birds. Second, The Gaga Wildlife Sanctuary is a unique grassland ecosystem, which is a regular route for the migratory birds. Salt works are operating all along the coastal zones from Jodiya to Okha. There are many ports like Sikka, Bedi, Okha, Salaya and Vadinar for the evacuation of products by tanker ships. Ships carrying petroleum, oil, lubricants and bulk of chemicals for Reliance Petro Chemical Ltd and Essar Petro Chemicals. Thermal Power Station like

Essar Power Gujarat Ltd and Sikka Thermal Power Station are also near coastline of MNPS. There are also cement factories located near the coastal area of MNPS.

Majority of Mangroves in Jamnagar Coast of GoK is scrubby and sparse. Diversity of forest on this coast is better than that on other parts of the State. The following six mangrove species recorded from MNPS are *Avicennia alba* Blume, *A. marina* (Forsk.) Vierh., *A. officinalis* L., *Ceriops tagal* Arnold., *Rhizophora mucronata* Lamk and *Aegiceras corniculatum* (L.) Blanco. (Singh 2001, 2006). In addition major non-mangroves or mangrove associated plants such as *Prosopis* spp., *Salvadora persica* and *Euphorbia nerifolia* are observed in the study area. The shoreline is rocky and configuration is highly crenulated and characterized by extensive mudflats, offshore islands and rocky platform with narrow beaches. Most of the islands having mudflat shores with mangrove vegetation dominated by *Avicennia marina*, but there are also sandy beaches and few islands with rocky shores.

The area consists of tropical thorn forests as well as warm semi-arid climate. As per the Indian Meteorological Department rainfall data the mean annual rainfall is 60-70 cm (Fig. 2) during 2016 to 2017. In the GoK the air temperature varies from 10°C to >36°C throughout the year.

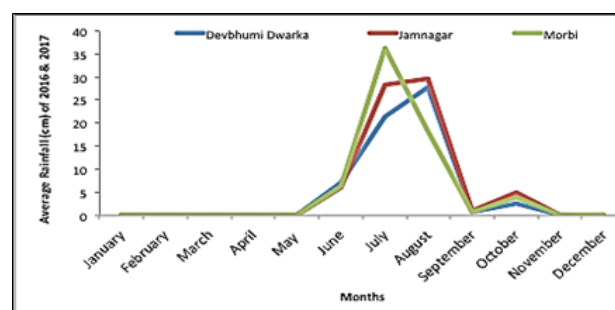


Fig 2: Mean annual rainfall (cm) in three districts of MNPS, GoK, Gujarat. Source: IMD

January is considered to be the coldest month with night temperatures falling below 10°C while May and June are considered to be the hottest months with mean maximum temperature of 36°C during day and mean minimum of 26°C during night. The relative humidity is generally high during monsoon months and range from 70 to 80%. Whereas, rest of the year, humidity ranges between 55 and 70% (Nair 2002).

For the convenience of the study and for the comparison of the distribution of the lichen, the study area has been divided into major two zones: the coastline and the islands. Further, the coastline has been divided into three sub-zones such as Eastern coastal - the area from Jodiya to Rozi bet; Central coastal - the area from Rozibet to Salaya; and Western coastal - the area from Salaya to Okha (Fig. 3).

MATERIALS AND METHODS

The lichen specimens were collected during the year 2015-2018 from islands and various localities of coastal areas with varied substrata (Fig. 3). All the collected specimens were dried in air. The specimens were identified following standard procedure by observing their external morphology, anatomy and chemistry. The Stereo-zoom-dissecting microscope Leica S8APO is used for observing the morphological characteristics. A compound and phase contrast microscope Leica DM500 was used for studying the anatomical characters. The specimens were identified using Awasthi (2007) and voucher specimens are preserved in herbarium of CSIR-National Botanical Research Institute, Lucknow (LWG).

The percentage of the locality and substratum has been deduced based on the collected specimens of *R. montagnei* using the following formula.

The percent locality and substratum of the lichen specimens



Fig 3: Showing zones and sampling locations/sites in MNPS area. 1. Jodiya jetti, 2. Rozi bet, 3. Mandha, 4. Positra, 5. Mulvel, 6. Azad, 7. Beyt Dwarka, 8. Gadu, 9. Q-Tapu, 10. Khimrana, 11. Bhaidar, 12. Bhens bid, 13. Dhabdhaba, 14. Didika Mundeka, 15. Divadi, 16. Lafa Marodi, 17. Patha Pir, 18. Pirotan, 19. Saneda, 20. Kalubhar

collected were assessed using following rank:

Rank A: No lichen specimens collected from any locality/substratum; **lichen desert**

$$\text{Locality (\%)} = \frac{\text{Number of specimens collected from the locality}}{\text{Total number of specimens collected in all the localities}} \times 100$$

$$\text{Substratum (\%)} = \frac{\text{Number of specimens collected from the substratum}}{\text{Total number of specimens collected from all the substrata}} \times 100$$

Rank B: Below 5% of lichen specimens collected from any locality/substratum; **lichen poor**

Rank C: Between 5-10% of lichen specimens collected from any locality/substratum; **lichen average**

Rank D: Above 10% of lichen specimens collected from any locality/substratum; **lichen forest**

RESULTS AND DISCUSSION

The lichen *Roccella montagnei* Bél. Em. D.D. Awasthi (Fig. 4) is characterized by corticolous (rarely saxicolous),



Fig 4: Photographs of *Roccella montagnei* Bél.

fruticose thallus, up to 20 (-25) cm long, profusely branched; branches irregularly widened, strap-shaped, 5 (-10) mm at base or in middle part, tapering, greenish grey, soralia marginal to laminal, orbicular. The spot test includes, cortex K-, C+ red, P-; medulla K-, C-, KC-, Pd- and erythrin present in TLC.

A total of 108 specimens of *R. montagnei* were collected from 20 out of 54 localities surveyed and 17 out of 34 substrates in the study area (Table 1). On the basis of habitat selection or preference for substratum, it was observed that out of the total specimens collected from the study area for *R. montagnei* maximum 99 specimens (92%) consisted of corticolous and only nine specimens (8%) of saxicolous habitat, which exhibits its presence on more than one substratum i.e., multiple substrata, both on barks and rocks (Fig. 5).

With respect to selection of substratum by epiphytic *R. montagnei* in the study area, it is observed (Table 2, Fig. 6) that, four phorophytes provide suitable conditions for support and growth and that constitute collectively almost 67% to the total specimens collected. Each of these plants contribute more than 10% hence fall under rank D. Thus, they form **Roccella forest** in the area. It is interesting to know that out of four plants, two are mangrove species such as, *Ceriops tagal* and *Rhizophora mucronata* and remaining are non-mangroves plants such as *Salvadora persica* and *Prosopis cineraria*. Moreover, these phorophytes constitute only 12% to the total substrata surveyed in the MNPS area. On the other hand, 52% phorophytes do not support *R. montagnei* and showed **Roccella desert**. *Grewia* sp. and *Euphorbia nerifolia* both showing moderate number of *R. montagnei* thallii, contributing 5-10% to the total specimens collected, thus both form **Roccella average** in the area. In addition, 10 plants though supporting growth of *R. montagnei* thallii but their contribution is below 5% to the total specimens collected, forming **Roccella poor** in the MNPS area. A mangrove dominating in the study area i.e., *Avicennia marina* do not support any lichen growth, due to its smooth light-grey bark made up of thin, stiff, brittle flakes, so it forms **Roccella poor** in the MNPS area. On the basis of localities/sites it is observed (Table 3, Fig. 7) that out of total 54 localities surveyed only 20 supported the growth of *R. montagnei*, hence 63% of the surveyed localities (34 locations) can be considered as **Roccella desert**. However, out of the remaining 37% localities, only two localities such as Bhens bid and Bhaidar islands provide suitable microclimatic conditions for the luxuriant growth

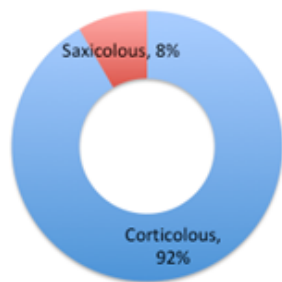


Fig 5: Showing substratum preference of *R. montagnei* in the study area

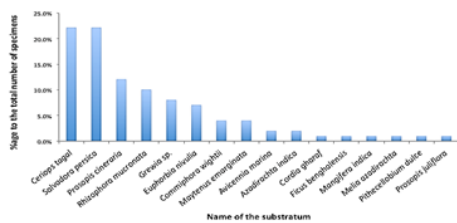


Fig 6: Showing name of the substrata used by epiphytic lichen *R. montagnei* in the study area

of *R. montagnei* that constitute collectively only about 4% to the total localities surveyed. Each of these localities contribute above 10% hence fall under rank D. Thus, these two sites form **Roccella forest** in the area. Moreover, there are 7 localities that constitute about 13% to the total localities surveyed in the MNPS area hence form **Roccella average** in the area. In addition, 11 localities though constitute maximum 20% to the total localities surveyed and, supporting growth of *R. montagnei* but each of these localities contributed below 5% to the total specimens collected hence, forming **Roccella poor** in the MNPS area.

As per above observation 63% of the surveyed localities (34 locations) found to be **Roccella desert**. In short, only 37% locations support growth of the *R. montagnei* lichen. From the Table 4 it can be observed that in the MNPS area, except 4 islands such as, Ashabha Pir, Dariya Pir, Khara Chusna and Noru, almost all the surveyed islands showed presence of *R. montagnei*, contributing up to 27.8% to the total sites surveyed in MNPS area. The remaining 9.2% sites in the coastal area contributed in the collection of the fruticose lichen showed the area is very poor for *R. montagnei* growth.

Out of the two zones of MNPS the islands alone contributed maximum of 92% specimens to the total of 108 specimens of *R. montagnei* collected throughout the study period, whereas coastal area showed very poor contribution of only 9% specimens. Hence, it is clear from the present study that islands in the MPA are richer in fruticose lichen *R. montagnei* than coastal area or mainland. It can be noted that the islands in MNPS have dense mangrove vegetation and more diversity of mangroves as well as their associated species that actually support good growth of *R. montagnei* in comparison to mainland or coastline. In addition, islands showed less anthropogenic activities leading to luxuriant growth of the lichen in the MNPS area.

CONCLUSION

This is the first study conducted to determine the distribution of a single fruticose lichen *R. montagnei* growing in MNPS area using primary data collected during 2015-2018 field explorations across the marine protected area.

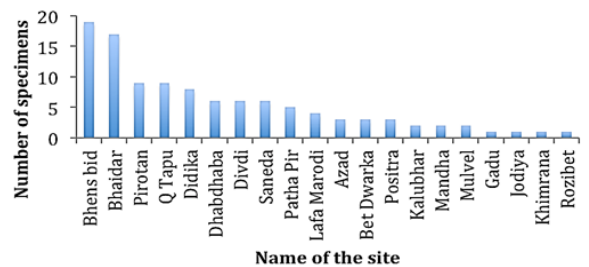


Fig 7: Showing locality-wise number of *R. montagnei* specimens collected from the MNPS area

Distribution of *Roccella montagnei* in MNPS

Table 1: Detailed information on *R. montagnei* collected from MNPS, GoK, Gujarat, India

Sl.No	Locality	Latitude	Longitude	Zone	Substratum
1	Rozibet	N 21°32.216	E 072°02.124	EC	<i>Prosopis juliflora</i>
2	Jodiya jetty	N 22°41.912	E 070°18.579	EC	<i>Prosopis cineraria</i>
3	Mandha	N 22°20.030	E 069°38.793	CC	<i>Ficus benghalensis, Mangifera indica</i>
4	Positra	N 22°23.485	E 069°11.995	WC	<i>Melia azedarach, Rocks</i>
5	Mulvel	N 22°20.306	E 069°10.087	WC	<i>Salvadora persica</i>
6	Azad	N 22°22.551	E069°20.105	Island	<i>Salvadora persica, Prosopis cineraria, Rocks</i>
7	Beyt Dwarka	N 22°27.253	E 069°05.519	Island	<i>Azedarach indica, Euphorbia nerifolia</i>
8	Gadu	N 22°19.577	E 069°20.959	Island	Rocks
9	Q Tapu	N 22°24.273	E069°06.108	Island	<i>Grewia sp., Commiphora wightii, Euphorbia nerifolia, Prosopis cineraria, Rocks</i>
10	Khimrana	N 22°20.181	E 069°19.705	Island	Rocks
11	Bhaidar	N 22°27.492	E 069°17.717	Island	<i>Salvadora persica, Euphorbia nerifolia, Ceriops tagal, Maytenus emarginata, Prosopis cineraria</i>
12	Bhens bid	N 22°33.002	E 069°56.617	Island	<i>Ceriops tagal, Salvadora persica, Avicennia marina, Prosopis cineraria, Rhizophora mucronata</i>
13	Dhabdhaba	N 22°22.187	E 069°11.500	Island	<i>Commiphora wightii, Grewia sp., Pithecellobium dulce, Salvadora persica, Rocks</i>
14	Didika Mundeka	N 22°31.871	E 069°55.619	Island	<i>Ceriops tagal, Rhizophora mucronata, Salvadora persica</i>
15	Divadi	N 22°22.770	E 069°10.446	Island	<i>Grewia sp., Euphorbia nerifolia, Commiphora wightii, Maytenus emarginata</i>
16	Lafa Marodi	N22°23.044	E 069°11.586	Island	<i>Cordia gharaf, Salvadora persica, Commiphora wightii, Rocks</i>
17	Patha pir	N 22°31.288	E 069°55.930	Island	<i>Rhizophora mucronata, Ceriops tagal</i>
18	Pirotan	N 22°36.181	E 069°57.179	Island	<i>Ceriops tagal, Salvadora persica, Avicennia marina, Prosopis cineraria, Rhizophora mucronata</i>
19	Saneda	N 22°33.515	E 069°57.419	Island	<i>Ceriops tagal, Salvadora persica, Rhizophora mucronata</i>
20	Kalubhar	N22°25.349	E 069°36.053	Island	<i>Ceriops tagal, Rocks</i>

CC: Central Coastal; EC:Eastern Coastal; WC:Western Coastal.

Distribution of *Roccella montagnei* in MNPS

Table 2: Showing plant species on the basis of percent substratum along with rank for *R. montagnei* from MNPS

Scale, Rank	No. of substratum recorded for lichens	Name of the substratum for lichens	% age to the total substrata surveyed	Inference/Remark
0%, A	17	<i>Acacia senegal</i> , <i>Asparagus recemosus</i> , <i>Cocos nucifera</i> , <i>Crataeva nurvala</i> , <i>Hyphaene indica</i> , <i>Maerua oblongifolia</i> , <i>Parkinsonia aculeata</i> , <i>Salvadora oleoides</i> , <i>Suadea</i> sp., <i>Syzygium cuminii</i> , <i>Tamarandus indica</i> , <i>Thespesia populnea</i> , Lime plaster, Wood, Wood of old door, Soil, Roofing tile	52%	<i>Roccella</i> desert
Below 5%, B	10	<i>Commiphora wightii</i> , <i>Maytenus emarginata</i> , <i>Avicennia marina</i> , <i>Azedarach indica</i> , <i>Cordia gharaf</i> , <i>Ficus benghalensis</i> , <i>Mangifera indica</i> , <i>Melia azedarach</i> , <i>Pithecellobium dulce</i> , <i>Prosopis juliflora</i>	30%	<i>Roccella</i> poor
Between 5-10%, C	2	<i>Grewia</i> sp., <i>Euphorbia nerifolia</i>	6%	<i>Roccella</i> average
Above 10%, D	4	<i>Ceriops tagal</i> , <i>Salvadora persica</i> , <i>Prosopis cineraria</i> , <i>Rhizophora mucronata</i>	12%	<i>Roccella</i> forest
Total	33		100%	

Table 3: Showing name of locality on the basis of percent locality along with rank for *R. montagnei* from MNPS

Scale, Rank	No. of localities recorded for lichens	Name of the locality for lichens	% age to the total localities surveyed	Inference/Remark
0%, A	34	Ashabha Pir, Dariya Pir, Khara Chusana, Noru (islands) and except Positra, Mandha, Mulvel, Jodiya and Rozi bet remaining all coastline localities	63%	<i>Roccella</i> desert
Below 5%, B	11	Lafa Marodi, Azad, Beyt Dwarka, Positra, Kalubhar, Mandha, Mulvel, Gadu, Jodiya, Khimrana, Rozi bet	20%	<i>Roccella</i> poor
Between 5-10%, C	7	Pirotan, Q-Tapu, Didika Mundeka, Dhabdhaba, Divdi, Saneda, Patha Pir	13%	<i>Roccella</i> average
Above 10%, D	2	Bhens bid, Bhaidar	4%	<i>Roccella</i> forest
Total	54		100%	

Distribution of *Roccella montagnei* in MNPS

Table 4: Showing name of zones and percentage to the sites surveyed and specimens collected of *R. montagnei* from MNPS area

Zone/Coastal area	Total no. of localities/ sites surveyed	No. of sites from where <i>R. montagnei</i> recorded	% age to total sites surveyed	No. of specimens collected	% age to the no. of total specimens
Islands	19	15	27.8%	99	92%
Western coastal	17	2	3.7%	5	5%
Central coastal	12	1	1.8%	2	2%
Eastern coastal	6	2	3.7%	2	2%
Total	54	20	37.0%	108	100%

Being sensitive to change in the microclimatic conditions *R. montagnei* can be used as biomonitor keeping in view of anthropogenic activities prevailing in the protected area. The study also opens some of the interesting areas such as ecological difference governing the distribution of *R. montagnei* in GoK. The physiological responses and adaptation of *R. montagnei* in the islands and coastal areas would be another interesting area for the future study. The abundant growth of *R. montagnei* in the islands of the study area can be utilized as resource for bio-prospecting studies and study related to air pollution as the lichen thallus directly absorbs pollutants from the atmosphere.

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