ABSTRACT OF THE THESIS

The present study deals with the assessment of Marine Algal diversity of the Maharashtra Coast, India. In recent times, considerable importance is given to preserve or rather conserve our flora and fauna. The area has been less explored so far. There are very few collections from the Maharashtra coast deposited in various herbaria. Though the area has tremendous potential from the floristic point of view, it was ignored due to many reasons like inaccessibility to many places, remoteness from the main coast and only few species or a particular genus has been studied from taxonomic point of view.

Floristic study of Marine algae from the Maharashtra Coast was undertaken as a part of the Botanical Survey of India and Ministry of Environment & Forests Project. The findings of this research study are presented in the thesis.

The thesis is divided mainly into Introduction, Review of Literature, Materials and Methods, Habitat photographs, Maps & Line drawings, List of the species from the Maharashtra Coast, Systematic Treatment, Discussion & Concluding Remarks, Bibliography and Websites consulted, followed by an Index to Botanical Names and Publications.

India has a long coast line of about 7500 km including the coastal belt around Andaman & Nicobar islands and Lakshadweep group of islands on either side of the peninsular India and Exclusive Economic Zone (EEZ) of about 2.5 million km² and have a large shelf area i.e. 0.13 million km² extending from the shore towards seaward side. This EEZ is economically and ecologically potential area in terms of resource base i.e. both biological and non-biological in the form of seaweeds, sea grasses, marine aquatic fauna, microbial populations, minerals etc. The marine ecosystem becomes vibrant due to these life forms with interactions among themselves and with the surrounding aquatic habitat.

The Indian coast harbours as many as 844 marine algal species (Chlorophyta: 216, Phaeophyta: 191, Rhodophyta: 434) as per the extant checklists available in the public domain. These life forms, as primary producers, provide food and shelter to a variety of animal species in the marine environment while contributing carbon content to the coastal habitat. Survey and exploration of marine algae since the beginning of the
20th century by the Danish phycologist Børgesen on the Indian coast followed by Indian algologists viz. M.O.P. Iyengar, Srinivasan, Desikachary, Joshi & Krishnamurthy, Untawale, Umameshwara Rao and a host of other algologists has enriched our knowledge on the marine algal biodiversity on the Indian coast.

Maharashtra Coast - Area under study:

The west coast of India, particularly Gujarat coast, is well studied for marine algal resources but the data available on the marine algal wealth of Maharashtra coast which is 720 Km long, is scattered and relatively meagre. The total number of species collected and reported from the Maharashtra coast is around 240 of which how many are presently available is less known due to lack of periodical survey. In the present attempt studies are made systematically from 2004 to 2009 during low tides along the Maharashtra coast after tide time tables are invariably consulted in order to have a holistic view so that the ensuing regional flora will be of much use for those who are engaged in writing Indian Marine Algal Flora.

Børgesen, Chaugule, Gunale, Kinkar, Deodhar have been the pioneering algologists who have contributed to our knowledge on the marine algal wealth of the Maharashtra coast. Their studies, however, left much scope for subsequent workers to continue survey and exploration of unexplored and under explored areas and seasons. In this context the author has taken up continuous and periodical studies by selecting several localities on the Maharashtra coast as detailed below.

Different spots were selected from the four major districts of Maharashtra viz. Mumbai, Part of Thane, Raigad, Ratnagiri & Sindhudurga. Mumbai district is spread between 18° 53' & 29° 20' N lat. & 72° 45' to 73° 00' E long. From Mumbai - Aksa beach, Bandra band stand and Colaba beaches were selected. Thane District is spread between 18° 42' & 20° 20' N lat. & 72° 45' to 73° 45' E long. The geographical location of Raigad District is 17° 51' lat. & 73° 40' E long. From Raigad district - Murud Janjira, Alibagh, & Harihareshwar etc. were selected. The geographical location of Ratnagiri District is 16° 30' & 18° 04' N lat. & 73° 02' & 73° 52' E long. From Ratnagiri - Dapoli, Guhagar, Hedvi were selected. Sindhudurga District lies in between 15° 40' & 16° 40' N latitudes & 73° 20' & 74° 10' E longitudes. Malvan has been selected from Sindhudurga district.
MATERIALS AND METHODS

The present study is an outcome of the intensive and extensive studies carried out during 2004 - 2009. The study consists of both field and laboratory work which includes study of specimens under microscope besides herbarium consultation. Botanical explorations to the west coast of Maharashtra have been carried out in various seasons. During the study tour, while collecting the seaweeds, all essential data was gathered and recorded in the field book. The specimens collected were processed as per the standard procedure followed in the Botanical survey of India. Identifications were done with the help of monographs available for different groups of marine algae viz. Rhodophyta, Chlorophyta and Phaeophyta and the specimens were confirmed by comparing them with the sheets deposited in various Herbaria like NIO, CAL, ISIM, BSI & CSMCRI.

The families were arranged as per Fritsch's classification. The genera under each family & species under each genus is arranged alphabetically for the sake of convenience. Bracketed keys have been provided for families, genera and species. The keys are artificial and are largely based on exomorphic characters to help in easy identification of the taxa. The species which aren't collected and also the descriptions not available so placed alphabetically. The nomenclature of the plants has been made so far as possible up to date as per Catalogue of Benthic Marine algae (Silva et al., 1996). For each species accepted, botanical name & basionym if any have been given with the full citation. The names of the authors, title of the books, Genus abbreviations & journals are abbreviated following ‘Authors of the plant names’ (Brummit & Powell, 1992), ‘Taxonomic literature ed. 2’ (Stafleu & Cowan, 1976 - 1988), Index Nominum Genericorum - ING (Plantarum) Vol – I, II, III & Botanico – Periodicum - Huntianum (1968) & Botanico - Periodicum - Huntianum Supplementum (1991) respectively. The species have been described showing primary characters followed by relevant data on reproductive structures, references to illustrations, Camara Lucida drawings and colour photoplates. The specimens collected from the West coast of Maharashtra are deposited in BSI & CAL herbaria. Under *exsiccata* exact locality, date of collection, name of collector and field numbers are given. If more than one specimen is cited in *exsiccata*, then they are arranged according to the date and year of collection. Special observation and nomenclatural information if any are given, under the notes. In distribution data the states are arranged from west to east. Throughout the present work, decimal and metric
system have been included along with colour photographs, which depict the ecology and association. Maps and tables representing various data in connection with the present work are provided wherever required. The present taxonomic study has been undertaken on a calibrated compound microscope with 10 x & 40 x immersion objectives & 10 x eyepieces. Also Line drawings of the species have been included. An exhaustive bibliography giving all essential references consulted during the course of the study is appended at the end. Reprints of the published papers are also attached at the end of the synopsis.

**GENERAL NOTE ON THE COAST**

General note on the Indian Coast, Conservation and sustainable use, Coastal Regulation Zone (CRZ), Physiography of the West coast, Geomorphology, Offshore geomorphology, Onshore morphology, Beach formation, Classification of Coastal Zones in India, Coastal sand dune formation, Climate of the West coast, Studies On Seaweed Resources In India and studies on marine algal flora of the Maharashtra.

**Fauna associated with the Seaweeds:** Animals associated are Sea Urchins, Star fishes, Sea Snails, Sea Cucumber & Eel fishes.

**Systematic Treatment:** Family Key and Enumeration of all the taxa with a number of colour photo plates besides 55 - 60 line drawings drawn with the help of mirror type of Camera Lucida.

**DISCUSSION**

The present work on marine algal flora of Maharashtra Coast is an outcome of intensive and extensive field collections and laboratory work between the years 2004 - 2008. Near about 3 - 4 field tours were undertaken every year covering various seasons. Each tour is lasting 4 - 5 days as per the tide tables or Chart datum. The tide table for every year has been obtained from the India Meteorological Department (IMD), Simla Office, Shivajinagar, Pune. Especially, the tide table for Marmagoa - India, West Coast (Lat. 15° 55’ N. Long. 73° 48’E) & Mumbai (Apollo Bandar) - India, West Coast (Lat. 18° 25’ N. Long. 72° 50’E) are followed.

During explorations enough care was taken to record the field observations such as habit, area of the collection, distribution, frequency of occurrence, associated species
and the specific fauna associated with the seaweeds. If the species was found in vegetative condition, exact locality of the live plant was marked and in the subsequent tours it was collected in the reproductive form. The specimens collected were dried and mounted following conventional methods as discussed earlier in materials and methods.

Many of the seaweeds were tentatively identified in the field itself with the help of Phycologia Indica by K.S. Srinivasan (1969, 1970); Phaeophyceae of India by J. N. Misra (1966) & Monographs of Rhodophyceae by V. Krishnamurthy (1990, 1998) etc. The identity of the plants was confirmed by studying the specimen externally and as well as by taking the sections and observed under the compound microscope. To study various earlier collections of seaweeds from Maharashtra as well as from the other Coasts, consultation tour was undertaken to Krishnamurthy Institute of Algology (KIA), C/o Madras Institute of Magnetobiology, Chennai, where lot of specimens collected by Dr. V. Krishnamurthy have been deposited; National Institute of Oceanography (NIO), Goa where collections by A.G. Untawale, V.K. Dharaghalkar, T.G. Jagtap etc were deposited; Central National Herbarium, (CAL) & Industrial Section, Industrial Museum (ISIM) Kolkata where most of the Srinivasan’s collections were deposited and CSMCRI, Bhavnagar specimen photographs (Courtesy Dr. P.S.N. Rao).

In the recent survey, the entire Maharashtra Coast from Raigad, Ratnagiri, Sindhudurga, Mumbai & partly Thane was studied. Different spots were selected from each district for the present study. Earlier 69 species of Chlorophyta from 22 genera, 39 species of Phaeophyta from 18 genera & 132 species of Rhodophyta from 62 genera; were reported from the Maharashtra Coast. In the recent collection, 46 species from Chlorophyta, 21 species from Phaeophyta & 79 species from Rhodophyta.

**Table: 1. Comparison of marine algal diversity on the Indian Coast and Maharashtra Coast.**

<table>
<thead>
<tr>
<th>Marine Algae</th>
<th>Marine Algae from India</th>
<th>Marine Algae from Maharashtra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyta</td>
<td>216</td>
<td>69</td>
</tr>
<tr>
<td>Phaeophyta</td>
<td>191</td>
<td>39</td>
</tr>
<tr>
<td>Rhodophyta</td>
<td>434</td>
<td>132</td>
</tr>
</tbody>
</table>
Xanthophyta | 03 | -
---|---|---
Total | 844 | 240

Table 2: Marine algal diversity of the Maharashtra Coast

<table>
<thead>
<tr>
<th>Marine algae</th>
<th>Families</th>
<th>Genera</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyta</td>
<td>12</td>
<td>22</td>
<td>69</td>
</tr>
<tr>
<td>Phaeophyta</td>
<td>08</td>
<td>18</td>
<td>39</td>
</tr>
<tr>
<td>Rhodophyta</td>
<td>26</td>
<td>62</td>
<td>132</td>
</tr>
<tr>
<td>Grand Total</td>
<td>46</td>
<td>102</td>
<td>240</td>
</tr>
</tbody>
</table>

NOTEWORTHY FINDINGS

- One new species *Dasya ulhasii* Sonali Jadiye & P.S.N. Rao (Dasyaceae).
- Also reported is the genus *Antithamnionella* Lyle for the first time from Maharashtra for the west coast of India.
- Reporting of *Jania ungulata f. brevior* (Yendo) Yendo here is the 2nd report for India the first report being from Visakhapatnam by Umashwar Rao.
- *Caulerpa sedoides* C. Agardh of Chlorophyta is collected here for the first time from the west Coast of India (under publication).
- *Caulerpa verticillata f. charoides* Weber Bosse of Chlorophyta collected for the first time from the Maharashtra Coast. (under publication).
LIST OF PUBLICATIONS


CONCLUDING REMARKS

Indian coast as a whole and Maharashtra coast in particular are ecologically and economically important. Of late, all over the world the coasts are subjected to both natural and human threats such as tsunami, tourism industry (other than eco-tourism),
coral and sand mining, ship-anchoring, oil leaks from sea going vessels, effluent & sewage releases from the coast-based industrial units, power plants etc. All these threats directly or indirectly affect the natural growth of seaweeds on the coralline substrata. Loss of marine algal diversity in turn will affect coral growth, habitat for a myriad of marine life forms & microbial populations. Besides, many rare species of algae get endangered due to above threats as they are more susceptible than the common marine algae. It is therefore suggested to minimize the threat perception to the extent possible by initiating the preventive measures in addition to the mariculture of selected algae.

The present work envisages for generating baseline data on the marine algal resources from the Maharashtra coast as such studies are highly essential to be undertaken periodically so as to know the current status of the resource base in the natural habitats which indirectly helps us to assess the ecological degradation of natural habitats, nature of habitat required for shade-loving animals and food availability for marine fauna in a given marine ecosystem. These studies also help our policy makers and planners in implementing various conservation strategies for sustainable future. The data collected will guide us so as to know which type of seaweed based industries could be setup and the places of seaweed abundance along the coastline etc. Wherever the resource base is shrinking, any information on the resource size will enable us to initiate maricultural practices to augment seaweed biomass and feed the seaweed based industries. Besides, basic studies on the growth pattern of certain marine algae will help to undertake physiological studies by others as the algae are known to have shorter lifespan hence help to understand the nature of growth pattern in higher plants too. It is also well known that many algae are presently being used for bioremediation in cleaning-up polluted water bodies, both in fresh water and marine water bodies. Economic uses of the seaweeds are dealt with elsewhere in the thesis for exhaustive information. As of now, we have a number of checklists of marine algae rather than regional flor as unlike in case of higher plants. The present endeavour of bringing out regional marine flora for the Maharashtra coast will certainly help when attempts are made to bring out Indian marine algal flora ultimately.