Studies on the diversity and distribution of seaweeds along the selected rocky shores of Goa, West coast of India.

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DECLARATION BY STUDENT

I hereby declare that the data presented in this dissertation report entitled, "Studies on the diversity and distribution of seaweeds along the selected rocky shores of Goa, West coast of India" is based on the results of investigations carried out by me in the Marine Sciences at the School of Earth, Ocean and Atmospheric Sciences, Goa University under the supervision of Prof. C. U. Rivonker and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities will not be responsible for the correctness of observations/experiments or other findings given in the dissertation.

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COMPLETION CERTIFICATE

This is to certify that the dissertation report "Studies on the diversity and distribution of seaweeds along the selected rocky shores of Goa, West coast of India" is a bonafide work carried out by Ms. Bhagyashri Shetye under my supervision/mentorship in partial fulfillment of the requirements for the award of the degree of Master of Science in the discipline of Marine Sciences at the School of Earth, Ocean and Atmospheric Sciences, Goa University.

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PREFACE

This thesis, titled "Studies on the diversity and distribution of seaweeds along the selected rocky shores of Goa, West coast of India", delves into the intricate ecosystems thriving within the intertidal zones of rocky shores along the captivating coastline of Goa, India. The essence of this work lies in unraveling the diversity and distribution patterns of seaweeds, a vital component of coastal marine environments.

The genesis of this study stems from a profound curiosity about the ecological dynamics of Goa's rocky shores, which serve as a haven for diverse marine life forms. Inspired by the rich biodiversity of these coastal habitats and the imperative to understand their ecological intricacies, the journey toward this thesis commenced.

The motives driving this study are manifold. Foremost among them is the imperative to contribute to the scientific understanding of seaweed diversity and distribution in the intertidal zones of Goa's rocky shores. By compiling an inventory of seaweed species and scrutinizing their distribution patterns across various study sites, this research endeavors to shed light on the ecological dynamics of these critical habitats. It is hoped that this research will provide valuable insights for sustainable management and conservation initiatives.

Furthermore, this thesis is motivated by a desire to foster scientific inquiry and promote interdisciplinary collaboration in the realm of marine ecology. Through meticulous fieldwork, data analysis, and scholarly discourse, it is envisioned that this study will contribute to the broader scientific discourse surrounding coastal ecosystems and inspire future research endeavors.

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ABSTRACT

Goa, along the west coast of India, was surveyed for seaweed diversity along its 105 km coastline. Six rocky shores were selected as ideal sites for collection, based on preliminary survey results and available information. Monthly surveys were conducted along the selected sites during the period from November2023 to February 2024 with emphasis on the collection of marine macroalgae. Seaweed samples were collected from the intertidal zone of selected rocky shores by random sampling. The study provides an inventory of thirty two taxa of twelve families and twelve orders, with Phaeophyceae dominating with seventeen taxa (53%), followed by Rhodophyceae with nine species (28%), and Chlorophyceae with six species (19%). The Rhodophyceae group was more diverse at the order level, while the Phaeophyceae group was more diverse at the species level. Padina and Sargassum genera were dominant, with *Ectocarpus siliculosus* and *Stoechospermum marginatum* being commonly found. Anjuna showed richness in seaweed diversity, contributing twenty five species. A detailed investigation on Goa's marine seaweed flora will provide an insight on updated information on seaweed diversity, while exploration of subtidal region through use of snorkeling and SCUBA diving can focus and provide updated knowledge on seaweeds.

Keywords: Seaweeds, Inventory, Intertidal zone, Chlorophyceae, Rhodophyceae, Phaeophyceae.

CHAPTER 1: INTRODUCTION

Seaweeds, or macroalgae, are an integral component of marine ecosystems, encompassing a diverse array of multicellular algae that thrive in aquatic environments. These organisms play pivotal roles in coastal ecosystems, contributing to primary productivity, providing habitats and food for marine organisms, and participating in nutrient-cycling processes (D'Souza & Prabhu, 2015). As such, understanding the diversity and ecological significance of seaweeds is essential for the conservation and management of marine biodiversity.

Structurally, seaweeds exhibit a remarkable diversity in morphology, ranging from simple filaments to complex thalli with differentiated tissues (Littler & Littler, 2003). Generally, seaweeds are classified into three main groups based on their pigmentation and photosynthetic pigments: green algae (Chlorophyta), brown algae (Phaeophyta), and red algae (Rhodophyta) (Lüning, 1990). Green algae, belonging to the phylum Chlorophyta, are characterized by the presence of chlorophyll a and b, as well as β-carotene, giving them a green coloration (Lüning, 1990). Brown algae, belonging to the phylum Phaeophyta, are characterized by the presence of fucoxanthin, which imparts a brown coloration to their thalli (D'Souza & Prabhu, 2015). Red algae, belonging to the phylum Rhodophyta, contain phycoerythrin and phycocyanin, which give them a red coloration. However, some species may appear green or brown due to variations in pigment composition (Littler & Littler, 2003).

1.1 Background

Seaweeds are abundant in marine environments worldwide, with diverse species found in oceans, seas, and coastal regions across the globe. They play crucial ecological roles, serving as primary producers, providing habitats, and contributing to nutrient cycling

in marine ecosystems (Littler & Littler, 2003). Seaweed cultivation is a significant industry in many countries, particularly in East Asia, where seaweeds such as nori, kombu, and wakame are important components of traditional diets (FAO, 2018). Globally, there is increasing interest in the commercial cultivation of seaweeds for food, pharmaceuticals, biofuels, and bioremediation purposes, highlighting their economic and environmental significance.

India has a rich diversity of seaweeds along its extensive coastline, encompassing species from various taxonomic groups such as green algae, brown algae, and red algae (D'Souza & Prabhu, 2015). Seaweeds are traditionally used in Indian cuisine, medicine, and agriculture, with species like Gracilaria, Gelidiella, and Sargassum being commercially important (D'Souza & Prabhu, 2015). However, the commercial seaweed industry in India is still developing compared to countries like China, Japan, and Korea. Efforts are underway to promote seaweed cultivation, sustainable harvesting practices, and value-added product development to harness the economic potential of seaweeds in India (Gupta *et al*., 2020).

Goa, located on the west coast of India, has a diverse array of seaweeds inhabiting its coastal waters, including species adapted to intertidal zones, rocky shores, and coral reefs (Kulkarni & Waikar, 2010). Seaweeds play important ecological roles in Goan marine ecosystems, providing habitats, and food sources, and contributing to nutrient cycling (Kulkarni & Waikar, 2010). However, studies on seaweed diversity in Goa are relatively limited, with research focusing on specific beaches and taxa. There is a need for comprehensive surveys covering a wider range of habitats and seasons to fully understand the dynamics of seaweed communities in Goa's coastal waters.

Along the coast of Goa, India, seaweeds exhibit distinct vertical zonation patterns, with different species occupying specific zones along the intertidal and subtidal gradients

(Kulkarni & Waikar, 2010). This vertical zonation is influenced by factors such as wave exposure, substrate type, light availability, and desiccation tolerance, which shape the distribution of seaweed communities in response to environmental gradients (Lüning, 1990). Understanding these vertical zonation patterns is essential for comprehensively characterizing seaweed diversity and assessing the ecological processes driving their distribution along the Goan coast. They contribute to the overall biodiversity and functioning of coastal ecosystems, influencing nutrient dynamics and trophic interactions. Monitoring seaweed communities provides valuable insights into the ecological integrity and resilience of coastal ecosystems, aiding in conservation and management efforts. Seaweeds create complex habitats that support a diverse array of marine life, including fish, invertebrates, and microorganisms (Lüning, 1990). They provide shelter, food, and breeding grounds for various species, contributing to overall biodiversity and ecosystem stability. Seaweeds play a crucial role in nutrient cycling by absorbing nutrients from the water and sediment, which are then recycled back into the ecosystem upon decomposition (Borowitzka, 1997). They help regulate nutrient levels, carbon sequestration, and oxygen production, influencing the productivity and health of coastal ecosystems. Seaweeds have significant economic value, being utilized in various industries such as food, pharmaceuticals, cosmetics, and agriculture (D'Souza & Prabhu, 2015). They are harvested for human consumption, processed into products like agar and carrageenan, and used in bioremediation and biofuel production, contributing to local economies and livelihoods.

1.2 Aim and Objectives

Seaweeds are significant both ecologically and economically, through sequestering of carbon and supporting livelihood of coastal communities, respectively. Existing published literature on seaweed diversity is limited in Goa with special emphasis on their geographic and taxonomic aspects. There is a need for comprehensive surveys covering a wider range of habitats and seasons to fully understand seaweed diversity and distribution patterns along Goa. Thus, the present study was conducted with the following objectives:

1. To compile an inventory of seaweed species present in the intertidal zones of selected rocky shores along the Goa coast.
2. To study the distribution patterns of seaweeds at different study sites.

The goal of this endeavor is to create an inventory of all the collected seaweed species found along the Goan coast, encompassing a variety of taxonomic categories such as red, brown, and green algae.

1.3 Scope

The study aims to understand seaweed diversity and distribution patterns in Goa through comprehensive surveys covering various rocky shores. It will help identify vulnerable species, inform conservation efforts, and provide insights into climate change's impacts on marine biodiversity and ecosystem resilience. The study also aims to address limited geographic and taxonomic studies in Goa.

1.4 Limitations

During this study, several limitations were encountered such as potential sampling bias, logistical issues, and difficulty in accurately identifying species due to morphological variety, cryptic species complexes, and taxonomic revisions. The study also does not capture temporal variability in seaweed diversity and distribution patterns. Moreover, low historical data on seaweed diversity makes it difficult to evaluate long-term patterns or variations in

populations over time. However, the present study will highlight the importance of seaweed diversity along the selected sites of the Goa coast.

CHAPTER 2: LITERATURE REVIEW

In 1672, Hermann produced the first known algal collection from the Indian Ocean when he brought Amphiroa, a coralline alga, from the Cape of Good Hope in South Africa. Subsequently, J.G. Koenig (1728–1789), traveling to India in 1768 as a Moravian missionary, collected a large number of marine algae from the South Indian coast near Tranquebar (Srinivasan, 1965). To gather seaweed from the Indian coasts, foreign laborers conducted several expeditions in the 18th and 19th centuries, including the Galathea expedition (1845–1847), Novara (1857–1859), Preussische (1859–1863), Challenger (1872–1876), Investigator (1890–1892), and Siboga (1899–1900). But it wasn't until the Father of Indian Algology, Prof. Iyengar (1886–1966), released a report on seaweeds of the Krusadai Island in the Gulf of Mannar in 1927 that algal research in India took off. He went on to produce several publications on the study of algae. Boergesen (1928–1938) subsequently published several articles between 1928 and 1938 in which he recorded around 150 taxa from the west coast of India, specifically from the coastlines of Gujarat and Bombay, as well as five new genera and 38 species. In parallel, many other employees were researching other facets of the marine algae from different regions of the nation.

In 1930, Dixit conducted research on the chemical characteristics of several seaweeds, including their iodine concentration. He subsequently published a comprehensive report of seaweeds from Maharashtra's Malvan coast in 1940. The algal flora of Chilka Lake, Odisha, on the east coast of India, was published by Biswas in 1932. A description of the seaweeds found on the west coast (now in Pakistan) near Karachi was published by Anand in 1940. Many academics have since investigated the seaweed resources from India's marine states. The first monograph on Phaeophyceae of India was published by Misra in 1966, and it contained 93 species of brown seaweed from 33 genera. A comment on edible seaweeds in the Indian context was published in 1977 by Chennubhotla of the Central Marine Fisheries

Research Institute (CMFRI), Cochin. About fifty different species of seaweeds from the Indian coast are described in two volumes of Phycologia Indica: The Icons of Marine Indian Algae, published by Srinivasan in 1969 and 1973. A Checklist of Indian Marine Algae, compiled by Krishnamurthy & Joshi in 1970, had data from Sri Lanka and Pakistan and contained 520 taxa of seaweeds. Later, 624 species of seaweed were identified by Untawale *et al*., (1983), who published a list of marine algae found in India in the form of a mimeograph. A seminal book on Indian seaweeds, The Catalogue of the Benthic Marine Algae of the Indian Ocean was published by Silva *et al*. in 1996. The Rhodophyta, or red seaweeds, of India were published in two volumes by Desikachary *et al.,* (1990, 1998). 770 species were identified in a checklist of seaweeds found on the Indian Coast by Sahoo *et al*., (2001). These included 186 species of Chlorophyceae, 166 species of Phaeophyceae, and 420 species of Rhodophyceae. 844 seaweed species, encompassing forms and variants from all around the Indian coasts, were included in the 2001 Revised Checklist of Indian Marine Algae by Oza & Zaidi of the Central Salt and Marine Chemicals Research Institute (CMFRI), Bhavnagar. Krishnamurthy & Baluswami (2010) and Krishnamurthy & Ezhili (2013), respectively, published revised monographs on brown seaweeds, or Phaeophyceae of India and Neighbourhood (Volume I & II). A revised checklist of 865 seaweed taxa, including 212 taxa of the Chlorophyceae, 211 taxa of the Phaeophyceae, and 434 taxa of the Rhodophyceae, was released more recently by the Botanical Survey of India, Kolkata (Rao & Gupta, 2015).

Several works have been completed on India's east coasts, from the shores of Tamil Nadu (Thivy, 1964, 1966; Desai, 1967; Subharamaiah *et al.,* 1979, Chennubhotla & al., 1988; Kaliaperumal *et al.,* 1989; Kaliaperumal & Chennubhotla, 1997; Krishnamurthy & Baluswami, 1984, 2010), Odisha (Mitra, 1946; Chennubhotla *et al.,* 1992; Adhikary & Sahoo, 1992; Rath & Adhikary, 2005a&b; Sahoo *et al.,* 2001, 2003) and West Bengal

(Mukhopadhyay & Pal 2002; Mukhopadhyay *et al.,* 2003), and Andhra Pradesh (Rao & Sriramulu, 1964, 1968, 1970; Rao, 1969; Rama Rao, 1969, 1977).

Similarly, many workers have conducted early seaweed surveys and explorations on the West Coast. The longest shoreline of Gujrat in India has been thoroughly investigated (Desai, 1967; Chauhan & Krishnamurthy, 1968; Chauhan & Mairah, 1978). Seaweeds of India: The Diversity and Distribution of Seaweeds on Gujarat Coast, a preliminary account of Gujarat's seaweeds, was published by Jha *et al.,* (2009). They identified 198 seaweed taxa that fall under 101 genera. Many researchers have examined Maharashtra's seaweed resources. From 1930 to 1935, Boergesen wrote and published some articles from the Bombay coast. Later, some other researchers also made significant contributions (Chauhan, 1978; Untawale *et al.,* 1977; Dhargalkar et al., 1980). In a recent taxonomic investigation on the seaweeds along this shore, Sonali Piwalatkar (2010) of the Botanical Survey of India, Western Regional Centre, Pune, identified 240 taxa. Likewise, numerous researchers have examined the diversity of marine algae throughout Karnataka's coastline. Agadi (1985, 1986) found 43 species of seaweed in his initial investigation into the distribution of marine macroalgae from the littoral zones of the Karnataka coast. According to Untawale *et al.*, (1989), there are 65 species of seaweeds from 42 genera that are found along the coast of northern Karnataka. From the Karnataka coast, only 39 species of seaweeds from 52 genera and 28 families were reported by NAAS (2003) and Venkataraman & Wafar (2005). From the entire Karnataka coast, 78 species of seaweeds and seagrasses were identified by Kaladharan *et al.*, (2011). After surveying the whole Karnataka coastline, Palanisamy & Yadav (2017) identified 108 taxa of marine macroalgae.

In addition, the seaweed vegetation is supported by estuaries and backwater ecosystems like the Keralan Ashtamudi estuary (Nair *et al.,* 1982), the Godavari estuary in Andhra Pradesh (Rao, 1987), the Goan Zuari and Mandovi estuaries (Jagtap & Untawale,

1980; Jagtap, 1986), Vellar estuary (Kannan & Krishnamurthy, 1978; Krishnamurthy & Jayaseelan, 1984).

There has been little to no surveying or documentation of marine algal research undertaken along the coast, according to an assessment of the literature on the Goa coast's algal flora. The first coastal survey was carried out in 1975 by researchers from the National Institute of Oceanography (NIO), Goa. The early studies of this region's seaweed resources were conducted by Agadi (1983), Untawale *et al.,* (1983), and Dhargalkar (1981).

The research paper titled "Marine algal flora of Goa coast" by VVAgadi and AG Untawale, published in Seaweed Research and Utilization in 1978 explores the diverse range of marine algae found along the coast of Goa, India. Through meticulous study and documentation, the authors provide insights into the rich biodiversity of algae inhabiting this coastal region. Their work likely includes detailed taxonomic classifications, ecological observations, and possibly insights into the economic significance of these algae. About 50 species of algae were recorded in Goa belonging to 37 genera. Of those 14 species belong to Phaeophyceae, 13 to Chlorophyceae, and 4 to Cynophyceae.

The research paper titled " Addition to the Marine Algal Flora of Goa" by V Kerkar published in 2004 provides a record of newly added 7 species of marine algae (2 Chlorophyta, 2 Phaeophyta, and 3 Rhodophyta) from different coastal locations of Goa. The paper presents a detailed account of the habitat, distribution, and morphological features of the newly added species of marine algae.

The research paper titled " A preliminary checklist of marine algae from the coast of Goa" by N. Pereira and M. R. Almeida published in 2012 provided a compiled updated list of marine algae from the Goa coast by fresh sample collection method. The preliminary list contains 64 species of red algae, 41 species of green algae, and 40 species of brown algae.

The book titled “SEAWEED FLORA OF GOA COAST” by Palanisami & Yadav was published in the year 2022 by the BOTANICAL SURVEY OF INDIA. The book explores the diversity of seaweeds along the coast of Goa. The authors documented 90 species of seaweed including 19 taxa of newly added species, 36 taxa of Rhodophyceae, 26 taxa of Phaeophyceae, and 28 taxa of Chlorophyceae.

CHAPTER 3: METHODOLOGY

3.1 STUDY AREA

3.1.1 Goa coastline

The Goa state's coastline, which stretches roughly 105 kilometers (Gujar *et al.,* 2021) along the Arabian Sea on India's western coast, is surveyed to study seaweeds. The Goa coastline is renowned for its beautiful beaches, various marine habitats, and rich biodiversity. It is an essential ecosystem that supports a wide range of plant and animal species.

3.1.2 Geographical Location

Goa is located between longitudes 73°40'33" E and 74°20'13" E and latitudes 14°53'54" N and 15°40'00" N. Karnataka to the south and east and Maharashtra to the north define its borders. From the Terekhol River in the north to the Galgibaga River in the south, the coastline extends.

3.1.3 Physical Features

The terrain of the Goa coastline is diverse, with tidal flats, estuaries, rocky outcrops, and sandy beaches. The headlands, cliffs, and bays that dot the coastline offer a variety of habitats for marine species. The area has a tropical monsoon climate with dry winters and rainy summers, and an average annual rainfall of 2500 to 3500 millimetres.

The Goa coastline's aquatic environments include:

- Sandy beaches: Found throughout the coastline, sandy beaches are home to various intertidal creatures and are used by marine turtles as nesting places.
- Estuaries: Coastal regions, like those found in the Mandovi and Zuari rivers, are crucial fish spawning grounds and bird feeding sites for migratory birds.

- Coral reefs: Offshore coral reefs provide habitat to a variety of fish and coral species, despite their limited size. Despite their small size, offshore coral reefs serve as habitat for a wide range of fish and coral species. Some less well-researched coral reefs can be found off the coast of Goa, in the Grande Island group, and on Bat Island.
- Rocky shorelines: Diverse assemblages of fish, mollusks, seaweeds, and crustaceans are supported by rocky outcrops and tidal pools.

Seaweeds can attach to various substrates such as rocks, shells, coral, sand, or other seaweed species. Seaweed attachment is the process by which seaweeds adhere to substrates in their marine environment. It must establish and maintain its position, where it grows and reproduces. Seaweeds attach to substrates through various mechanisms, including holdfasts, adhesive secretions, morphological adaptations, chemical signals, and biofilm formation.

Rocky shores and seaweeds have a close and mutually beneficial relationship, making rocky shores one of the primary habitats for seaweeds. Rocky shores provide a stable and durable substrate for seaweeds to attach and grow upon. Seaweeds anchor themselves to rocks using specialized structures called holdfasts, which grip onto the irregular surfaces of rocks, providing a secure attachment point. This attachment allows seaweeds to withstand the strong wave action and turbulent water movement typical of rocky shore environments. Rocky shores offer diverse microhabitats and niches for seaweeds to colonize. The varying topography of rocky shores, including crevices, tide pools, and rock pools, creates a range of environmental conditions such as light exposure, wave intensity, and moisture levels. Seaweeds exhibit zonation patterns along the rocky shore gradient, with different species adapted to specific zones based on factors like wave exposure, desiccation tolerance, and competition with other organisms. Rocky shores facilitate nutrient uptake for seaweeds through the circulation of nutrient-rich waters and the accumulation of organic matter. Wave action and tidal movements help circulate nutrients around rocky substrates, providing a

continuous supply of dissolved nutrients for seaweeds to absorb. Additionally, organic matter, such as detritus and decaying seaweeds, accumulates in crevices and rock pools, serving as a nutrient source for seaweed growth.

Seaweeds on rocky shores play a critical role in stabilizing sediments and preventing coastal erosion. The dense growth of seaweeds helps bind sediments together, reducing the impact of wave energy and minimizing erosion of the shoreline. Seaweed-covered rocks act as natural breakwaters, dissipating wave energy and protecting coastal habitats from wave-induced damage. Thus, to accomplish the objectives of the study, selecting rocky shores for seaweed collection offers several advantages and opportunities.

3.1.4 Preliminary survey and identification of study sites

Conducting a preliminary survey is crucial before initiating seaweed collection to ensure the effectiveness and success of the sampling effort. With a thorough preliminary survey, essential information about the study area, sampling sites, and planning an effective seaweed collection program was designed considering accessibility, diversity of habitats, and environmental conditions.

3.1.5 Study sites

With the help of a preliminary survey total of six rocky shores have been selected as ideal study sites for seaweed collection (Fig. 3.1.5.a; Table 3.1.5.a).

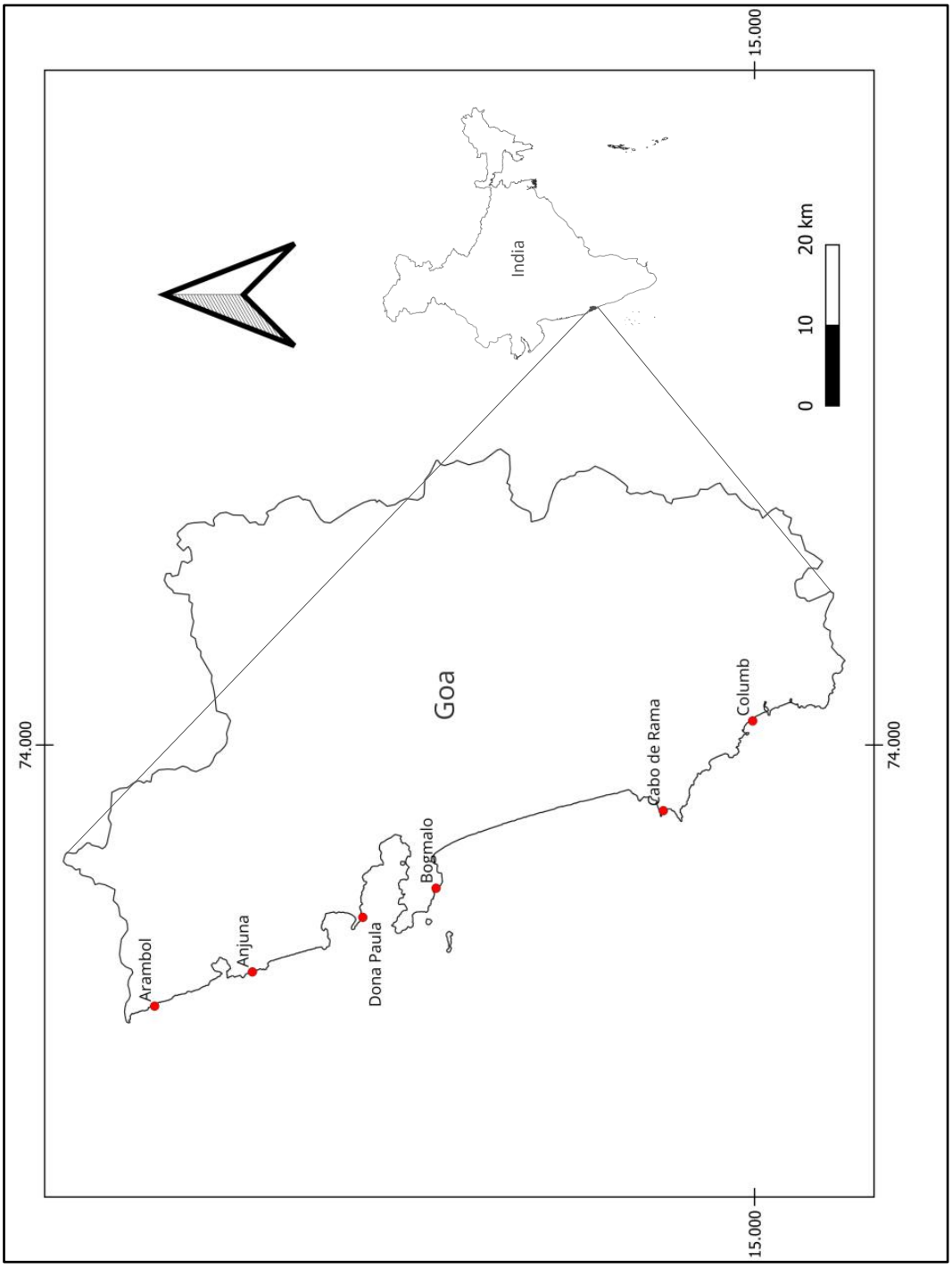


Figure 3.1.5.a: Map of Goa showing seaweed collection sites for the present study

Table 3.1.5.a: Sampling sites for collection of seaweeds from Goa coast

Sl. No.	Seaweed collection sites	Latitudes	Longitudes
1. NORTH GOA			
1	Arambol	15° 41’ 32’’ N	73° 41’ 55’’ E
2	Anjuna	15° 34’ 46’’ N	73° 44’ 17’’ E
3	Dona Paula	15° 27’ 07’’ N	73° 48’ 04’’ E
2. SOUTH GOA			
4	Bogmolo	15° 22’ 03’’ N	73° 50’ 05’’ E
5	Cabo de Rama	15° 06’ 19’’ N	73° 55’ 27’’ E
6	Columb	15° 00’ 08’’ N	74° 01’ 40’’ E

Arambol

Arambol Beach, nestled in the northernmost region of Goa, India, is renowned for its pristine beauty, laid-back atmosphere, and vibrant cultural scene. Situated approximately 35 kilometers from the capital city of Panaji. Along the coast, Precambrian micaceous quartzites intruded by dolerite dykes and sub-recent laterites and beach rocks are exposed (Kidwai & Wagale, 1975).

Anjuna

Anjuna Beach, located in North Goa, India, is renowned for its vibrant atmosphere, picturesque coastline, and rich cultural heritage. The coast is mainly rocky shore has small intertidal rock pools that are rich with diverse marine flora and fauna(Chatterji & Nanajkar, 2019).

Dona Paula

Dona Paula Beach is located on North Goa's Arabian Sea shore, about 7 kilometers from Panaji, the state capital. Tucked up on the southern edge of the stony headlands shaped like hammers that separate the Zuari and Mandovi estuaries lies Dona Paula Beach.

Bogmalo

The main feature of Bogmalo Beach in Goa, India, is its sandy shoreline as opposed to its rocky structures. It does have some rocky outcrops or formations along some parts of the shore, though, like many coastal places. Particularly at low tide when they could be more visible, these rocky locations provide beautiful views and exploration opportunities.

Cabo de Rama

The Cabo de Rama shoreline features some rocky outcrops or formations along certain sections. The shoreline of Canacona exhibits a good number of Cliffs and headlands

but the most prominent is Cabo-de-Rama Cliff located to the North of Canacona Taluka (Nadaf,2019).

Colomb

Between the Palolem and Patnem Beaches in a tiny horseshoe-shaped harbor is Colomb Beach, also known as Colom Beach. Among South Goa's most secluded beaches is this one. The beach is bordered by limited vegetation and a variety of oddly shaped rock formations on three sides.

3.2 MATERIAL AND METHODS

The primary method used in this investigation of the seaweed resources along the Goa coast includes fresh seaweed collections. From November 2023 to February 2024, 6 study surveys were conducted monthly in the selected sites of Goa, focusing on marine macroalgae in the post-monsoon period. Tide tables were collected from the Meteorological Department website to determine the best time for the survey. Seaweeds were collected from rocks during low tides by random sampling. Small and delicate algae were carefully collected to avoid damage. A total of 214 seaweed samples were collected (Table 3.2.1).

To promote accurate and effective data collection while reducing environmental damage, it is crucial to make sure that the right materials are selected and used while collecting fresh seaweed through random sampling in intertidal zones. During field trips materials utilized are listed below:

3.2.1 Sampling Equipment

a. *Waterproof Boots and Gloves*:

For personal protection against damp and potentially slick conditions in intertidal zones, waterproof boots and gloves were used. Additionally, they avoid coming into direct touch with seaweed species that could irritate skin or trigger allergic reactions.

b. *Collection Buckets or Containers*:

Seaweed samples were kept in sturdy, water-resistant containers. These containers ought to be big enough to hold samples without breaking them.

c. *Handheld Rake or Knife*:

These instruments were used for carefully removing seaweed samples from substrates to cause the least amount of disruption to the surrounding environment.

Table 3.1.2: Summary of the field exploration and number of samples collected

Tour No.	Month	Field Book Series	No. of samples
1	November	01-62	62
2	December	63-114	51
3	January	115-158	43
4	February	159- 217	58
Total no of samples collected			214

d. *Sampling bags for Sample Transportation*:

Seaweed samples were gathered and then put into waterproof bags to keep moisture inside and avoid leaks during transportation.

e. *GPS Device or Maps*:

To ensure repeatability and spatial reference in data collection, these instruments are crucial for precisely noting the locations of sampling sites. The GPS Maps app on the VIVO Android mobile phone is used for this purpose.

f. *Camera*:

The pictures of the specimens, the collection site, and any pertinent environmental elements were captured by a camera (Canon DS 126311 No. 063023028257) using a different lens. Visual documentation gives context for further investigation and aids in sample identification.

g. *Field Notebook and Pen*:

To keep track of details like the date, time, and conditions of the sampling as well as the features of the habitat and any observations a field notebook was used.

h. *Labels for Sample Identification*:

Each sample was clearly labeled with unique identifiers, including sampling site information, date, and any relevant metadata.

i. *Zip-lock Bags*:

These are useful for storing smaller samples within the larger collection container, allowing for better organization and moisture control during transportation.

j. *Ice Packs or Coolers*:

If immediate processing of samples is not possible, the use of ice packs or coolers to maintain low temperatures and preserve sample freshness during transportation is very important. This avoids decomposition and maintains the integrity of the seaweed samples.

3.2.2 Collection technique

- Sampling points within the intertidal zone were randomly selected.
- At each sampling point, a visual assessment of the surrounding area was done for seaweed diversity.
- The representative seaweed samples were collected by using a handheld rake or trowel and knife by carefully detaching seaweed from substrates including their holdfasts, without damaging other organisms and their habitats.
- Each sample was placed into a different labeled waterproof bag or container, ensuring proper identification and separation of different species.

3.2.3 Documentation

- Detailed information for each sampling point was recorded including GPS coordinates, date, time, and environmental conditions.
- Photographs of the sampling site, including close-up shots of individual specimens were taken for reference.

3.2.4 Post-Field Processing

- Collected samples were kept cool and moist during transportation to the laboratory.
- Samples were gently rinsed with seawater to remove excess debris or sediment and stored in a refrigerator to prevent decay.
- Prolonged exposure to sunlight or extreme temperatures was avoided.

3.2.5 Preservation

All the collected seaweed specimens were preserved by the dry preservation method which is also called seaweed herbarium. Seaweed herbarium preparation was done by following the procedure from "Seaweeds – A Field Manual" by V.K. Dhargalkar (2004).

3.2.6 Materials required for herbarium preparation

- Plastic trays
- Forceps
- Specimen mounting paper (herbarium sheets)
- Cheesecloth
- Blotting paper
- Herbarium wooden or iron press
- Painting brush
- Pencils, knives, etc.
- Polyethylene bags

3.2.7 Procedure for preparing herbarium

- Fresh specimens were cleaned of sand particles, rocks, shells, mud, and other adhering materials and epiphytes.
- A tray containing fresh water (half-filled) was taken and the specimen was placed in the water.
- A herbarium sheet, a size smaller than the tray was inserted from below the specimen, and then the specimen was spread on the herbarium sheet with the help of a brush in such a way that overlapping of the specimen is minimized.

- After mounting the specimen on the herbarium sheet, the sheet was lifted slowly and tilted to one side to allow water to drain gradually without disturbing the mounted specimen.
- The sheet was removed and the specimen was properly arranged with the help of forceps or a needle.
- Wet herbarium sheets were then placed on newspaper sheets or blotting paper to remove the remaining water from the herbarium.
- A cheesecloth was placed on the top of the specimen in such a way that it covered the entire specimen.
- After that, a sheet of blotting paper was placed over the herbarium sheet.
- Finally, all the herbarium sheets of specimens were piled one above the other and then placed between the two sheets of wooden or iron press.
- The press was tied tightly with appropriate pressure by a rope and kept at room temperature for 24 hrs.
- After 24 hours, blotting papers were replaced. The process of replacing blotting papers was repeated till the time specimen was free of moisture.
- On drying the specimen, the specimen got attached to the paper due to the hydrocolloid present in the seaweed.
- The cheesecloth was carefully removed and the herbarium sheet was properly labeled containing the collection number, name of the specimen, locality, and date of collection.
- Sometimes, specimens are thick and do not stick to herbarium sheets.
- In such cases, gum or glue may be used to stick the specimen or the specimen may be tied with thread.
- Sheets were then placed in polyethylene bags and stored.

3.2.8 Taxonomic Identification

Morphological characteristics, as well as the following standard references, were used to identify all of the collected samples.

Taxonomic keys used:

- Silva, P. C., Basson, P. W., & Moe, R. L. (1996). Catalog of the benthic marine algae of the Indian Ocean (Vol. 79). Univ of California Press.
- Srinivasan, K.S., 1969, 1973. PhycologiaIndica (Icones of Indian Marine Algae) Vol.I&II.Botanical Survey of India, Calcutta.
- Palanisami, M., & Yadav, S. K. (2022). Seaweed flora of Goa coast. The Director, Botanical Survey of India, Kolkata.

Online resources used

- Glover, A. G., Higgs, N., & Horton, T. (2023). World Register of Deep-Sea Species (WoRDSS). Accessed at https://www. marine species. org/deepsea on yyyy-mm-dd.
- Guiry, M. D., Guiry, G. M., Morrison, L., Rindi, F., Miranda, S. V., Mathieson, A. C., & Garbary, D. J. (2014). AlgaeBase: an online resource for algae. Cryptogamie, Algologie, 35(2), 105-115.

CHAPTER 4: ANALYSIS AND CONCLUSIONS

Seaweed taxa recorded from selected rocky shores of Goa during post-monsoon season:

The characteristics of seaweeds, especially morphometry is very crucial for their identification and classification. These macroalgal communities offer a fascinating insight into the diverse forms and functions within marine ecosystems. These organisms exhibit remarkable morphological, anatomical, and physiological adaptations, reflecting their evolutionary divergence and ecological niches. One of the distinguishing features of seaweeds is their complex thallus structure, ranging from simple filamentous forms to highly differentiated tissues resembling those of terrestrial plants. Additionally, the pigmentation of seaweeds, including chlorophylls, carotenoids, and phycobiliproteins, contributes to their diverse coloration and photosynthetic capabilities (Freitas *et al.,* 2021). Furthermore, the reproductive strategies of seaweeds, encompassing both sexual and asexual mechanisms, exhibit considerable variation across taxa and life stages (*Liu et al.,* 2017). Understanding the unique characteristics of seaweeds, facilitates their ecological assessment, conservation, and utilization in various fields, including aquaculture, biotechnology, and ecosystem management.

The seaweed taxa collected from the intertidal zone of rocky shores of the Goa coast have been classified following (Palanisamy & Yadav, 2022). According to them the diagnostic characteristics for each collected species are mentioned here. The taxonomical classification of each seaweed species has been taken from AlgaeBase (Guiry and Guiry, 2024).

CHLOROPHYCEAE

1. *Acrosiphonia orientalis*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Viridiplantae

Infrakingdom: Chlorophyta infrakingdom

Phylum: Chlorophyta

Subphylum: Chlorophytina

Class: Ulvophyceae

Order: Acrosiphoniales

Family: Acrosiphoniaceae

Genus: Acrosiphonia

Distribution:

India: Andaman & Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Arambol

Morphology:

Thallus dark-muddy green in color, usually 2-8 cm long, caespitose, remiform, bushy, growing gregariously, profusely branched, corymbose, lithophilic. Holdfast small, discoid, attached firmly on calcareous bedrocks in intertidal zones. Stipe up to 2 cm long, stalked, tufted, profusely branched. Fronds repeatedly branched, cylindrical, uniseriate, filamentous, 2-5 cm long and up to 1.6 mm in diameter; branching pseudo-dichotomous or trichotomous sometimes alternate, margins entire, apex acute.

2. *Caulerpa peltata*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Viridiplantae

Phylum: Chlorophyta

Subphylum: Chlorophytina

Class: Ulvophyceae

Order: Bryopsidales

Family: Caulerpaceae

Genus: Caulerpa

Distribution:

India: Andaman & Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna

Morphology:

Thallus dark-bright green in color, rhizomatous, usually 6-15 cm long, tufted, growing as patches, prostrate, stoloniferous, epilithic. Holdfast rhizoidal, colorless, stout, variable in length, often loosely attached. Fronds consist of creeping stolons and erect assimilators. Stolon stalked, slender to terete, up to 2 mm in diameter, colorless to blackish green in older regions, tufted, branched. Assimilators are usually arranged at intervals of 1-5 cm long, cylindrical, up to 4 (-8) cm long; ramuli radially arranged, peltate, disc-like, smooth, entire, 1-5 mm in diameter; rachis 1-2.4 × 0.4-1 mm.

3. *Caulerpa taxifolia*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Phylum: Chlorophyta

Subphylum: Chlorophytina

Class: Ulvophyceae

Order: Bryopsidales

Family: Caulerpaceae

Genus: Caulerpa

Distribution:

India: Andaman & Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Colomb

Morphology:

Thallus yellow-dark green in color, rhizomatous, usually 5-12 cm long, tufted, growing as patches and forming thick mat-like structures, prostrate, stoloniferous, epilithic. Holdfast rhizoidal, colorless, stout, often loosely attached on rocky substrata. Fronds consist of creeping stolons and erect assimilators. Stolon stalked slender, 0.6-2 mm in diameter, colorless to light green in older regions, tufted, branched. Assimilators usually arranged at intervals of 0.5-2.8 cm long, foliose to slightly feathery, compressed, 4-12 (-20) cm long and up to 1.4 cm broad, simple or branched with densely arranged ramuli; ramuli linear to sickle-shaped, flexible, slightly curved upward, usually longest in middle portion, opposite-distichous and densely arranged, entire, 0.5-5 × 0.2-0.5 mm, ramuli at apex usually dense and forked.

4. *Chaetomorpha antennina*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Viridiplantae

Infrakingdom: Chlorophyta infrakingdom

Phylum: Chlorophyta

Subphylum: Chlorophytina

Class: Ulvophyceae

Order: Cladophorales

Family: Cladophoraceae

Genus: Chaetomorpha

Distribution:

India: Andaman & Nicobar Islands, Andhra Pradesh, Goa, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra, Odisha and Tamil Nadu.

Goa Coast: Anjuna, Bogmalo, Cabo de Rama

Morphology:

Thallus dark green in color, 4-15 cm long, filamentous, brush-like, caespitose, tufted, erect, gregarious, lithophilic. Holdfast small, rhizoidal, attached tightly on rocky and muddy substrata in the tidal or intertidal zones. Stipe and fronds undifferentiated, filamentous, differentiated into nodes and internodes, unbranched, uniseriate, cylindrical or barrel-shaped with regular nodes and internodes; basal cells long, usually barrel-shaped with narrow base; apical cell with acute apices.

5. *Ulva lactuca*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Viridiplantae

Infrakingdom: Chlorophyta infrakingdom

Phylum: Chlorophyta

Subphylum: Chlorophytina

Class: Ulvophyceae

Order: Ulvales

Family: Ulvaceae

Genus: *Ulva*

Distribution:

India: Andaman & Nicobar Islands; Andhra Pradesh; Gujarat; Karnataka, Kerala; Lakshadweep Islands; Maharashtra; Odisha, Tamil Nadu and West Bengal.

Goa Coast: Anjuna, Arambol

Morphology:

Thallus light-dak green in color, usually 3-8 cm long, leafy, tufted, translucent, membranous, rosette-like, lithophilic. Holdfast minute, discoid, attached firmly on rocky substratum, sometimes epiphytic on mollusk shells.Stipe small, simple, or branched. Fronds foliaceous, surface smooth, thin, delicate, much broader and obovate in young stage, rounded, lanceolate to irregularly proliferated into several small lobes at maturity; margins undulated, wavy or ruffled; apex acute to obtuse.

6. *Ulva prolifera*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Viridiplantae

Infrakingdom: Chlorophyta infrakingdom

Phylum: Chlorophyta

Subphylum: Chlorophytina

Class: Ulvophyceae

Order: Ulvales

Family: Ulvaceae

Genus: *Ulva*

Distribution:

India: Andaman & Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra, Tamil Nadu and West Bengal.

Goa Coast: Anjuna, Arambol, Dona Paula

Morphology:

Thallus dark-yellowish green in color, usually 4-18 (-25) cm long, usually proliferated, growing in densely intricated masses, regularly tubular throughout. Holdfast small.Stipe slender, small, simple or branched. Fronds tubular, 0.4-1.5 cm width across, simple below and prominently proliferated above from main axis forming several secondary proliferations, side branches up to 1 mm in width, margins entire, apex obtuse. Cells in surface view are usually polygonal, thin-walled, 8-15µm across, linear to irregularly arranged; in cross-section oblong, 9-24 × 5-10 µm wide, sheath up to 4 µm thick; uninucleate; chloroplast complete, filling almost entire cell, pyrenoids one to many.

PHAEOPHYCEAE

7. *Ectocarpus siliculosus*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Fucophycidae

Order: Ectocarpales

Family: Ectocarpaceae

Genus: Ectocarpus

Distribution:

India: Andaman & Nicobar Islands, Karnataka, Kerala and Maharashtra.

Goa Coast: Anjuna, Arambol, Bogmalo, Colomb

Morphology:

Thallus light-dark to olive brown, filamentous, usually 1-5 cm long, caespitose, heterotrichous, profusely branched forming a dense subglobose tuft, epilithic, occasionally epiphytic on other seaweeds. Holdfast minute, rhizoidal or discoid, firmly attached on rocky substrata in intertidal regions. Frond filamentous, alternate or irregularly branched; branches usually sparse below and profuse towards the apex, tapering towards the apex.

8. *Dictyota cervicornis*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Dictyoteae

Genus: Dictyota

Distribution:

India: Gujarat and Karnataka.

Goa Coast: Anjuna, Arambol, Bogmalo, Colomb, Dona Paula.

Morphology:

Thallus light to olive green in color, frondose, 8-18 cm long, foliose, epilithic. Holdfast minute, rhizoid, loosely attached, occasionally free-floating. Frond foliose, almost uniformly flattened, up to 1.5 cm wide, membranous, profusely branched in upper portion; margins entire to slightly undulate; apices broadly rounded to obtuse.

9. *Dictyota ceylanica*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Dictyoteae

Genus: Dictyota

Distribution:

India: Gujarat. Karnataka, Kerala and Tamil Nadu.

Goa Coast: Colomb.

Morphology:

Thallus light to olive green in color, frondose, small, 1-3 cm long, tufted, epilithic. Holdfast minute, cuneately discoid, firmly attached. Frond foliose, almost uniformly flattened, up to 1 mm wide, membranous, dichotomously branched in upper portion; margins entire; apices broadly rounded to obtuse.

10. *Dictyota ciliolata*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Dictyoteae

Genus: Dictyota

Distribution:

India: Gujarat, Karnataka, Kerala and Tamil Nadu.

Goa Coast: Anjuna, Arambol, Colomb

Morphology:

Thallus light-dark brown 4-12 (-20) cm long and 0.4-1.5 cm wide, leafy, flat, ribbon-like, bushy, tufted, epilithic. Holdfast minute, discoid, firmly attached on rocky substrata in surf-exposed areas. Stipe flat, up to 1.5 cm long, and 2-10 mm broad. Fronds foliose, usually 5-12 cm long and up to 1.5 cm wide, width gradually increases from the base towards the apex, membranous, regularly dichotomously branched in the upper portion, irregular towards apex; branches flat, lobed; proliferations flat, strap-like, sometimes branched; apices simple or dichotomously forked, rounded to obtuse or acute, occasionally truncate.

11. *Dictyota dichotoma*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Dictyoteae

Genus: Dictyota

Distribution:

India: Andaman & Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Arambol.

Morphology:

Thallus dark-yellowish brown, usually 2-8 cm long, leafy to frondose or ribbon-like, bushy, tufted, epilithic. Holdfast minute, discoid, firmly attached on rocky substrata in surf-exposed areas in intertidal region. Stipe foliose to stalked, 0.5-1.5 cm long. Fronds foliose, up to 8 cm long, membranous, regularly dichotomously branched; branches profuse towards the apex, flat, uniform, slightly broader at base; margins entire; apices dichotomously forked, rounded to obtuse, occasionally acute.

12. *Padina boergesenii*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Zonarieae

Genus: *Padina*

Distribution:

India: Karnataka, Kerala, Gujarat and Tamil Nadu.

Goa Coast: Arambol, Cabo de Rama, Dona Paula.

Morphology:

Thallus light- dark brown, frondose, circular to fan-shaped, 4-10 × 4-12 cm, usually without calcification, moderately calcified in ventral surface, epilithic. Holdfast small, thick, rhizomatous, several small proliferations or young branches develop from the disc, firmly attached on rocky substrata in intertidal regions. The stipe is flat to slightly stalked, 2-5 × 0.2-0.5 cm wide. Fronds leafy, circular to fan-shaped, surface membranous, alternate rows of microscopic hairs (piliferous zones) and glabrous surface, irregularly cleft into several broad lobes; lobes reaching up to half or even more in the young stage; base cuneate; margins entire to slightly wavy; apex obtuse or acute with involute margins.

13. *Padina boryana*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Zonarieae

Genus: Padina

Distribution:

India: Karnataka, Kerala, Gujarat and Tamil Nadu.

Goa Coast: Cabo de Rama, Colomb.

Morphology:

Thallus light to dark brown, frondose, circular to fan-shaped, 4-8 × 2-5 cm broad, lightly calcified on both surfaces of thallus, whitish with occasional blue tinge, epilithic. Holdfast small, thick, rhizomatous or bulbous, 2-5 mm across, attached firmly on rocky substrata in intertidal zones. Stipe stalked, narrowly flat. Fronds leafy, spreading, circular or fan-shaped, usually dichotomously branched, surface membranous, younger fronds usually entire, mature fronds irregularly cleft into several lobes; usually incised up to half, rarely more; lobes narrow, upto 8 cm long and 2-5 cm broad; base cuneate; margins entire to slightly undulate; apex obtuse to circular with involute margins.

14. *Padina gymnospora*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Zonarieae

Genus: Padina

Distribution:

India: Andaman Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Colomb, Dona Paula.

Morphology:

Thallus dark brown, circular to fan-shaped, 5-15 × 3-8 cm broad, usually heavily calcified on the lower surface with whitish patches, tufted, epilithic. Holdfast small, bulbous, or discoid, 3-8 mm across, attached firmly on rocky substrata. Stipe small, stalked, up to 1.6 cm long and 2-8 mm wide. Fronds are leafy, spreading, forming fan-shaped structure, surface membranous, younger fronds are usually simple, mature fronds usually multilobed into several cleft; lobes flat, circular to fan-shaped; surface membranous, with alternate rows of microscopic hairs (piliferous zones) and glabrous surface, base cuneate; margins entire to slightly undulate; apex obtuse to circular with involute margins.

15. *Padina pavonica*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Genus: Padina

Distribution:

India: Andaman Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Arambol, Bogmalo.

Morphology:

Thallus light to dark brown, circular to fan-shaped, 2-8 × 2-5 cm broad, heavily calcified on the lower surface and light on the upper surface of the mature thallus, whitish, tufted, epilithic. Holdfast small, bulbous, or discoid, 2-6 mm across, attached firmly on rocky substrata in intertidal zones. Stipe small, stalked, narrow to gradually flat upwards, up to 1.4 cm long, and 2-6 mm wide. Fronds leafy, spreading, forming fan-shaped structure, surface membranous, younger fronds usually simple, mature fronds usually dichotomously cleft down up to half or sometimes up to the base into several lobes; lobes flat, circular to fan-shaped, occasionally mature lobes further divided into several irregular parts; surface membranous, with alternate rows of microscopic hairs (piliferous zones) and glabrous surface, base cuneate; margins entire to slightly undulate; apex obtuse to circular with involute margins.

16. *Padina tetrastromatica*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Zonarieae

Genus: *Padina*

Distribution:

India: Andaman & Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Bogmalo, Cabo de Rama.

Morphology:

Thallus light to dark brown, frondose, circular to fan-shaped, 3-12 × 2-10 not calcified, tufted, epilithic. Holdfast small, thick, rhizomatous to bulbous, up to 5 mm across. Stipe stalked or flat, up to 3 cm long and 5 mm in diameter. Fronds fan or club-shaped, fragile, surface membranous with alternate rows of microscopic hairs (piliferous zones) and glabrous surface, irregularly cleft into several broad lobes; lobes narrow in young stage, later become wide and divide up to the base, individual lobes usually 2-8 cm long and 2-5 cm wide towards apex; base cuneate; margins entire to slightly wavy; apex usually obtuse with involute margins.

17. *Spatoglossum asperum*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Tribe: Zonarieae

Genus: Spatoglossum

Distribution:

India: Andaman & Nicobar Islands, Goa, Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Arambol.

Morphology:

Thallus light to dark brown, usually 8-30 cm, frondose, flattened to ribbon-shaped, epilithic. Holdfast small, rhizomatous, attached tightly on substratum. Stipe flat to foliose, sometimes stalked, margins slightly spinous. Fronds foliaceous, thin, irregularly dichotomously branched or sub-divided into several broad lobes; surface usually glabrous, shining; base attenuate; margins entire to wavy or slightly dentate with several small proliferations; apical margins undulate or irregularly forked, irregular, young proliferations with obtuse dichotomy.

18. *Stoechospermum marginatum*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Dictyotophycidae

Order: Dictyotales

Family: Dictyotaceae

Genus: Stoechospermum

Distribution:

India: Goa, Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu.

Goa Coast: Arambol, Anjuna, Cabo de Rama, Dona Paula.

Morphology:

Thallus light to yellowish brown, usually 8-20 cm and 1-5 cm broad, foliaceous, frondose, ribbon-shaped, epilithic. Holdfast small, rhizomatous, attached firmly on calcareous rocks in shallow and intertidal zones. Stipe stalked, slightly flat, rough. Fronds foliose, flat, 5-15 cm long, regularly dichotomously branched into several broad lobes; lobes uniformly broad, strap-like; surface rough, provided with microscopic hairs; margins entire to slightly undulate towards base; apex with median notch and regular dichotomy, obtuse, margins distinctly involute.

19. *Sargassum cinctum*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Class: Phaeophyceae

Order: Fucales

Family: Sargassaceae

Genus: Sargassum

Distribution:

India: Gujarat, Karnataka, Kerala and Tamil Nadu.

Goa Coast: Bogmalo, Colomb.

Morphology:

Thallus dark brown, 3-15 cm long, foliose, bushy, tufted, erect, epilithic.Holdfast discoid, up to 2 cm in diameter, rigid, firmly attached on rocky substrata in intertidal zones. Stipe stalked, simple or branched, terete, cylindrical to terete, slightly compressed towards the apex, 1-3 mm wide, margins smooth or rough. Fronds well developed, differentiated into several primary and secondary branches; the primary axis usually 3-15 cm long and 0.5-4 mm wide, glabrous, cylindrical to terete, slightly compressed near nodes towards apex; secondary branches several, develop alternately on primary branches, rarely subopposite, much crowded towards apex; leaves develop on secondary branches, rarely on primary axis in basal areas, linear-lanceolate or slightly ovate, 0.5-4.4× 0.5 -1.6 cm, usually basal leaves smaller, thin, transparent or translucent, stalked or subsessile; stalk up to 2.5 mm and 1.5 mm wide; base cuneate or gradually tapering; surface usually smooth; midrib prominent towards base; margins serrate to sparsely dentate; dentation upward, much crowded towards the apex, 140-360 × 190-250 µm; apex narrowly obtuse to round.

20. *Sargassum cinereum*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Class: Phaeophyceae

Subclass: Fucophycidae

Order: Fucales

Family: Sargassaceae

Genus: Sargassum

Distribution:

India: Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Colomb.

Morphology:

Thallus light-dark brown, usually 5-20 (-30) cm long, bushy, foliose, tufted, erect, epilithic. Holdfast usually discoid, attached tightly to rocky substrata in lower intertidal zones. Stipe stalked, dark, wiry to terete, tufted, variable in length. Fronds are well developed, stout, richly differentiated into the primary and secondary branches; primary branches are usually 5-20 cm long and 0.5- 3 mm wide, cylindrical to terete, slightly flattened towards apex and near nodes, producing several secondary lateral branches, radially or alternately organized, up to 5 cm long, densely and much crowded towards apex; leaves usually develop on primary laterals or sparsely on the lower portion of the main axis in the mature thallus, simple, wedge-shaped, ovate, mature leaves slightly elongate or lanceolate in the apical region, stalked; stalk cylindrical to flat; base slightly curved, cuneate; surface membranous, smooth, transparent or translucent; midrib distinct towards base and gradually disappearing towards apex; margins dentate to broadly serrate; apex round to broadly obtuse.

21. *Sargassum polycystum*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Class: Phaeophyceae

Subclass: Fucophycidae

Order: Fucales

Family: Sargassaceae

Genus: Sargassum

Distribution:

India: Andhra Pradesh, Goa, Karnataka, Kerala and Tamil Nadu.

Goa Coast: Anjuna, Colomb.

Morphology:

Thallus light-dark brown, usually 4-12 (-30) cm long, bushy, tufted, erect, epilithic. Holdfast rhizoidal or discoid, up to 1.2 cm wide, attached tightly on rocky substrata in lower intertidal zones, occasionally secondary holdfast develops in the mature thallus. Stipe or main axis stalked, dark, wiry, cylindrical to terete, rough, usually calcified. Fronds well developed, bushy, stout, differentiated into several primary and secondary lateral branches; primary branches cylindrical to terete, often muricated towards base; secondary branches several, alternately or spirally arranged, 4-8 cm long, alternate, densely crowded towards apex; leaves simple, develop directly on primary laterals, small, linear to narrowly lanceolate, 0.5-4 × 0.4-2 cm wide, usually alternate or radially arranged, thin, membranous, stalked; base cuneate to narrowly tapering; surface usually smooth; midrib distinct towards base, gradually vanishing towards apex; margins dentate to broadly toothed, dentation straight or turning upwards; apex narrowly acute to obtuse.

22. *Sargassum tenerrimum*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Class: Phaeophyceae

Order: Fucales

Family: Sargassaceae

Genus: Sargassum

Distribution:

India: Andaman Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Dona Paula.

Morphology:

Thallus yellowish-dark brown in color, usually 8-20 (-40) cm long, bushy, tufted, erect in the young stage, epilithic.Holdfast discoid, rigid, firmly attached on rocky substrata in intertidal zones. Stipe stalked, stout, simple or branched, cylindrical to terete. Fronds well developed, stout, primary branches 10-25 cm long and 0.5-4 mm wide, glabrous, cylindrical towards the base and terete to compressed towards the apex, bearing several secondary branches in the upper region; secondary branches cylindrical or terete to compressed, usually alternate to radial; leaves develop on primary as well as on secondary branches, linear-lanceolate, 1.5-8 × 0.2-1.4 cm, alternate, usually large towards the base and gradually become smaller towards the apex, sometimes irregular, stalked or subsessile; base cuneate; surface usually smooth, thick, coriaceous; midrib prominent, thick towards base, occasionally inconspicuous; margins sinuate or dentate, wavy in a young stage, dentation towards apex; apex acute to narrowly obtuse.

23. *Sargassum wightii*

Classification:

Empire: Eukaryota

Kingdom: Chromista

Phylum: Heterokontophyta

Subphylum: Ochrophytina

Class: Phaeophyceae

Subclass: Fucophycidae

Order: Fucales

Family: Sargassaceae

Genus: Sargassum

Distribution:

India: Andaman & Nicobar Islands, Andhra Pradesh, Karnataka, Kerala, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Colomb, Dona Paula.

Morphology:

Thallus dark brown, usually 12-30 cm long, erect, epilithic. Holdfast discoid, 1-3.5 mm wide, stout, occasionally calcified, firmly attached. Stipe stalked, cylindrical to terete, 1-3 mm wide, rough, occasionally calcified in older thallus. Fronds well developed, forming bushy appearance, differentiated into primary and secondary branches; primary branches cylindrical-terete, 5-20 cm long and 1.5-5 mm wide, usually glabrous; secondary branches cylindrical or terete, occasionally slightly compressed in upper region, alternately arranged; leaves develop on primary as well as on secondary branches, narrowly oblong-linear or lanceolate, 2.3-8.5× 0.6-12 cm, alternate, stalked or subsessile; stalk up to 2 mm long; base cuneate; surface glabrous or rough, thick; midrib usually inconspicuous; margins entire to wavy or sinuate; apex broadly acute.

RHODOPHYCEAE

24. *Amphiroa fragilissima*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Phylum: Rhodophyta

Class: Florideophyceae

Subclass: Corallinophycidae

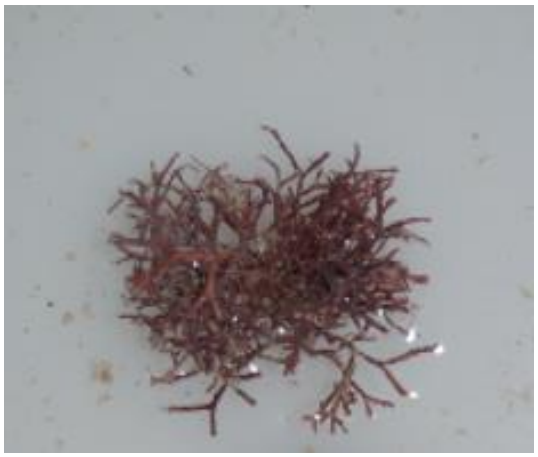
Order: Corallinales

Family: Lithophyllaceae

Subfamily: Lithophylloideae

Tribe: Amphiroeae

Genus: Amphiroa



Distribution:

India: Andaman & Nicobar Islands, Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna.

Morphology:

Thallus light-pinkish grey, occasionally yellowish white or colorless, cylindrical-terete, usually 2-5 cm long, calcified, solid, fragile, caespitose, usually epilithic. Holdfast minute, discoid, sometimes indistinct, brittle, attached on rocky substrata in intertidal region. Stipe stalked, cylindrical. Fronds erect, cylindrical to terete, regularly dichotomously branched, articulated, sometimes irregularly proliferated, consist of alternate segments of cylindrical intergenicula and narrow bands of genicula, mature fronds usually covered with prominent hemispherical reproductive parts.

25. *Amphiroa rigida*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Biliphyta

Infrakingdom: Rhodaria

Phylum: Rhodophyta

Subphylum: Eurhodophytina

Class: Florideophyceae

Subclass: Corallinophycidae

Order: Corallinales

Family: Lithophyllaceae

Subfamily: Lithophylloideae

Tribe: Amphiroeae

Genus: Amphiroa

Distribution:

India: Andaman & Nicobar Islands, Gujarat, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Colomb.

Morphology:

Thallus dark-muddy pinkish in colour, cylindrical-terete, usually 3-6 cm long, heavily calcified, solid, fragile, caespitose, usually epilithic. Holdfast minute, discoid, britle, lightly attached on rocky substrata in intertidal region. Stipe stalked, cylindrical. Fronds erect, cylindrical to terete, regularly dichotomously branched, articulated, sometimes irregularly proliferated, consist of alternate segments of cylindrical intergenicula and narrow bands of genicula.

26. *Cheilosporum spectabile*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Biliphyta

Infrakingdom: Rhodaria

Phylum: Rhodophyta

Subphylum: Eurhodophytina

Class: Florideophyceae

Subclass: Corallinophycidae

Order: Corallinales

Family: Corallinaceae

Subfamily: Corallinoideae

Genus: Cheilosporum

Distribution:

India: Gujarat, Karnataka, Kerala, Lakshadweep Islands, Maharashtra and Tamil Nadu.

Goa Coast: Arambol, Anjuna.

Morphology:

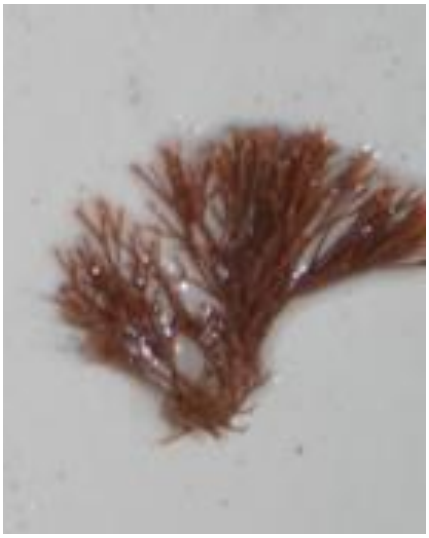
Thallus light purple-red in color, calcareous, bushy, fragile, erect, articulated, caespitose, epilithic. Holdfast minute, rhizoidal, brittle. Stipe minute, stalked, up to 0.5 mm long, sometimes indistinct. Fronds are erect, filamentous, usually 2-5 cm long, usually regularly dichotomously branched, articulated, segmented, and consist of alternate segments of long and flattened intergenicula and narrow bands of genicula.

27. *Jania rubens*

Classification:

Empire: Eukaryota

Kingdom: Plantae



Subkingdom: Biliphyta

Phylum: Rhodophyta

Subphylum: Eurhodophytina

Class: Florideophyceae

Subclass: Corallinophycidae

Order: Corallinales

Family: Corallinaceae

Subfamily: Corallinoideae

Tribe: Janieae

Genus: Jania

Distribution:

India: Andaman Islands, Andhra Pradesh, Goa, Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu.

Goa Coast: Colomb.

Morphology:

Thallus light-dark purple red in colour, cylindrical, usually 2-5 cm long, bushy, calcareous, erect, articulated, solid, fragile, caespitose, epilithic. Holdfast minute, rhizoidal or discoid, firmly or loosely attached. Stipe stalked, cylindrical, up to 8 mm long, calcified. Fronds erect, cylindrical, 1-5 cm long and 90-310 µm in diameter, filamentous, regularly differentiated into long and cylindrical intergeniculata and narrow bands of genicula, slightly constricted in geniculata region and widened near dichotomies, main axis usually regularly dichotomously branched; branches profuse in upper regions, forming a cymoid structure.

28. *Gelidium micropterum*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Biliphyta

Phylum: Rhodophyta

Subphylum: Eurhodophytina

Class: Florideophyceae

Subclass: Rhodymeniophycidae

Order: Gelidiales

Family: Gelidiaceae

Genus: Gelidium

Distribution:

India: Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Arambol, Bogmalo.

Morphology:

Thallus dark-purple red, flattened, tufted, erect, cartilaginous, usually 2-5 cm long, epilithic. Holdfast small, rhizoidal, branched, up to 2 mm long and 0.2 mm wide, firmly attached on calcareous stones and bedrocks in tidal and intertidal regions. Stipe small, flat, rarely cylindrical. Fronds erect, flattened more in the middle portion and gradually narrowing towards both ends, profusely branched; branches irregular, pinnate, flattened, 2-5 cm long and 0.3-3 mm wide; pinnules usually develop marginally oppositely or irregularly, dense in middle and upper portion, thick, flat to slightly slender in shape, sometimes spathulae, up to 5 mm long and 1 mm wide; surface smooth; margins entire in lower portion and wavy to truncate or irregular in upper portion; apex acute or obtuse, occasionally irregularly forked, fertile tip usually blunt.

29. *Gelidium pusillum*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Biliphyta

Infrakingdom: Rhodaria

Phylum: Rhodophyta

Subphylum: Eurhodophytina

Class: Florideophyceae

Subclass: Rhodymeniophycidae

Order: Gelidiales

Family: Gelidiaceae

Genus: Gelidium

Distribution:

India: Andaman Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala Maharashtra, Tamil Nadu and West Bengal.

Goa Coast: Anjuna, Bogmalo, Cabo de Rama, Dona Paula.

Morphology:

Thallus dark-purple red in color, flattened, tufted, erect, cartilaginous, small, 1-3.5 cm long, epilithic. Holdfast is very minute, rhizoidal or stoloniferous, branched, firmly attached on calcareous stones and bedrocks in tidal and intertidal regions. Stipe small, flat, up to 3 mm long and 0.5 mm wide. Fronds erect, terete in the lower portion and flattened in middle, gradually narrowing towards both ends, profusely branched in upper region; branches irregular, pinnate, flattened; pinnules develop marginally oppositely or irregularly, thick, tufted, usually truncate to slightly flat, up to 3 mm long and 1 cm wide; surface smooth; margins entire or truncate or irregular; apex acute or obtuse; fertile tip blunt or rounded.

30. *Chondracanthus acicularis*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Biliphyta

Infrakingdom: Rhodaria

Phylum: Rhodophyta

Subphylum: Eurhodophytina

Class: Florideophyceae

Subclass: Rhodymeniophycidae

Order: Gigartinales

Family: Gigartinaceae

Genus: Chondracanthus

Distribution:

India: Andaman Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu.

Goa Coast: Anjuna, Arambol.

Morphology:

Thallus dark-purple red, occasionally greenish towards the base in the young stage, usually cylindrical, wiry, usually 4-12 cm long, cartilaginous, prostrate, loosely intricate, tufted, epilithic; Holdfast minute, rhizoidal, delicate, firmly attached on rocky substrata in surf-exposed areas in intertidal regions. Stipe small or indistinct. Fronds slender, slightly compressed, rigid, profusely branched; branches irregular, pinnate or dichotomous, slightly curved or forked towards apex; surface smooth; margins entire; apex acute-acuminate with usually light purple color, apical dichotomy 0.4-5 mm long and 180-360 µm broad.

31. *Gracilaria corticata*

Classification:

Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Biliphyta

Phylum: Rhodophyta

Subphylum: Eurhodophytina

Class: Florideophyceae

Subclass: Rhodymeniophycidae

Order: Gracilariales

Family: Gracilariaceae

Subfamily: Gracilarioideae

Tribe: Gracilarieae

Genus: Gracilaria

Distribution:

India: Andaman & Nicobar Islands, Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu.

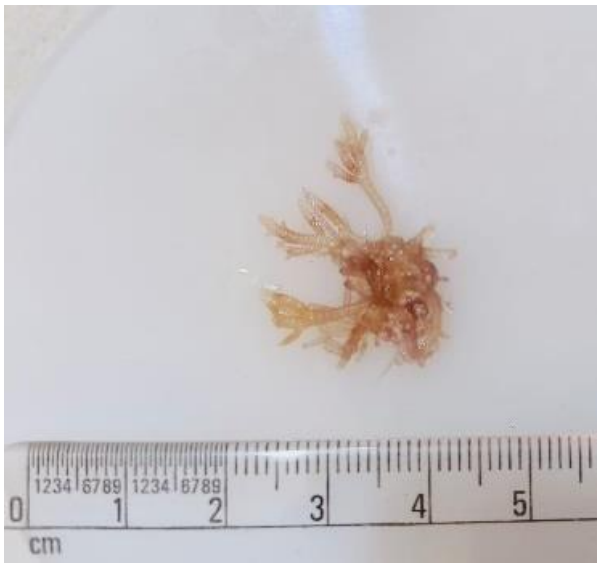
Goa Coast: Anjuna, Arambol, Cabo de Rama.

Morphology:

Thallus is dark to yellowish red, 5-18 cm long, bushy, tufted, cartilaginous, rigid, epilithic. Holdfast small, discoid, firmly attached on rocky substrata in intertidal zones.Stipe flatterned to slightly terete, rigid, 0.5-1.5 mm wide.Fronds flattened below and gradually become cylindrical to subterete upwards, alternately or irregularly dichotomously branched; branches usually sparse below and dense towards apex; margins entire; apex acute or narrowly pointed.

32. *Champia compressa*

Classification:



Empire: Eukaryota

Kingdom: Plantae

Subkingdom: Biliphyta

Infrakingdom: Rhodaria

Phylum: Rhodophyta

Subphylum: Eurhodophytina

Class: Florideophyceae

Subclass: Rhodymeniophycidae

Order: Rhodymeniales

Family: Champiaceae

Genus: Champia

Distribution:

India: Goa, Gujarat, Karnataka, Maharashtra and Tamil Nadu.

Goa Coast: Arambol.

Morphology:

Thallus light-bright purple or occasionally greenish red, frondose, caespitose, densely clumped, articulated, 2-8 cm long, membranous, usually transparent, gelatinous, erect, epilithic. Holdfast is usually rhizoidal, irregularly branched, and firmly attached. Stipe small, cylindrical to slightly compressed, up to 8 mm long. Fronds foliose, compressed to gradually flattened upwards, up to 5 cm long and 1-3 mm wide, segmented; segments 0.5-1.4 mm apart; sparsely branched; branches alternate or sub-opposite or irregular; surface smooth to slightly rough with markedly parallel constrictions; margins entire to irregularly proliferated; apex obtuse to acute, occasionally acuminate.

4.1 RESULTS AND DISCUSSION

The current study identifies thirty two different species of seaweeds classified into seventeen genera, which are part of twelve families and twelve orders. Among the thirty two documented taxa, nine belong to the Rhodophyceae group, six belong to the Chlorophyceae group, and seventeen belong to the Phaeophyceae group (Table 4.1.1). Out of the three classes, Phaeophyceae is the most prevalent (53%), Rhodophyceae follows at 28%, followed by Chlorophyceae (19%) (Fig 4.1.1).

The observation made in the present study and the data analyzed indicate that the group Rhodophyceae shows high diversity at order, family, and genus levels compared to the other two groups. However, at the species level, Phaeophyceae is found to be the highly diverse group (Fig.4.1.2).

The Chlorophyceae group consists of 4 genera and 6 species. Among these genera, Caulerpa and Ulva were more dominant than Acrosiphonia and Chaetomorpha (Fig 4.1.3).

The Phaeophyceae includes 17 species from 6 genera. The Padina and Sargassum followed by Dictyota were the most prevalent genera. Single species from the Ectocarpus, Spatoglossum, and Stoechospermum genera were recorded (Fig 4.1.4).

There are nine species from the seven genera that make up the Rhodophyceae group. The Amphiroa and Gelidium genera were the most prevalent (Fig 4.1.5).

Table 4.1.1: Summary of the numerical report of seaweeds from the selected sites of Goa coast:

Sr. No.	Class	Order	Family	Genus	Species
1	Chlorophyceae	04	04	04	06
2	Phaeophyceae	03	03	06	17
3	Rhodophyceae	05	05	07	09
	Total	**12**	**12**	**17**	**32**

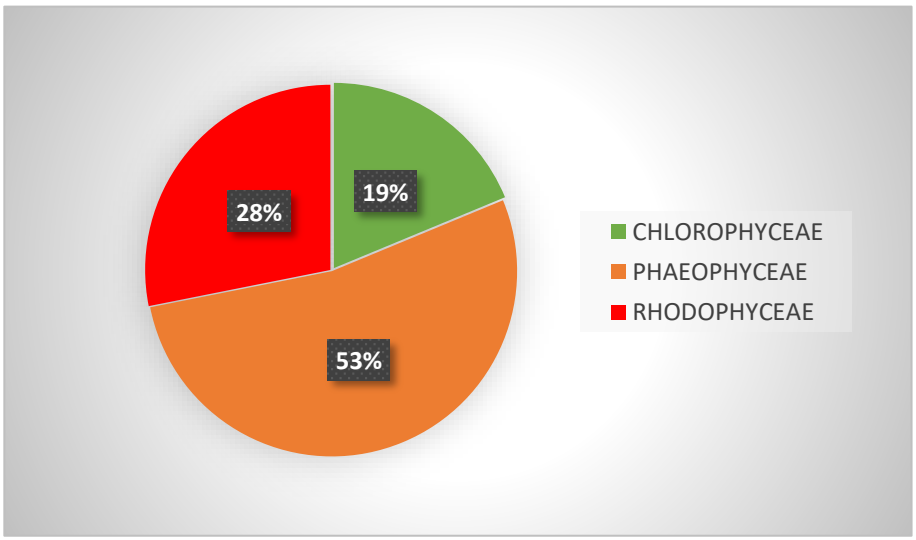


Fig 4.1.1: Pie chart showing the diversity of seaweeds

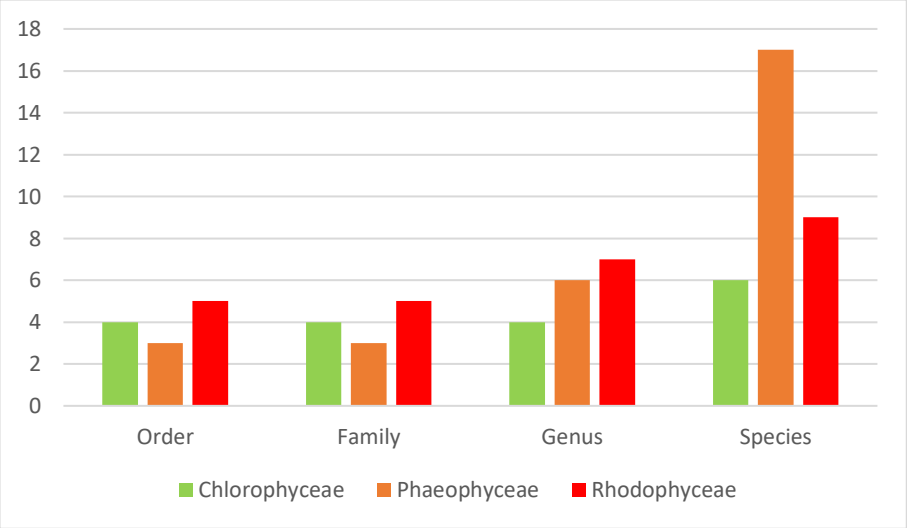


Fig 4.1.2: Numerical report of different seaweed groups from selected sites of Goa.

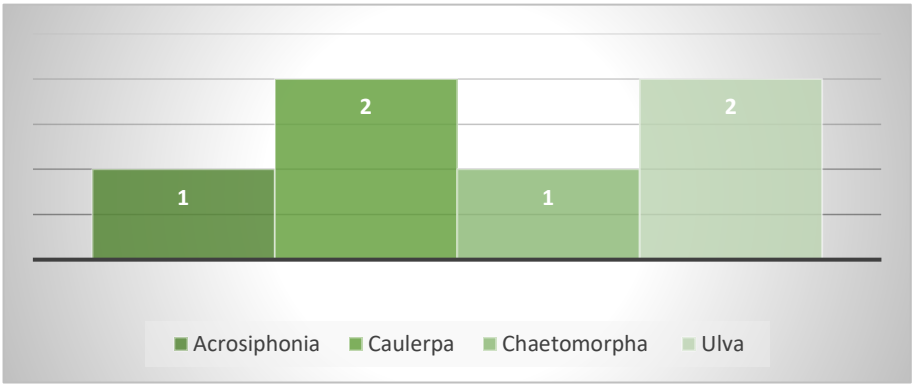


Fig 4.1.3: Dominant genus among Chlorophyceae

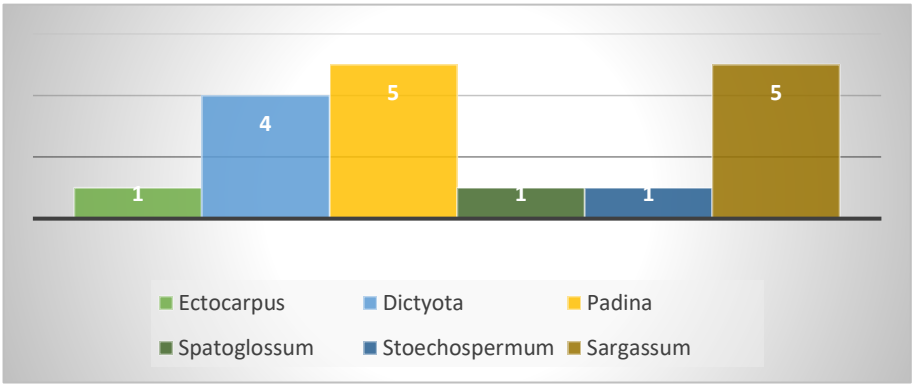


Fig 4.1.4: Dominant genus among Pheophyceae

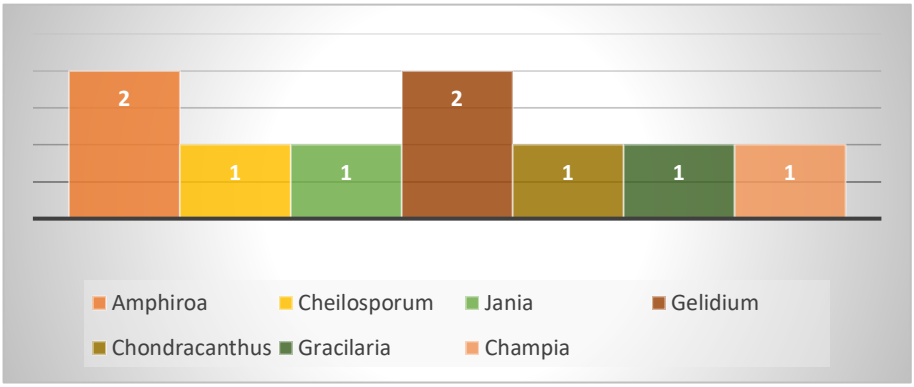


Fig 4.1.5: Dominant genus among Rhodophyceae

The recent investigation discovered thirty-two different species of seaweeds from seventeen genera, twelve families, and twelve orders. With four genera and eleven species, the Dictyotaceae family has the highest diversity of species. The next in line were the families Sargassaceae (one genus, Sargassum, with five species) and Corallinaceae (three genera, four species). Comparatively speaking, as shown in (Table 4.1.2), the most well-known genera among the many genera are Sargassum, Dictyota, and Padina.

The seaweed taxa seen on a selected rocky coasts during the post-monsoon season include a variety of Phaeophyceae species. The fact that brown algae generally demand cold waters for optimal growth helps to explain the diversity of Phaeophyceae species along the selected rocky coasts of Goa. In India, coastal regions experiencing cooler temperatures, such as those along the western coast and parts of the eastern coast, provide suitable conditions for brown algae growth (Bast,1966). The Goan coast has colder weather from November to January, which encourages the growth of brown algae.

The current analysis indicates the low diversity of Chlorophyceae in comparison to Phaeophyceae. (Mishra *et al.,* 2009) says "Dominance of Chlorophyceae during the monsoon period showing influence of the freshwater discharge". It is observed that the increased rainfall during these seasons provides the nutrients and moisture required for these algae to flourish. The low variety of Chlorophyceae found in the current study can be due to sampling during an unfavorable season for Phaeophyceae, viz November to February.

Table 4.1.2: List of the seaweed taxa recorded from selected rocky shores of Goa

Sr. No.	Order	Family	Genus	Species name
CHLOROPHYCEAE				
1	Acrosiphoniales	Acrosiphoniaceae	Acrosiphonia	*Acrosiphonia orientalis* (J. Agardh) P.C. Silva
2	Bryopsidales	Caulerpaceae	Caulerpa	*Caulerpa peltata* J.V. Lamour.
3				*Caulerpa taxifolia* (Vahl) C. Agardh
4	Cladophorales	Cladophoraceae	Chaetomorpha	*Chaetomorpha antennina* (Bory) Kuetz.
5	Ulvales	Ulvaceae	Ulva	*Ulva lactuca* L.
6				*Ulva prolifera* O.F. Muell.
PHAEOPHYCEAE				
7	Ectocarpales	Ectocarpaceae	Ectocarpus	*Ectocarpus siliculosus* (Dillwyn) Lyngb.)
8	Dictyotales	Dictyotaceae	Dictyota	*Dictyota cervicornis* Kuetz.
9				*Dictyota ceylanica* Kuetz.
10				*Dictyota ciliolata* Kuetz
11				*Dictyota dichotoma* (Huds.) J.V. Lamour.
12			Padina	*Padina boergesenii* Allender& Kraft
13				*Padina boryana* Thivy
14				*Padina gymnospora* (Kuetz.) Sonder
15				*Padina pavonica*(L.) Thivy
16				*Padina tetrastromatica* Hauck
17			Spatoglossum	*Spatoglossum asperum* J. Agardh

18			Stoechospermum	*Stoechospermum marginatum* (C. Agardh) Kuetz.
19	Fucales	Sargassaceae	Sargassum	*Sargassum cinctum* J. Agardh
20				*Sargassum cinereum* J. Agardh
21				*Sargassum polycystum* C. Agardh
22				*Sargassum tenerrimum* J. Agardh
23				*Sargassum wightii* Grev
RHODOPHYCEAE				
24	Corallinales	Corallinaceae	Amphiroa	*Amphiroa fragilissima* (L.) J.V. Lamour.
25				*Amphiroa rigida* J.V. Lamour.
26			Cheilosporum	*Cheilosporum spectabile* Harv. ex Grunov
27			Jania	*Jania rubens* (L.) J.V. Lamour
28	Gelidiales	Gelidiaceae	Gelidium	*Gelidium micropterum* Kuetz.
29				*Gelidium pusillum* (Stackh.) Le Jolis
30	Gigartinales	Gigartinaceae	Chondracanthu	*Chondracanthus acicularis* (Roth) Fredericq
31	Gracilariales	Gracilariaceae	Gracilaria	*Gracilaria corticata* (J. Agardh) J. Agardh
32	Rhodymeniales	Champiaceae	Champia	*Champia compressa* Harv

The spatial distribution of different seaweed taxa along different study locations:

An analysis of the field observation made during the study survey along the rocky shores of the Goa coast reveals that the seaweeds show much variation in the pattern of seaweed distribution (Table 4.1.3). In Chlorophyceae, *Ulva prolifera* and *Chaetomorpha antennina* species were recorded from three study sites each (4.1.6). Species like *Ectocarpus siliculosus* and *Stoechospermum marginatum* from Phaeophyceae group were commonly found and widely distributed along four study sites each (4.1.7). *Gelidium pusillum* species from the Rhodophyceae group was recorded from four study stations (4.1.8). While, *Caulerpa peltata* from Chlorophyceae, *Dictyota ceylanica* from Phaeophycea and *Amphiroa fragilissima*, *Jania rubens* and *Champia compressa* from the Rhodophyceae group were found scantly distributed.

An analysis of the spatial distribution of seaweed along the selected rocky shores of Goa displays that the seaweed species distribution was highest at Anjuna followed by Arambol (Fig 4.1.9). A total of 25 species were found on Anjuna Shore; six of these were in the Chlorophyceae family, twelve were in the Phaeophyceae family, and seven were in the Rhodophyceae family. Arambol's rocky shore was home to the total 16 species, of which 3 were members of the Chlorophyceae family, 8 of the Phaephyceae family, and 5 of the Rhodophyceae family. Out of all the study sites, the Cabo de Rama coast provided the fewest kinds of seaweed.

Table 4.1.3: List showing spatial distribution of seaweed species:

Sr. No.	Species name	Locations
CHLOROPHYCEAE		
1	*Acrosiphonia orientalis*	Anjuna, Arambol
2	*Caulerpa peltata*	Anjuna
3	*Caulerpa taxifolia*	Anjuna, Colomb
4	*Chaetomorpha antennina.*	Anjuna, Bogmalo, Cabo de Rama
5	*Ulva lactuca*	Anjuna, Arambol
6	*Ulva prolifera*	Anjuna, Arambol, Dona Paula
PHAEOPHYCEAE		
7	*Ectocarpus siliculosus*	Anjuna, Arambol, Bogmalo, Colomb
8	*Dictyota cervicornis*	Anjuna, Arambol, Bogmalo, Colomb, Dona Paula
9	*Dictyota ceylanica*	Colomb
10	*Dictyota ciliolata*	Anjuna, Arambol, Colomb
11	*Dictyota dichotoma*	Anjuna, Arambol
12	*Padina boergesenii*	Arambol, Cabo de Rama, Dona Paula
13	*Padina boryana*	Cabo de Rama, Colomb
14	*Padina gymnospora*	Colomb, Dona Paula

15	*Padina pavonica*	Anjuna, Arambol, Bogmalo
16	*Padina tetrastromatica*	Anjuna, Bogmalo, Cabo de Rama
17	*Spatoglossum asperum*	Anjuna, Arambol
18	*Stoechospermum marginatum*	Anjuna, Arambol, Colomb, Dona Paula
19	*Sargassum cinctum*	Bogmalo, Colomb
20	*Sargassum cinereum*	Anjuna, Colomb
21	*Sargassum polycystum*	Anjuna, Colomb
22	*Sargassum tenerrimum*	Anjuna, Dona Paula
23	*Sargassum wightii*	Anjuna, Colomb, Dona Paula
RHODOPHYCEAE		
24	*Amphiroa fragilissima*	Anjuna
25	*Amphiroa rigida*	Anjuna, Colomb
26	*Cheilosporum spectabile*	Anjuna, Arambol
27	*Jania rubens*	Colomb
28	*Gelidium micropterum*	Anjuna, Arambol, Bogmalo
29	*Gelidium pusillum*	Anjuna, Bogmolo, Cabo de Rama, Dona Paula
30	*Chondracanthus acicularis*	Anjuna, Arambol
31	*Gracilaria corticata*	Anjuna, Arambol, Cabo de Rama
32	*Champia compressa*	Arambol

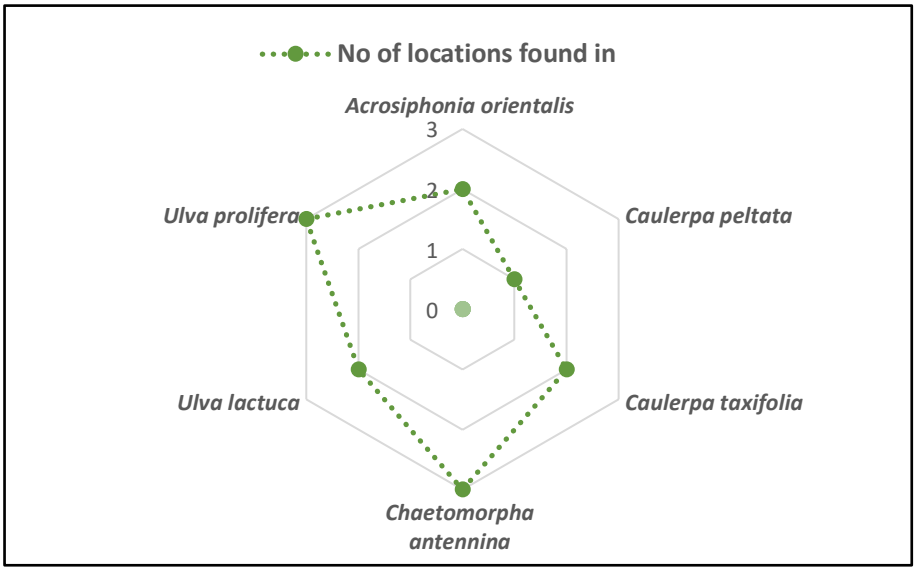


Fig 4.1.6: Species-wise distribution of Green seaweed

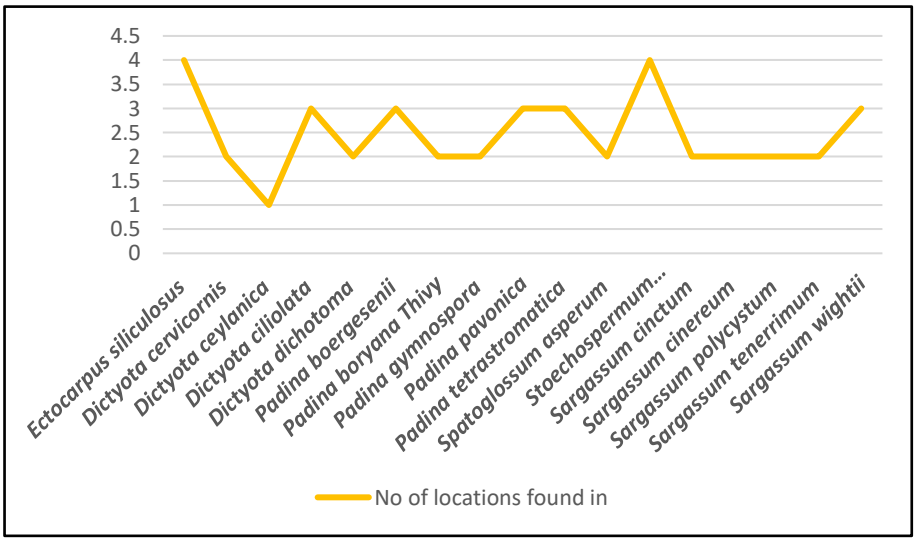


Fig 4.1.7: Species-wise distribution of Brown seaweed

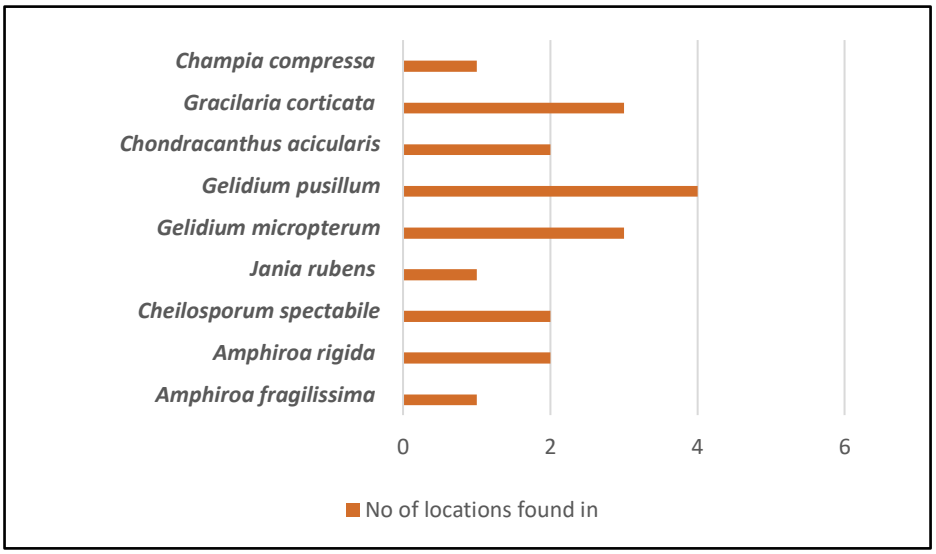


Fig 4.1.8: Species-wise distribution of Red seaweed

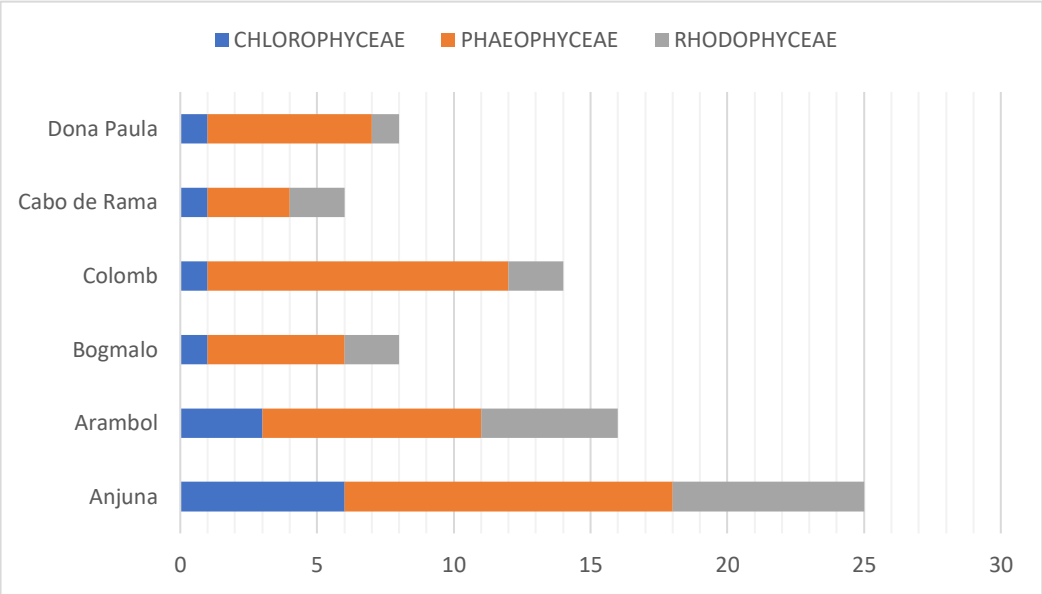


Fig 4.1.9: Spatial distribution of seaweed along the study area

A total of 70 macroalgae species were recorded from the intertidal rocky shores of Anjuna and Vagator. Of these, Anjuna was more diverse with 61 species and Vagator recorded 54 species (Imchen & Anil, 2017). Similarly, the present study reveals that the species diversity was highest at the Anjuna rocky shore contributing 25 different taxa. The coastal waters of Anjuna are subjected to a variety of anthropogenic activities contributing to eutrophication (Alkawri & Ramaiah, 2011). Excessive tourist and anthropogenic activities results in release of high levels of nitrogenous nutrients to support rapid growth rate of seaweeds. The tropographical features and the localized habitat specificity also provide suitable substratum for the seaweed community in this region.

The diversity of seaweeds in Arambol Beach in North Goa is not specifically mentioned in the literature that is currently in publication. However, the coastline of the state Goa is more rocky in the North Goa and supports more growth and diversity of seaweeds (Palanisamy & Yadav, 2022). Anjuna and Arambol are the northen coasts of Goa and in present study highest number of seaweed species recorded from these two study sites.

In case of the Cabo de Rama, the physical processes(wave action)along the coast could limit the colonization of diverse seaweed species. Intense wave action can create a harsh environment that only a few seaweed species are adapted to thrive in (Sharma & Desai, 2019).

4.2 CONCLUSIONS

- The compiled inventory provides a list of thirty two seaweed species found in the intertidal zones of rocky shores along the Goa coast during post-monsoon season.
- The Rhodophyceae group is more diverse in order, family, and genus-wise but the phaeophyceae group is more diverse at the species level (17) than Rhodophyceae (09) and Chlorophyceae (06).
- Dictyotaceae followed by Sargassaceae and Gelidiaceae show dominance over other families of seaweeds.
- Padina and Sargassum genera dominate other seaweed genera by contributing the highest number of seaweed species.
- *Ectocarpus siliculosus* and *Stoechospermum marginatum* from phaeophyceae group and *Gelidium pusillum* from the rhodophyceae group are commonly found and widely distributed.
- While, *Caulerpa peltata* from Chlorophyceae, *Dictyota ceylanica* from Phaeophycea and *Amphiroa fragilissima*, *Jania rubens* and *Champia compressa* from the Rhodophyceae group are found scantly distributed.
- In spatial diversity of seaweeds, Anjuna shows richness in seaweed diversity contributing twenty five species of seaweeds.

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