MORPHOLOGICAL AND ANATOMICAL EVALUATION OF A FEW RED ALAGE FROM THIKKODI AND THIRUMULLAVARAM COAST

DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF

BACHELOR OF SCIENCE IN BOTANY

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ST. TERESA'S COLLEGE (AUTONOMOUS)

ERNAKULAM

2022-2023

CERTIFICATE

This is to certify that the dissertation entitled "**Morphological and Anatomical evaluation of a few Red Algae from Thikkodi and Thirumullavaram Coast**" submitted by Ms. Maria Jilda as a part of the B.Sc. Degree in Botany during the year 2022-2023 has been carried out under the supervision of Mrs. I.K. Nishitha, Department of Botany, St. Teresa's College, Ernakulam.

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DECLARATION

We hereby declare that the project entitled **"Morphological and Anatomical evaluation of a a few red algae from Thikkodi and Thirumullavaram coast"**submitted to Mahatma Gandhi University, Kottayam, in partial fulfilment of the requirement for the Degree of Bachelor of Science in Botany is an original project done by me under the supervision and guidance of Mrs I. K. Nishitha., Department of Botany and Centre for Research, St. Teresa's college (Autonomous), Ernakulam.

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CONTENT

MORPHOLOGICAL AND ANATOMICAL EVALUATION OF A FEW RED ALGAE FROM THIKKODI AND THIRUMULLAVARAM COAST

Introduction

Algae is an extremely diverse group consisting predominantly of aquatic plants showing relatively little differentiation of tissues and organs. It includes both prokaryotic and eukaryotic photosynthetic organisms with chlorophyll *a* and other photosynthetic pigment releasing oxygen. Algal plant body ranges from unicellular to colonial filamentous , siphonous and even parenchymatous and never contains roots ,stems or leaves. Plant body may be as small as unicellular to as large as 50 meter or more in length as in morphology. Algae also demonstrate great variation in reproduction .They reproduce by vegetative, asexual and sexual processes.

Macroalgae are part of the algae family and range completely in size and form. They are commonly referred to as seaweed, and macroalgae can all be identified and seen by the human eye. The smallest seaweeds are just a few millimeters in size, but they go up to fifty meters for the largest ones. They are found at the bottom of the seabed or are attached to rocks, shells, boats hulls, or natural reefs. In the ocean, macroalgae play a massive role within the ecology of coral reefs. For herbivores living in the ocean, they are a source of food and act as the base of the food chain. Many seaweeds only live for one season. Seaweed is integral to the marine ecosystem and provides energy and nutrients for the animals. Seaweed also acts as a shelter for many animals, who create their habitat from a bed of macroalgae. They are the most accessible marine resource to the coastal community and a comprehensive assessment of their utility can substantially enhance the community economics and make an equal contribution to the economy of the country.

India with a coastline of about 7500 km including 1256 islands with 2 million km^2 of Exclusive Economic Zone (EEZ) (Subba Rao, 2000), is home to a wide variety of seaweeds. The evaluation of seaweed diversity along the Indian coasts has been attempted by several workers (Biswas, 1945; Biswas and Sharma, 1950; Srinivasan, 1960 and Krishnamurthy and Joshy, 1970). These evaluations are very significant to record the numbers, types, characteristics, distribution patterns, economic and ecological importance and their contribution to the marine environment for balancing the primary productivity (Suparna Roy *et al*, 2016). Umamaheshwara Rao (2011) has listed 896 species of macroalgae from the Indian coasts.

Kerala has a coastline of nearly 600 km, which is about 10% of the total coast length of India and is situated in the south—western part of India. Greater part of the shoreline of Kerala is

straight i.e., from Kozhikode to Kollam, but in Kannur, Thiruvananthapuram and Kollam districts, indentations, cliffs and protruberances are present. Geomorphologically, Kerala coast can be classified into two categories, rocky and sandy. The coast north of Kozhikode and south of Kollam are mainly rocky but at certain places sandy beaches are formed especially at bayheads and river confluences. The central part of Kerala coast is mainly sandy.

There are many different types of macroalgae, which vary in their color and size.

Chlorophyceae

The Chlorophyceae are one of the classes of green growth, recognized primarily based on ultrastructural morphology. They are typically green because of the strength of the colors chlorophyll an and chlorophyll b. They generally have a cell wall comprised of an inward layer of cellulose and an external layer of pectose.

The majority of Chlorophyceae species are aquatic, though a small number also grow on land and in brackish and saline water. They exhibit a wide range of variations in their thallus structures..Flagella are inserted either apically or subapically, are one in number, and are of equal size.

Cellulose, which is primarily composed of xylans and mannans and hydroxyproline glycosides, makes up the majority of the cell wall. Their green color comes from the presence of chlorophyll a and b, however, the shade may vary from light to dark green. This color is dependent on the presence of beta-carotene and xanthophylls, which can alter the shade of Chlorophyta. Green algae are used for food for both humans and sea creatures. They are often what we would typically refer to as seaweed in restaurants or grocery stores. If you are wondering what is chaeto, or Chaetomorpha, these are a type of green algae, which are often referred to as sea emerald.

Phaeophyceae

The class Phaeophyceae includes a group of algae known as brown algae. Their colour, which ranges from would be in the colour of dark or light brown to green which is olive, inspired their names. The majority of their habitats are maritime. The size and shape of the approximately a thousand five hundred species of Phaeophyceae vary widely. They have many cells, and the proportion of fucoxanthin to chlorophyll determines their color. Brown algae are primarily

marine in habitat. They are located on chilly coastal seas. Either they are found floating freely or adhered to the substrate. Brown algae come in a wide range of sizes and shapes. They can be as big as 100 metres or a few centimetres.

They have a multicellular algae structure. They have branches and filaments. Since there are no genuine roots, stems, or leaves, the plant's body is a thallus. They are anchored to their substrate by a holdfast, a root-like structure. Distinct species' holdfasts have different structures. Like the roots of plants, they do not participate in the uptake of nutrients or water. They stop the water current from carrying algae away.

Rhodophyceae

It is a large group of algae consisting of about 831 genera and over 5;250 species. They are commonly known as red algae due to the presence of a water soluble red pigment, r-phycoerythrin. The r-phycoerythrin is, however, present sufficiently and completely to mask the chlorophyll a, giving the characteristic red colouration. More than 98% members are marine and the rest grow in fresh water. The marine species have the ability to live at greater depth (even at 30-90 meters) than the other members of different classes. They also exhibit a high degree of parasitism and epiphytism. The parasitic members show great reduction in their size and pigmentation.

Most of the members are marine. The members may grow either as saprophytes, parasites and also as epiphytes. The plant body may be unicellular (*Porphyridium*) or multicellular. The multi-cellular form may be filamentous They do not attain the size like that of the brown algae (Phaeophyceae), but may reach up to 2 meters in *Schizymenia*. The flagellated motile stages are totally absent.

The characteristic red colouration of the algae is due to the sufficient presence of r-phycoerythrin which completely masks the chlorophyll a. The reserve food is floridean starch, floridi- side and mannoglycerate. Reproduction takes place by all the three means: vegetative, asexual and sexual.

Red algae are true plants in the phylogenetic sense since they share a single common ancestor with the green lineage (green algae e and higher plants) (Adi, 2005) However, the phylum Rhodophyta is easily distinguished from other groups of eukaryotic algae due to a number of features listed below (Woelkerling,1990, Grossman1993, Pereira, 2012):

- Total absence of centrioles and any flagellate phase;
- Presence of chlorophylls a and d, and accessory pigments (light-harvest) called phycobilins (phycoerythrin and phycocyanin);
- Plastids with unstacked thylakoids and no external endoplasmic reticulum;
- Absence of parenchyma and presence of pit-connections between cells (i.e., incomplete cytokinesis);
- Floridean starch as storage product.

Traditionally, red algae can be morphologically separated in three major groups:

- A unicellular group with reproduction by binary cell division only;
- A multicellular group where a carpogonial branch is absent or incipient (Bangiophyceae)
- A multicellular group with well-developed carpogonial branches (Florideophyceae).

Objectives of the current study:

1. Diversity study of rhodophytes at selected coasts of Kerala.
2. Identification of the collected specimen.
3. Taxonomic evaluation of a few collected specimen by morphological and anatomical evaluation.

REVIEW OF LITERATURE

R Iyer et al (2004) conducted the morphological and taxonomic studies of *Gracilaria* and *Gracilariopsis* species (Gracilariales, Rhodophyta) from South Africa. They studied morphology and taxonomy of nine *Gracilaria* species. The result shows that the taxonomic identity of *G. vieillardii* specimens from South Africa and the differentiation of *G. canaliculata* and *G. salicornia* has been confirmed based on morphology.

G. M. Gargiulo et al (2019) conducted a cross reference study about morphology, reproduction and taxonomy of the Mediterranean species of *Gracilaria* (Gracilariales, Rhodophyta). Species of the marine algal genus *Gracilaria* (Gracilariaceae, Rhodophyta) reported from the Mediterranean are critically reassessed. The result of the examination of the reproductive morphology of these species suggests that the currently accepted criteria for distinguishing between the genera *Gracilaria*, *Hydropuntia* (Polycavernosa) and *Gracilariopsis* are not sustainable, particularly with regard to the development and nutrition of the developing carposporophyte and the formation of sperrnatangia.

Muhammad Nur Arif Othman et al (2018) conducted morphological characteristics and habitats of red seaweed *Gracilaria* spp.(Gracilariaceae, Rhodophyta) in Santubong and Asajaya, Sarawak, Malaysia. This study was designed to identify the species of *Gracilaria* using morphological approach and to assess selected water quality parameters in *Gracilaria* habitats. The study had provided better information on identification of *Gracilaria* and their habitat in Sarawak. Future work involving DNA barcoding of each species is in progress.

Kaoru Matsumoto, Satoshi Shimada (2018) conducted taxonomic reassessment of *Chondrus verrucosus* (Rhodophyta, Gigartinales), with a description of *Chondrus retortus*. Phylogenetic and morphological reinvestigation of *Chondrus verrucosus* Mikami was conducted in the Pacific coast of southeastern Honshu, Japan, including the holotype specimen and samples near the type locality. Two entities were recognized

by phylogenetic analyses of plastid rbcL and nuclear EF2 sequences. In morphological analyses, the two entities were distinguished by: (i) thallus size and form, and (ii) cell shape of the medullary layer surrounding young carposporangia: one has larger thalli, is regularly canaliculated, with linear medullary cells (large-type); the other is smaller, canaliculated with crispation and has roundish medullary cells (small-type).

Pil Joon Kang et al (2020) conducted new record of *Chondrus retortus* (Gigartinales, Rhodophyta) in Korea. A marine red algal species was collected from Honghyeon-ri, Namhae located on the southern coast of Korea during a survey of marine algal flora. The result shows that this alga shares the generic features of *Chondrus*, and is characterized by short and thin, canaliculated and crisped fronds as *C. retortus*.

Su Qiao et al (2002) conducted morphological observations and rbcL sequence analyses of *Chondrus* collected from Pingtan and Zhangpu of Fujian province, Qingdao of Shandong province and Dalian of Liaoning province were made. Total DNA were extracted from fresh or silica gel-dedicated plants and used as templates for polymerase chain reactions. Purified polymerase chain reaction products were directly sequenced. The results indicated three Chondrus species.

CJ Bird, J McLachlan - (1986) conducted studies on several characteristics that have been neglected in assessing species of *Gracilaria* are (I) type of spermatangia, (2) chromosome number and (3) interfertility. Spermatangial configuration, although easily determined, is documented for fewer than half of the currently recognized species, mostly those of the Pacific Ocean. It is shown, however, how discrepancies in type of spermatangia are useful in distinguishing otherwise similar entities from widely separated locales.

Conxi Rodríguez-Prieto et al(2016) conducted morphological evaluation of *Gracilaria corallicola* and *G. multipartita* (Gracilariales, Rhodophyta), two related flattened European species. *Gracilaria multipartita* (Clemente) Harvey and *G. corallicola* Zanardini are morphologically similar European species of *Gracilaria* (Gracilariales, Rhodophyta), having broadly flattened blades borne on cylindrical stipes. The result shows that two European species of *Gracilaria* possess flattened blades borne on cylindrical axes, namely, *G. multipartita*, known primarily from the Atlantic coast, and

G. corallicola from the Mediterranean Sea. They are sister species that cluster wit *G. armata, G. bursa-pastoris* and *G. longa* in rbcL analyses with strong bootstrap support. Blades of *G. multipartita* taper towards the tips, whereas those of *G. corallicolla* have broadly rounded tips. Spermatangia of *G. corallicola* are borne in shallow conceptacles (textorii-type) and data from the literature indicate that the same is true of G. multipartita. Cystocarp morphology is similar, with the gonimoblast filaments initially elongated, narrow and densely filled with cytoplasm, and with tubular nutritive cells issuing initially from lower gonimoblast cells and fusing with cells in the lowermost regions of the outer pericarp.

S Fredericq et al (1992) conducted developmental morphology of *Chondrus crispus* (Gigartinaceae, Rhodophyta). The vegetative and reproductive development of the type species of *Chondrus, C. crispus* Stackhouse (Gigartinaceae, Rhodophyta), is described based on material from Britain and Ireland. *Chondrus* is distinguished from other members of the Gigartinaceae primarily by the absence of enveloping secondary filaments in the cystocarp. The result shows a revised description of *Chondrus* and the relationship of North Atlantic *C. crispus* to species of *Chondrus* from the western North Pacific is discussed.

D. Wilson et al (2022) has conducted studies on *Gracilaria parva* sp. nov. (Gracilariales, Rhodophyta) a Diminutive Species. It is a speciose genus, currently with 193 species recognized primarily from tropical and subtropical waters worldwide. Distinguishing species of *Gracilaria* has been vexing due to their simple morphology primarily as flat, dichotomously to irregularly branched blades, or as terete, irregularly branched, thalli. The result was that specimens from Panama and Ecuador of the studied tropical eastern Pacific species of *Gracilaria* were resolved in a clade with two western Atlantic species, *G. gurgelii* Freshwater from the northwest Gulf of Mexico and *G. galatensis* Gurgel, Fredericq and J.N. Norris from the Caribbean coast of Panama.

Alison R Sherwood et al (2010) conducted the Hawaiian Rhodophyta biodiversity survey, well studied from a morphological and anatomical perspective, making it an excellent candidate for assessment using a combination of traditional taxonomic and molecular approaches. The result shows that a total of 1,946 accessions are represented

in the collections from 305 different geographical locations in the Hawaiian archipelago. These accessions represent 24 orders, 49 families, 152 genera and 252 species/subspecific taxa of red algae. One order of red algae (the Rhodachlyales) was recognized in Hawaii for the first time and 196 new island distributional records were determined from the survey collections.

Fionnuala Ni Chualain et al (2004)conducted a study on the genus Asparagopsis using 25 Falkenbergia tetrasporophyte strains collected worldwide. The 3 species of asparagopsis such as A. sanfordiana and A. taxiformis were identified.

Won Boo Yeon(2010) conducted study on Characterization of Centroceras gasparrinii (Ceramiaceae, Rhodophyta) known as Centroceras clavulatum in Korea.The type species of Centroceras, C. clavulatum, was widely known as a prime example of a cosmopolitan species by most phycologists.After the first record of "Ceramium clavulatum" was made from Busan by Okamura "Centroceras clavulatum" has been reported from all coasts of Korea including Guryongpo, Gampo, Wando and Jeju. It has been known as a very common species of Korean marine flora.

Palanisamy, M. et al (2015) Conducted study on Distribution and Diversity of Seaweeds at Thikkodi Coast, Kerala,
South India. The result shows that the Kozhikode district has a coastline of about 71 km ranging from Kadalundi Nagaram in the south to Mahe in the north. Thikkodi coast is a long and wide rocky coast with black–clayish sand. The granite natural rocks and the artificially laid stones provide suitable substratum for the growth of a large number of seaweed. After critical analysis and study, a total of 48 species of seaweeds were recorded and their taxonomic and morphological description also were recorded.

Nadya R Mamoozadeh and D Wilson Freshwater (2011) conducted taxonomic evaluation of 5 species of Polysiphonia (Ceramiales, Florideophyceae) from Florida, USA and Mexico.Molecular-assisted identification using plastid-encoded rbcL and mitochondrion-encoded COI loci identified five species of Polysiphonia sensu lato from 16 Florida and Caribbean Mexico samples. Morphological character states were examined and used to identify these species as *Neosiphonia bajacali comb. nov., N. echinata comb. nov., N. sphaerocarpa, N. tepida, and Polysiphonia anomala.*

Descriptions are provided and the phylogenetic relationships of the five species were determined through maximum likelihood analyses of rbcL and nuclear-encoded SSU sequence data.

Materials and Methods

The present study was aimed to study the rhodophyte diversity in selected coasts of Kerala and to evaluate these based on morphology and anatomy. Literature reviewed showed rich diversity and luxuriant growth of seaweeds at Mullur, Vizhinjam, Kovalam, Varkala, Edava,Thangassery, Thirumullavaram, Baypore, Thikkodi, Mahe, Ezhimala, Manjeshwar and Hosabettu coasts. The presence of natural rocks, bedrocks, the artificially made cement boulders and laid stones along the coast support the growth of a large number of seaweeds.

Study area

The current study intended to carry out morphological and anatomical studies on a few red algal specimens. The survey and collection of the seaweeds were conducted at Thikkodi coast, Kozhikode district and Thirumullavaram coast in Kollam district. The original field photographs showing the habits and habitats of seaweeds were taken.

Collection of samples and its preservation

The seaweed samples were collected randomly from the intertidal regions during low tides. All the collected samples were thoroughly washed with fresh water without damaging

the specimens. The representative samples were preserved in 4% formalin solution and a major share of collected sample kept in deep freezer. The samples are removed from the freezer, thawed and used for morphological and anatomical evaluation.

Taxonomic Study

For the taxonomical studies the habit of the plant, thallus organization – filamentous/branched/massive and so on, colour of the thallus, texture – gelatinous, cartilaginous, fibrous, calcareous, reproductive structures and such other features were considered. Identity of the collected samples was confirmed following the standard available literatures Srinivasan, 1969, 1973; Desikachary et al.,1990, and online resourses like AlgaeBase and WoRMS

Anatomical Studies

Anatomical characters were observed by using the freehand sections. The thallus were sectioned transversely, then placed on a glass slide, dripped water, and covered with cover glass. The anatomical features were observed and recorded using a light microscope (Olympus – Magnus) connected to and displayed on a laptop. Photographs were taken for evaluation.

Observation and Results

Macroalgae or seaweeds are macroscopic marine algae that exhibit diverse thallus organisation. As primary producers, macroalgae are at the base of the marine food chain supporting several communities of herbivorous animals, providing habitat where they end up finding refuge from their predators.

During the study period, totally many samples of seaweeds were collected from the rocky substratum of the intertidal zones of Thikkodi coast. After critical analysis and study of the various characters of the collected samples a total of 7 species of red algae have been recorded. The presence of more numbers of seaweeds at the coast shows the importance of this coast for the conservation of marine biodiversity. However, some activities like cutting of calcareous stones along the coast for making bricks, extensive fishery and tourism activities creating threats to the seaweed flora of the region.

Morphological Types

Thallus is the plant body of algae, fungi, lichens, and some liverworts, a plant body that is not differentiated into stem and leaves and lacks true roots and a vascular system.

The thalli of most macroalgal species are erect, especially when immersed The thallus of a macroalgae is divided into the frond, the upright part, which presents a great variability in shape and size, and a fixation organ, the holdfast. These variations can be heightened by the external environmental conditions where they develop.

Main Morphological Characteristics of Macroalgae

The shape or morphology of a given thallus is a very useful feature to distinguish the various species of macroalgae. In addition, different species present different consistencies or textures to the touch, which are critical features in distinguishing them,

Some algae are filamentous. The frond may be reduced to a filament in which the cells meet one after the other, and the filaments may be straight or branched.

The consistency and texture to the touch of the thalli are very diverse. They can be cartilaginous, leathery or coriaceous, mucilaginous, spongy, etc., and some thalli, are

calcareous because thec ells are impregnated with calcium carbonate, have a rock-hard consistency.

While some thalli have cylindrical axes, others are flattened, and others form hollow tubes. Some thalli form monostromatic or polistromatic blades or sheets (with one or more layers of cells, respectively), being thin, more or less thick, or even coriaceous; orbicular or elongated; divided or not; and lobed or deeply divided (laciniated blades, ribbons, straps or belts).

Filamentous Thalli

The frond can be reduced to a filament, in which the cells are placed, linearly, one after the other. The filaments can be simple or branched (in the form of a bush). The ramifications can be irregular, dichotomous, alternate, opposite, verticillate, or pectinate.

Massive Thalli

The massive stems usually have a compact structure, and some species may have a soft consistency and delicate texture. Massive thalli are subdivided into four distinct types:

1. Cylindrical shafts, also called “strings”, normally erect when immersed, sometimes appearing prostrate, that can branch out according to the above mentioned modalities;
2. Cylindrical or flattened tubes, when the thalli are hollow, and their walls are composed of one or more layers of cells and the tube axes may present constrictions at regular intervals (articulated thalli);
3. Sheets, monostromatic (one layer of cells) or polistromatic (two or more layers of cells)
4. Vesicular, when the thalli, usually polistromatic, have a globose shape.

The blades can be thin, more or less thick, or even leathery; orbicular or elongated; divided or not; and lobed or deeply divided (lacinated blades or belts). The blades (or straps) can be traversed by “ribs” (prominent, clearly visible formations), or by “veins” (rows of less prominent cells).

The Reproductive Structures of Red Algae

Rhodophytes exhibit advanced oogamous type of reproduction with an elaborate post fertilization development resulting in the formation of a carposporophyte that is mostly parasitic on the female gametophyte.

The cystocarp is composed of the carposporophyte plus all protective sterile haploid tissue of the female gametophyte encircling and interacting with it (pericarp). Carpospores develop into a second free-living phase called tetrasporophyte, which can be morphologically similar to (isomorphic alternation of generations) or different (heteromorphic alternation of phases) from the gametophytes. Tetrasporophyte thalli produce tetrasporangia by meiosis, which releases tetraspores. This pattern of meiotic cell division in the tetrasporangium is stable in red algae and can be one of three types: cruciate, tetrahedral, or zonate. When released, each tetraspore gives rise to either a male or a female haploid gametophyte.

In general, Florideophyceae present triphasic isomorphic or heteromorphic, diplohaplontic (haploid gametophyte, diploid carposporophyte and diploid tetrasporophyte), or diphasic diplohaplontic lifecycles

The taxonomical description of 7 species of seaweeds during the current study collected are given below. All seven specimen belonged to Florideophyceae.

1.*Gelidium pusillum* (Stackhouse) Le Jolis.

Class: Florideophyceae

Order: Gelidiales

Family: Gelidiaceae

Plants dark red in colour; thallus small, tuft, cartilaginous,1-2 cm long;fronds up to 2 mm wide, irregularly and pinnately branched, usually cylindrical; pinnae truncate, margins irregular; apex usually obtuse with sunken growing points; holdfast small, rhizoidal, branched, arising from the creeping stolons, up to 0.4 mm long; growing on calcareous stones and bedrocks substratum in the tidal and intertidal zones. The cystocarp protrudes equally on both surfaces of the branch, usually with one or, more rarely, several openings on each surface of the frond. Occasionally, two cystocarpic cavities coalesce laterally, forming enlarged cystocarps of up to 1 mm long.

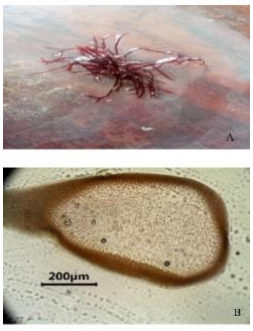

PLATE 1: .*Gelidium pusillum* (A- habit; B-Thallus)

2. Gracilaria corticata (J. Agardh)

Class: Florideophyceae

Order: Gracilariales

Family: Gracilariaceae

Plants dark- yellowish red in colour; thallus bushy, cartilaginous, rigid, usually upto 15 cm long, dichotomously branched with narrow segments; fronds flattened, usually 2-3 mm wide, margins almost entire, apex acute- obtuse with dichotomousky branched tips, rarely proliferated; anatomically thallus consist of cortex and medulla; cortx 1-2 layered; outer layer cells usually small, elongated- circular; inner layer cells comparatively bigger, compressed, circular; medulla consists of larger thick walled cells towards the center; cells mostly circular-elongate; holdfast small, discoid, tuft, attached tightly to the rocky and calcareous substrata in the lower and mid littoral zones.

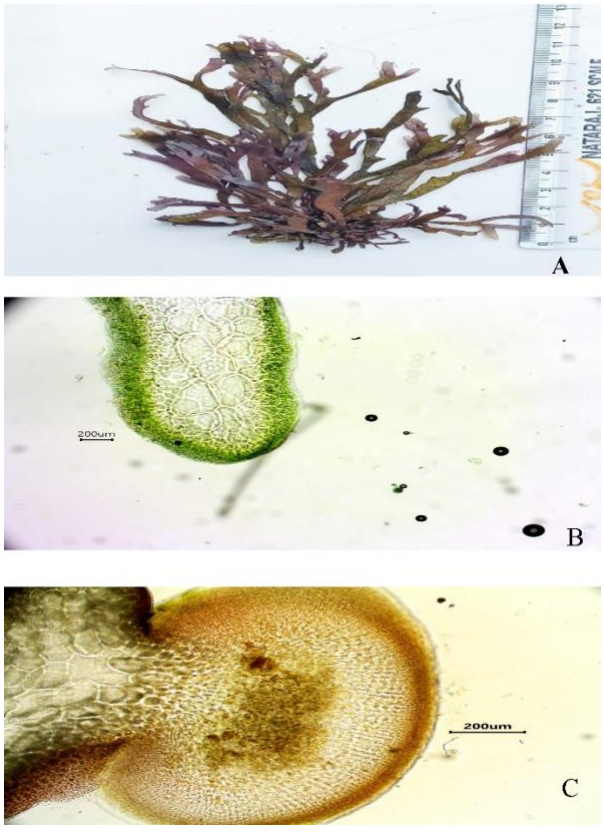

PLATE 2*; Gracilaria corticata* (A-Habit ; B-Thallus ; C-Cystocarp)

3. *Asparagopsis* (Delile) Trevisan.

Class: Florideophyceae

Order: Bonnemaisoniales

Family: Bonnemaisoniaceae

Plants pink red in colour;Thallus frondose, gregarious, brush like, rigid, usually 5-20 cm long, upright plumose with a single axis forming densly branched determinate branches in all directions, branches sub opposite with delicate branchlets; holdfast small, rhizomatous, arising fron the creeping stolos, attached firmly on the bedrocks in the lower and mid littoral zones.

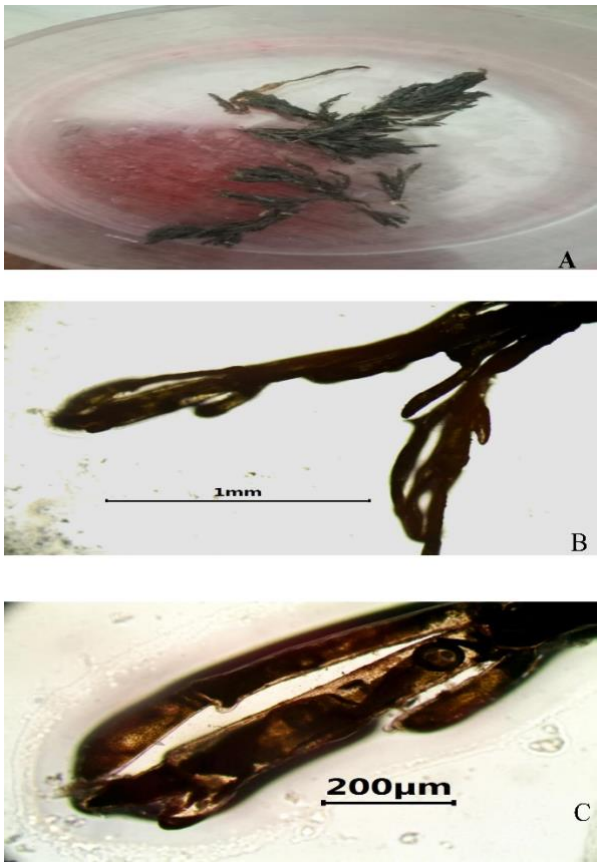

PLATE 3; *Asparagopsis* (A-Habit ; B-microscopic view of asparogopsis).

4. *Centroceras clavulatum* (C. Agardh)Montagne.

Class: Florideophyceae

Order: Ceramiales

Family: Ceramiaceae

Plants dark- pinkish red in colour; Thallus filamentous, bushy, erect, usually 2-5 cm long; filaments usually dichotomously branched, differentiated into nodes and corticated internodes; ultimate branched forcipate with slight curves; each dichotomy with 6-10 segments; covered with longitudinally arranged cortical cells; cells mostly rectangular, quadrate to spherical, nodal cortical cells with a ring of uni-multicellular spines; holdfast small, discoid, attached to the rocky and muddy substrata in the upper and mid littoral zones.

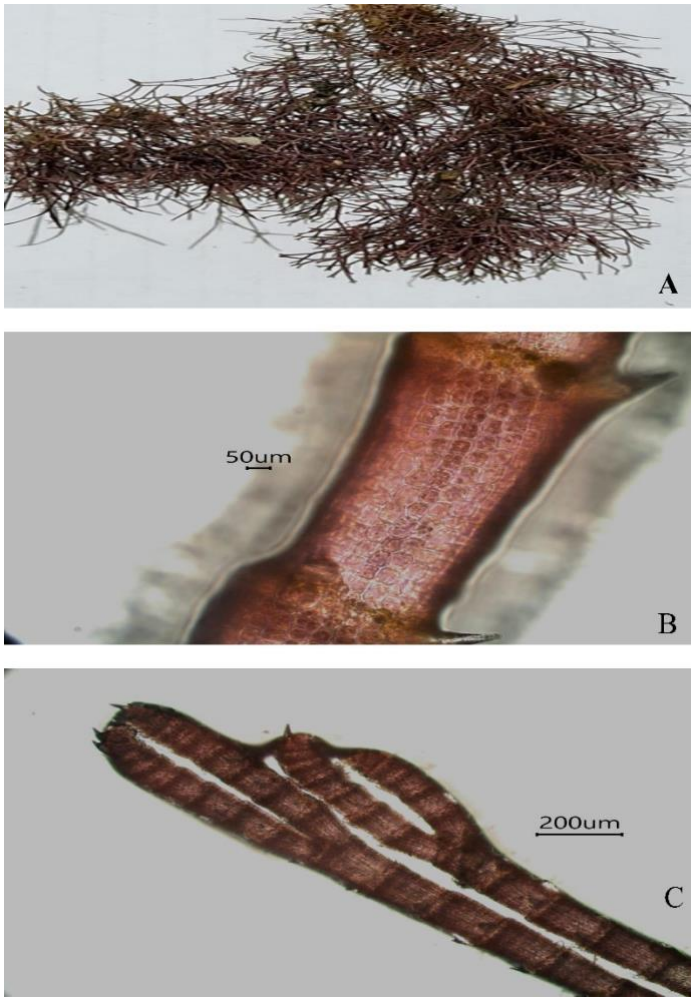

PLATE 4; *Centroceras clavulatum* (C. Agardh)Montagne (A-Habit ;
B-microscopic image of *Centroceras clavulatum)*

5. *Acanthophora specifera* (Vahn) Borgesen.

Class: Florideophyceae

Order: Ceramiales

Family: Rhodymelaceae

Plants brownish-purple red in colour; Thallus remiform, bushy, erect, cylindrical, gregarious, tuft, upto 15 cm long; fronds without any spines, cylindrical, 1-3 mm in diameter, beaded, irregularly or alternately branched, branchesspirally arranges, ultimate short branchelets slightly spinous; holdfast small, clustered colourless, rhizoidal, branched, attached to the rocky and muddy substarta in the upper and mid littoral zones.

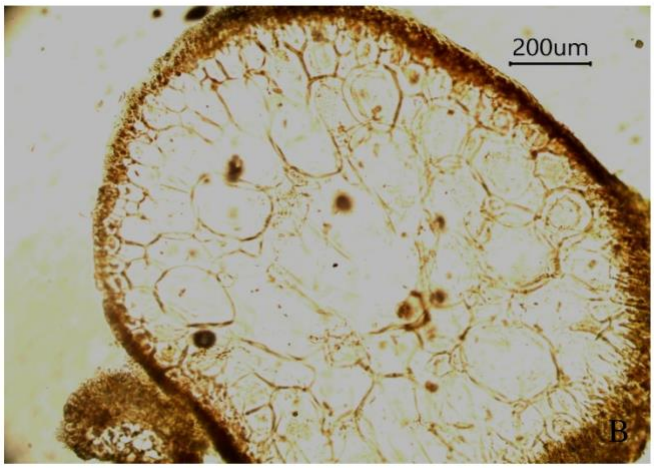

PLATE 5; *Acanthophora specifera* (Vahn) Borgesen. (A- habit ; B-thallus)

6. Polysiphonia denudate (Dillwyn) Greville Borgesen.

Class: Florideophyceae

Order: Ceramiales

Family: Rhodymelaceae

Plants brownish dark red in colour; thallus remiform, polysiphonous, bushy, erect, gregarious, tuft, expanded sub-globose, upto 15 cm long;fronds glabrous, dichotomously branched, branches divaricate, upper branches slender, segments with 6-8 pericentral cells; holdfast small, colourless,discoid, attached to the rocky and muddy substrata in the upper and mid littoral zones.

PLATE 6; *Polysiphonia denudate* (Dillwyn) Greville Borgesen. (A- microscopic view of *Polysiphonia denudate*)

7. *Chondrus crispus*

Class: Florideophyceae

Order: Gigartinales

Family: Gigartinaceae

Plants relatively small red algae, reaching upto a little over than 20 cm in length. It grows from a discoid holdfast and branches four or five times in a dichotomous, fanlike manner. The morphology is highly variable, especially the broadness of thalli. The branches are 2-15 mm broad, firm in texture and dark reddish brown in colour bleaching to yellowish in sunlight.

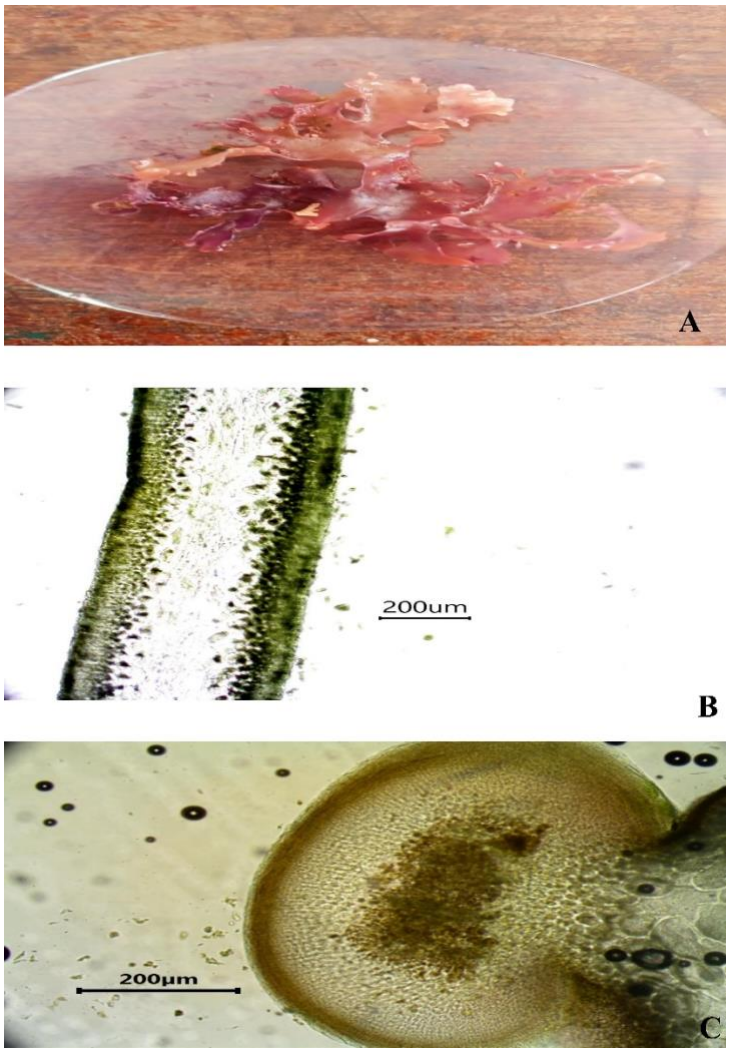

PLATE 7; *Chondrus crispus* (A-Habit;B-Thallus;C-Cystocarp*)*

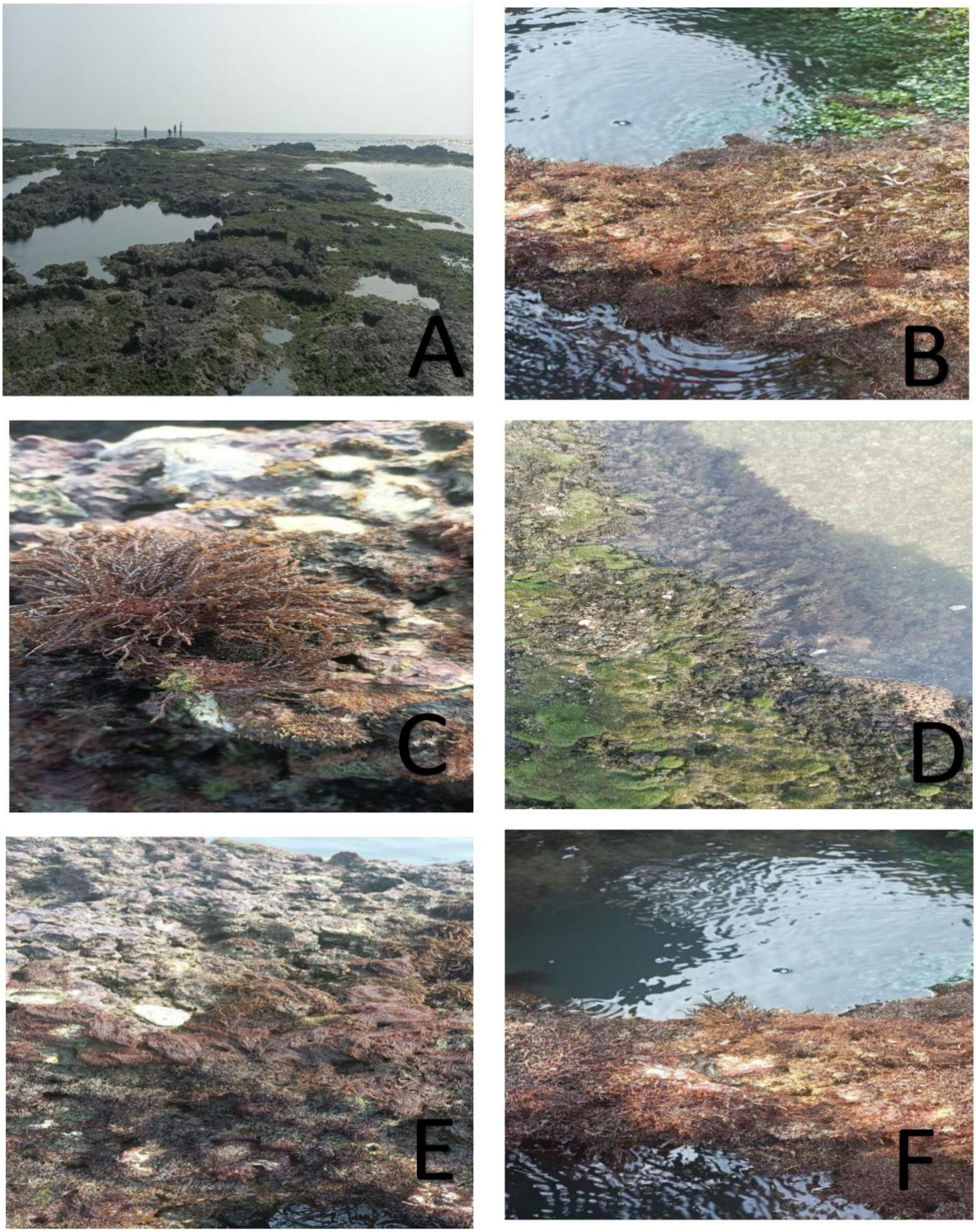

PLATE 8; (A-Thikkodi Coast; B-*Gracilaria* habitat;C-*Acanthophora* habitat; D-*Asparagopsis* habitat ;E-*Centroceras* habitat ;F-*Gelidium. habitat.*

DISCUSSION

Most of the red algae have branched thallus, small holdfast and are rhizomatous. Gelidiaceae has 159 species, considered to be the largest family in Gelidiales with four major genera: *Capreolia, Gelidium, Gelidiophycus,* and *Ptilophora. Gelidium* are widely distributed globally, specifically in tropical to temperate regions, but lacking in polar regions. In the ocean, *Gelidium* can be found inhabiting the intertidal to subtidal zone. Species from the genus require further studies to distinguish boundaries among members, as recent molecular research have shown that there are cryptic, unidentified species assumed to be regionally endemic and isolated but may also be ubiquitous in nature. Some species are common in the Atlantic and Pacific Ocean (*G. crinale)* while some are confined in North Atlantic waters (*G. pussillum).* Reports of *G. pussillum* occurrence outside of its specified range may be questionable and requires further verification.

The genus *Gracilaria* was established by Greville in 1830 and is the third largest genus in the red algal group with over 150 species worldwide. Nearly 28 species of *Gracilaria* have been reported from the Indian coast (Sahoo et al., 2001). Gracilaria corticata has often been inadequately described due to the diversity of vegetative morphologies assumed. Mophological features observed in our study is similar to the morphological and taxonomic studies of *Gracilaria* and *Gracilariopsis* species (Gracilariales, Rhodophyta) from South Africa conducted by R Iyer et al (2004).

The genus *Asparagopsis,* belonging to the order Bonnemaisoniales of the phylum Rhodophyta (red algae), includes three taxonomically accepted species: *Asparagopsis armata* Harvey, *Asparagopsis svedelii* Taylor and *Asparagopsis taxiformis* Trevisan. However, opinions regarding the taxonomic validity of the species can vary depending on the author (hualáin F.N. et al (2004)

Referring to Silva et al. (1996) Catalogue of the benthic marine algae of the Indian Ocean, it seems *Centroceras clavulatum* has been reported from India. Another species, *C. minutum* was reported from the Maldives and the Seychelles. A new species, *C. secundum* has been documented from Oman. Morphological features such as filamentous thallus, erect; branched forcipate with slight curves observed in our study is similar to the characterization of *Centroceras gasparrinii* (Ceramiaceae, Rhodophyta) known as *Centroceras clavulatum* in Korea conducted by Won Boo Yeon.

The genus *Acanthophora* is currently composed of 7 accepted species according to AlgaeBase (Guiry and Guiry, 2022): *A. spicifera*, *A. muscoides*, *A. aokii*, *A. dendroides*, *A. nayadiformis*, *A. pacifica* and *A. ramulosa*. Although, most species are restricted to tropical regions, some species such as *A. spicifera* and *A. muscoides* extend into temperate regions.

The genus *Polysiphonia* is represented by more than 150 species, out of which about 16 species are reported from India. They grow in marine habitat and are cosmopolitan in distribution Morphological features such as dark red thalli, with erect filaments dichotomously branched widely branched; attached to substratum observed in our study is similar to the morphological and molecular analyses of *Polysiphonia sensu lato* in southern central America and the Caribbean conducted by Nadya Mamoozadeh .

Morphological and anatomical features observed in our study is somewhat similar to the developmental morphology of *Chondrus crispus* (Gigartinaceae, Rhodophyta) conducted by S. Fredericq J. Brodie and M. H. Hommersand. Grows abundantly along the rocky parts of the Atlantic coast of Europe and North America. In its fresh condition this algae is soft and cartilaginous, varying in color from a greenish-yellow, through red, to a dark purple or purplish-brown.

SUMMARY AND CONCLUSION

During the study various morphological and anatomical features of 7 species of red algae have been recorded.

India has a vast coastline of about 7500 km with diverse habitats and rich marine biota. This includes about 6100 km coastline of Indian mainland and about 1400 km coastlines of various islands of the country. Kerala, a part of the south west coast of India and located in the extreme southwest coast of the peninsular India, has about 580 km long coastlines. It is flanked by the Arabian Sea on the west and the mountains of the Western Ghats on the east. The Kozhikode district has a coastline of about 71 km ranging from Kadalundinagaram in the south to Mahe (a part of Puduchery U.T.) in the north. Thikkodi coast is a long and wide rocky coast with black – clayish sand. The granite natural rocks and the artificially laid stones provide suitable substratum for the growth of a large number of seaweed. Another coast in Kerala is Thirumullavaram coast in kollam. Samples for our study were collected from Thikkodi coast and Thirumullavarm coast. There were more algae but we centralized on red algae (rhodophytes).

The Rhodophyta comprises one of the largest phyla of algae, containing over 7,000 currently recognized species with taxonomic revisions. Red algae are abundant in marine habitats but relatively rare in freshwaters. Over 7,000 species are currently described for the red algae,but the taxonomy is in constant flux with new species described each year. Red algae do not have flagella and centrioles during their entire life cycle. Presence of normal spindle fibres, microtubules, un-stacked photosynthetic membranes, presence of phycobilin pigment granules, presence of pit connection between cells filamentous genera, absence of chloroplast endoplasmic reticulum are the distinguishing characters of red algal cell structure. Red algal morphology is diverse ranging from unicellular forms to complex parenchymatous and non-parenchymatous thallus. Species of rhodophytes reported in our study are : .*Gelidium pusillum* (Stackhouse) Le Jolis , Gracilaria corticata (J. Agardh), *Asparagopsis*, *Centroceras clavulatum* (C. Agardh) Montagne, *Acanthophora specifera* (Vahn) Borgesen, *Polysiphonia denudate* (Dillwyn) Greville Borgesen, *Chondrus crispus.*

Gelidium pusillum (Stackhouse) is dark red in colour; thallus small, tuft, cartilaginous,1-2 cm long; fronds up to 2 mm wide, irregularly and pinnately branched, usually cylindrical; pinnae truncate, margins irregular.

Gracilaria corticata (J. Agardh) is dark- yellowish red in colour; thallus bushy, cartilaginous, rigid, usually upto 15 cm long, dichotomously branched with narrow segments;

Asparagopsis is pink red in colour; Thallus frondose, gregarious, brush like, rigid, usually 5-20 cm long.

Centroceras clavulatum (C. Agardh) Montagne is dark- pinkish red in colour; Thallus filamentous, bushy, erect, usually 2-5 cm long; filaments.

Acanthophora specifera (Vahn) Borgesen is brownish-purple red in colour; Thallus remiform, bushy, erect, cylindrical, gregarious, tuft, upto 15 cm long; fronds without any spines.

Polysiphonia denudate(Dillwyn) Greville Borgesen is brownish dark red in colour; thallus remiform, polysiphonous, bushy, erect, gregarious, tuft, expanded sub-globose, upto 15 cm long.

Chondrus crispus is relatively small red algae, reaching upto a little over than 20 cm in length.

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