SOME OBSERVATIONS ON THE ECOLOGY AND BIOCHEMICAL ASPECTS OF THE SEAWEEDS OF KERALA COAST

THESIS SUBMITTED BY

SAJI SUSAN MATHEW, M. Sc.

TO THE COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY

भाकृअनुप
ICAR

CENTRE OF ADVANCED STUDIES IN MARICULTURE
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
KOCHI - 682 031 INDIA

1991

DECLARATION

I hereby declare that the thesis entitled **Some observations on the ecology and biochemical aspects of the seaweeds of Kerala coast** has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar title or recognition.

Saji Susan Mathew

(SAJI SUSAN MATHEW)

Kochi - 31

January, 1991

CERTIFICATE

This is to certify that this thesis is an authentic record of the work carried out by Miss. Saji Susan Mathew, under my supervision at Central Marine Fisheries Research Institute and no part thereof has been presented before for any other degree in any University.

14/1/91

Dr: V.S.K. CHENNUBHOTLA
Principal Scientist
Central Marine Fisheries
Research Institute
Kochi - 682 031
(Supervising Teacher)

Kochi - 31
14th January, 1991.

ACKNOWLEDGEMENTS

It is with great pleasure that I place on record, my indebtedness and deepest sense of gratitude to my revered teacher Dr.V.S. Krishnamurthy Chennubhotla, Principal Scientist, Minicoy Research Centre of Central Marine Fisheries Research Institute, for his able guidance, thorough supervision, valuable suggestions, constant help and encouragement throughout the course of this work. I consider it my singular good fortune for having worked as a research scholar under him, and I feel that I was greatly benefitted for being so well initiated into the field of marine algal research by him.

I will be failing in my duty if on this occasion, I do not make a special mention of the multifarious help and advice extended to me by Dr.C.V. Kurien, Professor Emeritus, School of Marine Sciences, Cochin University of Science and Technology, Kochi.

I recall with gratitude, Dr. Desikachary the eminent botanist and authority on algae for the advice, encouragement and affection shown to me.

My thanks are due to Dr. V. Krishnamurthy, Professor, Department of Botany, Centre for Advanced Studies, Madras for the confirmation of the algal identifications and for the healthy discussions I had with him.

I express my gratitude to Mr. T.N. Rajan, Geologist, Geological Survey of India, Kochi, for sparing his valuable time for discussions with me.

My sincere thanks are also due to Mr. M. Srinath, Scientist, Central Marine Fisheries Research Institute, Kochi for helping me with the statistical analysis of my data.

In this context, I like to express my gratitude to Mr.A. Nandakumar for the immense and untiring help he rendered throughout the period of my work.

I thank Dr. P.S.B.R. James, Director, Central Marine Fisheries Research Institute, Kochi, for the facilities provided for doing this research work.

Above all, I thank Indian Council of Agricultural Research for awarding me with the Senior Research Fellowship during the tenure of which I did this work.

SOME OBSERVATIONS ON THE ECOLOGY AND BIOCHEMICAL ASPECTS OF THE SEAWEEDS OF KERALA COAST

CONTENTS

Page No.

Page No.

1. PREFACE

While the common man is familiar with land plants, the world of marine plants is a hidden world for him. Today, envisaging the continued growth of the world's population, man is increasingly turning his attention to the plant life of the oceans as a major source of food and industrial raw materials.

Marine plants primarily fall under two evolutionary divergent groups, the primitive plants - algae - and the most advanced plants - angiosperms. Among the angiosperms only a small group - seagrasses - is represented in the sea. About 90% of the marine plants, belong to one group of algae or the other. Thus vegetation-wise the sea remains to this day, a province of algae.

Under the term algae, we group a large number of simple plants which originated at different levels on the evolutionary scale. Among the marine algae, the macroscopic algae - seaweeds - form a very important living renewable resource of the oceans. They are available in the coastal waters, wherever there is a substratum on which they can grow and flourish. Based on their pigmentation they are grouped into three major divisions Chlorophyta (green algae), Phaeophyta (brown algae) and Rhodophyta (red algae).

Economically seaweeds have proved themselves to be a very significant group.

1.1 Seaweeds as food

Seaweeds have been harvested since many centuries in the South-East Asian countries where they form staple human food. Many of the seaweeds are eaten raw or processed, in many parts of the world.

The nutritive value of the seaweeds lie in the fact that they are very rich in proteins, carbohydrates and lipids. They also contain more than 60 trace elements, in concentrations, higher than that in terrestrial plants. The algal proteins have many essential amino acids including iodine containing ones. The seaweed *Porphyra vietnamensis* is reported to contain 16-30% protein on dry weight basis, and this amount is higher than that of cereals, eggs and fish (Visweswara Rao, 1964). Other seaweeds like *Ulva fasciata*, *U. lactuca*, *U. rigida*, *Centroceras clavulatum* etc., are also rich in protein. In Japan about 21 varieties of seaweeds are being used as sea-vegetables in everyday cookery. According to Fujiwara *et al* (1983) Japanese consume seaweeds as much as 1.6 kg (dry) per capita annual. The thin delicate red seaweed *Porphyra* is processed and used as a culinary dish known as 'Laver' in Britain and 'Nori' in Japan (Chapman and Chapman 1980). Apart from this, the Japanese use 'Kombu' a preparation out of *Laminaria* and 'Wakame' a preparation out of *Undaria* in their daily diet.

It is reported that 100 gm of algae per day provide all that a human being needs in respect of sodium, potassium and magnesium (Chapman and Chapman, 1980).

In India, except for the use of *Gracilaria edulis* for making gruel in the coastal areas of Tamil Nadu, seaweeds are not being directly used as food (Anon, 1987). Seaweeds as food has a great potential in India where 60% of the population are vegetarians.

1.2 Seaweeds in industry

Seaweeds are the only source of phyco-colloids, viz., agar-agar, algin and carrageenan. These phytochemicals are extensively used in various industries like food, confectionary, textile, cosmetics, paper, pharmaceutical, dairy, paint etc., mainly as gelling, stabilising and thickening agents.

1.2.1 Agar-agar

It is a gelatinous colloidal carbohydrate present in the cell walls of some red algae. It is a mixture of two polysaccharides, agarose and agaropectin. This substance has the property of forming a gel on cooling. The best known use of agar is as a solidifying agent in bacteriological culture media. Apart from this, it finds use in various industries, mentioned before. The market value of I.P. grade and food grade agar in India is Rs.500/- and Rs.200/- respectively (Anon, 1990).

Agar yielding seaweeds are called agarophytes and some important agarophytes of Indian waters are *Gelidiella acerosa*, *Gracilaria edulis*, *G. corticata*, *G. crassa*, *G. foliifera* and *G. verrucosa*.

1.2.2 Algin

Algin is a polysaccharide occurring in the cell walls of brown algae. It consists of D-mannuronic acid and 2-guluronic acid in various proportions. The sodium, potassium and magnesium salts of alginic acid are soluble in water and they give a viscous liquid without gel formation. Algin also has a variety of industrial uses. The market rate of sodium alginate varies from Rs.90/- to Rs.120/- depending on its quality (Anon, 1990).

Algin yielding seaweeds are called alginophytes and important among them in India being species of Sargassum and Turbinaria.

1.2.3 Carrageenan

Certain red algae produce gel-like extracts called agaroids. They differ in their properties and chemical nature from agar. Carrageenan comes under this group. Organic sulphate content in these compounds is very high. Pure solutions of agaroids are viscous and do not form gel when cooled. But inorganic and organic solutes can alter the properties of agaroids and improve their gelling power.

Important carrageenan yielding seaweeds of India are Gigartina acicularis, Hypnea musciformis, species of Acanthophora, Laurencia, Sarconema Spyridea and Chondria. Apart from these, seaweeds yield phycocolloids of lesser importance but very valuable in specific uses like mannittol, laminarin, fucoidin etc.

In India, seaweeds are being commercially exploited from Tamil Nadu and Gujarat coasts since 1962. At present there are about 21 agar and 25 algin manufacturing industries in our country (Anon, 1987).

1.3 Seaweeds in medicine

Various red algae like Corallina officinalis, C. rubens and Alsidium helminthocorton are being employed as vermifuge from ancient times. Dulse is being used in the treatment of goitre (Umamaheswara Rao, 1970). Range of iodine in Indian seaweeds is 0.02 - 0. 024% on dry weight basis (Thivy, 1958). Antibiotic substance extracted from Enteromorpha affected complete inhibition of 'tubercle bacilli' in cultures (Sreenivasa Rao et. al., 1979). Hundred percent antifertility activity was observed in three species of algae namely Padina tetrastromatica, Gelidiella acerosa and Acanthophora spicifera (Naqvi et al., 1981). Extracts of Chondrus crispus and Gelidium cartilagineum have been found to be active against influenza B and mumps virus (Garber et al., 1958). Analgesic, mild anesthetic, anticoagulant, anti-inflammatory, antilipemic and antitumour activities are also reported from marine macroalgae. Apart from this, agar and algin are being extensively used in pharmaceutical preparations. Agar is used in the manufacture of dental impression moulds. Alginates when injected into the lung cavities of tuberculosis patients, stop internal bleeding (Thivy, 1958).

1.4 Seaweeds as fodder

Seaweeds are rich sources of proteins, lipids, carbohydrates, trace elements, vitamins etc. Hence it has been tried as animal feed in many countries, the world over. Some experiments have shown that seaweed meal improves the fertility and birth rate of animals. Stephenson (1974) suggested that this may be due to the presence of antisterility Vit-E (tocopherol). Seaweed meal has been found to improve the iodine content of eggs (Thivy, 1958) and colour of egg yolk. Seaweed feeds have been used extensively in the farming of milkfish successfully (Thivy, 1958). Enteromorpha clathrata feed used in prawn culture fields has been found to improve their growth and survival rates (Krishnamurthy, et al., 1982).

In conclusion it may be said that seaweed meal upto 10% in the basic daily ration has beneficial effects on animals.

1.5 Seaweeds as manure

In coastal areas throughout the world the use of seaweeds as manure is a common practice. The high amount of water soluble potash, minerals and trace elements present in seaweeds are readily absorbed by plants and they control various deficiency diseases. The carbohydrates present in seaweeds improve the water retaining capacity of the soil. The easy decomposability of seaweed organic matter is beneficial for the growth of soil micro-organisms. It is observed that nitrifiability of organic nitrogen from Ulva lactuca was higher compared to farmyard manure (Mehta et al., 1967). Application of seaweed manure can maintain a high level of nitrogen in the soil. Seaweed manure either used directly or as compost was found to be superior to conventional farmyard manure (Chennubhotla et al., 1987). Seaweed extracts were successfully used as foliar spray for inducing faster growth in agriculture and horticulture.

Large quantities of Gracilaria and Caulerpa are being used as manure for coconut plantations in Kerala and Tamil Nadu.

1.6 Seaweeds as a source of vitamins

Chapman & Chapman (1980) reported that 100 gm of algae/day provide more than the necessary daily intake of Vit-A, B_2, B_{12} and 67% of Vit-C.

Vitamin-A is abundant in seaweeds like Ulva lactuca, Laminaria digitata, Undaria, Codium etc. Ulva, Enteromorpha, Porphyra and Rhodymenia are rich in Vitamin B_1. Vitamin C is abundant in Ulva, Enteromorpha, Porphyra etc. Weight for weight, dulse contains half as much Vitamin C as in oranges. Niacin is present in marine algae in quantities ranging from 1-68 μgg^{-1} dry weight. Other vitamins detected in marine algae include pantothenic acid, folic acid and Vitamins D & E.

1.7 Seaweeds as a source of energy

Two thirds of the total solar energy which reaches the surface of our planet falls on water. The energy is captured by algae - the abundant photosynthetic organisms which grow in water. Thus seaweeds can potentially be used as biomass for energy production (Bird and Benson, 1987). Seaweeds contribute to 50% of the total marine primary productivity on an year round basis.

1.8 Seaweed ecosystem

In addition to their commercial importance, macroalgae together with a number of marine and estuarine angiosperms, play an important role in many marine ecosystems. They provide habitation and spawning sites for commercially important marine animals and make a significant contribution to the food of man. Their contribution can be viewed more importantly as a source of organics leading to detrital food chains of demersal fish species. Devastation of seaweed beds through grazing by predators or other means have been found to cause serious ecological imbalances which in turn has significant fisheries interactions.

Many marine algae have the capacity to selectively concentrate different trace elements and thus are useful in radio-active research as biological monitors. This will be of particular use in the radioactive waste water treatment of oceans.

Seaweeds, thus are very important, not only for their economic uses, but also for their biological role in marine environments. Therefore, there seems to be a great potential in investigating into the basic biological problems of seaweeds, especially their ecology and biochemical composition.

2. INTRODUCTION

Despite numerous investigations on the ecology of marine plants, the subject has not advanced as much as the ecology of terrestrial plants, because, unlike the study of land vegetation, field experiments are more difficult in marine environment.

Considering the importance of marine algae, especially seaweeds as food and raw material for industrial products, it is surprising that no attempt has been made so far to survey its resources until the beginning of the present century. This may be attributed to the unfamiliarity on the importance and potentials of seaweed resources, or to the fact that there seemed to be such an abundance of seaweeds in the past, that it did not seem worthwhile attempting to estimate the quantities available. However, due to the continued growth of the world's population resulting in increasing pressure for food and energy, seaweeds which form an annually renewable resource is becoming increasingly important.

2.1 Places of algal interest in India

India, has a coastal stretch of 6,100 km bathed on the east by Bay of Bengal, west by Arabian Sea and south by Indian Ocean.

The rocky inter-tidal and sub-tidal coasts of India support a good growth of marine algae. The total seaweed resource estimated from India is 77,000 tons wet weight (Subbaramiah, 1987). Among the maritime states of India, Tamil Nadu on the east coast of India occupies the prime position in seaweed resource availability (22,000 tons wet weight). The important places of algal interest in Tamil Nadu are Gulf of Mannar, Palk Bay, Tuticorin, Tiruchendur, Madras, Mahabalipuram, Colachel, Muttom, Cape Comorin etc. In Gulf of Mannar, there are quite a number of small islands of algal interest like Pamban, Rameswaram, Keelakarai, Krusadai, Shingle, Dhanushkodi, Hare Island etc. which have a wide variety and luxuriance of algae. Cape Comorin the southern most tip of Indian peninsula has a distinctive algal flora which for its diversity and abundance is noteworthy.

Gujarat on the west coast of India has a seaweed resource of 20,000 tons wet weight (Chennubhotla et al., 1990). The important places of algal interest being Okha, Dwaraka, Adatra, Suharashtra, Hanumandandi and Veraval. Gujarat coast excels all other places of India for the occurrence of a variety of algae, not usually found in the tropical waters.

Preliminary surveys have revealed that island ecosystems of India, like Andaman-Nicobar islands in the Bay of Bengal and Lakshadweep group of islands in the Arabian sea harbour a variety of marine algae, in good quantities. More intensive surveys on a long term basis covering all the sub-islands is likely to give more information on the marine algal flora of these places.

Chilka lake of Orissa, creeks and inlets of Sunderbans in West Bengal, coasts of Andhra Pradesh, Goa, Karnataka and Kerala also support a fairly rich growth of marine algae.

In addition to these, the estuarine systems of India are also reported to harbour benthic macroalgae, viz. Vellar in Tamil Nadu (Kannan and

Krishnamurthy 1978, Krishnamurthy and Jayaseelan 1984), Ashtamudi in Kerala (Nair et al., 1982), Mandovi estuary in Goa (Jagtap, 1986) and Godavari estuary in Andhra Pradesh (Umamaheswara Rao, 1987).

2.2 Objectives of the present study

Although considerable amount of work has been done on marine algae of the Indian region, we have still a long way to go towards compilation of Marine Algal Flora of India. So far, about 681 species of marine algae are reported from Indian coasts. Inspite of this impressive number of species from Indian coastal waters, a renewed investigation is likely to yield many more species. Many areas of the Indian coast have been worked out thoroughly as far as the marine algae are concerned, but a major part of the coast still remains to be explored. Thus the notable lacunae in the knowledge of marine algae of the Indian regions is due to the lack of proper exploration.

Knowledge of the distribution and ecology of algae is a basic aspect of algal research. Ecologically, algal communities of the sea shore lend themselves admirably to a detailed study. The principal marine algal species together with certain animals form well marked belts on the shore and the phenomenon is not confined to one region, but is more or less universal, though the component species obviously vary in different parts of the world. In a variety of localities it can be seen that there is a variation both in the number of species and abundance of individual species. Comparisons of this type are well worth making since they provide information about the species present and absent respectively in different localities and the possible reasons.

Many of the ecological investigations have provided data on the correlation between the seasonal changes in density of macroalgae and the environmental conditions existing in the areas of their growth. The changes of tidal emergence and submergence, topography of the coast, surf action, levels at which they grow, chemical nature of sea water etc., were found to contribute much to the growth behaviour of the algae.

Compared to other maritime states of India, information on the seaweeds of Kerala coast is meagre. Although some preliminary investigations have been made by some authors, our information on the marine algal flora of Kerala still remains fragmentary. Therefore, it was thought worthwhile to carry out a detailed investigation of the ecology of seaweed flora of Kerala coast.

Ecological observations like species of seaweeds available along Kerala coast, their distribution and zonation pattern, frequency of occurrence, monthly/seasonal density of seaweeds at each station, standing crop, monthly/seasonal/place-wise variation in physico-chemical characters of ambient waters at the areas of seaweed growth like atmospheric temperature, surface water temperature, salinity, dissolved oxygen, phosphate, nitrate and silicate contents, and their influence on seaweed density have been documented in the study. Besides providing a complete picture of the ecology of seaweed flora of Kerala, this type of data will help us in the farming of economically important seaweeds, by providing information on the ideal conditions of seaweed growth.

Many Indian and foreign authors like Woodward, (1955)., Zaneveld, (1955)., Tamiya, (1960)., Thivy, (1960)., Hoppe, (1966)., Umamaheswara Rao, (1967)., Levring et al (1969)., Chapman, (1970)., Umamaheswara Rao, (1970)., Krishnamurthy, (1971)., Subramanyan and Gopinathan, (1971)., Valasquez, (1972)., Tsuda and Bryan, (1973)., Bersamin, (1974)., Gopinathan and Pillai, (1974)., Bryan, (1975)., Bonotto, (1976)., Chennubhotla (1977)., Dave et al (1977)., Chaturvedi et al (1979)., Jaganathan and Venkatakrishnan, (1979)., Dave et al, (1979)., Chapman and Chapman, (1980), Dawes et al (1981)., Chennubhotla et al (1981)., Paciente, (1983)., Fujiwara et al (1983).,Sivalingam, (1983)., Silas et al (1983)., Mc Hugh and Lanier, (1984)., Anon, (1987)., Chennubhotla et al (1987)., Kaliaperumal et al (1987)., Silas, (1987)., Ananza-Corrales, (1988)., Chennubhotla and Susan Mathew, (1989)., Krishnamurthy, (1990)., Swamy, (1990) have documented the utilization of seaweeds as food or for fodder purposes.

Nutritive value of seaweeds lie in the fact that they are rich sources of protein, carbohydrate, lipid, trace elements, minerals, and vitamins. They have many essential amino acids including iodine containing amino acids. Lewis and Gonzalves (1959 a-c, 1960, 1962 a-c) and Lewis 1962 a-c, 1963 a-d) have shown that Indian marine algae contains all essential amino acids. Lewis (1967) observed that Indian marine algae compare favourably with over vegetable proteins with regard to their total essential amino acids. Similar observation was made by Block and Weiss (1956). They suggested that algal proteins are comparable in essential amino acid composition with vegetables, nuts, seeds and cereals, and that algal proteins are richer in tryptophan content.

Taking into consideration, the ever growing demand for proteinaceous food for human consumption it has become very essential to locate non-conventional resources of nutritive value. In this context, the food value of marine algae is currently gaining a lot of importance. Therefore in the present study it was thought worthwhile to investigate into the bio-chemical constitution of the seaweeds of Kerala coast. The studies on major bio-chemical constituents of seaweeds viz., protein, lipid and carbohydrate will give us an idea of the nutritive value of each species of seaweed. Seaweeds with high content of proteins, carbohydrates and lipids can be then recommended for food and feed formulations after subjecting them to toxicological studies. The study on monthly/seasonal/place-wise variation in bio-chemical composition of seaweeds will provide necessary information on the appropriate time and place of harvesting an algal species for exploiting its constituents.

3. MATERIALS AND METHODS

3.1 Ecological features of Kerala coast

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. Kerala lies between north latitudes 5°15' and 12°85' and east longitudes 74°55' and 77°05' and covers 38.864 sq.km. Kerala is accessible to maritime influence from the west and has been important in history for nearly 2000 years.

3.2 Shoreline of Kerala

Greater part of the shoreline of Kerala is straight i.e., from Kozhikode to Kollam, but in Cannore, Thiruvananthapuram and Kollam districts, indentations, cliffs and protruberances are present. The shoreline is a compound one with a variety of features some of which have resulted from submergence and others from emergence. The coastal plains of Kerala have about 34 back water systems. The Vembanad lake, south of Kochi is the largest one followed by Ashtamudi lake further south. Inspite of so many rivers discharging into the sea, no major delta has been formed anywhere. The coastal plain from Alapuzha to Kochi has a series of parallel to subparallel sand dune ridges. Sea erosion on the coastal tract is a frequent feature of Kerala. But now groins and seawalls serve as a protection against sea erosion.

3.3 Geology of Kerala coast

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.

Geologically, the immediate hinterland of rocky coasts are made up of sedimentary rocks or Precambrian crystallines represented by charno-ckite, pyroxene granulites, khondalites and leptynites. Laterite formations cover parts of the shore north of Ponnani and south of Kollam. Outcrops of bedrocks can be seen along the coast north of Kozhikode and from Kovalam southwards. Bedrocks directly exposed to waves on beach are seen at Kovalam and in isolated patches north of Kozhikode.

3.4 Tides and storm tides in Kerala

The mean tidal range varies from 0.9 M in the south to 1.8 M in the north. The tides are semi-diurnal type (12 hour). The coastline is very low and coastal areas are flooded by storm tides in many sections during the south-west monsoon.

3.5 Waves of Kerala coast

The sea is rough during the monsoon months (May - August). During this period high waves with storm surges, attack the coast. The highest wave averages 3.2 M, and wave periods of 5 - 12 seconds are observed. Coastal erosion is an alarming problem in Kerala. South-west monsoon with its full fury hits the Kerala coast and it has to bear the brunt of a full blast of monsoon storms with steep waves and rising water level.

3.6 Metereological features of Kerala

The annual rainfall is high ranging from 200 - 300 cm most of which falls during the south-west monsoon. During the north–east monsoon the rainfall is negligible. The climate is tropical with three seasons as follows:

1. Monsoon (May - August)
2. Post-Monsoon (September - December)
3. Pre-monsoon (January - April)

3.7 Description of the study area

An initial survey was conducted along the Kerala coast from Kovalam to Cannore, to identify the major areas of seaweed growth. For the convenience of study, the entire coast of Kerala was divided into three zones viz., (1) North zone (2) Central zone and (3) South zone. Stations were fixed in each zone (Fig.1).

In North-zone, two stations (1) Elathur (8 km north of Kozhikode) and (2) Thikkotti (45 km north of Kozhikode) were fixed. In Central zone, one station Saudi about 10 km south of Fort Kochi was fixed. In South zone, two stations (1) Varkala (about 41 km north of Thiruvananthapuram) and (2) Mullur (about 25 km south of Thiruvananthapuram) were fixed.

3.7.1 Elathur

The study area at Elathur covered a distance of about 1 km along the shore. Here the beach was ill developed with many rocks scattered at various distances from the shore into the sea. These rocks were fully submerged during high tide and exposed during low tide. Some of the rocks formed wave cut terraces of laterite-an alteration product of rocks.

In the central sector of the study area were seen artificial dykes of rubble used as a preventive measure against sea erosion sunk into the sea due to the constant action of the waves. In this area steep rocks with varying gradations extended into the sea. In the northern sector of the study area were seen flat topped rocks extending into the sea. Many rock pools were observed on these rocks. In southern sector of the study area there were many laterite rocks submerged at varying depths in the sea. These rocks were constantly splashed by waves. Towards the extreme south, silt covered rocky flats extended into the sea upto a distance of 25 M from the shore. The average distance upto which the rocks extended into the sea from the shore was about 5 M at Elathur.

3.7.2 Thikkotti

The study area at Thikkotti covered a distance of 1 km along the shore. This area was characterised by a sandy beach. At a distance of about 4 M from the shore into the sea, laterite rocks covered by a thin veneer of sand and gravel were scattered at varying depths. These rocks were exposed and submerged depending on the tides. Many wave cut terraces of laterite were also met with in this area.

3.7.3 Varkala

The station selected for study was the beach near the famous Varkala temple. The study area covered a distance of 1 km along the shore. Beach in this area was sandy. Near the entrance to the beach on one side artificial dykes of rubble were erected as a preventive measure against sea erosion. A part of this seawall had sunk into the sea due to wave action.

this sector the landward face of the beach was a cliff exposing the limentary rocks and the laterite cover on the top. Due to undercutting the waves, the cliff gradually receded and chunks of laterite have fallen to the sea. Towards the southern end of the beach, several sedimentary ocks of sandstone belonging to Mio-pliocene age were scattered in the a at varying distances (upto 2 M) from the shore. Towards the northern de of the beach also several cliffs of sedimentary rocks weree found hich were continuously acted upon by strong waves.

.7.4 Mullur

In Mullur, the study area covered a distance of about 1 km along e shore. The beach was mainly rocky with crystalline rocks with minor dented inlets extending into the sea. Rocks were observed at varying stances from the shore in the sea at varying depths. The average distance om the shore upto which rocks were scattered in the sea was about M. The rocks were made of charnochite and fully exposed during low de. The rocks near the shore formed a flat topped wave cut terrace tending into the sea at varying gradients. Towards the southern end the study area steep overhanging cliffs were observed. Some of the cks formed lowlying narrow ridges, because of differential weathering. eep rocks about 2 - 3 metres in height were also observed near the shore. he lower portion of these rocks were submerged under water for major rt of the year. During monsoon high waves splash on the upper portion these rocks. This rocky shore extended from Vizhinjam harbour to olakarai.

3.7.5 Saudi

In the Fort Kochi area the beach was sandy and severly affected by coastal erosion especially during monsoon months. Therefore longitudinal, coast parallel dykes have been constructed as a preventive measure. These artificial dykes of rubble, being constructed on a sandy base, part of the material have sunk into the sand and drifted seawards due to action of the waves. In the entire Fort Kochi area from Manassery to Saudi, the beach is more or less similar. Study area covered a distance of about 1 km along the shore.

3.8 Methods of study

Once every month, trips were undertaken to each of the three zones for making ecological observations and for seaweed collection. The time for making field trips were fixed during the hours of low tides as predicted by the tide table. Ecological observations like atmospheric temperature, surface water temperature, species of seaweeds available and their densities were made in the field itself. Water samples for hydrological studies and seaweed samples for biochemical studies were collected. Water samples for dissolved oxygen analysis were fixed in the station itself.

3.8.1 Determination of seaweed density

Density of seaweeds was determined using a 0.25 m^2 metallic quadrat. All algal species, in the randomly placed quadrat was handpicked. These were sorted out species-wise, washed in seawater, and weighed on a physical balance separately. This process was repeated and the calculation was done as follows:

$$\text{Average density of each species} = \frac{\text{Total weight of the species collected from different rocks using the 0.25 m}^2\text{ quadrat}}{\text{Total number of rocks studied}} \times 4$$

3.8.2 Hydrological studies

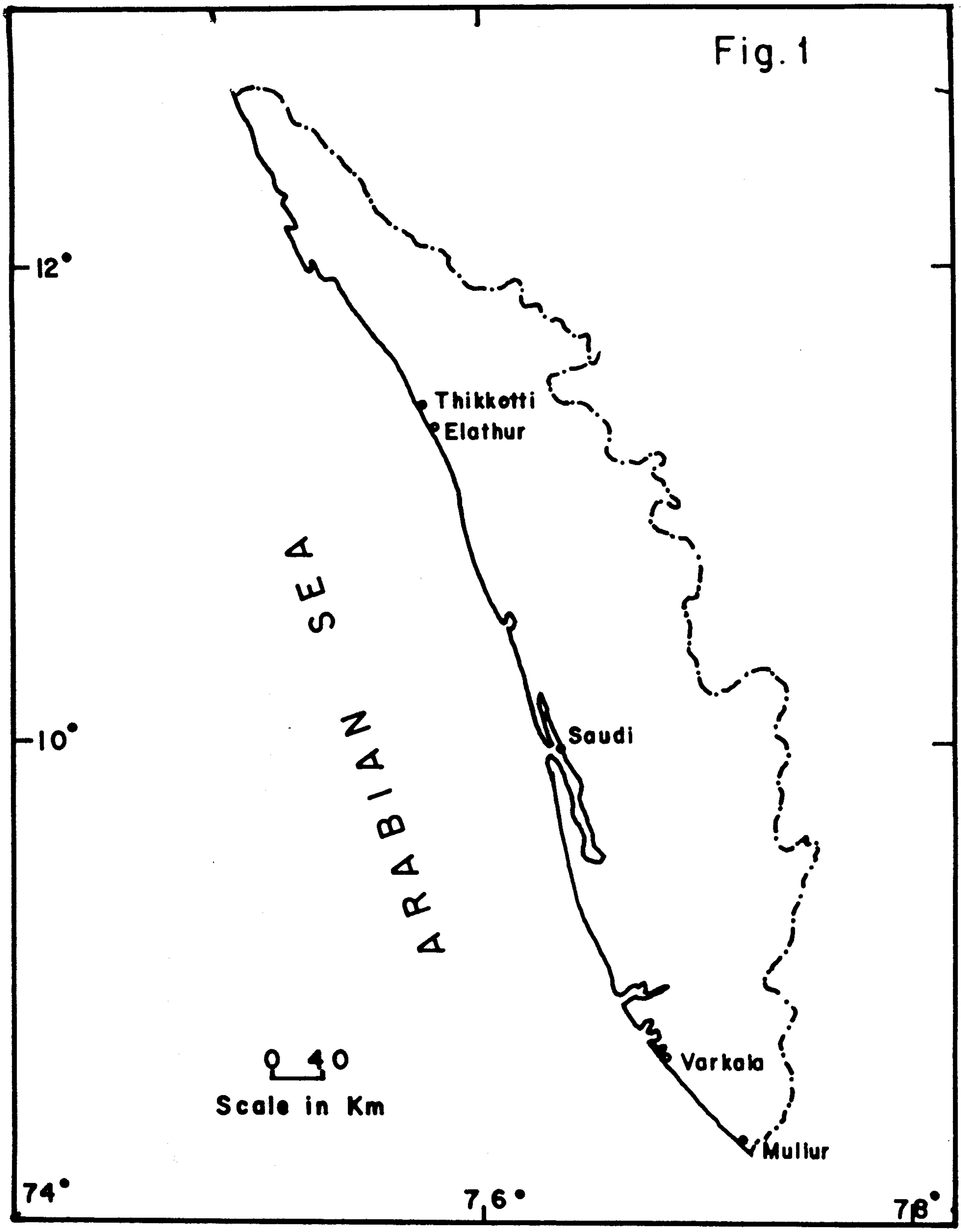
Water samples brought to the laboratory from each station were analysed immediately for dissolved oxygen content, salinity and concentration of nutrients like phosphate, nitrate and silicate. Dissolved oxygen content was analysed by Winkler's method and salinity by titration with silver nitrate. Concentration of phosphate, nitrate and silicate were analysed using the standard procedures of Strickland and Parsons (1968).

3.8.3 Biochemical studies

Each species of seaweed was sorted out in the laboratory, cleaned off extraneous material, washed thoroughly in seawater followed by tap water and finally rinsed in distilled water. These were then spread on blotting paper in enamel trays under the fan for 2-3 days after which these were dried in hot air oven, below 60°C, till constant weight was attained. Dried seaweeds were then powdered and sieved. The powder is either immediately used for analysis or packed in polythene bags, sealed and stored in dessicator for subsequent analysis.

The protein content was analysed by the method of Lowry et al. (1951), carbohydrate content by the method of Dubois et al. (1956) and lipid content by the method of Barnes et al. (1973) with necessary modifications. All values were expressed as percentage of dry weight. The calorific values were calculated using caloric equivalents of 5.65 for proteins, 4.15 for carbohydrates and 9.40 for lipids on dry weight basis.

MAP OF KERALA SHOWING STATIONS OF STUDY



4. ECOLOGICAL OBSERVATIONS

4.1 LIST OF SEAWEEDS RECORDED FROM KERALA COAST DURING THE PRESENT STUDY

DIVISION : CHLOROPHYTA

CLASS : CHLOROPHYCEAE

Order : Ulotrichales

Family : Ulvaceae

Ulva fasciata Delile

U. lactuca (Linn.) Le Jollis

Enteromorpha compressa (Linn.) Grev.

E. flexuosa (Wulf.) J. Ag.

E. intestinalis (L.) Link

Order : Cladophorales

Family : Cladophoraceae

Chaetomorpha antennina (Bory.) Kutz.

C. linum (Muell.) Kutz.

Spongomorpha indica Thivy. & Visalakshmi

Cladophora fascicularis (Mertens) Kutz.

C. glomerata (L.) Kutz

Cladophora sp.

Order : Siphonocladales

Family : Siphonocladaceae

Cladophoropsis zollingeri (Kutz.) Boergs.

Order : Codiales

Family : Bryopsidaceae

Bryopsis plumosa (Huds.) Ag.

Family : Caulerpaceae

Caulerpa racemosa (Forssk.) V. Bosse.

C. peltata Lamour

C. fastigiata Mont.

C. scalpelliformis (R. Br.) V. Bosse.

C. sertularioides (Gmel.) Howe

Family : Valoniaceae

Boodlea composita (Harv. et. Hook. f. Brand.)

Valoniopsis pachynema (Martns) Boergs.

DIVISION : PHAEOPHYTA

CLASS : PHAEOPHYCEAE

Order : Scytosiphonales

Family : Chnoosporaceae

Chnoospora minima (Hering) Papen.

Order : Dictyotales

Family : Dictyotaceae

Dictyota bartayresiana Lamour.

D. dichotoma (Huds.) Lamour

Padina gymnospora (Kutz.) Vick.

P. tetrastromatica Hauck.

Spathoglossum asperum J. Ag.

Order : Fucales

Family : Sargassaceae

Sargassum tenerrimum J. Ag.

S. wightii (Grev. & Mscr.) Ag.

Turbinaria conoides Kutz.

T. ornata J. Ag.

DIVISION : RHODOPHYTA

CLASS : RHODOPHYCEAE

Order : Goniotrichales

Family : Bangiaceae

Porphyra kanyakumariensis Krish and Balus

Order : Nemalionales

Family : Acrochaetiaceae

Acrochaetium sp.

Family : Gelidiaceae

Gelidium pusillum (Stackh.) Le Jolis

Order : Cryptonemiales

Family : Corallinaceae

Amphiroa fragilissima (L.) Lamour

Jania rubens (L.) Lamour.

Family : Cryptonemiaceae

Grateloupia comoronii Boergs.

G. filicina (Wulf.) Ag.

G. lithophila Boergs.

Order : Gigartinales

Family : Hypneaceae

Hypnea musciformis (Wulf.) Lamour.

H. valentiae (Turn.) Mont.

Hypnea sp.

Family : Gracilariaceae

Gracilaria corticata J. Ag.

G. foliifera (Forssk.) Boergs.

Gelidiopsis variabilis (Grev.) Schmitz

Family : Gigartinaceae

Gigartina acicularis (Wulf.) Lamour.

Order : Rhodymeniales

Family : Champiaceae

Champia indica Boergs.

Order : Ceramiales

Family : Ceramiaceae

Centroceras clavulatum (Ag.) Mont.

Ceramium rubrum (Huds.) Ag.

Spyridea filamentosa (Wulf.) Harv.

Family : Rhodomeliaceae

Laurencia sp.

Acanthophora spicifera (Vahl.) Boergs.

Bostrychia tenella (Vahl.) J. Ag.

During the present investigation, 52 species of seaweeds were collected from Kerala coast. Out of this, 20 species belonged to Chlorophyceae, 10 to Phaeophyceae and 22 to Rhodophyceae.

Table 1. Number of Orders, Families, Genera and species of seaweeds recorded from Kerala.

	Chlorophyta	Phaeophyta	Rhodophyta	Total
Orders	4	3	6	13
Families	6	3	11	20
Genera	10	6	17	33
Species	20	10	22	52

Most of the seaweeds recorded from Kerala coast belonged to Rhodophyceae and Chlorophyceae. Phaeophycean algae were found to be relatively less along the Kerala coast.

ECONOMICALLY IMPORTANT SEAWEEDS OF KERALA COAST

.1 Commercially important seaweeds of Kerala coast

le 2. Commercially important seaweeds of Kerala coast

mes of species	Places of availability
AROPHYTES	
ldium pusillum	Mullur, Thikkotti, Elathur
cilaria corticata	Mullur, Varkala, Thikkotti, Elathur
foliifera	Varkala, Thikkotti, Elathur
AROIDOPHYTES	
pnea valentiae	Thikkotti, Varkala, Mullur
musciformis	Thikkotti, Varkala
pnea sp.	Thikkotti
ridea filamentosa	Mullur
rencia sp.	Mullur, Thikkotti
nthophora spicifera	Mullur, Thikkotti
artina acicularis	Thikkotti, Elathur
GINOPHYTES	
tyota dichotoma	Varkala, Thikkotti
bartayresiana	Mullur
gassum wightii	Mullur, Varkala
tenerrimum	Mullur, Varkala

Table 2. (Contd....)

Names of species	Places of availability
Padina gymnospora	Mullur, Elathur
P. tetrastromatica	Mullur, Thikkotti, Elathur
Turbinaria conoides	Varkala
T. ornata	Thikkotti
Spathoglossum asperum	Thikkotti

4.2.2 Edible seaweeds of Kerala coast

Many edible seaweeds were observed along the Kerala coast during the present study and the important among them are species of *Ulva*, *Enteromorpha*, *Chaetomorpha* and *Caulerpa* among Chlorophyceae, *Dictyota*, *Padina*, *Chnoospora*, *Sargassum* and *Turbinaria* among Phaeophyceae and *Porphyra*, *Grateloupia*, *Gracilaria*, *Hypnea*, *Centroceras*, *Acanthophora* and *Laurencia* among Rhodophyceae.

4.3 DISTRIBUTION OF SEAWEEDS IN DIFFERENT ZONES OF KERALA COAST

4.3.1 Seaweeds from North zone of Kerala coast

Table 3. Seaweeds from north zone of Kerala coast

Division and names of species	Place of collection	
	Elathur	Thikkotti
DIVISION : CHLOROPHYTA		
Ulva fasciata	+	+
U. lactuca	+	+
Enteromorpha intestinalis	+	+
Chaetomorpha antennina	+	+
C. linum	-	+
Spongomorpha indica	-	+
Cladophora fascicularis	+	-
C. glomerata	-	+
Cladophora sp.	+	+
Cladophoropsis zollingeri	-	+
Bryopsis plumosa	-	+
Caulerpa fastigiata	-	+
C. scalpelliformis	-	+
C. peltata	-	+
C. sertularioides	+	+

able 3. (Contd....)

ivision and names of species	Places of collection	
	Elathur	Thikkotti
oodlea composita	–	+
aloniopsis pachynema	–	+
IVISION : PHAEOPHYTA		
ictyota dichotoma	–	+
adina gymnospora	+	–
. tetrastromatica	+	+
pathoglossum asperum	–	+
urbinaria ornata	–	+
IVISION : RHODOPHYTA		
orphyra kanyakumariensis	+	–
crochaetium sp.	+	–
elidium pusillum	+	+
ania rubens	+	+
rateloupia comoronii	+	+
. filicina	+	–
. lithophila	+	+
ypnea musciformis	–	+
. valentiae	–	+
ypnea sp.	–	+
racilaria corticata	+	+

Table 3. (Contd.....)

Division and names of species	Places of collection	
	Elathur	Thikkotti
G. foliifera	+	+
Gelidiopsis variabilis	+	+
Gigartina acicularis	+	+
Champia indica	-	+
Centroceras clavulatum	+	+
Ceramium rubrum	-	+
Laurencia sp.	-	+
Acanthophora spicifera	-	+
Bostrychia tenella	-	+

Out of the 52 species of seaweeds collected from Kerala coast, 42 were available at North zone. Out of the 42 species, 17 species belonged to green algae; 5 to brown algae and 20 to red algae. Number of species of red algae was more followed by green and brown algae, in the North zone. Among the 20 species of green algae recorded from Kerala, 17 were available at North zone. Among the 10 species of brown algae, recorded from Kerala, 5 were available at North zone and among the 22 species of red algae, recorded from Kerala, 20 were available at North zone.

le 4. Number of orders, families, genera and species of seaweeds recorded from North zone.

	Chlorophyta	Phaeophyta	Rhodophyta	Total
ders	4	2	6	12
milies	6	2	11	19
nera	10	4	15	29
ecies	17	5	20	42

aweeds exclusive to North zone

haetomorpha linum

ongomorpha indica

adophoropsis zollingeri

ulerpa fastigiata

odlea composita

athoglossum asperum

rbinaria ornata

ateloupia comoronii

pnea sp.

gartina acicularis

ampia indica

ramium rubrum

strychia tenella

13 species of algae were found to be exclusive to North zone of Kerala, out of which 5 species belonged to Chlorophyceae,2 to Phaeophyceae, and 6 to Rhodophyceae.

4.3.2 Seaweeds from South zone of Kerala coast

Table 5. Seaweeds from South zone of Kerala coast

Division and names of species	Place of collection	
	Varkala	Mullur
DIVISION : CHLOROPHYTA		
Ulva fasciata	+	+
U. lactuca	+	+
Enteromorpha compressa	+	+
Chaetomorpha antennina	+	+
Cladophora glomerata	-	+
C. fascicularis	-	+
Cladophora sp.	+	+
Bryopsis plumosa	-	+
Caulerpa racemosa	-	+
C. peltata	-	+
C. scalpelliformis	-	+
C. sertularioides	-	+
Valoniopsis pachynema	+	+

Table 5. (Contd....)

Division and names of species	Place of collection	
	Varkala	Mullur
DIVISION : PHAEOPHYTA		
Chnoospora minima	+	+
Dictyota bartayresiana	-	+
D. dichotoma	+	-
Padina gymnospora	-	+
P. tetrastromatica	-	+
Sargassum tenerrimum	+	+
S. wightii	+	+
Turbinaria conoides	+	-
DIVISION : RHODOPHYTA		
Porphyra kanyakumariensis	+	+
Acrochaetium sp.	+	+
Gelidium pusillum	-	+
Amphiroa fragilissima	-	+
Jania rubens	+	+
Grateloupia filicina	+	+
G. lithophila	+	+
Hypnea musciformis	+	-
H. valentiae	+	+
Gracilaria corticata	+	+

Table 5. (Contd...)

Division and names of species	Place of collection	
	Varkala	Mullur
G. foliifera	+	–
Gelidiopsis variabilis	+	+
Centroceras clavulatum	+	+
Spyridea filamentosa	–	+
Laurencia sp.	–	+
Acanthophora spicifera	–	+

Out of 52 species of seaweeds collected from Kerala coast, 37 were available at South zone. Out of the 37 species, 13 belonged to green algae, 8 to brown algae and 16 to red algae. Rhodophyceae were more abundant in the South zone, followed by Chlorophyceae and Phaeophyceae. Out of the 20 species of green algae recorded from Kerala, 13 species were available at South zone, out of the 10 species of brown algae, 8 were available at South zone and out of the 22 species of red algae 16 were available at South zone.

Table 6. Number of orders, families, genera and species of seaweeds recorded from South zone.

	Cholorophyta	Phaeophyta	Rhodophyta	Total
Orders	3	3	5	11
Families	5	3	9	17
Genera	7	5	13	25
Species	13	8	16	37

Seaweeds exclusive to South zone

Caulerpa racemosa

Chnoospora minima

Dictyota bartayresiana

Sargassum tenerrimum

S. wightii

Turbinaria conoides

Amphiroa fragilissima

Spyridea filamentosa

8 species of seaweeds, 1 belonging to Chlorophyceae, 5 to Phaeophyceae and 2 to Rhodophyceae were found to be exclusive to South zone of Kerala.

4.3.3 Seaweeds from Central zone of Kerala coast

DIVISION : CHLOROPHYTA

Enteromorpha compressa

E. flexuosa

Chaetomorpha antennina

Bryopsis plumosa

DIVISION : PHAEOPHYTA

Nil

DIVISION : RHODOPHYTA

Acrochaetium sp.

Jania rubens

Grateloupia filicina

G. lithophila

Centroceras clavulatum

Out of the 9 species of seaweeds collected from Central zone, 4 species belonged to Chlorophyceae and 5 to Rhodophyceae. No Phaeophyceaen member was present.

Table 7. Number of orders, families, genera and species of seaweeds in Central zone.

	Chlorophyceae	Rhodophyceae	Total
Orders	3	3	6
Families	3	4	7
Genera	3	4	7
Species	4	5	9

Enteromorpha flexuosa was found to be exclusive to Central zone of Kerala.

Table 8. Number of seaweed species recorded from different zones of Kerala.

Division	Number of seaweed species recorded from different zones of Kerala		
	South zone	Central zone	North zone
Chlorophyta	13	4	17
Phaeophyta	8	0	5
Rhodophyta	16	5	20
Total number of species	37	9	42

Thus number of seaweed species was maximum in North zone (42 species), followed by South zone (37 species) and Central zone (9 species). Number of species of Chlorophyceae and Rhodophyceae in North zone was greater than in South zone. But number of species of Phaeophyceae was greater in South zone than in North and Central zones. In Central zone 4 species of Chlorophyceae and 5 species of Rhodophyceae were present, but no Phaeophycean member was present.

4.4 ZONATION PATTERN OF SEAWEEDS ALONG KERALA COAST

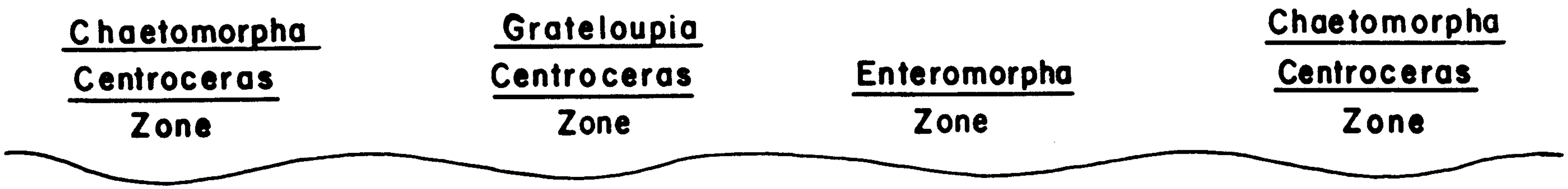
During the course of the present investigation, a definite zonation pattern was observed with regard to several species of seaweeds. Ulva fasciata, U. lactuca, Chaetomorpha antennina, Enteromorpha compressa, Porphyra kanyakumariensis, Grateloupia lithophila, G. filicina and Centroceras clavulatum were found to grow on the rocks of the upper littoral zone. Rocks exposed to heavy breakers and swells harboured algae with strong holdfasts like Chaetomorpha antennina, Porphyra kanyakumariensis, Grateloupia spp., Gracilaria spp., Spyridea filamentosa, Sargassum spp. and Chnoospora minima. Hypnea valentiae, Acanthophora spicifera, Laurencia sp. and Caulerpa scalpelliformis were observed in the deeper regions of the mid-littoral zone at Mullur. At Mullur, Caulerpa peltata was found to grow on the leeward side of the rocks in the mid littoral zone which is constantly covered and uncovered by water. At Thikkotti and Mullur, Caulerpa sertularioides was found to grow on sandy bottoms of the sea, at about 1 m depth. At Elathur, this species was found to grow on the sides of rock pools in the mid littoral zone which was exposed for the major part of the day. At Mullur, the lower littoral zone was inhabited by species of Sargassum, Spyridea, Gracilaria and Dictyota which cannot tolerate long exposures and dessication. Sargassum spp. always grew on the seaward side of the wave exposed rocks. Species of Enteromorpha were found to grow in almost all the aquatic biotypes. At Elathur, Enteromorpha intestinalis was found to grow in a highly polluted coconut ting area. At Varkala, Enteromorpha occupied the rocks which were iodically covered and uncovered by sand.

At Saudi, a definite pattern of horizontal zonation of seaweeds s observed (Fig.2). In the Central part of the station two distinct zones seaweeds were found to exist. The first zone was occupied by species e Grateloupia lithophila, G. filicina and Centroceras clavulatum. The ond zone was occupied by only Enteromorpha compressa. On either e of the Central zone, Chaetomorpha antennina and Centroceras clavulatum wed a mixed growth.

At Varkala also a definite horizontal zonation was observed (Fig.3). e first few rocks near the entrance to the beach were occupied by teromorpha. This area showed marked seasonal changes in the topography, racterised by the covering and uncovering of rocks by sand. After zone there was a definite zone of Ulva lactuca, Enteromorpha compressa Chaetomorpha antennina. This zone is followed by a zone with mixed wth of Grateloupia lithophila, G. filicina, Ulva fasciata, U. lactuca, etomorpha antennina and Centroceras clavulatum.

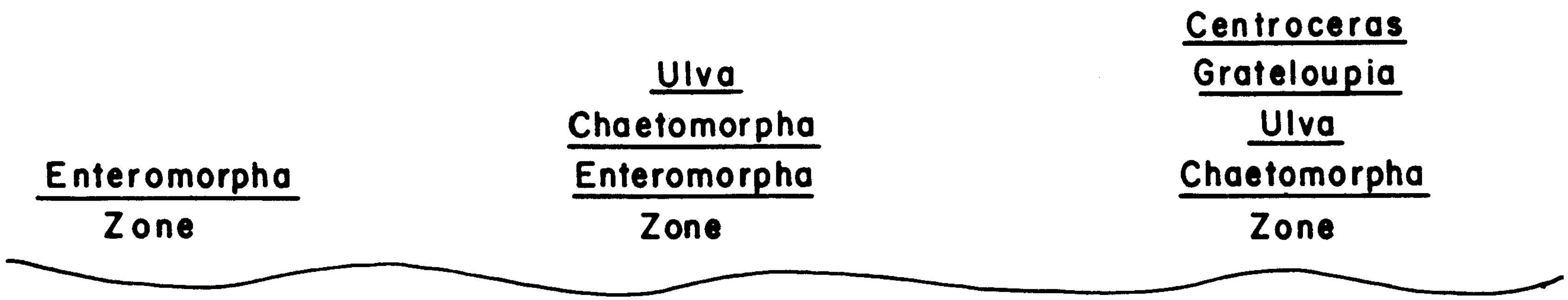
HORIZONTAL ZONATION OF SEAWEEDS OBSERVED AT SAUDI

Fig. 2



HORIZONTAL ZONATION OF SEAWEEDS OBSERVED AT VARKALA

Fig. 3



DENSITY OF SEAWEEDS IN DIFFERENT STATIONS ALONG KERALA COAST

Density of a seaweed species is described based on the scheme given below:

Seaweed species showing an average monthly density of 450 gm/m^2 or above	Very high density
Seaweed species showing an average monthly density between 150 gm/m^2 and 450 gm/m^2	High density
Seaweed species showing an average monthly density between 20 gm/m^2 and 150 gm/m^2	Fairly high density
Seaweed species showing an average monthly density below 20 gm/m^2	Low density

4.5.1. Density of seaweeds at Mullur

Table.9 Density of seaweeds at Mullur (gm/m^2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	Total density/ month
Feb. 88	600	550	-	-	-	-	-	-	-	-	-	-	-	350	-	500	-	-	800	-	-	150	-	75	-	-	450	650	200	150	450	-	-	4925
Mar. 88	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	300	-	-	700	-	-	-	-	-	-	-	400	600	-	150	700	-	-	3350
Apr. 88	800	-	-	200	-	-	200	100	25	-	-	-	-	-	-	800	-	-	800	-	-	-	-	-	-	-	-	800	-	150	800	-	-	4675
May. 88	-	20	-	40	-	-	-	-	500	-	-	200	800	-	-	20	-	*	200	-	-	240	200	200	-	-	-	800	160	400	-	-	-	3780
Jun. 88	800	-	-	200	-	-	-	-	-	400	-	-	-	-	-	-	-	-	600	-	-	-	-	-	-	-	-	600	-	-	600	-	-	3200
Jul. 88	3000	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	100	300	*	-	-	-	-	-	-	950	-	-	200	-	-	4650
Aug. 88	4000	200	-	600	-	-	-	60	-	1400	-	-	-	500	-	-	-	-	200	-	-	20	-	-	-	-	600	480	20	120	200	-	-	8400
Sep. 88	2000	800	-	200	-	-	-	-	-	1000	-	-	-	1000	-	400	-	-	2400	-	-	-	-	-	-	-	-	800	-	400	400	-	-	9400
Oct. 88	300	-	-	300	-	-	-	200	-	100	-	-	-	100	-	-	-	-	200	-	-	-	-	-	-	-	*	200	-	200	400	-	-	2000
Nov. 88	600	200	-	400	-	-	-	-	-	200	-	-	-	400	-	-	600	-	600	-	-	-	-	-	500	200	900	800	200	400	200	-	-	6200
Dec. 88	-	600	-	700	-	-	-	-	-	200	-	-	-	-	-	-	600	-	2000	-	-	-	-	-	-	600	200	1000	-	600	1400	-	-	7900
Jan. 89	1000	-	-	400	-	-	-	100	-	1000	-	-	-	400	-	300	-	-	1500	-	-	-	-	-	-	100	*	600	-	350	600	-	-	6350
Feb. 89	400	100	-	75	-	-	-	350	-	400	-	-	-	150	-	400	-	-	600	-	-	*	-	-	-	100	100	600	-	250	400	-	-	3925
Mar. 89	100	25	100	60	100	-	-	150	-	150	-	-	-	50	250	200	-	-	350	-	-	-	-	-	-	75	75	300	-	125	2100	70	-	4280
Apr. 89	150	-	-	-	-	50	-	-	-	75	-	-	-	-	-	-	250	-	300	-	-	*	-	-	-	75	25	500	-	500	550	-	-	2475
May. 89	175	150	-	50	-	-	-	-	-	150	-	-	-	*	-	150	-	-	75	-	-	-	-	-	-	-	50	500	-	75	300	-	-	1675
June. 89	500	-	-	250	-	-	-	-	-	250	-	-	-	-	-	-	-	-	250	500	-	-	-	-	-	-	-	300	-	350	250	-	-	2650
Jul. 89	750	250	75	350	-	-	-	-	-	250	-	-	-	150	-	-	-	-	250	500	-	-	-	-	-	-	-	150	-	250	150	-	-	3125
Aug. 89	350	350	150	150	-	-	-	*	-	300	-	-	-	250	-	-	-	-	175	250	-	-	-	-	-	-	250	200	-	-	250	-	-	2675
Sep. 89	350	100	-	350	-	-	-	-	-	350	-	-	-	500	-	-	-	-	150	75	-	50	-	-	-	-	-	500	-	100	350	-	-	2875
Oct. 89	200	150	-	150	-	-	-	-	-	150	-	-	-	100	100	-	-	-	100	-	-	*	-	-	-	*	150	200	-	100	200	75	-	1675
Nov. 89	150	150	-	150	-	-	-	-	-	150	-	-	-	75	50	-	-	-	150	-	-	-	-	-	-	*	50	150	-	50	100	100	-	1325
Dec. 89	150	150	-	150	-	-	-	-	-	100	-	-	-	-	-	75	-	-	150	-	-	-	-	-	-	100	50	150	-	150	100	100	-	1425
Jan. 90	200	50	-	25	-	-	-	25	-	150	*	-	-	-	50	75	-	-	500	-	-	-	-	-	-	-	50	450	-	150	500	150	*	2375
Average monthly density of each species	690.63	181.04	13.54	200	4.16	2.08	8.33	41.04	23.95	282.29	*	8.33	33.33	171.88	18.75	134.17	60.42	*	547.92	67.71	*	19.16	8.33	11.45	20.83	52.08	139.58	511.67	24.17	209.17	466.67	20.63	*	3971.25

INDEX TO TABLE 9

Species 1	*Ulva fasciata*
Species 2	*U. lactuca*
Species 3	*Enteromorpha compressa*
Species 4	*Chaetomorpha antennina*
Species 5	*Cladophora glomerata*
Species 6	*C. fascicularis*
Species 7	*Cladophora* sp.
Species 8	*Bryopsis plumosa*
Species 9	*Caulerpa racemosa*
Species 10	*C. peltata*
Species 11	*C. scalpelliformis*
Species 12	*C. sertularioides*
Species 13	*Valoniopsis pachynema*
Species 14	*Chnoospora minima*
Species 15	*Dictyota bartayresiana*
Species 16	*Padina gymnospora*
Species 17	*P. tetrastromatica*
Species 18	*Sargassum tenerrimum*
Species 19	*S. wightii*
Species 20	*Porphyra kanyakumariensis*
Species 21	*Achrochaetium* sp.
Species 22	*Gelidium pusillum*

NDEX TO TABLE 9. (Contd...)

pecies 23 *Amphiroa fragilissima*

pecies 24 *Jania rubens*

pecies 25 *Grateloupia filicina*

pecies 26 *G. lithophila*

pecies 27 *Hypnea valentiae*

pecies 28 *Gracilaria corticata*

pecies 29 *Gelidiopsis variabilis*

pecies 30 *Centroceras clavulatum*

pecies 31 *Spyridea filamentosa*

pecies 32 *Laurencia* sp.

pecies 33 *Acanthophora spicifera*

denotes that the species was available in traces only and hence, density could not be estimated.

denotes that the species was not available during that month.

At Mullur, Ulva fasciata showed the highest density (690.63 gm/m^2). Other seaweeds that showed very high densities were Sargassum wightii, Gracilaria corticata and Spyridea filamentosa. Ulva lactuca, Chaetomorpha antennina, Caulerpa peltata, Chnoospora minima and Centroceras clavulatum showed high densities. Bryopsis plumosa, Caulerpa racemosa, Valoniopsis pachynema, Padina gymnospora, P. tetrastromatica, Porphyra kanyakumariensis, Grateloupia filicina, G. lithophila, Hypnea valentiae, Gelidiopsis variabilis and Laurencia sp. showed fairly high densities. Species that showed low densities at Mullur were Enteromorpha compressa, Cladophora glomerata, C. fascicularis, Cladophora sp., Caulerpa scalpelliformis, C. sertularioides Sargassum tenerrimum, Achrochaetium sp., Amphiroa fragilissima and Jania rubens.

Table 10. Seasonal density of different divisions of seaweeds at Mullur.

Algal Division	Average seasonal density gm/m^2		
	Pre monsoon	Monsoon	Post monsoon
Green Algae	1026.25	2090	1343.75
Brown Algae	1203.13	377.50	1218.75
Red Algae	1815	1301.88	1537.50
Seasonal seaweed density	4044.38	3769.38	4100

'rom Table 10 we can draw the following conclusions:

At Mullur,

1. Green algal density was highest during monsoon followed by post monsoon and a comparatively low density was recorded during pre monsoon.
2. Brown algal density was high during both pre and post monsoon but comparatively low during monsoon.
3. Red algal density was highest during pre monsoon followed by post monsoon and comparatively low during monsoon.
4. During pre monsoon and post monsoon red algae showed the highest density.
5. During monsoon, green algae showed the highest density.
6. Both brown and red algae showed a reduction in their densities during monsoon.
7. Algal density was maximum during post monsoon followed by pre monsoon and monsoon.

ble 11. Seasonal density of some seaweeds from Mullur

Names of seaweeds	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Ulva fasciata	406.25	1196.88	468.75
U. lactuca	153.13	121.25	268.75
Chaetomorpha antennina	95	205.00	300
Caulerpa peltata	221.88	343.75	281.25
Chnoospora minima	118.75	125	271.88
Padina gymnospora	321.88	21.25	59.38
Sargassum wightii	693.75	231.25	718.75
Gracilaria corticata	562.50	497.50	475
Centroceras clavulatum	228.13	149.38	250
Spyridea filamentosa	762.50	243.75	393.75
Hypnéa valentiae	137.50	112.50	168.75
Porphyra kanyakumariensis	0	193.75	9.38
Grateloupia lithophila	43.75	0	112.50
Laurencia sp.	27.50	0	34.38

4.5.2 **Density of seaweeds at Varkala**

Table.12 Density of seaweeds at Varkala (gm/m^2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total Density/month
Feb. 88	350	-	-	500	50	-	-	-	-	-	-	-	-	•	-	300	-	300	650	250	100	-	2500
Mar. 88	-	300	-	500	-	-	-	-	-	-	-	-	-	-	-	400	-	-	-	-	-	-	1200
Apr. 88	150	150	-	350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	850
May 88	-	-	-	800	-	-	-	-	-	-	-	-	-	•	-	400	-	-	-	-	-	-	1200
June 88	-	-	-	600	-	-	-	-	-	-	-	-	-	-	100	-	-	-	100	-	-	-	800
July 88	1000	4000	-	400	-	-	-	-	-	-	-	1600	•	-	-	-	-	-	•	-	-	-	7000
Aug. 88	1000	800	200	600	-	-	200	-	-	-	-	200	•	-	-	-	-	-	-	-	-	200	3200
Sep. 88	600	800	800	600	-	-	-	-	-	20	-	-	•	-	-	40	-	-	-	20	-	20	2900
Oct. 88	400	600	320	200	-	-	800	-	-	•	-	-	-	-	-	•	-	-	-	-	-	-	2320
Nov. 88	-	900	800	-	-	-	-	-	-	800	-	-	-	-	-	-	-	-	-	-	-	600	3100
Dec. 88	-	900	-	80	-	-	-	-	CA	•	-	-	-	-	-	400	-	-	-	-	-	600	1980
Jan. 89	-	1500	-	500	-	350	-	-	CA	3000	CA	-	-	-	-	600	-	•	-	-	-	350	6300
Feb. 89	-	300	100	150	-	-	-	•	-	300	-	-	-	-	100	550	-	250	250	-	-	250	2250
Mar. 89	150	300	75	250	-	-	-	-	-	-	-	-	-	-	-	175	50	-	-	-	-	-	1000
Apr. 89	-	-	-	300	-	-	-	-	CA	-	-	-	-	-	-	300	-	-	-	-	-	-	600
May. 89	500	-	•	500	-	-	-	-	-	-	-	-	-	-	-	500	-	-	-	-	-	•	1500
June. 89	-	350	-	350	-	-	•	-	-	-	-	500	-	-	-	75	-	-	75	-	-	100	1450
July. 89	500	-	-	350	-	-	-	-	-	-	-	500	-	-	-	-	-	-	-	-	-	-	1350
Aug. 89	150	150	50	75	-	-	-	-	-	-	-	75	-	-	-	-	-	-	-	-	-	-	500
Sep. 89	200	200	-	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	475
Oct. 89	250	250	-	75	-	-	-	-	-	-	-	-	-	-	-	•	-	-	-	-	-	-	575
Nov. 89	-	900	800	-	-	-	-	-	-	300	-	-	-	-	-	-	-	-	-	-	-	500	2500
Dec. 89	-	800	-	40	-	-	-	-	-	-	-	-	-	-	-	300	-	-	-	-	-	500	1640
Jan. 90	-	800	-	300	-	-	-	-	-	150	-	-	-	-	-	350	-	-	-	-	-	350	1950
Average monthly density of each species.	218.75	583.33	131.04	316.46	2.08	14.58	41.66	•	CA	190.42	CA	119.79	•	•	8.33	182.92	2.08	22.92	44.79	11.25	4.16	152.92	2047.50

INDEX TO TABLE 12

Species 1	Ulva fasciata
Species 2	U. lactuca
Species 3	Enteromorpha compressa
Species 4	Chaetomorpha antennina
Species 5	Cladophora sp.
Species 6	Valoniopsis pachynema
Species 7	Chnoospora minima
Species 8	Dictyota dichotoma
Species 9	Sargassum tenerrimum
Species 10	S. wightii
Species 11	Turbinaria conoides
Species 12	Porphyra kanyakumariensis
Species 13	Achrochaetium sp.
Species 14	Jania rubens
Species 15	Grateloupia filicina
Species 16	G. lithophila
Species 17	Hypnea musciformis
Species 18	H. valentiae
Species 19	Gracilaria corticata
Species 20	G. foliifera
Species 21	Gelidiopsis variabilis
Species 22	Centroceras clavulatum

INDEX TO TABLE 12. (Contd...)

* denotes that the species was available in traces only and hence, density could not be estimated.

- denotes that the species was not available during that month.

CA denotes that the species was collected as cast ashore weed and hence the quantity could not be estimated.

<u>Ulva lactuca</u> recorded the highest monthly density of 583.33 gm/m^2 at Varkala. <u>Ulva fasciata</u>, <u>Chaetomorpha antennina</u>, <u>Sargassum wightii</u>, <u>Grateloupia lithophila</u> and <u>Centroceras clavulatum</u> showed high densities. <u>Enteromorpha compressa</u>, <u>Porphyra kanyakumariensis</u>, <u>Chnoospora minima</u>, <u>Gracilaria corticata</u> and <u>Hypnea valentiae</u> showed fairly high densities. <u>Cladophora</u> sp., <u>Valoniopsis pachynema</u>, <u>Dictyota dichotoma</u>, <u>Achrochaetium</u> sp., <u>Jania rubens</u>, <u>Grateloupia filicina</u>, <u>Hypnea musciformis</u>, <u>Gracilaria foliifera</u> and <u>Gelidiopsis variabilis</u> showed low monthly densities. <u>Sargassum tenerrimum</u> and <u>Turbinaria conoides</u> were collected as cast ashore weeds.

Table 13. Seasonal density of different divisions of seaweeds at Varkala

Algal Division	Average seasonal density gm/m^2		
	Pre monsoon	Monsoon	Post monsoon
Green Algae	928.13	1546.88	1323.75
Brown Algae	431.25	25	240
Red Algae	721.88	553.13	372.50
Seasonal seaweed density	2081.25	2125.01	1936.25

From Table 13 we can draw the following conclusions:

At Varkala,

1. Green algal density was highest during monsoon, followed by post monsoon. Pre monsoon recorded comparatively low density of green algae.

2. Brown algal density was maximum during pre monsoon followed by post monsoon. During monsoon brown algal density was very low.

3. Red algal density was high both during pre monsoon and monsoon but comparatively low during post monsoon.

4. During all the seasons green algae showed the highest density.

5. Monsoon season recorded the maximum seaweed density followed by pre monsoon.

Table 14. Seasonal density of some seaweeds at Varkala

Names of seaweeds	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Ulva fasciata	81.25	393.75	181.25
U. lactuca	418.75	662.50	668.75
Enteromorpha compressa	21.88	31.25	340
Chaetomorpha antennina	356.25	459.38	133.75
Centroceras clavulatum	143.75	37.50	277.50
Porphyra kanyakumariensis	0	359.38	0

4.5.3. Density of seaweeds at Elathur

Table.15 Density of seaweeds at Elathur (gm/m^2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total Density / month
Feb. 88	75	50	-	100	-	-	100	50	-	-	-	50	-	-	150	250	250	-	-	150	100	1325
Mar. 88	-	-	-	500	-	-	-	-	-	-	-	-	-	-	-	475	600	-	-	-	-	1575
Apr. 88	-	-	-	1600	-	-	-	-	-	-	-	-	-	-	1000	1000	1000	-	-	-	400	5000
May 88	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	800	-	-	-	-	900
Jun. 88	-	-	-	-	-	-	-	-	-	-	-	400	•	-	-	-	1000	-	-	-	-	1400
Jul. 88	-	-	50	150	-	-	-	-	-	•	-	-	-	-	-	150	250	-	-	-	100	700
Aug. 88	•	200	800	1000	-	-	-	-	-	75	•	-	-	•	-	1000	-	-	-	-	•	3075
Sep. 88	-	100	800	1200	-	20	-	-	-	-	•	-	-	-	1400	1400	100	-	-	-	20	5040
Oct. 88	•	•	-	400	400	-	-	-	-	-	-	-	-	-	•	•	•	-	-	-	-	800
Nov. 88	-	2000	-	•	-	-	-	-	-	-	-	1200	-	-	-	-	2000	-	400	-	-	5600
Dec. 88	1000	1000	-	-	-	-	-	-	-	-	-	•	-	-	-	-	1000	•	-	-	-	3000
Jan. 89	-	•	•	-	-	-	300	•	-	-	-	-	-	-	-	-	-	-	150	-	250	700
Feb. 89	400	-	-	-	-	-	600	-	250	-	-	200	-	-	-	250	400	-	250	-	250	2600
Mar. 89	60	-	-	-	-	-	600	-	-	-	-	-	-	-	-	80	200	-	•	-	45	985
Apr. 89	-	•	-	200	-	-	-	-	-	-	-	-	-	-	-	100	250	-	200	200	-	950
May. 89	-	•	-	350	•	-	150	-	-	-	-	•	-	-	150	250	500	-	-	75	150	1625
Jun. 89	-	-	-	150	-	-	-	-	-	-	-	-	-	-	150	-	250	-	-	-	100	650
Jul. 89	-	450	475	175	-	-	-	-	-	-	-	•	-	-	-	250	400	-	-	-	100	1850
Aug. 89	150	50	150	100	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	50	600
Sep. 89	300	•	-	300	-	-	-	-	-	-	-	•	-	-	150	150	250	-	-	--	100	1250
Oct. 89	•	•	-	250	100	-	-	-	-	-	-	-	-	-	•	•	-	-	-	-	-	350
Nov. 89	-	500	-	-	-	-	-	-	-	-	-	150	-	-	-	-	500	-	150	-	-	1300
Dec. 89	500	500	-	-	-	-	-	-	-	-	-	50	-	-	-	-	500	-	-	-	-	1550
Jan. 90	50	150	-	75	-	-	150	-	-	-	-	-	-	-	100	250	250	-	-	50	75	1150
Average monthly density of each species	105.63	208.33	94.79	272.92	20.83	0.83	79.17	2.08	10.42	3.13	•	85.58	•	•	129.17	237.71	437.50	•	47.92	19.79	72.50	1832.29

INDEX TO TABLE 15

Species 1	*Ulva fasciata*
Species 2	*U. lactuca*
Species 3	*Enteromorpha intestinalis*
Species 4	*Chaetomorpha antennina*
Species 5	*Cladophora fascicularis*
Species 6	*Cladophora* sp.
Species 7	*Caulerpa sertularioides*
Species 8	*Padina gymnospora*
Species 9	*P. tetrastromatica*
Species 10	*Porphyra kanyakumariensis*
Species 11	*Achrochaetium* sp.
Species 12	*Gelidium pusillum*
Species 13	*Jania rubens*
Species 14	*Grateloupia comoronii*
Species 15	*G. filicina*
Species 16	*G. lithophila*
Species 17	*Gracilaria corticata*
Species 18	*G. foliifera*
Species 19	*Gelidiopsis variabilis*
Species 20	*Gigartina acicularis*
Species 21	*Centroceras clavulatum*

* denotes that the species was available in traces only and hence the density could not be estimated.

- denotes that the species was not available during that month.

At Elathur, Gracilaria corticata recorded the highest monthly density of 437.50 gm/m^2. Ulva lactuca, Chaetomorpha antennina and Grateloupia lithophila also recorded high monthly densities. Ulva fasciata, Enteromorpha intestinalis, Cladophora fascicularis, Caulerpa sertularioides, Gelidium pusillum, Grateloupia filicina, G. lithophila, Gelidiopsis variabilis and Centroceras clavulatum recorded fairly high monthly densities. Cladophora sp., Padina tetrastromatica, P. gymnospora, Porphyra kanyakumariensis and Gigartina acicularis recorded low monthly densities.

Table 16. Seasonal density of different divisions of seaweeds at Elathur

Algal Division	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Green Algae	626.25	550	1171.25
Brown Algae	37.50	0	0
Red Algae	1121.88	800	1190
Seasonal seaweed density	1785.63	1350	2361.25

From Table 16 we can draw the following conclusions:

At Elathur,

1. Green algal density was maximum during post monsoon. Pre monsoon and monsoon recorded a comparatively low density of green algae.

Brown algae were observed only during pre monsoon.

Red algal density was high both during pre and post monsoon but comparatively low during monsoon.

Algal density was highest during post monsoon followed by pre monsoon. Monsoon recorded a comparatively low algal density.

During all the seasons, red algae showed the highest density.

Table 17. Seasonal density of some seaweeds at Elathur

Names of seaweeds	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Ulva fasciata	73.13	18.75	225
U. lactuca	25	87.50	512.50
Chaetomorpha antennina	309.38	240.63	268.75
Caulerpa sertularioides	218.75	18.75	0
Gelidium pusillum	31.25	62.50	175
Grateloupia filicina	156. 25	37.50	193.75
G. lithophila	300.63	218.75	193.75
Gracilaria corticata	368.75	400	543.75
Centroceras clavulatum	140	62.50	15

4.5.4. Density of seaweeds at Thikkotti

Table.:8 Density of seaweeds at Thikkotti (gm/m^2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total Density/Month
Feb. 88	-	-	-	-	-	75	-	-	-	-	200	-	-	-	-	-	-	-	250	-	-	-	-	200	-	725
Mar. 88	-	55	-	-	-	-	-	-	-	-	300	-	-	-	-	-	-	-	400	-	-	-	-	150	-	905
Apr. 88	-	200	-	-	-	-	800	-	-	-	400	-	-	-	-	-	-	40	-	-	-	-	-	-	-	1440
May 88	-	-	-	150	-	-	-	-	-	-	250	-	•	-	•	-	-	-	-	-	-	-	-	250	-	650
Jun. 88	-	-	-	200	-	-	-	-	-	-	1000	-	40	40	-	-	-	-	-	-	-	-	-	1400	-	2680
July 88	-	20	-	200	-	-	20	20	-	-	-	-	-	20	-	-	-	-	-	-	-	200	-	20	-	500
Aug. 88	50	50	200	250	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	570
Sep. 88	100	100	-	50	-	-	-	-	-	-	-	-	-	150	-	-	-	-	100	-	-	-	-	-	-	500
Oct. 88	400	400	-	200	-	-	-	-	•	-	-	-	-	-	-	-	-	-	400	-	-	-	-	-	•	1400
Nov. 88	-	-	-	-	-	-	-	60	-	-	1000	60	-	2000	-	160	-	-	2000	-	1000	-	600	800	-	7680
Dec. 88	-	-	-	-	-	1000	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	800	-	1900
Jan. 89	-	-	-	-	-	150	-	-	-	200	500	-	-	-	-	-	-	-	250	•	150	-	-	-	-	1250
Feb. 89	-	-	-	-	-	75	-	-	-	-	250	-	-	-	-	-	-	•	200	-	-	500	-	300	-	1325
Mar. 89	-	•	-	-	-	200	-	-	-	50	150	-	-	•	-	-	-	-	150	-	•	•	-	350	-	900
Apr. 89	-	-	-	-	-	500	-	-	-	-	350	-	-	-	-	-	-	-	500	-	•	•	-	600	-	1950
May 89	-	-	•	-	75	500	-	-	-	550	550	-	-	300	-	-	-	-	500	-	75	500	-	500	-	3550
Jun. 89	-	-	-	-	75	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75	75	-	75	-	450
Jul. 89	-	-	-	-	350	500	-	-	-	-	-	-	-	120	-	-	-	-	-	-	-	400	-	300	-	1670
Aug. 89	100	-	-	-	250	-	-	-	-	-	-	-	-	100	-	-	-	-	•	-	-	•	-	300	-	750
Sep. 89	250	250	-	-	-	-	100	-	-	-	-	-	-	-	-	-	•	-	-	-	-	-	-	100	-	700
Oct. 89	200	200	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-	550
Nov. 89	-	-	-	-	-	-	-	-	-	-	100	-	-	75	-	-	75	-	100	-	-	-	-	50	-	400
Dec. 89	-	-	-	-	-	250	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	150	-	500
Jan. 90	-	-	-	-	-	250	-	-	-	200	250	-	-	-	-	-	-	-	150	-	-	-	-	-	-	850
Average monthly density of each species	45.83	53.13	8.33	43.75	31.25	152.08	42.50	3.33	•	41.66	229.17	2.50	1.67	116.88	•	6.67	3.96	1.67	208.33	•	54.17	69.79	25.00	266.46	•	1408.13

INDEX TO TABLE 18

Species 1 Ulva fasciata

Species 2 U. lactuca

Species 3 Enteromorpha intestinalis

Species 4 Chaetomorpha antennina

Species 5 Spongomorpha indica

Species 6 Cladophora glomerata

Species 7 Cladophora sp.

Species 8 Cladophoropsis zollingeri

Species 9 Bryopsis plumosa

Species 10 Caulerpa scalpelliformis

Species 11 C. sertularioides

Species 12 Boodlea composita

Species 13 Valoniopsis pachynema

Species 14 Gelidium pusillum

Species 15 Jania rubens

Species 16 Grateloupia comoronii

Species 17 G. lithophila

Species 18 Hypnea valentiae

Species 19 Gracilaria corticata

Species 20 G. foliifera

Species 21 Gelidiopsis variabilis

Species 22 Gigartina acicularis

INDEX TO TABLE 18 (Contd...)

Species 23 Champia indica

Species 24 Centroceras clavulatum

Species 25 Bostrychia tenella

* denotes that the species was available only in traces and hence the density could not be estimated.

- denotes that the species was not available during that month.

At Thikkotti, 12 species of seaweeds, 3 belonging to green algae, 4 belonging to brown algae and 5 to red algae were collected as cast ashore weeds and hence their densities could not be estimated.

Table 19. Cast ashore weeds and their months of occurrence at Thikkotti.

Names of seaweeds	Months of occurrence
Chaetomorpha linum	January and February
Caulerpa fastigiata	January, February and July
C. peltata	January and May
Dictyota dichotoma	November and March
Padina tetrastromatica	November and March
Spathoglossum asperum	November and March
Turbinaria ornata	February and April
Hypnea musciformis	November and December
Hypnea sp.	January and March
Ceramium rubrum	November
Laurencia sp.	February and March
Acanthophora spicifera	January - May, September, November

At Thikkotti, Centroceras clavulatum recorded the highest density of 266.46 gm/m^2. Cladophora glomerata, Caulerpa sertularoides and Gracilaria corticata also showed high monthly densities. Ulva fasciata, U. lactuca, Chaetomorpha antennina, Spongomorpha indica, Cladophora sp., Caulerpa scalpelliformis, Gelidium pusillum, Gelidiopsis variabilis, Gigartina acicularis and Champia indica showed fairly high monthly densities.

Table 20. Seasonal density of different divisions of seaweeds from Thikkotti.

Algal Division	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Green Algae	644.38	693.75	627.50
Red Algae	523.75	658.75	1076.25
Seasonal seaweed density	1168.13	1352. 50	1703.75

From Table 20 we can draw the following conclusions:

At Thikkotti,

1. Green algal density was highest during monsoon followed by pre monsoon and post monsoon.

2. Red algal density was highest during post monsoon. Monsoon and pre monsoon recorded comparatively low densities.

3. During pre monsoon and monsoon green algae showed higher density than red algae.

4. During post monsoon red algae showed higher density than green algae.

5. Algal density was highest during post monsoon followed by monsoon. Pre monsoon recorded the lowest algal density.

Table 21. Seasonal density of some seaweeds at Thikkotti

Names of seaweeds	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Ulva fasciata	0	18.75	118.75
U. lactuca	31.88	8.75	118.75
Chaetomorpha antennina	0	100	31.25
Cladophora glomerata	156.25	143.75	156.25
Caulerpa sertularioides	300	225	162.50
Gelidium pusillum	0	72.50	278.13
Gracilaria corticata	237. 50	62.50	325
Gigartina acicularis	62.50	146.88	0
Centroceras clavulatum	200	355.63	243.75

4.5.5. Density of seaweeds at Saudi

Table.22 Density of seaweeds at Saudi (gm/m^2)

	1	2	3	4	5	6	7	8	9	Total density/month
Jan. 88	-	-	1000	-	-	-	350	350	20	1720
Feb. 88	-	-	600	-	-	-	450	450	150	1650
Mar. 88	200	-	600	-	-	-	300	250	100	1450
Apr. 88	-	-	1000	-	-	-	-	-	300	1300
Mar 88	200	-	800	-	-	-	400	-	400	1800
Jun. 88	900	800	1000	-	•	-	-	-	-	2700
Jul. 88	600	-	400	-	•	-	-	-	-	1000
Aug. 88	800	•	1000	•	•	-	800	-	20	2620
Sep. 88	800	-	100	-	-	-	1000	-	-	1900
Oct. 88	600	-	1000	-	-	600	2000	-	1000	5200
Nov. 88	-	-	700	-	-	-	480	-	-	1180
Dec. 88	-	-	1000	-	-	-	705	-	600	2305
Jan. 89	-	-	1000	-	-	-	•	-	500	1500
Feb. 89	-	-	500	-	-	-	500	-	250	1250
Mar. 89	25	-	500	-	-	-	50	-	400	975
Apr. 89	300	-	400	-	-	-	-	-	50	750
May. 89	250	-	200	-	-	-	•	-	100	550
Jun. 89	250	-	200	-	-	-	•	-	100	550
Jul. 89	75	-	•	-	-	-	250	-	175	500
Aug. 89	175	-	350	-	-	-	-	-	175	700
Sep. 89	100	-	150	-	-	-	-	100	100	450
Oct. 89	•	-	125	-	-	-	-	150	150	425
Nov. 89	•	-	125	-	-	-	-	150	150	425
Dec. 89	50	-	125	-	-	-	-	125	100	400
Average density of each species	221.88	33.33	536.46	•	•	25.00	303.54	65.63	201.67	1387.50

INDEX TO TABLE 22

Species 1 Enteromorpha compressa

Species 2 E. flexuosa

Species 3 Chaetomorpha antennina

Species 4 Bryopsis plumosa

Species 5 Achrochaetium sp.

Species 6 Jania rubens

Species 7 Grateloupia filicina

Species 8 G. lithophila

Species 9 Centroceras clavulatum

* denotes that the species was available only in traces and hence the density could not be estimated.

- denotes that the species was not available during that month.

At Saudi, Chaetomorpha antennina recorded the highest monthly density of 536.46 gm/m^2. Enteromorpha compressa, Grateloupia filicina and Centroceras clavulatum recorded high monthly densities. Enteromorpha flexuosa, Jania rubens and Grateloupia lithophila recorded fairly high densities. Bryopsis plumosa and Acrochaetium sp. were found only in traces.

Table 23. Seasonal density of different divisions of seaweeds at Saudi

Algal Division	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Green Algae	765.63	1000	609.38
Red Algae	558.75	302.50	926.25
Seasonal seaweed density	1324.38	1302.50	1535.63

From Table 23 we can draw the following conclusions:

At Saudi,

1. Green algal density was maximum during monsoon followed by pre and post monsoons.

2. Red algal density was maximum during post monsoon followed by pre monsoon. During monsoon the density was comparatively low.

3. During both pre monsoon and monsoon green algal density was more than that of red algae.

During post monsoon red algal density was more than that of green algae.

Algal density was maximum during post monsoon followed by pre monsoon and monsoon.

Table 24. Seasonal density of some seaweeds at Saudi

Names of seaweeds	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Enteromorpha compressa	65.63	406.25	193.75
Chaetomorpha antennina	700	493.75	415.63
Grateloupia filicina	206.25	181.25	523.13
G. lithophila	131.25	12.50	68.75
Centroceras clavulatum	221.25	121.25	262.50

Table 25. Seasonal density of different algal divisions along Kerala coast

Algal division	Average seasonal density (gm/m^2)		
	Pre monsoon	Monsoon	Post monsoon
Green Algae	798.13	1176.13	1015.13
Brown Algae	334. 38	80.50	291.75
Red Algae	948.25	723.25	1020.50
Seasonal seaweed density	2080.76	1979.88	2327.38

From Table 25 we can draw the following conclusions:

Along Kerala coast,

1. Green algal density was highest during monsoon.
2. Brown algal density was highest during pre monsoon.
3. Red algal density was highest during post monsoon.
4. Among seasons, post monsoon recorded the highest density.

4.6 FREQUENCY OF OCCURRENCE OF SEAWEEDS ALONG THE KERALA COAST

It was observed that the frequency of occurrence of each species of seaweed (number of months during which a particular species was observed) fell in one of the three classes described below:

Species showing very high frequency of occurrence (taken as those species that occurred for 15 months or more, in the present study).

Species showing high frequency of occurrence (taken as those species that occurred for 8 months or more but less than 15 months in the present study.

Species showing low frequency of occurrence (taken as those species that occurred for less than 8 months in the present study.

Based on the above described scheme, the seaweed species showing very high, high and low frequencies of occurrence along the different zones of Kerala coast are represented in Tables 26-28.

4.6.1 Seaweed species showing very high frequency of occurrence along Kerala coast.

Table 26. Seaweed species showing very high frequency of occurrence along Kerala coast.

North zone	Central zone	South zone
Chlorophyta	Chlorophyta	Chlorophyta
Ulva lactuca	Chaetomorpha antennina	Ulva fasciata
Chaetomorpha antennina	Enteromorpha compressa	U. lactuca
Caulerpa sertularioides		Chaetomorpha antennina
		Caulerpa peltata
Rhodophyta	Rhodophyta	Phaeophyta
Gelidium pusillum	Grateloupia filicina	Chnoospora minima
Grateloupia lithophila	Centroceras clavulatum	Sargassum wightii
Gracilaria corticata		
Centroceras clavulatum		
		Rhodophyta
		Grateloupia lithophila
		Hypnea valentiae
		Gracilaria corticata
		Centroceras clavulatum
		Spyridea filamentosa

More number of algal species showing very high frequency of occurrence were met with in South zone followed by North and Central zones. Phaeophycean algae showing very high frequency of occurrence were met with only in the South zone. *Chaetomorpha antennina* and *Centroceras clavulatum* showed very high frequency of occurrence in all the three zones.

4.6.2. Seaweed species showing high frequency of occurrence along Kerala coast.

Table 27. Seaweed species showing high frequency of occurrence along Kerala coast.

North zone	South zone
Chlorophyta	Chlorophyta
Ulva fasciata	*Enteromorpha compressa*
Cladophora glomerata	*Bryopsis plumosa*
Phaeophyta	Phaeophyta
Dictyota dichotoma	*Padina gymnospora*
Rhodophyta	
Grateloupia filicina	
Gelidiopsis variabilis	
Gigartina acicularis	
Acanthophora spicifera	

No seaweed species from Central zone was observed in this category. Maximum number of seaweeds of this category was observed from North zone. This included members of Chlorophyceae, Phaeophyceae and Rhodophyceae. In the South zone no Rhodophycean algae belonging to this category was observed.

4.6.3 Seaweed species showing low frequency of occurrence along Kerala coast

Table 28. Seaweed species showing low frequency of occurrence along Kerala coast

North zone	Central zone	South zone
Chlorophyta	Chlorophyta	Chlorophyta
Enteromorpha intestinalis	*Enteromorpha flexuosa*	*Cladophora glomerata*
Chaetomorpha linum	*Bryopsis plumosa*	*C. fascicularis*
Spongomorpha indica		*Cladophora* sp.
Cladophora fascicularis		*Caulerpa racemosa*
Cladophora sp.		*C. scalpelliformis*
Cladophoropsis zollingeri		*C. sertularioides*
Bryopsis plumosa		*Valoniopsis pachynema*
Caulerpa fastigiata		
C. scalpelliformis		
C. peltata		
Boodlea composita		
Valoniopsis pachynema		
Phaeophyta	Rhodophyta	Phaeophyta
Padina gymnospora	*Acrochaetium* sp.	*Dictyota bartayresiana*
P. tetrastromatica	*Jania rubens*	*D. dichotoma*
Spathoglossum asperum	*Grateloupia lithophila*	*Padina tetrastromatica*

Table 28 (Contd....)

North zone	Central zone	South zone
Phaeophyta		Pheophyta
Turbinaria ornata		Sargassum tenerrimum
		Turbinaria conoides
Rhodophyta		Rhodophyta
Porphyra kanyakumariensis		Porphyra kanyakumariensis
Achrochaetium sp.		Achrochaetium sp.
Jania rubens		Gelidium pusillum
Grateloupia comoronii		Amphiroa fragilissima
Hypnea musciformis		Jania rubens
H. valentiae		Grateloupia filicina
Hypnea sp.		Hypnea musciformis
Gracilaria foliifera		Gracilaria foliifera
Ceramium rubrum		Gelidiopsis variabilis
Bostrychia tenella		Laurencia sp.
Laurencia sp.		Acanthophora spicifera
Champia indica		

4.7 STANDING CROP OF SEAWEEDS ALONG KERALA COAST

Standing crop of seaweeds in different stations fixed along the Kerala coast was estimated in the present study.

Standing crop of seaweeds at Mullur = 3971.25 gm/m^2 (wet weight)

Standing crop of seaweeds at Varkala = 2047.50 gm/m^2 (wet weight)

Standing crop of seaweeds at Elathur = 1832.29 gm/m^2 (wet weight)

Standing crop of seaweeds at Thikkotti = 1408.13 gm/m^2 (wet weight)

Standing crop of seaweeds at Saudi = 1387.50 gm/m^2 (wet weight)

Average standing crop of seaweeds along Kerala coast based on 5 stations studied = 2129.33 gm/m^2 (wet weight)

4.7.1 Standing crop of economically important seaweeds along Kerala coast.

Table 29. Standing crop of Agarophytes along Kerala coast (gm/m^2)

Places of collection	Agarophytes		
	Gracilaria corticata	G. foliifera	Gelidium pusillum
Mullur	511.66	-	19.16
Varkala	44.79	11.25	-
Elathur	437.5	Traces	89.58
Thikkotti	208.3	Traces	116.88
Saudi	-	-	-
Average	240.45	2.25	45.13

- denotes that the species was not available at the station.

Table 30. Standing crop of Agaroidophytes along Kerala coast (gm/m^2)

Places of collection	Agaroidophytes				
	Hypnea valentiae	*H. musciformis*	*Spyridea filamentosa*	*Laurencia* sp.	*Gigartina acicularis*
Mullur	139.58	-	466.66	20.62	-
Varkala	22.90	2.08	-	-	-
Elathur	-	-	-	-	19.79
Thikkotti	1.66	CA	-	CA	69.79
Saudi	-	-	-	-	-
Average	32.83	0.48	93.33	4.12	17.92

\- denotes that the species was not available at the station.

CA - denotes that the species was obtained as cast ashore weed.

Table 31. Standing crop of Alginophytes along Kerala coast (gm/m^2)

Place of collection	*D. bartayresiana*	*Padina gymnospora*	*P. tetrastromatica*	*Sargassum wightii*
Mullur	18.75	134.16	60.40	547.90
Varkala	-	-	-	190.40
Elathur	-	2.08	10.40	-
Thikkotti	-	-	CA	-
Saudi	-	-	-	-
Average	3.75	27.25	14. 16	147.66

- denotes that the species was not available at the station.

CA - denotes that the species was obtained as cast ashore weed.

Table 32. Standing crop of edible seaweed *Porphyra kanyakumariensis* along Kerala coast (gm/m^2)

Place of collection	Standing crop
Mullur	67.70
Varkala	119.79
Elathur	3.13
Thikkotti	-
Saudi	-
Average	38.12

Standing crop of agarophytes = 287.83 gm/m^2

Standing crop of agaroidophytes = 148.62 gm/m^2

Standing crop of alginophytes = 192.82 gm/m^2

Agarophytes constitutes 13.5%, agaroidophytes 6.98% and alginophytes 9.06% of the seaweed standing crop of Kerala. Thus 29.53% of the seaweed standing crop of Kerala is constituted by commercially important seaweeds.

4.8 ENVIRONMENTAL FEATURES OF KERALA COAST

4.8.1 Environmental data recorded at the various stations

Table 33. Environmental data recorded at Mullur

Year	Months	Temperature AT	Temperature SWT	Dissolved Oxygen ml/l	Salinity ppt	Phosphate µgat/l	Nitrate µgat/l	Silicate µgat/l
	Feb.	29.00	30.00	3.60	30.00	1.00	0.50	0.20
	Mar.	31.00	30.00	4.90	35.00	0.90	0.50	0.10
	Apr.	32.00	31.00	4.60	30.00	1.07	0.60	0.20
	May	32.00	30.50	5.00	31.00	1.00	1.30	0.15
	Jun.	30.00	26.00	4.60	34.20	1.08	1.50	0.75
1988	Jul.	27.00	25.00	5.00	34.20	1.08	2.85	1.60
	Aug.	29.50	27.00	5.00	35.00	0.36	0.90	0.05
	Sep.	28.00	27.00	4.00	33.20	3.24	2.70	0.06
	Oct.	28.00	29.00	4.30	35.40	0	1.20	0.07
	Nov.	33.20	30.00	4.90	33.00	0	2.85	0.05
	Dec.	26.00	28.00	7.60	33.00	0	0.75	0.05
	Jan.	30.00	29.00	6.13	33.40	0	0.15	0.20
	Feb.	35.00	30.00	7.10	34.00	0.72	1.20	0.25
	Mar.	28.00	28.00	7.70	34.00	1.55	0.60	0.08
	Apr.	28.00	28.00	3.60	34.70	2.25	0.90	0.17
	May	27.00	25.00	6.80	32.20	1.00	1.20	0.11
	Jun.	27.00	26.00	6.90	31.50	1.40	1.30	0.08
1989	Jul.	27.00	23.00	4.00	34.00	1.40	2.00	0.07
	Aug.	27.00	23.00	4.30	34.00	3.20	0.80	0.17
	Sept.	29.00	28.00	4.80	32.00	2.80	2.40	0.08
	Oct.	28.00	27.00	4.90	32.00	0	1.00	0.03
	Nov.	30.00	30.00	5.00	31.50	0	2.00	0.04
	Dec.	29.00	28.00	6.50	32.00	0	0.80	0.07
1990	Jan.	30.00	29.00	6.00	32.50	0.90	0.20	0.20
Mean		29.19	27.80	5.30	32.99	1.04	1.26	0.20

Table 34. Environmental data recorded at Varkala

Year	Months	Temperature AT	Temperature SWT	Dissolved Oxygen ml/l	Salinity ppt	Phosphate µgat/l	Nitrate µgat/l	Silicate µgat/l
	Feb.	29.50	30.80	3.50	35.00	0.90	0.90	0.10
	Mar.	32.50	31.00	4.90	35.00	1.20	1.10	0.05
	Apr.	31.00	31.00	4.40	30.00	1.26	2.20	0.25
	May	33.50	30.50	4.00	32.00	1.00	2.20	0.25
	Jun.	32.00	31.50	5.00	34.40	0.90	1.65	1.15
1988	Jul.	27.00	26.00	5.00	34.20	1.26	3.30	2.00
	Aug.	28.00	28.50	5.00	34.60	0.36	0.60	0.05
	Sep.	29.00	27.00	4.00	34.00	1.08	4.80	0.06
	Oct.	29.00	29.00	4.38	35.20	0.36	4.50	0.07
	Nov.	30.00	30.00	4.50	33.00	0	1.20	0.07
	Dec.	32.00	30.00	5.90	32.40	0	1.05	0
	Jan.	30.00	29.00	5.90	33.70	0	0.15	0.20
	Feb.	30.00	29.00	6.80	33.50	0	1.05	0
	Mar.	33.00	30.00	4.00	28.00	1.55	1.00	0.10
	Apr.	35.00	31.00	3.49	31.50	2.25	1.90	0.08
	May	30.50	25.00	7.60	30.80	1.00	1.90	0.08
	Jun.	27.00	26.00	7.10	33.00	1.00	1.30	0.11
1989	Jul.	30.00	25.00	3.00	34.00	1.90	4.00	0.11
	Aug.	30.00	25.00	4.30	34.00	2.10	0.80	0.26
	Sep.	29.00	29.00	4.50	33.20	0.50	4.00	0.05
	Oct.	27.00	25.00	5.06	34.00	0.40	4.50	0.06
	Nov.	29.00	29.00	5.00	33.00	0	1.20	0.06
	Dec.	31.00	30.00	5.50	32.50	0	0.80	0
1990	Jan.	31.00	29.00	5.40	33.00	0.10	0.20	0.15
Mean		30.25	28.64	4.93	33.08	0.79	1.93	0.22

ble 35. Environmental data recorded at Elathur

r	Months	Temperature AT	Temperature SWT	Dissolved Oxygen ml/l	Salinity ppt	Phosphate µgat/l	Nitrate µgat/l	Silicate µgat/l
	Feb.	32.00	31.00	4.60	30.00	0.01	1.00	0.50
	Mar.	30.00	31.50	3.00	29.00	1.20	1.20	0.60
	Apr.	31.50	30.00	3.00	30.00	1.07	1.33	1.60
	May	30.00	29.00	3.50	24.00	2.00	2.30	2.00
	Jun.	28.00	28.50	3.50	23.00	1.62	1.20	2.45
3	Jul.	27.00	28.00	3.50	29.00	1.00	2.00	3.00
	Aug.	28.00	27.50	5.20	23.00	3.06	3.30	4.90
	Sep.	30.50	30.00	4.25	29.60	0.72	7.20	0.40
	Oct.	32.00	30.00	3.40	28.80	2.34	3.00	0.20
	Nov.	31.00	30.00	4.25	36.60	2.34	3.30	0.14
	Dec.	31.00	31.00	5.80	33.70	0	1.20	0.10
	Jan.	25.00	29.00	5.00	33.10	1.08	2.10	0.60
	Feb.	32.00	31.50	5.46	34.00	0	1.02	0
	Mar.	31.50	31.00	3.89	27.00	2.25	0.90	0.30
	Apr.	32.00	31.00	3.30	36.00	2.25	1.80	0.30
	May	30.00	29.50	5.50	34.00	2.30	2.20	0.10
	Jun.	27.00	28.00	3.70	27.00	4.60	1.00	0.08
[illegible]	Jul.	23.50	22.50	3.85	21.00	1.00	3.00	0.11
	Aug.	28.00	29.00	4.25	33.00	1.46	2.90	0.44
	Sep.	29.00	29.00	3.70	26.20	2.80	6.70	0.35
	Oct.	30.00	30.00	3.40	29.00	2.20	2.90	0.20
	Nov.	31.00	29.00	4.50	35.00	2.20	3.00	0.10
	Dec.	32.00	31.00	5.40	32.00	0	0.90	0
	Jan.	26.00	28.00	4.90	32.00	1.20	1.00	0.30
[illegible]		29.50	29.38	4.20	29.83	1.61	2.35	0.78

Table 36. Environmental data recorded at Thikkotti

Year	Months	Temperature AT	Temperature SWT	Dissolved Oxygen ml/l	Salinity ppt	Phosphate µgat/l	Nitrate µgat/l	Silicate µgat/l
	Feb.	33.00	32.00	4.50	30.00	3.00	4.20	0.35
	Mar.	29.00	31.00	4.00	30.00	4.80	4.40	0.40
	Apr.	33.00	32.00	4.30	29.00	4.42	2.20	0.40
	May	31.00	31.00	4.00	30.00	4.20	1.90	0.30
	Jun.	27.00	28.00	3.00	33.50	4.80	6.30	1.55
1988	Jul.	26.00	25.00	5.60	28.00	1.98	1.05	1.70
	Aug.	27.00	26.00	4.60	29.00	2.16	4.50	3.90
	Sep.	28.00	27.00	4.60	30.00	1.80	1.50	0.05
	Oct.	29.00	27.50	3.60	34.70	3.42	1.20	0.03
	Nov.	34.00	33.00	5.50	35.50	0.18	4.05	0
	Dec.	32.00	31.50	7.60	34.60	0	4.80	0.10
	Jan.	28.00	29.00	6.70	33.00	1.08	1.50	0.20
	Feb.	33.00	32.00	8.00	35.30	0	3.90	0
	Mar.	31.50	31.00	4.30	29.30	1.55	0.60	0.10
	Apr.	28.00	28.00	4.12	31.50	1.55	1.20	0.19
	May	30.00	28.00	8.00	33.20	1.00	1.50	0.07
	Jun.	25.00	27.00	7.60	30.80	2.80	5.00	0.04
1989	Jul.	25.00	22.50	3.50	30.60	1.40	1.00	0.17
	Aug.	27.00	26.00	4.80	32.90	4.40	3.50	0.50
	Sep.	28.00	28.00	5.86	27.00	1.90	1.30	0.03
	Oct.	29.00	27.50	4.00	30.00	2.16	1.20	0.01
	Nov.	32.00	33.00	5.00	33.00	0.20	3.50	0
	Dec.	32.00	31.50	6.00	33.50	0	4.20	0.10
1990	Jan.	29.00	29.00	5.60	33.00	1.00	1.30	0.30
Mean		29.44	29.02	5.19	31.56	2.08	2.74	0.44

Table 37. Environmental data recorded at Saudi

Year	Months	Temperature AT	Temperature SWT	Dissolved Oxygen ml/l	Salinity ppt	Phosphate µgat/l	Nitrate µgat/l	Silicate µgat/l
	Feb.	30.20	30.00	3.60	31.00	0.40	7.70	0.20
	Mar.	31.00	32.00	3.10	35.00	2.40	2.20	0.20
	Apr.	33.00	31.50	3.40	29.00	2.40	8.80	1.80
	May	33.00	30.00	4.00	33.30	4.50	1.65	1.85
	Jun.	26.50	26.50	4.00	22.00	1.26	7.50	3.60
1988	Jul.	30.00	29.00	5.29	22.00	1.08	1.80	3.70
	Aug.	31.00	29.50	4.79	21.40	1.08	2.55	0.60
	Sep.	30.00	29.00	4.47	20.00	2.88	2.40	0.02
	Oct.	29.00	28.50	4.35	25.00	5.22	3.60	1.75
	Nov.	30.00	29.50	4.30	34.00	0	0	0
	Dec.	34.00	30.00	5.59	33.70	0	1.50	0
	Jan.	30.00	32.00	5.62	33.00	1.54	1.50	0.45
	Feb.	32.00	31.00	6.40	34.40	0	2.70	0.05
	Mar.	33.00	30.50	4.12	30.00	2.25	0	0.19
	Apr.	32.00	31.00	3.49	32.50	3.80	6.50	1.20
	May	33.30	31.00	8.00	26.00	2.90	0.15	0.06
	Jun.	30.00	29.00	5.00	27.00	2.00	6.00	0.44
1989	Jul.	28.00	27.00	3.87	18.00	1.00	1.30	1.75
	Aug.	29.00	28.00	3.80	31.70	1.90	2.00	0.33
	Sep.	33.00	31.00	4.79	17.00	1.90	1.90	0.03
	Oct.	29.00	28.00	4.70	28.00	3.25	3.00	1.50
	Nov.	30.00	30.00	4.50	32.00	0	0	0
	Dec.	33.00	31.00	5.00	33.00	0	1.30	0
1990	Jan.	31.00	30.00	4.80	32.00	1.30	1.20	0.35
Mean		30.88	29.79	4.62	28.38	1.79	2.80	0.84

During the present study, atmospheric temperature and the various hydrological parameters such as surface water temperature, dissolved oxygen content, salinity, and concentration of nutrients like phosphate, nitrate and silicate were studied from all the stations fixed along the Kerala coast, on a monthly basis for a period of two years. The results of this study are represented in Tables 33-37.

4.8.2 Seasonal variation in environmental data recorded at the various stations.

The seasonal variation in each parameter was statistically analysed (analysis of variance 1 way classification or ANOVA-1) to see whether the observed seasonal variation is significant or not. The results of this study from each station are represented in Tables 38- 47.

Table 38. Environmental data recorded at Mullur during the three seasons.

Sl. No.	Parameter studied	Average value for			Remarks
		Pre monsoon	Monsoon	Post monsoon	
1.	Atmospheric temperature	30.37	28.31	28.90	N.S.
2.	Surface water temperature	29.38	25.68	28.37	HI. SIG
3.	Dissolved oxygen	5.45	5.20	5.25	N.S.
4.	Salinity	32.95	33.26	32.76	N.S.
5.	Phosphate content	1.05	1.31	0.75	N.S.
6.	Nitrate content	0.58	1.48	1.71	HI. SIG
7.	Silicate content	0.17	0.37	0.05	N.S.

N.S. - Not Significant ; HI. SIG. - Highly Significant

Table 39. Environmental data recorded at Varkala during the three seasons.

Sl. No.	Parameter studied	Average value for Pre monsoon	Monsoon	Post monsoon	Remarks
1.	Atmospheric temperature	31.50	29.75	29.50	N.S.
2.	Surface water temperature	30.10	27.19	28.63	N.S.
3.	Dissolved oxygen content	4.79	5.13	4.86	N.S.
4.	Salinity	32.46	33. 38	33.40	N.S.
5.	Phosphate content	0.90	1.19	0.29	N.S.
6.	Nitrate content	1.06	1.97	2.76	N.S.
7.	Silicate content	0.12	0.50	0.05	N.S.

N.S. - Not Significant

Table 40. Environmental data recorded at Elathur during the three seasons.

Sl. No.	Parameter studied	Average value for Pre monsoon	Monsoon	Post monsoon	Remarks
1.	Atmospheric temperature	30.00	27.69	30.80	N.S.
2.	Surface water temperature	30.38	27.75	30.00	HI. SIG.
3.	Dissolved oxygen content	4.14	4.13	4.34	N.S.
4.	Salinity	31.39	26.75	31.36	N.S.
5.	Phosphate content	1.13	2.13	1.58	N.S.
6.	Nitrate content	1.29	2.24	3.52	N.S.
7.	Silicate content	0.52	1.64	0.19	N.S.

N.S. - Not Significant ; HI. SIG. - Highly Significant

Table 41. Environmental data recorded at Thikkotti during the three seasons.

Sl. No.	Parameter studied	Average value for			Remarks
		Pre monsoon	Monsoon	Post monsoon	
1.	Atmospheric temperature	30.56	27.25	30.50	N.S.
2.	Surface water temperature	30. 50	26.69	29.87	HI.SIG.
3.	Dissolved oxygen content	5.19	5.14	5.27	N.S.
4.	Salinity	31.39	31.00	32.28	N.S.
5.	Phosphate content	2.18	2.84	1.21	N.S.
6.	Nitrate content	2.41	3.09	2.72	N.S.
7.	Silicate content	0.24	1.03	0.04	N.S.

N.S. - Not Significant ; HI. SIG. - Highly Significant

Table 42. Environmental data recorded at Saudi during the three seasons

Sl. No.	Parameter studied	Average value for			Remarks
		Pre monsoon	Monsoon	Post monsoon	
1.	Atmospheric temperature	31.53	30.10	31.00	N.S.
2.	Surface water temperature	31.00	28.75	29.63	HI. SIG.
3.	Dissolved oxygen content	4.32	4.84	4.71	N.S.
4.	Salinity	32.11	25.18	27.84	N.S.
5.	Phosphate content	1.76	1.97	1.66	N.S.
6.	Nitrate content	3.83	2.87	1.71	N.S.
7.	Silicate content	0.55	1.55	0.41	N.S.

N.S. - Not Significant ; HI. SIG. - Highly Significant

Surface water temperature showed a significant variation between seasons in all stations, except Varkala. Refer ANOVA (analysis of variance) Tables below:

Table 43. Variation in surface water temperature at Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN. SQR	F-VAL	RAMARKS
TREAT	2	58.188	29.094	10.49	HI. SIG(1%)
ERROR	21	58. 219	2.772		

MEAN COMPARISONS	REMARKS
T 1 - T 2	SIG
T 1 - T 3	N.S.
T 2 - T 3	SIG

SIG - Significant ; N.S. - Not Significant ; HI. SIG - Highly Significant
T 1 - Pre monsoon ; T 2 - Monsoon ; T 3 - Post monsoon

Table 44. Variation in surface water temperature at Elathur between seasons

SOURCE	D.F.	SUM.SQR	MEAN. SQR	F-VAL	REMARKS
TREAT	2	32.25	16.125	6.79	HI.SIG(1%)
ERROR	21	49.875	2.375		

MEAN COMPARISONS	REMARKS
T 1 - T 2	SIG
T 1 - T 3	N.S.
T 2 - T 3	SIG

SIG - Significant ; N.S. - Not Significant ; HI. SIG - Highly Significant
T 1 - Pre monsoon ; T 2 - Monsoon ; T 3 - Post monsoon

Table 45. Variation in surface water temperature at Thikkotti between seasons.

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	66.896	33.448	6.42	HI.SIG(1%)
ERROR	21	109.344	5.207		

MEAN COMPARISONS	REMARKS
T 1 - T 2	SIG
T 1 - T 3	N.S.
T 2 - T 3	SIG

SIG - Significant ; N.S. - Not Significant ; HI. SIG - Highly Significant
T 1 - Pre monsoon ; T 2 - Monsoon ; T 3 - Post monsoon

Table 46. Variation in surface water temperature at Saudi between seasons.

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	20.584	10.292	7.49	HI.SIG(1%)
ERROR	21	28.875	1.375		

MEAN COMPARISONS	REMARKS
T 1 - T 2	SIG
T 1 - T 3	SIG
T 2 - T 3	N.S.

SIG - Significant ; N.S. - Not Significant ; HI. SIG - Highly Significant

T 1 - Pre monsoon ; T 2 - Monsoon ; T 3 - Post monsoon

At Mullur, nitrate content also varied significantly between seasons (Table 47).

Table 47. Variation in nitrate content at Mullur between seasons.

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	5.715	2.858	6.47	HI.SIG(1%)
ERROR	21	9.273	0.442		

MEAN COMPARISONS	REMARKS
T 1 - T 2	SIG
T 1 - T 3	SIG
T 2 - T 3	N.S.

SIG - Significant ; N.S. - Not Significant ; HI. SIG - Highly Significant
T 1 - Pre monsoon ; T 2 - Monsoon ; T 3 - Post monsoon

No other parameter showed significant seasonal variation in any of the stations studied.

4.8.3. Comparison of environmental data from different stations.

Table 48. Comparison of environmental data from different stations

Sl. No.	Parameter studied	Average value at				
		Mullur	Varkala	Thikkotti	Elathur	Saudi
1.	Atmospheric temperature	29.19	30.25	29.44	29.50	30.88
2.	Surface water temperature	27.80	28.64	29.02	29.38	29.79
3.	Dissolved oxygen	5.30	4.93	5.19	4.20	4.62
4.	Salinity	32.99	33.08	31.56	29.83	28.38
5.	Phosphate content	1.04	0.79	2.08	1.61	1.79
6.	Nitrate content	1.26	1.93	2.74	2.35	2.80
7.	Silicate content	0.20	0.22	0.44	0.78	0.84

Statistical analysis (analysis of variance 2 way classification or ANOVA-II) was done to see whether the observed variation in each factor, between stations was significant or not. The results are given below:

(1) Atmospheric temperature did not vary significantly between stations. Among the stations the lowest mean atmospheric temperature was recorded at Mullur (29.19°C) and the highest at Saudi (30.875°C).

(2) Surface water temperature varied significantly between stations (Table 49).

Table 49. Variation in surface water temperature between stations.

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	4	6.849	1.712	6.62	SIG (5%)
REPLIC	2	24.417	12.208	47.18	HI.SIG(1%)
ERROR	8	2. 070	0.259		

TREATMENT MEAN COMPARISONS	REMARKS
T 1 - T 2	N.S.
T 1 - T 3	SIG
T 1 - T 4	SIG
T 1 - T 5	SIG
T 2 - T 3	N.S.
T 2 - T 4	N.S.
T 2 - T 5	SIG
T 3 - T 4	N.S.
T 3 - T 5	N.S.
T 4 - T 5	N.S.

Table 49 (Contd...)

REPLICATION MEAN COMPARISONS	REMARKS
R1 - R2	SIG
R1 - R3	SIG
R2 - R3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Mullur ; T2 - Varkala ; T3 - Thikkotti ; T4 - Elathur ; T5 - Saudi

R1 - Pre monsoon ; R2 - Monsoon ; R3 - Post monsoon

Mullur recorded the lowest mean surface water temperature (27.80°C) and Saudi the highest (29.79°C).

(3) Dissolved oxygen content varied significantly between stations (Table 50).

Table 50. Variation in dissolved oxygen content between stations.

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	4	2.406	0.602	19.5	HI.SIG(1%)
REPLIC	2	0.036	0.018	0.59	N.S.
ERROR	8	0.247	0.031		

TREATMENT MEAN COMPARISONS	REMARKS
T 1 - T 2	SIG
T 1 - T 3	N.S.
T 1 - T 4	SIG
T 1 - T 5	SIG
T 2 - T 3	N.S.

Table 50 (Contd....)

TREATMENT MEAN COMPARISONS	REMARKS
T 2 - T 4	SIG
T 2 - T 5	N.S.
T 3 - T 4	SIG
T 3 - T 5	SIG
T 4 - T 5	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant
T1 - Mullur ; T2 - Varkala ; T3 - Thikkotti ; T4 - Elathur ; T5 - Saudi
R1 - Pre monsoon ; R2 - Monsoon ; R3 - Post monsoon

Elathur recorded the lowest mean dissolved oxygen content (4.2 ml/l) and Mullur the highest (5.3 ml/l).

(4) Salinity did not vary significantly between stations. The lowest mean salinity was recorded at Saudi (28.38 ppt) and the highest at Varkala (33.08 ppt).

(5) Phosphate content varied significantly between stations (Table 51).

Table 51. Variation in phosphate content between stations.

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	4	3.402	0.850	7.68	HI.SIG(1%)
REPLIC	2	1.594	0.797	7.20	SIG (5%)
ERROR	8	0.886	0.111		

TREATMENT MEAN COMPARISONS	REMARKS
T 1 - T 2	N.S.
T 1 - T 3	SIG
T 1 - T 4	N.S.

Table 51 (Contd...)

TREATMENT MEAN COMPARISONS	REMARKS
T 1 - T 5	SIG
T 2 - T 3	SIG
T 2 - T 4	SIG
T 2 - T 5	SIG
T 3 - T 4	N.S.
T 3 - T 5	N.S.
T 4 - T 5	N.S.
REPLICATION MEAN COMPARISONS	**REMARKS**
R1 - R2	N.S.
R1 - R3	N.S.
R2 - R3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Mullur ; T2 - Varkala ; T3 - Thikkotti ; T4 - Elathur ; T5 - Saudi

R1 - Pre monsoon ; R2 - Monsoon ; R3 - Post monsoon

Varkala recorded the lowest mean phosphate content (0.79 μgat/l) and Thikkotti the highest (2.08 μgat/l).

(6) Nitrate content did not vary significantly between stations. Lowest mean nitrate content was recorded at Mullur (1.26 μgat/l) and the highest at Saudi (2.8 μgat/l).

(7) Silicate content varied significantly between stations (Table 52).

Table 52. Variation in silicate content between stations

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	4	1.088	0.272	4.21	SIG (5%)
REPLIC	2	2.108	1.054	16.31	HI.SIG(1%)
ERROR	8	0.517	0.065		

TREATMENT MEAN COMPARISONS	REMARKS
T 1 - T 2	N.S.
T 1 - T 3	N.S.
T 1 - T 4	SIG
T 1 - T 5	SIG
T 2 - T 3	N.S.
T 2 - T 4	SIG
T 2 - T 5	SIG
T 3 - T 4	N.S.
T 3 - T 5	N.S.
T 4 - T 5	N.S.

REPLICATION MEAN COMPARISONS	REMARKS
R1 - R2	SIG
R1 - R3	N.S.
R2 - R3	SIG

N.S - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Mullur ; T2 - Varkala ; T3 - Thikkotti ; T4 - Elathur ; T5 - Saudi

R1 - Pre monsoon ; R2 - Monsoon ; R3 - Post monsoon

Lowest mean silicate content was recorded at Mullur (0.2 µgat/l) and the highest at Saudi (0.84 µgat/l).

4.8.4 Correlation between environmental factors observed at the various stations.

Statistical analysis (Correlation matrix) revealed some relationships between the various environmental factors studied at each station. These are given below:

At Mullur,

A positive correlation was observed between atmospheric and surface water temperature and the 'r' value was 0.7.

A negative correlation was observed between surface water temperature and phosphate content with an 'r' value of -0.413.

At Varkala,

A positive correlation was observed between atmospheric and surface water temperature with an 'r' value of 0.63.

A negative correlation was observed between atmospheric temperature and salinity with an 'r' value of -0.482.

A negative correlation was observed between dissolved oxygen and phosphate content with an 'r' value -0.479.

At Elathur,

A positive correlation was observed between atmospheric and surface water temperature with an 'r' value of 0.816.

A positive correlation was observed between atmospheric temperature and salinity with an 'r' value of 0.428.

A positive correlation was observed between surface water temperature and salinity with an 'r' value of 0.571.

A negative correlation was observed between dissolved oxygen content and phosphate content with an 'r' value of -0.396.

A negative correlation was observed between salinity and silicate content with an 'r' value of -0.510.

At Thikkotti,

A positive correlation was observed between atmospheric temperature and surface water temperature with an 'r' value of 0.911.

A negative correlation was observed between dissolved oxygen and phosphate content with an 'r' value of -0.586.

At Saudi,

A positive correlation was observed between atmospheric and surface water temperature with an 'r' value of 0.764.

A positive correlation was observed between surface water temperature and salinity with an 'r' value of 0.515.

A negative correlation was observed between nitrate content and dissolved oxygen content with an 'r' value of -0.407.

Silicate content was found to have a negative correlation with atmospheric temperature, surface water temperature and salinity with 'r' values -0.458, -0.520 and -0.388 respectively.

4.9 CORRELATION BETWEEN ENVIRONMENTAL FACTORS AND THE DENSITY OF SEAWEEDS

Correlation between environmental factors studied and the density of selected species of seaweeds, from each station was studied statistically (Correlation matrix). Results of this study are represented in Table 53.

Table 53. Correlation between environmental factors and the density of seaweeds

Names of seaweeds	Environmental Parameters showing correlation with density	Type of correlation observed	Co-efficient of correlation 'r' value	Station in which correlation was observed
Ulva fasciata	Atmospheric temperature	Negative	-0.552	Varkala
	Surface water temperature	Negative	-0.472	Varkala
	Nitrate content	Positive	0.415	Varkala
	Dissolved oxygen content	Positive	0.567	Elathur
	Phosphate content	Negative	-0.502	Elathur
	Silicate content	Positive	0.444	Mullur
U. lactuca	Atmospheric temperature	Negative	-0.411	Varkala
	Dissolved oxygen content	Positive	0.438	Elathur
	Silicate content	Positive	0.680	Varkala

Table 53 (Contd...)

Names of seaweeds	Environmental parameters showing correlation with density	Type of correlation observed	Co-efficient of correlation 'r' value	Station in which correlation was observed
Bryopsis plumosa	Atmospheric temperature	Positive	0.461	Mullur
Chaetomorpha antennina	Silicate content	Positive	0.737	Thikkotti
Cladophora glomerata	Dissolved oxygen content	Positive	0.390	Thikkotti
	Phosphate content	Negative	-0.467	Thikkotti
Caulerpa sertularioides	Salinity	Positive	0.430	Thikkotti
Enteromorpha compressa	Salinity silicate content	Negative Positive	-0.592 0.50	Saudi Saudi
Chnoospora minima	Phosphate content	Positive	0.390	Mullur
	Nitrate content	Positive	0.418	Mullur
Padina gymnospora	Atmospheric temperature	Positive	0.399	Mullur
	Surface water temperature	Positive	0.454	Mullur
Gracilaria corticata	Silicate content	Positive	0.399	Mullur
Spyridea filamentosa	Nitrate content	Negative	-0.470	Mullur

Table 53 (Contd...)

Names of seaweeds	Environmental parameters showing correlation with density	Types of correlation observed	Co-efficient of correlation 'r' value	Station in which correlation was observed
Porphyra kanyakumariensis	Atmospheric temperature	Negative	-0.434	Mullur
	Surface water temperature	Negative	-0.669	Mullur
Grateloupia lithophila	Atmospheric temperature	Positive	0.463	Varkala
	Dissolved oxygen content	Positive	0.478	Mullur
	Dissolved oxygen content	Positive	0.436	Varkala
	Nitrate content	Negative	-0.499	Varkala
G. filicina	Nitrate content	Positive	0.452	Elathur
Gelidiopsis variabilis	Salinity	Positive	0.601	Elathur
Gigartina acicularis	Dissolved oxygen content	Positive	0.440	Thikkotti
Centroceras clavulatum	Phosphate content	Negative	-0.557	Varkala
	Nitrate content	Negative	-0.428	Varkala

It is clear from Table 53 that the density of each species of seaweed studied, was showing a correlation of some kind with one or more of the environmental factors monitored. Therefore it may be said that each species of seaweed requires a specific combination of environmental factors for its biomass production.

5. BIOCHEMICAL OBSERVATIONS

5.1 BIOCHEMICAL COMPOSITION OF SEAWEEDS FROM VARIOUS STATIONS ALONG KERALA COAST

5.1.1 Biochemical composition of some seaweeds from Mullur (Tables 54-57 & Figs. 4-12)

At Mullur, for green algae

Highest protein content of 16.4% was observed in Enteromorpha compressa (July 1989) and the lowest of 1.4% in Ulva lactuca (March 1988) and (March 1989).

Caulerpa peltata (February 1989) recorded the highest carbohydrate content of 75% and Chaetomorpha antennina (July 1989) the lowest of 8.75%.

Bryopsis plumosa (February 1989) and Caulerpa peltata (January 1989) recorded the highest lipid content of 6.1% and Chaetomorpha antennina (July 1989) the lowest of 0.9%.

At Mullur, for brown algae

Padina gymnospora (May 1989) recorded the highest protein content of 16.4% and the same alga in February 1988 recorded the lowest of 2.8%. Sargassum wightii (February 1989) recorded the highest carbohydrate content of 16.75% and Padina gymnospora (February 1988) recorded the lowest of 3.5%.

Padina gymnospora (December 1989) recorded the highest lipid content of 8.75% and Sargassum wightii (May 1988) recorded the lowest of 1%.

At Mullur, for red algae

Porphyra kanyakumariensis (June 1989) recorded the highest protein content of 19.6% and *Grateloupia lithophila* (March 1989) the lowest of 2.3%.

Gracilaria corticata (April 1989) recorded the highest carbohydrate content of 37.5% and *Hypnea valentiae* (March 1989) the lowest of 6%.

Gracilaria foliifera (March 1988) recorded the highest lipid content of 5.5% and *Centroceras clavulatum* (November 1988) the lowest of 0.5%.

Table 54. Biochemical composition of some green algae from [illegible]

Sl. No.	Name of Alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	*Ulva fasciata*		Feb.	12.00	27.00	2.10	67.80	112.05	19.74
			Apr.	3.90	35.00	2.00	22.03	145.25	18.80
			Jun.	9.00	27.25	2.00	50.85	113.09	18.80
		1988	Jul.	13.00	29.00	1.80	73.45	120.35	16.92
			Aug.	6.00	32.96	1.90	33.90	136.78	17.86
			Sep.	10.00	30.00	2.40	56.50	124.50	22.56
			Oct.	11.20	32.00	1.90	63.28	132.80	17.86
			Nov.	16.00	18.00	2.65	90.40	74.70	24.91
			Jan.	9.20	24.00	1.10	51.98	99.60	10.34
			Feb.	9.00	23.00	1.10	50.85	95.45	10.34
			Mar.	3.00	36.00	1.55	16.95	149.40	14.57
			Apr.	4.10	37.50	2.37	23.17	155.62	22.28
			May	13.20	21.75	2.00	74.58	90.26	18.80
		1989	Jun.	11.40	17.25	2.50	64.41	71.59	23.50
			Jul.	15.20	16.25	2.00	85.88	67.44	18.80
			Aug.	15.20	21.75	1.55	85.88	90.26	14.57
			Sep.	15.80	18.50	2.65	89.27	76.78	24.91
			Oct.	10.00	30.00	2.40	56.50	124.50	22.56
			Nov.	15.00	17.00	2.50	84.75	70.55	23.50
			Dec.	15.00	17.00	2.30	84.75	70.55	21.62
		1990	Jan.	9.00	23.00	1.10	50.85	95.45	10.34
			AVERAGE	10.77	25.44	1.99	60.85	105.58	18.71

Table 54 (Contd...)

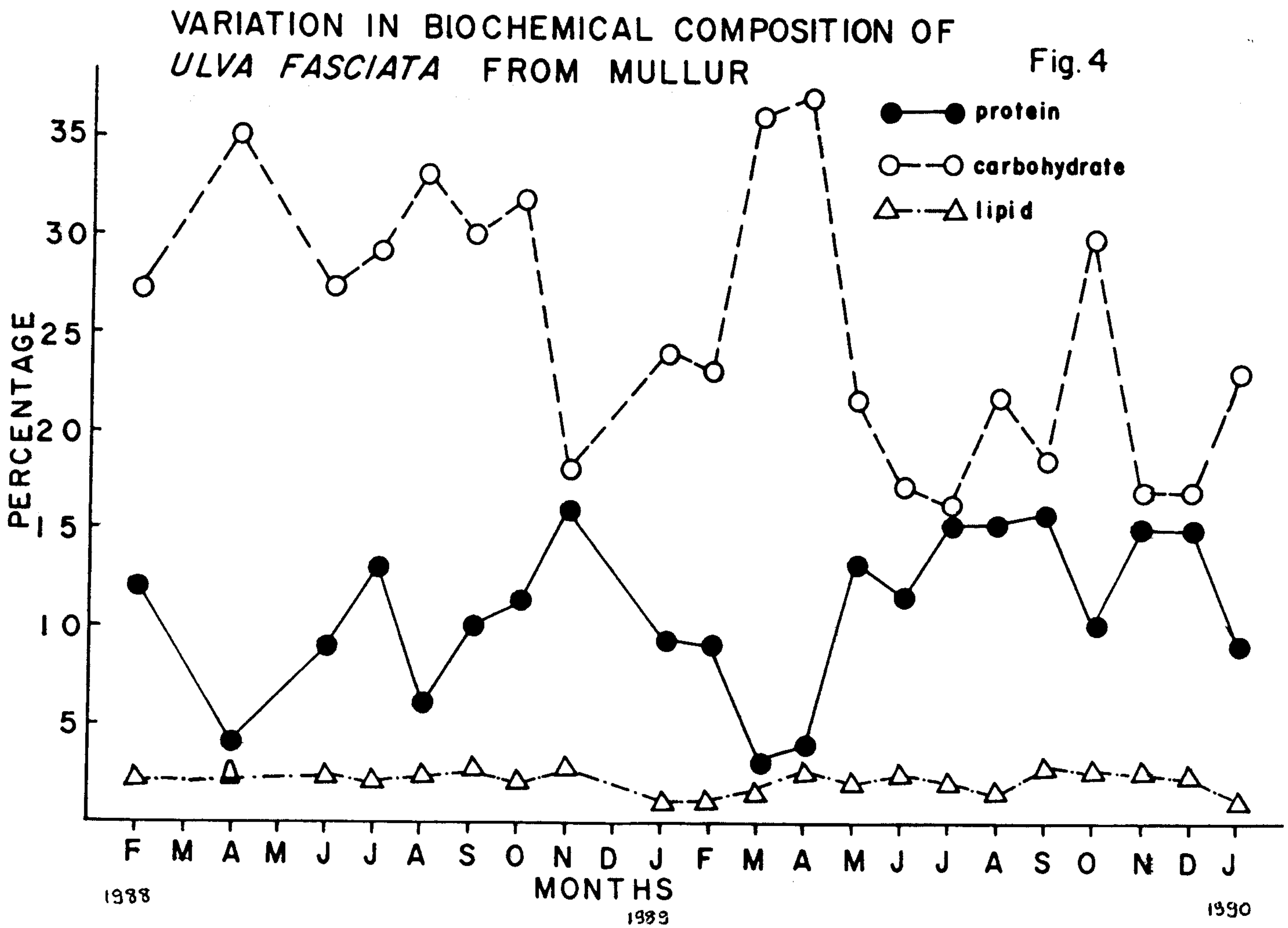
Sl. No.	Name of Alga	Year	Month of collection	Percentage of Protein	Percentage of Carbohydrate	Percentage of Lipid	Calorific value of Protein	Calorific value of Carbohydrate	Calorific value of Lipid
2.	U. lactuca	1988	Feb.	5.80	30.00	4.25	32.77	124.50	39.95
			Mar.	1.40	18.25	5.20	7.91	75.74	48.88
			May	2.00	20.50	1.60	11.30	85.08	15.04
			Aug.	12.00	25.50	1.10	67.80	105.83	10.34
			Sep.	14.00	32.00	2.75	79.10	132.80	25.85
			Nov.	13.80	31.50	3.50	77.97	130.73	32.90
			Dec.	15.80	32.50	3.75	89.27	134.88	35.25
		1989	Feb.	6.20	33.50	1.10	35.03	139.03	10.34
			Mar.	1.40	28.50	1.60	7.91	118.28	15.04
			May	10.00	25.50	4.00	56.50	105.83	37.60
			Jul.	11.00	24.50	1.00	62.15	101.68	9.40
			Aug.	13.00	26.00	1.50	73.45	107.90	14.10
			Sep.	15.00	34.50	2.00	84.75	143.18	18.80
			Oct.	14.00	23.50	3.50	79.10	97.53	32.90
			Nov.	14.00	30.00	2.80	79.10	124.50	26.32
			Dec.	16.00	33.00	3.75	90.40	136.95	35.25
		1990	Jan.	7.00	28.50	1.60	39.55	118.28	15.04
			AVERAGE	10.14	28.10	2.64	57.29	116.62	24.82
3.	Enteromorpha compressa	1989	Jul.	16.40	12.00	1.20	92.66	49.80	11.28

Table 54 (Contd...)

Sl. No.	Name of Alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
4.	Chaetomorpha antennina	1988	May	7.40	14.50	3.75	41.81	60.18	35.25
			Jun.	5.80	13.00	3.00	32.77	53.95	28.20
			Aug.	12.00	20.25	3.95	67.80	84.04	37.13
		1989	Jan.	9.60	12.75	3.00	54.24	52.91	28.20
			Jun.	13.80	13.00	3.75	77.97	53.95	35.25
			Jul.	8.80	8.75	0.90	49.72	36.31	8.46
			Aug.	12.00	13.75	3.10	67.80	57.06	29.14
			Sep.	10.80	9.75	3.30	61.02	40.46	31.02
			AVERAGE	10.03	13.22	3.09	56.67	54.86	29.05
5.	Bryopsis plumosa	1989	Feb.	15.40	9.00	6.10	87.01	37.35	57.34
6.	Caulerpa peltata	1988	Jun.	10.40	66.15	5.20	58.76	274.52	48.88
			Aug.	13.00	63.00	5.50	73.45	261.45	51.70
			Sep.	14.00	25.00	2.50	79.10	103.75	23.50
			Oct.	13.00	28.00	3.00	73.45	116.20	28.20
			Nov.	10.00	30.00	2.80	56.50	124.50	26.32
			Dec.	10.00	30.00	5.50	56.50	124.50	51.70
		1989	Jan.	14.40	33.50	6.10	81.36	139.02	57.34
			Feb.	12.60	75.00	5.15	71.19	311.25	48.41

Table 54 (Contd...)

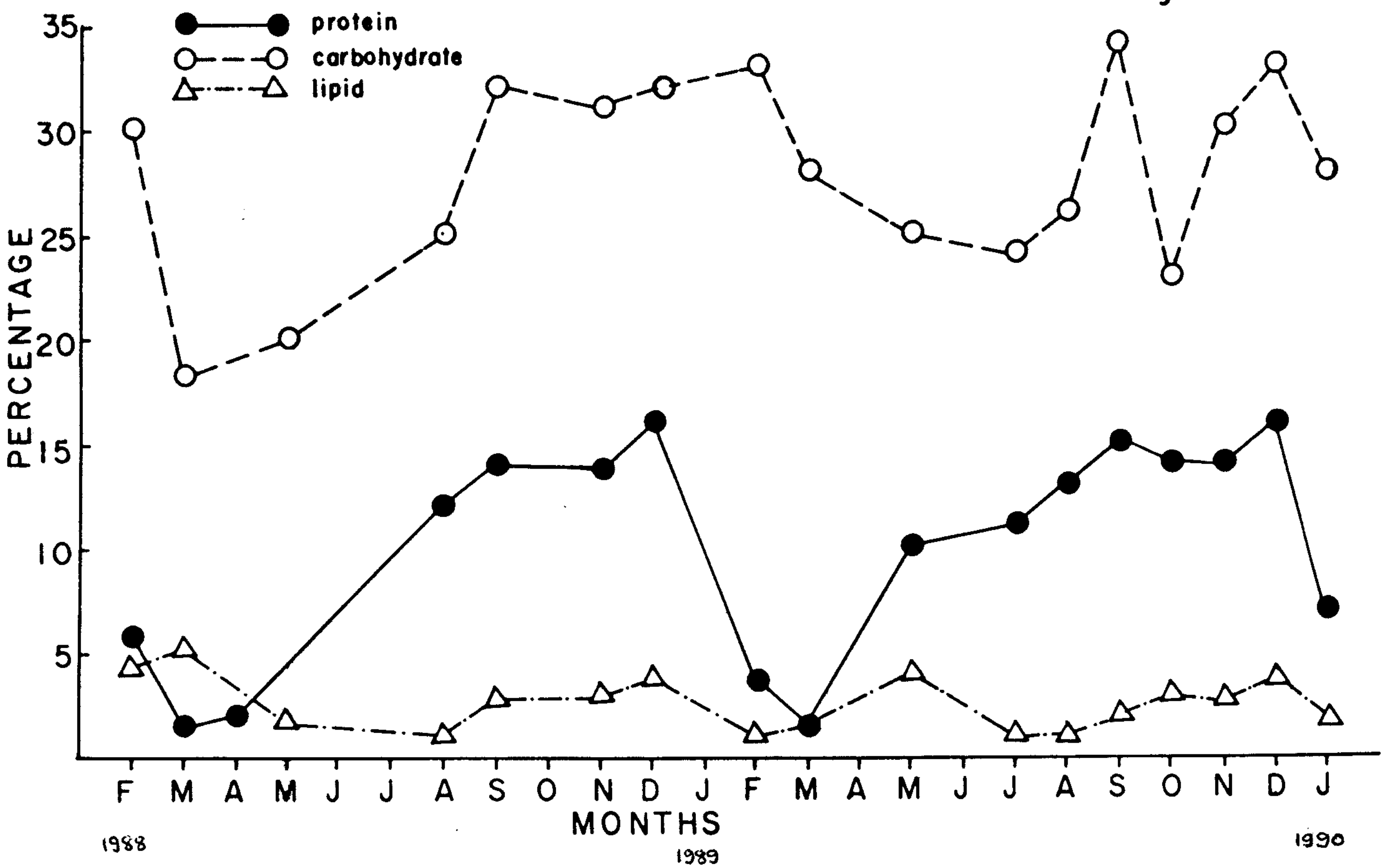
Sl. No.	Name of Alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	Caulerpa peltata	1989	Mar.	5.70	50.00	4.00	32.21	207.50	37.60
			Apr.	5.10	37.50	4.00	28.82	155.63	37.60
			May	6.00	33.50	2.45	33.90	139.03	23.03
			Jun.	6.50	30.00	4.15	36.73	124.50	39.01
			Jul.	8.20	17.50	3.50	46.33	72.63	32.90
			Aug.	12.00	28.75	3.50	67.80	119.31	32.90
			Sep.	11.60	25.50	2.45	65.54	105.83	23.03
			Oct.	13.00	25.50	2.45	73.45	105.83	23.03
			Nov.	10.50	30.00	1.80	59.33	124.50	16.92
			Dec.	10.00	31.00	4.50	56.50	128.65	42.30
		1990	Jan.	15.00	32.50	6.10	84.75	134.88	57.34
			AVERAGE	10.58	36.44	3.92	59.77	151.23	36.85



VARIATION IN BIOCHEMICAL COMPOSITION OF
ULVA FASCIATA FROM MULLUR
Fig. 4
protein
carbohydrate
lipid
PERCENTAGE
35
30
25
20
15
10
5
F M A M J J A S O N D J F M A M J J A S O N D J
MONTHS
1988
1989
1990

VARIATION IN BIOCHEMICAL COMPOSITION OF
ULVA LACTUCA FROM MULLUR

Fig.5



VARIATION IN BIOCHEMICAL COMPOSITION OF *CAULERPA PELTATA* FROM MULLUR

Fig. 6

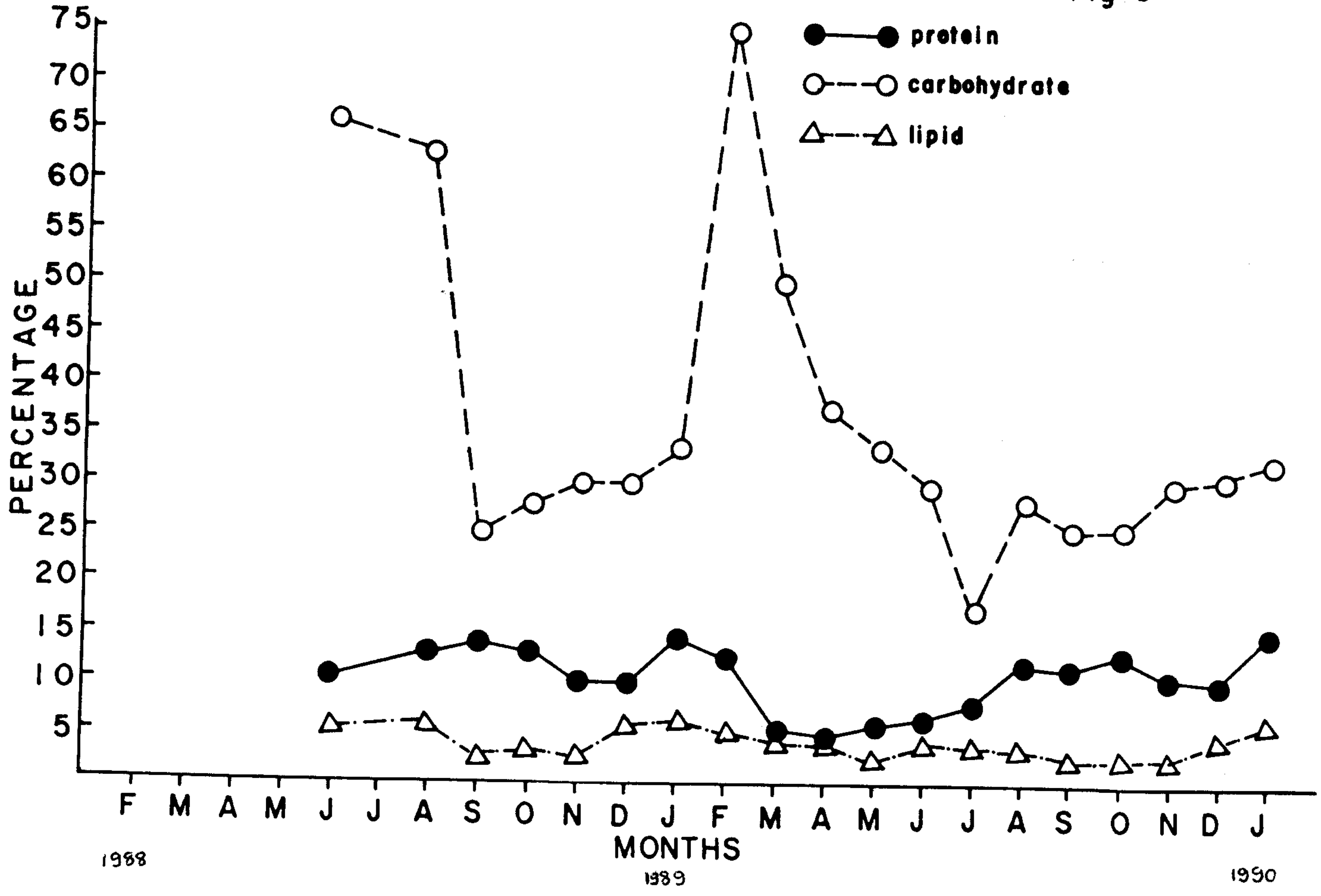


Table 55. Biochemical composition of some brown algae from Mullur

Sl. No.	Name of Alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Chnoospora minima	1988	Feb.	8.60	13.00	7.55	48.59	53.95	70.97
			Jul.	9.00	12.00	6.00	50.85	49.80	56.40
			Aug.	10.00	12.00	6.00	56.50	49.80	56.40
			Sep.	10.40	11.75	4.50	58.76	48.76	42.30
			Oct.	12.00	11.25	4.50	67.80	46.69	42.30
			Nov.	11.50	10.00	3.90	64.98	41.50	36.66
		1989	Jan.	13.00	11.00	4.00	73.45	45.65	37.60
			Feb.	14.20	11.50	4.00	80.23	47.73	37.60
			Mar.	13.00	5.12	4.50	73.45	21.25	42.30
			Jul.	11.00	10.25	2.00	62.15	42.54	18.80
			Aug.	14.40	7.25	3.75	81.36	30.08	35.25
			Sep.	14.40	7.87	3.75	81.36	32.66	35.25
			Oct.	13.00	10.25	3.50	73.45	42.54	32.90
			Nov.	11.00	10.00	3.90	62.15	41.50	36.66
			AVERAGE	11.82	10.23	4.42	66.78	42.46	41.55
2.	Dictyota bartayresiana	1989	Mar.	3.40	11.00	2.80	19.21	45.65	26.32

Table 55 (Contd...)

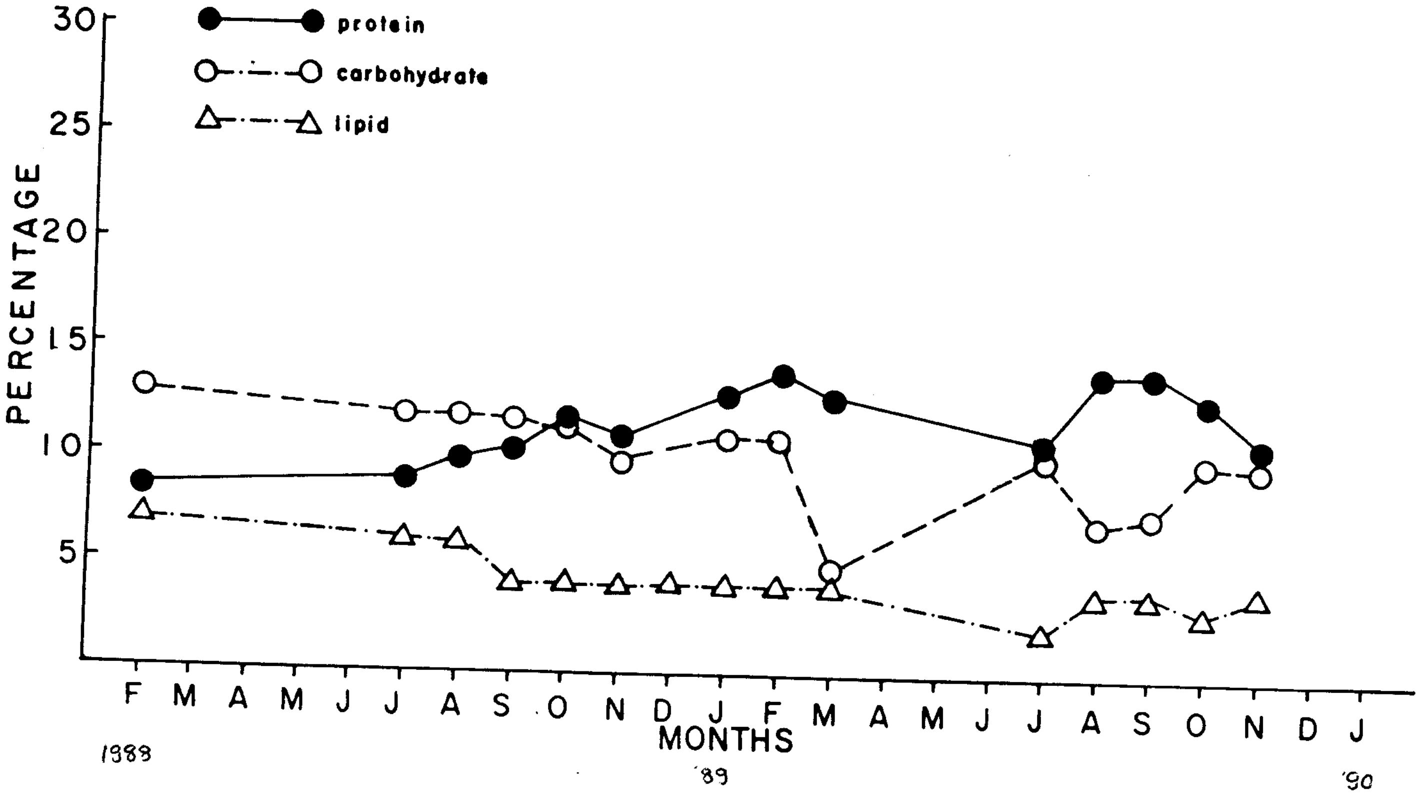
Sl. No.	Name of Alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
3.	Padina gymnospora	1988	Feb.	2.80	3.50	3.00	15.82	14.53	28.20
			Mar.	3.10	4.00	1.60	17.52	16.60	15.04
			Apr.	4.00	5.50	3.00	22.60	22.83	28.20
			May	4.50	6.00	4.00	25.43	24.90	37.60
			Sep.	8.00	6.50	3.60	45.20	26.98	33.84
		1989	Jan.	12.20	10.25	3.00	68.93	42.54	28.20
			Feb.	10.00	10.00	4.00	56.50	41.50	37.60
			Mar.	4.40	6.00	1.60	24.86	24.90	15.04
			May	16.40	6.87	4.50	92.66	28.51	42.30
			Dec.	6.80	9.75	8.75	38.42	40.46	82.25
		1990	Jan.	11.00	10.00	3.00	62.15	41.50	28.20
			AVERAGE	7.56	7.12	3.64	42.71	29.55	34.22
4.	P. tetrastromatica	1988	Dec.	16.00	11.25	4.25	90.40	46.69	39.95
5.	Sargassum wightii	1988	Feb.	8.00	13.50	5.05	45.20	56.03	47.47
			Mar.	9.60	10.50	6.00	54.24	43.58	56.40
			Apr.	5.00	10.00	6.00	28.25	41.50	56.40
			May	8.50	5.00	1.00	48.03	20.75	9.40
			Jun.	7.00	10.75	1.80	39.55	44.61	16.92

Table 55 (Contd...)

Sl. No.	Name of Alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	Sargassum wightii	1988	Jul.	8.00	8.00	2.50	45.20	33.20	23.50
			Aug.	8.90	15.00	3.50	50.29	62.25	32.90
			Sep.	12.00	6.00	3.00	67.80	24.90	28.20
			Oct.	10.40	11.00	2.80	58.76	45.65	26.32
			Nov.	13.80	11.25	4.50	77.97	46.69	42.30
			Dec.	13.00	15.50	5.20	73.45	64.33	48.88
		1989	Jan.	13.40	15.00	6.10	75.71	62.25	57.34
			Feb.	9.20	16.75	4.00	51.98	69.51	37.60
			Mar.	4.30	6.50	2.95	24.29	26.98	27.73
			Apr.	5.40	9.75	6.37	30.51	40.46	59.88
			May	8.80	6.00	1.80	49.72	24.90	16.92
			Jun.	8.20	8.37	1.80	46.33	34.74	16.92
			Jul.	8.00	8.00	1.35	45.20	33.20	12.69
			Aug.	12.00	8.38	3.95	67.80	34.78	37.13
			Sep.	13.60	7.00	3.75	76.84	29.05	35.25
			Oct.	9.50	10.00	2.95	53.68	41.50	27.73
			Nov.	14.00	11.00	1.80	79.10	45.65	16.92
			Dec.	12.00	16.00	5.20	67.80	66.40	48.88
		1990	Jan.	14.00	14.00	5.00	79.10	58.10	47.00
			AVERAGE	9.86	10.55	3.68	55.71	43.78	34.59

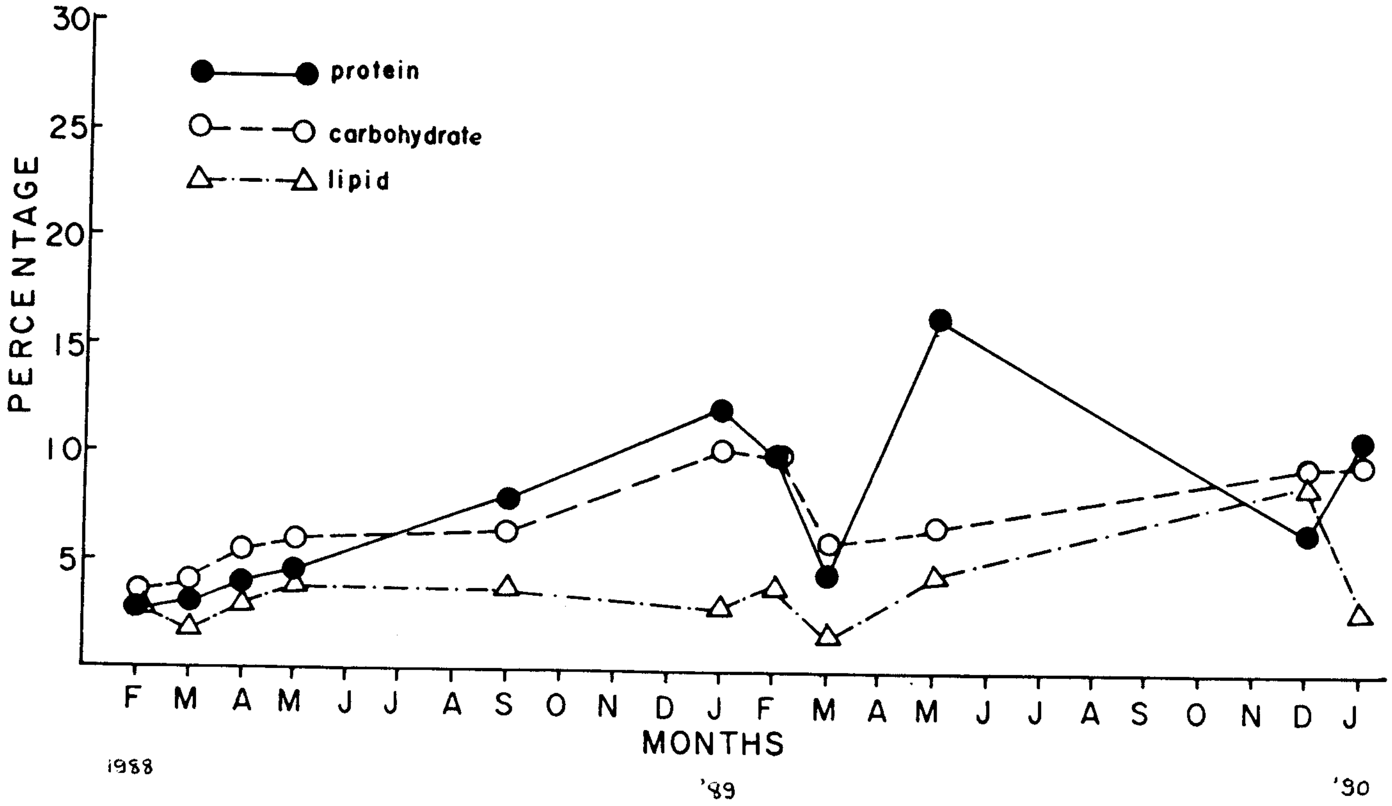
VARIATION IN BIOCHEMICAL COMPOSITION OF *CHNOOSPORA MINIMA* FROM MULLUR

Fig.7



VARIATION IN BIOCHEMICAL COMPOSITION OF *PADINA GYMNOSPORA* FROM MULLUR

Fig. 8



VARIATION IN BIOCHEMICAL COMPOSITION OF *SARGASSUM WIGHTII* FROM MULLUR

Fig.9

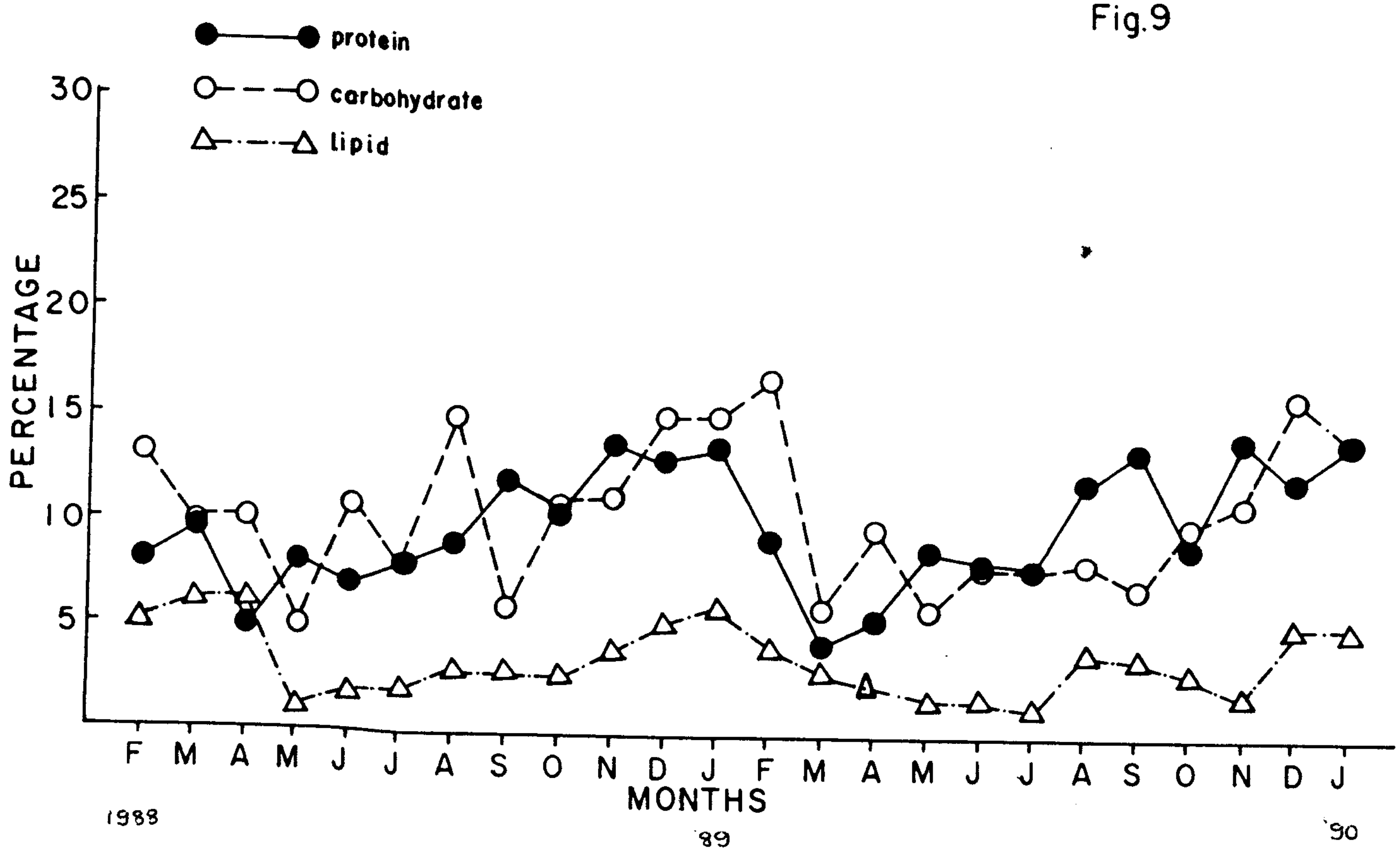


Table 56. Biochemical composition of some red algae from Mullur

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Porphyra kanyakumariensis	1988	Jul.	18.30	29.00	2.40	103.39	120.35	22.56
		1989	Jun.	19.60	21.75	2.45	110.74	90.26	23.03
			Jul.	19.00	20.00	3.10	107.35	83.00	29.14
			Aug.	17.00	18.75	3.50	96.05	77.81	32.90
			AVERAGE	18.48	22.38	2.86	104.41	92.88	26.88
2.	Grateloupia filicina	1988	Nov.	10.60	33.50	1.50	59.89	139.03	14.10
3.	G. lithophila	1988	Nov.	6.20	23.50	2.05	35.03	97.53	19.27
		1989	Mar.	2.30	30.00	2.38	12.99	124.50	22.37
			Apr.	3.20	17.50	1.60	18.08	72.63	15.04
			AVERAGE	3.90	23.66	2.01	22.04	98.19	18.89
4.	Hypnea valentiae	1988	Feb.	7.20	18.00	2.50	40.68	74.70	23.50
			Mar.	5.20	6.00	4.00	29.38	24.90	37.60
			Aug.	10.60	16.25	2.00	59.89	67.43	18.80
			Nov.	15.40	16.00	2.05	87.01	66.40	19.27
			Dec.	14.00	16.00	2.00	79.10	66.40	18.80

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	Hypnea valentiae	1989	Feb.	11.80	24.25	1.10	66.67	100.64	10.34
			Mar.	10.00	21.00	1.10	56.50	87.15	10.34
			Apr.	9.00	20.00	1.50	50.85	83.00	14.10
			May	14.40	10.87	1.50	81.36	45.11	14.11
			Aug.	18.20	12.50	2.20	102.83	51.88	20.68
			Oct.	14.00	15.00	3.00	79.10	62.25	28.20
			Nov.	15.00	10.25	2.20	84.75	42.54	20.68
			Dec.	16.00	20.00	1.80	90.40	83.00	16.92
		1990	Jan.	6.00	17.00	2.00	33.90	70.55	18.80
			AVERAGE	11.91	15.94	2.07	67.29	66.15	19.46
5.	Gracilaria corticata	1988	Feb.	6.20	21.50	2.10	35.03	89.23	19.74
			Mar.	7.40	14.25	1.40	41.81	59.14	13.16
			Apr.	7.20	30.00	2.00	40.68	124.50	18.80
			May	7.00	25.00	1.40	39.55	103.75	13.16
			Jun.	9.80	20.00	1.70	55.37	83.00	15.98
			Jul.	8.00	15.50	2.30	45.20	64.33	21.62
			Aug.	8.50	17.00	2.40	48.03	70.55	22.56
			Sep.	9.00	15.00	2.40	50.85	62.25	22.56

Table 56 (Contd...)

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	Gracilaria corticata	1988	Oct.	8.50	14.50	2.30	48.03	60.18	21.62
			Nov.	9.00	18.75	1.75	50.85	77.81	16.45
			Dec.	7.00	20.00	1.80	39.55	83.00	16.92
		1989	Jan.	8.00	22.00	1.75	45.20	91.30	16.45
			Feb.	9.80	25.00	2.40	55.37	103.75	22.56
			Mar.	4.80	32.50	5.00	27.12	134.88	47.00
			Apr.	5.90	37.50	4.37	33.34	155.63	41.08
			May	9.80	15.75	4.00	55.37	65.36	37.60
			Jun.	13.00	19.50	2.65	73.45	80.93	24.91
			Jul.	10.00	16.25	2.45	56.50	67.44	23.03
			Aug.	12.40	15.00	2.90	70.06	62.25	27.26
			Sep.	11.40	9.75	2.95	64.41	40.46	27.73
			Oct.	9.00	15.00	2.00	50.85	62.25	18.80
			Nov.	9.00	18.00	1.80	50.85	74.70	16.92
			Dec.	5.00	15.00	1.75	28.25	62.25	16.45
		1990	Jan.	8.00	20.00	2.00	45.20	83.00	18.80
			AVERAGE	8.49	19.69	2.39	47.97	81.71	22.47

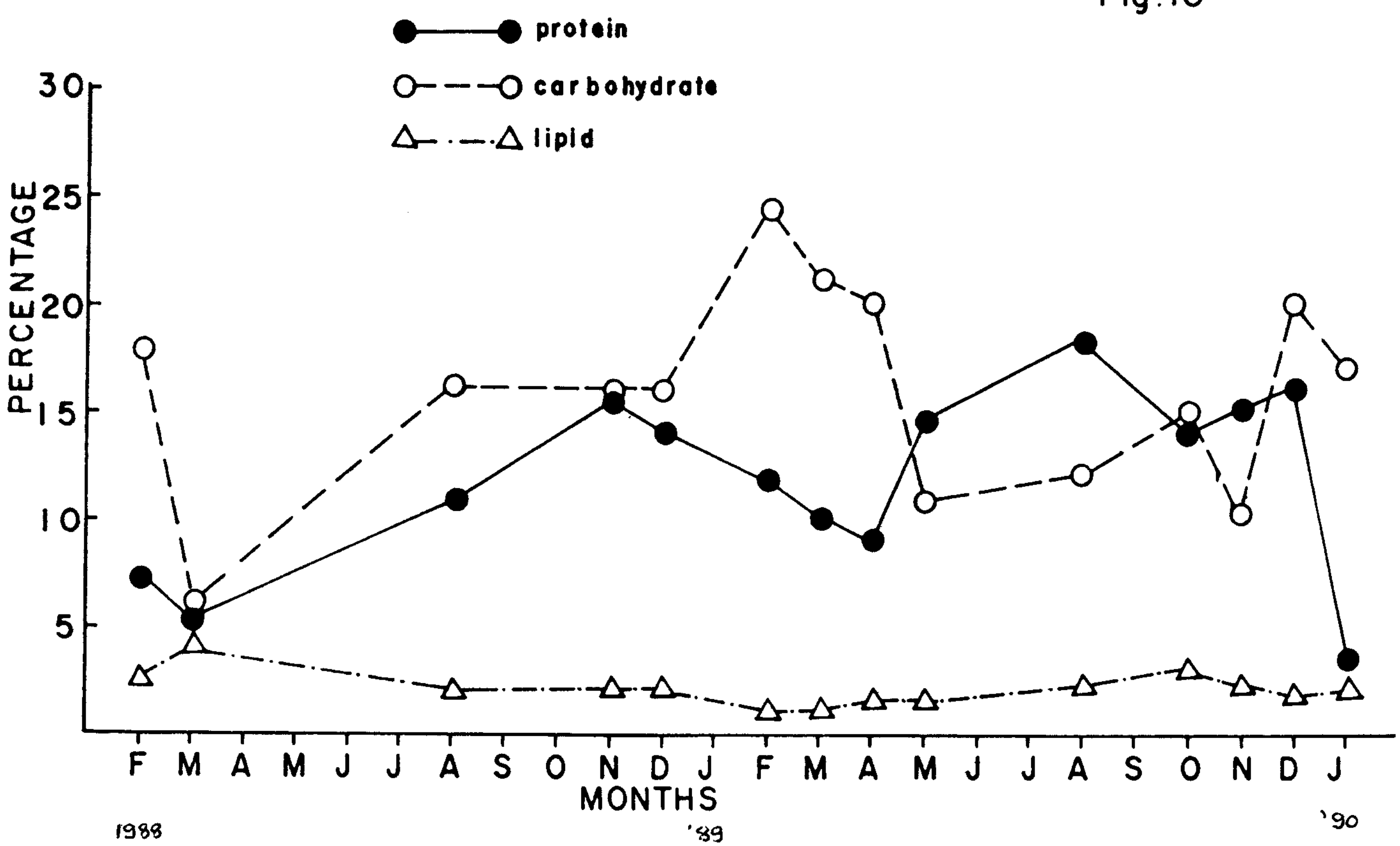
Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
6.	G. foliifera	1988	Mar.	7.80	8.42	5.5	44.07	34.94	51.70
7.	Centroceras clavulatum	1988	Nov.	7.20	10.25	0.50	40.68	42.54	4.70
			Dec.	15.40	20.25	0.80	87.01	84.04	7.52
			AVERAGE	11.30	15.25	0.65	63.85	63.29	6.11
8.	Spyridea filamentosa	1988	Feb.	8.00	13.00	5.05	45.20	53.95	47.47
			Mar.	7.40	11.50	4.00	41.81	47.73	37.60
			Apr.	8.60	16.00	4.55	48.59	66.40	42.77
			Jul.	7.00	18.75	4.00	39.55	77.81	37.60
			Jul.	6.00	13.25	3.90	33.90	54.99	36.66
			Aug.	10.00	17.16	3.50	56.50	71.21	32.90
			Sep.	9.00	16.00	3.20	50.85	66.40	30.08
			Oct	13.00	15.50	4.00	73.45	64.33	37.60
			Nov.	10.40	16.75	3.50	58.76	69.51	32.90
			Dec.	16.00	19.00	3.00	90.40	78.85	28.20
		1989	Jan.	14.40	24.75	3.00	81.36	102.71	28.20
			Feb.	9.40	18.75	2.65	53.11	77.81	24.91
			Mar.	5.10	14.00	1.85	28.82	58.10	17.39
			Apr.	6.60	15.00	2.00	37.29	62.25	18.80

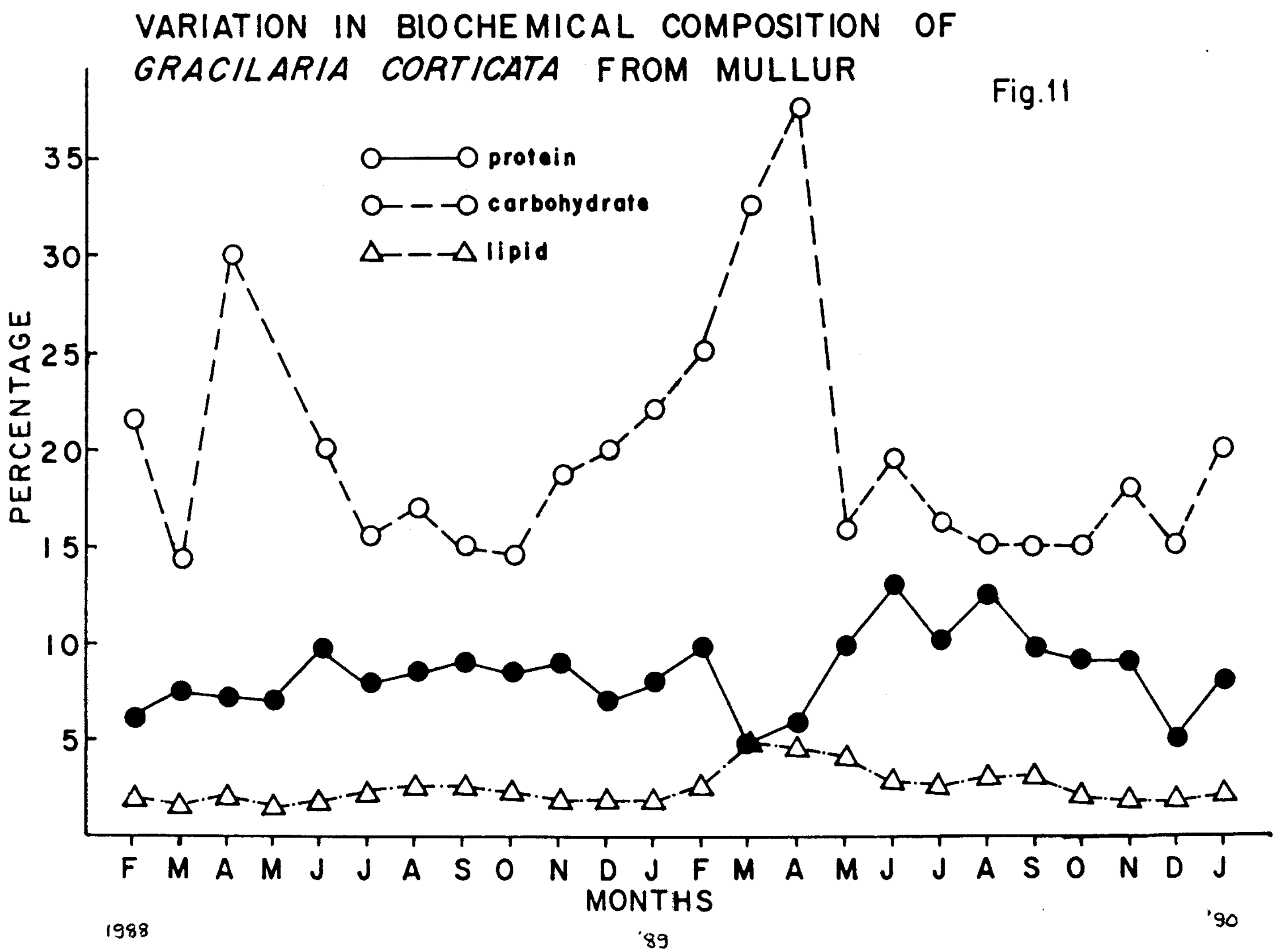
Table 56 (Contd...)

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	Spyridea filamentosa	1989	May	12.20	10.75	1.35	68.93	44.61	12.69
			Jun.	10.80	15.00	1.20	61.02	62.25	11.28
			Jul.	12.60	13.00	1.10	71.19	53.95	10.34
			Aug.	14.40	10.87	2.45	81.36	45.11	23.03
			Sep.	13.20	12.25	2.65	74.58	50.84	24.91
			Oct.	14.00	11.00	2.50	79.10	45.65	23.50
			Nov.	10.50	16.00	3.00	59.33	66.40	28.20
			Dec.	15.00	18.00	3.00	84.75	74.70	28.20
			Jan.	15.00	23.00	3.00	84.75	95.45	28.20
			AVERAGE	10.80	15.62	2.98	61.02	64.82	28.01
9.	Laurencia sp.	1989	Mar.	3.00	17.50	2.55	16.95	72.63	23.97
			May	9.20	17.25	2.00	51.98	71.59	18.80
			Aug.	10.80	18.50	2.45	61.02	76.77	23.03
			AVERAGE	7.66	17.75	2.33	43.28	73.66	21.90
10.	Acanthophora spicifera	1989	Jan.	9.00	20.00	1.75	50.85	83.00	16.45

VARIATION IN BIOCHEMICAL COMPOSITION OF *HYPNEA VALENTIAE* FROM MULLUR

Fig.10




VARIATION IN BIOCHEMICAL COMPOSITION OF
GRACILARIA CORTICATA FROM MULLUR
Fig.11
protein
carbohydrate
lipid
PERCENTAGE
35
30
25
20
15
10
5
F M A M J J A S O N D J F M A M J J A S O N D J
MONTHS
1988
'89
'90

VARIATION IN BIOCHEMICAL COMPOSITION OF *SPYRIDEA FILAMENTOSA* FROM MULLUR

Fig.12

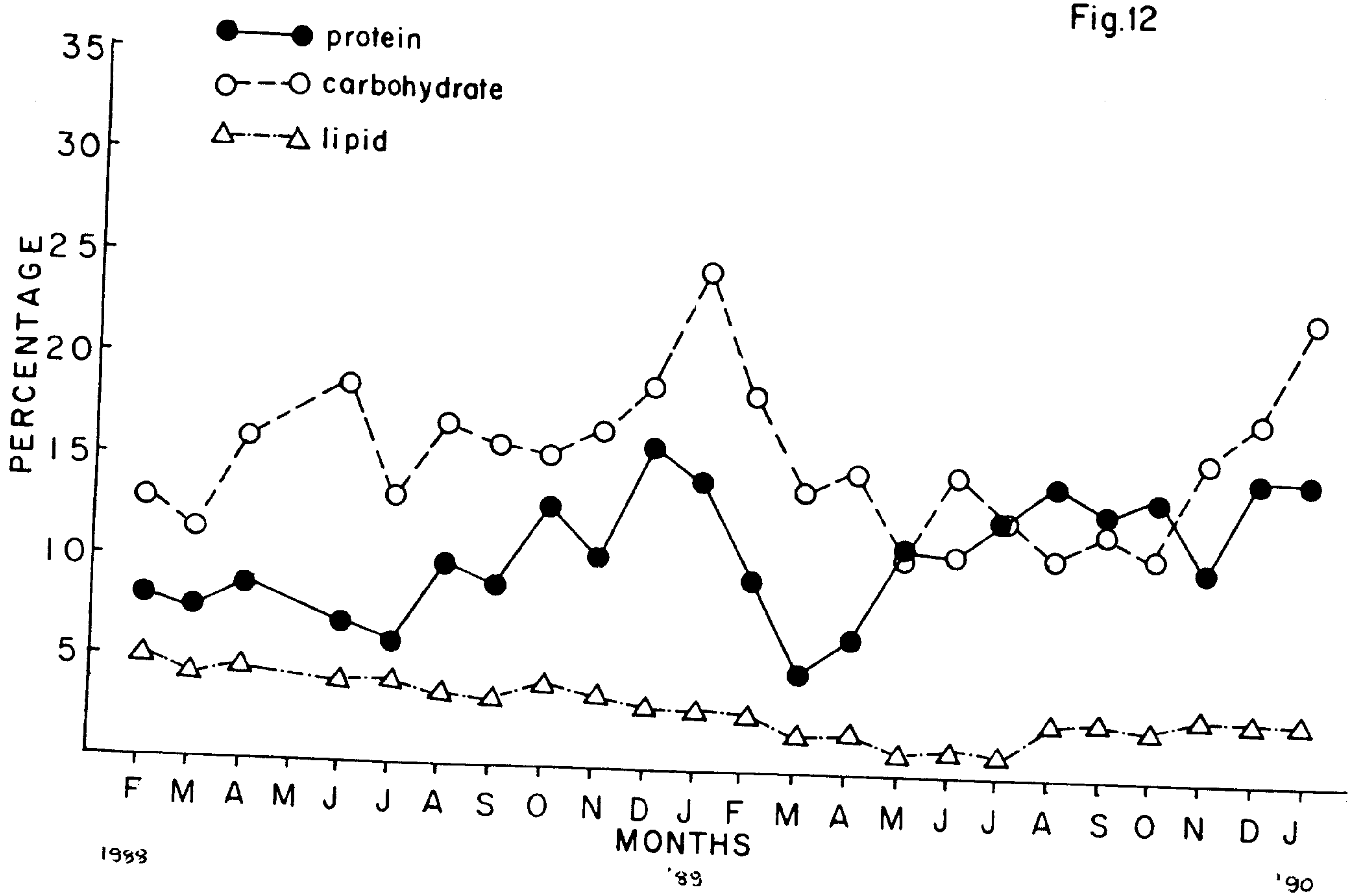


Table 57. Biochemical composition of different algal divisions at Mullur

Algal Division	% Biochemical composition			Calorific value of		
	Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
Green Algae	10.62	27.33	2.89	60.00	113.42	27.17
Brown Algae	9.89	9.75	3.87	55.88	40.46	36.38
Red Algae	10.23	17.91	2.49	57.80	74.33	23.41

At Mullur,

Green algae recorded the highest protein and carbohydrate content.

Brown algae recorded the highest lipid content.

5.1.2 Biochemical composition of some seaweeds from Varkala (Tables 58-61 and Figs. 13-16)

At Varkala among green algae

Ulva fasciata (August 1989) recorded the highest protein content of 16.5% and Valoniopsis pachynema (July 1988) the lowest of 1%.

Ulva lactuca (January 1989) recorded the highest carbohydrate content of 38% and Valoniopsis pachynema (July 1988) the lowest of 2.75%.

Bryopsis plumosa (February 1989) recorded the highest lipid content of 6% and Valoniopsis pachynema (July 1988 and September 1988) the lowest of 0.5%.

Among brown algae

Sargassum wightii (January 1989) recorded the highest protein content of 13% and S. tenerrimum (April 1989) the lowest of 4.6%.

Sargassum wightii (January 1989) recorded the highest carbohydrate content of 18.25% and S. tenerrimum (April 1989) the lowest of 10.75%.

Sargassum tenerrimum (January 1989) recorded the highest lipid content of 9.35% and Turbinaria conoides the lowest of 0.15%.

Among red algae

Porphyra kanyakumariensis (June 1989) recorded the highest protein content of 16.4% and Grateloupia lithophila the lowest of 3.2%.

Grateloupia lithophila (January 1989) recorded the highest carbohydrate content of 31.25% and Hypnea valentiae (February 1989) the lowest of 14.5%.

Grateloupia filicina (February 1988) recorded the highest lipid content of 5.2% and G. lithophila (February and March 1988) the lowest of 0.9%.

Table 58. Biochemical composition of some green algae from Varkala

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	*Ulva fasciata*	1988	Feb.	8.00	23.00	4.25	45.20	95.45	39.95
			Apr.	8.00	22.50	4.00	45.20	93.38	37.60
			Jul.	7.80	25.00	3.20	44.07	103.75	30.08
			Aug.	8.80	27.00	2.00	49.72	112.05	18.80
			Sep.	9.00	23.00	2.80	50.85	95.45	26.32
			Oct.	7.20	30.00	2.00	40.68	124.50	18.80
		1989	Mar.	8.50	23.00	3.50	48.03	95.45	32.90
			May	8.70	25.00	3.50	49.16	103.75	32.90
			Jul.	9.40	16.75	1.50	53.11	69.51	14.10
			Aug.	16.50	21.00	2.45	93.23	87.15	23.03
			Sep.	15.00	25.00	3.50	84.75	103.75	32.90
			Oct.	13.00	20.00	4.00	73.45	83.00	37.60
			AVERAGE	9.99	23.44	3.06	56.44	97.28	28.76
2.	*U. lactuca*	1988	Mar.	5.00	26.50	1.60	28.25	109.98	15.04
			Apr.	4.30	27.00	3.00	24.29	112.05	28.20
			Jul.	10.00	16.00	2.50	56.50	66.40	23.50
			Aug.	6.00	28.00	2.00	33.90	116.20	18.80
			Sep.	7.00	28.50	1.70	39.55	118.28	15.98
			Oct.	7.20	29.50	2.00	40.68	122.43	18.80

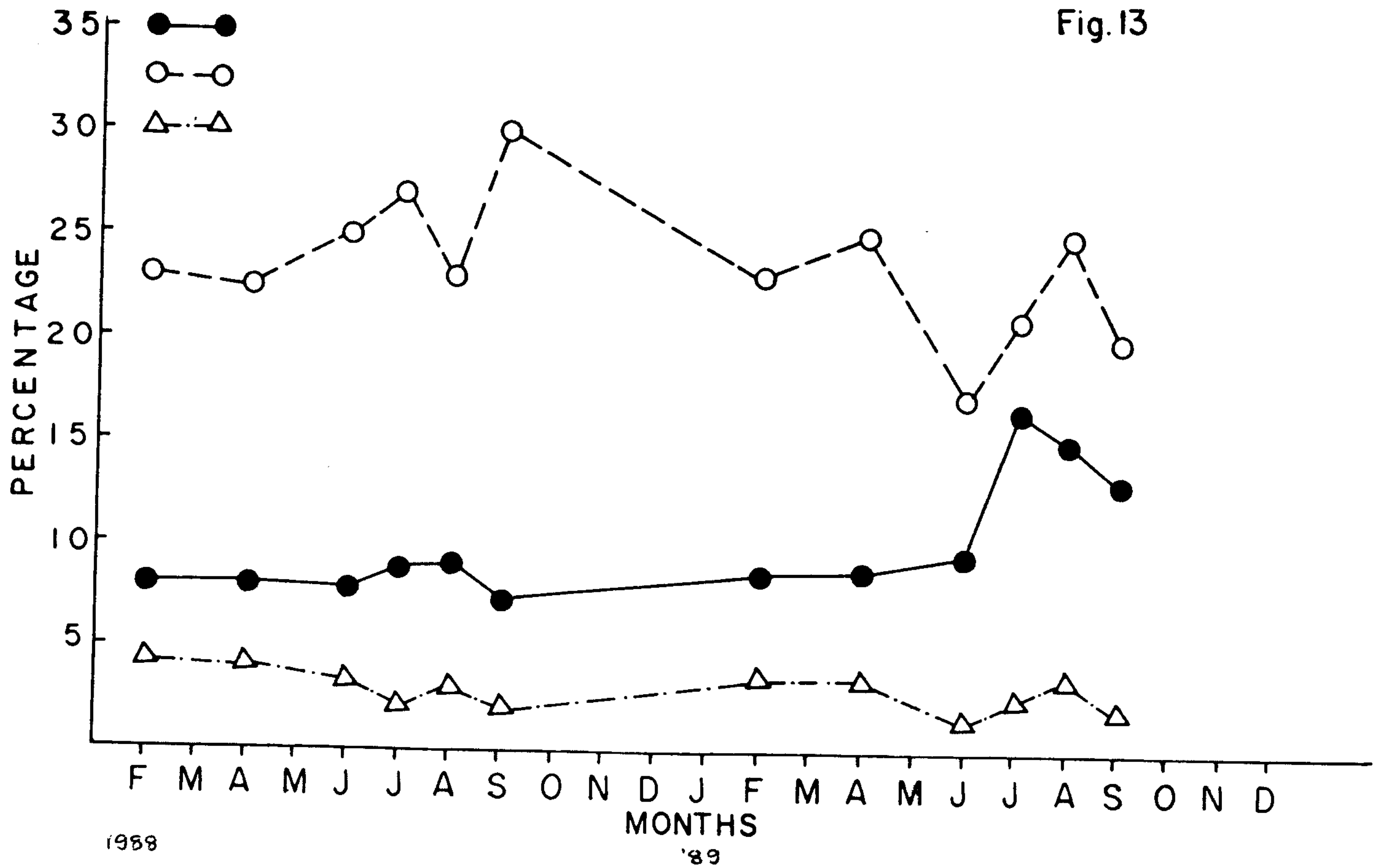
Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	U. lactuca	1988	Nov.	10.60	27.25	2.40	59.89	113.08	22.56
			Dec.	9.20	19.75	3.30	51.98	81.96	31.02
		1989	Jan.	9.80	38.00	2.05	55.37	157.70	19.27
			Feb.	6.00	33.50	2.40	33.90	139.03	22.56
			Mar.	4.30	27.50	3.37	24.29	114.13	31.68
			Jun.	10.00	16.75	2.20	56.50	69.52	20.68
			Aug.	7.00	27.00	2.00	39.55	112.05	18.80
			Sep.	7.00	28.20	1.50	39.55	117.03	14.10
			Oct.	8.00	28.00	2.00	45.20	116.20	18.80
			Nov.	11.00	25.00	2.30	62.15	103.75	21.62
			Dec.	9.00	20.00	3.00	50.85	83.00	28.20
		1990	Jan.	9.80	36.00	3.00	55.37	149.40	28.20
			AVERAGE	7.84	26.80	2.35	44.30	111.22	22.09
3.	Chaetomorpha antennina	1988	Feb.	5.90	9.00	5.00	33.33	37.35	47.00
			Mar.	6.50	21.00	4.95	36.73	87.15	46.53
			Apr.	6.80	21.70	5.50	38.42	90.05	51.70
			May	9.50	13.00	3.00	53.67	53.95	28.20
			Jun.	5.40	21.25	1.75	30.51	88.19	16.45
			Jul.	6.00	22.00	2.50	33.90	91.30	23.50
			Aug.	12.50	8.00	3.10	70.63	33.20	29.14
			Sep.	13.00	7.50	3.00	73.45	31.13	28.20

Table 58 (Contd...)

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	Chaetomorpha antennina	1988	Oct.	8.00	6.00	3.10	45.20	24.90	29.14
			Dec.	10.00	8.50	2.90	56.50	35.28	27.26
		1989	Jan.	10.00	8.75	4.00	56.50	36.31	37.60
			Feb.	9.80	9.00	3.50	55.37	37.35	32.90
			Mar.	4.50	20.00	3.00	25.43	83.00	28.20
			Apr.	4.60	22.50	3.00	25.99	93.38	28.20
			May	9.80	14.00	3.10	55.37	58.10	29.14
			Jun.	12.00	8.75	3.50	67.80	36.31	32.90
			Jul.	11.00	7.80	3.10	62.15	32.37	29.14
			Aug.	12.50	7.90	2.90	70.63	32.79	27.26
			Sep.	11.90	8.20	4.00	67.24	34.03	37.60
			Oct.	12.00	14.00	3.10	67.80	58.10	29.14
			Dec.	9.80	8.00	3.00	55.37	33.20	28.20
		1990	Jan.	10.00	8.50	4.00	56.50	35.28	37.60
			AVERAGE	9.16	12.52	3.41	51.75	51.96	32.05
4.	Bryopsis plumosa	1989	Feb.	15.00	9.00	6.00	84.75	37.35	56.40
5.	Valoniopsis pachynema	1988	Jul.	1.00	2.75	0.50	5.65	11.41	4.70
			Sep.	7.00	7.75	0.50	39.55	32.16	4.70
		1989	Jan.	11.00	14.75	3.60	62.15	61.21	33.84
			AVERAGE	6.33	8.42	1.53	35.76	34.94	14.38

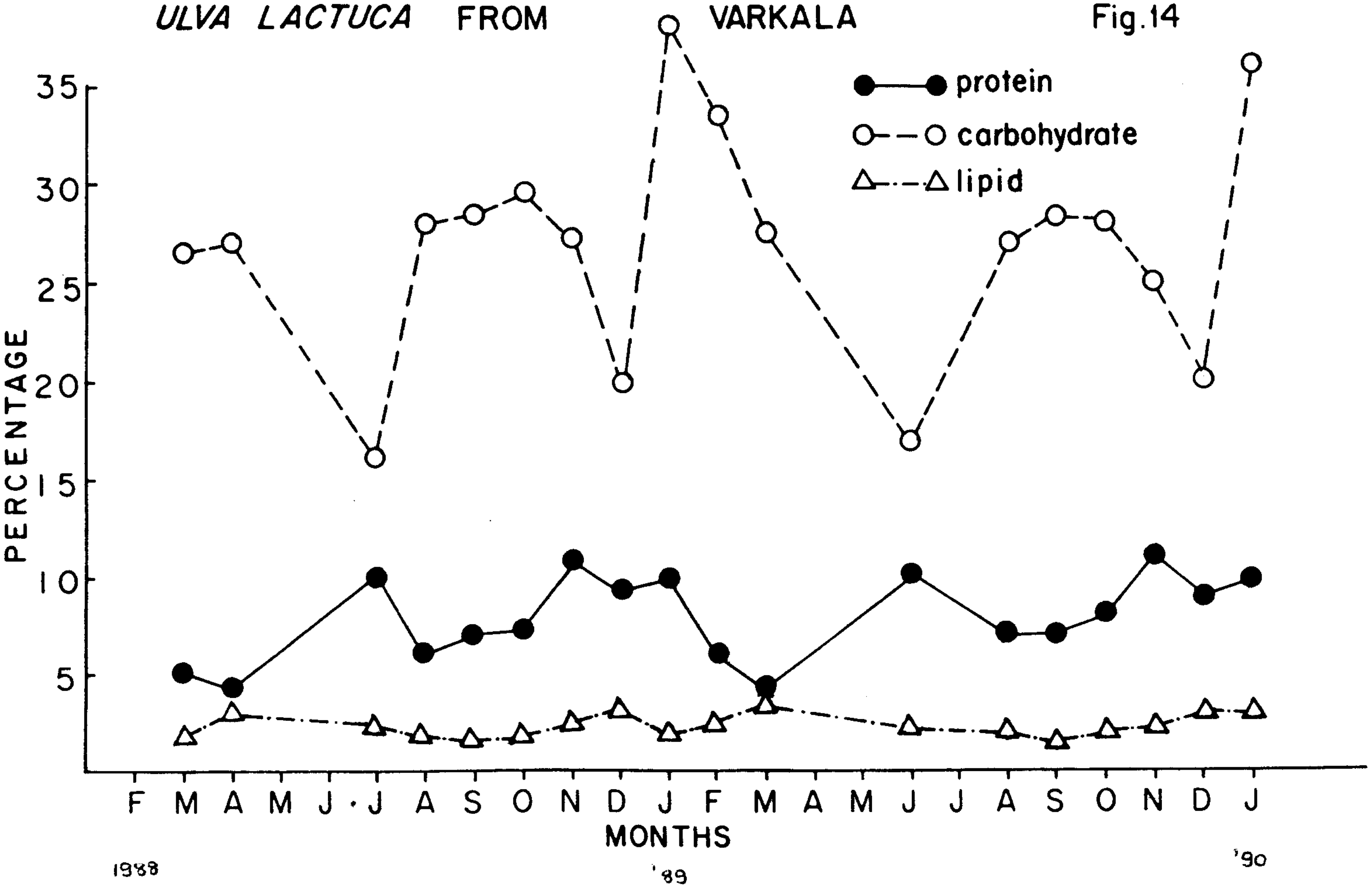
VARIATION IN BIOCHEMICAL COMPOSITION OF *ULVA FASCIATA* FROM VARKALA

Fig. 13



VARIATION IN BIOCHEMICAL COMPOSITION OF *ULVA LACTUCA* FROM VARKALA

Fig.14



VARIATION IN BIOCHEMICAL COMPOSITION OF *CHAETOMORPHA ANTENNINA* FROM VARKALA

Fig. 15

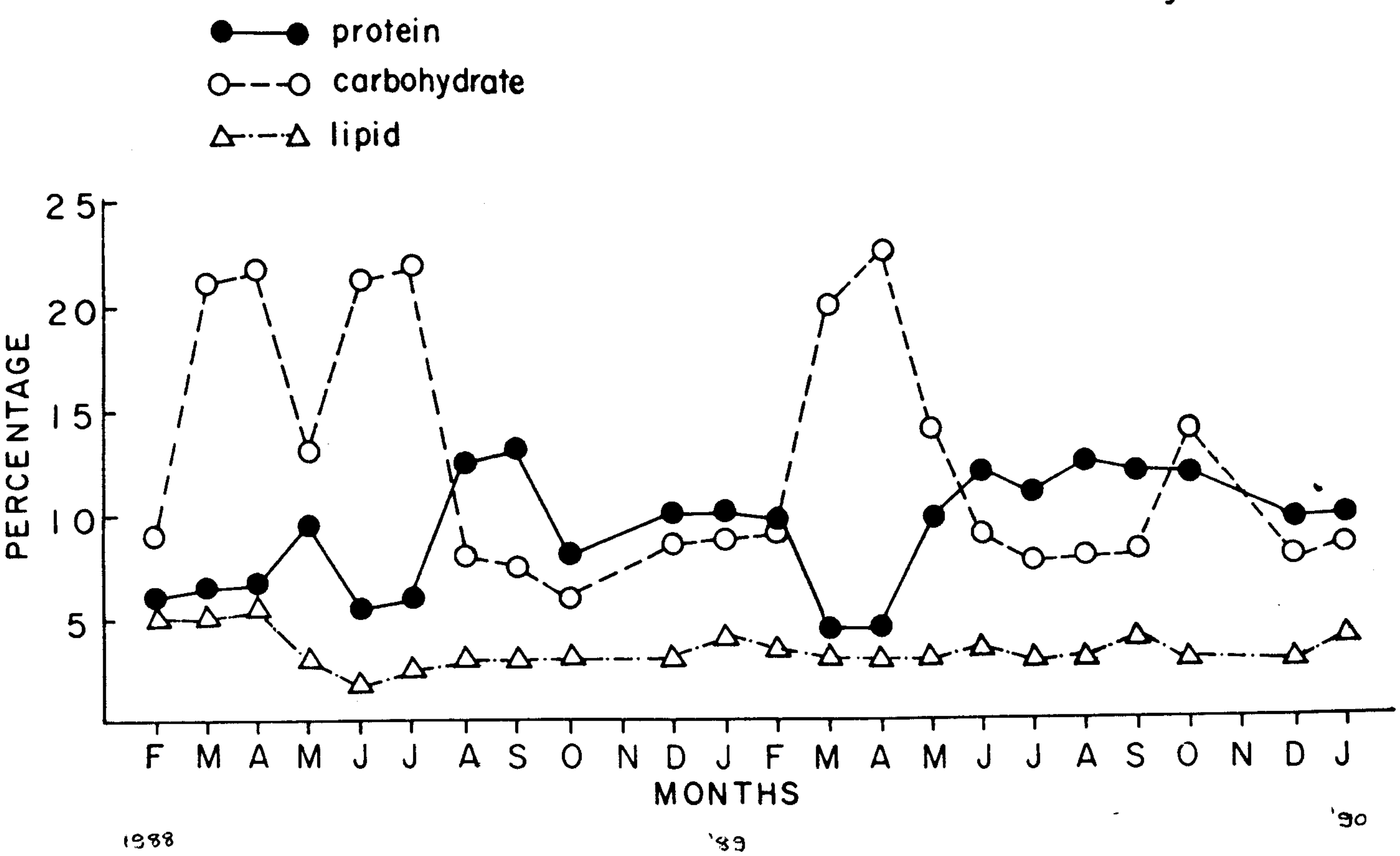


Table 59. Biochemical composition of some brown algae from Varkala

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	*Chnoospora minima*	1988	Oct.	9.60	11.50	4.00	54.24	47.73	37.60
2.	*Sargassum tenerrimum*	1989	Jan.	10.40	13.50	9.35	58.76	56.03	87.89
			Apr.	4.60	10.75	5.00	25.99	44.61	47.00
			AVERAGE	7.50	12.13	7.18	42.38	50.34	67.49
3.	*S. wightii*	1988	Sep.	8.00	12.50	6.00	45.20	51.88	56.40
		1989	Jan.	13.00	18.25	4.60	73.45	75.74	43.24
			Feb.	10.60	16.00	4.25	59.89	66.40	39.95
			AVERAGE	10.53	15.58	4.95	59.50	64.66	46.53
4.	*Turbinaria conoides*	1989	Jan.	9.40	13.50	0.15	53.11	56.03	1.41

Table 60. Biochemical composition of some red algae from Varkala

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	*Porphyra kanyakumariensis*	1989	Jun.	16.40	25.00	1.50	92.66	103.75	14.10
			Jul.	13.80	18.50	2.00	77.97	76.77	18.80
			Aug.	15.20	21.75	1.55	85.88	90.26	14.57
			AVERAGE	15.13	21.75	1.68	85.48	90.26	15.79
2.	*Grateloupia filicina*	1988	Feb.	6.90	30.00	5.20	38.99	124.50	48.88
3.	*G. lithophila*	1988	Feb.	7.00	30.00	0.90	39.55	124.50	8.46
			Mar.	6.50	16.80	0.90	36.73	69.72	8.46
			May	6.50	15.00	1.20	36.73	62.25	11.28
			Aug.	5.50	17.00	1.50	31.08	70.55	14.10
			Dec.	7.00	30.00	1.50	39.55	124.50	14.10
		1989	Jan.	8.40	31.25	1.75	47.46	129.69	16.45
			Mar.	6.20	16.25	1.00	35.03	67.44	9.40
			Apr.	3.20	27.50	1.60	18.08	114.13	15.04
			May	6.00	13.87	1.30	33.90	57.56	12.22
			Jun.	6.00	16.00	1.20	33.90	66.40	11.28
			Dec.	8.00	28.00	1.90	45.20	116.20	17.86
		1990	Jan.	8.00	29.50	1.75	45.20	122.43	16.45
			AVERAGE	6.53	22.60	1.38	36.89	93.79	12.97

Table 60. (Contd...)

Sl. No.	Name of alga	Year	Month of collection	Percentage of Protein	Percentage of Carbohydrate	Percentage of Lipid	Calorific value of Protein	Calorific value of Carbohydrate	Calorific value of Lipid
4.	Hypnea valentiae	1989	Feb.	12.20	14.50	2.65	68.93	60.18	24.91
5.	Gracilaria corticata	1988	Jul.	9.00	15.00	1.50	50.85	62.25	14.10
		1989	Feb.	7.60	24.50	1.75	42.94	101.68	16.45
			AVERAGE	8.30	19.75	1.63	46.89	81.96	15.32
6.	G. foliifera	1988	Feb.	7.20	23.50	1.50	40.68	97.53	14.10

VARIATION IN BIOCHEMICAL COMPOSITION OF *GRATELOUPIA LITHOPHILA* FROM VARKALA

Fig. 16

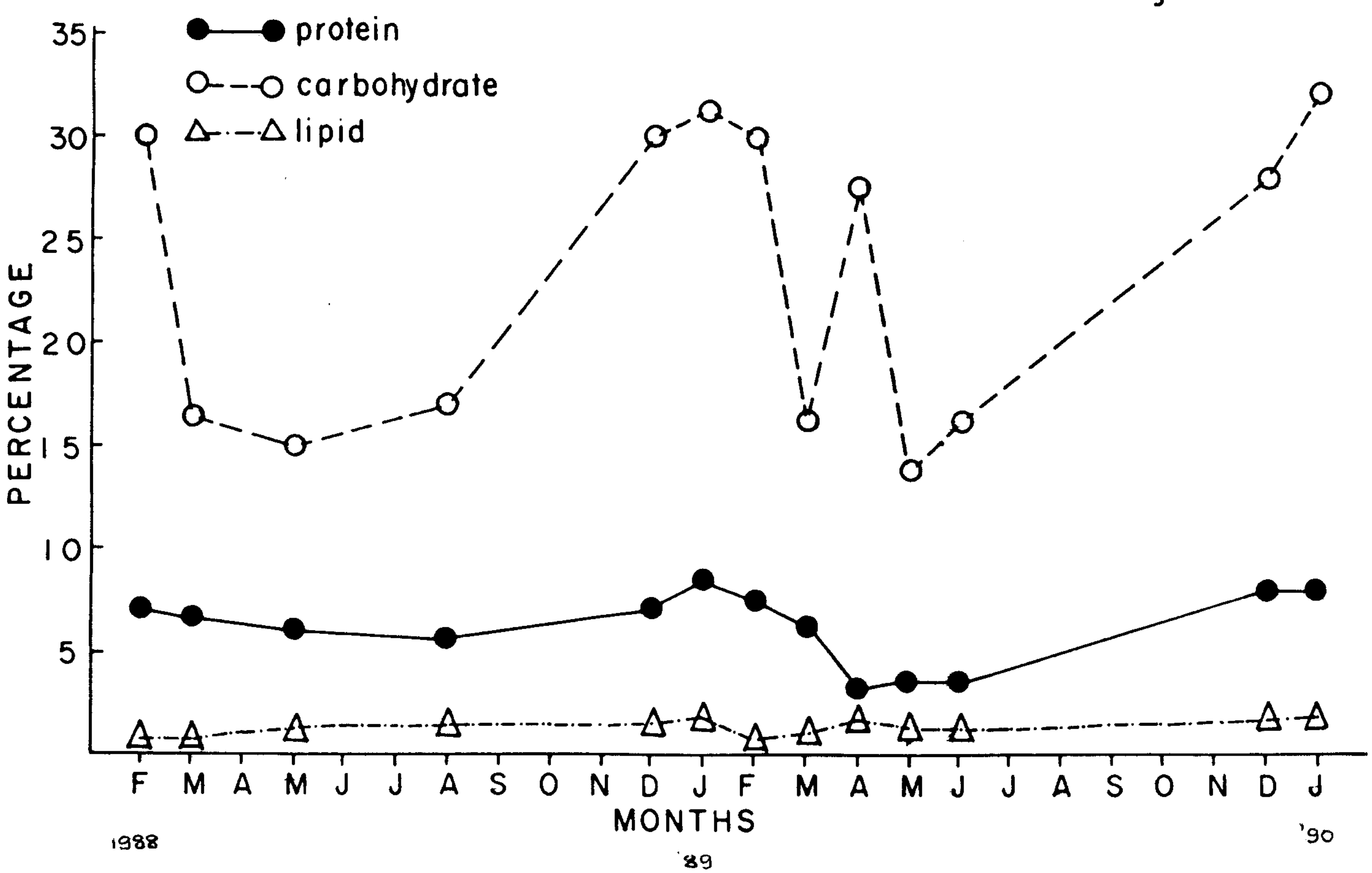


Table 61. Biochemical composition of different divisions of algae at Varkala

Algal division	% Biochemical composition			Calorific value of		
	Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
Green Algae	8.87	19.17	2.94	50.12	79.56	27.64
Brown Algae	9.37	13.71	4.76	52.94	56.90	44.74
Red Algae	8.33	22.20	1.71	47.06	92.13	16.07

At Varkala,

Brown algae recorded the highest protein content followed by green algae. Red algae recorded the lowest protein content.

Red algae recorded the highest carbohydrate content followed by green algae. Brown algae recorded the lowest carbohydrate content.

Brown algae recorded the highest lipid content followed by green algae. Red algae recorded the lowest lipid content.

5.1.3 Biochemical composition of some seaweeds from Elathur (Tables 62-65 and Figs. 17-20)

At Elathur among green algae

Ulva fasciata (December 1988) and U. lactuca (December 1988, November 1989 and December 1989) recorded the highest protein content of 16% and Chaetomorpha antennina (July 1988) recorded the lowest of 3%.

Caulerpa sertularioides (February 1989) recorded the highest carhohydrate content of 47% and Chaetomorpha antennina (January 1990) the lowest of 5.9%.

Caulerpa sertularioides (January 1990) recorded the highest lipid content of 12% and Ulva lactuca (September 1988) the lowest 1.5%.

Among brown algae

Padina tetrastromatica (February 1989) recorded the highest protein content of 19.4% and Dictyota dichotoma (January 1989) the lowest of 10.6%.

Padina tetrastromatica (February 1989) recorded the highest carbohydrate content of 13.5% and P. gymnospora (January 1989) the lowest of 9.75%.

Padina tetrastromatica (February 1989) recorded the highest lipid content of 8.35% and P. gymnsopora (January 1989) the lowest of 3.6%.

Among red algae,

Grateloupia lithophila (July 1989) recorded the highest protein content of 14.4% and Gigartina acicularis (April 1989) the lowest of 3.3%.

Grateloupia lithophila (March 1989) recorded the highest carbohydrate content of 45% and Gracilaria corticata (April 1988) the lowest of 13%.

Gelidiopsis variabilis (April 1989) recorded the highest lipid content of 4% and Gigartina acicularis (January 1989) the lowest of 0.55%.

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	*Ulva fasciata*	1988	Feb.	12.90	30.00	4.00	72.89	124.50	37.60
			Dec.	16.00	27.00	2.40	90.40	112.05	22.56
		1989	Feb.	13.80	32.00	4.30	77.97	132.80	40.42
			Mar.	9.90	23.00	4.37	55.94	95.45	41.08
		1989	Aug.	14.40	18.50	2.20	81.36	76.78	20.68
			Sep.	13.00	20.00	2.80	73.45	83.00	26.32
			Dec.	15.00	25.00	4.30	84.75	103.75	40.42
		1990	Jan.	12.00	29.00	4.00	67.80	120.35	37.60
			AVERAGE	13.38	25.56	3.55	75.60	106.08	33.37
2.	*U. lactuca*	1988	Feb.	14.00	22.00	2.50	79.10	91.30	23.50
			Aug.	14.40	21.00	2.05	81.36	87.15	19.27
			Sep.	13.80	25.00	1.50	77. 97	103.75	14.10
			Nov.	15.00	30.00	1.90	84.75	124.50	17.86
			Dec.	16.00	35.00	2.87	90.40	145.25	26.98
		1989	Jul.	14.40	18.50	2.00	81.36	76.78	18.80
			Aug.	13.50	19.00	2.50	76.28	78.85	23.50
			Nov.	16.00	19.00	2.10	90.40	78.85	19.74
			Dec.	16.00	34.00	2.80	90.40	141.10	26.32
		1990	Jan.	13.50	21.00	2.10	76.28	87.15	19.74
			AVERAGE	14.66	24.45	2.23	82.83	101.47	20.96

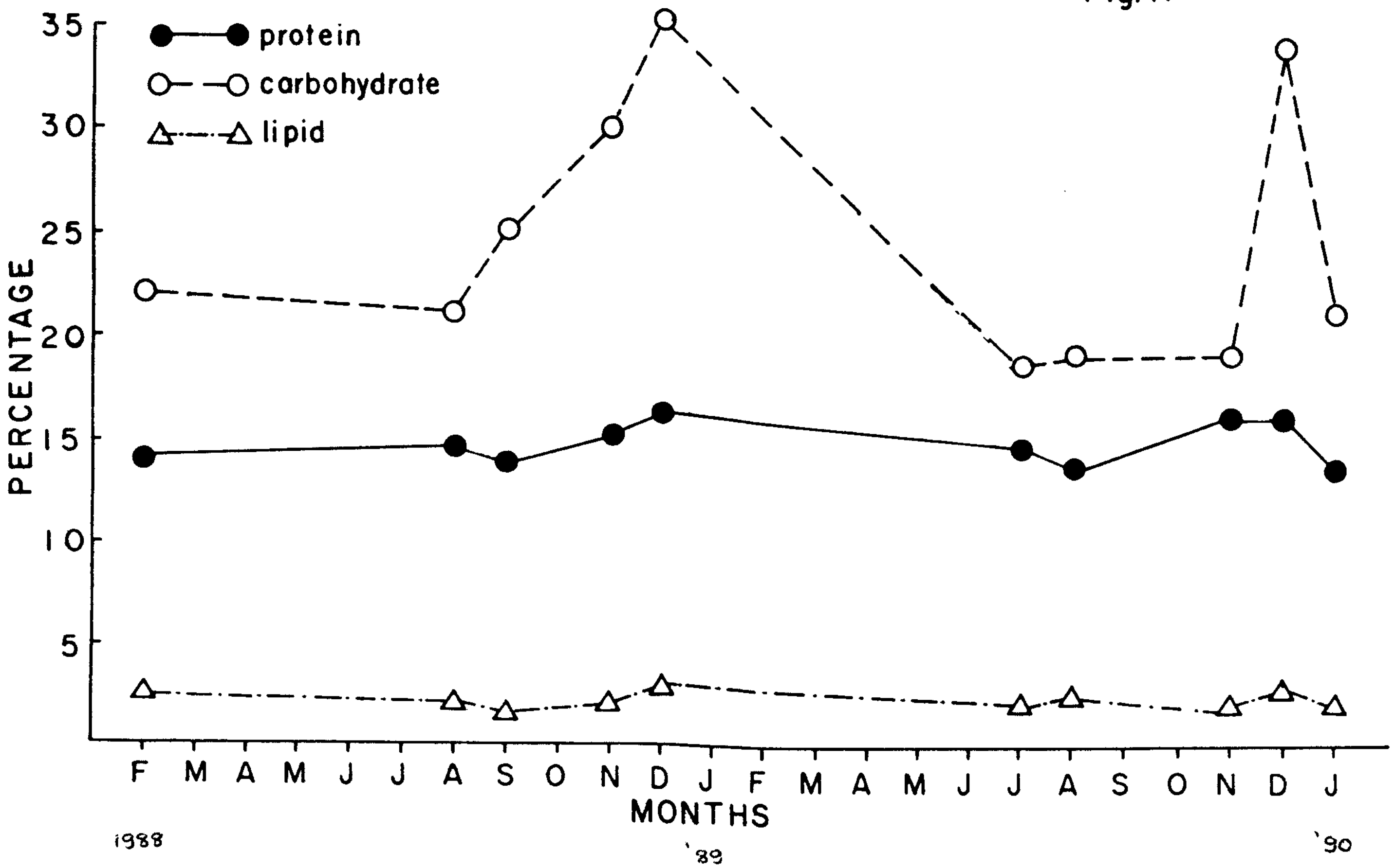
Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
3.	<u>Chaetomorpha antennina</u>	1988	Feb.	4.90	6.00	2.00	27.69	24.90	18.80
			Mar.	5.00	6.50	2.10	28.25	26.98	19.74
			Apr.	5.00	7.00	2.00	28.25	29.05	18.80
			Jul.	3.00	8.00	1.90	16.95	33.20	17.86
			Aug.	14.50	8.00	2.50	81.93	33.20	23.50
			Sep.	13.90	7.00	1.90	78.54	29.05	17.86
			Oct.	13.00	7.50	2.10	73.45	31.13	19.74
		1989	Apr.	5.10	7.50	2.80	28.82	31.13	26.32
			May	10.00	9.25	2.00	56.50	38.39	18.80
			Jun.	10.80	8.75	2.85	61.02	36.31	26.79
			Jul.	9.90	8.50	2.50	55.94	35.28	23.50
			Aug.	13.20	8.00	2.20	74.58	33.20	20.68
			Sep.	14.50	6.00	2.10	81.93	24.90	19.74
			Oct.	12.50	7.50	2.10	70.63	31.13	19.74
		1990	Jan.	4.00	5.90	2.80	22.60	24.49	26.32
			AVERAGE	9.29	7.43	2.26	52.49	30.83	21.24
4.	<u>Cladophora fascicularis</u>	1988	Oct.	11.30	10.84	5.45	63.85	44.99	51.23
5.	<u>Cladophora</u> sp.	1988	Sep.	10.60	18.00	5.00	59.89	74.70	47.00

Table 62 (Contd...)

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
6.	Caulerpa sertularioides	1988	Feb.	5.90	35.00	9.00	33.34	145.25	84.60
		1989	Jan.	11.00	38.00	11.75	62.15	157.70	110.45
			Feb.	10.00	47.00	10.00	56.50	195.05	94.00
			Mar.	5.90	25.00	4.80	33.34	103.75	45.12
			May	11.00	29.00	5.05	62.15	120.35	47.47
		1990	Jan.	11.00	37.00	12.00	62.15	153.55	112.80
			AVERAGE	9.13	35.17	8.77	51.58	145.96	82.44

VARIATION IN BIOCHEMICAL COMPOSITION OF *ULVA LACTUCA* FROM ELATHUR

Fig. 17



VARIATION IN BIOCHEMICAL COMPOSITION OF *CHAETOMORPHA ANTENNINA* FROM ELATHUR

Fig. 18

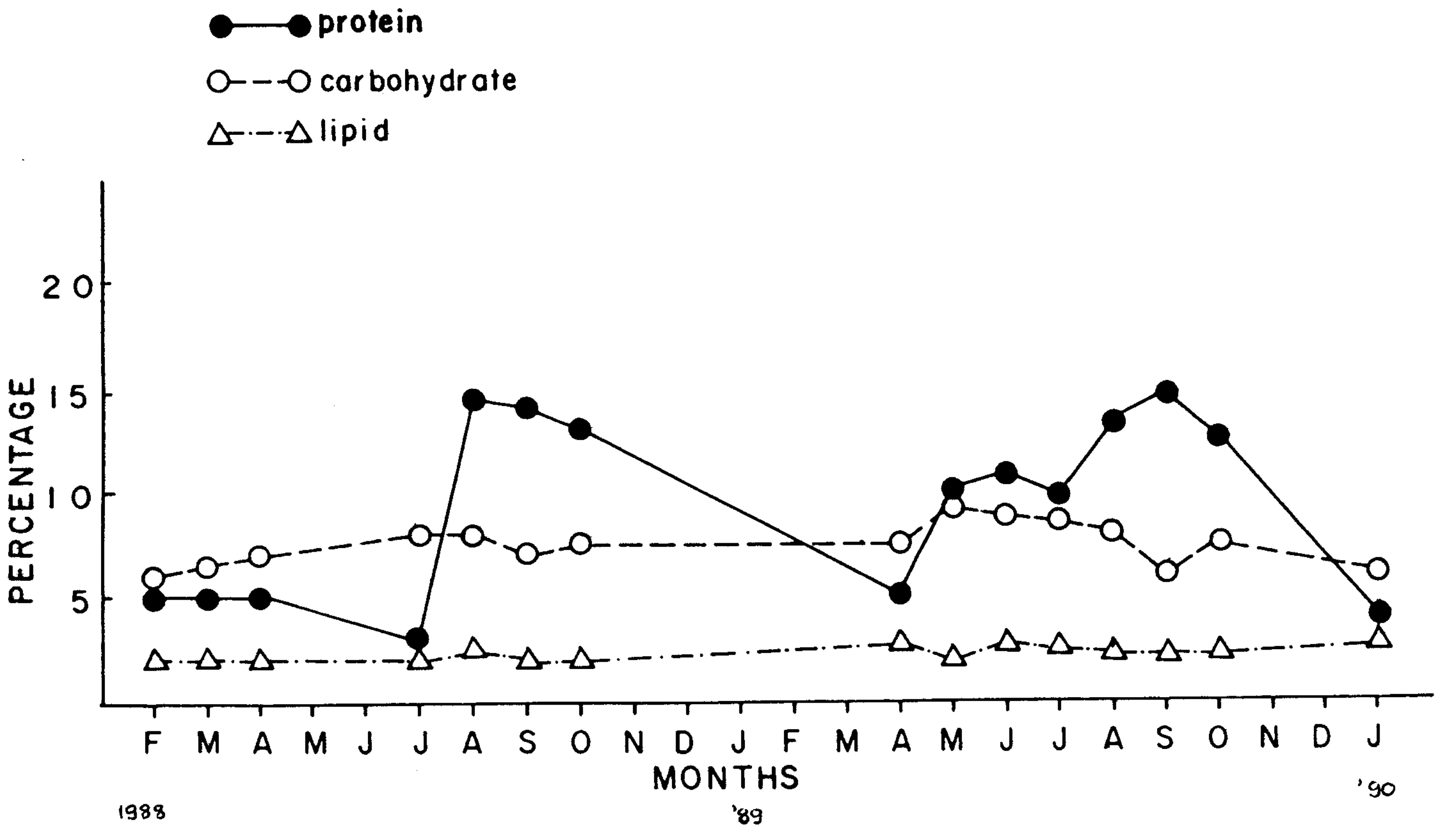


Table 63. Biochemical composition of some brown algae from Elathur

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Dictyota dichotoma	1989	Jan.	10.60	10.25	5.50	59.89	42.54	51.70
2.	Padina gymnospora	1989	Jan.	12.20	9.75	3.60	68.93	40.46	33.84
3.	P. tetrastromatica	1989	Feb.	19.40	13.50	8.35	109.61	56.03	78.49

Table 64. Biochemical composition of some red algae from Elathur

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Gelidium pusillum	1988	Nov.	7.20	25.75	1.75	40.68	106.86	16.45
2.	Grateloupia lithophila	1988	Feb.	13.00	34.00	2.00	73.45	141.10	18.80
			Mar.	7.00	40.00	3.10	39.55	166.00	29.14
			Apr.	9.00	15.80	3.00	50.85	65.57	28.20
			Jul.	11.00	19.00	2.80	62.15	78.85	26.32
			Aug.	12.50	22.00	1.90	70.63	91.30	17.86
			Sep.	13.00	25.00	2.00	73.45	103.75	18.80
		1989	Feb.	13.60	36.00	2.70	76.84	149.40	25.38
			Mar.	6.30	45.00	3.37	35.59	186.75	31.68
			Apr.	8.90	18.50	2.80	50.29	76.78	26.32
			May	13.00	21.50	2.50	73.45	89.23	23.50
			Jul.	14.40	18.50	2.20	81.36	76.78	20.68
			Aug.	13.20	23.70	2.00	74.58	98.36	18.80
			Sep.	14.00	21.00	2.00	79.10	87.15	18.80
		1990	Jan.	12.00	21.00	2.10	67.80	87.15	19.74
			AVERAGE	11.49	25.78	2.46	64.92	107.00	23.12
3.	Gracilaria corticata	1988	Feb.	5.00	17.00	1.90	28.25	70.55	17.86
			Mar.	5.00	14.50	2.00	28.25	60.18	18.80
			Apr.	5.60	13.00	2.00	31.64	53.95	18.80

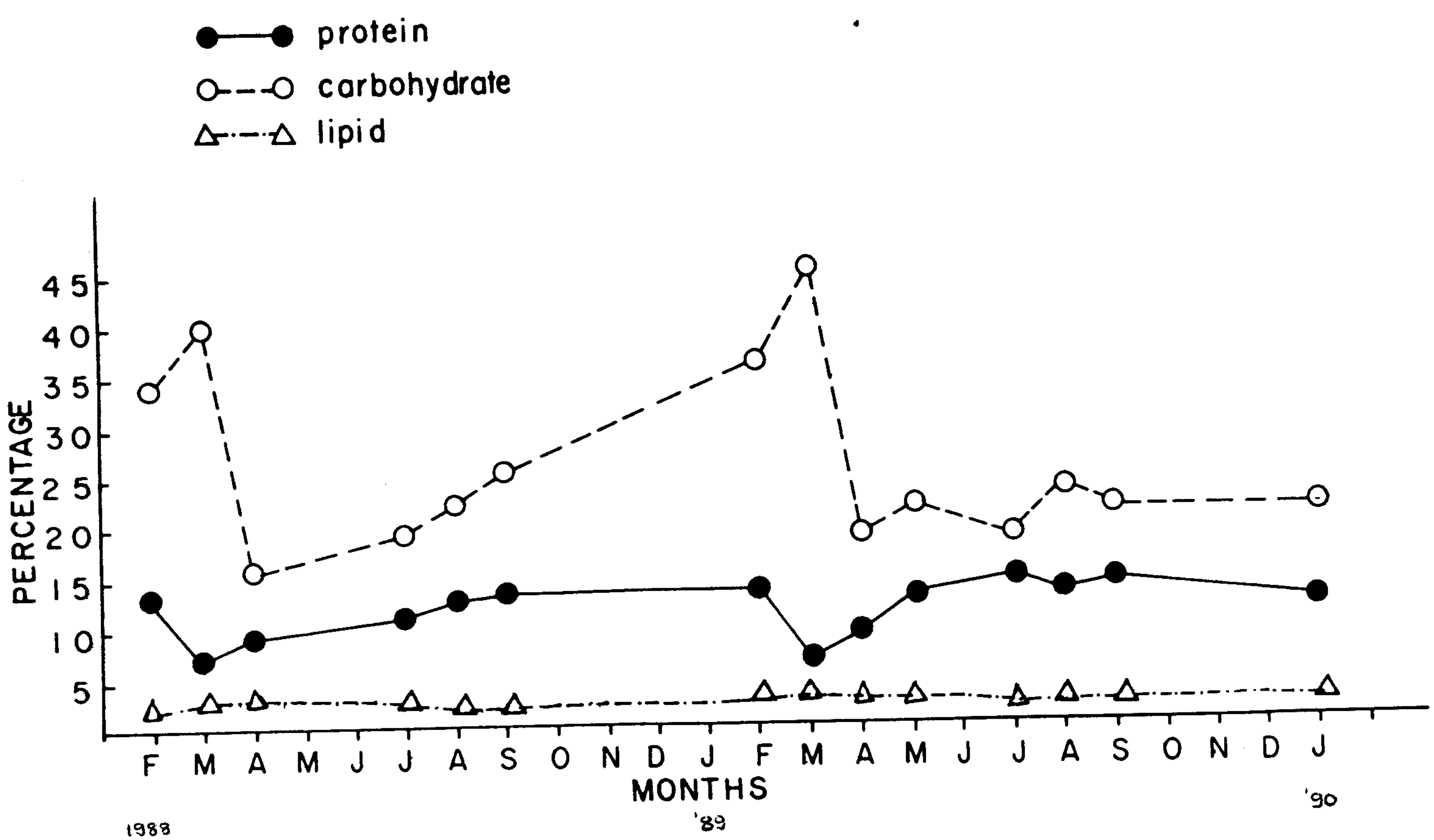
Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	Gracilaria corticata	1988	May	9.80	15.00	1.50	55.37	62.25	14.10
			Jun.	12.80	20.00	2.10	72.32	83.00	19.74
			Jul.	11.00	15.00	2.10	62.15	62.25	19.74
			Sep.	12.00	15.00	2.00	67.80	62.25	18.80
			Nov.	10.30	27.00	1.75	58.19	112.05	16.45
			Dec.	10.60	29.25	2.75	59.89	121.39	25.85
		1989	Feb.	5.00	17.00	2.10	28.25	70.55	19.74
			Mar.	5.70	18.00	2.40	32.21	74.70	22.56
			Apr.	6.50	18.00	1.90	36.73	74.70	17.86
			May	10.80	20.00	2.50	61.02	83.00	23.50
			Jun.	13.80	21.75	2.45	77.97	90.26	23.03
			Jul.	11.60	16.25	2.45	65.54	67.44	23.03
			Sep.	11.30	14.00	2.00	63.85	58.10	18.80
			Nov.	9.90	25.00	1.80	55.94	103.75	16.92
			Dec.	10.00	28.00	2.00	56.50	116.20	18.80
		1990	Jan.	10.00	20.00	2.10	56.50	83.00	19.74
			AVERAGE	9.30	19.14	2.09	52.55	79.43	19.65
4.	G. foliifera	1988	Dec.	10.60	28.25	2.80	59.89	117.24	26.32
5.	Gelidiopsis variabilis	1989	Jan.	9.80	22.50	0.85	55.37	93.38	7.99

Table 64 (Contd...)

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	Gelidiopsis variabilis	1989	Feb.	11.00	29.00	3.00	62.15	120.35	28.20
			Mar.	5.50	22.25	3.00	31.08	92.34	28.20
			Apr.	6.30	18.75	4.00	35.59	77.81	37.60
			Nov.	5.50	22.25	3.00	31.08	92.34	28.20
			AVERAGE	7.62	22.95	2.77	43.05	95.24	26.04
6.	Gigartina acicularis	1989	Jan.	10.40	32.50	0.55	58.76	134.88	5.17
			Apr.	3.30	27.00	1.20	18.65	112.05	11.28
			May	8.20	15.75	2.00	46.33	65.36	18.80
			AVERAGE	7.30	25.08	1.25	41.25	104.08	11.75

VARIATION IN BIOCHEMICAL COMPOSITION OF *GRATELOUPIA LITHOPHILA* FROM ELATHUR

Fig.19



VARIATION IN BIOCHEMICAL COMPOSITION OF *GRACILARIA CORTICATA* FROM ELATHUR

Fig.20

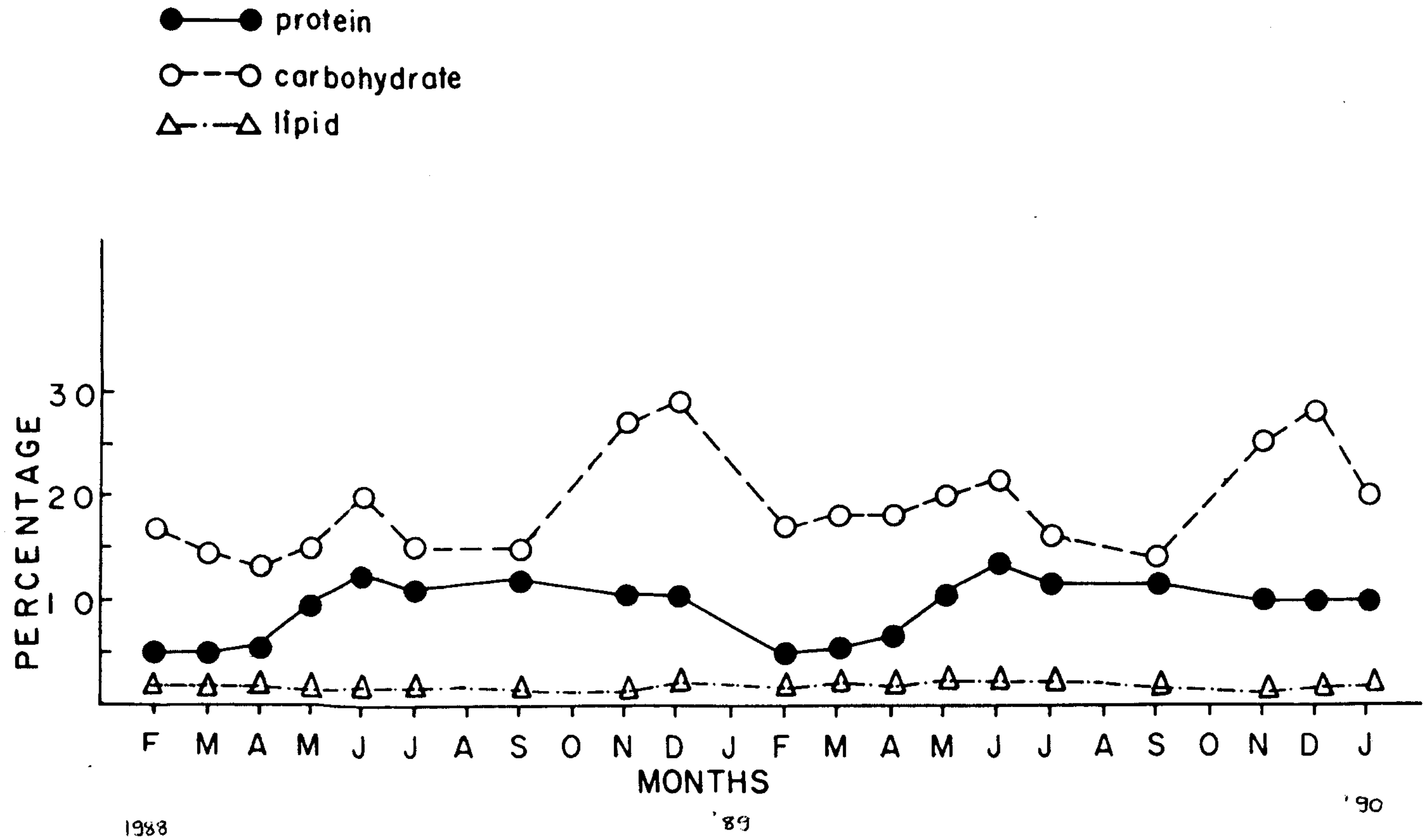


Table 65. Biochemical composition of different divisions of algae at Elathur

Algal Division	% Biochemical composition			Calorific value of		
	Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
Green Algae	11.45	19.52	3.60	64.70	81.00	33.84
Brown Algae	14.06	11.17	5.82	79.44	46.36	54.71
Red Algae	9.66	22.53	2.24	54.58	93.49	21.06

At Elathur

Brown algae recorded the highest protein content followed by green algae. Red algae recorded the lowest protein content.

Red algae recorded the highest carbohydrate content followed by green algae. Brown algae recorded the lowest carbohydrate content.

Brown algae recorded the highest lipid content followed by green algae. Red algae recorded the lowest lipid content.

5.1.4 Biochemical composition of some seaweeds from Thikkotti (Tables 66-69 and Figs. 21-23)

At Thikkotti, among green algae

Caulerpa fastigiata (February 1989) recorded the highest protein content of 20% and C. sertularioides (April 1989) the lowest of 4.1%.

Caulerpa peltata (February 1989) recorded the highest carbohydrate content of 69% and Cladophora glomerata (May 1989) the lowest of 5.5%.

Caulerpa sertularioides (April 1989) recorded the highest lipid content of 18.75% and Spongomorpha indica (July 1989) the lowest of 1.03%.

Among brown algae,

Padina tetrastromatica (February 1989) recorded the highest protein content of 18% and Dictyota dichotoma (March 1989) the lowest of 5.2%.

Spathoglossum asperum (January 1989) recorded the highest carbohydrate content of 17.75% and Padina tetrastromatica (March 1989) the lowest of 6.25%.

Dictyota dichotoma (February 1989) recorded the highest lipid content of 11.3% and Padina tetrastromatica (March 1989) the lowest of 4.1%.

Among red algae,

Hypnea musciformis (November 1988) recorded the highest protein content of 14.2% and Gracilaria corticata (September 1988) the lowest of 7%.

Gracilaria corticata (February 1989) recorded the highest carbohydrate content of 31.5% and Bostrychia tenella (October 1988) the lowest of 12%.

Laurencia sp (January 1989) and Acanthophora spicifera (April 1989) recorded the highest lipid content of 3.3% and Gelidiopsis variabilis (November 1988) the lowest of 0.8%.

Table 66. Biochemical composition of some green algae from Thikkotti

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Chaetomorpha linum	1989	Jan.	13.00	19.00	3.60	73.45	78.85	33.84
			Feb.	12.50	17.25	4.00	70.63	71.59	37.60
			AVERAGE	12.75	18.13	3.80	72.04	75.24	35.72
2.	Spongomorpha indica	1989	Jun.	12.60	7.25	2.50	71.19	30.09	23.50
			Jul.	11.00	8.12	1.03	62.15	33.69	9.68
			Aug.	14.40	7.80	1.50	81.36	32.37	14.10
			AVERAGE	12.66	7.72	1.68	71.53	32.04	15.79
3.	Cladophora glomerata	1988	Feb.	12.00	8.00	5.60	67.80	33.20	52.64
			Dec.	17.20	14.50	7.05	97.18	60.18	66.27
		1989	Jan.	12.20	12.00	7.05	68.93	49.80	66.27
			Feb.	13.60	9.00	7.10	76.84	37.35	66.74
			Mar.	4.90	12.00	9.60	27.69	49.80	90.24
			Apr.	4.50	11.25	3.90	25.43	46.69	36.66
			May	12.60	5.50	3.50	71.19	22.83	32.90
			Jun.	14.40	8.75	5.05	81.36	36.31	47.47
			Jul.	14.00	8.00	9.10	79.10	33.20	85.54
			Dec.	16.90	13.00	6.80	95.49	53.95	63.92
		1990	Jan.	12.00	10.00	6.80	67.80	41.50	63.92
			AVERAGE	12.21	10.18	6.50	68.99	42.25	61.10

Table 66. (Contd...)

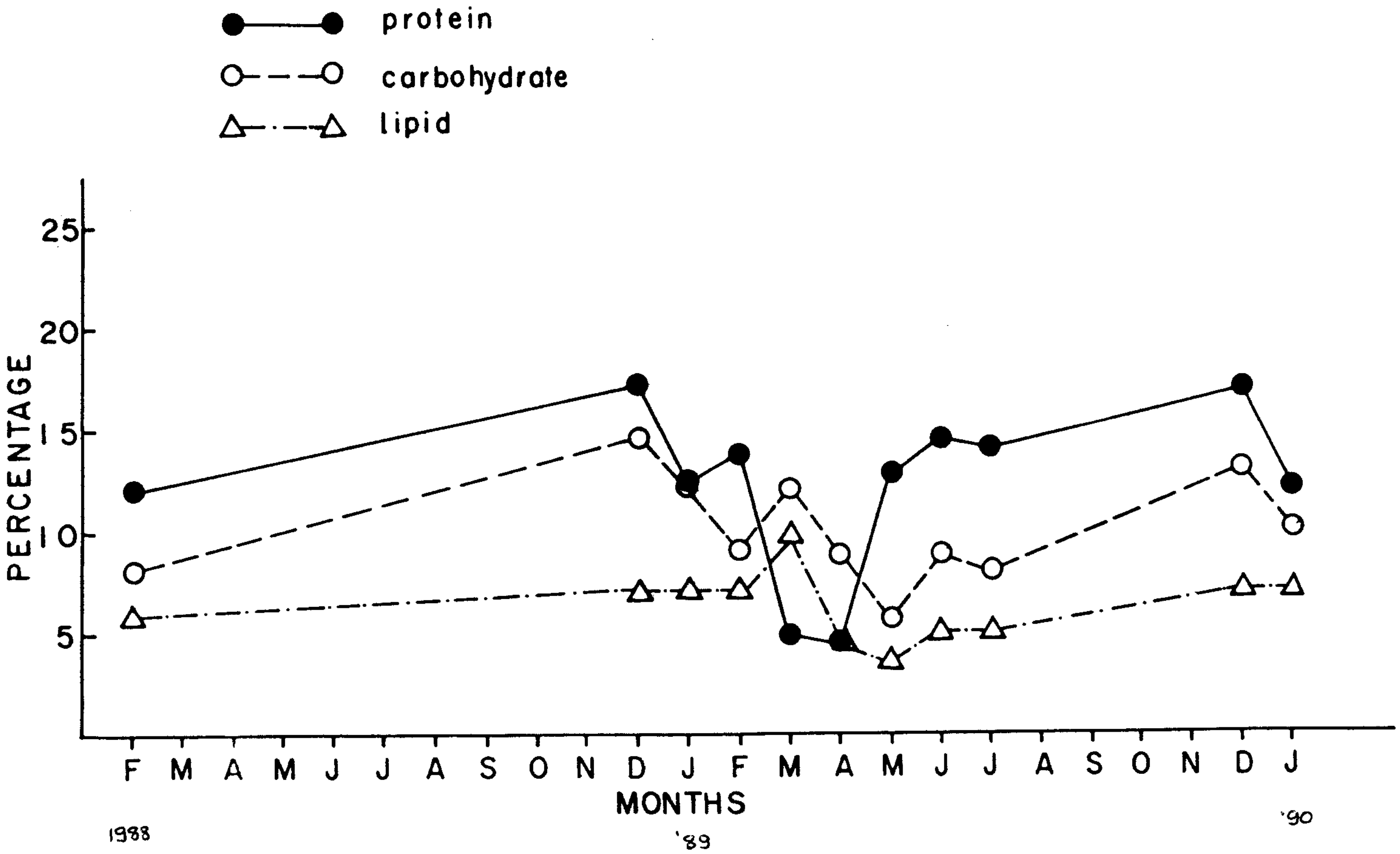
Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
4.	Caulerpa peltata	1989	Jan.	12.40	63.00	6.45	70.06	261.45	60.63
			Feb.	13.60	69.00	6.45	76.84	286.35	60.63
			Mar.	8.60	34.50	4.25	48.59	143.18	39.95
			Apr.	5.50	33.00	4.70	31.08	136.95	44.18
			May	12.00	42.00	2.25	67.80	174.30	21.15
			AVERAGE	10.42	48.30	4.82	58.87	200.45	45.31
5.	C. fastigiata	1989	Jan.	15.00	53.00	5.85	84.75	219.95	54.99
			Feb.	20.00	62.00	11.10	113.00	257.30	104.34
			AVERAGE	17.50	57.50	8.48	98.88	238.63	79.71
6.	C. sertularioides	1988	Feb.	8.40	50.00	11.00	47.46	207.50	103.40
			Mar.	6.80	39.00	10.75	38.42	161.85	101.05
			Apr.	7.40	40.00	10.10	41.81	166.00	94.94
			May	10.00	25.00	4.50	56.50	103.75	42.30
			Jun.	11.00	26.00	3.60	62.15	107.90	33.84
			Nov.	10.80	60.50	12.00	61.02	251.08	112.80
			Dec.	13.40	42.50	6.40	75.71	175.38	60.16
			Jan.	7.40	48.00	9.60	41.81	199.20	90.24

Table 66. (Contd....)

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
	C. sertularioides	1989	Feb.	7.20	49.00	12.85	40.68	203.35	120.79
			Mar.	4.20	35.00	17.10	23.73	145.25	160.74
			Apr.	4.10	47.50	18.75	23.17	197.13	176.25
			May	11.80	29.00	5.05	66.67	120.35	47.47
			Nov.	10.50	55.00	11.00	59.33	228.25	103.40
			Dec.	12.50	40.00	5.70	70.63	166.00	53.58
		1990	Jan.	8.00	47.00	10.00	45.20	195.05	94.00
			AVERAGE	8.90	42.23	9.89	50.29	175.25	92.97
7.	*C. scalpelliformis*	1989	Jan.	11.60	67.00	7.45	65.54	278.05	70.03
			May	12.00	43.50	7.45	67.80	180.53	70.03
			AVERAGE	11.80	55.25	7.45	66.67	229.28	70.03

VARIATION IN BIOCHEMICAL COMPOSITION OF *CLADOPHORA GLOMERATA* FROM THIKKOTTI

Fig.21



VARIATION IN BIOCHEMICAL COMPOSITION OF *CAULERPA SERTULARIOIDES* FROM THIKKOTTI

Fig.22

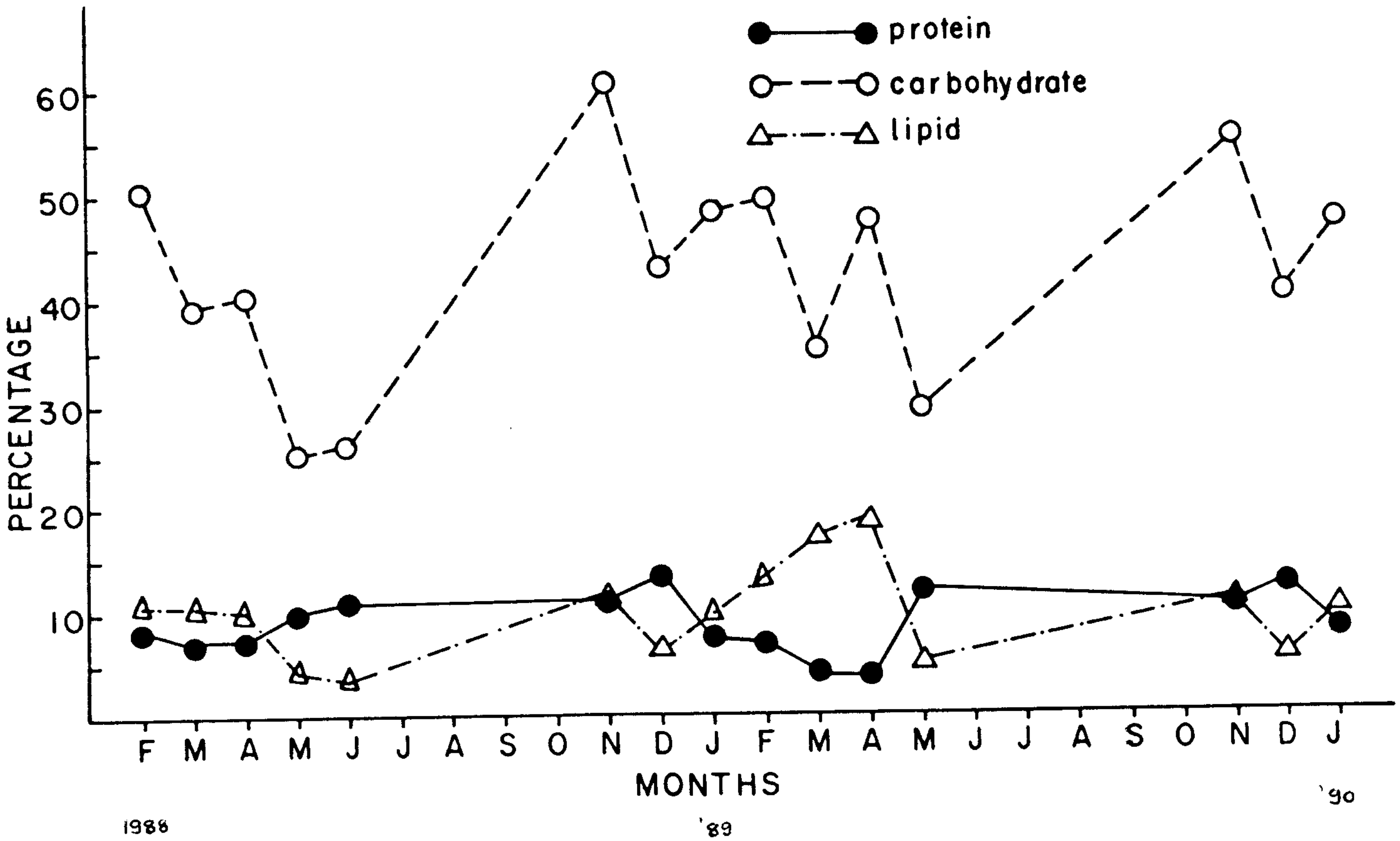


Table 67. Biochemical composition of some brown algae from Thikkotti

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Dictyota dichotoma	1988	Nov.	15.40	13.00	10.50	87.01	53.95	98.70
		1989	Jan.	8.20	10.00	8.00	46.33	41.50	75.20
			Feb.	10.00	9.25	11.30	56.50	38.39	106.22
			Mar.	5.20	6.62	5.35	29.38	27.47	50.29
			AVERAGE	9.70	9.72	8.79	54.81	40.34	82.63
2.	Padina tetrastromatica	1988	Nov.	16.60	13.25	5.55	93.79	54.99	52.17
			Feb.	18.00	13.75	6.35	101.70	57.06	59.69
			Mar.	8.20	6.25	4.10	46.33	25.94	38.54
			AVERAGE	14.27	11.08	5.33	80.63	45.98	50.10
3.	Spathoglossum asperum	1989	Jan.	11.20	17.75	8.65	63.28	73.66	81.31
			Feb.	13.80	15.50	10.50	77.97	64.33	98.70
			AVERAGE	12.50	16.63	9.58	70.63	68.99	90.05

Table 68. Biochemical composition of some red algae from Thikkotti

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Gelidium pusillum	1988	Nov.	7.20	25.75	1.75	40.68	106.86	16.45
2.	Hypnea musciformis	1988	Nov.	14.20	20.00	0.85	80.23	83.00	7.99
3.	Hypnea sp.	1989	Jan.	13.20	25.00	1.50	74.58	103.75	14.10
4.	Gracilaria corticata	1988	Feb.	10.00	29.00	0.90	56.50	120.35	8.46
			Mar.	10.00	15.00	0.90	56.50	62.25	8.46
			Sep.	7.00	13.00	0.85	39.55	53.95	7.99
			Oct.	8.50	20.00	0.90	48.03	83.00	8.46
			Nov.	8.00	22.00	1.10	45.20	91.30	10.34
		1989	Jan.	7.80	26.00	1.75	44.07	107.90	16.45
			Feb.	11.20	31.50	1.10	63.28	130.73	10.34
			Mar.	10.00	29.00	0.95	56.50	120.35	8.93
			Apr.	9.10	14.50	1.75	51.42	60.18	16.45
			May	8.90	13.00	1.10	50.29	53.95	10.34
			Nov.	7.80	20.00	1.20	44.07	83.00	11.28
		1990	Jan.	8.50	27.00	1.75	48.03	112.05	16.45
			AVERAGE	8.90	21.66	1.19	50.29	89.89	11.19

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
5.	Gelidiopsis variabilis	1988	Nov.	8.00	25.75	0.80	45.20	106.86	7.52
6.	Gigartina acicularis	1989	Jan.	7.80	26.00	0.85	44.07	107.90	7.99
			Feb.	9.20	26.50	2.05	51.98	109.98	19.27
			May	8.20	25.00	2.00	46.33	103.75	18.80
			Jun.	9.80	14.50	1.10	55.37	60.18	10.34
			Jul.	9.20	14.50	1.05	51.98	60.18	9.87
			AVERAGE	8.84	21.30	1.41	49.95	88.39	13.25
7.	Laurencia sp.	1989	Jan.	12.20	26.00	3.35	68.93	107.90	31.49
			Feb.	11.50	25.00	2.85	64.98	103.75	26.79
			AVERAGE	11.85	25.50	3.10	66.95	105.83	29.14
8.	Acanthophora spicifera	1988	Nov.	10.00	22.50	3.00	56.50	93.38	28.20
		1989	Jan.	9.00	19.50	2.05	50.85	80.93	19.27
			Feb.	10.25	20.00	2.50	57.91	83.00	23.50
			Apr.	8.30	18.00	3.30	46.89	74.70	31.08
			May	12.60	18.50	3.00	71.19	76.78	28.20
			AVERAGE	10.03	19.70	2.77	56.66	81.76	26.04
9.	Bostrychia tenella	1988	Oct.	10.60	12.00	2.00	59.89	49.80	18.80

VARIATION IN BIOCHEMICAL COMPOSITION OF *GRACILARIA CORTICATA* FROM THIKKOTTI

Fig.23

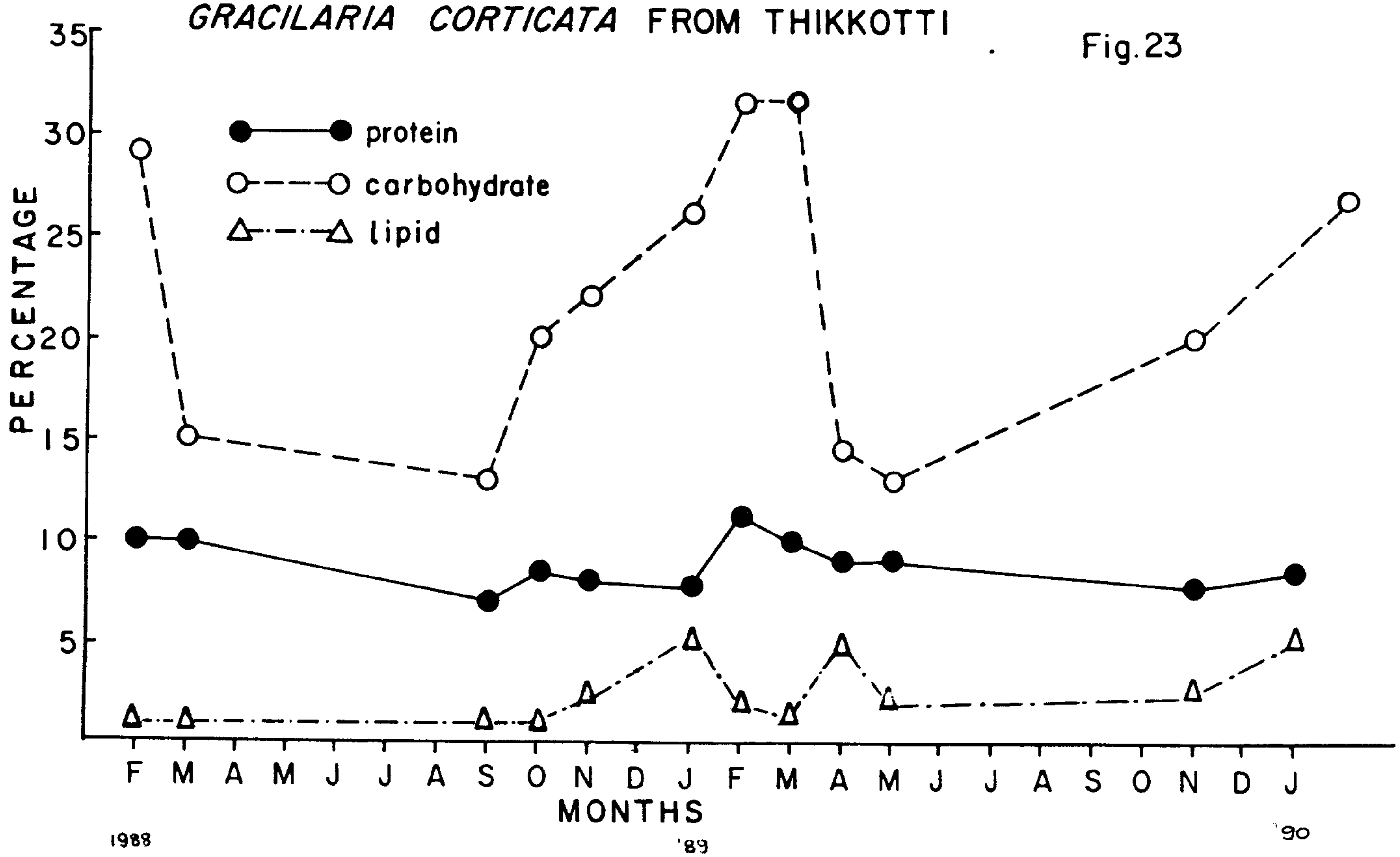


Table 69. Biochemical composition of different divisions of algae at Thikkotti

Algal Division	% Biochemical composition			Calorific value of		
	Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
Green Algae	11.05	31.79	7.21	62.43	131.93	67.77
Brown Algae	11.84	11.71	7.81	66.90	48.59	73.41
Red Algae	9.59	21.53	1.66	54.18	89.35	15.60

At Thikkotti,

Brown algae recorded the highest protein content followed by green algae. Red algae recorded the lowest protein content.

Green algae recorded the highest carbohydrate content followed by red algae. Brown algae recorded the lowest carbohydrate content.

Brown algae recorded the highest lipid content followed by green algae. Red algae recorded the lowest lipid content.

5.1.5 Biochemical composition of some seaweeds from Saudi (Tables 70-72 and Figs. 24-26).

At Saudi, among green algae,

Enteromorpha compressa (September 1988) recorded the highest protein content of 13% and Chaetomorpha antennina (March 1989) the lowest of 5.1%.

Enteromorpha compressa (August 1988) recorded the highest carbohydrate content of 27.75% and the same species in March 1988 and June 1988 recorded the lowest of 6.75%.

Chaetomorpha antennina (April 1988) recorded the highest lipid content of 7.35% and Enteromorpha compressa (April 1989 and December 1989) the lowest of 1.2%.

Among red algae,

Grateloupia filicina (November 1988) recorded the highest protein content of 18.6% and Centroceras clavulatum (June 1988) the lowest of 7.6%.

Grateloupia filicina (August 1988) recorded the highest carbohydrate content of 55% and Centroceras clavulatum (June 1988) the lowest of 14.25%.

Grateloupia filicina (May 1988) recorded the highest lipid content of 2.85% and G. filicina (November 1988) the lowest of 0.85%.

Table 70. Biochemical composition of some green algae from Saudi

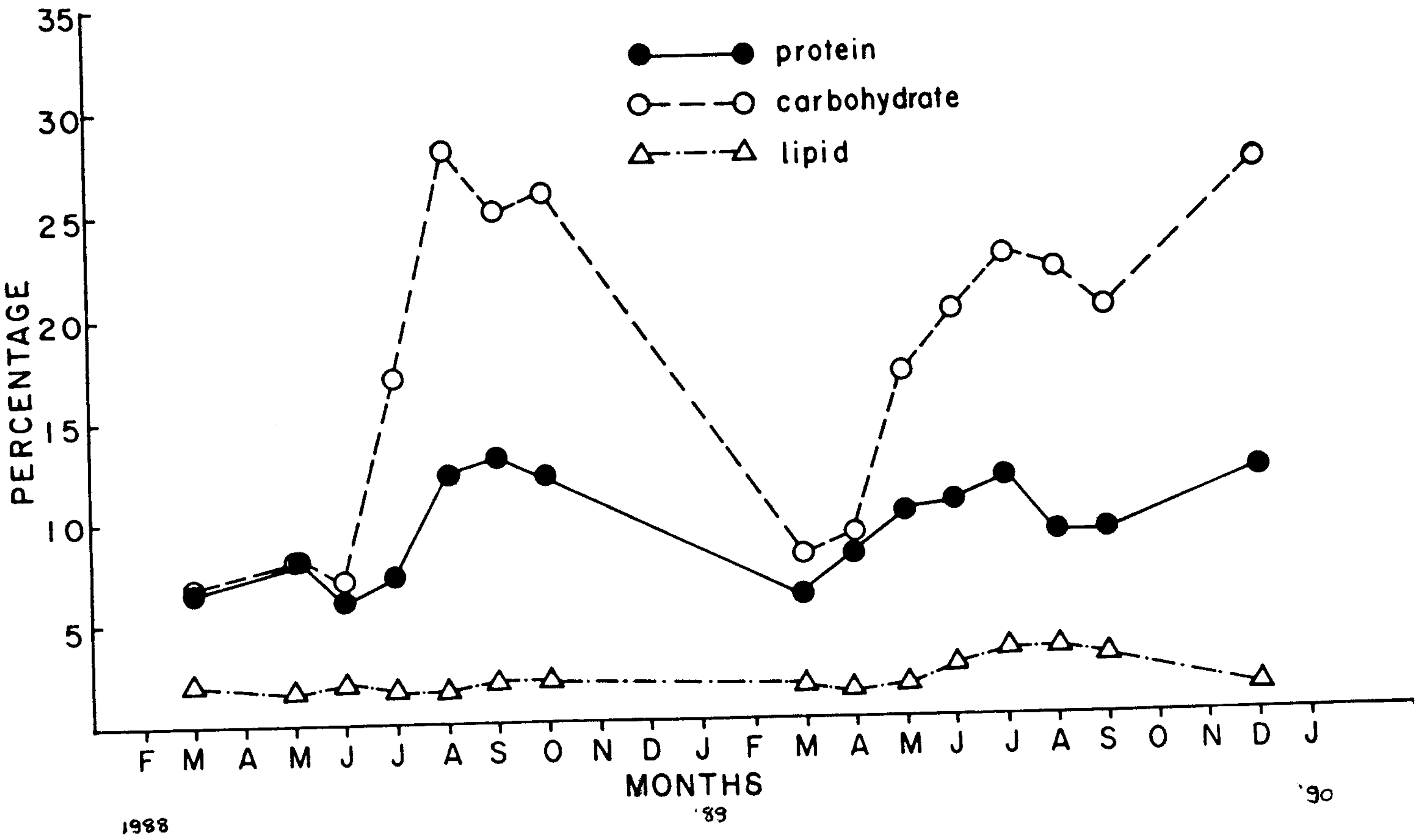
Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Enteromorpha compressa	1988	Mar.	6.50	6.75	2.00	36.73	28.01	18.80
			May	8.00	8.00	1.50	45.20	33.20	14.10
			Jun.	5.80	6.75	1.90	32.77	28.01	17.86
			Jul.	7.20	17.00	1.45	40.68	70.55	13.63
			Aug.	12.26	27.75	1.50	69.27	115.16	14.10
			Sep.	13.00	25.00	2.00	73.45	103.75	18.80
			Oct.	12.00	26.00	2.00	67.80	107.90	18.80
		1989	Mar.	5.90	8.00	1.50	33.33	33.20	14.10
			Apr.	8.00	9.00	1.20	45.20	37.35	11.28
			May	10.00	17.00	1.45	56.50	70.55	13.63
			Jun.	10.50	20.00	2.50	59.33	83.00	23.50
			Jul.	11.60	22.75	3.30	65.54	94.41	31.02
			Aug.	8.80	21.75	3.30	49.72	90.26	31.02
			Sep.	9.00	20.00	3.00	50.85	83.00	28.20
			Dec.	12.00	27.00	1.20	67.80	112.05	11.28
			AVERAGE	9.37	17.52	1.99	52.94	72.71	18.71
2.	Chaetomorpha antennina	1988	Jan.	8.90	14.00	3.50	50.29	58.10	32.90
			Feb.	9.40	15.00	4.00	53.11	62.25	37.60
			Mar.	9.00	13.50	7.10	50.85	56.02	66.74

Table 70. (Contd...)

Sl. No.	Name of alga	Year	Month of collection	Percentage of Protein	Percentage of Carbohydrate	Percentage of Lipid	Calorific value of Protein	Calorific value of Carbohydrate	Calorific value of Lipid
	Chaetomorpha antennina	1988	Apr.	7.40	13.00	7.35	41.81	53.95	69.09
			May	6.50	13.00	7.10	36.73	53.95	66.74
			Jun.	5.40	13.00	7.10	30.51	53.95	66.74
			Jul.	7.60	11.50	6.50	42.94	47.73	61.10
			Aug.	7.30	10.70	5.70	41.24	44.41	53.58
			Sep.	8.00	11.00	6.00	45.20	45.65	56.40
			Oct.	9.00	15.00	6.80	50.85	62.25	63.92
			Nov.	10.00	18.00	4.00	56.50	74.70	37.60
			Dec.	12.60	19.75	4.85	71.19	81.96	45.59
		1989	Jan.	12.60	21.50	6.15	71.19	89.23	57.81
			Feb.	10.00	16.50	4.00	56.50	68.48	37.60
			Mar.	5.10	10.00	2.50	28.82	41.50	23.50
			Apr.	9.90	10.25	2.30	55.94	42.54	21.62
			May	10.00	12.00	2.10	56.50	49.80	19.74
			Jun.	5.40	12.00	2.00	30.51	49.80	18.80
			Aug.	12.60	14.50	3.95	71.19	60.17	37.13
			Sep.	9.00	10.00	4.00	50.85	41.50	37.60
			Oct.	9.40	15.00	4.00	53.11	62.25	37.60
			Nov.	9.00	11.50	4.00	50.85	47.73	37.60
			Dec.	9.50	16.50	5.70	53.67	68.48	53.58
			AVERAGE	8.85	13.79	4.81	50.00	57.23	45.21

VARIATION IN BIOCHEMICAL COMPOSITION OF *ENTEROMORPHA COMPRESSA* FROM SAUDI

Fig. 24



VARIATION IN BIOCHEMICAL COMPOSITION OF *CHAETOMORPHA ANTENNINA* FROM SAUDI

Fig. 25

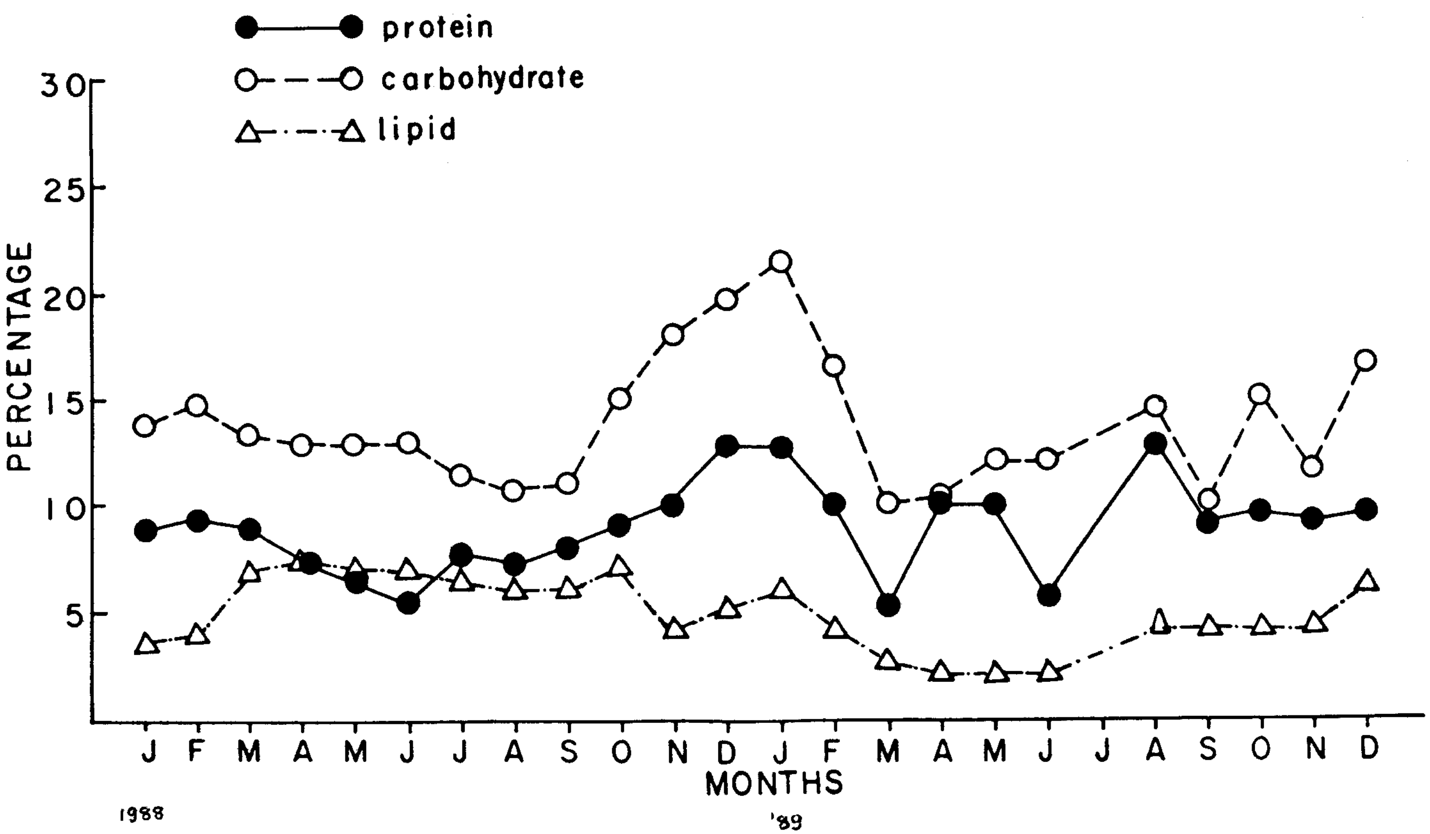


Table 71. **Biochemical composition of some red algae from Saudi**

Sl. No.	Name of alga	Year	Month of collection	Percentage of			Calorific value of		
				Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Grateloupia filicina	1988	Jan.	13.90	30.00	1.85	78.54	124.50	17.39
			Feb.	13.00	29.00	1.80	73.45	120.35	16.92
			Mar.	14.10	30.00	0.95	79.67	124.50	8.93
			May	14.10	31.50	2.85	79.67	130.73	26.79
			Aug.	13.25	55.00	2.00	74.86	228.25	18.80
			Sep.	11.00	28.00	1.90	62.15	116.20	17.86
			Oct.	10.60	27.50	1.80	59.89	114.13	16.92
			Nov.	18.60	32.25	0.85	105.09	133.84	7.99
			Dec.	17.00	31.00	1.50	96.05	128.65	14.10
		1989	Feb.	16.00	30.00	1.00	90.40	124.50	9.40
			Mar.	17.00	17.25	2.00	96.05	71.59	18.80
			Jul.	17.00	21.75	1.80	96.05	90.26	16.92
			AVERAGE	14.63	30.27	1.69	82.66	125.62	15.89
2.	G. lithophila	1988	Feb.	13.20	24.50	2.00	74.58	101.68	18.80
3.	Centraceras clavulatum	1989	Jan.	9.00	20.00	1.10	50.85	83.00	10.34
		1988	Jun.	7.60	14.25	1.50	42.94	59.14	14.10
			AVERAGE	8.30	17.13	1.30	46.89	71.09	12.22

VARIATION IN BIOCHEMICAL COMPOSITION OF *GRATELOUPIA FILICINA* FROM SAUDI

Fig. 26

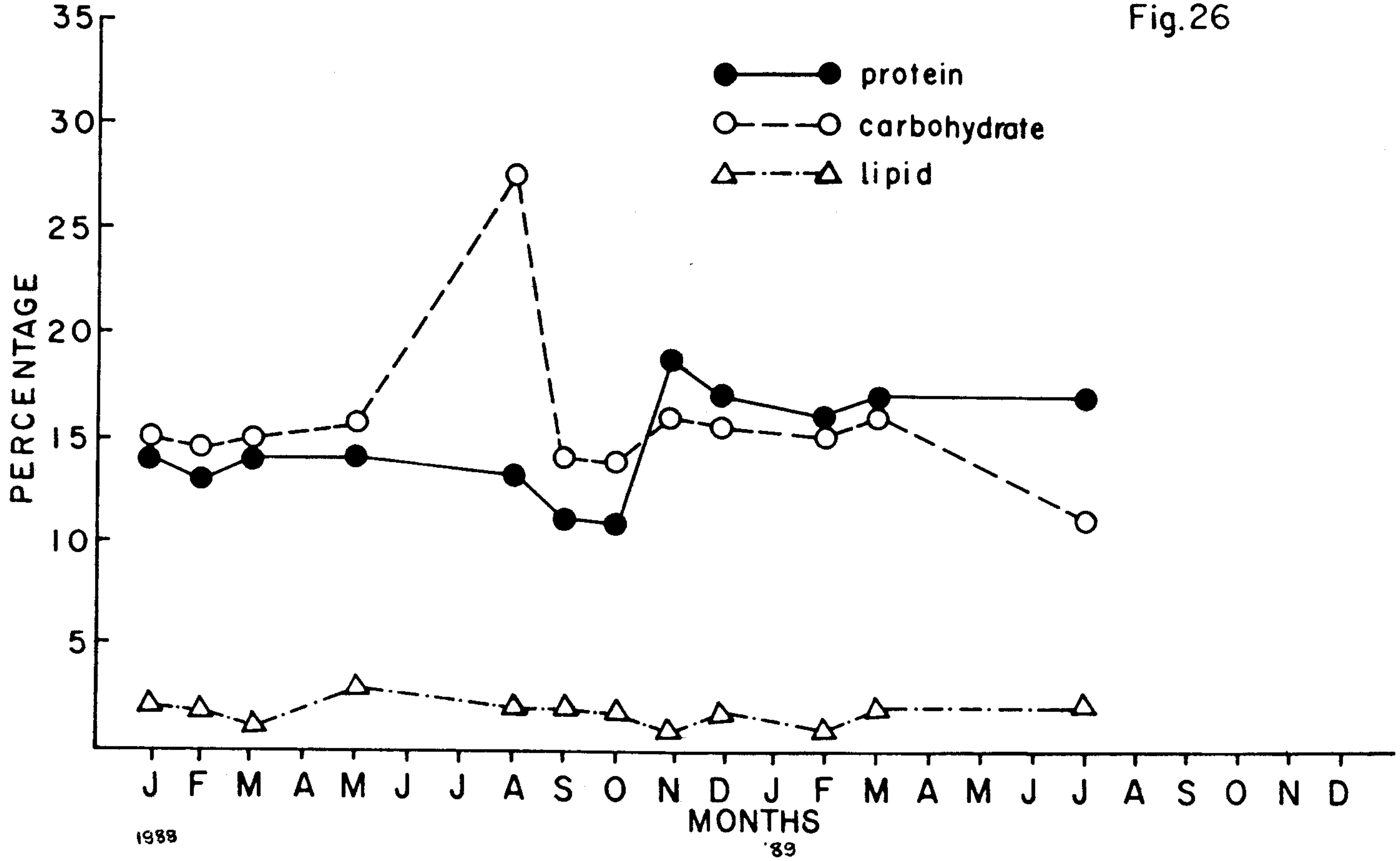


Table 72. Biochemical composition of different divisions of algae at Saudi

Algal Division	% Biochemical composition			Calorific value of		
	Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
Green Algae	9.06	15.26	3.70	51.19	63.33	34.78
Red Algae	13.69	28.13	1.66	77.35	116.74	15.60

At Saudi,

Red algae recorded more of protein and carbohydrate content than green algae.

Green algae recorded more of lipid content than red algae.

Table 73. Biochemical composition of green algae from different stations along Kerala coast

Sl. No.	Station	Percentage of			Calorific value of		
		Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Mullur	10.62	27.33	2.89	60.00	113.42	27.17
2.	Varkala	8.87	19.17	2.94	50.12	79.56	27.64
3.	Thikkotti	11.05	31.79	7.21	62.43	131.93	67.77
4.	Elathur	11.45	19.52	3.60	64.70	81.00	33.84
5.	Saudi	9.06	15.26	3.70	51.19	63.33	34.78
	Average	10.21	22.61	4.07	57.69	93.85	38.24

For green algae,

Elathur recorded the maximum protein content and Varkala the minimum. Carbohydrate and lipid contents were highest at Thikkotti. Saudi recorded the lowest carbohydrate content and Mullur the lowest lipid content.

Table 74. Biochemical composition of brown algae from different stations along Kerala coast

Sl. No.	Station	Percentage of			Calorific value of		
		Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Mullur	9.89	9.75	3.87	55.88	40.46	36.38
2.	Varkala	9.37	13.71	4.76	52.94	56.90	44.74
3.	Thikkotti	11.84	11.71	7.81	66.89	48.59	73.41
4.	Elathur	14.06	11.17	5.82	79.44	46.36	54.70
	AVERAGE	11.29	11.59	5.57	63.78	48.08	52.31

For brown algae,

Elathur recorded the highest protein content and Varkala the lowest. Varkala recorded the highest carbohydrate content and Mullur the lowest. Thikkotti recorded the highest lipid content and Mullur the lowest.

Table 75. Biochemical composition of red algae from different stations along Kerala coast

Sl. No.	Station	Percentage of			Calorific value of		
		Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
1.	Mullur	10.23	17.91	2.49	57.80	74.33	23.41
2.	Varkala	8.33	22.20	1.71	47.06	92.13	16.07
3.	Thikkotti	9.59	21.53	1.66	54.18	89.35	15.60
4.	Elathur	9.66	22.53	2.24	54.58	93.49	21.06
5.	Saudi	13.69	28.13	1.66	77.35	116.74	15.60
	AVERAGE	10.30	22.46	1.95	58.19	93.21	18.35

For red algae,

Saudi recorded the highest protein and carbohydrate contents, and Mullur the highest lipid content. Varkala recorded the lowest protein content and Mullur the lowest carbohydrate content. Saudi and Thikkotti recorded the lowest lipid content.

Table 76. Biochemical composition of different divisions of algae in different stations along Kerala coast

Station	Green Algae			Brown Algae			Red Algae		
	Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid	Protein	Carbohydrate	Lipid
Mullur	10.62	27.33	2.89	9.89	9.75	3.87	10.23	17.91	2.49
Varkala	8.87	19.17	2.94	9.37	13.71	4.76	8.33	22.20	1.71
Thikkotti	11.05	31.79	7.21	11.84	11.71	7.81	9.59	21.53	1.66
Elathur	11.45	19.52	3.60	14.06	11.17	5.82	9.66	22.53	2.24
Saudi	9.06	15.26	3.70	-	-	-	13.69	28.13	1.66
AVERAGE	10.21	22.61	4.01	11.29	11.59	5.57	10.30	22.46	1.95

At Mullur,

Both green and red algae recorded high protein contents of 10.62% and 10.23% respectively.

Green algae recorded the highest carbohydrate content of 27.33% followed by red algae with 17.91%. Brown algae recorded the lowest carbohydrate content of 9.75%.

Brown algae recorded the highest lipid content of 3.87% followed by green algae with 2.89%. Red algae recorded the lowest lipid content of 2.49%.

At Varkala,

Brown algae recorded the highest protein content of 9.37%. Both green and red algae had almost the same protein contents of 8.87% and 8.33% respectively.

Red algae recorded the highest carbohydrate content of 22.20% followed by green algae with 19.17%. Brown algae recorded the lowest carbohydrate content of 13.71%.

Brown algae recorded the highest lipid content of 4.76% followed by green algae with 2.94%. Red algae recorded the lowest of 1.71%.

At Thikkotti,

Both green and brown algae recorded high protein contents of 11.05% and 11.84% respectively. Red algae recorded the lowest protein content of 9.59%.

Green algae recorded the highest carbohydrate content of 31.79%, followed by red algae with 21.53%. Brown algae recorded the lowest carbohydrate content of 11.71%.

Brown algae recorded the highest lipid content of 7.81% followed by green algae with 7.21%. Red algae recorded the lowest lipid content of 1.66%.

At Elathur,

Brown algae recorded the highest protein content of 14.06% followed by green algae with 11.45%. Red algae recorded the lowest protein content of 9.66%.

Red algae recorded the highest carbohydrate content of 22.53% followed by green algae with 19.52%. Brown algae recorded the lowest carbohydrate content of 11.17%.

Brown algae recorded the highest lipid content of 5.82% followed by green algae with 3.6%. Red algae recorded the lowest lipid content of 2.24%.

At Saudi,

Red algae recorded a higher protein content of 13.69% while green algae recorded only 9.06%.

Carbohydrate content was also higher in red algae 28.13%. Green algae recorded only 15.26%.

Lipid content was higher in green algae with 3.7% and red algae recorded only 1.66%.

Thus, along the Kerala coast,

Brown algae recorded the highest protein content of 11.3%. Both green and red algae recorded almost the same protein content of 10.2% and 10.3% respectively.

Both green and red algae recorded high carbohydrate contents of 22.6% and 22.5% respectively and brown algae the lowest of 11.6%.

Brown algae recorded the highest lipid content of 5.6% followed by green algae with 4% and red algae the lowest with 1.9%.

5.2. SEASONAL VARIATION IN BIOCHEMICAL COMPOSITION OF SOME SELECTED SEAWEEDS FROM VARIOUS STATIONS ALONG KERALA COAST

5.2.1 Seasonal variation in biochemical composition of some selected seaweeds from Mullur

From Mullur, 3 species each of green, brown and red algae were selected for this study. Average biochemical composition of each species, during the different seasons are given in Table 77. Statistical analysis (Analysis of variance 1 way classification or ANOVA-I) was done to test the significance of the observed seasonal variations and the results are represented in Table 78.

Table 77. Average biochemical composition of seaweeds from Mullur during the different seasons

Name of alga	Pre monsoon			Monsoon			Post monsoon		
	P	C	L	P	C	L	P	C	L
Ulva fasciata	7.17	29.35	1.61	11.85	23.74	1.96	13.28	23.21	2.40
U. lactuca	4.36	27.75	2.75	9.60	24.40	1.84	14.65	31.00	3.15
Caulerpa peltata	10.56	45.70	5.05	9.35	39.81	4.05	11.51	28.12	3.12
Sargassum wightii	8.61	12.00	5.18	8.67	8.68	2.21	12.28	10.96	3.65
Chnospora minima	12.20	10.15	5.01	11.10	10.37	4.43	12.05	10.08	4.00
Padina gymnospora	6.78	7.03	2.74	10.45	6.43	4.25	7.40	8.12	6.17
Hypnea valentiae	8.20	17.70	2.03	14.40	13.20	1.90	14.88	15.45	2.21
Spyridea filamentosa	9.31	17.00	3.26	10.42	14.11	2.50	12.63	15.56	3.10
Gracilaria corticata	7.16	25.34	2.62	9.81	18.00	2.47	8.48	15.75	2.09

P - protein ; C - carbohydrate ; L - lipid

Table 78. Significance of seasonal variation in biochemical composition of some seaweeds from Mullur based on statistical analysis

Name of alga	Remarks based on statistical analysis		
	Protein	Carbohydrate	Lipid
Ulva fasciata	HI.SIG	N.S.	HI.SIG
U. lactuca	HI.SIG	HI.SIG	N.S.
Caulerpa peltata	N.S.	N.S.	HI.SIG
Sargassum wightii	N.S.	N.S.	HI.SIG
Chnoospora minima	N.S.	N.S.	N.S.
Padina gymnospora	N.S.	N.S.	HI.SIG
Hypnea valentiae	HI.SIG	N.S.	N.S.
Spyridea filamentosa	N.S.	N.S.	N.S.
Gracilaria corticata	N.S.	HI.SIG	N.S.

HI.SIG - Highly Significant ; N.S. - Not Significant

ANOVA Tables of the biochemical constituents that showed significant seasonal variation are given below:

Table 79. Variation in protein content of Ulva fasciata from Mullur between seasons.

SOURCE	D.F.	SUM.SQR	MEAN.SQR.	F-VAL	REMARKS
TREAT	2	143.223	71.611	6.96	HI.SIG(1%)
ERROR	18	185.30	10.294		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	N.S.

HI.SIG - Highly Significant ; SIG - Significant ; N.S. - Not Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 80. Variation in lipid content of Ulva fasciata from Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	2.154	1.077	7.34	HI.SIG (1%)
ERROR	18	2.642	0.147		

MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	SIG
T2 - T3	SIG

N.S - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 81. Variation in protein content of Ulva lactuca from Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	371.148	185.574	29.67	HI.SIG (1%)
ERROR	18	112.569	6.254		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T2 - T3	SIG
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 82. Variation in carbohydrate content of Ulva lactuca from Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	152.469	76.234	6.05	HI.SIG (1%)
ERROR	18	226.859	12.603		

MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	N.S.
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 83. Variation in lipid content of Caulerpa peltata from Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	14.87	7.435	7.25	HI.SIG(1%)
ERROR	21	21.531	1.025		

MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	SIG
T2 - T3	N.S.

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 84. Variation in lipid content of <u>Padina gymnospora</u> from Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	41.432	20.716	8.36	HI.SIG (1%)
ERROR	18	44.616	2.479		

MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	SIG
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 85. Variation in lipid content of <u>Sargassum wightii</u> from Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	35.326	17.663	13.20	HI.SIG(1%)
ERROR	21	28.101	1.338		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 86. Variation in carbohydrate content of <u>Gracilaria corticata</u> from Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	402.755	201.377	7.7	HI.SIG(1%)
ERROR	21	549.367	26.16		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	N.S.

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 87. Variation in protein content of <u>Hynea valentiae</u> from Mullur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	166.586	83.293	13.5	HI.SIG(1%)
ERROR	15	92.528	6.169		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	N.S.

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

5.2.2 Seasonal variation in biochemical composition of some selected seaweeds from Varkala

From Varkala, 3 species of green algae were selected for this study. Average biochemical composition of each species during the different seasons are given in Table 88. Statistical analysis (Analysis of variance 1 way classification or ANOVA-I) was done to test the significance of the observed seasonal variations and the results are represented in Table 89.

Table 88. Average biochemical composition of selected seaweeds from Varkala during the different seasons

Name of alga	Pre monsoon			Monsoon			Post monsoon		
	P	C	L	P	C	L	P	C	L
Ulva fasciata	8.16	22.83	3.91	10.24	22. 95	2.53	11.05	24.50	3.07
U. lactuca	6.53	31.41	2.57	8.25	21.93	2.17	8.62	25.77	2.27
Chaetomorpha antennina	7.26	15.06	4.11	9.84	12.84	2.90	10.78	8.70	3.18

P - protein ; C - carbohydrate ; L - lipid

Table 89. Significance of seasonal variation in biochemical composition of some selected seaweeds from Varkala based on statistical analysis

Name of alga	Remarks based on statistical analysis		
	Protein	Carbohydrate	Lipid
Ulva fasciata	N.S.	N.S.	N.S.
U. lactuca	N.S.	HI.SIG	N.S.
Chaetomorpha antennina	N.S.	N.S.	HI.SIG

N.S. - Not Significant ; HI.SIG - Highly Significant

ANOVA Tables of the biochemical constituents that showed significant seasonal variation are given below:

Table 90. Variation in carbohydrate content of <u>Ulva lactuca</u> from Varkala between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	363.621	181.811	7.93	HI.SIG(1%)
ERROR	21	481.443	22.926		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	N.S.

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 91. Variation in lipid content of <u>Chaetomorpha antennina</u> from Varkala between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	6.764	3. 382	7.75	HI.SIG(1%)
ERROR	21	9.163	0.436		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	N.S.

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

5.2.3 Seasonal variation in biochemical composition of some selected seaweeds from Elathur

From Elathur, 3 species green algae and 1 species of red algae were selected for this study. The average biochemical composition of these selected seaweeds for the different seasons are given in Table 92. Results of the statistical analysis (Analysis of variance 1 way classification or ANOVA-1) done to test the significance of the observed seasonal variation in biochemical composition are represented in Table 93.

Name of alga	Pre monsoon			Monsoon			Post monsoon		
	P	C	L	P	C	L	P	C	L
Ulva fasciata	12.15	28.50	4.16	14.40	18.50	2.20	14.66	24.00	3.16
U. lactuca	13.75	21.50	2.30	14.10	19.50	2.18	15.36	28.60	2.23
Chaetomorpha antennina	4.80	6.58	2.34	10.23	8.41	2.33	13.48	7.00	2.05
Gracilaria corticata	6.11	16.78	2.05	11.63	18.00	2.18	10.68	23.04	2.05

P - protein ; C - carbohydrate ; L - lipid

Table 93. Significance of seasonal variation in biochemical composition of some selected seaweeds from Elathur based on statistical analysis

Name of alga	Remarks based on statistical analysis		
	Protein	Carbohydrate	Lipid
Ulva fasciata	N.S.	HI.SIG	HI.SIG
U. lactuca	HI.SIG	HI.SIG	N.S.
Chaetomorpha antennina	HI.SIG	HI.SIG	N.S.
Gracilaria corticata	HI.SIG	N.S.	N.S.

N.S. - Not Significant ; HI.SIG - Highly Significant

ANOVA Tables of the biochemical constituents that showed significant seasonal variations are given below:

Table 94. Variation in carbohydrate content of Ulva fasciata from Elathur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	200.667	100.333	12.7	HI.SIG(1%)
ERROR	9	71.08	7.898		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	SIG

SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 95. Variation in lipid content of Ulva fasciata from Elathur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	7.743	3.871	15.83	HI.SIG(1%)
ERROR	9	2.201	0.245		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T2 - T3	SIG
T2 - T3	SIG

SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 96. Variation in protein content of Ulva lactuca from Elathur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	7.171	3.585	9.23	HI.SIG(1%)
ERROR	12	4.662	0.388		

MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	SIG
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 97. Variation in carbohydrate content of Ulva lactuca from Elathur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	228.700	114.350	7.55	HI.SIG(1%)
ERROR	12	181.780	15.148		

MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	SIG
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 98. Variation in protein content of Chaetomorpha antennina from Elathur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	230.570	115.285	20.80	HI.SIG(1%)
ERROR	15	83.121	5.541		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	SIG

SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 99. Variation in carbohydrate content of Chaetomorpha antennina from Elathur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TEEAT	2	11.113	5.557	17.58	HI.SIG(1%)
ERROR	15	4.741	0.316		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	N.S.
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 100. Variation in protein content of Gracilaria corticata from Elathur between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	121.875	60.937	32.97	HI.SIG(1%)
ERROR	18	33.27	1.848		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	N.S.

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

5.2.4 Seasonal variation in biochemical composition of two selected seaweeds from Thikkotti

From Thikkotti, one species each of green and red algae were selected for this study. The average biochemical composition of these seaweeds during different seasons are given in Table 101. Results of the statistical analysis (Analysis of variance 1 way classification or ANOVA-1) done to test the significance of the observed seasonal variations are represented in Table 102.

Table 101. Average biochemical composition of selected seaweeds from Thikkotti during the different seasons

Name of alga	Pre monsoon			Monsoon			Post monsoon		
	P	C	L	P	C	L	P	C	L
Caulerpa sertularioides	6.68	44.43	12.52	10.93	26.66	4.38	11.80	49.50	8.77
Gracilaria corticata	9.51	24.57	1.30	8.90	13.00	1.10	7.82	18.75	1.01

P - protein ; C - carbohydrate ; L - lipid

Table 102. Significance of seasonal variation in biochemical composition of two selected seaweeds from Thikkotti based on statistical analysis

Name of alga	Remarks based on statistical analysis		
	Protein	Carbohydrate	Lipid
Caulerpa sertularioides	HI.SIG	HI.SIG	HI.SIG
Gracilaria corticata	HI.SIG	HI.SIG	N.S.

N.S. - Not Significant ; HI.SIG - Highly Significant

ANOVA Tables of biochemical constituents that showed significant seasonal variations are given below:

Table 103. Variation in protein content of <u>Caulerpa sertularioides</u> from Thikkotti between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	119.625	59.813	37.33	HI.SIG(1%)
ERROR	21	33.644	1.602		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	N.S.

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant
T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 104. Variation in carbohydrate content of <u>Caulerpa sertularioides</u> from Thikkotti between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	2298.981	1149.490	29.54	HI.SIG(1%)
ERROR	21	817.074	38.908		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	N.S.
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant
T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 105. Variation in lipid content of Caulerpa sertularioides from Thikkotti between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	265.523	132.761	18.70	HI.SIG(1%)
ERROR	21	149.071	7.099		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	SIG

SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 106. Variation in protein content of Gracilaria corticata from Thikkotti between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	10.185	5.092	10.24	HI.SIG(1%)
ERROR	18	8.948	0.497		

MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	SIG
T2 - T3	SIG

N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 107. Variation in carbohydrate content of *Gracilaria corticata* from Thikkotti between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	468.649	234.324	12.59	HI.SIG(1%)
ERROR	18	335.044	18.614		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	SIG

SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

5.2.5 Seasonal variation in biochemical composition of two selected seaweeds from Saudi

From Saudi, 2 green algae were selected for this study. Average biochemical composition of each species, during the different seasons are given in Table 108. Results of the statistical analysis (Analysis of variance 1 way classification or ANOVA-1) done to test the significance of the observed seasonal variations are represented in Table 109.

Table 108. Average biochemical composition of two selected seaweeds from Saudi during the different seasons

Name of alga	Pre monsoon			Monsoon			Post monsoon		
	P	C	L	P	C	L	P	C	L
Chaetomorpha antennina	9.03	14.22	4.61	7.83	12.38	4.92	9.56	14.59	4.92
Enteromorpha compressa	6.8	7.91	1.56	9.27	17.62	2.11	11.50	24.50	2.05

P - protein ; C - carbohydrate ; L - lipid

Table 109. Significance of seasonal variation in biochemical composition of two selected seaweeds from Saudi based on statistical analysis

Name of alga	Remarks based on statistical analysis		
	Protein	Carbohydrate	Lipid
Chaetomorpha antennina	N.S.	N.S.	N.S.
Enteromorpha compressa	HI.SIG	HI.SIG	N.S.

N.S. - Not Significant ; HI.SIG - Highly Significant

ANOVA Tables of biochemical constituents that showed significant seasonal variations are given below:

Table 110. Variation in protein content of Enteromorpha compressa from Saudi between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	88.437	44.219	16.22	HI.SIG(1%)
ERROR	21	57.254	2.726		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T/	SIG

SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

Table 111. Variation in carbohydrate content of Enteromorpha compressa from Saudi between seasons

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	1111.316	555.658	27.38	HI.SIG(1%)
ERROR	21	426.209	20.296		

MEAN COMPARISONS	REMARKS
T1 - T2	SIG
T1 - T3	SIG
T2 - T3	SIG

SIG - Significant ; HI.SIG - Highly Significant

T1 - Pre monsoon ; T2 - Monsoon ; T3 - Post monsoon

5.3 PLACE-WISE VARIATION IN BIOCHEMICAL COMPOSITION (Figs. 27-38)

For this study, 4 species of seaweeds , 3 belonging to green algae and 1 to red algae were selected each of which was collected from more than one station along the Kerala coast. Average biochemical composition during the different seasons, for each of these species of seaweeds, are represented in Tables 112-123. All values were expressed in percentage dry weight.

Table 112. Station-wise variation in protein content of *Ulva fasciata*

Seasons	Stations		
	Mullur	Varkala	Elathur
Pre monsoon	7.17	8.16	12.15
Monsoon	11.85	10.24	14.40
Post monsoon	13.28	11.05	14.66

Table 113. Station-wise variation in carbohydrate content of *Ulva fasciata*

Seasons	Stations		
	Mullur	Varkala	Elathur
Pre monsoon	29.35	22.83	28.50
Monsoon	23.74	22.95	18.50
Post monsoon	23.21	24.50	24.00

Table 114. Station-wise variation in lipid content of Ulva fasciata

Seasons	Stations		
	Mullur	Varkala	Elathur
Pre monsoon	1.61	3.91	4.16
Monsoon	1.96	2.53	2.20
Post monsoon	2.40	3.07	3.16

Table 115. Station-wise variation in protein content of Ulva lactuca

Seasons	Stations		
	Mullur	Varkala	Elathur
Pre monsoon	4.36	6.53	13.75
Monsoon	9.60	8.25	14.10
Post monsoon	14.65	8.62	15.36

Table 116. Station-wise variation in carbohydrate content of Ulva lactuca

Seasons	Stations		
	Mullur	Varkala	Elathur
Pre monsoon	27.75	31.41	21.50
Monsoon	24.40	21.93	19.50
Post monsoon	31.00	25.77	28.60

Table 117. Station-wise variation in lipid content of _Ulva lactuca_

Seasons	Stations		
	Mullur	Varkala	Elathur
Pre monsoon	2.75	2.57	2.30
Monsoon	1.84	2.17	2.18
Post monsoon	3.15	2.27	2.23

Table 118. Station-wise variation in protein content of _Chaetomorpha antennina_

Seasons	Stations		
	Saudi	Varkala	Elathur
Pre monsoon	9.03	7.26	4.80
Monsoon	7.83	9.84	10.23
Post monsoon	9.56	10.78	13.48

Table 119. Station-wise variation in carbohydrate content of _Chaetomorpha antennina_

Seasons	Stations		
	Saudi	Varkala	Elathur
Pre monsoon	14.22	15.06	6.58
Monsoon	12.38	12.84	8.41
Post monsoon	14.59	8.70	7.00

Table 120. Station-wise variation in lipid content of *Chaetomorpha antennina*

Seasons	Stations		
	Saudi	Varkala	Elathur
Pre monsoon	4.61	4.11	2.34
Monsoon	4.92	2.90	2.33
Post monsoon	4.92	3.18	2.05

Table 121. Station-wise variation in protein content of *Gracilaria corticata*

Seasons	Stations		
	Mullur	Elathur	Thikkotti
Pre monsoon	7.16	6.11	9.51
Monsoon	9.81	11.63	8.90
Post monsoon	8.48	10.68	7.82

Table 122. Station-wise variation in carbohydrate content of *Gracilaria corticata*

Seasons	Stations		
	Mullur	Elathur	Thikkotti
Pre monsoon	25.34	16.78	24.57
Monsoon	18.00	18.00	13.00
Post monsoon	15.75	23.04	18.75

Table 123. Station-wise variation in lipid content of Gracilaria corticata

Seasons	Stations		
	Mullur	Elathur	Thikkotti
Pre monsoon	2.62	2.05	1.30
Monsoon	2.47	2.18	1.10
Post monsoon	2.09	2.05	1.01

Statistical analysis (Analysis of variance 2 way classification ANOVA-II) was done to test the significance of place-wise variation in biochemical composition, and the results are represented in Table 124.

Table 124. Significance of place-wise variation in biochemical composition based on statistical analysis

Name of alga	Remarks on place-wise variation based on statistical analysis		
	Protein	Carbohydrate	Lipid
Ulva fasciata	HI.SIG	N.S.	N.S.
U. lactuca	N.S.	N.S.	N.S.
Chaetomorpha antennina	N.S.	N.S.	N.S.
Gracilaria corticata	N.S.	N.S.	HI.SIG

N.S. - Not Significant ; HI.SIG - Highly Significant

Protein content of Ulva fasciata and lipid content of Gracilaria corticata were found to vary significantly between stations. ANOVA Tables are given below:

Table 125. Result of statistical analysis done to test the significance of station-wise variation in protein content of Ulva fasciata

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	25.052	12.526	11.75	SIG (5%)
REPLIC	2	24.427	12.213	11.45	SIG (5%)
ERROR	4	4.265	1.066		

TREATMENT MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	SIG
T2 - T3	SIG

TREAT	MEAN
T1	10.77
T2	9.818
T3	13.736

REPLICATION MEAN COMPARISONS	REMARKS
R1 - R2	SIG
R1 - R3	SIG
R2 - R3	N.S.

REPLIC	MEAN
R1	9.16
R2	12.16
R3	12.998

N.S. - Not Significant ; SIG - Significant

T1 - Mullur ; T2 - Varkala ; T3 - Elathur

R1 - Pre monsoon ; R2 - Monsoon ; R3 - Post monsoon

Table 126. Result of statistical analysis done to test the significance of station-wise variation in lipid content of *Gracilaria corticata*

SOURCE	D.F.	SUM.SQR	MEAN.SQR	F-VAL	REMARKS
TREAT	2	2.602	1.301	62.18	HI.SIG (1%)
REPLIC	2	0.122	0.061	2.92	N.S.
ERROR	4	0.084	0.021		

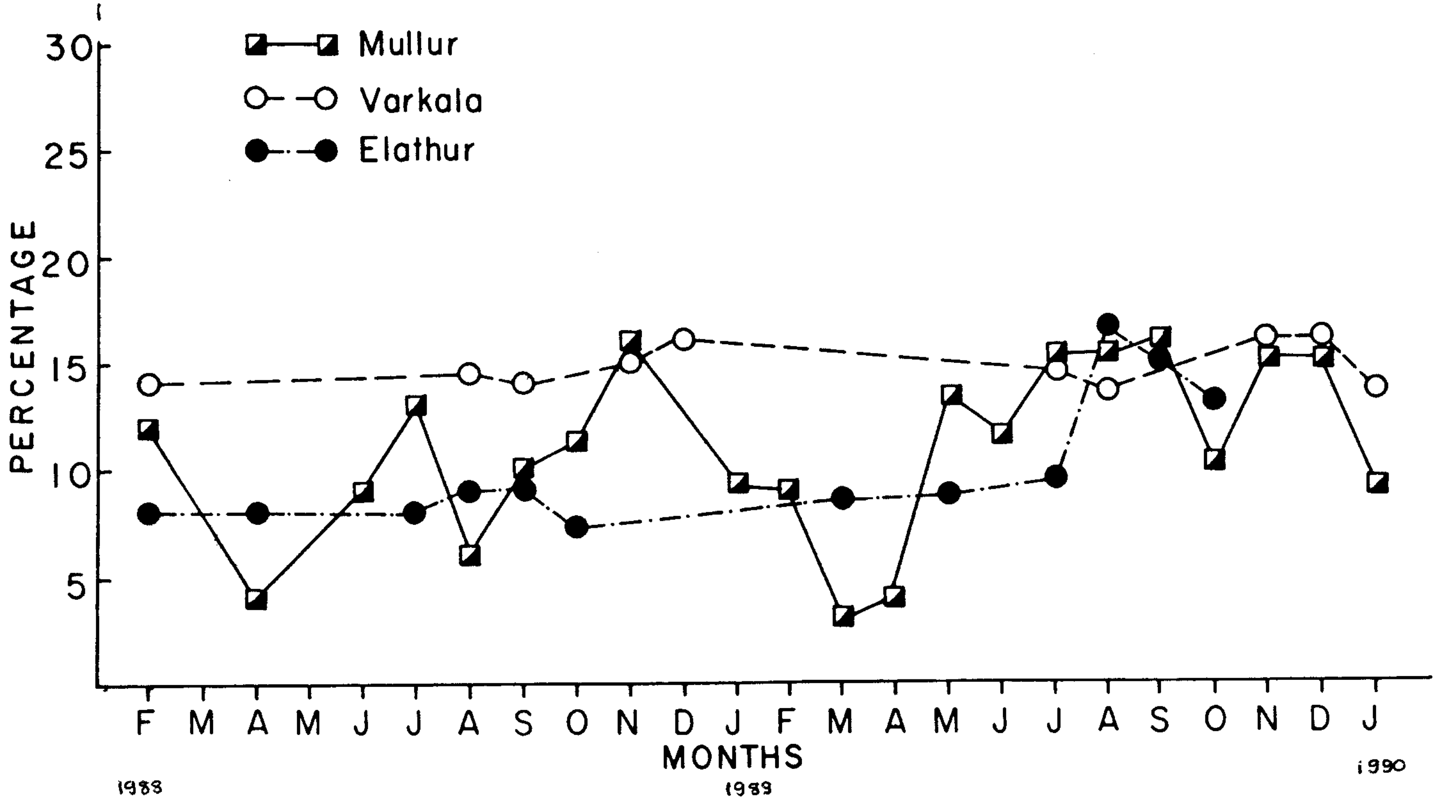
TREATMENT MEAN COMPARISONS	REMARKS
T1 - T2	N.S.
T1 - T3	SIG
T2 - T3	SIG

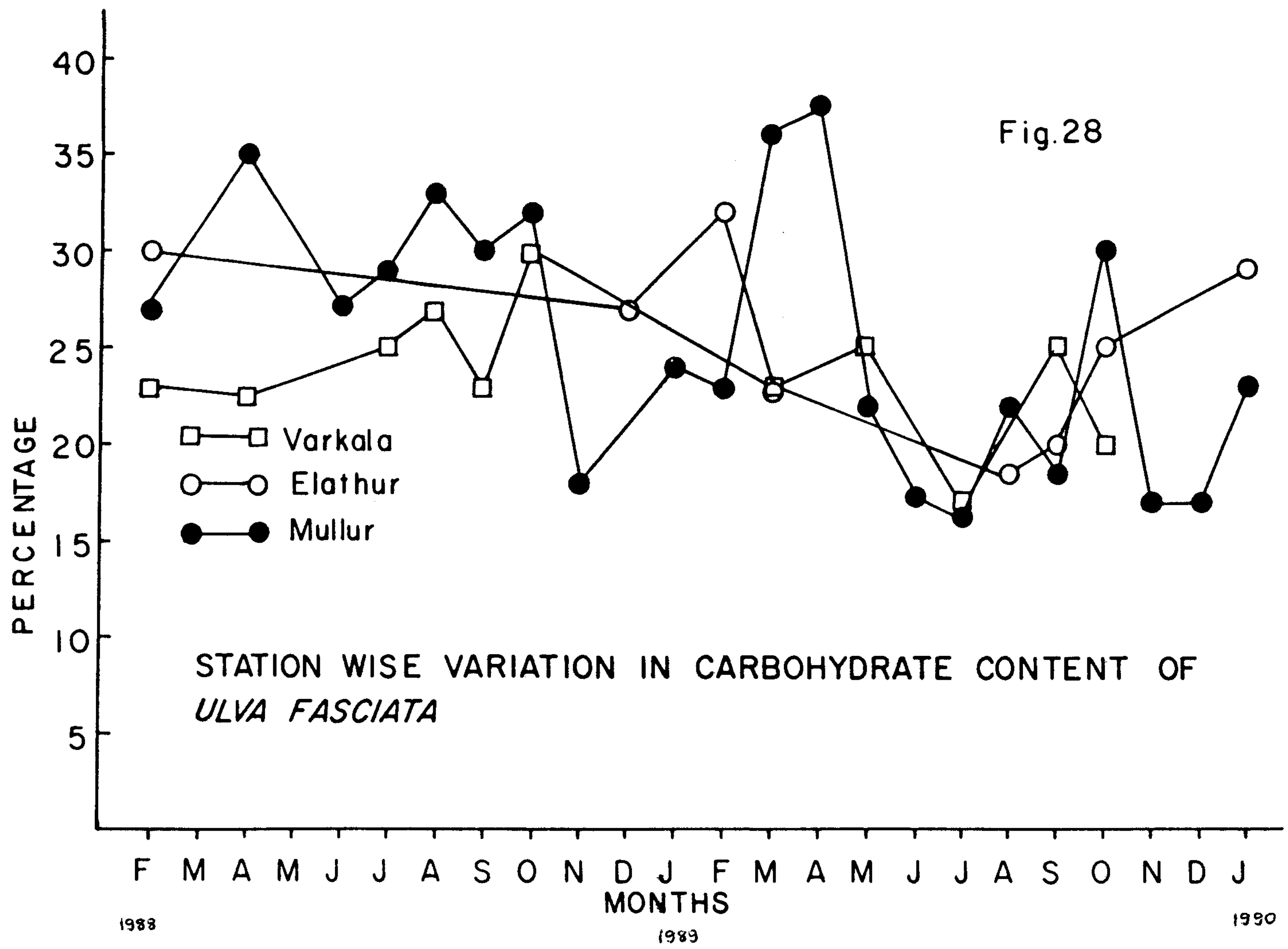
N.S. - Not Significant ; SIG - Significant ; HI.SIG - Highly Significant

T1 - Mullur ; T2 - Elathur ; T3 - Thikkotti

STATION WISE VARIATION IN PROTEIN CONTENT OF *ULVA FASCIATA*

Fig.27

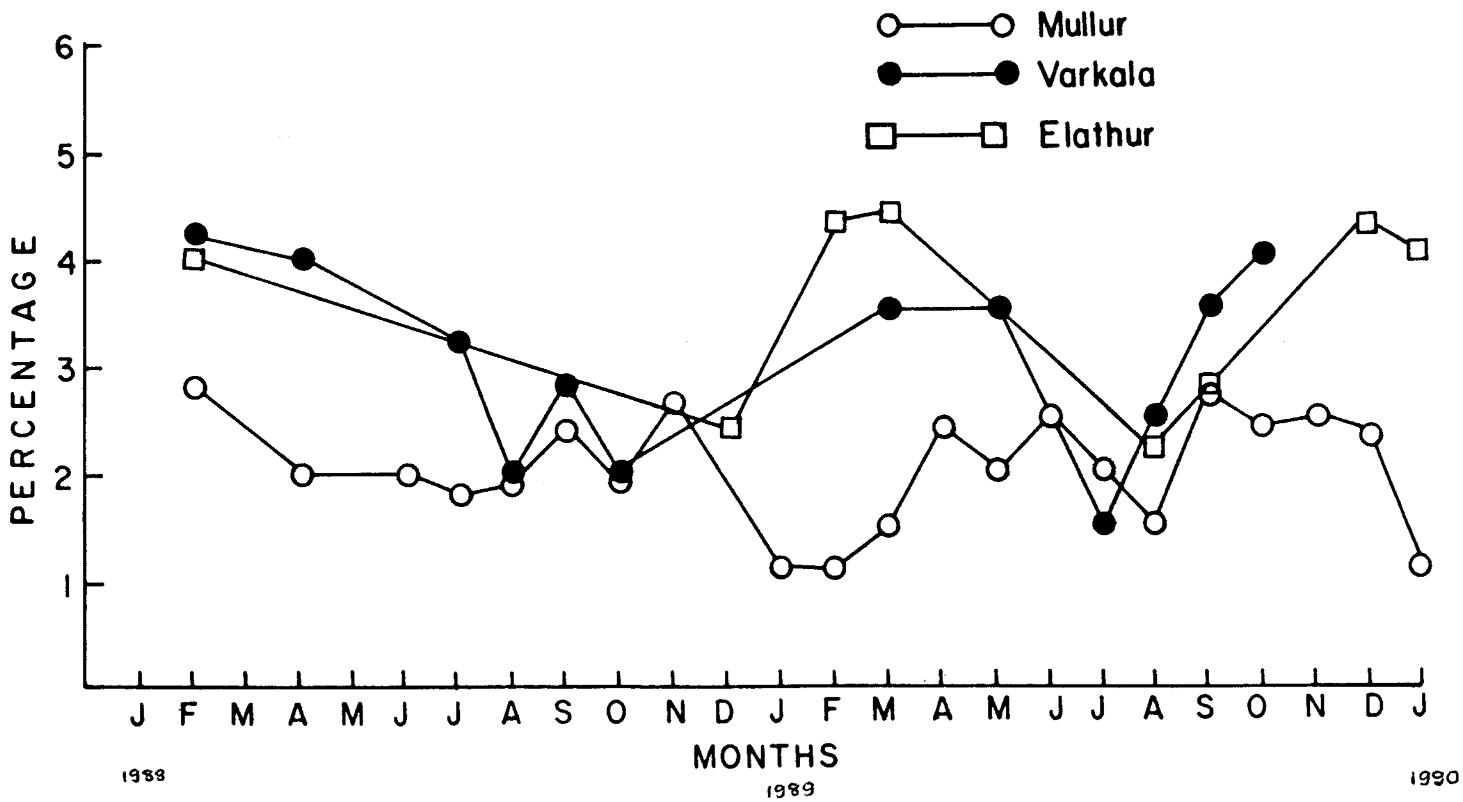




STATION WISE VARIATION IN CARBOHYDRATE CONTENT OF *ULVA FASCIATA*

STATION WISE VARIATION IN LIPID CONTENT OF
ULVA FASCIATA

Fig. 29



STATION WISE VARIATION IN PROTEIN CONTENT OF *ULVA LACTUCA*

Fig.30

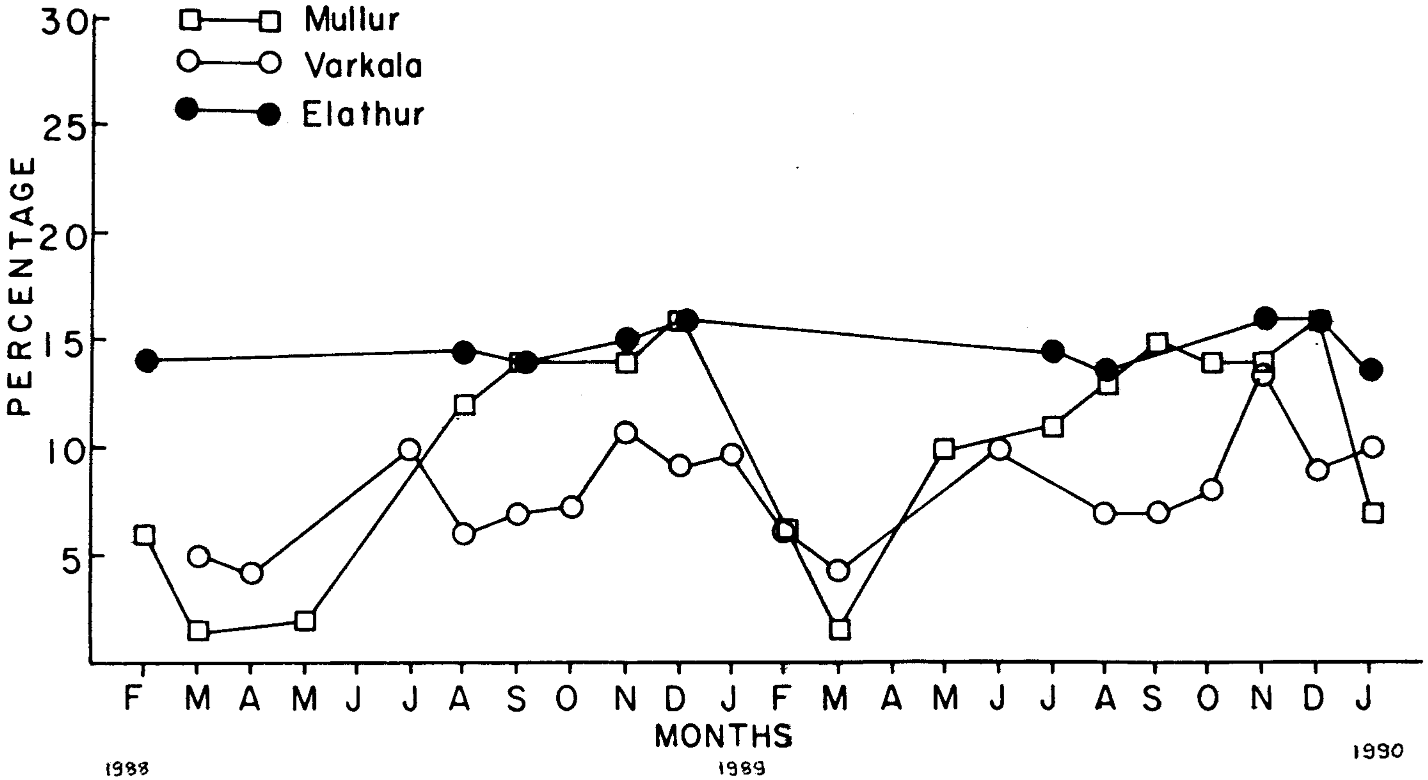
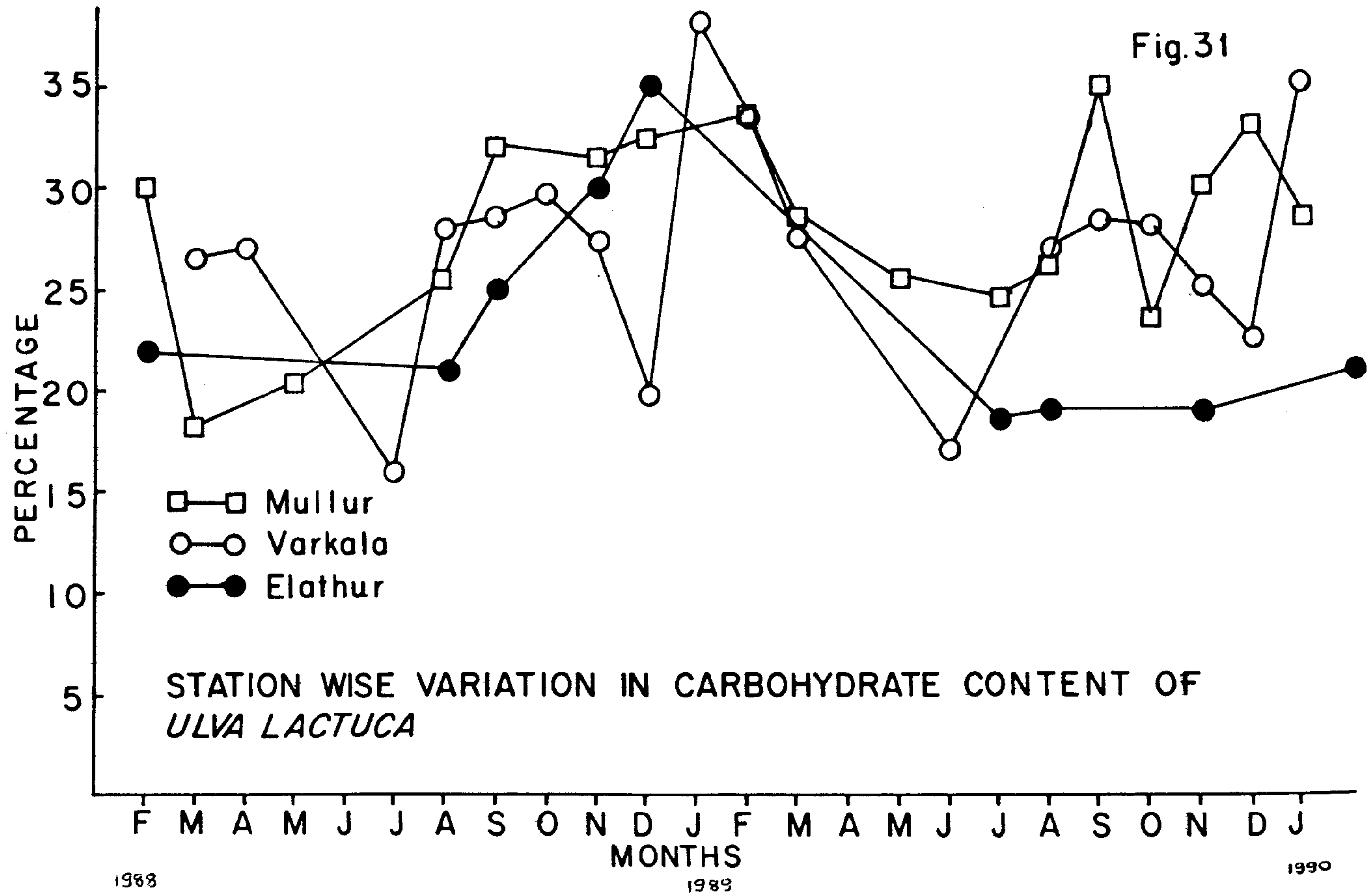


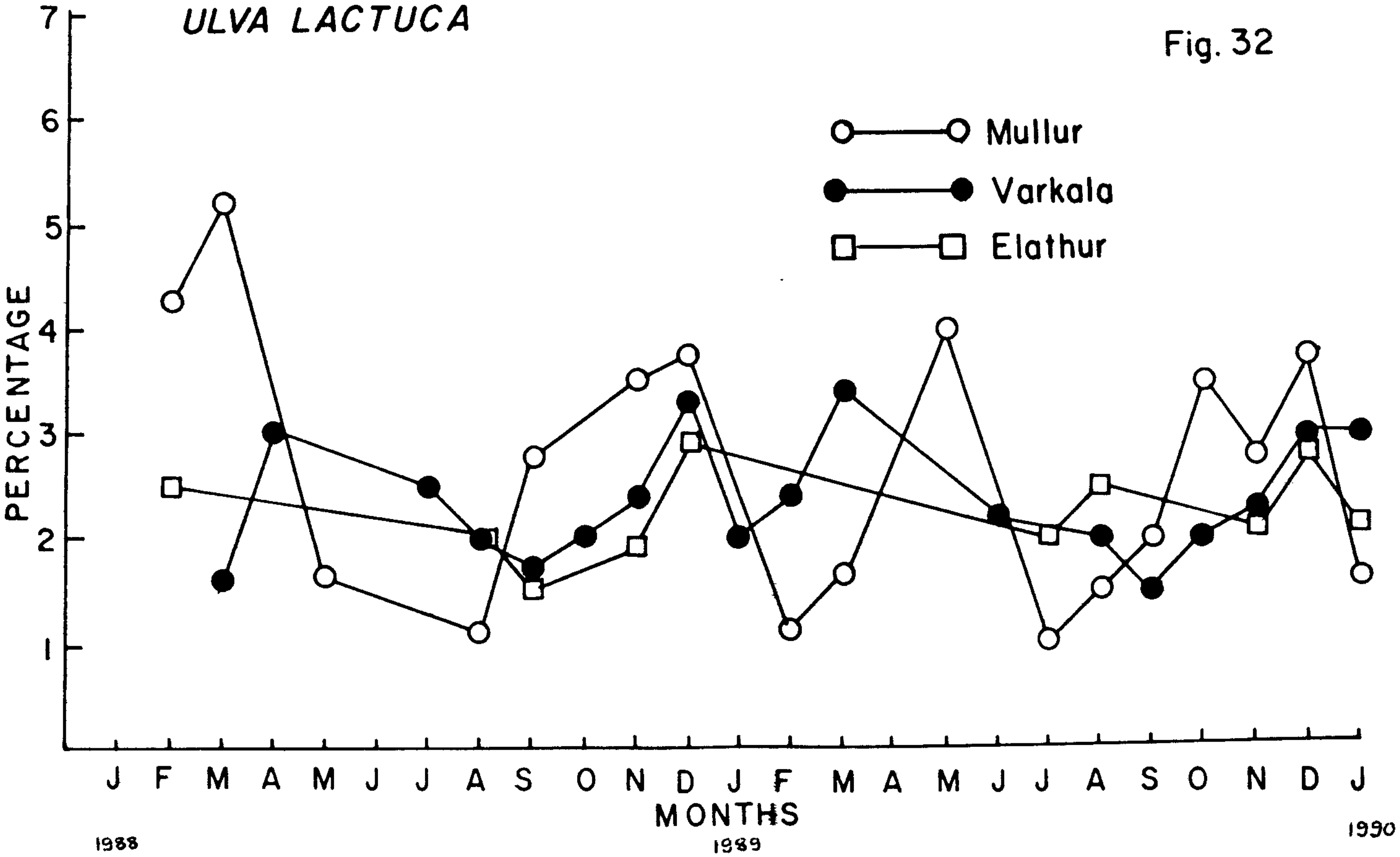
Fig.31



STATION WISE VARIATION IN CARBOHYDRATE CONTENT OF *ULVA LACTUCA*

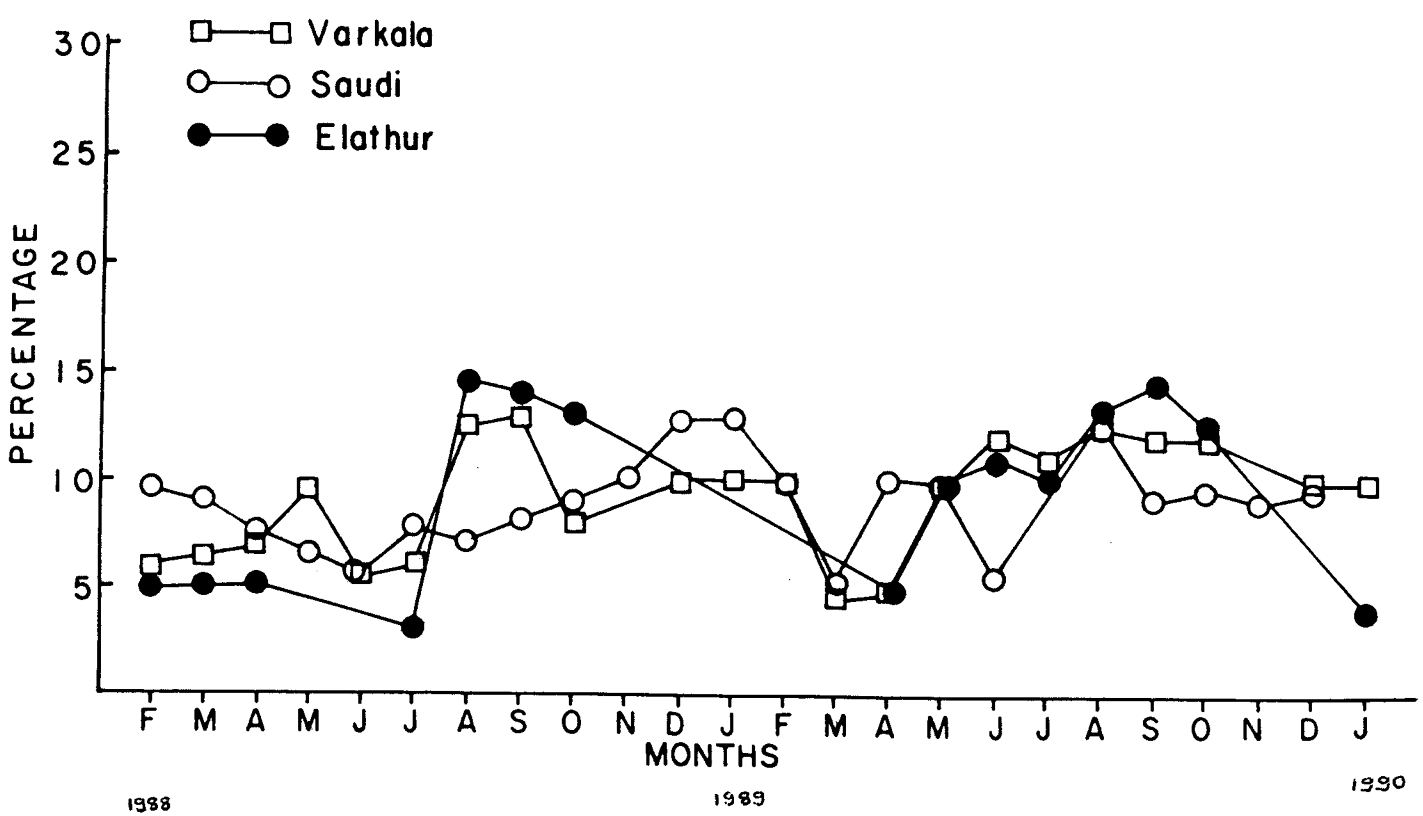
STATION WISE VARIATION IN LIPID CONTENT OF
ULVA LACTUCA

Fig. 32



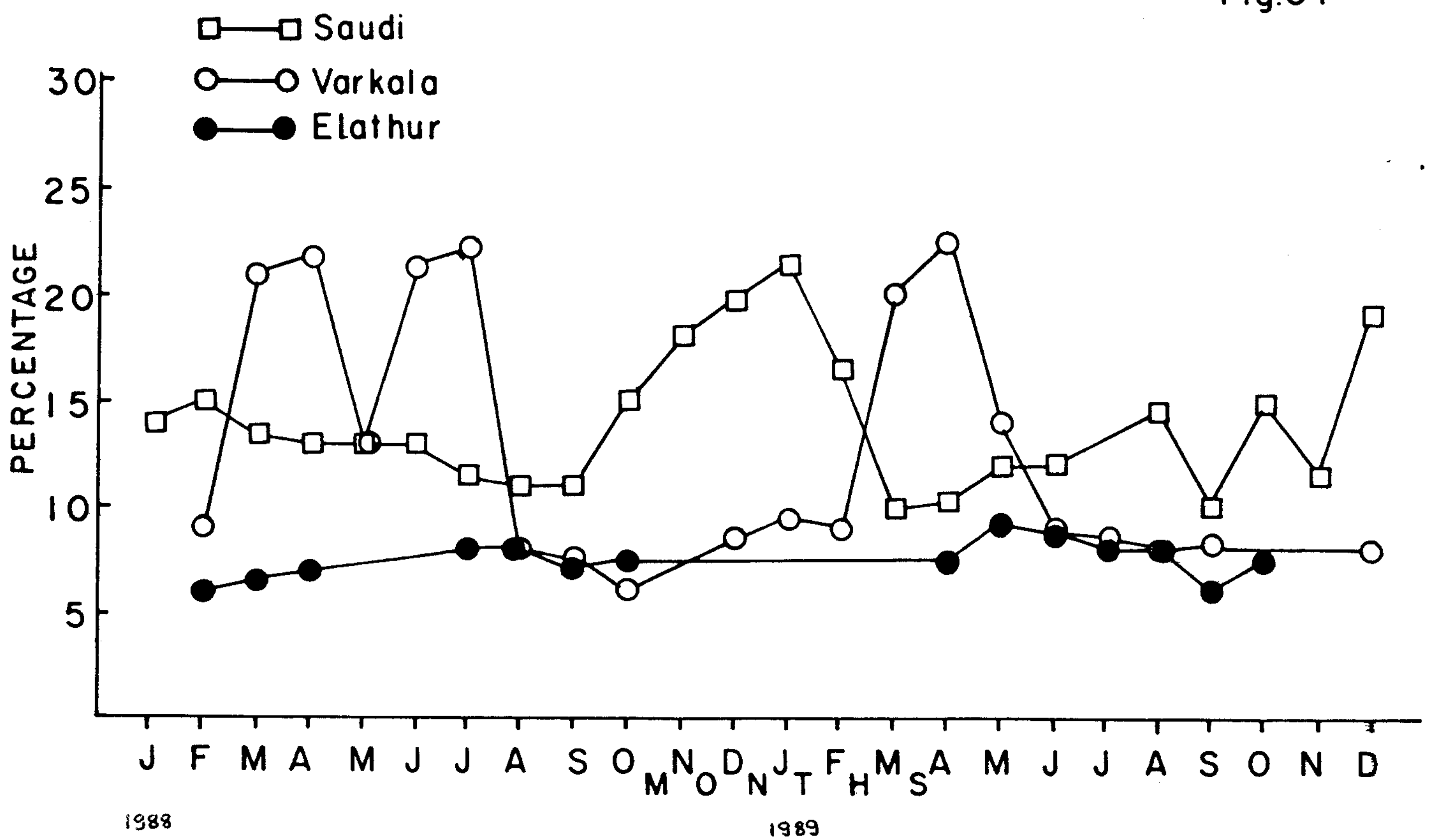
STATION WISE VARIATION IN PROTEIN CONTENT OF *CHAETOMORPHA ANTENNINA*

Fig. 33



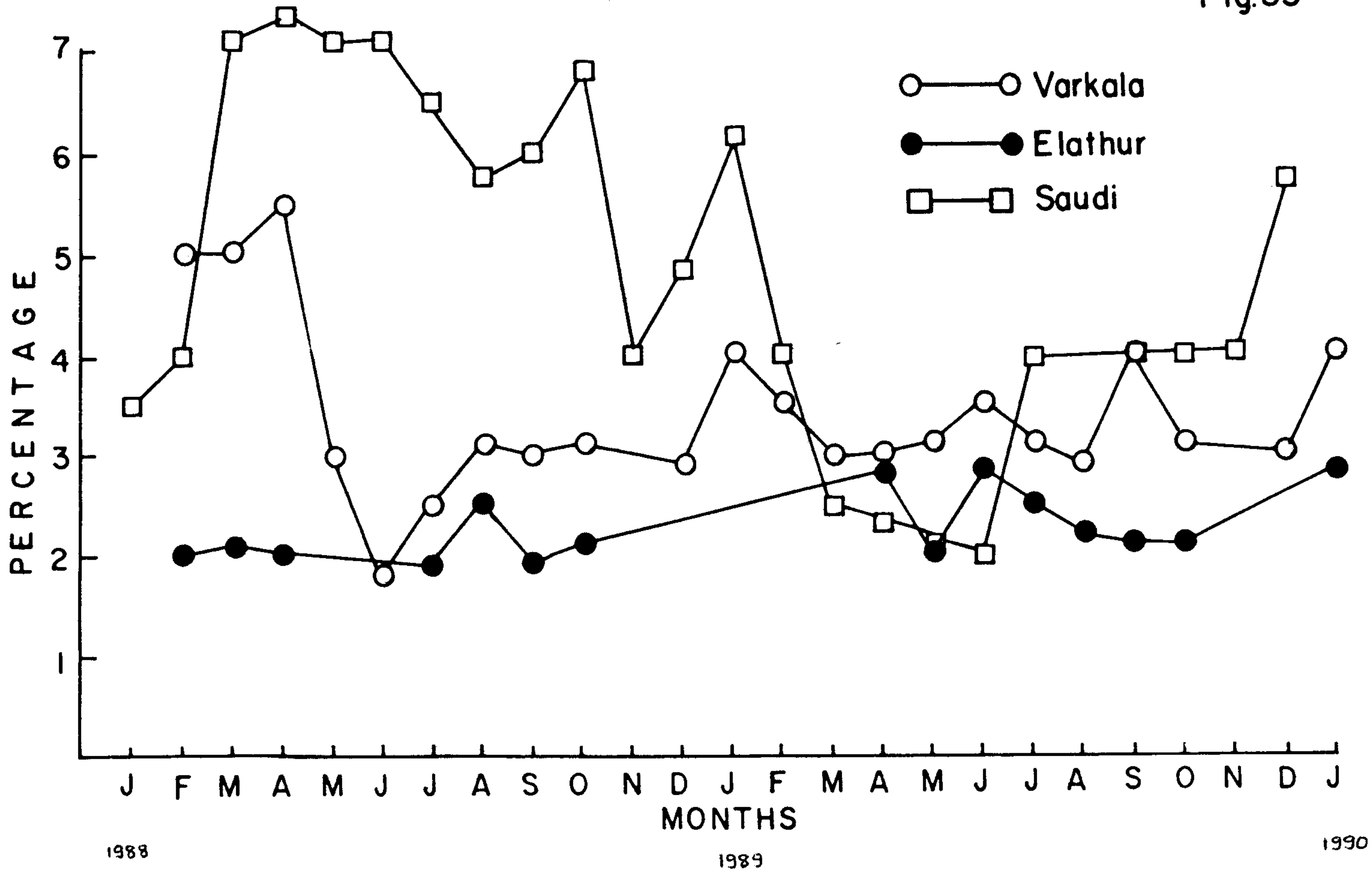
STATION WISE VARIATION IN CARBOHYDRATE CONTENT OF *CHAETOMORPHA ANTENNINA*

Fig.34



STATION WISE VARIATION IN LIPID CONTENT OF *CHAETOMORPHA ANTENNINA*

Fig.35



STATION WISE VARIATION IN PROTEIN CONTENT OF *GRACILARIA CORTICATA*

Fig. 36

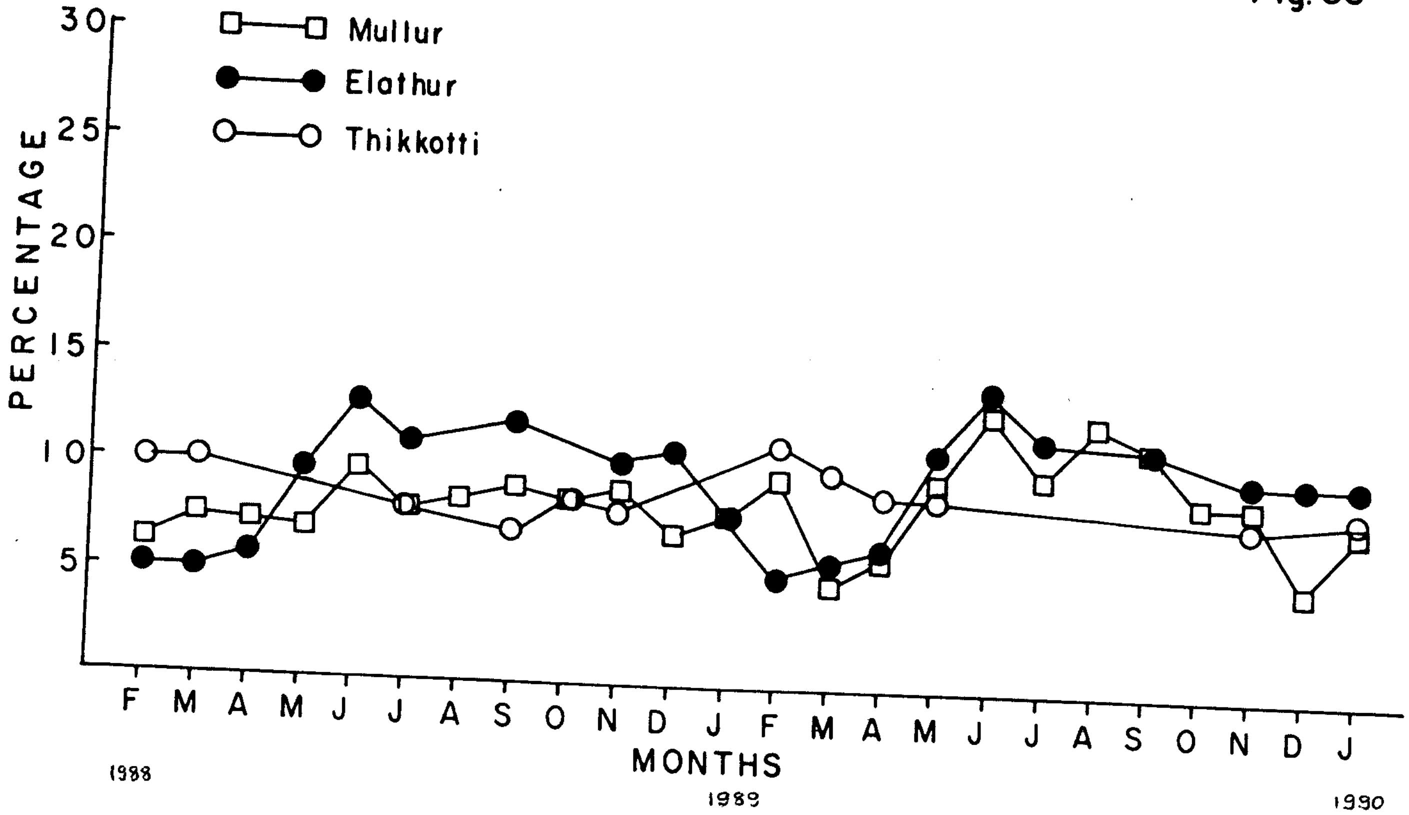
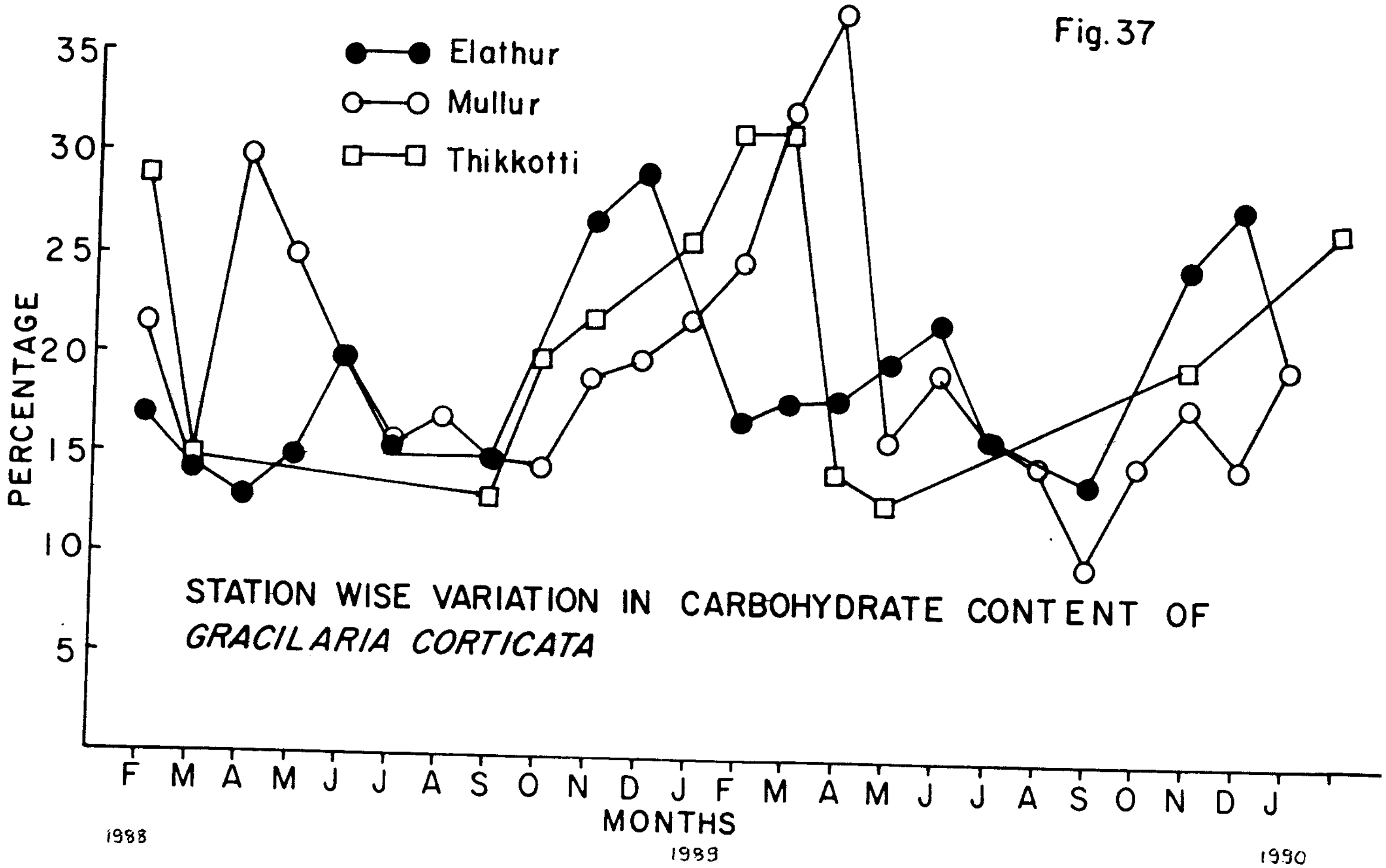


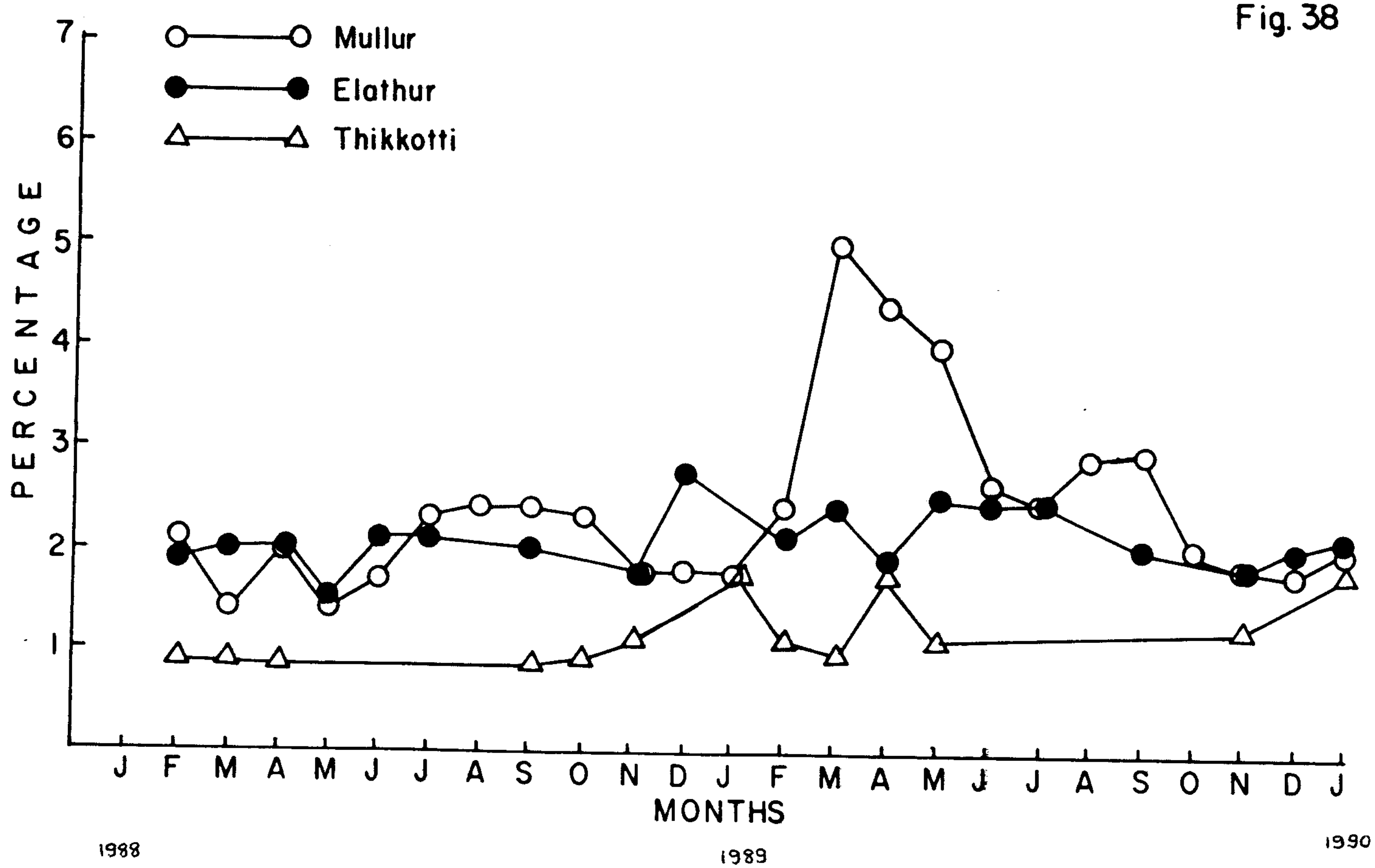
Fig. 37



STATION WISE VARIATION IN CARBOHYDRATE CONTENT OF *GRACILARIA CORTICATA*

STATION WISE VARIATION IN LIPID CONTENT OF *GRACILARIA CORTICATA*

Fig. 38



5.4. PARAMETERS SHOWING CORRELATION WITH BIOCHEMICAL CONSTITUTION OF SEAWEEDS

Table 127 Parameters showing correlation with biochemical constitution of seaweeds

NAME OF ALGA AND STATION OF COLLECTION	PARAMETER SHOWING CORRELATION WITH PROTEIN	TYPE OF CORRELATION OBSERVED	CORRELATION COEFFICIENT	PARAMETER SHOWING CORRELATION WITH CARBOHYDRATE	TYPE OF CORRELATION OBSERVED	CORRELATION COEFFICIENT	PARAMETER SHOWING CORRELATION WITH LIPID	TYPE OF CORRELATION OBSERVED	CORRELATION COEFFICIENT
Caulerpa sertularioides	Salinity	Positive	0.543	Surface Water temperature	Positive	0.483	Protein	Negative	- 0.820
THIKKOTTI	Nitrate	Positive	0.550	Phosphate	Negative	-0.562	Carbohydrate	Positive	0.535
				Silicate	Negative	-0.509			
Gracilaria corticata	Atmospheric temperature	Negative	- 0.489	Dissolved oxygen	Positive	0.621			
ELATHUR	Surface Water temperature	Negative	- 0.576	Salinity	Positive	0.491	-	-	-
Chaetomorpha antennina	Salinity	Positive	0.414	Salinity	Positive	0.555	Monthly Seaweed density	Positive	0.480
SAUDI	Silicate	Negative	- 0.421	Protein	Positive	0.658	Silicate	Positive	0.507
Ulva fasciata VARKALA	-	-	-	Phosphate	Negative	-0.630	-	-	-
U. lactuca	Monthly seaweed density	Positive	0.477	-	-	-	Atmospheric temperature	Positive	0.492
VARKALA	Phosphate	Negative	- 0.505				Salinity	Negative	- 0.732
Chaetomorpha antennina	Atmospheric temperature	Negative	- 0.541	Atmospheric temperature	Positive	0.418	-	-	-
VARKALA	Surface Water temperature	Negative	-0.610	Phosphate	Positive	0.474			
				Silicate	Positive	0.499			
				Protein	Negative	-0.757			
Ulva fasciata MULLUR	Nitrate	Positive	0.576	Protein	Negative	-0.842	Nitrate	Positive	0.528
U. lactuca	Nitrate	Positive	0.460	Protein	Positive	0.521	-	-	-
MULLUR	Silicate	Negative	- 0.530						
Caulerpa peltata	Monthly seaweed density	Positive	0.479	Atmospheric temperature	Positive	0.553	Nitrate	Negative	- 0.674
				Silicate	Positive	0.572	Carbohydrate	Positive	0.506
Hypnea valentiae	Surface water temperature	Negative	- 0.509	-	-	-	Carbohydrate	Negative	- 0.716
MULLUR	Nitrate	Positive	0.540						
Spyridea filamentosa MULLUR	Silicate	Negative	- 0.420	-	-	-	Surface water temperature	Positive	0.548
Gracilaria corticata	Surface water temperature	Negative	- 0.495	Protein	Negative	- 0.502	Atmospheric temperature	Negative	- 0.393
MULLUR							Phosphate	Positive	0.473
							Carbohydrate	Positive	0.410
Sargassum wightii	-	-	-	Phosphate	Negative	- 0.597	Surface water temperature	Positive	0.438
MULLUR				Silicate	Negative	- 0.440	Nitrate	Negative	- 0.497
								Carbohydrate	Positive	0.556

6. DISCUSSION

6.1 ECOLOGY OF SEAWEEDS

In the present study, 52 species of seaweeds, 20 belonging to Chlorophyta, 10 to Phaeophyta and 22 to Rhodophyta were recorded from Kerala coast. Anon (1981) reported the occurrence of 17 species of seaweeds from Kerala, 5 belonging to Chlorophyta, 8 to Phaeophyta and 4 to Rhodophyta. Balakrishnan Nair *et al* (1982) reported 44 species of seaweeds, from the south-west coast of India, 17 belonging to Chlorophyta, 6 to Phaeophyta and 21 to Rhodophyta. Out of these, 8 species were recorded exclusively from Kanyakumari (Tamil Nadu) and the rest from Kerala. Sobha and Balakrishnan Nair (1983) recorded the occurrence of 34 species of algae from south-west coast of India, out of which 27 species were collected by the authors from Cape Comorin, and the rest from Kerala. Chennubhotla *et al* (1983) gave a list of 34 species of seaweeds collected from the inter-tidal and subtidal regions of Kerala coast. Out of these, 24 species were recorded in the present study also. Sobha and Balakrishnan Nair (1985) reported the occurrence of 44 species of algae from Kerala, including 17 species collected from Kanyakumari. Out of the species recorded by the above authors, 22 species were recorded in the present study also. Chennubhotla *et al* (1986) recorded 35 species of seaweeds from Kerala, out of which 30 species were recorded in the present study also. Balakrishnan Nair *et al* (1986) recorded 101 species of seaweeds from Kerala coast. But their study included stations like Muttom and Cape Comorin in Tamil Nadu and Mahe in Pondicherry, and the authors have not indicated the exact place of collection of each species of seaweed, and a list of seaweeds from Kerala, including the above mentioned stations is given. Cape Comorin is a place noted for its distinctive marine algal flora, which for its diversity and luxuriance is noteworthy (Sreenivasan, 1969). Inclusion of this station in all the studies relating to marine algal flora of Kerala by the authors, have created a lot of confusion regarding the species of seaweeds recorded exclusively from Kerala.

Along the Kerala coast, in the present study, Rhodophycean algae showed maximum diversity with 22 species, followed by Chlorophyceae with 20 species. Phaeophycean algae were comparatively less along the Kerala coast with only 10 species. Agadi and Untawale (1978) reported 51 species of marine algae from Goa, out of which 19 belonged to Rhodophyta, 15 to Phaeophyta, 13 to Chlorophyta and 4 to Cyanophyta. Diversity-wise Rhodophycean algae were more in Goa, as was observed in the present study. Number of green and red algae recorded from Goa, was less than that of Kerala but brown algae were more in Goa.

Murthy et al (1978) recorded more of Rhodophycean algae along Gujarat coast. Gopinathan and Panigrahy (1983) recorded 55 species of marine algae from Andaman and Nicobar islands, out of which 16 belonged to Chlorophyta, 17 to Phaeophyta and 22 to Rhodophyta. Here also diversity-wise red algae outnumbered other divisions of algae. Number of green algal species recorded from these islands was less than that in Kerala, but brown algae were more in number. Kaliaperumal and Pandian (1984) studied the distribution pattern of marine algae in 6 localities of Tamil Nadu, and found that in all the stations studied, red algae were more in number. The marine macrophytes of Minicoy Atoll were studied by Untawale and Jagtap (1984). Out of the 37 species of algae reported by them, 10 belonged to Chlorophyta, 5 to Phaeophyta 19 to Rhodophyta and 3 to Cyanophyta. Number of species of all divisions of algae from Minicoy, reported by them was less than that recorded from Kerala coast in the present study. Subba Rao et al (1985) recorded 65 species of marine algae from Andhra coast, out of which 23 belonged to Chlorophyta, 7 to Phaeophyta, 34 to Rhodophyta and 1 to Cyanophyta. The number of green and red algae from Andhra was more than that of Kerala but the number of brown algae was less. Agadi (1985) recorded 42 species of algae, 16 each belonging to Chlorophyta and Rhodophyta and 10 to Phaeophyta, from Karnataka coast. Though the red and green algae were lesser in number than in Kerala, the number of brown algae was the same in both places. Jagtap (1985) recorded 64 species of marine algae from Andaman islands, 26 species belonged to Rhodophyta 21 to Chlorophyta, 14 to Phaeophyta and 3 to Cyanophyta. Number of algae belonging to each division was lesser in Kerala compared to Andaman Islands as reported by him. Kaliaperumal et al (1989) studied the seaweed resources of 12 islands of Lakshadweep. They recorded 43 species of Chlorophyceae, 14 species of Phaeophyceae and 54 species of Rhodophyceae. In all islands studied by them, maximum diversity was found in Rhodophycean algae, and minimum in Phaeophycean algae, as was observed in Kerala.

Thus almost throughout the entire coast of India, Rhodophyta outnumbered all other divisions in terms of diversity and Phaeophycean algae were comparatively less. Misra (1965) suggested that tropical ecological conditions, especially extremely high range of temperature and long periods of severe insolation are responsible for the absence of many brown algae, which occur in the temperate regions of the world, from Indian coasts. Red algae on the other hand may be more tolerant to the tropical environmental conditions.

6.1.1 Environmental factors controlling species composition, distribution and density of seaweeds

Species composition, diversity and density of seaweeds varied significantly from station to station in the present study. Thikkotti showed the maximum species diversity with 37 species of seaweeds, followed by Mullur with 33 species. Varkala recorded 22 species, Elathur 21 species and Saudi 9 species. Mullur recorded the highest density of 3971.25 gm of seaweeds/m^2 (wet weight) followed by Varkala with 2047.50 gm/m^2. Elathur recorded 1832.29 gm/m^2, Thikkotti 1408.13 gm/m^2 and Saudi 1387.50 gm/m^2. The station which showed the highest diversity of seaweeds did not thus show the highest density. Therefore it can be said that the factors controlling the occurrence and distribution of a species of seaweed need not necessarily be condusive for its further growth and development. Distribution and growth of seaweeds is therefore a combined or synergetic effect of a number of environmental and other biotic factors, out of which some factors play major roles, while others minor roles.

In order to get a clear picture of the cause of disparity observed between stations, in species composition, diversity and density of seaweeds, the environmental peculiarities observed at each station and its possible effect on the above mentioned aspects of seaweeds are briefed below.

Krishnamurthy (1965) and Krishnamurthy and Subbaramiah (1970) described the importance of shore types in the zonation of Indian marine algae. According to them sandy shores are bereft of algal vegetation, because of the absence of firm substratum for attachment, while rocky shores harbour a good amount of algae. A similar observation was made along the Kerala coast during the present study. The Central zone of Kerala from Kollam in the South to Kozhikode in the North is sandy with complete absence of rocks and boulders in the sea, unlike the other parts of Kerala coast. The representative station in this zone-Saudi-differed from all other stations studied, mainly in this regard. In this context, it may be noted that, in the present study, Saudi recorded the lowest density and diversity of seaweeds. Moreover no Phaeophycean alga was recorded from Saudi. Mullur in the South zone quite unlike the other stations had a vast expanse of natural rocks and boulders extending several metres into the sea and submerged at varying depths, a factor that might have favourably influenced the distribution and density of seaweeds in this area. This station recorded the highest seaweed density, good diversity and highest number of Phaeophycean algae. Moreover most of the seaweeds from this station showed very high frequency of occurrence. All these can well be attributed to the vast expanse of rocks and boulders in this area, which serves as a suitable substratum for settlement of seaweed spores and its development. Varkala, the second station in South zone recorded a lower density and diversity of seaweeds compared to Mullur. This disparity can mainly be due to the lesser number of natural rocks and boulders in the area. Moreover rocks were observed only upto a distance of 2 m into the sea in this area, thus greatly reducing the width of the seaweed belt. Elathur in North zone was also bestowed with outcrops of natural rocks submerged at varying depths upto a distance of 5 m into the sea from the shore. Thikkotti had a sandy beach with numerous sand covered rocks extending upto a distance of 4 m from the shore into the sea. Unlike Saudi, Thikkotti showed the occurrence of many psammophytic species of seaweeds like Caulerpa.

From the above, it is clear that absence of suitable substratum was primarily responsible for delimiting the growth of many varieties of algae, especially in the Central zone of Kerala. Substratum is an essential pre-requisite for distribution and growth of algae and the disparity observed between stations in species composition, density and diversity is mainly due to the disparity in availability of substratum.

General information on the effects of sand on marine communities are given by Chapman (1943, 1955), Stephenson (1943) and Lewis (1964). Srinivasan (1969), reported that sandy beaches harbour very little or few algal forms, while hard substratum supports innumerable variety of algae. Untawale and Dhargalkar (1975) observed that along Goa coast, seaweed growth occurs mostly along rocky shores while sandy shores are devoid of macrophytes. They suggested that constant accretion and erosion were responsible for the absence of algae along sandy beaches. Daly and Mathieson (1977) suggested that sandy beaches exhibit reduced populations of seaweeds because of extensive sand abrasion, reduced light levels and lack of stable substrate. Subbaramiah et al (1977) observed that the distribution and growth of marine algae in Pamban area is mainly controlled by availability of substratum. Agadi and Untawale (1978) suggested that along Goa coast an important factor for algal growth is the nature of substratum. Agadi (1985) noted that along Karnataka coast, sandy areas were devoid of algal growth. Shunula (1985) observed that sandy beaches were devoid of algal vegetation in the five shores of Zanzibar, studied by him. Trono Jr. (1988) observed that different types of substratum influence the local distribution of seaweed species.

Temperature is another major factor that was observed to play an important role in controlling the distribution, diversity and density of seaweeds in the present study. Statistical analysis revealed that there was significant variation in the surface water temperatures between stations. Variation in atmospheric temperature between stations though not found to be statistically significant, its biological significance cannot be ruled out. In the present study, Saudi recorded the highest atmospheric and surface water temperature. Densities of two species of algae, Ulva fasciata and U. lactuca showed a negative correlation with temperature. These two algae were found to grow in all the stations studied except Saudi. Nienhius (1971) observed the explosive development of Enteromorpha spp. at higher temperatures. This alga was observed to be growing abundantly in Saudi. Therefore it can well be assumed that temperature plays an important role in controlling the algal distribution. Severe insolation may be considered an important factor in the absence of brown algal species at Saudi. In the present study, Mullur recorded the lowest atmospheric and surface water temperature which might have favourably influenced the seaweed growth in the area. Varkala recorded higher atmospheric and surface water temperature than Mullur and here the effect of insolation also was observed to be more. This is because, at Varkala, rocks were submerged only upto a depth of 0.75 m in the sea, unlike that in Mullur. This factor might have played an important role in the absence of many species of seaweeds recorded at Mullur, from Varkala. Krishnamurthy (1965) observed that in tropical intertidal shores, only a few algae grow due to intense insolation and strong light which makes the coast uninhabitable to algae not adapted to withstand dessication. Chapman (1978) observed that sea temperatures affect biogeographic distribution and sets limits to many species of seaweeds. Trono Jr. (1988), suggested that the local distribution of seaweeds in inter-tidal areas and tide pools are influenced by temperature and that very high temperatures often excludes many algal species.

A third factor that was found to control the occurrence and density of seaweeds in the present study was salinity. Among all the stations studied, lowest salinity was recorded at Saudi and this area showed wide fluctuations in salinity regimes. During monsoon, salinities as low as 17 ppt and 18 ppt were recorded at Saudi. This might have been a primary factor that restricted the density and distribution of seaweeds at Saudi. This is further confirmed by the fact that Mullur with high density and diversity of seaweeds recorded the highest mean salinity. Elathur also recorded comparatively lower salinity and here also salinities fluctuated between 21 ppt during monsoon to 36.6 ppt during post monsoon. This might have controlled the seaweed distribution and growth in the area, inspite of the fact that enough substratum for seaweed growth were available at Elathur. Various floristic studies along salinity gradients in estuaries and lagoons (Doty and New house, 1954; Conover, 1964; Munda, 1978; Coutinho and Seelinger, 1984) have documented a reduction in species diversity with increasing dilution and concentration of sea water and have postulated the halotolerance of marine algae based on their distribution. Marine red algae as a whole are considered to be sensitive to mesohaline conditions (5-18‰) as relatively few representatives are recorded from salinities below 15‰ (Munda 1978; Coutinho and Seelinger 1984). According to Munda (1978) salinity along with substrate configuration is the major factor responsible for changes in algal growth. Durairatnam and Reghunathamuthaliar (1973) suggested that water temperature had no effect on algal growth whereas salinity affected the growth of algae. Chapman (1978) suggested that salinity factor is very important in estuaries where red and brown algae tend to disappear. Bird and Mc.Lachlan (1986) studied the effect of salinity on the distribution of several species of Gracilaria. Euryhalinity of most isolates suggested that salinity is not a critical factor in determining its distribution. But maximum growth occurred at salinities of the natural environment. Umamaheswara Rao (1987) observed that as salinity decreased there was a reduction in members of red algae and green algae became more abundant. Gavino Trono Jr. (1988) observed that there is a low diversity of seaweeds in habitats with highly fluctuating salinity regimes.

In the present study, the dissolved oxygen content was found to vary significantly between stations. Elathur recorded the lowest dissolved oxygen content. Saudi and Thikkotti recorded almost the same dissolved oxygen content. Elathur recorded a higher density of seaweeds than both Saudi and Thikkotti and a greater species diversity than Saudi. Densities of many species of algae were found to have a positive correlation with dissolved oxygen content of ambient waters. Therefore it can be said that eventhough dissolved oxygen content of the waters is not a critical factor in controlling the marine algal density and diversity, it does favourably influence the seaweed growth when available in good quantities. This may be one of the reasons for the good algal growth at Mullur, which recorded the highest dissolved oxygen content in the present study. Gaur et al (1982) observed a positive correlation between phytomass of Ulva lactuca and dissolved oxygen content as was observed in the present study. Gavino Trono Jr. (1988) observed that dissolved oxygen content never becomes a limiting factor for the growth and development of seaweed communities. This observation was similar to the one made in the present study.

Rodhe (1948) and Blinks (1951) have cited the availability of nutrients as an important factor in governing the distribution of algae and that phosphorous and nitrogen are often limiting. In the present study, Mullur with comparatively lower concentrations of nutrients recorded high density and diversity of seaweeds. Saudi which had the highest concentration of nutrients, recorded low density and diversity of seaweeds. Densities of some species of algae were found to show correlations (positive or negative) with one or more of the nutrients in the present study. Therefore it can be said that the optimum amount and type of nutrients required for proper growth and development is specific for each species. When required nutrients are available in the optimum quantities in the station of growth, the species thrive well. But like dissolved oxygen content, nutrients also do not play a critical role in controlling seaweed density and diversity. Murthy et al (1978) observed that nutrients are not limiting for intertidal algae because of remineralisation from dead forms coupled with efficient mixing of waters. Agadi and Untawale (1978) suggested that nutrients promote growth of algae, but unlike temperature, tides etc. are not controlling factors in the distribution of algae. According to them seawater in the coastal areas are rich in nutrients needed for algal growth. Chapman (1978) suggested that nutrient variations in seawater are mainly of concern in development of plankton but not an important factor in controlling seaweed vegetation. Gaur et al (1982) suggested that the availability of nutrients in seawater was not related to phytomass production of Ulva lactuca. Inger Wallentinus (1983) conducted in-situ experiments with different combinations of annual and perennial seaweeds, simultaneously exposed to varying ambient conditions. He demonstrated that while nutrient uptake by annual macro-algae were much higher than that of perennials and strongly correlated to nutrient concentrations of water, their productivity did not increase to the same extent and was less dependent on ambient nutrient concentrations.

Another major factor that appeared to influence seaweed density and diversity, in the present study was turbidity of the ambient waters. At Elathur, the water was observed to be turbid throughout the year especially during monsoon due to the influx of fresh water. This was found to adversely affect the light penetration to the deeper waters in this area. Dawson (1966) suggested that transparency of the waters largely determines the thickness of the productive zone. Srinivasan, (1969) described the clearness of seawater as an important factor in influencing the growth of seaweeds. According to him many seaweeds are susceptible to turbidity and pollution of seawater and only a few marine algae tolerate such environments. This may be one of the major reasons why Elathur bestowed with an abundance of natural substratum did not show as much seaweed growth and diversity as Mullur. Chapman (1978) observed that a combination of light intensity and clarity of water will determine the maximum depth to which seaweeds can descend. According to him for every sublittoral alga there must be a minimum light intensity below which there is no growth.

In the present study it was observed that Varkala and Saudi were subjected to heavy breakers and high swells especially during monsoon, which often results in sea erosion in this area. Thus wave action might have adversely affected the growth of algae in this area. Srinivasan (1969) suggested that exposed rocks subjected to heavy breakers and swells, harbour algae with strong hold fasts. In the present study also species like

Chaetomorpha antennina, Grateloupia filicina and G. lithophila with strong holdfasts were found to grow on rocks exposed to heavy breakers and swells. Arudpragasam (1970) observed that at Galle Buck in Sri Lanka the variation in species composition was related to wave action. Chapman and Chapman (1975) suggested that tidal currents affect the growth of plants and presence or absence of seaweed species. According to them wave tolerant species have strong holdfasts and higher tensile strength of thalli and rapid attachment of swarmers to rocky substrate. Chapman (1978) suggested that wave action is essentially a presence or absence factor for algal vegetation in an area. According to him, it can also be a modifying factor as big waves elevate the height of seaweed communities along the littoral zone. Agadi and Untawale (1978) suggested that both tidal currents and waves affect the growth of seaweeds. Agadi (1983) observed that along Anjuna coast, Goa, during mid February there is tremendous increase in wind direction and speed making coastal waters turbulent resulting in uprooting and removal of algal crop. Trono Jr. (1988) observed that big waves mechanically remove significant amounts of seaweed stock as illustrated by the tremendous amounts of drift weeds that accumulate on the shore after a storm.

Morphological changes in the topography of Varkala beach was noticed during the present study. Periodically, the artificial sea wall made of granite on which the seaweeds grew were completely covered by sand. Similar observations were made by Umamaheswara Rao and Sreeramulu (1964) at Vishakapatnam coast. Daly and Mathieson (1977) studied the sand movement and benthic intertidal organisms at New Hampshire, U.S.A.

According to them the lower intertidal zone was dominated by opportunistic annuals like Enteromorpha spp. and psammophytic seaweeds. Similar observation was made at Varkala during the present study. According to the authors the limited species diversity of seaweeds at the study area is attributable to unstable environmental conditions and limited number of habitats. Therefore the seasonal sand movement observed at Varkala can be considered a major factor that delimited seaweed density and diversity in the area. Krishnamurthy and Balasundaram (1990) reported the covering and uncovering of rocks of the intertidal region by sand along Tiruchendur shore. According to them this is a regular feature in various places of South India. Murthy and Varadhachari (1980) observed morphological changes at Valiathura beach, near Trivandrum. They attributed it to turbulent diffusion, advection etc. related to wave action. This may hold true with Varkala beach also.

Misra (1959) described temperature, tidal depth, submergence, emergence, salinity, pH and biotic factors as responsible for algal growth. Jones (1959) found that currents enhanced the growth of Gracilaria verrucosa by exposing more of the thallus to light. Conover (1968) recorded differential standing crops of seaweeds under varying current regimes and stated that the effects of currents are to produce faster uptake and diffusion of dissolved substances. Prescott (1969) suggested that the growth and distribution of marine algal flora depends on topography, geological features, physico-chemical characters of water and other biological factors. Srinivasan (1969) described nature of substratum, effect of tides, surf and wave action, clearness of water, biotic and seasonal changes as important factors affecting seaweed growth. Doty (1971b) observed that the water motion is beneficial to the growth of algae as it enhances better absorption of nutrients. Chapman (1978) described various factors like photoperiod, tides, submergence exposure, water loss, wave action, tidal currents, substrate, humidity, temperature, pressure, light and other chemical and biological factors as influencing the algal vegetation. Trono Jr. (1988) suggested that quality and intensity of light changes, as it penetrates the water column, which in turn affects the distribution of various species. According to him, water movement caused by waves and currents aerates the water and helps in nutrient transport, prevents water temperature from rising and favours good light penetration. Water depth also, according to him, is important in influencing the abundance and distribution of seaweeds. Thomas and Subbaramaih (1990) observed that Sargassum wightii had a shading effect on the growth of other seaweeds.

From the above, it is clear that a combination of environmental factors operating at each station together with the specific preferences of each species of algae act and counteract to determine the algal composition,diversity and density of any given area.

6.1.2 Seasonal changes in species composition, distribution and density of seaweeds

Misra (1965) observed that corresponding with the changes brought about by tropical monsoonic and temperate conditions marine algal vegetation undergoes marked seasonal successions. In the present study also marked seasonal changes in algal distribution, species composition, number of species, dominant species, and density of each species were observed. Balasundaram (1985) made similar observation on the Tiruchendur shore. Along Kerala coast, post monsoon season (September-December) recorded the highest seaweed density, followed by pre-monsoon. Brown algal density was maximum during pre monsoon and red algal density during post monsoon. Both red and brown algal densities were minimum during monsoon. Misra (1965) observed that October-November period marked by the end of South-west monsoon, constitutes the regeneration period of all types of algae, and the earliest to grow is Chlorophyceae. Growth of species of Dictyota, Padina, Spathoglossum and Sargassum occur. Occasionally such growths show reproductive structures on the thalli. The progress of vegetative phase becomes very active and marked, during late November-January. January was observed by him to be the climatic climax for algal growth on the west coast littoral regions. Dictyotales and Fucales maintain their growth through February and May and according to him can reasonably be called as reproductive period. In the succeeding monsoonic period beginning in June and extending upto September, all algal growth declines and ultimately comes to an end. Similar observations were made along the Kerala coast during the present study. High densities of red and brown algae observed during post and pre monsoon seasons may be corresponding to the growth and reproductive phases of these algae which are reported to occur during late post monsoon and pre monsoon.

Sreenivasan (1969) observed that seasons had marked effect on the growth of several species of seaweeds, particularly those flourishing on the upper limits of littoral belts. According to him the cool winter months of December and January support a climax of littoral algal vegetation. Gopalakrishnan (1970) observed that red and brown algae appear in large quantities during post monsoon and last till the end of April ie, pre monsoon. This observation was similar to the one obtained in the present study. Agadi and Untawale (1978) observed that along Goa coast, the period from November to March was the best season for algal growth. Similar observation was made along the Kerala coast during the present study. Agadi (1983) observed that along the Anjuna coast of Goa, maximum biomass was recorded during December-January which gradually decreased thereafter. From March to August algal growth was negligible. According to him more number of species were observed during December-January when water temperature is low and wave action mild. Thereafter the number of algal species shows a gradual decrease during summer when temperature is high and nutrients in water low. Gavino Trono Jr. and Teresita Buchan (1987) studied the seasonality in biomass of Acanthophora spicifera in Bacoor Bay, Philippines. According to them the biomass production was high during colder, calmer months of November-January and low during the rest of the year. Along Kerala coast also, this alga was collected as cast up weed from the Thikkotti beach during the period from November to January. Balakrishnan Nair et al (1990) surveyed the occurrence, distribution and relative abundance of brown algae at four representative stations along

South-west coast of India. They observed that species composition of brown algae varied with stations, as was observed along Kerala coast during the present study. They also observed that brown algal density increased during monsoon. But this observation was quite contrary to the one obtained in the present study, where brown algal density decreased during monsoon. Sampathkumar et al (1990) observed that in Pudumadam and Tuticorin the biomass of Phaeophycean algae was more during post-monsoon than monsoon as was observed in the present investigation. In the present study, there was a marked fall in brown and red algal densities during monsoon. The heavy rains during monsoon, often results in severe wave action and tidal currents. During this period many delicate seaweeds get washed off. Only those species with strong holdfasts survive the turbulence of the sea. This is one of the factors responsible for the reduction of brown and red algal species during monsoon. Transparency or clarity of water is another important factor influencing the density of seaweeds. Agadi and Untawale (1978) suggested that transparency value of 3.3 m observed during post monsoon favoured the growth of seaweeds at Goa and the value of 0.2 m observed during monsoon had an adverse effect on the growth. As discussed earlier turbidity of the waters hampers light penetration. This in turn will affect the density of the seaweeds especially those of the deeper waters. These areas are usually occupied by red and brown algae, and hence the seasonal reduction in densities of these two divisions of algae during monsoon.

Density of green algae was observed to be maximum during monsoon in the present study. Densities of many species of green algae showed a negative correlation with temperature. It was also observed that during monsoon, the atmospheric temperature, surface water temperature and salinity decreased and nutrient concentrations increased due to upwelling. Therefore it can be said that the low atmospheric temperature, surface water temperature and salinity and the high nutrient concentrations in the ambient waters observed during monsoon, favoured the growth of green algae. Shunula (1983) studied the biomass trends of Ulva fasciata in Dar-es-salaam, Tanzania. He observed that the standing crop of U. fasciata was highest during cool months and lowest during hot months due to insolation, heating, evaporation and dessication. Salinity around the thallus increases during hot season leading to plasmolysis and death of alga. Similar observation was made by Lawson (1957) on the west coast of Ghana. This might be the case along the Kerala coast also during pre and post monsoon periods with regard to green algae. Balakrishnan Nair et al (1990) studied the occurrence, distribution, growth and abundance of green algae from South-west coast of India. According to them the maximum of green algae was observed during monsoon, due to low temperature, low salinity, low dessication and increased nutrient concentrations in ambient waters. This confirms the observation made in the present study.

Along the Kerala coast seasonal variation was observed in the environmental factors studied like atmospheric and surface water temperature, salinity, dissolved oxygen content and concentration of nutrients like phosphate, nitrate and silicate in the ambient waters. Seasonal variation in surface water temperature, phosphate and silicate contents were very significant statistically. Densities of several species of seaweeds were found to be correlated with one or more of these parameters in the present study. Therefore it can be said that monthly/seasonal variation in the environmental parameters is one of the factors responsible for the monthly/ seasonal variation in seaweed densities. But the way these parameters affect the seaweed density varies with algal division, species etc.

Several authors have studied the seasonal variation in seaweed densities and have explained it in different ways. Lawson (1957) observed a correlation between the seasonal changes in the growth of Hypnea musciformis and seasonal changes in tides at Ghana. Similar observations was made by Richardson (1969) for the same species at Trinidad coast. Rama Rao (1972) observed that seasonal changes in lowest lower low water (LLLW) along with parameters like exposure to air and temperature control the seasonal changes in density, growth and upper limit of Hypnea musciformis along the Indian coast. Prasanna Varma (1959) suggested that in Palk Bay, maximum growth and vegetation occurred during months of low salinity, and rhythmic fluctuations in total nitrogen seems to correspond with periodic vegetative and reproductive phases of algae. According to him consideration of temperature as a contributory factor has limited scope. Doty (1971a) observed that in tropical non-monsoonal areas like Hawaii, random effects of storm is the most influential factor regulating the size of marine algal crop, and seasonal factors like light and temperature were less important. He noticed that in polar and temperate latitudes seasonality is strongly related to seasonal light and temperature changes. Umamaheswara Rao and Sreeramulu (1964) and Umamaheswara Rao (1972) suggested that seasonal variations in algal growth is due to seasonal variations in submergence and other physical conditions of the environment. Murthy et al (1978) observed that temperature of air and seawater and dissolved oxygen content of ambient waters were the critical factors governing the monthly fluctuations in biomass, zonation and distribution of intertidal algae. Shakuntala Moorjani (1979) studied seasonal changes in marine algal flora along Kenya coast and according to her richest flora occurs, during the end of South-east monsoon when temperature is lower. This shows that in Kenya also seasonal changes in marine algal standing crop is related to monsoonic changes. Thom (1980) studied the seasonality in benthic marine algal communities in Central Puget Sound, Washington. According to him fluctuations in algal cover were positively correlated with air temperature and sunlight and negatively correlated with precipitation. Agadi (1983) suggested that composition and abundance of marine algal species in different zones varied seasonally, depending mainly on factors like temperature, salinity, currents, substrate and tidal range. Monsoon has a great influence on this, because rains bring down the temperature and salinity of water, and increases turbulence of the waters. This is true with regard to Kerala coast also. The lowering of temperature, salinity and increased turbulence of waters during monsoon, adversely affected the red and brown algae. Trono and Saraya (1987) observed that seasonal distribution of small species appeared to vary mainly by the abundance of large perennial macrophytes. Chennubhotla et al (1990) observed that no single environmental parameter could be pin pointed as responsible for variation in seaweed production between seasons. According to them a complexity of environmental factors operating in a dynamic inshore area may be responsible for seasonal variation in the production of seaweeds.

During the course of the present study, the red algae Porphyra kanyakumariensis was found to occur along the Kerala coast (Anon 1988, Chennubhotla et al 1990). This alga was found to show a marked seasonal occurrence. It was found to grow along the upper littoral regions of the coast during monsoon, on Chthamalus encrusted or smooth rocks, daily covered and uncovered by tides. During early monsoon (June) they appear as patches and later forms distinct purplish bands on boulders exposed to waves. The growth period of this alga was from June to September along the Kerala coast. Krishnamurthy and Baluswami (1984) have given an account of four species of Porphyra occurring in India and the species collected from Kerala, confirms to their description of Porphyra kanyakumariensis (Chennubhotla et al 1990). The genus Porphyra has a distribution along the west coast of India, from Kanyakumari to Gujarat and on the east coast at Visakhapatnam (Umamaheswara Rao and Sreeramulu, 1963).

Iverson (1976) suggested that a combination of low winter temperature and nutrients carried by the stream to the sea during monsoon stimulates the growth of this alga. Dhargalkar et al (1981) reported the occurrence of Porphyra vietnamensis along Goa coast during monsoon. They observed that this alga is stimulated by low temperature, salinity, light intensity and high nutrient concentrations. Agadi (1985) reported the occurrence of Porphyra along the supra-littoral fringe of Karnataka coast during monsoon and suggested that high monsoonal waves reaching the top portion of the supra-littoral zone, along with low atmospheric temperature, surface water temperature, salinity etc. favour the growth of this alga.

6.1.3 Standing crop of seaweeds along Kerala coast

In the present study the average density of seaweeds along Kerala coast was estimated to be 2129.33 gm/m^2 (wet weight). Out of this agarophytes constituted 13.5%, agaroidophytes 6.98% and alginophytes 9.06%. Thus 29.53% of the seaweed standing crop of Kerala was constituted by commercially important seaweeds. Koshy and John (1948) estimated 10,000 lbs (dry) agarophytes from Travancore coast from 1942 to 1946. Chennubhotla et al (1986) estimated 1000 tonnes of seaweeds from the entire coast of Kerala.

Subbaramaih, (1987) reported a seaweed resource of 77,000 tonnes (wet) from the Indian coast. Several authors have carried out the seaweed resource survey of Tamil Nadu coast. Koshy and John (1948) surveyed the area from Cape Comorin to Colachel and estimated 5 tons of seaweeds; Chacko and Malupillai (1958) estimated 66,000 tons from Calimere to Cape Comorin, Varma and Rao (1962) recorded 1000 tons of seaweeds from Pamban area, Umamaheswara Rao (1973) estimated the seaweeds from Palk Bay area, Subbaramaiah (1979a) reported 22,044 tonnes (wet) of seaweed standing crop from an area of 17,125 ha in Tamil Nadu. This constituted 1,709 tonnes agarophytes 10,266 tonnes of alginophytes and 10,069 tonnes of other seaweeds. Anon (1989) estimated a standing crop of 9100 tons (wet) seaweeds from an area of 125 km^2 off Tuticorin-Tiruchendur.

Seaweed resource surveys of Gujarat coast was conducted by several authors. Sreenivasa Rao et al (1964) estimated 60 metric tons of Sargassum from Adatra reef. Desai (1967) surveyed Gulf of Kutch region and estimated 10,000 tons dry brown algae, 5 tons (wet) Gelidiella and 20 tons (dry) Gracilaria. Chauhan and Krishnamurthy (1968) recorded 19,000 tonnes (wet) seaweeds from Gulf of Kutch. Bhanderi and Raval (1975) conducted a survey from Okha-Dwaraka and estimated 1000 m. tons of fresh Sargassum. Bhanderi and Trivedi (1975) reported an annual yield of 650 tons (wet) of seaweeds from Hanumandandi reef and Vumani reef near Okha Port. Chauhan and Mairh (1978) estimated the standing crop of seaweeds from Okha to Mahuva.

The marine algal resource of Maharashtra coast was reported by Chauhan (1978), Untawale et al (1979) estimated an annual yield of 20,000 tons (wet) of seaweeds from the entire coast of Maharashtra.

Untawale and Dhargalkar (1975) surveyed the total area occupied by the seaweeds along Goa coast and they estimated an yield of 256.6 metric tons net weight per year from an area of 0.150 sq.km. Seaweed standing crop of Karnataka coast is reported to be negligible (Anon, 1981). Krishnamurthy (1985) has indicated new seaweed exploration survey being conducted at Andaman and Lakshadweep islands, Andhra coast and Idinthakarai, Tamil Nadu.

The marine algal resources of 9 islands of Lakshadweep were estimated by Subbaramaih et al (1979b). Out of the 2555 ha surveyed, 785 ha was found to be productive, and the total standing crop was estimated to be between 3645-7698 tons (wet) of which agarophytes constituted 27%, alginophytes 0.2% and other seaweeds 72.8%. Kaliaperumal et al (1989) estimated a standing crop of 19,345 tonnes (wet) of seaweeds from Lakshadweep.

Attempts to estimate drift seaweeds have been made by several workers. Krishnamurthy et al (1967) and Subramanyan (1967) have indicated the importance of estimating drift seaweeds. In the present study 12 species of seaweeds from Thikkotti and 2 species from Varkala were collected as cast ashore weeds. All seaweeds thus collected were in fresh and healthy condition. The presence of cast up weeds in fresh condition indicated the occurrence of their beds in the near shore waters (Krishnamurthy et al 1967 and Masao Ohno, 1983). But in the present study the beds of these weeds could not be located, except those of *Acanthophora spicifera* and *Caulerpa peltata* at Thikkotti.

From the above it is clear that compared to the other maritime states of India, like Gujarat, Maharashtra and Tamil Nadu and island eco-systems of Andaman-Nicobar and Lakshadweep, the seaweed resource of Kerala coast is scanty. Therefore the state cannot be solely depended for the raw material supply for industries. But the seaweed resources of Kerala can be used to supplement the raw materials needed for expanding seaweed based industries. A deep water survey in the offshore waters of Kerala might yield better results with regard to seaweed standing crop.

6.1.4 Zonation of seaweeds along Kerala coast

During the course of the present investigation a definite pattern of zonation of seaweeds was observed. Misra (1959) observed *Ulva Enteromorpha* belt in the upper mid-littoral zone. He observed the association of *Hypnea musciformis*, *Acanthophora*, *Laurencia* and *Caulerpa scalpelliformis* in deeper pools. Similar association of these seaweeds was observed at Mullur in the present study. Srinivasan (1959) indicated that rocks subjected to heavy breakers or wave action harbour algae like *Chaetomorpha antennina*, species of *Cladophora*, *Chnoospora*, *Sargassum*, *Porphyra*, *Halimeda*, *Ectocarpus*, *Sarconema* and *Gracilaria*. Many of the above said species were found to grow on wave exposed rocks along the Kerala coast also. Subbaramaiah (1971) has described the vertical distribution of marine organisms on Jalleshwar Shore, Veraval. According to him *Enteromorpha* occupies the lower high water level, *Ulva lactuca* the higher low water level, *U. fasciata* (Subbaramaiah, 1970), *Gracilaria corticata* and Hypnea musciformis extend to the lower low water level and Sargassum tenerrimum extends to the sub-tidal region. Agadi and Untawale (1978) observed along Goa coast that species of Chaetomorpha, Ulva and Enteromorpha occur at higher levels, on rocks exposed to light where only humidity is required for algal growth. Similar observation was made along Kerala coast also. Kannan and Krishnamurthy (1978) observed that along Coromandal coast Enteromorpha and Chaetomorpha inhabits all aquatic biotypes suggesting the adaptability of these algae. Along the Kerala coast, these two species of algae were recorded from all the five stations of study, thus confirming the adaptability of these species. Agadi (1983) observed along the Goa coast that the upper part of the algal zone, Chlorophycean members like Ulva, Enteromorpha and Chaetomorpha were present. This confirms the observation, made along the Kerala coast. The author observed several rock pools in the mid algal zone at Goa, occupied by Sargassum, Padina, Gracilaria corticata, Hypnea musciformis and Grateloupia filicina. Several associations like Spatoglossum-Stoechospermum-Dictyota and Gracilaria-Grateloupia-Ulva were observed along Goa coast. As observed along Kerala, in Goa coast also the lower regions were occupied by species of Sargassum, Gracilaria and Hypnea. Agadi (1985) observed species like Porphyra, Ulva, Enteromorpha and Chaetomorpha along the supra-littoral fringe of Karnataka coast as observed in the present study. He observed the lower littoral zone to be occupied by species of Sargassum, Dictyota, Laurencia, Acanthophora, Spyridea and Hypnea growing on rocky substratum. Gracilaria corticata and Grateloupia lithophila grew in places with strong wave action along Karnataka coast. These observations were similar to those obtained in the present study. Jagtap (1985) observed Caulerpa species growing in rock pools in Andaman islands. Chaetomorpha and Ulva were growing at the high tide mark in the spray zone. Enteromorpha intestinalis was observed to be growing in a sewage polluted area in Aberdeen Jetty. These observations were similar to the one made in the present study. Doty (1946) observed that critical tide factors are responsible for vertical zonation of marine algae. Krishnamurthy (1965) observed that nature of tides, extent of intertidal zone, physiographic factors and topography of the shore are the factors controlling the zonation of marine algae on the Indian coasts. Dawson (1966) suggested that the adaptation of different plants to varying conditions of light, temperature, exposure to sea, salinity etc. results in distinct zonation of plants. Krishnamurthy and Subbaramaiah (1970) observed the importance of shore types in the zonation of Indian marine algae. Schwenke (1971) described wave action and tidal currents as the important factors determining the local distribution of seaweeds. Mathieson et al (1977) described current regimes, topography of shore and type of substrate as responsible for spatial variations in species composition and abundance of benthic organisms. According to them vertical substrates exposed to strong tidal currents are devoid of algae, while recessed shoreline with sloping substrate exhibited good diversity and abundance of intertidal organisms. Umamaheswara Rao and Sreeramulu (1964) and Umamaheswara Rao (1978) observed that the differences in the distribution of algae in relation to changes in tidal exposure and submergence at Mandapam and Visakhapatnam coasts clearly indicate the importance of tidal factor on the zonation of intertidal algae. Trono and Saraya (1987) suggested that degree of water movement and availability of substrates are major factors in controlling the horizontal distribution of large foliose dominants. Mechanically strong macrophytes attained peak development in the wave exposed portions of the reef, while mechanically weak species were limited to protected portions.

6.2 BIOCHEMICAL COMPOSITION OF SEAWEEDS

Along the Kerala coast, brown algae recorded the highest protein content followed by red and green algae. The protein content in green algae varied from 1% recorded in Valoniopsis pachynema to 20% recorded in Caulerpa fastigiata. In brown algae it varied from 2.8% in Padina gymnospora to 19.4% in P. tetrastromatica. In red algae, it varied from 2.3% in Grateloupia lithophila to 19.6% in Porphyra kanyakumariensis.

High carbohydrate content was recorded in both red and green algae. Brown algae recorded the lowest carbohydrate content along Kerala coast. In green algae, it varied from 2.75% recorded in Valoniopsis pachynema to 75% in Caulerpa peltata. In brown algae it varied from 3.5% in Padina gymnospora to 18.25% in Sargassum wightii. In red algae it varied from 6% in Hypnea valentiae to 55% in Grateloupia filicina.

Highest lipid content was recorded in brown algae followed by green and red algae, along Kerala coast. Lipid content in green algae varied from 0.5% in *Valoniopsis pachynema* to 18.75% in *Caulerpa sertularioides*, in brown algae it varied from 0.15% in *Turbinaria conoides* to 11.3% in *Dictyota dichotoma* and in red algae it varied from 0.5% in *Centroceras clavulatum* to 5.5% in *Gracilaria foliifera*.

Thus in the present study, it was observed that biochemical composition varied markedly between different species of the same algal division, suggesting that the quantity of biochemical constituents in an alga is independent of its taxonomic division. Ogino (1955) studied variation in protein nitrogen fraction in a number of Chlorophyceae, Rhodophyceae and Phaeophyceae. He found that these fractions varied with species. Lewis (1967) observed that, although green algae were generally rich in protein, *Grateloupia lithophila* belonging to red algae and *Dictyota maxima* belonging to brown algae showed high protein contents. Andrea *et al* (1987) observed that although relatively high protein content was recorded in red algae, *Eucheuma striatum* belonging to red algae had low protein content. According to them, brown seaweeds likewise did not yield uniformly low protein contents. *Dictyota* sp. (brown alga) contained fair amount of protein.

Lewis and Gonzalves (1960) reported more than 28% protein in algae from Bombay coast, while the maximum protein content recorded in algae from Kerala coast was only 20% (*Caulerpa fastigiata*). Dhargalkar *et al*

(1980) observed that protein content of marine algae from Maharashtra varied from 10-33%, suggesting that protein content of seaweeds of Maharashtra was higher than that of Kerala. In Maharashtra, both protein and carbohydrate contents were highest in red algae, but as was observed in Kerala, green algae like Caulerpa and Ulva also recorded high carbohydrate contents. Sitakara Rao and Tipnis (1964) estimated the crude protein content of algae of Gujarat coast. Dave and Parekh (1975) studied 8 genera of green algae from Saurashtra. They observed significant variation in protein contents in the same species of alga grown in different localities. In the present study the protein content of Ulva fasciata and the lipid content of Gracilaria corticata varied significantly between stations. Porphyra kanyakumariensis from Varkala recorded 15.13% protein, 21.75% carbohydrate and 1.68% lipid. The same species from Mullur, recorded 18.47% protein, 22.37% carbohydrate and 2.86% lipid. Thus the biochemical constitution were higher in the specimen collected from Mullur. Tewari et al (1968) reported 16.01% protein content in Porphyra species from the east coast of India. Protein content of 33.5% is reported in P. yezoensis from Japan. Jagtap (1985) recorded 17.49% protein, 50.5% carbohydrate and 0.85% lipid in Porphyra vietnamiensis. Durairatnam et al (1988) estimated the chemical composition of some species of brown algae, along Rio Grande Do Norte, Brazil. The protein content of Padina gymnospora varied from 6.6%-12.5%; lipoid content from 0.94%-2.25% and carbohydrate content from 10.7%-41.2%. In the present study the protein content of Padina gymnospora varied from 2.8%-16.4%; lipid content varied from 1.6%-8.75% and carbohydrate content varied from 3.5%-10.25%. Reeta (1990) studied the variation in biochemical composition of *Sargassum wightii* from Mandapam. Carbohydrate content varied from 6.65% to 15.18%, protein content varied from 3.15%-7.20% and lipid content from 0.16% to 1.55% at Mandapam. In the present study, carbohydrate content varied from 5% to 16.75%, protein content from 4.30% to 14% and lipid content from 1% to 6.37%. Murthy and Radia (1978) estimated the biochemical composition of seaweeds at Port Okha and its monthly variations. They attributed the seasonal variation in biochemical constitution to the environmental parameters operating at the site of seaweed growth. In the present study also, the biochemical constituents of many seaweeds showed significant monthly/seasonal variations. Statistical analysis revealed correlations between biochemical constituents of seaweeds and one or more environmental parameters operating at the site of seaweed growth. But how exactly the parameters affect the biochemical constitution of seaweeds is not known. It may be assumed that environmental factors at the site of seaweed growth may be affecting the physiology of the seaweed, which in turn affects its biochemical composition. Correlations were also observed between the biochemical constituents, in many of the seaweeds studied. Dave and Chauhan (1985) recorded the highest protein content of 29.38% in *Spathoglossum variable* among brown algae from Gujarat coast and the lowest of 4.98% in *Iyengaria stellata.*

They also observed monthly and place-wise variation in biochemical composition of seaweeds and attributed it to environmental factors operating at the site of seaweed growth as in the present study. Average protein content of brown algae recorded by them from Gujarat coast was higher than that of Kerala. Dave et al (1987) observed place-wise and monthly variations in the protein contents of red seaweeds from Gujarat coast. Dhargalkar (1979) observed seasonal variation in protein and carbohydrate contents of seaweeds, but according to him lipid content did not show any seasonal trends. But in the present study, lipid content of many of the seaweeds studied, showed significant seasonal variations. Umamaheswara Rao (1970) estimated the protein content of some seaweeds from Mandapam coast. Most of the species recorded by him had a higher protein content than the same species from Kerala, confirming the place-wise variation in biochemical composition of seaweeds. Chennubhotla et al (1987) estimated the biochemical composition of seaweeds from Mandapam. They observed that green algae had the highest protein content while red algae the highest carbohydrate and lipid contents. Compared to Mandapam, green algae from Kerala recorded a lower protein content. But the maximum protein content recorded in brown and red algae, was higher in Kerala, than Mandapam. Maximum carbohydrate content recorded in green and red algae was higher in Kerala than Mandapam. Lipid content of green and brown algae from Kerala was higher than that of Mandapam. Reeta et al (1990) recorded a higher protein content in green algae from Mandapam compared to that of Kerala, but maximum values of carbohydrate and lipid contents were higher in Kerala. They recorded 56.25% carbohydrate content in green alga Caulerpa laeteverens from Mandapam. Along Kerala coast also, species of Caulerpa recorded very high carbohydrate contents. Sumitra et al (1980) studied seasonal variation in biochemical composition of seaweeds of Goa coast, and suggested that biochemical composition did not show marked seasonal changes, unlike the observation made in the present study. Jagtap and Untawale (1980) estimated the protein and carbohydrate contents of Caloglossa lepreiurii (red alga) from Zuari estuary, Goa. They observed marked seasonal variation in biochemical composition of this alga, but have suggested that environmental factors did not have any bearing on biochemical composition of seaweeds. Jagtap and Untawale (1984) estimated the protein contents of marine algae from Minicoy, Lakshadweep. It was found to vary from 100-330 $mg.g^{-1}$ dry weight. Kaliaperumal et al (1987) estimated protein contents of some seaweeds from Lakshadweep. According to them, green algae recorded the highest protein content, red algae the highest carbohydrate content and green algae the highest lipid content. But the biochemical composition of most of the seaweeds from Lakshadweep reported by them was lower compared to that of Kerala. Parekh et al (1983) and Parekh et al (1985) estimated the biochemical composition of Enteromorpha. Both protein and carbohydrate contents recorded by them were higher than that in the present study. Mairh et al (1983) also studied the proximate composition of Enteromorpha. The carbohydrate and lipid contents recorded by the authors were higher than that recorded from Kerala. Solimabi et al (1988) observed seasonal changes in protein and carbohydrate contents in Hypnea musciformis and suggested that protein levels were highest when nitrogenous nutrients were high. Temperature and salinity also according to them had significant effect on biochemical composition of seaweeds. Comparison of abundance and biochemical composition of seaweeds with environmental factors by the authors indicated that during the period of maximum growth, carbohydrates are comparatively higher than proteins. In the present study also significant seasonal variation in biochemical composition of seaweeds was observed. Sobha et al (1988) observed that biochemical constitution varied with species of alga and place of its collection, as observed in the present study. Black, (1954)., Harvey, (1955)., have suggested that the chemical composition of algae does not depend only on their specific characters but also on other factors like seasonal variation in temperature, salinity, sea depth, stages of growth and part of plant studied.

7. SUMMARY

1. The main objective of the study was to collect information on the ecology and basic biochemical composition of the seaweeds of Kerala coast.

2. For the convenience of study, the entire coast of Kerala was divided into three zones, viz. 1) North zone 2) Central zone and 3) South zone. Stations were fixed in each zone. Once every month, trips were undertaken to each station for making ecological observations and for seaweed collection, for a period of two years.

3. During the period of study, 52 species of seaweeds were collected from Kerala coast, out of which 20 species belonged to Chlorophyta, 10 to Phaeophyta and 22 to Rhodophyta. Thus Rhodophyceaen algae were most abundant along Kerala coast, followed by Chlorophycean algae. Phaeophycean algae were relatively less along the Kerala coast.

4. Commercially important seaweeds of Kerala coast and the places of their availability are given. This included 3 species of agarophytes, 7 species of agaroidophytes and 9 species of alginophytes. Names of important edible seaweeds of Kerala are also given.

5. Zone-wise and station-wise distribution pattern of seaweeds of Kerala coast are described. Number of seaweed species was maximum in North zone (42 species), followed by South zone (37 species) and Central zone (9 species). Out of the 42 species of seaweeds recorded from North zone, 13 were exclusive to North zone. Out of the 37 species of seaweeds

recorded from South zone, 8 were exclusive to South zone. Out of the 9 species of seaweeds recorded from Central zone, 1 was exclusive to Central zone. No Phaeophycean alga was present in the Central zone.

6. A definite zonation pattern was observed with regard to several species of seaweeds in the present study. Horizontal zonation pattern of seaweeds was observed at Saudi and Varkala.

7. Density of seaweeds was estimated to be 3971.25 gm/m^2 at Mullur, 2047. 5 gm/m^2 at Varkala, 1832.29 gm/m^2 at Elathur, 1408.13 gm/m^2 at Thikkotti and 1387.5 gm/m^2 at Saudi (wet weight). Density of each species of seaweed, seasonal density of different divisions of algae and of some selected species of seaweeds at each station are given.

8. Along Kerala coast, post monsoon recorded the highest seaweed density followed by pre monsoon. Monsoon recorded the lowest seaweed density. Green algal density was highest during monsoon, brown algal density during pre monsoon and red algal density during post monsoon.

9. Frequency of occurrence of each species of seaweed along Kerala coast is given.

10. Average standing crop of seaweeds along Kerala coast (based on the stations studied) was estimated to be 2129.33 gm/m^2. Out of this, agarophytes constituted 13.5%, agaroidophytes 6.98% and alginophytes 9.06%. Thus 29.53% of the seaweed standing crop of Kerala is constituted by commercially important seaweeds.

11. Environmental data viz. atmospheric temperature, surface water temperature, dissolved oxygen content, salinity, phosphate, nitrate and silicate contents of ambient waters were recorded from Mullur, Varkala, Elathur, Thikkotti and Saudi for a period of two years. Statistical significance of seasonal variation in each environmental factor studied at Mullur, Varkala, Elathur, Thikkotti and Saudi are given. Comparison of environmental data recorded from different stations has been made. Statistical significance of the variation between stations, with regard to each environmental factor is also given. Correlation observed between environmental factors at each station are described.

12. Effect of environmental factors on the density of some selected seaweeds from each station was studied statistically and the results of this study are presented. Density of each species of seaweed studied, showed a correlation of some kind (positive or negative) with one or more environmental factors studied. From this we can conclude that each species of seaweed requires a specific combination of environmental factors for its biomass production.

13. The protein, carbohydrate and lipid contents and the corresponding calorific values of the seaweeds collected from Mullur, Varkala, Elathur, Thikkotti and Saudi are given. Along Kerala coast, brown algae recorded the highest protein content of 11.3%. Green and red algae recorded protein contents of 10.2% and 10.3% respectively. Both green and red algae recorded

high carbohydrate contents of 22.6% and 22.5% respectively and brown algae the lowest of 11.6%. Brown algae recorded the highest lipid content of 5.6% followed by green algae with 4% and red algae the lowest with 1.9%.

14. Seasonal variation in biochemical composition of some selected seaweeds from each station and their statistical significance are described.

15. Station-wise variation in protein, carbohydrate and lipid contents of Ulva fasciata, U. lactuca, Chaetomorpha antennina and Gracilaria corticata are given.

16. Parameters showing correlation (positive or negative) with protein, carbohydrate and lipid contents of some seaweeds from each station were identified statistically.

17. Thus in the present study, observations on the ecology of seaweed flora of Kerala, their distribution and zonation pattern, monthly/seasonal density of seaweeds at each station, frequency of occurrence, standing crop, monthly/seasonal/place-wise data on physico-chemical characters of ambient waters at the stations and their influence on seaweed density have been made. This data will help us in the farming of economically important seaweeds, by providing information on the ideal conditions of seaweed biomass production. Biochemical observations on protein, carbohydrate and lipid contents of different species of seaweeds will give us an idea of their

nutritive value. Seaweeds with high content of proteins, carbohydrates and lipids can be recommended for food and feed formulations after subjecting them to toxicological studies. The study on monthly/seasonal/placewise variation in biochemical composition of seaweeds will provide necessary information on the appropriate time and place of harvesting the algal species for exploiting its constituents.

8. REFERENCES

Agadi, V.V., 1983. Intertidal ecology of marine algae along Anjuna coast, Goa. Seaweed Res. Utiln. 6(1) : 27-30.

Agadi, V.V., 1985. Distribution of Marine Algae in the Littoral zone of the Karnataka coast. In: Marine Plants (ed.) Krishnamurthy, V. pp.35-42.

Agadi, V.V. and A.G. Untawale, 1978. Marine algal flora of Goa coast. Seaweed Res. Utiln., 3 (1 & 2) : 56-70.

Ananza-Corrales Rhodora, 1988. An Introduction to the seaweeds: their characteristics and economic importance. Lecture presented during ASEAN/UNDP/FAO Regional small-scale Coastal Fisheries Development Project and Sea Farming Development and Demonstration Project University of Philippines, Diliman, Quezon City.

Andrea H. Luistro, N.E. Montano, G.J.B. Cajipe and E.C. Laserna, 1987. Protein content of some Philippine seaweeds with notes on the amino acid content of Ulva lactuca Linn. and Gracilaria verrucosa (Huds.) Papenfuss. The Philippine Journal of Science Monograph No.17, pp.23-28.

Anon, 1981. Status report on Marine Algal resources of the Indian coast for research and development, N.I.O., Goa. 12 p.

Anon, 1987. Seaweed Research and Utilisation in India. Bull. Cent. Mar. Fish. Res. Inst. No.41.

Anon, 1988. Seaweed Resources of Kerala, Tamil Nadu and Lakshadweep. C.M.F.R.I. news letter No.40 (April-June) on Seaweed Resources, pp. 2-3.

Anon, 1989. Seaweed resources off the Tuticorin-Tiruchendur coast, Tamil Nadu, India, Report of C.M.F.R.I. and C.S.M.C.R.I.

Anon, 1990. Present status of seaweed exploitation and seaweed industry in India. Marine Fisheries Information Service of Cent. Mar. Fish. Res. Inst. March 1990, pp. 7-8.

Arudpragasam, K.D. 1970. Zonation on two shores on the west coast of Ceylon. J. mar. biol. Ass. India Vol.XII (1 & 2) pp. 1-14.

Balakrishnan Nair, N., V. Sobha and M. Arunachalam, 1982. Algae from Southern Kerala Coast. Indian J. mar. Sci., 11: 266-269.

Balakrishnan Nair, N., V. Sobha, R. Chandran, M. Rathiammal, P.K. Miranda, S. Maya and H. Suryanarayanan, 1986. Algal Resources of Kerala Coast II - An update list of Indian Marine Algae. Aquatic Biology, Vol. VI, pp. 25-52.

Balakrishnan Nair, N., V. Sobha, R. Chandran, M. Rathiammal, S. Maya and H. Suryanarayanan, 1990. Algal resources of Kerala coast X - Occurrence and relative abundance of Phaeophyta along south-west coast of India. Presented at the Seminar on Phaeophyceae in India, held at Madras.

Balakrishnan Nair, N., V. Sobha, R. Chandran, M. Rathiammal, S. Maya and H. Suryanarayanan, 1990. Algal resources of Kerala coast IX - Occurrence and relative abundance of Chlorophyceae along south west coast of India. Seaweed Res. Utiln. 12 (1 & 2) : 125-135.

Balasundaram, A., 1985. Seasonal succession of algae in the mid-algal zone on the Thiruchendur shore. In: Marine Plants (ed.) Krishnamurthy, V. pp. 179-190.

Barnes, H. and J. Blackstock, 1973. Detailed investigation of the sulpho-vanillin method for total lipid. J. exp. mar. Biol. Ecol, 12 : 103-118.

Bersamin, S.V., 1974. Some seaweeds consumed fresh in Philippines. The Philippines. Jour. of Fish. 8(2) : 183-189.

Bhanderi, P.P. and Y.B. Raval, 1975. Possibility of seaweed cultivation along the Gujarat coast. Seafood Export Jour., 7(12) : 33-36.

Bhanderi, P.P. and Y.A. Trivedi, 1975. Seaweed resources of Hanumandandi reef and Vumani reef near Okha Port. Indian J. mar. Sci., 14 (1) : 97-99.

Bird, K.T. and P.H. Benson, 1987. Seaweed Cultivation for renewable resources. Developments in Aquaculture and Fisheries Science, Vol. 16.

Bird, C.J. and J. McLachlan, 1986. The effect of salinity on the distribution of species of Gracilaria Grev. (Rhodophyta, Gigartinales) : An experimental assessment. Bot. Mar. Vol.XXIX, pp. 231-238.

Black, W.A.P. 1954. Constituents of marine algae. Ann. Rep. Chem. Soc., 50 : 322-335.

Blinks, L.R., 1951. Physiology and biochemistry of algae. In: Manual of phycology (Ed. Smith, G.M.) pp. 263-291.

Block, R.J. and K.W. Weiss, 1956. Amino acid handbook. Methods and results of protein analysis Spring field, Illinois, U.S.A.

Bonotto, S., 1976. Cultivation of plants. Multicellular plants. In: Kinne,O. (ed.). Marine Ecology Vol.3. cultivation Part I. Wiley, New York.

Bryan, P.G., 1975. Food habits, functional digestive morphology and assimilation efficiency of the rabbit-fish, Siganus spinus (Pisces, Siganidae) in Guam. Pac. Sci., 29 (3) : 269-277.

Chacko, P.I. and C. Malupillai, 1958. Studies on utilisation of seaweed resources of Madras state. Contr. Mar. Biol. St. Krusadai Island, 6: 1-12.

Chapman, V.J., 1943. Zonation of marine algae on the sea shore. Proc. Linn. Soc. Lond. 154, 239-253.

Chapman, V.J., 1955. Marine algal ecology. Bot. Rev. 23, 320-350.

Chapman, V.J., 1970. Seaweeds and their uses. 2nd ed. Methusen, London.

Chapman, V.J., 1978. Coastal vegetation. 2nd ed. Pergamon Press Ltd.

Chapman, V.J. and D.J. Chapman, 1975. The algae, Macmillan Press Ltd., London and Basingstoke, 2nd ed. pp. 497.

Chapman, V.J. and D.J. Chapman, 1980. Seaweeds and their uses. 3rd ed. Chapman and Hall, London. pp. 62-97.

Chaturvedi, D.K., S.S. Verma and S.P. Khare, 1979. Studies on Feeding Marine Algae (Gracilaria meal) in Laying White Leghorn birds. Int. Symp. on Marine Algae of the Indian Ocean region, (Abstract) p.51

Chauhan, V.D., 1978. Report on the survey of marine algal resources of Maharashtra coast. Salt. Res. Ind., 14 (1) : 1-10.

Chauhan, V.D. and V. Krishnamurthy, 1968. An estimate of algin bearing seaweeds in the Gulf of Kutch. Curr. Sci. 37: p. 648.

Chauhan, V.D. and O.P. Mairh, 1978. Report on the survey of marine algal resources of Saurashtra coast, India. Salt. Res. Ind., 14 (2) : 21-41.

Chennubhotla, V.S.K., 1977. Food from the sea. Food from the seaweeds. Seaweed Export Journal, Vol. IX, No.3, pp. 1-4.

Chennubhotla, V.S.K., N. Kaliaperumal and S. Kalimuthu, 1981. Seaweed recipes and other practical uses of seaweeds. Seafood export Journal Vol. XIII, No.10, pp. 1-4.

Chennubhotla, V.S.K. and N. Kaliaperumal, Seaweed resources of Kerala coast. (unpublished project report of Cent. Mar. Fish. Res. Inst. 1983).

Chennubhotla, V.S.K., B.S. Ramachandrudu, P. Kaladharan and S.K. Dharmaraja, 1986. Seaweed resources of Kerala coast. Presented at the seminar on Fisheries Research and Development in Kerala, Trivandrum.

Chennubhotla, V.S.K., M. Najmuddin, J.R. Ramalingam and N. Kaliaperumal, 1987. Biochemical composition of some marine algae from Mandapam coast (South India). (unpublished project report of Cent. Mar. Fish. Res. Inst. 1987).

Chennubhotla, V.S.K., N. Kaliaperumal and S. Kalimuthu, 1987. Common seaweed products. Bull. Cent. Mar. Fish. Res. Inst. No.41. pp. 26-30.

Chennubhotla, V.S.K. and Susan Mathew, 1989. Economic green algae and their possible utilization in India. Presented at the National Workshop on Taxonomy of Economically Important Marine Algae of India held at the Mandapam Regional Centre of C.M.F.R.I. in March, 1989.

Chennubhotla, V.S.K., Susan Mathew and Imelda Joseph, 1990. A note on the occurrence of Porphyra kanyakumariensis (Bangiales,Rhodophyta) along the Kerala coast. Seaweed Res. Utiln., 13 (1) : 1-4.

Chennubhotla, V.S.K., N. Kaliaperumal and M.S. Rajagopalan, 1990. Seaweed culture in India - An appraisal. Bull. Cent. Mar. Fish. Res. Inst. No.44. pp. 394-402.

Conover, J.T., 1964. The ecology, seasonal periodicity and distribution of benthic plants in some Texas lagoons. Bot. Mar. 7 : 4-41.

Conover, J.T., 1968. The importance of natural diffussion gradients and transport of substances related to benthic marine plant metabolism. Bot. Mar. 11: 1-9.

Coutinho, R. and U. Seelinger, 1984. The horizontal distribution of the benthic algal flora in the Patos Lagoon estuary, Brazil, in relation to salinity, substratum and wave exposure. J. Exp. Mar. Biol. Ecol. 80: 247-257.

Daly, M.A. and A.C. Mathieson, 1977. The effects of sand movement on Intertidal seaweeds and selected Invertebrates at Bound Rock, New Hampshire, U.S.A. Marine Biology, 43, 45-55.

Dave, M.J. and R.G. Parekh, 1975. Protein content of green seaweeds from Saurashtra coast. Salt. Res. Ind., 11 (2) : 41-44.

Dave, M.J., S.K., Garg and E.R.R. Iyengar, 1977. Assessment of the possibility of seaweeds to be utilised as supplementary animal feed. Salt. Res. Ind., 13 (1 & 2) : 33-40.

Dave, M.J., R.G. Parekh, S.K. Garg and D.J. Metha, 1979. Preparation of seaweed meal for feeding of farm animals. Salt Res. Ind., 15 (2) : 34-38.

Dave, M.J. and V.D. Chauhan, 1985. Protein content of brown seaweeds from Gujarat coast, West coast of India. Indian Jour. Mar. Sci., Vol. 14, pp. 46-47.

Dave, M.J., R.G. Parekh, B.K. Ramavat, Y.A. Doshi and V.D. Chauhan, 1987. Protein contents of red seaweeds from Gujarat coast. Seaweed Res. Utiln. 10 (1) : 17-20.

Dawson, E.Y., 1966. Marine Botany : An Introduction. Holt, Rinehart and Winston Inc, New York. 37 pp.

Dawes, C.J., F.M. Scott and E. Bomler, 1981. Marine Botany John Wiley and Sons, New York, Brisbane, Toronoto, Singapore.

Desai, B.N., 1967. Seaweed resources and extraction of alginate and agar. Proc. Semi. Sea. Salt. and Plants, C.S.M.C.R.I. Bhavnagar. pp. 343-351.

Dhargalkar, V.K., 1979. Biochemical studies on Ulva reticulata Forsskal. Proc. Int. Symp. Marine Algae of the Indian ocean region, C.S.M.C.R.I., Bhavnagar, p. 40 (Abstract).

Dhargalkar, V.K., T.G. Jagtap and A.G. Untawale, 1980. Biochemical constituents of seaweeds along the Maharashtra coast. Indian J. Mar. Sci., 2 (4) : 297-299.

Dhargalkar, V.K., V.V. Agadi and A.G. Untawale, 1981. Occurrence of Porphyra vietnamiensis (Bangiales, Rhodophyta) along the Goa coast. Mahasagar-Bulletin of N.I.O. 14(1) : 75-77.

Doty, M.S. and J. Newhouse, 1954. The distribution of marine algae into estuarine waters. Amer. J. Bot. 41 : 508-515.

Doty, M.S., 1946. Critical tide factors that are correlated with the vertical distribution of marine algae and other organisms along the Pacific coast. Ecology, 27, 315-328.

Doty, M.S., 1971 a. Antecedent event influence on benthic marine algal standing crops in Hawaii. Exp. mar. Biol. Ecol., Vol.6, pp. 161-166.

Doty, M.S., 1971 b. Measurement of water movement on benthic marine algal growth. Bot. Mar. 14 : 32-35.

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Roberts and F. Smith, 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem. 28: 350-356.

Durairatnam, M. and V. Raghunathamuthaliar, 1973. Ecological study of marine algae on the littoral and sublittoral zone off Mandativu. J. mar. biol. Ass. India, 15(2) : 652-657.

Durairatnam, M., Luci F. da Silva, Guacryra G.M. de Farias and Edda L. Leite, 1988. Chemical composition of some species of marine brown algae collected in the sublittoral areas of the state of Rio Grande do Norte. Seaweed Res. Utiln. 11(1) : 45-49.

Fujiwara-Arasaki, T., M. Mino and M. Kuroda, 1983. The protein value in human nutrition of edible marine algae in Japan. Proc. XI Int. Seaweed. Symp. China, 1983, 74 p. (Abstract).

Garber, P., J.D. Dutcher, E.G. Adams and J.R. Sherman, 1958. Protective effects of seaweed extracts for chicken embryos infected with influenza B or mumps virus. Proc. Soc. Exp. Biol. Med. 99, 590-593.

Gaur, K., T. Ramakrishna, D.P. Subbaraju and M.S. Murthy, 1982. Ecological studies on <u>Ulva lactuca</u> L. from Veraval, India. Hydrobiologia, 89, 89-94.

Gavino, C. Trono, Jr. and Teresita A. Buchan-Antalan, 1987. Biomass production in Acanthophora associated algal communities in Bacoor Bay, Cavite, Philippines. The Philippine Journal of Science, Monograph No.17, pp. 1-10.

Gavino C. Trono, Jr. and Anant Saraya, 1987. The structure and distribution of macrobenthic algal communities on the reef of Santiago Island, Bolinao, Pangasinan. The Philippine Journal of Science, Monograph No.17, pp. 63-81.

Gavino C. Trono, Jr., 1988. "Seaweed Ecology" Influence of environmental factors on the structure, phenology and distribution of seaweeds communities. Lecture by Gavino Trono, Jr. during ASEAN/UNDP/FAO Regional small-scale Coastal Fisheries Development Project and Sea Farming Development and Demonstration Project University of Philippines, Diliman, Quezon City.

Gopalakrishnan, P., 1970. Some observations on the shore ecology of the Okha coast. J. mar. biol. Ass. India, 12 (1 & 2) : 15-34.

Gopinathan, C.P. and R. Panigraphy, 1983. Seaweed Resources. Bull. Cent. Mar. Fish. Res. Inst. No.34. on Mariculture potential of Andaman and Nicobar Islands. An indicative Survey, pp. 47-51.

Gopinathan, C.P. and P. Parameswaran Pillai, 1974. Protein from the sea. Seafood Export Journal, Vol. VI, No.5, 1-7.

Harvey, H.W., 1955. The chemistry and fertility of the seawater, London, Cambridge University Press.

Hoppe, H.A., 1966. Nahrungasmittel aus Meeresalgen. Bot. mar. 9 (Suppl.) : 18-40.

Inger Wallentinus., 1983. Partitioning of productivity and nutrient uptake between annual and perennial seaweeds in a Baltic Archipelago area. Proc. XI Int. Seaweed Symp., China (Abstract).

Iverson, E.S., 1976. Farming the edge of the sea. Fisheries News Books Ltd., Surrey, England.

Jagannathan, V. and R. Venkatakrishnan, 1979. Nutritional investigations of seaweeds in chick ration. Proc. Int. Symp. on Marine Algae of the Indian Ocean Region, C.S.M.C.R.I., Bhavnagar, India, pp. 49-51 (Abstract).

Jagtap, T.G., 1985. Studies on Littoral Flora of Andaman Islands. In: Marine Plants (ed.) Krishnamurthy, V. pp. 43-50.

Jagtap, T.G., 1985. Major metabolites from Monostroma sp. Thuret. and Porphyra vietnamensis Tan. et. Ho. In: Marine Plants (ed.) Krishnamurthy, V., pp. 89-92.

Jagtap. T.G., 1986. Studies on the associated flora of the mangrove environment. Proc. Natl. Symp. Biol. Utiln. Conr. Mangroves, Kolhapur, pp. 180-187.

Jagtap, T.G. and A.G. Untawale, 1980. Some ecological and biochemical observations on Caloglossa lepreiurii (Harvey) from Zuari estuary, Goa. Seaweed Res. Utiln. 4(1): 17-24.

Jagtap, T.G. and A.G. Untawale, 1984. Chemical composition of marine macrophytes and their surrounding water and sediments, from Minicoy, Lakshadweep. Indian Jour. Mar. Sci. Vol. 13, pp. 123-125.

Jones, W.E., 1959. Experiments on some effects of certain environmental factors on Gracilaria verrucosa (Hudson). Papenfuss. J. Mar. Biol. Assoc., U.K. 38: 153-167.

Kaliaperumal, N. and G. Pandian, 1984. Marine algal flora from some localities of South Tamil Nadu coast. J. Mar. biol. Ass. India., Vol. 26 (1 & 2) pp. 159-164.

Kaliaperumal, N., V.S.K. Chennubhotla, S. Kalimuthu, J.R. Ramalingam, M. Selvaraj and M. Najmuddin, 1987. Chemical composition of seaweeds. Bull. Cent. Mar. Fish. Res. Inst. No.41. on Seaweed Research and Utilisation in India, pp. 31-51.

Kaliaperumal, N., V.S.K. Chennubhotla, N. Najmuddin, J.R. Ramalingam and S. Kalimuthu, 1987. Biochemical composition of some common seaweeds from Lakshadweep. (unpublished project report of Cent. Mar. Fish. Res. Inst. 1987).

Kaliaperumal, N., P. Kaladharan and S. Kalimuthu, 1989. Seaweed and seagrass resources. Bull. Cent. Mar. Fish. Res. Inst. No.43. on Marine Living Resources of the Union Territory of Lakshadweep, pp. 162-175.

Kannan, L. and K. Krishnamurthy, 1978. A survey of the algae of the Porto Novo region (Coramandel coast, Bay of Bengal). Seaweed Res. Utiln. 3: 1-4.

Koshy, T.K. and C.C. John, 1948. Survey of Gracilaria resources of Travancore coast. Dept. Res. Univ. Travancore, Rep. for September, pp. 53-55.

Krishnamurthy, V., 1965. Some general considerations on zonation of marine algae on the Indian coasts. Proc. Sem. Sea, Salt and Plants, C.S.M.C.R.I., Bhavnagar, (ed.) Krishnamurthy, V. pp. 219-223.

Krishnamurthy, V., 1971. Seaweed Resources of India and their utilisation. Seaweed Res. Utiln. Vol. 1, pp. 55-66.

Krishnamurthy, V., 1985. Towards a marine algal flora of India. In: Marine Plants, their Biology, Chemistry and utilisation. Proc. All India. Symp. mar. plants, Goa, 1985. pp. 1-16.

Krishnamurthy, V., 1990. Algae as Food. Lecture presented at the workshop on algal products and seminar on Phaeophyceae in India, held by seaweed research and utilisation association at Madras.

Krishnamurthy, V., R. Venugopal, James G. Thiagaraj and H.N. Shah, 1967. Estimating drift seaweeds on the Indian coasts. Proc. Sem. Sea, Salt and Plants, C.S.M.C.R.I., Bhavnagar, pp. 315-320.

Krishnamurthy, V. and K. Subbaramaih, 1970. The importance of shore-types in intertidal ecology of Indian marine algae. Pro. Indian Nat. Sci. Acad. Vol. 38 B, Nos. (3 & 4), 259-266.

Krishnamurthy, K., S. Sambasivan, P. Subramanian and R. Rajan, 1982. Seaweeds: Their use as a source of feed in the culture of prawns. Seaweed Res. Utiln. 5(2) : 61-67.

Krishnamurthy, V. and M. Baluswami, 1984. The species of Porphyra from the Indian region. Seaweed Res. Utiln. 4(1) : 31-38.

Krishnamurthy, K. and M.J.P. Jayaseelan, 1984. Human's impact on the Pichavaram mangrove ecosystem: A case study from southern India. Proc. As. Symp. Mangr. Env. Res. Mang., pp. 624-632.

Krishnamurthy, V. and A. Balasundaram, 1990. Vertical distribution of marine algae at Tiruchendur, South India. Seaweed Res. Utiln. 12: (1 & 2), pp. 1-22.

Lawson, G.W., 1957. Seasonal variations of Intertidal zonation on the coast of Ghana in relation to the tidal factor. J. Ecol. 45: 831-841.

Levring, T., H.A. Hoppe and O.J. Schmidt, 1969. Marine Algae. A survey of research and utilization. Cram, de Gruyter, Hamburg.

Lewis, E.J., 1962 a. Studies on the proteins, peptides, and free amino acid contents in some species of Padina from South-eastern coast of India. Curr. Sci., 31, 90-92.

Lewis, E.J., 1962 b. Studies on the proteins, peptides and free amino acid contents in some species of brown algae from south-eastern coast of India. Rev. Algol., 6: 209-216.

Lewis, E.J., 1962 c. Studies on the proteins, peptides and free amino acid contents in some species of brown algae from south-eastern coast of India. Rev. Algol., 6: 209-216.

Lewis, E.J., 1963 a. Studies on the proteins, peptides and free amino acid contents in some species of marine algae from south-eastern coast of India. Rev. Algol., 7: 15-25.

Lewis, E.J., 1963 b. The proteins, peptides and free amino acid composition in species of Acanthophora from south east coast of India. Rev. Algol., 7: 237-241.

Lewis, E.J., 1963 c. Studies on the proteins, peptides and free amino acid contents in some species of red algae from south-eastern coast of India. Proc. natn. Inst. Sci. India, 29: 137-145.

Lewis, E.J., 1963 d. Studies on fortnightly analysis of proteins, peptides, and free amino acids in some marine algae from Bombay. Proc. natn. Inst. Sci. India, 29: 363-386.

Lewis, J.R., 1964. The ecology of rocky shores, XII, 323 pp. London: English Universities Press Ltd.

Lewis, E.J., 1967. A review of protein, peptide and free amino acid contents of Indian Marine Algae. Proc.Semi. Sea, Salt and Plants, C.S.M.C.R.I., Bhavnagar, pp. 296-308.

Lewis, E.J. and E.A. Gonzalves, 1959 a. Studies on the free amino acid contents of some marine algae from Bombay. Jour. Univ. Bombay, 28: 1-5.

Lewis, E.J. and E.A. Gonzalves, 1959 b. Amino acid contents of the erect and creeping fronds of species of Caulerpa from Bombay. Jour. mar. biol. Ass. India, 1: 54-56.

Lewis, E.J. and E.A. Gonzalves, 1959 c. Studies on the free amino acid contents of species of Caulerpa from Bombay. Jour. mar. biol. Ass. India, 1: 203-205.

Lewis, E.J. and E.A. Gonzalves, 1960. Amino acid contents of some marine algae from Bombay. New Phytol, 59: 109-115.

Lewis, E.J. and E.A. Gonzalves, 1962 a. Studies on the protein, peptide and free amino acids in cystocarpic and tetrasporic plants of Agardhiella robusta from Bombay. New Phytol. 61: 288-290.

Lewis, E.J. and E.A. Gonzalves, 1962 b. The protein, peptide and amino acid contents of some species of marine algae from Bombay. Ann. Bot. N.S., 26: 301-316.

Lewis, E.J. and E.A. Gonzalves, 1962 c. Periodic studies of the proteins, peptides and free amino acid in Enteromorpha prolifera, f. capillaris and Ulva lactuca var. rigida. Ann. Bot. N.S., 26: 317-327.

Lowry, O.H., N.J. Rosebrough, A.L. Farr and R.J. Randall, 1951. Protein measurement with Folin-phenol reagent. J. Biol. Chem. 193: 265-275.

Mairh, O.P., R.G. Parekh, V.D. Chauhan, P.S. Rao and D.J. Mehta, 1983. Ecology, culture and chemical constituents of Enteromorpha from Gujarat coast. Seaweed Res. Utiln. 6(1): 1-22.

Masao Ohno, 1983. Observation on the floating seaweeds in near shore water of Southern Pacific of Japan. Proc. XI Int. Seaweed Symp. China p. 193 (Abstract).

Mathieson, A.C., Eleanor Tveter, Maureen Daly and J. Howard, 1977. Marine Algal Ecology in a New Hampshire Tidal Rapid. Bot. mar. Vol.XX, pp. 277-290.

McHugn, D.G. and B.V. Lanier, 1984. Korea's edible seaweed trade. Infofish Marketing Digest. No.3/84, pp. 17-19.

Mehta, V.C., B.S. Trivedi, K.K. Bokil and M.R. Narayana, 1967. Seaweeds as manure: 1-Studies on nitrification. Proc. of the Seminar on Sea, Salt and Plants, C.S.M.C.R.I., Bhavnagar, pp. 357-365.

Misra, J.N., 1959. The ecology, distribution and seasonal succession of the littoral algae on the west coast of India. Proc. of the Symp. on Algology, pp. 187-203.

Misra, J.N., 1965. The Phaeophyceae of the west coast of India. Proc. of the Seminar on Sea, Salt and Plants, Bhavnagar, pp. 227-233.

Munda, I., 1978. Salinity dependent distribution of benthic algae in estuarine areas of Icelandic fjords. Bot. Mar. 21: 451-468.

Murthy, M.S., M. Battacharya and R. Radia, 1978. Ecological studies on the Intertidal Algae at Okha (India). Bot. mar. Vol.XXI, pp. 381-386.

Murthy, M.S. and P. Radia, 1978. Eco-biochemical studies on some economically important intertidal algae from Port Okha (India). Bot. Mar., 21(7): 417-422.

Murthy, C.S. and V.V.R. Varadachari, 1980. Topographic changes of the beach at Valiathura, Kerala. Indian J. mar. Sci., Vol.9, pp. 31-34.

Naqvi, S.W.A., B.D. Solimabi, S.Y. Kamat, L. Fernandes and C.V.G. Reddy, 1981. Screening of some marine plants from the Indian coast for biological activity. Bot. Mar., 24 (1): 51-55.

Nienhius, P.H., 1971. The use of permanent sample plots in studying the quantative ecology of algae in salt marshes. Proc. VII Int. Seaweed Symp. Sappro, Japan, 251-254.

Ogino, C., 1955. Biochemical studies on the nitrogen compounds of algae. Jour. Tokyo Univ. Fish., 41, 107-152.

Paciente A. Cordero, 1983. Some sea vegetables from Luzon island, Philippines. Proc. XI Int. Seaweed Symp. China, 1983, pp.50 (Abstract).

Parekh, K.S., H.H. Parekh, H.M. Mody and P.S. Rao, 1983. Total lipid, sterol and chlorophyll contents of some Indian seaweeds. Seaweed Res. Utiln. 6(1) : 23-25.

Parekh, R.G., Y.A. Doshi, K.H. Mody, B.K. Ramavat and V.D. Chauhan, 1985. Biochemical investigations of Enteromorpha flexuosa (Wulf.) J. Ag. of Gujarat Coast. Seaweed Res. Utiln. 8 (1 & 2) : 5-11.

Prasanna Varma, R., 1959. Studies on the succession of marine algae on a fresh substratum in Palk Bay. Proc. of Indian Acad. of Sci. Vol. XLIX, 1959, 245-262.

Prescott, G.W., 1969. The Algae: A Review, Thomas Nelson and Sons Ltd., London.

Rama Rao, K., 1972. Role of critical tide factor in the vertical distribution of Hypnea musciformis (Wulf.) Lamour. Proc. Indian. Natl. Sci. Aca. Vol. 38 B (3 & 4) : 267-272.

Reeta Jayasankar, 1990. Seasonal variation in biochemical constituents of Sargassum wightii (Greville) with reference to alginic acid content. (Submitted for publication).

Reeta Jayasankar, J.R. Ramalingam and N. Kaliaperumal, 1990. Biochemical composition of some green algae from Mandapam coast. Seaweed. Res. Utiln. Vol. 12 (1 & 2), 37-40.

Richardson, W.D., 1969. Some observations on the ecology of Trinidad marine algae. Proc. VI Int. Seaweed Symp. Spain, 357-363.

Rodhe, W., 1948. Environmental requirements of fresh water plankton algae. Symbolae Botan. 10: 1-49.

Sampathkumar, P., M. Ganesan, R. Kanna, C. Govindasamy, K. Rajendran and L. Kannan, 1990. Seasonal variation in distribution and biomass of Phaeophycean algae in the Gulf of Mannar. Presented at the Seminar on Phaeophyceae in India held at Madras, 1990.

Schwenke, H., 1971. Water movement, 2. Plants. In: Marine ecology, Vol.1, Pt. 2, edited by O. Kinne, Wiley - Inter-science, London, 1091-1121.

Shakuntala Moorjani, 1979. Seasonal changes in the marine algal flora on the Kenya coast. Proc. Int. Symp. Marine Algae of the Indian ocean region, C.S.M.C.R.I., Bhavnagar, (abstract) p. 8.

Shunula, J.P., 1983. Biomass trends in Ulva fasciata Delile and Ulva pulchra Jaasund (Chlorophyta, Ulotrichales) in Dar-es-Salaam-Tanzania. Seaweed Res. Utiln. 6(2) : 49-52.

Shunula, J.P., 1985. A preliminary check list of Phaeophyta and Rhodophyta of economic importance on five shores of Zanzibar. Seaweed Res. Utiln. 7: (2), 65-70.

Silas, E.G., 1987. Prospects of seaweed research and utilisation. Bull. Cent. Mar. Fish. Res. Inst. No.41. on Seaweed Research and utilisation in India, 1987, pp. 80-81.

Silas, E.G., V.S.K. Chennubhotla and N. Kaliaperumal, 1983. Seaweed production, their products and utilisation in India. Proc. XI Int. Seaweed. Symp. China, 1983, 225 p. (Abstract).

Sitakara Rao, V. and U.K. Tipnis, 1964. Protein content of marine algae from Gujarat coast. Curr. Sci., 33: 16-17.

Sivalingam, P.M., 1983. Biotechnological economic utilization of marine algae in Malaysia for rural communities. Proc. XI Int. Seaweed. Symp. China, 1983. 226 p. (Abstract).

Sobha, V. and N. Balakrishnan Nair, 1983. Marine Algae of Kerala II; Report on a collection from Varkala, Kovalam, Poovar and Cape Comorin. Mahasagar - Bulletin of N.I.O. 16(4): 469-471.

Sobha, V. and N. Balakrishnan Nair, 1985. Marine Algae of the Southwest coast of India. In: Marine Plants (ed.). Krishnamurthy, V. pp. 17-24.

Sobha, V., K.S. Maya Devi and T. Vasudevan Nair, 1988. Proximate composition of certain algae at Kovalam, S.W. coast of India. Seaweed Res. Utiln. 11(1): 31-38.

Solimabi, B.D., S.Y. Kamat, L. Fernandes and C.V.G. Reddy, 1980. Seasonal changes in Carrageenan and other biochemical constituents of Hypnea musciformis. Indian J. Mar. Sci. Vol. 9, 134-136.

Sreenivasa Rao, P., E.R.R. Iyengar and F. Thivy, 1964. Survey of algin bearing seaweeds at Adatra reef, Okha. Curr. Sci. 33: 464-465.

Sreenivasa Rao, P., K.S. Parekh, H.H. Parekh, S.B. Trivedi and B.A. Dave, 1979. Effect of seaweed extracts on Mycobacterium tuberculosis Proc. Int. Symp. Marine Algae of the Indian Ocean Region, C.S.M.C.R.I., Bhavnagar, India, p. 47 (Abstract).

Srinivasan, K.S., 1959. Distribution patterns of marine algae in Indian seas. Proc. Symp. on Algology, pp. 219-242.

Srinivasan, K.S., 1969. Phycologia indica, Vol. 1.

Stephenson, T.A., 1943. The causes of vertical and horizontal distribution of organisms between tide marks in South Africa. Proc. Linn. Soc. Lond. 154, 219-234.

Stephenson, W.A., 1974. Seaweed in Agriculture and horticulture, 3rd ed., Rateaver, Pauma Valley, Cal., 241 pp.

Strickland, J.D.H. and T.R. Parsons, 1968. A practical hand book of seawater analysis. Bull. Fish. Res. Bd. Canada, 167: 1-311.

Subbaramaiah, K., 1970. Growth and Reproduction of Ulva fasciata Delile. in Nature and in culture. Bot. Mar., 8: 25-27.

Subbaramaiah, K., 1971. Distribution of marine organisms on the Jalleshwar Shore, Veraval. Seaweed Res. Utiln. Vol.1, pp. 19-29.

Subbaramaiah, K., M.R.P. Nair and V. Krishnamurthy, 1977. Distribution pattern of Marine algae on the shore of Pamban. Seaweed Res. Util., Vol. 2(2): 74-77.

Subbaramaiah, K., K. Rama Rao, M.R.P. Nair, V.S.K. Chennubhotla and M. Paramasivam, 1979 a. Marine Algal Resources of Tamil Nadu. Proc. Int. Symp. Marine Algae of the Indian Ocean Region, C.S.M.C.R.I., Bhavnagar, India, p. 14 (Abstract).

Subbaramaiah, K., K. Rama Rao and M.R.P. Nair, 1979 b. Marine Algal Resources of Lakshadweep. Proc. Int. Symp. Marine Algae of the Indian Ocean Region. C.S.M.C.R.I., Bhavnagar, India, pp. 6-7 (Abstract).

Subbaramaiah, K., 1987. Resources, Management and possible cultivation of some economic seaweeds in India. Proc.Internl. Symp. on phycology. Univ. Madras, 8-13 January, 1987.

Subba Rao, P.V., K. Rama Rao, M.R.P. Nair and K. Subbaramaiah, 1985. A systematic list of marine algae from Andhra Pradesh and their distribution. In: Marine plants (ed.) Krishnamurthy, V. pp. 29-34.

Subramanyan, R., 1967. Methods of assessing seaweed resources and problems. Proc. Semi. Sea, Salt and Plants, C.S.M.C.R.I., Bhavnagar, pp. 311-314.

Subramanyan, R. and C.P. Gopinathan, 1971. Vegetable resources from the sea. Seaweed export Journal, Vol.III, No.1, pp. 1-7.

Sumitra Vijayaraghavan, M.D. Rajagopalan and M.V.M. Wafar, 1980. Seasonal variations in biochemical composition of some seaweeds from Goa coast. Indian J. Mar. Sci., Vol. 9, pp. 61-63.

Swamy, P.K., 1990. Export prospects for Indian seaweeds. Presented in the Group Discussion on seaweed resources, farming and utilisation organised by C.M.F.R.I. at Mandapam Camp.

Tamiya, H., 1960. Role of Algae as food. Proc. of the Symp. on Algology pp. 379-389.

Tewari, A., M. Prasada Rao and V. Krishnamurthy, 1968. Chemical composition of species of Porphyra from Visakhapatnam, S. India. Curr. Sci., 37: 138.

Thivy, F., 1958. Economic seaweeds. In: Fisheries of west coast of India, Bangalore, pp. 74-80.

Thivy, F., 1960. Seaweed utilization in India. Proc. of the Symp. on Algology, pp. 345-365.

Thom, R.M., 1980. Seasonality in Low Intertidal Benthic Marine Algal Communities in Central Puget Sound, Washington, U.S.A. Bot. Mar. Vol. XXIII, pp. 7-11.

Thomas, P.C. and K. Subbaramaiah, 1990. Growth of marine algae in a Sargassum wightii dominated population at Mandapam. Presented at the Seminar on Phaeophyceae in India, held at Madras.

Tsuda, R.T. and P.G. Bryan, 1973. Food preference of juvenile Siganus restratus and S. spinus in Guam. Copeia, 3: 604-606.

Umamaheswara Rao, M., 1967. Seaweed Resources of India. Souvenir 20th Anniversary of C.M.F.R.I., pp. 125-129.

Umamaheswara Rao, M., 1970. The economic seaweeds of India. Bull. Cent. Mar. Fish. Res. Inst. No.20.

Umamaheswara Rao, M., 1972. Ecological observations on some intertidal algae of Mandapam coast. Proc. Indian Natl. Sci. Aca. Vol. 38B (3 & 4), pp. 298-307.

Umamaheswara Rao, M., 1973. The seaweed potential of the seas around India. Proc. Symp. on Living Resources of the Seas Around India, pp. 687-692.

Umamaheswara Rao, M., 1978. Seaweed resources of Andhra Pradesh. Seaweed Res. Utiln. 3 (1 & 2): 51-55.

Umamaheswara Rao, M. 1987. Algae of Indian estuaries. J. Mar. Biol. Ass. India 29 (1 & 2), pp. 1-10.

Umamaheswara Rao, M. and T. Sreeramulu, 1963. Vertical zonation and seasonal variation in the growth of Porphyra on Visakhapatnam coast. Curr. Sci., 32, 173-174.

Umamaheswara Rao, M. and T. Sreeramulu, 1964. An ecological study of some intertidal algae of Vishakapatnam coast. J. Ecol., 52, 595-616.

Untawale, A.G. and V.K. Dhargalkar, 1975. Seaweed resources of the Goa Coast. Tech. Report. Natl. Inst. of Oceanography, Goa.

Untawale, A.G., V.K. Dhargalkar, V.V. Agadi and T.G. Jagtap, 1979. Marine Algal Resource of Maharashtra Coast. Tech. Report. Natl. Inst. of Oceanography, Goa, 48 pp.

Untawale, A.G. and J.G. Jagtap, 1984. Marine macrophytes of Minicoy (Lakshadweep) Coral Atoll of the Arabian sea. Aquat. Bot., 19: 97-103.

Varma, R.P. and K. Krishna Rao, 1962. Algal resources of Pamban area. Indian J. Fish. 9: 205-211.

Velasquez, G.T., 1972. Studies and utilization of Philippine marine algae. Proc. Intl. Seaweed Symp., 7: 62-65.

Visweswara Rao, A., 1964. Protein from Ulva. Salt Res. Ind., 1: 37.

Woodward, F.N., 1955. The Times Review of Industry, London, September and October.

Zaneveld, J.S., 1955. Economic marine algae of the tropical regions of South and East Asia. Econ. Bot. 13 (2) : 89-131.