Distribution of marine ornamental fishes along the Malabar Coast with studies on the biology of important species

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By

K.K.Philipose

Department of Zoology, St. Joseph's College,

Devagiri, Calicut, Kerala, India

Pin: 673008

2006

Department of Zoology
St.Joseph's College

Devagiri, Calicut
Kerala, India
PIN-673008

Date: 20-04-2006

Dr.V.J.Zacharias
Professor (Retired) & Supervising Teacher
St.Joseph's College, Devagiri, Calicut.

CERTIFICATE

This is to certify that this thesis entitled "Distribution of marine ornamental fishes along the Malabar coast with studies on the biology of important species" is an authentic record of work carried out by Shri.K.K.Philipose, from September 2000 to August 2003 under my supervision and guidance in partial fulfillment of the degree of **Doctor of Philosophy** in the faculty of Science of the University of Calicut. No part of this thesis has been presented for any other degree. I also certify that Shri.K.K.Philipose has passed the PhD Preliminary Qualifying Examination held in December 2001.

(V.J.Zacharias)

Declaration

I do hereby declare that the thesis entitled **"Distribution of marine ornamental fishes along the malabar coast with studies on the biology of important species"** is an original work and has not been published or submitted in part or full for any other degree, diploma or recognition.

Calicut,
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Chapter I
Introduction

Ornamental fishes are always fascinating for their brilliant and attractive colouration, peaceful nature, tiny sizes and its ability to adapt to the confines of aquarium tanks. These fishes are a fancy for people all over the world and fish keeping has developed as a hobby next to photography (Alava and Gomes 1989). Even though many marine fishes suitable for aquaria are reported and described in the nineteenth century itself, marine fish keeping did not gain popularity among aquarists even in the first half of twentieth century. The main reason for this was the scarcity of information on ecological, behavioural and physiological aspects of these fishes and the lack of technical knowledge on marine fish keeping. Recent studies made on wild populations and reef fishes had yielded a wealth of scientific information on their ecology, feeding habits, reproduction and social behaviour. This together with the development of sophisticated aquarium gadgets enabled the aquarists to develop a miniature marine ecosystem in the aquarium tanks. The attraction and species diversity of marine ornamental fishes had always fascinated the aquarists, which inspired them to take up marine aquarium keeping. A miniature form of aquatic ecosystem is created in an aquarium and hence this hobby, a challenging avocation, requires scientific knowledge, constant attention and innovation.

Maintaining a marine aquarium requires a different type of scientific and technological approach from that of a freshwater one. The higher pH of seawater is one of the major factors contributing to the complexity in the maintenance of a marine aquarium.

While the pH of unpolluted freshwater is around 7.0, it ranges from 8 to 8.2 for unpolluted seawater. The toxicity due to unionized ammonia will be very high for seawater due to its alkaline nature when compared to neutral freshwater. Removal of unionized ammonia from the aquarium water is essential to maintain the animals in a healthy condition. Ammonia-detoxifying devices of anemone fishes and sea anemones have been a subject of interest for marine biologists for over a century. Various aspects of this association, viz. benefits to the host and fish, mechanisms of host location, specificity and biochemical aspects have been subjected to extensive studies. The mechanism of protection from sea anemones was a subject of intensive studies and various theories were suggested (Schlichter, 1972; Elliott *et, al.*, 1994; 1995; Mebs, 1994; Elliott and Elliott, 1996).

The growth of marine aquarium hobby has led to an increased demand for marine ornamental fishes and consequently a lucrative marine ornamental fish trade has emerged on a global basis. At present the total turnover from ornamental fish trade across the world has been estimated as US $ 6.5 billion. Of these the Asian countries contribute 58% in value terms. However the contribution by India to this lucrative market is only Rs. 6.5 crores and hence offers tremendous potential for expansion. In India marine ornamental fishes are abundant in the coral reef areas of Lakshadweep islands, Andaman and Nicobar islands, Gulf of Mannar, Palk bay, South east coast and south west coast.

Of nearly 20,000 fish species available in the world only a small percentage is represented by ornamental fishes. 85% of the market for ornamental fishes is represented by freshwater species and only 15% by marine species. Hence there is very bright potential for exploiting the marine ornamental fish resources for the export market.

Even though information on the breeding and larval development is available from studies on the wild populations, captive breeding and rearing technique of most of the species have not yet been perfected for commercial level production. Only twelve species of anemone fishes have been reared in captivity in large numbers (Arvedlund *et, al.*, 2000a). The larval rearing of *Dascyllus aruanus* and *D. albisella* (Danilowicz and Brown, 1992). *Pomacentrus amboinensis*, *P. coelestis* and *Neopomacentrus bankieri* (Job *et, al*, 1997), *Abudefduf saxatilis* (Alshuth *et, al.*, 1998) and *Microspathodon chrysurus* (Pothoff *et, al.*, 1987) have been reported. But all these were trials done on experimental levels, and large-scale production methods are yet to be developed.

The present marine ornamental fish trade is entirely dependant on natural stocks. The increasing demand for marine ornamental fishes has resulted in over exploitation of their wild stock and consequent destruction of reef areas (Alava and Gomes, 1989). The reefs are the results of hundreds of years of reef building activity, and the biodiversity of these delicate ecosystems has to be protected for posterity. The indiscriminate exploitation of reefs may convert the coral paradises into the graveyards of reef animals. In this context, the captive breeding and hatchery production of marine ornamental fishes assumes great significance. Hatchery produced fishes will prove to be an eco-friendly approach towards the development of a global marine ornamental fish trade. Information on the reproductive biology, breeding patterns and larval rearing methods are the major pre-requisites for their production in hatcheries, and hence intensive studies on these aspects are required to achieve the goal. In India, research on marine ornamental fishes is still in its infancy. Comprehensive information of the taxonomy, distribution and ecology is scanty for many groups of marine ornamental fishes from Indian waters. Investigations on the ecological and reproductive aspects of reef fishes have to be undertaken from the wild habitat. Research on captive brood stock development, breeding and larval rearing has to be initiated.

In India, the coral reefs in the Lakshadweep islands are a rich abode of marine ornamental fishes. Recent studies conducted in the lagoons and reefs of Lakshadweep islands revealed that more than 165 species of marine ornamental fishes are available in abundance (Murthy 2002). Similarly the Andaman and Nicobar group of islands has also plenty of coral reefs available in the inshore waters and studies revealed that more than 150 species of marine ornamental fishes are available in abundance.

The south west coast and north west coast of Kerala has plenty of rocky areas and patch reefs where marine ornamental fishes are available in plenty. Studies conducted along the Trivandrum coast revealed that more than 135 species of marine ornamental fishes are available in the area. However no study was conducted prior to this one along the north kerala coast to understand the availability of marine ornamental fishes and their biological and ecological characteristics.

Lakshadweep and Andaman-Nicobar group islands and mainland reef areas such as Gulf of Kutch, Gulf of Mannar, Palk Bay and the south west coast thus offers potential to develop a trade for many species of ornamental fishes. With this in view, a study on ornamental fishes with emphasis on their distribution, seasonal abundance, food and feeding, estimation of length weight-relationship, growth, mortality and recruitment patterns was undertaken, to acquire valuable information that can be applied for the development of marine ornamental fishery along the Indian coast.

Among the marine ornamental fishes Pomacentrids are widely distributed through out the inshore waters offering immense potential to develop breeding techniques for these fishes so as to promote their trade and export. Basic information required as a requisite for any breeding studies such as food and feeding, estimation of length weight-relationship, growth, mortality and recruitment patterns is collected in relation to two species viz. *Neopomacentrus filamentosus* and *Neopomacentrus cyanamos.*

The major objectives of the present study are the following.

1. To study the taxonomy and distribution of commonly available marine ornamental fishes.
2. To gather information on the seasonal abundance of these fishes
3. To gather sufficient information on population characteristics food and feeding and reproduction of *N. filamentosus* and *N. cyanamos.*
4. To gather information on the hydrographic conditions of the study area.

In the present investigation an account of the environmental characters and its influence on the abundance of ornamental fishes is given in chapter four. A systematic account of the ornamental fishes collected from Malabar region with its taxonomic characters is given in chapter five. In chapter six food and feeding characters of *Neopomacentrus filamentosus* (Macleay, 1882) and *N.cyanamos* (Bleeker 1857), two important pomacentrids from Malabar area, is given. Chapter seven includes estimation of length weight relationship, growth and mortality parameters and recruitment patterns of *Neopomacentrus filamentosus* (Macleay, 1882).

Chapter.2
Review of Literature

2.1. Introduction

Marine ornamental fishes are reef dwelling or reef associated fishes comprising more than 600 species. A vast majority of these species have been reported from the tropical Indo-West Pacific region (Allen 1991). Carcasson (1977) published an exhaustive account of the coral reef fishes of the Indian and West pacific oceans. Though there are a large number of publications dealing with Marine fishes of India and other countries bordering the Arabian Sea and the western Indian Ocean, information regarding the marine ornamental fishes from Indian waters is rather very little. Jones and Kumaran (1980) described about 601 species of fishes from laccadive archipelago, Kuthalingam *et al.*, (1979), reported a number of ornamental fishes from Indian waters. Pillai *et al.*, (1986) recorded the commonly occurring fishes of Lakshadweep. Vijayanand and Varghese (1990) recorded a number of ornamental fishes from Lakshadweep islands with description about their ecology. Gopakumar *et. al.*, (1991) described about the pomacentrids available in Lakshadweep Island and reported their population characteristics. Allen (1991) recorded 41 species of pomacentrids from Indian waters. Murty 2002 reported 165 species of Marine ornamental fishes from Lakshadweep. Most of the marine ornamental fishes are resident fishes, which do not move long distances from their territory (Allen, 1991). Different species occupy the same reef head but no species has a constantly greater efficiency for settlement than others and hence chance events may play an important role in determining their distribution (Sale 1978). Some species among the pomacentrids, especially anemone fishes are symbionts on sea anemones (Stevenson, 1963; Mariscal, 1970 a; 1970 b; 1972; Allen, 1972) and more than one species of anemone fish has been reported to inhabit the samé host anemone in nature (Hattori, 1995).

2.2. Environmental Characteristics

Reef ecosystems are complex with numerous plant animal interactions and a rapid but efficient cycling of nutrients. They are oasis in the nutrient poor deserts of the tropical seas. Productivity in reefs is considerably higher than in surrounding waters in spite of nutrient limitation. A fundamental reason for this high productivity is abundant light energy. This is coupled by the ability to fix nitrogen by a host of reef organisms and the continuous recycling of phosphorus.

Environment plays an important role in fish behaviour and abundance, which in turn profoundly influence the fishery. Environmental characteristics of the coastal waters along the Malabar Coast were extensively studied in the past. Hornell and Nayudu (1923) gave detailed description of the physical and climatic characteristics of Malabar and the details of planktons in coastal waters. Observations on the sea surface temperature from Calicut were later made by Chidambaram (1950), Pradhan and Reddy (1962), George (1953) and Kasthurirangan (1957), which showed the annual maximum of inshore sea surface temperature reaches by April/May. Later Seshappa and Jayaraman (1956) observed the temperature at 19-meter depth where the temperature in pre-monsoon months was as high as that of surface and the minimum temperature was observed during August/September. Banse (1959) opined that the sudden decrease in temperature after the fury of monsoon subsides was caused by upwelling of cold bottom water with low oxygen content regularly found during the whole period of south west monsoon.

Sharma (1968) studied the upwelling along the Calicut coast. The Thermocline with temperature below 25°C start moving up from a depth of about 115 meters in February and by June reach a depth of about 15 meters. The oxygen content of this upwelling water was found to be 2.5 ml/L. Ramasastry and Maryland, 1959; Rao and Ramamritham, 1976; Ramamritham and Rao, 1974; observed the maximum intensity of upwelling in the Calicut – Karwar region. During July and August the surface mixed layer become more or less obliterated with temperature declining to 26° C and oxygen deficit layer migrating even up to the surface.

Anon (1976 a) explained the upwelling phenomenon in this area in detail. The process starts in March/April and ends in October/November. The strength of upwelling varies from year to year. Though upwelling start well in advance of monsoon, it is caused directly or indirectly by wind system. The low oxygen concentration below the thermocline, which during upwelling is very shallow, forces the pelagic fishes towards the surface.

Panikkar (1949) observed that the delay in the onset of monsoon was followed by delay in the fishing season for many commercial species along the west coast. Chidambaram and Menon (1945) found factors like rainfall, surface temperature, salinity, specific gravity and planktonic abundance had correlation with fish landings in Calicut area. Peak landings of most commercial resources like sardine and Mackerel occurred here when factors like temperature, salinity and specific gravity of surface waters start rising from these minimum during south east monsoon period coinciding with or following plankton abundance in Calicut area. This was supported by George (1953), Subramanyan (1959), Sekharan (1958) and Pradhan and Reddy (1962). Mukundan (1967) attempted a correlation between the temperature, salinity and plankton of coastal waters of Calicut with the

Mackaral fishery. Yohannan and Balasubramanian (1991) found direct relationship between total rainfall and fishery abundance in the same area. But they observed that the rainfall in September, which is the peak fishing season for most of the pelagic resources, had an inverse relation with the catch. Noble (1972) observed an inverse relationship between Mackeral fishing and rainfall at Karwar. Murty and Edelman (1966) found that the monsoon intensity to a certain level decreased the catches beyond which intensity had a certain relationship with catches. They explained that the monsoon intensity to a certain level brings up poorly oxygenated bottom water. Further increase will oxygenate this water by strong winds and wave action, which will also increase primary production. Murty (1969) observed that seasonal and regional variations in fishery of pelagic resources are to be found partly in variations in coastal currents. The relation of coastal fishery resources and coastal oceanographic features was studied by Pillai (1991) and Madhupratap et.*al.,* (1994).

2.3. Seasonal abundance of marine ornamental fishes

Seasonal abundance of marine ornamental fishes in the inshore waters is influenced by environmental changes, primary and secondary production. Pillai *et.al.,* (1983) studied the unusual abundance of *Ctenochaetus Strigosus* (Bennet) in Lakshadweep waters and related it with the environmental changes. Madanmohan and Pillai (1988), found evidence in the abundance of convict surgeonfish and secondary production. Madanmohan *et.al.,* (1987), Murty *et.al.,* (1989), Pillai and Jasmine, (1989), Pillai and Madanmohan (1990), studied the biology of marine ornamental fishes from Lakshadweep waters and suggested inverse relationship between the abundance of reef fishes and productivity. Murty (1996) observed that marine ornamental fishes breed after the monsoon and the new recruits enter the fishery normally by September-October months. Vijayanand and Varghese (1990) studied the marine ornamental fishes from the northern Lakshadweep islands and reported maximum abundance in the post monsoon months. Vijayanand and Pillai (2002) studied the biology of some common coral reef fishes from the Indian EEZ and suggested inverse relationship between maximum recruitment and secondary production. Tomey (1985) studied the distribution of marine ornamental fishes in the Union territory of Lakshadweep, Bombay and Madras area and observed maximum abundance of these fishes from October to May in the inshore waters. Philipose (1998) studied the abundance of marine ornamental fishes along the Trivandrum coast and observed inverse relationship between environment and their abundance in the inshore waters. Murty (2002) studied 165 species of ornamental fishes from the Lakshadweep waters and recorded their seasonal abundance, stock size and suggested conservation measures for the development of the fishery.

2.4.Systematic Studies

Day (1865) studied the fishes of Malabar and described taxonomic characteristics of a number of species from the Malabar Coast in his study on reef fishes. Alcock (1890) described the bathybial fishes of Arabian Sea and gave valuable information on the fishes from Malabar area. Ayyangar (1922) described the fauna of Lakshadweep and reported more than 60 varieties of reef fishes with taxonomic characteristics. Burton (1940) studied the taxonomy of a number of reef fishes from Lakshadweep islands with special reference to Acanthuridae. Hornell (1910) while reporting the results of experimental fishing along the Malabar Coast described more than 35 species with taxonomic characteristics. Jones and Banerji (1973) in a review of the living resources of the central Indian Ocean described systematics of a number of pomacentrids used as live baits in the tuna fishing. Carcasson (1977), in his study on the reef fishes of Indian and Pacific Ocean described the coral reef fishes of the Indian and Pacific oceans with taxonomic characters. Jones and Kumaran (1980) described 601 fish species with taxonomy from Lakshadweep. Many of the species were reported for the first time from Indian waters. Subsequently Vijayanand and Varghese (1990) described systematics of about 65 species of ornamental fishes from Lakshadweep islands. Philipose (1998) described 68 species of marine ornamental fishes belonging to 24 families from the Trivandrum coast. Murty (2002) described 165 species of marine ornamental fishes from Lakshadweep with notes on their systematics, seasonal abundance and growth

2.5.Food and Feeding

In terms of the food and feeding behaviour two groups are widely recognized among reef fishes. They are the herbivores and planktivores. However the classification into various trophic levels does not have uniformity. The trophic classification of reef fishes includes those of Talbot (1965), Bakus (1966), Goldman and Talbot (1976), Parrish and Zimmerman (1977), Gladfelter and Gladfelter (1976) and Sale (1980).

General descriptions of the feeding biology of reef fishes are provided by Fishelson *et.a.l,* (1974), Hobson (1974), Hobson and Chess (1978) and Gladfelter *et.al.,* (1980). Detailed analysis of diets has been presented for fishes of Marshall Islands (Hiatt and Strausburg; 1960) and Carribean (Randall; 1967). Diets of particular groups of fishes have also been presented from many regions (Choat, 1968; Vivien and Peyrot-Clausade, 1974; Harmelin-Vivien and Bouchon, 1976). Studies on trophodynamics are mainly those of Odum and Odum (1955), Hatcher (1981), Carpenter (1986), Klumpp *et al.,* (1987) and Klumpp and Polumin (1989). Plant-herbivore interactions have received wide attention in areas such as plant assemblages and herbivore activity (Ogden and Lobel, 1978; Williams, 1983; Choat, 1983; Carpenter, 1986; Lewis, 1986) and Plant defense mechanisms (Hay, 1981 and 1984; Hatcher and Larkum, 1983; Paul *et al.*, 1990). Sale (1980), Robertson and Polumin (1981) and Doherty and Williams (1988) deal with demography and behaviour of herbivorous reef fishes. The herbivores that are most characteristic of reef environments belong to the families Acanthuridae, Pomacentridae, Scaridae and Sigandae (Randall, 1961; Choat 1991). Herbivores occur throughout the world's oceans but their distribution patterns are modified by striking gradients in diversity and abundance (Bouchon-Navaro and Harmalin-Vivien, 1981; Horn, 1989).

Fishes that feed on Zooplankton are also major components of reef communities. These fishes are adapted to specific photic conditions and feed either strictly by day or by night. Most diurnal reef planktivores feed primarily on crustaceans; particularly copepods while fish eggs are favoured by others.

Apart from studies on herbivores and planktivores observations have also been made on other sources of food to reef fishes. Riley (1963), Johannes (1967) and Qasim and Sankaranarayanan (1970) observed organic aggregates mostly composed of coral mucous forms a very important food for reef fishes. Detritus formed from coelenterate mucus, organic aggregates, algal filaments, pieces of phyto and Zooplankton and faecal pellets produced in reefs is transported to lagoon where they form food of Zooplankton and fishes (Marshall, 1965; Qasim, 1979; Gerber and Marshall, 1974 and 1982).

From the Indian waters food and feeding habits of *S.delicatulus* and *S.gracilis* (Mohan and Kunhikoya, 1985) and *Chromis caeruleus* (Mohan *et.al.,* 1986) has been investigated. Gopakumar *et.al.,* (1991) examined the gut contents of 17 species of tuna live baits. Mathew and Gopakumar (1986) observed the influence of Zooplankton on tuna catch indirectly through the abundance of live baits.

Pomacentrids are generally omnivores feeding on algae, zooplankton and a wide variety of other invertebrates (Allen, 1991). The gut analysis of *N.filamentosus* was done by Allen (1972) who reported the occurrence of algae and Zooplankters. The diet of four species of chromis comprised mainly of copepods and larvaceans (Tribble and Nishikawa, 1982) and that of *Chromis notata* was pelagic tunicates and copepods (Ochi 1985 c). Coughlin (1990) reported that the use of specialized feeding behaviour and the ability to vary feeding behaviour are adaptations for feeding evasive prey such as copepods. Pillai and Madanmohan (1990) reported that the damselfish *Abudufduf glaucus* is an herbivore. Certain species such as *Parma victoriae* (Jones and Norman, 1986), *Stegastes nigricans* (Galetto and Bellwood, 1994) and *Pomacentrus wardi* (Sale, 1976) are herbivores. Letourneur *et.al.,* (1997) stated that adult *Stegastes nigricans* are mainly algal feeders, where as Zooplankters were seen in the gut of *Neopomacentrus Cyanamos.* Since marine ornamental fishes are available more in the reef environments of Lakshadweep, food and feeding studies are largely restricted to these areas.

2.6.Growth Parameters

Length weight studies and population dynamics of damselfishes have received attention only in recent times. The object of these investigations is to rationally manage and conserve the damselfish resources.

Dalzell (1990) reviewed the studies on biology and population dynamics of damselfishes in Papua New Guinea. Tiroba et.al, (1990) studied the length frequency of pomacentrids and sprats in Solomon Islands and found that pomacentrids were moderately fished while the sprats experienced higher mortalities. Milton et.al (1990 c) studied population characteristics of a number of pomacentrids from Solomon Islands and Maldives and reported variations in growth. Luther (1990) studied the biology and population characteristics of the Apagonids from India. Biology of damselfishes received considerable attention as they were used as bait fishes in Tuna Pole and line fishing. Somerston (1990) applied a new stock assessment procedure known as the egg production method on Hawaiian anchovy *Encrasicholina purpurea.* Milton *et.al.,* (1991) found that damsel fishes have extremely flexible growth pattern and that biological variation within a site can be as great as variations between sites.

In India the population studies of damselfishes have been restricted mostly to length weight relationships of baitfishes. Mohan and Kunhikoya (1985) studied the age and growth of *S.delicatulus* and *S.japonicus (gracilis)* from length frequency data and length weight relationship, age and growth at Mincoy. They reported a growth rate of 3mm per month for both the species. Pillai *et.al.*, (1986), suggested a possible reason for shortage of live bait, especially pomacentrids, as the over exploitation of the resource by the increased effort. Mohan *et.al.,* (1986) reported that blue púller *Chromis caeruleus* has a monthly growth rate of 5.43 mm for the first year and 2.26 mm for the second year at Minicoy. Gopakumar *et.al.,* (1991) calculated the length weight relationship of 17 species of live baits including pomacentrids from Lakshadweep.

The family Pomacentridae, which is one of the largest families of reef fishes, includes about 320 known species of fishes, which are distributed in the coral reef areas and shallow rocky seas. A vast majority of these species have been reported from the tropical Indo-West Pacific region (Allen, 1991). There are various reports on the occurrence of pomacentrid fishes from Indian waters also. Jones and Kumaran (1980) described 35 species of pomacentrid species from the Laccadive archipelago. Kuthalingam *et al.*, (1979) reported two species of pomacentrids from Indian waters. Pillai *et al.*, (1986) recorded the commonly occurring fishes of Lakshadweep waters including pomacentrids. Vijayanand and Varghese (1990) reported that labrids and pomacentrids are the most commonly distributed fishes in Lakshadweep. Four species of pomacentrids were collected and their population characteristics were studied by Gopakumar *et al.*,. (1991). Allen (1991) recorded 41 species of pomacentrids from Indian waters. Murty (2002) reported 25 pomacentrids from Lakshadweep.

Vijayanand and Varghese (1990) described the population characteristics of *chromis caeruleus* from Lakshadweep with suggestions for development of the fishery. Murty (2002) studied the population characteristics of 16 species of pomacentrids from Lakshadweep and estimated the exploitable stock size of each species for the possible development of ornamental fishery. Although some studies were done on the population characteristics of *Neopomacentrus filamentosus* from Lakshadweep waters practically very little or no information is available on the length weight relationship, growth and mortality parameters of *N.filamentosus* from the North Malabar Coast.

Chapter.3

Material and Methods

3.1. Introduction

The area of present study is shown in Fig 3. 1. Regular observations and collection of detailed fishery and biological data were made from two major ornamental fish collection centers such as Thikkody and Dharmadom along the Malabar area. Thikkody was the southernmost and Dharmadom was the northernmost centre of observation. Marine ornamental fishes were collected from Puthiyappa, Moodady, Thikkody (Plate.3.1.a), Chombal and Dharmadom areas using an ornamental fish trap. This trap is 5' long, 2' wide and 2' high. The trap is made of 8mm steel frame covered with fibre coated chicken mesh. The mouth region of the trap is designed in such a way it looks like a reef crevice. The mouth of the trap is narrow and turned upwards into the Trap. (Plate.3.1.b). An opening of 1'x1' size is provided in the side of the cage. Fishes trapped in the cage is collected through this side door. Crushed mussels and live mussels are used as feed in the trap. Trap is permanently placed in the reef and is lifted every day morning, fishes collected and fresh feed is added and the trap is again kept in the reef. Fishing was done continuously for a week every month and the results analysed. The collected fishes were transported to Calicut and after their meristematic studies reared in the marine research aquarium. Samples were also collected from the commercial fishing vessels from Puthiyappa, Chombal and Dharmadom to study the species diversity and seasonal abundance.

3.2.Environmental Characters

Water samples were collected from Thikkody for a period of 24 months from January 2001 to December 2002. Samples were collected and stored in 250 ml polythene bottles.

3.2.1.Temperature: Water temperature was measured in the field using a calibrated thermometer.

3.2.2.Rainfall: Rainfall data for Calicut supplied by meteorological department was analysed.

3.2.3.Salinity: Salinity was determined by Mohr's titration method and dissolved oxygen by Winkler's method (Strickland and Parsons, 1968).

3.2.4.Dissolved Oxygen: Samples for dissolved oxygen estimation was carefully siphoned into 125 ml glass bottles and fixed with Winkler A and B solutions. These bottles were kept in dark, cool conditions in an icebox till time of analysis on the same day.

3.2.5.Nutrients: All nutrients except nitrate was analysed using the methods outlined by FAO (Anon.1975) and measured on a spectrophotometer (ECIL GS866D). Nitrate was determined by a modified method of Mullin and Riley (1955).

3.2.6.Phosphate: The phosphate in seawater is allowed to react with ammonium molybdate, forming a complex heteropoly acid. This acid is reduced by ascorbic acid, to a blue-coloured comples, the light absorption of which is then measured at 882 nm.

3.2.7.Nitrate: The nitrite in seawater is reduced to nitrate and then measured in the same way as described for nitrite. To the water sample a buffer reagent (phenol + sodium hydroxide) and a reducing agent (copper sulphate + hydrazine sulphate) was added and kept in dark for 20 hrs. This reduced solution is treated with sulphanilamide and NNED and the intensity of colour developed is measured at 545 nm.

3.2.8.Silicate: The determination of dissolved silicon compound is based on the formation of a yellow silicomolybdic acid, when a more or less acidic sample is treated with a molybdate reagent. Since this acid is rather weak in colour, they are reduced (by ascorbic acid) to intensely coloured blue complexes. The absorbance of the sample is measured against distilled water at a wavelength of 810 nm.

3.3.Seasonal abundance

Marine ornamental fishes were collected from Thikkody, Moodady, Chombal and Dharmadom areas using the ornamental fish trap. Trap is permanently placed in the reef and is lifted every day morning, fishes collected and fresh feed is added and the trap is again kept in the reef. Fishing was done continuously for a week every month and the results analysed. The collected fishes were transported to Calicut and after their meristematic studies reared in the marine research aquarium.

3.4. Taxonomical studies

3.4.1.Identification

The specimens were identified with the help of the work of Jones and Kumaran (1980);occasionally the work of Smith and Heemstra (1986) and Burges, *et. al.,* (1998) were also consulted for conforming the identification and nomenclature of certain species.

3.4.2.Length data

All the specimens of each species collected were measured for total length, standard length, snout length and eye diameter. Number of fin rays and spines were counted; colour patterns of the body and body shape were also recorded.

3.4.3.Photography

All the specimens collected from the trap was transported in aerated containers to Calicut and maintained in the marine research aquarium of central Marine Fisheries Research Institute, Calicut and photographs were taken in the rearing tank using a digital camera of 4 million mega pixels and the images were stored in a computer.

3.5.Food and Feeding

Various methods are in vogue in the study of food of fishes. Pillai (1952) in critical review of the various methods used for analysis of food of fishes emphasized that the method used for any fish should suit its diet and is of the opinion that the volumetric methods are the most accurate for studying the food and feeding of carnivorous fishes.

The volumetric method as described by Pillai (1952) was used for the analysis of food of *N.filamentosus* and *N.cyanamos*. Since *N.filamentosus* and *N.cyanamos*, is found to be omnivorous the determination of volume of each item of food was easily made by the displacement method. For this purpose, a narrow measuring cylinder was taken and filled up with water to a certain mark. The food item was then immersed in the water and the new level of water was noted. The differences in the two readings gave the volume of particular food item. Then the percentage volume of each food item was determined from the total volume of all the stomach contents. The percentage occurrence of different items of food in different months was determined by summing the total volume of all items from which the percentage occurrence of each item was calculated

During the study period considerable amount of digested material was encountered in the stomach of the fishes. This item was considered as gut content and not a food item.

Damselfish samples were collected from Thikkodi in Kozhikode district by using an ornamental fish trap. Samples collected from the traps were preserved in 5% formation. In the laboratory the fishes were measured, weighed, sexed and their stomach and gut removed for further analysis. To ascertain the conditions of feeding the degree of fullness of stomach was noted before the stomach was actually opened. A stomach was designated as full when it was completely gorged with food and considered ¾ full when it was partly collapsed condition. Similarly they were classified ½ full and ¼ full depending on the relative fullness and space occupied by the stomach contents. These stomachs, which were termed 'empty', contained practically nothing in them. Fishes with stomachs classified on full and ¾ full were considered to have actively fed, ½ full moderately fed and '1/4 full' as poorly fed.

The gut contents were teased out carefully and examined under a light microscope. Prey items were identified and the member of each prey in the gut were counted. The total length and diameter of each prey (body only in the case of Zooplankton) were measured with an ocular micrometer and converted to millimeters. Prey volume was calculated assuming that prey shape approximated a cylinder of length equal to the prey length and a diameter of prey width. A ranking based on these measurements was constructed for various food items as follows.

Rank	Prey	Volume (mm)
1.	Semi digested matter	0.070
2.	Fish egg	0.065
3.	Copepod	0.055
4.	Zoea	0.054
5.	Megalopa	0.053

6.	Other Decapod larvae	0.051
7.	Mysis	0.050
8.	Amphipod	0.048
9.	Ostracod	0.045
10.	Isopod	0.042
11.	Cumacean	0.040
12.	Plant material	0.030
13.	Crustacean remains	0.010
14.	Fish scale	0.009
15.	Bivalve larvae	0.007
16.	Polychaete larvae	0.005
17.	Invertebrate eggs	0.002

These volumes were multiplied by the number of the particular prey in the gut to determine its total volume. The percentage frequency of occurrence of each prey item was also calculated.

Apart from the Zooplankton, which was identified, the remaining gut contents were classified into groups for easy comparison. In almost all the cases the gut contained partly digested food and this was classified as ' Semi digested matter'. Deccapod larvae other than Zoea and megalopa such as the mysis stage of crustaceans were grouped as' other deccapod larvae'. 'Plant material' comprised mostly fragments of macrophytic algae, seaweeds and phytoplankton. The broken appendages of crustacean larvae, copepod and other Zooplankton were grouped as 'Crustacean remains'. ' Invertebrate eggs' was constituted mainly by copepod eggs, which may have detached from the copepod after its ingestion by the fish.

A grading of the gut contents was made based on the 'Index of preponderance' proposed by Natarajan and Jhingran (1961). If Vi and Oi are the volume and occurrence index of food item I (as indicated by their percentages) the Combined Index (I) for food i may be represented as:

$$Ii = \frac{Vi\ Oi}{E\ Vi\ Oi} \times 100$$

Another index that was followed is the 'Index of relative importance' (Pinkas *et al.*, 1971) in which the percent volume and percent number are added up and weighted by the frequency of occurrence.

$$=(Vi + Ni)\ fi$$

Where Vi is the percent volume of food i

Ni is the percent number of food i

And f i is the percentage frequency of occurrence of food i.

3.6. Length frequency distribution

As there is no dedicated fishing for ornamental fishes on a commercial scale, it is not possible to generate time series data on catch and effort for studies on population dynamics. Fishing was conducted for varying periods in different centers. The catch obtained from ornamental fish trap for a period of one week (every month) was taken as the total catch of the available resources

Sampling of the catch for length frequency distribution studies of *Neopomacentrus filamentosus* was made once a week, depending upon the availability from Thikkody and

Dharmadom landing centers mainly from trap catches. A minimum of 50 fishes was measured in the field using a measuring board. The length of the fish referred to hereafter is the total length from the tip of the snout to the tip of the upper lobe of the caudal fin in mm unless otherwise mentioned. The catch percentages of these distinct size groups were estimated visually. The idea was not to mix different broods in one sample as far as possible. A sample of 25-30 fishes was taken to the laboratory for detailed study.

The length measurements were grouped in to 10 mm length intervals, the frequencies were summed up to get the total frequency in each length intervals of 10 mm. Length frequencies were then raised to correspond to the weight of the catch assessed for the day. This was done by multiplying the frequencies with a multiplication factor (Mf) calculated for the day as

$$Mf = \frac{\text{Weight of the catch}}{\text{Weight of the sample}}$$

These raised frequencies corresponding to each of the length groups on the sampling days in a month were then added up to get the monthly figure. These figures were again raised to get the corresponding frequencies with respect to the estimated total landing of a month. This was done by multiplying with a factor (Mf_1) calculated as

$$Mf_1 = A/B$$

Where, A = sum of the estimated catch landed on all the fixed sampling days of the month.

B= Sum of the catch observed on the days when samples were collected.

These length frequency data actually formed the basis for further analysis and estimation of parameters.

3. 7. Estimation of growth parameters

The length frequency was analysed using the FISAT programme (FAO-ICLARM STOCK Assessment Tools). This is a modified version of the ELEFAN programmes developed by Pauly and David (1981) and Pauly (1987). Since an element of subjectivity is involved when growth curves are fitted by eye, ' FISAT' method of growth parameter estimation has been applied. This method allow one to perform the analysis in 3 stages

1. Restructuring of length frequency samples in order to facilitate the identification of peaks and trough in frequency polygons of each sample.
2. A large number of alternative runs are performed modifying the growth parameters and starting points.
3. Comparing the results from different runs by calculating the ratio of Explained sum of peaks (ESP) to Available sum of peaks (ASP) and allowing to select best of growth parameters.

FISAT works with seasonalised VBGF also (Picher and Macdonald, 1973 and Cloern and Nichols, 1978), which can be advantageously used when any species show oscillations of growth are expected.

The January 2001 – December 2002 data were pooled and manipulated to January–December for easy estimation of growth parameters in the FISAT programme.

3.7.1. Methods for estimation of mortality parameters

The reduction in number in a cohort is caused by fishing activity and due to all other causes like predation, disease and death due to old age. The later is called as natural mortality and the former as fishing mortality. The combination of both the factors gives the total mortality.

3.7.1.1. Fishing mortality (F)

Wetheral *et al.,* (1987) discussing Powel (1979) suggested method of estimating Loo and Z/K by relating L^{-} with L^{1} using the regression equation $L^{-} - L^{1} = a+b*L^{1}$, where L^{1} is the lower limit of the length interval which is taken as that length at which all fish of that length or longer are under full exploitation. L^{-} is the mean length of fish of length L^{1} and above.

From the values of regression coefficients 'a' and 'b' we get,

$Z/K = -(1+b)/b$ and $Loo = -(a/b)$

Where, Z is total mortality, L_{∞} is the length at infinity and K is annual growth coefficient.

3.7.1.2. Total Mortality (Z)

1. The Jones and van Zalinge cumulated catch curve method of estimating Z

Based on the length composition data, Jones and van Zalinge (1981) suggested the cumulated catch curve equation, which is given as in $(C_{Li,\infty}) = a + b \cdot \ln(L_{\infty} - L_i)$ where $C_{Li,\infty}$ is the cumulative catch (computed from the highest length class with non-zero catch) corresponding to length class i, and L_i is the lower limit of length class i. The slope b is an estimate of Z/K.

2. The linearised catch curve based on length composition data

This model described by Pauly (1983b, 1984 a and b) was also used in the present study for the estimation of Z.

$\ln(N) = a + b \cdot t$

Where, N is the number of fish in (pseudo) cohorts "sliced" by means of successive growth curves, t' the relative age of the fish in that pseudocohort, while b, with sign changed, provides an estimate of Z.

3.7.1.4. Estimation of Natural Mortality (M)

After regression analysis of M (per year) on K (per year), L_{∞} (cm) and T (mean annual temperature at the surface in ^{0}C) by referring to the data collected from 175 fish stocks, Pauly (1980b) estimated at the empirical relationship as

$$\ln (M) = -0.0152 - 0.279 \ln(L_{\infty}) + 0.6543 \ln(K) + 0.463 \ln(T)$$

This was employed in the present study for the estimation of M. The average annual temperature (28^{0}C) estimated by Seshappa and Jayaraman (1956) was used for the estimation of natural mortality.

3.7.2. Yield Per Recruit

The yield per recruit model (Beverton and Holt, 1959) was used for estimation of yield per recruit; Y/R was calculated in the form suggested by Gulland (1969)

3.7.3. Length weight relationship

Length-weight relationship was attempted following Le Cren (1951). The logarithmic form of the general equation $W = a\ L^b$ is $\log W = a + b \log L$. Here, 'W' represents weight in gram and 'L' the total length in mm and 'a' and 'b' are constants.

3.7.4. Recruitment pattern

Using a set of length frequency data and growth parameter values, recruitment patterns were derived as described by Pauly (1982). The t_o estimated by Balasubramanian Natarajan (2000) was used for this purpose.

For estimation of growth, mortality, recruitment patterns and Y/R the computer programmes of Sparre (1987) and Gayanilo *et al.,* (1996) were used.

Figure.3.1.Map of North Kerala showing the study area

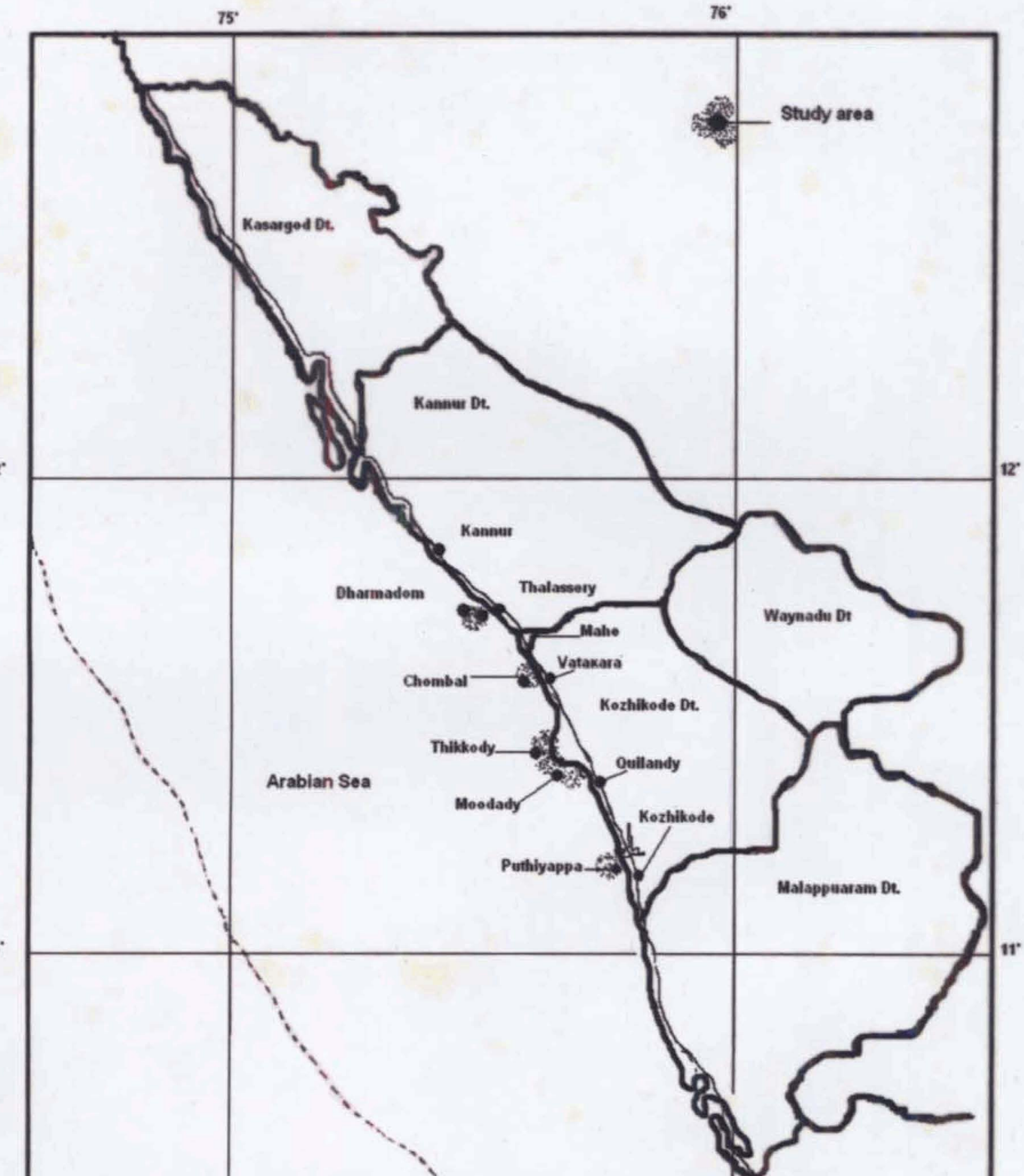


Plate.3.1

a. Collection site in Thikkody

b. Ornamental fish trap

Chapter.4

Environmental Characteristics of the Coastal waters and Seasonal Abundance of Ornamental Fishes.

4.1.Introduction

Environment plays an important role in fish behaviour and abundance, which in turn profoundly influence the fishery. Information available on the environment and behaviour of marine ornamental fishes in the area and concerned data collected during the study period are summarized in this chapter.

Hornell and Nayudu (1923) gave detailed description of the physical and climatic characteristic of Malabar and the details of planktons in the coastal waters. Observations on the surface sea temperature from Calicut were later made by Chidambaram (1950), Pradhan and Reddy (1962), George (1953) and Kasturirangan (1957), which showed that the annual maximum of inshore sea temperature reaches by April/May. The lowest temperature of about 25°C was found in July/August and only in October/November there was a remarkable increase. Seshappa and Jayaraman (1956) observed the temperature at 19-meter depth where the temperature in pre-monsoon months was as high as that of surface and minimum temperature during August/September. Banse (1959) opined that the sudden decrease in temperature after the fury of monsoon subsides was caused by upwelling of cold bottom water with low oxygen content regularly found during the whole period of South-west monsoon. The proof of the deduction that the upwelling was the reason for peculiar temperature condition in the Malabar Coast was the rise of temperature towards the open sea. This upwelling water coming from near the oxygen minimum layer was found to drive away the demersal fishes from the broad belt parallel to the coast.

Sharma (1968) studied the upwelling along the Calicut coast. The thermocline with temperature below 25°C start moving up from a depth of about 115 meters in February and by June reaches a depth of about 15 meters. By the middle of June a slight sinking to a depth of about 20 meters take place to rise again to a depth less than 10 meters by September. Then the sinking starts and reaches a depth of about 110 meters by November. The oxygen content of this upwelling water was found to be about 2.5 ml/L. Maximum intensity of upwelling is in Calicut-Karwar region (Ramasastry and Myrland, 1959; Rao and Ramamritham, 1976; Ramamritham and Rao, 1974). During July and August, the surface mixed layer become more or less obliterated with temperature declining to 26° and oxygen deficit layer migrating even up to the surface.

Anon (1976a) explained the upwelling phenomenon in this area in detail. The process starts in March/April and ends in October/November. In 1974 August, Cochin and Kasargod sections exhibited 1 ml O^2/L at a depth of 20m. At outer stations it sloped down to 40m. With the slowing down of the southward coastal flow and setting or northward flow 1 ml O^2/L start retreating. Upwelling either started first in north and slowly spread to south or it happened in the entire area within a short period. Similarly, sinking either starts in the south and spread to north slowly or it happens approximately the same time. The strength of upwelling varies from year to year. Though, upwelling start well in advance of monsoon, it is caused directly or indirectly by wind system. The low oxygen concentration below the thermocline, which during upwelling is very shallow, forces the pelagic fishes towards the surface.

Seshappa and Jayaraman (1956) studied the phosphate cycle in the inshore waters of Malabar Coast and found that the bottom mud contains large quantities of interstitial and absorbed phosphates in the non-monsoon period. During monsoon there is a rapid release of phosphates into the overlying column of water and the quantity of phosphate in water increase to a maximum by August/September.

Subramanian and Sarma (1965) gave the volume of plankton in the coastal waters of Calicut during the years 1955-'62. They found a peak production of phytoplankton during the southwest monsoon, but fluctuated widely from year to year. Peak nanoplankton was in July and September, which is crucial for survival of fish larvae. 30-50% of the total phytoplankton was constituted by nanoplankton. The magnitude of phytoplankton in the Malabar area is of a very high order. From observations made by Mukundan (1967) it can be deducted that zooplankton abundance in Calicut waters increase by August and it is generally good till October.

Upwelling along the coast appeared to trigger the primary production, which was followed closely by secondary production of zooplankton. Zooplankton biomass tended to increase after April towards a peak sometime before December and fell into low values subsequently, January to April being a lean period. In general, January to March is a period of low plankton density over the shelf, April to June a period of moderate densities. July to September/October is the time of high plankton densities along the southwest coast of India then there is a fairly uniform concentration of plankton slightly beyond the near shore waters all along the coast. (Anon, 1976 b).

Johannessen *et. al.*, (1987) made a study of the oceanographic conditions of the southwest coast of India, especially the water masses, coastal currents and upwelling. He observed that the fishes concentrate in the surface layer due to oxygen deficiency below the oxycline. Ornamental fishes were present in the area also during monsoon month, but even though they are not visible during rougher weather conditions of monsoon, they occurred in the deeper areas of the reef. Johannessen *et.al.*, (1987).

According to Madhupratap *et. al.*,(1994) upwelling and river runoff make the coastal surface waters nutrient rich and the primary production shoots up. Concomitant changes are discernible in zooplankton population. Higher density is sustained even after southwest monsoon period up to December. The increase of zooplankton need not necessarily depend on phytoplankton abundance alone, but can happen through the microbial loop (bacteria – heterotrophic flagellates – micro zooplankton – mesoplankton) or a short circuit of the loop (bacteria – ciliates – mesozooplankton). Presence of micro zooplankton during introduction of freshwater plumes can enhance zooplankton production by several hundred percent which happens along the coastal waters of west coast in rainy season.

Madhupratap *et. al.*,(1994) had given changes of circulation of surface waters of the north Indian Ocean month by month. From February/March the coastal drift is southwards. An anticyclonic vortex is seen near Kerala coast, between Calicut and Cochin, which shifts westwards by April and disappear in May. By June the equator ward circulation move around the peninsula and a branch move north along the coast by October the reversal of southward flow set in and by November the drift is clearly northwards along the Malabar Coast. These changes in the coastal currents are basically due to monsoon currents.

During northeast monsoon the current is towards west causing a northward drift along the Malabar Coast. During the southwest monsoon the current is from east resulting in a southwards drift from February/March to October.

Ramamritham and Rao (1974) have observed strong southern drift especially in the region Calicut-Karwar, prominent in the upper layers during southwest monsoon. It starts in February, gets stronger and by June is well developed. It is most energetic during July-August, the peak southwest monsoon season. Data collected in 1987-88 showed a depth of 75-100 meters for this movement in June with a width of 150 Km (Madhupratap, *et.al.*, 1994).

In general seasonal variations is oceanographic conditions are very repetitive from year to year. During southwest monsoon period, May to October the currents flow southwards, causing uplifting of isoclines for different oceanographic parameters near the coast and generates upwelling most strongly in August/September when water with oxygen content of less than 0.5 ml/L is observed to cover the whole shelf area over the bottom. In the northeast period, November to March, the current system reverses; thereby transporting the low salinity water from equatorial region called equatorial surface water with salinity less than 32.6% is seen up to a depth of 50-60m. In March the flow is reversed to southward and the low salinity equatorial surface water retreats and salinity increases to 33.4% (Anon, 1976 a).

Pradhan and Reddy (1962) have given the temperature and salinity values of the Calicut coastal waters. Salinity values show a minimum in July corresponding to peak monsoon and river runoff but the lowest temperature is recorded in August.

Marine ornamental fishes are found in the shallow water reefs along the Malabar coast. Their abundance in the coastal waters is greatly influenced by the environmental changes like salinity, Temperature, dissolved oxygen levels etc. Unlike in coral reef ecosystems, the rocky reef ecosystem undergoes seasonal changes and these changes greatly affects the fishes living within. Marine ornamental fishes are mostly resident fishes living in the crevices and rock pools. The onset of monsoon during the first week of June intensifies by July and brings in large amount of river run off into the coastal region and results in a decline in the salinity of the reef waters. The availability of marine ornamental fishes in the Thikkody reef ecosystem is discussed in this chapter and the results are given.

The present study was aimed to understand the influence of environmental characters in the abundance and seasonal variations of marine ornamental fishes along the Malabar coast.

4.2.Results

4.2.1.The Environment

4.2.1.1.Temperature

The average Temperature values for the year 2001 and 2002 showed that the lowest temperature 26.7°C was observed during July and the highest temperature 31.8°C during April. However there was a secondary peak 30.75°C was observed during December (Figure.4.1).

During 2001 the lowest temperature 27.2°C was observed during August 2001 and the highest temperature 32.6°C was observed during April 2001. The secondary peak 31.5°C was observed during December 2001 (Table.4.1). During 2002 the lowest temperature recorded was 25.9°C observed during July 2002 and the highest 31.3°C during March 2002. The secondary peak 30.0°C was observed during December 2002(Table.4.2).

It can be seen that the temperature values of the surf water varied from 26.7°C to 32.6°C with averages between 26.7°C to 31.8°C during the study period.

4.2.1.2. Rainfall

The rainfall recorded at Thikkody during 2001 and 2002 is given in Table.4.1 & 4.2.In general the Calicut area receives an average annual rainfall of 350 cm to 375 cm. In 2001 the annual rainfall was 339 cm with highest rainfall 105 cm recorded during July 2001 and the lowest 2 cm recorded during March. During 2002 the highest rainfall 147 cm was recorded during July and the lowest 1 cm recorded during December 2002. When compared with 2001, rainfall during 2002 was fairly good with a total volume of 403 cm.

The Figure. 4.1 shows peak rainfall in June-July with a secondary peak in October. Good pre-monsoon showers normally occur in April/May. In 2001 pre-monsoon showers were fairly good recording 39 cm rain where as in 2002 the pre-monsoon showers recorded was only 25 cm. In 2002 southwest monsoon became active, rainfall started by 29th May, and it was heavy in June and July. The northwest monsoon was good in October recording 45 cm rainfall.

In 2001 after a very active monsoon in July there was a respite by 7th of August, which continued till 16th. By 10th September the rainfall subsided with only occasional showers afterwards. In 2002 there was intense rainfall in July but the respite came only by September 10th the cumulative rainfall in these years is shown in Figure. 4.1. The differences in July rainfall between the years are very clear. Normally a respite after intense rainfall with good sunshine causes good fishing all along the coast. With a vigorous rainfall followed by a good lull always results in good fishing for ornamental fishes.

4.2.1.3. Salinity

The salinity increases from January and reaches a peak of around 35.0 ‰ by April. Like in the case of temperature, which comes down to the lowest value in July-August, the minimum salinity is observed in July when peak rainfall occurs. Salinity increases to a high value by December. The average salinity values for Thikkody surf waters for the year 2001 and 2002 are given in Figure.4.2. In 2001 the salinity values reached peak, 35.0 ‰ during April. Subsequent decline was very sharp to 29.9 ‰ during July. There was a secondary minimum with the northeast monsoon in November (Table.4.1). But in 2002 though the peak salinity was in April the decline was sharper than in 2001. The minimum salinity value 28.3 ‰ was observed in July 2002. The secondary minimum 33.4 ‰ was observed in November (Table.4.2).

4.2.1.4. Dissolved Oxygen

The two-year average oxygen values of the Thikkody surf waters increased from 4.25ml/l during January to a peak of 5.25ml/l during August and subsequently decreased to a minimum of 3.85ml/l during November (Figure.4.2). During 2001 the maximum oxygen value 5.7ml/l was observed during August and the minimum 4.1ml/l during December (Table.4.1). During 2002 the dissolved oxygen levels increased from 4.4ml/l during January to a peak in August and then declined in the following months. A secondary peak of 3.9ml/l was observed during December 2002 (Table.4.2).

4.2.1.5. Nitrite

The average values of nitrate in the surf waters of Thikkodi are given in Figure.4.3. The nitrate levels in the surf waters showed highest values in March and the lowest values in April. The nitrate levels showed a declining trend in the early months of the monsoon, then gradually increased to 0.38 Mu.g a/L during October, and again showed decline after the northeast monsoon. The nitrite value for the year 2001 and 2002 is given in Table.4.3 and Table.4.4 respectively.

4.2.1.6. Nitrate

The two yearly average nitrate values in the surf waters of Thikkody are given in Figure.4.3. The nitrate levels showed a peak in January and decreased in the pre-monsoon months. From July with the monsoon becoming very vigorous the nitrate values increased to a secondary peak during August. The lowest nitrate values were observed in November. The nitrate values for the year 2001 and 2002 are given in Table 4.3 and Table.4.4 respectively.

4.2.1.7. Silicate

The two yearly average silicate values in the surf waters of Thikkody are given in Figure.4.3. Similar to nitrate the silicate levels also showed a primary peak in January and minimum during October. The secondary peak after the monsoon was observed in August. The silicate values for the year 2001 and 2002 are given in Table.4.3 and Table.4.4 respectively.

4.2.1.8. Phosphate

The two yearly average phosphate values are given in Figure.4.3.The peak value for phosphate was observed in August after the peak monsoon and the minimum values during December. The phosphate values for 2001 and 2002 are given in Table.4.3 and Table.4.4 respectively.

4.3.2.Seasonal abundance

50 species of marine ornamental fishes belonging to 18 families were monitored for their abundance in the fishery.

4.3.2.1. Acanthuridae

Members of the family Acanthuridae community known as surgeon fishes were represented in the fishery by 6 species. *Acanthurium nigricans, A.lineatus, A.matoides, A.leucosternon, A.Xanthopteres* and *Ctenochaetus strigosus*. Their abundance is given in figure.4.4.

4.3.2.2. Apogonidae

Paramia quinquelineata and *Apagon aureus* represented Apagonidae in the fishery and their abundance is given in Figure. 4.5.

4.3.2.3. Balistidae

Balistidae are very important marine ornamental fishes. *Odonus niger, Sufllanen Capistratus, Pseudobalistes flavimarginatus* and *Balistapus undulatus* represented balistidae in the fishery and their abundance is given in Figure.4.6.

4.3.2.4. Carangidae

Although carangids are very commonly available in the coastal waters only two species were taken in the present study for their ornamental value. *Trachinotus blochi* and *Trachinotus* baillonii was selected because of their rare beauty and adaptability to aquarium condition. Figure.4.7 shows the abundance of carangids in the Thikkody area.

4.3.2.5. Chaetodontidae

Butterfly fishes are probably the most important marine ornamental fishes available along the Thikkody coast. *Chaetodon collare*, *C.vagabundus*, *C.auriga* and *Heniochus acuminatus* were observed in the fishery. Figure.4.8 shows the abundance of butterfly fishes along the Thikkody coast.

4.3.2.6. Diodontidae

Porcupine fishes are very common in coastal waters. *Diodon hystrix* was observed in the fishery at Thikkody and Figure.4.9 shows its seasonal abundance.

4.3.2.7. Holocentridae

Commonly known as Soldier fishes and Squirrel fishes, holocentridae are very important aquarium fishes. Four species of holocentridae namely *Holocentrus diadaema, H.ruber, Myripristus adustus* and *M.murdian* were represented in the fishery. Their seasonal abundance is given in Figure.4.10.

4.3.2.8. Labridae

Wrasses are some of the most beautiful marine ornamental fishes. Two species, viz *Thalassoma lunure*, and *labroides dimidatus* were observed in the fishery. Figure.4.11 the abundance of wrasses along the Thikkody coast.

4.3.2.9. Muraenidae

Morey eels are typical reef dwellers found throughout the coast. In Thikkody two species are represented in the fishery viz. *Gymnothorax favigineus* and *G.flavimarginatus*. Figure.4.12 shows its seasonal abundance.

4.3.2.10. Ostraciodontidae

Boxfishes and trunkfishes have rigid body made up of bony plates covered with a sensitive skin. In Thikkody two species were observed in the reef fishery viz. *Lactaria cornuta* and *Ostracion tuberculatum*. Their seasonal abundance is given in Figure.4.13.

4.3.2.11. Platacidae

Members of the platacidae are known as batfishes in the aquarium trade and are represented in the fishery by *Platax orbicularis* and *Platax teira*. Figure.4.14 shows the abundance of batfishes along the Thikkody coast.

4.3.2.12. Pomacanthidae

This family contains the highly sought after angelfishes. Angelfishes enjoy a unique place in marine aquaria for its beauty and elegance. *Pomacanthus annularis* is the only species recorded from Thikkody. Figure.4.15 shows its seasonal abundance.

4.3.2.13. Pomacentridae

Pomacentridae are the largest group observed in the fishery at Thikkody and Dharmadom. *Neopomacentrus Cyanomos, N.filamentosus, N.nemurus, N.taeniurus. Abudufduf bengalensis, A.sexfasciatus, A.sexatilis, A.sordidus* and *A.septemfasciatus* was the commonly available pomacentrids observed in the fishery. Figure.4.16 shows the abundance of pomacentrids along the Thikkody coast.

4.3.2.14. Scorpaenidae

Scorpion fishes or Lionfishes are highly sought after ornamental fishes for their easy adaptability to aquarium condition. Among the scorpion fishes *Pterois volitans, P.antennata* and *P. radiata* were observed in the fishery at Thikkody. Figure.4.17.

4.3.2.15. Serranidae

Gramistes Sexlineatus, Cephalopholis boenack C.argus Epinepheles tauvina represented Serranidae in the ornamental fishery in Thikkody. Their seasonal abundance is given in Figure.4.18.

4.3.2.16. Siganidae

Siganids are known as rabbit fishes in the ornamental fish trade and are very sturdy and sought after fishes. *Siganus Javus is* abundantly available in the Thikkody waters. Figure.4.19 shows the abundance of rabbitfishes along the Thikkody coast.

4.3.2.17. Tetradontidae

Tetradon immaculatus and *T.hispidus* represent puffer fishes in the fishery at Thikkody. Figure.4.20 shows their seasonal abundance.

4.3.2.18. Zanclidae

Zanclidae are known as Tobies or Moorish idols in aquarium trade. *Zanclus Cornutus* was the only species observed in the fishery. Figure.4.21 shows its seasonal abundance.

4.2.3.Discussion

It is observed that newly recruited juveniles of ornamental fishes start appearing in the coastal waters of Thikkody by October. Their abundance increases in January when surface temperature is the lowest. They maintain high abundance from November to March. The situation continues till the middle of May until the coastal waters become very rough prior to the monsoon. Surface temperature given by Hornell and Nayudu (1923) and Sheshappa and Jayaraman (1956) from July to September varied from 24.72°C to 26.6C, with the mean value at 25.49°C. The present data gave an average value of 25.93°C. Since

November-march is the peak period of availability of ornamental fishes in the coastal waters the optimum temperature for majority of the ornamental fishes in the coastal waters can be considered as around 25-26°C. When temperature of the coastal waters increase ornamental fishes goes to deeper region of the reef, probably for an environment of their temperature.

By May the coastal waters become very rough due to pre-monsoon turbulance and in June with the onset of Monsoon the temperature in the coastal waters decrease. The salinity also declines due to heavy river runoff this situation continues till the end of August along the Calicut coast (Yohannan and Balasubramanyan 1991). During this time the ornamental fishes are rarely collected in the cages in shallow waters and it is assumed that they moved to deeper waters to avoid the low saline waters along the coast (Philipose 1998).

During September intermittent algal blooms occur in the coastal waters almost on year after year basis with varying intensity. The resultant low oxygen water causes fish mortality along the Calicut coast. Sheshappa and Jayaraman (1956) reported this phenomenon and attributed this to the high production of phytoplankton in the inshore waters due to the abundance of nutrients resulting from upwelling. During 2001 and 2002 this was observed in the coastal waters. This also resulted in the movement of many ornamental fishes towards shallower regions of the reef.

Sharma (1968) studied the upwelling along the Calicut coast. The thermocline with temperature below 25°C start moving from a depth of about 115metres in February and by June reaches a depth of about 15metres. By the middle of June a slight sinking to a depth of about 20 Metres takes place and to rise again to a depth of 10 meter by September. Then the sinking starts and reaches a depth of about 110metres by November. The oxygen content of this upwelling water was found to be about 2.5ml/l. The maximum intensity of upwelling is in Calicut – Karwar region (Ramasastry and Myrland 1959; Rao and Ramamrutham, 1976, Ramamrutham and Rao, 1974). During July and August, the surface mixed layer become more or less obliterated with temperature declining to 26°C and oxygen deficit layer migrating even to surface. This results in the movement of ornamental fishes in the reef to shallower regions and in extreme case results in mass mortality. Anon (1976a) explained the upwelling phenomenon in this area in detail. The process starts in March/April and ends in October/November. In 1974 August Cochin and Kasargod stations showed 1ml O_2/L at a depth of 20M. At outer stations it slopped down to 40 meter with the slowing down of the southward coastal flow and setting of northward flow, 1ml O_2/L start retreating. Upwelling either started first in north and slowly spread to south or it happened in the entire area within a short period. Similarly sinking either starts in the south and spread to north slowly or it happens approximately the same time. The strength of upwelling varies from year to year. Though upwelling start well in advance of monsoon, it is caused directly or indirectly by wind system. The low oxygen concentration below the Thermocline, which during upwelling in very shallow, forces the reef fishes towards the surface.

Sheshappa and Jayaraman 1956 studied the phosphate cycle in the inshore waters of Malabar Coast and found that the bottom mud contain large quantities of interstitial and absorbed phosphates in the non monsoon period. During monsoon there is a rapid release of phosphates into the overlying column of water and the quantity of phosphate in water increases to a maximum by July/August.

Nutrient supply and loss from reef are difficult to estimate. This has resulted in very limited knowledge about the nutrient budget for reef ecosystems. The importance of nutrients as a primary growth limiting element in the sea, the aspects of marine nitrogen cycling and its availability has been well documented (Thomas 1970; Ryther and Dunstan, 1971; Corner and Davies, 1971; Dugdale 1976; Carpenter and Capone 1983). Similarly, nitrogen and its role in estuarine mangrove swamps and other aquatic ecosystem have also received attention (Boto and Wellington 1963, Ovalle *et. al.*, 1990; Gilbert and Garside, 1992). But the abundance and function of nitrogen in rocky reefs have been addressed only in limited studies.

Like dissolved nitrogen and phosphorus, Silicic acid concentration in reef waters are also low. Smith and Jokiel (1978) observed higher concentrations in areas of upwelling and Webb (1981) concluded that chemical and biological processes affect Silicate cycle in reefs. Seasonal differences in the uptake and release of silicic acid have been observed (Johannes et.al 1983 a). Studies on silicates in reefs have shown that there is low utilization of silicates in most reef environments (Smith and Jokiel, 1978; Smith et.al, 1984). The silicate values observed in the present study varying from 0.05 to 0.93 Mug a/L is perfectly normal and comparable with the results observed by Seshappa and Jayaraman (1956); Subramanian and Sharma (1965) and Mukundan (1967).

Generally speaking the nutrient levels in the coastal waters and reef ecosystem are largely influenced by the upwelling and monsoon activity. Nutrient availability influences the primary and secondary productivity of the coastal waters creating a conducive environment for the fishes to breed. Availability of food is an important factor for the juveniles to grow and recruit into the population and in the monsoon and post monsoon months the high levels of primary and secondary productivity ensures the food availability to the larvae and juveniles.

Earlier studies on reef zooplankton by Bakus (1964) indicate that plankton in reef areas are much more abundant than in the surrounding waters making the reefs ideal nursery grounds for the juveniles of marine ornamental fishes to grow and enter into the fishery. Spatial variations are insignificant while seasonal fluctuations are profound with the maximum biomass in the post monsoon period. This generally agrees with the observations at all the study centers where it was observed that most of the marine ornamental fishes breed in the monsoon months. Environment plays an important role in the breeding and recruitment of marine ornamental fishes along the Malabar Coast and thereby influences their abundance in the coastal waters.

Table.4.1. Temperature, Rainfall, Salinity and dissolved oxygen of the surface waters of Thikkodi during 2001

Month	Temperature (°C)	Rainfall (cm)	Salinity (ppt)	Dissolved Oxygen(ml/lt)
Jan-2001	28.4	0	32	4.1
Feb-2001	29.6	0	32.6	4.4
Mar-2001	31.1	2	33.5	4.2
Apr-2001	32.6	14	35.1	4.5
May-2001	29.7	25	33.6	4.4
Jun-2001	29.5	90	32	5
Jul-2001	27.5	105	29.9	4.3
Aug-2001	27.2	41	33.7	5.7
Sep-2001	27.6	25	32.5	4.4
Oct-2001	29.3	29	32.8	4.5
Nov-2001	30.2	5	31.9	4.1
Dec-2001	31.5	0	32.8	4.1
Annual	29.5	336	32.7	4.5

Table.4.2. Temperature,Rainfall,Salinity and dissolved oxygen of the surface waters of Thikkodi during 2002

Month	Temperature (°C)	Rainfall (cm)	Salinity (ppt)	Dissolved Oxygen(ml/lt)
Jan-2002	29.4	0	33.4	4.4
Feb-2002	30.5	0	33.9	4.2
Mar-2002	31.3	5	34.1	4.4
Apr-2002	31	19	35.4	4.2
May-2002	29.5	6	34	4.3
Jun-2002	26.9	108	29.8	4
Jul-2002	25.9	147	28.3	4.6
Aug-2002	26.4	46	29.8	4.8
Sep-2002	27.1	18	34.5	4.3
Oct-2002	28.6	45	33.8	3.5
Nov-2002	30	8	33.4	3.6
Dec-2002	30	1	33.8	3.9
Annual	28.9	403	32.9	4.2

Table.4.3. Nitrites, Nitrates, Silicates and Phosphates in the coastal waters of Thikkody during 2001(μ g/lt)

Month	Nitrites	Nitrates	Silicates	Phosohate
Jan-2001	0.05	0.94	0.91	0.69
Feb-2001	0.21	0.2	0.19	0.66
Mar-2001	0.73	0.33	0.33	0.42
Apr-2001	0.01	0.01	0.01	0.63
May-2001	0.6	0.19	0.19	0.87
Jun-2001	0.43	0.33	0.36	1.18
Jul-2001	0.3	0.48	0.45	1.32
Aug-2001	0.34	0.57	0.53	1.39
Sep-2001	0.38	0.58	0.53	0.94
Oct-2001	0.38	0.16	0.19	1.48
Nov-2001	0.08	0.021	0.02	0.87
Dec-2001	0.38	0.36	0.36	0.48
Annual	0.324	0.347	0.339	0.91

Table.4.4. Nitrites, Nitrates, Silicates and Phosphates in the coastal waters of Thikkody during 2002 (μ g/lt)

Month	Nitrites	Nitrates	Silicates	Phosohate
Jan-2002	0.07	0.92	0.96	0.73
Feb-2002	0.05	0.31	0.25	0.59
Mar-2002	0.08	0.41	0.38	0.49
Apr-2002	0.03	0.09	0.09	0.67
May-2002	0.8	0.34	0.23	0.99
Jun-2002	0.51	0.44	0.32	1.33
Jul-2002	0.41	0.49	0.59	1.41
Aug-2002	0.48	0.61	0.65	1.49
Sep-2002	0.41	0.55	0.63	0.99
Oct-2002	0.39	0.22	0.34	1.49
Nov-2002	0.21	0.19	0.08	0.99
Dec-2002	0.29	0.41	0.39	0.53
Annual	0.31	0.415	0.409	0.975

Fig.4.1. Average values of Temperature and rainfall in the coastal waters of Thikkody during 2001 & 2002

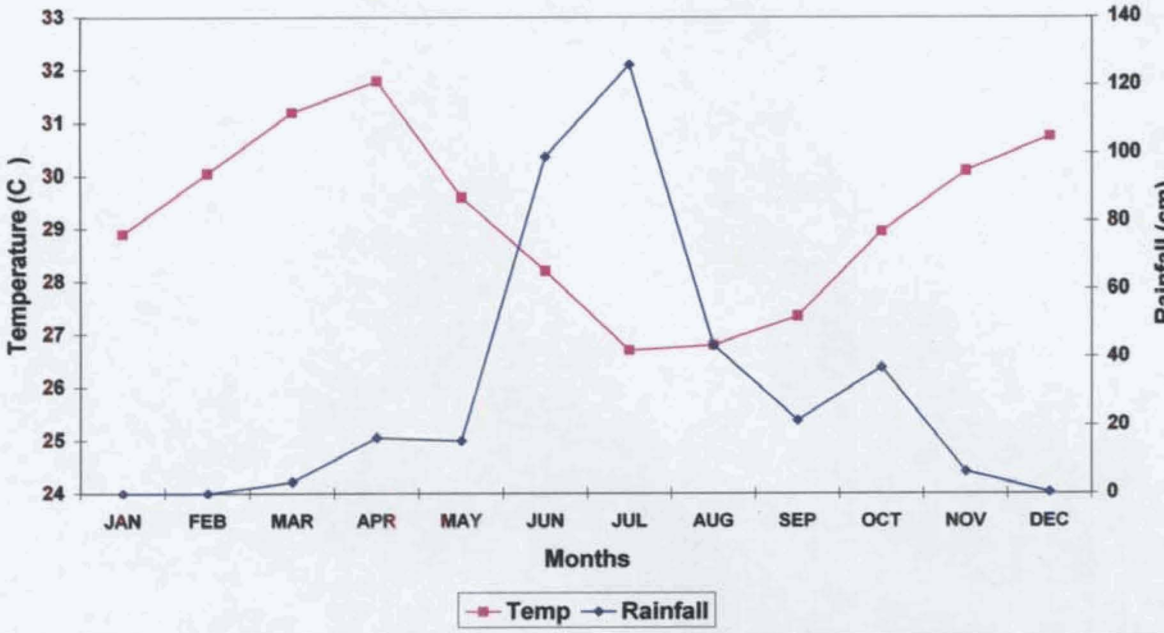


Fig.4.2. Average values of salinity and dissolved oxygen in the coastal waters of thikkody during 2001 & 2002

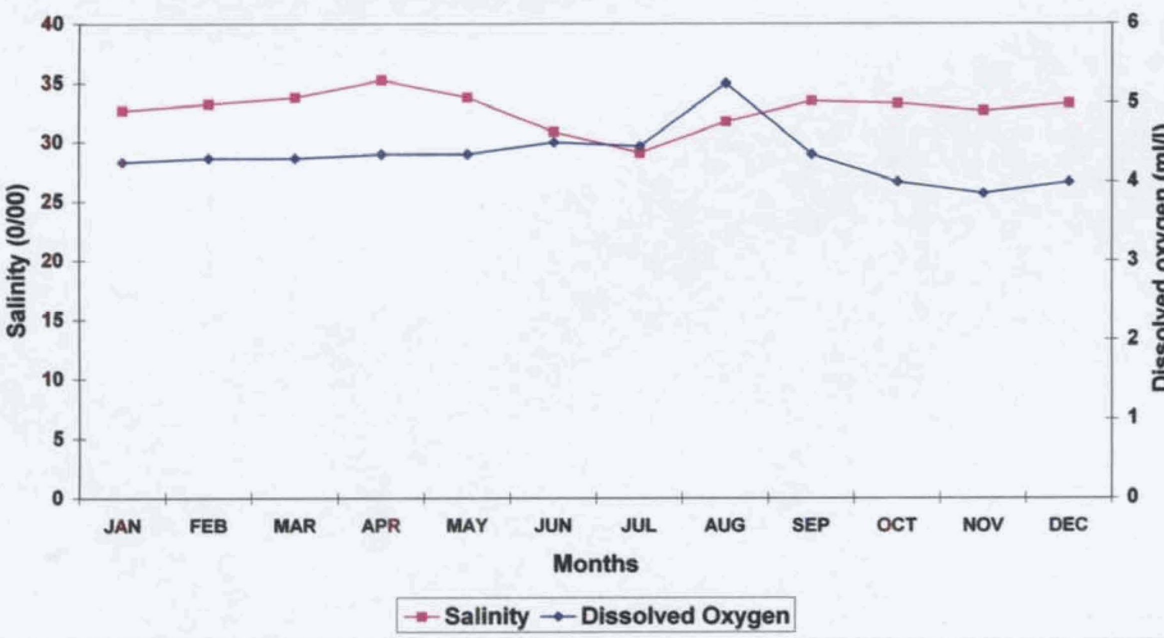


Fig.4.3. Average values of Nitrites, Nitrites, Silicates and Phosphates in the coastal waters of Thikkody during 2001 & 2002

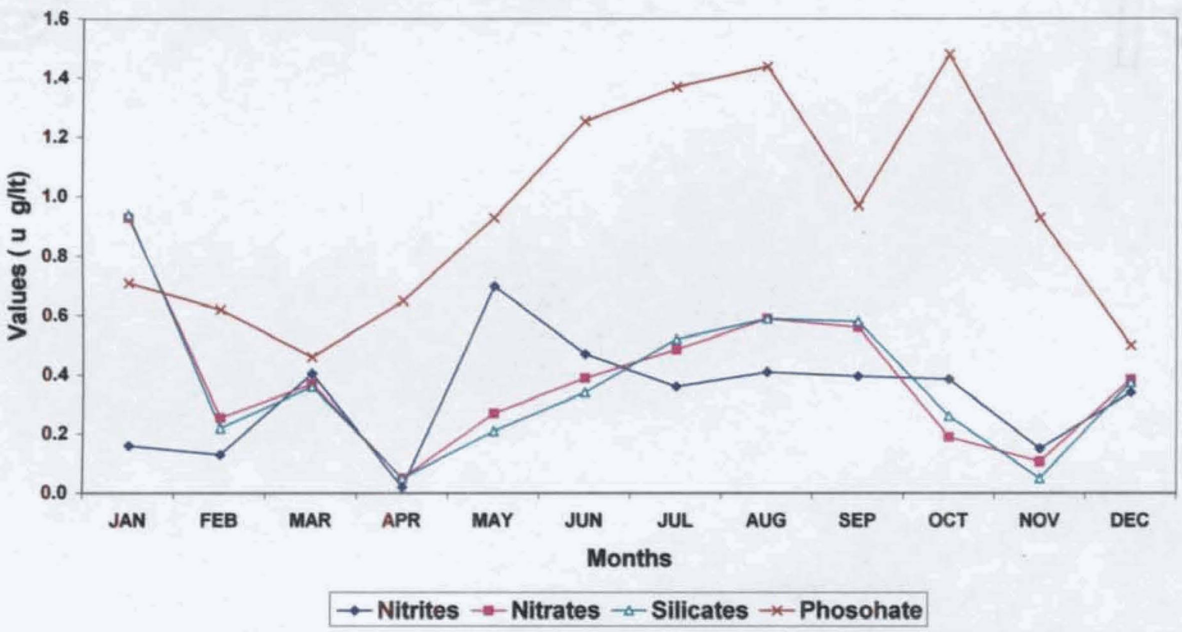


Fig. 4.4. Seasonal abundance of Acanthuridae at Thikkody

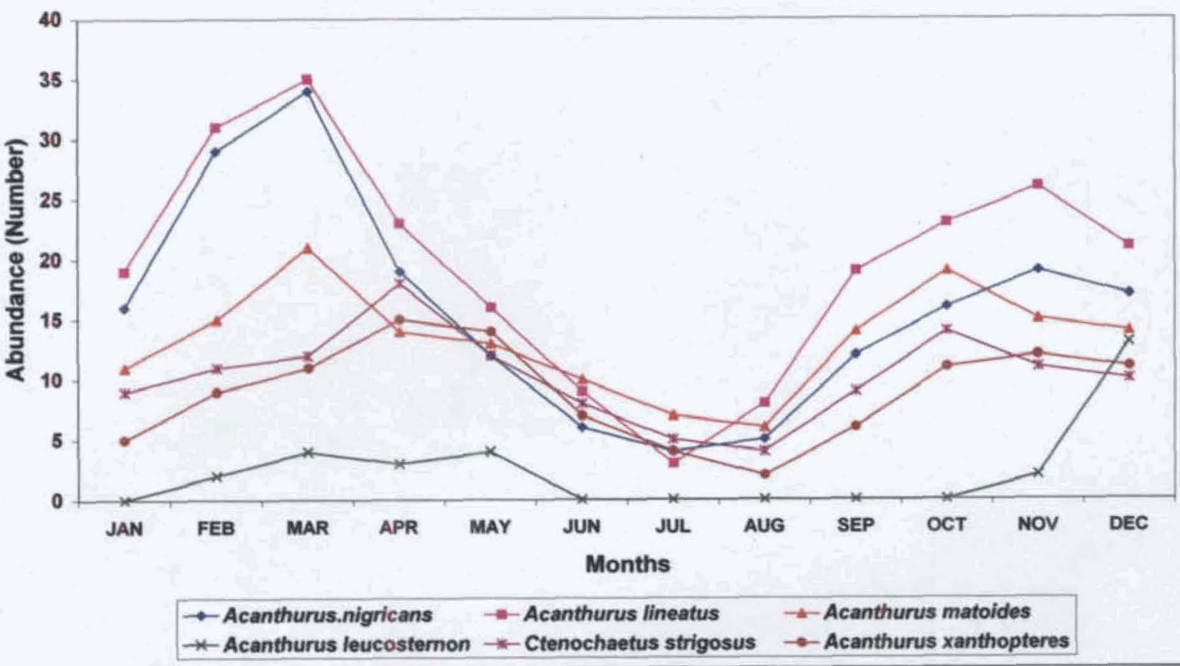


Fig. 4.5. Seasonal Abundance of Apagonidae at Thikkodi

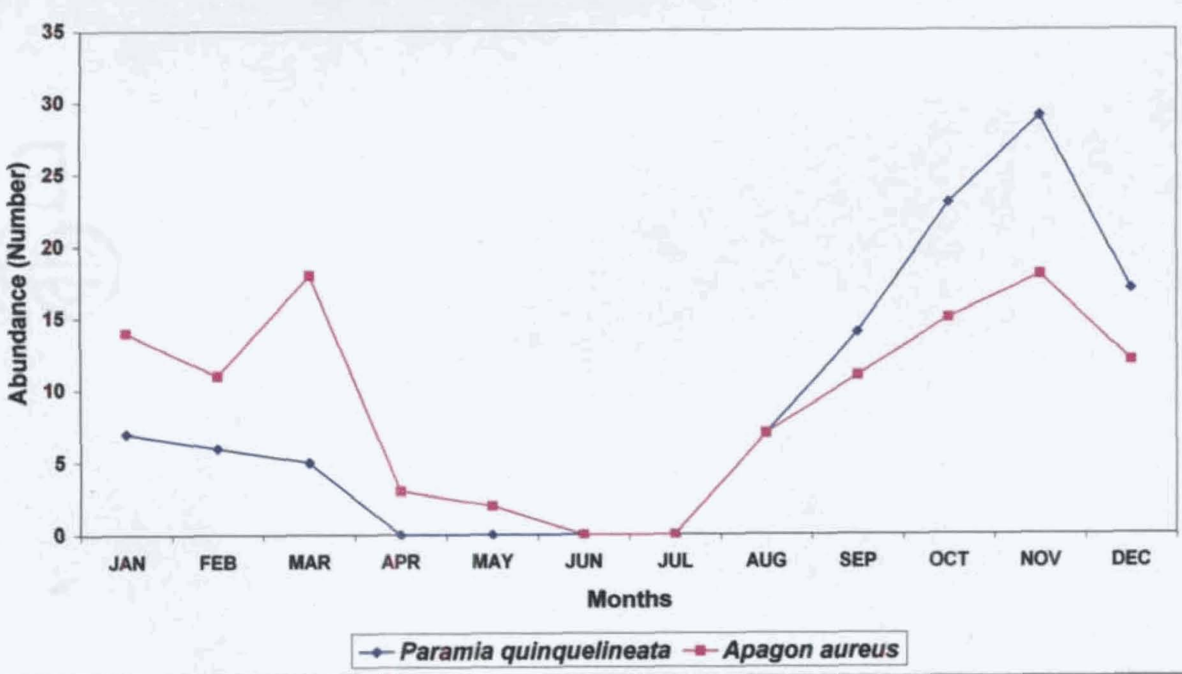


Fig.4.6. Seasonal Abundance of Balistidae at Thikkodi

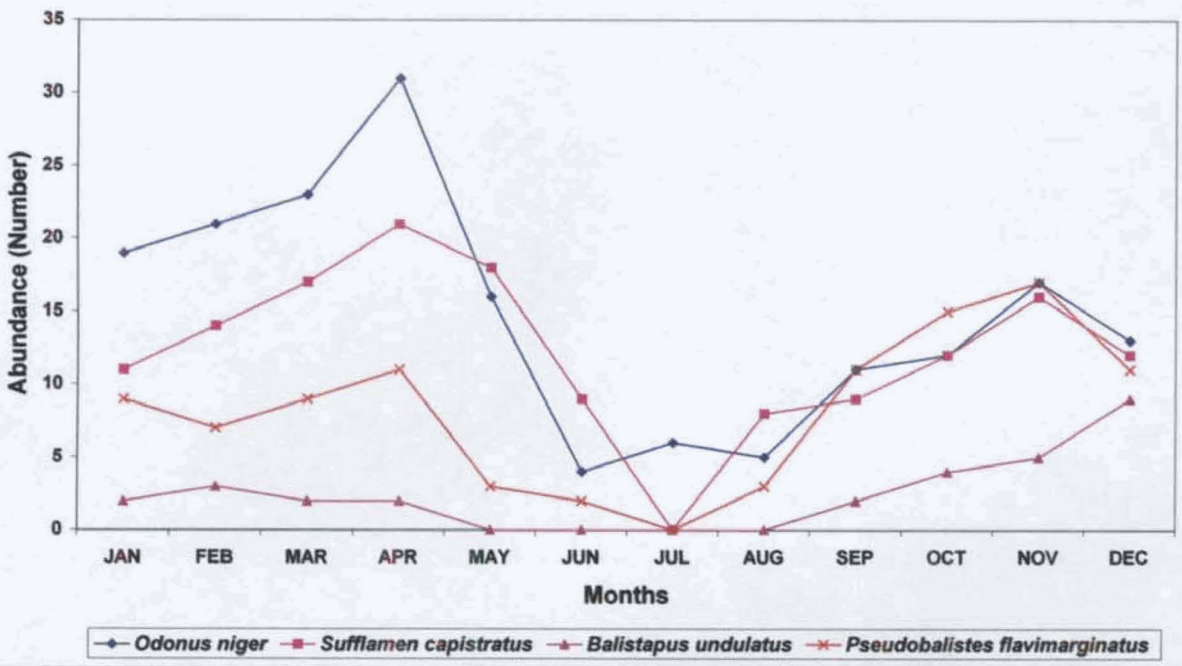


Fig.4.7. Seasonal abundance of Carangidae at Thikkody

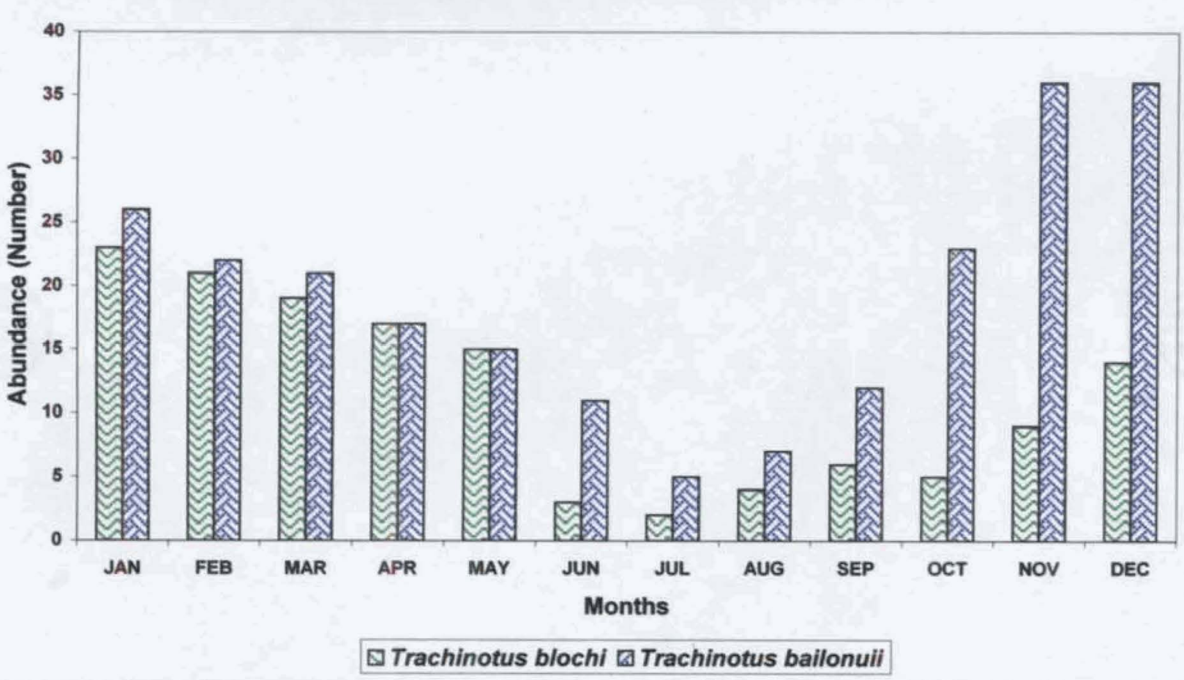


Fig.4.8. Seasonal Abundance of Chaetodontidae

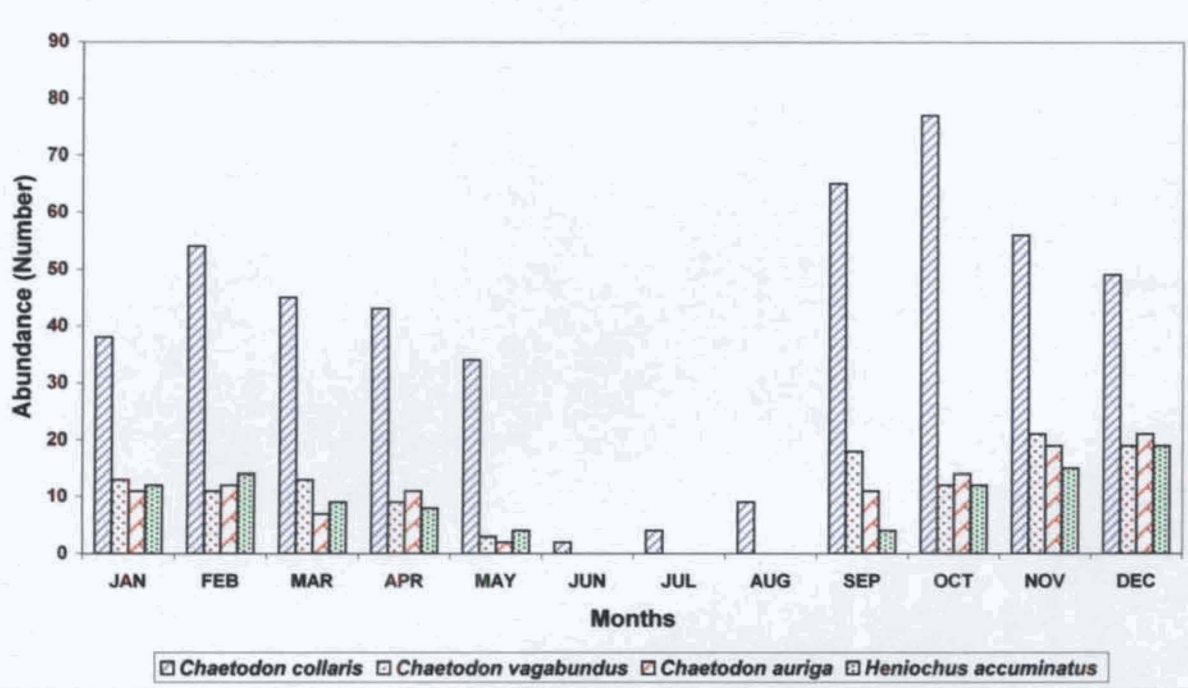


Fig. 4.9. Seasonal abundance of Diodontidae at Thikkody

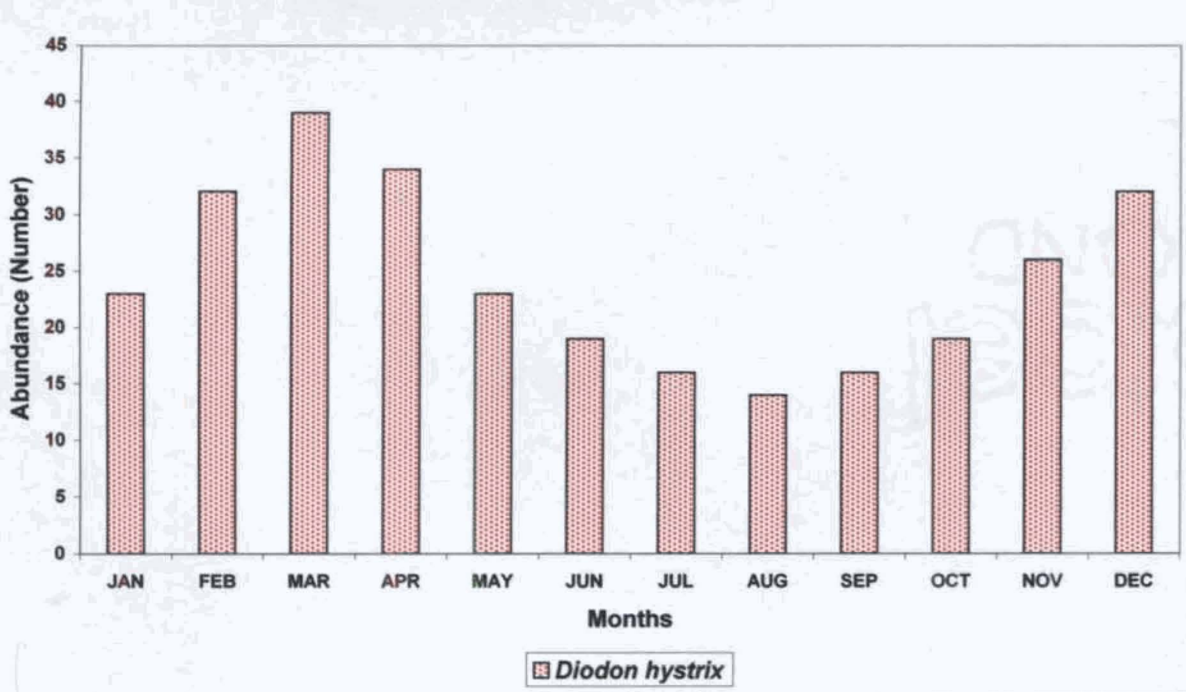


Fig.4.10. Seasonal Abundance of Holocentridae at Thikkodi

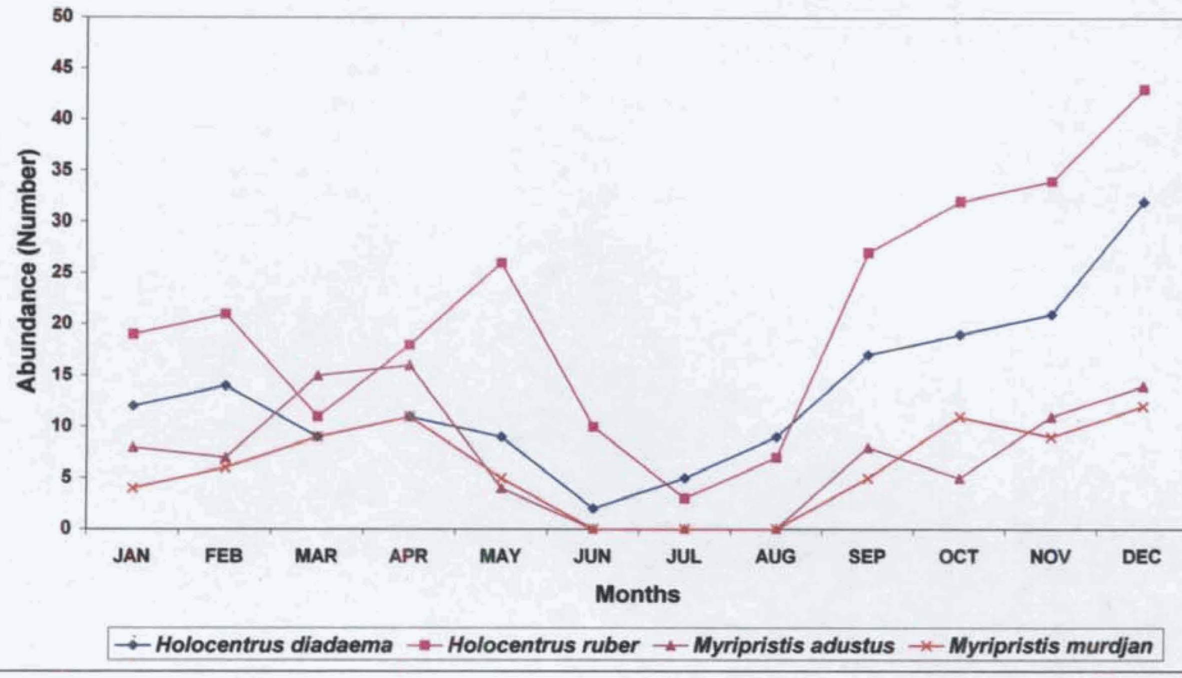
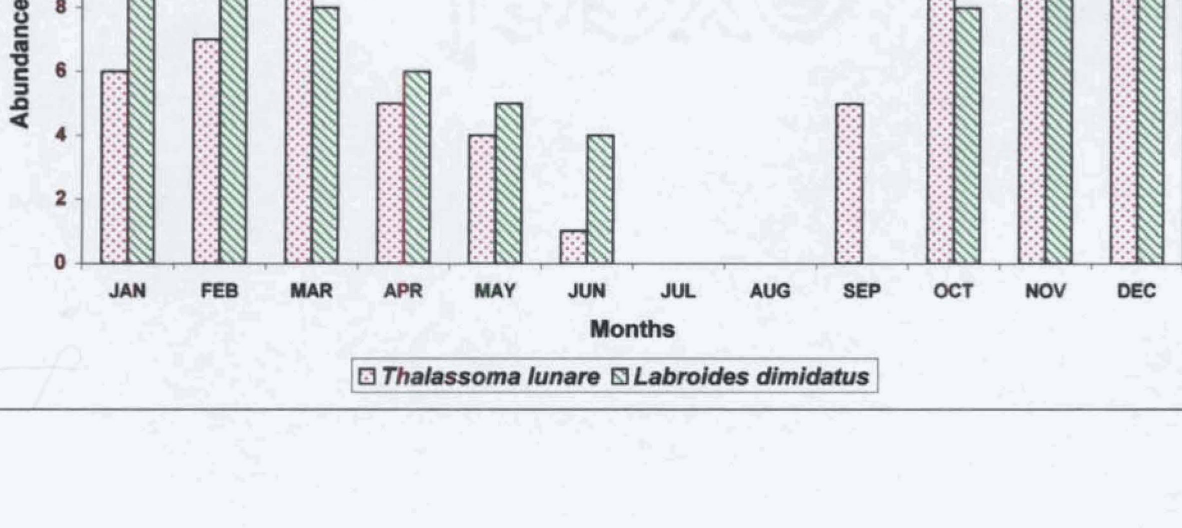


Fig.4.11. Seasonal Abundance of Labridae at Thikkody



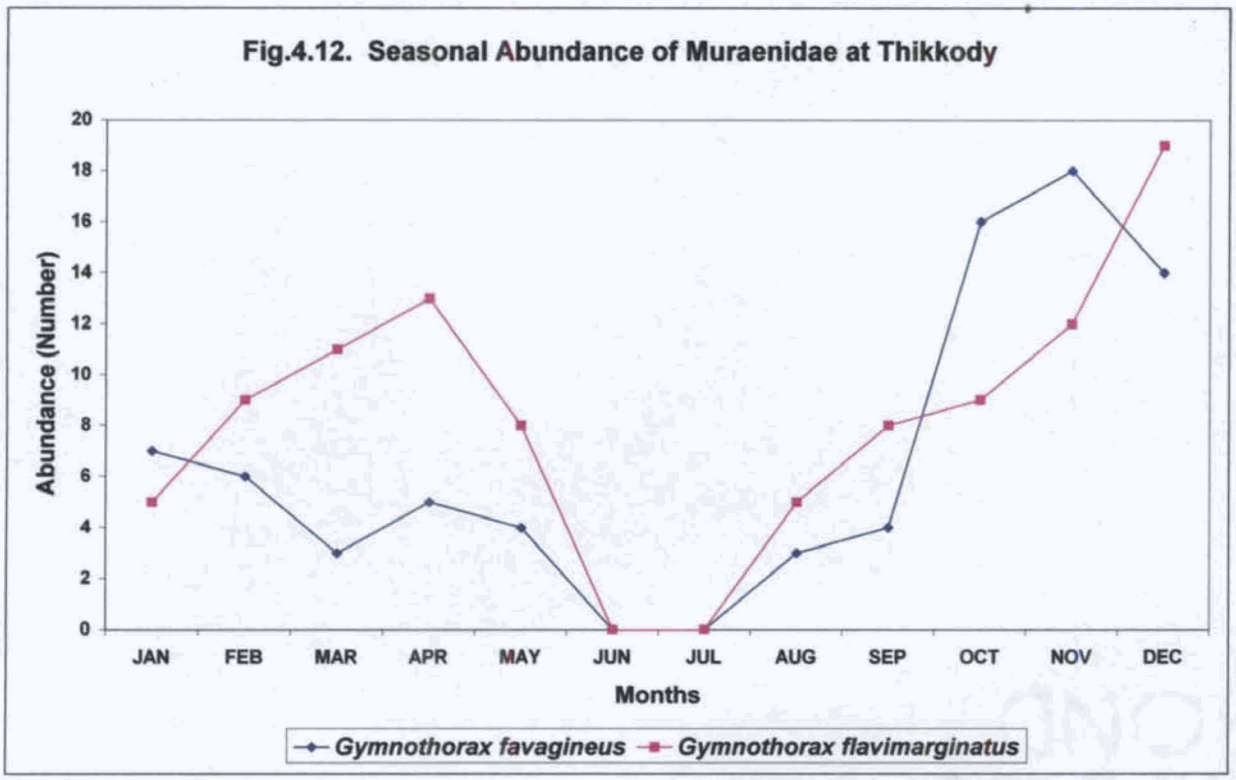


Fig.4.12. Seasonal Abundance of Muraenidae at Thikkody
Abundance (Number)
0
2
4
6
8
10
12
14
16
18
20
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Months
Gymnothorax favagineus
Gymnothorax flavimarginatus

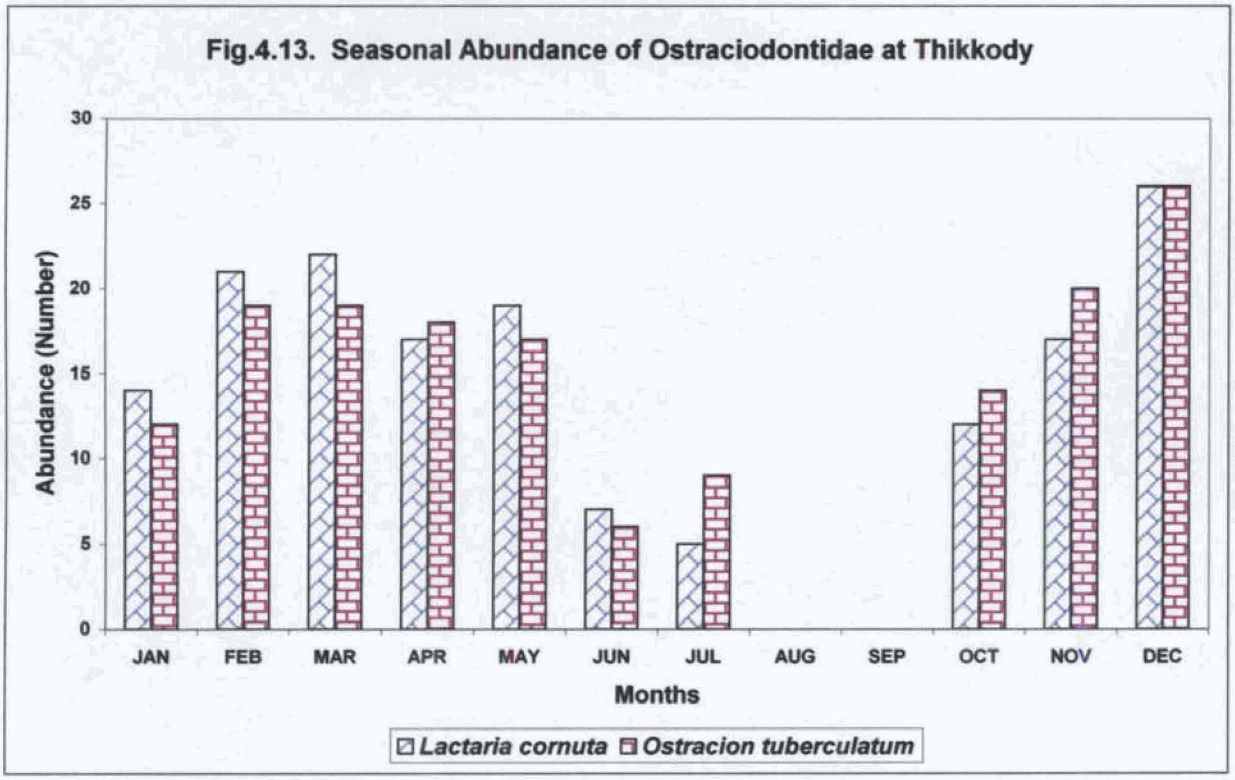


Fig.4.13. Seasonal Abundance of Ostraciodontidae at Thikkody
Abundance (Number)
0
5
10
15
20
25
30
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Months
Lactaria cornuta
Ostracion tuberculatum

Fig.4.14. Seasonal Abundance of Platacidae at Thikkody

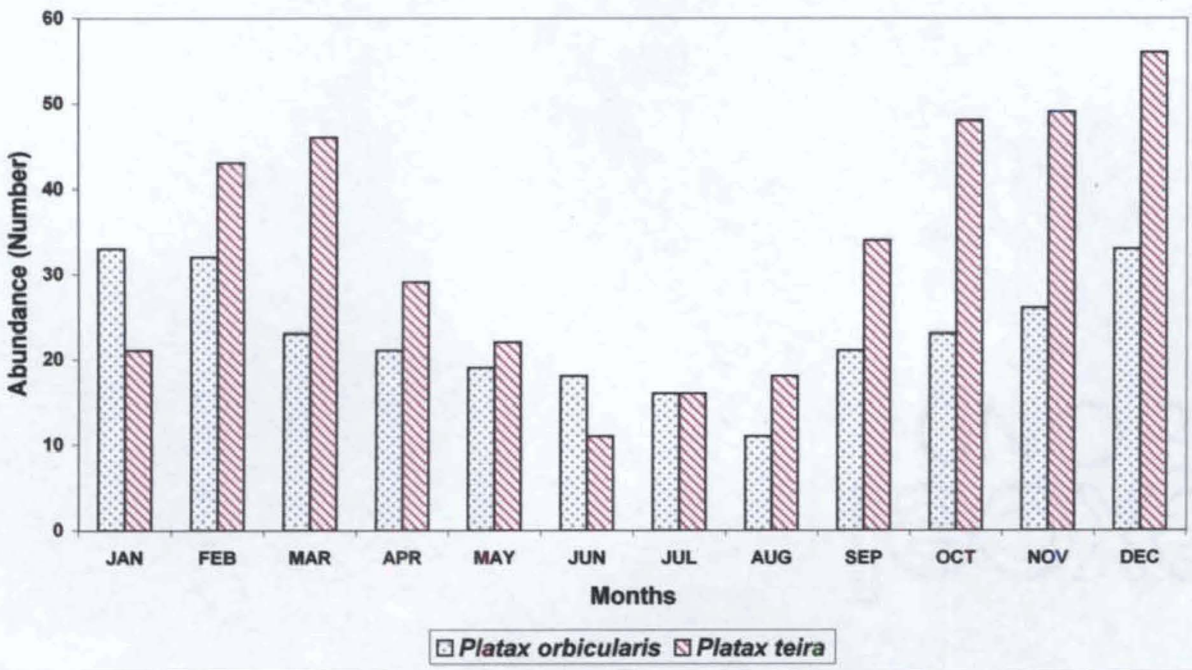


Fig.4.15. Seasonal abundance of Pomacanthidae at Thikkody

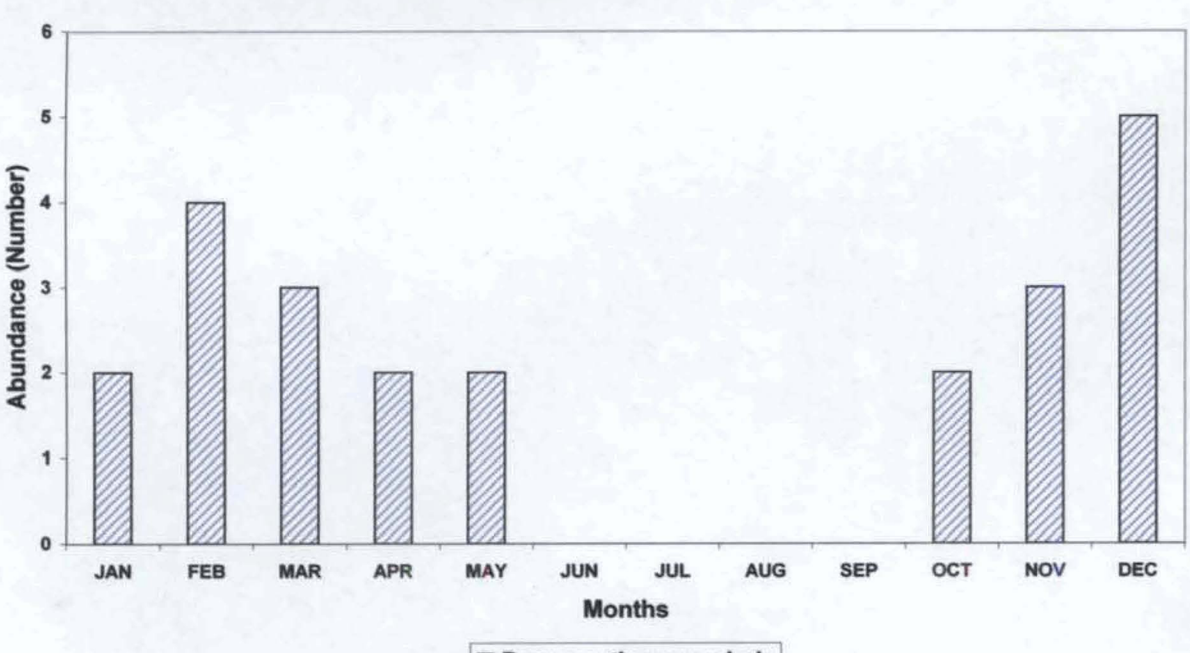


Fig.4.16. Seasonal Abundance of Pomacentridae at Thikkody

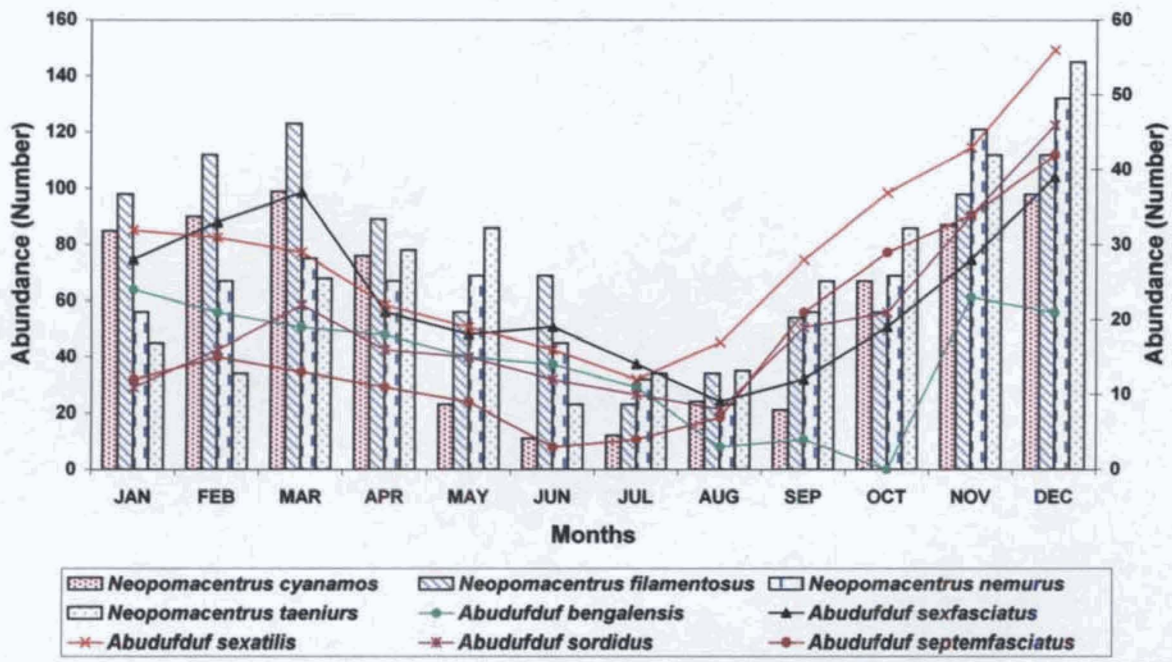


Fig.4.17. Seasonal Abundance of Scorpaenidae at Thikkody

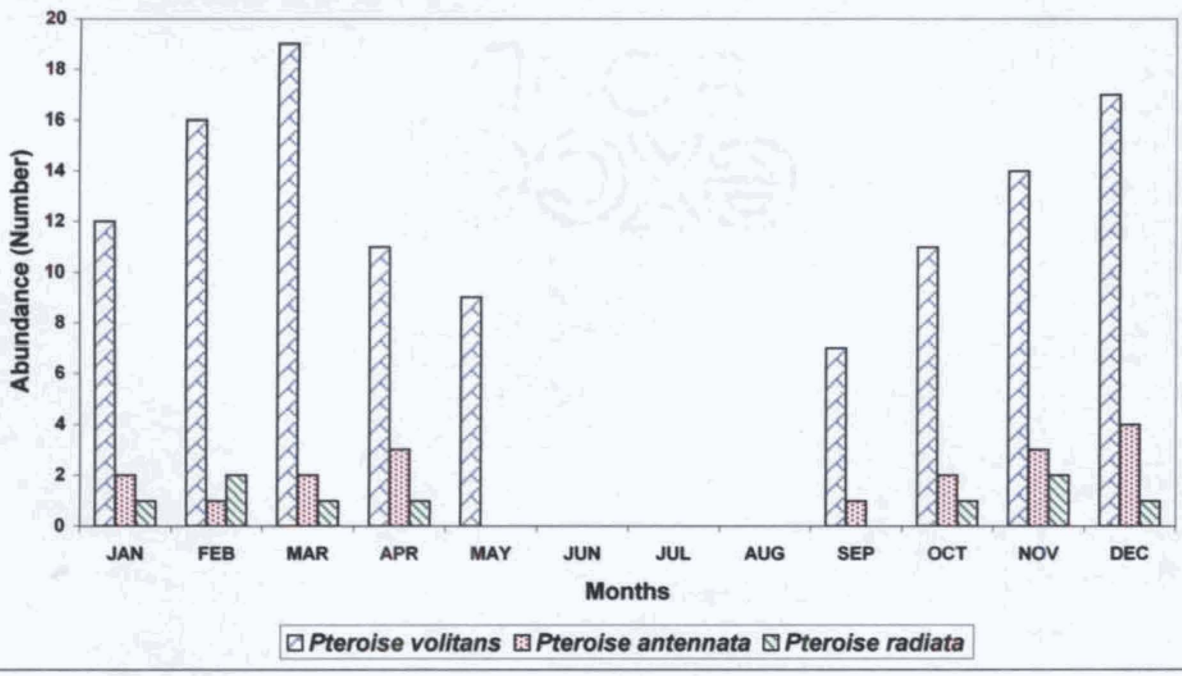


Fig.4.18. Seasonal Abundance of Serranidae at Thikkody

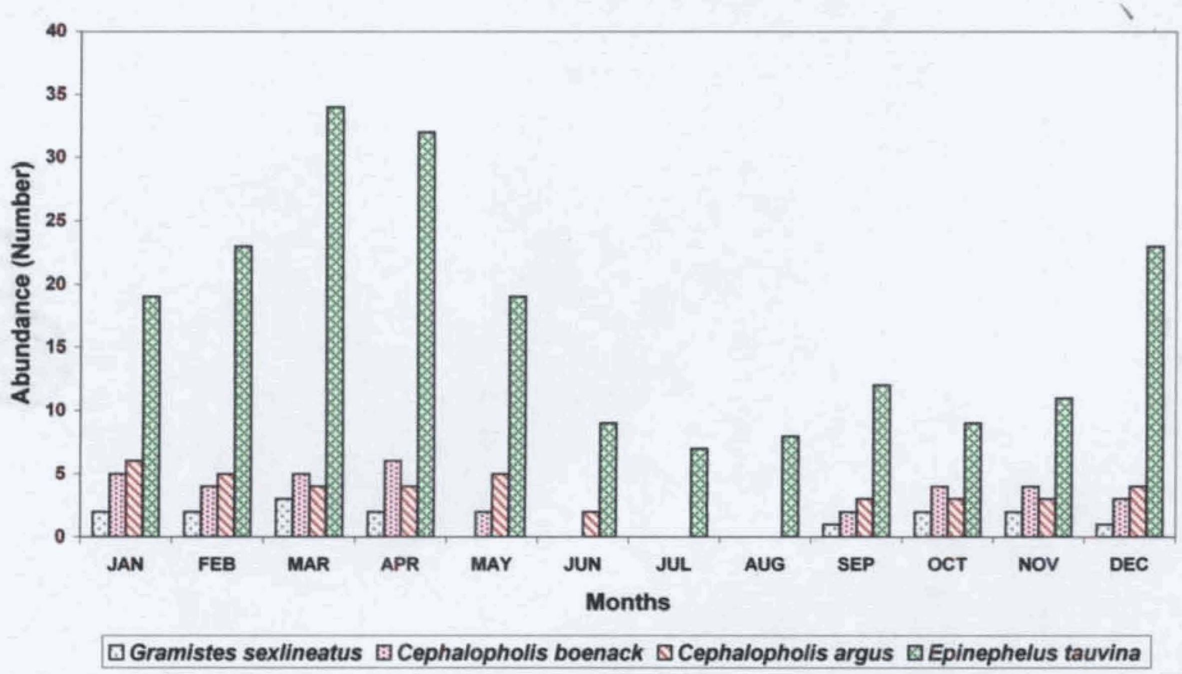


Fig.4.19. Seasonal Abundance of Siganidae at Thikkody

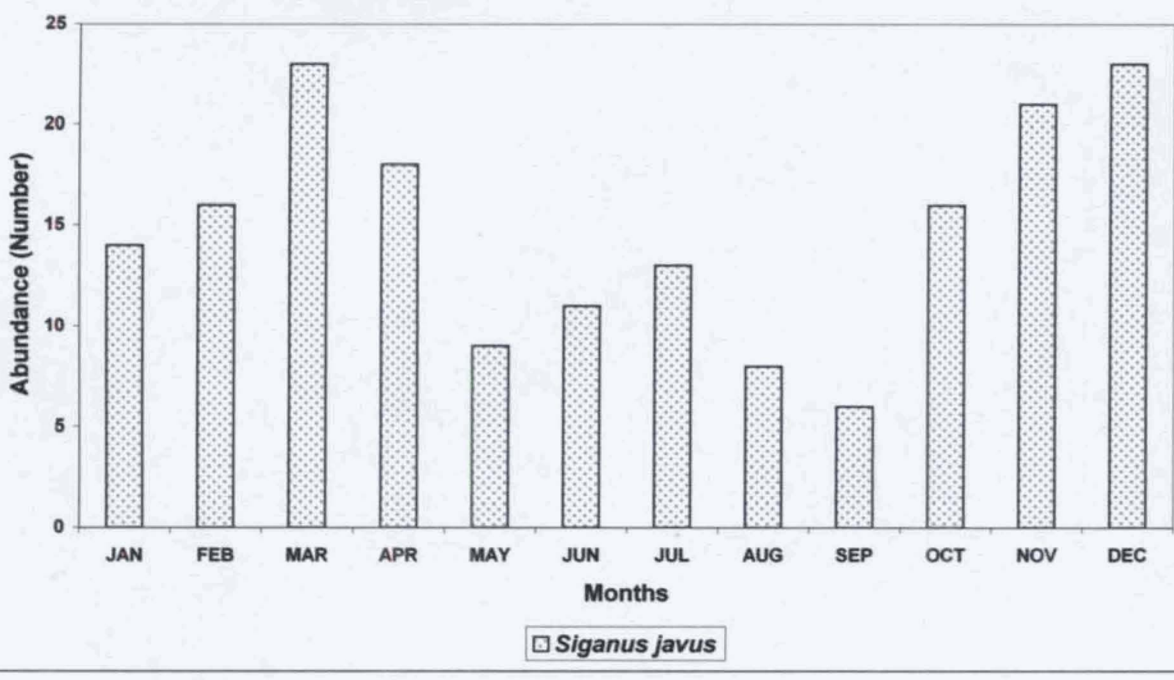


Fig.4.20. Seasonal Abundance of Tetradontidae at Thikkody

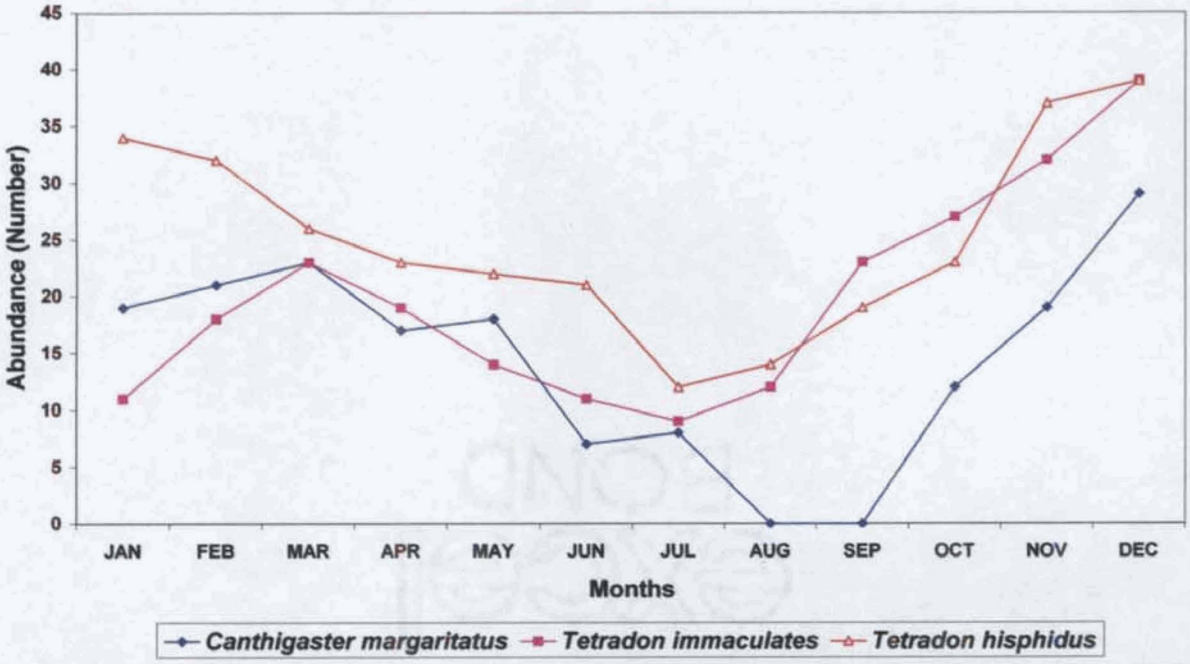
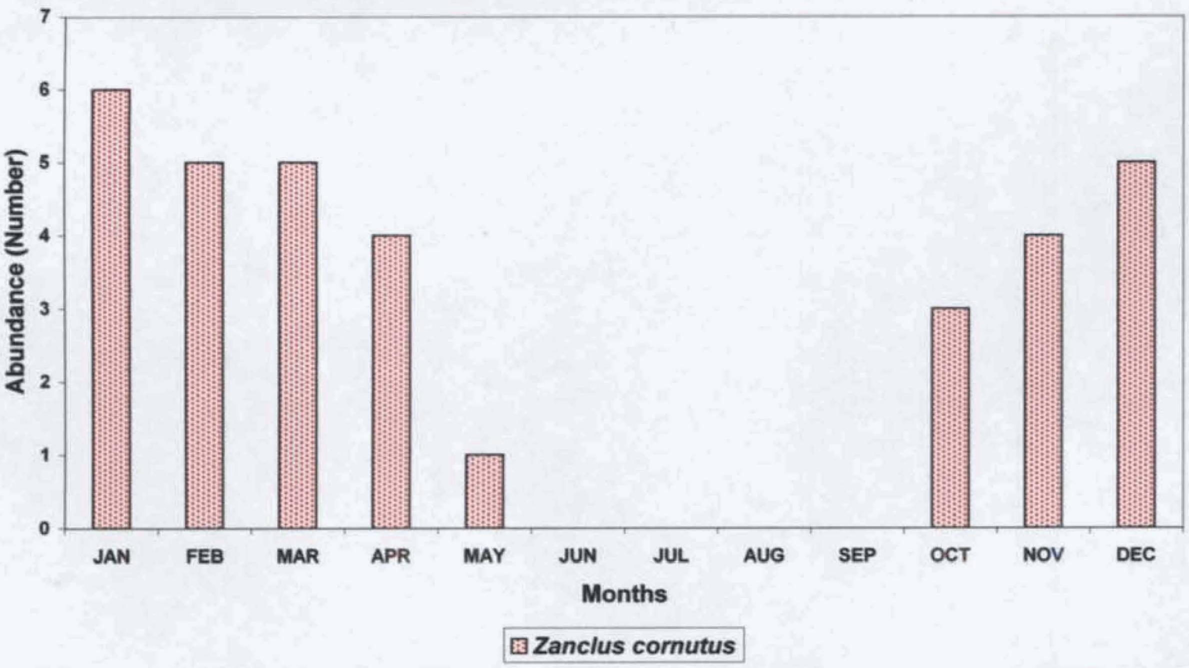


Fig.4.21. Seasonal abundance of Zanclidae at Thikkody



Chapter.5

A systematic account of the common ornamental fishes from Malabar Coast

5.1.Introduction

Ornamental fishes are reef residents comprising of a large number of species belonging to different families. Over six hundred species of marine fishes are known from lakshadweep seas (Jones and Kumaran, 1980) of these over 300 species belonging to about 35 families are known for their attractive colouration and shapes (Murty *et.al.* 1989) and can be termed as ornamental fishes for aquarium keeping. Among these 35 families 18 are represented in the collections made under this study. Theses seventeen families are represented by 50 species collected from different collection centres.

A systematic study of the different species collected was made and the results along with important family and species characteristics are given below.

5.2.Results

5.2.1.Family Acanthuridae (Surgeon fishes)

Members of this family are characterized by their high profile and laterally compressed oval bodies. They have scalpel like erectile spines on the caudal peduncle, which are used in defence. The dorsal and anal fins are long based and the eyes are set high on the head. The scales often end in a small protuberance giving a rough feel to the skin.

There are no drastic colour changes between juveniles and adults in most species. However some like *Zebrasoma veliferum* (Sail fin tang) has a yellow juvenile form. Although external differences between the sexes are normally rare, darkening of the male's colours during breeding season is reported. Size is not a reliable indication of the sex of the fishes. Eggs are pelagic, important species collected under the family are given below.

Acanthurus lineatus (Linnaeus) 1758

Clown surgeonfish. Very active and agile fish. Often grows to sizes up to 280mm (SL) D IX/27-30, A111/25-28 P.ii, 14-15 LI. 97-108:

First anal spine short, second ¾th of third, Pectoral slightly longer than head, ventral equal or longer than pectoral. Caudal lobes pointed colour, canary yellow sides and back with 9 or 10 light blue bands broadly bordered by blackish bands separated by very narrow pale bands directed towards dorsal and the base of caudal. A vertical bluish band at base of caudal bordered with black. An active swimmer generally feeds, on algae. Suitable for marine community aquaria. (Plate.5.1.a)

Collection site: Thikkody.

Acanthurus nigricans (Linnaeus) 1758

Chaetodon nigricans	Linnaeus 1758
Acanthurus gahhm	de Beaufort 1951,
Acanthurus gahm	Smith 1963
Acanthurus nigricans	Jones 1969

Size range: 84 - 184mm

D IX 26-28, A 111 24-26; P ii 14-15, V.1.5. L1. 138-145; Ltr. 13-14+62-70

Depth of body 2.0-2.3 in standard length. First dorsal spine very small second about twice as long as the first subsequent spines increasing in length, first anal spine short, 3rd longer than 2nd, Caudal lunate, the lobes produced. Colour dark brown with one elongate black bar from behind upper edge of gill opening to above middle of pectoral. Groove of caudal spine black with black tapering stripe extending forward on side. Posterior part of caudal peduncle and base of caudal abruptly for community aquarium feeds on algae. (Plate.5.1.b)

Collection site: Thikkody.

Acanthurus leucosternon (Bennett) 1832

Powder blue surgeon

Acanthurus leucosternon	Day 1878
Acanthurus leucosternon	Beufort 1951
Acanthurus leucosternon	Munro, 1955
Acanthurus leucosternon	Jones and Kumaran 1959
Acanthurus leucosternon	Smith. 1961
Acanthurus leucosternon	Jones, 1969

Length 57 - 139 mm.

D IX 28-31 A111. 26-28; P. 11. 14; V. 1.5. L1 179-194 Ltr. 17-20 + 76-79.

First spine of dorsal minute, subsequent spines increasing in length. First anal spine minute, third longer than second, but shorter than last dorsal spine. Caudal emarginated. Colour: Head deep blue, body bluish grey to dark bluish brown. Caudal peduncle lighter, chest and a ring encircling hind part of mouth yellowish orange towards base with a narrow white outer border and a blackish sub marginal line. One of the costliest surgeonfish. Feeds on algae. Suitable for community aquarium. Active swimmer. (Plate.5.1.c)

Collection site: Moodady.

Acanthurus xanthopterus (Smith and Smith) 1963.

Acanthurus matoides	Cuvier and Valenciennus 1835

Acanthurus matoides	Day 1878
Acanthurus matoides	de Beaufort 1951
Acanthurus matoides	Munro 1955
Acanthurus matoides	Jones and Kumaran 1959

Size range: 47 - 390 mm

D. (V111) IX, 25-27, A: 111. 23-25.

First dorsal spine small. The following spines increasing in length to the last, it being about 2 ½ eye diameter or more in length. Third anal spine twice eye diameter in length. Caudal lunate, lobes pointed. Colour dark brown with violet tinge. A dark post ocular blotch in very large specimens. Area adjoining caudal spine blackish. Dorsal and dark brown to violet with 5 to 7 light longitudinal bands and often with very narrow blackish edge. Basal two thirds of pectoral, brownish. Posterior thin pale. Caudal dark brown, base sometimes lighter. Ventral dark brown. In small specimens, posterior part of caudal, peduncle and base of caudal white, pectoral white, dusky basally. Feeds on algae, active swimmer. (Plate.5.1.d)

Collection site: Chombal.

Acanthurus matoides (Valenciennes) 1831

Acanthurus matoides	Cuvier and Valenciennes 1835.
Acanthurus matoides	Day 1878
Acanthurus matoides	de Beaufort 1951
Acanthurus matoides	Jones and Kumaran 1959
Acanthurus xanthopterus	Smith and Smith1963.

Size range: 47 - 160 mm

D. (VIII) IX, 25-27; A. III, 23-25; P. ii, 15; V. I, 5. L1. about 170-195; Ltr. 16-19+70-80.

Head 3.3-3.7 in standard length, 4.3-4.8 in total length. Depth of body 1.8-2.2 in standard length, 2.4-2.8 in total length. Eye 3.6-5.2 in head, 2.0-3.0 in snout and 1.2-1.4 in convex interorbital space. Corner of mouth nearer to hind border of preopercle than to eye. 8 or 9 lobate teeth on each side of both jaws. First dorsal spine small, the following spines increasing in length to the last, it being about 2 ½ eye diameter or more in length. Third anal spine twice eye diameter in length. Caudal lunate, lobes pointed. Colour: Dark brown with violet tinge. A dark post ocular blotch in very large specimens. Area adjoining caudal spine blackish. Dorsal and anal dark brown to violet with 5 to 7 light longitudinal bands and often with very narrow blackish edge. Basal two-thirds of pectoral brownish, posterior third pale. Caudal dark brown, base sometimes lighter. Ventral dark brown. In small specimens, posterior part of caudal, peduncle and base of caudal white; pectoral white, dusky basally. (Plate.5.1.e)

Collection site: Moodady

Ctenochaetus strigosus (Bennett) 1828

Acanthurus strigosus	Bennett 1828
Acanthurus strigosus	Day 1878
Ctenochaetus strigosus	de Beaufort 1951
Acanthurus strigosus	Smith 1949
Acanthurus strigosus	Munro 1955
Acanthurus strigosus	Jones 1969

Size range: 31 - 103 mm

D. VIII-IX, 27-29; A. III, 24-25; P. ii, 14-15; V. I, 5. L1. about 115; Ltr. 13+39-44.

Head 3.3-3.4 in standard length, 4.5-4.7 in total length. Depth of body 1.9-2.0 in standard length, 2.5-2.7 in total length. Eye 3.4-3.7 in head, 1.7-2.0 in snout and 1.2 in convex interorbital space. Teeth long, slender, movable and bristle like with expanded tips serrulated, 24 to 36 in upper jaw and 32 to 40 in lower jaw. First dorsal spine minute, spines increasing in length to the last measuring 2.2-2.3 eye diameters. First anal spine very small, third longest, 1.6-1.7 eye diameter. Pectoral longer than head. Ventral slightly shorter than head. Caudal deeply emarginated, lobes pointed, upper lobe slightly longer than the lower. Colour: Uniform dark brown to chocolate brown, some specimens with greenish tinge posteriorly, often with numerous narrow wavy longitudinal pale to light bluish lines on sides of body and tail. Dorsal and anal dark violet to blackish brown with pale bluish longitudinal bands. Caudal dark violet with indications of dark spots in distal third of the fin. Pectoral pale hyaline, rays dusky, upper border narrowly edged with dark. Ventral dark brown, basal part of inner 2 or 3 rays lighter. (Plate.5.1.f)

Collection site: Thikkody

5.2.2.Family: Apogonidae

Cardinal fishes

Cardinal fishes are slow moving nocturnal fishes that hide among coral heads during daytime. However at the approach of a net they can move very fast. They are usually found on coral reefs but some frequent tidal pools. Two separated dorsal fins are carried erect. This feature together with the large head, mouth and eyes is a characteristic of the family.

Reproduction is by mouth brooding. The male generally incubate the eggs, although in some species females do incubation of the eggs. In other species within the family, both sexes share the responsibility. Cardinal fishes usually feed on live organisms including copepods and fish larvae but accept prepared feeds in aquarium conditions.

Paramia quinquelineata (Cuvier and Valenciennes) 1829

Cheilodipterus quinquelineatus	Day 1878
Cheilodipterus quinquelineatus	Weber and de-Beaufort 1929
Cheilodipterus quinquelineatus	Smith 1949
Cheilodipterus quinquelineatus	Munro 1955
Paramia quinquelineata	Jones 1969

Length 30 - 81mm.

D1 V1; D2. 1,9; A. 11, 8; P.ii 10; V.1, 5 L1 25-26 Ltr 2+1+6 ½

Pectoral equal to snout and eye together; ventral equal to or slightly shorter than pectoral. Colour; Dull yellowish with fine longitudinal dark bands on sides and a sixth median band from isthmus to vent. The lateral band from snout through eye ending in a black yellow edged spot on caudal base. Front border of spinous dorsal blackish, soft dorsal anal and caudal more or less pale to dusky, pectoral and ventral yellowish.(Plate.5.2.a)

Collection site: Thikkodi, Calicut

Apogon aureus (Valenciennes) 1831

Apogon auritus	Cuvier and Valenciennes 1831
Apogon auritus	Day 1878
Apogon auritus	Weber and de Beaufort 1929
Fowleria aurita	Smith 1961

Fowleria aurita Jones 1969

Papillapogon auritus Smith 1949

Size range: 23 - 52mm

D1. V11; D2. 1,9; A. 11,8; P. ii 11-12; V. 1,5. L1 11-13 L1 at. 22. 24 Ltr. 2+1+6

First dorsal spine short, 2nd exceeding half-length or 3rd. Ventral equal to slightly longer than snout and eye, pectoral a little longer than ventral. Lateral line ending below end of soft dorsal. Colour. Yellowish brown with brown spots on scales and a dark brown exellus edged white on operculum. Some specimens with one oblique brown bar across check from the eye. Vertical fins pale with brown bars or spots. Pectoral light. Ventral brownish or with brown spots. (Plate.5.2.b)

Collection site: Moodady.

5.2.3.Family Balistidae

Trigger fishes

Members of this family have acquired their common name from the characteristic locking and unlocking mechanism of the first dorsal fin. This fin is normally carried flat in a groove but it can be locked into position by a third ray and prevent fish from being eaten or withdrawn from a crevice in which it has taken refuge.

Triggerfishes are relatively poor swimmers. They achieve propulsion by undulating wave motions of the dorsal and anal fins, the caudal fin being saved for emergency accelerations when required. The pelvic and ventral fins are absent in most species or are restricted to a single spine or a knob like protuberance.

Body colouration can range from the dull to the psychedelic. The patterning around the mouth is typically exaggerated probably to deter predators. The teeth are very strong and often protrusive- ideal for eating shelled invertebrates and sea urchins.

Reproduction takes place in pits dug in the sand within the territory of the female fish. These territories are all enclosed within the dominant males greater territory. Eggs are demersal. Some species guard their eggs but others do not. Triggerfishes feeds on sea urchins, mussels, small crabs and other shelled invertebrates.

Odonus niger (Rippell) 1840

Red-mouthed triggerfish

Xenodon niger	Rippell. 1835
Balistes niger	Lacepede 1798
Balistes erythrodon	Day 1878

Size range: 121 - 182mm.

D111, D211 32-34; Aii 27-29; P.1, 13 L1at 27-28+8-9 Ltr. 18-19

Head 3.3-3.5 in SL. 47-49 in total length. Upper profile of head slightly convex, chin prominent. Eye 4.9-5.2 in head, 3.3-3.5 in snout and 1.5-1.8 in convex inter orbital space. A groove before eye. Teeth red. Second dorsal spine about ½ length of first spine, third spine equal to 1/3 of second spine. Anterior ray of 2^{nd} dorsal and anal elevated rays becoming shorter posteriorly. Scales along middle of body and caudal peduncle each with an elevated tubercle. Colour dark brown to bluish black with a black stripe from mouth towards base of pectoral. Feeds on crustaceans and small fishes. Slow swimmer not good for community aquaria. (Plate.5.2.c)

Collection site: Thikkody

Sufflamen Capistratus (Shaw) 1804

Masked triggerfish

Size range 118-152mm

D111; 29-31; A 26-28; SC 55-65; Ltr. 34 scales on peduncle and base of tail armed with a rather prominent tubercle. Head. 2.8 in SL; 3.5 in TL. Depth of body 2.0 in SL. Snout profile almost straight. A groove present before eye below nostril 2.1 in head, third spine small. Pectoral about 3.2 in head. Caudal fin truncate. 7 rows of small tubercles on caudal peduncle not extending forward than posterior 3/5 of soft dorsal fin. Colour: Head and body brown. Lips pale. Two pale cross bands on chin. Membrane of first dorsal pale basally, dark brown distally. Feeds on crustaceans, small fishes and mollusks. Slow swimmer. Not good for community aquarium. (Plate.5.2.d)

Collection site: Thikkody

Pseudobalistes flavimarginatus (Rupell) 1828

Pseudobalistes Flavimarginatus	Day 1878
Pseudobalistes Flavimarginatus	de Beaufort 1962
Pseudobalistes Flavimarginatus	Jones and Kumaran 1959
Pseudobalistes Flavimarginatus	Klausewitz 1974.

Size range: 100- 218 mm

D111; 26-27; A 22-24; SC 30-35; tr. 19-21

Four to six spines on posterior body. Head. 2.7-2.8 in SL. 3.4-3.5 in total length. Depth of body 1.65-1.80 in SL. A short groove in front of eye and a few shallow longitudinal depressions, below the eye. Front of first dorsal spine with small tubercles. Second dorsal and anal rounded, rather high anteriorly rays decreasing in length to the last.

Pectoral slightly shorter than half-length of head. Ventral spine movable and covered with tubercles and spinules. Posterior part of tail and caudal peduncle with 5 rows of small conical spines. Colour: Brownish anterior and lower parts of head pale yellowish.Feeds on crustaceans, small fishes and mollusks, aggressive, slow swimmer. (Plate.5.2.e)

Collection Site: Thikkody

Balistapus undulates (Mungo park) 1797

Balistapus undulates	Day 1878
Balistapus undulates	de Beaufort and Briggs 1962
Balistapus undulates	Smith 1949
Balistapus undulates	Munro 1955
Balistapus undulates	Jones and Kumaran 1959

Red lined triggerfish

Size range: 150 - 232mm

111; 25-27; A.22-24; SC 40-50 Ltr. 23-26.

Caudal peduncle with 6 large spines in a row. Head. 2.8-3.0 in SL Depth of body 1.9-2.1 in standard length. Profile of snout almost straight. First dorsal spine with blunt tubercles in front equal to or slightly longer than half of head. Second spine about ½ length of first. Third spine about ½ length of second. Second dorsal and anal rounded, Median rays longest. Pectoral rounded, equal to 2/5 length of head. Ventral spine covered with blunt tubercles and with some spinules at tip. Caudal slightly rounded. Colour dark brown with 12 to 15 more or less parallel undulating and oblique yellow bands with reddish tinge from eye and back to anal and caudal fins. One band above the upper tip and another below lower tip joining behind corner of mouth and proceeding to above ventral a black band often present below this band. Snout with several yellowish spots. Base of caudal spines black. Interspinous membrane of first dorsal with dark brown margin. Aggressive, feeds on crustaceans, coral polyps, small fishes etc. (Plate.5.2.f).

Collection site: Moodady.

5.2.4.Carangidae

Carangids are a large group of fast swimming fishes of moderate to large size. They usually run in large schools in the vicinity of reefs. Excellent eating and good sporting fishes. Body is compressed with slender caudal peduncle and forked tail. Scales very small and inconspicuous. Lateral line simple, arched anteriorly and armed posteriorly with large keeled scutes. Two dorsal fins. The second dorsal and anal elevated and falcate in front. Two detached spines in front of anal. Pectorals long and falcate, teeth small. Some species are excellent aquarium fishes. They grow very fast in aquarium tanks. Accept live as well as prepared foods.

Trachinotus bailloni (Lacepede) 1802

Trachinotus bailloni	Day 1878
Caesiomorus bailloni	Lacepede 1802
Trachinotus bailloni	Weber and de Beaufort 1936
Trachinotus bailloni	Smith 1949
Trachinotus bailloni	Munro 1955
Trachinotus bailloni	Balan 1958
Trachinotus bailloni	Jones and Kumaran 1959
Trachinotus bailloni	Jones 1969

Size range: 65 - 196 mm

DI-VI; D2.1, 22-24;A.11 1,22-24,P.ii 15-16;V.1, 5.GR.8+1+14-16

Head 3.6 –3.8 in standard length. Depth of body 2.1-2.4 in standard length. Eye 3.8-4.2 in head length. Maxillary reaching to below anterior border of iris. Teeth villiform in jaws, vomer and palatines. Scales small, lateral line only slightly curved anteriorly. Anterior rays of soft dorsal and anal produced, extending nearly to end of the fins in adults. Pectoral slightly shorter than head without snout. Caudal with produced lobes, the upper longer. Upper parts of the body black greyish with bluish tinge, becoming lighter on sides and silvery white below.3-5 round black spots along sides on lateral line. Fins pale yellowish, elongate lobes of dorsal, anal and caudal blackish. (Plate.5.3.a).

Collection site: Thikkody

Trachinotus blochi (Lacepede) 1802

Caesiomorus blochi	Lacepede 1802
Trachinotus ovatus	Day 1878
Trachinotus blochi	Weber and de Beaufort 1936
Trachinotus bailloni	Smith 1949
Trachinotus bailloni	Munro 1955
Trachinotus bailloni	Jones and Kumaran 1959
Trachinotus bailloni	Jones 1969

Size range: 49 - 96 mm

D1.VI; D2.I, 18-20;A.II, I, 16-18;P.ii, 16;V.I, 5.GR.5+1+10-11

Head 3.1-3.4 in standard length, 4.2-4.5 in total length. Depth of body 1.7 – 1.9 in standard length, 2.3-2.4 in total length. Eye 3.7 – 4.3 in head, 1.0-1.2 in snout and 1.3-1.4 in highly convex interorbital space. Villiform teeth in jaws, disappearing in adult. Scales small and lateral line slightly curved anteriorly. Anterior rays of soft dorsal and anal produced, much more than length of head in larger specimens. Caudal deeply forked. Colour greyish above becoming silvery white with yellowish tinge below. Fins yellowish hyaline, lobes of dorsal, anal, and outer rays of caudal dark. (Plate.5.3.b).

Collection site: Thikkody

5.2.5.Family chaetodontidae

Butterfly fishes.

This family contains butterfly fishes. The body form is oval laterally compressed. They reside in coral reefs. Their amazing colour patterns help the fish to camouflage and protect vulnerable body parts. Mouth is often protruded and pointed. There are no external differences between the sexes although at breeding time females may become noticeably swollen with eggs. Eggs are pelagic. Larvae feeds on planktons for some time and sink to the bottom. Most members of the butterfly fishes are grazing fishes that feed on algae, sponges and corals. Some are omnivores and include small planktonic animals in their diet. Most of the butterfly fishes are peaceful in nature. Except for a few species that feeds on coral polyps most of the members in this group is ideal for aquarium rearing.

Chaetodon collare (Bloch) 1787

Chaetodon Collaris	Day 1878
Chaetodon collare	Weber and de Beaufort 1936
Chaetodon collare	Munro 1955
Chaetodon collare	Jones 1969

White collar butterfly fish

Size range: 45 - 85mm

D X11, 26; A111 22; P.16; V. 1.5, 1 Lat. 32; Ltr 8+16

Pectoral shorter than head, ventral slightly shorter than pectoral. Base of spinous dorsal about equal to base of soft dorsal. Fifth dorsal spine longest. Posterior spines slightly shorter. Second anal spine stronger and slightly longer than the third. Lateral line running straight to below 9th dorsal spine and curving downwards posteriorly. Colour brownish olive, scales of body with pale centre. A dark brown band from before dorsal through eye to lower border of interopercle bordered behind with a broad white band and narrow white front border and a brown band on snout, chin whitish, dorsal brownish, distal margin of soft dorsal white edged with black, pale dark and white intra marginal bands. Anal brownish edged with white, black and pale bands. Pectoral hyaline, ventral blackish, caudal scarlet basally, a black cross band in the middle and broadly whitish distally. (Plate.5.3.c).

Collection Site: Thikkody

Chaetodon vagabundus (Linnaeus) 1758

Chaetodon pictus	Day 1878
Aniscochaetodon (Linophora) vagabundus	weber and de Beaufort 1936
Chaetodon vagabundus	Smith 1949
Linophora vagabundus	Munro 1955.
Chaetodon vagabundus	Smith and Smith 1963
Chaetodon vagabundus	Jones 1969

Vagabund Coral fish

Size range: 36 -112mm

D XIII. 25; A 111, 22; P.16; V. 1,5. L1at 31; Ltr. 6+16

Rostro-dorsal profile steeply ascending snout slightly concave, eye about 3 in head 0.9 in snout and 0.8 in inter orbital space. Gape of mouth slightly above a level of the lower border of eye. Lateral line strongly arched, ending below posterior rays of dorsal base of spinous dorsal longer than that of soft portion. Fourth or fifth dorsal spine longest about 1.8 eye diameter. Pectoral and ventral half-length or snout shorter than head. Colour yellowish with a black band edged white from front of dorsal through eye to interopercle, united with the one from the other side only on nape. Six dark lines from behind upper part of opercle obliquely upwards towards dorsal and from the lowest of the above lines. 11 dark lines directed downwards and backwards to anal and caudal peduncle. Dorsal and anal from blackish especially posteriorly with clear outer margin for soft portions of both fins. The blackish colour extending on to the posterior part of body as a broad vertical band. Caudal yellowish, pectoral yellowish ventral pale. (Plate.5.3.d).

Collection Site: Thikkody.

Chaetodon auriga (Forskal) 1775

Chaetodon auriga	Day 1878
Chaetodon auriga	Jones 1969
Anisochaetodon (Linophora) auriga	Weber and de Beaufort 1936
Linophora auriga	Munro 1955
Linophora auriga	Jones and Kumaran 1959.

Size range: 62 - 127 mm

D.XIII, 23-25; A. III, 20-21; P. 16; V. I, 5. Liat. 30-34; Ltr. 5-6+14-16.

Head 2.8-3.1 in standard length, 3.4-3.7 in total length. Depth of body 1.5-1.7 in standard length, 1.8-2.1 in total length. Eye 3.4-4.0 in head, 1.3-1.7 in snout and equal to or slightly less than convex interorbital space. Gape of mouth below lower border of eye. Pectoral about half-length of snout shorter than head; ventral slightly shorter than pectoral. Third anal spine equal to or slightly longer than 2nd spine. Dorsal spines gradually increasing in length, last spine longest, 5th and 6th dorsal rays filamentous. Lateral line strongly arched. Colour: Yellowish white, lighter to white below, upper part of head light greyish; a dark brown band from nape, broadening below eye to lower margin of opercle. Anterio-dorsal part of body with 5-6 oblique dark stripes towards dorsal and 10-11 dark stripes posterio-ventrally. Dorsal yellow basally, whitish sub marginal part and black margin and a black round or oval blotch between 5th or 6th and 11th or 12th dorsal rays. Anal yellow at base, white outer margin and a narrow sub marginal black line. Caudal pale yellowish at base, white distally and two dark sub marginal vertical stripes. Pectoral and ventral white. (Plate.5.3.e).

Collection site: Thikkody

Heniochus acuminatus (Linnaeus) 1758

Heniochus acuminatus	Weber and de Beaufort 1936
Heniochus acuminatus	Smith1949
Heniochus acuminatus	Munro 1955
Heniochus acuminatus	Jones, Bull 1969
Heniochus macrolepidotus	Day 1878

Size range: 80 - 109 mm

D. XI, 26; A. III, 19; P. ii, 16; V. I, 5. L1. 46; Ltr. 10+1+24.

Head 2.9 in standard length, 3.6 in total length. Depth of body 1.3 in standard length, 1.55 in total length. Eye 3.4 in head, 1.1 in snout and 0.8 in convex interorbital space. Preoperculum finely serrated. Lateral line strongly arched, obliquely descending posteriorly and ending at base of caudal. Fourth dorsal spine and attached membrane greatly prolonged. Soft dorsal rounded posteriorly. Anal angulate. Pectoral about equal to length of head, ventral slightly longer than pectoral. Colour: Pearly white, upper surface of snout dark, a black band over eyes and a wide black band from first three dorsal spines touching operculum and base of pectoral and extending on to the ventrals, belly and lower part of anal fin. A broad black band from 5^{th} to 8^{th} dorsal spines obliquely downward and extending on the posterior half of anal. Pectoral, soft dorsal and anterior half of anal yellowish; ventral black. (Plate.5.3.f).

Collection site: Moodady

5.2.6.Family: Diodontidae

Porcupine fishes

Porcupine fishes are very similar to the other inflatable fishes, the puffers. They can be distinguished from puffer fishes by the spines in their scales and their front teeth, which are fused together. Hard crustaceans like crabs and lobster present little problems to them. The pelvic fins are absent. Normally the spines are held flat but in times of danger they stand out from the body as the fishes inflate itself. Their appearance and inflatability makes them interesting subjects for the aquarium.

Diodon hystrix (Linnaeus) 1758

Diodon hystrix	Day 1878
Diodon hystrix	Smith 1949
Diodon hystrix	Munro 1955
Diodon hystrix	de Beaufort and Briggs 1962

Diodon hystrix	Smith and Smith 1963
Diodon hystrix	Jones1969

Size range: 220 - 345 mm

D. ii, 13; A. ii, 13; P. i, 22.

Head 2.8-3.0 in standard length, 3.3-3.6 in total length. Eye 4.5-5.0 in head, 1.3-1.6 in snout and 3.3-3.8 in slightly concave interorbital space. Nostril a compressed tube with openings on both sides. Spines two rooted except some on posterior part of back and sides. Most spines movable. 3 or 4 spines above eye, 16 or 17 series of spines from snout to dorsal origin. Spines on forehead equal to or slightly longer than eye, those behind pectoral longer, 1.5-1.8 eye diameter. Pectoral as long as half-length of head. Longest dorsal rays 1.7-2.1 of eye diameter, longest anal rays as long as those of dorsal. Colour: Brownish above, white below; back and sides covered with small black spots; corner of mouth dark, a dark bar below eye and another in front of gill opening; brownish band from lower edge of gill opening to throat joining a similar band from the other side. Fins pale with black spots. (Plate.5.4.a).

5.2.7.Family: Holocentridae

Squirrelfish's

Squirrel fishes are large eyed nocturnal fishes that hide by day among crevices in the reefs. They usually have red patterning on their elongate bodies, spines on the gill covers and sharp rays on the fins. The dorsal fin looks as if it has two separate parts; a long based spiny part at the front and a high triangular softer rayed section at the back.

Normally feeds on small fishes, polychaete worms and invertebrates. In the aquarium condition they accept any prepared feed.

Holocentrus diadema (Lacepede) 1803

Holocentrus diadema	Lacepede 1802
Holocentrus diadema	Day 1878
Holocentrus diadema	Weber and de Beufort1929.
Holocentrus diadema	Smith1949
Holocentrus diadema	Munro 1955
Holocentrus diadema	Jones 1969

Size range: 45 to 135mm

D.XI, 13 (14); A.IV, 8-9;P.ii, 12; V.1, 7.L1.46-48; Ltr.3+1+7

Head 2.8 – 3.2 in standard length, 3.5-4.0 in total length. Depth of body 2.9-3.1 in standard length.3.5-3.7 in total length. Eye about 2.7-2.9 in head, 0.6 to 0.7 in snout and about 0.7 in inter orbital space. Preorbital and sub orbital strongly serrated, a spine anteriorly on pre orbital. Preopercular spine slightly shorter than snout and extending beyond opercular flap.opercular bones strongly serrated.

Colour reddish brown with pale yellow longitudinal bands bordered by brown pigments along scale rows. Axil of pectoral often brownish.spinous dorsal blackish with a median curved white band sometimes broken about the middle of the fin and often the upper margin of the membrane pale white. Anal pale yellowish, membrane between third and fourth anal spine blackish or dusky. Other fins pale yellow. (Plate.5.4.b).

Collection site: Thikkody

Holocentrus ruber (Forskal) 1775

Holocentrus praslin	Jordan & Seale 1908

Red squirrelfish

Size range: 65 - 145 mm

DXI/14-15; A IV/8-10;LI 33-36;tr 3/6-7.

Preopercular spine reaching gill opening. Two opercular spines, upper longest. Third anal spine longest. Colour: Pale brownish with reddish tinge above becoming lighter below, with small-scattered dark spots on head and body. Basal two third of spinous dorsal reddish, outer portion pale; other fins pale in another colour variety. The general ground colour pale brownish with reddish tinge above becoming lighter below, but the dark spots on head and body less numerous than in the other variety and the sides of the body with pale yellowish longitudinal bands along scale rows. (Plate.5.4.c).

Collection site: Thikkody.

Myripristus murdjan (Forskal) 1775

Myripristus murdjan	Day 1878
Myripristus murdjan	Weber and de Beaufort 1929
Myripristus murdjan	Smith 1949
Myripristus murdjan	Munro 1955
Myripristus murdjan	Jones and Kumaran 1959
Myripristus murdjan	Jones 1969

Size range: 54 - 112 mm

D XI/12-14;A IV/13-14;tr 3/7.

Head 2.5 to 2.9 in standard length, 3.4 –4 in total length. Maxillary reaching to below hind border of pupil. Orbital and opercular bones serrated. Pectoral shorter than head without snout. Two rows of teeth in upper row, outer enlarged, teeth in two rows anteriorly in lower jaw and in a single row behind. Ventral shorter than pectoral. Third anal spine stronger and equal to fourth. Colour; Reddish brown, Scales above lateral line often with light centers. Spinous dorsal pale. Posterior border of operculum above the level of pectoral blackish. Axil of pectoral black. Soft dorsal and anal pale, anterior rays dusky to blackish. Sub marginal rays of caudal lobes dusky, rest of the fin pale. (Plate.5.4.d).

Collection site: Thikkody

Myripristus adustus (Bleeker) 1853

Myripristus adustus	Smith 1949
Myripristus adustus	Jones 1959

Size range: 41 - 96mm

D X-XI/13-14; A IV/13-14;Li 27-29;tr 3/6.

Head 2.7 in standard length, 3.5 in total length. Depth of body 2.3 in standard length, 2.9 in total length. Maxillary reaching past hind border of pupil. Teeth in jaws, biserial. Orbital and opercular bones serrated. Pectoral equal to ventral, shorter than head without snout. Third anal spine stronger, but slightly shorter than fourth spine. Colour: Reddish brown, lighter below. Upper part of the head brownish. Scales above lateral line with brownish margin. Opercular margin above and below the opercular spine dark brown. Pectoral axil dark brown. Spinous dorsal dusky with the distal parts black. Soft dorsal and the anal dusky anteriorly, lighter posteriorly but the tips of anterior rays black. Ventral pale. (Plate.5.4.e).

Collection site: Thikkody

5.2.8.Family: Labridae

Wrasses and Rainbow fishes

The labridae is a very large family encompassing about 400 species. The body shape varies from species to species. Some wrasses are cylindrical while others are much deeper bodied. Like many other fishes wrasses swim without making much use of the caudal fins. The main propulsion comes from the pectoral fins. Sex reversal is quite common in wrasses, the necessary change occurring in single sexed groups as required. Reproductive activity can occur between pairs or collectively in a group. Eggs are pelagic. Food and feeding habits vary from species to species but most relish molluscs and crustaceans.

Thalassoma lunare (Linnaeus) 1758

Labrus lunaris	Linnaeus 1758
Julis lunaris	Day 1878
Thalassoma lunare	de - Beaufort 1940
Thalassoma lunare	Smith 1949
Thalassoma lunare	Munro 1955
Thalassoma lunare	Balan 1958
Thalassoma lunare	Jones 1969

Size range: 68 - 116 mm

D. VIII, 13(14); A. III, 11; P. ii, 13; V. I, 5. Ll. 27-29; Ltr. 3+1+10.

Head 3.3-3.6 in standard length, 4.5-4.9 in total length. Depth of body 3.3-3.7 in standard length, 4.6-5.1 in total length. Eye about 2 in snout and 1.3-1.5 in convex interorbital space. Teeth in a single series in both jaws with a pair of anterior canines in each. Bases of dorsal and anal fins with scaly sheath. Lateral line continuous. Pectoral slightly more than head, without snout. Ventral with the first ray slightly prolonged, equal to postorbital part of head. Colour: Dark green, chin lighter. Operculum sometimes with 3-4 light bands, two oblique bands on lower part of head continued on body, the upper one reaching below pectoral and the lower to above origin of anal. Narrow brown vertical stripes on scales. Dorsal white with a median longitudinal dark brown band. Anal white with a dark brown band. Base of caudal and outer rays of the same dark brown. A longitudinal dark brown blotch on upper half of pectoral. (Plate.5.4.f).

Collection site: Thikkody

Labroides dimidiatus (Valenciennes) 1839

Cossyphus dimidiatus	Cuvier and Valenciennes 1839
Fissilabrus dimidiatus	Smith1949
Labroides dimidiatus	Jones and Kumaran1959
Labroids dimidiatus	Jones 1962
Labroids dimidiatus	Day1878
Labroids dimidiatus	de Beaufort 1940
Labroids dimidiatus	Jones1969

Size range: 24 - 68 mm.

D. IX, 10-11; A. III, 10; P. ii, 11; V. I, 5. Ll. 50-54; Ltr. 4+1+12-13

Head 3.1-3.5 in standard length, 3.8-4.2 in total length. Depth of body 4.2-4.6 in standard length, 5.2-5.5 in total length. Snout 3.4-3.5 in head. Eye 1.5-1.6 in snout and about 1.3 in convex interorbital space. Upper lip slightly fleshy and the lower lip separated into two lobes by a median frenulum. Teeth in a single row in jaws of which two in front are canines and 2 or 3 irregular rows near symphysis. A canine at corner of mouth. Lateral line continuous. Colour; Bluish brown on back and pinkish or white below. A bluish black band from snout through eye to the end of caudal, broader on the posterior part of body, curving down at end of caudal fin and continued forward along lower part of caudal peduncle. A bluish black streak from lower edge of base of pectoral towards ventral. Basal part of dorsal bluish black, distal part whitish. Anal pale to white with a dark brown basal part. Pectoral and ventral yellowish. (Plate.5.5.a).

Collection site: Thikkody

5.2.9.Family: Muraenidae

Moray eels

The tropical eels are often splendidly marked and all grow very long. Many are nocturnal and are hardly seen during the daytime, since they hide in the crevices. They detect their food by smell and are usually quite undemanding in captivity. Sexual maturity is attained in many species only when the fish grows to more than 100 cms in length. Predatory in nature

Gymnothorax flavimarginatus (Riippell) 1878

Muraena flavimarginata	Riippell 1878
Muraena flavimarginata	de Beaufort 1916
Lycodontis lemayi	Smith 1949
Lycodontis flavimarginatus	Smith 1962
Gymnothorax flavimarginatus	Jones 1969

Size range: 316-945 mm

Head 8.0 – 9.2,depth of body 14.8 –17.5,both in total length. Tail equal to or about ½ length of head. Longer head and trunk. Head 2.9 – 3.4 in trunk. Eye 8.3 – 10.4 in head, 1.4-

1.7 in snout and 1.1 – 1.4 in interorbital space. Anterior nostrils tubular, on each side of tip of snout, posterior nostrils above anterior ridge of eye, with slightly raised rims. Teeth in single series in jaws, those near the symphysis longer than others; maxillary with an inner row of 2-3 teeth; premaxillary with a median series of 2-3 fang like teeth; vomer with 2 irregular series of small teeth. Dorsal origin nearer to gill opening than to corner of mouth. Colour highly variable, generally brown to blackish, densely mottled with light brown to whitish spots. Colouration some times consisting of very small indistinct dark brown spots which may fuse to form larger irregular patches. (Plate.5.5.b).

Collection Site: Thikkody.

5.2.10.Family: Ostraciodontidae

Boxfishes and Trunkfishes

These fishes have a rigid body made up of bony plates covered with a sensitive skin that may be damaged by cleaner fishes. The only flexible part is the caudal peduncle, where the most obvious growth occurs rearwards. The pelvic fins are missing, although bony stumps may appear at the corners of the body box in some species. They are slow moving. Some have been designated as hovercraft fishes by some authors as they have a similar form of locomotion. Most are poisonous releasing poison into the water when threatened. Feeds on crustaceans, invertebrates, and tubifex worms.

Lactoria cornuta (Linnaeus) 1758

Ostracion cornutus	Linnaeus 1758
Ostracion cornutus	Day 1758
Ostracion cornutus	de Beaufort 1916
Lactoria cornutus	Smith 1949

Lactoria cornuta Munro 1955

Lactoria cornuta Jones 1969

Size range: 46 – 77 mm

D.i, 8;A.i, 8;P.11

Carapace four ridged and generally a feeble spine on middle of back. Head 2.9-3.1 in standard length, 3.7-3.9 in total length. Eye 2.5-2.6 in head, 1.4-1.5 in snout and less than 2.0 in concave interorbital space. Profile of snout almost vertical. Gill opening a little more than half eye diameter. Lateral and pelvic ridges rounded. Long and slender sub orbital spine directed forward and upward. Pelvic ridge terminating posteriorly in a backwardly directed spine. Colour brownish to greenish brown with some round bluish spots on bony plates. Fins light yellowish, caudal some times with bluish spots. (Plate.5.5.c).

Collection Site: Thikkody.

Ostracion tuberculatum (Linnaeus) 1758

Ostracion tuberculatus Linnaeus 1758

Ostracion cubicus Day 1878

Ostracion tuberculata Munro 1955

Size range: 176 –215 mm

D. I, 8 (9); A.i, 8; P.i, 9.

Head 3.7-4.1 in standard length, 4.8-5.1 in total length. Dorsal profile of snout some what concave with a hump above mouth. Body four ridged, pelvic ridges more prominent than the lateral ones. Anterior opening of carapace equal to or less than diameter of eye. Longest pectoral rays about 1.3 in head. Colour: Brownish to yellowish with numerous black spots on head, bony plates of body with one or two or exceptionally three black spots. Caudal peduncle with a black spot. Fins yellowish. (Plate.5.5.d).

Size range: 77 – 205 mm.

Collection site: Thikkody

5.2.11.Family: Platacidae

Batfishes

The oval bodied high finned batfish is unmistakable. The body is round with large rounded fins. There are one or two dark stripes on the head and form part of the body, but these fade with age. Young specimens have more elongated fins and redder colouration. It is found in coastal and brackish waters and in mangrove swamps. It often lies on its side to avoid capture or detection. There are three species in this family *Platax pinnatus*, *Platax tiera* and *Platax orbicularis*. Juveniles are deeply coloured where as adult fishes have less colouration than juveniles. Feeds on small crustaceans, worms, small fishes etc.

Platax orbicularis (Forskal) 1775

Chaetodon orbicularis	Forskal 1775
Platax orbicularis	Weber and de Beaufort1936
Platax orbicularis	Munro1969
Platax vespertilio	Day1878.

Size range: 75 - 145 mm

D. V, 35-38; A. III, 26-28; P. ii, 15-16; V. I, 5. L1. 54-59; Ltr. 20-22+ 39-43. GR. 8+1+9-10.

Highly compressed, rhomboidal, anterior profile angular. Head 3.0-3.2 in standard length, 3.8-4.1 in total length. Depth of body 0.9-1.0 in standard length, 1.15-1.25 in total length. Eye 2.8-3.1 in head, 0.8-0.9 in snout and 1.2-1.3 in interorbital space. Teeth long and slender with 3 cusps, the median one longest. Height of longest rays of soft dorsal much less than standard length, height of longest soft rays of anal shorter than that of soft dorsal. Pectoral ½ length of snout, shorter than head. Outer ray of ventral produced, shorter than ½ total length. Colour: Greyish brown with broad dark cross bands, the first through eye often bordered with narrow black broken lines, the second through base of pectoral and a more diffuse and very obscure band from soft dorsal to anal. Dorsal and anal greyish brown, posterior rays distally edged with white in small specimens. Caudal dusky basally, rest of the fin pale yellowish. Pectoral pale yellowish. Ventral blackish. (Plate.5.5.e).

Collection Site: Thikkody

Platax teira (Forskal) 1775

Chaetodon teira	Forskal 1775
Platax teira	Day 1878
Platax teira	Weber and de Beaufort 1936
Platax teira	Munro 1955
Platax teira	Jones and Kumaran1959
Platax teira	Jones1969

Size range: 65 - 120 mm

D. V, 33; A. III, 24; P. ii, 15; V, I, 5. L1. 63; Ltr. 26-51. GR. 8+1+10.

Highly compressed, rhomboidal, the anterior profile evenly convex. Depth of body equal to standard length, about 1.3 in total length. Head 3 in standard length, 4 in total length. Eye 2.8 in head, 0.7 in snout and about 1.3 in interorbital space. Teeth long, slender with 3 cusps of about equal length. Soft dorsal and anal produced and falcate in young, the former longer than total length and the latter slightly shorter than total length. Pectoral equal to length of head without snout. First ray of ventral produced, about equal to standard length. Colour: Light greyish brown with three broad dark cross bands, the first through eye to before ventral fin, the second from spinous dorsal through base of pectoral to behind vent and the third indistinct from soft dorsal to anal. Dorsal and anal dark greyish; caudal pale; pectoral pale yellowish; ventral blackish. (Plate.5.5.f).

Collection site: Thikkody.

5.2.12.Family Pomacanthidae

Angel fishes

Angel fishes and butterfly fishes were earlier classified under chaetodontidae. Angelfishes are also oval in shape, body laterally compressed mouth is terminal; reside in coral heads, where their thin sectioned bodies can pass easily between the branches. Their amazing colour pattern camouflage and protect their body parts from predators. Juvenile Angelfishes have a different colouration pattern to the adults. There appear to be no external difference between the sexes although at breeding time females may become noticeably swollen with eggs. Eggs are pelagic. The larvae feed on planktons for some time then sink to the bottom and settle among the coral heads. Most of the angelfishes are grazing fishes that feed on algae, sponges and corals. Some are omnivores and include planktonic animals in their diet.

Pomacanthus annularis (Bloch) 1787

Pomacanthodes annularis (Bloch) 1787

Blue ringed Angelfish

D XIII/20-21; A III/20;L I 70

Size range: 180 – 250 mm

Anal spines: 3;anal soft rays: 20.Juveniles black with alternating white and blue curved well-spaced stripes on the sides. Adults golden brown or orange with well-spaced curved horizontal stripes radiating from the pectoral-fin base area, running along the sides towards the posterior portion of the dorsal fin. Two similar blue stripes run horizontally across the face, one running through the eye, from above the snout to the edge of the operculum. A blue ring is behind and slightly above the edge of the operculum. Caudal fin is white with bright yellow margin.

Inhabits coastal reefs to at least 30 m. Adults often found in pairs. Juveniles settle in very shallow inshore habitats with short filamentous algae growth on rock or dead coral substrates. Feeds on sponges and tunicates. Undergoes a complete color transformation from the juvenile to adult stage. (Plate.5.6.a).

Collection Site: Thikkody

5.2.13. Family Pomacentridae

Damselfishes

Pomacentridae constitute one of the largest groups of reef fishes, which include more than 300 species. They are generally small in size, rarely exceeding a length of 10 to 15cm. There is a wide range of colouration from black, brown and grey to bright shades of orange, yellow red and blue. They are characterized by ovate to elongate and laterally compressed body shape, a single dorsal fin composed of 8 to 15 spines and a number of flexible segmented rays and an anal fin containing two spines and a variable number of segmented rays. The head body and fin bases are covered with medium sized scales that usually have macroscopic serrations along the exposed margins. The jaw teeth are arranged in one or two rows and range from a conical shape to a flattened columnar or spatulate form.

Small crustaceans, plankton and algae are the main diet. In the aquarium these fishes take live foods, algae, fish meat, mussel meat, prawn meat and flakes.

Abudefduf bengalensis (Bloch) 1787

Chaetodon bengalensis	Bloch 1787
Abudefduf bengalensis	de Beaufort1940
Abudefduf bengalensis	Smith 1960
Abudefduf bengalensis	Jones 1969
Glyphidodon bengalensis	Day 1878.

Size range: 62 - 111 mm

D. XIII, 13-14; A. II, 13-14; P. ii, 16; V. I, 5. L1. 20-21+8; Ltr. 3 ½ +1+11-12.

Head 2.9-3.2 in standard length, 3.9-4.2 in total length. Depth of body 1.6-1.8 in standard length. 2.2-2.4 in total length. Eye 3.3-3.7 in head, equal to or slightly more than snout and 1.0-1.3 in interorbital space. Teeth truncate, in a single series in jaws. Preorbital naked, sub orbital with a few scales. Scales on upper part of head reaching almost to nostrils. 3 ½ rows of scales on preopercle, a narrow inferior and posterior limb naked. Pectoral as long as head, ventral equal to or slightly longer than pectoral. Colour: Greenish brown above, paler below. Sides with 7 vertical dark brown bands, narrower than the pale interspaces. Vertical fins dusky to brownish. Ventral dusky basally, pale posteriorly. Pectoral light yellowish with a black spot at origin of fin. (Plate.5.6.b).

Collection site: Thikkody

Abudefduf sexfasciatus (Lacepede) 1802

Labrus sexfasciatus	Lacepede1802
Glyphidodon coelestinus	Day1878.

Abudufduf coelestinus	de Beaufort 1940
Abudefduf sexfasciatus	Jones1969

Size range: 25 - 120 mm

D. XIII, 13; A. II, 12-13; P. ii, 16-17; V. I, 5. Ll. 19-20+7-9; Ltr. 3 ½ +1+11.

Head 3.0-3.2 in standard length, 4.2-4.4 in total length. Depth of body 1.8-2.0 in standard length. Eye 3.4-3.6 in head, 0.8-0.9 in snout and 1.1-1.3 in interorbital space. Teeth uniserial in jaws, truncate. Preorbital and sub orbital scaly. 3 ½ rows of scales on preopercle, the inferior and posterior limbs scaly. Scales on head reaching beyond nostrils. None of the opercles serrated. Pectoral slightly longer than head. Ventral shorter than pectoral and equal to head. Colour: Bluish green on back, becoming pale yellowish below. Sides of body with five dark brown transverse bands narrower than interspaces, tapering and fading ventrally. The second, third and fourth bands continued on to the base of dorsal. A black spot superiorly on base of pectoral. Dorsal blackish. Anal pale yellowish, median part dusky. Caudal pale, lobes with a dusky longitudinal band. Pectoral yellowish. Ventral pale, outer rays dusky. (Plate.5.6.c).

Collection site: Moodady.

Abudefduf saxatilis (Linnaeus) **1758**

Chaetodon saxatilis	Linnaeus1758
Abudefduf saxatilis vaigiensis	de Beaufort1940
Abudefduf saxatilis	Smith1949
Abudefduf saxatilis	Munro 1955
Abudefduf saxatilis	Jones and Kumaran1959
Abudefduf saxatilis	Jones1969

Size range: 48 - 125 mm

D. XIII, 12-13; A. II, 12-13; P. ii, 16-17; V. I, 5. L1. 20-21+7-9; Ltr. 3 ½ +1+11.

Head 3.0-3.3 in standard length, 4.1-4.4 in total length. Depth of body 1.8-2.0 in standard length, 2.4-2.6 in total length. Eye 3.2-3.6 in head, 0.8 in snout and 1.1-1.3 in interorbital space. Teeth somewhat truncate, uniserial in jaws. Preorbital naked, sub orbital scaly. 3 ½ rows of scales on preopercle, posterior flange naked. Scales on upper part of head reaching to nostrils. Pectoral slightly longer than head. Ventral as long as pectoral. Colour dusky yellow to brownish above, pale below with five dark brown transverse bands. Ventral fins light or dark brown, lighter distally. Pectoral yellowish with a black spot at its base. Ventrals dusky to greyish. (Plate.5.6.d).

Collection Site: Thikkody

Abudefduf sordidus (Forskal) 1775

Chaetodon sordidus	Forskal 1775
Glyphidodon sordidus	Day 1878.
Abudefduf sordidus	de Beaufort, Fishes 1949
Abudefduf sordidus	Jones and Kumaran1959
Abudefduf sordidus	Jones 1969

Size range: 69 - 71 mm.

D. XIII, 15; A. II, 14-15; P. ii, 15-16; V. I, 5. L1. 20-21+8-9; Ltr. 4+1+12.

Head 2.7-2.9 in standard length, 3.7-4.0 in total length. Depth of body 1.7-1.9 in standard length, 2.3-2.5 in total length. Eye 3.3-3.7 in head, 1.1-1.4 in snout and 1.0-1.3 in interorbital space. Teeth in a single series in jaws, truncate. Posterior part of sub orbital scaled. Three rows of scales on pre operculum flange naked. Ventral with the first ray produced, equal to head. Pectoral as long as ventral. None of the opercular bones serrated. Colour: Brownish, lighter below with 4-5 pale yellow cross bars below dorsal. A black saddle on caudal peduncle just behind dorsal. Pectoral hyaline with a black blotch superiorly at its base. Ventral dusky. Dorsal and anal brownish. Caudal brownish, pale posteriorly. (Plate.5.6.e).

Collection site: Thikkody

Abudefduf septemfasciatus (Cuvier) 1830

Glyphisodon septemfasciatus	Cuvier and Valenciennes1830
Glyphidon septemfasciatus	Day 1878.
Abudefduf septemfasciatus	de Beaufort 1940
Abudefduf septemfasciatus	Munro 1955
Abudefduf septemfasciatus	Balan1958.
Abudefduf septemfasciatus	Smith 1960
Abudefduf septemfasciatus	Jones 1969

Size range: 63 - 136 mm

D. XIII, 13; A. II, 12-13; P. ii, 16; V. I, 5. Ll. 20-21+7-9; Ltr. 3 ½ +1+11-12.

Head 2.9-3.2 in standard length, 3.9-4.2 in total length. Depth of body 1.8-1.9 in standard length, 2.3-2.4 in standard length. Eye 3.4-3.8 in head, 1.2-1.4 in snout and 1.3-1.5 in interorbital space. Teeth uniserial in jaws, truncate. Sub orbital scaly. Scales not reaching nostrils. Three rows of scales on preopercle, inferior and posterior limbs naked. None of the opercles serrated. Scales on head not reaching nostrils. Pectoral equal to head. Ventral as long as pectoral. Colour: Yellowish brown with seven dark transverse bands. Spinous dorsal pale brown with dark brown edges. Soft dorsal, anal and caudal pale brownish. Pectoral yellowish with a basal triangular black spot. Ventrals greyish. (Plate.5.6.f).

Collection Site: Thikkody

Neopomacentrus cyanamos (Bleeker) 1856

Pomacentrus cyanamos Bleeker 1856

Pomacentrus leucosphyrus Fowler 1904

Pomacentrus prateri Fowler 1928

Size range: 65 – 100 mm

D XIII/11;AII/11;Sc 26;tr 3/10

Body dark brown. Posterior part of dorsal fin and middle area of caudal fin distinctly dark. Blue spots on body. A dark blue blotch behind the opercle at the origin of lateral line and other at the upper part of pectoral fin base. Sub orbital margin hidden by scales. Body depth 2.2 – 2.3 (SL), head length 3.5 – 3.6 (SL) dorsal fin base 1.6(SL). Eye diameter 2.8 – 3.2 (HL), inter orbital width 2.8 – 3.2 (HL). Snout length 5.3 – 7.0 (HL), anal fin base 1.1 – 1.2 (HL) and caudal peduncle depth 1.8 (HL). (Plate.5.7.a).

Collection site: Thikkody

Neopomacentrus filamentosus (Macleay) 1882

Gliphidodon filamentosus Macleay 1882

Size range: 44 – 95 mm

Brown to brownish black in colour. Posterior part of soft dorsal and middle part of caudal fin light grey. Other caudal fin rays black. Dark blotch present at the origin of lateral line and pectoral fins. Sub orbital margin hidden by scales. Body depth 2.2 – 2.3 (SL), head length 3.1 – 3.2 (SL), dorsal fin base 1.5 – 1.7 (SL). Eye diameter 3.3 – 3.8 (HL), Inter orbital width 2.4 – 2.6 (HL). Snout length 3.8 – 4.3(HL), anal fin base 1.1 – 1.2 (HL) and caudal peduncle depth 1.6 – 1.7 (HL). (Plate.5.7.b).

Collection site: Thikkody, Dharmadom.

5.2.14.Family: Scorpaenidae

Lion fishes, Scorpion fishes

These fishes are predators that glide up to their prey and engulf it with their large mouth. The highly ornamental fins have poison gland under the spines. The red- brown body has many white edged vertical bars. The dorsal fin is multirayed and tissue spuns the elongated rays. When spread the fins have more obvious transverse patterning. The male have a longer pectoral fins and a larger head than the female. At breeding time the male darkens in colour, females become paler and have longer abdomens. Grows up to 25 cm in wild. Generally live foods such as shrimps and small fishes are preferred. In aquarium condition frozen foods are also accepted.

Pterois volitans (Linnaeus) 1758

Gasterosteus volitans	Linnaeus 1758
Pterois volitans	Day1878.
Pterois miles	Smith 1949
Pterois volitans	Munro 1955
Pterois volitans	de Beaufort and Briggs 1962
Pterois volitans	Jones 1969

Size range: 65 - 255mm

D. XIII, 10-11; A. III, 6-7; P. 14; V. I, 5. Liat. 85-102; Ltr. 10-13 +1+21+24.

Head 2.6-2.8 in standard length, 3.5-3.9 in total length. Depth of body 2.7-3.0 in standard length, 3.7-4.1 in total length. Eye 4.0-4.8 in head, 1.5-1.8 in snout and equal to or slightly more than highly concave interorbital space. Maxillary reaching to nearly below anterior third of eye. Villiform teeth in jaws and on vomer. Interorbital space and nape without scales. Spination on head highly variable; generally consisting of one spine near anterior nostril, supra orbital ridge with 2 spines, superior postorbital ridge, sub orbital with several irregular small spines, 3 blunt spines on preopercle edge and a flat opercular spine. Filaments on front of snout, on pre orbital, on snout and preopercle margin and a long supraorbital tentacle. Length of pectoral varying with age and reaching to caudal base or beyond. All rays of pectoral simple. Ventral longer than head. Colour reddish with numerous dark brown cross bars and narrower pale interspaces. Dorsal, anal and caudal with black spots. Pectoral brownish with a few blackish spots. Ventral dark brown with small pearly spots and blackish markings. (Plate.5.7.c).

Collection Site: Moodady

Pterois antennata (Bloch) 1787

Scorpaena antennata	Bloch 1787
Pterois antennata	Smith1949
Pterois antennata	de Beaufort and Briggs 1962
Pterois antennata	Smith and Smith1963.
Pterois antennata	Jones1969

Size range: 60- 205 mm

D. XIII, 11; A, III, 7; P. 19; V. I, 5. Liat. 52; Ltr. 7+1+17.

Head 2.6 in standard length, 3.4 in total length. Depth of body 2.7 in standard length, 3.5 in total length. Profile of snout deeply notched. Head 3.2 in head, 0.8 in snout and about 0.6 in interorbital space. Maxillary reaching almost to below middle of eye. Villiform teeth in jaws and on vomer. One spine behind anterior nostril, supraorbital ridge with 2 spines, superior postorbital ridge with 3 spines, inferior postorbital ridge with 4 small spines and 2 larger spines, sub orbital ridge with 5 spines, and 3 blunt preopercular spines. Seventh dorsal spine longest, slightly shorter than head; last two dorsal spines sub equal, a little more than one eye diameter. Supraorbital tentacle with black lateral flaps, about 1 ¾ eye diameter in length. Anterior nostril with a flap and flaps at tip of snout, sub orbital and lower edge of preoperculum. Longest rays of pectoral reaching beyond base of caudal. Ventral about half-length of snout shorter than head. Predorsal scales reaching to hind border of eye; interorbital. Snout, chin and margin of preopercle naked, rest of the head with small scales. Colour: Reddish brown with broad dark transverse bands on head and body; the dark band from eye to angle of preopercle more prominent. Orbital tentacle alternating with white and black. Dorsal, anal and caudal yellowish with small black spots on rays. Pectoral bluish brown with large dark blotches. Ventral dark bluish brown. (Plate.5.7.d).

Collection Site: Moodady

Pterois radiata (Cuvier) 1829

Pterois radiata	Cuvier 1829
Pterois radiata	de Beaufort and Briggs 1962
Pterois radiata	Jones 1969
Pterois cincta	Day 1878
Pteropterus radiata	Smith 1957.

Size range: 70-190 mm

D.XIII, 11; A. III, 6; P. 16; V. I, 5. Liat. 50-53; Ltr. 7-8+1+11-14.

Head equal to depth of body, 2.5-2.7 in standard length, 3.3-3.5 in total length. Eye 3.6-3.7 in head, equal to snout and 0.8 in concave interorbital space. Maxillary reaching to below middle of eye. Villiform teeth in jaws and on vomer. Spination consisting of one behind anterior nostril, supraorbital ridge with three spines, interorbital ridges ending posteriorly in postfrontal spines, superior postorbital ridge with 3spines, inferior postorbital ridge with 5 or 6 spines, sub orbital ridge with several small spines, preoperculum with 3 spines and a large flat opercular spine. Tentacles on preopercle, lower margin of preorbital and smaller ones on snout; anterior nostril with a small flap and a fleshy tentacle above eye. Pectoral reaching to end of caudal. Ventral equal to head. Colour: Reddish brown with 8 narrow white transverse lines, two below posterior dorsal spines being bifurcated above and below and two longitudinal white lines on caudal peduncle being joined anteriorly to the last transverse line. A deep brown band through eye to angle of preopercle. Dorsal and anal whitish, base a little darker. Caudal white, rays spotted. Basal part of pectoral brownish with two whitish lines, rays white. Ventral brownish with one white line. (Plate.5.7.e).

Collection Site: Puthiyappa

5.2.15.Family: Serranidae

Sea bass and groupers

Most of the species within the group are hermaphrodite and therefore lack any clear sexual dimorphism. Many species undergo colour changes during breeding turning darker paler or taking on a bicolour pattern. Females become distended with eggs during breeding season. Most of the species are predators that feed on small fishes, crustaceans and polychaete worms. In aquariums they are peaceful when kept in pairs but often attacks other small fishes.

Grammistes Sexlinneatus (Thunberg) 1792

Perca sexlineata	Thunberg 1792
Grammistes orientalis	Day 1878
Grammistes sexlineatus	Weber and de Beaufort 1931
Grammistes sexlineatus	Smith 1949
Grammistes sexlineatus	Munro 1955
Grammistes sexlineatus	Jones 1969

Size range: 40 - 83 mm

D VII, 14; A.II, 9; P. I, 16; V. I, 5. Liat. 65-74; Ltr. 11-14+1+34+40.

Head 2.5-2.7 in standard length, 3.3-3.4 in total length. Depth of body 2.4-2.6 in standard length, 3.1-3.3 in total length. Eye 4.4-4.6 in head, 0.8 in snout and 0.7 in somewhat convex inter-orbital space. Maxillary reaching to somewhat behind hind border of eye. Chin with a rudimentary dermal appendage. Preoperculum with 3 distinct spines on hind edge. Four or five rows of small teeth in jaws and a patch of teeth on vomer and two rows on palatines. Pectoral equal to postorbital length of head. Ventral 1/3 eye diameter shorter than pectoral. Colour: Dark brown with five or six yellowish longitudinal bands, which become narrow and may increase in number up to 9 with age. In young specimens only 3 longitudinal bands are present. Spinous dorsal brownish. Other fins yellowish, slightly brownish at base. (Plate.5.7.f).

Collection Site: Moodady.

Cephalopholis boenack (Bloch) 1790

Bodianus boenack	Bloch 1790.
Cephalopholis boenack	Munro 1955
Cephalopholis boenack	Jones 1969
Epinephelus boenack	Weber and de Beaufort 1931
Serranus boenack	Day 1878.

Size range: 120 - 190 mm,

D.IX, 16; A. III, 8-9; P. i, 16; V. I, 5. Liat. 94-106; Ltr. 12-15+1+30-34.

Head 2.5-2.6 in standard length, 3.1-3.2 in total length. Depth of body 2.7-2.9 in standard length. Maxilla reaching to a vertical from the hind border of eye. Outer row of teeth in the upper and inner row of teeth in the lower jaw larger than others; a pair of moderate canines in each jaw near symphysis. Fourth or fifth dorsal spine longest, 1 ¾ eye diameter in length. Second anal spine longer than 3rd, about equal to longest dorsal spine. Pectoral equal to postorbital part of head plus ½ eye diameter. Colour: Yellowish brown, somewhat paler below. Cheek with bluish black spots. Undulating bluish black lines on head and sides of body sometimes continued on the vertical fins. Membranes of spinous dorsal tipped black. Pectoral and caudal dark brownish. (Plate.5.8.a).

Collection Site: Thikkody

Cephalopholis argus (Bloch and Schneider) 1801

Cephalopholis argus	Munro 1955
Cephalopholis argus	Jones and Kumaran 1959
Cephalopholis argus	Smith and Smith 1963
Epinephelus argus	Weber and de Beaufort 1931

Serranus guttatus Day 1878.

Size range: 56 – 150 mm

D. IX, 15-16; A. III, 8-9; P. i, 16-17; V. I, 5. Liat. 95-108; Ltr. 13-15+1+34-38.

Head 2.4-2.6 in standard length, 3.0-3.2 in total length. Depth of body 2.8-3.1 in standard length, 3.6-3.8 in total length. Eye 5.7-6.5 in head, about 1.5-1.7 in snout and equal to interorbital space. Maxillary reaching far posterior to a level from hind border of eye. Posterior dorsal spines sub equal, shorter than twice diameter of eye. Second anal spine slightly longer than third. Pectoral equal to or shorter than postorbital length of head. Ventral shorter than half-length of head. Colour: Background colour variably uniform bluish brown, head and body with bluish dark edged spots. Fins dark brown with spots as on body; soft dorsal, anal, caudal and pectoral with narrow white margin. A few specimens with 5-7 dark transverse bands narrower than interspaces on body. (Plate.5.8.b).

Collection Site: Thikkody

Epinephelus tauvina (Forskal) 1775

Percia tauvina Forskal 1775

Epinephelus tauvina Weber and de Beaufort 1931

Epinephelus tauvina Smith 1949

Epinephelus tauvina Munro 1969

Serranus salmoides Day 1878

Size range: 76 - 215 mm

D. Xi, 15; A. III, 8; P. i, 17; V. I, 5. Liat. 102; Ltr. 13+1+37.

Head 2.5 in standard length, 3.1 in total length. Depth of body 3.2 in standard length, 3.9 in total length. Eye 5.6 in head, 1.3 in snout and about 0.8 in interorbital space.

Maxillary reaching to below the hind border of eye. Teeth in narrow bands in jaws, canines near symphysis short. Preopercle serrated behind, serrations at angle enlarged. Opercular spines equidistant. Pectoral as long as postorbital length of head. Colour: Brown, with indistinct dark broad cross bars and brown spots on head, body and median fins. Pectoral with a few spots. Ventral brownish distally. (Plate.5.8.c).

Collection Site: Thikkody

5.2.16.Family: Siganidae

Rabbit fishes

Rabbit fishes have deep oblong bodies and are fairly laterally compressed. The mouth is small and equipped for browsing on algae and other vegetation. The spines on the dorsal and anal fins are poisonous. Only about a dozen species belongs to this family but they have economic significance in the tropics. Feeds on algae, Small crustaceans, Polychaete worms and small fishes: They accept prepared foods in aquarium conditions.

Siganus javus (Linnaeus) 1766

Teuthis javus	Linnaeus 1766
Siganus javus	de Beaufort 1951
Siganus javus	Munro 1955
Siganus javus	Jones 1969

Size range: 65-145 mm

D. XIII, 10; A.VII, (; P. ii, 15; V. I, 3,I.

Head 3.9 in standard length, 4.9 in total length. Depth of body 2.0 in standard length, 2.4 in total length. Eye 3.3 in head, 1.4 in snout and about 1.2 in convex interorbital space. First dorsal spine as long as diameter of eye; sixth spine longest, much longer than snout; following spines decreasing in length, the last as long as snout. Pectoral slightly longer than head without snout. Ventral shorter than pectoral. Caudal fin emarginated. More than 30 scales between median dorsal spines and lateral line. Soft dorsal and anal angular. Colour: Brownish becoming lighter on the abdomen. Sides with several brown wavy lines, those on back broken up into spots. Dorsal, anal, caudal and ventral brown. Pectoral pale yellowish. (Plate.5.8.d).

Collection Site: Thikkody

5.2.17.Family: Tetradontidae

Puffer fishes

Puffers are generally smaller than porcupine fishes and smooth scaled. Their jaws are fused but a divided bone serves as front teeth. 'Tetradon' means four toothed (Two teeth at the top and two at the bottom) where as diodon means two teethed (one at the top and one at the bottom). These fishes use their pectoral fins to achieve highly maneuverable propulsion, as the pelvic fins are absent. Their inflating capabilities vary from species to species. *Tetradon* spp – among which is some freshwater members- are fully inflatable, but members of the genus Canthigaster can only manage partial inflation. The flesh is poisonous. Puffer fishes eat small crustaceans, mussels and polychaete worms. They accept prepared food in aquariums.

Tetradon immaculatus (Blotch and Schneider) 1801

Tetrodon immaculatus	Blotch and Schneider 1801.
Tetrodon immaculatus	Day 1878.
Arothron immaculatus	Smith 1949.
Arothron immaculatus	Munro 1955.

Arothron immaculatus	Jones and Kumaran 1959.
Tetraodon immaculatus	de Beaufort and Briggs 1962

Size range: 45 - 120 mm

D. i, 8-9; A. i, 8-9; P. ii, 15-16.

Head 2.7-2.9 in standard length, 3.6-3.9 in total length. Eye 4.7-5.2 in head, 1.7-2.2 in snout and 2.3-2.7 in somewhat flat interorbital space. Nasal organs of two tentacles joined at the base. Head, body and tail excepting snout and posterior part of tail and base of anal covered with slender spines. Longest rays of dorsal and anal 2.4-2.8 in length of head. Pectoral 2.6-3.0 in head. Caudal peduncle longer than high. Colour: Brownish to dark brown above, lighter below. Upper and lower edges and margin of caudal blackish. Dorsal, anal and pectoral light yellowish. (Plate.5.8.e).

Collection Site: Thikkody

Tetraodon hispidus (Linnaeus) 1758

Tetraodon hispidus	Linnaeus 1758
Tetrodon hispidus	Day 1878
Arothron hispidus	Smith1949
Arothron hispidus	Munro 1955
Arothron hispidus	Balan 1958.
Arothron hispidus	Jones and Kumaran 1959.
Tetraodon hispidus	de Beaufort and Briggs1962

Size range: 44 - 117 mm

D. i, 9-10; A. i, 9; P. ii, 16.

Head 2.4-2.6 in standard length, 3.0-3.3 in total length. Body short and flabby. Eye 4.2-4.6 in head, about 2.0- in snout and 2.4-3.0 in concave interorbital space. Longest dorsal rays 2.6-2.8 in head. Longest anal rays 3.0-3.2 in head. Pectoral 2.4-2.8 in head. Whole body except caudal peduncle usually spiny. Two nasal tentacles on each side. Colour: Brown above, lighter below with small bluish white spots on upper half of head and body and 4 or 5 broad irregular dark bars on sides from snout to above anal. A bluish white line around gill opening and behind base of pectoral. Caudal light brown, the margin a little darker. Other fins lighter, their bases light brown. (Plate.5.8.f).

Collection site: Thikody

Canthigaster margaritatus (Riippell) 1828

Tetrodon margaritatus	Day 1878
Canthigaster margaritatus	Smith 1949
Canthigaster margaritatus	Munro 1955
Canthigaster margaritatus	Jones and Kumaran 1959
Canthigaster margaritatus	de Beaufort and Briggs 1962
Canthigaster margaritatus	Jones1969

Size range: 45 - 77 mm

D. i, 8; A. i, 8; P. ii, 14-15.

Head 2.5-2.6 in standard length, 3.1-3.3 in total length. Depth of body 2.2-2.5 in standard length, 2.8-3.2 in total length. Nostrils with a low rim. Dorsal ridge somewhat well developed. Head and entire body covered with minute spines. Pectoral about twice diameter of eye. Caudal peduncle deeper. Colour: Bluish brown, lighter on sides and below. Interorbital space crossed by blue lines. Horizontal bluish lines on upper part of head and on back. Check, body and caudal fin covered with small bluish ocelli edged dark. A large black blue edged ocellus below base of dorsal fin. Pectoral, dorsal and anal yellowish. (Plate.5.9.a).

Collection site: Thikkody.

5.2.18.Family: Zanclidae

Tobies

Tobies are shoaling fishes found throughout the indo-pacific region. They are more closely related to Acanthuridae (through the sub order Acanthuroiden) particularly because of the physical form of the young fish, although it is difficult to see any resemblance at first glance in the adult. Other authors feel that it is superficially nearer to the chaetodontidae family especially to the similar genus Heniochus. The common name of Moorish idol is derived from the high esteem in which some Moslem populations hold the fish.

Tobies have a horn like projection in front of the eye. Three black vertical bands cross the body one from the pelvic fins to the beginning of dorsal fin another midway along the anal and dorsal fins, the third across the caudal fin. Behind the first black band the body is yellow. Immediately in front of the eyes across the beak like snout is a yellow saddle marking. The dorsal fin is extremely elongated often trailing well past the caudal fin. Adult fishes have hornlike protuberance in front of the eyes.

Feeds on small crustaceans, small fishes polychaete worms and algae. In aquarium it accepts meaty foods and chopped green foods.

Zanclus cornutus (Linnaeus) 1758

Chaetodon cornutus	Linnaeus 1758
Zanclus cornutus	Day 1878.

Zanclus cornutus Balan 1958

Zanclus cornutus Jones and Kumaran 1969

Size range: 70 - 123 mm

D. VII, 39-41; A. III, 33-36; P. ii, 16; V. I, 5.

Body strongly compressed and elevated dorsoventrally. Snout produced, profile of snout conclave. Head 2.2-2.5 in standard length, 2.9-3.2 in total length. Depth of body 1.15-1.25 in standard length, 1.40-1.45 in total length. Eye 3.5-4.3 in head, 1.9-2.5 in snout and equal to or a little more than interorbital space. A pair of interorbital protuberances in young developing as horns in adult. Teeth slender bristle like. First two dorsal spines short and strong; third spine greatly elongated and filamentous, equal to or more than total length; rest of the spines and dorsal rays gradually becoming shorter. First two anal spines short, third spine 3/5 length of succeeding ray; rays gradually becoming shorter posteriorly. Pectoral and ventral sub equal, much shorter than snout and eye together. Colour; Yellowish white with two broad black cross bands; the first one extending from interorbital and dorsal origin down to sides of breast to vent and the other from front part of soft dorsal to anterior part of soft anal; a dark vertical line immediately behind it. Four white lines present on the anterior band, one from behind interorbital protuberances to the eye, wards ventral fin and the other from front of pectoral towards vent. A blackish saddle over snout; lower lip and angle of mouth black. Rays of dorsal and anal edged dark. Caudal with a broad black crescent, posterior margin whitish. Pectoral pale. Ventral blackish. (Plate.5.9.b).

Collection site: Thikkody.

5.3. Discussion

There are about 300 species of marine ornamental fishes belonging to 35 families reported from Indian waters. Of these about 165 species have been reported from the south west coast and Lakshadweep waters. (Murty 2002). Among these the most important families are Pomacentridae, Chaetodontidae, Acanthuridae, Zanclidae, Labridae, Balistidae, Scorpaenidae, Platacidae, Ostraciodontidae and Diodontidae in the order of their trade preference. (Philipose 1998).

Inspite of the plentiful distribution of coral reef, rocky reef and associated fish fauna in the Indian waters, much attention has not been given to the studies on the reef fishes. (Tomey 1985). Reliable and updated works on the distribution and systematics of marine ornamental fishes are scanty from our waters. Jones and Kumaran (1980) gave a systematic account of the fishes of Laccadive archipelago and described more than 600 species of reef fishes. Comprehensive survey of our reef areas is needed to record and describe all the species marine ornamental fishes.

In the present study samples were collected mainly from the rocky areas of Moodady, Thikkody, Chombal and Dharmadom in the Malabar region. Out of the 50 species described in the present study *Acanthurus matoides*, *A.xanthopteres*, *Apogon aureus, Chaetodon collare, Diodon hystrix, Gymnothorax flavimarginatus, Pseudobalistes flavimarginatus, Ostracion tuberculatum, Lactaia cornuta, Platax teira, pteroise volitans, Siganus javus, Tetradon immaculatus* and *T.hispidus* are important species for their abundance and economic value.

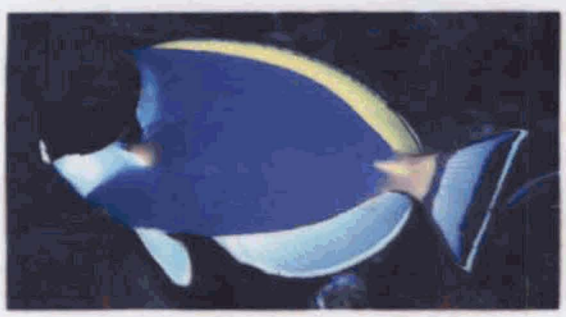
Artificial reefs play an important role in aggregating the ornamental fishes and establishing their community in the reef areas. It is significant to note that artificial reefs were installed by Central Marine Fisheries Research Institute in the inshore waters of Moodady, Thikkody and Dharmadom prior to the study period as part of its effort to conserve and increase the fisheries resources of the area and this has played an important role in conserving these resources. Majority of the specimens collected for this study was collected from these reef areas using the ornamental fish trap. Artificial reefs when properly designed and established not only increases the fishery resources but also provide habitat to the smaller fishes especially ornamental fishes. Hence artificial reef building can be used as a tool to increase the marine ornamental fish resources in the inshore waters. This will help to develop a sustainable exploitation of these resources.

Detailed exploration and sampling of the reef areas of the country especially Andaman and Nicobar Islands, Lakshdweep Islands, South east coast, North west coast and South west coast is required to understand the species diversity, seasonal abundance and population characteristics of ornamental fishes from the Indian waters. Such a study will help policy makers to prepare futuristic plans for the development of ornamental fishery.

Plate.5.1

a. *Acanthurus lineatus*

b. *A. nigricans*



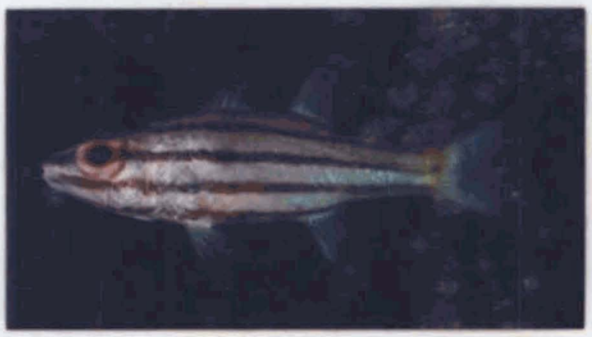
c. *A.leucosternon*

d. *A. xanthopterus*

e. *A.matoides*

f. *Ctenochaetus strigosus*

Plate.5.2



a. *Paramia quinquelineata*

b. *Apogon aureus*

c. *Odonus niger*

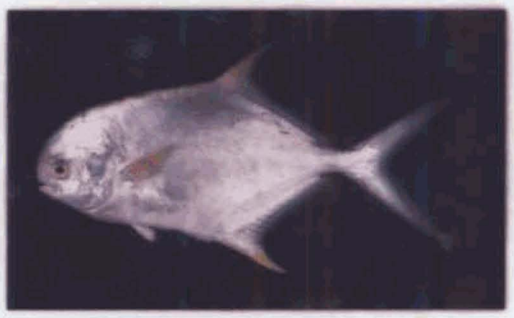
d. *Sufflamen capistratus*

e. *Pseudobalistes flavimarginatus*

f. *Balistapus undulates*

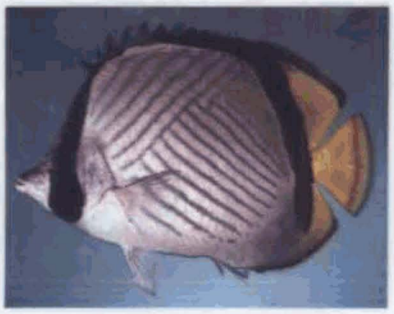
Plate.5.3

a. *Trachinotus bailloni*



b. *Trachinotus blochi*

c. *Chaetodon collare*

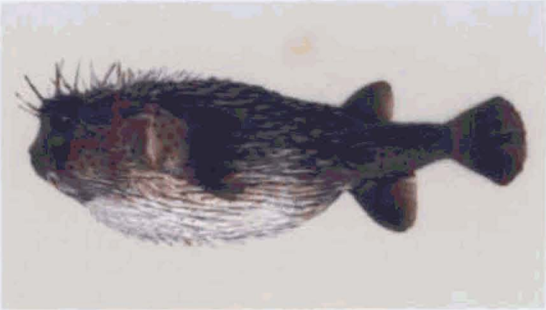


d. *C.vagabundus*

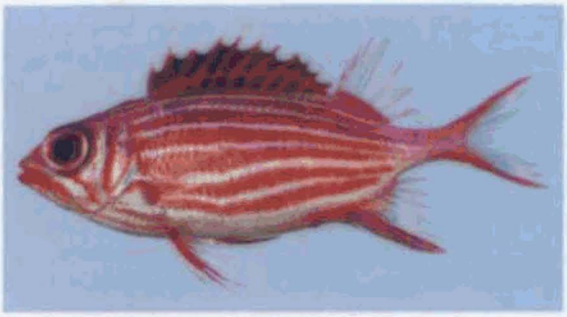
e. *Chaetodon auriga*

f. *Heniochus acuminatus*

Plate.5.4



a. *Diodon hystrix*

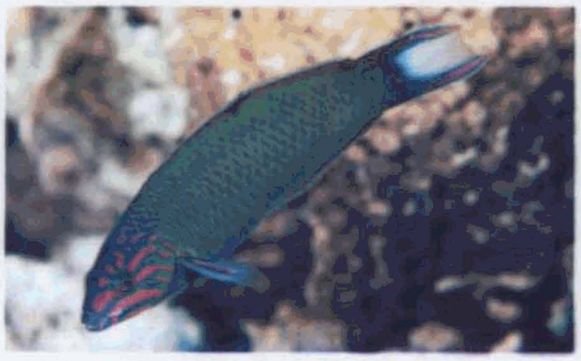


b. *Holocentrus diadema*

c. *H.rubber*

d. *Myripristis murdjan*

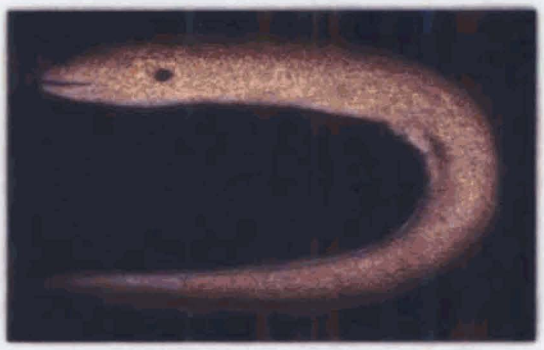
e. *M.adustus*



f. *Thalassoma lunare*

Plate.5.5

a. *Labroides dimidatus*



b. *Gymnothorax flavimarginatus*

c. *Lactaria cornuta*

d. *Ostracion tuberculatum*

e. *Platax orbicularis*

f. *Platax teira*

Plate.5.6

a. *Pomacanthus annularis*

b. *Abudefduf bengalensis*

c. *A.sexfasciatus*

d. *A.sexatilis*

e. *Abudefduf sordidus*

f. *A.septemfasciatus*

Plate.5.7

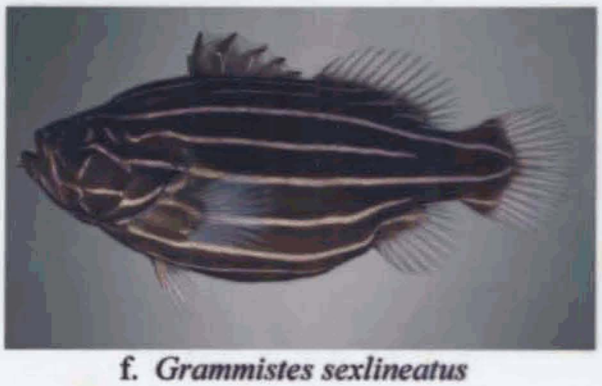
a. *Neopomacentrus cyanamos*

b. *N.filamentosus*

c. *Pterois volitans*

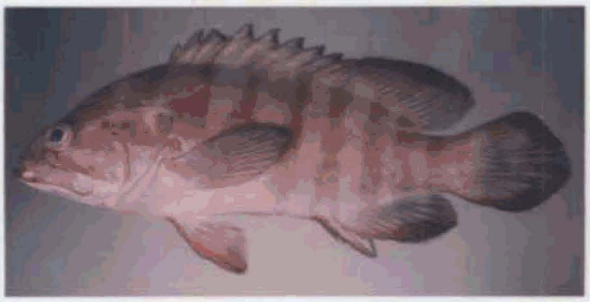
d. *P.antennata*

e. *P.radiata*



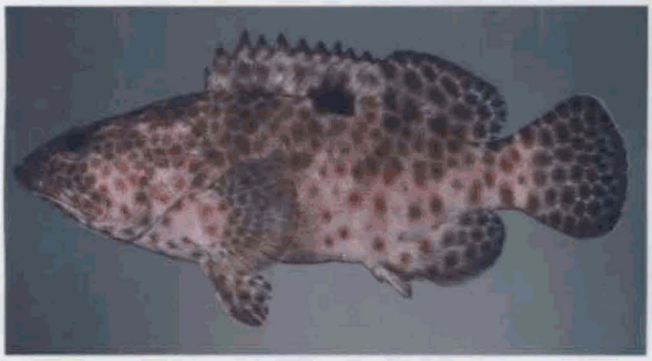
f. *Grammistes sexlineatus*

Plate.5.8



a. *Cephalopholis boenack*

b. *C.argus*



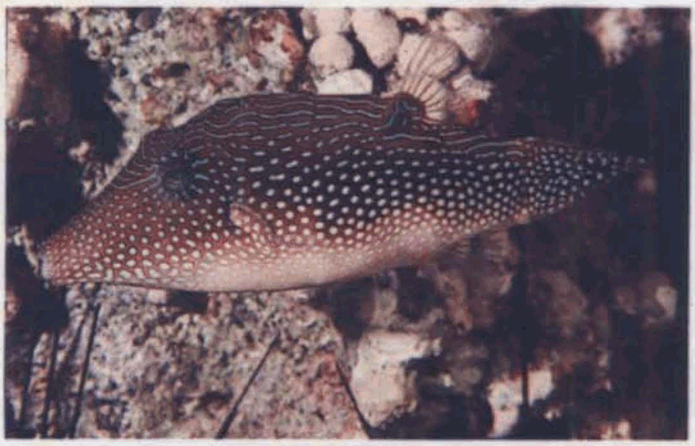
c. *Epinephelus tauvina*

d. *Siganus javus*

e. *Tetradon immaculatus*

f. *Tetradon hispidus*

Plate.5.9



a. *Canthigaster margaritata*

b. *Zanclus cornutus*

Chapter.6
Food and Feeding

6.1.Introduction

In terms of their food and feeding behaviour two groups are widely recognized among reef fishes. They are the herbivores (feeding on the macro and micro vegetation) and the planktivores. However the classification into various trophic levels does not have uniformity and at times groups identified as herbivores by some authors are placed under coral feeders by others. The category of omnivore is a flexible one, while planktivores, piscivores and crustacean feeders are some times included as carnivores. Trophic classifications of reef fishes include those of Talbot (1965), Bakus (1966), Gold man and Talbot (1976), Parrish and Zimmerman (1977), Gladfelter and Gladfelter (1978) and Sale (1980). General descriptions of the feeding biology of reef fishes is provided by Fishelson *et. al.,* (1974), Hobson (1974), Hobson and Chess (1978) and Gladfelter *et.al.,* (1980). Detailed analysis of diets has been presented for fishes of Marshal Islands (Hiatt and Strasburg (1960) and Caribbean (Randall 1967). Diets of particular groups of fishes have also been presented from many regions (Choat, 1968; Vivien and Peyrot-Clausade, 1974; Harmelin vivien and Bauchon, 1976).

Herbivores have attracted special attention because they are the consumers of primary production and help in channeling food materials and energy to other members of the food chain. Herbivores fishes of coral reefs are among the most abundant and widespread groups of vertebrate herbivores. These fishes differ greatly in the morphology and power of their mouthparts, their digestive physiologies and their foraging rates and behaviour. As plants are sessile, processing food poses few problems but the difficulties are in the quality of food materials, which are highly variable, and in their resistance to processing and digestion. Herbivores fishes are involved in three important processes of reefs. They are i) trophodynamics, ii) effect on the distribution and composition of plant assemblages and iii) interactions among herbivores fishes which have been used as a basis for developing demographic and behavioral models of reef fishes (Choat 1991). Studies on trophodynamics are mainly those of Odum and Odum (1955), Hatcher (1981), Carpenter (1986), Klumpp et al., (1987) and Klumpp and Polunin (1989). Plant herbivore interactions have received wide attention in areas such as plant assemblages and herbivore activity (Ogden and Lobel, 1978; Williams, 1983; Choat, 1983; Carpenter, 1986; Lewis, 1986) and plant defense mechanisms (Hay 1981 and 1984; Hatcher and Larkum 1983; Paul *et, al.,* 1990). Sale (1980), Robertson and Polumin (1981) and Doherty and Williams (1988) deal with demography and behaviour of herbivorous reef fishes. The herbivores that are most characteristic of reef environments belong to the families Acanthuridae, Pomacentridae, Scaridae and Siganidae (Randall, 1961 Choat 1991). Herbivores occur throughout the world's oceans but their distribution patterns are modified by striking gradients in diversity and abundance (Bouchon-Navaro and Harmelin-Vivien, 1981; Horn, 1989).

Fishes that feed on Zooplankters are also major components of coral reef communities. Virtually every major family includes species that are specialized as planktivores and most of them feed with visually oriented strikes at individual prey. Incident light being an important factor aiding vision, these fishes are adapted to specific photic conditions and feed either strictly by day or by night. Most diurnal reef planktivores feed primarily on crustaceans; particularly calanoid and cyclopoid copepods while larvae or fish eggs are favoured by others. The important modification in day feeders has taken place in the region of head and jaws, including dentition, which permits large individuals to prey on tiny organisms. Other features are the protrusible jaw and the oblique orientation of the mouth. Fishes that feed on Zooplankters during night are strongly influenced by the difficulty of visually locating prey in dim light. Major preys of these fishes are plankton that is relatively large and semi pelagic residents that rise into the water column during the night. Adaptations to nocturnal feeding include large eyes, deep compressed body and tendency to remain solitary. Planktivores reef fishes that feed by day typically form aggregation in the water column, and from a distance is often difficult to distinguish one species from another (Hobson, 1991). Most diurnal Planktivores have a small mouth that in many are sharply upturned and with highly protrusible often toothless jaws. Gill rakers tend to be long, numerous and closely spaced to prevent ingested prey from escaping through the gill openings. They are most abundant along reef edges adjacent to deeper water probably because their major prey the holoplankters are most accessible at outer reef areas (Hobson, 1974; Hobson and Chess 1978). Twilight is a time of transition between distinctive diurnal and nocturnal feeding modes among planktivores reef fishes. The crepuscular change over is an orderly sequence of responses to specific levels of diminished daylight; with the morning and evening sequences being essentially mirror images of one another (Hobson 1972). Nocturnal feeders emerge from their shelters in large numbers about thirty minute after sunset and migrate to distant feeding grounds (Gosline, 1965; Hobson 1972; Gladfelter, 1979). Similarly, a transition is also observed in the Zooplankters when they emerge in large numbers during late twilight. They include the holoplankters that had been in swarms close to benthic substrata during the day, mostly copepods and mysids (Emergy, 1968; Hammer and Clarleton 1979; Carleton and Hammer, 1989) and at nightfall disperse in the water column. Apart from these swarms a variety of bottom dwelling organisms such as polychaetes, ostracods, isopods, amphipods and crustacean larvae also enter the water column (Aldridge and King 1977; Mc William *et al.*, 1984). Nocturnal planktivores generally are more widespread in the reef area than their diurnal counterparts. This distinction may have developed because the nocturnal species feed mainly on reef residents that are themselves widespread over the reef, where as the diurnal species take mainly open water transits that are most available at reef edges (Hobson 1991). Major nocturnal zooplankton feeders of reefs belong to the families Clupeidae, Engraulidae, Athernidae, Holocentridae and Apogonidae

Apart from studies on herbivores and planktivores, observation has also been made on other sources of food to reef fishes. Riley (1963), Johannes (1967) observed organic aggregates mostly composed of coral mucus, a food for many fishes and Zooplankton in the coral reef areas. The unicellular algae Zooxanthellae found in corals also produce extra cellular organic material that adds to the productivity of coral reefs (Muscatine, 1967). Detritus formed from these mucus, organic aggregates, algal filaments, pieces of phyto and zooplankton and faecal pellets produced in reefs are transported to lagoons where they form food of zooplankton and fishes (Marshall, 1965; Qasim, 1979; Gerber and Marshall, 1974 and 1982).

Although studies on food and trophic relationship of reef fishes are numerous from abroad, studies from Indian waters are rather limited. Food and feeding habits of a few damselfishes belonging to the genus Pomacentridae was carried out by Mohan *et. al*,.,

(1986) from Lakshadweep. Diet and feeding habit of *S.delicatulus* and *S.gracilis* was carried out by Mohan and Kunhikoya (1985) and *Chromis Caeruleus* by Mohan *et, al.,(*1986). Gopakumar et.al., (1991) examined the gut contents of 17 species of tuna live baits. Mathew and Gopakumar (1986) observed the influence of Zooplankton biomass on tuna catch indirectly through the abundance of live baits.

As part of the ornamental fish resource studies of Malabar Coast, the feeding condition and the quantitative and qualitative estimation of gut contents of selected ornamental fishes were carried out. The objective of the study was to understand the feeding habit of these ornamental fishes and the state of feeding at various seasons.

6.2. Results

The diet of 5432 fishes belonging to *Neopomacentrus filamentosus* and *N.cyanamos* at Thikkody was analyzed. Both the species ate a similar range of prey items although the proportions varied considerably between species. Copepods had the highest frequency of occurrence and when copepods are in scarce fish eggs and other deccapod larvae dominated the food items.

6.2.1.N. filamentosus

In the two-year study period on the feeding condition of *N. filamentosus,* active feeding was observed only for a period of five months from August to December. In the case of males, during 2001 poorly fed conditions were observed from February to August. Moderately fed fishes were dominant from September to December. Actively fed fishes were observed in the fishery from August to December months and also in January. (Table 6.1). During 2002 poorly fed conditions were observed from February to August. Moderately fed fishes were dominant from September to December and actively fed fishes were observed in the fishery from August to December months and also in January. (Table 6.3).

In the case of females during 2001 poorly fed fishes were dominant from February to August. Moderately fed fishes were dominant from September to December and actively fed fishes were observed from August to December and also in January (Table 6.2). During 2002 poorly fed fishes were dominant from February to August, Moderately fed fishes were abundant from September to December and actively fed fishes were observed from August to December and also in January (Table 6.4). While studying the percentage composition of the feed it was observed that during 2001 copepods were the most important food item throughout the year and in their scarcity fish eggs and other deccapod larvae dominated the feed in certain months in males. (Table 6.5). In 2002 copepods were the most important food item throughout the year and in their absence fish eggs and other deccapod larvae dominated the feed in certain months in males. (Table 6.7). In females during 2001 and 2002 copepods were dominant in the feed throughout the year except during April and May months, during which period other deccapod larvae and fish eggs dominated the food. (Table 6.6 & 6.8). There was a complete absence of actively fed guts in the case of both sexes of *N. filamentosus* during the period February to June in both the years. Zoea larvae formed moderate percentage in the feed during the monsoon months from June to September. Mysids appeared in the food in minor quantities throughout the year. Amphipods were also observed in the food items at varying percentages throughout the study period. Isopods were observed in the food in significant percentages during the pre-monsoon and post-monsoon months and in very low percentages in the monsoon months.

6.2.2.N.cyanamos

During 2001 active feeding was observed from January to February and from July to December in the case of *N.cyanamos*. In the case of male *N.cyanamos* poorly fed individuals dominated the population during 2001 from March to August at varying percentages (Table 6.9). More or less similar pattern was observed during the year 2002 also (Table 6.11). Moderately fed males were dominant in the population from October to December months in both the years. During January and February months actively fed males were dominant in the population. Poor feeding was observed during March to June in both the years.

During 2001 in the case of females actively fed individuals were observed during January and February months and poorly fed individuals were observed in the population from March to August (Table 6.10) closely following the feeding pattern of males. In the year 2002 poorly fed individuals were dominant from March to August, moderately fed females from October to December, and actively fed individuals during January and February (Table 6.12).

While studying the percentage composition of food items it was observed that in males copepods formed the most important food item. During May and June months fish eggs formed the major food item. Other deccapod larvae also formed significant percentage in the feed of male *N.cyanamos*. Semi digested matter mostly algal remains were observed in the gut content from 3.5% in January 2001 to 5.6% in December 2001(Table 6.13) and from 3.6% in January 2002 to 6.5% in December 2002 (Table 6.15). Zoea larvae constituted 3.9% during January 2001 to 16.5% during July 2001 and to 15.3% during November 2001. Mysids also appeared in the food from 2.5% during January 2001 to 7.5% during December

2001. Mysids formed 2.5% in the food during January 2002 and 6.5% during December 2001. Amphipods appeared in the food item from 1.8% during January 2001 to 5.4% during November 2002. In the case of females Amphipods formed 2% during January 2001 to 6.1% during December 2002. Isopods also formed an important food item of *N.cyanamos*. In males isopods formed 2.1% during January 2001 to 4.9% during May 2002.

In females the percentage of Isopods varied from 1.4% during March 2001 to 5.2% during November 2001 (Table 6.14), and from 2.6% during January 2002 to 3.7% during December 2002.Crustacean fragments mostly of undigested remains of small shrimps and crabs formed a significant item of the food of *N.cyanamos* the percentage of crustacean fragments varied from 2.6% during January 2001 to 5.3% during August 2002(Table 6.16). During both the years of study crustacean fragments consistently appeared in the gut contents. In the case of females also crustacean fragments appeared from 3.3% during January 2001 to 5.8% during November 2002(Table 6.16). Only during March 2001 crustacean fragments formed insignificant percentages.

6.3.Discussion

Both the species of damselfishes studied showed poor to moderate feeding status with actively fed stomachs in low percentages. Feeding rate depends on the availability of Zooplankton, the feeding behaviour (diurnal or nocturnal), the time the fish was caught, prey selectivity, size of prey and feeding method employed by the species. While studying the feeding behaviour of Pomacentrids used as live bait for tuna fishing, Mathew and Gopakumar (1986) reported an influence of Zooplankton on the availability of live baits. They opine that a higher secondary production resulted in a greater biomass of bait fishes at Minicoy, which in turn increased the abundance, and catch of Tunas. Nasser (1993) reported that abundance of Zooplankton in the reef areas during post monsoon months resulted in the abundance of Pomacentrids. Emery (1968) also observed a variety of reef fishes feeding on resident Zooplankton and added that these Zooplankton are an important energy source for planktivores fishes. It is therefore evident that various species eat prey in proportion to its density in environment. In general pomacentrids are diurnal in feeding (Nasser 1993). Studies have shown that nocturnal feeders cease feeding one hour before sunrise and diurnal feeders start feeding one hour after sunrise. Therefore the time when the fish was collected, which was generally in the morning between 0800 and 1000 hrs is a period when diurnal feeders like Pomacentrids are yet to enter into an active feeding mode. This may explain the high percentage of empty and low to moderately fed conditions in a majority of the guts examined. Like wise the percentage of food in advanced stages of digestion as shown by semi digested matter implies preceded feeding activity. Milton *et al* (1990 a) based on field observations and diet data concluded that sprataloides and pomacentrids are generally diurnal feeders.

The diets of the two species of pomacentrids studied are similar to those reported for the species from elsewhere or other species in the same family. Zooplankton especially copepods were the major food item among the reef fishes and only in Apagonids did other food items dominate. Milton *et al* (1990 a) observed a significant negative selectivity for Calanoids by *Archamia Zosterophora* at Solomon Islands and suggested that it is a visual predator which pursues the prey item that appear largest at the start of the search. Another reef fish, which do not have a high percentage of Copepods in the gut, was *P.chrysozona.* But *P. pisang* collected from the same location and at about the same period had copepod as a major item. Species comparisons also showed significant difference in feeding habits of

G. argenteus and *P. chrysozona*. This implies that there may exist competition for favoured food among reef fishes occupying the same area. The argument gets further support, albeit a weak one, from the comparison of feeding of *S. delicatulus*. *S. delicatulus* an inhabitant of the minicoy lagoon had a significant deviation in feeding from that of the reef and outer reef dwelling *P. pisang* and *P. chrysozona* and the coral residing *Archaemia fucata* of the lagoon. Further more, *S.delicatulus* found in similar habitat but at different locations did not show significant variation in diet. Similarly it is assumed that in the present study also inter specific competition and the habitat may therefore influence the diet of pomacentrids.

Along the Kerala coast, Southwest monsoon sets in early June and the sea conditions are turbulent from June to September. The upwelling phenomenon along the Malabar Coast increases the primary and secondary productivity in the coastal waters from August – September onwards (Yohannan and Balasubramanyan 1991). This explains the moderate to active feeding by pomacentrids during the post monsoon months. Similarly the Northeast monsoon, which sets in Kerala coast by early October, lasts till December and also results in high levels of primary and secondary productivity in the coastal waters (Anon 1976 a). The high levels of productivity and the relatively calm sea conditions explain the active feeding by the pomacentrids from December to February.

Plant materials have also been found in the gut contents of *N.filamentosus and N.cyanamos*. Algal contents in the guts of *C. caeruleus* (Gerber and Marshall, 1974; Mohan *et.al.*, 1986) and *S.delicatulus* (Mohan and Kunhikoya, 1985) have also been reported. Reef fishes are opportunistic feeders since the most frequently occurring food items, with the exception of Copepod, changes from month to month. Quite often the presence of multiple prey in the stomach may be the result of the incomplete digestion of a previous meal rather than the predator taking multiple preys during a meal (Crow-1982).

In the present study also it is observed that *N.filamentosus* and *N.cyanamos* are largely opportunistic feeders feeding on available prey in the reef.

Table.6.1. Condition of feeding (%) in *N. filamentosus* Male

Months	Feeding condition (%)		
	Poorly fed	Moderately fed	Actively fed
Jan-2001	-	10.0	90.0
Feb-2001	66.5	33.5	-
Mar-2001	100.0	-	-
Apr-2001	100.0	-	-
May-2001	100.0	-	-
Jun-2001	62.5	37.5	-
Jul-2001	69.0	31.0	-
Aug-2001	55.0	31.0	14.0
Sep-2001	39.0	47.5	13.5
Oct-2001	31.5	65.5	3.0
Nov-2001	16.0	69.4	14.6
Dec-2001	9.5	76.5	14.0
Annual-2001	54.0	33.5	12.5

Table.6.2. Condition of feeding (%) in *N. filamentosus* Female

Months	Feeding condition (%)		
	Poorly fed	Moderately fed	Actively fed
Jan-2001	-	14.0	86.0
Feb-2001	62.0	30.0	8.0
Mar-2001	94.0	6.0	-
Apr-2001	100.0	-	-
May-2001	64.0	36.0	-
Jun-2001	67.5	32.5	-
Jul-2001	70.0	30.0	-
Aug-2001	53.5	28.5	18.0
Sep-2001	29.5	54.5	16.0
Oct-2001	36.0	58.0	6.0
Nov-2001	23.5	60.5	16.0
Dec-2001	8.0	81.0	11.0
Annual-2001	50.7	35.9	13.4

Table.6.3. Condition of feeding (%) in *N.filamentosus* (Males)

Months	Feeding condition (%)		
	Poorly fed	Moderately fed	Actively fed
Jan-2002	4.0	82.0	14.0
Feb-2002	63.0	1.0	36.0
Mar-2002	94.0	-	6.0
Apr-2002	96.5	-	3.5
May-2002	66.0	-	34.0
Jun-2002	71.0	3.0	26.0
Jul-2002	76.0	5.0	19.0
Aug-2002	59.0	15.0	26.0
Sep-2002	34.0	12.0	54.0
Oct-2002	26.0	15.0	59.0
Nov-2002	12.0	24.0	64.0
Dec-2002	4.0	25.0	71.0
Annual-2002	50.5	15.2	34.3

Table.6.4. Condition of feeding (%) in *N.filamentosus* (Females)

Months	Feeding condition (%)		
	Poorly fed	Moderately fed	Actively fed
Jan-2002	2.0	16.0	82.0
Feb-2002	54.5	29.5	16.0
Mar-2002	98.0	2.0	-
Apr-2002	94.0	6.0	-
May-2002	73.0	24.0	3.0
Jun-2002	69.0	31.0	-
Jul-2002	76.0	24.0	-
Aug-2002	56.0	24.0	20.0
Sep-2002	33.0	26.0	41.0
Oct-2002	41.0	49.0	10.0
Nov-2002	32.5	49.0	18.5
Dec-2002	31.5	53.5	15.0
Annual-2002	55.0	27.8	17.2

Table.6.5. Percentage composition of main food items in male *Neopomacentrus filamentosus* during 2001

Months	No.of specimen examined	Food Items (%)							
		Semi digested matter	Fish eggs	Copepod	Zoea	Other Deccopod larvae	Mysid	Amphipod	Isopod
Jan-2001	68	3.05	2.3	59.63	2.33	29.06	1.09	1.36	0.94
Feb-2001	72	13.51	18.92	21.62	10.14	13.51	10.41	4.73	6.76
Mar-2001	64	14.42	9.69	18.27	9.62	15.38	9.69	9.62	10.73
Apr-2001	76	6.25	16.67	25.0	8.33	10.42	10.5	4.06	16.67
May-2001	54	6.1	67.52	2.33	6.65	5.32	4.0	1.32	6.21
Jun-2001	19	4.78	7.42	33.49	7.18	22.25	16.51	0.96	3.83
Jul-2001	18	4.55	8.16	50.01	6.58	26.93	3.36	0.09	0.26
Aug-2001	34	7.65	10.98	42.05	8.85	25.89	3.77	0.22	0.44
Sep-2001	62	7.66	9.36	12.77	16.17	19.57	5.11	11.06	6.38
Oct-2001	56	7.89	4.86	43.86	4.39	8.77	9.65	12.28	6.54
Nov-2001	58	8.42	6.51	39.65	6.32	7.4	6.95	13.62	9.41
Dec-2001	62	5.6	4.34	55.25	3.66	21.42	2.41	4.56	1.92
Annual	643	7.7	14.2	34.4	7.7	17.6	7.0	5.4	6.0

Table.6. 6. Percentage composition of main food items in female *Neopomacentrus filamentosus* during 2001

Months	No.of specimen examined	Food Items (%)							
		Semi digested matter	Fish eggs	Copepod	Zoea	Other Deccopod larvae	Mysid	Amphipod	Isopod
Jan-2001	71	3.88	2.56	58.15	3.11	26.12	2.11	2.44	0.96
Feb-2001	74	12.98	19.445	30.66	9.14	14.66	8.41	2.21	1.81
Mar-2001	69	15.4	18.32	23.56	12.41	14.66	8.91	4.41	1.95
Apr-2001	72	7.6	16.54	29.63	18.14	9.98	9.31	7.4	0.94
May-2001	59	6.96	66.94	4.35	5.91	5.62	4.92	3.22	1.86
Jun-2001	22	4.92	8.46	39.45	9.94	26.33	3.22	2.64	2.41
Jul-2001	17	4.34	9.33	38.66	8.19	23.63	12.9	2.11	0.54
Aug-2001	36	8.12	10.31	45.36	7.29	19.43	4.56	1.98	2.36
Sep-2001	90	7.41	8.53	15.94	16.19	20.43	6.32	13.91	8.91
Oct-2001	69	7.99	5.36	45.64	5.29	8.55	9.64	13.62	2.94
Nov-2001	62	8.59	8.11	42.43	7.32	9.14	6.71	11.64	5.32
Dec-2001	65	5.91	4.84	54.62	9.14	14.81	4.68	3.41	1.99
Annual	706	7.9	15	36	9.4	16.3	6.9	5.8	2.7

Table.6.7. Percentage composition of mainfood items in male *Neopomacentrus filamentosus* during 2002

Months	No.of specimen examined	Food items (%)							
		Semi digested matter	Fish eggs	Copepod	Zoea	Other Deccopod larvae	Mysid	Amphipod	Isopod
Jan-2002	52	3.95	3.12	54.1	5.41	20.32	1.99	3.96	4.51
Feb-2002	49	9.43	10.56	49.42	6.11	15.11	3.11	3.98	1.29
Mar-2002	56	11.56	9.43	31.56	7.8	26.14	5.14	3.12	3.75
Apr-2002	69	6.13	19.43	29.41	9.65	21.59	4.29	5.34	2.99
May-2002	65	5.94	14.31	39.62	11.32	19.44	3.94	4.11	1.23
Jun-2002	26	4.26	9.63	45.61	13.31	15.22	3.14	2.33	2.63
Jul-2002	24	4.69	23.11	51.64	2.12	10.54	4.12	3.14	1.94
Aug-2002	32	8.33	10.12	58.44	4.6	9.14	3.6	2.05	2.43
Sep-2002	54	8.59	10.58	53.16	3.87	8.14	4.5	3.96	3.89
Oct-2002	21	7.99	11.39	55.15	3.94	7.16	4.59	3.14	4.21
Nov-2002	69	8.23	10.15	53.11	4.69	8.36	4.63	4.14	3.98
Dec-2002	64	6.44	3.99	53.5	5.34	20	2.16	3.91	2.91
Annual	581	7.2	11.6	48.7	6.5	15.4	3.8	3.8	3.0

Table.6.8. Percentage composition of main food items in female *Neopomacentrus filamentosus* during 2002

Months	No.of specimen examined	Food items (%)							
		Semi digested matter	Fish eggs	Copepod	Zoea	Other Deccopod larvae	Mysid	Amphipod	Isopod
Jan-2002	54	3.81	3.95	53.8	4.9	19.6	2.34	3.8	5.2
Feb-2002	56	8.11	9.4	50.32	5.7	18.4	2.74	2.23	2.1
Mar-2002	69	10.58	9.56	29.23	8.4	26.2	6.45	3.14	4.1
Apr-2002	74	6.11	20.22	28.14	9.23	19.42	4.91	5.61	3.39
May-2002	62	6.13	13.81	39.64	10.36	18.45	4.12	4.71	2.1
Jun-2002	23	4.31	9.54	44.93	14.11	15.39	3.94	2.44	3.22
Jul-2002	19	4.71	20.94	48.58	3.61	10.44	4.41	2.31	2.15
Aug-2002	32	8.11	10.46	56.44	4.92	9.11	3.72	3.1	2.98
Sep-2002	56	8.64	10.54	53.82	3.98	7.69	4.31	4.39	3.99
Oct-2002	73	7.94	11.42	55.41	4.11	8.31	3.98	4.66	3.1
Nov-2002	61	8.12	10.94	53.36	4.72	9.11	4.21	4.51	3.12
Dec-2002	59	8	9.61	51.9	4.81	16.1	2.08	3.2	2.4
Annual	638	7.2	11.9	48.0	6.7	15.1	4	3.8	3.3

Table.6.9. Condition of feeding (%) in *Neopomacentrus cyanamos* male

Months	Feeding condition (%)		
	Poorly fed	Moderately fed	Actively fed
Jan-2001	-	21	79
Feb-2001	12	34	54
Mar-2001	94	6	-
Apr-2001	96	4	-
May-2001	71	29	-
Jun-2001	63	37	-
Jul-2001	59	36	5
Aug-2001	54	26	20
Sep-2001	42	44	14
Oct-2001	29	54	17
Nov-2001	21	63	16
Dec-2001	11.5	77.5	11
Annual	46	36	18

Table.6.10. Condition of feeding (%)in *Neopomacentrus cyanamos* female

Months	Feeding condtition (%)		
	Poorly fed	Moderately fed	Actively fed
Jan-2001	2	23	75
Feb-2001	9	34	57
Mar-2001	93	7	-
Apr-2001	95	5	-
May-2001	73	27	-
Jun-2001	62	38	-
Jul-2001	58	37	5
Aug-2001	56	27	17
Sep-2001	44	45	11
Oct-2001	28	56	16
Nov-2001	20	62	18
Dec-2001	13	78	9
Annual	46	36.6	17.4

Table.6.11. Condition of feeding (%) in *Neopomacentrus cyanamos* male

Months	Feeding condtition (%)		
	Poorly fed	Moderately fed	Actively fed
Jan-2002	2	23	75
Feb-2002	14	35	51
Mar-2002	92	8	-
Apr-2002	93	7	-
May-2002	79	21	-
Jun-2002	64	36	-
Jul-2002	62.5	30.5	7
Aug-2002	53	27	20
Sep-2002	44	40	16
Oct-2002	31	50	19
Nov-2002	23	62	15
Dec-2002	12.5	78	9.5
Annual	47.5	34.8	17.7

Table.6.12. Condition of feeding (%) in *Neopomacentrus cyanamos* female

Months	Feeding condtition (%)		
	Poorly fed	Moderately fed	Actively fed
Jan-2002	1.5	24	74.5
Feb-2002	14	32	54
Mar-2002	91	9	-
Apr-2002	92	8	-
May-2002	76	24	-
Jun-2002	65	35	-
Jul-2002	63	30	7
Aug-2002	54	26	20
Sep-2002	44	39	7
Oct-2002	32	51	17
Nov-2002	23	63	14
Dec-2002	11.5	76.5	12
Annual	47.6	35	17.4

Table.6.13. Percentage Composition of main food items in male *Neopomacentrus cyanamos* during 2001

Months	No.of specimen examined	Food items (%)							
		Semi digested matter	Fish eggs	Copepod	Zoea	Other Deccopod larvae	Mysid	Amphipod	Isopod
Jan-2001	54	3.5	1.6	48.5	3.9	33.5	2.5	1.8	2.1
Feb-2001	56	8.6	20.5	31.5	9.5	18.2	2.3	1.9	2.4
Mar-2001	55	9.5	21.6	33.5	11.6	14.5	4.5	2.3	1.3
Apr-2001	60	8.5	19.5	29	12.5	15.4	2.9	2.4	5.4
May-2001	53	7.4	61.4	5.4	3.5	7.4	5.2	4.3	3.4
Jun-2001	55	4.6	49.5	29.4	4.1	3.1	2.3	2.6	2.3
Jul-2001	58	9.8	16.5	33.2	16.5	8.4	4.6	2.9	3.6
Aug-2001	62	7.1	24.5	29.5	8	16.5	5.2	3.1	3.5
Sep-2001	59	7.9	12.4	40.4	7.5	14.9	6.1	2.9	4.3
Oct-2001	54	6.4	9.5	38.6	6.8	20.4	5.2	4.5	3.9
Nov-2001	60	8.1	4.5	29.5	15.3	24.9	4.6	5.1	4.9
Dec-2001	59	5.6	12.9	26.9	4.5	32.1	7.5	3.4	3.9
Annual	685	7.5	21.9	32.3	8.9	18	4.7	3.2	3.5

Table.6.14. Percentage Composition of main food items in female *Neopomacentrus cyanamos* during 2001

Months	No.of specimen examined	Food items (%)							
		Semi digested matter	Fish eggs	Copepod	Zoea	Other Deccopod larvae	Mysid	Amphipod	Isopod
Jan-2001	55	3.6	1.7	48	3.6	33	2.5	2	2.3
Feb-2001	58	8.5	21.1	31.2	9.2	19.4	2.4	1.6	2.6
Mar-2001	54	9.8	21.2	32.8	12.1	15.2	4.7	2.2	1.4
Apr-2001	59	8	18.8	30	13.1	15.1	2.8	2.7	5.2
May-2001	55	7.2	61.5	5.8	3.6	7.5	5.2	4.5	3.2
Jun-2001	54	4.8	49.1	29.1	4	3.5	2.1	2.5	2.9
Jul-2001	57	9.5	16.5	32.5	15.5	10.6	4.5	3	3.1
Aug-2001	61	7.4	23.8	28.9	8.1	18.9	5.3	3.4	3.3
Sep-2001	60	7.9	12.5	41.2	7.2	14.8	6.5	2.8	4.1
Oct-2001	55	6.5	9.2	38.5	6.5	20.5	6.1	4.6	3.8
Nov-2001	62	7.9	4.2	31	15.1	23.9	4.5	5.2	5.2
Dec-2001	60	6.5	12.6	27	4.2	32	6.5	3.8	4
Annual	690	7.5	21.6	32.3	8.8	18.4	4.6	3.3	3.5

Table.6.15. Percentage Composition of main food items in male *Neopomacentrus cyanamos* during 2002

Months	No.of specimen examined	Food items (%)							
		Semi digested matter	Fish eggs	Copepod	Zoea	Other Deccopod larvae	Mysid	Amphipod	Isopod
Jan-2002	63	3.6	2.4	52.5	3.5	26.5	2.8	2.1	3.6
Feb-2002	54	4.8	25.9	36.5	8.5	15.5	3.1	1.9	2.6
Mar-2002	59	7.6	24.3	31.5	10.9	13.9	2.9	2.6	3.5
Apr-2002	52	9.5	20.2	26.5	13.5	14.5	4.2	3.3	4.6
May-2002	65	9.5	21.9	15.8	6.8	21.5	6.9	4.5	4.9
Jun-2002	59	7.2	39.5	20.5	5.5	15.6	2.8	2.3	3.1
Jul-2002	62	6.3	41.4	21.5	10.5	11.4	1.9	2.1	2.9
Aug-2002	64	9.1	21.5	27.5	11.2	13.5	4.5	3.1	4.3
Sep-2002	65	7.8	20.3	29.9	14.5	10.1	5.9	2.8	4.6
Oct-2002	66	5.9	9.3	35.4	13.6	20.1	5.4	3.1	3.9
Nov-2002	55	8.9	5.4	26.5	15.4	24.6	5.2	5.1	4.8
Dec-2002	52	5.4	11.6	27.5	9.6	24.5	7.1	4.9	4.5
Annual	716	7.4	21.1	30.5	10.7	18.4	4.6	3.3	4

Table.6.16. Percentage Composition of main food items in female *Neopomacentrus cyanamos* during 2002

Months	No.of specimen examined	Food items (%)							
		Semi digested matter	Fish eggs	Copepod	Zoea	Other Deccopod larvae	Mysid	Amphipod	Isopod
Jan-2002	64	3.5	2.6	51.5	4.5	26.9	2.6	2.6	3.4
Feb-2002	53	4.7	26.1	36.5	7.6	15.5	3	1.8	3.2
Mar-2002	60	7.5	24.2	31.2	11.2	12.9	3.5	2.7	3.9
Apr-2002	58	9.8	21.1	26.9	12.6	13.9	4.1	3.6	4.7
May-2002	60	10.4	21.8	15.7	6.4	21.5	8	4.6	4.1
Jun-2002	60	7.3	38.6	21.6	5.6	15.7	2.6	3.1	3.2
Jul-2002	64	6.6	40.5	19.6	10.1	10.9	5.8	2.7	1.9
Aug-2002	65	9.2	21.6	27.2	11.3	13.6	4.8	2.7	4.9
Sep-2002	66	7.6	21.1	28.6	15.6	10.3	6.1	2.9	4.8
Oct-2002	65	6	9.4	34.2	13.8	21	5.2	2.9	3.8
Nov-2002	55	8.8	5.6	25.6	15.5	24.2	5.3	5	4.2
Dec-2002	53	5.2	11.7	26.9	10.2	24.9	8.9	6.1	3.7
Annual	723	7.5	21	29.8	10.7	18.3	5.2	3.5	4

Chapter.7

Estimation of Length-weight Relationship, Growth and Mortality Parameters and Recruitment Patterns of *Neopomacentrus filamentosus* (Macleay, 1882)

7.1. Introduction

Length-weight studies and population dynamics of damselfishes have only received attention in recent times. The objective of these investigations is to rationally manage and conserve the damselfish resource. Effective management of any fishery requires considerable knowledge regarding population parameter such as age and growth, mortality and recruitment patterns of the exploited stock. Damselfishes by their very nature are reef dwellers do not form commercial fishery except in areas where they are used as live baits for tuna fishery. Only a limited quantity of pomacentrids is caught for aquarium rearing as marine ornamental fishes.

Marine fisheries are based on stocks of wild populations inhabiting the sea. The success of capture fisheries depends on the state of these stocks. The purpose of study of fish population dynamics of exploited stocks is to offer scientific advice on the possible range of options for rational exploitation. By increasing the fishing effort, the yield can be increased to a certain level, but further increase in exploitation levels leads to reduction in the yield and if the effort is still further increased regardless of the reduction in total catch and catch rates, the stock under exploitation may collapse. Such a situation would arise if proper scientific advice on the maximum possible effort and safe gear and mesh levels that could be deployed to exploit the resources of a stock/stocks in a given geographic area, was not made available and even if made available, not implemented. Hence, the exploited stocks need to be maintained carefully and scientific advice rendered to the government and the industry on the range of measures required ensuring maximum economic and sustainable yield.

The basic objective of fish stock assessment is to provide advice on the optimum exploitation of the living resources under investigation. F (MSY) indicates the maximum effort level, which in the long term gives the highest yield, and the corresponding yield is the MSY (Maximum Sustainable Yield). It is rather well known that the fundamental concept while describing the dynamics of an exploited marine resource is that the 'stock'. A stock is a subject of a species, which is considered as the basic taxonomic unit. Stocks are discrete groups of animals, which show little mixing with the adjacent groups. The population parameters or stock parameters remain constant over the distribution area of the stock. The growth parameters and mortality coefficients are the two fundamental stock parameters required for the identification of a stock. The former are the numerical values in an equation by which we can predict the body size of a fish when it reaches a certain age and the latter are the rates at which the animals die either by fishing (fishing mortality) or by other causes such as predation, disease, etc. (natural mortality). The recruitment pattern as well as the size at first capture also play key role in regulating the exploitation of a fishery.

7.2. Results

7.2.1. Length-weight relationship

According to Le Cren (1951), a knowledge on the length – weight relationship serves generally two purposes; first towards deriving or describing a mathematical relationship between length and weight so that one of the variables may be converted into the other; secondly to measure variations from the expected weight for length of individual fish or relevant groups of individual as indicators of fatness, general well being and gonad development etc. The length and weight of fishes may be determined with accuracy. Weight of the fish may be considered a function of the length. This relationship of the length and weight follows approximately the cube law. In order to find out the length weight relationship, it was decided to consider juveniles and adults together and represent a combined regression equation so that it can be applied for stock assessment studies uniformly. The length is considered in millimeter and weight in gram.

The length-weight relationships of *Neopomacentrus filamentosus* at two stations viz. Thikkody and Dharmadom are given below.

Thikkodi	**Dharmadom**
$0.000879\,L^{2.4219}$ (r =0.9827)	$0.000882\,L^{2.5132}$ (r = 0.9921)

<u>Pooled (Thikkody and Dharmadom</u>

$0.000805\,L^{2.46755}$ (r = 0.9874)

The regression values between length and weight indicated that the length-weight relationship was highly correlated at Thikkody and Dharmadom.

7.2.2. Growth parameters.

For estimation of growth and mortality parameters, the raised length frequencies corresponding to each month pooled over the years 2001 and 2002 are used. The restructured length frequency distribution and the line drawn along the modal values marks their growth line using the FISAT programme is given in Fig 7.1 and Fig.7.2 for Thikkody and Dharmadom respectively. It indicates that the juveniles start entering the fishery in June and it continues up to February.

. The estimate of $L\infty$ using FISAT programme indicated that it is around 70 mm at Thikkody and the Rn value for this estimate was 0.168. The growth coefficient (K) for *N.filamentosus* exploited at Thikkody is 0.44 Y^{-1}.

The growth parameters for *N.filamentosus* exploited from Dharmadom was estimated as 74mm and 0.40 Y^{-1} at an Rn value of 0.189.The $L\infty$ estimate from Dharmadom is slightly higher than the $L\infty$ estimate from Thikkody, while the K value of the species from Thikkody is marginally higher than the K value estimated from Dharmadom.

The length frequency data analyses using the FISAT programme show a distinct brood originating in October. The figure 7.1 and 7.2 shows the growth curve of the brood originating in October and the fit is perfect. For further analysis the estimated growth parameters of this brood were taken. The values of L_{00}, K, C, WP and Rn values for this brood from Thikkody and Dharmadom is as given below.

Thikkody		**Dharmadom**	
$L\infty$	: 70.00 mm	$L\infty$	: 74.00 mm
K	: 0. 44 y^{-1}	K	: 0. 40 y^{-1}

C	: 0.00	C	: 0.00
WP	: 0.00	WP	: 0.00
Rn	: 0.168	Rn	: 0.189

7.2.3. Mortality Parameters

Mortality in fish occurs because of natural causes as well as due to fishing. Death from any cause is unique event for the individual. The probability of death at any given age is a statistical property of the population as a whole that can be measured only by observation of many individuals.

7.2.4. Estimation of Total Mortality (Z)

The growth parameters of the October brood were used for estimation of total mortality (Z). The Z estimated for *N.filamentosus* from Thikkody and Dharmadom is estimated using the catch curve is depicted in the fig 7.3 and 7.4. The estimated Z using the growth parameters for Thikkody and Dharmadom is 2.43 Y^{-1} and 3.98 Y^{-1} respectively.

This broods would have been probably born in October and persisted until January - February of the second year. These 16-17 months can be considered as the fishable life span of the *N.filamentosus.*

7.2.5. Natural mortality (M)

The natural mortality (M) was estimated using the Pauly's empirical formula for an average temperature for 28° C. The value of temperature was found to be fluctuating between 27 and 29 C and hence, the mean temperature was taken as 28 °C (Seshappa and Jayaraman, 1956). The estimated natural mortality for the Thikkody and Dharmadom stock is 0.64 Y^{-1} and 0.66 Y^{-1} respectively.

7.2.6. Fishing mortality (F)

Fishing mortality was estimated by subtracting the values of natural mortality (M) from the total mortality coefficient (Z). Z obtained form catch curve analysis was used for estimation of fishing mortality. The value of natural mortality obtained by Pauly's method was deducted from the total mortality obtained from the catch curve method and fishing mortality obtained was as follows.

Thikkody	Dharmadom
$F = Z - M$	$F = Z - M$
$M = 0.64\ Y^{-1}$	$M = 0.66\ Y^{-1}$
$Z = 2.43 Y^{-1}$	$Z = 3.98\ Y^{-1}$
$F = 1.79\ Y^{-1}$	$F = 3.32\ Y^{-1}$

Natural mortality at both the sites were almost similar while fishing mortality at Thikkody was nearly double that of Dharmadom.

7.2.7. Recruitment pattern

The recruitment pattern of *N.filamentosus* was estimated for Thikkody and Dharmadom and is presented in Fig 7.5 and 7.6. In the October brood two distinct peaks were observed. Maximum recruitment for *N.filamentosus* from Dharmadom was observed between June and July and a second one in September - November. The maximum recruitment was in the July and October. In June - July the recruitment was 40.77 %. During the second phase, highest recruitment was taken place in October (21.49 %).

The recruitment pattern of *N.filamentosus* exploited from Thikkody also showed two distinct peaks in June – July and October- November.

From the above, it can be concluded that the peak recruitment of *N.filamentosus* along the Malabar region takes place in two phases. The pooled data for Thikkody and Dharmadom indicates that the primary recruitment takes place in June-July and the secondary recruitment in October- November months.

7.3. Discussion

Length-weight data are often used to study the indication of fatness, general well being or gonad development. It is also assumed that heavier fish of a given length are in better condition. *N.filamentosus* showed allometric growth at both the sites studied with weight increasing at a faster rate ($b>3.0$). Between the sites there was a wide variation with lowest b value at Thikkody. Similar variation between locations for *N.filamentosus* has been reported (Milton *et al.*, 1990b). They attributed the reduced weight at one site in Solomon Islands to less favorable conditions, and the variation between locations to the quantity and quality of food available at each site. Dalzell and Wankowski (1980) reported isometric growth for this species at Papua New Guinea and pointed out that whether a radical change in body proportions takes place between juvenile and adult phases is not known. The results of Gopakumar *et al.* (1991) for juvenile and adult *S. gracilis* from Lakshadweep seems to imply that juveniles have a slower rate of increasing weight than adults. The b values obtained in this study are higher than those reported for this species from other locations (Dalzell and Wankowski, 1980; Conand, 1988; Milton *et al.*, 1990b; Gopakumar *et al.*, 1991). It is also significant that the values reported from similar studies conducted in Minicoy for pomacentrids (Mohan and Kunhikoya, 1985) are much lower than those obtained in this study. This may indicate the influence of changed environmental conditions on the general well being of the fish stock at Thikkody.

The higher b values for most caesionids seems to testify that reefs surroundings are highly productive and hence support a higher biomass. Fusiliers are migrant forms (Gopakumar *et al.*, 1991), which are found shoaling in the outer reef areas, and temporarily associated with reefs. This migration is mainly a prey avoidance strategy coupled with active feeding. They are in a different category in contrast to the other damselfishes with only juveniles used as baits in pole-and line fishery and grows up to a length of about 25 cm (Carpenter 1984). Except for a few reports (Cabanban, 1984; Bell and Colin, 1986) there is practically no information on this group of damselfishes. The deep-bodied Pomacentrid, *C. caeruleus* have a slower weight gain with b values approaching isometry. This is in agreement with the findings of Mohan *et al.* (1986) who reported slightly lower values of 2.67 from Minicoy. Similar values were obtained for the relatively deep-bodied apogonids, *A. fucata* with growth constant considerably lower than 3.0. Gopakumar *et al.* (1991), however, observed values above 3.0 for this species from Lakshadweep. The length-weight studies on ornamental fishes indicated that except in one case the relationship was not significantly different between sexes. Most of them have allometric growth rates and faster weight gain. The conclusion therefore could be that damselfishes enjoy a favorable habit and habitat at the various locations.

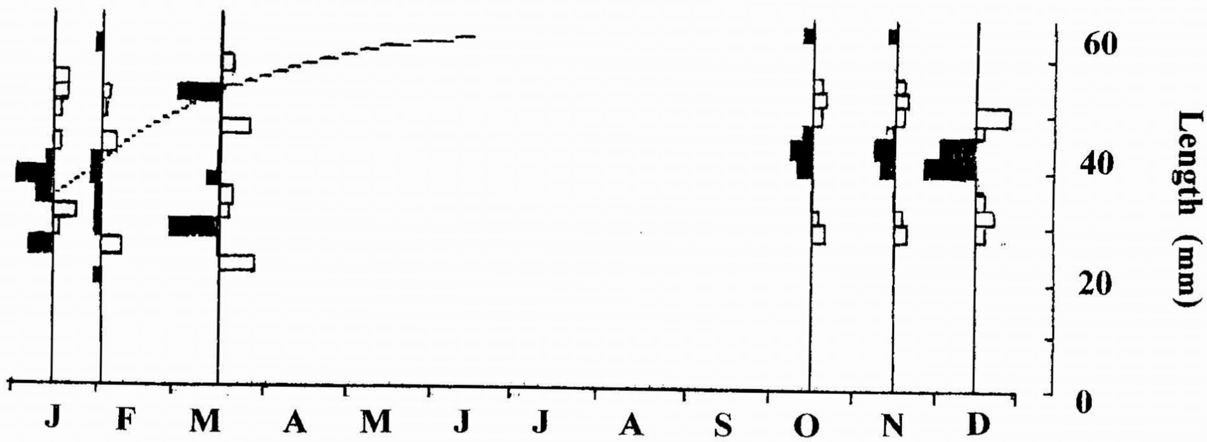
Population dynamics does not feature as a prominent aspect of damselfish biology. The data in most cases are wanting for lack of a continuous and long time series and also in the number of fish available for study. The results of *N.filamentosus* presented are based only on a two-year data, involving length of only about a thousand specimens from each site. The paucity of information in this field of damselfish biology is however an allurement to make a few observations in spite of severe restrictions on the data. The growth parameter estimates of *N.filamentosus* are in broad agreement with published values for this species (Munch-Petersen, 1983; Dalzell *et al.*, 1987; Tiroba *et al.*, 1990; Milton et al., 1991). The damselfishes are a fast growing, short-lived group of fishes. For example, the life expectancy of *N.filamentosus* is around 1 year (Dalzell *et al.*, 1987) and it is generally less than 4 months for the genus Spratelloides (Milton *et al.*, 1991). *N.filamentosus* is the smaller fish among damselfishes while L∞ values of other species are much higher. Dalzell and Wankowski (1980) estimated L∞ and K values for *S. gracilis* at 83 mm and 0.438 Y^{-1} and Dalzell (1987a) calculated K value for *S. lewisi* at around 0.544/ Y^{-1}.

The high total and fishing mortalities observed at both Dharmadom and Thikkody indicate that there is an over exploitations of this species. On the basis of life cycle strategies, damselfishes are classified as type 1 (Lewis, 1990). They are species with short life cycle, are relatively small in size, grow rapidly, attain sexual maturity in 5-6 months, spawn over an extended period and have batch fecundities of 500-1500 oocytes per gram of fish. Lewis (1990) also explains that recovery from periods of heavy exploitation of such species are rapid because of the fast population turnover, existence of unfished buffer zones and division of stocks into discrete but spatially overlapping units. The fishery to a large extend is self-regulatory due to the availability of a large number of alternative fishing sites for damselfishes along the coast. There has been instances when concentration of fishing at Thikkody alone, resulted in considerable decrease in the stock. Resumption of fishery was possible only after a delay of few months. The mortality values observed here are higher than those reported for the Solomon Islands fishery (Tiroba *et al.*, 1990). Pauly (1987) cautions that assessment of whether a stock is over fished, based solely on length-frequency data is possible only in principle. In reality, the estimates of Z will be biased one way or the other by the sampling gear and by the behavior of the animals sampled. The ratio of fishing mortality to total mortality or exploitation rate (E) can be used as a measure of the exploitation of a fish stock. Gulland (1971) suggested that in a stock that is optimally exploited, fishing mortality should be about equal to natural mortality or Fopt = M and Eopt = 0.5. Pauly (1984) proposed a more conservative definition of optimum fishing mortality where Fopt = 0.4 M and Eopt = 0.3. The E values obtained for the damselfish fishery at Dharmadom and Thikkody exceeds the suggested optima. The results of this study, therefore, indicate that the fisheries for damselfishes of this area require close monitoring and further studies are needed for conservation of the resource through artificial reef programmes.

Recruitment patterns obtained by the ELEFAN program gives only approximate results because it is based on assumptions which will hardly ever be met in reality (Pauly, 1987). The results, however, suggest that recruitment pattern contain useful information, from which legitimate inferences on the dynamics of fish stocks can be drawn. The peak recruitment period observed at Dharmadom and Thikkody tallies with the major recruitment months of *N.filamentosus* at Solomon Islands (Tiroba *et. al.*, 1990). Milton and Blaber (1991) found that spawning of six species of baitfish correlated with particular environmental conditions, especially moon phase and less importantly, rainfall and temperature. They also point out that the lack of clear proximate stimuli for spawning makes it difficult to predict the timing of major spawning events. Lewis (1990) opined that the highly fecund sprats appear to spawn year round, with recruitment occurring on a much less predictable basis and the probability of success determined by stochastic processes. Milton *et. al.*, (1990b) established that a significant proportion of the live bait population at

Solomon Islands is spawning at any given time. This means that even if there is heavy fishing during peak spawning, it will not seriously affect the overall fishery, as there will be some recruitment to the fishery from fish spawning at other sites. A similar mechanism may be operating at Dharmadom and Thikkody as is evident from the protracted recruitment and continued availability of *N.filamentosus* in spite of continued exploitation.

Fig.7.1.Restructured Growth curve of *N.filamentosus* off Thikkody



Loo = 70.00 mm, 0.44 y⁻¹, C =0.00,WP=0=00,Rn=0.168

Fig.7.3. Length converted catch curve of *N.filamentosus* off Thikkody

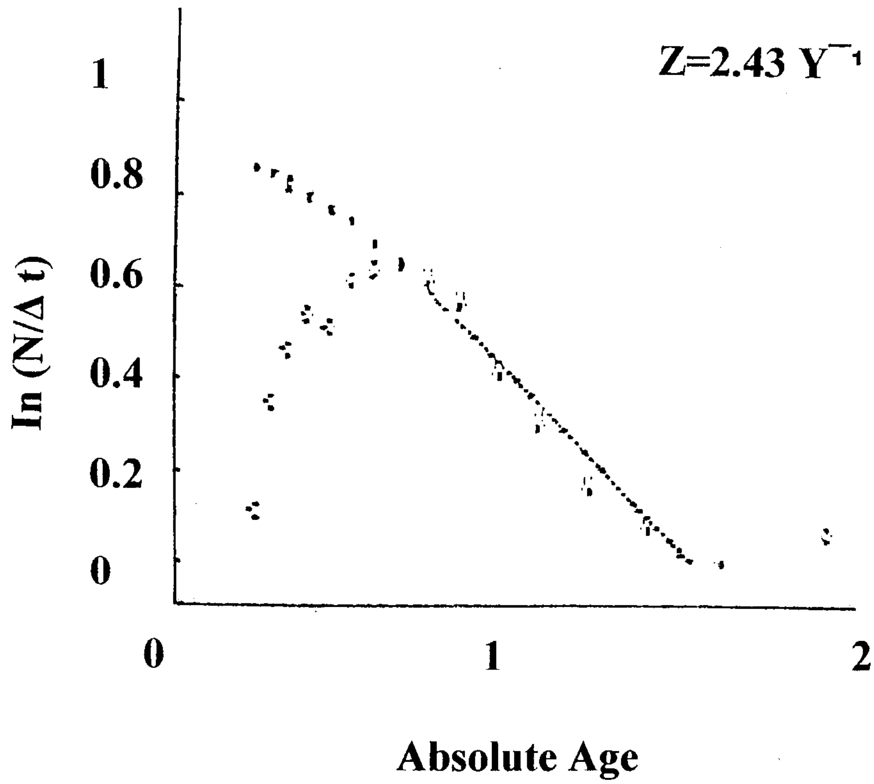


Fig.7.4. Length converted catch curve of *N.filamentosus* off Dharmadom

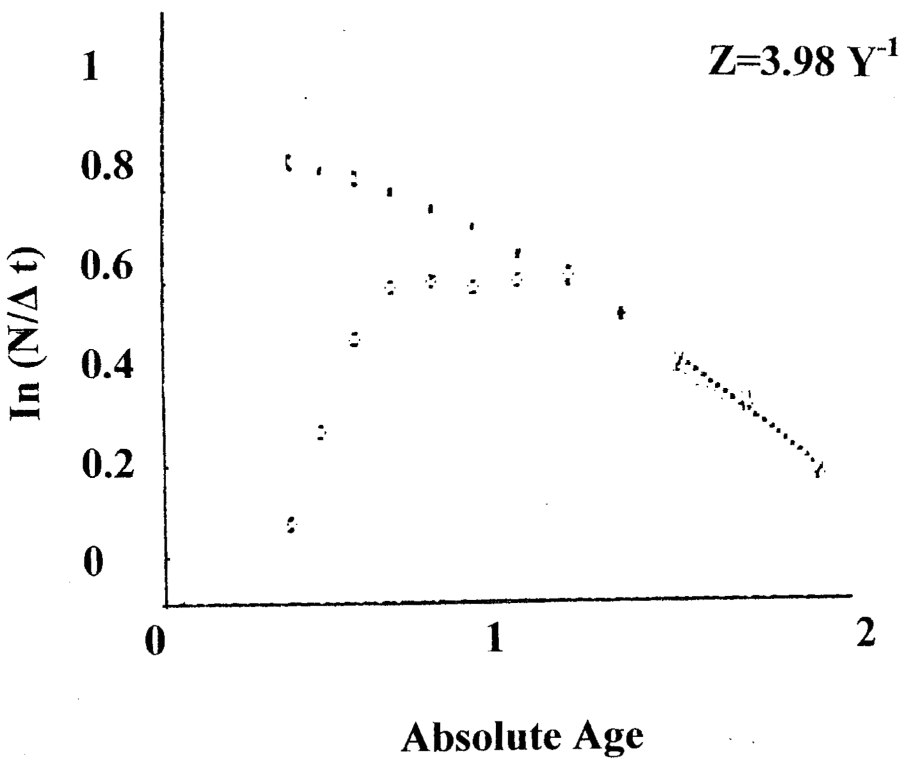
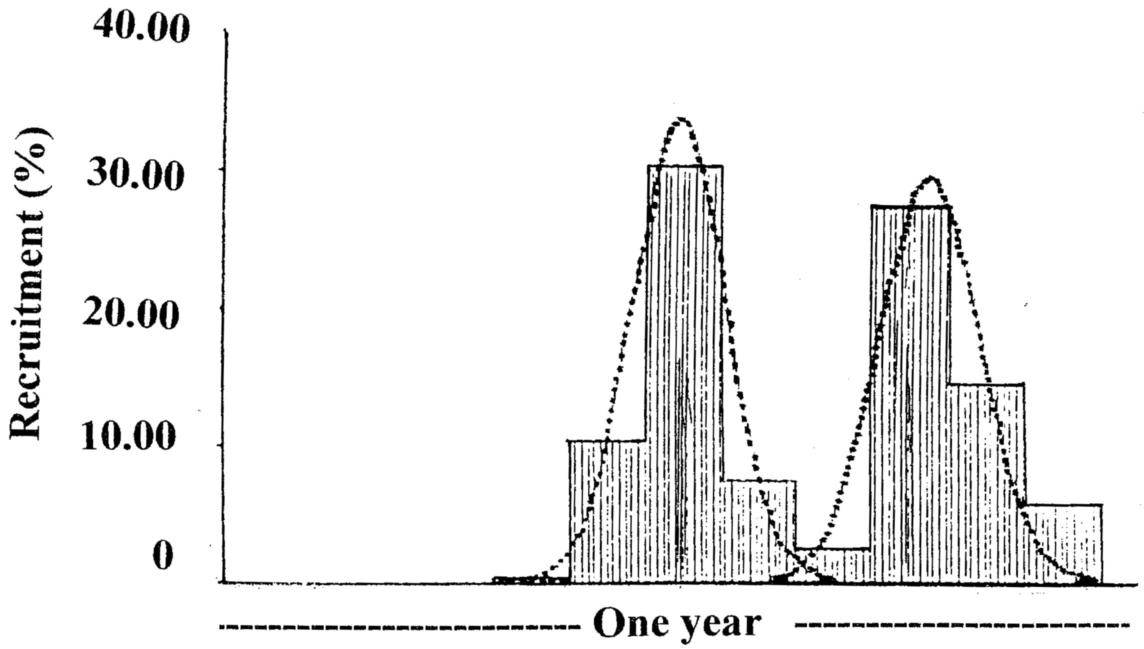
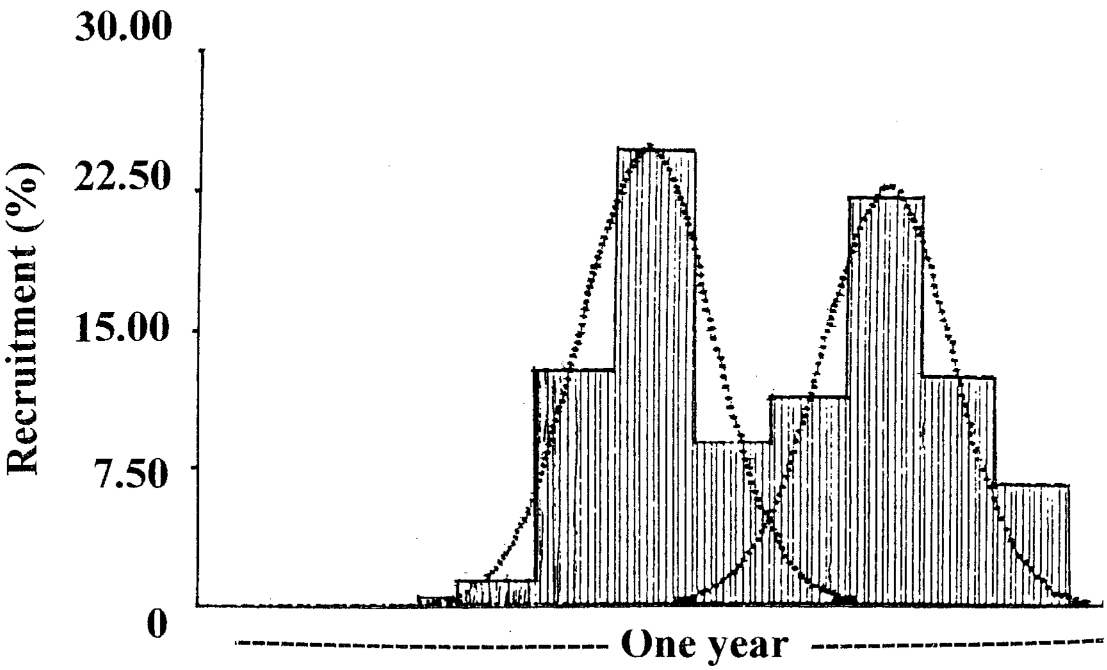


Fig.7.5. Recruitment pattern of *N.filamentosus* off Thikkody



Loo-70.00 MM, K= 0.4 Y^{-1}, C=0, WP=0, t_0=0

Fig.7.6. Recruitment pattern of *N.filamentosus* off Dharmadom



Loo-74.00 MM, K= 0.4 Y^{-1}, C=0, WP=0, t_o=0

Summary

The growth of marine aquarium industry has led to an increased demand for marine ornamental fishes and consequently a lucrative marine ornamental fish trade has emerged on a global basis. At present the total turnover from ornamental fish trade across the world has been estimated as US $ 6.5 billion. Of these the Asian countries contribute 58% in value terms. However the contribution by India to this lucrative market is only Rs. 6.5 crores and hence offers tremendous potential for expansion. In India marine ornamental fishes are abundant in the coral reef areas of Lakshadweep islands, Andaman and Nicobar islands, Gulf of Mannar, Palk bay, South east coast and south west coast.

The present marine ornamental fish trade is entirely dependant on natural stocks. The increasing demand for marine ornamental fishes has resulted in over exploitation of their wild stock and consequent destruction of reef areas. In this context, the captive breeding and hatchery production of marine ornamental fishes assumes great significance. Hatchery produced fishes will prove to be an eco-friendly approach towards the development of a global marine ornamental fish trade. Information on the reproductive biology, breeding patterns and larval rearing methods are the major pre-requisites for their production in hatcheries, and hence intensive studies on these aspects are required to achieve the goal.

A study of the systematics of commonly available marine ornamental fishes along the Malabar Coast was conducted mainly off Puthiyappa, Moodady, Thikkody, Chombal and Dharmadom centers. 50 species of marine ornamental fishes belonging to Acanthuridae,

Apagonidae, Balistidae, Chaetodontidae, Carangidae, Holocentridae, Ostraciodontidae, Platacidae, Pomacentridae, Labridae, Muraenidae, Siganidae, Serranidae, Scorpaenidae Tetradontidae and Zanclidae were observed in the fishery

The average sea surface temperature values showed that the lowest temperature 26.7°C was observed during July and the highest temperature 31.8°C during April. However there was a secondary peak 30.75°C was observed during December. During 2001 the lowest temperature 27.2°C was observed during August 2001 and the highest temperature 32.6°C was observed during April 2001. The secondary peak 31.5°C was observed during December 2001. During 2002 the lowest temperature recorded was 25.9°C observed during July 2002 and the highest 31.3°C during March 2002. The secondary peak 30.0°C was observed during December 2002.

In general the Calicut area receives an average annual rainfall of 350 cm to 375 cm. In 2001 the annual rainfall was 339 cm with highest rainfall 105 cm recorded during July 2001 and the lowest 2 cm recorded during March. During 2002 the highest rainfall 147 cm was recorded during July and the lowest 1 cm recorded during December 2002. When compared with 2001, rainfall during 2002 was fairly good with a total volume of 403 cm.

In 2001 the salinity values reached peak, 35.0% during April. Subsequent decline was very sharp to 29.9% during July. There was a secondary minimum with the northeast monsoon in November. But in 2002 though the peak salinity was in April the decline was sharper than in 2001. The minimum salinity value 28.3% was observed in July 2002. The secondary minimum 33.4% was observed in November.

The oxygen values of the surf waters increased from 4.25ml/l during January to a peak of 5.25ml/l during August and subsequently decreased to a minimum of 3.85ml/l during November. During 2001 the maximum oxygen value 5.7ml/l was observed during August and the minimum 4.1ml/l during December. During 2002 the dissolved oxygen levels increased from 4.4ml/l during January to a peak in August. A secondary peak of 3.9ml/l was observed during December 2002.

The nitrite levels showed a declining trend in the early months of the monsoon and then gradually increased to 0.38 Mu.g a/L during October. The nitrate levels showed a peak in January and decreased in the pre-monsoon months. From July with the monsoon becoming very vigorous the nitrate values increased to a secondary peak during August. Silicate levels also showed a primary peak in January and minimum during October. The secondary peak after the monsoon was observed in August. The peak value for phosphate was observed in August after the peak monsoon.

The nutrient levels in the coastal waters and reef ecosystem are largely influenced by the upwelling and monsoon activity. Nutrient availability influences the primary and secondary productivity and thereby influences the abundance of ornamental fishes in the coastal waters.

Marine ornamental fishes were abundantly available in the reef areas along the Calicut coast from September to May. Maximum abundance was observed from December to April. Newly recruited young ones start appearing in the fishery from October onwards. By the middle of May, prior to monsoon, sea become rough and the fishes are observed to move to deeper areas of the reef.

In the two-year study period Active feeding were observed in the case of *N. filamentosus* only for a period of five months from August to December. In the case of males poorly fed conditions were observed from March to August. Actively fed fishes were observed in the fishery from August to December months and also in January in both the years.

In the case females poorly fed fishes were dominant from February to August and actively fed fishes were observed from August to December and also in January in both the year. In males copepods were the most important food item throughout the year and in their scarcity fish eggs and other deccapod larvae dominated the feed in certain months. In females copepods were dominant in the feed throughout the year except during April and May months, during which period other deccapod larvae and fish eggs dominated the food.

During the study period active feeding was observed in the case of *N.cyanamos* during 8 months except from March to June. In the case of male *N.cyanamos* poorly fed individuals dominated the population from March to August during 2001 at varying percentages. More or less similar pattern was observed during the year 2002 also. During January and February months actively fed males were dominant in the population.

In the case of *N.cyanamos* actively fed females were observed during January and February months. Poorly fed individuals were observed in the population from March to August in both the years closely following the feeding pattern of males.

In males and females of *N.cyanamos* copepods formed the most important food item. Other deccapod larvae formed significant percentage in the feed of males. In females the percentage of Isopods varied from 1.4% during March 2001 to 5.2% during November 2001 and from 2.6% during January 2002 to 3.7% during December 2002. During both the years of study crustacean fragments consistently appeared in the gut contents.

Both the species of damselfishes studied showed poor to moderate feeding status with actively fed stomachs in low percentages. Feeding rate depends on the availability of Zooplankton, the feeding behaviour (diurnal or nocturnal), the time the fish was caught, prey selectivity, size of prey and feeding method employed by the species.

The upwelling phenomenon along the Malabar Coast increases the primary and secondary productivity in the coastal waters from August – September onwards. This explains the moderate to active feeding by pomacentrids during the post monsoon months. Similarly the Northeast monsoon, which sets in Kerala coast by early October, lasts till December and also results in high levels of primary and secondary productivity in the coastal water. The high levels of productivity and the relatively calm sea conditions explain the active feeding by the pomacentrids from December to February.

The length-weight relationship of *N.filamentosus* from Thikkody and Dharmadom is worked out as

Thikkodi	Dharmadom
$0.000879\ L^{2.4219}$ (r =0.9827)	$0.000882\ L^{2.5132}$ (r = 0.9921)

Pooled (Thikkody and Dharmadom

$0.000805\ L^{2.46755}$ (r = 0.9874)

The estimate of L∞ using FISAT programme indicated that it is around 70 mm at Thikkody and the Rn value for this estimate was 0.168. The growth coefficient (K) for *N.filamentosus* exploited at Thikkody is 0.44 y^{-1}. The growth parameters for

N.filamentosus exploited from Dharmadom was estimated as 74mm and 0.40 y^{-1} at an Rn value of 0.189.

The estimated Z using the growth parameters for Thikkody and Dharmadom is 2.43 Y^{-1} and 3.98 Y^{-1} respectively. The estimated natural mortality for the Thikkody and Dharmadom stock is 0.64 Y^{-1} and 0.66 Y^{-1} respectively.

The maximum recruitment was during the May - June months with maximum production in June. In May - June the recruitment was 40.77 %. During the second phase, highest recruitment was taken place in October (27.49 %). The recruitment pattern of *N.filamentosus* exploited from Thikkody also showed two distinct peaks in June - July and November – December

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